Analyzing the network analyzer. As complex an instrument as you will ever find, the network analyzer needs care to produce best results. There are at least half a dozen error sources that can assault accuracy. What the errors are and how they combine is up to you to find out. Dig into analyzers starting on p. 50.
New Hybrid Potentiometer Combines the Best of Wirewound and Conductive Plastic—$5.33*

The new BOURNS® HYBRITRON™ resistance element brings you the best of both worlds...the long life and infinite resolution of conductive plastic...plus the tight linearity and low temperature coefficient of a wirewound...at a new, low price.

You'll find this new element in BOURNS® Model 3541 ten-turn precision potentiometer...a new member of BOURNS popular 3540 family of compact (7/8" dia., 3/4" deep), low-cost multi-turn potentiometers.

Significant specifications of the Model 3541: service life of 5,000,000 shaft revolutions; linearity 0.25%; temperature coefficient of ±100 ppm/°C maximum; reliable SILVERWELD® direct terminal-to-element bond; output smoothness of 0.015%; essentially infinite resolution; rugged, mechanically locked construction (no rear lid "pop-off"); special heat resistant insert around terminals to prevent damage during soldering.

If a low-cost wirewound satisfies your control requirement...you can't do better than our Model 3540 ten-turn at $3.97*. Same quality construction features, same 0.25% linearity...with rotational life of 1,000,000 revolutions. A wide range of standard and custom options are available, including three- and five-turn versions.

FREE SAMPLE:
Write or phone the BOURNS PANEL POWER PEOPLE and tell us about your application. We'll send you the Model 3540/41 that best suits your needs.

Available off-the-shelf from extensive factory stock and nearly 100 local distributor inventories. TRIM POT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, California 92507. Telephone 714 684-1700. TWX 910 332-1252.

*1,000 pieces, same R.C., U.S. Dollars, F.O.B. Riverside, California
That's a synthesizer/function generator, cousin—the first one ever.

Our new Model 171 combines the accuracy and stability of a synthesizer with the versatility of a function generator. This means you can generate sine, square, triangle, TTL pulse and dc outputs with synthesizer accuracy. Frequency range is 0.01 Hz to 2 MHz. Sometimes all you'll need to use is the generator dial, which is accurate to 3% of full scale. But for more precise operations, you'll want the synthesizer's 4½ digit accuracy which is 0.01% of setting. Synthesizer stability is ±0.002% from 0 to 50°C.

Now we all know that your average synthesizer goes for two grand or better. But the Model 171, which is also a function generator, goes for just $795*. Which means you could have two of our SFGs for the price of an ordinary synthesizer and have some bucks left over. Gitchyseff a couple WAVETEK, P.O. Box 651, San Diego, California 92112 Phone (714) 279-2200, TWX 910-335-2007.

*US domestic price only

Actual spectrum analyzer photographs showing the improved waveform characteristics in the synthesizer mode.
The only Double-Balanced Mixers with a 2-YEAR GUARANTEE featuring Hi-Rel tested diodes—still only $7.95 (500 pieces) $9.95 (1-49)

*including diodes!

Yes, a two-year guarantee for DBM's is now a reality . . . made possible by an accelerated-life diode screening program adopted at Mini-Circuits.

Each Schottky diode used in Mini-Circuits' SRA-1 mixers is now preconditioned by the HTRB (High Temperature Reverse Bias) technique, previously reserved almost exclusively for semiconductors assigned to space applications. With HTRB testing, each diode is operated for 168 hours at 150°C with one volt reverse bias applied.

To screen out "infant mortality", the diodes are deliberately stressed to accelerate aging and to force time-related failure modes to take their toll. In conventional testing or "baking", the diode does not experience anywhere near the stress encountered with the HTRB program. Hence, the ability at Mini-Circuits to locate the potentially-unreliable diodes before they are assembled into SRA-1 units.

And, with double-balanced mixers, the overall reliability hinges almost entirely on the diodes used.

Yes, the HTRB procedure costs us more and screens out more devices. But our goal is to improve reliability to a level unmatched for off-the-shelf DBM's at no increase in cost to our customers. You — our customers by your overwhelming confidence in our product line have made us the number one supplier of DBM's in the world.

To earn your continuing support, we are now employing HTRB Hi-Rel testing for every diode used in the SRA-1, at no increase in cost to you. So, for the same low price of $7.95, you can purchase our SRA-1, with a two-year guarantee, including diodes.

To ensure highest system reliability demand highest quality diodes on your source-control drawings and purchase orders. Specify SRA-1 mixers, with HTRB tested diodes from Mini-Circuits... where low price now goes hand-in-hand with unmatched quality.

**Mini-Circuits Laboratory**

837-843 Utica Avenue, Brooklyn, NY 11203

(212) 342-2500 Int'l Telex 620156

Domestic Telex 125460

For complete product specifications and U.S. Rep. listing see MicroWaves "Product Data Directory," Electronic Designs' "Gold Book" or Electronic Engineers' "EEM"
NEWS
21 News Scope
26 Scope in FM tuner monitors quality of audio and rf reception.
28 'Intelligent' turntable contains µP and LED in playback unit.
30 Digital time-delay device greatly enhances living room acoustics.
32 Where is Natalia Makarova's tutu? It was there a minute ago.
39 Washington Report

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43 MICROPROCESSOR DESIGN
50 FOCUS on Network Analyzers: Unwrap the veil covering this most complex of instruments. Study the key elements in selection—accuracy, resolution, group delay—and make the choice easier.
58 Put microprocessor software to work by taking advantage of different addressing modes. Here are the basics of how these modes function.
66 Use SOT-23 packaged components in mass-produced hybrid circuits. They can cut size and cost while simplifying production and boosting over-all reliability.
72 Isao Someya of Nippon Electric speaks on educating engineers.
76 Ideas for Design: Party-line intercom system needs only three wires. Chopper amplifier for thermocouples has long-term drift of only 0.5 µV/yr. Logic circuit ensures definite break-before-make action for relay drive.
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PRODUCTS
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Cover: Illustration by James Jany, network analyzers courtesy of Hewlett-Packard, GenRad and Rohde & Schwarz.
Our $9.95 CPU is actually less than half the price of the 8080 or 6800 CPU. And it’s just the beginning of your saving. On-chip RAM, ROM and timers make an even bigger difference. Difference in cost. Difference in reliability and difference in manufacturing time. The following is the whole price/performance story of our F8 system, from minimum configurations to expanded systems.

Lowest cost configuration
Our minimum configuration F8 is perfect for controlling home appliances, braking systems, vending machines, ignition systems and other uses with modest memory and I/O requirements.

Two chips do it all - a $9.95 PSU (Program Storage Unit) and F8 CPU (Central Processing Unit) for $9.95. The CPU is an 8-bit device, with a cycle time of 2 microseconds. It’s the heart of all F8 microprocessors. It includes 70 instructions, 64-byte RAM (Random Access Memory), instruction register, accumulator, 16 individually controllable I/O lines, power-on reset, on-chip clock and control lines to other devices.

The PSU features a 1K byte ROM (Read Only Memory), program counter, 16 individually controllable I/O lines, 8-bit data port, stack register, incrementer/adder and programmable timer and interrupt.

We’re the only manufacturer in the world to offer this 2-chip performance. The 8080 requires 7 chips (9 chips with timer) to do the same thing.

Double the program storage
If you need more program space, just substitute PSUs. Our new 2K byte PSU offers twice the ROM for only $14.95.

Built-in interface to external memory
But suppose you need a couple of RAM's added to your CPU and 2K/PSU. Again, substitute PSUs for one with a built in memory interface. Avoid paying for extra chips. Order our new 2K/PSU-MI for $14.95. This is super microprocessor power on 4 chips.

The 8080 takes 10 chips (12 with timer) to do the same thing.

Fairchild’s $9.95 F8 Microprocessor
Half the Cost Twice the Versatility
A system that needs no ROM

If you don't want to commit to ROM, consider interfacing RAM and/or PROM (Programmable Read Only Memory) directly into the CPU. This approach is ideal when your production run is under 1,000 units, and for development prior to long production runs.

This F8 configuration uses only four chips: a CPU, a $7.45 SMI (Static Memory Interface with interrupt and programmable timer) and two 2K PROMs. Competitors take twice as many chips to do the same thing.

Where more I/O is needed

By adding our $6.45 PIO (Parallel I/O) to this aforementioned configuration, you gain 16 I/O ports, another level of interrupt and a programmable timer. Now you have the perfect 5-chip microprocessor system for electronic scales, paper tape and cassette tape handlers, electronic games, traffic light control, cash register and similar applications.

Competitors take 10 chips to do the same thing.

Memory intensive systems

In memory intensive applications like message concentrators, floppy disc controllers, and store-and-forward message switching you'll enjoy big benefits with the F8's DMI (Dynamic Memory Interface).

This $7.45 device fits between your CPU and dynamic or static memory WITHOUT A MEMORY REFRESH CHIP. Memory refresh logic is built into the DMI, and operates in sync with the CPU. Your CPU never stops. There's no cycle stealing. No performance degradation. We are the only manufacturer in the world to offer this advantage.

A supercharger for this memory intensive configuration is DMA (Direct Memory Access). This $5.95 option comes in one chip. It creates a direct link between your memory and external data. All functional and internal system timing is built in. The DMA can run at 500K bytes/sec and never slows down the rest of the system.

Expand your system

Interchangeability and compatibility are maximized for you. All inter-component timing is built in. Gang PSUs. Add PIO's. Daisy-chain multiprocessor systems.

To cut design time even more, you'll enjoy our Formulator™ Think of it as an instant breadboard - a system developer, tester, debugger, and more. Of all hardware/software development aids on the market, this one is easiest to operate. Easiest to understand. Discover how easy it is to assemble your own microprocessor. We provide a spectrum of hardware and software development aids. Everything you need including kits, hardware simulators and full program development support.

And then we will show you how to do it all, step by step in our brand new brochure, "THE PATHS OF LEAST RESISTANCE - Four Optimum Ways To Bring Your Microprocessor Product To Market". Write us now, your competitors probably will. We know ours will.

Fairchild Micro Systems
1725 Technology Dr. San Jose, CA 95119 (408) 998-0123

*All prices quoted are for 100 to 999 plastic packaged parts effective Sept 1 1976
Thin-Trim capacitors

Tucked in the corner of this Pulsar Watch is a miniature capacitor which is used to trim the crystal. This Thin-Trim capacitor is one of our 9410 series, has an adjustable range of 7 to 45 pf, and is .200" x .200" x .050" thick.

The Thin-Trim concept provides a variable device to replace fixed tuning techniques and cut-and-try methods of adjustment. Thin-Trim capacitors are available in a variety of lead configurations making them easy to mount.

A smaller version of the 9410 is the 9402 series with a maximum capacitance value of 25 pf. These are perfect for applications in sub-miniature circuits such as ladies' electronic wrist watches and phased array MIC's.

Johanson Manufacturing Corporation
Rockaway Valley Road
Boonton, New Jersey 07005
(201) 334-2676  TWX 710-987-8367
Robot project arouses envy from a pioneer

The article, “Wanted: A Robot That Thinks For Itself,” (ED No. 12, June 7, 1976, p. 67) arouses great envy in certain people. Those lucky fellows at JPL, NRL, and Tetra Tech are getting to do what a group at Applied Physics Laboratory—Johns Hopkins University (APL-JHU) tried to obtain funds to do 13 years and more ago.

The APL group proposed independent mobile automata for undersea, lunar, and planetary exploration, listing all the reasons given in your article. Alas, in those days manned space shots were the glamour projects, and no government funding could be found for unmanned "toys."

APL dipped into its own in-house budget to design and build two prototypes to test some of the concepts of self-sufficient robots. These automata were given the mission of surviving in the laboratory itself. Even this proved to be a harsher environment than first imagined, with stairwells, cul-de-sacs, floor level shifts between building sections, and hanging cables in the halls. When the silver-cadmium battery ran low, the automaton had to locate and plug into an AC wall outlet to recharge.

The MOD II robot's equipment was a sense of touch, sonar guidance, a vidicon eye for long range detection of outlets, a telemetry system for monitoring system states and issuing very general commands and a brain with discrete logic and a program patch panel. (Oh, to have had microprocessors, ROMs, RAMs, PROMs, and the like!) With a three-hour battery life, MOD II "lived" over 40 hours at a stretch before a mechanical failure disabled it.

Later models were to have been given useful tasks to perform in addition to simply surviving. (A leading soap manufacturer inquired about the economics of a robot floor-sweeper/waxer.) Planetary or aquatic models would, of course, need something like a solar or nuclear energy source. The problems of existing, moving, and working in alien environments were being tackled.

The two robots are now in APL's technical project museum. A couple of years ago someone gave MOD II a battery charge. It still worked.

The project received some publicity in the popular press at the time. There was a demonstration on NBC's "Today" show. There were articles in Science Digest (Aug., 1964), Radio-TV Experimenter (Oct.-Nov. 1964), Parade (Sept. 27, 1964), France's Science et Vie, and others. A short film clip can still be seen in the film: Future Shock.

The JPL team, who were already developing many ideas of their own and who managed to come up with money, came to compare notes with the APL group, who were nearing the end of their funds. Judging from articles in the past few years and your article now, it appears that the JPL group has really been doing a great job.

Now they and NRL are ready to send their brain children into space and under the sea to prepare the path for man: One small step for a robot; one giant leap for automata.

George Carlton, John Chubbuck, Jim Jacques, Leonard Scheer, Lee

(continued on page 8)
try out the prototype, about one half of my group was laid off, al-
legedly with my consent, and
neither the president nor anybody else in the “top management” had
the guts to call and inform me of
their decision or action. Now, how
is that for a reward?

Needless to say with such a
bright leadership the company
went broke a few years later.

Maybe, you can use this for a
future editorial, but it is probably
old hat for many engineers.

Gerhard T. Weiss
Senior Engineer

Yale University
School of Medicine Research
Facilities
34 Park St.
New Haven, CT 06508

Micron unit will not
be a strapdown unit

In your April 26, 1976 issue,
(ED No. 9, p. 16) an article was
printed on our Micron strapdown
inertial-navigation system, which
is being developed under contract
to the Air Force Avionics Labora-
tory at Wright-Patterson AFB.
The article said the high-accuracy
version of Micron “will not be a
strapdown unit.” That is not the
case. Both the medium and the
high-accuracy systems are strap-
down, as opposed to gimbaled,
systems.

The inertial instruments will be
case-rotated about the “azimuth”
axis to achieve the high-accuracy
performance. This rotation does
not constitute a stabilized axis, as
it would for a gimbaled system.
The rotation takes place for added
accuracy.

J. A. Schwarz
Micron Program Manager
Autonetics Group
Rockwell International
3370 Miraloma Ave.
Anaheim, CA 92803

Magicam gives credit
where credit is due

The article about Magicam
(“Analog Servo System,” ED No.
11, May 24, 1976, p. 30) states that
Magicam developed the proportional
video matting process. This is not
correct; the proportional process
was invented independently by
Petro Vlahos and Carl Hanseman,
and developed by Image Trans-
form, Inc. and Vidtronics, Inc.
Magicam has used both systems.

John Gale
Technical Director

Magicam Inc.
5451 Marathon St.
Hollywood, CA 90038

Data on radar in our
Bicentennial issue

Along with all the others, I too
think your “200 Years of Progress”
is tops. I’m saving my copy.

I saw one statement that I knew
to be wrong, but who can be 100% correct in such a fine compilation?
I did not intend to say anything
but since others have cited what
they believe to be errors, I thought
I’d throw mine in.

You stated, “In 1943 the term
‘Radar’ was coined by Commander
S. M. Tucker of the U.S. Navy.”
I was assigned as Personnel Officer
of the Signal Corps General De-
velopment Laboratory in February
1942. Just prior to my assignment
a section of the laboratory known
as the RPF section (Radio Position
Finder) was separated from the
SCGDL and made a separate labo-
atory at Belmar, New Jersey. It
was named the Signal Corps Radar
Laboratory, Lt. Col. Rex Van Dam
Corput commanding (later to be-
come Brig. General).

In April 1942, I was recruiting
civilian engineers for the SCGDL
and a Major Bannister, was recruit-
ing for the Radar Laboratory.
While in California we received
orders to discontinue the use of the
word “Radar.”

We joked about it, because we
had already seen it in print in a
trade magazine. We also joked that
perhaps we should spell it back-
wards. Thousands of brochures had
already been printed re the SC
Radar Labs and a few hundred
distributed.

Of course it’s trivia, but none-
theless it’s true.

John T. Freeman
Sr. Res. Engineer

E. I. DuPont De Nemours & Co.,
Inc.
Photo Products Department
Parlin, NJ 08859

Electronic Design 16. August 2, 1976
HP 3000 Series II systems are a powerful combination of software and hardware designed to deliver optimum performance.

Manage fast-growing data bases efficiently with new HP 3000 computer

As a terminal-oriented, general purpose computer, the new HP 3000 Series II is designed to operate in both batch and interactive terminal environments. Three compatible models allow you to select the configuration needed for present applications whether yours is a small or large organization or a corporate division. As your needs grow, the HP 3000 Series II can be upgraded—main memory can be expanded to 512K bytes.

Big system capabilities include:
- Fault control main memory—detect and correct memory errors with no reduction of speed
- Teleprocessing—data entry and processed-data-return via telephone lines
- Multi-terminal update and inquiry
- Data and file security
- On-line program development
- Job accounting
- Input and output spooling—for optimum use of peripherals
- Multiprogramming—for concurrent batch and terminal operations
- Remote job entry to large computers

In this issue

- Instruments "talk" and "listen" with HP interface
- Automatic RF network measurements
- New mini-processor board for your instruments
- Five most popular commercial programming languages
- Data base management software (IMAGE/QUERY)
- Virtual memory

The HP 3000 Series II has been job-performance rated. Benchmark results are available to help you choose the proven capability that you need.

The HP 3000 Series II functions as a complete, independent data processing center, or as a satellite in a network of large computers.

If you plan to install a computer or upgrade your present system, you owe it to yourself to get all the facts. Check E on the HP Reply Card and we will send you a brochure with all the details.
High power pulse generator ideally suited for varied applications.

The highly flexible and carefully controlled output pulse characteristics of the Hewlett-Packard 214A make this pulse generator well suited to many applications. With output amplitude continuously variable from 80 mV to 100 V into a 50Ω load and fast (<15 ns) transition times, as well as minimum jitter, this pulse generator is particularly well suited for such applications as driving high-power modulators, semiconductor device testing, laser system testing, nuclear research and biomedical research.

Some of the more unusual applications of the 214A are:

1. A scientist at the University of California's Coastal Marine Laboratory used the 214A to measure the sound transmission in the head of a porpoise.
2. Engineers at the Convair Aerospace Division of General Dynamics in California used their 214A to find flaws in material by ultrasonic interference spectroscopy.
3. A French scientist used the 214A to measure the mobility of radioactive ions.

In addition to these applications, other engineers and scientists have used the 214A as a modulator driver in laser research and a pulse stimulus in basic material research. If you have an application for a pulse source that requires a high power signal, up to 200 watts, or a good, general purpose pulse generator for your lab, consider the HP 214A.

For additional details, check B on the HP Reply Card.

New multi-family logic clip speeds IC troubleshooting

Hewlett-Packard's new 548A logic clip troubleshoots IC digital logic circuits faster than ever:

- Its LEDs show logic states of 16 IC pins at once—a "truth table" display.
- It automatically adapts to TTL, DTL, RTL, CMOS and HTL circuits, and automatically seeks Vcc and ground.
- It's overload protected to 30V dc, to avoid damage from linear ICs.
- It draws <15 µA per pin—no circuit loading worries.

Use it with in-circuit stimuli or replace the system clock with our 546A Multi-Family Logic Pulser and slowly step sequential logic devices through a cycle to verify operation.

The 548A joins three other new HP IC troubleshooters to bring you the most modern set of handheld logic troubleshooting instruments available:

- The 547A Current Tracer lights up when held on or close to circuits carrying logic pulses from 1 mA to 1 A. Troubleshoot wired-AND/OR busses, three-state busses, or pinpoint the one bad device on a stuck node.
- The 546A Logic Pulser is programmable to give one pulse per command, a 1, 10, or 100 Hz stream or a burst of 10 or 100 pulses. It drives TTL or CMOS high nodes low and low nodes high for stimulus/response testing.
- The 545A Multi-Family Logic Probe lights up to show logic highs, lows or bad level. Its pulse stretcher catches pulses as short as 10 ns.

Check C on the HP Reply Card.

The 548A logic clip is so easy to use that you can concentrate on the circuit under test instead of the test equipment.

For more information, circle A on the HP Reply Card.

NEW "minicomputer on a board" is user programmable

For the first time, Hewlett-Packard is offering the 21MX K-Series mini-processor components. Conveniently packaged for integration into your systems, the series includes the 2108K mini-processor board, instruction ROMs, front panel control assembly, and a choice of 18-slot or 8-slot cages.

As a 24-bit microprocessor, it is capable of performing a register-to-register add in one 325-ns cycle.

With the 12728E instruction set ROM, it becomes compatible with 21MX processor options, peripherals and operating systems.

Users can also benefit from the complete library of 21MX software systems for standard high level languages and microprogramming language, including the powerful new RTE-III Real-Time Executive operating system.

Systems which could be designed around the HP processor include spectrometers, numerical control units, smart terminals, graphic display systems, medical diagnostic systems and other test equipment. A broad range of peripherals and instrumentation interfaces are available.

The 2108K gives you an opportunity to design high performance processing into your system. Accessories are priced separately. OEM discounts are available for quantity purchases.

For additional details, check B on the HP Reply Card.
Accurate measurements in hard-to-reach spots using touch-hold probe on new DMM

The touch-hold probe accessory for the new Hewlett-Packard 3½ digit, five-function autoranging digital multimeter allows the user to "freeze" the reading on the display—a convenience when probing closely-packed circuit boards.

Autoranging and manual modes: ac voltage, dc voltage and resistance can be measured either autorange or manually selected ranges. Select autorange to speed readings and minimize reading error—the LED readout always displays appropriate units. For repetitive readings, or ac and dc current measurements, use the manual mode, selecting from at least five ranges for each function...again the appropriate units will be automatically displayed on the high-efficiency LED annunciators.

Eliminate the need for both a high frequency ac voltmeter and a low-range ohmmeter inasmuch as the 3435A operates over a bandwidth five times greater than most comparable priced DMMs. Measure up to 1200V rms between 30 Hz and 100 kHz, with midband accuracy of 0.3% of reading plus three digits. Or, test resistance from a new low range of 20Ω full scale up to 20 MΩ. Dc voltages up to 1200V are measured with a full-year best accuracy of 0.1% of reading plus one digit. Ac and dc current ranges extend from 20 µA to 2A. All inputs are protected; polarity is automatically sensed and displayed, and autozero occurs before each reading. Open circuit voltage on the ohm terminal, at its lowest range, does not exceed 5 volts, thus preventing damage to most solid-state devices.

Contact and transformer winding resistance are easily measured with 10 milliohm sensitivity. 100 µA sensitivity on the ac and dc ranges make the 3435A ideal for both bench and field applications.

An extensive line of accessories also includes probes for measuring ac voltages at frequencies as high as 700 MHz and dc voltage up to 40 kV.

The standard 3435A is ac line or battery operated and includes batteries and recharging circuitry. If you don't need battery operation, Option 001 gives you line operation only. A rack mounting model is also available. The touch-hold probe is an inexpensive accessory.

For more details, check F on the HP Reply Card.

With new touch-hold probe, you can concentrate on your circuit, conveniently hold the measurement, and read the 3435's display after removing the probe. You are confident of measuring at the right point without accidently shorting the circuit.

HP logic state analyzer speeds digital design and logic troubleshooting

In the TABLE mode, the 1600S displays up to 16 lines of code, and up to 32 bits wide, with their sequential relationships in familiar logic notation.

If you've ever spent more time than you care to account for in looking for the source of elusive digital problems, you will appreciate the effectiveness of using an HP logic state analyzer.

Look inside your operating circuit, right on the busses and qualifier lines. The HP 1600S logic state analyzer gives you two ways to view system operation—MAPPING and TABLE.

MAPPING, which consists of a display of interconnected dots, offers a dynamic overall view of the program flow.

Each dot represents a specific data word with its position determined by the binary content of the word and its brightness indicates its relative frequency of occurrence. Once the suspected problem area is located, switch to the TABLE display mode.

Now, look at events leading up to, surrounding, or following the trigger word. Or, page through a program up to 99 999 clock cycles beyond your trigger point.

Circle D on the HP Reply Card for your copy of an 8-page brochure.
HP calculators control your instruments with easy do-it-yourself interfacing

NEW 4-channel tape recorder offers 32:1 time base expansion or compression plus remote control via HP-IB option

The new HP 9815 and HP 9825 computing controllers make interfacing practical and inexpensive. Whether your interfacing application is simple data logging, dedicated instrument control, or large system integration, these controllers can save you time and money while increasing productivity.

Converting the signals from one device to another or vice versa, is now simplified. You simply plug the correct interface card into the back of the controller that fits your need. Connect your instrument to the other end of the I/O card, program your controller with a few simple instructions, and you’re ready to put your automated system to work.

Types of interfaces available for the 9815 and 9825 include:

**HP-IB—Hewlett-Packard Interface Bus**—up to 14 instruments with built-in HP-IB capability can be interconnected to a computing controller via this interface system, HP’s implementation of IEEE Standard 488-1975. Bi-directional, asynchronous communication is now possible between many instruments.

**BCD—The Instrumentation/Measurement Interface**—the majority of instruments produced today output four-bit parallel BCD data.

**Bit-Parallel—The General Purpose Interface**—choose either 8 or 16-bit parallel input bus and an 8 or 16-bit parallel latched output bus combination. Use this interface to connect to HP devices such as plotters, tape readers, printers, or other equipment such as scanners, scanning electron microscopes, etc.

The HP 9815 calculator is an inexpensive alternative to manual monitoring of an instrument or small system. For large complex instrumentation systems, the HP 9825 can interface to as many as 42 measuring instruments through its three I/O slots. The internal processing speed is so fast that transferring data and commands, accepting inputs, analyzing data, and printing or plotting results appear to happen simultaneously.

**For additional information on additional features and options, check H on the HP Reply Card.**

Easily interface your instruments—scanners, counters, spectrometers, meters, converters and many others—with an HP calculator, thus achieving greater efficiency of the use of their outputs. An automated system giving you results and reports faster and easier will eliminate manual readings, adjustments and calculations, freeing you for creative project management.

A new four-channel (0.6 cm) ¼-inch instrumentation tape recorder, the HP 3964A, has all of the standard features of the recently announced eight-channel HP 3968A ITR but at a much lower price.

Versatility, portability and durability are factors that will interest both the individual researcher and the OEM user, both for laboratory and field use.

Record at six tape speeds from 15/32 ips to 15 ips. Standard features include remote control, internal AC/DC calibrator, tape/tach servo mode and flutter compensation. Channel 2 may be interrupted for voice annotation; microphone and speaker are included.

FM recording is from DC to 5 kHz with a signal-to-noise ratio (SNR) of 48 dB at 15 ips. Direct recording is from 50 Hz to 64 kHz with SNR of 38 dB.

**For additional information on additional features and options, check H on the HP Reply Card.**

**NEW 4-channel tape recorder offers 32:1 time base expansion or compression plus remote control via HP-IB option**

A new four-channel (0.6 cm) ¼-inch instrumentation tape recorder, the HP 3964A, has all of the standard features of the recently announced eight-channel HP 3968A ITR but at a much lower price.

Versatility, portability and durability are factors that will interest both the individual researcher and the OEM user, both for laboratory and field use.

Record at six tape speeds from 15/32 ips to 15 ips. Standard features include remote control, internal AC/DC calibrator, tape/tach servo mode and flutter compensation. Channel 2 may be interrupted for voice annotation; microphone and speaker are included.

FM recording is from DC to 5 kHz with a signal-to-noise ratio (SNR) of 48 dB at 15 ips. Direct recording is from 50 Hz to 64 kHz with SNR of 38 dB.

**For additional information on additional features and options, check H on the HP Reply Card.**

**NEW 4-channel tape recorder offers 32:1 time base expansion or compression plus remote control via HP-IB option**
Two HP-IB compatible counters measure UHF and TACAN/DME frequencies

The compact HP 5305B is designed for bench and portable applications in communications service; the HP 5328A is a full capability Universal Counter including precision frequency and time interval measurement for bench and systems use in laboratory or production test.

New capabilities extend two HP counters to 1300 MHz with 20 mV sensitivity to cover the VHF and UHF TV and mobile communications bands, TACAN/DME, and AM and FM broadcast bands. Each also includes a first for electronic counters—a probe power outlet to drive an accessory 22 dB (×10) preamp. The HP 10855A Preamp (plugged into 5328A counter above) enables the measurement of very low level signals. See article to the left.

Model 5305B operates with the 8-digit 5300B mainframe for frequency measurements from 50 Hz to 1300 MHz. A phase-locked multiplier gives ×1000 resolution for rapid, accurate, automatic audio tone measurements to 10 kHz. With both extended high frequency range and improved audio range resolution, the 5305B is ideal for servicing mobile communications equipment that uses tone modulation for digital transmission.

The 5305B is one of eight snap-on modules for the 5300B measurement system. Any of seven other modules can be snapped onto the 5300B upper “readout module” in place of the 5305B in less than 30 seconds to convert the 5300B for other frequency or time interval measurements, or to a digital multimeter for ac/dc volts/ohms. Other accessories that snap between upper and lower halves include a battery pack and charger, a digital-to-analog converter for high resolution plots on analog recorders, and an HP-IB module for outputting digital data to the Hewlett-Packard Interface Bus.

With the HP 5328A Universal Counter, Option 031 adds 1300 MHz frequency measurement range to the extensive period, time interval, totaling, ratio and voltage measurement capability of this 8-digit counter (9 digits optional).

The 5328A achieves its extended versatility by any of eight options which are either factory or field installable in about an hour. In addition to Option 031, there’s: an ultra-stable time base option for higher accuracy, complete remote operation via the Hewlett-Packard Interface Bus, choice of two different built-in DVMs, a third frequency input channel up to 512 MHz with 9-digit display and a high performance time interval option.

For more information, check N on the HP Reply Card.

How to make your spectrum analyzer measurements more accurate

Just published is a new application note, AN 150-8, a comprehensive discussion of spectrum analyzer accuracy considerations. Factors that determine amplitude and frequency accuracy are examined and procedures for obtaining the best accuracy are presented. Special cases such as swept measurements, low-level signals and closely spaced signals are described.

For your copy, check T on the HP Reply Card.

Boost low level signals with new 1300 MHz preamp

The new HP 10855A preamp enhances measurements of very low level signals by 22 dB minimum. Uses include amplifying “on-the-air” signals for measurement with counters or spectrum analyzers and restoring the loss of scope divider probes. The 10855A boosts the input sensitivity of HP counters by a factor of 10.

This preamp features ±1 dB flat response from 2 MHz to 1300 MHz, with 50 Ω input and output impedances. This covers the VHF and UHF television, mobile communications and TACAN/DME bands. An input fuse prevents costly preamp damage.

The 10855A operates conveniently with HP measuring instruments having probe power outlets (see counter above right) or will work with a separate probe power supply such as the HP 1122A.

For more information, check R on the HP Reply Card.
The HP 8640B now phase locks with 500 Hz resolution. Companion down converter extends output down to 5 kHz.

Models 8640A/B signal generators are now offered with improvements in resolution, power, and modulation setability.

Some mobile FM receivers (especially in Europe) are now using channel spacing of 12.5 kHz to increase communications capacity. To meet this need, the HP 8640B signal generator now features an additional half digit of phase lock resolution across its entire band of 500 kHz to 1024 MHz. (500 Hz lock points from 100 MHz to 1 GHz).

Internal design changes provide simplified front panel operation for output power and modulation settings. New, low-power counter circuits and other component changes have reduced heat and component count for added reliability.

The same power and modulation changes have been made in the HP 8640A slide-rule-dial tuning signal generator.

New 5 kHz to 550 kHz down converter

Design and service of AM-FM broadcast receivers often require test signals for both RF bands as well as the standard IF frequencies at 262 kHz and 455 kHz.

The HP 11710A down converter, as an accessory for the above-mentioned 8640A/B, provides a frequency range of 5 kHz to 500 kHz by mixing a 5.0 to 5.5 MHz carrier from the 8640 signal generator with a fixed 5 MHz oscillator in the 11710A.

Calibrated output level is preserved from 0 to −107 dBm, and the calibrated modulations may be set on the 8640. Intermixing spurious is more than 80 dBc (dB below carrier) and harmonics are more than 30 dB down. For user convenience, an RF switch bypasses the down converter and eliminates the need to switch cables when using the standard 8640 band.

Equipment designers who require a broadband microwave detector with excellent performance and small dimensions now have an answer.

The HP 33330B detector covers the frequency range 0.010 to 18 GHz with excellent flatness (±0.6 dB to 18 GHz). Package size is ideal for designing into small spaces. Total length of the package is 4.2 cm (1.70 in) and diameter is .97 cm (0.38 in). The model 33330C extends the frequency range to 26.5 GHz with reduced performance.

RF input is 50Ω with an SWR of less than 1.5 to 18 GHz. The connector is the new APC-3.5 precision subminiature which exhibits outstanding reliability and repeatability even after 1000 connections. The APC-3.5 is fully compatible with the industry-standard 3.5 mm SMA series. The video output connector mates with the SMC series, which is especially well suited for the miniature cabling of modern equipment.

Models 33330B/C utilize the same field-replaceable diode module developed by Hewlett-Packard for measurement-quality microwave detectors and are specifically designed for use in rugged environmental conditions.

For more details, check K on the HP Reply Card.
New low loss absorptive modulators cut insertion loss 0.5 dB

New hermetically sealed semiconductor devices in a rugged overall package are matched at all attenuation levels.

Three new HP absorptive modulators (33001E/F; 33008E) provide at least 0.5 dB improvement in insertion loss over previously available models. This improvement has been made possible by incorporating Hewlett-Packard low-loss PIN diodes into the modulators.

Absorptive modulator applications include level setting, wideband amplitude modulation, pulse modulation and switching. The absorptive modulators present constant impedance and therefore are useful where load sensitive sources are used.

These absorptive modulators are electronically controllable attenuators for the frequency range from 3.7 to 18 GHz. Each product covers greater than one octave and presents a good impedance match (\(Z_0 = 50\Omega\)) at both RF ports for all values of attenuation.

Details of these test programs are described in a new technical data sheet. For your copy, check I on the HP Reply Card.

For technical data, check I on the HP Reply Card.

High reliability test programs for microwave transistors

If your procurement needs are immediate and you need microwave transistors screened by high-reliability test programs, Hewlett-Packard offers four levels of high-reliability testing patterned after MIL-S-19500.

Applications for these “off-the-shelf” microwave transistors include satellite equipment, avionics, radar, military radio and communications.

Four small-signal NPN transistors are presently offered: 35824A for general use to 1 GHz; 35826E for microstrip use to 4 GHz; 35829E optimized for high “tuned” gain at 2 GHz; and 35866E optimized for low noise at 4 GHz.

For more information, check L on the HP Reply Card.

Four new .43” universal overflow digits

Overflow digits expand HP display family.

Available in red, high-efficiency red, yellow or green these devices can be driven common anode or common cathode because both leads of each LED are brought out to separate pins. Right-hand decimal point is a standard feature on this 5082-7756 series.

These devices are available from any franchised HP distributor.

New microwave components short form catalog

Microwave circuit designers will want this new 4-page quick reference guide to Hewlett-Packard’s line of diodes and transistors. A condensed review of the company’s microwave components, this new brochure gives important specifications of HP’s microwave transistors, and PIN, IMPATT, step recovery and Schottky diodes. Also included are condensed specifications of MIS capacitor chips and a printed circuit balanced mixer.

For your copy, check S on the HP Reply Card.

New low-power monolithic displays

Now available from Hewlett-Packard is a new series of low monolithic LED displays for instrument design. These magnified displays require only 1/3 the power of conventional seven-segment displays while offering excellent readability in high ambient light conditions.

Close digit-to-digit spacing allows over 4 digits per inch in a pre-aligned multi-digit package.

The 5082-7265/75/85/95 series comes in 5 and 15-digit packages with centered or right-hand decimal points.

These devices are available from any franchised HP distributor.

For a technical data sheet, check M on the HP Reply Card.
Make RF network measurements automatically—cassette programs simplify system start-up

Hewlett-Packard’s new 1.3 GHz network analyzer, the 8505A, brings unprecedented capability to RF network characterization: 100 dB dynamic range, high-resolution digital data readout with analog display, direct measurement of group delay, and a unique electronic line stretcher to measure deviation from linear phase.

The 8505A is also the most programmable network analyzer available today, permitting the analyzer to combine with the programmable HP 9830 calculator through the Hewlett-Packard Interface Bus (HP-IB) to become an immensely powerful automatic network analyzer.

Key advantages of automating the network analyzer include: extreme measurement accuracies (by virtue of the system’s ability to measure, store, then subtract such vector errors as frequency response, directivity and source match) ability to make many measurements quickly, and the ability to manipulate data and format results in a suitable form.

Unique to this new automatic analyzer is its “Learn Mode” of operation which makes it possible to automate measurements without programming. A single key stroke can cause the calculator to store (Learn) the front-panel control settings of the network analyzer. These can later be recalled which turns the analyzer to its original test conditions. An entire test procedure can be created without writing a single program line!

A fully-configured automatic analyzer, Model 8507A, includes the 8505A analyzer, 8503A s-parameter test set, 9830 calculator (controller) with printer, necessary interfaces, cables, calibration kit, table and cassette programs which permit you to start making measurements immediately.

For more details, check O on the HP Reply Card.
CSC'S DESIGN-MATE 4: $124.95. NO OTHER DIGITAL PULSE GENERATOR GIVES YOU SO MUCH, FOR SO LITTLE.

Sounds hard to believe... but even a brief look at Design-Mate 4's specifications proves CSC's engineers have done it again. Whatever your application—whether you're looking for precision, flexibility or just plain economy—this compact source of fast, clean digital pulses offers the performance you need... at a price that discourages procrastination.

Use it as a clock source, delayed pulse generator, synchronous clock, manual system stepper, pulse stretcher, clock burst generator or in dozens of other applications. Use it alone or in tandem with other DM-4's for gated control. The wide range of controls and multiple outputs give you enormous versatility... plus compatibility with all major logic families, for research, design, development, quality control, production testing, maintenance, troubleshooting... you name it.

Now, read the specs that follow... and check the price again. Or better yet, try DM-4 for yourself at your local CSC distributor. Once you do, we think you'll find it's as hard to do without as it is easy to own.

For more information about CSC's other fine products, and a list of distributors, please call or write.

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**DM-4 SPECIFICATIONS**

- **Frequency Range:** 0.5 Hz to 5 MHz
- **Pulse Width and Spacing Controls:**
  - **Pulse Width:** 100 nanosec to 1 sec in 7 overlapping decade ranges
  - **Duty Cycle:** 10 to 1 range adjustable over entire pulse width/spacing range. 100 nanosec 'ON' 1 sec OFF to 1 sec 'ON' and 100 nanosec OFF
- **Operating Modes:**
  - **RUN:** 0.5 Hz to 5 MHz as per width/spacing and amplitude control settings
- **TRIG Input requirements:**
  - DC to approx. 10 MHz
- **GATE Input requirements:**
  - Sine waves 2 VPP pulses 1 V peak >40 nanosec wide, maximum input 10 V (input impedance approx. 10KDC coupled.)
  - Synchronous gating. Leading edge of gate signal turns generator ON. Last pulse is completed even if gate ends during pulse.
- **Input requirements:** Same as TRIG Mode

---

**ONE-SHOT**

- Pushbutton for single pulse.
- Output pulse occurs each time push button is pressed.

**OUTPUTS**

- **VAR OUT**
  - Amplitude: 0-10 V positive
  - Rise/fall time: 0.1-10V
  - Impedance: 4000Ω max
- **TTL OUT**
  - Fan-out: 40 TTL Loads
  - Sink: 160 milliamps—0.8 V max
  - Rise/fall time: Less than 20 nanosec
- **SYNC OUT**
  - Pulse width: Approx. 40 nanosec. Other sync pulse spec's same as TTL out.
  - Pulse lead: Sync pulse leads outputs by approx. 20 nanosec.
- **POWER**
  - 117 VAC 10%, 50/60 Hz; 5 watts (220 VAC 50/60 Hz also available, at slightly higher cost)
  - SIZE: 7.5 x 6 x 3.25
  - WEIGHT: 191 X 155 X 63 mm
  - 2 lbs. (0.91 Kg)

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**THE LOGICAL CHOICE: Third in a series**

**INDEPENDENT CMOS AND TTL OUTPUTS Fan-out to 40 TTL loads**

**SYNCHRONOUS OUTPUT GATING**

100 mV-10V POSITIVE OUTPUT Less than 30 nanosec rise/fail times
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CIRCLE NUMBER 8
Photovoltaic applications studied by NASA and ERDA

Sun-powered campers and electric cars with batteries recharged by sun power, are two ideas now being studied by the Photovoltaic Test and Demonstration Project under way at NASA's Lewis Research Center in Cleveland, OH. The project is a joint venture of NASA and ERDA (Energy Research and Development Agency).

A solar-powered camping refrigerator, to be tested at a remote trail-construction camp in Isle Royale National Park, MI, will be the project's first demonstration.

Battery chargers on electric vehicles will be the recipients of 1-1/2-kW arrays currently under study at Lewis.

All solar cells used by the Lewis group will be standard off-the-shelf photovoltaic cells that will be procured from several different sources, according to Robert Easter, assistant to the project manager at Lewis. The refrigerator project uses Type 785 silicon cells from Solarax, Rockville, MD.

To power the refrigerator, modules containing an array of 3 x 6 cells contained in a flat plate 10-1/4 x 20 in. are used. Each module produces a 6-V output with 9.2-W capacity. Since the refrigerator requires 12-V operation, the modules are connected in 2-module series pairs. Twelve of these series pairs are paralleled to provide 220 W of available power.

In addition to powering the refrigerator when the sun is out, the cells also charge six automotive lead-acid 100 A-h batteries, which power the refrigerator at night or during bad weather.

The Lewis group is currently designing a prototype residence with solar cells arrayed on the roof. They will provide up to 10 kW of power to get the residence through peak usage periods. This prototype residence should be completed around January of 1977.

Photovoltaic arrays with 1 kW of output are now being designed into US Forest Service lookout towers. The first two prototype towers will be installed by September.

Weather reporting from remote locations will be eased by 200-W solar arrays being designed to go into remote weather stations by September, 1976.

Not to be outdone, the Dept. of Defense is in on the studies as well. Prototype completion by later this year is planned for arrays to be used in telephone vans, radio relays, remote radars, intrusion detection systems, battery chargers and water purification plants. Most of these systems will be tested at Fort Belvoir, VA.

Finally, Lewis is designing large demonstration panels for use in industry and shopping centers. By 1977 the panel will have a capacity of 100 kW. So far 2 kW are installed. By the end of August, 10 kW will be in place. And in a year, 40 kW will be in use.

Calculator remembers—even when turned off

The pocket calculator race continues at full gallop. Two new members of this ever-growing family were introduced last month, one from Hewlett-Packard and the other from Texas Instruments.

HP’s offering is the addition of a nonvolatile memory to its model-25 programmable scientific calculator. Designated the model 25C, the new unit is identical to the older HP 25, with the added feature that information, once entered, is retained even while the calculator is turned off. Program steps and data that are repeatedly used can thus be stored in the calculator. This storage results in the saving of operator time, and extends battery life.

Two data storage chips in the calculator use CMOS (complementary metal oxide semiconductor) technology to achieve continuous memory. Typically, the two chips require about 5 μW steady power drain to preserve the information. This figure represents about 1/80,000 of the 400 mW normally used when the machine is on. The model 25C is priced at $200.

From Texas Instruments comes the model TI-30, a low-cost ($24.95) unit aimed at the 15-million member high school student market.

Texas Instruments’ TI-30 scientific calculator retails for $24.95.

Like its more expensive cousins, the SR-52, SR-56, and SR-60, the TI-30 features Texas Instruments’ Algebraic Operating System (AOS), a method of solving algebraic equations through multiple parentheses. With AOS, equations are entered from left-to-right, following standard algebraic hierarchy. Powers and roots are computed first, then multiplication and division, and finally, addition and subtraction. The calculator “remembers” all entries and then acts on them using this hierarchy.

The TI-30, in addition to the usual four functions (+, −, ×, ÷) includes, among other capabilities,
logarithms and trigonometric functions (in degrees, radians and grads).

For HP  CIRCLE NO. 318
For TI  CIRCLE NO. 319

Bell plans digital system to use occupied channels

The Bell System is testing a new digital system that takes advantage of normal pauses in telephone conversations to provide additional information-carrying capacity over an occupied communications channel.

Called TASI (Time Assignment Speech Interpolation), the system is being tested by Bell Telephone Laboratories and AT&T's Long Lines Dept. on Bell System microwave radio facilities between New York and Boston.

The new TASI is a modernized version of a system installed in 1960 in undersea cables between the United States and Europe and between Canada and Australia.

The earlier TASI worked with analog telephone transmissions. For each voice channel, individual speech detectors and speech-processing circuits were needed.

In the new TASI, the voice signals are converted into digital form, which allows single, high-speed digital circuits to perform speech-processing functions on a large number of channels.

The digitized speech can be sent directly to a distant location over a digital transmission system such as the T4M digital coaxial cable system. Or, the signal can be converted into its original analog form for transmission over conventional analog facilities.

The signal is transmitted via single-sideband using frequency-division multiplexing.

Sampling head measures electro-optic pulses

An oscilloscope sampling head has been built that measures both electrical and optical pulses with a potential resolution of 10 picoseconds.

The device's other advantages over conventional instruments: it has a broader bandwidth, greater dynamic range and it's free of sampling-pulse interference. The head was developed by the National Bureau of Standards, Boulder, CO.

Optical pulses, at present, are measured with a sampling oscilloscope whose sampling head uses a photodiode as an optical-to-electrical transducer. These oscilloscopes, however, distort the sampled pulse because of limited bandwidth in the detector circuits.

The NBS sampling head isolates sampling interference by optically sampling electrical pulses, and, conversely, electrically sampling optical pulses. The new head uses a gallium arsenide (GaAs) photodiode—instead of a photodiode—as a transducer.

The photoconductor's output is the product of the optical and electrical waveforms, regardless of which is the sampling pulse and which is the sampled. This product-forming property, essential to the sampling operation, cannot be obtained with a photodiode in its normal reverse-biased mode.

The NBS sampling circuit uses the photoconductor shunt capacitance and stray-wiring capacitance as a sampling capacitor. Thus, unwanted and unavoidable effects are exploited to gain greater bandwidth in sampling optical waveforms.

By combining the detecting and sampling functions in one GaAs chip and centralizing these and other original processing operations in the sampling head, the developers expect to attain greater fidelity in the scope's displayed waveform.

Cable TV firm installs first fiber-optic cable

Fiber optics is beginning to thread its way into the television industry.

Early this month, Teleprompter Manhattan Cable Co., a New York City home cable television firm, began using an 800 ft length of fiber-optic cable to carry signals from its receiving equipment atop a tall apartment building in Manhattan to its central processing offices, 34 floors below. Excellent quality of the transmitted picture was reported by William Bresnan, Teleprompter Cable's president.

The Teleprompter hookup is reported to be the first practical use of fiber optics in the television industry.

Only 90 microns (90 x 10^-6 meter) in diameter, the fiber-optic cable replaces a conventional 3/4 inch coaxial cable that was used until now.

TV signals on the roof are first amplified, and then used to modulate a light-emitting diode. The resulting optical signal is carried down the length of fiber-optic cable.

Advantages of fiber-optic communications are by now well known. They include such benefits as:

- Conventional coaxial transmission requires the use of repeater amplifiers approximately every 1/3 mile. Using fiber optics, however, the number of such repeater stations is reduced to one every 1.5 miles.
- A single optical fiber can potentially carry many more TV and audio channels than a coaxial cable.

The new Teleprompter installation currently carries a single channel, that of Home Box Office, the pay-television service. However, by using a laser as the light source instead of the present LED, up to 167 TV channels could be transmitted on the single fiber cable.
Introducing the amazing EECO

This machine uses a computer, and people, and hardware all under the same roof, and gives you a chance to correct or change your circuitry before we go to hardware. We deliver in as little as two weeks, including time for you to review.

We’ve been doing this for more than five years, almost in secret. Now we’re telling you and the world because it’s about time.

Write or phone the keeper of the EECO machine, Dick Hunter.

machine: in one end you put your raw, un-annotated logic diagram, and out of the other comes your fully wire wrapped socket board/frame/drawer/system—your choice. Together with a Final Exception Report, a Final String List, an IC Location List, lists for IC Type and Socket Size, a Wire Loop List, a Pin Assignment List, an Unused Circuit Elements and Pins List, a Pin by Pin Wire List, and your diagram back, fully annotated.
Motorola switches on SWITCHMODE II.*
The world's fastest Darlington.

If you can't use the speed, think about the money.

When we say fast, we mean fast — like 40 nanosecond typical inductive fall time at 10 amps.
Switchmode II MJ10004-07 silicon power turns off twice as fast as any other high-current, high-voltage Darlington. Period.
The faster, the better — and at twice the speed, switching losses are cut in half. That's efficiency anyone can use.
It's all because of Motorola's recognized leadership in power Darlington devices. We introduced 'em, refined 'em and keep coming up with the right parts for today's applications.
The new 10 and 20 amp units are perfect examples. Literally.

Besides offering up to 450-volt sustaining capability, they're true Switchmode devices with all the essentials for high-frequency, 200°C inductive use spelled out on Designers' Data Sheets. Up to 5,500-volt-ampere RBSOA capability. High-temperature, clamped inductive load switching specs. Switching times as functions of collector current and temperature. Spec'd limits for active region SOA. Maximized stability through high-performance glass passivation. Optimized B/E resistor values and current gain.
Switchmode II is the biggest story in years in switching Darlington devices.
You've got a chance to read it in our special Switchmode literature package of Designers' Data Sheets, Selector Guide and application notes. Write Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036, or use your in-plant VSMF center.
Oh, yeah, the money. You pay less for the MJ10004 family. Right. Less than competitive parts. At up-to-999 prices of $4.50 to $9.50, you can save a bundle over parts that are microseconds slower.
Think about that on the way to the bank.

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General Time’s new DIGITAL Timers are changing the way equipment is being designed...

here’s what you should know about them.

• Their low, low prices and high dependability enable them to replace both low and high accuracy analog timers as well as most electro-mechanical timers.

• Their digital circuitry provides exceptional + 0.5% repeat accuracy in all time ranges — even those as long as 60 minutes. Their short reset, recycle and abort times give you a new level of design flexibility.

• They’re now in stock at all Distributors listed below. For complete information about General Time Q-20 Digital Timers use the reader service number provided.

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[CIRCLE NUMBER 11]
At the Consumer Electronics Show

Scope built in FM tuner monitors quality of audio and rf reception

A unique FM tuner—the Sequerra 1—is the first consumer device to incorporate a multifunction oscilloscope for visual, as well as aural, evaluation of the rf input and of the demodulated stereo or quadraphonic audio of the station to which it is tuned.

A panoramic spectrum analyzer in the Sequerra 1, demonstrated at the recent Consumer Electronics Show in Chicago, provides a visual display of FM stations broadcasting a signal above the ambient interstation noise, which is represented by the scope base line. When the set is properly tuned to a particular frequency, the station is centered on the scope screen, as shown in the tuner photo.

The height of the vertical pips indicate relative signal strength. Alternate channel stations appear at 400-kHz intervals from the center frequency, and adjacent channel stations appear at a point 200-kHz away from the station tuned in.

The panoramic analyzer can be used to orient the FM antenna for greatest signal strength, and is also useful in detecting and identifying interference from other radio stations or from electrical devices.

Exact visual tuning possible

A tuning-signal-analyzer function provides precise visual tuning of the FM signal as well as indicating the rf-signal strength and percentage of modulation. It can also aid in antenna orientation by showing the best compromise of antenna position with respect to multipath reception and signal strength.

A typical selectivity response pattern is shown in Figure 1a, which displays the bandwidth, signal amplitude, threshold of noise level and noise density. A correctly tuned station is shown in 1b.

To analyze the separation, balance and phase characteristics of stereo program material, an internal vector separation circuit can be switched into the scope display.

For stereo broadcasts the instantaneous peak deviation of the right and left stereo channel information appears as in Figure 1c. The wider the angle of the display, the greater the separation; and the higher the trace the stronger the signal.

Audio signals from external sources can also be displayed. For example, with four-channel information, the left-rear vector is shown below the base line at 225° while the right rear vector is shown at 315°, as in Figure 1d.

Designers of the Sequerra 1, produced by the Sequerra Company, Inc., of Jamaica, NY for the audiophile who has everything—including the $2995 to buy it—
Buy our boards now if you want to stop buying them later.

If you’re thinking of making your own microcomputer boards sometime in the future, ours are the only boards to buy right now.

Because the chips on our microNOVA boards are the same ones you can buy in the microNOVA chip set.

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The microNOVA board is a full 4K microcomputer. With a number of standard features. Like power-fail/auto-restart. Real-time clock. NOVA instruction set with hardware stack. Hardware multiply/divide. Data channel logic.

Yet all the above computer costs only $589, in OEM quantities of 100.*

Which is a lot of computer for a little money. Because it’s a NOVA computer, the microNOVA board comes with powerful run-time software. Like RTOS, our NOVA-compatible, field proven realtime executive. And it runs both Assembler and FORTRAN.

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Yet the microNOVA 4K board is only one member of an entire family. Besides the board (and all the supporting boards), you can get complete development systems. Or you can get completely packaged MOS minicomputers. Or chip sets that include the mN601 CPU, plus all the supporting chips.

So if you want to end up in the chips, call our toll free number, 800-225-9497. (Unless you’re in Massachusetts. In which case, call 1-617-485-9100, EXT. 2509.)

microNOVA: A giant reduction in the NOVA line.
minimized the use of microcircuits to obtain the higher performance of discrete construction.

Other features in the tuner include the use of a varactor-tuner front end to minimize both packaging space and microphonics associated with standard gang-capacitor tuning. Also, n-channel FETs are used in balanced push-pull stages of rf amplification to cancel out the even harmonics, which produce the highest level spurious response.

Another special circuit in the tuner varies the separation of the high frequencies in stereo broadcasts to suit the listener. A "Maximum" position provides the best spatial and directional definition of the tuner's audio output. A "High Blend" position eliminates some high frequency noise under adverse listening conditions, such as excessive record hiss.

The station-frequency readout is a four-digit LED frequency counter that is controlled by the local oscillator. The use of a local oscillator rather than a frequency synthesizer was decided upon for two reasons.

First, although the synthesizer is inherently more accurate, there are stations abroad that do not fall at the equal frequency intervals to which it is programmed. Also it produces only even or odd frequency intervals, which would make it impossible to tune in some stations.

A combination of electro-optic, microprocessor and ultrasonic technologies has produced the first intelligent electronic turntable, the Accutrac 4000. It can select any or all of the dozen or more tracks on long-playing records, under programmed control.

The microprocessor specially designed for the turntable can store and execute up to 25 individual commands. Tracks can be played in any order the listener wants by inserting commands through program switches on the unit or by using a hand-held ultrasonic remote control with a similar keyboard. Tracks can also be skipped or repeated, according to Audio Dynamics, New Milford, CT, the turntable producer.

Electro-optics in the head of the playback assembly finds the individual tracks and also tells the microprocessor when the track has ended. A small infrared LED is built into the special cartridge. The beam from the LED is focused onto the record. Closely spaced grooves scatter this light (Fig. 1), but smooth surfaces between the recorded portions reflect the infrared energy back to a detector. The detector output then triggers the arm-lifting and moving servo and

'Intelligent' turntable contains \( \mu \)P and LED in playback assembly

is fed to the microprocessor, which then initiates the next command.

The integrated design of the Accutrac tone arm and cartridge results in an ideal tone-arm resonance between 8 and 10 Hz. Although the arm is raised, lowered and moved sideways automatically by its own servo motor, which is independent of the turntable drive. It instantly decouples from the system as soon as the needle touches the grooves. This prevents unwanted groove wear.

The rate at which the playback head is lowered to the record is deliberately slower than with manual operation in order to extend record life.

A brushless, electronically controlled direct-drive turntable motor is used to eliminate the rumble, wow and flutter caused by the belts, wheels or pulleys of more conventional turntable drives.

The manufacturers of the new turntable say the system cuts record wear and avoids accidents—such as dropping the playback head on the record surface.

Direct-drive 12-V motor used

The electronically controlled, direct-drive turntable motor is a 12-V, brushless dc unit with speed-sensing circuitry, and Hall sensors for commutation. The speed of the motor, manufactured by Matsushita in Japan, is governed by the output of an RC oscillator. Speed-trimming controls, mounted on the turntable panel, permit locking the turntable speed to either 50 or 60 Hz of the local line frequency.

Pushbutton switches give the operator close to 33-1/3 or 45 rpm coarse speed. Two speed-trimming
Come up with an Optocoupler Application. And you might come up a winner.

Announcing the Optocoupler Contest. Sponsored by Schweber.

Send us your unique optocoupler/isolator application and you might win one of three terrific HP calculators. Winners will be selected on the basis of originality and workability of application.

**ENTRY FORM:** (Attach extra sheets if needed)

Description (50 words or less): __________________________

Circuit Diagram:

Mail to: Bill Gordon, Schweber Electronics, Westbury, N.Y. 11590

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Three winners will receive HP calculators from Schweber.

Deadline for entry is: September 30, 1976.

1st prize: HP 27 Calculator

2nd prize: HP 25 Calculator

3rd prize: HP 21 Calculator
Digital time-delay device greatly enhances living room acoustics

A new stereo component can make the acoustics of a living room sound like those of a concert hall, a theatre or a cathedral. It's a 37-kbit computer-like device programmed with an adjustable electronic model of acoustical space.

Called the Digital Time Delay System, the device synthesizes a live listening experience by digitizing stereo-channel audio signals and then adding multiple, continuous time delays to them. The signals are reconverted to analog audio voltages that contain echoes and reverberation.

The Digital Time Delay System, developed by Audio Pulse, Inc., Bedford, MA, overcomes mechanical resonances or electrical distortions of the signals that occur in the analog time delay systems used in other consumer electronic products. With the Audio Pulse system, on the other hand, once the audio input is converted to its digital equivalent, time delays can be introduced without signal distortion.

The key to the wide-range delays—up to 94 ms in the Audio Pulse system—is two developments. One, called "Delta Modulation with Memory," permits time-delay enhancement of audio signals at moderate cost, according to Richard F. DeFreitas, vice president of Audio Pulse.

The second development is the design of an elaborate set of mixing, phase-shifting, filtering and recirculating circuits that enhance the delayed sounds with the reverberation qualities characteristic of halls and auditoriums.

Delta modulation is not new, but this system includes an important new addition—a scratch-pad memory programmed to examine the recent history of the audio waveform and to predict what its slope will be during the next encoding interval.

Quadrupling the slew rate

Scratch-pad use has overcome the severe slew-rate limitations that restricted the high-frequency response of previous delta modulators. In the Audio Pulse system the encoder's slew rate has been quadrupled to provide a response of 8 kHz, thus providing an ample dynamic range for high-frequency transients. Since the cutoff of reverberation frequencies in real-life situations is an estimated 2 kHz, the available response is more than sufficient.

Conventional pulse-code modulation uses coded groups of pulses to represent the amplitude of the audio signal at each sample. But with delta modulation, the encoding circuit generates a series of pulses whose rate reflects momentary changes in audio voltage.

This is more efficient than conventional PCM encoding because only about half as many pulses per second are required to reproduce a signal with equal fidelity. Consequently, only half as many shift registers are required to achieve a desired time delay.

With the Audio Pulse system the audio signal is encoded into digital pulses that are fed to a series of 37 shift registers of 1-k bit each. The encoding occurs at rates of either 400-k or 250-k pulse/s, as selected.

As the resulting pulses are loaded into the first register, its previous contents are shifted into the second. Simultaneously, the second register's contents are shifted into the third register, and so on. When the pulses emerge from the last shift register, they are decoded to recover the audio signal. The amount of time delay is proportional to the number of shift registers used.

In the Digital Time Delay system four different delays are obtained—two in each channel. In each channel the fully and partially delayed audio signals are fed to a variable mixer. Here, the relative proportions of the partial and full delays are controlled by Decay Time switches on the front panel. Discrete delays available are: 8, 12, 22, 36, 58 and 94 ms.
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Where is Natalia Makarova's tutu?

It was there a minute ago....

Low-light and high-contrast conditions are problems that Lincoln Center must combat in the attempt to improve the quality of live telecasts such as this one, as shown in this photograph of a home set.

ON June 30, millions of Americans saw the American Ballet Theatre's "Swan Lake," on television. It was broadcast in color live from New York City's Lincoln Center. And if the viewers tuned in their FM stereo radios, they also heard Tchaikovsky's music—live—in living stereo.

Part of the miracle of this telecast was that it was done under existing performance conditions. There were no extra lights, obtrusive cameras or microphones to distract the audience—people who had paid up to $10.95 a ticket to see one of the world's great ballets danced by two of the world's great dancers, Natalia Makarova and Ivan Nagy.

Instead, a van full of electronic equipment was used to overcome some of the staggering handicaps that "performance conditions" pose for televising video and sound. "One of the most obvious problems is poor lighting," says John Goberman, director of the Lincoln Center Media Development Dept., which for the past two years has been experimenting with new techniques for televising Lincoln Center's performing arts.

"Television studios operate with 150 to 300 footcandles. We have to televise performances with light levels that range from less than one footcandle to roughly 25."

Goberman's group is motivated on several levels to solve this problem and the several others, even more difficult, that stand in the way of improving telecast quality.

"We are developing a television product for Lincoln Center," Goberman says. "The Center puts on some 3000 performances a year of ballet, opera, plays and concerts. Televising some of these would provide a cultural contribution to the nation and the world. Also, Lincoln Center has an annual deficit of some $25 million. Selling these telecast performances to pay television would constitute an important new source of revenue."

"Swan Lake" is actually the third telecast the Center has produced under existing performance conditions. In January the New York Philharmonic was broadcast live, and in April, an opera—"The Ballad of Baby Doe."

"Besides having to televise in the dark, we have other problems to solve," says Mark Schubin, technological consultant for the department and technical producer of the telecasts.

"We have high contrast ratios to deal with—a soprano wears a white dress and the villain a black velvet suit: the soprano turns into a blob of white and the villain is so black you can't see him."

Nonuniform color is a problem, too. Different lights have different color temperatures, and often colored gels are used.

Microphones must be invisible, and able to pick up at great distances so that high-fidelity stereo can be transmitted nationwide.

"We've made great strides in solving the low-light-level problem," Schubin says, "but we've still got a long way to go."

One by-product of poor lighting is "lag," which occurs when the tube doesn't have enough light to refresh the information on it from a previous frame. "You have to remember," Schubin says, "that you can't make time exposures with TV cameras; the faceplate of the camera tube has roughly 1/30 of a second to integrate the light on its photosensitive surface."

Some cameras get around lag by using "bias light," an even projec-
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tion of light directed on the face-
plate of the camera tube to raise
the input level above the threshold
necessary for erasing the informa-
tion that it had in the previous
frame. Then, if the light projection
is perfectly even, you can simply subtract it from the signal
coming out of the camera.

In going to extremely low-light
levels—down to 1 fc or less—the
amplification system of the camera
cannot raise the signal to a view-
able level without producing a tre-
mendous amount of noise, Schubin
says. To counter this, various
noise-reduction techniques have
been developed, and more are in
the works. They include integra-
tion on a line-to-line or frame-to-
frame basis, and noise coring.
Noise coring is a process, some-
what like the Dolby method used
for reducing audio noise. The por-
tion of your signal that is most
susceptible to noise is amplified
when it's still noise free. The pro-
cessed signal is then re-equalized to
a flat signal that is still relatively
noise free.

We're not sure what the solu-
tion to this noise problem might
be,” Schubin says. “Noise reduc-
tion of an existing signal is one
possibility. Noise coring is another.
Or the answer might be a cooled
amplifier or something of that
nature. We've just started looking.”

“We made one experiment with
image-intensified tubes—a two-
stage image intensifier in front of
each tube in a 3-tube Philips cam-
era. And while I'm sure it would
be fine for the military—they
could find a tank in the dark and
even tell what color it was—the
picture quality was very bad.”

The group has also used cameras
with secondary electron conduction
(SEC) tubes, made by Westing-
house. The camera itself, made by
Commercial Electronics, Inc.,
Mountain View, CA, “turned out
to have more lag than ordinary
bias-lit broadcast cameras.”

The group is now looking at new
tubes such as the silicon-intensi-
ﬁed target tube (SIT) and the iso-
con tube. “Both of these tubes are
supposed to be better than any-
thing we're using today. Cohu has
built a color camera using isocon-
tubes. It's a three-tube color cam-
era that should be capable of per-
cieving a black cat in a coal mine
at night. But whether it's going to
have the commercial television
quality we need is still a question.”

“Fortunately,” Schubin re-
calls, “the company was small
and we rented ofﬁce space
from Visual Information Sys-
tems, which ran a 24-hour-a-
day tape-dubbing operation.
I got interested, and every after-
noon after work, at five, I'd
wander in and ask questions.
Now I have a patent on a
pay-TV stereo television device
I designed for Lincoln Center,
and I have been nominated for
an Emmy for designing and de-
veloping a stereo network.

“The rack just makes life a
lot easier,” Schubin says.
“With it we can put a show to-
gether in a matter of hours.
Without it, it would take us a
week.”

Schubin, who is now techni-
cal consultant for Lincoln Cen-
ter's Development Media Dept.
and technical director of its
teletcasts, began his career as
a chemical engineer. From
there he became a newspaper
publisher, then chief engineer
for Computer Television, which
was in the hotel pay-television
business.

The Lincoln Center group is in-
vestigating color cameras built
with SIT tubes and isocon tubes.
“If someone has one with broadcast
quality, we'd sure like to see it,”
Schubin says.

“In the long run, the trend may
be toward solid-state imagers,”
Schubin says. “I think we'll get
away from tubes altogether and go
into charge-coupled devices and
charge-injection devices. But no
one has a broadcast-quality color
camera yet that's ready for use.
RCA is the only company we know
of that's exhibited a color CCD
camera intended to be used some
day for broadcasting. Bell Labs
has shown a low-resolution color
camera for Picturephone service,
but that's three to five years off.

“Worse than poor lighting, our
most horrendous problem is the
contrast ratio, which on stage

Mark Schubin and his audio ‘rack’

This transmission and stereo-
control pick-up terminal is
called “the rack” by its de-
signer, Mark Schubin, who is
standing to one side. It relays
the sound from the theatre up-
stairs in Lincoln Center to the
satellite and terrestrial trans-
mision network.

The rack provides high-
quality audio, compressed for
portions of the networks that
desire audio compression. And
it provides dynamic-range com-
pression for recordings so that
the original dynamic range can
be restored whenever tapes are
played.

“The rack just makes life a
lot easier,” Schubin says.
“With it we can put a show to-
gether in a matter of hours.
Without it, it would take us a
week.”

Schubin, who is now techni-
cal consultant for Lincoln Cen-
ter’s Development Media Dept.
and technical director of its
teletcasts, began his career as
a chemical engineer. From
there he became a newspaper
publisher, then chief engineer
for Computer Television, which
was in the hotel pay-television
business.

Fortunately,” Schubin re-
calls, “the company was small
and we rented ofﬁce space
from Visual Information Sys-
tems, which ran a 24-hour-a-
day tape-dubbing operation.
I got interested, and every after-
noon after work, at five, I'd
wander in and ask questions.
Now I have a patent on a
pay-TV stereo television device
I designed for Lincoln Center,
and I have been nominated for
an Emmy for designing and de-
veloping a stereo network.

“I got to Lincoln Center via
the pay-TV stereo device. Lin-
coln Center came to me for it
and after I did it, I just stayed
on as part of the staff.”

Much of Lincoln Center's
gap between box office receipts
and costs is taken care of by
donations from foundations.
But individuals and companies
also make tax-exempt gifts of
services and money to the
Center.

“We have lawyers and man-
agement consultants who do-
nate their time, but no elec-
tronics companies. It would be
a real shot in the arm for the
performing arts—and for the
electronic state-of-the-art—for
an electronics company or
labatory to donate a develop-
ment project for some of the
breakthroughs we need.

“We can be reached at
Lincoln Center, 1865 Broad-
way, New York, NY 10023.”

Wanted: A good color camera

The Lincoln Center group is in-
vestigating color cameras built
with SIT tubes and isocon tubes.
“If someone has one with broadcast
quality, we'd sure like to see it,”
Schubin says.

“In the long run, the trend may
be toward solid-state imagers,”
Schubin says. “I think we'll get
away from tubes altogether and go
into charge-coupled devices and
charge-injection devices. But no
one has a broadcast-quality color
camera yet that's ready for use.
RCA is the only company we know
of that's exhibited a color CCD
camera intended to be used some
day for broadcasting. Bell Labs
has shown a low-resolution color
camera for Picturephone service,
but that's three to five years off.

“Worse than poor lighting, our
most horrendous problem is the
contrast ratio, which on stage

Electronic Design 16, August 2, 1976
48-pin IC Tester:
Total programming flexibility and no program boards put the IT-200 in a class by itself.

Here is an extremely flexible integrated circuit tester that can handle virtually all digital devices.

Its 100 kHz functional capability, coupled with a powerful DC parametric capability, allows testing of CMOS, NMOS, PMOS, ECL, and TTL devices of any complexity. The particularly powerful DC parametric test capacity provides current ranges from $\pm 200$ na to $\pm 200$ ma, and voltage ranges up to $\pm 20$ V.

The versatile IT-200 operates under ROM or RAM program control (software load) and readily interfaces with handlers, probers and other instrumentation.

Check out the IT-200. You'll find the specs are truly in a class by themselves and the price is surprisingly low. For complete details, write or call:

Siemens Corporation, Computest Products, 3 Computer Drive, Cherry Hill, New Jersey 08034 (609) 424-2400.
Once there was an engineer named Digital Don who was into gates and flops and stuff like that. Don was well... he was consistent.

He wasn't like the guys down the hall who were into microprogramming—the ones with lots of technicians, three-piece suits, fancy new equipment and snappy secretaries.

Don didn't know much about microprogramming. There was never an easy way to get into it. And besides, he always did things the way he always did them, so why should he change now?

SIGH.

The Advanced Micro Devices Learning and Evaluation Kit can teach Don how to configure a microprogrammed architecture using the industry standard Am2900 family. He'll be able to write and execute microinstructions that will completely control an Am2901 microprocessor slice and Am2909 microprogram sequencer—just like a high-performance CPU.
The Am2900K1 Learning and Evaluation Kit.

It's terrific. For only $289.00 you can master the basic theory and application of microprogramming. Here's what you get:

A read/write memory storing up to 16 microinstructions driving a pipeline register. From the pipeline register, the microinstructions control: an Am2901; circuits for logical and arithmetic shift and rotation; and the Am2909 sequencer that selects the next microinstruction address. Sixteen sequence control functions are built in, including conditional branch, loop, jump to subroutine and return. Built-in display logic makes nearly every point in the system available at an LED display.

The Kit includes forty IC's, LED's, switches, resistors, decoupling capacitors, PC board and a really comprehensive manual covering assembly instructions, theory and experiments. The only thing you need to add is a 5-volt power supply.

Throw away your gates and flops. Get the Advanced Micro Devices Learning and Evaluation Kit from your AMD distributor. And become one of the really popular guys.
Get more for your money!
Use This New 3/8" Square Cermet Trimmer From Allen-Bradley

Our new TYPE E trimmer is a high performer with a realistic price. It has some important advantages:

• Immersion seal is tested in 85°C water (not 50° or 70°C).
• Temperature characteristic is 100 PPM/°C for stability.
• Multifingered contact for excellent adjustability.
• $0.49 each—1000 piece price. For more information call your A-B distributor or write for Publication 5219.
The Dearborn family of metallized polycarbonate film capacitors gives you excellent capacitance stability, low temperature coefficient, high insulation resistance...plus a choice of construction and styles.

1. **STYLES LP8, LP9** Hermetically-sealed metal-case tubular capacitors • LP8, bare case. LP9, insulating sleeve • Capacitance values from .01 to 100.0 µF, voltage range from 50 to 400 WVDC • Also available as Styles CHR01 and CHR10 to MIL-C-39022.

2. **STYLE LP7A** Epoxy-case rectangular capacitors with axial leads • Capacitance values from .01 to 6.8 µF, voltage range from 50 to 400 WVDC.

3. **STYLE LP7S** Epoxy-case rectangular capacitors with radial leads • Capacitance values from .01 to 18.0 µF, voltage range from 50 to 400 WVDC.

4. **STYLE LP66** Wrap-and-fill miniature tubular capacitors • Capacitance values from .01 to 56.0 µF, voltage range from 50 to 200 WVDC.

5. **STYLE LP88** FUZ-ION* SEALED tubular capacitors...epoxy end-seals fused to heat shrinkable plastic case • Capacitance values from .01 to 50.0 µF, voltage range from 50 to 200 WVDC.

6. **STYLES LP42, LP44** CLEAR-PASS® feed-thru metal case capacitors for radio interference reduction • LP42, threaded neck... 10 and 15 amps. LP44, threaded case... 10 amps • Capacitance values from .01 to 27.0 µF, voltage range from 50 to 400 WVDC.

*Trademark

Write for Engineering Bulletins on the Styles that meet your needs.
HIGH PERFORMANCE STARTS WITH ACCESS TIME.

150ns

With MOSTEK's new 4K RAM your system performance can match data sheet specs.

At 150 ns access time (worst case), the MK 4027-2 is the fastest 16-pin 4K RAM in the industry. It appears even faster when compared to 18 or 22-pin 4Ks that require high-level clocks and differential outputs. In this comparison, our 150ns is actually better than their 120ns.

But fast MOS memory can't be used efficiently unless you can surround it with high performance logic. You can with the MK 4027 because it's completely Schottky-TTL compatible with a max $V_{IL}$ spec of .8 volts. And a wide ±10% tolerance on all power supplies is a standard feature from MOSTEK.

Gated CAS, another new MK 4027 feature, provides an expanded timing window to compensate for timing skews encountered in the multiplexing operation. This window is a full 25% of overall access time.

The MK 4027 can further upgrade system performance with an improved output drive capability. It sources 5mA and sinks 3.2 mA while driving a 100 pF load. Other 4Ks drive only one TTL load and 50 pF.

By employing essentially all dynamic internal circuitry, the MK 4027 dissipates very little DC power. This allows the device to remain much cooler in operation than competitive products and is one reason for its outstanding reliability.

A new operating mode improves access time to 100ns.

It's called "page mode," an addition to the normal cycles of read, write, read-write, and read-modify-write. In a nutshell, page mode allows for successive memory operations at multiple column locations at the same row address with increased speed — 100ns — and decreased power.

Page mode is not limited to any single chip. Since the CS input can be used to select or disable any cycle(s) in a series of "page" cycles, the page boundary can be extended to multiple 4K memory blocks.

MOSTEK's 16-pin package reduces memory board size 50% over 22-pin packages.
How about density — yours and ours?
As you might expect the MK 4027 is in the industry standard 16-pin package allowing the greatest possible density for your high performance memory system.
We've been working on our own density, too. At 104 mils x 140 mils the MK 4027-2 is the smallest 4K RAM in the industry.

Reliability? MOSTEK sets the standard.
The fastest, the smallest, the most versatile is not automatically the best. Not without MOSTEK quality. Every 4K RAM MOSTEK ships is subjected to these screens and stresses: pre-burn at high temperature, temperature cycling, centrifuge, dynamic burn-in at 125° C, and final test with wide guardbands.

High Performance 4K RAMs ... Here's your choice:

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>16-pin</th>
<th>18-pin</th>
<th>22-pin</th>
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<tr>
<td>Access Time</td>
<td>150ns</td>
<td>200ns</td>
<td>200ns</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>320ns</td>
<td>400ns</td>
<td>400ns</td>
</tr>
<tr>
<td>Read/Modify/Write</td>
<td>350ns</td>
<td>600ns</td>
<td>520ns</td>
</tr>
<tr>
<td>Worst Case Power</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissipation</td>
<td>462mw</td>
<td>478mw</td>
<td>680mw</td>
</tr>
<tr>
<td>$V_{IL}$ (all inputs)</td>
<td>0.8v</td>
<td>0.6v</td>
<td>0.6v</td>
</tr>
<tr>
<td>$V_{IH}$ (data, address)</td>
<td>2.2v</td>
<td>2.2v</td>
<td>2.4v</td>
</tr>
<tr>
<td>$V_{HC}$ (clocks)</td>
<td>2.4v</td>
<td>12.0v</td>
<td>12.0v</td>
</tr>
<tr>
<td>Clock Cap</td>
<td>7pF (max)</td>
<td>33pF (max)</td>
<td>25pF</td>
</tr>
<tr>
<td>Power Supply Tol.</td>
<td>±10%</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Page Mode</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

MOSTEK's 16K RAM is coming soon.
In addition to an unatched output, MOSTEK's 16K RAM will include all the features found in our high performance 4K. This means Schottky-TTL compatibility, ±10% tolerance on power supplies, page-mode, gated CAS and low power. Designing and testing with MOSTEK's MK 4027's in your production systems now is a logical "first step" toward an efficient 16K system.

Want more information? There's an application note and data sheet package that tells the complete MK 4027 story. Write on your letterhead to MS 402 for quick response. Or pick up the literature package and a sample at your local MOSTEK distributor.
We've doubled our high voltage Power Transistor line.

Read what's in it for you.
Our new, expanded line offers a lot more types than we could show here. But that isn't important to you. What is important is that now you can probably get a better device than you are now using, for these reasons.

All of the top power transistor companies make pretty good high voltage devices with low sats, broad operating areas, low switching losses. IR gives you that, and more.

For example, we use hard-glass passivation for our chips. That gives our devices longer life than those using organic passivating materials. It also gives a high-temperature stability that you can see in Figure 1, but may never see for other devices. It costs us more to apply. But it is far better for you in the long run.

We build and rate our devices to operate reliably and continuously at maximum rated junction temperatures. Other brands which come up short in high-temperature stability may require temperature derating. Check the performance of the ones you use.

Because we've specialized in "power" semiconductors for more than 28 years, we know the importance of reliability testing. In addition to testing the 11 basic parameters of every device, we perform 100% tests on a curve tracer to make sure each part has a sharp high-voltage characteristic.

And there are other demands on power devices we've learned to handle over the years. Like mounting chips to the substrate so they stay there through years of temperature cycling. And making connections between the chip and case that last. Little things? No. They loom large when things go wrong on other devices.

In the case of chips to package yourself, you'll get a completely finished, fully protected and tested transistor for more flexibility in design and higher yields in your end product.

We offer the most popular types for the applications listed, so get our "Power Transistor Application Guide". Check it for our equivalents to the types you're using now. When you find them, you've found the way to add more stability and longer life to your product without adding to your costs.

That's what's in it for you!

Contact your local IR salesman, rep or distributor, or write to: International Rectifier, 233 Kansas Street, El Segundo, CA 90245. Call (213) 322-3331.
Is Your Memory Design Static?

Make Your Designs Dynamic.

Texas Instruments TTL Compatible 4K RAMs Make It Easy...

HERE'S WHY DYNAMIC DESIGNERS USE TI 4K RAMs.

36% Less Operating Power
Compare 1K low-power static RAMs with TI's TMS 4051 4K dynamic RAM. The table refers to maximum—not typical—values to provide a realistic comparison.

40% Less Standby Power
Low standby power is inherent in the 4K dynamic RAM operation—while static RAMs require extra circuitry to reduce Vcc to a low level.

Fully TTL Compatible
The TMS 4051 inputs and output (including clock) interface directly with TTL.

Fast Access Time
TI's 4K dynamic RAMs are fast. The TMS 4051-1 (with TTL clock) has a maximum access time of 250 ns, the same as the 2102AL-2.

80% Less Board Area
You get almost four times the memory density by switching to TI 18-pin 4K RAMs. The reason? TI's compact 18-pin 300-mil-wide package—available in either plastic or ceramic.

Simple Refresh
It's easy! Just 4-8 TTL packages per memory system are typically needed. To see how easy refresh can be, send for our Application Note.

Easy to Use
TI's 18-pin 4K RAMs feature simple 12-line non-multiplexed address and a single non-critical clock. Data input and output are multiplexed—ideal for use with microprocessor-based systems.

Applications Help
For your copy of the 4K dynamic RAM Application Note covering simple refresh, contact: Texas Instruments, M/S 669-4K, P.O. Box 1443, Houston, Texas 77001.
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We want to prove the fact that Monsanto’s advances in materials and processing technologies have significantly improved quality and reliability.

We’ll send you a FREE COPY of our internal QA Report on our standard MCT2 device. It shows the requirements we place on our product before you even see it. It will prove that Monsanto means quality and reliability, which means cost savings and value to you.

We offer more choices of output configuration in standard products—to perform more functions—than any other manufacturer. Transistors. Darlington transistors. Diodes. SCR’s. Logic gates. We also have slotted limit switches and reflective sensor switches. And, there is immediate availability of most models.

<table>
<thead>
<tr>
<th>Output Format Type</th>
<th>Package Types</th>
<th>Min. Current Transfer Ratio</th>
<th>Min. DC Isolation Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistor 6 Lead Plastic DIP</td>
<td>6% - 100%</td>
<td>1500 - 3550</td>
<td></td>
</tr>
<tr>
<td>Transistor 8 Lead Plastic DIP (Dual Channel)</td>
<td>6% - 20%</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>Transistor TO-18 Metal Can</td>
<td>15%</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Darlington 6 Lead Plastic DIP</td>
<td>100% - 200%</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>Diode 6 Lead Plastic DIP</td>
<td>.15%</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>Diode TO-18 Metal Can</td>
<td>.10%</td>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Format Type</th>
<th>Package Types</th>
<th>Forward Blocking Voltages (VFxm)</th>
<th>Min. DC Isolation Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR 6 Lead Plastic DIP</td>
<td>200V - 400V</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>2 SCR’s (Connected Anode to Cathode) 8 Lead Plastic DIP</td>
<td>200V</td>
<td>1500 - 2500</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Format Type</th>
<th>Package Types</th>
<th>Typical Bandwidth</th>
<th>Min. DC Isolation Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Gate 8 Lead Plastic DIP</td>
<td>0.1MHz - 1.0MHz</td>
<td>2000</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Output Format Type</th>
<th>Package Types</th>
<th>Collector Current (IC) (Ic, Vce)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistor Slotted Limit Switch</td>
<td>50μA @ 20mA, 10V</td>
<td></td>
</tr>
<tr>
<td>Darlington Slotted Limit Switch</td>
<td>1.6mA @ 50mA, 1V</td>
<td></td>
</tr>
<tr>
<td>Darlington Reflective Sensor Switch</td>
<td>20mA @ 16mA, 1V</td>
<td></td>
</tr>
<tr>
<td>Darlington Slotted Limit Switch</td>
<td>50μA @ 50mA, 5V</td>
<td></td>
</tr>
</tbody>
</table>

Write now, on your company letterhead, for a copy of our MCT2 Reliability Evaluation Report. You can also get up-to-date information on our products. Or, contact your Monsanto representative or distributor for assistance or immediate delivery. Monsanto Electronics Division, 3400 Hillview Avenue, Palo Alto, California 94304. Phone: (415) 493-3300.

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Our ±0.25% tolerance is low for any capacitor.

In short, our cased-radial NPO Ceramic Capacitors are unique. They feature capacitance tolerances as low as ±0.25% — the tightest we've seen advertised — in all values from 10 pF to .051 μF.

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We offer them all — as well as 29 styles of 'VY' Porcelain Capacitors that put the word monolithic into capacitor technology nearly three decades ago.

As important, we deliver what we offer. Call us at (203) 268-6261.
Presenting our better-mouse-trap line.
No frills at all.

When you cut price without cutting quality, soon no one thinks of it as a cut price. That's where our Norsman line of Wire-Wrap* P/C connectors is headed. Here's why:

The insulator — it's tough, resilient, non-conductive — everything you need in a Wire-Wrap body. And it's made out of low cost phenolic, not the higher cost dialyl phthalate (if you need to meet mil specs, we have that in one of our other lines).

Contacts are semi-bellows and gold-plated — but plated with our unique AuTac (TM) process. You get .000050" gold plate all along the mating surfaces for a sure, gouge-proof, pop-off-proof contact — but that's it. No wasted gold.

And you can find the size you need — Norsman is a full line from 15/30 to 50/100 contacts, in either .100 or .125 contact centers.

The whole Norsman idea is as simple as it is old: keep performance up and cost down. It works.

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Electronic Design 16, August 2, 1976
sometimes verges on the infinite.”

Television studios, he explains, usually light on a 1:1 basis—in which the maximum amount of light is the same as the minimum. Within that 1:1 lighting ratio no one will be wearing a white shirt; white is too “hot” for TV. And no one will be wearing a black suit; it’s too dark for TV. Given all the grays in between in a 1:1 lighting ratio, you wind up with a contrast ratio of maybe 5:1 or 8:1, which TV can handle very well.

“But in our shows,” Schubin says, “we may run into lighting ratios of 100:1 or 1000:1.”

In “Swan Lake” when Makarova’s costume is white and the scenery dark, the television camera doesn’t pick up the scenery and Makarova appears to be dancing in limbo. Then, when she dances in front of a white background, her tutu, as well as her torso, disappears (see photo).

Now, about all that’s possible is “to play with the gamma of the system”—that is, to alter the curve of input brightness vs. output voltage. You can put more detail in the blacks, the whites or the grays—but not simultaneously. Those changes can be performed in any camera available today, but they’re not entirely satisfactory.

Reducing the brightness

So the Media Development Dept. is working on a contrast-compensation scheme that uses spatial frequency filtering. A picture that has many points in any given direction is said to have a high spatial frequency. One with few points has low spatial frequency. The spatial “high pass” filter lets detail through while reducing the amplitude of major brightness differences (low frequencies).

The National Aeronautics and Space Administration and a number of other groups have performed contrast compressions using spatial frequency filtering, but those experiments have usually involved the use of digital pictures.

Lincoln Center isn’t trying to tell people how to solve the problem, but its engineers have considered the use of a scan-conversion tube for instantaneous x-y filtering. They’ve also considered using various types of delay lines that might do the whole job in the electronic circuit—leaving the tube out of it.

“Using the digital approach,” Schubin says, “contrast compression simply becomes a processing problem. We have to digitize the signal coming in and tell the processor to filter it in both x and y direction—that is, to do a low-pass filtering operation. Then we just subtract this low-pass information from the original signal. The result is a picture that has much more emphasized detail than it had originally.

A third problem is nonuniform color in lighting. Lights of different color temperatures change the lighting in video pictures as they do with color film. If you have a carbon spotlight and an incandescent light, the carbon is going to show up much bluer than the incandescent.

Another possibility: the carbon might have a blue filter on it and the incandescent a pink.

The nonuniform color problem is handled manually now, which isn’t entirely satisfactory, Schubin says. The ideal solution would be to have some sort of device to tell all the cameras that a certain object is a certain color and to keep it that way. That would entail some sort of object-recognition system, perhaps based on contour detection.

Meanwhile Lincoln Center is working on automatic black-and-white balance and color-correction techniques.

The fourth problem—picking up voices at the other end of a long stage—is now handled fairly well with shotgun microphones, but eventually, some sort of ultradirectional microphones will probably be used.

The transmission of high-fidelity stereo sound nationwide is done now by the Center’s patchwork network, which feeds into microwave links, land lines and satellites. Ultimately, there will be a network of broadband-satellite and terrestrial links, all using analog or digital techniques.

“People come to us with unusual ideas and we’re always glad to hear them,” Schubin says. “These include holographic scenery or props, three-dimensional television and anamorphic video projection.”
How to pick the right panel meter for your product.

The choice you make in panel meters can do a lot to help or hurt your product. Yet it's not all that difficult to pick the right one, even if panel meters aren't your specialty. Here are nine easy steps many experts follow to make sure they choose the right panel meter every time.

1. Make sure the panel meter will fit your exact mounting requirements.

Only those panel meters whose barrel diameters and mounting hole locations will match your panel cutout are worth considering. Otherwise, you'll get stuck later with costly drawing changes, new setups, and redrilling operations.

2. Choose the scale you think your customers will find easiest to read.

Make sure the digits and subdivisions can be easily read from a reasonable distance. Check the shape of the pointer. Does it help or hurt readability?

3. Specify the style and size you think will work best and look best on your product.

Smart looks can sell. Your product's panel meters are often the very first "embellishments" your customer notices.

4. Determine what accuracy class you need.

Accuracy to ±2% of full scale is by far the most common. You can, of course, get cheaper, less accurate panel meters. Or pay a premium for higher accuracy when the application truly demands it.

5. Find out what the panel meter's loading effect will be on your product.

ANSI C39.1 Specs pretty well dictate these guidelines. But check them yourself to make sure the terminal resistance of your dc instrument, or the burden data of your ac instrument, won't overburden your circuit.

6. Choose between taut-band or pivot-&-jewel suspension.

Both have their advantages. Taut-band construction is extremely durable, friction-free and resistant to shock. Pivot-&-jewel instruments, on the other hand, have the inherent stability and strength to work best in most high vibration environments.

7. Analog or digital?

You be the judge. Digital applications are hampered by power supplies and background signal "noise." They add more to the cost of your product. And it's next-to-impossible to quick-scan them or to monitor rapid change. Analog panel meters still outsell digitals by nearly 10 to 1.

8. Make sure it will work in dirty environments.

Since you can't control where your customer might use your product, you'd better make sure your panel meters are sealed in a good, tight case.

9. Then, if you're still undecided, consider the manufacturer's reputation.

Make sure your choices are reliable, that the manufacturer will stand behind them, and that the panel meters meet all ANSI specifications for performance.

For a free guide entitled "Pick the Right Panel Meter" (GEP-10340) and our complete Catalog (GEP-307), write to General Electric Co., Section 592-65, Schenectady, N.Y. 12345.
As bright as many incandescents!

Meet the LED Superstars... red, amber and green superbright panel and PCB lights. Their high brightness 50 MCD @ 20 MA (typical clear red) make them the perfect cost and power saving replacements for incandescents. Available with built-in resistors for all popular voltages.

Subminiature Panel LED's (also suitable for PCB mounting)—available in hundreds of sizes, shapes and styles.

PCB LED's—Horizontal or vertical viewing... optional built-in resistor for 5V applications.

Bi-Pin (T1-3/4) LED's—Ideal for dead front panel applications, e.g. DEC's PDP Series computers.

Midget-Flanged (T1-3/4) LED's—Direct replacements for incandescents in panel light and switch applications.

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EIA projects government electronics growth

The electronics content of the Federal budget will rise steadily from $19.1 billion for the new fiscal year beginning Oct. 1 to $25.5 billion five years later in fiscal 1981, according to the new annual report of the Electronic Industries Assn.

The Defense Dept. will lead the growth, accounting for $15.7 billion in fiscal 1977 and $21.7 billion in fiscal 1981. Electronics spending will remain essentially level at the National Aeronautics and Space Administration and Dept. of Transportation, amounting to about a half billion dollars a year for each agency over the five-year period. Growth will be moderate at all other federal agencies—from $2.3 billion next year to $2.7 billion in fiscal 1981.

The EIA concedes that the actual electronics content of the budget is still a matter of debate within both government and industry, but maintains its projections are conservative because of the increasing application of high technology, particularly in the nondefense categories.

Science advisor post hit by politics

A political controversy has stalled the appointment of a new Presidential science advisor. President Ford wants National Science Foundation Director Dr. H. Guyford Stever for the post, but a group of conservative Republican senators opposes the nomination on the grounds that the NSF sponsored elementary and secondary-school courses in sex education.

The science advisor was an important White House post until President Nixon abolished it three years ago because he didn’t like the advice he was getting. President Ford wanted it restored and worked closely with Congress in writing new legislation to create a permanent office of Science & Technology Policy. That legislation was signed into law May 11, but Ford has been careful not to alienate the conservative element of his party before the nominating convention later this month.

Stever has vocal support from science-oriented legislators, such as Sen. Frank Moss (D-UT), chairman of the Senate Space Committee, who called for “early action” on the appointment, and Sen. Edward Kennedy (D-MA), chairman of the subcommittee that oversees the NSF budget.

DOD to encourage plant modernization

Investing in new facilities will become more attractive for firms dealing with the DOD, if a recent ruling by the Cost Accounting Standards Board is put into effect.
Firms that borrow money to improve their facilities will be allowed to pass the interest expenses along as part of the cost of the contract—up to the rate approved by the Renegotiation Board, currently about 8%. This pass-along will improve profits by about 1%, if Deputy Defense Secretary William Clements decides to allow the increase.

Defense profits under negotiated contracts currently average about 8.8% of sales at the time contracts are written, but cost overruns—shared by the contractors and the government—have driven down actual profits to an average of 4.7%. The new formulas are intended to reduce this profit loss, and to reduce the overruns themselves, by making it more attractive for contractors to hold down their costs.

Under the present formula for determining profits the factors are weighted 65% for costs, 30% for risk, and 5% for other factors. The new plan would reduce cost to 45%, increase risk to 45%, and assign 10% to investment. Defense facilities, on the average, are twice as old—half as modern—as those of commercial manufacturers, according to Air Force Brig. Gen. James Stansberry, director of the Pentagon’s year-long series of “Profit ’76” studies, of which these recommendations form a part.

Air Force to finalize EF-111A design

The EF-111A, the Air Force’s proposed $586 million program to convert 40 surplus fighters into tactical jamming aircraft, is due to complete the final design phase this month. The program successfully passed critical design review in June at the Long Island facilities of prime contractor Grumman Aerospace Corp., and the results were reviewed by the Air Force Scientific Advisory Board.

The program involves installing electronic countermeasures (ECM) equipment in the weapons bays of surplus F-111s so they can neutralize enemy surface-to-air missile (SAM) radars during tactical air strikes. The equipment was originally developed by Grumman for the Navy’s EA-6B ECM aircraft.

The major difference is that on the EF-111A the equipment will be carried below the fuselage in the weapons bay rather than on external wing-mounted pods. This is expected to increase reliability because operating temperature of the electronic equipment can be reduced—from 160 to 40 F. The EF-111A is also expected to be more effective than the earlier EB-66 ECM aircraft, which were only partially successful in Vietnam.

Capital Capsules: A fully automatic system for classifying fingerprints has been demonstrated by Calspan Technology Products, Buffalo, NY. The prints are first converted to digital form with the company’s Finder reader, now used by the FBI, and then classified according to fingerprint pattern by its new device . . . The Naval Research Laboratory has devised an optical waveguide system for transforming the output of a phase modulator into an amplitude modulation. Laser light is propagated in the waveguide system and forwarded into branches of the waveguide. Then an electro-optic material placed in one or more of the branches in the system is electrically controlled to vary the phase in each branch, causing different propagating modes . . . How to use CB radios to promote public safety is the prime subject of exploration during the 42nd annual conference of the Associated Public-Safety Communication Officers, Aug. 2 to 5, at New York City’s Americana Hotel.
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CIRCLE NUMBER 22

Electronic Design 16. August 2, 1976
μC board sizes will be standardized, provided that customers demand it

In the past year, several leading manufacturers such as Intel, National Semiconductor, DEC and Data General have introduced microcomputer boards with a variety of physical dimensions and pinouts. Bill Walkup of Cambridge, Thermionics Corp., Cambridge, MA, presents his views on board standardization.

There is no standard, military or otherwise, and there is no progress toward a standard, that I know of, and is my job to know. There is no real desire among the hardware industry to adopt one because then it becomes a business of buying on the basis of price, and not features. The price would go down, and the margins would go down, and nobody who is in this business wants this to happen. I don't see any trend developing or any standard emerging other than the so-called Universal Panel approach introduced by Augat, our competitor, 5 or 6 years ago and now manufactured by us and about 10 or 15 others. Universal Panels (continued on page 44)

μP prototyping board contains Basic interpreter

The EVK300 microprocessor prototyping board contains a Basic language interpreter, a debug program, and an EPROM programmer for the 6800 μP.

The interpreter is supplied on 2-k words of EPROM and executes a subset of the full Basic language called Tiny Basic. It is less powerful than Basic because only integer numbers may be handled, variables must be identified by single letters, and no arrays or strings may be used.

The debug software is programmed into 2-k words of PROM. The program reads the teletypewriter, displays or changes the contents of a memory location or μP register, and performs other functions.

Electronics for programming EPROMS is also on the card. A supply of −50 V is required, in addition to the 5 V, +12 V and −12 V required for the rest of the card. The board also contains 1-k words of RAM. Up to 56-k words of additional memory may be added externally.

The EVK300 costs $950 (unit qty), measures 10.5 × 10.5 in. and has two 86-pin edge connectors for external interface.

AMI, 3800 Homestead Rd., Santa Clara, CA 95051. (408) 246-0330.

CIRCLE NO. 571
MICROPROCESSOR DESIGN

(continued from page 43)

are wire-wrapped together with no connectors used. Since the boards cannot be individually removed, all repairs are done at the component level.

However, I would like to see users get together and come up with a standard. This would be good for the industry although maybe not so good for my company. Users should get together and say to the manufacturers “this is what we want.” It would take a few years probably, but standard could be developed. Then, the hard-ware card manufacturers would be forced to comply with the wishes of the marketplace.

The military and nuclear instrumentation industries have several standard function modules. These are not in wide use because of their specialized requirements and are almost an order of magnitude more expensive than wrapped-wire boards with equivalent features. Since the modules specify particular functions to be performed, they are blocked into a format 6 to 8 years old and do not take advantage of the latest technology. The Standard Electronic Module (SEM), for example, started out as a generalized physical module, but it hasn’t turned out that way.

By the way, Europe has a standard board size. Theirs is called Eurocard, and it has become quite popular. It was first developed in Germany around 1970 and subsequently adopted by the Common Market. The card has dimensions of 100 x 160 mm, and has a 64-pin male plug. It is produced presently by six or eight manufacturers and many more are very interested in making it. There are also double and triple-width sizes if more ICs must fit on the card. We ought to develop a similar standard.

\[\mu P \text{ improves accuracy of data-tablet digitizer}\]

A magnetostrictive data-tablet digitizer improves point-location accuracy over similar systems by an order of magnitude through use of an 8080 microprocessor. The digitizer produces binary data that identifies the locations of X-Y coordinate intersections on the tablet. Magnetic pulses applied to X-Y wire ends drive strain-wave pulses down the wires. The pulses generate voltages in the cursor.

The 8080, in combination with a special ROM, provides the data tablet—called the Intelligent Digitizer by Summographics Corp., Fairfield, CT—with a software-based system that performs a ratiometric calculation for each point on the tablet selected by a stylus or cursor. This type of calculation gives an absolute, corrected value for each coordinate point anywhere on the tablet surface to within ±0.004-in. tolerance.

Nonlinearities inherent in the measuring system, which uses magnetostrictive ranging along an X-Y grid of wires underneath the tablet surface, are therefore cancelled out.

This improvement is in contrast to earlier Summagraphic systems in which the accuracy was specified as ±0.08% of the distance from the coordinate origin, which was located in the lower, left-hand corner. In the present case, the absolute accuracy remains the same with the distance from the origin.

For example, at a distance of 6-in. from the origin the absolute accuracy was about ±0.005-in., whereas 36-in. from the origin it was ±0.029 in.

Measurements of absolute accuracy over the entire tablet are produced by the Intelligent Digitizer, because, first, it makes two measurements for each coordinate intersection. That is, the intersection on the coordinate is measured first from the left (X1) and then from the right (X2); and the point on the Y coordinate is measured from the top (Y1) and from the bottom (Y2).

Second, these measurements are fed into the 8080, which corrects for nonlinearities in the
**X and Y measurements by performing the following calculations:**

\[ K_1 \left( \frac{X_2 - X_1}{X_2} \right) = X_{TRUE} \]
\[ K_2 \left( \frac{Y_2 - Y_1}{Y_2} + Y_2 \right) = Y_{TRUE} \]

The \( \mu P \) in the Intelligent Digitizer also gives added functions not previously obtainable with a stand-alone tablet system. One function is the automatic correction of skew in a drawing that is not perfectly aligned on the tablet. Another is "floating origin"—the origin can be placed anywhere on the tablet that the operator desires.

A third feature is automatic scaling of drawings in the ranges of 2, 5, 10 and 50 to 1. Also, the perimeters and areas of enclosures can be readily calculated by simply tracing the enclosure with the stylus or cursor.

The use of the 8080 also unburdens any host computer to which the digitized information is fed, thus saving central computer time. In addition the 8080 provides binary to BCD conversion for the tablet.

The Intelligent Digitizer has a 36 by 48-in. working surface and a resolution of 200 lines per inch. Specified accuracy is \( \pm 0.004 \)-in., plus or minus one least significant bit.

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**Mini and microcomputers work together to lower heating costs**

An automated energy-management can cut the cost of heating a building by as much as 25%. Further, the cost of such a system can be reduced by teaming up the minicomputer that controls the system with several microcomputers which gather and process sensor data. Such a system can reduce both normal and peak-power consumption loads.

The microcomputer, used by Systems Technology, Detroit, MI in their version of the automated energy conservation system described, is a standard MicroPac 80 manufactured by Process Computer Systems, Flint, MI. It works in conjunction with a minicomputer to automatically turn heating and cooling equipment on and off each day, and to minimize the use of this equipment when power consumption approaches a peak demand level. The new system can also be used to cycle ventilation equipment. By sensing outdoor temperatures and sending data to the computer, the system automatically determines when ventilation equipment can be shut off without any noticeable changes in temperature inside the building. Typically, whenever outside air is brought into a building, power is consumed both circulating it and heating or cooling it.

Sometimes it is desirable to circulate outside air because it can be used to achieve the same temperatures as that provided by air conditioning. Even when it is freezing outside, a concentration of people inside a building heats up the inside air. Outside air rather than air conditioning can then be used to cool down the building’s interior. Since the computer constantly receives readings on inside and outside temperatures, it can determine when it is better to introduce outside air into a building.

*Process Computer Systems, Inc., 5467 Hall 23 Dr., Flint, MI 48507. (313) 767-8920.*

---

**Nonvolatile memory available for the IMP-16P microcomputer**

A nonvolatile core-memory card—one that will not lose data when power is removed—has been designed to mate with the IMP-16C microcomputer development system from National Semiconductor. The board, designated the MM16P, and offered by Micro Memory, Inc., stores 8-k \( \times \) 16 words. It has a byte-control feature, and can be operated also as 16-k \( \times \) 8 words.

The card contains timing, control, decode and drive circuits, and address and data registers. Access and cycle periods are 350 and 1000 ns, respectively.

Depending on the capacity of the development system, a separate supply of 12 V at 1 A might be required. The card dimensions are 8.5 \( \times \) 11 \( \times \) 1 in. The board costs $1500 in unit quantity.

*Micro Memory, Inc., 9438 Irondale Ave., Chatsworth, CA 91311. (213) 998-0070.*
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<th>POWER SUPPLY</th>
<th>FEATURES</th>
<th>PRICE (1-9)</th>
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<tr>
<td>DM-350D1</td>
<td>3-1/2</td>
<td>+5VDC @ .3A</td>
<td>UNIPOLAR, LOW POWER, DISPLAY ONLY</td>
<td>$69 (1-9) $59 (100's)</td>
</tr>
<tr>
<td>DM-350D2</td>
<td>3-1/2</td>
<td>+5VDC @ .3A</td>
<td>BIPOLAR, LOW POWER, DISPLAY ONLY</td>
<td>$75</td>
</tr>
<tr>
<td>DM-350A1</td>
<td>3-1/2</td>
<td>115/230 VAC</td>
<td>UNIPOLAR, XFMR-ISOLATED, DISPLAY ONLY</td>
<td>$79</td>
</tr>
<tr>
<td>DM-350A2</td>
<td>3-1/2</td>
<td>115/230 VAC</td>
<td>BIPOLAR, XFMR-ISOLATED, DISPLAY ONLY</td>
<td>$89</td>
</tr>
<tr>
<td>DM-4000</td>
<td>4-1/2</td>
<td>+5VDC @ .6A</td>
<td>OPTOISOLATED RATIO-METRIC AUTO ZERO XTAL LINE FILTER</td>
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<tr>
<td>DM-4300</td>
<td>4-3/4</td>
<td>+5VDC @ .6A</td>
<td>OPTOISOLATED RATIO-METRIC AUTO ZERO XTAL LINE FILTER</td>
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<td>DM-2000AR</td>
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CIRCLE NUMBER 23
Research it till you have the answer you want

Jack was always right and he could prove it—with research. Mostly it was other people's research he used, but, if necessary, he would conduct his own. And it did become necessary—often—when he found that other research disproved his point.

Jack was always willing to research something till he got the right answer—the one he started with. Research that gave the wrong answers—“intermediate results,” he called it—was discarded. And since he found that research always proved his initial assumptions he realized after a while that it wasn't necessary to waste so much of his time with it.

It was necessary, merely, to proclaim “the truth” to his subordinates, and to demand that they act on it. If his research—or instinct, which was just as good—showed that many people needed scopes, for example, he would set his people to designing scopes. His engineers might challenge his findings. They might say he had looked at only a small part of the situation and had seen only a limited “truth.” They might, for example, suggest that other vendors had already discovered the widespread need for scopes.

For such carping, Jack was always ready. His engineers were being negative; they'd never get ahead with such negative thinking. They clearly needed the advantage of his forward thinking and, with it, some of his guidance on superior, innovative thought processes.

On more than one occasion Jack's projects were disasters. His engineers might develop a fine scope, for example, perhaps the best they could make with CRTs they could buy. But customers would stay away in droves.

The conclusion? Somebody had blundered—probably one of Jack’s engineers. It couldn’t have been Jack. He was always right.
All the people who bought our DUMB TERMINAL (the ADM-3) because of its low $995* unit price didn't really expect a lot. But they hadn't counted on the 32 switches. Switches that let you turn the DUMB TERMINAL into a pretty clever animal.

Take the 20 switches under the LSI name plate, for example. Among them, 11 communication rate positive action switches that let you select bauds from 19200 to 75. Also an RS232 interface extension port switch. It allows you to connect the DUMB TERMINAL to all kinds of clever devices — to recorders, printers and smarter terminals. And switches for odd-even parity. Optional upper and lower case (the complete set of 128 USASCII characters) — plus a lot more.

Inside on the PC board, 12 more switches. More positive action types that instruct the DUMB TERMINAL how to behave. And for all those who bought the 24-line optional display, there's a switch to change over from the standard 12-line format. So instead of showing 960 standard characters in 12 rows, you have the option of displaying 1920 characters in 24 rows of 80 letters. And there are still more switches that make your terminal a cinch to operate.

Now people aren't sure what turns them on: the low price, the 32 switches, or the DUMB TERMINAL's standard features. Features like a full 12” diagonal screen. 59 data entry keys, arranged like on a typewriter. Compatibility with all popular computers. Simple, quiet operation. An optional numeric key pad. And fast data throughput. All features that make this terminal a perfect video replacement for the old teletypewriter.

The fact is, people keep finding more and more jobs for our DUMB TERMINAL. Because they can do anything within reason — with just a little switching and training. And that's why the DUMB TERMINAL really turns out to be a smart buy. Which may be the biggest switch of them all.

For full information, write: Lear Siegler, Inc., E. I. D. / Data Products, 714 N. Brookhurst St., Anaheim, CA 92803; Tel. (714) 774-1010.

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Please write on company letterhead for complete technical test reports.
In evaluating network analyzers, it's generally not a lack of specs you must contend with but an abundance. As one of the most complex pieces of test gear around, the network analyzer needs quite a bit of explaining. And that often extends to the very definition of a network analyzer.

What a network analyzer is depends on whom you speak with, because anything that measures any aspect of a network's response to a stimulus can be called an “analyzer”—even the plain old DVM.

One viewpoint holds that a true network analyzer must measure both magnitude and phase and must be able to measure and display simultaneously both transmission and reflection characteristics. Others affix the label to equipment that can show just magnitude or that can measure only transmission.

Not surprisingly, you may find that the people you ask happen to manufacture an “analyzer” that conforms to their viewpoint.

Other equipment that loosely bears the title of network analyzer includes vector or phase-sensitive voltmeters; communications-link analyzers; data-link monitors that check data-comm networks for bit-error rate, bias distortion and other specs; tracking filters; and servomechanism analyzers.

Look alikes may not act alike

Whatever a network analyzer is, it's generally agreed that there are some things a network analyzer isn't: for instance, it's not a spectrum, wave or distortion analyzer.

Although the difference may seem rather obvious, there are some functional similarities between network and spectrum analyzers, and that often leads to confusion. Both analyzers use tuned front ends, and both are variations of the heterodyne receiver. The resemblance ends there, however.

It is true that you can add a tracking generator to a spectrum analyzer to make some measurements of magnitude. But that isn't the primary intent of the spectrum analyzer. Similarly, design trade-offs between distortion and phase characteristics in the network analyzer practically ensure that it will make a poor spectrum analyzer.

Thus the first question you should ask in analyzer selection is not: Spectrum or network? Rather ask: Which network analyzer? That...
question often boils down to: Do I really need phase information?

There's no question as to the usefulness of phase measurements. In many cases, knowledge of phase is a necessity. But the price of making complex (vector) measurements rings up as a steep cost differential—up to six to one over scalar units.

Where will you need phase? In general, if the performance of the circuit under test is phase sensitive; if phase response and magnitude response interact; if you must characterize phase variations with frequency (as in a filter); if phase is more sensitive than magnitude to changes in frequency (as phase often is at resonance)—then consider a vector analyzer.

Exchangeable directional couplers provide a choice of three characteristic impedances, 50, 60 or 75 Ω, in the Rohde & Schwarz ZWD Sweep Diagraph. Crystal-controlled markers in the ZWD, with spacings of 1, 10 and 100 MHz, determine particular frequencies on the displayed curve.

A further implication of phase and magnitude interaction is the requirement for an analyzer with two measurement channels. With two channels you can simultaneously view phase and magnitude or transmission and reflection, and you can observe interactions while you tweak, tune or adjust the circuit under test.

Also, having two channels lets you look at both outputs of a diplexer as you adjust, lets you compare two devices or measure one device against a calibration standard.

Group 'therapy' reduces distortion

You might be interested in measuring group delay, a quantity related to phase. Sometimes called differential time delay or envelope delay, group delay is defined as the change in phase with frequency, \( \frac{d\phi}{d\omega} \). It represents the relative delays of signals of different frequencies as the signals pass through a circuit.

Ideally, you'd like the relative delays to be zero, so that an original waveform will be reconstructed without distortion at an output. Of course, practical circuits exhibit some group delay. Just how much delay tells you what to expect in the way of, say, a network's pulse response or the color-reproduction quality of a TV i-f strip.

Although you can plot group delay on a point-by-point basis using a vector voltmeter or phase meter, it is a tedious process. With the network analyzers that offer group delay, all you do is push a button or flip a few switches to display the delay as a function of frequency.

As you can with other network analyzer measurements, you can make adjustments while you watch. Consequently, you can tune a device for either constant delay or flat phase response.

Obviously, only you can judge your need for...
phase or group-delay measurements. But one vendor—who doesn’t offer those features—states that magnitude-only will satisfy 80% of network analyzer applications.

No matter what characteristics you elect to measure, one question will be uppermost in your mind: How well can I measure?

To tell the truth

When you spend up to $25,000 for a network analyzer, you’d like to know a few things about what you’re getting for your money. Like how much accuracy you can get, how much resolution, and how much sensitivity. The questions come easy. The answers don’t.

The basic problem in pinning down a key spec like accuracy is that generally there’s no one-number label that will do the job. In making transmission measurements, for example, up to six possible error sources can creep into your test setup to nibble away at accuracy.

What accuracy (really inaccuracy) you’ll get depends on a number of things besides the accuracy of the basic analyzer itself: the kind of measurement (reflection or transmission), how well the device under test is matched to the source and detector, and what errors are contributed by external gear—power splitters, directional couplers, pads, terminations, transformers, and the like. And those factors aren’t all.

Some vendors try to help by providing extensive data on all possible error terms, by offering error-analysis and interpretation techniques and by supporting applications with notes, seminars and technical papers. Other vendors lean on a far simpler solution—they just ignore the situation.

Sometimes “forgotten” is the fact that accuracy can deteriorate over the full dynamic or frequency range or in the presence of signal distortion. Signal amplitude, distortion and frequency can all team up to tear a hefty chunk out of accuracy.

Getting back to the source

Other memory lapses occur, perhaps provoked by the excitement of competitive skirmishes. Never mentioned, for instance, is the substantial role played by the source (usually a sweep generator), and how frequency stability, spurious responses, noise and other “garbage” in the source affect performance.

Often, the source is not integrated into the analyzer, but stands alone. In such a case you might decide to use an existing sweeper. If you do, you’ve got the responsibility for determining how clean the sweep is and how the measurement is affected.

At the very least the vendor should tell you how well his equipment performs in the presence of harmonics and noise. Then you can “add up” all the individual errors in some manner to get an over-all number. Note: Every component must be considered as a possible error source.

When you are given an accuracy spec, be cautious. If the number is stated in decibels, remember that a seemingly small dB change can translate to a sizable swing when measured in volts.

Don’t overlook the importance of high directivity in directional couplers to reduce errors in reflection measurements. To measure a standing-wave ratio (SWR) of 1.2 with ±1-dB accuracy, you’ll need a directivity of 40 dB.

To keep mismatch errors down, look for source and detector matches of at least 20 dB, and preferably 30 dB.

You can squeeze better performance out of some analyzers by using a storage unit, calculator or computer to correct, compensate or subtract certain fixed errors.

You may well wonder how an analyzer’s data sheet can shout a basic accuracy of 0.01 dB (or a resolution of 0.005 dB) on page one, yet quietly list on another page a magnitude or frequency-response error of ±0.2 dB.

Smooth those troubles

Frequency-response error generally refers to a ripple in flatness caused by small mismatches within a system. You can get the lower spec of 0.01 dB all right. But you’ll have to buy an optional error compensator to iron out the ripples.
(Bear in mind that external connectors can upset flatness to a greater extent than small internal
mismatches.)

Fortunately, you can check out the response error and other important areas. For response,
set the analyzer to its highest resolution to "magnify" the display. To verify accuracy or
resolution, use traceable calibration standards—
variable attenuators, and air lines to calibrate
phase or absolute group delay.

One caution. In evaluating analyzers, be sure
you don't confuse accuracy with resolution, a
favorite trick of some vendors who try to blur
true performance.

Source headaches—in stability, noise, spurious
signals—can be spotted (maybe) with a spectrum
analyzer.

Noise together with crosstalk (leakage between
channels) limits dynamic range, another im-
portant analyzer spec. A wide dynamic range is
desirable, for instance, to show filter reject bands
and to measure isolation, crosstalk and attenua-
tion.

The lower limit of the dynamic range—the
measurement floor—is blurred by noise and cross-
talk; the upper limit by the nonlinearities of over-
driven stages. You can limit noise by narrowing
bandwidth, but at the sacrifice of speed. Leakage
isn't easy to keep out, requiring such measures
as good shielding, or special rf connectors.

When you look into dynamic range, watch for
statements like "displayed dynamic range," "rated range," and "over-all range." What they
mean is that the instrument can't accommodate
the entire range at once on the screen. To see
across the range, you have to use switching or
some substitution technique. The extra trouble
may not faze you . . . if you know about it in
advance.

Another aspect of dynamic range is how well
the system measures phase or group delay under
various amounts of attenuation. It's tough to get
accurate phase measurements with 100 dB of at-
tenuation, but below about 50 or 60 dB, you can
expect good results.

You can verify dynamic range by continuously
adding attenuation while checking the response
on the display.

Sometimes, being narrow is better

In general, greater dynamic range is achieved
by going to a narrow-band system, an arrange-
ment that also brings immunity to source har-
monics, and provides greater resolution and other
advantages over broad-band equipment.

If you're working with narrow-band devices—
crystals, crystal filters and the like—you'll need

---

**Push a button and see group delay** displayed as a func-
tion of frequency in GenRad's 1710 rf network analyzer.
The unit shows absolute levels.

**One alternative** to a totally integrated analyzer package
is the A51, from Wide Band Engineering. The A51 works
with external equipment—a source, attenuator, bridge
and scope—to measure gain, loss and VSWR.
test equipment with adequate signal purity and frequency stability. Most conventional sweepers can't meet these requirements. Only top-flight units or frequency synthesizers can do the job.

To resolve details requires a narrow bandwidth. But usually, the narrower the bandwidth, the slower you must sweep. The limitation results from the response time of the filters built into the analyzer.

Other points to keep in mind:
- Analyzers are linear instruments, designed for small-signal testing. Operation in a nonlinear region (large signals) will likely give unreliable results.
- Reflection measurements may be just as important as those for transmission.
- Accessories and options can eat into speed, accuracy or other basic specs.
- Most analyzers are ratio devices, that is, the analyzer compares the test-channel signal with a signal on a reference channel.

Again, the source can be a major trouble spot.

Take care to look over those specs that spell out signal purity and stability.

After you've sorted out the specs, what else should you look for in a network analyzer? Features, options and capabilities in analyzers are almost as diverse as those in the automotive industry.

Getting it all together

You might look for a unit that's totally integrated, with the stimulus, receiver or detector, display and all other necessary circuitry built in.

One such unit is Hewlett-Packard's 8505A, a 500-kHz-to-1.3-GHz analyzer with 100-dB of displayed dynamic range and a built-in 1.3-GHz counter that operates while the source sweeps. Along with the CRT, digital displays read out the measured parameters. A top-of-the-line analyzer like the 8505A doesn't come cheap. It will cost you about $25,000.

Or you can start with a basic core—like the A51 from Wide Band Engineering—and surround the core with individual signal generators, bridges, oscilloscopes and other building blocks to form a complete analyzer.

The A51 provides 1-to-500-MHz swept or single-frequency measurements of gain, loss and VSWR on 50 and 75-Ω systems.

Somewhere between the "all-under-one-roof" and totally-individual-components approaches, you'll find semi-integrated packages, with perhaps the tracking receiver and display in one cabinet, the sweep generator in another, and so on.

GenRad's 1710 RF analyzer (to 500 MHz), for one, is composed of three or four 19-in. units in its basic form, and it measures the magnitude and phase of two signals relative to a reference. Thus you can make simultaneous transmission and reflection measurements with the 1710.

Basic price of the 1710 is $9700. The group-delay option costs $495, and the polar option another $150.

Also made up of several packages is the ZWD Sweep Diagrap, from Rohde & Schwarz. Covering 10 to 1000 MHz in one sweep, the ZWD also offers two independent channels plus an over-all dynamic range of 120 dB (90 dB displayed).

Yet another way to go in analyzers is the plug-in route. One example: Wiltron's 640, a recently unwrapped system that measures transmission and reflection from 1 to 1500 MHz. Plug-ins for the 640—which sells for under $4000 complete—include a sweeper and transmission reflection units with detectors, bridges and log converters.

If point-by-point plotting—rather than a continuous sweep—is all you need, then a number of phase gain meters, with digital displays, are available.

The Dranetz Engineering Laboratories 305, for
Digital readout of gain, phase and amplitude mark the Series 305, from Dranetz Engineering Laboratories. The autoranging unit works to 700 MHz.

example, digitally reads out gain and phase shift from 5 Hz to 700 kHz with the 305’s PA-3009 plug-in. Besides several nice features, like autoranging and autocalibration, the 305 offers high phase accuracy—±0.1 degrees to 50 kHz.

Phase gain meters, or vector voltmeters, are also marketed by HP, North Atlantic Industries and others.

Not quite a gain/phase meter, or a network analyzer for that matter, is an instrument called the LAB-ALL, built by UFAD Corp. Actually a multifunction instrument (12-in-one, says UFAD), the LAB-ALL (model 850) can, among other things, produce a Nyquist plot on an external oscilloscope.

The 850 rejects both even and odd harmonics to the tune of 55 dB, and offers ±1% phase accuracy, ±2% amplitude accuracy, from 30 Hz to 100 kHz.

Making things better

Accuracy, of course, is what you’re after in a network analyzer. One way to enhance accuracy is to buy a programmable analyzer and store correction data in a calculator or computer.

HP’s 3042A system does just that via the HP Interface Bus (HP-IB). With additional hardware, calculator enhancement routines can upgrade accuracy to 0.01 dB over 100 Hz to 10 MHz. The calculator can also manipulate data, make decisions based on test results and control other instruments at the same time.

Automatic analysis with a fast switching, synthesizer-based system is yet another option. One example is the GenRad 2261. Intended primarily for precision narrow-band measurements, the 2261 lets you work in frequency increments as narrow as 0.1 Hz.

A frequency programmer—rather than a calculator or computer—is used to enter sweep data in the GR unit.

Network analysis today extends into the microwave region. Microwave buffs will find the selection rather limited, however, because HP’s 40-GHz 8410B is virtually the only unit available that works at such lofty frequencies. With it, you can plot both magnitude and phase above 18 GHz, in coaxial and cable waveguides. And you can measure the S-parameters of microwave semiconductors.

Other commercial analyzers also offer attachments, or test sets, for S parameters and other capabilities. A sampling: calibration kits, biasing of active devices, polar displays (nice to have, but they offer less resolution than the rectilinear display), impedance attachments for non 50 or 75-Ω systems, Smith-Chart overlays.

Note that these and other features can be standard, optional or a mixture of both, depending on the unit. The price, of course, can soar when all options are added. The performance, unfortunately, can plunge when you add an option ... and the spec sheet may not tell you. You’ll have to ask. ■

Need more information?

The products cited in this report don’t represent the manufacturers’ full lines. For additional details, circle the appropriate number on the Reader Service Card. For data sheets and more vendors, consult ELECTRONIC DESIGN’S GOLD BOOK.


Circle No. 501

Dranetz Engineering Laboratories, Inc., 2385 South Clinton Ave., South Plainfield, NJ 07080. (201) 755-7080. (A. Ackerman)

Circle No. 502


Circle No. 503

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Elsytec Div. of Computa Inc., 6150 Canoga Ave., Woodland Hills, CA 91364. (213) 884-5200.

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Ferranti Frequency Labs, P. O. Box 527, Farmingdale, NY 11777. (201) 938-9221.

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(213) 670-1515. (Joe Jelinek)

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Electronic Design 16, August 2, 1976
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Put microprocessor software to work by taking advantage of different addressing modes.
Here are the basics of how these modes function.

Get the most out of your microprocessor-based system by using the optimum addressing mode for each program step. Different addressing techniques—indexed, indirect, relative, paged and others—originally developed for use in large computers, can be used in μP systems.

But beware—even though the technique may have the same name as in larger computers, the internal procedure performed by the μP may be different. The short word lengths used in most μP systems make it difficult to handle addresses. Common processors such as the 8080, 6800, F-8, PPS-8, CDP1802 or 2650 all have word lengths of only 8 bits, though some of these μPs simplify addressing by using 16-bit address busses.

Eight-bit busses are fine for handling 4-bit binary-coded decimal and 8-bit ASCII or EBCDIC characters, but they are not adequate for a viable memory address bus. A typical 8-bit μP, when using direct addressing, needs three memory cycles to get the instruction and address into the processor. Only in the fourth cycle does the μP actually do any useful work (Fig. 1). About 75 percent of all central processor (CPU) time is spent on overhead functions.

Know the different addressing modes

Obviously, a better way than simple direct addressing is needed. With an 8-bit μP, the fewer 16-bit addresses you transfer, the more CPU time and memory space you save. For fixed-program applications, a ROM that holds the operating program would be the simplest solution. However, you cannot store subroutine return addresses in the ROM or modify its program instructions.

Data cannot be stored with the program either; temporary data must be placed in a separate part of memory. That also restricts the movement of the program and data in the memory unless special provisions have been made beforehand.

The limited chip size of μPs keeps the number of registers, busses and other elements minimal. Many signals may have to be generated externally, thus adding to the system cost. Let's take a hard look at the different addressing methods to see how they can increase or decrease the complexity of the system.

Indexing is one of the most commonly used addressing modes. With this technique, the contents of the index register are added to the address supplied with the instruction (Fig. 2). The sum of the two is called the effective address, and is used to fetch the data.

The indexed instruction shown in Fig. 2 is Load Accumulator 300, X. (The , X indicates that indexed addressing is to be used.) If the index register contains the number 15, the indexed instruction has the same effect as a Load Accumulator 315 instruction. The contents of location 315 are fetched and placed in the accumulator. However, we can change the effective address of the indexed Load instruction by altering the contents of the index register. A Load Accumulator 315 instruction, though, is frozen for the life of the program.

Processing of data stored in arrays or tables is the usual application of indexed addressing. An entire array of data can be processed or moved with a simple program, just by starting the index register at a base number and incrementing it each time the program cycles through (Fig. 3a and 3b). Inside the program, indexed addressing is used to get the data. The address supplied with the instruction is the base address of the data stack. Indexing saves program memory space and adds flexibility. When you're only using one element at a time, though, indexing slightly slows down the program since you must add several instructions to increment the index register.

On the other hand, if several elements of an array are used each time the program cycles, indexing can speed things along. All the elements can be accessed just by changing the address that accompanies the instruction. Thus, each time the program cycles, the next six data elements can be accessed with the addresses:

```
BASE, X
BASE + 1, X
BASE + 2, X
BASE + 3, X
BASE + 4, X
BASE + 5, X.
```

Dr. Lance Leventhal, Instructor, Engineering and Technology Dept., Grossmont College, 8800 Grossmont College Dr., El Cajon, CA 92020.
1. A simple instruction cycle, performed on an 8-bit μP, requires four memory cycles if data must be fetched from memory. Three cycles are needed to get the instruction and data address and one cycle to actually do any processing.

2. Getting information by indexing cuts the number of memory cycles needed by the processor, but slows down processing since the contents of the index register are added to the address supplied with the instruction.

For applications that require sorting, searching and editing, this accessing feature is very useful.

Several data arrays can be processed simultaneously if they are similarly structured. For instance, if one array contains names, one contains addresses and another contains Social Security numbers, once you locate a name you also have the location of all of the other data in the accompanying arrays.

Table access is simplified

When indexed addressing is applied to tables, you can simplify any look-up routines considerably. All that has to be done is to put the number of the desired element into the index register, then use the base address of the table as the fixed address.

The table of Fig. 3c shows how you can use a table to convert a number in the index register to a seven-segment code for display. The instruction —Load Accumulator 1000, X—does the conversion. The CPU obtains the seven-segment code from the effective address (1000 plus the decimal digit stored in the index register) and places it in the accumulator.

A microprocessor could do indexing in the same way as larger computers. However, the base address included in the instruction would have to be 16 bits long, and the CPU would have to perform a 16-bit addition of the base address and the index register. In an 8-bit CPU the arithmetic section would have to “double-up” to do the addition, thus slowing down the overall program.

Of course, you can save time and memory by limiting to 8 bits the address that is included with the instruction, and by using a 16-bit index register. The 6800 μP does indexing that way, which is the reverse of normal indexing because the 16-bit base address is placed in the index.
3. You can easily use indexed addressing to process a data array (a), move data blocks from one area in memory to another (b) or to access a table for code conversion look-up (c).

4. When you access a table using 6800 indexing, the index register must be used as a counter to keep track of the table entry. When the counter reaches zero the table pointer has reached the desired item.

register instead of in the program memory.

Of course, this addressing mode still requires the CPU to do a 16-bit addition to arrive at the effective address. You must also load, increment and store the contents of the 16-bit index register. However, only rarely will you actually have to load the index register's contents. Often, you can just add one to it in the same way that the program counter gets incremented.

Accessing a table to get an entry can be done in several different ways. One of the simplest uses the index register as a counter to keep track of the table entry and increments the register for each entry (Fig. 4). This procedure is slow and, if used often, can cause major delays in processing the data.

Another way is to perform 16-bit addition in the program. If the 6800 µP is used, the base address is placed in the two 8-bit accumulators and the index added to the eight least-significant bits (LSB). The resulting carry, if any, gets added to the most significant bits (MSB). Unfortunately, the 6800 cannot be instructed to shift the contents of both accumulators into the index register. So, the sum must be temporarily stored in a memory location before you can put it in the index register. This procedure is independent of table size, and requires eight instruction cycles to calculate the effective address and fetch the table entry. A typical program listing might read:

- **LDA** # **UPPER**  upper base add to A
- **LDB** # **LOWER**  lower base add to B
- **ADDB** INDEX  add index
- **ADCA** # 0  and carry
- **STAB** **SUML**  lower entry add.
- **STAA** **SUMU**  upper entry add.
5. You can access the entire memory with indirect addressing but doing so can be confusing because the data byte or bytes fetched are used as the address of the actual data word.

LDX SUMU  get it to index reg.
LDAA X  get entry

Alternatively, you can set up the tables so that their starting addresses are always a multiple of 100 (hexadecimal). Then you can refer to any table by means of an 8-bit address. (An address of 4 means that the table starts at location 400 hex.) To get into the table, place the 8-bit table address in the eight MSBs of the index register and the 8-bit index in the eight LSBs of the index register.

In any of the methods just described, indexing is not really used to full advantage. The CPU does unnecessary 16-bit addition and time is lost for each indexing cycle that adds zero to the contents of the index register.

Get the addresses indirectly

If you can spare a memory cycle, indirect addressing can retrieve the full 64 kilobytes of available memory. When you use indirect addressing, the address supplied with the instruction is used to get the address of the data rather than the data itself (Fig. 5). The effective address is thus part of the data memory. Parentheses are used around an address to indicate that the contents of the location shown are what the CPU is after. Thus: ADDR is an address and (ADDR) represents the contents of that address.

Indirect addressing permits you to store a program in ROM, yet alter the contents of RAM locations called out from the ROM. Thus you can use the same instructions to process data anywhere in memory. All you do is put the starting address of the data into the RAM location specified by the program.

6. To do a sorting routine for an array that starts at an address other than that specified by the program, an extra program that first relocates the array must be included when direct addressing is used (a). Indirect addressing permits you to keep the program simple and start at any location (b).

7. To process a data array, indirect addressing can be used, but it won’t be the most efficient method because the memory must be accessed twice for each data word.
8. **Register-indirect addressing** can eliminate the delays introduced by memory-indirect addressing. In register addressing, the address of the data is stored in a special register instead of in a memory location.

9. **Relative addressing techniques** require the CPU to add the contents of the program counter to the address that follows the instruction. The sum forms the effective address of the actual data.

Consider a sorting routine that orders an array that starts in memory location 1000 (Fig. 6a): it cannot be used to sort an array that starts in location 6000. To sort any array but the one that starts in memory location 1000, you first have to move the array. To get around the location problem, indirect addressing can be used in the program to pull the base address of the array from a RAM location (Fig. 6b).

Indirect addressing can simplify array handling, but does add to processing delays, since addresses must be pulled from memory locations. Further, you won’t need the index register, and you’ll eliminate the additions previously needed to get the effective address.

When you must search a table or array for a particular element, indexing is the simplest method to use. Applications that use all or most of the array elements would probably do better with indirect addressing, though.

Many people find that indirect addressing is difficult to use, because the distinction between data and addresses can be confusing. Most of the popular microprocessors don’t have true indirect addressing (as described) available to them, and would need an enormous number of cycles to get a 16-bit address from memory and then use it to get another 16-bit address. Even if some ad-
addresses were limited to 8 bits, too much time would be spent on overhead operations.

What some µPs (the 8080 and CDP1802, for example) use instead is “register indirect addressing,” in which the address is stored in a register rather than in a memory location (Fig. 8). That eliminates the address fetch cycle. All you have to do to get the data is get the instruction from memory, then place the contents of the address register onto the address bus.

Register indirect addressing does have some advantages over indexing. You do not have to provide an offset as part of the instruction and you can eliminate the 16-bit addition to get the effective address. Thus, you save both program memory and time.

To process a data array, the same procedures used to perform the operations in Fig. 7 can be applied (Fig. 8). However, there is a restriction: you cannot reach any other elements in the array unless the program changes the address stored in the address register. If more than one array element is needed for a program, indexing may prove easier. Indirect addressing is ideal for processing single pieces of data.

Relative addressing keeps addresses short

By using relative addressing you can often keep addresses short and make programs easy to relocate in memory (Fig. 9). To get the effective address, the contents of the program counter are added to the address that is supplied along with the instruction. This procedure is similar to indexing, except that the contents of the program counter are used instead of the contents of the index register.

In Fig. 9, the flowchart shows a procedure that loads the accumulator with data from a memory location that is 100 words away from the instruction. The offset is usually interpreted as a signed two’s-complement number so that locations in either direction can be accessed.

Relative addressing is particularly effective if the locations being addressed are very close to the program instruction. And moving programs around in memory won’t cause any problems since relative addresses remain the same so you can put a program or subroutine in any unoccupied area of the memory.

Microprocessors can’t take full advantage of relative addressing because they have short words and in many cases, read-only program memories. If 16-bit relative addresses are used, they must be stored as two memory words, with two memory cycles needed to recall them. On the other hand, if 8-bit relative addresses are used, you can save space and time but must use locations within ±128 words of the instruction. In most programs, 128 words are not sufficient.

11. Page-zero addressing permits fast access of often used data, that are not on the current page, without an extra memory cycle (a). Current-page addressing can rapidly reach locations that are on the same page as the instruction (b). You can also use page-zero addressing indirectly to reach data on other pages (c).

The main advantage of relative addressing in µPs is the use of short offsets as jump addresses. However, just as with indexed addressing, the processor must perform a 16-bit addition to get the effective address each time the relative mode is used. So, slower execution time is traded for memory savings.

Turn the pages carefully

To avoid long addresses in computer programs, paging procedures can be used. Divide the memory into fixed-size sections called pages. You can then refer to a memory location by its page number and its address on that page. Often, the page number is put into a page register and then locations on the same page can be referenced with just the paged address (Fig. 10).

For small programs you can avoid using the
12. Different memory decoding systems permit you to store the service routines and addresses in either the lower (a) or upper (b) parts of the memory. With these techniques, you can add extra memory space, if required, up to the addressable maximum. However, memory system design is easier in case (a) since the lower memory configuration is continuous.

Page register by limiting the pages that have to be addressed. If only addresses on the first page are used, the technique is called Page-Zero Addressing (Fig. 11a). When you can reach addresses that are on the same page as the current instruction, the technique is called Current-Page Addressing (Fig. 11b). Other pages can be addressed by using an indirect paging method, that is much like the indirect addressing mode (Fig. 11c). Many computers let you select current and zero-page addressing, with just a single bit change in the instruction.

For computers of 16 bits and larger, paging is a great solution to many of the processor limitations. Unfortunately, with μPs, page sizes must be kept to 256 words in order to get paged addresses into 8-bit words. Page zero is, in turn, restricted to 256 words—and there will be many page boundaries that must be handled.

As with relative addressing, you can’t use current page addressing for anything except jump instructions because in most cases data are not on the same page as the instructions. Current-page addressing does have the advantages of not requiring a 16-bit addition to get the effective address. The CPU gets the effective address from the eight MSBs of the program counter and the paged address.

If you use page-zero addressing, use a RAM for memory page zero. But remember that you don’t want to put your interrupt and startup routines in the RAM, since you’ll have to reload them each time the system is turned on. Thus the interrupt and startup service’ addresses must be stored on a page other than page zero.

However, the addresses on page zero are the easiest to generate since they’re only 8 bits long. Additional circuitry, either internal or external, must be used to generate addresses on other pages. Furthermore, decoding is simple if you use a continuous memory that starts at location zero. If the service routines are put at fixed locations, either the memory will have to be divided into sections, or a complex decoding system must be used.

For example, assume you have a system with 6-k words of memory and the lowest 1-k are used to store the service addresses (Fig. 12a). In that case, additional memory can be added without causing any addressing problems. The 3-of-8 decoder can handle up to 8-k words. By using a 4-of-16 decoder you can address up to 16-k words.

A ROM with service addresses at the highest memory addresses can also be used (hexadecimal FF00 and up). The ROM that contains the service addresses must then be placed in a separate area of the memory so that additional memory can be added without moving that ROM (Fig. 12b). System design is made more difficult because the memory space must be divided into two sections.

If service addresses are externally generated to handle large interrupts, systems 8-bit addresses can be generated on page zero by using some encoders. Extra circuitry will be needed to generate 16-bit addresses and place them on the data bus in 8-bit sections.

Note: Some of the material in this article is based on sections of the author’s forthcoming book on Microprocessors.

Bibliography

GR's Network Analyzer Costs Less and Performs Better

In the market for a high-performance network analyzer? The choice usually boils down to three instruments. All three are excellent products and the final selection typically centers around how important certain specifications are to one's applications. If overall value is the deciding criteria, then GR's widely used 1710 RF Network Analyzer has a definite edge. Here's why:

<table>
<thead>
<tr>
<th></th>
<th>GR 1710</th>
<th>HP 8407*</th>
<th>HP 8505*</th>
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<tbody>
<tr>
<td>Price</td>
<td>$9,850</td>
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<td>Frequency Range</td>
<td>0.4 to 500 MHz</td>
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</table>

*Based on information contained in HP's 1976 Catalog

Now, of course, there are many more specs to compare and GR doesn't win in all areas, but the specs cited above are among the most important...including price. Unfortunately, one important feature of the GR 1710 that doesn't show up in the specs is its convenience of operation. Nothing can be more simple than GR's pushbutton switching from displays of magnitude to phase, or to both magnitude and phase, to delay, or to polar.

To get the full story on the capabilities of the GR 1710 request a copy of "RF Network Analysis", a 12-page brochure that describes the 1710 plus all its options and accessories. We'll also include a copy of Application Note 7, which describes how simple it is to make measurements with a GR 1710 at frequencies up to 2000 MHz or even higher.

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Use SOT-23 packaged components in mass-produced hybrid circuits. They can cut size and cost while simplifying production and boosting over-all reliability.

Transistor chips for use in hybrid-circuits come in many sizes, but the unpackaged chips present both handling and connection problems. For better reliability and lower cost, consider using prepackaged chips in SOT-23 cases. The SOT-23 was originally developed in Europe but at least three international manufacturers are currently offering devices in that package.

As a designer of hybrid circuitry, you want as small a package as possible and a reliable bond between device and substrate. Equally important is cost. The attachment process used with the chip directly reflects the manufacturing cost and reliability of the hybrid assembly (see table). Although you can choose from such other packages as leadless inverted devices (LIDs), flip chips, or beam leads, only the SOT-23 can meet all of the above design requirements (Fig. 1).

The ribbon leads of the SOT-23 make it easy to handle during assembly. That includes positioning and mounting of the chip on its substrate, inspection of connections after the bond is made and the bonding technique itself. The SOT-23 can be bonded to the substrate either by the reflow soldering attachment technique or by dip soldering. This cuts costs since very little in the way of specialized equipment is needed to perform the assembly.

The triangular arrangement of the leads provides the package with excellent high-frequency response. Active devices in SOT-23 packages, including ICs, are available from the low to ultra-high frequency range. For example, Siemens recently introduced the popular 741 operational amplifier in a package similar to the SOT-23.

Ease assembly with SOT-23

Here are some benefits listed by manufacturers of the SOT-23:

- Technology: high reproducibility of device characteristics, and greatly reduced circuit volume.

- Production: ease of attachment, suitable for automatic mounting, and elimination of storage problems.

- Profitability: reduction of mounting costs, testing costs, mounting times, line rejects and initial component cost.

The chip-and-wire technique is still the one most commonly used today, since wire bonding remains the cheapest form of assembly (Fig. 2a). But problems with the attachment technique spurred the development of the other methods—flip-chips, beam-leads, LIDs and, finally, SOT-23 devices.

The wire bond is one of the most common causes of failure in thick-film hybrid circuits. Weak bonds and overstressed or overbonded wires lead to malfunctions, and thus affect the product's over-all cost, quality and reliability.

Donald Epand, Product Marketing Manager, Siemens Corp., Iselin, NJ 08830.
The flip-chip bonding techniques totally eliminate wires and the die-attach step (Fig. 2b). Good bonds can be made if the bump's height and the substrate's flatness are accurately controlled to within a few microinches. All the bumps and their respective pads also have to be lined up accurately for the chip to be put down and bonded in place.

In a flip-chip arrangement, the operator must see the underside of the chip to observe the metallization pattern on the substrate. That requires sophisticated optics and greatly increases the cost of bonding. Another serious problem with the flip-chip is that there is no way to inspect the bond after it has been made.

On the other hand, beam-lead-mounted components (Fig. 2c) can be completely tested. But like flip-chip bonders, beam-lead bonders are expensive, because that process also requires the superimposed image of the beam and bonding pads. The cost of bonding and of associated equipment is the major disadvantage of the beam-lead attachment technique.

The LID, sometimes called the channel carrier, has a distinct advantage (Fig. 2d). It can be attached to a hybrid circuit by standard solder techniques without the high investment in die-bonding and wiring machines. Another advantage is the availability of a more diversified family of active devices than can be found in any other packaging format.

However, compared with the SOT-23, the LID has two disadvantages:

1. Cost: It requires a carrier, which adds to the initial price.

2. Inspectability: Pads are obscured by the body of the LID, thus making it hard to check for complete attachments.

Fig. 3 shows both the SOT-23 and LID packages. The same active device is used in both cases.

A choice of mounting methods

The SOT-23 packaging concept has been designed to give the hybrid manufacturer a choice of mounting techniques. The most popular and economical is reflow soldering, which uses a conveyor belt over a hot plate and does not require highly specialized equipment.

In that process the printed and fired substrates are dipped into a soldering bath kept at 220 to 230°C. The solder alloy must contain from 2 to 4% silver to prevent the conductor pattern from dissolving in liquid solder. The flux used is usually slightly activated.

The SOT-23s and other components are positioned on the substrate, their correct position secured by the adhesive force of the flux. The entire substrate is then dipped into the flux and
mounted on a heater plate. Soldering should be done as fast as possible—just enough for the solder in all locations to liqudize. A full soldering cycle depends on the equipment used and the size of the substrate. The soldering cycle time, placement and removal of the substrate are usually controlled automatically.

SOT-23 packages can also be attached using thermal compression techniques. With a low-wattage iron you can solder the SOT-23 directly to a circuit board during the preliminary design stage. For fully automatic production, a vacuum chuck, acting as a resistance soldering tool, can be used. The vacuum chuck picks up the transistor from an alignment tray, transports it to the correct spot on the substrate and then performs the resistance-soldering operation.

**Reliability: A problem with SOT-23s?**

The reliability of the SOT-23 package is essentially comparable to that of the popular TO-92,

### Inside the SOT-23 package

The SOT-23 package contains a vacon strip, a photoresist-coated, nitride-passivated chip, a piece of gold foil for alloying, and gold wires. Its body is made from molded plastic (Fig. A). The surface of the etched or stamped vacon strip (Fig. B) is first plated with 2 to 3-μm of gold. A piece of gold foil and the chip are then placed on the alloying point of the vacon strip.

Alloying is done in an inert atmosphere at about 460 C. The structure’s emitter and base contact areas are connected to the transistors’ leads with gold wires, 20-μm in diameter. The structure is next coated with photoresist to reduce photosensitivity and resist moisture, and then molded in plastic.

Next the transistors are tempered, and all plastic residue is removed. When the connections have been trimmed, they are stamped out and bent as required. Since the epoxy used on the Siemens transistors will withstand immersion in molten solder at 240 C for up to 5 s, these packages can be dip-soldered.

### Comparison of active-chip prepackaging

<table>
<thead>
<tr>
<th>Item</th>
<th>Wire &amp; Chip</th>
<th>SOT-23</th>
<th>Lid</th>
<th>Flip-Chip</th>
<th>Beam Lead</th>
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<td>Reliability of bond</td>
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<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
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</tbody>
</table>
What makes the SOT-23 so small?

A line of active devices was developed at Siemens especially for the SOT-23 package. For example, the BCW60 silicon-planar epitaxial transistor in a SOT-23 case has the same characteristics as the conventional BC107 transistor housed in a TO-18 case, but is 30 times smaller and weighs only 7 mg. To accomplish that, the basic structure of the transistor had to be greatly improved. Siemens did so by adding a guard ring, shielding electrode and a silicon nitride passivation layer (Fig. A).

These changes were essential to account for certain properties in the silica film and the silicon-silicon interface. Although use of a thermally grown silicon dioxide film to protect the pn junction improved the stability and quality to some degree, compared with that of the unprotected pn junction, more protection was still needed.

The oxide contains both mobile and stationary positive charges whose field acts upon the charge carriers in the silicon below. At temperatures around 200 C, ions of alkali metals (such as sodium) or of hydrogen act as mobile charges that can pass through the oxide. Ions travel not only within the oxide but also over the surface of the oxide film and change the characteristics of the pn junction.

The movement of the surface ions depends greatly on the relative humidity of the surrounding atmosphere. To make a stable transistor, it is necessary to grow a clean oxide and protect it from subsequent contamination and the influence of the surface ions.

The guard ring and shielding electrode prevent the uncontrolled spread of an inversion layer on the collector. The inversion layer could cause excessive leakage currents and eliminate the influence of surface ions. The silicon nitride layer prevents contaminants from entering the oxide. Silicon nitride is an effective insulator (resistivity is 10¹⁵ to 10¹⁴ Ω/cm) and is very hard (above 9 on the Mohs scale).

The nitride's most important property, though, is its resistance to the passage of ions. If the transistor structure without a nitride passivating layer is coated with a substance containing sodium and then exposed to a temperature of 200 C, a considerable drop in the current gain occurs within a few hours. However, nitride-passivated transistors are unaffected by such treatment (Fig. B).

The excellent stability of nitride-passivated transistors is illustrated by the results of endurance tests performed with the BCW60 and BCW61. Fig. C shows the distribution of the drift coefficient of current-gain B. The drift coefficient is the reading taken after a 1000-hour endurance test, divided by the reading at the start of the test.
3. Outline drawings of an SOT-23 package from Siemens (a) and a LID package (b) from Amperex Electronic Corp. show that the cases are approximately equal in size. Other SOT-23 makers include Amperex, NEC and Texas Instruments.

because it uses the same type of construction. Power dissipation is less than that of the TO-92, because of the difference in size. The total power dissipation allowed is determined by the thermal resistance which in turn depends on the mounting conditions and material of the substrate. It can be expressed as

\[ P = \frac{V_{\text{max}} - V_{\text{amb}}}{R_{\text{th}(j-a)}} \]

Thermal resistance from junction to ambient, \( R_{\text{th}(j-a)} \), of the SOT-23 package transistor is about 0.58°C mW. At a maximum junction temperature of 125°C, the maximum power dissipation is 170 mW. If the device is mounted on a ceramic or epoxy fiber glass substrate, the power dissipation can be increased by about 20%. Thus, power dissipation in excess of 200 mW is possible.

4. SOT-23-housed transistors and diodes are used in part of a hand-held communicator (a). Similarly housed transistors are used as LED drivers in a digital watch module (b). The transistors are mounted just above the digital LED display.

Fig. 4a shows a hybrid circuit manufactured by Pulse Engineering in San Diego. It is part of a subminiature module designed for hand-held communications equipment. The active devices used include vhf transistors, audio-frequency transistors and silicon diodes, all in SOT-23 packages.

Several other major original-equipment manufacturers of hand-held communications equipment are adopting SOT-23 packaged devices in their hybrid circuits. Fig. 4b shows SOT-23 packaged transistors used as LED drivers on a digital watch module. SOT-23 packaged phototransistors designed for cameras are finding use in digital watches as a sensor for ambient lighting; they regulate the LED drive current.

At least one major company that is in the telecommunications field had been using TO-18 devices in its equipment, but recently decided to hybridize its circuits by using SOT-23 packages. Tests conducted by that company showed the moisture resistance and reliability of the new package are about the same as for hermetically sealed devices.
Amperex extends the range of microminiature components for your hybrid IC's with all-gold SOT-23's and SOT-89's.

The Amperex line of all-gold SOT-23 and SOT-89 plastic microminiature semiconductors consists of just about everything the hybrid IC maker needs, including several unique types that appreciably extend the range of applications for low cost hybrid IC's: Zener diodes, switching diodes, tuning diodes, Schottky mixers, general-purpose low-level transistors, fast-switching transistors, wideband amplifiers for IF and VHF, FET's, low-current/low noise transistors, UHF transistors, and even high voltage transistors that can handle up to 120 volts V CEO.

In addition, we offer a whole series of drivers and switches that can dissipate up to 1 watt. These are available in the slightly larger SOT-89 plastic microminiature package and can be used on the same substrates as the SOT-23.

Both the SOT-23 and SOT-89 packages are suitable for either automated or manual mounting and for soldering by all the conventional methods, including the popular reflow-soldering technique. Intermetallic compound problems never strike Amperex SOT-23 or SOT-89 semiconductors because they contain no aluminum. We use a dual layer of Gold-over-Titanium at the contacts; we bond Gold wire directly to Gold surface; and we encapsulate the chip in a high-purity, neutral plastic which has no effect on semiconductor life.

The result: A more reliable, low cost microminiature package. The way is now open for the manufacture of high yield, high-reliability, low-cost hybrid integrated circuits... with Amperex SOT-23's and SOT-89's.

For data on the entire line of Amperex SOT-23's and SOT-89's, or for applications engineering assistance on any of your hybrid needs... from basic components to complete circuits (thick and thin film — custom or standard) ... contact: Amperex Electronic Corporation, Slatersville Division, Slatersville, R.I. 02876, Tel: 401-762-9000.
Too many of us take the education of our engineers for granted. When we hire an engineer, we assume that he's already been fully educated, that he has learned all there is to know at a university. If there is any further learning he needs, most of us feel that he'll learn what's needed on the job—by osmosis.

At Nippon Electric, we feel it's wise to make a positive commitment to educating our engineers—not only when they join the company but as they grow in the company as well. We feel the investment in educating engineers is paid back handsomely in greater engineering productivity and innovation. The techniques we use to educate our engineers are certainly not remarkable. They are the techniques almost anybody might arrive at if he sincerely felt that educating engineers was important. Let me show you some of them.

The first thing we do with a newly hired engineer is something you might consider elementary. Yet most companies, in their eagerness to plunge a new engineer into productive activity, completely neglect it. We give him indoctrination.

Is that paternalistic? Not at all. Most engineers, like all other employees, welcome it. We tell an engineer how our factory operates, what kinds of products we make, how we distribute our products, how we provide service to our customers, who our customers are, how we communicate with our customers, and how we communicate with each other.

This kind of indoctrination, which doesn't require more than a few hours, gives everybody a powerful start because it shows people where they fit into a large organization and helps show them their own importance.

After his indoctrination, we subject an engineer to 20 days of education in the use of computers. This has a double advantage. It familiarizes our engineers with some of our products and it teaches them how to use a powerful design tool. Most engineers and most companies know how important the computer is to engineering. Yet, most companies simply assume that their engineers will learn computer programming, somehow, on their own. Of course, an engineer isn't going to become an expert programmer in 20 days. But at least he gets the groundwork. He can learn more later.

Next, as a general policy, we encourage further education for our engineers even to the extent of sending them overseas for advanced specialized courses or post-graduate schooling.
But, in general, the engineer gets most of his specialized training in his own division. We feel that on-the-job training is extremely important for engineers as well as for others in the company. On-the-job training is not accidental with us; it’s very deliberate and we spend a lot of time planning it.

A lot of this emphasis began three years ago when we started a program called Operation Quality, whose aim was to improve the quality of everything—management, engineering, manufacturing and, of course, products. As one might expect, education was an essential ingredient in this program.

In fact, part of the job of every section manager involves educating his engineers—not only for the immediate needs of their jobs—but for future requirements as well. One measure of the effectiveness of a section manager is how well he trains his engineers.

**So the section managers train the engineers. Who trains the section managers? The department managers.**

The question now is who trains the department managers. The answer is, largely, that they train themselves. Periodically, our department managers get together for brain-storming sessions. They discuss their failures and their successes. They trade ideas. They learn from each other. In addition, we often provide special courses, with guest experts invited to lecture at our plants. Further, we send our people to special seminars that might be given by institutes or universities. And, of course, department managers learn a great deal from division managers.

The division managers get most of the educational opportunities that are offered to the department managers. In addition, we periodically send them to a resort hotel where their minds are taken off the day-to-day activities. Here, we provide the division managers with five days of intensive study including brainstorming sessions. They hear lectures from outside experts, from our president, Mr. Koji Kobayashi, and from other NEC executives. We provide concentrated courses on subjects like developing a strategic philosophy. And we have sessions on accounting because we feel managers, especially engineering managers, should be able to understand accounting documents. We equip them to analyze investment decisions. And we involve them in computer-assisted management games.

In addition, for high-ranking division managers, we provide specialized education in things like managing multi-national companies. We operate dozens of foreign companies so we want our managers equipped to step into those situations when it is necessary.

Another element of education, not just for engineering managers but for engineers as well, involves training in foreign languages. English is the main language, of course, since information on new technology so often appears first in English. But we also provide courses in Spanish, Portuguese, French and German. In most cases the engineer selects the language he would like to study. But if we want to send an engineer to a foreign country, we’ll insist that he learn the language of that country. We don’t want our people to be total strangers in host nations.

Now all of this is part of the formalized train-

---

**Who is Isao Someya?**

In 1966, the year NEC established the basis for Japan’s first time-sharing system, Isao Someya joined the firm. A graduate of Tokyo University, he received a doctor of engineering degree in 1952. In 1972 he was promoted to the post of senior vice president in charge of the R&D group. Although his particular interest is radio engineering, he provides direction in all R&D areas for the firm’s 8500 engineers.

Nippon Electric Company was founded in 1899, and the following year began producing telephone sets and switchboards. NEC is today a company with 34,000 employees and an annual sales volume approaching $2 billion. It is a leading installer of earth stations around the world and in communications satellites. NEC’s other activities include microwaves, mobile radio communications, defense electronics, air navigation, radio, sonar and guided-missile electronic systems.

Someya’s interests include classical music, golf, and the ancient game of “Go,” a kind of Oriental chess game that combines the intricacy of chess with the simplicity of tic-tactoe and the subtlety of Zen.
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As you can see, NEC is very much an education-oriented company. We even learn by teaching.

All of these courses are an addition to those given by company lecturers at our own facilities, usually in the evening. Further, we help our engineering departments by providing a good flow of technicians. We own a technical college in which we provide three-year evening education or one-year full-time education to employees who are high-school graduates who pass a qualifying examination. There's a secondary advantage here. Not only do we develop good technicians but we use our own engineers to teach these courses. And they educate themselves as they teach others. Everybody has heard the old maxim that the best way to learn something is to teach it.

We go still further with what we call our Career Development Assistance Program. We give young engineers aptitude tests to determine which phase of engineering they would be best at. We may find early in the game, for example, that one man may be a good circuit designer and another a good software designer.

So we want to help an engineer go down the path he is best suited for, though we don't want to lock him in. We want to broaden his horizons at the same time with everything else available to him in the company.

But since aptitude tests are not as perfect as we all wish they were, we allow room for modification. In the early years of a man's career at NEC, he might move around from job to job, spending perhaps three months in one specialty, then six months in another, until he finds the one that gives him maximum job satisfaction. That one will invariably be the one in which he is most productive for the company.

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<thead>
<tr>
<th>Specification</th>
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<tr>
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<td>NO NOISE</td>
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CIRCLE NUMBER 34

Electronic Design 16, August 2, 1976
Party-line intercom system needs only three wires

A large number of intercom stations can be tied together, party-line style, with only three wires (Fig. 1). The wires can even be reduced to a single twisted pair between stations, if a separate ground system is used. All units are connected in parallel, and the entire system is buzzed by only one signalling circuit.

Each unit is shown powered individually from 1.5-V cells for redundancy. In the event of a line break, the stations on either side of the break can still function, though only the units on the side with the signalling circuit will be able to buzz each other. If desired, a fourth wire can be run to permit the entire system to function from a single 1.5-V source.

For greater signal volume, 3-V sources can be used for the supplies without changing any other parts of the system. When separate 1.5-V D cells are used, they last approximately one year.

The carbon microphone of a standard telephone handset at each station feeds into a common-base amplifier, and a tandem high-gain common-emitter stage drives the intercom line. All the phone earpieces are in parallel across the line.

The signaling circuit, also connected across the line, is a simple oscillator that drives all the earpieces. Simple buzz codes can be used to reach the desired station.

Simplicity, ruggedness, redundancy and low-power consumption make this system well suited for use in the field or in underground mining applications.

Andrew M. Hudor Jr., Cosmic Ray Physics Group, Department of Physics, University of Arizona, Tucson, AZ 85721. CIRCLE NO. 311
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### Table: QPS Series

<table>
<thead>
<tr>
<th>MODEL</th>
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CIRCLE NUMBER 35

Electronic Design 16, August 2, 1976
Chopper amplifier for thermocouples has long-term drift of only 0.5 μV/yr

The differential chopped-signal amp in Fig. 1 is designed for the amplification of low-level voltages from low-impedance sources such as thermocouples.

The extremely low input-offset voltage of about 2 μV without external trim over a -25-to-85°C operating-temperature range results from five design features:

1. Strict symmetry in all the switching circuits and use of a nonsaturating square-wave oscillator (Q₁, Q₂).
2. Inherent thermal and dynamic balance of the monolithic dual-FET differential chopper, Q₄.
3. Low impedance of both the signal source and the external gain-setting divider resistors Rₐ and Rₜ.
4. High gain of the carrier amplifier (Q₅, Q₆) as set by capacitors C₂, C₃, and C₄.
5. Careful circuit layout and low stand-by power consumption.

Features 1, 2 and 3 make the usual need for compensation of chopper-spikes entirely unnecessary; features 2, 4 and 5 help in minimizing internally generated thermoelectric voltages.

The output op amp, Q₅, contributes to the circuit's over-all open-loop gain of 10⁶, isolates the load, and, together with the external Miller-capacitor, Cₚ, establishes the desired closed-loop bandwidth and output noise.

Other circuit features include a long-term drift of 0.5 μV per year, an input-noise voltage of 0.2 μV peak to peak from 0.01 to 1 Hz, an input-bias current of 50 pA and a CMRR of 120 dB.

The circuit's common-mode input-voltage, though limited to a range of only ±0.1 V, allows a very simple chopper drive that can be referenced to ground. The low input range is more than adequate for most thermocouple applications.

Jiri Dostal, Design Engineer, Research Institute for Mathematical Machines, Prague 5, Czechoslovakia.

CIRCLE NO. 312
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Logic circuit ensures definite break-before-make action for relay drive

The 4-bit-binary to 16-line decoder (Fig. 1) provides the definite break-before-make action that is usually needed when the circuit drives relays. If a logic circuit’s turn-off time is equal to or slower than its turn-on time, the circuit can unintentionally produce two active ON positions at the same time. This may lead to welded relay contacts.

Under quiescent conditions, the same 4-bit binary number is present at both the input and output of the quad latch, IC₁. If the input changes, the 4-bit comparator output (pin 6 of IC₂) goes LOW. The negative transition triggers a one-shot, IC₄. One of the one-shot outputs temporarily inhibits outputs from the decoders (IC₃ and IC₅). The other enables a new binary input number to appear at the output of the quad latch. The decoders are again enabled when the one-shot resets.

The time interval between the circuit’s release of one relay and actuation of a second is determined by the one-shot’s pulse duration. This interval should be twice the relay’s drop-out time, or for solid-state relays, two power cycles.

Thomas Neal, Test Engineer, Beckman Instruments Inc., 2500 N. Harbor Blvd., Fullerton, CA 92634.

CIRCLE NO. 313

1. This circuit’s break-before-make action ensures that no more than one relay is energized at any one time by the 4-to-16-line decoder drive. The one shot determines the timing between activations.

IFD Winner of March 29, 1976

Gerald L. Vano, Systems Engineer, Alden Research Foundation, 117 N. Main St., Brockton, MA 02403. His idea, “Digital Frequency Doubler Works to 100 kHz” has been voted the Most Valuable of Issue Award.

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CIRCLE NUMBER 39
International Technology

Process boosts IC packing densities

Higher packing densities for integrated circuits may be possible through the use of a metal-removal developed by Siemens. The Siemens technique removes aluminum layers as thick as 1 μm and gives conductor spacings of only 1.25 μm. These dimensions contrast with a minimum conductor spacing of the standard chemical etching process of 3 μm and a maximum layer removal per etch of 0.25 μm.

In the Siemens process the substrate (a-1 in the photo) is first coated with an intermediate layer of aluminum 0.02-μm thick (a-2), on top of which the photoresist mark (a-3) is applied. Those parts of the intermediate layer not covered with resist are then etched out, as in b.

Next, the substrate is coated with a 1-μm layer of aluminum (c-4), which forms on top of the remaining photoresist and also on the substrate from which the intermediate layer was removed. The photoresist is then dissolved, taking with it those portions of the 1-μm layer deposited upon it (d).

This leaves only the aluminum patterns of the 0.02-μm intermediate layer and the 1-μm final layer. The intermediate layer is then removed, leaving the final 1-μm-
thick conductor pattern.

The Siemens process results in slanting, conductor edges rather than vertical ones, and that facilitates the application of the additional coatings required for multilayer devices.

**Semi amplifier developed for IR thermal imagers**

A single-chip semiconductor amplifier with a 15-GHz gain-bandwidth and a low noise-figure of 1 V/Hz$^{1/2}$ has been developed for infra-red thermal imagers that use cadmium-mercury-telluride detectors and serial CCD memories.

Produced by Ferranti Ltd., under a Ministry of Defense contract, the amplifier requires an external resistor to set the gain between 40 and 60 dB. The specified gain of 60 dB is accurate to within 1 dB for a 90% confidence level.

The high gain-bandwidth product, according to designer Stephen Harding, is due to the high-density CDI bipolar fabrication process pioneered by Ferranti.

For higher than 60 dB gain, the amplifiers can be cascaded. Each device draws about 2 mA.

**Ion implant equipment can handle 6-in. wafers**

Ion-implantation equipment that can handle unusually large wafers—up to 6-in. in dia.—has been developed by Lintott Engineering in conjunction with the Harwell Research Laboratories in England. Lintott says that the equipment will have a higher throughput than any system currently available—typically 400 2-in. wafers or 200 3-in. wafers per hour. In addition, doping uniformity from wafer to wafer is better than 1%.

To conform to United States safety regulations, the target chamber is held at ground potential. The implantation accelerating potential is 160 kV. The control system uses optical-fiber links and servomechanisms for maximum isolation.

Present equipment operates automatically except for specimen handling, and work is in progress to automate that.

**New fail-safe method used in controller**

A self-checking controller configuration for high-reliability systems uses a new approach—the dual fail-safe technique—that combines two fail-safe controllers. The dual system, according to Cambridge Consultants in Cambridge, England—the developers—is fully fault tolerant. (Conventional techniques such as triple modular redundancy were rejected as too expensive and inefficient.)

In each fail-safe controller every element is self-checking. The controllers react to an input signal by matching it with signal-verification data in a special memory.

A new memory architecture was devised to perform this verification function. The controller was developed as part of a study commissioned by the European Space Agency.
Sound advice for the alarm industry.

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84 CIRCLE NUMBER 40

**Electronic Design** 16, August 2, 1976
Inductosyn/digital converter modules offer top resolution

Analog Devices, Rte. 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. See text; stock (only available in U.S. and Canada).

Combining what is claimed to be the highest resolution and smallest size, the IDC1701 and IDC1703, Inductosyn-to-digital converter modules also offer the lowest cost—only $550 in singles. The modules, made by Analog Devices, offer 12-bit resolution and a package size of 2.625 × 3.125 × 0.4 in. (29.3 × 66.6 × 10.2 mm).

The Inductosyn, originally developed and patented by Farand (Valhalla, NY) is a linear distance transducer that uses air coupling between flat coil windings. The 1701 converter delivers a 12-bit parallel output and an up/down serial output. The 1703 only offers an up/down serial output that is scaled to 4000 pulses per period instead of 4096.

Both units have a tracking rate of 150 revolutions/s, which corresponds to a slew rate of 33.3 cm/s for an Inductosyn pitch of 2 mm. Any carrier frequency between 2 and 10 kHz can be used to excite the Inductosyn transducer. Accuracy of the converters is ±9 arc minutes.

Only 400 mW at 5 V dc is required to power the converters over an operating range of 0 to 70°C. Two external differential amplifiers and a current amplifier are needed to complete the type II servo loop needed for operation.

Aside from complete Inductosyn systems such as offered by Farand for several thousand dollars, ILC Data Devices Corp. (Bohemia, NY) also produces Inductosyn-to-digital converter modules, the IDC101, and 102. The 101 produces 4000 pulses per cycle in a BCD output format while the 102 delivers 4096 pulses is a straight binary format. Both models cost $495. The price, though, includes a second module with the necessary buffer amplifiers and isolation transformers.

The Analog Devices’ modules and the DDC units use two different methods to arrive at equivalent digital outputs. The 1701 and 1703 from Analog Devices require a current generator op amp on the primary side of the Inductosyn and two differential amplifiers on the secondaries.

The 101 and 102, from DDC, on the other hand have two current drivers built into the main module that send signals into the Inductosyn secondaries and use a single amplifier on the primary side to pick up the difference signals. Both companies claim their method works best, so make your choice carefully.

Photodetector/amplifier boasts 50-MHz BW


Model DA-60 is a silicon photodetector/amplifier that has a bandwidth in excess of 50 MHz. Its responsivity is 3 mV/μW at a wavelength of 900 nm. The DA-60 is housed in a metal enclosure that will fit standard 1.25 in. diameter optical eyepiece mounts. In addition, detector centering adjustment screws, input power filters and a coaxial output connector are provided.

Telephone-tone filters offer many options

Beckman, 2500 Harbor Blvd., Fullerton, CA 92634. (949) 871-4848. 100-up prices: from $8.20 to $240.60; stock to 8 wks.

The series 883 hybrid tone-receiver circuits are available as individual modules or assembled on a completely pretested, ready-to-use card. Included are a dial-tone reject filter (883-1), a low-band filter (883-2), a high-band filter (883-3), a dual limiter (883-4), eight bandpass filters (883-6 to 16), and a quad tone detector (883-5). Two additional products, Models 883-107 and 883-108, are available as a set of series 883 hybrids together on PC boards with other required components forming a complete tone-decoder subsystem. The hybrids meet Bell System requirements for application in its central office equipment manufactured by Western Electric. They also satisfy the requirements of other major and independent manufacturers of telephone equipment in supporting their respective operating companies (e.g., GTE Automatic Electric).
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MODULES & SUBASSEMBLIES

Hybrid d/a converter takes 12-bits at 3 MHz

ILC Data Device Corp., Airport International Plaza, Boeheim, N.Y. 11716. (516) 567-5600. From $75 (1 to 9) stock.

The DAC-S, a 12-bit d/a converter can be clocked at throughput rates of 3 MHz. It is available in hermetically-sealed, 24-pin double DIPs. The unit is complete with its own temperature-compensated internal reference and output amplifier. The hybrid converted has programmable voltage outputs of ±2.5, ±5, ±10, 0 to +5 or 0 to +10 V. Its gain temperature coefficient is ±20 ppm/°C (max.) and the offset drift is ±10 ppm of full-scale reading/°C. In the current-output mode, settling time is 300 ns, while voltage output units settle to within 0.1% in 5 µs (for a full-scale change). Digital inputs are TTL/TL compatible and are standard TTL one-unit load. For unipolar configurations, the coding is complementary straight binary or BCD; for bipolar it is complementary offset binary. Operating temperature ranges of 0 to 75 and -25 to +85 C are available.

Display assemblies have 0.6-in.-high characters

Instrument Displays, Div. of Kelton, 225 Crescent St., Waltham, MA 02154. (617) 894-1577. See text; stock.

From two to eight decades of numeric displays are available in the SD series of display assemblies. The LED numeric characters are 0.6 in. high and center-to-center mounting distances are only 0.6 in. A four-decade display typically can mount in a panel cutout of 3.25 × 2.1 in., and has a depth of 3.2 in. Typical cost of a SD series four-digit display would be $68 in quantities of 25 assemblies. There are four versions available: the SD, which has the decoder-driver and display; the SDM, which also includes a latch; the SDC, which has a unidirectional 15 MHz counter and display decoder-driver; and the SDCM, which has the counter, latchs and decoder-driver.

CIRCLE NO. 345
INSTRUMENTATION

Linear IC tester uses program boards

Biomation/Sitek, 10411 Bubb Rd., Cupertino, CA 95014. (408) 255-9500. $8650; 8 wks.

Model 1440 linear circuit tester uses dedicated program boards to perform large-signal dc tests on a wide range of circuits—both standard and special device types. The company offers a catalog of over 300 standard device numbers for which programs are available. Single, dual, triple and quad devices can be tested on the 1440 under the worst-case limits and conditions specified by the manufacturer. A multipass sequence option permits testing of all sections of multiple devices automatically.

CIRCLE NO. 349

Audio generator offers low distortion

Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. $295.

A new low-frequency generator, the PM5107, features a typical distortion figure of 0.02%. The unit provides sine/square wave and TTL outputs in a compact package. Output frequency from 10 Hz to 100 kHz is set by a large fully variable control and range-multiplier pushbuttons to an accuracy better than 4%. Signal amplitudes to a maximum of 2 V for sine waves and 4 V for square waves are set by variable control and a fixed 20-dB attenuator can be pushbutton inserted to simulate output signals.

CIRCLE NO. 350

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The Capitol Machine and Switch Co., 87 Newtown Road, Danbury, Conn. 06810
Phone: 203-744-3300

CIRCLE NUMBER 44

Electronic Design 16, August 2, 1976
Systems DMM takes 30 readings/s

California Instruments, 5150 Convoy St., San Diego, CA 92111. (714) 279-8620. $995; stock to 30 days.

DSM 44 4-1/2-digit systems multimeter offers noise rejection of 60 dB at dc reading rates of up to 30 per second. Also provided are five ranges of dc V and three-wire dc/dc ratios as standard. Optional are: Ac V (true rms or average reading), true four-wire resistance, bipolar four-wire dc/dc ratio, ac/ac ratio (true rms or average reading), ac/dc ratio and dc/ac ratio. System features include priority remote, data storage, self-programmed delays, gate line, false-program indication and more.

CIRCLE NO. 351

LRC meter uses $\mu$P to take on new look

Electro Scientific Industries, 13900 NW Science Park Dr., Portland, OR 97229. (503) 646-4141. Under $5000: 60-90 days.

Model 296 $\mu$P-controlled LRC meter measures R, L, C, G, and calculates D and Q. Programmable limits option allows up to 10 comparison values to be set for multi-band sorting. Deviations can be displayed in percentage or in units. The addition of the IEEE 488-1975 interface option modifies the unit for automatic component testing applications. Standard features include autoranging, dual frequency (1 kHz and 120 Hz), two selectable test voltage/current levels and two 4-1/2-digit readouts. Measurement speed is 70 to 300 ms.

CIRCLE NO. 352

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A total of 15 Series 206 DIP switch packages are now available from CTS...7 with SPST actuation, 4 with SPDT actuation and 4 with DPST actuation. All have .100" by .300" centers for PCB or standard DIP socket insertion.

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Here’s a new permanent magnet stepper motor line created to meet the design needs of analytical instrumentation and computer peripherals. Applications include tape drives, printer and chart drives and optical disc drives. Both 5 volt and 12 volt models are available.

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Cheshire, Conn. 06410 • (203) 272-0301
CIRCLE NUMBER 46

INSTRUMENTATION

Benchtop tester handles mixed components

GenRad, 300 Baker Ave., Concord, MA 01742. (617) 369-4400. Starts at $14,500.

The GR 2230 is a fully automated, user programmable, benchtop system for high-volume testing of multileaded devices. Using a powerful microcomputer, the DEC LSI-11, the 2230 evaluates, tests, and provides hard copy data for both discrete and hybrid networks. The unit performs mixed measurements on circuits containing resistors, capacitors, inductors, and diodes or transistors. Each component is measured against (individually) specified limits.

CIRCLE NO. 353

Skinny panel meters include DVMs, clocks


Clocks from $76, dc voltmeters from $87, transducer readouts from $90: These are quantity-10 prices for the new Slimline indicator-only series. These instruments measure only 4-1/2 × 3-1/2 × 5/16 in. Displays are red-orange, seven-segment LEDs, 0.55-in. standard, 0.75-in. optional. Clocks are available in 4-digit (HR:MIN) or 6-digit (HR:MIN:SEC) models. The DVMs are 3-1/2 digits (1999 counts) with autopolarity and auto-zero. Four models cover from 199.9 mV to 199.9 V with an accuracy of ±0.05% of reading ±1 count.

CIRCLE NO. 354

ELECTRONIC DESIGN 16, August 2, 1976
Synthesizer goes to 80 MHz in 1-Hz steps


A new programmable frequency synthesizer, the PRD 7838, covers 1 kHz to 80 MHz in 1-Hz steps with an output level of 10 mV to 1 V rms into 50 Ω. Stability when locked to the internal frequency standard is 1 part in $10^6$ per month, with an optional standard of 5 parts in $10^9$ per day. Typical spurious outputs are 70-dB non-harmonic and 40-dB harmonic.

CIRCLE NO. 355

Events delay module spans digital & analog

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $925; 10 wks.

With the 7D10 events-delay plug-in, you can verify or identify pulse or word timing in digital systems. The unit operates in both the digital and analog domain. In the digital domain, it identifies transient locations or incorrect logic-state locations. With the company’s 7D10 logic analyzer, you can expand the effective memory or delay the memory by a specific number of digital words. In this delay-by-events mode, the 7D10 counts arbitrary trigger events and delivers an output after the preselected count has been reached.

CIRCLE NO. 356

Measure SWR/return loss with 35 dB directivity from 2 to 18 GHz

Over the entire 2 to 18 GHz range, this one new WILTRON 87A50 SWR bridge gives you 35 dB directivity for SWR/return loss measurements. That’s much better than couplers — by about 10 dB. WILTRON SWR bridges are the way to go. Not only for high directivity but also for coverage all the way down to 50 kHz if you wish.

(If you want the ultimate in swept measurement accuracy, check into our swept precision reflectometer using our Model 58A50 4-port bridge. It also covers 2 to 18 GHz.)

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In Canada: WILTRON Instruments, Ltd.
Short 10-turn pots need less space

TRW Inc., 2801 72nd St. N., St. Petersburg, FL 33733. (813) 347-2181. $4.65 (100 up); stock.

Type 6800 series of 7/8-in. diameter, 10-turn potentiometers, which features a shorter design than earlier units, projects only 11/16-in. behind the mounting panel. The units mount in standard 0.406-in. diameter holes and include integral locating keys that can be cut off if not needed. Construction features include brazed terminations, permanently sealed end lids and a flame-retardant case. Ten standard resistance values from 100 Ω to 100 kΩ have corresponding nominal resolutions from 0.031 to 0.007%. Resistance tolerance is ±5%, and independent linearity is ±0.25%. A 1% tolerance and 0.1% linearity are available on request. The units have a power rating of 2 W at 40 C and an operating temperature range of −55 to 105 C.

CIRCLE NO. 357

Metal-film resistors meet MIL qualifications

Dale Electronics Inc., Dept 860, Box 609, Columbus, NE 68601. (402) 371-0080.

New metal-film resistors, ERL07, are qualified as RLR07 types in accordance with MIL-R-39017. The new 1/4-W resistors provide an extended resistance range of 10 Ω to 1 MΩ (100 ppm/°C) and tolerances of 1% and 2%. In contrast with competitive models, the ERL07 uses a welded-cap-and-lead assembly that is press-fitted onto each end of the resistor core. This provides both strength and heat resistance and eliminates potential disconnects which can occur on other types of construction, if production soldering is done close to the body, according to Dale.

CIRCLE NO. 358

Cermet trimmer features dust cover

Allen-Bradley Co., 1201 South Second St., Milwaukee, WI 53204. (414) 671-2000. $0.42 (1000 up); distributor stock.

Allen-Bradley's new Type D cermet trimmer is dust-covered, for use in applications where immersion-sealed types (such as Type E) are not required. It is approximately 3/8 in. in diameter, is rated at 0.5 W at 70 C and has a temperature range of −55 to 125 C. Resistance range is 10 Ω to 2 MΩ. Temperature coefficient is ±100 ppm/°C. A multifingered wiper provides greater adjustability and low contact-resistance variations. In six configurations, they provide three terminal spacings for top adjust and three for side adjust. Terminals are 0.025-in. dia.

CIRCLE NO. 359
Chip capacitors designed for hf ICs


Series 5082-0900 MIS chip capacitors are intended for use in microwave ICs. Specific functions include shunt rf bypassing and series dc blocking. They can also be applied as series or shunt elements in filters. Eleven standard units are offered in the 0.5-to-45-pF range. Capacitance tolerance is ±15%. Tolerances to ±5% and values in the 45-to-100-pF range are available on special order. Minimum breakdown voltage for units from 0.5 to 2.0 pF is 250 V. A breakdown voltage of 150 V is specified for units from 5.0 to 15 pF, and breakdown voltage for units from 20 to 45 pF is 100 V.

CIRCLE NO. 360

Plasma display provides 6 rows of 40 characters

Burroughs Corp., P. O. Box 1226, Plainfield, N.J. 07061. (201) 757-5000. $170 (1000 up); First quarter 1977.

A flat-panel, 240-character, gas-plasma display, designed primarily for data terminals, provides six rows of 40 characters each. This addition to the SELF-SCAN II product line is compatible with presently available and proposed microprocessor terminal designs. The assembly measures 11 × 4 in. and is less than 1-1/4-in. thick including drive electronics, needing significantly less space and weighing less than CRT displays. Its 5 × 7 dot-matrix characters are 0.26-in. high by 0.14-in. wide. They are readable up to 18-ft away at horizontal viewing angles up to 120 degrees. The characters are uniform in size, brightness and contrast, with no fuzziness or distortion at the panel edges. Characters are jitter-and-flicker free; the neon-orange color minimizes eye fatigue. The panel can display ASCII, Cyrillic, Hebrew, and Kata kana, as well as special symbols and characters. Power requirements are +5 V at 900 mA, –12 V at 200 mA and –250 V at 70 mA.

CIRCLE NO. 361

MEET OUR FAMILY OF GRABBERS

Our Grabber family is five years old now, and we’re adding new members to keep pace with the complexities of state-of-the-art electronic packaging. Grabber is our name for a series of test clips designed to simplify testing of electronic packages from conventional components to maximum density DIP’s. They’re rugged, dependable, versatile, and very easy to use. Write for our catalog and get the complete story on the whole family of Grabbers. Find out why they are your best solution to your electronic testing problems.

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Booth 722 Wescon

ITT POMONA ELECTRONICS
1500 East Ninth St., Pomona, Calif. 91766
Telephone (714) 623-3463, TWX: 910-581-3822
CIRCLE NUMBER 50
INTEGRATED CIRCUITS

Bipolar Schottky ROM comes with 10-k storage

Intersil, 10900 N. Tantau Ave.,
Cupertino, CA 95014. (408) 996-5000. From $36 (100-up); stock.
The IM 53SX family of Schottky bipolar ROMs is available with
organizations of 1024 words by 8, 9 or 10 bits. Access time is 55 ns,
typical, and maximum cycle times are under 100 ns. The ROMs are
housed in 24-pin DIPs and have on-chip address decoding and op­
tional on-chip storage latches. All chips have an OR-tie capability
with either open collector or three­
state outputs. Power dissipation is
65 $W$/bit and the input current in
the address lines is 250 $\mu$A,
maximum.

CIRCLE NO. 362

Power amp IC delivers
5 W into 4-$\Omega$ load

Siemens, 188 Wood Ave. S., Iselin,
NJ 08830. (201) 494-1000. Under
$2 (1000-up).

The TDA-1037 power amplifier delivers 5 W at a 14-V bias and
4-$\Omega$ load resistance. The operating
voltage range starts at 4 V and
the amplifier has an input sensi­
tivity of 150 mV at full load. The
9-pin single-in-line package simpli­
fies mounting in a limited space.
The thermal resistance between
the chip and the plastic case is 12
K/$W$.

CIRCLE NO. 363

The Accuracy Policy
of Electronic Design

Is:

- To make diligent efforts to
eNSure the accuracy of editorial
matter.
- To publish prompt corrections
whenever inaccuracies are
brought to our attention. Cor­
rections appear in “Across the
Desk.”
- To encourage our readers as
responsible members of our bus­
iness community to report to us
misleading or fraudulent adver­
tising.
- To refuse any advertisement
deemed to be misleading or
fraudulent.

This statement of accuracy has
appeared in every issue of
Electronic Design, from the very
first one. Staff members are imbued with it, from their very
first day.

Electronic Design
50 Essex Street
Rochelle Park, New Jersey 07662
(201) 843-0550
High-speed comparator settles in 2 ns

Plessey Semiconductors, 1674 McGaw Ave., Irvine, CA 92714. (714) 550-9945. $18 (100-up); stock.

The SP750B high-speed comparator has a maximum settling time of 2 ns and a propagation delay of just 3.5 ns. It can operate at rates of up to 10^6 samples per second. Input and output levels are ECL-compatible. In addition to the basic comparator function, the SP750B includes a latch function so that it can be used in the hold mode; integral gating for decoding comparator outputs in a multi-level comparator chain and wired-OR outputs to decode 4-bit lines.

CIRCLE NO. 364

2-k shift registers have 6-MHz data rates

Synertek, 3050 Coronado Dr., Santa Clara, CA 95051. (408) 241-4300. From $15 (100-up); stock.

The SY2825A/26/27 family of 3-channel dynamic shift registers can provide shift rates of up to 6 MHz. The 2048-bit units are available in three options: the SY2825A is a dual, 1024-bit register with internal recirculating logic; the SY2826 is a dual, 1024-bit nonrecirculating register with dual-selectable data inputs; and the SY2827 has a single 2048-bit organization with internal recirculating logic. Required supply current is only 40 mA at 3 MHz—claimed to be the lowest available. The clock capacitance is also low—only 110 pF.

CIRCLE NO. 366

Video game chip offers choice of six games

General Instrument, 600 W. John St., Hicksville, NY 11802. (516) 733-3107. $6 to $7 (100 qty.); stock.

The AY-3-8500 video game IC provides six switch-selectable games. The n-channel circuit is, in part, a dedicated microprocessor and can be set to play tennis, hockey, (soccer), squash, practis, rifle ( skeet) shooting and rifle shooting with a random target. Each ball-and-paddle game can be played with a fast or slow ball speed, high or low ball angles and large or small bats. Various options for the circuit include four-player connection, full color display when color receivers are used, random ball speed and angle and black and white bats to ease player identification. Two versions of the circuit are available: The AY-3-8500-1 is designed for use in 525-line, 60 half-frame/s systems and the AY-3-8500 works with 625-line, 50 half-frame/s systems. Both circuits have automatic scoring and can display the scores (numbers up to 15) on the TV screen. A sound generator circuit on the chip creates realistic sound effects, depending upon the game selected. The game chips are housed in 28-pin DIPs and have an operating temperature range of 0 to 50 C. A 6 to 7 V supply that delivers 32 mA is required for the circuit.

CIRCLE NO. 365

Electronic Design 16, August 2, 1976

Is there a recorder just for spectrum analyzers?

The new 19" rack-mounting SPECTRUM ANALYSIS RECORDER from Raytheon. It's the first dry paper line scanning recorder specifically developed for direct plug-in operation with commercially available spectrum analyzers.

Any new or existing spectrum analyzer equipped with the SAR-097 will have a lot more going for it. Like infinitely variable 100:1 speed range—5 sec/scan to 50 millisecond/scan... stylus position encoder... automatic recorder synchronization... computer/ analyzer compatibility... high resolution and dynamic range... all-electronic drive. And more.

If you design and build — or buy and use — spectrum analyzers, you don't have to settle for multi-purpose recorders any more. The SAR-097 is here. For full details write the Marketing Manager, Raytheon Company, Ocean Systems Center, Portsmouth, Rhode Island, 02871, U.S.A. (401) 847-8000.

CIRCLE NUMBER 52
Meet the First Opto-coupled Linear IC Amplifiers

Starting at $26.50* each, and less than one cubic inch in volume, our 3650 and 3652 Isolation Amplifiers represent a major breakthrough in linear circuits. Opto-Isolators have already made a name for themselves in digital designs but until now they weren't suitable for linear circuits. Trouble was, they were inherently non-linear. And the light source tended to degrade with age, which degraded gain accuracy. Temperature drifts, too, were a problem. But we felt that opto-coupling held too much promise in linear applications to be discarded. Now those problems are solved. Look at the price and size reductions. Look at the splendid isolation they provide (1500V peak, continuous; 4000V peak for 10 seconds) without the cross-talk or EMI problems inherent in transformer isolators. And leakage is less than 0.5 microamp at 240VAC! Our 3650 transconductance amplifier (current-in, voltage-out) and buffered-input 3652 (voltage-in, voltage-out) let you use isolation where you never could before. We know you will want more information on the new Burr-Brown Model 3650/3652 amplifiers and on our complete line of instrumentation amplifiers. Contact Burr-Brown, International Airport Industrial Park, Tucson, Arizona 85734. Telephone (602) 294-1431.

Burr-Brown

A revolution in price and size.

CIRCLE NUMBER 54

DISCRETE SEMICONDUCTORS

JEDEC Schottky diodes switch supplies

International Rectifier, Semiconductor Division, 233 Kansas St., El Segundo, CA 90245. (213) 678-6281, $8.60 to $9.75 (1-100); stock.

A series of JEDEC registered Schottky diodes rated for 40 V operates at a junction temperature of 125 C. The units in DO-5 cases feature a nonrepetitive rating of 50 A. Units in the line designated 1N6097 are rated for 30-V and 1N6098 for 40-V operation. Chief application is in high-frequency switching power supplies operating at frequencies of 20 to 30 kHz.

CIRCLE NO. 367

LED alphanumeric display claimed lowest priced

Litromix, 1900 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. $4 (1000 up); stock.

A LED-alphanumeric display provides the lowest price per character obtainable anywhere, according to Litromix. The DL-416 display has four 0.16-in.-high characters preassembled for multiplex operation on a PC board with pins on 0.075-in. centers. Boards may be stacked end to end to create a display with any number of characters, all evenly spaced on 0.260-in. centers. The high-contrast characters are readable in daylight at distances up to 5 ft, within a 20-degree half angle. Characters are formed with a 16-segment starburst pattern. Luminous intensity is 0.5 mcd/digit at 5 mA/segment.

CIRCLE NO. 368

CHRS

an ARMCO company
HV rectifier meets magnetron power needs

Semtech Corp., 652 Mitchell Rd., Newbury Park, CA 91320. (805) 498-2111. $2.50 (1000 up); stock.

A new high-voltage rectifier, called KV-Stud, is specifically designed for microwave ovens. The rectifier's parameters meet the special characteristics of a magnetron power supply. This multi-junction silicon rectifier is encased in an aluminum hex rod to provide good heat dissipation, when properly mounted.

CIRCLE NO. 369

Avalanche photodiodes serve laser systems

RCA, Solid State Div., Box 3200, Somerville, N.J. 08876. (201) 685-6423. $159 to $475 (1-9) 60 days.

Four new silicon avalanche photodiodes are designed for a wide variety of applications including laser detection and ranging, optical communications and high-speed switching. Three of the devices, the C30817, C30884 and C30895, are supplied in low-profile TO-5 packages and have useful photosensitive areas of about 0.5 mm². The other—the C30872—is a large-area photodiode; its useful photosensitive area is about 7 mm². This diode is supplied in a low-profile TO-8 package. The C30817 and C30872 have a useful spectral range extending from about 400 to 1100 nm and rise and fall times of typically 2 ns. The C30884 has very high modulation capability, up to 400 MHz, and typical rise and fall times of 1 ns. Its spectral range is from 400 to 1100 nm. The C30895 is optimized for high responsivity and low noise at 1060 nm. Its spectral range extends from about 700 to 1100 nm. Rise and fall times are typically 2 ns. This device is also designed for use in adverse environments.

CIRCLE NO. 370

LED indicator contains red and green dies

IEE, 7740 Lomona Ave., Van Nuys, CA 91405. (213) 787-0311. $159 (1000 up); stock.

Low cost red/green solid-state indicators, Model 232RG, in T-1-3/4 size use anode switching for single lamp go/no-go or on/off indications. A white, diffused-resin lens, three-lead capsule contains both red and green LED dies of GaP light-emitting material for high brightness. If desired, both red and green dies can be energized simultaneously providing a trichromatic capability with the red and green combining to emit yellow. The viewing angle is 80-degrees with a 1.5-mcd typical luminous intensity at 10 mA (red) and 20 mA (green) forward current.

CIRCLE NO. 371

New from Standard Grigsby

P/rel

the programmable rotary encoded logic switch everyone will be talking about...

... because no other rotary switch has as much versatility with as low a cost as Standard Grigsby's P/rel switch!

The economy is twofold. This switch not only lends itself to full automation, but installed costs are lower by the use of our printed circuit terminals (solder terminals are also available).

A specially processed printed circuit disc is fully programmable to the truth table of any code. We provide 100% program disc inspection to customer specifications. Up to 60 detent positions are available with our new double ball Dual Flex detent. And, the use of concentric shafts allows up to 120 detent positions from a single switch! Everyone will be talking about P/rel... so will you!

Send for your free “Yes” button and literature.

CIRCLE NO. 370

standard grigsby, inc.

920 Rathbone Avenue, Aurora, Illinois 60507, Phone (312) 897-8417

CIRCLE NUMBER 56
DATA PROCESSING

Core-memory card plugs into Interdata 7/32
Pushpa Int'l Corp., 41142 Ipswich St., Westminster, CA 92683. (714) 898-5611. $3200 (8 up).

The model 65-KB core memory card fits into the Interdata 7/32 main chassis. Eight such cards allow packaging 1/2 Mbytes of memory into the Interdata computer. Each card presents one TTL load per input line. The 65-KB memory cards feature good thermal design with lower power consumption than comparable 32-kilobyte cards. Access period is 240 ns and cycle period is 650 ns. The manufacturer offers a lifetime warranty on parts and 2 years warranty on labor.

CIRCLE NO. 372

5½ DIGIT ACCURACY.
4½ DIGIT PRICE.

The 4600 is our brand new 4½ digit multimeter. It gives you the accuracy and resolution of typical 5½ digit multimeters. At half the cost.

And the 4600 stays accurate longer than other DVM's. DC accuracy stays within 0.01% ± one digit for six months at a time. We guarantee it.

80dB normal mode noise rejection produces a 10,000:1 reduction of excess noise. A full decade better than the 1,000:1 reduction of comparable instruments.

Loading errors are virtually eliminated by the 4600's 10,000:1 input impedance on the two lowest DC voltage ranges.

There's a lot more. Send for a free catalog on our new 4½ digit 4600 multimeter. And find out how to get 5½ digit accuracy without paying for it.

Dana Laboratones, Inc., 2401 Campus Drive, Irvine, California 92715. 714/833-1234.

Others measure by us.

CIRCLE NO. 373

Unit adapts async to synchronous transmitter


Dubbed EASI-1A, for Elastic Asynchronous to Synchronous Interface, this device connects an asynchronous to a synchronous transmitting terminal where no absolute speed control is exercised between the two. The EASI contains an override feature that makes it capable of supporting a synchronous modem in a polled, switched or dedicated system environment. The input and output-data format are identical and consist of a start bit, eight data bits and one or more stop bits. The device functions by converting the input serial-data stream to parallel words and storing them in a memory. The output section of the EASI accesses the memory and shifts the words out serially under control of the modem clock signal. Should the input signal rate be faster than the output signal rate, the output section will fall behind the input and the memory will begin to fill. If the input rate is higher than the output rate by 0.02%, the maximum allowable, 20-k characters will be transmitted before the memory overflows. Should the speed difference be in the opposite direction, the EASI makes up the difference by inserting extra stop bits in the output stream when necessary. The input and output rates may be 2400, 4800, 9600 baud.

CIRCLE NO. 374

RS-232 modem works over short distances

Bo-sherrell Co., 36443 Shelley Court, Newark, CA 94560. (415) 792-0554. $149 (unit qty). 4 wks.

The M-1 is a modem intended for use over short distances. The unit has full-duplex capability. The M-1 transmits according to EIA RS-232 and CCITT V24 specs. The unit can be used as a local communication link between computers, displays, printers, etc. Line driving is performed by a two-way, balanced current loop. Transmission speed goes up to 9600 baud. Dimensions of the M-1 are 3.2 × 6 × 2 in.

FOR PRODUCT DEMONSTRATION
CIRCLE # 80

FOR LITERATURE ONLY
CIRCLE # 81

Electronic Design 16, August 2, 1976
Small-sized computer meets military specs

Rolm Corp., 18922 Forge Dr., Cupertino, CA 95014. (408) 257-6140. $23,000 (20).

The Rolm Model 1650 computer provides the computing capability of the Model 1602 computer, but in a smaller package. The unit meets military specifications MIL-E-5400 and MIL-E-16400. It is a microprogrammed, general-purpose, 16-bit processor compatible with Data General's Nova series. The 1650 is packaged in a short 1/2-ATR chassis, measuring 7.62 x 4.9 x 12.56 in. It contains the CPU module, two 16-k core memory modules and a +28-V-dc power supply. You may choose conductive cooling, external forced-air or a Rolm-supplied forced-air unit. Some options available include floating-point firmware and ac power supply. A line of peripherals is also offered.

CIRCLE NO. 375

Graphics are digitized for under $15,000


A digitizer that converts free form graphics sells for under $15,000. The model GDC digitizer is designed to convert maps, drawings, photographs and other graphic material into digital form suitable for processing by a data-processing system. The unit consists of a 36 x 48 in. digitizing table, control electronics, and a pedestal-mounted X and Y axes readout display. The digitizing table features variable-intensity backlighting. It has a resolution and repeatability of ±0.001 in. and a point-to-point accuracy of ±0.004 in. A display provides a six-digit readout of cursor position on each axis, including sign and decimal point.

CIRCLE NO. 376

16-bit minicomputer has LSI bit-slice chips

Monolithic Memories, 1165 E. Arques Av, Sunnyvale, CA 94086. (408) 739-3535. See text, Stock.

The μ-Mini 3 computer is built around bipolar LSI bit-slice chips. The 16-bit minicomputer features software and I/O compatibility with Data General's Nova. The μ-Mini 3 is microprogrammed, with microred high-useage special functional, to achieve an operating speed that is faster than a standand minicomputer. These execute more efficiently than comparable software implementations. A 32-K word computer system fits on 15 x 15 in. PC boards. The μ-Mini 3 will be offered as individual PC cards, or complete with a chassis, power supply and front panel. The price of the basic system with case, front panel and 8-K of memory is $2500 (qty 50).

CIRCLE NO. 377

LOW NOISE MODULAR DESIGN Switching Power Supplies!

A new line of compact, modular-switching units. That simplify design for 300-600 watt applications and sell for less than $90 per watt! End users benefit from low EMI noise levels and highly reliable operation plus easy add-on and maintenance features. Get everything you need to know to evaluate this high quality, money-saving line from: Magnetic Components Group

CIRCLE NUMBER 58

Electronic Design 16, August 2, 1976

ONE-CHIP SYSTEM LOGIC #1.
NEW AM/FM FREQUENCY SYNTHESIZER.
ONE-CHIP ELECTRONIC TUNING.

Now a single LSI chip that performs all digital control functions for generating AM/FM/G3 radio fregs. Uses PLL techniques. Up to 2000 AM/FM channels possible. Simply order from stock. #8X08.

Send book titled One-Chip System Logic. Clip coupon to letterhead.

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THINK SIGNETICS

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CIRCLE NUMBER 59

99
Compact high-voltage supply stands tall in performance

The 100-series high-voltage CRT supply, from PTK Corp., seems to support the old adage that nice things come in small packages. Out of the 100’s volume of 18 cubic inches comes an impressive 10 W of power. Blow 10 cfm of air across the supply, and you can double that.

There are smaller high-voltage units, of course. But you’ll be hard pressed to find one close to the PTK supply’s price neighborhood. The top-of-the-line 100 sells for $148; to get equal performance in a compact frame, you might have to spend five times more.

For instance, the petite MG-12 marketed by Venus Scientific, takes up a mere 6.4 cubic inches and delivers about the same power as the PTK unit. For the two-thirds reduction in size, you pay $690, a $542 differential. Another unit, the Lectrologic H series, is packed into 19 cubic inches and costs even more—$750.

All three competitors deliver a maximum current of 500 $\mu$A at voltages ranging from 1 to 20 kV, depending on the model. Inputs for each are 28 V, nominal. Other specs—like regulation, ripple and those that spell out transient performance—aren’t equal in the three.

The 100’s performance line-up includes a load and line regulation of 0.05% (10 V), full-load ripple of 0.05%, tempco of 150 ppm/°C max and a maximum transient of 5 V/100 $\mu$A pk-pk. Operating temperature ranges from 10 to 60 C.

A number of circuits protect the PTK 100 (which comes in three versions) from shorts, arcs, over-temperature and reversed input voltage. All models are housed in a 6061 T6 aluminum case, 4.13 $\times$ 3.16 $\times$ 1.37 in., with 1/2-in. stainless steel studs for mounting.

PTK Corp.  
Venus Scientific  
Lectrologic

CIRCLE NO. 337  
CIRCLE NO. 338  
CIRCLE NO. 339
Switchers claim high MTBF at 80 C


Series "B" 5-V, 10-A switching module (Model B5R00S10) comes complete with 5-year warranty, and features a 70,000-h MTBF at 80-C baseplate. Other specs are: 75% minimum efficiency, size of 4-7/8 × 1-3/4 in., weight of 2 lbs, remote sensing, and complete overload/short circuit and overvoltage protection, all with automatic recovery. The units provide ±10-mV max. line regulation, 10-mV max. load regulation and 250-μs transient response.

CIRCLE NO. 378

Ac source packs 2500 VA into one case

California Instruments, 5150 Convoy St., San Diego, CA 92111. (714) 279-8620. $3995 w/o oscillator; 30 days.

Said to be the first time this much power—2500 VA—has been incorporated into a single unit using a linear amplifier, Model 2501T delivers 110 to 120 V rms (±0.7 mV) of single-phase power from a three-phase input. Among its features is a selectable output of 0 to 30, 0 to 60, 0 to 120 or 0 to 240 V. Selection is by means of a rear-panel plug-in card.

CIRCLE NO. 379

Lab supply costs just $76

Power/Mate, 514 S. River St., Hackensack, NJ 07601. (201) 343-6294. $76; stock.

For those who need a bench-type laboratory supply at a low price, the BP-76 is a constant-voltage/constant-current unit that delivers full rated output voltage (10 V) at the maximum rated output current of 2 A. Key specs include: input of 105 to 125 V, 47-63 Hz, single phase; line and load regulation is less than 0.1% ±4 mV; ripple is less than 1 mV rms; transient response is 50 ms from full to half load; tempco is better than 0.01%/°C.

CIRCLE NO. 380

NOW!

PM and SHUNT-WOUND adjustable speed drive systems

CDC-PM describes PM systems, 1/12-1/4 Hp, 12 pages, 32 drawings, photos and tables.

CDC-SH describes shunt-wound systems, 1/50-1/4 Hp, 16 pages, 51 photos, drawings and tables.

... from Bodine and Bodine Distributors

Designed and built by Bodine to give you perfectly matched speed/torque control characteristics—provide reliability and performance you might expect only from far more costly and complex systems.

Send for catalogs today.

Bodine Electric Company, 2528 W. Bradley Place, Chicago, IL 60618

CIRCLE NUMBER 62

Electronic Design 16, August 2, 1976
Anodized heat sink clips onto transistor

Thermalloy, Inc., Dept. M., 2021 W. Valley View Lane, Dallas, TX 75234. $0.06 (1000 up). The 6046 Slip-Clip heat sink cools transistors that have TO-202, Motorola Case 152 or 306-02 device packages. The heat sink clips on like a clothespin, and a specially designed locking tab provides positive retention. The 6046 can be installed after board assembly has been completed. No adhesives, mounting hardware or PC board drilling are necessary. The 6046 is available in black preanodized material. Typical thermal resistance is 25°C/W with natural convection cooling at 3 W heat dissipation. It weighs 1.45 gm.

CIRCLE NO. 381

You know our Capacitors, but have you seen our...

EMI FILTERS

We’ve designed and produced thousands of EMI filters for military, space and commercial applications. These include intermittent and continuous duty units rated to 500 amps, 5000 VDC and 600 VAC, and DC to 25 KHz. Single and multicity circuit configurations (L, Pi and T) are offered as low pass, electrical noise, line, screen room and heavy duty filters. Send us your circuit requirements – our extensive file of existing designs can probably provide the benefits of standardization to meet your non-standard needs. Get complete information today on our EMI Filters; write Electrocube, 1710 So. Del Mar Ave., San Gabriel, CA 91776; (213) 573-3300.

Breadboard kit usable at high frequencies

Christiansen Radio, Inc., 1950 San Remo, Laguna Beach, CA 92651. (714) 497-1506. $60.00.

A breadboard kit with low-profile partitions accommodates rf circuits with high component density. The rf kit comes with component-mounting and partition hardware for circuits working into the GHz frequency range. Virtually all types of low-power packages may be mounted on a solid ground plane with no drilling. When used with an optional edge connector board and cover board, testing can be done directly in a card file. The kit comes complete with 100 component mounting pads, a storage box, a 10 x 20 cm solid ground plane, and a 1-m length of 18-mm high partitions.

CIRCLE NO. 382

Machine trims and forms axial lead parts

Fancort Industries Inc., 111 Clinton Rd., Fairfield, NJ 07006. (201) 575-0610. $1395; stock, 6 wks.

The Model AX-1, the Axiform, automatically cuts and bends components that have axial leads. The components may be packed in cards, loose or taped together on reels. The Axiform is capable of processing up to 15,000 taped parts per hour. Optional templates for component-to-component spacing and lead length preset the adjustable dies in the machine. The Axiform contains stainless steel, tungsten carbide cutting dies and nitrided steel or nylon forming dies. The machine will accept components with body diameters to 1 in., body lengths to 2.125 in. and lead diameters to 0.045 in. Leads may be bent at distances from the component body of 0.075 in. to 0.500 in.

CIRCLE NO. 383

Electrocube, 2021 W. Valley View Lane, Dallas, TX 75234. $0.06 (1000 up).
Service tool set contains 20 tools

The Model K-600 consists of 20 different tools and a zippered carrying case. The leather case has dimensions of 11 x 6 in. and weighs 2 lb. The kit assortment consists of a soldering iron, solder aid, three pliers, four screwdrivers, two tweezers, two nutdrivers and an assortment of other tools.

CIRCLE NO. 384

IC socket presents a low-profile

Molex, Inc., 2222 Wellington Court, Lisle, IL 60532. (312) 969-4550. 20c (low qty).
The LO PRO, Model 6197, is a low-profile, low-cost, integrated-circuit socket. This socket is available in 14 and 16-pin versions. The socket body has a locating/pick-up hole for automatic insertion equipment, beveled outside edges of the terminal channels, and a plastic barrier strip between each terminal. A small hole in the housing prevents solder-wicking and traps the terminals when soldered and is made of black polyester. The terminal pin, type 1938, features a wide-entry section for the IC lead.

CIRCLE NO. 385

Rugged system handles and ships PC boards

A box with adjustable inserts, called Plasticor, positions, stores and ships printed circuit boards. The box is coated to provide a barrier to grease, moisture and sulphur. The boxes are available in nine sizes with matching adjustable inserts, product identification cardholders, and opaque and transparent covers. Plasticor may also be custom manufactured in quantities of 500 or more without a molding charge.

CIRCLE NO. 386

We started a counter revolution

... in 1964, when we introduced the Hecon line... every kind of electro-mechanical, electronic and pneumatic/fluidic counter imaginable, from totalizing to predetermining to batching... every single one tested before it leaves our plant.
Find out for yourself. Contact us for free catalog today.

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Phone (416) 678-2441

CIRCLE NUMBER 64

CIRCLE NUMBER 65

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NEW CRC SYSTEM LOGIC #3

ONE-CHIP GENERATOR/CHECKER.
ONE-CHIP ERROR-CHECKING.

Eight polynomials in one chip Detects serial digital data errors including SDLC type, 1/L with on-chip TTL interface. Order #92X01.

CIRCLE NUMBER 66

ELECTRONIC Design 16, August 2, 1976
If you don't need it for forever, don't build it for forever.

Here's an application for our ACE solderless breadboards you may not have thought of:

Next time you only need a circuit for a little while, build it up on an ACE. There's an ACE the right size for almost any circuit you have to build. And ACE is a more reliable solderless breadboard, so your circuit can stay functional for as long as you need it together. Then, when your need for the circuit disappears, just disassemble it and use everything over again. It's all good as new.

And what's true for ACE is also true for our versatile A-P Super-Strip™, Terminal and Distri-

bution Strips.

So if you have a special application circuit that you won't need around forever—a test jig, a set-up-and-calibrate hookup, you name it—put ACE to work for you. The time you save may be your own. ACE. The All Circuit Evaluator from A-P Products.

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<th>Board Size</th>
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<td>923333</td>
<td>208-K (kit)</td>
<td>728</td>
<td>8 (16%)</td>
<td>2</td>
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<td>4-1/16x5-7/16</td>
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<td>872</td>
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<td>923301</td>
<td>212 (assem.)</td>
<td>1224</td>
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<td>923336</td>
<td>218 (assem.)</td>
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<td>18 (14%)</td>
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<td>10-1/4x9-1/4</td>
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Ohio and California Residents Add Sales Tax
All orders subject to acceptance at factory.

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PUSHBUTTONS All sizes, styles, colors, and legend styles including new photographic film legends with visible or hidden messages. Color matched for visual recognition and operator convenience.

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Other STACO Company products: Custom Transformers, STACO, INCORPORATED, Richmond, Indiana; Variable Transformers, STACO, INCORPORATED, Dayton, Ohio.

CIRCLE NUMBER 67

MICROWAVES & LASERS

Four-port circulator handles high power

Trak Microwave Corp., 4726 Eisenhower Blvd., Tampa, FL 33614. (813) 884-1411. $310 (10); 60-90 days.

Model 49A0031 microstrip four-port circulator can handle 200-W peak and 30-W average. Operating at 918 MHz ±20 MHz, the unit offers isolation of 20 dB minimum between all ports. Insertion loss is 0.3 dB maximum between ports 1 and 2; 0.6 dB maximum between ports 1 and 2. VSWR is 1.25 maximum. The circulators' impedance is 50 Ω nominal.

CIRCLE NO. 387

Measure frequencies automatically to 18 GHz

EIP, 3280 Scott Blvd., Santa Clara, CA 95051. (408) 244-7975. $7700: 60-90 days.

Model 451 provides fully automatic frequency measurement of pulsed signals. Measurements cover the frequency range of 0.3 to 18 GHz, and pulse widths may be as narrow as 100 ns with no requirement for external gating or manual tuning. Replacing previously used pulse-measurement techniques such as the cavity wavemeter and transfer oscillator, the Model 451 eliminates the need for auxiliary equipment and highly skilled operators. Pulsed-frequency measurement is accomplished by simply connecting the input and reading the frequency on a direct reading 7-digit LED display. No manual switching is required to distinguish between cw or pulsed inputs; the counter will automatically measure either type of signal. The FM tolerance of the 451 allows for measurement of cw microwave carriers with up to 40-MHz pk-pk deviation at 10-MHz modulation rates.

CIRCLE NO. 388

ELECTRONIC DESIGN 16, August 2, 1976
You can tune these mm-wave detectors

Hughes Aircraft Co. Electronic Dynamics Div., 3100 West Lomita Blvd., Torrance, CA 90509. (213) 534-2121. Start at $750; 60-90 days.

A new series of tunable millimeterwave detectors feature full waveguide bandwidth tuning capability in each of six bands between 26.5 and 110 GHz. The solid-state detectors, designated 4483XH, consist of Schottky-barrier diodes mounted in a Sharpless wafer and tunable reduced-height waveguide cavity mount. Minimum sensitivities are 200 mV/mW to 75 GHz and 100 mV/mW to 110 GHz. Instantaneous 3-dB bandwidths of 5 GHz are typical.

CIRCLE NO. 389

Microwave receiver programs by computer


Series 1770 programmable microwave receiver is for use in computer-controlled antenna measurement systems. The receiver covers the frequency range of 1 to 18 GHz in the automatic mode but can also be manually operated over the range of 1 to 90 GHz. An optional converter extends the frequency coverage down to 0.1 GHz. The 1770 has a 60-dB dynamic range and can be operated as a two-channel, separate mixer measurement system or as a three-channel system with two channels sharing a common mixer via an rf switch.

CIRCLE NO. 390

12-faced polygon offers adjustable mirrors

Scanco Inc., 145 Water St., S. Norwalk, CT 06854. (203) 846-2244. $675; stock.

The first member of a family of polygonal scanners is Model 1812, a unit with 12 precision faces that can be rotated at 1800 rpm. Each PolyScan consists of a metal hub with the required number of faces. Mounted on each face is a 1 x 0.55-in. high-reflectivity mirror, supported by a 1 x 1-in. adjustable metal plate. The angle of each mirror is individually adjustable. Mirror reflectivity is 85% min and mirror alignment is 30 arc seconds standard.

CIRCLE NO. 391

**MODEL SP-G11**

**SPEEDEX RECORDER**

Model SP-G11 is equipped with a built-in A/D converter in addition to common analog recorder functions. Since output terminals are also provided. It can be readily used in computation and for connection to a printer or paper tape punch.

*FEATURES*

1. Digital output terminal (10-bit binary or 3-digit BCD)
2. External clock terminal permits chart drive by external clock

*SPECIFICATIONS*

1. Chart width: 250 mm
2. Pen speed: 0.8 sec full scale
3. Measurement voltage: 0.5, 1.5, 10, 50, 100, 500 mV, 1.5, 10, 50, 100, 300, 600 mV/μA
4. Chart speed: 10, 20, 50, 100, 300, 600 mm/min
5. Digital output (A or B): A: 10-bit binary full scale at 1000 digits, 1 digit/0.1 sec; B: 3-digit BCD 10^0, 10^1, 10^2 full scale 999

Please write us on your letterhead for detailed information

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TEL: 711-6656. TELEX: 0246-8107

CIRCLE NUMBER 68

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**NEW CONTROL STORE SEQUENCER.**

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CIRCLE NUMBER 69

105
Aerospace Optics make this the only miniature pushbutton switch that is Sunlight Readable

-tested and Proven
Only Vivisun 20/20 legends are readable in a light ambient of 10,000 foot-candles (sunlight). When the lamps are not energized the hidden legend characters are not discernable in a 10,000 foot-candle ambient (sunlight).

- Switches are designed in accordance with MIL-S-22885
- Single or multi-color legend option
- Individual unit or matrix mounting options
- Momentary or alternate pushbutton action available with SPDT, DPDT, or 3PDT switches
- Companion sunlight readable annunciator available (without switching)
- 1, 2, 3, or 4 separate messages
- Messages available in green, yellow, red, or white
- Designed for low power consumption (5, 12, 14, 18 or 28 volts available)
- Lamps replace from front without tools

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Electrical components

Proprietary and custom-made electrical and electronic components ranging from molded terminal blocks to sophisticated controls for public service utilities are covered in a six-page brochure. Curtis Industries, Milwaukee, WI

Power sources

Choosing a power source is easier with this four-page selection guide that describes nearly 150 off-the-shelf line operated power supplies and dc/dc converters. Two charts give specifications, features, prices and package/pinout index. Semiconductor Circuits, Haverhill, MA

Circuit breakers

Circuit breakers, which offer complete circuit protection in one molded-case breaker, are described in a 12-page brochure. Westinghouse Electric, Beaver, PA

IC packaging panels

Pluggable IC packaging panels—custom or standard—are featured in a short-form catalog. Excel Products, New Brunswick, NJ

Tubular solenoids

Complete specifications on tubular solenoids are given in a data sheet. North American Philips Controls, Frederick, MD

Readouts

LED, incandescent and neon readout devices are covered in a 56-page catalog. Specifications, applications, performance characteristics and schematics are included. Dialight, Brooklyn, NY

Electron tubes

The latest EEV/M-OV catalog describes professional electron tubes in Europe. Data are given for 1150 types, including 80 new tubes. An Equivalents Index lists almost 4000 internationally used tubes for which the company offers an equivalent. English Electric Valve, Chelmsford, CM1 2QU, England.

Digital interface ICs

A 464-page data handbook, “Interface Integrated Circuits,” gives specifications on interface products such as: peripheral/power drivers, level translator/buffers, line drivers and receivers, memory and clock drivers, sense amps, display drivers and optocouplers. The text is supported by graphs, charts and diagrams. To purchase send a check for $4 (CA residents add 6% sales tax) to Marketing Services Dept., National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051.

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CIRCLE NUMBER 71

Electronic Design 16, August 2, 1976
Introducing One-Chip System Logic.

You get one-chip solutions to multiple-function problems!

Until now, when you wanted high-performance, you had to pay the high price. When you wanted low price, your performance options were limited.

That's exactly why Signetics has developed its line of "One-Chip System Logic" LSI products. To give you the best of both worlds. You get multiple functions on one chip. Great to build your own designs around. Great to upgrade from TTL and Schottky SSI and MSI. Great to save you time, hassle, board space, and reduce associated logic for overall lower systems cost.

"One-Chip System Logic" incorporates high-performance I²L and LS technologies and interfaces with TTL. The key is Signetics ¼ inch die capability which allows design and production of sophisticated LS building blocks.

System logic is one of the many LSI product families offered by Signetics including the MOS 2650 and bipolar 3000 series microprocessor.

Now, here are Signetics stock products

1 One-chip electronic tuning
( #8X08 AM/FM Frequency Synthesizer).
Do away with mechanical tuning and frequency generation forever.
It performs all digital control functions and gives you up to 2000 AM/FM/CB channels possible.

2 One-chip parallel data deskewing
( #8X03 & 8X04 Deskew FIFO).
Now, one chip synchronizes parallel data on a per-track basis and offers lowest system cost. It's easy to design with and solves a lot of multiple circuit problems while you're at it.
The only logical way to improve performance and save on systems cost.

3 One-chip error-checking
(#8X01 CRC Generator/Checker).

4 One-chip microinstruction sequencing
(#8X02 Control Store Sequencer).
You get 8 functions — everything you need for most efficient microprogramming. With low power Schottky LSI technology, 28 pin DIP with 1024 word addressability, and more.

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Control oriented bipolar fixed instruction microprocessor on one LSI chip. Eliminates up to 150 discrete SSI/MSI chips. You get easy programming and fast processing — 250ns instruction cycle time.

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| □ | Send me the whole book titled "One-Chip System Logic — Multiple Functions on One-Chip Now and in the Future." |
| □ | I have lots of questions. Please call me. |
| □ | Have a Field Applications Engineer make an appointment soon. |

Attach this to your letterhead for fast response.

My application is ____________________________________________

Name __________________________ Title __________________________
Telephone ______________________ Mail Stop ______________________

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<td>tubular solenoids</td>
<td>107</td>
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THE UP-FRONT BREAKER

PRECISE PROTECTION IN A PRETTY PACKAGE—AND A POWER SWITCH FOR YOUR FRONT PANEL.

Put a Heinemann Type J breaker on your front panel, and you get a power switch for free. An ingeniously simple way to cut component and assembly costs. There’s just no reason to keep your protection under cover when you can get such good-looking breakers, with a choice of handle types, colors, and mounting arrangements.

Maybe you think a fuse and a switch would be cheaper. But did you ever stop to think how much it costs when your technician makes a service call just to replace a blown fuse? An easily resettable Heinemann circuit breaker can keep that from happening. Saves you money and enhances your product’s reliability reputation.

Remember, too, that nothing works like a hydraulic-magnetic circuit breaker—close-tolerance protection and freedom from temperature-caused nuisance tripping. Our Type J can be custom-tailored to your circuit requirements in any integral or fractional rating from 0.020A to 30A at 240V 60 Hz or 400 Hz, or 65V dc. In a choice of four time-delay ranges and seven special-function internal circuits.

Values like the Type J have helped make Heinemann the world’s most respected name in OEM circuit breakers. Only Heinemann gives you such a complete selection of sizes and ratings. And now we offer you a choice of protection: electro-mechanical, hybrid, or all solid-state. Backed up with Quick-Draw delivery (most popular styles and ratings shipped in a day or two); the exclusive Heinemann five-year warranty; and manufacturing facilities in the U.S., Canada, West Germany, South Africa, and Australia.

We want to help you get the most for your protection dollar. Call us or your nearby Heinemann representative for knowledgeable applications assistance. For starters request our Type J bulletin. Heinemann Electric Company, Trenton, NJ 08602. Phone (609) 882-4800.

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Coming soon.
A Super Switch.
$t_s = < 200 \text{nsec}@6 \text{amps.}$

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<th>$I_C$ (amps)</th>
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<th>$V_{CBO}$ (volts)</th>
<th>$V_{CEO}$ (sus) (volts)</th>
<th>$P$ (watts)</th>
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RCA. Powerhouse in Transistors.

CIRCLE NUMBER 248