EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

Versatile busing scheme for programmable instrumentation

Space plan revolutionizes engineering department

A CAHNERS PUBLICATION

SEPTEMBER 1, 1972

New from Helipot: the lowest trimmer profile in the business.

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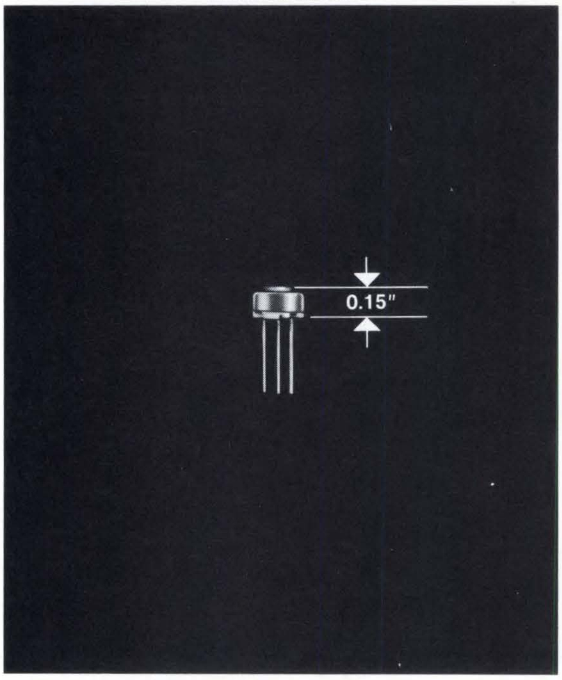

You can't do better than our Series 82 Trimmers for small size and low cost . . . and, of course, Helipot dependability. These ¼," single-turn, general-purpose cermet models have the lowest profile in the industry with a proven cermet resistance element that can be set to any voltage ratio within 0.05% of full scale. Sealed metal housings, solid stops, and essentially infinite resolution. They'll save you space—they'll save you money. (Our prices start at $1.40 list.) Two good reasons to write for specs and prices today.

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HELPING SCIENCE AND INDUSTRY IMPROVE THE QUALITY OF LIFE

CHECK NO. 3

Who's into back planes? You are. Cinch is.

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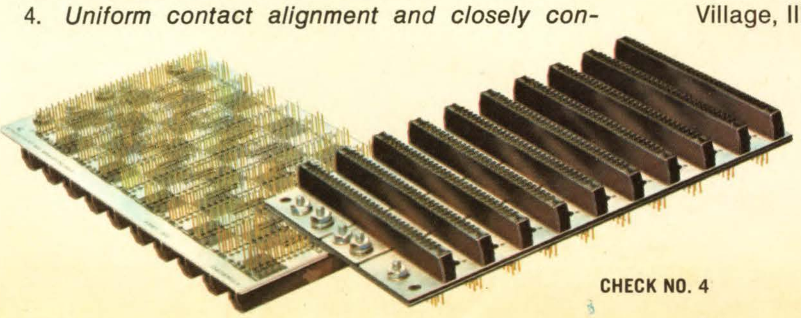
If you're into back planes already, you've probably talked to Cinch. If you're not into them yet, you ought to talk to us. Call us at (312) 439-8800, and we'll fly out to see you. Incidentally the book—Catalog C-164—is free, from your Cinch sales office or Cinch Connectors, an Operation of TRW Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007.

C-7200



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Look at all the space you can save.

You're looking at two of the smallest discrete components available in electronics today.

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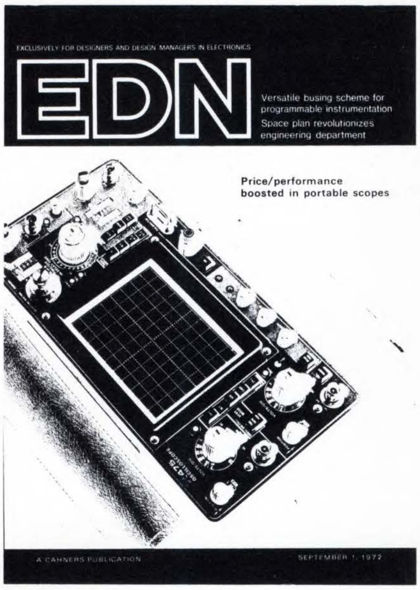
CORNING
ELECTRONICS

CHECK NO. 5

SEPTEMBER 1, 1972
VOLUME 17, NUMBER 17

EDN with EEE

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



COVER

Performance is up and the price comes down in the latest portable, battery-operated scopes introduced by Tektronix. For the story on this progress in instrumentation, see pg. 54.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

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brighten up
your world
...with SLOAN'S PANEL MOUNT FIXED LAMP INDICATOR LIGHTS
There's a whole world of applications waiting for Sloan's advanced family of Panel Mount Fixed Lamp Indicator Lights. But there's nothing elusive about these sub-miniature lamps. Sloan has captured a most admired selection for immediate use within its net.
No fluttering with these fixed neons that permit quick installation with speed clip mounting. They exhibit a versatility that is unmatched. Possible variations include unbased lamps and unbased incandescents, long neons or short neons, resistors built-in or not built-in, and LED availability. All of this at popular prices, too.
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CHECK NO. 7

The NIH syndrome revisited

Did you ever think of a common table lamp as a system? It's not really so far fetched, since it consists of a bulb, the lamp itself and maybe an extension cord, all of which must work together to accomplish its function of providing light.

When looked at in this light (no pun intended), it's really a remarkable system, inasmuch as you can buy the lamp itself in Chicago, the bulb in Los Angeles and the extension cord in Dallas. And when you put them together, they mate perfectly, despite the fact that they were made by a variety of manufacturers.

This sort of compatibility, unfortunately, is far from the norm. American industry, instead, has always been prone to design a never-ending variety of shapes, sizes, configurations and styles of just about everything it makes—even for items whose function and performance are virtually identical.

We realize that frequently these differences, even when merely of the cosmetic variety, are the dominent selling features of the products, and often contribute to the economic vitality of the country. Sometimes, though, they are strictly the result of the "not-invented-here" syndrome and represent a useless departure from someone elses better design or technique.

At best, this sort of thing is just a nuisance to the purchaser. But at worst, it can impede the acceptance of these products or the development of systems based on their use. Which brings us to our main point.

On page 22 a busing scheme is described which would allow the interconnecting of programmable instruments into test systems in an inexpensive, efficient way. No one will argue that automated test and measuring systems can play a very significant role in everything from industrial production to environmental monitoring and control. But to realize their full potential, such systems must be economical and capable of being assembled using devices from many different manufacturers. The article points out one way of doing this. For maximum success, though, it would have to be adopted by many manufacturers.

Hewlett-Packard, who developed the busing scheme, is going to use it extensively. They believe that technically and economically it does the job. Maybe it does and maybe it doesn't. That's not our point. Our point is that it should be evaluated objectively on its merits and not automatically discarded out of hand. The industry will not be served either in this case or in others like it by "not-invented-here" thinking.

Frank Egan

Editor

(219) 464-1081
FOR NEW APPROACHES TO SWITCH PROBLEMS

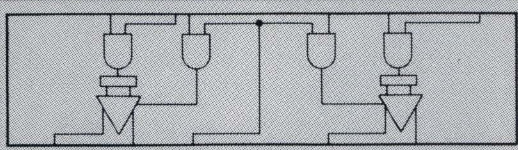
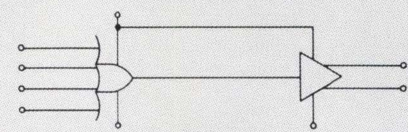
You'll find McGill switches on more and more consumer, commercial and industrial products every day. Part of the reason is functional versatility and high reliability combined with the right styling. Another part of the reason is that we are not too big or too busy to consider specific design problems. We have more types of switches to work with than any other switch manufacturer—toggle, rocker, snap-action, push-button; standard sizes on down through sub-miniature; variety of actuator shapes, materials and colors, circuitry and mounting hardware. If we don't have exactly what you need, we can modify and re-design as we have done for manufacturers of some of the most highly respected products on the market today. Just call us.
Or, if you have no immediate switch problems, ask for our Catalog 89.
McGill Manufacturing Co., Inc., Electrical Division, Valparaiso, Indiana 46383

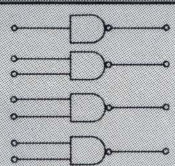
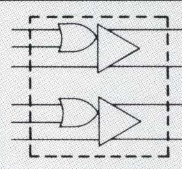
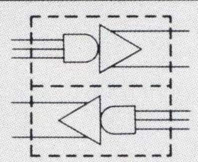
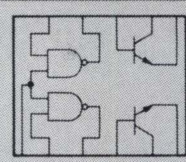
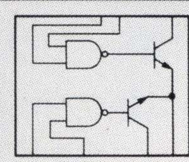
McGILL®
ENGINEERED SWITCHES
Available from recognized McGill Master Switch Distributors

CHECK NO. 9

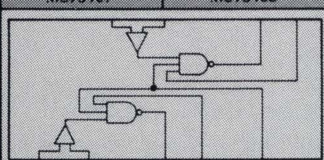
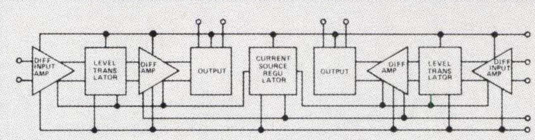
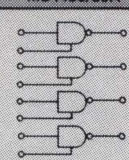
Line drivers and

MOTOROLA LINE DRIVERS

TYPE	MC75109	MC75110	MC75113
BLOCK DIAGRAM			
OPERATING FREQ.	<10 MHz	<10 MHz	<10 MHz
LENGTH OF LINE	<5000′	<10,000′	<20,000′
INPUT	TTL	TTL	TTL
TYPICAL LOAD CURRENT	6 mA	12 mA	± 20 mA
PARTY LINE OPERATION	YES	YES	YES
STROBE	YES	YES	NO
POWER SUPPLIES	± 5 V	± 5 V	± 5 V
FEATURES	INSENSITIVE TO SUPPLY VARIATIONS OVER ENTIRE OPERATING RANGE INHIBITOR AVAILABLE FOR DRIVER SELECTION		CAPABLE OR SOURCING CURRENT WITH ONE OUTPUT AND SINKING CURRENT WITH THE OTHER

TYPE	MC1488	MC1580	MC1582	MC75450	MC75451
BLOCK DIAGRAM					
OPERATING FREQ.	<2.5 MHz	<10 MHz	<10 MHz	1 MHz	1 MHz
LENGTH OF LINE	<50′	<5000′	<5000′	<500′	<500′
INPUT	TTL	MECL	TTL	TTL	TTL
TYPICAL LOAD CURRENT	10 mA	8 mA	8 mA	—	—
PARTY LINE OPERATION	NO	YES	YES	YES	YES
STROBE	NO	NO	NO	NO	NO
POWER SUPPLIES	± 9 V	± 5 V	± 5 V	± 5 V	± 5 V
FEATURES	SATISFIES EIA STANDARD RS-232 SIMPLE SLEW-RATE CONTROL	COMMON-MODE INPUT RANGE ± 3.5 V COMMON-MODE OUTPUT RANGE -3 V/ +9 V		TWO STANDARD TTL GATES TWO UNCOMMITTED HIGH VOLTAGE NPN TRANSISTORS	POSITIVE "AND" DRIVER OUTPUT TRANSISTORS INTERNALLY CONNECTED

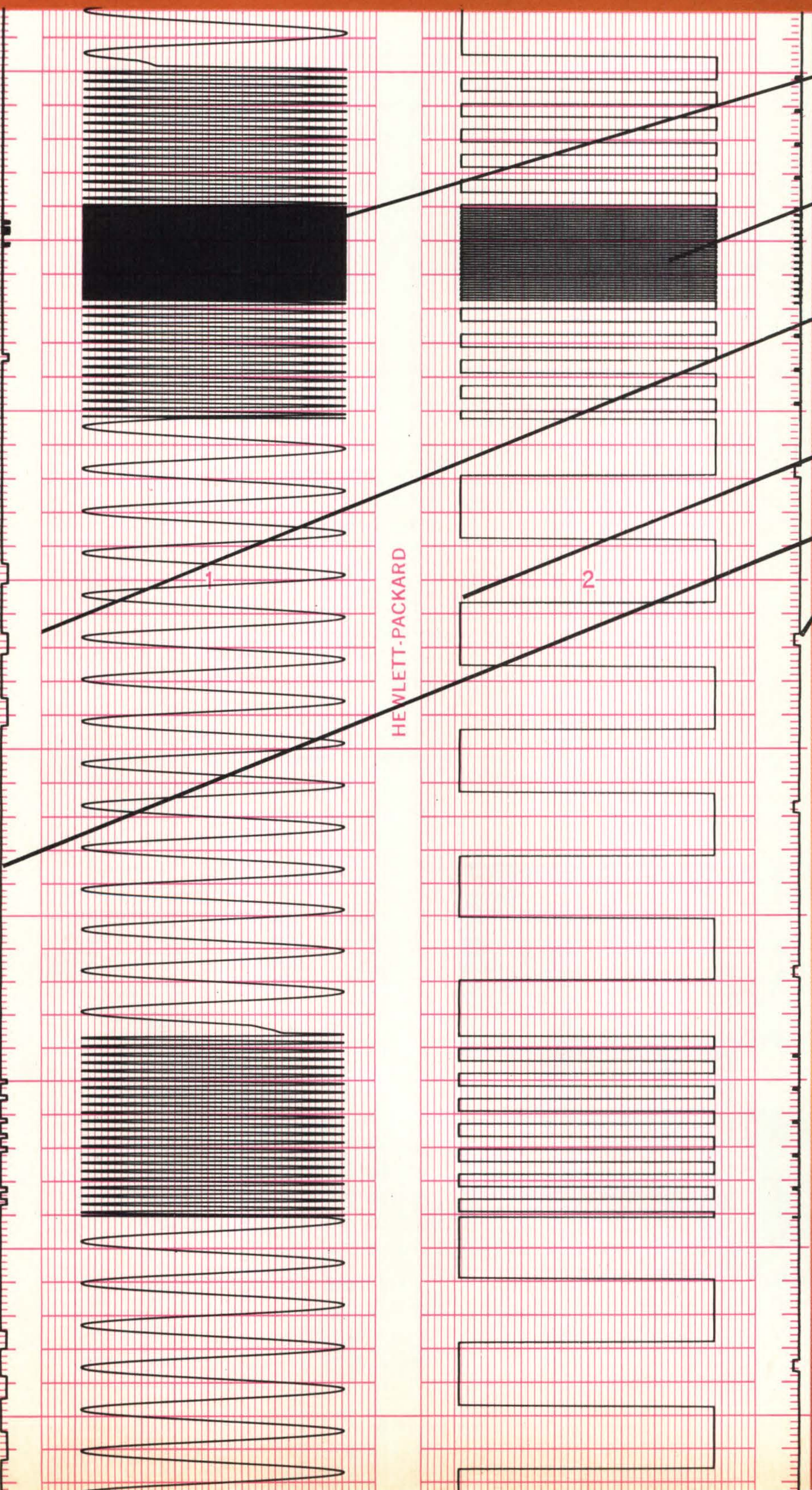
MOTOROLA LINE RECEIVERS

TYPE	MC75107	MC75108	MC1581	MC1583	MC1584	MC1489/89A
BLOCK DIAGRAM						
INPUT SENSITIVITY	25MV MAX	25MV MAX	50MV MAX	50 MV MAX	60MV MAX	ADJUSTABLE FROM -3 V TO +3 V
PROPAGATION DELAY NSEC	25 MAX	25 MAX	20 MAX	30 MAX	37 NSEC	50 MAX
STROBE CAPABILITY	YES	YES	NO	NO	NO	THRESHOLD ADJUST AND RESPONSE CONTROL
OUTPUT	TTL ACTIVE PULL-UP	TTL OPEN COLLECTOR	MECL	TTL OPEN – COLLECTOR	TTL – ACTIVE PULL-UP	RESISTIVE PULL-UP
POWER SUPPLIES	± 5 V	± 5 V	+5 V, -5.2 V	± 5 V	± 5 V	+5 V
FEATURES	DIODE PROTECTED INPUT STAGE HIGH COMMON-MODE REJECTION RATIO HIGH DC NOISE MARGINS		± 3.5 V COMMON-MODE INPUT RANGE HIGH INPUT IMPEDANCE			SATISFIES EIA STANDARD, RS-232 BUILT-IN HYSTERESIS

H-P's new low cost, plug-in oscillographic recorder gives you more of everything.

HEWLETT PACKARD

And gives it to you in writing.



Never a smear or skip with black ink that goes bone dry on contact, even at high speed.

Fail-safe trace insured by non-fatiguing stainless steel pens with carbide tips.

Big picture gives you 50mm per channel. Easiest to load, full-roll paper take-up available.

No overshoot problems with pulse or square wave recording.

Event marker and timer options can be remote controlled.

What you can expect to get out of our new 7402 two-channel Oscillographic Recorder depends entirely upon what you put into it. And you start by putting in plug-in signal conditioners that come in ten combinations. So if you expect to be doing low-gain recording, you can buy a 7402 for just $1740—complete with two 20MV/div plug-ins. To increase capability, add high or medium-gain modules priced from $225.

Even when you put it trace-to-trace with machines costing twice as much, you can't match the 7402's combination of plug-in versatility, high-performance, big picture, Hewlett-Packard reliability . . . and fail-safe writing.

Get details on the low cost Oscillographic Recorder that gives you more of everything. In writing. Contact your H-P field representative or write Hewlett-Packard, Palo Alto, California 94304; Europe: Box 85, CH-1217 Meyrin 2, Geneva, Switzerland; Japan: YHP, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

112-05

CHECK NO. 11

Videotape moves to the forefront of education in electronics.

It may seem only normal that an electronic medium—videotape—would be very popular within the electronics industry. However, the growth of educational videotape isn't just normal, it's phenomenal, and at least two of the leaders of our industry are deeply committed to its acceptance in education:

- •Texas Instruments' Learning Center will begin a road tour this month with their newest effort—a ten-hour course on semiconductor memories.
- •Hewlett-Packard's Corporate Training Div. (see EDN, March 15, 1971) has just published a new catalog listing 106 various tapes that they have produced.

TI's videotape effort, like HP's, began as an "in-house" training technique. Both have produced tapes on basic solid-state technology.

TI's "Understanding Semiconductors" is a 12-hour course which covers everything from basic electricity to integrated circuits. The course was developed for managers in electronics.

HP's "Practical Transistors" is 15-hours long, and is aimed directly at the technician. It assumes some prior knowledge of basic electronics, and begins with a discussion of "Transistors vs Vacuum Tubes." The sequel, "Logical Troubleshooting" is a 32-minute tape.

On a level of greater interest to EE's, HP has a 2-part tape on S-Parameter design techniques. The first, "Basic Microwave Review" is 54-minutes, and discusses S-parameters, transmission line theory and use of the Smith Chart. Part II is "High Frequency Amplifier Design Using S-Parameters".

Last September TI presented a videotape program on MOS in a nationwide CCTV linkup to hundreds of EEs. In a survey of the students TI was given an overwhelming vote of confidence with responses such as these:

- •Would you recommend this course to others?
  Yes—92%   No—8%
- •What is your opinion of the basic concept of TV instruction?
  Excellent—53%, Good—44%, Fair—3%, Poor—0%
- •Would you like to see more courses of this nature offered?
  Yes—98%   No—2%

TI will present this course again this year in 11 selected cities, in conjunction with their memories course.

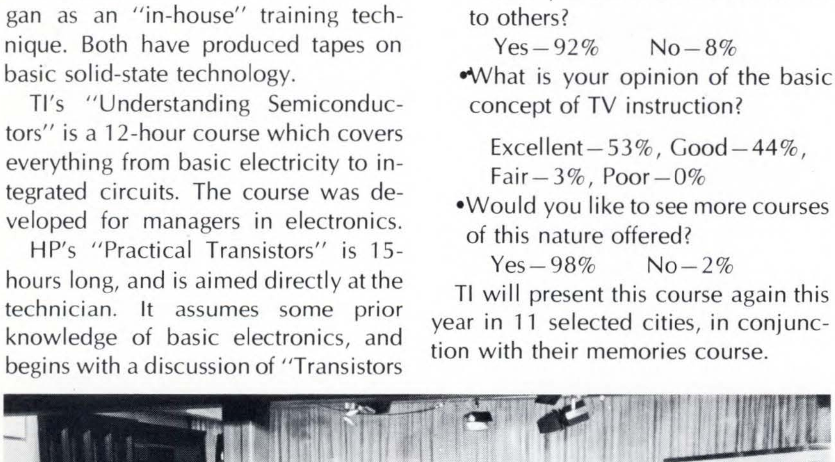


Fig. 1—TI Learning Center's videotape studio is fully equipped to handle major productions such as their newest tape on semiconductor memories. During a visit to Hewlett-Packard's studio last year, EDN noted that HP needed only a transmitter and an FCC license to launch into full commercial activity. Certainly the same must be said for TI.

Obviously, one factor drawing companies into videotape education is the potential of very large profits. As Doug Powell, Motorola's manager of computer industry marketing recently pointed out to EDN, one computer company which has a nationwide string of programming schools made a larger profit on education in 1971 than they did on their computer hardware sales. After what the industry has gone through for the last several years, the promise of a well earned profit is sweet music indeed.

What makes educational videotape a doubly pleasant venture, though, is that it offers tremendous benefits, not only to the seller, but to the consumer. Don Scharringhausen of TI points out that it is economically feasible to have the acknowledged leaders in the field deliver their lectures directly to every student in the country.

Several other benefits of videotape were pointed out by TI's Dr. Jack Mize in an interview with EDN. The first is the ability of visual media to make a point far more forcefully than textbooks. During a presentation of the concept of videotaping TI's "Understanding Semiconductors," Dr. Mize recalls that he decided to use some of the standard water analogies in describing electrical phenomena. A member of TI's board of directors told him "When you do the waterfall, don't use a little trickle of water, get Niagra or Victoria falls! Really drive your point home!" Such visual capabilities, and ability to edit and compress information, make videotape a very effective learning tool. In preparing the MOS course Dr. Mize, and Dr. William Carr, felt that 25 hours of tape would be required to cover the material. As it turned out they were mistaken. The course is 11-hours long. ☐

For more information on TI's courses check 272.

For the HP catalog describing videotapes and VTR equipment check 273.

NBS to maintain US legal volt using 2e/h via the ac Josephson effect

On July 1, 1972, the National Bureau of Standards, US Department of Commerce, adopted a new procedure for maintaining the US legal volt. The new method is based on the determination of the ratio of twice the electron charge to Planck's constant, (2e/h,) using the ac Josephson effect in superconductors. Recent work at NBS and elsewhere has shown that 2e/h can be determined in terms of a particular as maintained unit of voltage to 1 part in 10 million or better. Since 2e/h is an invariant fundamental constant of nature, the Josephson effect provides, for the first time, a means for deriving a reproducible, invariant voltage.

In the past, the US legal volt has been defined by means of a large reference group of saturated standard cells maintained at constant temperature, however; the mean emf drifts, perhaps as much as several parts in 10 million per year. Now, the assigned mean emf will be adjusted periodically to eliminate the apparent variation of 2e/h.

The ac Josephson effect occurs when two superconductors are "weakly" coupled together and cooled below their transition temperature (usually a few degrees kelvin). One method of obtaining the required weak coupling is to separate the two superconductors by a very thin (about 1 nm) insulating barrier, usually an oxide layer thermally grown on one of the superconductors. When a potential difference

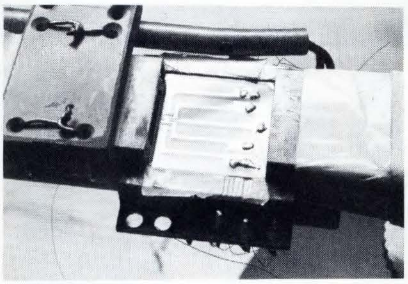


Fig. 1 – A Josephson tunnel junction mounted in a 10 GHz (X band) microwave waveguide. At NBS, such junctions are being used to maintain the US legal volt.

(V) is applied between the separated superconductors, electron pairs tunnel through the insulating barrier generating an oscillating or ac "supercurrent" between the two superconductors. The frequency (ν) of this ac supercurrent is related to the applied voltage by the so-called Josephson frequency-voltage relation, $\nu = (2e/h)V$. The Josephson junction is therefore an ideal frequency to voltage converter since the constant of proportionality is the invariant fundamental physical constant 2e/h. Furthermore, the frequency-voltage relation is essentially exact and independent of all experimental variables, including temperature, magnetic field, and type of superconductor used.

Since July of 1971, determinations of 2e/h in terms of the US legal volt have been made at about 2-week intervals. The actual value of 2e/h implied by these measurements as of July 1, 1972, and adopted by NBS for use in maintaining the legal volt is $2e/h = 483.593420\ \mathrm{THz}/V_{NBS}$. Bureau scientists believe that the legal volt can be maintained consistent with this adopted exact number indefinitely to within 1 part in 10^7.

Other national laboratories are carrying out Josephson effect measurements of 2e/h, including the National Physical Laboratory (NPL), United Kingdom; the National Standard Laboratory (NSL), Australia; and the Physikalisch-Technische Bundesanstalt (PTB), Germany. Recently, the values of 2e/h measured at these laboratories in terms of their respective as-maintained units of voltage were compared with the NBS value.

Since the values of 2e/h obtained at these laboratories all agreed to within 1 to 2 parts in 10^7 (when converted to a common unit of voltage), it has been concluded that the Josephson effect measurements of 2e/h are well in hand, and that serious consideration should be given to adopting a single international value of 2e/h for use in maintaining units of voltage.

It should be emphasized that in using 2e/h to maintain the US legal volt, the Systeme International (SI) definition of the volt remains unchanged. That is, the Josephson effect is not being used to redefine the absolute volt, but only as a means of better maintaining its physical embodiment. ☐

"Security Cradle" protects electronic calculators from unauthorized "borrowers"

There have only been two problems associated with Hewlett-Packard's HP-35 "electronic sliderule". They have been hard to get, and for some they have been hard to keep. The first problem, if not yet solved, has been eased. HP estimated that delivery time for the calculator is now ten weeks; it had been running as high as sixteen weeks shortly after introduction.

While HP continues its efforts to reduce delivery time the second problem, theft, has been attacked head-on with the "Security Cradle," which offers the user four methods for securing the calculator to a desk or table. The cradle can be attached to any surface with four screws, or with one central screw which allows 360° rotation, or with a double faced tape which HP claims to be "virtually unremoveable by hand". A six foot long, 1/4 in. diameter stainless steel cable is also part of the "security cradle." The looped end can be affixed to any convenient mounting point, the other end fits into the lock of the cradle, and allows somewhat freer use of the 35, while still retaining possession. A coded key is used to remove the calculator from the cradle.

At $24.50 the security cradle may prove to be cheaper than insurance premiums. ☐ **274**

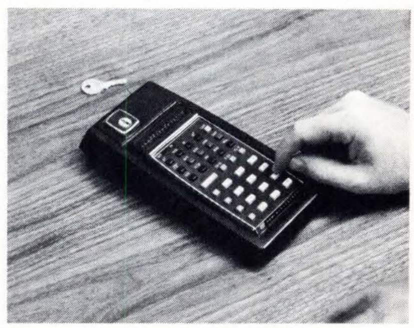


Fig. 1 – "Security Cradle" locks the HP35 calculator to a desk or table top. A 6 ft. steel cable, included, allows somewhat more portable use, while still retaining possession of the calculator.

5 LINEAR MONOLITHIC SUBSYSTEMS

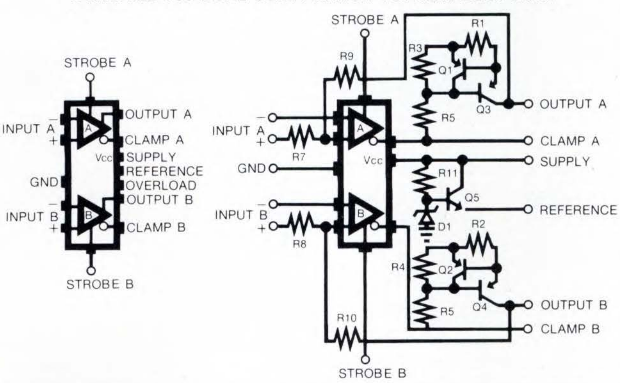
Subsystems: highly complex functions on a single chip. That's where it's happening in linear today. Where Fairchild is. In op amps, voltage regulators and interface.

Look at the facts. In the last 6 months alone 5 new Fairchild monolithic linear subsystems were introduced and are now in volume production.

New 791 High power op amp
Our latest monolithic op amp subsystem has 1 amp output at ±12 volts and automatic circuit protection. Everything is on one chip, so installation's easier. Fewer external connections, testing's easier, less external electronics. Naturally, system costs go down, system reliability goes up. Internally protected against short circuits, power and thermal overloads. 100-piece price: $12.50.

750 Dual comparator

FAIRCHILD 750 DUAL COMPARATOR VS. NEXT BEST WAY.



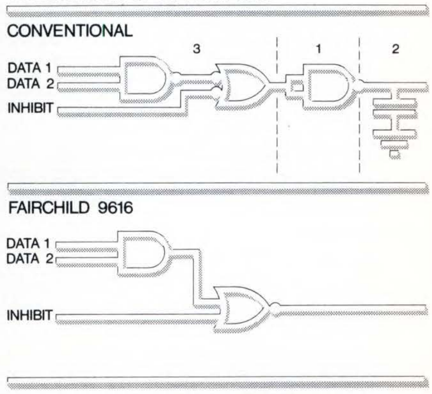
The world's first monolithic comparator subsystem. Eliminates up to 17 discrete components other comparators require for equivalent function and drive capability. A totally-self-contained subsystem consisting of two high-output current, independent comparators on a single chip. Eliminates the external components, board space, and virtually all the engineering calculations necessary to make other comparators function reliably and safely in complex control applications.
100-piece price: $5.95.

776 Programmable op amp
This subsystem is the closest thing to a universal op amp yet devised. Already an industry standard, it's a high quality device that, with the addition of a simple external resistor, can be tailored for optimum performance over an enormous span of applications. The wide range of programmable characteristics make it one of the most versatile and useful op amps to appear in years. Applications range from a nanowatt amplifier to a high-accuracy sample and hold amplifier. 100-piece price: $3.00.

7800 3-terminal voltage regulator
Seven members (5V, 6V, 8V, 12V, 15V, 18V, 24V) compose this family – the first with complete voltage regulation on one chip. The first high quality, sophisticated, versatile, yet simple way of solving VR design problems. At a price so low they can be inventoried in quantity, for use as required. Complete and self-contained in one TO-220 or TO-3 package. And fully self-protected: internal current limiting, thermal shut-down, safe area compensation protect device from current, power, temperature fluctuations. Typical 100-piece price: $1.75.

9616 EIA line driver (& 9617 receiver)
Our 9616 triple line driver subsystem has both internal inhibit and slew rate control. And it's all on one chip. Our 9617 EIA triple line receiver completes the set. They meet all EIA RS-232-C specs. And more. Together, they provide the simplest low-cost solution to problems at the interface in data terminal equipment and data communications. 100-piece price is $4.50 for the 9616; and $3.50 for the 9617.

COMPARISON OF EIA DRIVERS.



Conventional EIA Driver (1) requires external slew rate control capacitor (2) and external gating for inhibit function (3). 9616 EIA Driver requires neither.

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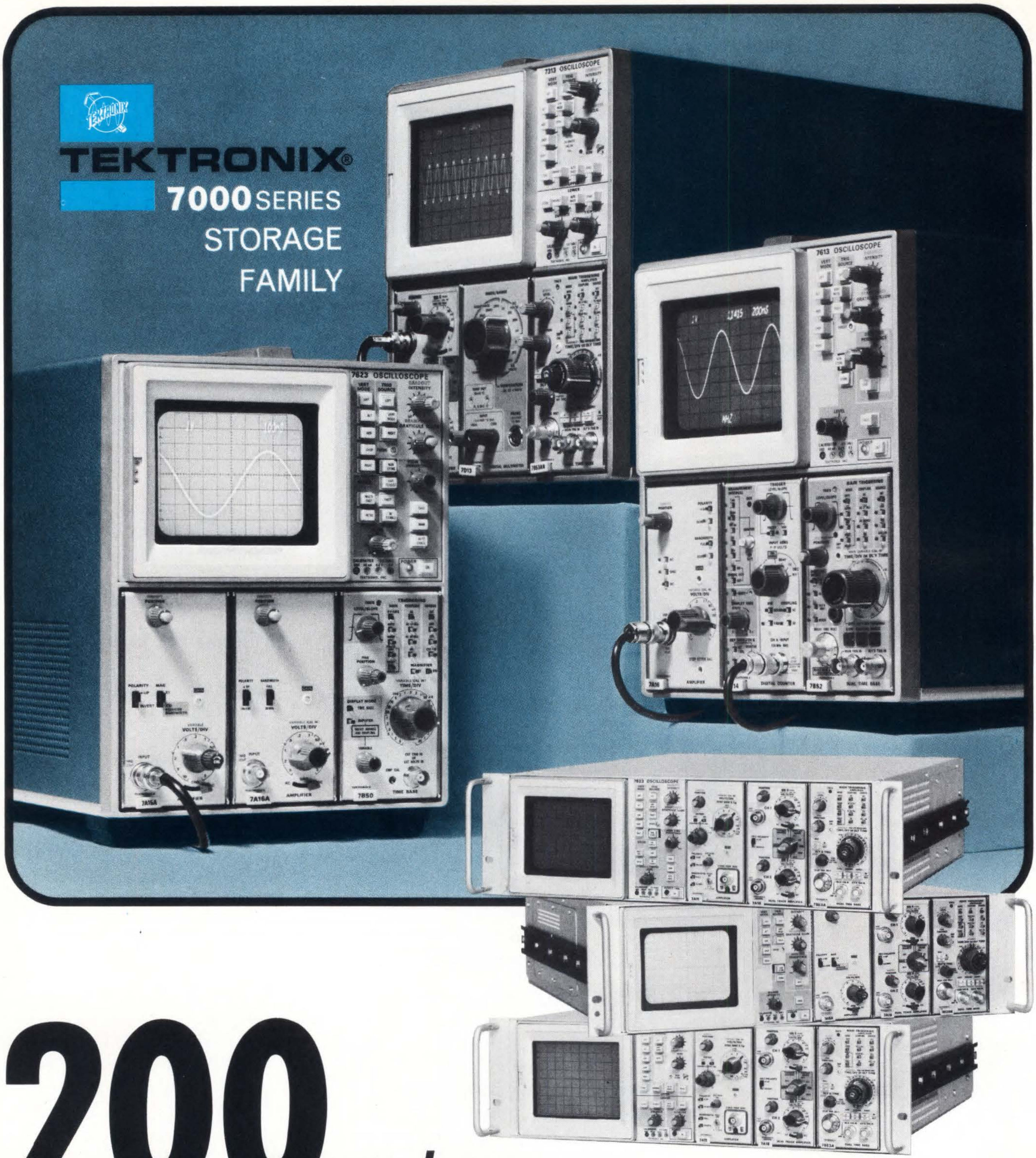

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CHECK NO. 13

Digital bus simplifies instrument system communication

Interconnecting programmable instruments into a test system is a formidible task. Here's a rundown on the considerations involved, and a busing scheme that does the job.

Donald C. Loughry, Hewlett-Packard Co.

Effective communication between two instruments, as in human communication, requires two essential elements—a good talker and a good listener. The design and use of instrumentation systems usually require many such communication links, or interfaces, as commonly termed. The practical implementation of these interfaces is not always easy. In designing or using an interface, have you ever been faced with the need to:

- Add new signal lines in order to interface two existing products?
- Design buffer circuits to couple the logic levels or polarities of two dissimilar products?
- Design not one but a set of interface options for your product to satisfy different system applications?
- Redesign an interface dedicated to one task to fit a new application?

An affirmative answer to one or all of these questions may cause you to recall the time, energy, money and perhaps, anxiety experienced in affecting a less-than-optimum interface solution. We all face some aspect of these or similar challenges as designers, manufacturers or users of instrumentation systems. These days it is not unusual to find cables by the dozens, as shown in **Fig. 1**, and about as many different interface solutions in one system. Why is the task so large, and what can be done about simplifying it?

Recognition of the fact that interface design involves much more than visible elements of cables, connectors and circuits in the exchange of digital messages between instruments is of critical importance. All too often it is assumed that agreement on physical hardware requirements will achieve compatibility. Circuit compatibility, perhaps, but that is only part of the picture. The scope of the messages to be communicated, the unambiguous definition of message content, and the techniques for exchanging these messages within a communications network are all important. Factors such as codes, formats, control techniques, timing, logic conventions and software requirements cannot be overlooked. Effective communications via a digital interface system must consider all of these parameters. What then are some of the specific problem areas causing outright incompatibility or, at best, costly interface design?

Message traffic increases. A few years ago, only the most frequently changed and easily programmed front-panel controls were candidates for remote control. Now, it is not unusual to have all the front panel controls on an instrument available for digital remote program control, even those usually implemented by analog means, such as vernier controls. Independent of the interface method, separation of the system elements (instruments) beyond eye contact usually demands the exchange of additional status data to assure proper system performance at remote locations. As instrument accuracy and capability increase, so do the requirements for more data interchange. The world of automated systems has significantly increased the need for an additional repertoire of messages to be carried over an instrument interface network.

Storage. Although the scene is changing, many products still do not contain storage capability on program-data input or basic-data output lines. The absence of storage places extra demands on the interface as well as on some of the system elements. In the case of program inputs, the availability of the affected interface lines to perform other useful tasks is absent while the instrument being programmed performs its task. For data-output lines, the reverse is true. The product producing the data is inhibited from further action until the transfer of data is complete. Without interface data-storage capability, message rates and system efficiency are limited.

Message convention. Each digital message carried on the interface must have an assertion state or logic convention associated with it. This is no different than many other conventions in life. Who would want to drive on the right-hand side of the road in the U.K.? Program-data inputs usually assert their intended action when a signal is in the LOW, or "ground-true," condition. This occurs because of factors such as better waveform integrity over the interface, compatibility with wire-OR logic, cable disconnect conditions, and the ability to program easily by simple switch closures (mechanical or solid state).

Measurement output data has traditionally been communicated with the opposite convention. Mathematics and logic have conditioned most of us to think "positive." Neither of these situations on the input and output lines is a problem when considered separately. Instrument systems, however, frequently require the coupling of positive-true measurement output data to ground-true program input data. The results may be unexpected and possibly unsafe if you happen to be programming a high-current or high-voltage power supply from the output of a frequency counter. These problems may be solved, of course, at the expense of special interface circuits or options.

Healthy trends promote commonality.

Some of the changes and demands arising in the world of programmable instrumentation and instrument systems are now aiding the move toward more commonality among interface techniques. These include the following:

It's a serial world. Serial interface techniques are in common use throughout the data processing field and within peripheral devices such as teletypewriters, line printers and magnetic tape drives. These products, in addition to calculators and processors, are now in frequent use as integral parts of instrumentation systems. Even simple input devices, such as paper tape and mark-sense card readers, are character-serial by nature. Remote data collection, interaction with numerous time-share systems, connection with hierarchical systems, and the increasing use of common-carrier bit-serial communication facilities, all help to further increase the trend and need for a more serial interface. The net result is that programmable instruments are required to interface with many devices which utilize some form of serial interface.

The smart product. Instruments are becoming more intelligent as they are optimized to solve complex measurement problems. The new HP 3570A Network Analyzer, for example, does not have to rely on an external calculator to provide some measurement results calculated from raw measurement data. A pair of sequential phase measurements at related frequencies are operated upon (an optional delay mode) to provide direct group delay (τ_g) measurements as shown in **Fig. 2**. In a companion instrument, the HP 3330A/B Automatic Synthesizer, an entire set of signals is produced automatically. The set of signals, each a different frequency, can be generated over the prescribed band, in predetermined increments, at a preselected rate. A few bytes of program data are all that is necessary to set up the boundary conditions.

The need for automatic measurements coupled with the availability of low-cost digital device technology to do the job have reduced the interface problem significantly. What used to take literally tens of interface interconnections all demanding new input data throughout a measurement cycle now requires but a few lines providing data input much less frequently. The result: Smart instruments are now able to communicate in a higher-level language, simplifying the interface task.

What are the design goals?

We see the phrase "Plug-to-Plug Compatible" almost

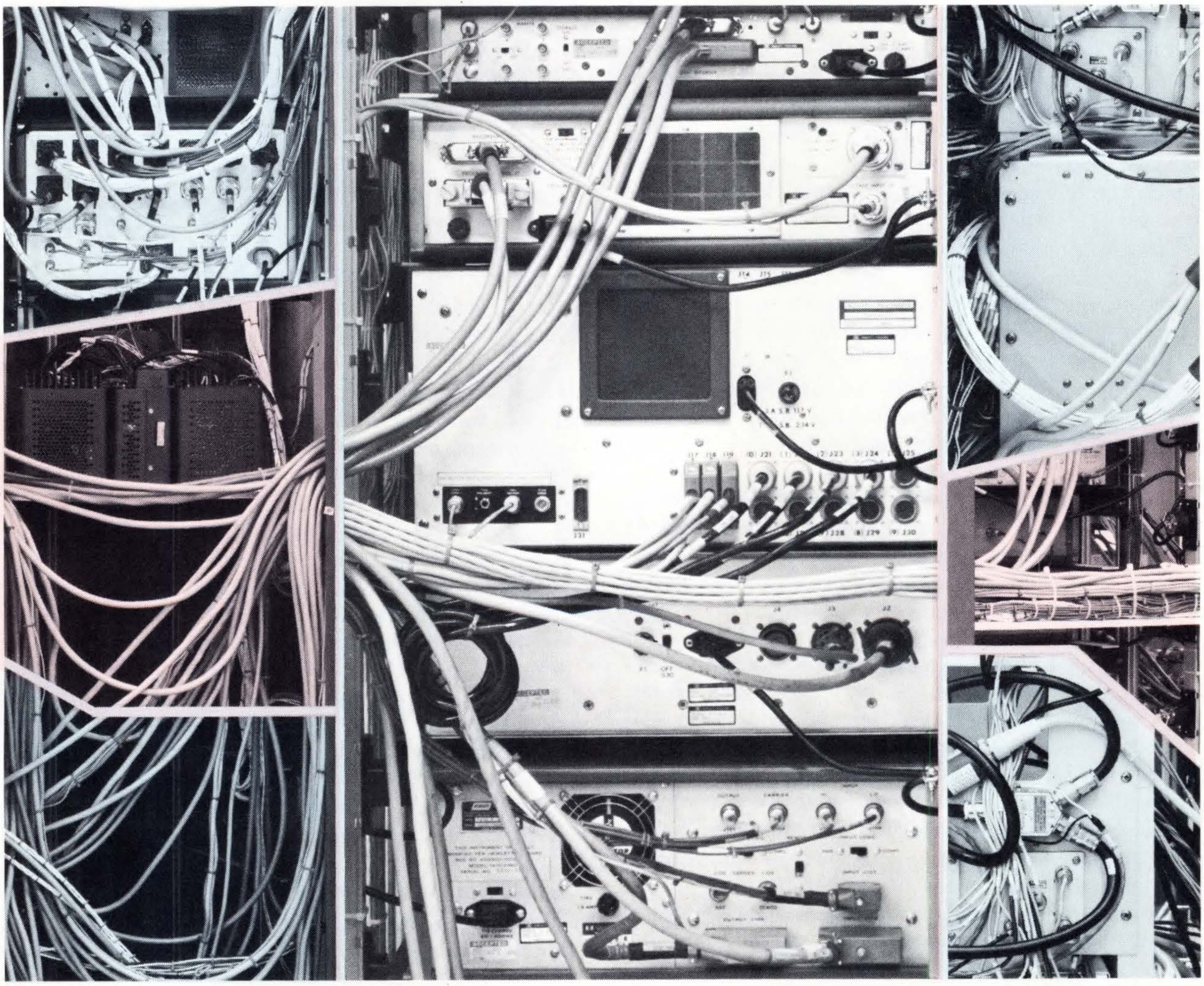


Fig. 1 — Cables, connectors . . . and MESSAGES. Each message carried on the interface generally communicates one of two primary types of information: (1) an input message to an instrument which may be program data (range, function, mode, speed, etc.) to set up a task to be performed, or command data (measure, read-write, display, etc.) to execute the task. (2) an output message from an instrument which usually carries the results of the task once it has been performed (1.256 kHz, +13.2 dBm, −5.0V, etc.), or a status report (overload, power on, underrange) on the internal condition of the instrument. Interface connections and interface systems must be capable of carrying a wide variety of address, basic, control and status data messages!

$$\tau_g = \frac{\phi_1 - \phi_2}{360\,(f_2 - f_1)}$$

Fig. 2 – Direct results. A ROM implemented microprocessor has the smarts to calculate group delay (τ_g) in direct engineering units.

daily. To achieve this goal in instrumentation systems implies more – much more – than just agreement on the hardware aspects of interface. The complete solution appears to require a comprehensive interface philosophy in order to bring about compatibility between instruments at reasonable cost, together with adequate capability and flexibility. What then are worthwhile objectives to keep in view?

Compatibility. The main objective of interface designs must be to effect accurate communication between two or more products. The interface system must take into account a wide variety of products and product capability. Unless an interface system philosophy can effectively couple a broad range of measurement, stimulus, display, processor and storage products, useful systems solving real problems may not be possible. In addition, the system philosophy should be compatible with control devices of varying complexity. If the interface is predicated only on operation in big system computer-controlled environments, low-cost systems would be difficult. Compatibility with simple controllers, such as card readers, keyboards and teletypes, is essential.

Cost. An omnipresent consideration, cost, plays a key role. Unless the costs of the interface hardware (and software) are low, relative to instrument cost, it becomes difficult to justify using whatever technique is proposed in small bench instruments. And if these small bench instruments are not available, economic systems in the noncomputer environment are not feasible. Easily assembled systems composed of bench instruments is a high-priority objective.

Control. If all management of message flow over an interface system is vested in one and only one device, the instrument system loses flexibility and efficiency. A capability to shift control among the instruments or devices of a system in an orderly manner is very desirable.

Conversion. There appears to be little likelihood of any one interface system philosophy solving all the world's interface problems. The requirements are too diverse (long distances, low cost, high-noise immunity, wide-data paths, rapid-data rates, etc.). Therefore, although the primary objective is to select a limited set (as broad as possible) of compatible parameters, a secondary objective of recognizing the other more specialized interfaces to which the primary interface system must interconnect or converse is a most important design goal.

The above goals form the basis for a general-purpose Bus Interface System which focuses on the needs of programmable instruments and measurement systems. Pertinent design and operating features of this bus system are described on the following pages.

The choice: star on bus.

With the interface system goals in view, what is the best method of interconnecting an instrumentation system? There are two basic concepts from which to choose – the star or the bus method. The star, as the name implies, is a radial structure with one separate data path for each device connected to one central unit. A bus, or party-line as it is sometimes called, interconnects the system elements with a data path common to all units, much in the same way a "four wheeled" bus picks up and drops off passengers along its route.

The passenger bus analogy is a useful tool in visualizing the advantages and disadvantages of star and bus systems. Consideration of cost, control flexibility and data flow factors makes the decision simpler. A bus structure permits a system interconnect network without the necessity of a central device dedicated to the control function. This alone reduces the overall system cost significantly. In addition, a bus system opens up the possibility of direct communication among any number of instruments simultaneously (limited, of course, to one talker at a time) without the necessity to transfer all data from device A through a central unit en route to device B. The potential penalties in using a bus system appear to be: (1) a small increase in instrument cost for some additional control capability, and (2) the limit of one message at a time. Today's circuit device technology has come to the rescue. Twenty-cent gate circuits operating at 1 MHz rates permit a great deal of freedom without loss in capability. A bus rather than a star interconnection system is thus the best choice.

What about bits and bytes?

The next choice focuses on the number of lines used to implement a bus. Should the digital communication take place in an all bit-parallel, bit-parallel word-serial, bit-parallel byte-serial, or an all bit-serial mode? The two extreme cases are not very attractive. An all-parallel system would require 50 to 100 lines from many programmable instruments and is not a good decision for obvious cost reasons. An all bit-serial technique could limit message traffic volume over the interface.

The choice thus narrows down to one of byte width (one word equals one or more bytes, one byte equals n bits). Key factors in the final selection focus on: (1) the many devices in the world now using some form of serial data, (2) typical computer-word data widths, (3) the need to be compatible with communication codes now in common use, and (4) the fact that we are dealing with a binary digital system. An 8-bit byte-serial data bus satisfies compatibility with many data processing peripheral devices, is a simple subset of most computer-word widths, and permits use of the widely used ASCII (American Standard Code for Information Interchange) code. With the bus data width decided, the next question is one of controlling information flow.

The communication network.

The primary element of the interface system is the main data bus over which all messages are to be carried. Additional signal lines are necessary to control the flow of messages over the main data bus. Boundary conditions are needed for the number and location of instruments to be interconnected and the message traffic volume to be handled. All of these parameters form what is called the communication network, as shown in **Fig. 3**.

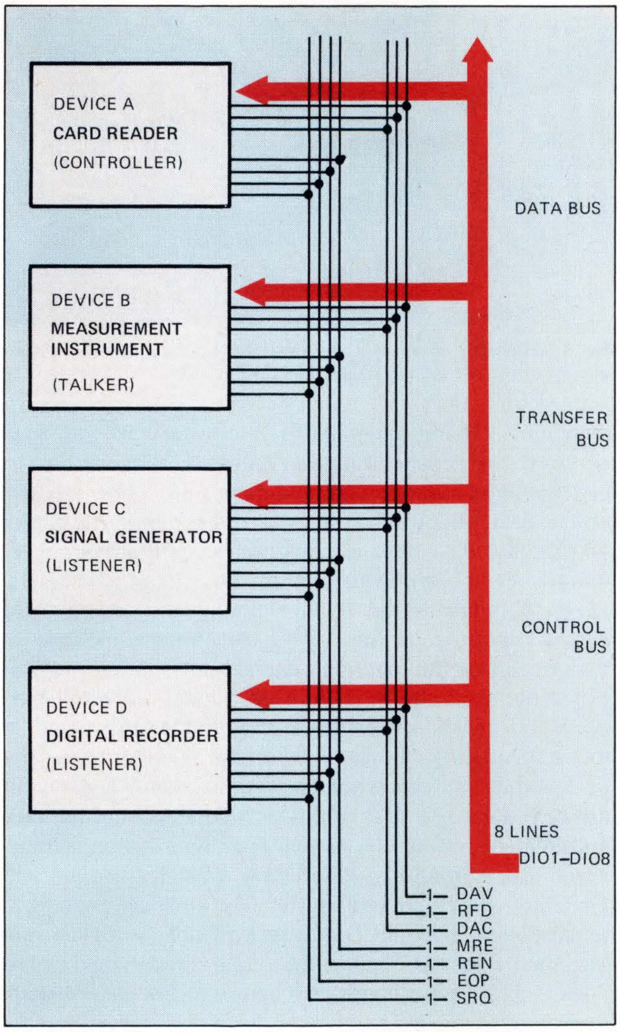


Fig. 3—Communication network to match system needs. A byte serial bidirectional bus operating on 15 signal lines carries the messages between products. Typical product types are identified, such as card reader and signal generator. Three types of device interaction with the bus are identified as talker, listener, and controller. Once a controller has established the communication network or data path, a talker may communicate with two or more listeners simultaneously—the communication path is direct.

Stations and locations. What are realistic numbers for the quantity and placement of instruments on the bus? Given no limits on cost, both of these numbers could be large, but cost is a critical consideration in the problem being solved . . . small economic instrument systems! Typically this involves from 3 to 20 devices, consisting of programmable instruments, peripherals and some form of system–control device. The typical system is usually mounted in one or adjacent equipment bays in the same room. To be sure, an occasional terminal, display or remote sensing device will be located in an adjoining building; however, this is considered to be atypical. These factors, coupled with the desire to have identical interface circuits in each instrument, reasonably high noise immunity, low power consumption and reasonable cable loads, leads to a conclusion—a maximum of 15 devices interconnected via a total transmission path of approximately 50 feet is a meaningful compromise among the deciding factors.

Control. Two different functions and levels of action involving the control of the byte serial data over the data bus are required. First, it is necessary to control each byte of data as it is transferred between predetermined locations. **Fig. 3** shows a set of signal lines dedicated to perform this task labeled transfer bus. Three lines are necessary if information is to be transferred reliably among instruments which vary widely in their response rates. This will be discussed later in more detail. Each device connected to the bus system must contain these three lines if it is to be a full participant in the buss communications.

A second set of four control lines, identified as the control bus, is necessary to enable the control device to maintain an efficient and orderly flow of messages. A controller communicates to the instruments on three of these control-bus lines, and the instruments alert the controller of the need for service on the fourth line. Again, each device connected to the bus system must contain these lines if it is to be fully compatible. The function of the individual lines will be discussed later.

Data speed and direction: What data (byte) rates are appropriate? A programmable instrument requires in the order of from 10 to 20 bytes of data for program setup and from 5 to 15 bytes of data for the output results. In between, of course, the instrument can take anywhere from 1 microsecond to 1 year to perform a measurement as a function of the specific task. A typical system configuration containing from 5 to 10 instruments, each with input and output data requirements as outlined above, leads to the conclusion that a 1 megabyte per second data rate is a reasonable figure.

Another system requirement is the ability to handle some measurement instruments and data peripheral devices operating at continuous data rates in the 1 megabyte per second region. The cost and performance factors of typical interface circuits (drivers, receivers and cables) supports the feasibility of a 1 MHz data rate system. In order to achieve efficiency in the communication network and rapid data transfer, the main data bus is bi-directional in nature. Address, basic, control and status data may be carried in either direction as a function of what product is talking and what product(s) are listening.

Signals and messages.

The 15 bus system signal lines are identified by a set of names and mnemonics to describe their general purpose in effecting bus communication. The names are reasonably self-explanatory; however, further definition is needed to pinpoint the specific responsibility for each line. In describing the meaning of these signal lines, the terms HIGH and LOW will be used in order to associate each of the two possible electrical states with a specific meaning. For this purpose, the term HIGH refers to the relatively more positive, and the term LOW refers to the relatively less positive electrical voltage level.

The bus system has been designed around TTL compatible circuits. The term "talker" applies to any device sending information out on the bus, while the term "listener" represents any device receiving information from the bus. The bus system may have but one talker at a time and up to 15 listeners. The term "controller" implies a device has been delegated the responsibility for bus management. A final term, "handshake," is useful in characterizing the logical sequence of events used to transfer information over the data bus.

Data input/output (DI01, DI02, . . . DI08): DI01 through DI08 carry data between devices connected to the bus. When a D10 line is HIGH, the data bit is a logical ϕ. This set of eight lines is intended to communicate address, basic, control and status data. Any number of bits, up to eight, may be used to transfer a given byte or character of information. While the ASCII code is preferred, it is possible to carry BCD, binary or unique codes, provided code compatibility exists between the devices.

Data valid (DAV): DAV indicates the validity of the data on the DI01 through DI08 lines for all data transmissions.

Ready for data (RFD): RFD indicates the readiness of devices to accept data.

Data accepted (DAC): DAC indicates acceptance of data.

Multiple response enable (MRE): MRE controls how the information on data lines DI01 through DI08 is to be interpreted and whether all or a selected few of the devices are to respond.

Remote enable (REN): REN controls all devices connected to the bus system to respond to either their local (front or rear panel) controls or to remote-programming codes.

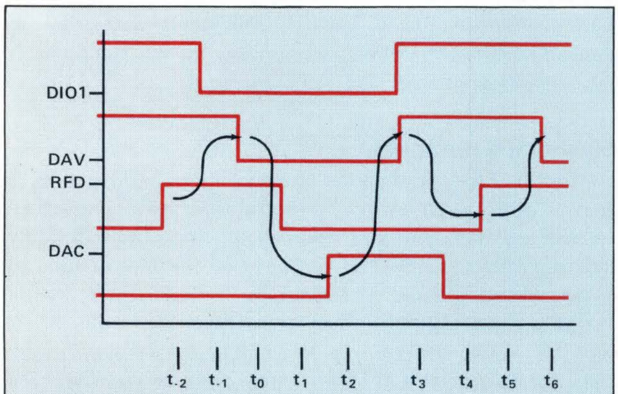
End output (EOP): EOP is used by a controller to terminate all activity on the bus system.

Service request (SRQ): SRQ indicates that one or more devices wants the attention of the controller. The timing of SRQ is asynchronous to any other operation on the bus.

Managing the bus.

Both the transfer bus and the control bus are used to effect unambigous communications over the bus system. Three of the most critical aspects of this management function merit further description.

Data transfer control. Each byte of information carried over the main data bus, whether it contains address, basic, control or status data, is transferred under the watchful eye of the transfer bus. Data transfer is achieved by using DAV, RFD, and DAC signal lines in an interlocked handshake



t_{-2} LISTENERS become ready to accept data.
t_{-1} TALKER places data on data bus.
t_0 TALKER indicates data is present and valid on the data bus
t_1 Fastest LISTENER accepts data.
t_2 Slowest LISTENER accepts data.
t_3 TALKER indicates data no longer valid.
t_4 Fastest LISTENER is ready for new data
t_5 Slowest LISTENER is ready for new data.
t_6 A new cycle begins.

(Only one DIO line shown for simplicity, composite wire-ORed waveforms are shown for RFD, DAC)

Fig. 4 – A handshake on the transfer bus and a data byte is transferred.

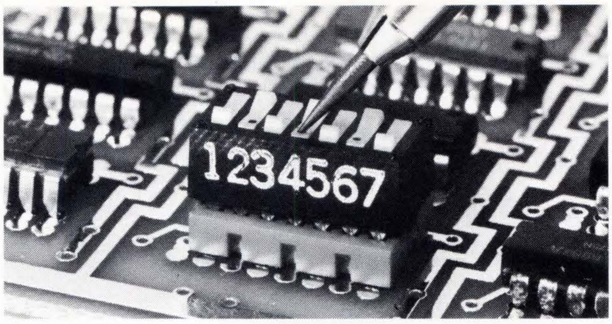


Fig. 5 – Have my address? Easily altered address recognition codes may be implemented with AMP, Inc., DIP switch.

technique. DAV is generated by the talker and both RFD and DAC are generated by the listener(s), allowing data to be transferred without external timing restrictions imposed on the data rate by either talker or listener. Both the timing and the net data rates are determined by the internal requirements of each device and the bus circuit parameters.

Fig. 4 indicates the relative timing and sequence of events occurring on the handshake lines as one byte of information on the main data bus is transferred from talker to listener. Both the RFD and DAC signals are wire-ORed on the bus by all listeners responding to the DAV signal. In this way, a talker can detect when the slowest listener has accepted its data and when the slowest listener is ready for the next data byte. Use of this technique satisfies two key requirements of the bus system. First, information is transferred asynchronously, permitting greater freedom and flexibility in system design and performance. Second, a relatively unintelligent controller will not be tricked into assuming data has gone to the proper place when, a fast device completes a handshake before a slow device starts to respond to the cycle.

Your address please: Addresses as well as measurement data are communicated on the data bus. A talker or controller addresses one or more listeners when MRE is LOW. In this condition, the signals on DI01 through DI05 are used to identify the address of a specific device. The signal on DI06 is used to designate the device to be addressed as either talker or listener. Two address codes are reserved for the function of clearing a device from the active state as an addressed talker or listener. **Fig. 5** shows one possible way of implementing address-code recognition.

A word is in order here about exactly when address information is sent over the bus. Each time a data byte or set of bytes is to be routed to a new device, the data byte is preceded by an address byte. A continuous string of bytes sent from talker to the same listener requires only one address byte.

Requesting service. Each device connected to the bus system may gain the attention of a controller by pulling the SQR signal line (common to all devices) LOW. When the controller is able to repond to one or more requests, it interrupts further communication on the bus. The controller is then able to communicate with a specific device either on the basis of a predetermined response to the SRQ signal or by soliciting further status information (coded or uncoded) from the device over the main data bus. Different service request sequences are used as a function of the number of potential devices requesting service and the scope of the service requests to be accommodated.

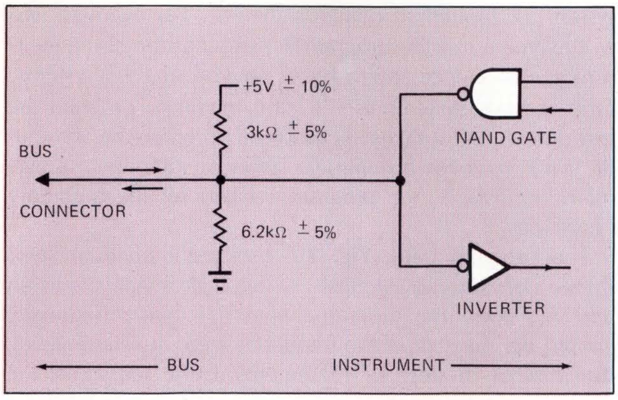


Fig. 6 — Standard TTL circuits interface directly with each signal line on the bi-directional bus.

What about bus hardware?

Basic criteria for the selection of driver and receiver circuits, as well as cable and connector components, have been covered previously. However, two additional facts merit emphasis. Simplicity and uniformity are the key words. Interconnections have to be made through simple, passive, interchangeable cables. The number of cable lines and connector pins must be kept to a minimum and restricted to signal use. The physical connector should be able to accommodate small bench instruments, where rear panel space is at a premium. Also, the impedances of each signal line in each device should be identical.

These considerations led to the TTL-compatible circuit shown in **Fig. 6**. The HIGH state voltage level of $\geq +2.4$V represents a logical ϕ and the LOW state voltage of $\leq +0.4$V represents a logical 1. **Fig. 7** illustrates the piggy-back 24-pin connector arrangement, which permits the use of only one connector per programmable instrument or device. The cable contains one overall shield to reduce susceptibility to external noise, and a mixture of individual conductors and twisted pairs are used to minimize internal crosstalk.

Network analysis rides the bus.

Does the bus system described above actually work? To answer this question, let's examine a new automatic-network analyzer system. Traditionally, network analysis has been done in one of two ways . . . either by manually controlled instruments or totally automatic computer controlled instrumentation of great complexity and expense.

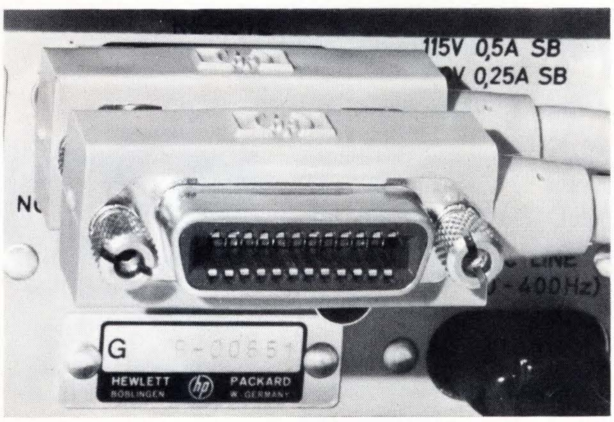


Fig. 7 — Interconnecting a system. Three instruments linked together with two cables.

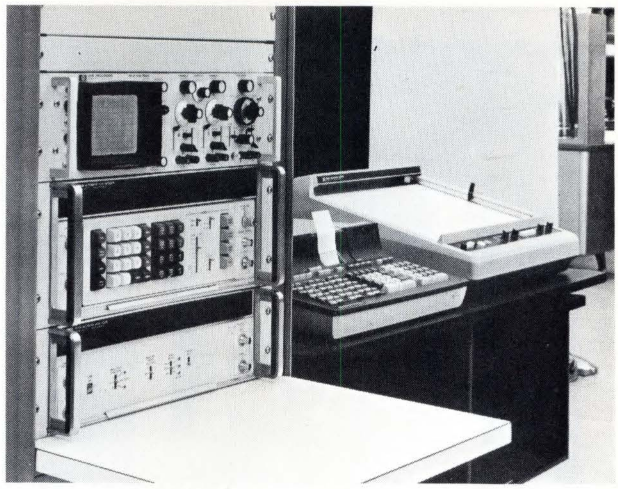


Fig. 8 — HP 3570A tracking detector rounds out the team for the HP 3942A Automatic Network Analyzer System.

The HP 3042A Automatic Network Analyzer System (see **Fig. 8**) provides the same capability as a large computer controlled system but at much lower cost. Thanks largely to the bus system, this network analyzer makes the automatic data analysis capability of the computer system available to the design engineer at a cost usually associated with a manual system. (For details on the 3042A, see EDN, August 15, 1972, page 66.) The network analyzer makes use of the bus system to communicate between the several system components. Its performance is dependent upon rapid transfer of digital data between the system elements. **Fig. 9** illustrates the straightforward communication link . . . one digital bus for all!

To point out the effect of good communication between these components, consider a series of tests on a filter requiring a sequence of stimulus-response measurements interspersed with statistical analysis of the measured results . . . a full exercise of the bus system. The measurement and display of filter parameters such as insertion loss, stop-band rejection, pass-band ripple, group delay and delay distortion takes 30 minutes on a manually controlled system and less than 1 minute on the HP 3042A! The bus system, plus the fact that the programmable instruments are intelligent and fast, is a major contributor to the fast, repeatable, precise, and low-cost measurement results.

A closer examination of the information which is carried across the interface will demonstrate the use of the bus

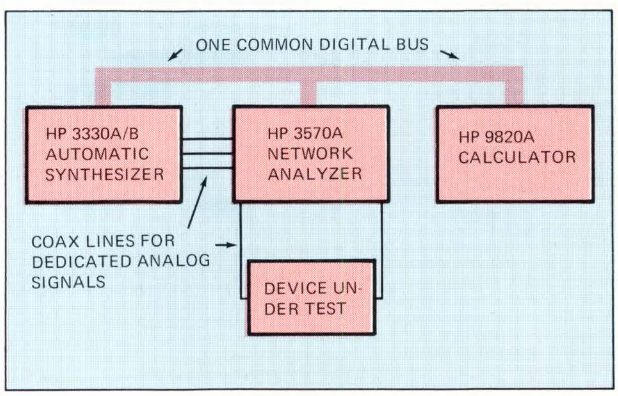


Fig. 9 — Done on one digital bus. One common bus system interconnects all elements of a network analyzer system. Only those signals of an analog nature are carried on separate lines.

system as applied to network analysis. For example, we will examine just the program or setup portion of the measurement sequence applicable to network analysis systems. One of these systems uses a card reader to program the instruments. All it takes to completely prepare the automatic synthesizer for a complete series of stimulus-response measurements is one program card to set the boundary conditions.

The program card, **Fig. 10**, lists the individual steps (bytes) necessary to establish: which instrument is to listen and act upon the program, what the center frequency should be, the size of the frequency step, the signal level, the number of steps or increments in the sequence, the duration of each step in the sequence, the sweep mode, and sweep direction. Seventeen bytes of data on the main data bus coupled with an MRE signal to enable the address starts the synthesizer on its way. After the seventeenth data byte (start single) is carried to the synthesizer, 1000 different frequencies are generated automatically.

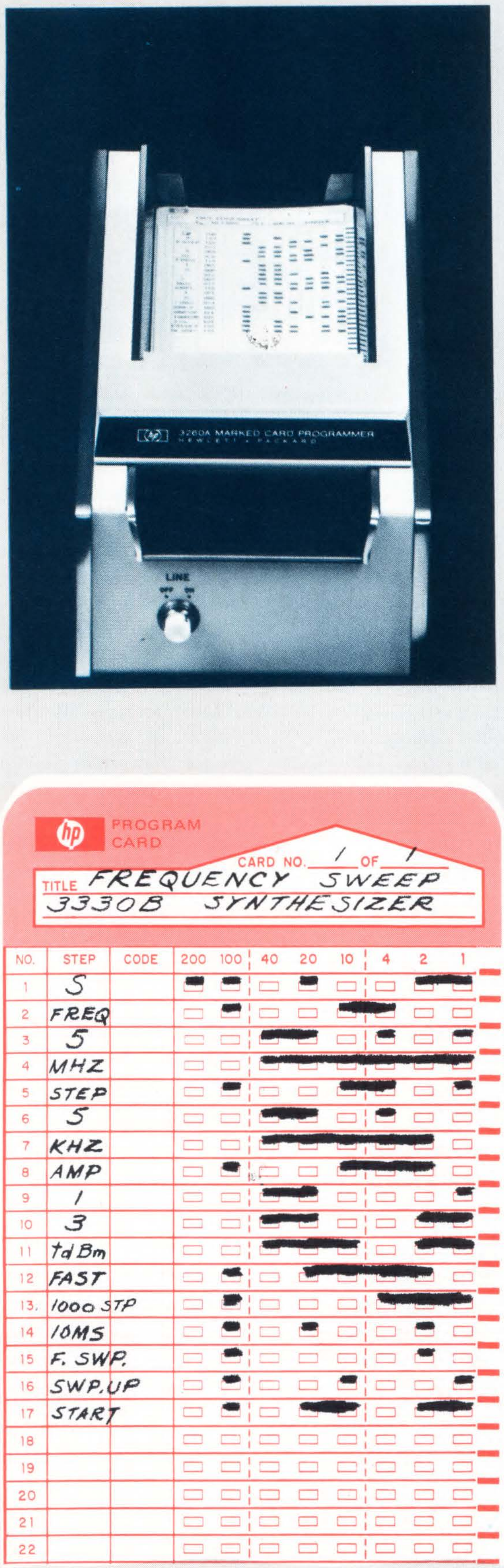


Fig. 10—Playing cards with a bus. Byte serial data programs the automatic synthesizer for a complete frequency sweep in a half a second.

System features.

The basic bus system described provides a general-purpose solution to interconnecting programmable instruments and system components. Of course, not all of the bus system characteristics take on the same relative importance for every system in which they are used. Nevertheless, the following list outlines a few of the key features associated with the bus system:

- Capable of operating effectively in small instrumentation systems with or without computer or calculator control.
- Able to delegate the control function among any interconnected devices having control capability.
- Adaptable to a diverse spectrum of data rates, codes and paths.
- Compatible with a wide range of measurement, stimulus, display, processor and storage products without a significant decrease in their performance capability.
- Compatible with many existing serial devices and techniques and amenable to conversion to other interface methods. □

Acknowledgement

The definition and development of this Bus Interface System is the result of a corporate-wide team effort. While many engineers at HP contributed vital elements to the system design, two men, Gerald E. Nelson and David W. Ricci, made outstanding contributions. Their talent and industry is gratefully acknowledged.

Author's biography

Don Loughry is with Hewlett-Packard's Automatic Measurement Division in Palo Alto, Calif. He earned a BSEE degree at Union College (1952) and joined HP in 1956. Since then he has held a number of positions related to Engineering Project Management. As Corporate Interface Engineer, he is responsible for the development of guidelines and services related to interfacing products throughout HP.

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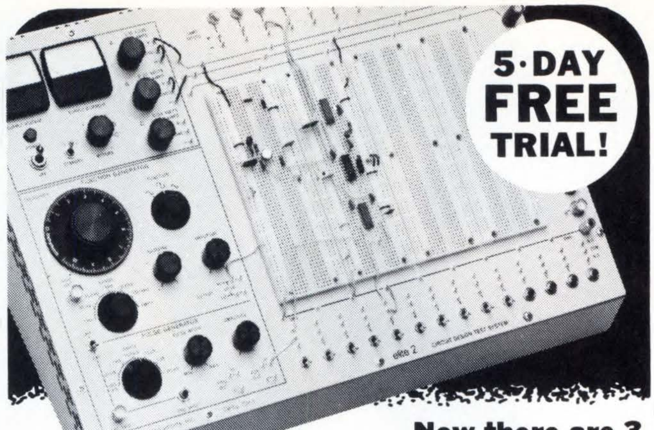

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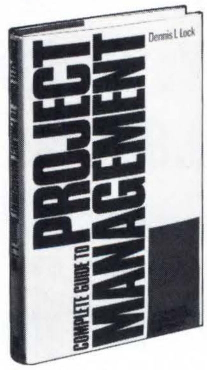

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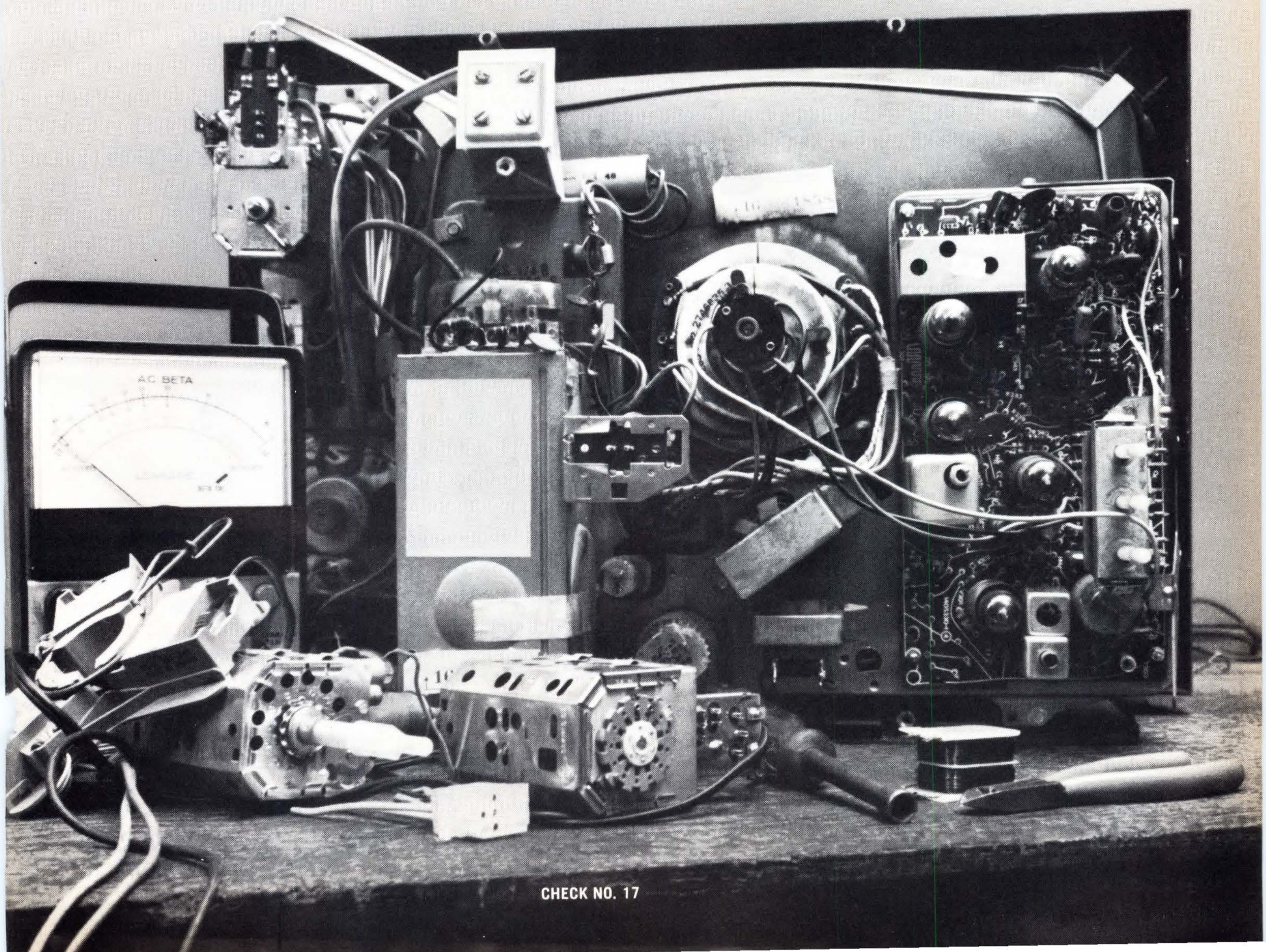

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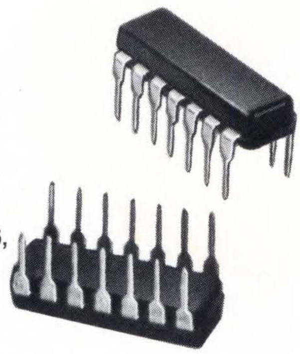

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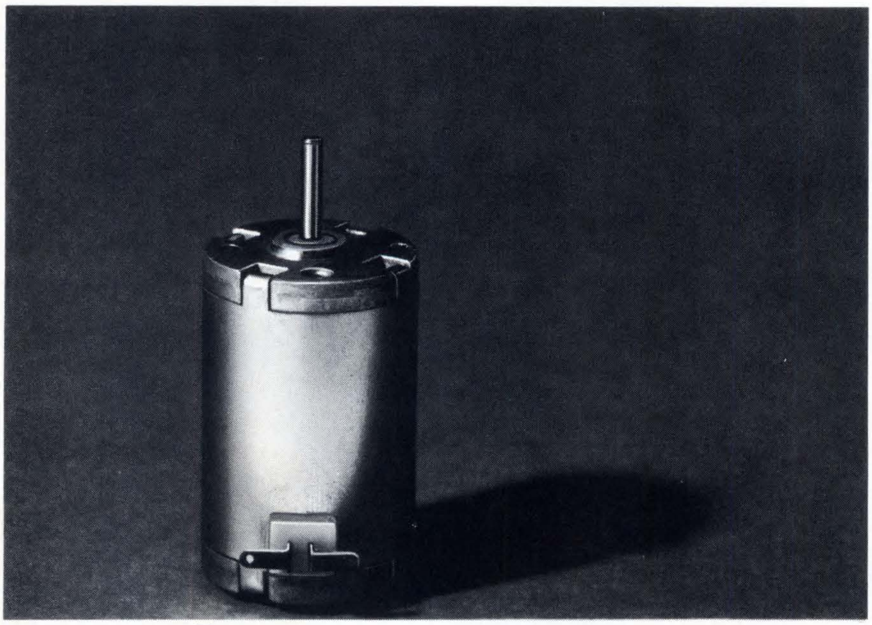

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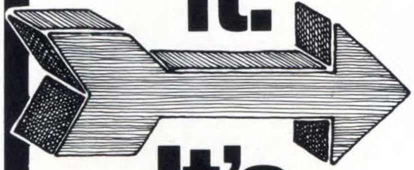

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DESIGN INTERFACE

The non-territorial office—a new type of engineering workplace

Maximum communication amongst engineers in an R & D department stimulates efficiency and teamwork. This new approach reinforces that stimulation.

Marion Carter, IBM Corp.

IBM's Essex Junction, Vermont site, like most industrial plants, has hallways lined with rows of cubicles, with one exception—a corner of one of its development laboratory buildings. Entrance to this pioneering, open-plan work space is made over a blue carpet. The familiar gray tile, so common to industrial plants, is gone. The walls are decorated with silk-screen panels, and two large photo murals stand in the center of the room. The morning sun streams through the windows creating an awareness that does not exist in the confinement of enclosed offices. The engineers, as well as the department manager, may sit at any one of twelve circular tables, and the openness and informality of the room make it easy to sense the most suitable time for consultation.

This new non-territorial work space includes all the tools required by function in basic forms; writing surfaces, seating, levels of information retrieval, specialty tools, environmental requirements, communications and privacy. Based on the premise that this particular department's function requires maximum communication between members, walls have been included only when necessary.

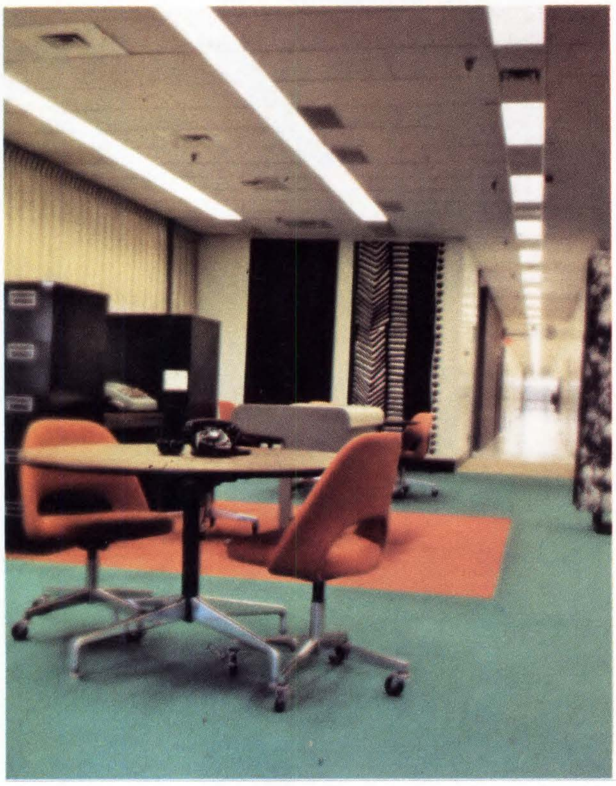
What is a non-territorial office?

The basic design philosophy is not unlike that of a private home. Both contain areas of specialization available to anyone needing them in the performance of their function. To maximize communications, no one is restricted to any one station. The major difference between this experimental design and the "bullpen," or "landscaped office," is the absence of fixed stations. An estimated 50-percent savings in space requirements, greater department flexibility, minimum setup costs, and lower equipment and maintenance costs are a few of the results.

Since one of the most important functions of a manager is to develop the capabilities of the individual, manager availability and interpersonal communications have top priority. Managers have no functional need for a fixed station. This is an extension of one of the principles espoused by Robert Townsend in his book, "Up The Organization."

Why a non-territorial office?

Our manager was concerned about our preoccupation with non-productive aspects of industrial life. He wanted to make productivity (individual accomplishment) easier and more obvious by designing the work area to that end. While much of our success is due to assembling talents for concentrated problem solving, the present "walled" system makes this flexibility difficult, and rearrangement is expensive. The time and expense involved in rearrangements and moving can only be subtracted from attention to productivity.



Communications center is easily identified by contrasting carpeting colors upon entering the non-territorial office space.

The need in our department for interpersonal communications, and the ability to quickly form teams for temporary tasks dictated this design. Indicators of status would be de-emphasized or eliminated in favor of accomplishment visibility. (Industrial psychologists have pointed out that good communication does not occur in formal sessions to the degree it does through accidental meetings).

We also burden one another with paperwork, firing typewritten memos back and forth between adjacent offices, and spend considerable time arranging meetings to solve problems. All of these are poor substitutes for good interpersonal communications.

Personal contacts are a prime vehicle for transmitting ideas, concepts, and other information that is necessary for assuring effective performance. Some of the questions asked were: How can we structure the space around what is to be accomplished? How can we increase the probability of accidental communication and, at the same time, reduce rearrangement inconvenience and expense?

Department members must participate

The issues of what takes place and how our needs change over time as tasks and people change were given serious thought. As a result, an "open-plan" was designed through the joint effort of the department manager*, the design center, the facilities design group, a consultant, department members, and this author.

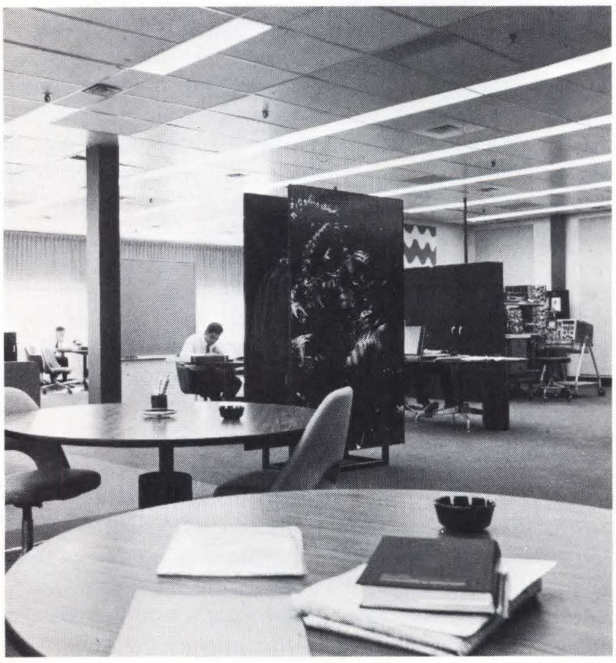
The basic nature of the functions to be performed by this particular department, the kind of interaction needed among members, and the tools required were analyzed.

The team wanted a flexible area where groups could form and disassemble easily. Our analysis indicated that under the conventional arrangement, with fixed stations and private offices, there was only a 50-percent occupancy at any given time. This fact, plus our need for interpersonal communications, indicated that fixed work stations, or territorial domains, tended to isolate people from their colleagues, and therefore, was undesirable.

The resultant design includes task oriented areas, like that of the modern home owner, i.e., a kitchen for cooking, a dining room for dining, etc. However, every family member does not have his own kitchen, living room, and dining room, nor is use of these speciality areas restricted to any one member. This same technique would apply to our department when all those tools required to perform our jobs are included in the plan. These tools would be easily accessible and available to any member of the department.

A three-dimensional model was constructed by the design center based on maintaining the same amount of square footage (appproximately 3000 sq. ft.) as our conventional layout. Included in the model were the basic pieces of office furniture, and most of the existing laboratory equipment. While the plan had become very logical in the minds of those initially involved, department members were apprehensive, and most were very traditional when stating their own requirements.

*Mr. Armand Beliveau of IBM, originated this concept of a non-territorial office.



Engineering laboratory at the right blends into the open-space plan. Storage cabinets separate the lab-space from the office area.

View from the communications center shows how storage facilities provide natural dividers.

How about the loss of status symbols?

Identity was a major concern. Even in landscaped offices, different levels of achievement are identified by means of color, size of desk, the space one occupies, ashtrays, or extra planters. Here we were talking about an open area where only group status symbols exist.

Recognizing the role that office space plays in the promotion and reward system, senior employees were quite negative to the whole concept. Some of the typical concerns were: "Where can I put my wife's picture? What about my certificates of recognition? I've had a picture of my kids on my desk for years. What about my desk calendar? I can't operate without it. My reference list of phone numbers is a must. Where can I keep my pencils, paper clips, staplers, and 3-hole punches? What about my motorcycle helmet? I always kept it on top of my bookcase. If I come to work late, the whole world will know—this could be embarassing." The need for a period of adjustment was obvious, as well as the importance of allowing people to be part of the planning. It may take a long time to readjust from physical status to achievement status, particularly for older employees.

From the beginning, young people were more inclined to try something new. They believed they didn't have much to lose, and that there was the possiblity of a great deal to gain. They had some worries, though, and felt the area might create a fish bowl atmosphere.

Some of the concerns were satisfied during our design period, others were not; and we could only request that our people have confidence in the experiment and give it a fair trial period. As planning evolved, the concern for expression of personal territory lessened, and there was excellent team effort.

How can a test lab fit in an engineering office?

There were four separate laboratories divided by floor-to-ceiling partitions. Each laboratory had a specialty, and was self-contained. The laboratories were fixed and referred to as "my lab" by the technician involved. Some technicians stored a special set of tools under lock and key as their personal property. There seemed to be a continual drive to acquire as many pieces of equipment as possible.

The engineers had been located in private offices along the windowed walls, and technicians were in two to four-man offices on the inner side of the corridor, with their respective and separate laboratories located in the rear. It was not a flexible situation. The technicians conducted their tests in the laboratories and then returned to their cubicles for the corresponding paperwork. If we were to remove the walls and make the laboratory part of the open plan, what would be the result?

Many of us could not imagine a laboratory in the open, and could only visualize it as being ugly. The design center turned the laboratory into an interesting part of the concept by arranging benches, cabinets and electrical test equipment in groups, all forming natural dividers for a large open room.

With this new exposure, the laboratories are neat. Attention is given to the care of the equipment, and all involved benefit from the convenience, whether their work is laboratory or office oriented.

With the assistance of the technicians, laboratory equipment and tools were reduced by more than 50 percent, and we gained approximately 300 sq. ft. of usable area (reducing twelve workbenches to five).

What are the actual physical office needs?

A standard desk, a personal phone extension, a file, bookcase, blackboard, easel holder, wastebasket, coat rack, etc. are the basics. Using a "pure" approach, these needs translate to be: a writing surface, some storage, telephone, seating for one to a large number, accessibility to supplies, etc. There was no need for fixed work stations. Obviously, the desk would be obsolete, and because we were trading furniture for function resulting in a non-territorial area, we chose round tables of varying diameters. Experience shows that they tend to encourage easier communication, an informality not brought about by a desk, and are more adaptable to seating numbers of people. The round tables provide the necessary writing surface, and serves for conferences as well. The number selected was based on two and one-half persons per table.

Coordinating colors used in furnishings enhance informality of the open-space concept.

Chairs were selected in fabrics of bright colors, a combination of arm and armless, all tilting and on carpet casters. They have ease of movement, comfort, and accoustical value. The numbers were significantly reduced (70 to 30) and we based this on one and one-half chairs per person.

Two moveable chalkboards replaced the fifteen individual wall boards: one was red, and one blue, thus adding to the decor and functioning as dividers both accoustically and visually.

Accoustically, the designers did a magnificant job. The carpeting, wall murals (fabric covered panels on perimeter walls), draperies on the windowed walls, and a few remaining semipartitions (around a computation area) are extremely effective in absorbing sound.

How would the engineers react to giving up a desk? During our design period, no logical explanation could be given for a true need, and some soon admitted that it was a good place to bury things, a catch-all for items, a place to collect and clutter.

In addition to the storage offered by a desk, they had a number of file cabinets, bookcases, and credenzas. Office "stuff" tends to grow to fill the space available.

Where are personal materials and supplies kept?

Based on a team decision, three levels of storage exist in the open-plan: day's-work-type storage consisting of personal file drawers located in a central area and/or briefcases for immediate needs, centralized department files containing the various product materials, and an enclosed area maintained as an attic during the transition. Such storage is psychologically comforting—a place where history can be kept nearby, until the members feel they can do without it. We assumed that 50 percent of our previous storage space could be eliminated, and our assumption proved to be correct.

The duplication of manuals, instrumental aids, dictionaries, reference materials, etc., is no longer required. One central set of documents is adequate, and the time and money saved in extra copies and updates is significant. Twenty, five-drawer files were reduced to six and twelve large two-door cabinets were reduced to six.

Isn't individual privacy important?

It is difficult for people to conceive of any privacy in an open area. How can they conduct confidential business? What about the times when they need to be alone? What prevents curious onlookers from gazing at personal, confidential paperwork? How can they cope with the constant interruptions and distractions that appear inevitable without walls and fixed work stations?

Levels of privacy were considered for the open-plan.

Assuming that there would be times when privacy is required (realistically or psychologically), a totally private area was included. In addition, for those needing semiprivacy to quietly read papers or technical journals, a semiprivate corner was designed with winged swivel chairs, divided from the rest of the area by a visual-drapery drop. The trial period of twelve months has indicated no adverse effects relative to privacy. In fact, those areas designed for privacy have been rarely used.

There have been some unexpected advantages in the open-plan. For example, distractions are less than we had anticipated. In the conventional layout, the clanking of footsteps along the hallway disturbed everyone. In the open-plan, the carpet controls this noise, and one hardly notices through-traffic.

Unwanted interruptions seem less frequent. People can see and sense whether to interrupt, and yet the advantage of inducing communications at the right time is conveniently at hand.

A cubicle often becomes a gathering place for friends who have time to spare. Friends are not always considerate of your time, and this often presents a problem to your roommate if you share a conventional office. In the open-space plan, these gatherings are minimized, and the roommate has the option of choosing another work area, since no one is assigned to any fixed station.

Won't phone usage be a problem?

Telephone and electrical power could have been a problem. Unless a building is designed for an open-floor plan, there are physical restrictions that make it difficult to bring the power down to the furniture and equipment.

We were able to utilize power poles for electrical drops to the lab workbenches (3 required), but we needed to find another solution for the telephones. The desire to keep the area flexible was the argument against fixed stations with telephones. The major requirements were:

- an adequate number of phones
- one incoming number for all department members
- elimination of the distraction of ringing phones
- a mechanism to transfer calls around the room

These four requirements were accomplished by utilizing a small switch controlled board which has five incoming lines and twelve extensions. The twelve phones are randomly located around the room, and, in addition to being an extension, a turn of the button gives them a separate outside line. Two standup phone stations are located on permanent building columns, four floor jacks near tables, and the remaining six phones are placed on radiator shelves or tables near perimeter walls. One fixed work station was developed to handle the transfer of incoming calls. The openness of the area allows this "controller" or "communicator" to glance around the room and quickly identify the party called. It is set apart from the rest of the room by a block of carpeting in a contrasting color, and serves as a guide for visitors, a central point for mail, files, and supplies.

How has the non-territorial office worked out?

The transition to the open-plan took approximately one month, and consistent with our expectations, a number of adjustments were required. Changes in attitude and sense of value resulted. The adjustments to using central-storage files and the sharing of work stations and tools were smoother than anticipated.

Engineers and technicians can discuss and evaluate experiments right in the lab area.

Rearrangement time and expense is minimal. If it's an office situation, it's as simple as inviting the person in and asking him to pull up a chair. This also applies to anyone leaving the group; a handshake good-bye is the extent of the arrangement. The most that can happen when we expand, is the addition of a few tables, chairs, and possibly some file drawers.

Laboratory rearrangement should be reduced by two-thirds. There are fewer pieces of equipment involved, thereby reducing electrical work and moving costs. Less equipment can save approximately one-half of depreciation expense to the department.

We estimate that should the entire facility have some type of open-planning, a 25% growth without new construction could be accomplished. Maintenance is 25% less than the cost of the conventional layout, due to ease of movement (no walls to go around), absence of tile floors to be cleaned, washed and waxed, and less furniture.

Will people like it? Will people adjust to it? We have adjusted, and we do like it. "I'd hate to think of going back to walls," states a senior technician.

An advisory engineer testifies, "There's a lot more contact with my colleagues. I may be going to sharpen my pencil, and overhear a conversation that's relative to my work."

A staff engineer with the company for 15 years states, "It's by far the most advantageous environment I have ever worked in. You're not restricted by four walls. It's a little inconvenient not having files and paper clips right next to you, but that's minor."

Semi-privacy is attained with natural partitions and a moveable blackboard, without sacrificing the overall flexibility of the area.

"In the old days, if you heard a phone ringing down the hall, you'd feel obliged to answer. Here you're not bothered by phones and a lot fewer people are making small talk. If I want to talk to someone, I look up to see if he's busy. If it looks as though I'm going to blow the whole formula by going over, I sit tight."

"At first, I thought it was quite a sacrifice. Now my values have changed." Or, as another member of the department put it, "Most of us realize that a fancy office doesn't mean that much. The real difference between people is in intelligence, creativity, and pay."

Some found the pace in open-space exhausting for a time. "In a cubicle you can just sit back and relax on occasion. I haven't adjusted to doing that here; it's a relearning experience."

The open-plan certainly has stimulated teamwork. Two of our engineers had to solve a problem fast, and they found the new environment helped them perform under pressure. They devised a fault-finding test in a week and a half. "Because of the flexibility of the area, we could get to the right people fast, sit in our office and at the same time talk with the guys running tests in the lab."

Management finds this open-plan an advantage. People-availability is an asset—getting to know them and their work.

We like the decor of our new area. It's nice having color, and we no longer have the need for decorating with posters, pictures, knickknacks, etc.

We have accomplished what many thought was an impossibility. We were constantly warned that it would never work, but we adjusted to working within a group territory and prefer it to the old enclosed offices. This concept can be adapted to similar groups, with caution. You must plan your area based on the function required.

Because of the initial fear of change a new concept creates, all occupants of the area must be involved in the planning. Setting an area aside for use by temporary teams (task-force situations) might acquaint groups with non-territorial open space. These teams would view the scheme as a temporary thing, but they may learn to enjoy it.

We have created an open, problem-solving climate, an area designed for more information sharing. Our open-plan, described in three words, is functional, comfortable, and pleasant.

Is a non-territorial office the answer for you? □

Editor's Note:

Mrs. Carter was an occupant of the non-territorial plan at IBM's Essex Junction, Vermont facility, and was one of the originators of this plan. Her comments represent her personal experience with the plan. Dr. Thomas J. Allen, of MIT, measured the experiment for a period of one year and submitted his findings in a final report, "Communications and Space Utilization in a Product Engineering Group." Dr. Allen also presented his findings at the American Psychological Association Convention in Washington, D.C. in September of 1971, and has prepared a report which will appear in "Human Factors" late this year.

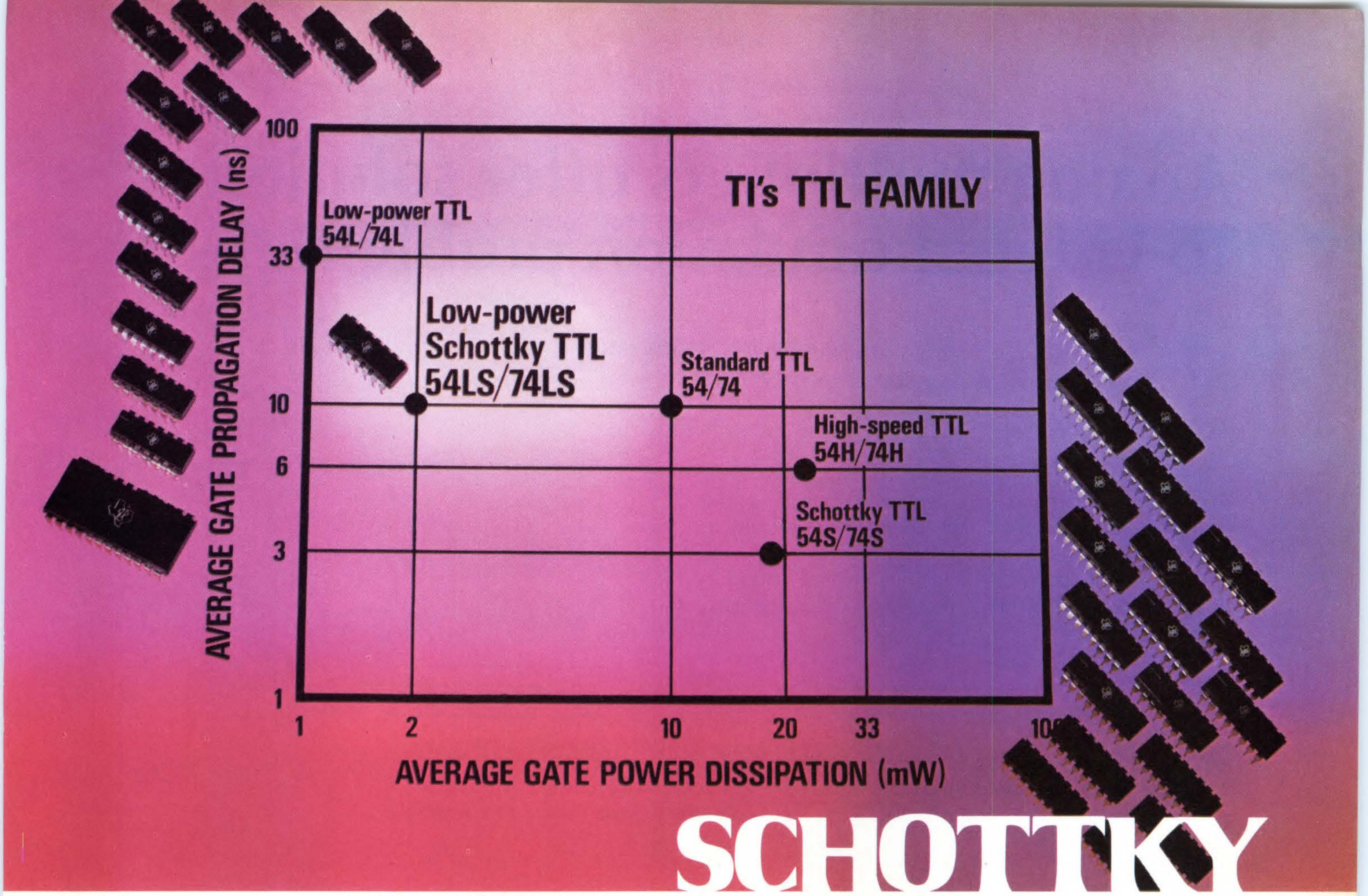
There are still unknowns in non-territorial office planning, including their long-range affects on people, and the breadth of business environments in which this type of planning will function well. The success of the original plan has, however, led to development of another at the same IBM site, and to consideration of others for different types of occupational groups.

EDN is curious what you, the reader, think about this open-space concept. Would you like to work in such a non-territorial office? Please check the appropriate number on the reader service card.

Yes R.S.#250 **No R.S.#251**

Author's biography

Marion Carter has worked at IBM for seven years. Her current job is editorial assistant for employee and management communications. As one of the originators of the open-space plan, Mrs. Carter was a team member throughout the experiment. She attended Lyndon State College, is married to the South Burlington, Vermont police chief and has two children.



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Analog multipliers offer solutions to video modulation problems

This modulation system is suitable for industrial color CCTV. Using JFETs and 741-type op amps, it provides modulation frequencies of up to 1 NHz.

Garry R. Shapiro, Vadic Corp.

In many applications utilizing analog multipliers, a designer may only require wide frequency response on one input and wide dynamic range and/or good linearity on the other (e.g., an AM modulator). Unfortunately, simple alternatives to commerical high-performance hybrid or IC multipliers often exhibit nonlinearity when approaching zero output.

The modulator/multiplier of **Fig. 1** uses the linear region of a FET drain characteristic and provides a reasonably linear response to both inputs through zero modulation factor.

Consider the N-channel FET drain characteristic of **Fig. 2**. In the linear region, the drain current is:

$$i_d = K_1 V_{DS}(V_{gs} - V_p)$$

Where $K_1 = \frac{1}{V_p R_{ON}}$

If signal plus bias is applied to the gate

$$V_{gs} = V_1(t) + V_{GS}$$

$$D = K_1 V_{DS}[V_1(t) + (V_{GS} - V_p)] \qquad (1)$$

In **Fig. 1**, V_{DS} is controlled by the input voltage

$$V_{DS} = K_2 V_2$$

Assuming a high beta for Q_1, and a low drain resistance for Q_2 (choose a low R_{ON} FET), essentially all the drain current will appear at the collector of Q_1, so that:

$$i_{cl} \approx K_1 K_2 V_2(t)[V_1(t) + (V_{GS} - V_p)]$$

If you eliminate the dc component by ac-coupling or level shifting, then,

$$V_o = K_3 V_2(t) V_1(t) \qquad (2)$$

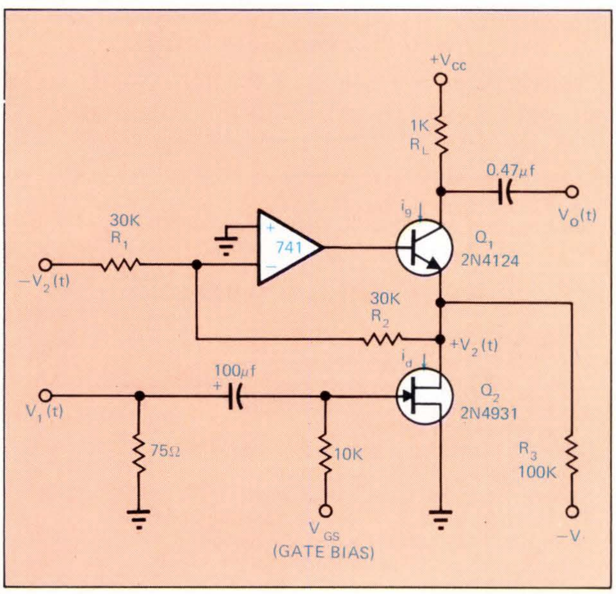


Fig. 1 – Modulator/multiplier circuit uses the linear portion of the 2N4931 FET to provide linear response at near zero modulation, an area where the more familiar differential-pair circuits are nonlinear.

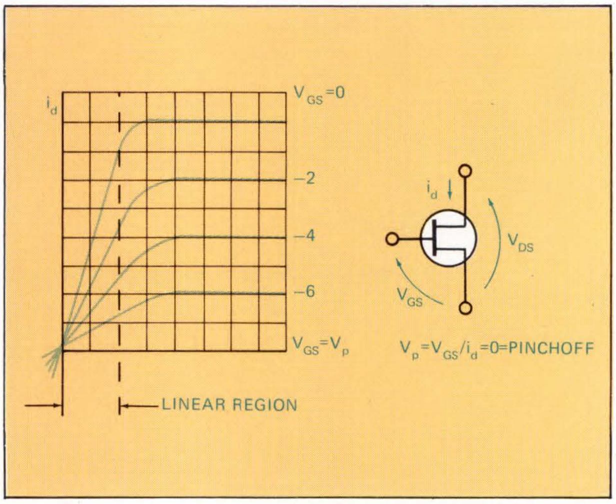


Fig. 2 – Choice of FET is important. R_{ON} must be low and the linear region of the drain curves must be wide. Typical voltage controlled resistor FETs show linear response from 0 to 100 mV V_{DS}, but the 2N4391 used in these circuits is linear to 300 mV.

The width of the linear region of the drain characteristic primarily determines the choice of a FET. Typical VCR (voltage controlled resistor) FETs are good to only 100 mV, while the 2N4391 is good to 300 mV, and usable to 500 mV for less critical applications. For good linearity, look for a FET with both low R_{ON} and high pinchoff. Extend the dynamic range of $V_2(t)$ by increasing the ration of R_1 to R_2. R_3 provides a small bias current to Q_1 to offset its beta drop-off at low collector currents.

$V_1(t)$ will normally be the input having the greater bandwidth. Q_1 and Q_2 are in cascode, and 15 MHz bandwidth was obtained with a 2N4124 for Q_1.

Since the FET signal current does not pass through the op amp, the bandwidth requirements of the op amp are those of $V_2(t)$. For $V_2(t)$ signals below 1 MHz, a 741 op amp is satisfactory.

In an industrial CCTV.RGB color system, it was necessary to modulate each video signal with a function F(t), according to:

$$V_o = [1\text{-}F(t)]V(t) + BF(t)$$

$$0 \leq F \leq 1 \text{ and } 0 \leq B \leq 1, \qquad (3)$$

where F(t) contained components to 1 MHz. The parameter B determined display color when video was blanked (F = 1).

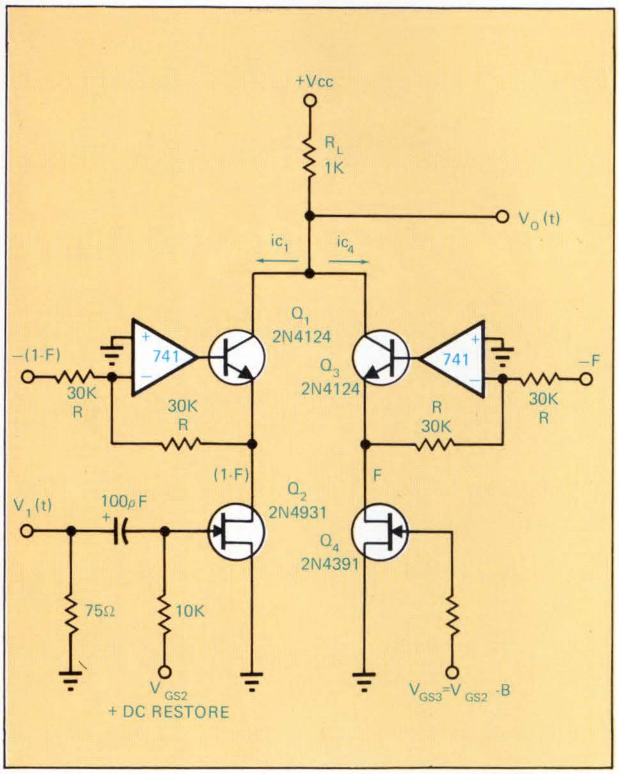


Fig. 3—FET modulator used in an industrial CCTV/RGB color system is a balanced, direct coupled version of **Fig. 1**. FET signal current does not pass through the op amp in these applications and 741 type op amps can handle modulation frequencies up to 1 MHz.

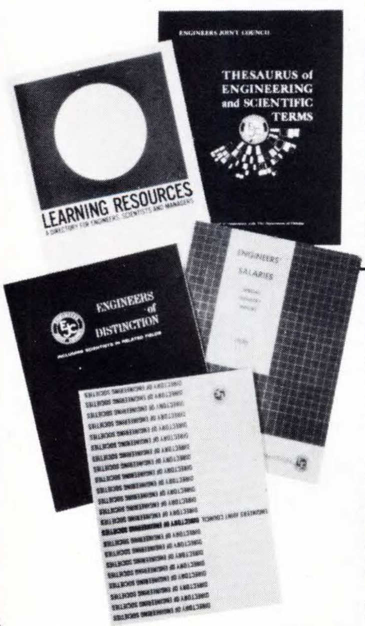
The circuit used to accomplish this is shown in **Fig. 3**; it utilized a balanced, direct-coupled version of **Fig. 1**. Using eq. 1, and assuming well-matched FETs:

$$V_o = (i_{cl} + i_{c4})R_L$$
$$= K_4[(1 - F)(V_1(t) + (V_{GS2} - V_p) + F(V_{GS3} - V_p)]$$
$$= K_4[(1 - F)V_1(t) + (V_{GS3} - V_{GS2})F - V_p]$$
$$= K_4[(1 - F)V_1(t) + BF] - (\text{Constant}) \qquad \text{(eq. 3)}$$

Note in eq. (3) that B is merely the difference in gate-source bias voltages. For B = O (equal bias on the FETs), the linear term is cancelled, leaving the product term only. The use of matched FETs enables a single voltage B to remotely control multiple channels. However, since the right side of the circuit provides only cancellation of the linear component, the circuit may be *greatly* simplified for single-channel applications by replacing Q4 with R4, obviating the requirement for matched FETs. The linear component may then be nulled by trimming R_4 or V_{GS2}. □

Author's biography

Garry Shapiro is a senior engineer at Vadic Corp., Palo Alto, Calif., where he is responsible for design and analysis of low and medium speed data modems. Garry received his BEE from Renselaer and his MSEE from Stanford University.



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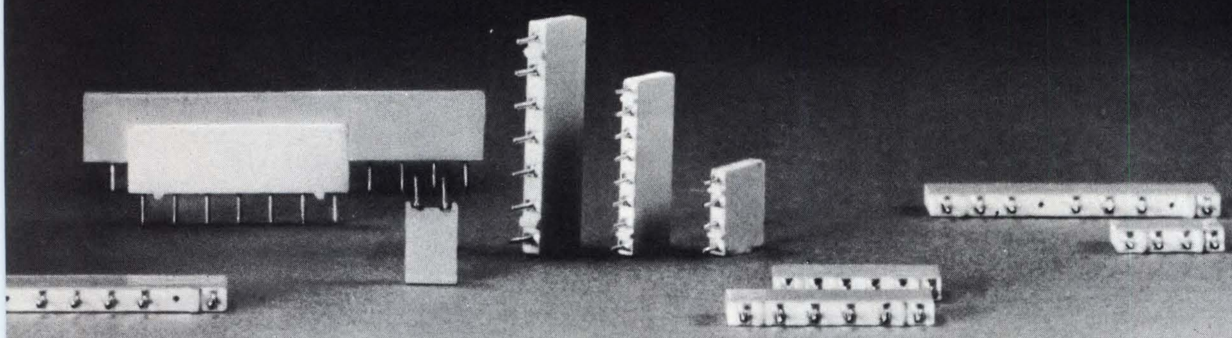

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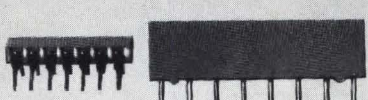

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CHECK NO. 20

Nomographs simplify calculations of magnetic shielding effectiveness

The complex equations which describe magnetic shielding effectiveness can be solved quickly and easily by using three nomographs and one graph.

Robert B. Cowdell, ITT Gilfillan

Shielding effectiveness (S_H) describes the ability of a given material to act as a shield against incident magnetic fields. It is composed of three factors: reflection losses (R_H), absorption losses (A) and secondary reflection losses (B). These factors can be calculated separately and added as follows:

$S_H = R_H + A + B$ (all quantities in decibels).

The first two factors can be determined by using one nomograph each; however, the third is complex and requires both a nomograph and a graph. In fact, B has been so difficult to calculate in the past, that it was usually neglected. The effect of neglecting B can result in errors of up to 20 dB at lower frequencies (<2 kHz), as shown in **Fig. 1** for two different shielding materials.

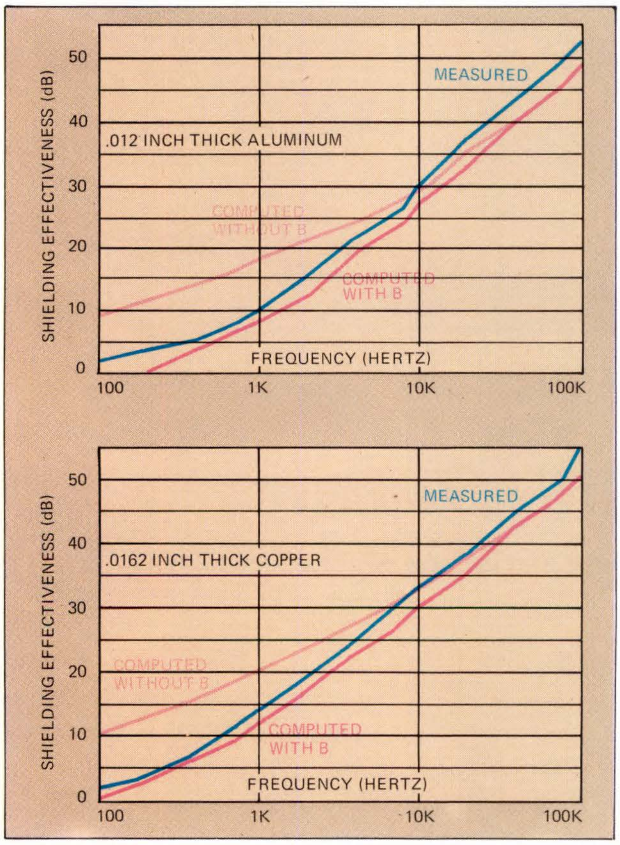


Fig. 1 – The effect of neglecting secondary reflection losses (B) can result in errors of up to 10 dB (Test distance = 2 in.) in magnetic shielding effectiveness.

Absorption losses

Absorption losses (A) are a function of the physical characteristics of the shield and are independent of the type of source field. For a given thickness, magnetic materials such as steel provide higher absorption losses than nonmagnetic materials (copper). When reflection losses are low, thicker high-permeability materials are employed to increase shielding effectiveness.

The equation used to solve for A is:

$$A = 3.334 \times 10^{-3} t (\mu_r \sigma_r f)^{1/2}$$

where t = metal thickness in mils,
μ_r = material permeability relative to air,
σ_r = material conductivity relative to copper,
f = frequency in Hz.

The nomograph in **Fig. 2** solves this equation for A.

Reflection losses

The computation of reflection losses can be greatly simplified by considering shielding effectiveness for incident electric fields as a separate problem from that of magnetic fields or plane waves. In the shielding equation, R thus becomes either R_E, R_H, or R_P as computed.

$$R_H = 20 \log_{10}[0.462/r(\mu_r/f\sigma_r)^{1/2} + 0.136r(\mu_r/f\sigma_r)^{-1/2} + 0.354]$$

where r is the distance between the source of energy and the shield in inches.

The nomograph in **Fig. 3** solves the equation for R_H.

Secondary reflection losses

When absorption losses are very low (usually less than 6 dB), the magnetic shielding effectiveness due to reflection losses changes, and the equation for R_H is no longer accurate. The complex equation for magnetic field secondary reflection losses shown below expresses this change. The factor B can be mathematically positive or negative (in practice it is always negative), and becomes insignificant when A > 6 dB. It is usually only important when metals are thin, and at low frequencies (i.e., below approximately 20 kHz).

$$B \text{ (in dB)} = 20 \log_{10} \left| 1 - \left(\frac{(K-1)^2}{(K+1)^2}\right)\left(10^{-A/10}\right)\left(e^{-j.227A}\right) \right|$$

where A = Absorption losses (dB)
$|K| = |Z_S/Z_H| = 1.3(\mu_r/f_r^2\sigma_r)^{1/2}$
Z_S = shield impedance
Z_H = impedance of the incident magnetic field

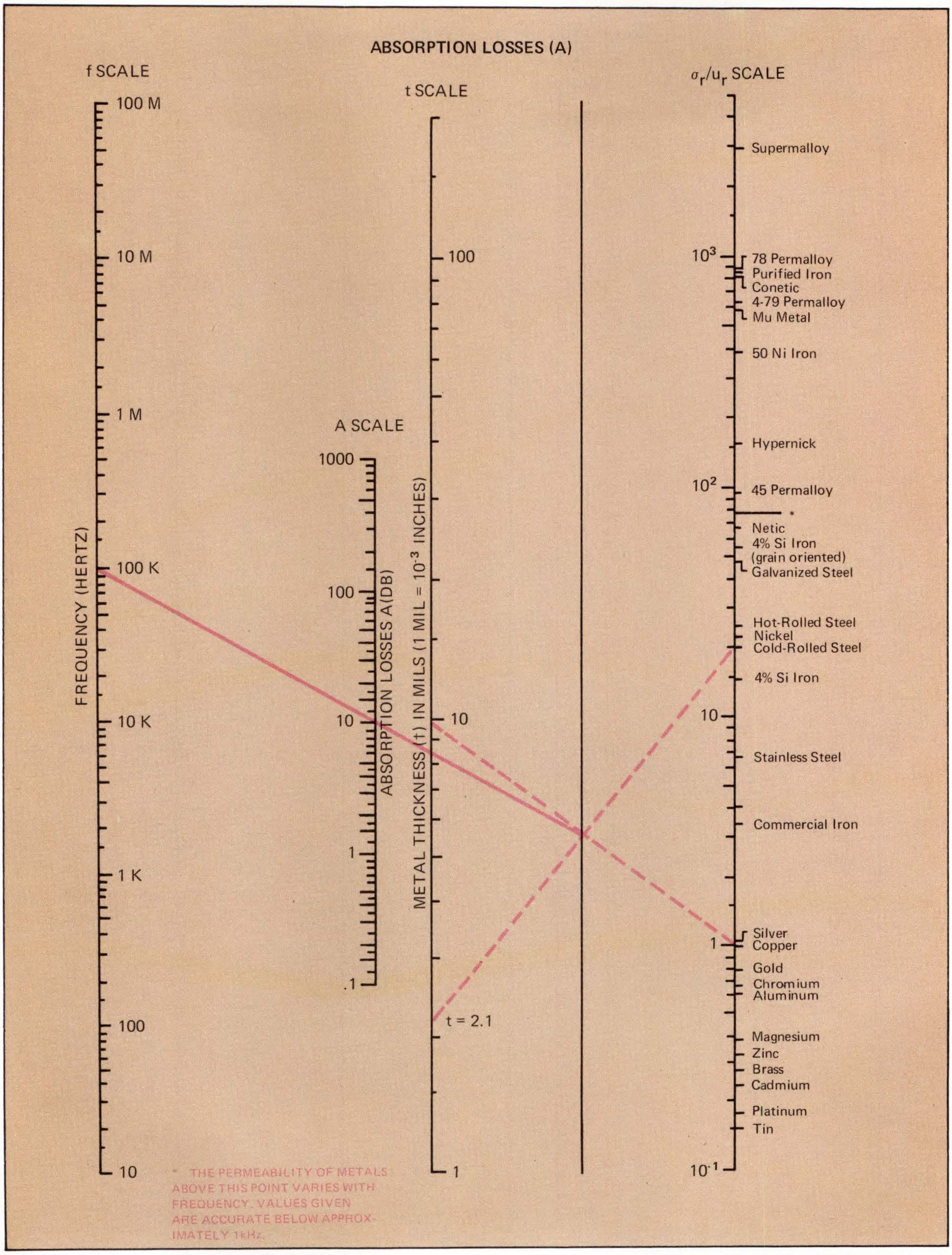


Fig. 2 — How to use the Absorption Loss nomograph. Given a desired amount of absorption loss at a known frequency, determine the required thickness for a known metal.

1) Locate the frequency on the **f scale** and the desired absorption loss on the **A scale**. Place a straightedge across these points and locate a point on the unmarked scale. (Example: A = 10 dB, f = 100 kHz.)

2) Pivot the straightedge about the point on the unmarked scale to various metals noted on the σ_r/μ_r **scale**. A line connecting the σ_r/μ_r **scale** and the point on the unmarked scale will give the required thickness on the **t scale**. (Example: for copper t = 9.5 mils, for cold rolled steel t = 2.1 mils.

3) The absorption loss nomograph can also be used in reverse of the above order.

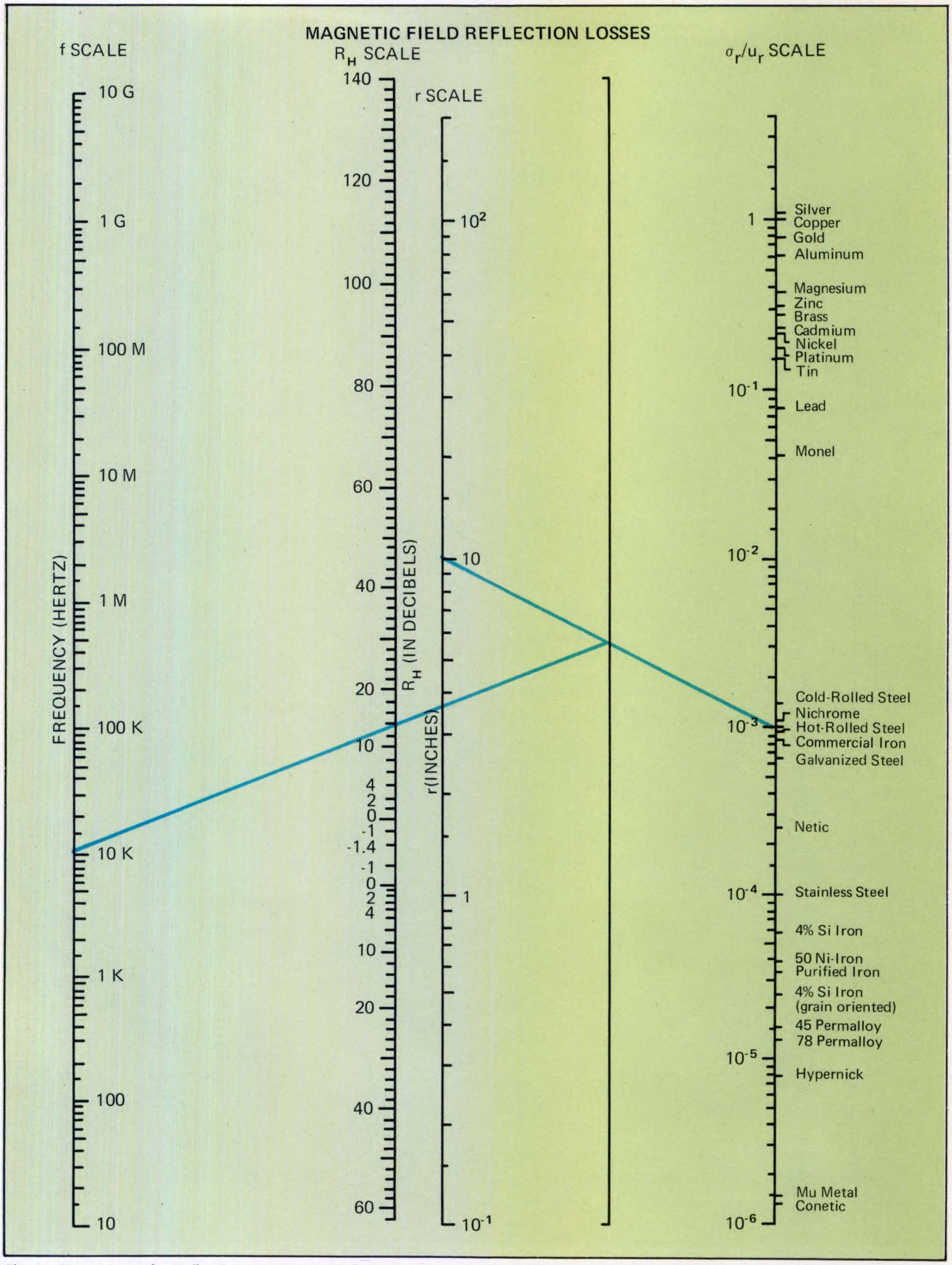


Fig. 3 – How to use the Reflection Loss nomograph.

1) Locate a point on the σ_r/μ_r **scale** for one of the metals listed. If the metal is not listed, compute σ_r/μ_r and locate a point on the numerical scale.

2) Locate the distance between the energy source and the shield on the **r scale**.

3) Place a straightedge between r and σ_r/μ_r and locate a point on the blank scale (Example: r = 10 inches for hot rolled steel).

4) Place a straightedge between the point on the blank scale and the desired frequency on the **f scale**.

5) Read the reflection loss from the $\mathbf{R}_H$ **scale**. (For f = 10 kHz, R_H = 13 dB).

6) By sweeping the f scale while holding the point on the blank scale, R_H versus frequency can be obtained. (For f = 1 kHz, R_H = 3.5 dB).

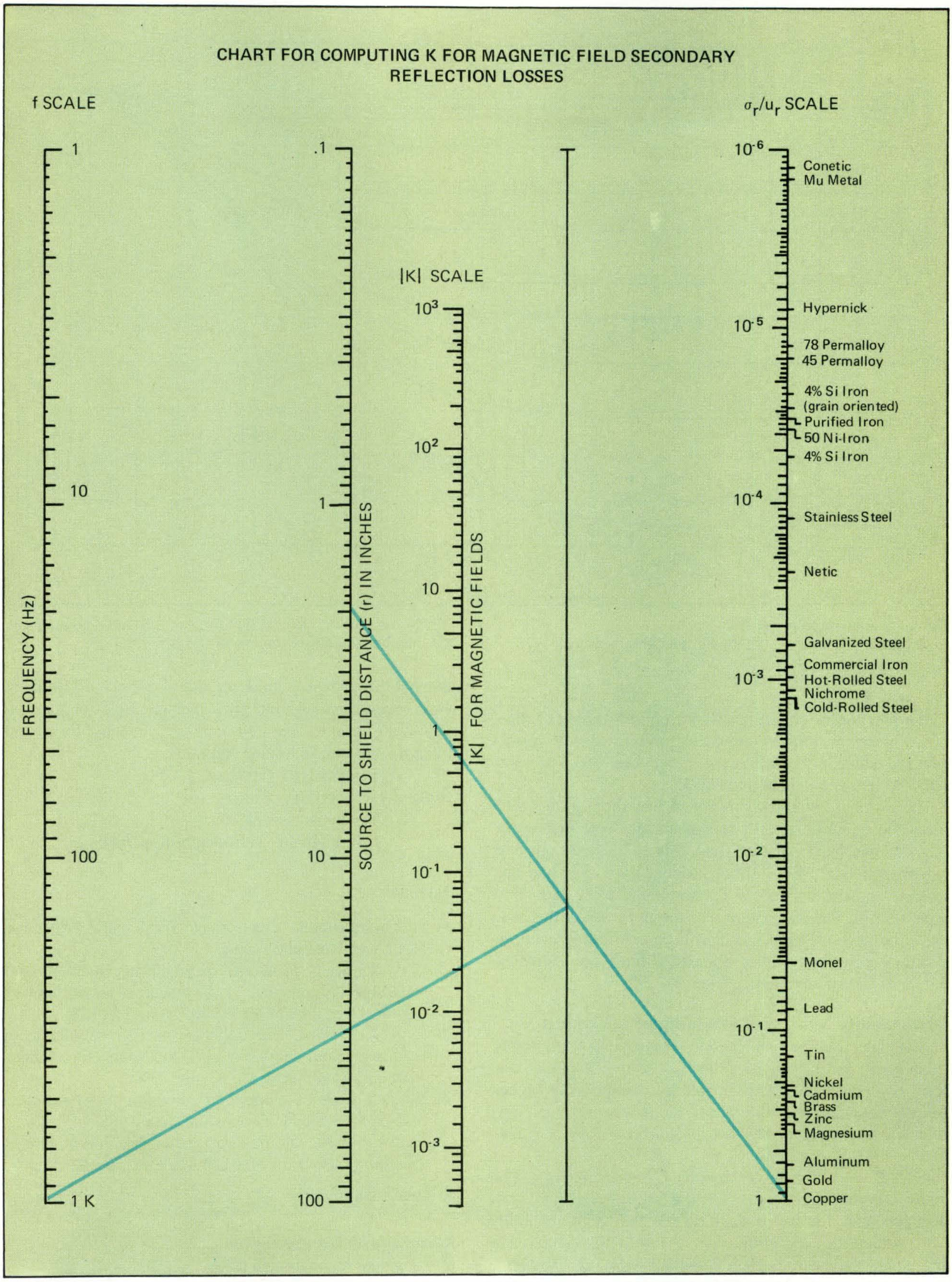


Fig. 4 – How to find |K|. B can easily be found using **Figs. 4 and 5** as follows:

Given: r = 2 inches for 0.0162 inch thick copper and A = 1.3 dB.

Find B at 1 kHz.

1) Draw a line between copper on the σ_r/μ_r **scale** and r = 2 inches on the **"source to shield distance scale"**. Locate a point on the blank scale.

2) Draw a line from the point on the blank scale to 1 kHz on the **f scale**.

3) At its intersection with the **|K| scale**, read $|K| = 2.2 \times 10^{-2}$

4) Now go to the graph (**Fig. 5**)

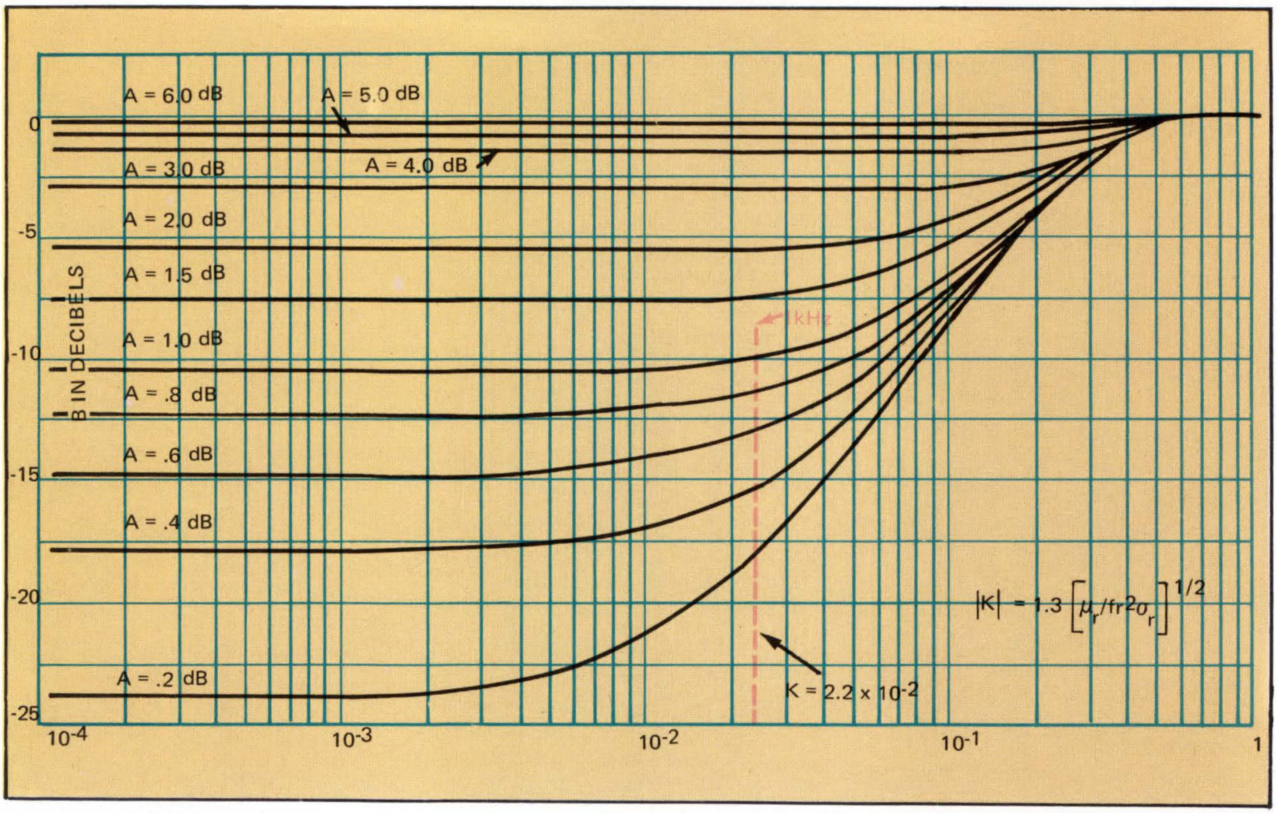


Fig. 5 – Use graph to locate B.
1) Locate $|K| = 2.2 \times 10^{-2}$ on the horizontal scale.
2) Move vertically to intersect the A = 1.3 curve (interpolate), and then horizontally to the left to find B = −8.5 dB.

The preceeding equation was solved in two parts. A digital computer was programmed to solve for B with a preselected value of A, while $|K|$ varied between 10^{-4} and 10^{3}. The results are plotted in **Fig. 5**.

The nomograph shown in **Fig. 4** was then designed to solve the equation for $|K|$ shown above. Note that when Z_H becomes much smaller than $Z_S (K > 1)$, large positive values of B may result. These produce very large and unrealistic computed values of S_H, and imply a low frequency limitation on the B equation. For the purposes of this article, only negative values of B will be considered valid. In practical cases, absorption losses (A) must be calculated before B can be obtained.

Permeability influences shielding effectiveness

Magnetic shielding effectiveness calculations are highly dependent on the permeability (μ) of the shield. It has long been thought that permeability decreased at higher frequencies, and that saturation due to exposure to high-intensity magnetic fields also produced a loss of shield permeability.

Recent work has shown that this is not entirely true. The more common building metals (i.e., cold rolled steel, galvanized steel, hot rolled steel) do not change permeability with frequency, and show only a 1 to 3 dB variation in S_H when exposed to high intensity fields (2 Oersteds). Higher permeability materials, such as netic or conetic, show both a change of permeability with frequency and a 5 to 8 dB saturation loss in 2 Oersted fields.

The permeabilities and conductivities shown on the nomographs have been measured and can be relied upon to provide accurate values of S_H. Calculations for high permeability materials may require about a 6 dB derating when exposed to high intensity magnetic fields of approximately 2 Oersteds. The field can be calculated for a loop radiator using the following formula:

$$H = 0.5\ NI/1 \text{ Oersteds}$$

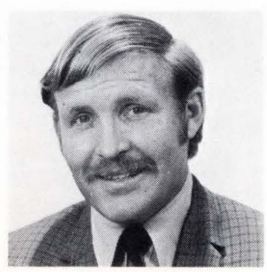
where N = number of turns
I = peak current
1 = magnetic path length in inches □

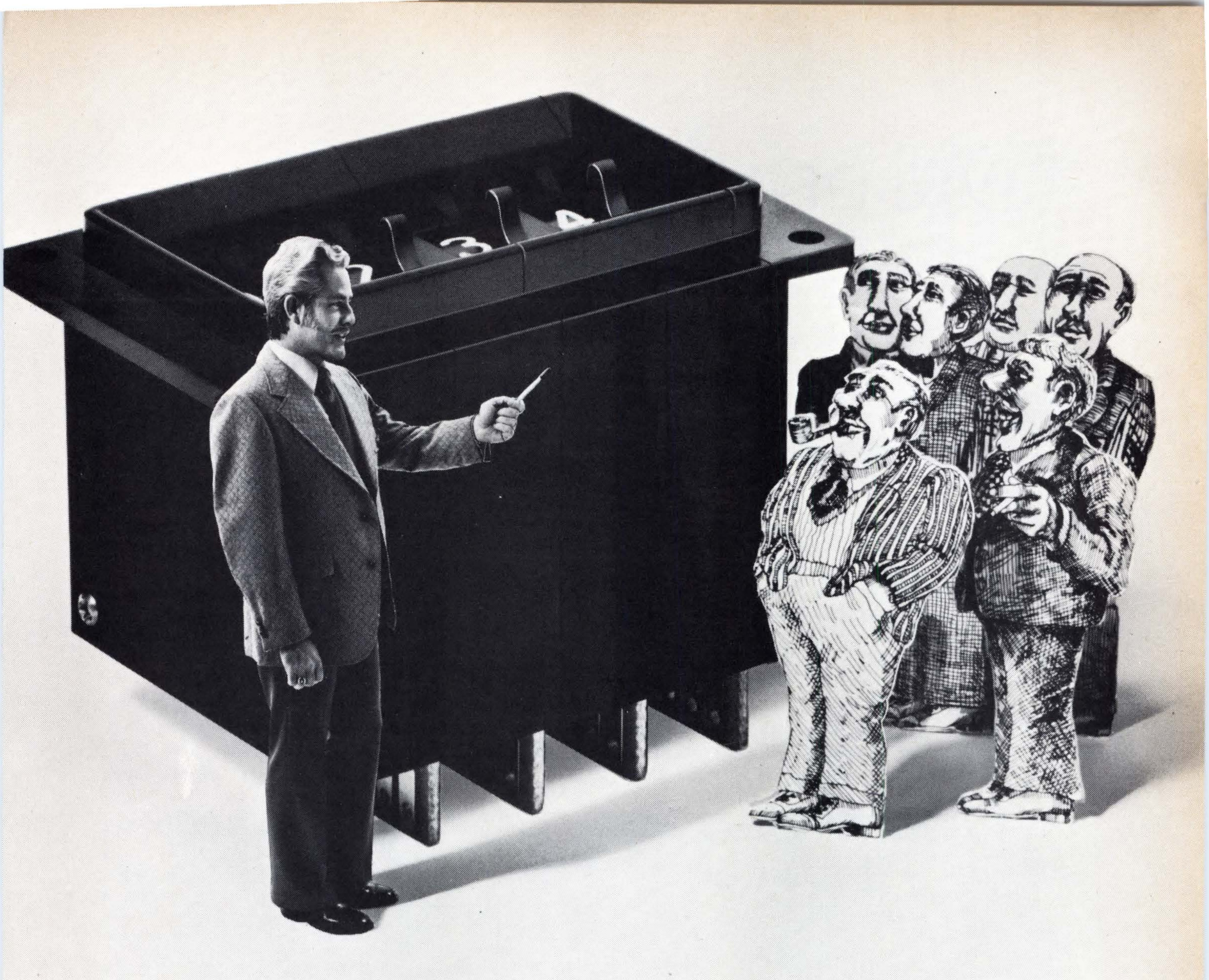
Databank

(1) S. A. Schelkunoff, "Electromagnetic Waves," Princeton, N. J.: Van Nostrand, 1943.
(2) C. S. Vasaka, "Problems in Shielding Electrical and Electronic Equipments," U.S. Naval Air Development Center, Dept. NADC-EL-N5507, June 8, 1955.
(3) R. B. Cowdell, "The Variation of Permeability With Frequency and High Permeability Magnetic Fields," 12th IEEE EMC Symposium, July 1970.
(4) R. B. Cowdell, "Simplified Shielding for Perforated Shields," 10th IEEE Symposium, July 1968.
(5) R. B. Cowdell," Nomographs Solve Tough Problems of Shielding," Electronics, April 17, 1967, p. 92.

Author's biography

Robert Cowdell is a senior project engineer managing all EMI programs at ITT Gilfillan, Van Nuys, Calif. He received his MSEE from the University of Southern California and is a member of the IEEE EMC Group Administrative Committee.





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CHECK NO. 21

EDN DESIGN AWARDS

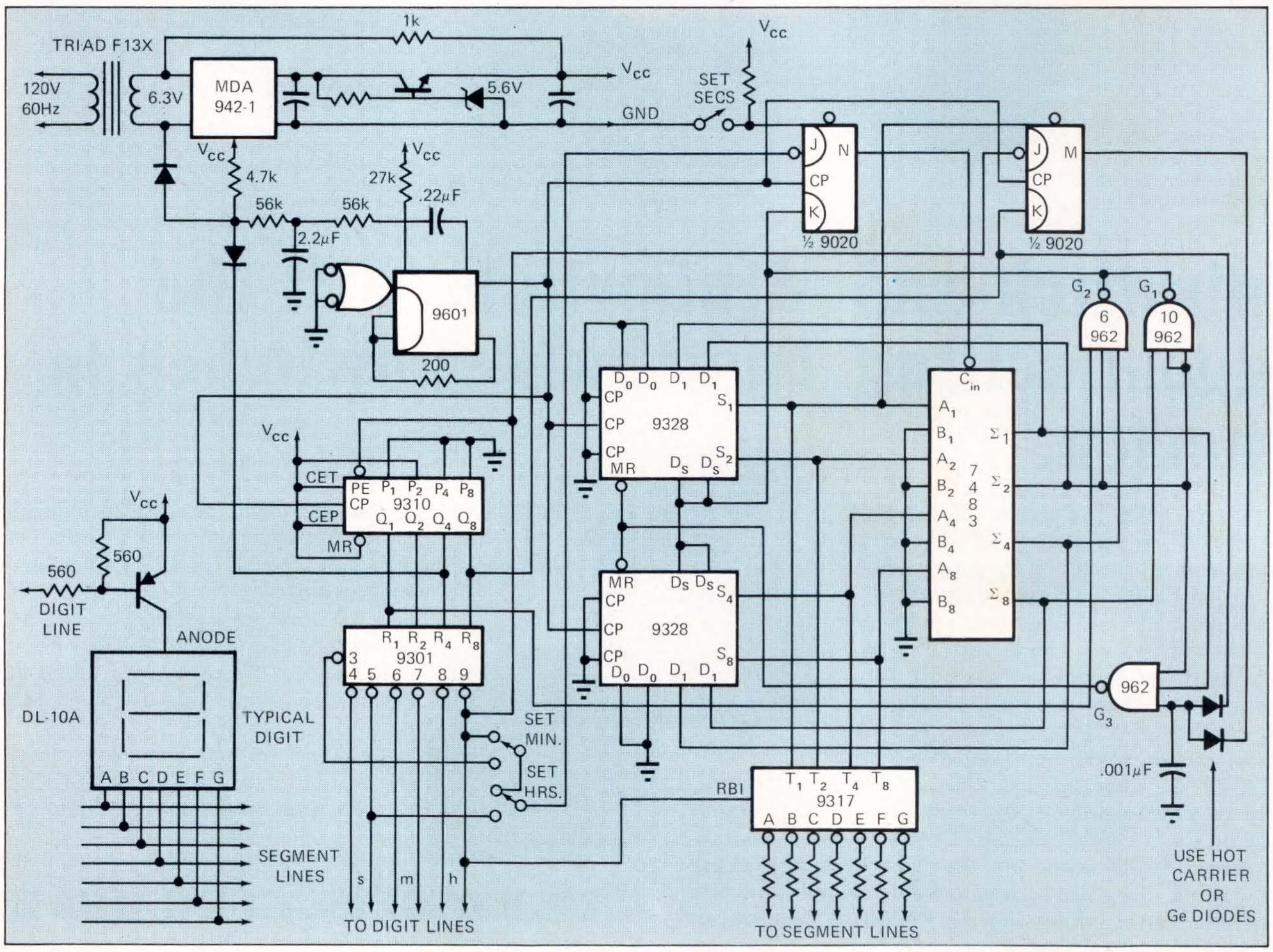
Novel clock circuit provides multiplexed display

George Smith
Litronix, Inc., Cupertino, Calif.

There are many clock circuits using TTL counters to count the 60-Hz line. The "can-count" and power consumption can be substantially reduced by a different MSI approach that yields a multiplexed display suitable for LED readouts.

Counting is accomplished by circulating the data through a binary adder, and adding one to the digit at the required times. Two 9328 packages give 8 BCD digits of storage, and a 7483 4-bit adder is used to add one when the carry flip-flop N is set.

A 9301 counter keeps track of the digit position, and via the 9301 decoder, drives the digit-select transistors. When the counter reaches state 9, the carry FF is enabled, and then set on the next clock pulse. The incremented count is reloaded into the shift register and the carry FF is reset, unless the adder output has reached 10. In this case gate G_1 switches the data select line to Do, and a zero is loaded. The carry FF reset is also inhibited, so the Cin is carried forward to the next digit. For every other digit, $Q_1 = 1$ and the gate G_2 forces a carry on 6 instead of waiting for 10. In this way, the 10, 6, 10, 6, 10, 6, 10, 6 sequence is generated. When the count reaches 10 o'clock, flip-flop M is set on every cycle. Gate G_3 then detects when the time goes to 13 o'clock, and asynchronously clears the shift register. The carry FF remains set so a 1 is loaded into the hours digit, and the transition from 12:59:59 to 1:00:00 is accomplished. The seven segment decoder driver looks at the shift register output and drives the LED segment lines.



Digital clock scheme uses TTL MSI circuits to minimize package-count. A further savings in package count is achieved by multiplexing the LED readout.

The leading hours digit is blanked, using the RBI input on the 9317.

Using push-button switches, the carry FF enable can be moved to speed up the count to permit setting the hours and minutes. The seconds are set by inhibiting the carry FF and letting the time catch up with the clock.

The 9601 one shot, in conjunction with the octal counter, and the diode AND gate forms a phase-lock loop that locks the 9601 to 480 Hz, to provide correct time. For a 50 Hz line frequency, the timing components of the 9601 must be changed to give 400 Hz, and another gate must be added to the G_1, G_2 pair to force the second digit to count by 5.

This basic scheme makes it easy to count by a different base. By using a decade counter instead of the octal counter, and adding two 9300 4-bit registers, and a few gates, the system will count down from a 1 MHz crystal.

To Vote For This Circuit
Check 150

Digital comparator is self-adjusting

Robert A. Scher
Aerosonic Corp., Clearwater, Fla.

Magnitude comparison of two 4-bit binary coded decimal numbers will normally yield a "greater than," "less than," or "equal to" decision. But greater or less by how much?

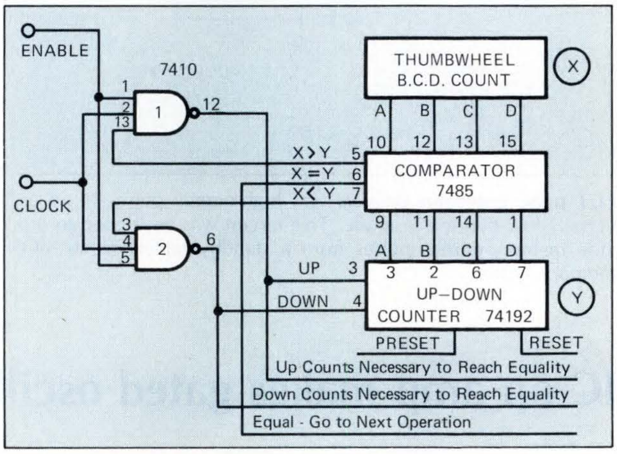
This circuit will calculate the exact difference between two 4-bit code lines X and Y. For this case X is programmed with a BCD thumbwheel switch. Y is a count preset into the 74192 up-down counter.

A 7485, 4-bit magnitude comparator is used to compare X and Y. When the NAND gates are enabled, the comparator outputs on pins 5, 6 and 7 enable either NAND gate 1 or NAND gate 2. This enables the clock to the up or down terminal of the counter. The counter continues to count until its output (Y) equals the thumbwheel count (X).

A separate register can be used to store the up or down counts necessary to reach equality.

The "equal" signal from pin 6 of the 7485 then allows the next operation to be enabled, since the difference computation has been completed.

Comparators and counters may be cascaded indefinitely to accomodate any number of BCD digits desired. □



BCD comparator provides "less than," "equal to" or "greater than" comparison between thumbwheel setting and input digit, as usual. However, if equality does not exist, the circuit will then count up or down until equality is reached, thus calculating the difference between compared digits.

To Vote For This Circuit
Check 151

PUT delivers ultra-low-power, high-energy pulses

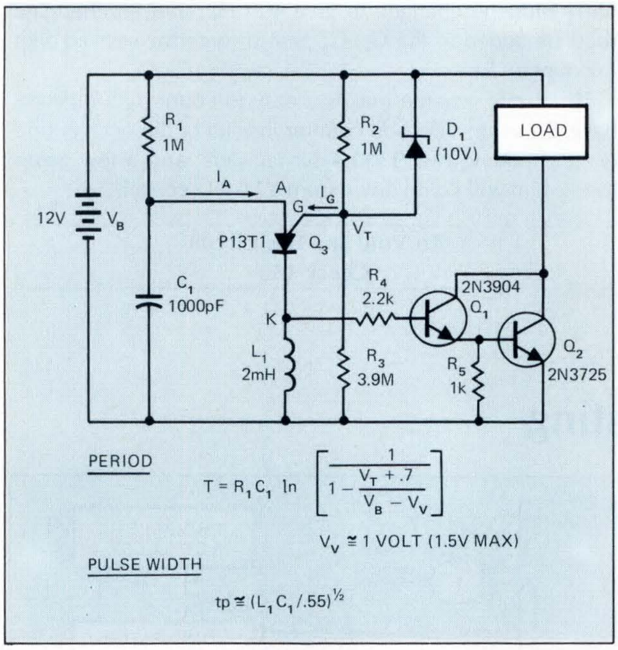
Jeffrey P. Stein
Honeywell Inc., Ft. Washington, Penn.

This circuit shows how a programmable unijunction transistor (PUT) can be used to generate an ultra-low-power, very-low-duty cycle pulse. The circuit has been applied in a battery back-up for an MOS memory system to periodically refresh the internal data-node capacitors by switching the power supply on for a very short time.

The circuit is basically a standard PUT oscillator with the voltage divider R_2/R_3 setting a threshold or trigger level. This voltage is such that the voltage across R_2 is much less than the breakdown of D_1. The zener diode, D_1, should be about 2 volts less than the battery or supply voltage. Capacitor C_1 charges through R_1 until V_A equals V_G + 0.7V. The PUT fires at this point and capacitor C_1 discharges into the base of Q_1 via R_4 and into inductor L_1. This turns on the Darligton driver pair very hard, sinking large currents from the load, and also stores some energy in the field of inductor L_1.

In order to complete one cycle and start the next oscillator cycle, the PUT must be turned off. This is done by the zener diode. When the PUT conducts, the device will "latch-up" if the anode current I_A exceeds a specified value, called the valley current, I_V. The valley current is directly related to the current flowing into the gate electrode. The PUT then conducts and the gate draws current, pulling the voltage at the gate down until the zener diode breaks down. The gate current then becomes very large until the point where I_A becomes less than I_V and the PUT turns off.

When the PUT turns off, the inductor no longer sees current flowing into its winding, and because of its collapsing field, generates a negative transient at the base of the Darlington, cutting it off rapidly. This generates a high-power pulse with very sharp rise and fall times. The



PUT pulse generator delivers very-high-energy pulses in an extremely-low-duty-cycle mode. This circuit was developed to provide memory-refresh pulses from a standby battery to an MOS memory system.

charging sequence then starts again to sustain the oscillation.

This circuit generates a very high energy pulse of short duration and low duty cycle. Typical values are:

t_p = 1.5 μsec
T = 1.5 msec
I_L = 1A Peak
$t_r \leq$ 200 nsec
$t_f \leq$ 200 nsec

Standby power is consumed only in the resistor divider R_2/R_3 and the charging resistor R_1 which can be very large. The only other currents are small leakage currents across the device junctions. The real key to low-power operation is the elimination of the interbase channel resistance (6k-10k) of the more common UJT used in this type of circuit. Also, the zener diode allows R_2/R_3 to be made very large while still maintaining proper operation without "latch-up." □

To Vote for This Circuit
Check 152

IC op amp makes gated oscillator

Frederick Macli
North American Philips, Briarcliff Manor, N.Y.

This circuit is a gated 5-MHz relaxation oscillator with several unique features. Its output always starts in the same phase with respect to the gating signal. The major circuit components are a gate controlled wideband amplifier, MC 1545G, and a frequency selective network comprised of R_1, R_2, and C. This network provides positive feedback around the amplifier. The conditions for oscillation are controlled by varying the amplifier gain via the gate input. For example, a gate signal supplied from T² L logic can vary the amplifier gain from −70 db at logic "0" to +20 db at logic "1".

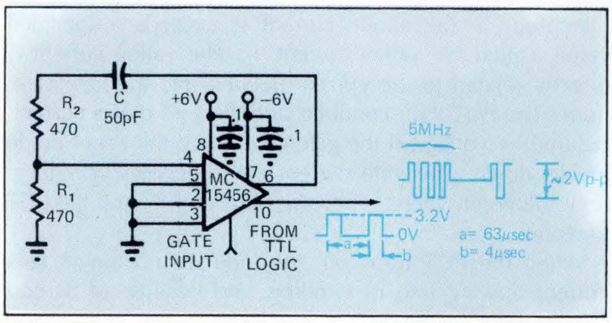
The selection of resistors R_1 and R_2 should be limited by:

$$[(R_1 + R_2) \div R_1] > K$$

where K is the amplifier gain with a high gate voltage. R_1 is also limited in value by bias current considerations of the amplifier. The period of oscillation has been found to be approximately:

$$T \approx 4(R_1 + R_2)\, C.$$

The MC1545G has a 3 db frequency of 75 MHz with a single ended voltage gain of 20 db. Thus, extending the operating frequencies well beyond the 1-10 MHz range should not be any problem. □



This single IC op amp makes a gated 5 MHz oscillator which always starts with a positive pulse. Adaptation for frequencies above 10 MHz should present no problems.

To Vote For This Circuit
Check 153

Rules & Announcements

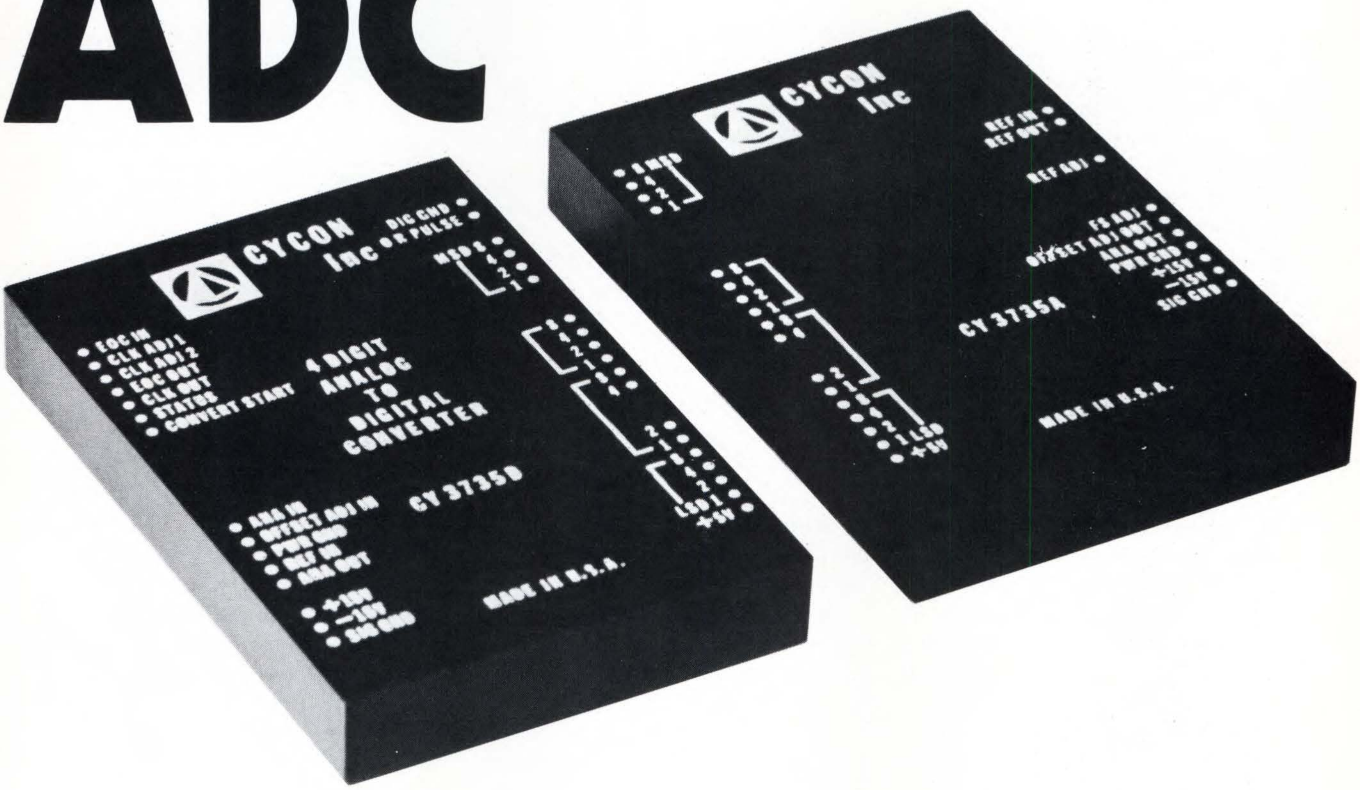
Your vote determines this issue's winner. All circuits published win a $20 cash award. In addition, all issue winners receive a $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by checking the appropriate number on the Information Retrieval card.

Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN, 221 Columbus Ave., Boston, MA 02116.

Readers have voted: Richard G. Sullivan winner of the June 1 Savings Bond Award. His winning circuit is "Test box indicates logic levels for entire IC." Mr. Sullivan is with Control Data Corp., Rochester, Mich.

THE ONLY $149 4-DIGIT ADC



CYCON's CY3735 is a complete 4-digit BCD-output ADC featuring 0.01% linearity and temperature stability of 0.003%/C° (0.001%/C° with external reference). You can buy one for $149, . . . or 100 for less than $125 each.

Packaged in two 2" x 3" modules, the CY3735 takes advantage of a unique conversion principal called "section counting" to achieve a combination of stability, accuracy and 200 μsec speed at remarkably low cost. And, for industrial control systems and other electrically noisy environments, the CY3735 incorporates automatic digital correction of transient-induced errors. A companion unit, the CY3335, offers the same features with 14-bit binary output.

Write, phone, or circle our Reader Service Number for detailed technical data and prices.

CYCON Inc

Exploiting a breakthrough in analog/digital interface technology.

1080E Duane Ave. / Sunnyvale, Cal. 94086 / Phone: 408–732-8311

CHECK NO. 32

Pair of new portable scopes eclipse predecessors

PROGRESS IN INSTRUMENTATION

Tektronix, Inc., has introduced two leapfrog updates of its successful 453 and 454 portable wideband oscilloscopes. The scope maker expects that the new 100-MHz 465 and 200-MHz 475 will easily push their predecessors (and Hewlett-Packard's competitive models 1707A and 1710A) out of the market because of their superior performance and lower price.

	"ECONOMY" MODEL			HIGH PERFORMANCE MODEL		
	Old	New	% Improve.	Old	New	% Improve.
Feature	453A	465		454A	475	
CRT Size	8 x 10 div (0.8 cm/div)	8 x 10 div (1.0 cm/div)	25%	8 x 10 div (0.8 cm/div)	8 x 10 div (1.0 cm/div)	25%
Bandwidth	60 MHz	100 MHz	67%	150 MHz	200 MHz	33%
Deflection Factor at Full BW	20 mV/div	5 mV/div	400%	10 mV/div	2 mV/div	500%
Min. Deflection Factor	5 mV/div	5 mV/div		2 mV/div	2 mV/div	
Trigger View	No	Yes	100%	No	Yes	100%
Scale-Factor Readout	No	Yes	100%	No	Yes	100%
Battery Operation	No	Yes	100%	No	Yes	100%
Fastest Sweep Speed	0.1μsec/div	0.05μsec/div	50%	0.02μsec/div	0.01μsec/div	50%
Weight (W/O Panel Cover)	29.3 lb	22.8lb	22%	29.3 lb	22.8 lb	22%
Cost	$2050	$1725	16%	$3200	$2500	22%
Delay Time Accuracy	1.5%	1%	50%	1.5%	1%	50%

These innovations arose out of Tektronix's desire to forestall the competition growing up in the lucrative area of battery operated instruments for field servicing of computers and communication gear. The table illustrates just what a dramatic improvement has been made. At the same time Tektronix believes that as the prices go down, there will be an increased use of these compact field instruments in laboratories. These smaller instruments save bench space, are easier to carry and when operated on their battery packs, can eliminate ground-loop problems. Also, they are good antidotes for the reduced utility-voltage levels becoming more common during "East Coast brownouts."

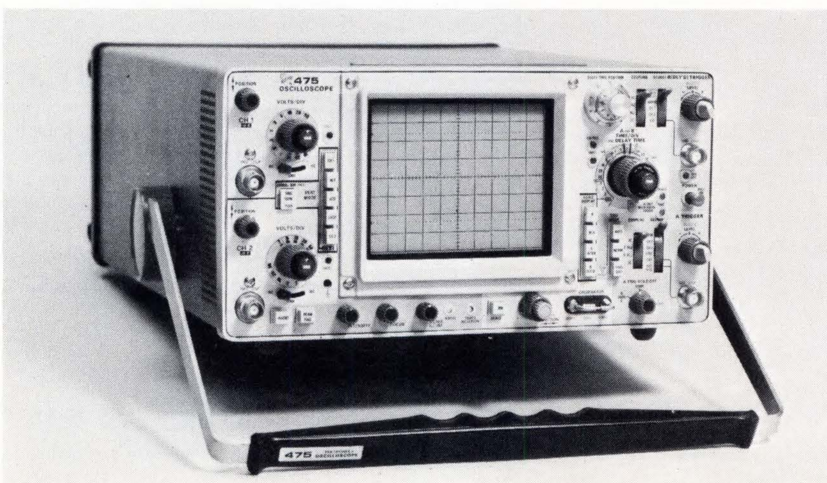
The wideband performance of the 475 comes from using the same Tektronix developed GHz-bandwidth IC-transconductance multiplier amplifier that Tektronix used on its recently announced 350-MHz, 485 portable scope (EDN, Mar. 15, 1972, pg. 77). This amplifier is a derivative of the well-known circuit developed by Barrie Gilbert while he was at Tektronix. The signal is applied at one of the two inputs while a dc gain-control signal is applied to the other. Because of the 475's lower frequency compared to the 485, it was possible to add a FET input stage (modified ground source) ahead of the Gilbert stage for high (1M) input impedance.

The lower prices for the new scopes come from the use of the "mount-everything-on-the-PC-board" philosophy made popular of late. It is almost as though Tektronix based its packaging design on EDN's report on that subject ("Make it Planar," EDN, Dec. 1, 1971).

All the front-panel switching is carried in mechanically to the electrical contacts on the PC boards, which puts the switching right at the correct points in wideband circuits. All the circuit-status outputs come from LEDs on the boards, the indications being carried to the front panel via light pipes. The configuration both helps circuit performance and reduces assembly labor.

The PC boards are mounted in a u-frame arrangement around the relatively large CRT needed for the large-screen displays in these small instruments. This "inside-out" construction makes all the circuit test points accessible and heeds the wise advice given to instrument designers in the 1950's by British medical electronics expert, P. E. K. Donaldson. Donaldson claimed that the "inside-out" package saved everybody's time because one could trouble-shoot an instrument while it was operating.

Tektronix has solved the problem of providing a reasonably stable internal temperature environment for an instru-



ment that will be operated out in the field. It has servo'd the speed of the cooling fan to a thermistor. When the instrument is out on an arctic ice flow, operating at −15°C, the fan motor (a dc hall-effect type) will be running at only about 600 rpm; when operating in the tropic sun at +55°C, the motor will be running at full speed of about 3300 rpm. Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **268**

High-speed IC for Data transmission contains four transceivers.

PROGRESS IN MICROELECTRONICS

A recently introduced quad driver-receiver from Signetics, designed for use in bus oriented systems, features a propagation delay of less than 17 nsec.

The 8T26 contains four pairs of inverting logic gates and two buffered common enable lines. Each pair of gates consists of a driver that has a 40-mA current sink capability, and a 16-mA receiver. Both the driver and receiver gates have "three-state" outputs and PNP inputs. Because PNP inputs are used, input loading is low less than 200 μA. Each driver output is internally connected to the input of its associated receiver to permit the 8T26 to transmit and receive on a single line.

A logic ONE on the bus enable input allows input data to be transferred to the output of the driver. A logic ZERO will force the output to a high impedance state, and it will also disable the PNP, resulting in negligible input load current. The receiver gate is enabled by logic ZERO on the input enable pin.

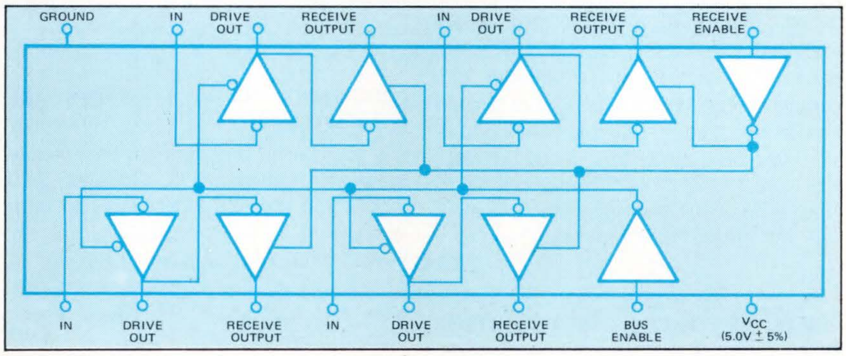


Fig. 1—The 8T26 quad transceiver, a Schottky TTL device, is produced by the 3-micron epitaxial film process introduced by Signetics earlier this year.

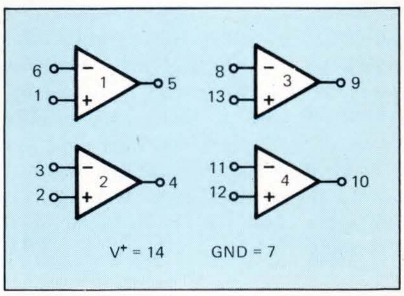
The 8T26 transceiver operates on a single +5V supply with a typical power consumption of 250 mW. When purchased in lots of 100, the "N8T26B" price is $3.90 each. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **269**

Quad op amps vie for industrial and automotive applications

PROGRESS IN MICROELECTRONICS

In February of 1971 Tom Frederiksen, then of Motorola, described a multiple, single supply voltage, high gain op amp at IEEE Solid State Circuits Conference in Philadelphia. Now Motorola Semiconductor and National Semiconductor have announced the availability of quad amplifiers. Since Tom Frederiksen is now at National, it isn't too surprising that the devices are rather similar. But there are differences.

The quad amps all share the pinouts shown in the accompanying diagram. Motorola's MC3401P and National's LM3900 are designated for use in the industrial temperature range of 0 to +75°C. Motorola's MC3301P is spec'd for the automotive temperature range of −40 to +85°C.



3 Monolitic quad op amps from Motorola and National use the same pinouts, as shown, and a single voltage supply. The use of as unique "current mirror" input results in a non-inverting unput rather than the usual differential inputs.

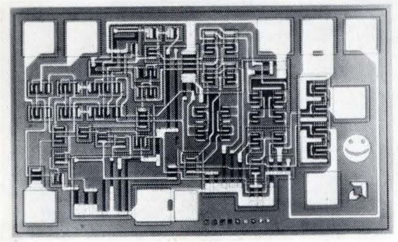
Unity gain bandwidth is 5 MHz for the 3401, 4 MHz for the 3301 and 2·5 MHz for the 3900, indicating slight differences in the internal compensation for each device. Single voltage supply ranges are +4 to +20V for the 3301, +5 to +18V for the 3401 and +4 to +36V for the 3900.

Open loop gain for the Motorola devices is typically 2000, while the National amp is typically 2800. Slew rate for National's is 0.6V/μsec vs Motorola's at 0.5V/μsec. So the tradeoffs have been bandwidth, gain and slew rate. Choose the one that best suits your design.

Pricing, the best part of the whole thing, is really a grabber: In 100-up quantities the MC3401P and the LM-3900 are priced at 75¢ each! The automotive version, MC3301P is 80¢ each.

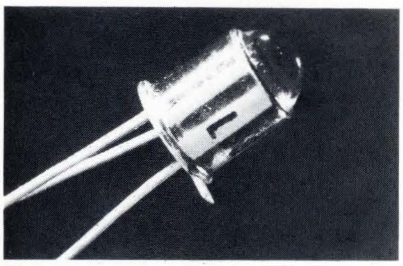
Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. Phone (602) 273-6900. **270**

National Semiconductor Corp., 2900 Semiconductor Dr, Santa Clara, CA 93152. Phone (408) 732-5000. **267**



$7^1/_2$ NSEC COMPARATOR, the Am685 was developed for those designers who require mV accuracies at nsec speeds. This comparator has 500μV input resolution and complementary ECL outputs. The circuit may be operated in a sample-hold mode at rates up to 100 MHz. Price in 100-up quantity is $8.95 to $22 each. Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvale, CA 94086. Phone (408) 732-2400. **185**

CMOS ARITHMETIC ARRAY INTRODUCED. DD4057A provides 4-bit arithmetic operations, time sharing of data terminals, and full functional decoding for all control lines. Applications of the CD4057A include parallel arithmetic units, process controllers, remote-data sets, and graphic display terminals. Price: $75.00 (1-99 quantity). RCA/Solid State Div., Route 202, Somerville, N J 08876. Phone (201) 722-3200. **186**

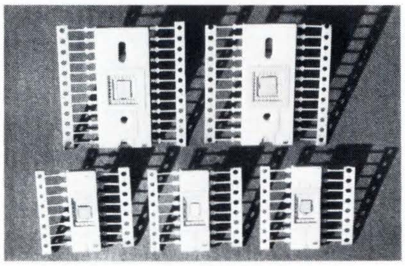


NPN PHOTOTRANSISTOR IS SPECTRALLY MATCHED TO INFRARED LEDS. The devices may be used as a sensor and emitter pair. Both the new sensor and the TIL31 emitter are compatible with the TTL and DTL circuitry. Rise time is typically 350 nsec. It is priced at $1.75 in 100-piece quantities. Texas Instruments Inc., P.O. Box 5012, Dallas, TX 75222. Phone (214) 238-2011. **187**

SUPER-BETA, MATCHED DUAL MONOLITHIC NPN SILICON TRANSISTORS now available. DC current gain is in excess of 2000 on the MPS 301. Other notable, typical specifications are $Vbe_1 - Vbe_2 = 0.2$ Mv and 11m $(VBe_1 - Vbe_2) = 1\mu V/C$. Price of the MPS 301 is $2.40 in quantities of 1000. Micro Power Systems Inc., 3100 Alfred St., Santa Clara, CA 95050. Phone (408) 247-5350. **188**

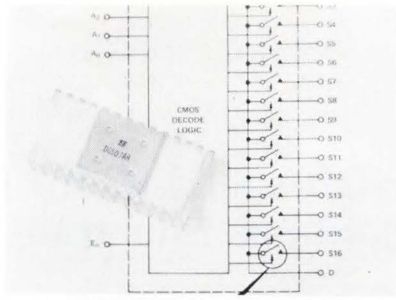
MONOLITHIC PHASE LOCKED LOOP OPERATES FROM 5 TO 26V. Frequency band is 0.5 Hz to 35 MHz, and it can accomodate analog signals between 300μV and 3V. The XR-215 also has digital tuning or multiplexing capability. Frequency can be stepped by a digital control or "channel-select" pulse. The 100-up price of the XR-215 is $10.00. Exar Integrated Systems Inc., 733 N. Pastoria Ave., Sunnyvale, CA 94086. Phone (408) 732-7970. **189**

QUADRUPLE D-TYPE FLIP-FLOPS ARE EDGE-TRIGGERED. 54/74175 quad flip-flop ICs contain four flip-flops with double rail output, buffered clock and direct clear inputs, and individual data input to each flip-flop. Max clock frequency is typically 25 MHz with a typical power dissipation of 38 mW per flip-flop. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **190**



MICROPROGRAMMABLE ARITHMETIC PROCESSOR SYSTEM PROVIDES most of the performance features of a mini-computer controller at a fraction of the cost. Unlike a mini-computer based controller, MAPS, once programmed, is dedicated to a particular application. MAPS includes an arithmetic unit (MM5700), a register unit (MM5701), a timing and control circuit (MM5702), control read only memories (MM5703 & 05), a keyboard interface (MM5704), and a static data monitor (MM5706). A typical MAPS set costs less than $100 in 100-up quantities. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. Phone (408) 732-5000. **191**

HYBRID VOLTAGE CONTROLLED OSCILLATOR, the ND-501, is a precision, wide-band oscillator sealed in a fourteen lead dual in-line package. The unit may be operated at center frequencies up to 1 MHz as determined by external timing components. Linearity is typically ±0.1%. Temperature stability is typically 70 ppm/°C over the range of −55°C to +125°C. Novadyne Inc., 3500 "B" Westminster Ave., Santa Ana, CA 92703. Phone (714) 839-5350. **192**



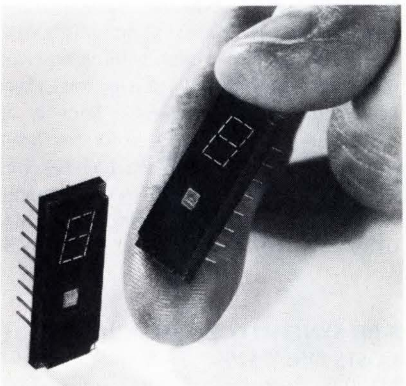
CMOS 8-CHANNEL DIFFERENTIAL ANALOG MULTIPLEXER has a 3-line binary decode input channel selection. The monolithic DG507 features a ±15V analog signal range with ±15V supplies and r_{ON} of less than 500Ω. Switching action of the DG507 is Break-Before-Make. Price in 1-29 quantity is $40.00 for parts intended for industrial service at −20°C to +85°C. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone (408) 338-0227. **193**

SCHOTTKY TTL/MSI LOOK-AHEAD CARRY GENERATOR can be combined with four 54S/74S181 arithmetic logic units (ALUs) to provide the fastest TTL adder/subtractor available. By using the S182, designers can achieve a 92% performance improvement over the standard 182. Time through the longest delay path is 6.75 nsec. Prices in 100 piece quantities are: SN74S182N, $7.56; SN54S182N, $9.45. Texas Instruments Inc., 1300 N. Central Expressway, Dallas, TX 75222. Phone (214) 238-2011. **194**

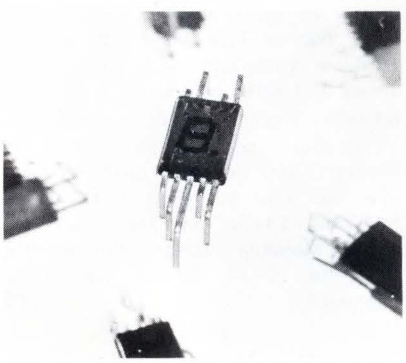
TWO WIDE-INPUT GATES ADDED TO SCHOTTKY TTL FAMILY. Designated the SN54S/74S133 and the S134, both circuits feature typical delay times of 4.5 to 5 nsec. The S133 gate has a 13-wide input section with a high fan-out. The S134 features a 12-wide input section and a three-state output. Price in 100 piece orders is $1.37 for the S133N and $1.71 for the S134N. Texas Instruments Inc., 13500 No. Central Expressway, Dallas, TX 75231. Phone (214) 238-2011. **195**

DUAL DARLINGTON DRIVER FOR INDUCTIVE LOADS. The RCA-TA8590 contains two amplifiers that can each deliver 5A with a current gain of 500, or 3A with a current gain of 600. The amplifiers include integral diodes for load-current commutation and are suited for driving inductive loads. The unit is priced at $4.25 in 1000-unit quantities, and is available from stock. RCA Solid State Div., Box 3200, Somerville, N J 08876. Phone (201) 722-3200. **196**

4.5-DECADE DVM LOGIC ARRAY contains the functions of a 4.5-decade digital voltmeter in a single logic array. The 3814 DVM Logic Array, operates from dc to 600 kHz and interfaces directly with TTL. It can drive multiplexed displays directly. The 100-999 price in a 24-pin DIP is $16.25. Fairchild Semiconductor Components Group, 464 Ellis Street, Mountain View, CA 94049. Phone (415) 962-3816. **197**

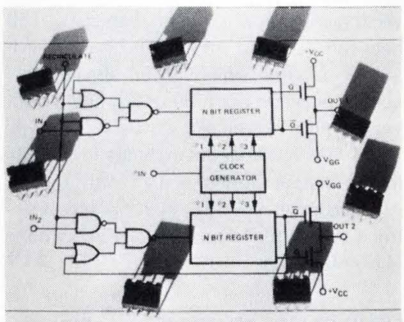


NUMERIC DISPLAY HAS INTEGRAL TTL MSI DRIVER. For application requiring BCD data display, the model 745-0008 readout contains constant-current drive for the LEDs. The decimal point is controlled independently with decimal-point latch. In quantities of 1000 units, cost is $10.00 each. Availability is from 4 to 6 weeks. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 497-7600. **198**



LED NUMERIC DISPLAY, AD-1, IS A GaAsP DISPLAY WITH 0.120 IN. HIGH CHARACTERS. Brightness of the display is greater than 200 ft-L. at 5 mA dc with a forward voltage of 1.65V at a peak wavelength of 650 nM. Power dissipation is 160 mW, and peak pulsed current is 150 mA. The display is encapsulated in red epoxy providing better contrast for improved viewing. Antex Industries, Inc., 1059 E. Meadow Circle, Palo Alto, CA 94303. Phone (415) 326-2441. **199**

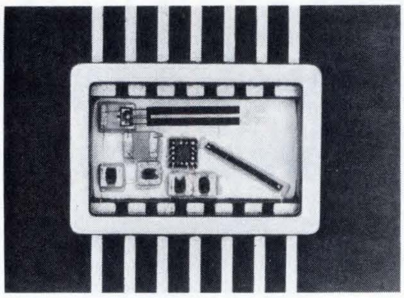
N-CHANNEL DUAL-GATE MOSFETs OFFER LOW NOISE AND HIGH GAIN. Designated the 3N204, 3N205, and 3N206, these MOSFETs feature typical noise figures ranging from 2 db at 200 MHz to 7 db at 900 MHz. In 100-piece quantities, price for the 3N204 and 3N205 is $0.80 each and $0.70 each for the 3N206. Texas Instruments Inc., 13500 No. Central Expressway, Dallas, TX 75213. Phone (214) 238-2011. **200**



LONG STATIC SHIFT REGISTERS DRAW ONLY 28 mA at 3 MHz. The Model "2527" is a dual 256-bit shift register, the Model "2528" is a dual 250-bit register, and the "2529" is a dual 240-bit version. All interface connections of the circuits are fully compatible with standard bipolar TTL ICs. Price is $9.20 ea. when purchased in a quantity between 100 and 999. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94096. Phone (408) 739-7700. **201**

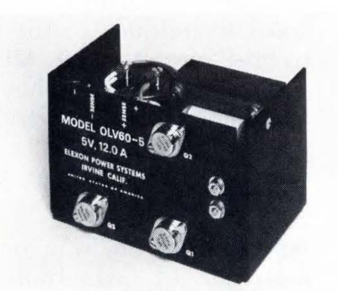
POSITIVE INPUT ANALOG SWITCHES PRICED UNDER $1 PER CHANNEL. The devices are known as the IH5025 through IH5038 series. OFF-state leakage current is 50 pA max., switching speed is less than 100 nsec. The family is designed to be driven from TTL open-collector logic (15V). Each package contains up to four SPST channels. Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. Phone (408) 257-5450. **202**

TWO-PHASE MOS CLOCK DRIVER PROVIDES FIXED-WIDTH PULSES. The HX 0009 features include dc coupling output swings to 30V, output drive to 500 mA and repetition rates to 2 MHz. Standard TTL/DTL line drivers with external capacitors can be used to set pulse width. Price is $18 ea. in 100 qty. Halex, Inc., 3500 W. Torrance Blvd., P.O. Box 2940, Torrance, CA 90509. Phone (213) 772-4461. **203**

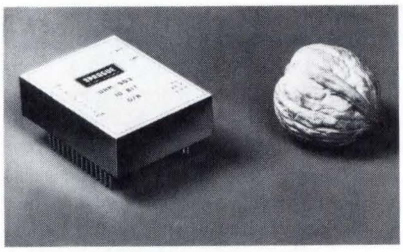


LOW-POWER CRYSTAL OSCILLATORS AND TIMERS IN SMALL PACKAGES. These subminiature CMOS timing circuits have frequencies between 600 kHz and 1 Hz per 6 hours. They draw only 5 μA at 3.5V and are packaged in TO-5's or 1/4 by 3/8 by 0.07 in. flatpacks. Standard options available include a reset and provisions for externally tuning the oscillator to the precise frequency with an external trimmer capacitor. Price is $36 each for 500 units. Statek Corp., 1200 Alvarez Ave., Orange, CA 92668. Phone (714) 639-7810. **216**

A/D CONVERTER FAMILY FEATURES LOW DRIFT. The 160 family of 10- and 12-bit modular A/D converters features better than ±1/2 LSB linearity over a temperature range of 25°C ±15°C. Two conversion speeds are offered for the 12-bit converters: Model 160-12 converts in 100 μsec and the 161-12 converts in 30 μsec. The 10-bit versions are faster—Model 160-10 converts in 75 μsec and the 161-10 takes only 20 μsec. Function Modules, Inc., 2441 Campus Drive, Irvine, CA 92664. Phone (714) 833-8314. **217**



REGULATED POWER SUPPLIES SPAN 4 TO 28V dc. The OLV-60 Series provides 15 different output voltages from 4 to 28V dc with current ratings of 12 to 3.5A. Specifications include: 0.1% line and load regulation, 0.1% ripple and noise, remote sensing, foldback current limiting, and electrostatically shielded transformers. Overvoltage crowbar protection is optional. Price is $75 in 1-9 quantities. Elexon Power Systems, 18651 Von Karman, Irvine, CA 92664. Phone (213) 375-9798. **218**

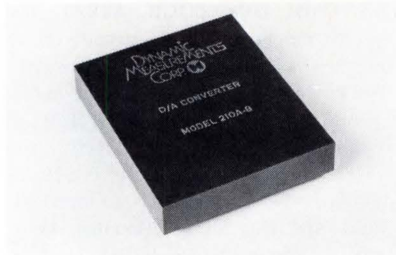


D/A CONVERTERS COME IN DIP-COMPATIBLE PLASTIC CASE. The Series UHM-500 consists of complete 8- and 10-bit hybrid D/A converters for operation over the temperature range of −55 to +125°C. Conversion accuracy is better than ±1/2 LSB between −25 and +85°C. The Type UHM-503 is a 10-bit unit with an absolute accuracy of better than ±0.048% and a conversion time of typically 2.5 μsec. The Type UHM-506 is similar but includes an op amp, for an output impedance of only 0.01Ω. All units meet MIL-STD-883. Sprague Electric Co., North Adams, MA 01247. Phone (413) 664-4411. **219**

SOLID-STATE TIMER IS IN PLUG-IN MODULE. The Series 2111 generates linear timing periods by providing a constant-current discharge path from a storage capacitor. In this way the repeat accuracy of ±2% remains constant for any sensing voltage. The timer has 11 different time ranges and maximum time settings from 1 sec to 15 min., minimum time setting of 0.10 sec, 100 msec maximum reset time, designed-in transient suppression and ac or dc input. General Time Corp., Thomaston, CT 06787. **220**

LOW-COST A/D CONVERTER ENCODES 8 BITS IN 4 μSEC. The aimAD0800 provides ±1/2 LSB max. Linearity over the entire −25 to +85°C temperature range. An economy version, the aimAD0801, provides 8-bit encoding in 12 μsec max., while retaining all other features of the aim-AD0800. The unit operates with analog supplies ranging from ±12V to ±18V; maximum power consumption is 1.85W. Price for the aimAD0800 is $160; and for the aimAD0801, $110. Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, CA 95050. Phone (408) 246-9225. **221**

FREQUENCY-TO-DC CONVERTER OPERATES OVER −55 to +85°C. The completely solid state FREQMETER will linearly convert frequency or repetition rate of signals to a proportional dc voltage. Four standard models cover the input frequency range of zero to 100 kHz. Model 410 covers zero to 100 Hz; Model 420, zero to 1 kHz; Model 430, zero to 10 kHz; and Model 440, zero to 100 kHz. Solid-State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. Phone (213) 785-4473. **222**



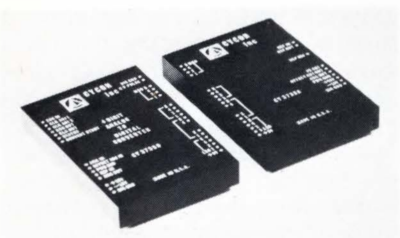
D/A CONVERTERS ARE DTL AND TTL COMPATIBLE. The 210 Series consists of 8, 10, 12 and 13-bit binary converters and one 3-digit BCD converter. Each is complete with a ±10V, ±40 mA amplifier capable of driving 75Ω cables. Settling times of 600 nsec for 8 bits and 1.2 μsec for 13 bits are standard, as is differential linearity of ±1/8 LSB for 10 bits. Price for the 8-bit Model 210A-8 is $75; for the 13-bit Model 210A-13, $145. Dynamic Measurements Corp., 6 Lowell Ave., Winchester, MA 01890. Phone (617) 729-7870. **223**

8-BIT SYNCHRO CONVERSION MODULE COSTS ONLY $295. The 8-bit (1.4) Model M4000S synchro-to-binary conversion module offers a solution to applications where extreme accuracy is not a requirement. An output register is included for computer interface. Update rate is 5 msec, and data transfer time is less than 100 nsec from the register. Astrosystems, Inc., 6 Nevada Dr., Lake Success, NY 11040. Phone (516) 328-1600. **224**

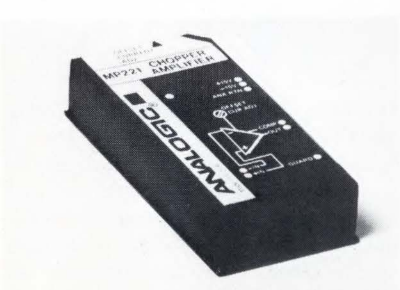
HYBRID CATV MODULES PROVIDE WIDEBAND AMPLIFICATION. Three hybrid modules for use in CATV systems provide a complete amplifier assembly. The input module, Type MHW560, provides 16 dB of power gain with a bandwidth of 40 to 300 MHz (within ±0.3 dB). The MHW561 module provides an additional 15 dB gain. Type MHW562, is for use as the output amplifier. Prices for 25-99 quantities are: Type MHW560, $39.00; Type MHW561, $44.50; and Type MHW562, $50.50. Motorola Semiconductor Products, P.O. Box 20924, Phoenix, AZ 85036. Phone (602) 273-6900. **225**

TIME-DELAY SWITCH USES ELECTRO-OPTICAL TIMING CELL. The Model 716 timer has no moving parts other than a tiny drop of clear liquid which moves back and forth within a sealed capillary tube. Standard cycle times available are from 15 minutes to 50 hours, with exact setting adjustable by user. Loads up to 30V dc, 5 mA, can be handled. Cost is $8.95 in 1000 quantities. Curtis Instruments, Inc., 200 Kisco Ave., Mount Kisco, NY 10549. Phone (914) 666-2971. **226**

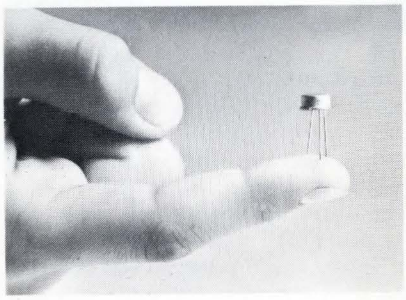
DIP TTL PULSE OSCILLATOR HAS RISE AND FALL TIMES <50 nsec. The modular unit is available at fixed frequencies from 1 Hz to 50 kHz at an accuracy of ±0.1% over the temperature range +20°C to +40°C, or ±0.25% over the range 0° to +50°C. Supply voltage is 5V dc ±5%. The negative pulse output has a fanout of 4 TTL loads with 5 mA supply current and a fanout of 10 with 20 mA supply current. Connor-Winfield Corp., Winfield, IL 60190. Phone (312) 231-5270. **227**



A/D CONVERTER COMBINES 4-DIGIT BCD OUTPUT WITH 200 μsec SPEED. The CY3735 is designed for incorporation into hard wired and minicomputer oriented industrial control systems. Zero drift of the unit is less than 0.001%/C° over the full 0-70°C operating temperature range. Gain drift is less than 0.003°C over 0-70°C using the unit's internal temperature compensated voltage reference circuit. Cost is $125 in 100 quantities. Cycon, Inc., 1080 E. Duane Ave., Sunnyvale, CA 94086. Phone (408) 732-8311. **228**



LOW-LEVEL SIGNAL AMPLIFIER GENERATES LESS THAN 0.1 μV OF NOISE. The MP221 chopper amplifier is optimized for non-inverting applications and is gain selectable up to 10,000. It generates less than 0.1 μV of noise, peak-to-peak, over the dc to 1 Hz bandwidth, less than 0.3 μV from dc to 10 Hz and less than 1 μV from dc to 100 Hz, with less than 3 pA noise current from dc to 1 Hz. Offset drift of the device is less than 0.5 μV/°C max. and bias drift is under 2 pA/°C max. Price is $59. Analogic, Audubon Rd., Wakefield, MA 01880. Phone (617) 246-0300. **229**

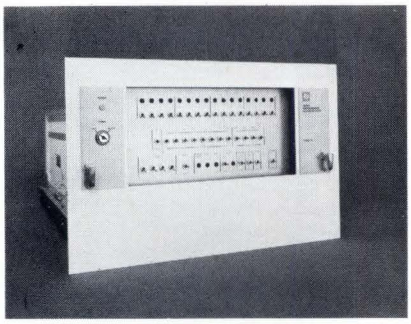


OVERVOLTAGE PROTECTOR PROTECTS ENCAPSULATED MODULES. The Model COP automatically cuts off power line transients above 18V or below 11-12V. It cuts back on instantly when voltage returns to the desired level. The device passes current from 0 to 1/2A of which it requires 25 mA for its own operation. Operating resistance is approximately 1Ω. Data Device Corp., 100 Tec St., Hicksville, NY 11801. Phone (516) 433-5330. **230**

THICK-FILM VOLTAGE REGULATOR HAS PLUS AND MINUS OUTPUT. The LMR-11 is housed in a standard TO-3 can and contains an optional bridge rectifier for ac use. Output voltages are externally adjustable from −8 to +22V. Line and load regulation is 0.1%. Maximum output current at continuous duty operation is 1A. Price is $25 in 1000 quantity. Ledex, Inc., 123 Webster St., Dayton, OH 45401. Phone (513) 224-9891. **231**

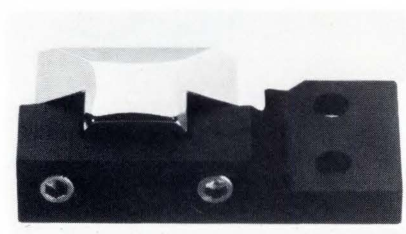
DC REGULATED POWER SUPPLIES HAVE DUAL AND TRIPLE OUTPUTS. Two module sizes are available in the PPM Series through the use of plug-in printed power cards. Units are regulated to ±0.01% + 1 mV line and load; ripple and noise is 0.3 mV rms and 2 mV peak-to-peak. Voltage output ranges are from 3 to 150V, and currents are from 900 mA to 10 mA, respectively. Prices are less than $90 in single quantities. Power Pac, Inc., 24 Stage St., Stamford, CT 06901. Phone (203) 359-4377. **232**

COMPUTER PRODUCTS



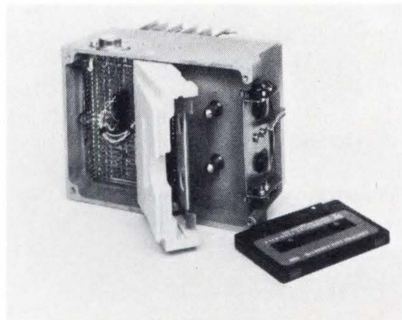
LOW-COST GENERAL-PURPOSE MINI EXPANDABLE TO 64k OF SC MEMORY. Model 980A, a 16-bit computer, has 750 nsec cycle time, hardware multiply/divide with double precision instructions, programmable-memory protect and privileged instructions, memory biasing, memory parity, power fail and auto restart, I/O bus with 4 ports, a switch initiated ROM bootstrap loader, an auxiliary processor port, and a DMA channel, expandable. $3475. Texas Instruments Inc., P.O. Box 1444, Houston, TX 77001. Phone (713) 494-2168. **248**

FUNCTION KEYS ADD POWER TO POCKET CALCULATOR. Besides performing the four arithmetic functions, MEC/1 and MEC/2 automatically provides percentages, constants, decimal places and round-off with an underflow ability that drops least important figures when the answer exceeds the 12-figure capacity. The MEC/2 has a memory that stores and accumulates positive or negative results. MEC/1 = $279, MEC/2 = $319. Victor Comptometer Corp., 3900 N. Rockwell St., Chicago, IL 60618. Phone (312) 539-8200. **249**



MAGNETIC HEADS OPERATE IN CONTACT WITH FLOPPY DISCS. Available in read only, read/write and read-after-write configurations, the heads are designed for operation in contact with the flexible oxide coated plastic based discs used in floppy-disc storage devices. Typically, the heads operate at a packing density of 1600 bpi with a disc speed of 90 RPM. Applied Magnetics Corp., 75 Robin Hill Rd., Goleta, CA 93017. Phone (805) 964-4881. **252**

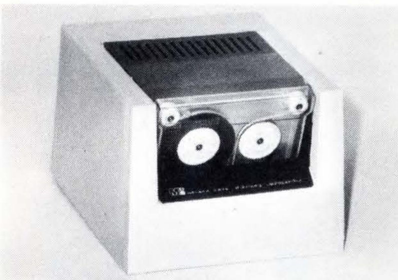
LOW SPEED DIGITAL COLUMN PRINTER. The three-line per second, six to eighteen-column, Model 318, uses a standard format of ten characters per linear in. and six lines per vertical in. TTL throughout, the printer features zero suppression, fully buffered memory, and serial or parallel input. $595. Datadyne Corp., Bldg. 37A, Valley Forge Ctr., King of Prussia, PA 19406. Phone (215) 265-1793. **253**



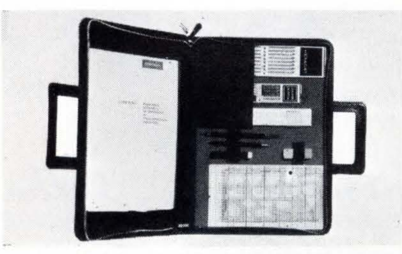
CASSETTE TAPE DRIVES PROVIDES 8 MILLION BITS OF STORAGE. PDC Model 4200 features a reel-driven servo control using only two moving parts that provides constant tape velocity. A torque feedback tension servo maintains precise tape tension, even during start/stop ramping. Standard recording speed is 37.5 ips. Rewind and search speeds are 120 ips. Start/stop times are 5 msec at 75 ips. $1000. Peripheral Dynamics Corp., 1809 National Ave., Anaheim, CA 92801. Phone (714) 871-2200. **254**

TELETYPE-COMPATIBLE TERMINAL SUBSTITUTES CRT FOR PRINTER. The ITT Model 3501 Asciscope is a low-cost display terminal with a keyboard. For users who wish to take advantage of a CRT's quieter operation, faster transmission speeds, compact size and portability, and editing capability, the Asciscope display is an ideal replacement for Teletype Models 33 or 35. $65/month lease. ITT Data Equipment and Systems Div., East Union Ave., East Rutherford, N J 17073. Phone (201) 935-3900. **255**

CIRCULAR CALCULATOR DESIGNED FOR HIGH-STYLE APPEARANCE. "DECOR," LE 120 T, includes not only the features of a 12-digit display but adds a new circular styling and colored decorator touch. The 4-in dia. unit has a beige color operating surface with sculptured design and a zero suppress system which eliminates all unnecessary zero ("0") display digits. $245. Busicom, U.S.A., 31 East 28th St., New York, NY 10016. **256**

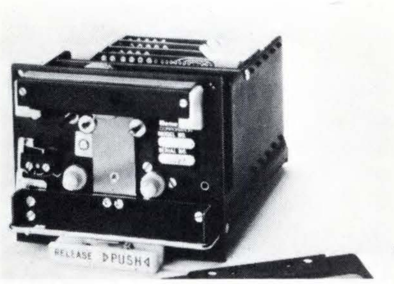


COMPACT CARTRIDGE TAPE DRIVE USES SINGLE DRIVE MOTOR. Model 2021 has a dual-gap read-while-write head and is available in one, two, or four-channel configurations. It is capable of recording at 800 to 1600 bpi, with read, write and backspace speeds of 30 ips. Rewind and fast forward search speeds are 90 ips. The data transfer rate (per channel) is up to 48,000 bps. $200-$500. Mohawk Data Sciences Corp., 781 Third Ave., King of Prussia, PA 19406. Phone (215) 337-1910. **257**



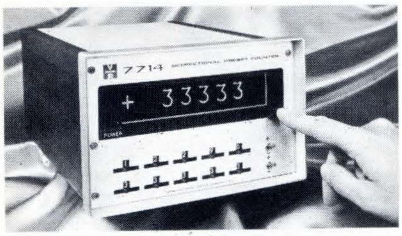
PROGRAMMER's KIT SIMPLIFIES COMPUTER PROGRAMMING. The kit has ten programming tools in a custom fitted, lockable leather briefcase. Tools included are: Hexadat, a calculator that adds and subtracts hexadecimal (base 16) numbers, a decimal calculator, a hexadecimal to decimal and decimal to hexadecimal conversion table, slide rule, programming flowchart template, and more. Radix Precision Co., P.O. Box 13861, Atlanta, GA 30324. Phone (404) 631-3942. **258**

DESK CALCULATORS FOR SCIENTIFIC AND STATISTICAL USES. Three 400 Series calculators have full-sized 16 dual-operation key keyboard and display, a complement of functions and decision-making capabilities, 64 steps of learn-mode programming or 8 additional storage registers. Also offered are 13 digits of accuracy or 10 digits with exponent, two complete arithmetic calculators, 16 full arithmetic registers and automatic conversion to scientific notation. $720-$1200. Wang Laboratories, Inc., 836 North St., Tewksbury, MA 01876. Phone (617) 851-7311. **259**



BIT BY BIT INCREMENTAL READ/WRITE DIGITAL CASSETTE SYSTEM. Model 143 moves tape incrementally at rates up to 3 ips. Data is recorded on the tape in serial complementary NRZI format using the two tracks, providing storage for over 50,000 8-bit ASCII characters on a single Phillips cassette. Electronics include motor drive, write circuits, read circuits, formatter, and baud buffer. $875. Memodyne Corp., 369 Elliot St., Newton Upper Falls, MA 02164. Phone (617) 527-6600. **260**

STEPPING MOTOR IS ONLY MOVING PART IN READER/SPOOLER. Model TRS9300B 7-1/2 in. reel punched tape reader/spooler reads tape in a standard search-rewind mode at 800 cps. It can stop on character bi-directionally at 300 cps, can be operated manually or by remote control and reads all standard 5, 6, and 8 level tapes without adjustment. Electronic Engineering Co. of Calif. 1601 E. Chestnut Ave., Santa Ana, CA 92701. Phone (714) 547-5651. **261**



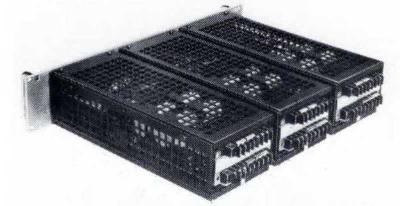
BIDIRECTIONAL PRESET COUNTER TOTALIZES AND CONTROLS at 100 kHz. The Series 7714 is used as a single, self-contained control, or interfaced with Veeder-Root Series 7700 product family to form a complete data acquisition system. Model variations and circuit options allow battery standby, multiplying or dividing, and latched and buffered BCD readout (DTL and TTL compatible). Veeder-Root, 70 Sargeant St., Hartford, CT 06102. Phone (203) 527-7201. **170**

DUAL-TRACE OSCILLOSCOPE HAS SIMPLIFIED CONTROLS. The PM3110 offers a simplified operator's panel, with only four signal adjustment knobs. Level and stability controls for triggering as well as dc balance controls have been eliminated and replaced by automatic internal circuits. IEC bandwidth of the PM3110 is 10 MHz with sensitivity of 50 mV/cm. Price is $550. Test and Measuring Instruments, Inc., 224 Duffy Ave., Hicksville, NY 11802. Phone (516) 433-8800. **171**

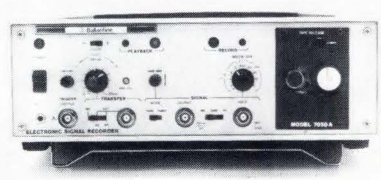
ELECTRONIC SWITCHER HAS DUAL CHANNELS. The Model 255E electronic switch for the testing of both active and passive devices is available in both 75 and 50Ω impedances. The unit may be used for comparative tests of frequency responses in the 5 to 1000 MHz range. It features dual-channel input and output modules. The 255E may be switched at external rates of from 0.2 to 200 Hz. Price is $260. Kay Electronics Corp., 23 Maple Ave., Pine Brook, N J 07058. Phone (201) 227-2000. **173**

FET-INPUT VOM IS "DROP-PROOFED". The Model 666 Solid State Circuit Tester is the latest in Weston's line of "drop-proofed" VOMs. The 666 has twelve current ranges, with a lowest full scale range of 1 μA; eighteen voltage ranges, from 100 mV full scale to 1000V; and fourteen ohms ranges, featuring seven low-power ohms ranges for "in circuit" measurements of semi-conductors. 400 hours of continuous operation is possible between battery changes. Price is $132.50. Weston Instruments, 614 Frelinghuysen Ave., Newark, N J 17114. Phone (201) 243-4700. **174**

DIGITAL FILTER IS PROGRAMMABLE. Model 4136 is a single-channel digital filter. Digital filters of up to eighth order are implemented in cascade, recursive form at a variable sampling rate of up to 80 kHz. All classical filter types can be programmed via twelve 16-bit filter coefficients. Price is $8500 and delivery is 12 weeks. Rockland Systems, 230 W. Nyack Rd., W. Nyack, NY 10994. Phone (914) 623-6666. **175**



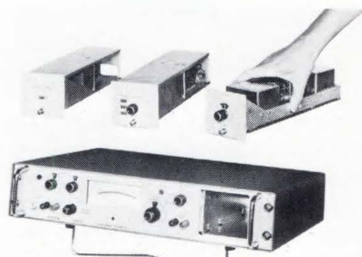
POWER MODULES HAVE AUTOMATIC CROSSOVER. The PTR automatic crossover power-supply modules feature integrated front ends in both the voltage and current control channels. They function from −20 to +71°C and can be programmed digitally, or with analog instructions. A selection of six power units, ranging from 0-7V at 5.5A to 0-100V at 0.6A, is available. Price is $225. Kepco, Inc., 131-38 Sanford Ave., Flushing, NY 11352. Phone (212) 461-7000. **176**



ELECTRONIC SIGNAL RECORDER HAS STORAGE CAPABILITIES. The Model 7050A Electronic Signal Recorder (ESR) uses a continuous magnetic loop upon which repetitive or transient signals of up to 20 msec duration are recorded. Bandwidth of the carrier system is dc to 100 kHz. The "captured" signal can then be displayed immediately or at a later time for analysis on any waveform/spectrum analyzer. Price is $985. Ballantine Laboratories, P.O. Box 97, Boonton, N J 07005. Phone (201) 335-0900. **177**

IC TESTER TESTS DIGITAL AND LINEAR CIRCUITS. The Model 716A general purpose IC tester, provides both parametric and functional test capability for digital and linear circuits. The tester is designed for use in device characterization applications as well as moderate-volume incoming inspection applications. Price is $2990 and availability is 60 days. Computest Corp., 3 Computer Dr., Cherry Hill, N J 08002. Phone (609) 424-2400. **178**

POWER SIGNAL GENERATOR MAKES AUTOMATIC MEASUREMENTS. As a power generator, the Type SMLU delivers a maximum output of 2W up to 595 MHz and 1W between 565 and 1000 MHz. Both output frequency and output power are programmable. Each of the frequency subranges may be externally swept. Internal and external amplitude modulation up to 90% and external frequency modulation are possible. Price is $6800. Rohde and Schwarz Sales Co., 111 Lexington Ave., Passaic, N J 07055. Phone (201) 773-8010. **179**

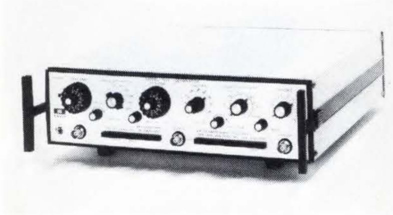


PHASE ANGLE VOLTMETER SPANS 30 HZ to 300 kHZ. The PAV-4 series has wide dynamic range (300 μV to 300V), harmonic filtering and high input impedance with or without input isolation. Each of the three mainframes accepts a range of fixed frequency and variable frequency plug-ins. Either isolated or direct inputs offer a 10 MΩ input impedance at all frequencies. Singer Instrumentation, 3211 South La Cienega Blvd., Los Angeles, CA 90016. Phone (213) 870-2761. **180**

DIGITAL UNIT MEASURES VOLTAGE OR TEMPERATURE. The D-2400 is a two-range or two-function, digital, voltage or temperature measurement and display unit. For temperature measurement, the D-2400 can simultaneously accept two different types of thermocouple modules. The voltage module features auto-ranging through five decades, plus 1 μV sensitivity. Esterline Angus, Box 24000, Indianapolis, IN 46224. Phone (317) 244-7611. **181**

UNIT CHECKS OUT PCM ENCODERS. Besides checking PCM encoders, Model ECO-1 also operates with data and clock from a bit synchronizer. The unit is programmed by front-panel thumbwheels, is compatible with any IRIG bit code representation, and sychronizes to formats with up to 12 bits per word, 33 bits for frame sync, 512 words per frame, and 256 frames per subframe. Price is $2400 and delivery 60 days. Coded Communications Corp., 533 Stevens Ave., Solana Beach, CA 92075. Phone (714) 755-6540. **182**

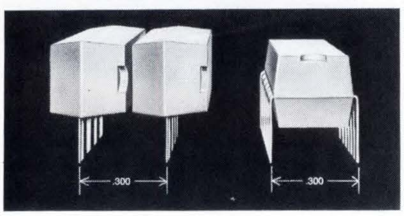
X-Y RECORDER HAS VERY FAST PEN ACCELERATION. The Model 7041A is an 11 in. by 17 in. OEM x-y recorder. An acceleration of 3000 in/sec² on the y axis and 2000 in/sec² on the x axis, coupled with comparable deceleration, results in low overshoot, even though the slewing speed is a relatively fast 30 in/sec. Price is $1050. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **183**



FUCTION GENERATOR HAS LINEAR, LOGARITHMIC AND GATED SWEEP. Model 7071 is a precision source of sine, square, triangle, ramp, pulse, and sync waveforms with trigger, burst, pulse, linear sweep, log sweep, gated sweep and ramp hold modes. The unit has a 0.0001 Hz to 11 MHz frequency range. Output voltage is 30V P-P open circuit or 15V P-P into 50Ω. Price is $1095. Exact Electronics, Box 160, Hillsboro, OR 97123. Phone (503) 648-6661. **184**

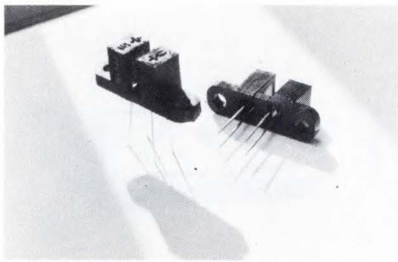
SHEILDING TAPES NOS. X-1245 AND X-1267 OFFER EMI CONTROL. The tapes are designed to restrict radiating energy conveniently and effectively. Tape No. X-1245 has an embossed copper backing which permits solder connections; tape No. X-1267 is an embossed aluminum foil-backed tape. Both have pressure sensitive adhesive backing. 3M Co., St. Paul, MN 55101. Phone (612) 733-4033. **204**

PHOTON COUPLED ISOLATORS CONSIST OF GALLIUM ARSENIDE LEDs optically coupled to silicon photo transistors in dual-in-line packages. The H11B1 and H11B2 are gallium arsenide solid-state lamps optically coupled to silicon photo-Darlington transistors. Types H11A1 and H11B1 are believed to offer the industry's highest specified min. current transfer ratios . . . 50% and 500% respectively and 2500V isolation. General Electric Co., Electronics Park, Syracuse, NY 13201. Phone (315) 456-2021. **205**

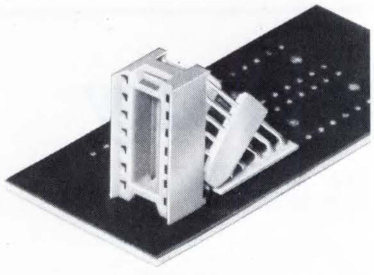


TWO REED RELAYS FIT IN THE SPACE OF A DIP SOCKET. GB 840 series has been designed for hi-density assemblies. Available in Form A and B models with 5, 12 or 24V dc coils, 10W contact ratings and integral magnetic shielding. Both models Form A and B offer a max. switching voltage of 100V. Price is as low as $1.43 each in 1000 piece lots. Grigsby-Barton Inc., 3800 Industrial Drive, Rolling Meadows, IL 60008. Phone (312) 392-5900. **206**

SILICONE SEMI-GEL TRANSPARENT POTTING FOR ELECTRONIC APPLICATIONS. The silicone cures to a soft elastomer-gel material which provides mechanical cushioning, vibration damping and protective coating of sensitive microelectronic devices. The physical properties are intermediate between true gel and elastomeric compounds. Price is $12 per lb. Transene Company, Inc., Route 1, Rowley, MA 01969. Phone (617) 948-2501. **207**

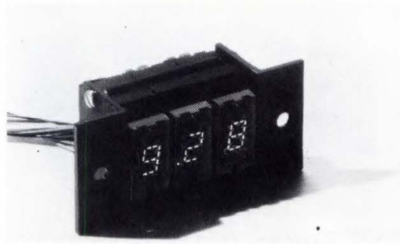


OPTOELECTRONIC INTERRUPTER MODULES INTRODUCED. This solid-state device can be used in limit-switch-type applications and is capable of 10,000 operations per sec. Each plastic module contains a GE SSL (solid state lamp) source and sensor separated by a throat width of 0.125 in. Suggested resale prices run as low as $1.35 for the H13A2. General Electric Co., Electronics Pk., Bldg. #7, Mail Drop 49, Syracuse, NY 13201. Phone (312) 456-2021. **208**



LED 90° 14-PIN SOCKET FOR DIGITAL DISPLAYS. The socket is molded of 30% glass filled nylon. Either round or flat LED leads are acceptable with the positive contact bifurcated pin/contacts. The company also offers 60° vertical, 90° and 60° horizontal and edge card LED sockets. Price $1.00 to $2.25. Aries Electronics Inc., P.O. Box 231, Frenchtown, N J 08825. Phone (201) 996-6200. **209**

OPTO-ISOLATOR COUPLERS PROVIDE $10^{11}\Omega$ ISOLATION. The CM4-5010 has a breakdown voltage of 1500V dc current transfer ratio is 10%. Breakdown voltage for the CM4-5020 is 2500V dc current transfer ratir is 20%. Costs for the CM4-5010 in 1000 quantities, is $1.40 each, the CM4-5020 in 1000 quantities, costs $2.95 each. Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, IL 60614. Phone (312) 784-1020. **210**



SIX MODELS OF DIGITAL READOUTS FEATURE PLUG-IN DECODER-DRIVER. Current limiting and non-glare viewing screen are standard. "Mono-digit" construction allows up to 24 digits in common array. Individual displays feature seven segment LEDs with 0.270 in. character height. Precision Dynamics Corp., 3031 Thornton Ave., Burbank, CA 91504. Phone (213) 845-7606. **211**

"NO-SNAG" GOLD BONDING WIRE AVOIDS SHORTS due to sagging of internal lead wires in microcircuits. "Sag-shorts" have been a mysterious, intermittent problem associated with even the most careful assembly methods and highest quality materials. A unique proprietary fabricating and heat treating process prevents these shorts. CRM, a Division of Consolidated Refining Co., Inc., 115 Hoyt Ave., Mamaroneck, NY 10534. Phone (914) 698-2300. **212**

FULLY SOLDERABLE FLEXIBLE PRINTED CIRCUIT MATERIAL. A new resin coated copper foil called Solder Flex doesn't lose its bond strength during continuous-flow solder processing. Bond strength is a minimum of four lbs, and shrinkage after exposure at 165°C for 30 minutes is 0.8%. Westinghouse Electric Corp., Industrial Plastics Div., P.O. Box 657, Bedford, PA 15522. Phone (412) 452-5000. **214**

CAPACITOR KITS OFFER MINIATURE ALUMINUM ELECTROLYTICS, non-polarized electrolytics, subminiature polyester film and metalized polyester film capacitors. Electrolytic and film capacitors are available in separate high- or low-voltage kits, with non polarized offered in high voltage. The array of capacitors permits design engineers to have a capacitor for virtually every circuit. This eliminates the problem of losing time waiting for the correct values. The kits, in plastic containers or metal cabinets, contain as few as 25 capacitors for $4 and as many as 250 capacitors for $49.50 retail. International Components, Div. of IESC, 10 Daniel St., Farmingdale, NY 11735. Phone (516) 293-1500. **215**

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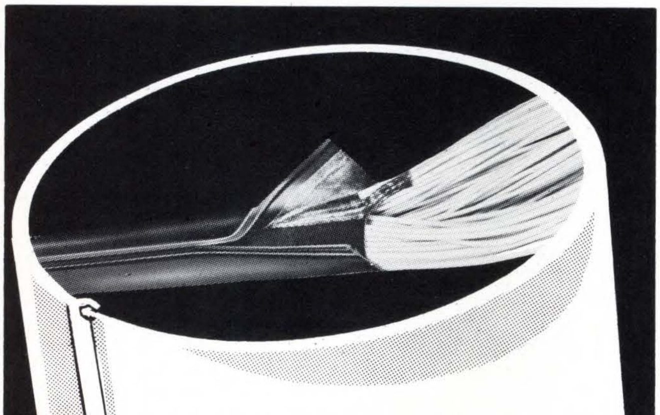

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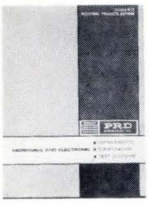


MICROWAVE INSTRUMENTS AND COMPONENTS are covered in a 72-page catalog. The catalog gives complete descriptions, specifications, photographs and prices of PRD's broad microwave line. It also contains descriptive material on PRD's recently introduced CAST (Computerized Automatic Systems Tester) system. Typical applications of many products are also described. PRD Electronics, Inc., 1200 Prospect Ave., Westbury, NY 11590. **233**

ROM SIMULATOR. A free six-page brochure describes equipment which simulates large read-only memory subsystems. Operational advantages of the SMS Model 1000A, Read-Only Memory Simulator are discussed. The simulator has a capacity of 65,536 bits and enables design engineers to determine instantly and accurately how a new read-only memory will perform in a system. Signetics Memory System, 740 Kifer Rd., Sunnyvale, CA 94066. **236**

MINICOMPUTER BOOK. A new 24-page book entitled "If Minicomputers are the Answer, What was the Question?" discusses the problems of implementing minis in new computer application areas. The evolution of today's mini is discussed, as well as how the changing needs of minicomputer users have had a marked impact on the computer marketplace. GRI Computer Corp., 320 Needham St., Newton, MA 02164. **239**

A CATALOG OF SEMICONDUCTOR CHIPS FOR USE IN HYBRID CIRCUITS describes a series of standard chips including FETS, PNP, and NPN switching transistors and monolithic interface circuits. These chips can be supplied in the following forms: probed chips; 100% tested, premounted chips temporarily mounted on special carrier headers and carrier mounted chips. Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. **242**

POWER RECTIFIERS. The six most frequently used circuits in the 25A PACE/pak series are described in a new data bulletin. The bulletin provides complete specifications, characteristics and ratings of the six circuits, as well as circuit diagrams for the different configurations. International Rectifier Corp., 233 Kansas St., El Segundo, CA 90245. **245**

12-PAGE CATALOG ON SOLID STATE AC RELAYS contains complete electrical and pricing information. The line includes three phase motor starters—from fractional to 10 horsepower with voltages to 480; octal-base relays; PCB relays with 1.00 in.- or 1.10 in.-pin spacing for mounting on PC boards and zero point switching relays. For a copy of bulletin A-00011B write Hamlin, Inc., Lake and Grove Sts., Lake Mills, WI 53551. **234**

32-PAGE SOLID-STATE CHOPPER CATALOG includes isolated microchoppers, field effect choppers, basic choppers, 60-cycle chopper, 400-cycle chopper, high-frequency choppers, high-voltage choppers, vibrachoppers, and other products. All units utilize a miniaturized, ruggedized design and are recommended for military and industrial application. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **237**

RESOLVERS VS. ENCODERS for numerical control are evaluated in a new bulletin. The 4-page bulletin gives a detailed evaluation of rotary synchro resolvers vs. rotary incremental optical encoders for use on all types of numerical controls. Allen-Bradley Co., 747 Alpha Dr., Highland Heights, OH 44143. **240**

MINIATURE TANTALUM CAPACITORS are described in two new 4-page data sheets which give information on environmental capabilities, voltage ratings, dissipation factors and all electrical characteristics for a new line of miniature tantalum capacitors. This bulletin also contains charts explaining the standard color code system and numbering system of these products. Nytronics Inc., Orange St., Darlington, SC 29532. **243**

ELECTRONIC TEST EQUIPMENT, over 5000 items of it, is listed in a 64-page catalog. The breakdown is into pure test equipment, waveguide and coaxial components, power supplies, environmental equipment, meters and electronic components. These categories are further sub-divided by manufacturer. Baynton Electronics Corp., 2709 N. Broad St., Philadelphia, PA 19132. **246**

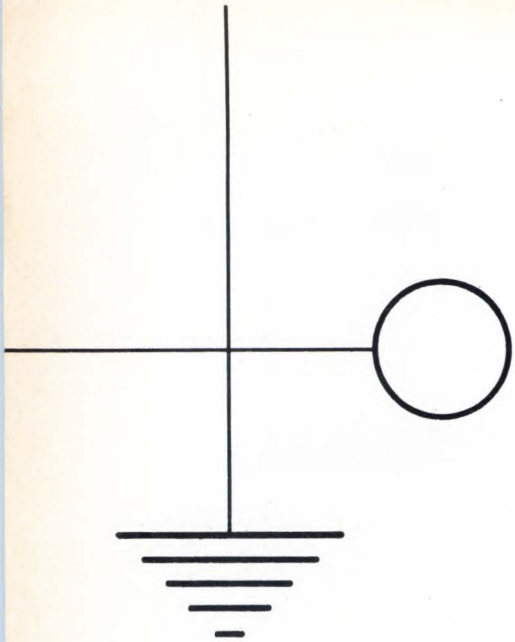
SEMICONDUCTOR TESTING. A new 8-page catalog/price-list describes product lines in three areas of semiconductor testing: (1) digital/linear parametric and/or functional bench-top testers; (2) integrated circuit handlers for all available IC packages with handling speeds from 3600 to 7200 devices per hour; and (3) real-time 10 MHz semiconductor memory test system. Computest, 3 Computer Dr., Cherry Hill, N J 08002. **235**

MOS MODEMS. A new six-page brochure describes a new MOS modem featuring 4800 bps full-duplex operation. The model 448/IV modem is adaptively equalized, EIA/CCITT compatible and available in pc card-only version for OEM applications, or as a compact, stand-alone modem featuring greater throughput and lower error rates than conventional modems. American Data Systems, 8851 Mason Ave., Canoga Park, CA 91306. **238**

DATA CONVERSION PRODUCTS are described in a new 14-page product guide. The guide contains detailed electrical and mechanical information on sample & hold amplifiers, wide band dc amplifiers, dc-dc converters, A/D-D/A converters and modular data acquisition systems. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **241**

COURSES AND SEMINARS. A free, 53-page catalog describes courses and seminars in computer, management, mathematical and statistical sciences. The catalog outlines more than 55 seminars and symposia, designed for management and data processing professionals. Registrar, Control Data Corp., The Institute for Advanced Technology, 5272 River Rd., Washington, DC 20016. **244**

CERAMIC HEADS. The new 12-page LTC brochure describes causes of conventional head wear. Many of the materials and processes investigated are discussed and the application of Nortronics' tough LTC surface is fully described. Test results are shown along with a curve of hear wear vs. hours of operation. Nortronics Co., Inc., 8101 Tenth Ave. N., Minneapolis, MN 55427. **247**



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PRECISION COUNTERS AND COUNTER SYSTEMS are detailed in a 36-page catalog. In addition to product information, the catalog includes a comprehensive section devoted to technical information and application tips. Hecon Corp., P. O. Box 247, Eatontown, N J 07724. **262**

"MEASURING NOISE SPECTRA WITH VARIABLE ELECTRONIC FILTERS" is the title of a new 12-page application note (IAN-102). A simple, general method of measuring a noise spectrum with a variable electronic filter is described, and all the necessary information for measuring a noise spectrum with an ITHACO Variable Electronic Filter is provided. Errors associated with making noise measurements, such as clipping errors and sampling errors are also discussed. Ithaco, Inc., 735 W. Clinton St., Ithaca, NY 14850. **263**

ANALOG-DIGITAL CONVERSION HANDBOOK. This 400-page practical reference for understanding A/D and D/A conversion techniques is particularly relevant to designers of instrumentation used in conjunction with computer-based systems in industry and the sciences. Heavily applications oriented, the HANDBOOK explains what A/D and D/A converters are, what role they play in the data handling environment, how they are applied in scientific applications, and how to specify them. Analog Devices, P.O. Box 796, Norwood, MA 02062. **264**

MICROPROGRAMMING HANDBOOK includes an expanded glossary of data-processing terms listing more than two-hundred commonly used data processing definitions. The expanded version covers the subject of microprogramming in a very practical and comprehensive manner. In precise terms it tells how to microprogram, why the concept is effective, and when it is most appropriate. Microdata Corp., 644 E. Young St., Santa Ana, CA 92705. **265**

PROPER APPLICATION OF ATTENUATORS is covered in a 6-page information kit. Discussed are attenuator applications in precision laboratory measurements and exact power level communication circuit settings. Answers are provided for such questions as: (1) How can measuring techniques be pulled together to ensure universal accuracy and repeatability? And (2) How does one live with less than perfect attenuators? American Electronic Lab., Inc., M.S. 1123, P.O. Box 552, Lansdale, PA 19446. **266**

POWER SEMICONDUCTOR DATA BOOK, an 816-page hardback publication, provides complete specifications on TI's broad line of power transistors, thyristors, and power functions. Among the new products featured in the data book are power Darlingtons and high-voltage transistors in popular plastic and metal-can packages, SCRs and sensitive-gate triacs. The Power Semiconductor Data Book from TI is priced at $3.95 per copy inside the U.S.A., F.O.B. destination. Send check or money order (no purchase orders) to: Texas Instruments Inc., P.O. Box 5012, MS/84, Dallas, TX 75222.

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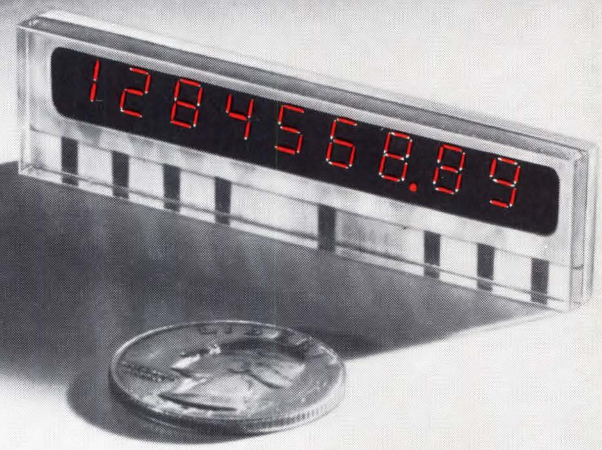

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