May Napier's bones rest in peace.

They taught previous computers a trick or two. Which brings us to Varian Data's 520/i.

The 520/i was designed to tackle dual programs for the price of a one-track mind computer.

That took some doing. Such as handling arithmetic functions in 8, 16, 24 or 32 bit lengths within the same program—with precision changeability at any time.

Hardware includes two 32-bit accumulators, two 16-bit index registers, two program counters and two overflow registers. Plus eleven interrupt lines. And its 1.5 μs memory is expandable from 4K to 32K bytes.

The price of our paragon? Just $7,500. Considerably more than Napier's bones—and considerably less than any comparable computer. Why not write for your brochure today?
Drum Memories by Vermont Research expand your computer's capabilities . . . expand the power of your digital controllers . . . expand the usefulness of your timesharing systems . . . and even expand in the field to meet your growing requirements for reliable, fast access storage.

At VRC, our drums have expanded our customer list . . . and our sales. We've had to expand our manufacturing space to fill three buildings.

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When it comes to engineering opportunities (and the good life, North Country style), the place to come is Vermont Research Corporation. For specific information, contact: RICHARD A. STOVER, Vice President-Engineering.
The den mother.

She always knows where all your little printed circuits are.

So in case you want to know anything about your order, just call (213) 722-6810, ext. 513. The Lockheed computerized control system — better known as our Den Mother — will have the answer for you immediately.

She knows how to keep track of thousands of orders, involving many thousands of lots and goodness knows how many parts. We update her daily, and she likes it. This way she can be aware of what and how many have been shipped, where parts and lots are and when others will be shipped.

So it only stands to reason. If we care enough to have a Den Mother just to look after our printed circuits — imagine our printed circuits.

LOCKHEED ELECTRONICS COMPANY

A Division of Lockheed Aircraft Corporation, Los Angeles, California

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JULY 1969 • VOLUME 8 • NUMBER 7

COMPUTER DESIGN

THE MAGAZINE OF DIGITAL ELECTRONICS

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the first of the
GIANTS™
GENERAL INSTRUMENT ADVANCED NITRIDE TECHNOLOGY PRODUCTS
the first static dual 16-bit shift register
directly compatible with TTL, DTL and MOS
is also the lowest priced* shift register

General Instrument’s exclusive MTNS process has now been
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The Dual 16-bit DC Shift Register is the first of the family of GIANTS (General Instrument Advanced Nitride Technology Products) to be introduced.

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The most outstanding feature of General Instrument’s Dual 16-bit DC Shift Register—and of every standard GIANT product—is the exclusive Vat terminal, which gives the user a choice of interfacing directly with TTL/DTL or MOS (as shown in the block diagrams above).

This shift register contains two independent 16-bit DC to 2MHz shift registers constructed on a single monolithic chip utilizing MTNS P-Channel enhancement mode transistors. Independent single phase TTL/DTL compatible clock and data inputs are provided for both registers. Each shift register bit is implemented with a cross coupled flip-flop, so that data is stored indefinitely regardless of the logical level of the clock. Data on the input is sampled while the clock is at a “0” level and the register shifts on a “0” to “1” transition. Separate input data selector controls are provided on each shift register. They determine which of the two inputs shall be shifted into the register. Each shift register also has its own set input which forces all stages of the register to a “1” level.

Among the other features of the Dual 16-bit DC Shift Register are: power dissipation of 120 mW, full military temperature range of -55°C to +125°C, high input impedance, stable threshold over time vs. temperature, multiplexible inputs, the need for fewer packages compared to equivalent TTL/DTL circuits, and set control.

The General Instrument Dual 16-bit DC Shift Registers are truly GIANTS among shift registers. They are immediately available from your authorized General Instrument Distributor.

For full information write, General Instrument Corporation, Dept. D, 600 West John Street, Hicksville, L.I., N.Y. 11802.

(In Europe, write to General Instrument Europe S.P.A., Piazza Amendola 9, 20149 Milano, Italy; in the U.K., to General Instrument U.K., Ltd., Stonefield Way, Victoria Road, South Ruislip, Middlesex, England.)

*$7.50 each in quantities of 100 pcs. in a 10-72 package (GI part #SS-6-8212). Also available in a 16-lead dual in-line package (GI part #SS-6-8211) at $13.80 each in quantities of 100 pcs. A
The Friden 1150 Digital Printer.
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So it won’t fail you.

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The complete specs are all in our Specification 1001.

For your copy, write: Friden Division, Component Products, The Singer Company, San Leandro, California 94577.
Throw out less versatile storage techniques.
Now our core memories are priced for applications like these:

Digital Instrumentation ☐ Special Purpose Computers ☐ Numerical Control ☐ Data Manipulation ☐ Digital Display ☐ Buffers ☐ Data Acquisition ☐ Business Machines ☐ And Much More

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The neat solution, though, is to select one of the 140 Ferroxcube FI-3 core memory systems. And now this is usually the low-cost solution, too. Even for applications in which you've never used core memory data storage.

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Ferroxcube Systems Division, Englewood, Colo.
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CIRCLE 6 ON INQUIRY CARD
There are almost no limits to the time-sharing capabilities of Bryant equipment.

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Bryant offers the largest and most experienced line of random access drum and disc file systems in the world. Systems that are standard with more computer
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A match for any computer
To the Editor:

In your April issue you published a letter by R. L. Dineley describing a simple method for treating product-of-sums logical expressions. An even simpler method is taught by D. A. Huffman. This method is based on recognizing that the Boolean expression will be zero when any of the factors in the product-of-sums form is zero. Plotting zeroes of factors on a Veitch diagram or Karnaugh map is as easy as locating ones for a sum-of-products expression.

To illustrate, using Dineley's example \((A+BC) (A+C)\):

The zeroes resulting from \(A+BC\) will be located wherever both \(A\) and \(BC\) are zero. Therefore we locate on the map the expression \(A-BC\) (which is equal to \(A\oplus B + A\oplus C\)). Similarly the zeroes of \(A+C\) are located and plotted at \(A\oplus C\). With all zeroes located, the rest of the map can be filled with ones. One can be a little more formal and work out algebraically the logical complement of the expression under consideration and then plot zeroes for that resulting expression. In a simple product-of-sums representation, however, the complementary terms can be written by inspection; or the zeroes can be plotted by inspection without writing the complementary expression.

James H. Hayes
Computer Center
University of California
Santa Cruz, Calif.

To the Editor:

I wish to add to my list of references for my article entitled "An Algorithm For the Synthesis of Complex Sequential Networks" published in the March 1969 issue of Computer Design Magazine. The reference is as follows:


Mr. Osborne's work draws close similarity to that I presented in this article and thus, would certainly be of interest to those readers seeking further information.

I understand he has done work to apply the technique of infrequent variables to the design of sequential networks constructed from Read Only Memories. Since he has not yet published anything on this area, if readers would like additional information, they can write Mr. Osborne at:

Thomas E. Osborne
Building 1U
1501 Page Mill Road
Palo Alto, California

Thank you for the opportunity to publish with you.

G. W. Schultz
Central Data Systems, Inc.
Sunnyvale, Calif.

To the Editor:

I received the June issue of Computer Design this morning and was very pleased to read the article, "Impact of LSI on the Next Generation of Computers." It was a refreshing break from what has previously been printed on this subject because it presents a balanced point of view. The article was very well presented and whoever is responsible has indeed done a very creditable job of reporting.

I also like the emphasis on special subjects such as process control. Other issues emphasizing digital signal processing, CRT terminals, or communications processors may be worthwhile.

Abhay Bhushan
Project MAC
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Lockheed has the fastest 2½D memory in the world.

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CIRCLE 9 ON INQUIRY CARD
If you're in the market for a mini computer, look at the Micro 800 first.
You'll probably end up with one anyway.

Here's one reason why: Microprogramming

Microprogramming gives you a more efficient system, tailor-made to your requirements, for less money. Since firmware absorbs many functions normally handled by core memory and interface hardware, requirements for both are reduced substantially. On the other hand, standard hardware can be retained even while changing architecture to match your particular demands. With little time and practically no effort, you can optimize computer characteristics for a particular operation without making a single hard wire change.

Here's another: Delivery

We began building 800's before we began selling them, and now we're in volume production. It's only natural then that delivery is off-the-shelf with custom variations taking a modest 30 days extra. Try us. Especially if your requirements are urgent.

Here's one more: Price

The Micro 800 costs $3200 with quantity discounts ranging up to 40%. For $3200 you get a basic processor with 16 multi-purpose registers, 256 words of read-only store, basic console, enclosure and power supply to function as a micro programmed controller. In addition, you get the fastest digital computer in its class with a 1.1\(\mu\)s memory cycle time and a 220ns micro command execution time. Core memory capacity is 0-32K bytes.

We also sell a microprogrammed adaptation of the 800 with 512 words of read-only store, a 4096-word by 8-bit core memory and a teletype interface. We call it the Micro 811 and it goes for $6300. Our third model, the $6900 Micro 810, is like the 811 except that 768 words of read-only store are used to implement an expanded instruction repertoire, including multiply and divide.

Just about any question you'll have is answered in our new mini-seminar booklet. We'll send you a copy gladly. But we'd really rather have you ask for a call from our marketing representative. You'll save a lot of time if you do because we're sure you'll end up with an 800 anyway. It's irresistible.
CONFERENCE CALENDAR


With every Raytheon computer you get AID... plug-in interface for incompatibles.

It's one thing to match a systems computer like the 706 to standard peripherals. But what about non-standards? Pick analog and parallel interfaces, scopes, data acquisition systems, or something you happen to have on the shelf.

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a new source of reliable epoxy case replacements for TO-18 transistors

The General Electric GET transistor series is your new answer to circuit design problems. GET is the most recent member of GE's proved epoxy encapsulated transistor family dating back to 1962 ... over 6 years of epoxy experience.

GET's package design conforms to TO-18 mounting patterns in existing PC boards. It's the ideal epoxy replacement for "hermetic devices" ... no expensive redesign necessary.

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Standard NPN and PNP devices are available now through GE distributors. Five family groups representing GE's new epoxy transistor lines are shown below. Additional family types are being added. For more information on GET's for all applications, plus GE's "specials" capability, call or write your GE sales representative or distributor, or write General Electric Company, Section 220-69, 1 River Road, Schenectady, N.Y. 12305.

In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: Electronic Component Sales, IGE Export Division, 159 Madison Avenue, New York, N.Y. 10016.
Space trade-offs are a pain in the rack

...and Fabri-Tek's NEW 380 Core Memory System packs 655,380 bits of fast relief in a case that's only 10½" x 19" x 21"... including complete power supply!

Or maybe you need even more capacity. Fine. The new 380 System is expandable to over 2.6 megabits! Which is a lot of storage.

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The 380 also includes our automatic DATA SAVER™ feature to minimize recovery time after any unpredicted temporary loss of external power. (Guards against any loss of data, too — and there's no manual reset required to get back on line!)

Speed? 950 nanoseconds. And of course word or byte control plus parity generation and checking are available.

If your storage requirements are less than 655,380 bits, you can save even more rack space by going to our 370 system. It's got the same major advantages as the 380 system scaled down to a 5⅞" x 19" x 21" case with a capacity of 163,840 bits (field-expandable in increments to 655,380 bits), and speeds ranging from 750 nanoseconds to 1.5 microseconds. Both systems are ideal for nearly any kind of data processing. See your Fabri-tek Representative for complete specs, or call or write us direct.

Fabri-Tek is a leader in advanced memory research, development and production. Our experienced Application Engineers are ready to help you find solutions to static and dynamic storage applications: Buffer Memories • Extender Memories • Peripheral Mass Memories • Mil-Spec Memories.

Fabri-Tek is a leader in advanced memory research, development and production. Our experienced Application Engineers are ready to help you find solutions to static and dynamic storage applications: Buffer Memories • Extender Memories • Peripheral Mass Memories • Mil-Spec Memories.

Fabri-Tek is a leader in advanced memory research, development and production. Our experienced Application Engineers are ready to help you find solutions to static and dynamic storage applications: Buffer Memories • Extender Memories • Peripheral Mass Memories • Mil-Spec Memories.
Think about it! What could it mean if you could pick up the phone, call your computer and get your question answered now! Your people could make immediate credit checks, keep track of inventory, find out the latest blueprint revision numbers, get the status of savings or checking accounts, or anything else that's programmed into the computer. How? The Cognitronics Speechmaker—a multiplexed voice response system. Interfaced with your computer (it's compatible with virtually any computer available), Speechmaker provides immediate retrieval of the vital information that's needed quickly for efficient business management. The Input/Output terminal is an inexpensive Touch-Tone telephone and the Speechmaker vocabulary of up to 189 words is tailored specifically for each application. Multiplexing allows independent, simultaneous multiple outputs over an unlimited number of lines. "Free Demonstration" — For complete information and to arrange for a demonstration of the Speechmaker, write or call today.

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CIRCLE 15 ON INQUIRY CARD
Now from Sprague Electric!

Your custom pulse transformer is a standard DST* transformer

You can select the transformer design you need from the new Sprague DST Family, a fully-characterized series of Designer Specified Transformers which Sprague Electric has pioneered. It's easy. Start with the two basic parameters dictated by your circuit requirements: primary (magnetizing) inductance and volt-second capacity.

New Sprague engineering data gives basic information from which all nominal sine wave parameters are derived. This data allows you to specify the one transformer from thousands of possibilities which will optimize performance in your application.

Design Style A minimizes magnetizing inductance change as a function of temperature. Typically it's \( < \pm 10\% \) change from 0 to 60\( ^{\circ} \)C; \( < \pm 30\% \) from -55 to +85\( ^{\circ} \)C.

Design Style B and C give you broad band-pass characteristics, and still keep magnetizing inductance change \( < \pm 15\% \) from 0 to 60\( ^{\circ} \)C. Design Style D is fast. Associated leakage inductance and coupling capacitance are kept at a minimum. This style is just what you need for interstage and coupling devices in computer drive circuits.

The Sprague DST Series packs a lot of transformer into minimum volume packages — epoxy dipped for minimum cost, or pre-molded. The 100 mil in-line lead spacing is compatible with integrated circuit mounting dimensions on printed wiring boards.


*Trademark
So what if Grant Slides save hours of down time?

Is there a quicker, more efficient way to get to a fault location than by immediate and smooth extension of the unit for simple, fast check-out?

Would you guess the savings from being able to keep equipment connected (and in operation) while maintenance takes place?

What's it worth if slides enable equipment to be serviced in half —or less than half the time it ordinarily takes bolting and unbolting, fastening and unfastening?

How great is the value of slides if individual chassis' can be interchanged with similar chassis' in moments?

Virtually every product can use the ready access provided by Grant Slides. There are thousands of types, styles and sizes available. Slides that tilt, lock, extend and lock and perform dozens of other functions. Undoubtedly, there's a Grant Slide that can help make your product better too.

Write for complete data.
New System 18/30...

computerized automation in easy, economical steps.

A computerized automation system must first perform today's tasks economically and predictably. The new GA 18/30 industrial computer system is the only automation system to do just that.

The 18/30 system centers around a family of compatible GA automation computers designed to work in distributed management information and control systems. The GA worker-level computers permit the user to automate at the primary control loop first, with predictable results and costs—and then add to these automation functions GA supervisory-level computers for total process optimization.

The heart of our new System 18/30 is the 1804 processor, which is fully software compatible at the binary code level with the IBM 1800 and 1130 computers and will work with or extend existing IBM 1800 installations. The 1804 executes over 400,000 instructions per second, has a core memory with a 960-nanosecond cycle time, has a 16-word MSI scratch pad memory with a 35-nanosecond cycle time, hardware double precision arithmetic with multiply and divide, memory storage protect and parity bits, and a 16-bit word and Input/Output rates over 1,600,000 characters per second.

The 1804 acts as a supervisory computer for several SPC-12 dedicated computers. SPC-12 is our primary control loop computer. It ties to your machines, devices, communication networks, sensors and instruments through our unique family of mini-controllers to form a primary control loop automation system. With GA unique Product Software, control programs can be accomplished quickly, economically, and on a fixed price basis. GA terminals, communication pre/post processors, process I/O, and data processing I/O, and computer to computer connectors provide the system building blocks required to take on large scale automation on a step by step basis with each step on a predictable cost and results basis.

Our Automation Sciences Division will provide all the process analysis, engineering, programming, installation and start-up service you need.

So if you have an automation requirement, large or small, ask us about step by step automation at any of our nation-wide sales offices. Or write for our System 18/30 Brochure.
30-gage wire needs Kynar®. If you've ever tried to locate a short in thousands of feet of small-gage computer wire, you'll appreciate the toughness found in insulation of Kynar.

With twice the cut-through resistance of totally fluorinated plastics, Kynar eliminates the worry over physical damage to the wire. You can bend it, loop it and pull it over knife-sharp edges without harm. It's compatible with automatic wiring machines or hand tools. And it cuts and strips fast and smoothly.

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For samples and information, write: Plastics Department, Pennwalt Corporation, 3 Penn Center, Philadelphia, Pennsylvania 19102.

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the most complete line of Bell compatible data sets!

Have you been purchasing data sets here and there? You don’t have to! SANGAMO can supply 93% of your data set requirements with guaranteed Bell compatible units now.

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103F2  201A3  202C2  401E2
201B1  201A4  202C3  401E3
201B2  202D1  202C4  401E4
201B3  202D2  202C5  401E5
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Your first step is simple...just phone, write or circle the reply number.

*You simply choose the module and write the signal name by each pin number. You don't worry where the wires go or the order of listing.
You don't win the Grand Prix or the "500" by driving a truck — or weaving all around the track. The same is true in the mass memory race.

Until now mass disc memories were ponderous brutes. They took up a dozen feet of valuable floor space. Weighed close to a ton. Required thousands of kilo-watts. Most used positioning heads which do have drawbacks. Time lost in positioning, Positioning errors, Positioner wear. Maintenance.

CPC has changed all this with a fast head-per-track disc memory which stores up to 200 million bits in a compact 19" chassis just 40" high. It weighs only 300 pounds. Requires but 1 Kw of power.

The secret to on-site expansion is the modularity. From one through four 25 million and/or 50 million bit disc modules may be used on the same compact drive. 256 "fail-safe" flying heads per surface access data fast. 16.7 milliseconds average. Data transfer rate is 3 MHz.

There's more to tell. Like the single disc security which eliminates the possibility of head avalanche. Or a worst-case-failure recovery time of only minutes. Or the ability to serve up to 3 controllers.

Want the whole exciting story? Request a copy of our DSU-8100 brochure.

CPC computer peripherals corp.
5037 Ruffner St., San Diego, Calif. 92111
Telephone (714) 279-7500

CIRCLE 22 ON INQUIRY CARD
GE ENTERS MINI PROCESS COMPUTER MARKET—General Electric Co. has announced its entry into the mini process computer market with a flexible, read-only-memory-based computer which sells for under $10,000.

The GE-PAC 30 features 16-32 instruction programming, direct addressing to 64K bytes, plug-in modular design, and dual in-line IC's. The standard ROM can be unplugged and replaced by a special hardware diagnostic ROM/, which, in combination with a test set and symptom dictionary, permits rapid fault location.

The computer, with models designated GE-PAC 30-1 and 30-2, has software which is fully upward compatible between models, permitting growth without re-programming.

The major difference between the models is in instruction execution times. The 30-1 costs less and is more flexible due to the general-purpose organization of its micro-processor. The 30-2, with more commitment to hardware, is far more powerful at the user level.

Typical applications of the GE-PAC 30 will include production testing of electronic components, process control, loading terminal automation, instrumentation and sub-system control.

ADAPSO'S POSITION ON OEM PRICING POLICIES—The Association of Data Processing Service Organizations, Inc. recently released its first in a series of position papers on industry views, dealing with "Computer Manufacturers' Pricing Policies."

It is ADAPSO's general position that the manufacturers' traditional practice of providing a variety of products and services in a single purchase or rental price represents in practice a tie-in sale and a form of price discrimination.

"ADAPSO believes that the best interests of all users (service organizations and others alike)," J. L. Dreyer, executive vice president, stated, "would be served if all computer manufacturers would price separately any service or function which is or can be available in the marketplace or provided by the user himself."

ADAPSO specifically recommends that systems engineering support, educational programs, and application-oriented software or programming be separated from the single price and offered to all customers at prices related to the cost of providing each unit of the service.

DATATROL TO MANUFACTURE ELECTRONICS HARDWARE — Datatrol Inc., a newly formed electronics hardware manufacturing company, has commenced its operations in Hudson, Mass. The company's four principals, Bob Frank, president, Leon Jackson, vice president, Jack Dumser, and Frank Hibberd, were formerly with the Digital Equipment Corp.

The company will specialize in digital data communications equipment, computer displays, and industrial control systems. Products already being marketed include a display unit and three communications interfaces.

The display is Fastplot, a previewing device for incremental plotters. Using a Tektronix 611 storage tube, it connects directly to any computer equipped with an interface to an incremental plotter and makes use of all the standard plotting software. Interfaces include the CI-12, which provides communications to remote teletypes over full duplex lines using the dial-up network; the CI-15 is a multi-line communications interface providing four full duplex lines; data-talk CI-14 allows any user to call a computer using a touch-tone telephone and receive a response in spoken words.

RYDAX WILL MANUFACTURE DIGITAL MESSAGE SYSTEMS— The formation of Rydax, Inc., in San Rafael, Calif., has been announced by its president, Chandos A. Rypinski.

He explains, "There is a tremendous need for specialized digital communications systems in today's complex world. Rydax offers a sophisticated capability on a standard product basis. Among our products is a digital terminal identification system and alarming system module (SAM) built for the Southern California Rapid Transit District. To date more than 200 modules have been installed in its buses, providing automatic identification of all voice transmissions from the bus as well as silent alarms as a crime deterrent."

Marketing vice president Max W. Kuypers, states, "Our major product will be digital message systems for data acquisition, monitoring, and supervisory control systems. Because of their compatibility with all radio, microwave, and telephone line networks, Rydax products are useful for public utilities and transportation systems, as well as industrial monitoring and control applications."

Rydax will also manufacture remote control terminals for teleprinters at attended and unattended high-frequency radio stations, featuring dual channel configuration for error correction, parity error detection and pulse regeneration, as well as address and control features for automatic operation.

SURVEY OF FACSIMILE FEATURED IN AUERBACH DIGEST— The latest edition of the Auerbach Computer Characteristics Digest features an article on facsimile devices, which sketches the historical development of facsimile technology, provides succinct characterizations of 22 general-purpose systems, and surveys the available units that can operate over common-carrier facilities. Selected for more detailed coverage are two representative systems: Xerox-LDX and Stewart Warner-Dial Dataflex.

A discussion of new developments in facsimile networks describes the franchising concept, similar to mail-
If you've got something to say to a computer you can say it best with a Datapoint 3300 — Here’s why:

- The Datapoint 3300 is the first data terminal to be designed specifically for interactive time sharing use.
- The Datapoint 3300 is engineered to be fully compatible with all time sharing services now using Teletype equipment as terminals.

In developing the Datapoint 3300, Computer Terminal Corporation sought a terminal that would amplify the productivity of the professional as he worked upon problem solutions in interactive dialogue with a computer. We sought to remove the traditional barriers to effective man/machine communications. We succeeded.

A central feature of the 3300 is the CRT display capacity of 1800 characters in a 25 line/72-character-a-line format. (A high “refresh” rate provides characters that are at once stable and easy to read.) In this expanse of data, a complex program or problem can easily be expressed, and comprehended at a glance. The interactive user, working the standard 64-character-set keyboard, can easily add, delete, correct or manipulate characters and lines of data. The remote computer becomes a powerful and flexible extension of the human thought process, directly responsive to and controlled by the user sitting at the Datapoint 3300. Because the 3300 is not shackled by the limitations of a mechanical printer, it can make available data transmission rates of up to 600 bits per second standard, and up to 4800 bps with optional speed buffer. This means the interactive user enjoys faster response from his remote computer; accordingly, his “on-line” time will shrink while his productivity goes up.

The 3300 is noiseless — no hum or clatter of keys to intrude upon the user’s concentration. It comes packaged in a handsome, totally self-contained unit, comparable in size to an executive typewriter, which blends well with today’s office environment. The female help will love the 3300’s appearance, as well as its ease of usage.

We think you’ll like it. For further information, simply write to Computer Terminal Corporation, P. O. Box 6967, San Antonio, Texas 78209.
by-phone, which provides customers with facsimile service via the public telephone network.

For additional information or a descriptive brochure, contact the publisher: Auerbach Info, Inc., 121 North Broad St., Philadelphia, Pa. 19107.

COMPUTING SERVICES OFFERED NATIONALLY — A joint marketing agreement has been reached between the Chi Corp., of Cleveland, Ohio, a scientific/engineering computer services company, and StatCom—the Statistical Communications division of Statistical Tabulating Corp. (STC), of Chicago, Ill., a firm specializing in commercial data processing services. StatCom will market the specialized capability of Chi Corp.'s Univac 1108 through STC's national sales organization, providing scientific and engineering computing services nationally.

According to Stanley Y. Curry, president of Chi, and Michael R. Notaro, STC president, the agreement represents “a blending of skills between the oldest scientific/engineering computing organization and a company with 33 years’ data processing experience. The third generation 1108 computer and Chi’s excellent staff will provide STC with a logical extension of its services into the area of complex computing, while our established national sales structure and network of data centers will allow Chi to greatly broaden the marketing of their computer time.”

COMPUTERS AND COMMUNICATIONS CONFERENCE—The IEEE Mohawk Valley Section and the Communications Technology and Computer Group Chapters will sponsor a conference entitled “Computers and Communications,” at the Beeches in Rome, N. Y., September 30 to October 2.

The conference will review recent communications/computer processing developments, taking advantage of computer techniques which may be applicable to problems confronting research and operations personnel in the communications area. The conference will also consider the role of communications techniques in computer systems development. Application and implementation will be emphasized, rather than just theoretical aspects. For further information contact: Computers and Communications Conference, 304 East Chestnut St., Rome, N. Y., 13440.

VRC TO EXPAND FACILITIES—Vermont Research Corp. of No. Springfield, Vt., has announced plans to establish a separate Systems Division in Tempe, Arizona. Headed by Prentiss L. Smith, vice president and founder, the division will produce standard and custom memory systems.

Standard products will include controllers for interfacing standard VRC drum and disk memories to a variety of computers, and off-the-shelf memory/interface packages for any data processing systems requiring peripheral memory. The company has already marketed standard memory systems for the PDP-5, 8, 8/S, and 9; and the Sigma 2, 5, and 7.

“Establishment of a separate systems facility in the west,” Smith says, “is a continuation of our rapid growth in Springfield, where increased drum orders have tripled our production capacity since the first of the year. The continued sales growth for drums and systems requires expansion of our systems capabilities.”

1969 ISA CONFERENCE & EXHIBIT—The Instrument Society of America will conduct three symposia concurrently with the 24th Annual ISA Instrumentation-Automation Conference and Exhibit, October 27 to 30 at the Astrohall in Houston, Texas. Themes of the symposia are data handling and computation, test measurement, metrology.

Registration fees for all technical sessions, including exhibit admission is $12 for ISA members and $18 for non-members. The fee for the exhibit only is $3 for non-members, with no charge to ISA members, or non-members registered by October 3. Registration forms may be obtained from: Public Relations Dept, Instrument Society of America, 530 William Penn Place, Pittsburgh, Pa. 15219.

DIGITAL EQUIPMENT CORP. FORMS CONTROL PRODUCTS GROUP—The creation of a Control Products Group has been announced by Stanley C. Olsen, vice president and group manager of the Digital Equipment Corp. of Maynard, Mass.

Olsen states that “penetration of sophisticated electronic technology into the industrial control market has advanced to the point where specific approaches are becoming well defined. Having followed this penetration for the ten years that DEC has been supplying this market, we are confident that our new approach will allow us to dedicate our resources most effectively to developing products and innovative techniques to meet specific demands.”

The product lines will include solid state machine control for repetitive processes—PDP-14—with John Holzer as manager; systems for numerically controlled machinery—n/c products, Russell Doane, manager; control modules for industrial applications—module products, with Frederick Gould as manager; and specialized industrial control systems, drawing on all product areas within DEC, to be managed by Martin S. Gordon. Product line manager is Allan T. Devault, who will be responsible for overall activities within the control products group.

COMPUTER SHORT COURSES SET AT UCLA—Three short courses in the computer sciences will be offered by UCLA Extension’s department of engineering and physical sciences in July and August on the UCLA campus. All courses meet Mondays through Fridays, 8:30 a.m. to 5 p.m.

Planners and managers of operational systems whose performance depends strongly on computers will be interested in Systems Analysis Techniques for Computer-Based Systems, July 21 through 24, in Room 5436 Boelter Hall. The course will provide a survey of techniques for predicting, measuring, and analyzing the performance of computers in an operational environment, of general concepts of systems analysis and of approaches to critical computer problems.

Error Detecting and Correcting Codes: Applications in Digital Systems Design will be offered, July 28 through August 2 in Room 4277 Boelter Hall. For engineers and scientists with training and/or experience in digital equipment design, the course will constitute a concentrated and self-contained study of current applications of error detecting and correcting codes in the design of digital systems.

Development of Real-Time Computer Systems will conclude the series, August 4 through 15 in Room 5436 Boelter Hall. The course will provide a greater understanding of real-time systems with emphasis on concepts and comparisons; techniques of designing and implementing real-time systems; applications; and computers and society.

Further information is available by writing P.O. Box 24902, Engineering and Physical Sciences Extension, 6115 Math Sciences Building, University of California, Los Angeles, Calif. 90024, or telephone (213) 825-3344 or 825-1295.
TTL/MOS/DTL INTERFACES

Some of our low-voltage MOS integrated circuits couple directly to TTL or DTL logic circuits, some take a resistor or two. Voltage translators and special buffers are not needed because the data-input stages are designed to accept relatively small changes in signal voltages as well as large MOS-style swings.

Interfaces like Figures 1a and 1b do nicely in most applications. Devices with active pullup and pulldown output stages don’t even need a current-sinking resistor (Figure 1b). An input pullup resistor can be used on the shift registers (MM506, MM510 and their cousins) in high-performance applications. We’ve clocked them at twice the normal MOS rate with the Figure 1c interface.

A pullup resistor is required by some of our larger-scale devices, particularly those containing a lot of logic and memory on the same chip. The MM521 read-only memory in Figure 1d is one of these. But considering that the MM521 stores 256 4-bit words and can replace an entire TTL assembly, we think that a few resistors is a small price to pay.

What makes our MOS circuits so compatible? Design improvements based on better MOS processes, of course. The National Semiconductor process lowers the voltage threshold to about 2V, allowing small transitions in the data signals to be handled reliably. TTL and DTL transitions are usually 4V or less, while conventional MOS circuits demand a change of at least 7V. Some look for transitions as great as 18V.

Note, however, that the biases on the shift registers in Figure 1 are positive and negative, a la regular MOS. Although low-voltage elements are used in the input stages, they are designed with ample overdrive to establish proper MOS logic levels for the following stages’ storage and switching elements. In fact, any number of our low-voltage MOS circuits can be placed in cascade between two TTL or DTL gates as long as MOS/MOS coupling specifications are met within the string.

You can usually disregard what has been the normal limits on our MOS inputs. Data levels can be as low as VSS -2.5V for a MOS “0” bit and VSS -4.2V for a “1”. If VSS, the MOS substrate voltage, is picked off the +5V supply used for TTL VCC, logic levels of 2.5 and 0.4V are acceptable to low-voltage MOS inputs. They’ll work even during worst-case VCC ±5% and gate-loading conditions with an input resistor to VCC.

At the output interface, different conditions must be satisfied (they can be calculated with the equations in Table 1). To drive a TTL gate, the MOS output stage must sink 1.6mA of current and allow the signals to go more positive than +2.4V and more negative than +0.4V. Some designs require an external resistor to provide the negative current path, but devices with output stages like the MM510 do not. The latter design has proven itself in numerous applications, so we are using it in all appropriate new products. Either one meets the voltage spec.

Fanout is normally one, but this can often be improved by trade-offs between VSS and V++. The voltage transitions for the clock signals (\(\phi_1\) and \(\phi_2\)) will have the same amplitude as specified for our MOS assemblies, but the levels should be shifted to correspond to VSS. During the logic “0” clock intervals, the clock should be within 1.5V of VSS.
When $V_{SS}$ is the same as $V_{CC}$, it doesn't make much difference what types of TTL or DTL gates are used as signal sources and receivers. But be sure the gate can withstand its output being pulled up if $V_{SS}$ is higher. That's why we recommend our DM8000 gates in Figures 1c and 1d. Even though its specifications read like a conventional TTL gate's, the DM8000 can be pulled as high as +14V without breakdown (a similar quad 2-input gate circuit, the DM8810, is specified for high breakdown voltages). The DM8000 is protected by a reverse-biased diode in the emitter-follower active-pullup string and a base-to-emitter resistor biases off the output-sinking transistor (see Figure 2). Also, the DM8000 has no trouble sinking the current required for an MOS input at the +0.4V level. It can handle 16 mA.

Both the 5V and 12V techniques shown reduce interfacing costs to a minimum. Inserting MOS devices into an otherwise TTL or DTL system can lower the cost per bit significantly when the application calls for shift registers, small memories and similar functions. Both methods are equally convenient, since neither requires an additional power-supply connection. Most systems contain 5V and 12V supplies for other purposes. So the choice depends on the voltages that are most compatible with the rest of the system and performance factors such as the operating frequency desired.

Detailed information on low-voltage MOS devices and instructions on clocking and other auxiliary circuits can be found in National Semiconductor literature.

Table 1. Output Conditions

In MOS logic “0” state:

$$\frac{V_{SS} - 2.4V}{Z_o} \geq \frac{2.4V - V^-}{R_o}$$

In MOS logic “1” state:

$$I_1 \leq \frac{0.4V - V^-}{R_o}$$

Definitions:

$I_1$ = Current through $R_o$ at $V_o = +0.4V$ (1.6 mA)

$R_o$ = Output resistor (internal or external)

$Z_o$ = MOS output impedance

$V^-$ = Supply sinking negative current

$V_{SS}$ = Most positive voltage

$V_{DD}$ = MOS drain voltage
Holographic Techniques Point Way To Improved Computer Memories

An experimental computer storage device has been developed by IBM’s Systems Development Laboratory in San Jose, Calif., which has attained a storage density of over 2 million bits per square inch of recording space, an average data read rate of 16 Megabits per second and an average access time of 8.5 milliseconds. Tests indicate as feasible a storage density of 6 Megabits per square inch, a data read rate of 160 Megabits/sec and an access time of 1.3 milliseconds. The device uses advanced holographic encoding techniques to work with units of one byte of data. An electron beam is employed to write computer-generated binary Fourier holograms on strips of photographic film. Each hologram contains one byte of data, made up of eight data bits and one clock bit. The holograms are organized into 256 tracks of each film strip, and the strips are placed on the inside surface of a transparent drum for readout by a laser beam. The device successfully reads holograms when up to 30% of their area is obscured.

IBM Develops 32-Channel Multiplexer on Single Chip

A 32-channel multiplexer with 40 analog switching devices on a single LSI MOS chip has been developed by IBM. The new component, replacing a previously developed 16-channel multiplexer, has circuits for multiplexing, timing logic and two shift registers requiring an external clock and power supplies. The total power requirement is reduced from 250 to about 120 milliwatts, total multiplexer size and weight are reduced, and reliability is greatly improved.

Prior to the 16-channel multiplexer, transistors, relays or switches were used. These, however, were bulky and not reliable for space applications.

For systems applications larger than 32 channels, the chip can be interconnected to form a 64-channel or larger multiplexer in multiples of 32 or in a multiplexer-sub-multiplexer configuration.

In its present configuration, the chip functions only as a serial multiplexer. However, it was designed to allow modification of masks to produce a random access multiplexer.

The analog switching devices are laid out in the shape of a horseshoe around the outside of the chip. Shift registers and associated logic are contained in the center. By modifying the center section, a holding register can be added to produce a random access capability. Chip design is such that a random access multiplexer could be produced with a minimum of mask modification.

The circuit and chip were developed jointly by IBM’s Federal Systems division’s Space Systems Center facility in Huntsville, Ala., and the Components division’s East Fishkill, N.Y., facility.

The chip is expected to be used in advanced aerospace and avionics systems requiring high reliability with minimum weight, size, and power dissipation.
**Functionally-Oriented Computer for Process Control**

A direct function processor has been developed for the process and numerical control market which can be programmed in the same kind of functional language the system designer must use to define his own overall system requirements. Recently revealed by GR Industries Inc. of Newton, Mass., the GR-909 is a functionally-oriented computer in which every processor or I/O element is directly addressable as if it were part of the internal processor logic. The source and destination buses are not terminated at the computer I/O terminals. Instead, all internal operations are handled by functionally-designed elements connected between the same set of buses as are external devices, so that all internal and external elements are directly addressable using a compiler-like functional language rather than a mathematically-oriented language.

Passage between the source and destination buses is linked by a modifier which can manipulate the data enroute under program control. Thus the bus system is extended into the computer itself; i.e. the elements of the computer are brought outside of the central processor and all elements, such as the instruction register and arithmetic unit are connected across the bus structure.

The key to making this type of structure effective is the addition of a programmable link between the source and destination buses. This programmable path provides a means of getting any data word or control pulses from any of the internal components of the computer appearing on the destination buses back to the source buses to be delivered to any other functional component in the system. Since each active component in the entire system is connected between the buses, any device can send a word in parallel directly to any other device. The memory of the GR-909 is random access core in 1024 and 4096 plug-in modules, which can be expanded to 8K in the basic processor frame without additional wiring. The basic unit has a capacity of 16 bits, and can be expanded to 32K directly addressable words.

GR-909 is now in prototype production and deliveries are expected to be made in the fall. The basic machine will sell for $3,600. The 4K machine with a Teletype interface (not including Teletype unit) will sell for $8,400.

The GRI 909 computer, designed specifically for the OEM control market, utilizes a unique concept that short-circuits the conventional I/O buses and enables the arithmetic operator, sequence counter, various registers, memory elements, and other operators usually found in the central processor unit (CPU) to be directly connected to the same set of buses as the computer peripheral equipment and the devices used in the customers' systems.
The new Fairchild \( \mu A715 \) is the fastest linear IC op amp available today.

For applications where power bandwidth, acquisition time or slew rate is the prime consideration, the \( \mu A715 \) stands alone. It’s ideal for applications such as wide-band amplifiers, high-speed integrators, precision comparators, sample-and-holds and video or deflection amplifiers. You can start raising the performance of your data acquisition, control, communications or display systems today.

The \( \mu A715 \) is a 3-stage amplifier, with a Darlington cascode input for optimized ac and dc performance, a differential second stage and a class AB output for low distortion. Bandwidth is 60MHz, open loop gain is 92dB, input offset current is only 80nA and both input and output are short-circuit protected.

And, even though op amps are available with slew rates higher than the \( \mu A715 \)'s 60V/\( \mu \)s (\( A_v = 100 \)), it’s still the fastest op amp available. The curve shown represents the typical response of any op amp to a step input at time \( T_o \). First, there’s a short delay, then the output starts rising to its final value at a rate determined by the slew rate (\( \Delta V/\Delta T \)). But, in most op amps made, there is first an overshoot, then ringing. The final output value is not achieved until the end of the settling time, when the excursions no longer exceed the bounds of the error band. The total time to achieve the final value (acquisition time) is the sum of the first delay, the rise time and the settling time. In most other op amps, the settling time is measured in microseconds. In the \( \mu A715 \), the settling time is just 300ns. Combine this with a maximum initial rise time plus delay of 350ns (for a 10V swing) and you’ve got a total acquisition time of just 650ns. And the fastest op amp made.

You can get it now in quantity from your Fairchild distributor.

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<td>TO-5</td>
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To order the \( \mu A715 \), ask for:
Optically Exciting a Magnetic Memory: A Feasibility Study

A study has been made to determine the feasibility of modifying the magnetic moment of a magnetically-ordered material by optical pumping for digital memory application.

The potential of optically addressed (often referred to as beam addressable) digital memories has been considered by a number of workers and is presently an area of much research. The goal to which these efforts are directed is the achievement of high-density bulk memory with storage capacity of approximately $10^8$ bits. This density can be achieved in reasonable size, for example a planar area of $10 \times 10$ cm, with bit resolution of 10 microns. Such a bit size is about an order of magnitude larger than diffraction-limited resolution of visible light. Thus optical approaches appear attractive. Additionally, the interaction of polarized light with magnetic materials exhibiting the magneto-Kerr and Faraday effects supplies a means for detecting the magnetization state of local regions via reflection or transmission providing communication with the "store" without interconnecting wires.

The limiting operation, however, in all presently proposed memory schemes is the write process. This has generally been accomplished by applying heat to the lattice, to effect a change in coercivity of a local spot. The heat source may be a laser or electron beam; both have been proposed and experimentally studied. The use of temperature changes to modify the magnetic state of a memory medium introduces speed performance limitations. In addition to the relatively long thermal time constants, another problem associated with thermal excitation is that of thermal creep. To prevent adjacent bit disturbing effects thermal barriers must be provided between storage element locations, resulting in a reduction of achievable storage density and an increase in the fabrication process complexity. To overcome these limitations associated with thermal excitation, the study sought to determine the feasibility of optically pumping a magnetic material to effect the switching process. This approach provides the potential of achieving excitation and decay times in the sub-microsecond range without the problem associated with thermal creep. The experimental work to date has been directed toward the rare earth iron garnets. These materials show a rapid change in coercive force versus temperature at the antiferromagnetic compensation temperature, an effect from slight variations in temperature causing a net magnetic moment to exist. A technique is therefore being sought for holding the lattice temperature constant while the magnetic moment is changed by optical excitation.

It is apparent from the study to date that the gadolinium iron garnet crystals grown by the present molten flux technique will not exhibit the desired characteristics. The conduction band causing the large competing absorption is probably a characteristic of the iron-oxygen combination rather than impurity-induced interband gap levels. As such, the rare earth garnets are all limited by this absorption edge. Only terbium and dysprosium offer a possibility of pumping at energies below the conduction band edge. Antiferromagnets overcome the problem of lattice phonons creating uncompensation, but little is known of the optical properties of the potentially useful materials.

The concept of uncompensating an antiferromagnetically-ordered system is of significant interest both theoretically and practically. The significance of achieving $10^8$-bit high-speed random access computer memories with passive element reliability should not be understated. Optical pumping is considered a powerful approach towards achieving that goal.

**Patent status:**

No patent action is contemplated by NASA. Source: F. L. Grismore and J. E. Rhodes of the Georgia Institute of Technology under contract to Marshall Space Flight Center (MFS-14854).

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For $11,950.10, you get MAC, 4 priority interrupts and a cup of coffee.

Why coffee? Because you won't be spending any time programming MAC for priority interrupts — since MAC's interrupts (with automatic store and restore) are in hardware, not software. So you've got to have something to do with your time.

And MAC's internal structure saves you still more time by reducing programming. On the job, the time saving goes on. MAC responds to interrupts in an average 6 microseconds. Which means it can operate with nearly any real-time or time-sharing system.

And another thing: MAC's 4 basic interrupt levels can expand to 64.
The same goes for MAC's basic 16-bit, 4K memory. It'll expand to 8K in the mainframe and to 65K with additional chassis.

Nothing mentioned here is exclusive with MAC, of course. Other computers offer 4 hardware priority interrupts and most of MAC's other features. They start at around $25,000.

But if you're spending money like that to get a computer like MAC, you may need a strong cup of coffee.

Write to MAC, Lockheed Electronics Company, Data Products Division, 6201 East Randolph Street, Los Angeles, Calif. 90022.

LOCKHEED ELECTRONICS
A Division of Lockheed Aircraft Corporation.

See MAC in action at WESCON in the Bircher Corporation booth, #3104/5.
Only one man in a thousand needs the output protection of this digital-to-resolver/synchro converter...

(the other 999 smile to themselves knowing it's there.)

North Atlantic Model 533/30 Digital-to-Resolver/Synchro Converter is designed to be integrated into GSE, ATE or aircraft simulators without using front-panel rack space. Optional features and other models to fit specific requirements are available.

This high-accuracy converter is another elegant example of North Atlantic's creativity in automatic test equipment, resolver/synchro instrumentation, and computer interface equipment.

For additional rewarding details call our field-engineering representative (see EEM), use the reply card, or call or write North Atlantic Industries, Inc., Terminal Drive, Plainview, Long Island, N.Y. 11803. TWX 510-291-1879 or phone (516) 881-8600.
In addition to demonstrating two techniques for deriving all possible 4-bit BCD weighted codes, this article illustrates the derivation of all 3-digit trinary coded decimal (TCD) codes and explains the relationship between trinary and negatrininary codes.

A New Approach to Weighted Number Systems

Monty Walker
Singer Company
Instrumentation Div.
Los Angeles, Calif.

"Weighted Number" is one of the most familiar concepts of the logical designer. The "idea" of weight is a universal concept and is intermeshed in all areas of mathematics. Considering that centuries have been spent investigating the properties of such systems, it would seem pretentious to attempt to modify these concepts. There are, however, several developments that make the attempt worth while: (1) a new interest in non-standard arithmetic systems such as residue arithmetic, and (2) new fundamental discoveries such as negative radix arithmetic and the Hartman conversion technique.

In this article a more generalized formulation of "weight" will be developed as well as possible applications of the expanded concepts.

CONVENTIONAL WEIGHTED NUMBER SYSTEM

The general form of a conventional weighted number is: \(a_r r^n + a_{r-1} r^{n-1} + \ldots + a_1 r^1 + a_0 r^0\), where \(r\) is the radix or base of the system and each \(a_i\) may have any integral value from 0 to \(r-1\). In the familiar decimal system, \(r = 10\) and each \(a_i\) will be either 0, 1, ..., or 9. The decimal number 324 is equivalent to: \(3(10^2) + 2(10^1) + 4(10^0)\). In the binary system, \(r = 2\) and each \(a_i\) will be either 0 or 1. The binary number 1101 is equivalent to: \(1(2^3) + 1(2^2) + 0(2^1) + 1(2^0) = 13\).

Binary Coded Decimal

To represent a decimal number using binary elements, at least four elements in combination must be used. Of course four binary elements in combination have a maximum of 16 different states, but in representing decimal numbers, only 10 states will actually be used. The remaining 6 will be constrained. This method of using binary elements to represent decimal numbers is called binary coded decimal or BCD.

BCD Codes

Any set of ten binary states can be used to form a BCD code. The total number of four element BCD codes is in excess of 29 billion. Many of these codes are merely reflections of others, but if reflections are not included, the number is still in excess of one billion.

\[
\frac{161}{61} = 29,059,430,400 \quad \frac{161}{41 \cdot 61} = 1,210,809,600
\]

A relatively small number of possible BCD codes have the characteristic of weight; that is, each decimal digit can be formed by adding the "assigned" binary element values (weights). In Figure 1 the 8421, 5211, 8-643 and excess-3 codes are illustrated. Each "1" has the column value and each "0" has the value of zero. The excess-3 code is considered non-weighted. It will be demonstrated later that in a sense it is also weighted.

The total number of four bit weighted BCD codes has been analyzed by several authors. There are exactly 17 positive weighted codes, 54 single negative codes, and 133 weighted codes where the total set of weights is not positive. The total number of weighted BCD codes is 253.
### Fig. 1 BCD Codes

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<td>0</td>
<td>6</td>
<td>1</td>
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</tr>
<tr>
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<td>0</td>
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<td>0</td>
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<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>1</td>
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</tr>
</tbody>
</table>

(a) excess -3

### Fig. 2 Weighted BCD 4-bit Codes

<table>
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<th>subcodes</th>
<th>subcodes</th>
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<td>6 5 -3 1 4</td>
<td>8 4 2 1 1</td>
</tr>
<tr>
<td>4 2 2 1 32</td>
<td>5 4 -3 2 8</td>
<td>6 4 -4 2 4</td>
<td>8 4 2 -1 1</td>
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<td>5 4 3 -3 16</td>
<td>6 5 -4 3 2</td>
<td>8 -4 2 1 1</td>
</tr>
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<td>6 2 2 1 8</td>
<td>6 5 -4 3 2</td>
<td>8 4 -2 -1 1</td>
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</tr>
<tr>
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<td>7 3 -2 -1 4</td>
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</tr>
<tr>
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<td>8 -4 -3 -2 1</td>
</tr>
<tr>
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<td>7 -3 -2 1 4</td>
<td>8 4 -3 -2 1</td>
</tr>
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<td>8 -5 4 -2 1</td>
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<td>8 5 -4 -2 1</td>
</tr>
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<tr>
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<td>7 -4 2 1 2</td>
<td>8 7 -4 -2 1</td>
</tr>
<tr>
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<td>7 -4 -2 1 2</td>
<td>8 6 -4 -1 1</td>
</tr>
<tr>
<td>5 3 -2 1 16</td>
<td>6 4 -2 1 4</td>
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<td>8 6 -4 -1 1</td>
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<tr>
<td>5 4 2 1 8</td>
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<td>7 5 -3 1 2</td>
<td>8 6 -4 -1 1</td>
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<td>8 7 -4 -2 1</td>
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<td>7 6 -5 3 1</td>
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<tr>
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<td>6 4 -3 2 4</td>
<td>7 -6 5 3 1</td>
<td>8 7 -4 -2 1</td>
</tr>
</tbody>
</table>

Fig. 2 Weighted BCD 4-bit Codes
codes, and 17 double negative codes, making 88 in all. In most of these codes, at least one decimal number can be formed in more than one way. Taking these alternates into account, there are 615 sub-codes. Figure 2 lists the basic codes with the number of sub-codes for each.

DERIVATION OF THE BASIC CODES

The derivation of four bit codes is an interesting exercise in combinatorial mathematics. The procedure is to find all sets of four integers (positive or negative) that can combine by addition to form the positive decimal integers 0 through 9.

Although there are a limitless number of four digit sets, by using common sense and combinational analysis the number of sets to be tested can be reduced to a few hundred. To demonstrate the technique, some typical theorems will be illustrated.

Theorem 1: At least one weight must be odd.
Proof: If all weights are even it is not possible to obtain odd decimal digits by the rule of combination.

Theorem 2: The sum of all the positive weights must be ≥9.
Proof: The maximum number that can be obtained by the rule of combination is the sum of the positive weights. If this sum is less than 9, then it is not possible to obtain decimal 9.

Theorem 3: At least two weights must be positive.
Proof: Assume a set of four weights, three being negative; i.e. A, -B, -C, -D. The positive combinations are:

(1) 0  
(2) A  
(3) A-B  
(4) A-C  
(5) A-D  
(6) A-B-C  
(7) A-B-D  
(8) A-C-D  
(9) A-B-C-D

Since there is a maximum of 9 distinct combinations, it is not possible to obtain 10 decimal numbers.

Several less obvious theorems are listed for the interested reader to prove.

(4) All weights must ≤8.
(5) A maximum of two weights can have the same absolute value.
(6) In positive codes the sum of the weights must be ≤15.

With the above theorems in mind, a table of integer sets can be made and tested for code validity. There will, of course, be only 88 valid codes in the table and we have absolute assurance that no others exist.

Surprisingly enough, it was not until 1960 when G.P. Weeg used the above techniques to uncover all 88 codes.*

In the next section it will be shown that in one sense there are actually fewer codes than indicated, and in another sense, an infinite number.

A NEW LOOK AT WEIGHT

A characteristic of all weighted numbers is that they have not one, but two values. True, one of the values is zero, but zero is a number and cannot be considered non-existent. The 8421 code is more properly a (8 or 0, 4 or 0, 2 or 0, 1 or 0) code.

To coordinate the material to come, a new notation will now be introduced, \( \frac{A}{B} \). In this notation, “A” represents the True or 1 value for a weight and “B” represents the False or 0 value for a weight. The 8421 code can be expressed as \( \frac{8421}{0000} \). By using this method of exhibiting both weights of a weighted code digit, certain rather interesting features can be proved.

Consider the weighted bits \( \frac{A\ C\ D}{B\ D} \). As shown in Figure 3, the readout is: If a constant k is added to both the “A” and “B” weights of \( \frac{A}{B} \), the new readout will be:

It can be seen in Figure 4 that the code is “shifted” k bits. As an illustration of the above, consider the two bit code \( \frac{21}{00} \). The normal readout is 0 through 3.

If 4 is “added” to the \( \frac{2}{0} \) bit, the new code \( \frac{61}{10} \) will have a readout of 4 through 7. This method of adding a constant to both the A and B weights will be called code addition.

It is obvious that the above technique can be extended to any number of weights. It must also follow that if k is code added to one weight and -k is code added to another weight, the read-out will be unchanged. Note that k can have any value; positive, negative, or even non-integral values.

Example: consider the \( \frac{8421}{0000} \) code. If a constant is added to one bit and subtracted from another, the code remains unchanged. To demonstrate this we can arbitrarily add 3 to the \( \frac{8}{0} \) bit and subtract 3 from the \( \frac{4}{0} \) bit. The resultant code is shown in Figure 5.

Note that the binary representation is unchanged although the weights of the first two digits have been changed. In column A, a “1” has weight 11 and “0” has weight 3, rather than 8 or 0. The implication is, that in a sense, there are an infinite number of weighted codes. Note also that each element is still binary in nature. The characteristic difference is that the “false” weight is not necessarily zero.

GENERATING NEGATIVE CODES

Consider the \( \frac{8421}{0000} \) code. By taking all possible combinations, it is possible to generate an unbroken sequence from 0 through 15. If a constant k is code subtracted from one of the weights, the sequence will be shifted k bits in the negative direction.

In Figure 6a, the basic \( \frac{8421}{0000} \) code is shown—the sequence range is 0 through 15. In 6b, 1 is code subtracted from the \( \frac{1}{0} \) weight and after subtracting it into \( \frac{1}{1} \), the sequence range is -1 through 14. In 6c, 4 is code subtracted from the \( \frac{4}{0} \) weight and 2 is code subtracted from the \( \frac{1}{0} \) weight transforming them into

*Fewer theorems and a computer were used to generate and test a table of 13,122 entries
The sequence range is -5 through 10. In Fig. 3, 5 is code subtracted from the \( \frac{8}{5} \) weight transforming it into \( \frac{3}{5} \). The sequence range is -5 through 10 as in Fig. 6c.

Comparing Fig. 6c with 6d, it can be seen that each decimal digit has the same binary code although the column weights are different. Again it is apparent that there are an infinite number of possible weighings for a given code.

Consider a code such as the 8421 being transformed so that each digit will have a "0" for either the True or False position. If the weights with a "0" in the True position are now inverted, the new code will be a standard negative weighted code. If the negative constant has not shifted the code below the maximum for decimal 9, the code will be one of those listed in Figure 2.

### EXCESS-3 CODE

The excess-3 BCD code uses the middle 10 of the first 16 binary numbers for the decimal readout. From this it must follow that if the excess-3 is weighted, one or more of the weights must be negative.

Consider the 8421 code transformed into the 8400 code. In Figure 7, range \( \frac{8}{4} \) is the conventional excess-3 BCD code. The code is interesting as both the A and B columns are negative weighted but from the False side of the weight. By inverting the A and B columns, the new weighing becomes the conventional 8421 code as listed in Figure 2.
Because the excess-3 is really a weighted code, it is possible to design an excess-3 weighted ladder using conventional techniques. In many instruments where digital to analog conversion is performed, the excess-3 is first encoded into the 8421. Figure 8 shows a three decade excess-3 ladder using conventional design techniques. Those familiar with ladder geometries will recognize that the ladder in Figure 8 is in no way different from the conventional 8421 BCD ladder. The modifications in the design are: (1) the -2 and -1 weights are driven from the False side of their respective flip-flops, and (2) the negative weights are driven from a negative source.

It follows that the same ladder geometry can be used for any code in the same family of transformed codes. The ladder in Figure 8 could be used for the 8421, 842-1, 84-21, 84-2-1, 8-421, 8-12-1, or 8-4-21 codes. If weight inversions are allowed as in the excess-3, there are 112 different codes that can use the 8421 ladder geometry.

**BASIC BCD CODES**

If four positive weights can combine by addition into ten sequential decimal digits, it is possible to shift the sequence up or down by code adding or subtracting constants to one or more of the weights. It is not known a-priori what these sequences are. It might be assumed that they are the transformed families of codes in Figure 2 but this does not prove that no others exist. It may be possible that a code exists that can not be transformed by integral constants to the 0 through 9 format.

By using similar methods to those in deriving the 88 conventionally weighted codes, it is possible to derive all $n$ sequences. A few of the theorems for "10-sequences" will be listed but not proved. Although the proofs are not difficult, some are rather tedious.

1. At least one weight must be odd.
2. The sum of the weights must be $\geq 9$.
3. All weights must be $\leq 8$.
4. There must be at least three unique weights.
5. If two weights have the same value, they must be $\leq 4$.
6. The sum of the two smallest weights must be $\leq 8$.

Use of the above theorems (plus several others) allows a table of about 80 code entries to be made and tested. Of the 80 entries, 33 are valid. Figure 9 shows each of the basic codes plus the sequence possible from each.

Comparing the basic 10-sequence codes against the code families of Figure 2 it can be seen that there are no surprises. Each code family is represented once and only once.

From the above it may be fairly stated that since all 4-bit BCD codes are transforms of the basic 10-sequence codes, there are, in a sense, only 33 codes.

**WEIGHTED BINARY NUMBERS**

As mentioned in the beginning of this article, the general form of a straight binary number is: $a_n2^n + a_{n-1}2^{n-1} + \ldots + a_02^0$, where each $a_i$ can have the value of 0 or 1. In tabular form the code can be written as shown in Figure 10.

Since each weight can have the value of $2^n$ or 0, the code might more properly be represented as: ...
I represented as--...
Both the Is and 2 s complement codes are widely used in arithmetic units of computers. An example of 2 s complement codes is shown in Figure 11 in

Fig. 9 Basic 10-sequence codes

```
<table>
<thead>
<tr>
<th>range</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>1-9</td>
<td>1-13</td>
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<td>2-9</td>
<td>2-13</td>
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<tr>
<td>3-9</td>
<td>3-13</td>
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<td>4-9</td>
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</tr>
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<td>9-13</td>
</tr>
</tbody>
</table>
```

Fig. 10 Binary Number Table

```
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<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
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</tr>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0...</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
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<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
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<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>0...</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
</tr>
</tbody>
</table>
```

Note that in Figure 11b, zero can be represented as either 0000 or 1111.

The forms shown in Figure 11 are not the only transformations possible. A special form of complementary codes is possible by transforming all weights except the 2^n (or 2^n-1) weight. In Figure 12, alternate weightings are shown. The computer arithmetic is identical in both the normal and alternate codes except that the decimal numbers will be carried in an inverted form.

### DECIMAL CODES

A 10^a or 9^a complement code can be considered a mixed radix weighted code. The usual form for a decimal number is: a_10^n + a_10^{n-1} + ... + a_10^0, where a_i can have any integral value 0-9. Consider the three-digit weighted code 100 10 1, where the weight is actually a multiplier of the column bit. In the 9^a complement form of this code a negative number is represented as the difference between the normal (positive digit) and 9. Figure 13 shows examples of 9^a and 10^a complement arithmetic.

The total code can be considered a

Note that in Figure 11b, zero can be represented as either 0000 or 1111.

The forms shown in Figure 11 are not the only transformations possible. A special form of complementary codes is possible by transforming all weights except the 2^n (or 2^n-1) weight. In Figure 12, alternate weightings are shown. The computer arithmetic is identical in both the normal and alternate codes except that the decimal numbers will be carried in an inverted form.

### TRINARY CODES

The base 3 or trinary* (more properly ternary) num-

```
The normal form of a trinary number is: \( a_n 3^n + a_{n-1} 3^{n-1} + \ldots + a_0 3^0 \), where each \( a_i \) can have the value of 0, 1, or 2. The trinary number 201 is equivalent to \( 2(3^2) + 0(3^1) + 1(3^0) = 19 \). A modified weight symbol will be used for trinary, namely \( A/B/C \) where A is the “2” weight, B the “1” weight and C the “0” weight. The general form can be shown in weighted symbols as \( \ldots 54/27/0, 18/9/0, 6/3/0, 2/1/0 \). The span of a trinary code will be \( 3^n \) where \( n \) is the number of digits. For a three digit code, the span is \( 3^3 = 27 \), i.e. from 0 through 26. Figure 14a shows the table for a normal two-digit trinary code.

**Negatrinary**

Consider the trinary code 2a/a/0, 2b/b/0. The range of the code will be 0 through 2a+2b. If “a” is code subtracted from the first weight and “b” code subtracted from the second weight, the new code: a/0/-a, b/0/-b will have a range from -a+b through (a+b). This shifted form of representing trinary codes is sometimes called negatrinary (Fig. 14b). There are several real advantages in using negatrinary: (1) a number can be converted to its negative equivalent by merely complementing every non-zero weight; and (2) it is usually more convenient to use equal bipolar voltages (+V and -V) rather than +V and +2V in a digital system.

The relationship between normal and negatrinary is easily seen. Consider a set of trinary digits, each “shifted” -1. This is equivalent to subtracting 111...3 from the number. If 111...3 (n+1 digits) were first added to the trinary set (mod 3) and then each digit shifted -1, the real value of the number would be the same as the original normal trinary number. Example: Consider the trinary number 021013 = \( 2(27) + 9 + 1 = 64 \).

\[
\begin{array}{cccc}
0 & 2 & 1 & 0 \\
+1 & 1 & 1 & 1 \\
2 & 0 & 2 & 1 \\
\downarrow & \downarrow & \downarrow & \downarrow \\
1 & 1 & 1 & 1 \\
\end{array}
\]

\[
\begin{array}{cccc}
0 & 1 & 1 & 0 \ 1 = 81 - 27 + 9 + 1 = 64 \\
\end{array}
\]
To convert directly from decimal to negatrinary:
1. add 1 to the number (n)
2. divide by 3 holding the remainder
3. add 1 to the dividend
4. continue dividing by 3 and adding 1 to each new
   dividend
5. shift each remainder -1

The new remainders (in reverse order) will be the
negatrinary number. Example: Convert decimal 70 to
negatrinary:

\[
\begin{array}{c}
70 \\
3 71 \\
23 + 2 \rightarrow 1 \\
3 24 \\
8 + 0 \rightarrow -1 \\
3 9 \\
3 + 0 \rightarrow -1 \\
3 4 \\
1 + 1 \rightarrow 0 \\
3 2 \\
0 + 2 \rightarrow 1
\end{array}
\]

As an interesting byproduct, the recreational math-
ematics problem of determining the weights to be
used on both pans of a balance scale to measure a
given integral weight is neatly solved by converting
the weight to negatrinary. The negative weights are
placed on one pan, the positive on the other.

Trinary Coded Decimal

As with binary, trinary logic must somehow relate to
the decimal world. One method of doing this is to
use trinary elements in combination to represent
decimal integers. Two trinary elements in combina-
tion have a maximum of 9 states (one less than is
needed). Thus three elements are the minimum ne-
cessary for trinary coded decimal or TCD.

The derivation of all TCD codes in similar to the
methods used in the derivation of BCD codes. First all
10-sequence trinary sets are derived, then the weights
are shifted in all possible integral units that will allow
the sequences 0 through 9. The 10-sequence sets are
all positive and each digit can take on the value of
0, a, or 2a. Note that a 10-sequence does not neces-
sarily start at 0. It turns out that there are 50 10-
sequence trinary sets. These are listed in Figure 15
with the sequence possible from each.

There are four basic types of TCD codes:
1. All digits positive
2. One digit negative
3. Two digits negative
4. Negatrinary

There are 16 positive codes, 74 1-negative codes, 19
2-negative codes, and 19 negatrinary codes, making 128
codes in all. If hybrid mixtures are allowed (e.g. one
digit -1, 0, or +1 and other (s) 0, 1, or 2) then 331
additional codes are possible. The basic codes are
listed in Figure 16. Note that sequence 4, 16 and 48

cannot be transformed into a basic code.

In a practical sense, either the positive or the
negatrinary codes should suffice for any normal ap-
lication. The negatrinary codes are actually double
codes. Each code has a minimum range of -9 through
+9. By using negatrinary rather than conventional
positive codes, a bipolar instrument or a digital ma-
chine using negative numbers would not require
modified logic to represent negative quantities as in
binary.

**SUMMARY**

- Binary codes were shown to be double weighted and
as such the False weight need not necessarily be zero.
- By code addition, any n-sequence set can be shifted
into any other n-sequence. The range is invariant
under the transformation.
- A method of deriving all 10-sequence binary sets
has been shown. By shifting these sets, all 4-bit BCD
codes can be derived.
- Certain BCD codes usually considered non-weighted
were shown to be disguised negative weighted codes.
- Two types of trinary codes and TCD codes were
derived in a manner analogous to the BCD codes.

By using the expanded concepts as outlined in the
foregoing pages, the mechanization of weighted codes
can be exploited in a much freer manner. In digital
instruments and machines the advantages of the new
concepts should be considerable.
Fig. 16 TCD Codes

REFERENCES

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3. nimo™, 6-decade display — Ideal for instrument use, read bright and clear at 75 F.L. — low, $2.90/decade. Highly compatible electronic interface cards.

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9. Series 360H — Jumbo size (2") characters, clearly visible from 50'. Unit is 3" h x 2" w; mounts on 2" centers for minimum panel space. Various Driver/Decoders.

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The Model 1220 is bidirectional, with synchronous or asynchronous operation. It will read accurately to speeds of 300 characters per second in local or remote locations and can be operated in either in-line or advanced sprocket formats. Completely modular, the Model 1220 can be tailored to fit a variety of applications.

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Systems Development Div.
Endicott, New York

Delay lines were used for storage and data flow registers in some of the first generation computers. Today they are popular as buffer-storage in terminal equipment and small capacity data flows.1 The delay line is economically competitive where a storage requirement of 1,000 to 20,000 bits exists. It is also quite versatile as shown by a number of applications reported by Peatman.2

Recently, high-speed delay lines of bit rates in excess of 100 MHz have been reported.3, 4 Eveleth5 states that quartz lines "have the unusual characteristic that when the frequency for which they are designed increases, the length can increase—thus maximum capacity increases rapidly with increasing frequency up to a limit of about 50,000 bits" at 150 MHz.

It is also observed that the major cost of a delay line, varying slightly with length, is in the input and output interfaces. In an application where more than one delay line (or serial store) is required, the capability of making a single delay line "look like" several delay lines is economically attractive.

A result of Newman, Davies, and Clayden5 shows that the bits of an N-bit high-speed cyclic store can be transferred to an N-bit slow-speed cyclic store if the slow-speed bit rate is \(1/n^{th}\) of the high-speed bit rate where \(n\) (the speed reduction factor) is an integer relatively prime to \(N\). In transferring from the high-speed to the low-speed store, the high-speed group of \(N\) sequential bits is repetitively presented \(n\) times. On each presentation, each \(n^{th}\) bit is transferred so the entire group is transferred after \(N\) (slow) bit-times or \(n\cdot N\) (fast) clock-times (\(n\) clock-times equals one bit-time.) Adjacent bits in the slow-speed store are \(n\) bits apart in the high-speed store.

DEFINITIONS

The following discussion of present techniques is presented to introduce terminology and concepts.

A conventional way of using a high-speed store with slower data flows was used in the Saturn V computer made by the IBM Federal Systems Division for NASA.6 There are four clock-times (\(W, X, Y,\) and \(Z\)) within a bit-time. These clock-times define four equal-length data channels on the delay line. Data channel 1 is written at clock-time \(W\). Data channels 2, 3, and 4 are written at clock-times \(X, Y,\) and \(Z\), respectively.

Each channel is used to store a 26-bit word. In the normal case, four words could be stored on a delay line (Fig. 1). This arrangement could be called the word-bit interlace. The bit arrangement on the Saturn V delay line could then be called the bit-word interlace (Fig. 2).

The concept of interlace can be extended just as the hierarchies are. If bits are assembled into digits, and digits are assembled into words, then the simple interlace would be the word-digit-bit interlace. If this is extended to groups of words, the group-word-digit-bit interlace is the simple interlace.
During a multiply in the Saturn V computer, two of the delay line registers are linked in series to form a data flow path of 52 bits. This is done by feeding the output of channel 1 into the input of channel 2 and the output of channel 2 to the input of channel 1.

As long as the length of the recirculation paths for the channels remains the same, or at least a multiple of the smallest loop length, the data will remain in step. By “in step” it is meant that if one channel reads out a lowest-order bit during a particular bit time, then all channels are reading out a lowest order bit in that bit time. It might be possible to be “in digit step” (bits within a digit or character are in step), but not be “in word step” (digits of unlike order being read off the line by some channels within the same digit time).

During some iterative operations like multiply, it is advantageous to keep the multiplier word out of step. If the multiplier word loop is foreshortened by two bits in each delay line cycle, the two lowest-order bits in the word are treated as operand bits; then, at the end of 13 cycles (iterations) all 26 bits of the multiplier word have served as operands.

Another method of using high-speed recirculating cyclic stores with slower speed data rates is precession. Precession can occur by making the data sampling interval, or multiples thereof, unequal to the recirculation time. For example, periodically writing bits at intervals one clock time longer than the recirculation time of the storage loop will produce a bit train with sequential data, one clock time apart. In another example, if the recirculation loop (or path) is made longer than the data to be stored, the information will walk backwards with respect to the timing. If the loop is foreshortened, then the information precesses forward. Precession is commonly used to “shift right” or “shift left” data on a delay line.

In order to foreshorten a recirculating loop containing an untapped delay line, a window must first be introduced (Fig. 3).

In Figure 3, the specific bit and shifting signals have not been explicitly shown. The bit appearing in the retiming trigger (RT) is shifted at the next clock time into the shift register (SR). It progresses through the four stages of SR and is then rewritten on the delay line (DL). The register SR is the window. The window length will be called W (in this case, W=4). Thus the recirculation path may be foreshortened by the window length of W bits by feeding the RT output (DLO) directly to the write driver. Thus a maximum of W bits may be shifted right in one delay line pass (revolution).

The complete system will be said to store N bits. The number N-W will be called the channel length C. (It includes the bit stored in the retiming trigger RT.) In the single channel case of Figure 3, the channel length C is simply equal to the delay line length, DL. In the previously mentioned four-channel scheme, the channel length is DL/4.

In many interesting applications, it may turn out that DL is not a multiple of n. From the Euclidean Algorithm, however, unique integers x and r, 0 ≤ r < n, exist that:

\[ DL = xn + r. \]

In this case x is defined to be the channel length C. In the Saturn V delay line, C=22 and r=1; this means the bits emerge 22 bit-times and one clock-time after they are written. (There are n clock-times to one bit-time.)

In the case r=0, the minimum loop length for a channel (minimum channel loop length) consists of C bits. When r=0, the minimum loop length for a channel is C + 1 bits. In the above example, channel 1 is written at X clock-time, and emerges 22 bit-times (and one clock-time) later at clock-time Y. In order to be rewritten into channel 1, it must wait three clock-times for clock time X. Thus the minimum loop length is 23 bits.

The bit read at clock-time Y must be stored somewhere until the next clock-time X. This storage device serves much the same function for the channel data path as the detector does for the delay line sense amplifier output. To carry the analogy further, each device detects (or assembles) a bit sometime during a basic timing period and stores it until the end of that period. In the case of the delay line, the timing period is a clock-time, and at the end of each clock-time, the detector output is shifted to the retiming trigger. In the case of the “channel 1 detector” the basic timing period is one bit-time, and the output is either written back onto the line (for a shift right operation) or shifted into the first stage of channel 1’s window. It is noted that the channel 1 detector is not a part of the
window but forms a necessary part of the 23 bit minimum loop of channel 1.

**SINGLE PATH UNTAPPED DATA FLOW SCHEME**

The definitions and concepts of the previous two sections may now be applied to a high-speed delay line storage system where the logic circuits operate at a much slower speed. One solution is to select n, make DL a multiple of n, and thereby set up n parallel channels (the digit-bit-word interlace). However, in order to keep the n channels in step, n windows must be provided if any shifting is to be done. If n is made equal to the number of bits in a digit, then a serial-by-digit, parallel-by-bit system (the simple interlace) may be designed. However, more logic is required because the data path is now n bits wide.

The high-speed serial store may be operated in the economical serial-by-bit, serial-by-digit mode by slower speed circuitry as shown in the following example.

**Example 1**

A 12-MHz delay line is available and can be cut to any desired length. The logic circuits to be used with the delay line allow the system bit rate to be no more than 1 MHz. However, special circuits for the 12-MHz clocking, retiming trigger, write driver, etc., are available. For the example a word of eight digits and eight bits per digit is to be recirculated, with a window of at least eight bits so the word may be easily shifted right one digit.

Figure 4 shows the scheme with the following constants:

- 1 bit time = 12 clock times, n = 12
- DL = 55 = 4·12 + 7
- W = 9
- C = 4
- r = 7

The signal OSC is assumed to be the last half of a clock time. Thus for the memory regen path, the bit is assembled in the detector and at the fall of the signal OSC is shifted into the RT. It remains in the RT for one clock time, during the latter half of which OSC is valid.

In order to trace the path of a particular bit in Figure 4, assume it is being written on the line from stage 64 at CL5 time. Define bits written at CL5 time to emerge at CL12 time, because r = 7. Thus the bit is rewritten into channel 12. Channel 12 bits emerge at CL7 and hence are rewritten into channel 7. This continues for 12 passes making a 12-channel spiral. A bit makes 12 trips (at 55 clock-times per trip) through the delay line before emerging in the retiming trigger at CL5 time. Thus it spends 55 bit times recirculating in memory before appearing in the “data” detector. Nine bit times are spent in the window, completing the cycle of 64 bit times. The system of Figure 4 contains just one path, and will recirculate 64 bits through the data flow window for any speed reduction factor n relatively prime to 55. The conditions to be satisfied are:

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**Diagram:**

- **Memory Regen Path:**
  - CL5
  - OSC
  - DL = 55 = 4·12 + 7
  - RT

- **Data Flow Regen Path:**
  - 12
  - 64
  - Shift Right 8
  - Det

- **Window:**
  - Not Shift Right 8

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**Fig. 4 A low-speed, single-path data flow scheme**
1. \( N = DL + W \) = number of bits in system.
2. \( n \) and \( DL \) are relatively prime.

To facilitate the explanation of additional schemes, some definitions will be introduced. The complete path followed by a bit is called the data path. While in the "spiral," the memory bits travel at "clock time speed." After emerging in the data detector, the bits shift at "bit time speed" and the path is called the window and the bits are data bits. The minimum loop length for a data path is defined as the number of bits stored in the path minus the length of the windows in the path. For Figure 4 the minimum loop length is simply \( DL = N - W \).

An example application for a speed-reduced delay line is a serial memory for phase-locked oscillator (PLO) systems. Assume it is desired to store the contents of two punched cards of 80 columns each, 12 bits per column, or 1920 bits. At a PLO bit rate of 100 KHz, the delay line would have to be 19.2 milliseconds long, a range barely attained by presently available delay lines. At a 1-MHz bit rate, however, the line would need to be only 1.92 milliseconds in length.

MULTIPLE PATH DATA FLOW SCHEMES

There are several classes of multiple path data flow schemes, including the simple parallel scheme used in the example drawn from the Saturn V computer. Other schemes will be illustrated by means of examples.

Example 2

Multiple-Path, Equal-Length Data Flow

In Figure 5, \( DL \) and \( n \) have a largest common divisor (LCD) of 2. This causes the 14 channels to be split into two spirals. One spiral circulates the "odd" bits in seven delay line passes ("spiral A"). The odd bits emerge in RT at CL5 and are shifted through window A before being written into spiral A again. The "even" bits circulate through "spiral B" and then through window B.

Each data path stores 29 bits in the spiral plus 4 bits in the window for a total of 33 bits. The minimum loop length for each path is 83–4 = 29 bits.

To visualize the movement of the bits in data path A, the motion of a bit written at bit 0 CL5 Time is depicted in Figure 6. Since there are \( n = 14 \) clock times to one bit time, bits emerge from the delay line \( C = 4 \) bit times plus \( r = 2 \) clock times after being written. Characteristics of this scheme are:

1. The number of data paths = LCD of \( n \) and \( DL \).
2. The number of channels in each spiral is \( n/LCD \).
3. The number of bits stored in each spiral is \( DL \cdot LCD/n \).
4. For the data paths to be of equal length, the windows must be of equal length.
5. The RT sampling times into each data path detector must be properly selected. Any group of LCD consecutive clock times would suffice.
6. The clock time used to gate a data path's bits into the data detector is the same clock time used to write that data path's bits onto the line.

Example 3

Single Path "Tapped" Data Flow Schemes

Two or more data paths can be connected in series to form one longer path. In Figure 7 this was accomplished from Figure 5 by writing A onto the line at CL6 (instead of CL5) and B onto the line at CL5 (instead of CL6). The effect here is to provide a read-write "tap" in the middle of the data flow path.

Multiple path "tapped" schemes, where paths are of equal or unequal length, can be designed from a multiple path equal length scheme by connecting paths as in Example 3 to attain a desired scheme. However, if \( n \) is not small, and windows are used, the windows plus data detection may involve a large number of circuits.
Example 4

A Multiple Path, Unequal Length, Data Flow Scheme

Spirals of unequal length can be formed by first making \( n \) and \( DL \) relatively prime as in Example 1. As was seen, this forms a single spiral of \( n \) channels because the LCD of \( DL \) and \( n \) is one. This single spiral may be broken to form 2, 3, or \( n \) spirals.

In Figure 8, \( n = 12, C = 4 \) and \( r = 7 \) as \( DL = 4 \cdot 12 + 7 \) as in Example 1.

The timing in the figure has been explicitly shown. The signal advancing the triggers is half a bit time, and will be called “bit time transition.” Its “falling” after \( CLI_2 \) initiates the shifting of the data detectors’ contents into their associated triggers.

The path of a bit appearing in the RT at \( CLI_5 \) time starts in DET A. At the subsequent bit time transition (from \( CLI_2 \) to \( CLI_1 \)) it is shifted into TRIG A. From TRIG A it is written onto the delay line at \( CL_3 \) time. It spends four bit times (\( C = 4 \)) plus seven clock-times (\( r = 7 \)) in channel 3 and then emerges at \( CL_10 \) time. It is rewritten through the memory regen path. Written at \( CL_10 \), it emerges in the RT, four bit times and seven clock-times later at \( CL_5 \) time. This causes it to enter DET A again. Thus data path A consists of a two-channel spiral (55 clock-times per channel) and window A. The window actually consists of only two clock-times; the bit is rewritten onto the line ten clock-times after it appears in RT. Thus window A is not sufficient for a shift right operation (hence has zero length). Data path A stores \( 2 \cdot 55/12 = 10 \) bits.

A bit appearing in the RT at \( CL_3 \) time is placed in DET B. It remains there for nine clock-times before being shifted into TRIG B. It remains in TRIG B for five clock-times before being written on the line at \( CL_5 \) time. It enters spiral B (10 channels) appearing in the RT at the end of each delay line trip at \( CL_12, CL_7, CL_2, CL_9, CL_4, CL_11, CL_6, CL_1, CL_8, \) and \( CL_3 \), in that order. Window B consists of 14 clock times, and spiral B of \( 55 \cdot 10 = 550 \) clock times. The length of data path B is \( 556/12 = 47 \) bits. By writing the output of DET B onto the line at \( CL_5 \) time, the bits in the B data path may be shifted right. Thus the minimum loop length for data path B consists of 46 bits, and window B is by definition one bit in length.

In data path A, however, the minimum loop length is already the data path length of 10 bits. Hence window A is zero bits in length. The fact that window A and window B are not the same length is not obvious from observing Figure 8. It is certainly not obvious that window A, with one latch and one trigger, is not at least one bit in length. The failure of window A to be one bit in length results from the data bit being detected at a later clock-time than it is written.

Assume that Figure 8 is changed so that data path A’s data bits are detected at \( CLI \) time, and that data bits from TRIG A are written at \( CL_11 \) time. Then it can be verified that the length of window A is 1 bit, and that data path A is now 11 bits in length—10 bits from spiral A and 1 bit from window A. By the same token, window B is now zero bits in length, and the length of data path B is then only 46 bits of spiral B.

It is noted that in Figure 8 the lengths of the two data paths are relatively prime, hence the two paths are certainly “out of step.” However, by adding two shift register stages to window A and one stage to window B, data paths A and B would be 12 and 48 bits in length respectively. If we defined a word to consist of three 4-bit digits, then data path A would be one word long, and data path B would be four words long, so the two data paths would be “in step.”

Example 5

A Desk-Top Computer Data Flow Scheme

In Figure 9, the A line and A register (A for accumulator) path stores one word of 8 digits with 8 bits per digit or 64 bits. The D line and D register path...
stores 16 words of 8 digits per word, 8 bits per digit or 1024 bits. The two paths are in step.

In Figure 10, DL = 1069 and n = 20; from this, 1069 = 53 \times 20 + 9, hence C = 53, r = 9. The delay line has 20 channels, 53 bits (and nine clock times) in each channel. Examining window A of Figure 10, the A data bits are written on the line at CL2 time and detected at CL11 time. Since r = 9, and 2 + 9 = 11, spiral A consists of just one channel. (This implies that spiral D consists of 19 channels.)

The minimum loop length for data path A (also the minimum channel loop length) is 54 bits: 53 bits + 1 bit (nine clock-times in the spiral, nine clock-times in the DET A Latch and two clock-times in a trigger). The 11 triggers in the A register, shifting with bit-time transitions (from CL20 to CL1), permit a maximum shift right of 10 bits per pass. This is because A data bits are detected later in a bit-time than they are written. As in data path A of Figure 8, one trigger is needed for retiming and performs no storage function. Hence, window A is 10 bits in length and data path A is 10 + 54 = 64 bits in length.

Spiral D consists of 19 channels of 1069 clock-times per channel or 20,811 clock-times. Dividing by n, this is 1015 bits plus 11 clock-times. The minimum loop length for data path D is then 1016 bits: 1015 bits plus 11 clock-times in spiral D, and nine clock-times in the DET D Latch. Since path D's bits are detected earlier within a bit time than they are written, a trigger is not needed strictly for retiming purposes, and all eight triggers in the B register actually store bits. Thus, window B = 8 bits and data path B is 8 + 1016 = 1024 bits in length. Thus it is verified that Figure 10 represents a single delay line scheme which imitates the two-delay-line scheme of Figure 9. With n = 20, a 10-MHz, 106.9-microsecond delay line (as used in Figure 10) would imitate the two 500-kHz lines. The higher speed configuration which imitates a slower speed data flow is not unique. In Figure 10, for example, one trigger could be removed from the A register and one could be added to the D register. Then by detecting A data bits at CL2 and writing them at CL13 (2 + 11 = 13), and detecting D data bits at CL13 and writing them at CL2, it can be verified that the new scheme derived from Figure 10 imitates Figure 9.

The principle of "slowing down" a high-speed cycle storage loop can thus result in "electronic" read-write taps. A limitation, of course, is when a read-write tap is desired near the end or beginning of a line. Assume, for example, that it is desired to store 81 columns on a delay line, with an electronic read-write tap between the 80th and 81st columns. This implies a minimum of 81 channels on the line, hence a minimum speed reduction factor, n, of 81. Depending on the application, a speed reduction factor this high might result in a data bit rate which is too slow. With a 100-MHz delay line, an n of 80 would result in a data bit rate of 1.25 MHz.

The design of single, high-speed delay lines schemes to imitate slower speed schemes proceeds on a trial-and-error basis. This is illustrated by the following example.

**Example 6**

A Three-Delay-Line Serial-By-Bit Arithmetic System

The scheme of Figure 11 is very similar to Figure 9, where the structure of a word has been retained. However, an additional double-word length MQ is provided. The MQ line is used in conjunction with the A line to perform multiplication, division, and root extraction in less time than the configuration of Figure 9.

The number of bits stored in lines A, MQ, and D is 56 + 120 + 1016 = 1192; hence the length of the high-
speed line DL cannot be over 1192 bits. Assuming delay line A can be replaced by a one channel spiral, then the minimum channel loop length cannot be greater than 64 - 8 or 56. Numbers must be fitted to the following equations:

\[ DL = CN + r \]  
(1)

\[ DL \text{ and } n \text{ are relatively prime} \]  
(2)

\[ DL \leq 1192 \]  
(3)

\[ C = 55 \]  
(4)

For reasons of economy, the values for DL and C should be close to their upper bound because this implies fewer bits to be stored in triggers. From the outset, however, the design should anticipate the use of at least 16 triggers for window MQ. This is eight more triggers than the eight required for the window.

Spiral A is to be a single-channel spiral, hence, spiral MQ will be a two-channel spiral. If C = 55, then spiral MQ can store at most 2C + 2 or 112 bits. The other 16 bits in the data path must be stored in register MQ. (2 was added to 2C because an additional bit could be stored in the spiral if r > n/2.) This gives:

\[ DL = 1192 - 8 = 1184 \]  
(3a)

Path D can store at most 1016 bits in its spiral. With C < 56, spiral D must be at least 18 channels (1016/56 = 18 + 20 remainder) which places a lower bound of 18 + 2 + 1 = 21 on n. Since 1184 = 56\cdot21 + 8 yields a C > 55, the following is tried:

\[ DL = 1183 = 53 \cdot 22 + 17 \]  
(3b)

As desired, C < 56; however, the 19-channel spiral D would store 53\cdot19 bits plus 17-19 clock-times = 1021 bits + 15 clock-times. This would give D a minimum loop of 1022 bits in length. Since 53 \cdot 19 = 1007, the length of spiral D contributed by r should not exceed nine bit-times or 189 clock-times. Dividing 189 by 19 yields an r of 9. So let:

\[ DL = 1175 = 53 \cdot 22 + 9 \]  
(3c)

Hence DL = 1175, C = 53, n = 22, and r = 9.

Now, properly ordered clock-times are required such that 1, 2, and 19-channel spirals are formed. Data path A's bits must be written on the line nine clock-times before they are detected. Data path MQ's bits must be written on the line 18 clock-times before they are detected. The conditions are satisfied if paths A, MQ and D are written at CL7, CL16, and CL12 respectively, and detected at CL16, CL12, and CL7 respectively.

The selection of the clock-times can be done by trial and error. Since a first trial is arbitrary, assume data path A's bits are written on CL1. Since this is nine clock-times before detection, path A's bits are detected at CL10. Now, either path MQ or Path D's bits are to be written at CL10. Assume path MQ. Then 10 + 18 = 28. But there is no CL28; so n is subtracted, and it is found that MQ's data bits are detected at CL6. This means path D must be written at CL6 and detected at CL1. By adding six to each clock-time, (utilizing clock-times toward the "center" of a bit-time) the former solution is obtained.

Spiral A contains 53 bits, nine clock times, so its minimum loop length is 54 bits. Window A is therefore 10 bits in length. Since A data bits are written at an earlier clock time than when they are detected, an extra retiming trigger must be added.

Spiral B contains 106 bits, 18 clock times, so its minimum loop length is 107 bits. Window B is therefore 21 bits in length. This involves more shift register storage than desired, and results from the fact that spiral MQ cannot store more than twice the number of bits in spiral A. This means window MQ is about twice the size of window A.

Spiral D contains 1007 bits plus 9-19 clock times or 1014 bits plus 17 clock times, so the minimum loop length is 1015 bits. Window D is therefore 9 bits in length. The resulting design, shown in Figure 12, imitates the three delay line scheme of Figure 11.

If a 100-MHz delay line were used above, a bit-time would be 220 nanoseconds. One pass of the A path would take 14.08 microseconds.

Example 7
A Parallel-By-Bit System

The techniques of the equal length data flow scheme of Example 2 may be applied to Example 6. By converting the organization of Figure 11 to a serial-by-digit, parallel-by-bit system: the data path has seven digits on the A line and a one digit window; the MQ data path has 15 digits on the MQ line and a one digit window; and the D data path has 127 digits on the D line and a one digit window. The word structure is the same as in the previous example.

Design of the parallel-by-bit system can utilize "digits" and "digit-times", as opposed to previous de-
signs which dealt with bit-times. Figure 13, an interim solution, is based on digital circuits.

Figure 13 may now be “expanded” to form an 8-bit wide path. Let DL be $8 \times 45 = 1160$ bits in length, and let the speed reduction factor be $24 \times 8 = 192$. The LCD of DL and n is now eight. Spirals A, MQ, and D now have eight equal-length “sub-channels” set up within them.

Rather than show the entire parallel-by-bit scheme, only data path D is shown in Figure 14. Assume that within each of the 24 “clock-times,” there are eight “subclock times.” Thus the fall of OSC advances the subclock ring; the fall of subclock time 8 advances the clock ring.

As Figure 14 indicates, an 8-wide path requires more complex timing, more high-speed circuits, and a large OR gate into the delay line write driver.

The detector assembles the digits and has been illustrated here as an 8-bit shift register; it could just as easily have been implemented as eight latches. By the same token, the 8-way OR fed by eight 8-way AND’s could be replaced by a parallel-in, serial-out, 8-stage shift register.

In the above scheme with a single delay line at a memory bit rate of 100 MHz, one digit time would be 1.92 microseconds. This means that the digits would “flow” at a 520-kHz rate, one pass of the A path would be 15.36 microseconds; one pass of the D path would be about 216 microseconds.

**CONCLUSION**

This article described how high-speed serial storage loops may be used in conjunction with slower circuits (although high-speed circuits are required in the interface) to form interesting multiple path data flow schemes. The cost of a delay line is usually independent of its length; to replace two or more slow-speed delay lines with one high-speed line may represent a cost advantage. A further advantage is better utilization of a single serial store for slow-speed technologies such as magnetics or FET where data flow rates must be slow.

When two or more delay lines are used in a single data flow scheme, their lengths must be “tuned” so the bits are in step. The single delay line schemes which imitate these data flows do not have this fine-tuning problem. Another advantage lies in connecting one or more spirals together to form electronic “read-write” taps.

Disadvantages lie in the requirement for high-speed interface circuits, and in possibly having to provide electronic storage for bits in excess of the desired window length.

**REFERENCES**

In any data communication application there are three major equipment considerations: computational facilities, terminal facilities and communications facilities. This survey is concerned with the third aspect—the data communications facility

A Survey of Data Communication Devices and Facilities

Abhay K. Bhushan
Massachusetts Institute of Technology
Cambridge, Mass.

The underlying principles and practices of data communications were established in the telegraph field long before the digital computer was a practical reality, but its large scale use and development began only in the mid-1950’s when it was recognized that teletypewriter circuits and machines used for transmitting messages could also be used for transmitting data to and from the computer. Because data communications is a significant aspect of information processing problems, it must naturally be considered by the system designer. There is a case for consideration of this technology whenever the elements of geographic dispersion, impatience for answers, and ultimate involvement of a computer system are present.

In any data communication application there are three major equipment considerations: computational facilities, terminal facilities and communications facilities. This survey is concerned with the third aspect, that is the data communications facility. Particular emphasis has been given to the problems of selecting the communications equipment and services. To aid the perspective user in a comparative evaluation for his needs, comprehensive charts have also been provided. Before proceeding to discuss the communications facilities, it is appropriate to consider the transmission techniques commonly employed and define some of the terms.

Transmission Techniques

Data transmission systems generally consist of three basic elements—a transmitter or source of information message; a transmission channel or carrier, often called a data link; and a receiver of the transmitted message. The channel or data link is a transmission path between two or more terminals and may be a single wire, a group of wires or a special part of the radio frequency spectrum. Channels are generally

Editor’s Note: The “Data Communications Terminals, Facilities, and Processing Equipment” section of the 1969-70 Computer Industry Annual is the foundation of this discussion. In addition to the facilities mentioned on the following pages, this section of the annual covers terminal devices, communication modes and processing equipment, data interchange codes, error control, reliability, system structure, design, and applications. Tables have been included illustrating comparative performances of communications-oriented processors, remote multiplexors, audio response units, CRT consoles, teleprinters, and card, tape, and other terminals.

Abhay K. Bhushan received a B. Tech degree from the Indian Institute of Technology in Kanpur. As a research staff member of the Massachusetts Institute of Technology, he is working toward a Ph.D. in electrical engineering. He has been associated with Project MAC at MIT, working on computer communications problems.
TRANSMISSION LINE FACILITIES

The concept of distance that characterizes most data communications applications is that of “many miles.” Consequently it is necessary to think in terms of obtaining communication facilities from the common carriers, the telephone companies and the Western Union Telegraph Company. While microwave and other radio facilities are doing an excellent job in many application areas, wire is still by far the most widely used medium. The wire circuits supplied by the common carriers are essentially of two grades, telegraph grade or narrowband and voice grade.

There are two basically different types of service that the common carriers offer. One is the public or exchange service which consists of subscriber lines connected to a switching system, as the telephone network. The other is the private line or channel leasing service which consists of full time leased point-to-point or multipoint lines connecting locations belonging to only one customer. The cost of the exchange service usually consists of toll charges based on the distance and length of connection, and a monthly service charge to maintain system access. The cost of private line service consists of a monthly rental based on the length and type of lines. The various common carrier offerings are discussed under the heading of common carrier facilities. Although the communications engineer prefers to measure the capacity of a communications channel in terms of bandwidth, it is much more natural to use the bits/sec or character/sec measure. Of the two measures, bits/sec is more universal as character sizes vary between systems. To achieve a desired transmission rate (in bits/sec) at a satisfactory low error rate, it is necessary to specify not only the nominal channel bandwidth, but also the line quality, the number of wires in the channel and the modulating-demodulating equipment (Modem).

MODEMS

These modems or datasets, as they are sometimes called, are necessary to adapt the modern data communications devices to wire transmission over long distances. These are usually furnished by the common carrier in the switched network or exchange service (public), but may be purchased from other vendors and manufacturers for the private leased line. Recently, in the Carterfone case decision the Federal Communications Commission (FCC), the regulating body for the common carriers, declared their blanket foreign attachments prohibition to be illegal, and has ordered the carriers to permit the attachment for harmless customer supplied equipment to the public switched networks. Thus the data communications user would be able to use the lower cost, higher performance modems supplied by numerous vendors. Voice channels have a nominal bandwidth rating of 4 kHz. Several different quality voice channels are available from the common carriers. The differences lie in the actual achievable bandwidth, the frequency responses and the delay characteristics. The better characteristics of the higher quality channels permit the use of modems with very high data transmission capabilities. The net effect of the combination of line...
quality and modem may be best illustrated by an example given below using the information provided by the Rixon Electronics Company.

<table>
<thead>
<tr>
<th>AT&amp;T Voice</th>
<th>Channel Type (All channels are 4 kHz nominal)</th>
<th>Rixon Modem</th>
<th>Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>Sebit-12M</td>
<td>1200 bits/sec</td>
</tr>
<tr>
<td></td>
<td>4A</td>
<td>Sebit-24M</td>
<td>2400 bits/sec</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td>Sebit-36M</td>
<td>3600 bits/sec</td>
</tr>
<tr>
<td></td>
<td>4C</td>
<td>Sebit-48M</td>
<td>4800 bits/sec</td>
</tr>
</tbody>
</table>

From this example it can be seen that achievement of desired data transmission rate on a communications facility requires careful engineering of the facility in combination with the modem. The remaining consideration in the communications setup choice is the number of wires in the channel. A two-wire channel can support transmission in one direction only (except when special paralleltone modems are used). The two-wire channel can, however, support transmission alternately in either direction. A four-wire channel can support transmission simultaneously in both directions at considerably less than twice the cost of a two-wire facility.

The choice between two-wire and four-wire facilities depends on the requirements for data transmission and acknowledgements. If a facility is to be used to transmit substantial quantities of data in both directions, then the four-wire channel may be favored. If transmission is primarily unidirectional there still exists the problem of delays due to acknowledgements. All modern systems for data transmission use block-by-block acknowledgement procedures. On a two-wire line, the system must halt transmission after each block and wait for acknowledgement. If the transmission rates are high and the blocks short, the delay experienced in receipt of the acknowledgement may reduce the net achievable transmission rate.

Tables I through IV summarize the equipment characteristics for most common carrier and non-carrier data sets. The cost data has also been included wherever possible. The monthly rentals are given for the common carrier equipment as these are almost always leased; but for the non-common carrier modems the purchase cost has been provided as these are usually purchased outright rather than leased. The prices are only approximate and vary with configurations and options. In the case of common carriers, prices also vary with the operating companies and it is recommended that the perspective buyer check with his local representative.

COMMON CARRIER FACILITIES

The common carriers, mainly the American Telephone and Telegraph Company (AT&T) or the Bell System, General Telephone and Electronics (GTE) and Western Union Telegraph Company offer a wide variety of communications services and facilities both with and without modems. The services mentioned in this section are presented to give a basic indication of some of the communications facilities available today. The representatives of the communications companies should be consulted in order to obtain current information on rates, availability of service, channels and other devices pertinent to data transmission.

The communications services offered by the carriers take on a variety of forms and names with which the user should become familiar. Some of the communications services of the Bell System are WATS, Telpak, TWX and DATA-PHONE. The names of the services that may be obtained from Western Union are TELEX, INFO-COM, and DIAL-PAK. Western Union also recently placed an advanced digital data network (AUTODIN) service for the Department of Defense. These services are described below:

**WATS** for Wide-Area-Telephone Service is the name given to a telephone-grade service in which essentially an unlimited number of calls may be made from a single point to any other subscriber within a very large area usually for a fixed monthly charge. Monthly charges are based on the size of the area and not on the number or length of calls. Under the WATS arrangement, the United States is divided into six zones. The subscriber is billed according to the zones to be called on a full-time or measured-time basis. Costs vary widely depending on both the service area and the state in which the customer is located.

**TELPAK** is the name given to the service in which several telephone-grade lines are leased as a group between two points. It is essentially a pricing arrangement as the rates for service are substantially lower than an equivalent number of voice channels. The group of lines can be employed for any type of usage such as wideband data communications, voice, typewriter or facsimile transmission.

**TWX and TELEX** are the names applied to the teleprinter exchange services of the Bell System and the Western Union, respectively. These provide direct dial, point-to-point connections using input/output equipment such as page printers, keyboards, paper tape readers and paper tape punches.

**DATA-PHONE** provides for the transmission of data between a variety of terminal equipment using the regular dial telephone network or the WATS service. The cost to the customer is the same as the ordinary communications service cost in addition to a monthly rate for the Data Set.

**DATA-PHONE 50** is the name of a recently announced switched wideband data communications service of the Bell system. A subscriber can now dial a call and send data at speeds up to 50,000 bits/sec, a 25-fold increase over the present "voiceband" DATA-PHONE service.

**INFO-COM** is the name of a new store-and-forward message or data communications service developed by Western Union.

**DIAL-PAK** is the name of a new concept by Western Union that will provide direct computer-to-computer communications using a 48-kHz wideband switched system.

In addition to the above services, voice grade and telegraph lines can be leased for the exclusive use of the subscriber. Table VI on tariffs for common carrier...
**TABLE I EQUIPMENT CHARACTERISTICS OF COMMON CARRIER MODEMS**

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>AUTOMATIC ELECTRIC</th>
<th>AUTOMATIC ELECTRIC</th>
<th>AUTOMATIC ELECTRIC</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL NUMBER</td>
<td>103C</td>
<td>401A/E</td>
<td>101A/C</td>
<td>103A</td>
<td>103B</td>
<td>103F</td>
<td>201A3</td>
<td>201A4</td>
<td>201B1</td>
<td>201B2</td>
<td></td>
</tr>
<tr>
<td>SPEED</td>
<td>---</td>
<td>20 char/sec</td>
<td>10 char/sec</td>
<td>200 bits/sec</td>
<td>200 bits/sec</td>
<td>300 bits/sec</td>
<td>2000 bits/sec</td>
<td>2000 bits/sec</td>
<td>2400 bits/sec</td>
<td>2400 bits/sec</td>
<td></td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>---</td>
<td>Parallel</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td></td>
</tr>
<tr>
<td>NUMBER of WIRES</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>2</td>
<td>2</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td></td>
</tr>
<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Full</td>
<td>Simplex</td>
<td>Half/full</td>
<td>Half/full</td>
<td>Half/full</td>
<td>Full on 4 wire</td>
<td>Full on 4 wire</td>
<td>Full on 4 wire</td>
<td>Full on 4 wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Alternate transmitting only</td>
<td>Used with Teletype 33 &amp; 35</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>COST*</td>
<td>Rental $/month</td>
<td>---</td>
<td>---</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Installation $</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>25</td>
<td>25</td>
<td>26</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

*Approximate only; prices vary with operating companies. Check with your local representative.

---

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED</td>
<td>1200 bits/sec</td>
<td>1800 bits/sec</td>
<td>1200 bits/sec</td>
<td>1800 bits/sec</td>
<td>600 bits/sec</td>
<td>3600 bits/sec</td>
<td>40,800 bits/sec</td>
<td>19,200/50,000/230,400 bits/sec</td>
<td>20 char/sec</td>
<td>20 char/sec</td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Parallel</td>
</tr>
<tr>
<td>NUMBER of WIRES</td>
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<td>2/4</td>
<td>2</td>
<td>2/4</td>
<td>2</td>
<td>2/4</td>
<td>2</td>
<td>2/4</td>
<td>2</td>
<td>2/4</td>
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<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Half</td>
<td>Full on 4 wire</td>
<td>Half</td>
<td>Full on 4 wire</td>
<td>Full</td>
<td>Full</td>
<td>Full (voice)</td>
<td>Full (voice)</td>
<td>Full (voice)</td>
<td>Full (voice)</td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
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<td>COMMENTS</td>
<td>---</td>
<td>---</td>
<td>202A</td>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
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<tr>
<td>COST*</td>
<td>Rental $/month</td>
<td>---</td>
<td>40</td>
<td>40</td>
<td>---</td>
<td>---</td>
<td>250</td>
<td>425/430/450</td>
<td>5</td>
<td>7.50</td>
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<td>50</td>
<td>---</td>
<td>200</td>
<td>300</td>
<td>15</td>
<td>20</td>
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</table>

*Approximate only; prices vary with operating companies. Check with your local representative.
<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
<th>BELL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELL WESTERN</td>
<td>401J</td>
<td>401H</td>
<td>X401L</td>
<td>X202F</td>
<td>402C</td>
<td>402D</td>
<td>X403A</td>
<td>X403B &amp; C</td>
<td>602A</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>BELL WESTERN</td>
<td>601A &amp; C</td>
<td>611B</td>
<td>8101-A</td>
<td>1001-A</td>
<td>2121-A</td>
<td>2241-A</td>
<td>4001-A</td>
<td>6001-A</td>
</tr>
<tr>
<td>BELL WESTERN</td>
<td>601A &amp; C</td>
<td>611B</td>
<td>8101-A</td>
<td>1001-A</td>
<td>2121-A</td>
<td>2241-A</td>
<td>4001-A</td>
<td>6001-A</td>
<td>6001-A</td>
</tr>
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<td>SYSTEM</td>
<td>SYSTEM</td>
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</tr>
<tr>
<td>MODEL NUMBER</td>
<td>401J</td>
<td>401H</td>
<td>X401L</td>
<td>X202F</td>
<td>402C</td>
<td>402D</td>
<td>X403A</td>
<td>X403B &amp; C</td>
<td>602A</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>SYSTEM</td>
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<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
<td>SYSTEM</td>
</tr>
<tr>
<td>SPEED</td>
<td>20 char/sec</td>
<td>20 char/sec</td>
<td>20 char/sec</td>
<td>1200 bits/sec</td>
<td>75 char/sec</td>
<td>75 char/sec</td>
<td>10 char/sec</td>
<td>10 char/sec</td>
<td>10 char/sec</td>
</tr>
<tr>
<td>SERIAL or</td>
<td>Parallel</td>
<td>Parallel</td>
<td>Parallel</td>
<td>Serial</td>
<td>Parallel</td>
<td>Parallel</td>
<td>Parallel</td>
<td>Parallel</td>
<td>Parallel</td>
</tr>
<tr>
<td>NUMBER or</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>WIRES</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
</tr>
<tr>
<td>SIMPLEX or</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
</tr>
<tr>
<td>CHANNEL MANDATORY?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Receive only; Transmit only;</td>
<td>Transmit only;</td>
<td>Transmit only;</td>
<td>Transmit only;</td>
<td>Receive only;</td>
<td>Touch tone; receive only;</td>
<td>Touch tone; transmit only;</td>
<td>Analog faceplate transmitter</td>
<td></td>
</tr>
<tr>
<td>COST*</td>
<td>Rental $/month 35</td>
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<td>25</td>
<td>30</td>
<td>30</td>
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<td>Installation $</td>
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<td>40</td>
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<td>25</td>
<td>50</td>
<td>75</td>
<td>25-50</td>
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</tbody>
</table>

*Approximate only; prices vary with operating companies. Check with your local representative.
TABLE III EQUIPMENT CHARACTERISTICS OF NON-COMMON CARRIER MODEMS

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>ANDERSON-JACOBSON</th>
<th>ANDERSON-JACOBSON</th>
<th>COLLINS RADIO</th>
<th>COLLINS RADIO</th>
<th>COLLINS RADIO</th>
<th>GENERAL ELECTRIC</th>
<th>GENERAL ELECTRIC</th>
<th>GENERAL ELECTRIC</th>
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<tbody>
<tr>
<td>MODEL NUMBER</td>
<td>ADC 200</td>
<td>ADC 300</td>
<td>TE-216A-2D</td>
<td>TE-216A-2D</td>
<td>TE-216A-4D</td>
<td>TDM-110</td>
<td>TDM-210</td>
<td>TDM-220</td>
</tr>
<tr>
<td>SPEED</td>
<td>300</td>
<td>300</td>
<td>2400</td>
<td>3600</td>
<td>4800</td>
<td>300</td>
<td>1000-1800</td>
<td>2400</td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
</tr>
<tr>
<td>CHANNEL TYPE</td>
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<td>Voice</td>
<td>Voice, type</td>
<td>Voice, type</td>
<td>Voice, type</td>
<td>Voice Type 3004</td>
<td>Type 4, Type 4A</td>
<td>Type 4A</td>
</tr>
<tr>
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<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2/4</td>
<td>2/4</td>
</tr>
<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>AUTOMATIC CALL UNIT?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>MODULATION SCHEME</td>
<td>Phase-shift (Kineplex)</td>
<td>Phase-shift (Kineplex)</td>
<td>Phase-shift (Kineplex)</td>
<td>Frequency shift</td>
<td>Frequency shift</td>
<td>AM vestigial Sideband</td>
<td>AM vestigial Sideband</td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Portable, originate only</td>
<td>Portable, originate/answer</td>
<td>Various options available</td>
<td>Various options available</td>
<td>Various options available</td>
<td>Compatible with BELL 103F</td>
<td>Compatible with BELL 2020</td>
<td>Internal clock at 2400 bps in sync. mode.</td>
</tr>
<tr>
<td>PURCHASE COST*</td>
<td>$875-970</td>
<td>$850-1,145</td>
<td>$695</td>
<td>$675</td>
<td>$1,485 (Async.)</td>
<td>$1,950 (Sync.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Cost data is approximate. Prices vary with configurations and options.

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>GENERAL ELECTRIC</th>
<th>GENERAL ELECTRIC</th>
<th>IBM</th>
<th>IBM</th>
<th>IBM</th>
<th>IBM</th>
<th>LENKURT ELECTRIC</th>
<th>MILGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL NUMBER</td>
<td>TDM-110</td>
<td>TDM-211</td>
<td>Line Adapter 1</td>
<td>Line Adapter 2</td>
<td>Leased Line</td>
<td>Shared Line</td>
<td>6C</td>
<td>4400/24PB</td>
</tr>
<tr>
<td>SPEED</td>
<td>300</td>
<td>1200</td>
<td>Up to 600</td>
<td>Up to 600</td>
<td>Up to 134</td>
<td>1200/2400</td>
<td>2400</td>
<td></td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
</tr>
<tr>
<td>CHANNEL TYPE</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice Schedule 4A</td>
<td>Voice Type 3002</td>
<td></td>
</tr>
<tr>
<td>NUMBER of WIRES</td>
<td>2</td>
<td>2/4</td>
<td>2</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>---</td>
<td>2</td>
</tr>
<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Full Duplex</td>
<td>Hal/ half Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Half/full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>MODULATION SCHEME</td>
<td>Frequency shift</td>
<td>Frequency shift</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Dubinary</td>
<td>Phase-shift (Kineplex)</td>
<td>---</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Compatible with BELL 103A2</td>
<td>Compatible with BELL 202C</td>
<td>Limited Distance</td>
<td>Limited Distance</td>
<td>---</td>
<td>Simultaneous voice/teletype transmission possible</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>PURCHASE COST*</td>
<td>$875-1,495</td>
<td>$850-1,145</td>
<td>$695</td>
<td>$675</td>
<td>$1,485 (Async.)</td>
<td>$1,950 (Sync.)</td>
<td>$4,995</td>
<td>---</td>
</tr>
</tbody>
</table>

*Cost data is approximate. Prices vary with configurations and options.

For additional information on products listed, circle these numbers on inquiry card:
<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>MILGO</th>
<th>PHILCO</th>
<th>PHILCO</th>
<th>PHILCO</th>
<th>PHILCO</th>
<th>PHILCO</th>
<th>RFL INDUSTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL NUMBER</td>
<td>4400/48</td>
<td>MD/NY</td>
<td>MC 12/24-2B</td>
<td>MC 12/24-1</td>
<td>Diplexer</td>
<td>EDC 1224</td>
<td>EDC 61-75 Series 2056</td>
</tr>
<tr>
<td>SPEED</td>
<td>Bits per second</td>
<td>4800</td>
<td>1200/1400</td>
<td>300-2400</td>
<td>300-2400</td>
<td>75</td>
<td>75-2400</td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
</tr>
<tr>
<td>CHANNEL TYPE</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Voice</td>
<td>Teleprinter</td>
</tr>
<tr>
<td>NUMBER of WIRES</td>
<td>2</td>
<td>2/4</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Simplex Full duplex Full Full Duplex</td>
<td>Full Full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Half/full</td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>MODULATION SCHEME</td>
<td>Phase-shift (Kineplex)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>High frequency radio modems</td>
<td>High frequency radio modems</td>
<td>For sending Teletype/voice signal simultaneously</td>
<td>Increased error detection and correction</td>
<td>Increased error detection and correction</td>
<td>Rack Mounting</td>
<td></td>
</tr>
<tr>
<td>PURCHASE COST*</td>
<td>$5,885</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>$625-850</td>
</tr>
</tbody>
</table>

*Cost data is approximate. Prices vary with configurations and options.

For additional information on products listed, circle these numbers on inquiry card:

MILGO ........................................ 155
PHILCO ........................................ 156
RFL INDUSTRIES .............................. 157
RIXON ELECTRONICS ....................... 158

For additional information on products listed, circle these numbers on inquiry card:

MILGO ........................................ 155
PHILCO ........................................ 156
RFL INDUSTRIES .............................. 157
RIXON ELECTRONICS ....................... 158

For additional information on products listed, circle these numbers on inquiry card:

MILGO ........................................ 155
PHILCO ........................................ 156
RFL INDUSTRIES .............................. 157
RIXON ELECTRONICS ....................... 158
rier services also provides a summary of the various common carrier services. These are approximate tariffs currently in use and may change, but they do give a good indication of the likely costs of the data communications service. The perspective user is advised to check with his local common carrier representative, especially for the WATS service, as the cost of service depends on areas of use and state of residence of the user.

In most cases, the telephone-grade service can be employed for the transmission of voice as well as data through the use of dataphone subsets supplied by the telephone company. Frequently, this ability permits considerable savings by combining voice and data needs. Telephone coupler (usually acoustic coupling) data sets are also available from the telephone company and others which allow data to be transmitted over the public telephone network via a conventional telephone set. Table VI exhibits the major characteristics of most telephone coupler data sets on the market.

A number of new developments with special interest to computer/communications systems are taking place in the Bell System. One arrangement (203 Data Set) intended for use on the dial telephone network will operate at 3600 bits per second. Thus it will match the asymmetrical characteristics of information flow found in many situations such as keyboard entry and display output. On private-line voiceband circuits, the data set will operate at 4800 bits per second and possibly 7200 bits per second. These increases in speed made possible by multi-level vestigial sideband and automatic adaptive equalization will permit very favorable economies to be made in computer/communications systems.

Another development is that of the touch-tone telephones which can be used very effectively as data terminals. In cases where limited input capability is tolerable and no hard copy is needed (such as banking, credit, and some inquiry systems) the push button telephone provides a very inexpensive and reliable terminal.

The introduction of digital transmission techniques into the communications networks is likely to drastically reduce the cost of data communications. Pulse code modulation (PCM) techniques are gradually being introduced into the Bell System. Since PCM systems transmit on the order of 50 kilobits per second for each voice channel, there is a large potential for substantial economies. The digital carrier systems T1 (1.54 megabits per second), T2 (62 megabits per second), and T4 (281 megabits per second) are currently being developed and used in the Bell Systems. These digital transmission system will use time-division multiplexing extensively thus providing a variety of bit rates.

### TABLE IV EQUIPMENT CHARACTERISTICS OF NON-COMMON CARRIER MODEMS (CONT.)

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
<th>SANGAMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL NUMBER</td>
<td>T103A</td>
<td>T103F</td>
<td>T201A</td>
<td>T201B</td>
<td>T202C</td>
<td>T202D</td>
<td>T401E</td>
<td>T401H</td>
</tr>
<tr>
<td>SPEED Bits per second</td>
<td>300</td>
<td>300</td>
<td>2000</td>
<td>2400</td>
<td>1800</td>
<td>1800</td>
<td>20 char/sec</td>
<td>20 char/sec</td>
</tr>
<tr>
<td>SERIAL or PARALLEL</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Serial</td>
<td>Parallel</td>
</tr>
<tr>
<td>NUMBER OF WIRES</td>
<td>2</td>
<td>2</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2/4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SIMPLEX or DUPLEX</td>
<td>Full Duplex</td>
<td>Full Duplex</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
<td>Half/full Duplex</td>
<td>Transmit</td>
<td>Only</td>
</tr>
<tr>
<td>PRIVATE LINE MANDATORY?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>AUTOMATIC CALL UNIT?</td>
<td>Optional</td>
<td>No</td>
<td>Yes</td>
<td>Optional</td>
<td>Optional</td>
<td>Optional</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>MODULATION SCHEME</td>
<td>Frequency shift</td>
<td>Frequency shift</td>
<td>Phaze shift</td>
<td>Phaze shift</td>
<td>Frequency shift</td>
<td>Frequency shift</td>
<td>3 of 14 code</td>
<td>3 of 14 code</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Designed for operation with Western Electric 810A</td>
<td>Designed for operation with Bell 401J</td>
<td>Designed for operation with Bell 401J</td>
<td>Designed for operation with Bell 401J</td>
<td>Designed for operation with Bell 401J</td>
<td>Designed for operation with Bell 401J</td>
<td>Compatible with Bell 401J</td>
<td>Compatible with Bell 401J</td>
</tr>
<tr>
<td>PURCHASE COST*</td>
<td>$580</td>
<td>$535</td>
<td>$2065-2110</td>
<td>$2135-2200</td>
<td>$1035-1320</td>
<td>$790-1015</td>
<td>$234-254</td>
<td>$234-254</td>
</tr>
</tbody>
</table>

*Cost data is approximate. Prices vary with configuration and options.

For additional information on products listed, circle 159 on inquiry card.
### TABLE V TARIFFS FOR COMMON CARRIER SERVICES

<table>
<thead>
<tr>
<th>COMMON CARRIER</th>
<th>TYPE OF SERVICE</th>
<th>BANDWIDTH or NOMINAL SPEED</th>
<th>TARIFFS* (Dollars)</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT&amp;T BELL SYSTEM</td>
<td>TWX dial network</td>
<td>100 words per min.</td>
<td>$1.75 first three minutes 0.60 each additional min. for 2000 miles and over 0.20/min. for 0–50 miles</td>
<td>Charges vary with distance, three minute minimum charge</td>
</tr>
<tr>
<td>WESTERN UNION</td>
<td>TELEX dial network</td>
<td>66 words per min.</td>
<td>From $0.175 to 0.60/min. depending on areas. 40% discount on excess if charges exceed $87.50/mo.</td>
<td>No 3 minute min. charge, fractions of min. are propor. charged.</td>
</tr>
<tr>
<td>AT&amp;T and WESTERN UNION</td>
<td>Private line services low-speed</td>
<td>60, 75 words/min.</td>
<td>$1.10/channel-mile/month for half-duplex $1.21 for full-duplex</td>
<td>Charges are telescopic, reduce to half after 250 miles and third after 1,000 miles</td>
</tr>
<tr>
<td>AT&amp;T BELL SYSTEM</td>
<td>Public telephone network, dial exchange</td>
<td>voiceband 3000 bps</td>
<td>$1.00 to $2.00/three min. 0.25 to 0.50 each add’l. min. for 2,000 mi. and over $0.30/three min. and 0.10 each add’l. min. for up to 30 mi.</td>
<td>charged by time and distance 3 minute min. charge for call.</td>
</tr>
<tr>
<td>WATS unlimited service</td>
<td>voice network 3,000 bps</td>
<td>$2,300/month for anywhere in USA for unlimited time. $500/month for Area 1</td>
<td>cost depends on service areas and the state.</td>
<td></td>
</tr>
<tr>
<td>WATS measured service</td>
<td>voice network 3,000 bps</td>
<td>$610/month for first 15 hours, $34 each add’l. hour for anywhere in USA</td>
<td>cost of service lower for indiv. areas, varies.</td>
<td></td>
</tr>
<tr>
<td>WESTERN UNION</td>
<td>BEX Broadband Exchange</td>
<td>2 kc/s, 4 kc/s</td>
<td>$0.15/minute to $0.65/min. 40% discount on excess of $3000 $0.20/minute to $0.75/min. 40% discount on excess of $400</td>
<td>Rates depend on areas, charges are broken down to tenths of a minute</td>
</tr>
<tr>
<td>AT&amp;T and WESTERN UNION</td>
<td>voice-grade leased lines</td>
<td>4KHz</td>
<td>$2.02 for half duplex $2.22 for full duplex (channel-mile/month) $10, $37.50, and $56. channel condition charges for schedule 4A, 4B, and 4C respectively</td>
<td>rates are telescopic drop by approx. 15% after 250 mi. and 25% after 500 miles.</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>TELPAK A</td>
<td>48 kc/s</td>
<td>$15/mile/month</td>
<td>12 voice channels</td>
</tr>
<tr>
<td></td>
<td>TELPAK B</td>
<td>96 kc/s</td>
<td>20/mile/month</td>
<td>24 voice channels</td>
</tr>
<tr>
<td></td>
<td>TELPAK C</td>
<td>240 kc/s</td>
<td>25/mile/month</td>
<td>60 voice channels</td>
</tr>
<tr>
<td></td>
<td>TELPAK D</td>
<td>1,000 kc/s</td>
<td>45/mile/month</td>
<td>240 voice channels</td>
</tr>
</tbody>
</table>

*These are approximate tariffs currently available and may change. Check with your local common carrier representative.*
### TABLE VI MAJOR CHARACTERISTICS OF ACOUSTIC COUPLERS

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>ANDERSON—JACOBSON</th>
<th>ANDERSON—JACOBSON</th>
<th>ANDERSON—JACOBSON</th>
<th>COMPUTER COMMUNICATIONS</th>
<th>DATA COMMUNICATIONS SYSTEMS</th>
<th>DATA COMMUNICATIONS SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL</td>
<td>ADC-260</td>
<td>ADC-270</td>
<td>ADC-1210</td>
<td>CC-302</td>
<td>DAC-337</td>
<td>DAC-347</td>
</tr>
<tr>
<td>TRANSMISSION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed bits/sec</td>
<td>300</td>
<td>300</td>
<td>1200</td>
<td>300</td>
<td>165</td>
<td>165</td>
</tr>
<tr>
<td>Simultaneity</td>
<td>Half or full duplex</td>
<td>Half or full duplex</td>
<td>Half duplex</td>
<td>Half or full duplex</td>
<td>Half or full duplex</td>
<td>Half or full duplex</td>
</tr>
<tr>
<td>Code</td>
<td>any</td>
<td>any</td>
<td>any</td>
<td>any</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td>COUPLING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmit</td>
<td>acoustic</td>
<td>acoustic</td>
<td>acoustic</td>
<td>acoustic</td>
<td>acoustic</td>
<td>acoustic</td>
</tr>
<tr>
<td>Receive</td>
<td>acoustic</td>
<td>acoustic</td>
<td>acoustic</td>
<td>Inductive</td>
<td>acoustic</td>
<td>acoustic</td>
</tr>
<tr>
<td>COMMENT</td>
<td>originate only</td>
<td>answer only</td>
<td>originate only</td>
<td>originate only</td>
<td>originate only</td>
<td>originate only</td>
</tr>
<tr>
<td>COST</td>
<td>Purchase $570</td>
<td>$645</td>
<td>$795</td>
<td>$600</td>
<td>$495</td>
<td>$560</td>
</tr>
</tbody>
</table>

*All data sets employ frequency shift keying and serial by bit asynchronous transmission and couple the data terminal (via EIA standard RS232C interface) to the public telephone network using a conventional telephone set (Bell 500 telephone set or equivalent). For additional information on products listed, circle these numbers on inquiry card:

**ANDERSON-JACOBSON** ........................................... 160  **GENERAL ELECTRIC** ........................................ 163
**COMPUTER COMMUNICATIONS** ..................................... 161  **OMNITECH** .................................................... 164
**DATA COMMUNICATIONS SYSTEMS** ................................ 162  **TYMSHARE** ...................................................... 165
When the output of a logic gate (Fig. 1) switches from false to true, it raises the voltage difference between the output pin of the gate and the reference through a voltage, \( v \), which is called the signal amplitude of the gate. It is important to think of the signal as being a differential mode signal between the front end of the signal line and the reference, which serves as the return path. This reference might be called "ground". This change in voltage difference between the signal and reference lines does not appear instantaneously at the point further down the signal line because there is capacitance between the signal and reference lines. This means that before the new logic level (voltage difference) can be established between the signal and reference lines at all points, an amount of charge \(+q\) must have been delivered by the gate to the signal line, and an equal and opposite charge must have been removed from the reference line by the gate, where

\[
q = cv,
\]

c being the capacitance between the signal line and the reference line. We might suppose that if the logic gate could instantaneously deliver that amount of charge \(+q\) to the signal line and remove it from the reference line, the signal would appear without delay at the far end. Unfortunately this is not so, because of inductance.

We know that movement of electrical charge is accompanied by the appearance of magnetic flux. Change of the rate of flow of electric charge down the line, (which is necessary if we are to suddenly transfer a charge \( \phi \) to the line) involves change of flux, \( \frac{d\phi}{dt} \), which by Faraday's law creates an induced back electro-motive force which tends to oppose the change of current. So if we try to introduce a charge \(+q\) instantaneously into the line, we get an infinite \( \frac{d\phi}{dt} \) and so an infinite back emf.

This means that in order to drive the voltage drop between signal line and reference line through a voltage change \( v \) instantaneously, we would need an infinite driving voltage for a short time to overcome the back emf.
...of perforated tape readers! Tally not only offers the most complete line of perforated tape readers (for paper, foil, or plastic tape), but the broadest and best performing line of perforators too. So whatever your needs in the field of perforated tape technology, write or call us today. Please address Tom Tracy, Tally Corporation, 8301 South 180th Street, Kent, Washington 98031. Phone: (206) 251-5500. TWX: 910-423-0895. In Europe and the U.K., address Tally Ltd., 6a George Street, Croydon, Surrey, England. Phone: (01) 686-6836.
Alternately the signal cannot travel instantaneously because as the electric charge travels down the line, energy appears around the line in the form of magnetic and electric flux. By the principle of energy conservation this energy must have been supplied by the only available source, the logic gate. Now the gate can ideally supply voltage and current instantaneously. However, $vi$ makes power but not energy. Power requires a third dimension, time, to give the full dimensions of energy, $viti$. So in the absence of infinite voltage or current, time is necessary for the signal to develop throughout the length of the signal line.

Note that in the above discussion the geometry of signal wire and reference was not specified.

**Logic Signal Transfer Down A Uniform Transmission Line**

Let us assume that a logic swing $v$ is introduced at $A_1G_1$ between the signal line $A$ and the reference line $G$ (Fig. 2), at time $t_0$. We can expect the logic swing to propagate down to the right, so that later in time ($t_1$) the signal has reached a point $A_2G_2$. Let us suppose that the capacitance per unit length between $A_1A_3$ and $G_1G_3$ is $C$. This means that if a steady potential difference $v$ existed between the lines the charge on each line would be $(q) = Cv$ per unit length.

Let the self inductance per unit length of the pair of lines $A_1A_3$ and $G_1G_3$ be $L$. The $L$ term means if a steady current $+i$ were flowing down $A_1A_3$ and a steady current $-i$ were flowing back along $G_1G_3$, the magnetic flux passing through a surface $A_1A_3G_3G_1$ bounded by the two wires would be $\phi = Li$ per unit length of the pair of lines.

Since the cross-sectional geometries and the surrounding dielectric of the pair of lines AG do not vary along their length, it is reasonable to assume that the signal travels at a constant velocity $c$. We know that the impedance which the pair of lines AG presents to an impressed signal $V_{A1G1}$ is not infinite, so there must be current as well as voltage contained in the signal. If a current $+i$ is flowing down line $A$ and a current $-i$ is flowing back along line $G$, we have a magnetic flux field as shown in Figure 3, and this results in a net flux passing between the pair of lines $AG$. Then in time $\Delta t$, the signal will have traveled a distance equal to $c\Delta t$, and the flux passing through the surface $A_1A_3G_3G_1$ will have increased by

$$\Delta \phi = Lic\Delta t. \quad (1)$$

Now Faraday's Law of Induction says that if the flux through a loop increases steadily at the rate $\Delta \phi/\Delta t$, an emf is induced equal to $-\Delta \phi/\Delta t$. By Lenz's law, ("Physics," by Hausmann–Slack Van Nostrand, p. 381) this opposes the original signal, and it can be called a back emf. Apart from the original signal $v$ introduced across $A_1G_1$, this back emf is the only voltage around the loop $A_1A_3G_3G_1$. By
Kirchhoff's Second Law, the sum of the voltages around the loop equals zero.

Impressed voltage \( v \) + back emf

\[ v + \left( -\frac{\Delta \phi}{\Delta t} \right) = 0 \]

\[ \therefore v = \frac{\Delta \phi}{\Delta t} = L i c \text{ from Eq. (1)}. \]

This gives us the first important relationship between voltage, current and velocity.

\[ \frac{v}{i} = Lc \quad (2) \]

The second relationship will be derived from the Principle of Conservation of Charge. We know that a current \( i \) is entering the line \( A \) at \( A_1 \). So in time \( \Delta t \), the total charge in line \( A_1A_3 \) will have increased by an amount \( q = i \Delta t \).

During time \( \Delta t \), the signal will have advanced a distance equal to \( c \Delta t \), and this new section of line will have been charged up through a voltage \( v \).

The charge absorbed

\[ = \text{capacitance} \times \text{voltage} \]

\[ = \text{capacitance per unit length} \times \text{distance} \times \text{voltage} \]

\[ = C c \Delta t v \]

By the principle of conservation of charge this must equal the charge introduced into the line, \( i \Delta t \).

\[ \therefore i \Delta t = C c \Delta t v \quad (3) \]

This gives us the second important relationship between voltage, current and velocity:

\[ \frac{v}{i} = \frac{1}{Cc} \quad (4) \]

Now if we divide equation (2) by (4) we eliminate \( c \) to get

\[ \frac{V}{i} = \pm \frac{L}{\sqrt{C}} \quad (6) \]

This means that the ratio between \( v \) and \( i \) is a constant for the line. This constant has been called the Characteristic Impedance, \( Z_0 \), of the line.

REFERENCES


Digitally-controlled power sources (DCPS's) are complete digital-to-analog links between a computer (or other digital source) and any application requiring a fast, accurately settable source of dc or low-frequency ac power. Initially these applications may be thought of as requiring a digital-to-analog converter with augmented output power capability, a digitally-controlled power supply, or a digitally-controlled waveform synthesizer.

However, such applications generally require more than a programmable power supply or the simple tandem combination of a D/A converter and an operational amplifier. Interface circuitry must be added to insure compatibility between the computer and D/A converter. Additional circuits required to complement the D/A converter include:

- reference and B+ sources
- isolation between input and output to avoid ground loops between the load ground and the computer main frame.
- internal storage to increase computer operating efficiency and eliminate programming overshoots
- programmable current limiting protection for the output power amplifier and the load
- feedback signals to inform the computer of the power source status

The name "digitally controlled power source" denotes a single compact package which includes interfacing, storage D/A conversion, bipolar power amplification, protection, digital feedback, and all necessary bias supplies. Models 6130B and 6131B DCPS's provide these functions:

All digital inputs are floating and isolated from the floating analog output, thus avoiding troublesome loops between the output ground and computer ground.

Inputs from all digital data lines are stored upon receipt of a gate signal from the computer; this stored information is provided as input to the D/A converter. Fifty-five microseconds after the gate, a flag signal informs the computer that enough time has elapsed for the commanded output voltage level to be achieved. The output level will be maintained until a new gate signal is received, leaving the computer free to perform other tasks in the interval between voltage level commands.

Storage also insures that non-simultaneous arrival of signals on all digital input lines will not cause programming overshoot or undershoot—this eliminates the necessity of programming the output to zero before setting each new output level.

The D/A converter converts one polarity bit plus 16 BCD voltage bits or 15 binary voltage bits to an analog voltage for input to the power amplifier. Resolution is 0.5 millivolt for straight binary and 1 millivolt for BCD operation.

The bipolar power amplifier programs either side of zero or through zero without output polarity switches or "notch" effects, with an accuracy of 1 mV, 5 mV or 10 mV depending on the range and model. Model 6130B programs over ±50 V @ 0-1A in less than 100 microseconds; model 6131B programs over ±100 V @ 0-0.5A in less than 200 microseconds.

The DCPS provides three feedback signals to the computer. The
When we started comparing apples to apples, we found that one of them was surrounded by an orchard.

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CIRCLE 32 ON INQUIRY CARD
first of these is a flag (completion of task) signal which occurs 55 microseconds after the input gate signal (2 milliseconds after input gate signal if range is changed) and informs the computer that the programmed level exists at the output. The remaining two bits send overload information through isolated data lines. Thus the computer is continuously informed of any current overload and power amplifier shutdown.

The application areas for DCPS's are practically unlimited—they are useful wherever digital signals must be converted to analog form with accuracy, precision, and a minimum of system interface complication. The digital input signals can be provided by a computer, tape reader, digital voltmeter, counter, external switch closures, etc. The output can be connected to any instrument or system requiring an analog source with power capability up to 50 watts.

Used in conjunction with a computer, a DCPS provides an automated source of calibrated dc or low-frequency waveforms. In the latter case, the waveshape can be designated on an exact point-by-point basis, with a computer specifying a new point every 50 μsec. In some applications, the DCPS output waveform is selected to be a staircase approximation of a sawtooth; the computer then analyzes the linearity of the system by comparing the output and input signals. In other cases a square wave or pulse output from the DCPS is used to calibrate the system gain and check the transient performance.

Computer/DCPS combinations are assuming greater significance because of the increasing thoroughness of systems testing requirements and the need for inexpensive high-speed calibration. Using a computer and a DCPS, system testing and calibration can be accomplished quickly during periods of inactivity or on a time-shared basis without interrupting system operation.

Other factors that contribute to the usefulness of the DCPS in calibration applications include:

- ease of interfacing between the computer and DCPS
- programming speed
- input/output isolation
- bipolar output—smooth programming through zero

Moreover, the low-output impedance of the DCPS insures the integrity of its accuracy specification even in the face of substantial load current requirements.

Computer-controlled test systems are finding increasing use in high-speed testing and sorting of electronic components, particularly transistors and IC's, as well as larger electronic subassemblies.

In a typical system, the computer is controlled either through manual keyboard entry, by previously prepared programs on a punchtape reader, or from a program stored in computer memory. The number of DCPS's employed depends upon the number of programmable voltages required by the device under test. Used as a stimulus, the DCPS covers a frequency range from dc to 20kHz—particularly valuable in generating complex special-purpose waveforms, and very low frequency test signals below the range of conventional oscillators.

With high-speed testing systems, components can be checked more thoroughly and inexpensively. The DCPS possesses a unique combination of speed, accuracy, resolution, and power output capability, making it ideal for large volume production testing. Its internal storage permits rapid programming between voltage levels without programming to zero between each desired output level to avoid overshoots. The programmable current limit assures that delicate components can be tested and sorted nondestructively; two different current overload signals are fed back from the DCPS so that the computer can distinguish between a short-term or transient violation of the current limit value and a long-term or transient violation of the current limit value, and a long-term or static excess. The bipolar output plus the ability to sink as well as source current permits testing of active as well as passive devices.

In addition to manufacturing separate instruments for connection into an automated test system, HP also manufactures self-contained test systems employing the DCPS, an HP computer, and other instruments tailored to specific applications.

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CIRCLE 33 ON INQUIRY CARD
A quiet, high-speed communications printer built for remote printing via conventional voice-grade public-switched telephone lines has been developed by the A. B. Dick Company of Chicago.

Designated the Videojet 960, the product is a non-impact printer utilizing a stream of controlled ink droplets to print 250 characters per second on conventional business forms ranging in weight from 20- to 125-pound stock, in overall widths from $3\frac{1}{2}$ to $14\frac{3}{4}$ inches, using Videojet offset ink and continuous-form masters. The 960 can also direct image masters for reproductions requiring distribution.

The 960 print rate, 25 times faster than most communications printers, is designed for data transmission in time-sharing networks; remote batch processing with local print requirements; message-switching systems; news wire services; and as a local line printer for use with small "mini" computers. It automatically answers the dataphone subset used in these systems, prints the information transmitted, and terminates the dataphone call—unattended.

Character spacing and line length are set to the industry norm of ten characters per inch and a line length of 136 characters. However, the character spacing is variable from five to fifteen characters per inch allowing up to 204 characters on a single line. It accommodates the 80-character line in communication networks.

Videojet 960's process is based on the principle that if fluid is forced through a nozzle it breaks up into droplets. The nozzle is subjected to a 66-kHz energy source which causes the droplets to be uniform in both size and spacing, a function of pressure at the nozzle, viscosity of ink, and diameter and vibration frequency of the nozzle. Each droplet may be given a precise electrostatic charge as it forms. The voltage present at the time the droplet breaks away from the ink stream induces the charge. Once it breaks, the charge is trapped—staying with the droplet until it reaches its destination.

Because the droplets pass between a pair of high-voltage deflection plates, the charge of the droplet determines the precise path of travel and final position of the droplet on paper.

The nozzle is moved in a horizontal plane, driven by a servomechanism-controlled, high speed, low inertia motor. The movement of the nozzle provides horizontal deflection of droplets; the high voltage plates provide vertical deflection.

A 9- by 11-dot matrix is used in a character generation to determine the charges for droplets. The 99 dots of the 9 by 11 matrix correspond to 99 droplets. If each droplet were appropriately charged, the resulting character would be a rectangle 9 droplets wide and 11 droplets high. Only those droplets required to form a character are charged. Uncharged droplets are collected and returned to the ink reservoir for reuse. Recirculation of unused ink allows the system to print for forty hours using only one quart of ink.
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Delta 1. The maxi display for the mini computers.

CIRCLE 34 ON INQUIRY CARD
CRT DISPLAY

An ultra-compact CRT display series offers the flexibility of the general-purpose lab scope.

Model 8602 has eleven sweep ranges selectable by a front panel control. Panel size is $3\frac{3}{4}$ by $5\frac{3}{4}$ inches with a 4-by 5-cm useful screen area. Sweep ranges are: 1 microsecond to 2 milliseconds per division, 10 $\mu$s to 20 ms, and 100 $\mu$s to 200 ms/div. Front panel signal attenuator is also available.

Model 8601 offers a choice of 18 single-range sweeps from 1 $\mu$s/div to 500 ms/div with 2.5:1 vernier.

Model 8601 is the basic x-y unit and may be fitted with front-panel controlled attenuators for both x and y channels. Deflection amplifiers are dc-coupled, high stability, all solid-state design. Indofex, Inc., Waterbury, Conn.

CIRCLE 200 ON INQUIRY CARD

HIGH-SPEED DATA TERMINAL

Series 720, Model 10 high-speed data terminal, utilizes a monolithic, solid-state printhead which produces characters on thermal-sensitive paper. The printer operates at rates up to 400 words per minute (40 characters per second).

A self-contained buffer memory provides more efficient utilization of lines in multi-drop private-line data systems by allowing twice the number of terminals per line, giving full service to each terminal. The buffer retains up to 50 characters in memory before transmitting them at high speed. The Model 10 is also designed with electronics for multi-station computer terminal operations: It responds to polling, addressing or broadcasting by a CPU in a multi-station network. Texas Instruments, Inc., Industrial Products Div., Houston, Tex.

CIRCLE 202 ON INQUIRY CARD

RANDOM ACCESS MEMORY

A 128-bit read/write random access memory, featuring access speeds of 35 nanoseconds, is available in a 1-inch-square multi-chip package. The M4L4027 is a bipolar product with a ceramic substrate incorporating two layers of metallized interconnects.

The device consists of eight 16-bit chips bonded face-down on the substrate. Memory organization is 64 2-bit words with uncommitted collectors that allow easy word or bit expansion. The organization is simplified by eight $X$ and eight $Y$ coincident-select lines.

All outputs are compatible with current sinking logic such as DTL and TTL, with true and complement outputs available for each bit. Fairchild Semiconductor, Mountain View, Calif.

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CIRCLE 36 ON INQUIRY CARD

NEW PRODUCTS

RELAY SCANNER

Designed for use with thermocouples and strain gage systems requiring resolution in the microvolt range is a low-level, 3-wire reed relay scanner. Model 1700 provides 10 to 40 channels in a 3½-inch cabinet and can be expanded to as high as 2,000 channels with the addition of slave units.

Individual channel selector push-buttons allow unlimited programming. Only the channels selected are scanned, while unselected channels are bypassed in zero time. Scanning rates ranging from 100 channels per second to one channel per 10 seconds are standard. Matrix Corp., Beech Grove, Ind.

CIRCLE 203 ON INQUIRY CARD

TIME AND DATE GENERATOR

The time and date can be produced in the form of machine-readable sequential signals into a TTY loop or as an optional EIA voltage by a time and date generator. For use with computer-switched teletypewriter communications systems, it offers a flexible method of input for time and date of message transmission. The code generator can also be pre-programmed for two 2-character responses for “answer back.” The variable T and D sequence output may contain other fixed-character intelligence.

Code configurations are available for any 5- or 8-level system to generate standard Baudot or 1963 ASCII output with the eighth pulse marking, as well as other codings, such as ASCII odd or even parity, 1966 ASCII, or IBM. Pioneer Electric & Research Corp., Forest Park, Ill.

CIRCLE 205 ON INQUIRY CARD

HYBRID IC MODULES

MCH1002 dual power driver hybrid microcircuit is the first in a series of off-the-shelf hybrid IC modules designed for interfacing high-threshold logic levels with electromechanical hardware. Composed of an expandable dual four-input line driver; two separate high-current, high-voltage discrete switching transistors; and four thick-film resistors, the MCH1002 features a maximum output current of 0.5A; a collector-emitter breakdown voltage of 40V minimum; a typical turn-on time of 115 ns; and typical turn-off time of 260 ns. It is encapsulated in a 14-lead, molded plastic plug-in package.

Also available is the MCH2005 Darlington power driver, housed in the TO-91, 10-lead ceramic flat package. At current gains greater than 1,000, the MCH2005 can convert the TTL output current level of 5 mA into a Darlington output current pulse of 5A—more than adequate to drive high-current ferrite switches used in phasemeter or phase-array-radar designs, with a total switching time of only 800 ns. Motorola Semiconductor Products, Inc., Phoenix, Ariz.

CIRCLE 206 ON INQUIRY CARD

PERMANENT-MAGNET DC MOTOR

A 33-Frame (3½-inch OD) permanent-magnet fractional-horsepower dc motor is available, in the standard length of 5⅞ inches. Armature windings may be varied by specification to meet application needs, making the motor operable at any desirable voltage with speeds up to 5,000 rpm.

Features include high current capability, long life brushes, double shielded precision ball bearings, Class 155 insulation, four permanent field magnets, stainless steel shafts and welded armature connections. Indiana General Corp., Electro-Mechanical Div., Oglesby, Ill.

CIRCLE 207 ON INQUIRY CARD

COMPUTER DESIGN/JULY 1969
Ordinary engineers have their place. Elsewhere.

Ordinary engineers are the guys who sit in somebody’s bullpen and slave away on a tiny part of some immense project. Doing the same kind of thing. Over and over, without ever really knowing what their contribution amounts to.

We go about things a little differently. And we think that’s the reason we’ve become a leader in computer memories. Our technique is to let engineers get involved in as many different activities as they can handle. Technical proposals, design, development, costing, production, marketing, planning—you name it, our engineers get involved in it. And the involvement leads to commitment. It’s worked out beautifully.

As a result we have a busy and extremely interested engineering staff. And the finest line of memory systems and stacks and interconnect circuitry on the market.

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CIRCLE 900 ON INQUIRY CARD
NEW PRODUCTS

DIGITAL ANGLE INDICATOR

An electronic instrument has been developed for measuring and displaying angular inputs from applied synchros or resolvers—the solid state digital angle indicator.

A visual readout displays the input angle on 1-inch character nixie tubes providing higher visibility and better readability than the normal servo drum dials. To drive printers and other off-line equipment, a four-decade BCD digital output is available without adding an encoder. The digital angle indicator will accept synchro or resolver inputs at 11.8, 26, or 90 volts line-to-line. Astrosystems, Inc., New Hyde Park, N.Y.

MULTI-CHANNEL ANALYZER

A portable multi-channel digital system analyzer which provides fast, positive analysis and evaluation of digital equipment and systems, measures both the direction and spatial or temporal position of signals in transition from one logic level to another. Multiple traces are displayed simultaneously in different colors. Display timing is derived from the external system clock; hence the rate is inherently stable. Display rate is variable from 1 to 99,999 intervals of 10 display divisions. Data Display Systems, Willow Grove, Pa.

SCHOTTKY SWITCHING DIODE

A triple-barrier Schottky switching diode, the MA4-A200, is a planar passivated silicon diode, utilizing a unique combination of two Schottky barriers and a p-n junction. The diode has the high breakdown voltage (>25 volts) and operating temperature characteristics of silicon, combined with the low turn-on voltage of germanium and the ultra-fast speed of a Schottky barrier device.

The MA4-A200 is recommended for pulse and analog applications. The diode is suited to pulse and digital circuits for clamping, clipping, speed-up, steering and sampling. Microwave Associates, Inc., Sunnyvale, Calif.

POWER TRANSISTORS

Fast switching 5.0-amp power transistors with turn on time less than 10 nanoseconds, designated the SDT6100 series, are packaged in the TO-5 case.

Typical characteristics are: VCEO = 40 volts, hFE @ 2.0 amp = 20 to 60; VCE (SAT) = 1.5 volt max; Ic @ 2.0 amps = 10 nsec max; and Ie max = 5.0 amps.

The devices have a total switching time of less than 60 nanoseconds and rise time of less than 10 nanoseconds. They feature planar construction and are typically fT = 500 MHz. Soliton Devices, Inc., Riviera Beach, Fla.

SYNCHRO REPEATER

The size 11 dc synchro repeater, CR4 0928 001, is designed for use as a torque repeater in displays operating directly from sources such as digital or pulse analog computers. The component functions when its two stator windings are energized by dc voltages proportional to the sine and cosine of an angle, causing its permanent magnet rotor to orient in the resultant field to an equivalent angular position. Since the device is a dc equivalent of a conventional ac synchro torque repeater, it can simplify repeater-indicator displays for A/D and D/A conversion and digital computer applications by utilizing digital pulses directly, thereby eliminating the need for more complex and costly ac instrumentation. Singer-General Precision, Inc., Kearfott Div., Little Falls, N.J.
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NUMERIC DISPLAY SYSTEMS

Three module sizes, 3, 4, and 5-inch, have been added to a line of bulbless C-Rite numeric displays.

The C-Rite is the only 7-bar system capable of producing information up to 5 inches.

The system is available in white or fluorescent, colored, seven-segment display. Unlimited life and reliability is assured using a teflon-suspended balanced rotor magnetic drive system. A self-latching memory insures fail-safe performance and low power consumption. James Electronics Inc., Components Div., Chicago, Ill.

MINIATURE KEYBOARD

A miniature solid-state numeric keyboard, measuring less than 4 inches wide and 1/2 inch thick, utilizes new infinite-life proximity keys to achieve 100% reliability.

The Mini-Line keyboard is designed for limited space applications. Its ten keys operate with non-contacting proximity transducers, a feature which eliminates key bounce, resultant mechanical wear, and the need for anti-bounce circuitry. Up to eight outputs from single keys eliminate the need for diode matrices. Transducer Systems, Inc., Willow Grove, Pa.

MEMORY POWER SYSTEM

A dc power system used to power thin film memories provides ten separate active outputs and three auxiliary outputs, with the active outputs regulated at ±0.5% with current limiting adjustable from 20 to 110%. Output ratings range from 1,800 to 7 watts. Each output has built-in over-voltage protection and all are adjustable for either ±10% or ±20% of their nominal levels.

The logic enables the system to turn on or off in proper sequence in response to a single computer input; to shift the levels of the ten outputs up or down, all in the same direction or mixed; and to signal the computer when an over or under voltage level has been exceeded. Rowan Industries, Inc., Electronic Measurements Div., Oceanport, N.J.

MULTI-PURPOSE POWER SUPPLY

The PM728 is a compact (3.0-inch by 3.7 by 8.4-inch overall), low-cost regulated dc power supply, using all silicon semiconductors, designed primarily to provide power for digital integrated circuit applications. The output of the PM728 is adjustable from 4.8 to 6.3 Vdc @ 3 amps and will operate from 115 Vac, ±10% at 60 to 400 Hz. Line and load regulation is ±0.05% each and ripple and noise is less than 1.0 mV RMS. Computer Products, Inc., Fort Lauderdale, Fla.
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As a technical design leader of complex digital projects, you will utilize your systems skills in both hardware and software, as well as analysis and applications for the process industries. Discharging these responsibilities demands leadership qualities, communications skills, planning and scheduling capabilities. A degree in engineering with a minimum of five years' experience in instrumentation, process control and on-line computer applications is desired.

SYSTEMS ANALYSTS
We are looking for candidates with a minimum of three years' process experience in the chemical, petro-chemical, pulp and paper or textile industries who can relate process requirements in terms of a digital control system. This experience should include instrumentation and unit operations, coupled with some digital computer background. The work is in a project team environment interfacing with design, programming and customer personnel. B.S. or M.S. degree in chemical engineering is preferred.

SYSTEMS PRODUCT DEVELOPMENT ENGINEERS
You will have overall technical responsibility for the functional design of major product improvements, make key decisions concerning hardware/software trade-offs and contribute to the influence of future Foxboro products. As a member of an operating division, you will critically review, comment on, and influence corporate new product designs from a user's point of view. Capabilities to interface with Corporate Development and Marketing personnel is an essential requirement. A B.S. or M.S. degree in Engineering with a minimum of three years' experience in a process industry or computer vendor's organization is desired. Experience should include: digital equipment or program development, customer sales order engineering or participation on a user's digital process control system project team.

Interested individuals should call (617) 543-8750, collect, or write to Tom Bryant, The Foxboro Company, Professional Placement Office, Dept. CD7, Neponset Avenue, Foxboro, Mass. 02035. Foxboro is an equal opportunity employer.
NEW PRODUCTS

HIGH TORQUE STEP MOTOR

Sequentially switching multiple circuits and at the same time remotely positioning loads in 30°-increments is a 12-position stepping motor. The motor has a breakaway torque of 150 ounce-inches and can drive a constant friction load of 56 ounce-inches. Units are available for both unidirectional and bidirectional positioning. Shaft extensions on both ends permit direct coupling for driving two loads simultaneously. A knob can be added for visual position indication or for manual positioning in either direction.

Positioning accuracy of ±1°, non-accumulative, is maintained by a spring-loaded ball detent which provides near-perfect internal alignment. All working parts are enclosed and permanently lubricated. Life is a minimum of 3,000,000 steps (3,000,000 in each direction for bidirectional models). Ledex, Inc., Dayton, Ohio.

CIRCLE 216 ON INQUIRY CARD

BUFFER MEMORY

The complete 1K by 1 random access high-speed buffer memory, including address decoding, stack drivers, data register and control circuits, occupies a single printed circuit card. The 0 and +5 Vdc TTL logic signal and +12, +5 and -6 regulated power source interface through a single gold-plated edge connector. Cycle speed is 1 microsecond in a read or write mode, and read data access time is 750 nanoseconds. Separate read or write initiate pulse signals activate the coincident current core storage memory. United Telecontrol Electronics, Asbury Park, N.J.

CIRCLE 217 ON INQUIRY CARD

ERROR TEST SET

The modem error rate test set, Model TS-100, is a multi-purpose instrument designed for performance testing of modems alone or on the communication channel over which they are operating. Error rate is clearly displayed on a decimal readout.

Features include the extra length of the pattern generated, 32,767 bits in duration. Additionally, an external error output is provided to attach a counter for long-duration testing. Rixon Electronics, Inc., Silver Spring, Md.

CIRCLE 218 ON INQUIRY CARD

LIGHTED PUSH-BUTTON SWITCHES

A line of lighted push-button switches is available, with the same electrical specifications as those for non-lighted switches. Basic rating is 0.45 amp @ 115 Vac (1.00 amp @ 28 Vdc). The lighted switches come with a wide range of lens colors and filters to permit adjustment of light diffusion and color intensity. Legends may be hot-stamped on lenses and/or filters; and lenses snap out to facilitate bulb replacement. Centralab, Milwaukee, Wis.

CIRCLE 219 ON INQUIRY CARD

MINIATURE POWER REGULATORS

High-efficiency transistor switching preregulators are offered in a 0.5 cubic-inch package weighing only 0.8 ounce with ratings up to 36 watts. The series is ideal for preregulator functions as they provide a 10:1 typical reduction in input voltage excursions at typical efficiencies of 80 to 90%. Units are available that handle source voltages from 6 to 60 volts dc, and that provide transient and spike protection to MIL-STD-704A. Powercube Corp., Waltham, Mass.

CIRCLE 220 ON INQUIRY CARD
FIBER OPTIC SENSOR

A compact low-cost reflective fiber optic sensor, called the Omni Sensor, uses random bundles to efficiently sense pencil and timing marks, punched holes, label codes and other types of printed or written data. It has double sensing bundles to detect the silvered mylar strips which signal load point and end of reel on computer tapes.

Encased in a phenolic molding, the Omni Sensor has leads from six inches to two feet long. One lead is placed next to a light bulb and the other is fixed to a photodetector selected to meet application requirements.

Designed for plug-in mounting, the package includes a 30,000-hour lens-end bulb and photo transistor coupled to a transistor amplifier circuit. Input is 5V dc at 140 mA. Output to a high impedance load is 5V for switching with a square wave having a rise-time of 2 microseconds. Electro Fiberoptics Corp., Worcester, Mass.

CIRCLE 221 ON INQUIRY CARD

45° STEPPERS

These 28-volt Rapid-Syn steppers in sizes 8, 11, 15 and 20 are available from stock and offer slew speeds up to 2,500 pps, response speed up to 700 pps, and static torque up to 14 oz/in. Other features include Class H insulation, ABEC 5 bearings, a high coercive alnico magnet and a one-billion-cycle endurance rating. Computer Devices Corp., Santa Fe Springs, Calif.

CIRCLE 222 ON INQUIRY CARD

We do front end jobs.

Get a load of what your Timesharing computer's front end really could do!

1. Service all speeds up to 4800 baud for 256 channels.
2. Service 256 concurrent users regardless of the mix of baud rates.
3. Allow all 256 channels equal access to the computer, and up to 128 channels access to either of two computers.
4. Have 5 microsecond access time and completely scan all 256 channels in 1.28 milliseconds.
5. Handle all control signals from the data set, test for carrier drop out, connect with the terminal, disconnect from the terminal, and alert the computer only when a user is connected and ready for service.
6. Control the number of users with access to the computer.
7. Visually display at all times all control signals on any channel and the number of users on the system.
8. Cost less than $1000 per channel.

(Better write TheGrayMatterGang for all the inside poop.)
NEW PRODUCTS

MAGNETIC MODULATORS

A line of magnetic modulators, analog voltage multipliers and demodulators in flat pack configurations, with typical dimensions of 0.1-inch thick by 0.5 by 0.75-inch is characterized by drift-free circuitry with superior phase and gain slope stability over a temperature range of −55° to +125°C. They are shock- and vibration-proof, have a MTBF of 0.15 per mm hours, they are not affected by high intensity nuclear radiation, and are capable of operating on carrier frequencies as high as 5 MHz.

One or more isolated or floating input signals may be used for modulating, multiplying, dividing, squaring or extracting a root. These modules have no external nulling or offset adjustments. No additional components or compensation are required, nor are external operational amplifiers. General Magnetics Inc., Bloomfield, N.J.

BI-PIN LAMPS

T-13/4 lamps are wire terminal models with a tough, plastic, bi-pin base, for printed circuit boards, indicator lights, and switches. Lamps are cemented into the base and lead wires soldered to the pins for permanent contact. Gas vent slots are designed into the base to prevent solder blowout during dip-solder operations.

The base diameter measures 0.225 ± 0.005 inch. Overall the lamp is 0.225 inch, exclusive of pin length. Standard pin length is 0.250 ± 0.010 inch, but lengths to 0.750 inch are optional. Pins are spaced at 0.125 ± 0.005 inch. Industrial Electronic Engineers, Van Nuys, Calif.

QUAD D-A-LADDER SWITCH

A hybrid IC quad D-A ladder switch is being offered, for use in binary and BCD-coded voltage summing ladders up to 14 bits with 1/2 LSB accuracy. Designated ATF-451, it measures only .550 by .500 by .160 inch, and is claimed to represent the smallest set of four matched switches ever offered in a single hybrid integrated circuit. Input circuitry is fully compatible with standard DTL and TTL monolithic circuits. Based on a thin film/LID hybrid process, the new device, designed around semiconductors and thin film substrates, offers low initial cost, elimination of redundant packaging, and the opportunity for combining multiple switches of high accuracy levels in a single circuit.

The switch has an on-resistance of 4 ± 1 ohm from −25° to +85°C and offset voltage of 1 millivolt maximum. An identical lower-accuracy version, the ATF-452, is also available, with an on-resistance tolerance of ± 3 ohms and maximum offset voltage of 1.25 millivolt. Amperex Electronic Corp., Cranston, R.I.

MICROCIRCUIT LADDER NETWORK

A miniature 8-bit high-speed binary ladder network sells for 75% below the cost of comparable MIL Spec networks. Model 815 meets applicable environmental requirements of MIL Spec 883, including those for thermal shock, temperature cycling, moisture resistance, solderability, shock and vibration.

The unit has a standard resistance value of 10K ohms. Maximum output voltage ratio error is 1.952 ppm over the operating temperature range of −55° to +125°C. The network offers a fast ladder settling time, with output voltage to within 0.1% of final value within 10 nanoseconds after application of input step.

The 815 is less than 0.1 inch thick and occupies only one square inch of board space. Prices are from $4.87 to $6.95. Beckman Instruments, Inc., Fullerton, Calif.

Nothing can print so much so fast.

Litton Datalog's MC 8800—the Ultra High Speed Printer that’s not for everyone.

If you need the incredible speed of 6000 lines a minute, 88 columns per line, from any digital source, you must get the MC 8800—nothing in the world can match it. But along with speed, this silent, non-impact printer offers serial input, modular construction, 5000 hour MTBF and easy computer compatibility as well.

It's a package that's truly unique, truly state-of-the-art. If you need less, take a look at other Datalog fiber optics printers; but if you need unequalled capacity, call us about the MC 8800. Datalog Division of Litton Industries, 343 Sansome St., San Francisco 94110. (415) 397-2813.

CIRCLE 41 ON INQUIRY CARD

CIRCLE 233 ON INQUIRY CARD

CIRCLE 24 ON INQUIRY CARD

CIRCLE 225 ON INQUIRY CARD

CIRCLE 226 ON INQUIRY CARD

COMPUTER DESIGN/JULY 1969
FIELD-EFFECT TRANSISTOR

The CMX740 FET, available from stock, claims extremely low on-resistance of 2.5 ohms maximum, providing high analog switching accuracy in D/A and A/D converters. It is the fastest core-driving transistor, handling short-duration very high current pulses up to \( \frac{1}{2} \) amp minimum.

Advantages for D/A and A/D converters are 50- and 75-nanosecond respective on and off times, it is radiation-tolerant, and takes 100 times more radiation than bipolar transistor before its on-resistance is doubled.

Crystalonics, Cambridge, Mass.

POWER SWITCHES

Miniature push-button switches are designed for electronic panel controls. Rated to carry 6 amps @ 230 Vac, they may be used to control circuits independently or with optional contractors or starters.

Synthetic rubber seals make the switches oil, water, and vaporproof. The "SW" series features doublebreak solid silver contacts for positive make or break. All switches mount in an one-inch diameter hole, and each model is supplied with a single (NO-NC) block. An additional block is available for converting these switches to a double pole unit. Alco Electronic Products, Inc., Lawrence, Mass.

SYNERGISTIC PRODUCTS, INC.
FORMERLY PRODUCT IMPROVEMENT CORPORATION
A SUBSIDIARY OF CAVITRON CORPORATION
150 E. Stevens Avenue • Santa Ana, Calif. 92707 • (714) 540-7755
New Products

High Speed A/D Converter

The ADX when used in conjunction with the companion differential input multiplexer, provides random or sequential access to as many as 512 analog channels at a rate of 200,000 conversions per second for a 14-bit binary data word. Input impedance is 500 kohms, and system accuracy, including multiplexer, is better than 0.05%.

Rack-mounted versions can house up to 256 channels of multiplexer, computer interface and off-line test circuitry within 4 1/4 panel-inches, while MIL-E-16400 and MIL-E-5400 versions are completely modular to simplify system integration for both original and retrofit installations. Dynalex, Inc., Burbank, Calif.

Indicator Light

The 104S ultra-miniature neon indicator light assembly mounts on 3/8-inch centers, with lenses available in five styles and a variety of color and materials.

The 104 uses a T1 1/8 neon lamp 0.3 millihamp with a 30,000-hour life. With a 220K resistor the 104 can be used on a 115-volt commercial line current, and with a 560K resistor, can be used on a 230-volts commercial line current.

Starting voltage for ac is 60 volts for dc, 90 volts. The Sloan Co., Sun Valley, Calif.

Core Memory System

A compact, low cost, expandable core memory system on plug-in cards has been developed. Memcard 418 is a 1.5-microsecond system featuring read/restore, read/write, read/modify/write, and a hybrid cycle—read/write/mask. The total 4096 by 18 system is contained on two 12-inch square plug-in circuit boards—one card providing all I/O electronics necessary to drive 32,768 words by 18 bits of memory. The second, a magnetics board, contains 4,096 words by 18 bits of core storage. All systems are complete with both address and data registers, power/off, protection and temperature compensation from 0° to +50°C operation. Sanders Associates, Inc., Nashua, N.H.

Magnetic Tape System

Hewlett-Packard 2114A, 2115B and 2116B computers can sort, match, collate and merge data when equipped with a digital magnetic tape system, the Tri-Data CartriFile 4096-04 cartridge-loaded system, which combines four magnetic-tape transports and is plug-compatible with the H-P computers. A software package providing system input/output, basic control system driver and diagnostic program subroutines is included.

Reading and writing may occur simultaneously at data-transfer rates of 667 8-bit bytes per second in variable-length records, with a storage capacity of 480,000 bytes. Data accuracy is assured by redundant recording and on-the-fly error correction. Tri-Data, Mountain View, Calif.
PHOTO-ELECTRIC TAPE READER

The Model 5401 is a photo-electric punched tape reader. It operates from 0 to 300 characters per second, asynchronously, and 625 cps, synchronously, in the standard configuration. Options increase the asynchronous rate to 400 cps and the synchronous rate to 850 cps. The reader stops on character in all modes.

An automatic lamp-brightness control compensates for varying tape opacities with no need for adjustment. The standard ac input is 50-60 Hz, 115 volts. An option for 40- to-800-Hz operation may be specified.

The basic reader occupies 3½ inches of panel space in a standard 19-inch rack. Chalco Engineering Corp., Gardena, Calif.

CIRCLE 233 ON INQUIRY CARD

READ-ONLY MEMORY SYSTEM

S-Series read-only memories operate at 500 nanoseconds access time, 900 nanoseconds cycle time, and range in capacity from 64 to 2,048 words, from 10 to 80 bits per word.

The S-Series are pin-for-pin compatible with the F-Series (180 nanoseconds access time, 300 nanoseconds cycle time) and the standard (200 nanoseconds access time, 500 nanoseconds cycle time).

Individual words or the entire memory content may be changed in the field within a few minutes.

The S-Series requires less than 5 watts of power, has TTL and DTL compatible interface, a 0° to +70°C temperature range, nondestructive readout and requires only one power supply (+5 volts). Memory Technology Inc., Waltham, Mass.

CIRCLE 234 ON INQUIRY CARD

Antiquated power supplies have you in a rut?

GIVE YOUR COMPUTER UNIPOWER

Replace obsolete, narrow-range slot supplies with POWER/MATE CORP.'s UniPower Series. These nine all-purpose, wide voltage range power supplies can replace thousands of narrow-range slot supplies and give you these big advantages: current output up to 34 amps • adjustable to any range from 0-34 volts • regulation to 0.005% • ripple a low 250 microvolts. The wide voltage range of the UniPower Series simplifies your power supply requirements because you can stock fewer units. In addition, these modules can be mounted in standard size racks or on any of three surfaces and in any position!

The UniPower Series of Nine

Uni-76 — 0-34 volts, 0.5 amps — $76.00
Uni-88 — 0-34 volts, 1.5 amps — $99.00
Uni-30C — 0-30 volts, up to 5 amps — $134.00
Uni-30D — 0-30 volts, up to 8 amps — $161.00
Uni-30E — 0-30 volts, up to 12 amps — $174.00
Uni-30F — 0-30 volts, up to 18 amps — $205.00
Uni-30G — 0-30 volts, up to 24 amps — $265.00
Uni-30H — 0-30 volts, up to 34 amps — $315.00
UniTwin-164 — dual output 0-25 volts, 0.75 amps — $164.00

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CURRENT vs. VOLTAGE OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6V</td>
<td>1.5 amps throughout range</td>
</tr>
<tr>
<td>Uni-76</td>
<td>0.05 amp throughout range</td>
</tr>
<tr>
<td>Uni-88</td>
<td>1.5 amps throughout range</td>
</tr>
<tr>
<td>Uni-30C</td>
<td>5.0  4.6  4.4  4.2  4.1  4.0  3.8  3.6  3.4  3.2  3.0  2.8  2.6  2.5</td>
</tr>
<tr>
<td>Uni-30D</td>
<td>8.0  7.6  7.3  6.9  6.6  6.4  6.2  6.0  5.7  5.3  5.0  4.7  4.4  4.0</td>
</tr>
<tr>
<td>Uni-30E</td>
<td>12.0 11.2 10.8 10.3 9.8  9.5  9.2  8.8  8.3  7.9  7.4  6.9  6.4  6.0</td>
</tr>
<tr>
<td>Uni-30F</td>
<td>18.0 16.9 16.2 15.5 14.8 14.4 14.0 13.3 12.6 11.9 11.2 10.5  9.8  9.0</td>
</tr>
<tr>
<td>Uni-30G</td>
<td>24.0 22.5 21.6 20.6 19.6 19.1 18.6 17.7 16.7 15.8 14.8 13.8 12.9 12.0</td>
</tr>
<tr>
<td>Uni-30H</td>
<td>34.0 31.9 30.5 29.2 27.8 27.1 26.4 25.0 23.7 22.4 21.0 19.7 18.3 17.0</td>
</tr>
</tbody>
</table>

SPECIFICATIONS: Regulation — up to ±0.005% or 1 MV for line and load; Ripple — Less than 250 microvolts; Response Time — Less than 20 microseconds; Overload and Short Circuit Protection — Solid state, instantaneous recovery, and automatic reset. Cannot be damaged by prolonged short circuit or overload. Internal or External Adjustable OVP Available.

FREE: Send for complete catalog. Write to:

POWER/MATE CORPORATION
514 S. RIVER ST., HACKENSACK, NEW JERSEY 07601
PHONE: (201) 343-6294
TWX: (710) 990-5023

CIRCLE 44 ON INQUIRY CARD
NEW PRODUCTS

MAGNETIC MEMORY SYSTEMS

Designated Alpha 10.2 and Alpha 12.2 memory systems, the units feature modular construction, excellent reliability, high density and low cost. Basic modules come in sizes of 1024 and 40,960 bits with expansion to larger capacities through the use of multiple modules. Cycle times are 1.50 microseconds for the Alpha 10.2, which has a maximum module size of 1024 by 10, and 1.75 microseconds for the Alpha 12.2, with module capacities to 4096 by 10.

High-density packages are the result of employing 23 mil cores, three-wire 3D organization and integrated circuits except for final drivers and selection. The Alpha 10.2 and 12.2 require 65 and 130 cubic inches respectively, for complete memories including registers and a temperature compensation regulator for the memory drive voltage. Only silicon semiconductors are used, none are in plastic packages. Tetra Corp., Minneapolis, Minn.

CIRCLE 235 ON INQUIRY CARD

TAPE CARTRIDGE DRIVE

A series of small inexpensive ¼-inch magnetic tape cartridge drives are oriented towards data communications systems. Called the RJ Delta-Corder 500 series, the drives are designed to mount internally in card readers, keyboard terminals, acoustic couplers and other terminal devices.

Input to the recorder can be any bit serial code, such as 11-bit-serial USASCII. Tape storage capacity is approximately 22,400 characters at eleven bits per character on 400 feet of tape.

Cartridges may be read-out over a Western Electric data-set or similar modem, or an acoustic coupler. Alternatively, the cartridge can be mailed to a central processing formatting area. Reader output is either 110 bits per second for remote transmission or 1,000 bits per second for the converter. RJ Communication Products, Inc., Phoenix, Ariz.

CIRCLE 236 ON INQUIRY CARD

We're computer/peripheral power supply experts.
Which means you don’t have to be.

We don’t think computer/peripheral designers should be bothered with power supply problems. That’s why we’re in business.

You tell us what your requirements are, and we’ll deliver a power supply or transformer to specs.

We’d like to be in on your project from the drawing board stage.
Because if you’re not exactly sure of your power supply requirements, that’s the ideal time to let us help you define them.

Starting with our basic Varoformer™ (constant voltage transformer) we can design power supplies to perform simple or complex functions by the addition of series regs.

From 4% regulating Varoformers to custom-designed power supplies with multiple outputs, on-off sequencing, and remote sensing.

If you’re a computer/peripheral designer, all you have to do is tell us what goes in and what comes out. We’ll take care of the rest.

VAROFORMER POWER SUPPLY

VARO

STATIC POWER DIVISION 1600 DALLAS NORTH PARKWAY, PLANO, TEXAS 75074 (214) AD 1-5111 TWX 910-860-5640

CIRCLE 45 ON INQUIRY CARD
COMPUTER POWER SUPPLIES

The supplies have power densities up to 2.5 watts per cubic inch (5 Vdc at 25 Adc in 50 cu. in.). Incorporating high frequency switching regulators, they meet the line transient requirements of Mil-Std-704A and EMI requirements of MIL-I-6181D.

The supplies weigh 3.5 pounds and require no additional heat sinking for operation between −55° and +85°C. Operation to +105°C is possible with minimal interfacing since all components are suitable for operation at 125°. 76 to 82% efficient, they provide ±0.1% line and 1% load regulation. Of particular significance is the supplies’ ability to store energy for 3 milliseconds. Short circuit and overvoltage (crowbar) circuits are included as well as power sequencing with optional power normal and power abnormal signals. Cal-Power Corp., El Segundo, Calif.

CIRCLE 237 ON INQUIRY CARD

DIGITAL MULTIMETER

Designated Model 6653A, the unit is an all IC-logic four-digit instrument with fifth-digit, 10% overrange. It measures dc and dc/dc ratios with an accuracy of ±1 digit from 0 to 1099.9V. Plug-in function options include ac in four ranges, ohms in five, and millivolts in three ranges. Digitized rate is 1,000 readings per second. Sample and hold is a plug-in option. Five print-out options (buffered or non-buffered), auto-ranging and remote control of all front panel functions are available. The unit is standard 19-inch rack-mount. Lear Siegler, Inc., Cimron Div., San Diego, Calif.

CIRCLE 238 ON INQUIRY CARD
LOW-LEVEL MULTIPLEXER

Plug-in circuit cards simplify interface of a solid-state low-level multiplexer to digital systems. Designated model 2930A, the unit handles up to 64 analog inputs. MOSFET integrated-circuit switches at each input connect signals one at a time to the instrument's programmable amplifier, which boosts signals in the 10-millivolt range (full scale) and higher to a 10-volt range. The Multiplexer thus makes it possible for an analog-to-digital converter to work with low-level signals, such as those from strain gages, thermocouples, and other low-level transducers. The amplifier's fast settling time, 40 microseconds, allows input multiplexing at rates up to 20 kHz. The analog input signals are completely isolated from the digital circuits.

Digital control signals program the amplifier to one of 11 factors, from 1 to 1024 in binary steps. Amplifier gain accuracy is better than ±0.02% and dc drift is less than 5 microvolts (referred to input) per day. Output impedance is less than 1 ohm, assuring high accuracy when driving an ADC, with input impedance as low as 1,000 ohms. Hewlett-Packard Co., Palo Alto, Calif.

OEM TAPE TRANSPORT

Mechanical and electronic capabilities are features of a tape transport, called the Tape-Dex 5000, which is built on a rugged (4 lbs. +) cast aluminum mainframe and can operate in vertical, horizontal or any intermediate position. All head adjustments are made from the front. Pressure pads have been eliminated through the use of a flutter filter hold-back tension idler.

The transport employs three 4-pole induction motors for fast, automatic operation. Tape speeds are 7 1/2, 3 1/4, and 1 3/4 inches per second. Rewind speed is 45 seconds (1200 feet on a 7-inch reel) with a timing accuracy of ±0.15%. The capstan shaft is made of casehardened steel, ground to an accuracy of ±0.00015 inch. The capstan drive is housed in oil-impregnated bronze bearings.

The standard head mounting accomodates three heads with an optional 5-head mounting. The solid aluminum casting is finished in black, semi-gloss baked enamel with optional vinyl front panel inserts. Dimensions are 10 1/2 inches high by 19 inches wide and will fit all standard rack cabinets. Beltronix Systems, Hauppauge, N.Y.
TIME-SHARING DATA TERMINAL

The Datapoint 3300 is a data terminal which streamlines man/machine communications for the computer time-sharing user.

Standard features of the 3300 include complete interchangeability with standard teletypewriter equipment, high-speed data transmission capabilities, a high capacity and flexible CRT display, easy to read characters, solid state construction, a 64-character set keyboard, and it is self-contained. Optional features include magnetic tape memory, hard copy printer and a ten-key numerical keyboard.

The Datapoint 3300 screen can accommodate 25 lines with 72 characters in each—a total of 1,800 characters in a single display.

Data transmission rates of up to 600 bits per second are available on the standard 3300, and up to 4,800 bps with optional speed buffer equipment. Also available is a magnetic tape memory designed as a companion unit. This memory, which utilizes replaceable tape cassettes, offers the remote user the flexibility of both forward and reverse line-incremental playback of data up to 200 full “frames” (25 lines of 72 characters each). Computer Terminal Corp., San Antonio, Tex.

CIRCLE 241 ON INQUIRY CARD

DATA RATE TAPE UNIT

A high-performance digital magnetic tape unit has the highest data rate of any such unit in the low cost category. The transport features a read-after-write dual stack head, operates at speeds of 37.5, 25, or 12.5 ips and has a rewind speed of 150 ips. The 6 by 40 is equipped with 10½-inch reels and can be ordered either in 9-track 800 bpi or 7-track dual-density configurations. The unit is compatible with IBM 729 and 2401 (Model 1) and IBM 2415 (Models 1-3 and 1-6).

Other features include an adjustment-free tape guiding system, electronic deskewing and low power consumption. It has all drive, control and write/read electronics, brings to load point logic and is organized for multiple transport operation. The low inertia capstan drive provides rapid acceleration and deceleration while maintaining positive control of the tape on the capstan at all times. Control of the tape path is maintained by a precision edge guidance system guaranteeing IBM interchangeability. Peripheral Equipment Corp., Chatsworth, Calif.

CIRCLE 242 ON INQUIRY CARD

Cut remote control costs with Dale Motorized Potentiometers

Thoroughly proven in entertainment instruments, Dale's AC Reversible Motor Driven Pot is a cost cutter for business machines and industrial equipment as well.

I. Used as a bias regulator for solid state devices, it now handles the remote control function for many types of heavy power equipment—eliminating heavy cables between control panels and resistive devices.

II. Versatility increases when equipped with Dale's patented motor load decoupler. Coasting is eliminated and manual control is free of gear motor inertial load.

III. Hysteresis synchronous motor and gear train can be coupled with a wide range of single and multi-turn carbon and wirewound pots as well as with variable capacitors. Motor and gear train are also used as television tuner drive.

SPECIFICATIONS
Operating Voltage—6, 12, 24, 117 VAC or any specified; Power Input—7.5 volt amperes; Output—5.6 RPM; Torque at Pot Shaft—10 in./oz. min. (with decoupler), 21 in./oz. min. (without decoupler). Up to 4 auxiliary switches can be added for actuation at any degree of cam rotation.

For complete specifications and application information, call 605—665-9301 or write

DALE ELECTRONICS, INC.
SIOUX DIVISION, Dept. CD
Yankton, South Dakota 57078

CIRCLE 48 ON INQUIRY CARD
Causes and Cures of Noise in Digital Systems

PART 1
Systems Design Considerations

PART 2
Noise Elimination in Digital Modules

PART 3
Control of External Noise

NEW PRODUCTS

DATA ACQUISITION/CONVERSION SYSTEM

Designed to meet MIL-E-5400J, MIL-I-6181D, and MIL-STD-704A, Model 460 all-solid-state airborne data acquisition and conversion system includes a multiplexer, differential amplifier, A/D and D/A converters, sample-and-hold data distributor, inverter power supply, and control and timing circuitry. Optional interfaces include computer, tape transport, telemetry, etc.

Features include MOS-FET switches, TTL logic, low-power, high-reliability circuitry, plated-through holes, flame-retardant printed circuit boards, expandability, flexibility in interface and timing, RFI shielding, and self-contained power supply.

The system has 0-64 differential analog low/high-level input channels, 0-32 analog output channels, full-scale input/output voltage (up to ±10.24V), resolution to 12 bits including sign, sampling accuracy to 0.01%, sampling rate to 50 KC, input impedance greater than 10 megohms, and a common mode rejection of 100 db at dc, 94 db at 60 Hz, and 80 at 400 Hz (with 5K source and up to 1K load). In data distributor output, Model 460 has a conversion accuracy up to 0.01%, decay rate of 160 mv/second, settling time less than 8 microseconds to 0.01%, conversion rate of 100KC, and output drive of 10 mA with up to 500 pF of load.

It operates efficiently between -55°C and +71°C, is only 6.25 inches by 15 inches by 9 inches in size, weighs 28 pounds, and operates on 28 Vdc ±6V and less than 2 amps.

Dynamic System Electronics, Tempe, Ariz.

MAGNETIC TAPE TRANSPORT

Readily adaptable to all forms of magnetic tape recording by the addition of modular audio or digital electronics is the model TT-1150 universal tape transport, available with two or more tape speeds for record/reproduce.

Tape speeds are 3½-7½ ips selectable at installation; tape width is ½ inch, reel size is 7 inch maximum; wind/rewind time is 1,200 feet in approximately 45 seconds; capstan assembly consists of a precision-ground spindle-mounted in composite porous bronze and ball bearing housing, permanently lubricated. Wow/flutter is 0.2% rms maximum @ 7.5 ips; 0.3% maximum @ 3.75 ips. A precision polyurethane belt drive is included for flutter control. The transport has fail-safe electro-mechanical-differential band brakes on both supply and take-up spindles, which in the case of power failure stops transport without tape deformation.

The unit can be supplied with or without a search mode having an adjustable or fixed search speed. A precision micrometer azimuth and height adjustment is provided to allow for recordings made on any transports to be reproduced with optimum precision on the TT-1150. All tape-handling components are mounted on a precision prepared tool and jig plate which is tempered after machining to ensure long-term dimensional stability. Lifters allow the tape to contact the heads only in play mode. In the moderate and fast modes of operation the tape contacts the search head only. Telectro Systems Corp., Corona, N.Y.

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A digital panel meter capable of reading from 0000 to 3999 with .05% accuracy features >1000 megohms input impedance, up to 60 readings per second, non-blink display, 300ms step response, 35dB at 60Hz normal mode rejection, 400% overrange, programmable decimal point, and display hold capability. Five standard full-scale voltage ranges from 39.99mV to 399.9V, seven current ranges from 399.9nA to 399.9mA, and five resistance ranges from 399.9Ω to 3.999M are available. Options include automatic polarity digital set points, 1- and 10-microvolt resolution preamplifiers, fully buffered BCD and 10-line outputs, wide range zero offset, differential input, remote display and ratio. The reading can be offset up to 2,000 digits, for industrial control applications, for zero suppression, and in weighing systems to provide Tare capability. The digital limits are designed so that each set point can easily be switched between any required number of thumbwheel assemblies in monitoring an automated production line or batching system. Electro-Numerics Corp., Santa Clara, Calif.

DATA ACQUISITION SYSTEMS

The 5400 Series D-DAS (digital data acquisition systems) are assembled from off-the-shelf instrument modules, each of which plugs into the next unit with a single “data-bus” cable. Up to 1,000 data-input channels are accommodated with scanners which expand in 1-channel increments. Data inputs can be dc, ac, resistance or binary-coded decimal as follows: dc: 5 microvolts to 300 volts; ac: 1 to 1,000 volts; ohms: 5 milliohms to 10 megohms; BCD: from digital transducers, shaft encoders, counters, etc. Output is encoded in computer-compatible format on punched or magnetic tape. Teletypewriter and printed paper tape systems are also available to provide a visual record of the digital data.

The systems offer excellent linearity and produce absolute reading accuracies in the 0.025 to 0.5% range. Floating input and data averaging (integration) eliminates superimposed noise effects. Dynamic range capability is over 80 dB (10,000:1). Vidar Instrumentation and Telecommunication Products, Mountain View, Calif.

Dale reversible AC hysteresis synchronous motors give you the industry’s best combination of miniature size and low price. Length 1.85”... diameter 1.250”... price, under $2 in quantity. Designed for long life in continuous use, they’re finding wide application in low power driving mechanisms, timing controls, blowers, etc. Output shaft and mounting to your specification.

SPECIFICATIONS
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Output: 1800 RPM no load
Torque: 0.125 oz./in.

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mex Division of Frenchtown/CFI, Inc., Frenchtown, N.J.

CIRCLE 300 ON INQUIRY CARD

Microminiature Indicator Lights

Bases, lamp types, and material and cap styles available for microminiature indicator lights that produce greater intensity than units five times their size, are detailed in a data sheet issued by Shelly Associates, of El Segundo, Calif.

CIRCLE 301 ON INQUIRY CARD

Digital Control Systems

A 4-page short-form catalog describing systems for data acquisition and/or control of scientific analytical instru-
m ents, including digital integrating and spectrometer recorders, comparator and spectrophotometer data systems, a mass spectrometer digitizer, x-ray diffrac-
tometer control system, and computer operated numerical rotary axis controller, is presented by the Conrac
Corp.'s Datex Division, of Duarte, Calif.

CIRCLE 302 ON INQUIRY CARD

Data Processing Equipment

Second and third generation comput-
ers, unit record machines, and peripheral equipment as well as advantages of purchasing or leasing equipment, are emphasized in a "full line" brochure released by the IOA Data Corp., New York, N.Y.

CIRCLE 303 ON INQUIRY CARD

Display Deflection Yokes

Details on four highly efficient stator-
type high-Q deflection yokes, including features and specifications, dimensional drawings, push-pull coil and single-ended coil data for all types, are presented in a 2-page bulletin by Syn-
tronic Instruments Inc., Addison, Ill.

CIRCLE 305 ON INQUIRY CARD

Digital Memory Modules

Low cost, high speed digital memory modules, made with zero-temperature coefficient glass, which include inter-
facing circuitry, may be plugged in with standard logic levels, and are capable of storage of from 200 to 200,000
bits with a per-bit cost of 2.5 cents, are described in an illustrated data sheet issued by Corning Glass Works,
Corning, N.Y.

CIRCLE 306 ON INQUIRY CARD

Magnetic Tape Transport

A data sheet, detailing capabilities and applica-
tions of a magnetic tape recorder designed for such severe envi-
ronment applications as rocket sleds and nuclear tests, has been released by the Genisco Technology Corp., of
Compton, Calif.

CIRCLE 307 ON INQUIRY CARD

Communications Data Set

The capability of operating over pri-

ivate lines or the direct distance dialing net-
work and transmitting and receiv-
ing asynchronous serial digital data, are features of a data set described in an illustrated bulletin from the San-
gamo Electric Co., of Springfield, Ill.

CIRCLE 308 ON INQUIRY CARD

Servo & Computing Modules

A short-form catalog listing details and specifi-
cations of over 75 solid-state de-

vices for converting and computing, and of synchro input and output de-
vices, and containing application draw-
ings of solid state servos, is available
from Transmagnetics, Inc. of Flushing,
N.Y.

CIRCLE 309 ON INQUIRY CARD

Data Recorder Integrator

A 4-page brochure detailing an inte-
grating device with potentiometric strip chart recorders, and including an
illustrated theory of operation, is available from Disc Instruments Inc., Santa
Ana, Calif.

CIRCLE 310 ON INQUIRY CARD

Digital Tape Drives/Memories

Performance and specifications of high-
environmental digital tape drives and
memories, designed for field data gath-
ering requiring extreme ruggedness, high reliability and generation of IBM-
compatible taped data, are described in a brochure from the Ampex Corp., of
Redwood City, Calif.

CIRCLE 311 ON INQUIRY CARD

Storage Tubes

Specifications and features of single
and dual gun storage tubes for data
processing and flying spot scanners are
included in a 4-page short-form tube
catalog available from Warnecke Elec-
tron Tubes, Inc., Des Plaines, Ill.

CIRCLE 312 ON INQUIRY CARD

Time Sharing Systems

A detailed description of systems, their
benefits, and a glossary of terms, are
featured in an illustrated 28-page book-
let obtainable from the General Elec-
tric Co., Schenectady, N.Y.

CIRCLE 313 ON INQUIRY CARD

Tape Preparation Centers

On- and off-line paper tape prepara-
tion centers with input and output
devices ranging from a keyboard-tape
punch to a I/O system are described in
a brochure available from the Invac
Corp. of Waltham, Mass.

CIRCLE 314 ON INQUIRY CARD

Compatible Calculators

Features and functions of all-purpose
electronic calculators, including appli-
cation problems and keyboard solu-
tions, are detailed in a 16-page book-
let, from Wang Laboratories, Inc., of
Tewksbury, Mass.

CIRCLE 315 ON INQUIRY CARD
Cermet Industrial Trimmers
A data sheet detailing trimming potentiometers, which sell for $3.50 or less and are the first industrial cermet trimmers priced competitively with wirewounds, is available from the Helipot Division of Beckman Instruments, Inc., of Fullerton, Calif.

CIRCLE 316 ON INQUIRY CARD

Germanium Power Transistors
Electrical specifications and characteristic curves for a new series of Ge power transistors in TO-8 cases are provided in a data sheet. KSC Semiconductor Corp., Chelmsford, Mass.

CIRCLE 317 ON INQUIRY CARD

Microcircuit FET-Input Op Amp
Specifications, applications, and performance curves of a 0.25" high by 0.6" square microcircuit operational amplifier with high impedance FET input circuitry, and with a 5 picamps guaranteed maximum bias current, are contained in a data sheet from Analog Devices, Inc., of Cambridge, Mass.

CIRCLE 318 ON INQUIRY CARD

Thick Film Circuits
A brochure has been issued, describing the capability of hybrid circuits to bring together the best portions of monolithic integrated circuits, thick film techniques and discrete components, plus the low cost of printed circuitry, combined in a reliable, compact package, by HFI, Inc., of Chaska, Minn.

CIRCLE 319 ON INQUIRY CARD

Optical Scanner
Details of a general-purpose transaction document scanner, equipped to read data recorded by five methods, to read four different machine codes, and to operate off-line without a computer, are the subject of a brochure issued by the Cummins-Chicago Corp. of Chicago, Ill.

CIRCLE 320 ON INQUIRY CARD

Manual Switches/Indicators
A 56-page revised catalog reviewing lighted and unlighted pushbuttons, indicators, matrix-mounted and toggle switches, as well as optional seals, boots, bushings, actuators and contact variations has been published by the Micro Switch division of Honeywell Inc., Freeport, Ill.

CIRCLE 321 ON INQUIRY CARD

Printed Circuit Connectors
Card and tape cable applications, as well as test point connectors for printed circuitry, highlight an 80-page printed circuit connector catalog issued by the Continental Connector Corp. of Woodside, N.Y.

CIRCLE 322 ON INQUIRY CARD

Selector Switches
Emphasizing the availability of a complete switch package from a single source is a 16-page catalog which includes ratings and specifications of the wafer assembly for continuous grounding of inputs, and of the index assembly for instrument design. Available from the CTS Corp., of Elkhart, Ind.

CIRCLE 323 ON INQUIRY CARD

Digital Tape Transport
Operation of the Model TM-7 digital tape transport as an incremental drive unit is described in data sheet C-085. Ampex Corp., Redwood City, Calif.

CIRCLE 324 ON INQUIRY CARD

Microminiature Bite Indicators
Built-in test equipment (BITE) indicators, for use on system, sub-system, module, and individual circuit card levels to sense fault signals and provide a visual indication of monitored equipment conditions, including specifications, dimensions, and application data, are contained in a bulletin issued by the A. W. Haydon Co., of Waterbury, Conn.

CIRCLE 325 ON INQUIRY CARD

MOS Product Guide
Lists of off-the-shelf MOS circuits, including shift registers, memories, multiplex arrays, logic circuits, and channel transistors are contained in a 12-page product guide published by American Micro-Systems Inc., of Santa Clara, Calif.

CIRCLE 326 ON INQUIRY CARD

Digital I/C Selection Guide
Digital integrated circuits selection has been simplified in a 6-page guide containing a graph-illustrated comparison of integrated circuits' operating characteristics, including operating temperature and power supply range, gate fanout and dissipation, average propagation delay, flip-flop toggle frequency, and noise margins. Copies, requested on company letterhead, may be obtained from Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

CIRCLE 327 ON INQUIRY CARD

Computer Support Services
Bulletin B-9550 describes the computer systems support services now available from the Westinghouse Information Systems Laboratory. Included is a discussion of the three criteria for determining the success of a computer system. Westinghouse Electric Corp., Pittsburgh, Pa.

CIRCLE 328 ON INQUIRY CARD

Data Communication Equipment
A thirty-five-page bulletin describes functional specifications, interfaces and applications of a 50 kilobits-per-second wideband data transmission series, including digital information systems for computer data, facsimile and digitized voice in government and military complexes, private microwave networks and dedicated transmission lines, and is available from the General Electric Co., Lynchburg, Va.

CIRCLE 329 ON INQUIRY CARD

Photo-Optical Memory
Details of the photo-optical random access mass memory, a system featuring larger capacity and faster access time, and requiring less space than any other, are presented in a 6-page illustrated brochure from Foto-Mem Inc., of Natick, Mass.

CIRCLE 330 ON INQUIRY CARD

IC Connector Harnesses
An illustrated data sheet describing applications of IC connector harnesses for computers and other electronic equipment, featuring round conductor ribbon cable harnesses with 14- or 16-pin IC compatible connectors on one or both ends, has been published by the Spectra-Strip Corp., of Garden Grove, Calif.

CIRCLE 331 ON INQUIRY CARD

Linear IC Applications
Linear devices for circuit and system designers are described in an applications brochure, including core memory sense and video amplifiers, by the Signetics Corp., of Sunnyvale, Calif.

CIRCLE 332 ON INQUIRY CARD

Standard Machine Controller
A 6-page illustrated description of an electronic machine and process controller, which serves as a solid-state replacement for relay control panels, including logic board, plug-in memory, input and output terminal boards, and system trouble-shooting aids, has been released by Information Instruments Inc., of Ann Arbor, Mich.

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