600-MHz COUNTER
A battery-powered 600-MHz frequency counter that's small enough to fit in the palm of your hand. Build it for less than 17 cents per MHz. Turn to page 39.

VIDEO MOTORCYCLE GAME
Rev your engine, hang a wheelie, accelerate up the ramp and see how many obstacles you can jump. Construction starts on page 44.

DIGITAL CIRCUIT DESIGN
Part 2. How to design digital circuits from scratch. The walk through sequential and comb rational circuits and circuit reduction techniques starts on page 47.

4-CHANNEL FM
A look at the different broadcast systems under consideration by the FCC and what it will mean to you. For the complete story, turn to page 51.

PLUS:
★ Build a NOM card for an 1802-based computer
★ Hobby Corner
★ Computer Corner
★ Jack Darr's Service Clinic
★ 2 Hi-Fi Lab Test Reports

COVER STORY
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35 Audio Test Station
5 in 1 instrument is a must for any audio bench.

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At less than 17-cents a megahertz, this instrument is worth its weight in gold.

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ON THE COVER

Harvey Sound’s midtown Manhattan store provides the backdrop for a complete audio test bench in a single instrument. It combines a digital AC multimeter, digital frequency counter, two sine/square/triangle wave generators and a pulse generator. It’s “the” instrument for audio testing. Turn to page 35 for all the details.

Simplified Logic Circuit is just one type of circuit design covered in this article. Turn to page 47.

Race Motorcycles across your TV screen. New TV game built around General Instruments chip makes it work. Story starts on page 44.


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Digital audio standards: Fearing a profusion of different types of digital audio disc systems, 29 Japanese, American and European firms have formed an informal organization to establish voluntary standards for a single system. Philips, Matsushita, JVC, RCA and others already have demonstrated or developed pulse code modulation (PCM) systems based on their videodisc developments. The advantage of digital recording is reduction in noise, expansion of dynamic range, decreased distortion and complete elimination of wow and flutter. Unfortunately, none of the PCM systems developed so far is compatible with any other.

Mindful of the lack of standardization in videocassette recorders, the 29 companies have agreed to work to develop a single standard within two years, presumably tacitly agreeing not to introduce any commercial systems until a standard is developed. The group was organized in Japan, but its members include RCA and MCA Disco-Vision of the U.S., Philips of Holland, Thomson-CSF of France, AEG Telefunken of Germany, in addition to Japanese hi-fi equipment and record manufacturers. The group will attempt to reconcile differences in record size, recording methods and rotation speed of the various proposed systems, and to develop standard sampling rates, technology, encoding, decoding and error correction systems. The group agreed to explore the possibility of interchangeability between laser-beam and needle-in-groove types of disc, compatibility with videodisc systems and measures to help prevent piracy.

The group was established in Tokyo not only because the majority of its members are Japanese firms, but also presumably because Japanese law is more tolerant of standard-setting meetings of competing firms than that of some other countries, including the U.S. The audio disc standardization group, known as "Digital Audio Disc Standardization Conference," is expected to set a pattern for a similar effort to standardized videodisc systems.

One for one: The United States has lost one TV manufacturer and gained one. Lost is Admiral, one of the first U.S. manufacturers to produce black-and-white, and later color, television. In 1974, Admiral was sold to Rockwell International, which announced last fall that it was leaving the TV business because of continued losses. The phaseout will come gradually during the first quarter of 1979. Admiral will continue to produce appliances. It's possible the brand name may be sold for a private-label TV line. Admiral offered its Chicago and Taiwan TV plants for sale. The new U.S. manufacturer is Sharp, the last of the Japanese TV majors to establish a plant here. Sharp's TV plant will be in the Memphis area and will produce microwave ovens as well as color TV sets.

Other Japanese TV makers with U.S. plants are Sony, Toshiba, Mitsubishi (MGA), Sanyo, Matsushita (Panasonic and Quasar). American TV brands which have ended production in recent years include Emerson, Philco (name purchased by Sylvania) and Motorola (whose TV set operation was sold to Matsushita and re-named Quasar). Warwick, controlled by Whirlpool, was sold to Sanyo. Magnavox was purchased by Philips of Holland. General Electric has agreed to sell its TV and picture-tube manufacturing facilities to a new firm, General Television of America, to be jointly owned by GE and Hitachi, pending approval by the U.S. and Japanese governments.

More color cameras: Just a year ago, the home color camera was a curiosity, the cheapest one was $1,500 stripped down and well over $2,000 for a version with electronic viewfinder and zoom lens. Black-and-white cameras chalked up impressive sales and have been in short supply all year, and the public snapped up whatever color cameras it could find. Starting this fall, color cameras are being produced by mass-production techniques for the first time and there's a good selection starting under $1,000 despite the drop in the value of the dollar in comparison to the yen (the cameras are all Japanese-made).

JVC and Magnavox are offering similar JVC-made cameras. Panasonic, Quasar and RCA feature a different model made by Matsushita. Zenith has one made by Hitachi, and GBC has cut the price of a Toshiba-made camera to slightly below $1,000. New color cameras which start slightly above $1,000 are offered by Hitachi and Sony, the latter with such deluxe features as through-the-lens viewfinder and 3-1 zoom lens. Meanwhile, an RCA official said the company hoped to offer an all-solid-state CCD color camera in about a year at around $500.

Flat-screen progress: Working with a team of former Zenith research engineers, GTE is confident that it is only a few years away from a giant flat-screen non-CRT color TV display using the principle of cathodoluminescence. The joint program is being conducted with Lucitron Inc., headed by Joseph Markin, formerly head of Zenith's display systems R&D operation. GTE owns TV set producers Sylvania and Philco in the United States and Saba in Europe and is a major manufacturer of picture tubes.

Lucitron has already developed monochrome gas-discharge displays and sees no major problems in developing color. A top GTE engineer predicted that large color TV displays would be ready for commercialization in three to five years. Lucitron officials are more conservative and talk in terms of five to ten. GTE envisions its first color TV panels to be larger in viewing area than the biggest picture tube, somewhere between 35 and 50 inches measured diagonally by about three inches thick. The Lucitron panels are claimed to provide good grey scale, have high efficiency, good brightness and potential economy and long life. Among their major advantages are the fact that they're "self-scanning," eliminating the need for complex drive circuitry; they use conventional color phosphors and in other respects employ technology similar to that required in the manufacture of picture tubes. Initial Lucitron developments will be alphanumeric displays for airports, stock brokerages and computer terminals, expected by 1981 at the latest.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR
Everything that's New and Exciting in Electronics...All in the NEW, Hot-Off-The Press

HEATHKIT CATALOG

Read about nearly 400 exciting do-it-yourself kits including Amateur Radio Equipment, Personal Computers, Home Improvement Products, Stereo Hi-Fi, Programmable Color TV, Automotive, Aircraft and Marine Accessories, Test Instruments, R/C Modeling, Self-Learning Programs and lots more! Something for everyone, and everything is easy to build and fun to use — it’s the Heathkit way!

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Blaupunkt car radios checked out by traveling van

The Blaupunkt Car Radio Division of Robert Bosch Corporation has devised a traveling tech shop on wheels called the Tech Van. In use since early 1978, the van has been testing Blaupunkt car radios in major marketing areas.

A sophisticated control panel uses a quick connect/quick release feature that allows up to four radios to be tested simultaneously; it also incorporates facilities for checking speakers, power amps and CB's. Company engineers use the van to test out new Blaupunkt car radio concepts in the field, make car radio installation tests and gather technical data.

Breach of computer security is a serious threat

An elevator-sized computer that is now commercially available can store three trillion bits. This is equivalent to a 500 page dossier on every man, woman and child in the U.S., a fact that is becoming a cause of concern to many. A report released by IBM Corporation officials to a panel investigating computers' potential abuse of privacy indicates their concern that such an invasion of privacy is a very real threat. More and more government and private agencies depend on computers for data storage and quick retrieval. The number of computers used by government agencies alone has increased considerably over a 13-year period, which raises the question of how to maintain security on the data in the computers' memory banks.

Although it would rarely be practicable to achieve absolute security with complete effectiveness, the report states: "reasonable protection can be provided . . . by increasing the cost of subverting the system to an unacceptable level." Other federal studies of the problem indicate that sensitive information should be isolated from routine data stored in memory. However, to curtail abuses effectively would seriously affect the efficiency of the data-retrieval system. For example, to reduce the possibility of some uncumbersome programmer penetrating and using the data, a computer system must be designed that can only process transactions and have no programming capability; airline reservation systems are examples of such limited operations.

Another report to Congress by the U.S. Comptroller General urges that "the President's top staff should move to have all federal agencies assess their roles in computer use and security," and indicated that a cost-effective approach to computer security should be sufficient to combine the necessity for data and the equally pressing need for privacy.

CO₂-based cycle aids in electricity storage

A research team from RCA Laboratories has determined that solar- or wind-generated electricity could be stored by applying the same chemical reactions inherent in a new CO₂-based energy-storage cycle.

In this cycle, surplus electricity (generated during maximum sun and wind conditions) is directed to electrodes that are immersed in water through which carbon dioxide (CO₂) gas is bubbled. The water is then broken down into its hydrogen and oxygen components; the hydrogen combines with the CO₂ to produce formic acid, a fuel that can be stored in tanks and used in electricity-producing cells. Additionally, palladium can be introduced as a catalyst into the formic acid to convert it into hydrogen gas; this can take place at room temperature. The RCA team point out that formic acid is safer to store and easier to transport than pure hydrogen gas because it is in non-explosive liquid form.

Using the CO₂/formic acid/hydrogen cycle has a long-range advantage in that it can supply hydrocarbons to be used as fuel instead of petroleum and as raw material for products that are presently based on petroleum. The fuel cycle could also serve to mitigate against the "greenhouse effect" that many scientists fear will result in the earth's atmosphere from continuous CO₂ emissions using present combustion methods.

Electrolent's Fuzzbuster "goes to court"

Electrolent, Inc., manufacturers of the Fuzzbuster radar detector have instituted legal proceedings against what the company terms "libelous and defamatory" statements made by several groups concerning the device.

One of the defendants is the Pennsylvania Turnpike Commission, which operates the state's toll roads. Evidently, the Commission has been distributing leaflets to motorists stating that the Pennsylvania State Police radar is immune to "the Fuzzbuster and other radar detectors." Another target for litigation is the Better Business Bureau of Miami, which was accused of distributing a letter to all South Florida newspapers, radio and TV stations requesting they not accept advertising for "Fuzzbusters."

Additionally, an unnamed radar manufacturer has been distributing brochures claiming its radar is "detector proof." (There are actually several radar companies that make this claim.)

Legal action has started against the turnpike commission and the Better Business Bureau. The Commission has been asked to stop handing out the flyers and issue new ones retracting the erroneous information contained in the first ones. Electrolent has also written the Miami Better Business Bureau asking that they retract their previous press statement alleging that anyone who purchases a radar detector is being encouraged to evade the law.

Crystal-layering technique improves semiconductor efficiency

Scientists at Bell Telephone Labs have developed a technique that is expected to double the speed with which electrons pass through semiconductor crystals at room temperature, thereby increasing the efficiency of such semiconductors used as IC's.
Miniaturization breakthrough! Realistic's fabulous new System Seven combines beauty, elegant small size and a level of acoustical quality you've never heard, until now, in low-priced bookshelf stereo.

System Seven includes our new STA-7 AM/FM receiver (10 watts per channel, minimum RMS into 8 ohms, 20-20,000 Hz, with no more than 0.5% total harmonic distortion) and a pair of our amazing Minimus®-7 speaker systems—featuring large-excursion woofers and soft-dome tweeters in diecast enclosures only 7 1/8" high.

Bass without bulk. Despite its small size, System Seven delivers rich, satisfying bass to 50 Hz and sound levels up to 90 dB for accurate reproduction of anything from classical to rock music.

What's the secret? The receiver has a unique equalization network engineered especially for the speakers. And it's switchable so you can use full-size speakers, if you wish.

Compact, but no compromises. You get "full-size" high-fidelity features with System Seven—magnetic and aux inputs, tape monitor, A/B speaker switching, even 75 and 300-ohm FM inputs. U.L. listed, of course, and housed in a stunning jet-black metal cabinet with blackout dial.

Receiver is briefcase-sized, a little taller than a credit card—just 3 1/2" high. Each speaker is about the size of two average books.

The price for all this may be the surprise of your audio life—only 219.95*, a savings of $39.90 off the "each" price!

Audition System Seven. Small has never been so beautiful!

*Price may vary at individual stores and dealers.

Sold only at Radio Shack®
The nationwide supermarket of sound®

A Division of Tandy Corporation
Fort Worth, Texas 76102
Now NRI makes it TV/Audio home

Side-by-side equipment comparison of NRI and two other leading schools shows what you get for what you pay. When you have to pay as much as $985 more for another school’s course, you should carefully consider your tuition investment.

When you sit down and try to pick out the school that’s best for you, it gets to be a problem. Catalogs are radically different and some are not too clear as to what you actually get for your money. So NRI has done a lot of the work for you. And put the prices right up front so you can make your own judgment.

Of course, we can’t compare everything. Lesson clarity and content vary. What one covers here, another covers there...or not at all. The material one school breaks down into eight lessons may be four at another. And the qualifications and abilities of instructors are another question.

<table>
<thead>
<tr>
<th>COURSE TITLE</th>
<th>NRI</th>
<th>SCHOOL A</th>
<th>SCHOOL B</th>
</tr>
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<tbody>
<tr>
<td>Master Course in TV, Audio, and Video System Servicing</td>
<td>Master Course in Color TV Servicing</td>
<td>Electronics Technology and Advanced Troubleshooting 1 &amp; 11</td>
<td></td>
</tr>
<tr>
<td>CASH PRICE (terms available)</td>
<td>$1295</td>
<td>$1539</td>
<td>$2280</td>
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<tr>
<td>TV SET</td>
<td>NRI designed-for-learning kit</td>
<td>Heathkit GR-2001 25&quot; (diagonal) color TV (cabinet extra)</td>
<td>Zenith model G4020W 19&quot; (diagonal) color TV (fully assembled)</td>
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<tr>
<td>Oscilloscope</td>
<td>NRI designed-for-learning kit</td>
<td>Heathkit 10-4541 5&quot; (8 x 10 cm) triggered sweep (not given until after graduation)</td>
<td>Heathkit 10-4541 5&quot; (8 x 10 cm) triggered sweep (not given until after graduation)</td>
</tr>
<tr>
<td>Color Bar Generator</td>
<td>NRI designed-for-learning kit</td>
<td>Elenco SG-200 (kit) 10 patterns</td>
<td>Elenco SG-200 (fully assembled) 10 patterns</td>
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<td>Frequency Counter</td>
<td>NRI designed-for-learning kit</td>
<td>Heathkit (part of TV kit) DC only: 1K Ohm/volt</td>
<td>Private label multimeter</td>
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<td>Trainer</td>
<td>NRI Discovery Lab</td>
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<td>Miscellaneous Equipment</td>
<td>EICO Digital Logic Probe</td>
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All data as shown in each school’s catalog as of September 1, 1978.

One Million Students, Over 60 Years’ Experience

So we can only tell you what NRI has to offer. We’ve been in education since 1914, starting as a radio school six years before commercial broadcasting was even on the scene. Since then, we’ve kept right up with the times, improving techniques, adding material, creating new courses to help people improve their skills and income.

Early on, we learned to keep our lessons compact...thoroughly covering a subject, but not so much that students would be overwhelmed. We call them “bite-size” lessons because they’re easy to digest.

Learn by Doing with “Hands-on” Training

And, we pioneered the concept of “hands-on” training. NRI goes far beyond theory and textbooks to give our students actual bench experience and prepare them for the realities of electronic servicing. Every piece of equipment in our Master Course in TV and Audio Servicing is designed for learning. As you assemble the kits we supply, you build a highest-quality, up-to-date 25" (diagonal) color TV, a 4-channel amplifier and tuner with speakers, your own oscilloscope,
digital frequency counter, and other
equipment you'll use in your course,
use later to earn good money as a TV/
Audio technician.

The point is, none of this equip-
ment is hobby-kit or commercial assem-
ably line units with lessons “retro-fitted”
to what was at hand. NRI has designed
each so you get invaluable training and
experience you just can't get any other
way. As you build, you study operation
of circuitry; see how sections interact,
perform “power-on” experiments only
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exclusive with NRI ... no other school,
home study or resident, offers it.

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NRI instructors are thoroughly
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students, always ready to help with a
question, a problem... give good advice
to help you reach your goals.

It's instructors and training like
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survey shows (summary on request), they
recommend NRI by a majority of three to
one over any other school.

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eliminating the middleman's profit on
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offering our training by mail only. We
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and effective lessons.

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nations of each and every experiment you
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that have gone before you, we think
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or Communications/CB
Equipment Servicing.

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to service and maintain digital computers,
check out our NRI course. You learn at
home, in your spare time, and actually
build a programmable, integrated circuit, digital
computer with
expanded memory.
Or maybe your
interest is CB or
the expanding world
of communications... mobile radio, microwave,
TV broadcasting, and much more. NRI
can help you there, too, as you build
and experiment with your own digitally
synthesized 2-meter transceiver. For these
and other NRI home study courses, just
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Education Center
3939 Wisconsin Avenue
Washington, D.C. 20016

www.americanradiohistory.com
countering the silicon are attracted to its positive charge, sometimes combine with it and stop moving along completely.

The Bell Lab technique isolates the electrons from the impurities by layering two semiconductor materials to form a single crystal, using a crystal-growing process molecular beam epitaxy (MBE) that allows layers of crystal atoms to be constructed one at a time. The scientists created a two-layer crystal using 50 layers of gallium arsenide and 50 layers of aluminum gallium arsenide, and silicon was added to the aluminum gallium arsenide layer only. Once in different layers, the silicon impurities have little chance to prevent electrons from moving freely. The technique can be used for any combination of semiconductor material having the same properties as gallium arsenide.

Using this technique, it is possible to greatly increase the capacity of communications systems as well as hastening the appearance of ultra-high-speed computers and the creation of new devices.

Bozak, Kloss and Marantz receive audio industry awards

Three pioneers of the audio industry were honored recently at the annual Audio Hall of Fame Awards dinner at the Hilton Hotel in New York. The awards are presented to those who have made significant contributions to the reproduction of music.

This year's recipients were Rudolph Bozak, Henry Kloss and Saul Marantz.

Mr. Bozak was honored for his work in loudspeaker design. Mr. Kloss both developed and was instrumental in the popularization of the acoustic suspension speaker. Mr. Marantz (founder of the Marantz Company) won his award for his part in transforming hi-fi from a post World War II hobby into today's multibillion dollar industry.

Proceeds from the Awards Dinner this year will go to the Metropolitan Opera.

RCA transmission service extended to Hawaii, Cuba and Hong Kong

The RCA Corporation (and its subsidiaries) has expanded its data transmission service to Cuba and Hong Kong, as well as an additional link-up to Hawaii.

NASA will use the data transmission facilities at RCA Americom's Kokee Park station on the island of Kauai in Hawaii, in addition to the RCA services already being used at Barking Sands Naval Air Station on Kauai. The link-up is to the Goddard Space Flight Center in Maryland, and will be used in connection with several on-going NASA programs, such as Mars photography, the space shuttle and the Voyager mission to the outer planets.

The recent agreement reached between mainland U.S. and Cuba will use cable circuits to provide Telex, telegram and leased-channel services between the two countries.

RCA has also established the first commercial international digital facsimile service between this country and Hong Kong. The service, called O-Fax, permits you to send and receive messages, legal briefs, graphics, contracts, etc., in Japanese (or Chinese) characters without translation. In the U.S., messages are sent by messenger or by local facsimile transmission to RCA operating centers in New York, Washington or San Francisco. In Hong Kong, the messages are delivered by messenger service to local post offices. Return messages are transmitted from Hong Kong to the U.S. via the mails, a domestic facsimile service or by messenger to the RCA centers.

New York City anti-radiation proposal causes concern

An amendment to the New York City Health Code that would set even stricter limits to the "field strength" of radio transmissions has been causing concern among the metropolitan area's amateur radio operators and CB'ers, not to mention commercial TV and radio broadcasters. Until recently, the high-level radiation was considered relatively harmless.

Dr. Leonard Solon of the New York City Department of Health drafted the proposal, and a public hearing has taken place, although no definite action has yet been taken by the Board of Health. At the public meeting, area broadcasters stated that if the amendment were adopted, they would be forced to move their transmitters elsewhere, since radio and TV reception would be reduced to mere "gibberish." However, amateur radio buffs would be even more seriously hit by the proposal since their maximum legal 2000-watt output would violate the Solon proposal's standards.

On the other hand, while objections were raised by the commercial broadcasters, they were muted. This has led to some speculation that the broadcasters privately believe the new standards, if adopted, would pave the way to increased cable service—thus cutting the considerable costs of operating regular transmitters.

FCC inquiry on fee refunds does not cover CB licensees

The Federal Communications Commission's inquiry on fee refunds and future fee schedules does not apply to CB owners. The present action deals only with fees greater than $20 collected between August 1, 1970 and January 1, 1977.

The FCC urged that CB owners not make inquiries now about future fee schedules, since any action on fees of $20 or less would be taken only in the near future.
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SPECIFICATIONS:
• DC volts in 5 ranges: 100µV to 1kV • AC volts in 5 ranges: 100 µV to 1kV • DC current in 6 ranges: 100 nA to 2A • AC current in 6 ranges: 100 nA to 2A • Resistance: 0.1Ω to 20MΩ in 6 ranges • AC frequency response: 40 Hz to 50kHz • Display: 0.36" (9.1mm) 7-segment LED • Input Impedance: 10MΩ • Size: 8"W × 6.5"D × 3.0H (203 × 165 × 76 mm) • Power requirement: 4.5–6.5 VDC-4 °C cells (not included).
Electronics Tomorrow

With this issue another new year begins. At the outset of all new years, there is always that temptation to start making predictions. The only trouble with predictions is that you can either predict things you know will happen, or you can predict things so far out that they won't happen. . . . this year!!

So I'll spare you the predictions. Instead, let's deal with facts. Video tape recording in the form of VCR's and projection TV will show great growth this year. If the video disc ever escapes the laboratory, it will become an instant success—assuming the price can be held to the $600 level.

Hi-fi sound for the car has already arrived. The only hazard is that it is so good that the driver won't be able to concentrate on driving. Digital wristwatches, calculators and electronic games are already drugstore-rack items. The yen/dollar relationship may cause the price of many consumer electronics items to go up, but it may also spur a resurgence of Made In U.S.A. labels on consumer electronics gear.

No matter how you look at electronics, it's going to be another great year. There will be dozens of exciting new devices that are built around new circuitry and IC's. Believe it or not, we are now seeing just the beginning of the electronics revolution.
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- If you want the Selection, do nothing. It will be sent to you automatically. If you do not wish to receive the Selection, or if you want to order one of the many Alternates offered, you simply give instructions on the reply form (and in the envelope) provided, and return it to us by the date specified. This date allows you at least 10 days in which to return the form. If, because of late mail delivery, you do not have 10 days to make a decision and so receive an unwanted Selection, you may return it at Club expense.
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CIRCLE 24 ON FREE INFORMATION CARD

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HYDROGEN—NEW ENERGY SOURCE?

With reference to your editorial, "The Real Energy Crisis," in the April 1978 issue, I am enclosing a diagram of an energy system that is similar to one presently being tested by a company in a new home in Provo, UT.

Pure hydrogen is produced on-site by the electrolysis of water using commercial power, solar cells or a wind turbine. The hydrogen is then stored in a large hydride storage tank. Hot water from solar collectors is also stored, and this heat is used to force the hydrogen out of the tank.

Gas appliances and the home's central heating and cooling system are hydrogen-powered.

Since we have an inexhaustible supply of water, wind and sunlight, hydrogen could just be our future source of fuel. And this colorless, odorless gas is pollution-free!

DARRELL E. TOMLINSON
Odessa, TX

continued on page 22
**REAL • STATE • OF • THE • ART**

**DIGITAL INSTRUMENTATION FROM OPTOELECTRONICS, INC.**

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ENERGY CRISIS

I read your editorial in the April 1978 with great interest. Ever since the energy crisis began, a lot has been said about it. I am in strong agreement with you as far as the cost of energy is concerned. It does not appear that this cost will go down unless there is a major change in the status of the national economy.

I do not think it would be wise to encourage the use of nuclear power. In fact, you should discourage the use of this particular source of energy because it represents a cost of energy which would discourage the age in which we live.

As far as I'm concerned, the lack of motivation, not the lack of imagination, is the only reason the nation has not been able to come to grips with this problem. I believe that the basic attitude among Americans is universal—they all feel that a lot more needs to be done in order to reduce or eliminate the adverse social, as well as economic, effects of the energy crisis on the nation. This is where Congress and the political leadership does not meet the expectation.

WHERE ARE THE ELECTRONIC DESIGNERS?

I think that the most important property of the IC is that it has freed us from the drudgery of solving hundreds of little interacting network equations, and has allowed us to get down to the real business of designing useful working systems.

My field for the past six years has been medical instrumentation, and because of the IC we are building instruments today that no sane person would have undertaken to build 20, or even 10 years ago.

The good instrument designer constantly scans the new IC release announcements, carefully reads about the properties of a new device and then thinks about ways to use it that the manufacturer never thought to suggest.

For example, a problem has been perplexing our design group for a long time. Just recently, however, one of the members of the group obtained some IC samples of a new device. We are testing it for an entirely different application from any the manufacturer has suggested, and it appears that the device will inexpensively and efficiently solve a problem that could have been solved by use of a combination of IC's and discrete components but at a prohibitive cost in terms of energy, space, weight and money.

I do not believe that the last remaining designers are the IC designers. They have relieved the rest of us of the dog work of figuring biases, temperature coefficients, stage gains... and a host of other annoying details so that we can get down to the real business of designing working systems to improve the quality and length of life.

The IC designers provide us with neat packages of gain, fast switches, comparators, voltage references and a multitude of other functions. It is up to the rest of us to apply our ingenuity to find the broadest spectrum of uses for these excellent reliable, low-cost devices.

Part of the usefulness of the IC is derived from its small size, not because it makes equipment smaller but because its smallness places all its components in the same physical environment, reducing temperature drift problems almost to the vanishing point in some cases.

I think the IC is the greatest invention since sliced bread!

W. Q. COCHRAN
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CIRCLE 11 ON FREE INFORMATION CARD
F. W. Bell Model CG-100A Current Gun

CIRCLE 110 ON FREE INFORMATION CARD

There are certain effects in electronics that we've known about for some time. One is the "Hall Effect," which was discovered by E. H. Hall in 1879! He discovered that "if a conductor is placed in a magnetic field perpendicular to the direction of current flow, a voltage will develop across it."

Semiconductor materials can be made to do tricks. It was found that a small bar made of semiconductor material (indium arsenide, gallium arsenide, etc.) could be placed in a magnetic field, and would develop a voltage on its opposite sides. This is the "Hall voltage," which is used in scientific instruments, for a while confined mainly to gaussmeters used primarily in labs.

F. W. Bell, Inc., (4949 Freeway Drive East, Columbus, OH 43229) has developed a versatile Hall-effect instrument. This little jewel uses a semiconductor Hall-effect sensor and is called the model CG-100A Current Gun. It's a clamp-on instrument—the jaws can be opened and clamped around a conductor and the conductor current read out.

Clamp-on instruments have been used to read alternating currents for a while. The model CG-100A not only reads AC, it reads DC and composite alternating and direct currents (you can read the direct current in a wire and the AC ripple too, separately). This compact device can be operated with one hand, and is powered by four AA cells located in the handle. The readout can be made on any accurate digital AC or DC voltmeter.

Using the model CG-100A is very simple. The gun is connected to a standard multimeter by a four-foot dual cable with a dual banana plug on each end. The meter is set for 0-1 volt, or 0-2 volts. Selecting AC or DC operation is easy. To read DC set the meter to DC volts; for AC, set it to AC volts. Press the thumbwheel on switch on top of the handle of the model CG-100A and the gun is adjusted for a zero reading. Release the switch, open the jaws, hook the conductor in them and close the jaws. Now, pressing the ON switch reads out the current on the meter. If one-handed operation is needed, you can lock the switch on by sliding the LOCK button under the handle.

The current gun has two ranges—0-10A, and 0-100A. Both of these ranges has a 1.0 volt output, with a 100% overrange capability. This instrument is ideal for use with DVM’s, most of which are calibrated in this way. You select the desired range by using a slide switch on top of the handle. All you do is mentally move the decimal point on the readout one place to the right; for example, a reading of 1.0 volt is 0.1 A, and so on.

continued on page 26
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www.americanradiohistory.com
The model CG-100A has a rated accuracy of ± 2% of rated output. (A full set of performance characteristics, curves and calibration data can be obtained from Bell.) If ever needed, calibration requires only four adjustments, which are sealed under the metal decals on the gun handle. The model CG-100A has an AC frequency response to 1.0 kHz, which makes it useful for audio measurements such as in telephone systems, etc.

Battery life should be good, since the battery isn't on until you press the trigger, which draws only a small amount of current. The instruction book cites only one precaution: "Don't let the jaws snap shut. This may

The unit should be very handy for electrical measurement applications. Alternating current readings have been used for a good while. The DC readings would be useful in automotive electronics and electrical work, as well as in other fields. The gun's jaws can fit around any conductor up to 5/8-inch (19-mm) diameter; but must be fully closed for best results. For maximum accuracy in reading currents in small conductors, the gun should be centered in the hole; however, the maximum error introduced by off-centering is very small.

The model CG-100A is $169.

CIRCLE 111 ON FREE INFORMATION CARD

DIGITAL TECHNIQUES ARE SHOWING UP IN CONSUMER PRODUCTS MORE FREQUENTLY THAN EVER BEFORE, ESPECIALLY IN ENTERTAINMENT DEVICES. ELECTRONIC GAMES THAT ONLY A FEW YEARS AGO WERE CONSIDERED FICTION TODAY ARE A REALITY. AN EXAMPLE OF THIS IS CompuChess (Data Cash Systems, Inc., Box 65, Largo, FL 33540) an electronic digital chess game packed with features and versatility.

The unit is housed in a wood-grain enclosure that measures 4 1/2 X 7/8 X 1 1/2-inches H with power supplied via a calculator-type line-plug/transformer combination. The metallic front panel contains a 4-digit 7-segment LED display, two slide switches (a power ON/OFF switch and a RESET/RUN switch) and a 16-key touchpad.

CompuChess does not display nor is it supplied with a chessboard. The location of the pieces are displayed via a coordinate system, which is obtained by labeling the columns of a standard board A through H and labeling the rows 1 through 8. For easy coordinate reference, CompuChess is supplied with a set of self-sticking decals with the coordinates of each square of the chessboard. Simply cut out each coordinate with a razor blade and attach it to the appropriate square of your chessboard.

CompuChess can play at any one of six levels. Level 1 is classified as an elementary level with an instant response to a move. Level 2 is for the practiced beginner, with CompuChess responding to a move within 15-20 seconds after entering it. Level 3 is for an average player and has a 20-second to 15-minute response time. Level 4 also has a 20-second to 15-minute response time and is intended for an above-average player. Level 5 has an 18-hour response time, and level 6 has up to 2 days response time. According to the owner's manual, levels 5 and 6 are intended to solve mate-in-two problems. The think times are long because the algorithm is a brute-force all-possible combination calculation of black's move, white's response, black's response, white's response, black's response on level 5 and an additional white's response on level 6.

The response times for levels 5 and 6, however, apparently only apply to solving mate-in-two problems. For a populated board, as is the case for standard mid-game play, the response times are much, much longer.

To play a game, first turn CompuChess on and then reset it by placing the reset switch first in the RESET position and then in the RUN position. The unit responds by displaying an L.

continued on page 32
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EQUIPMENT REPORTS continued from page 26

Now you must select a level of play by depressing one of the keys numbered 1 through 6. CompuChess now responds by displaying AP. Depress the key labeled A for a beginning game with CompuChess playing black. The display will now show a series of flashing dots. Enter your opening move by entering the letter-number coordinates of the piece to be moved and the letter-number coordinates of its destination. So, a move is made by entering a letter-number-letter-number combination. The move is confirmed on the display as it is entered. Now depress the key labeled PLAY to instruct CompuChess to make a move. The time it takes CompuChess to respond to a move depends on the level of play. While a move is being calculated, the level of play is flashed in the display.

Every key on the 16-key touchpad is a two-function key. Eight keys are labeled A through H, and eight keys are labeled 1 through 8 to correspond to the coordinate system. Each key is also labeled with its secondary function. The secondary functions for eight of the keys are a two-letter abbreviation corresponding to the eight chess pieces. For example, WK stands for king, and BK stands for black knight. The secondary function of the remaining keys are AP, which commands CompuChess to make a move; MD, which instructs CompuChess to move pieces on the board; PA, which enables you to place any piece anywhere on the board; and FR, which enables you to display the location of all the pieces on the board.

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For example, to confirm that the location of the pieces on your chessboard corresponds to the location of the pieces within CompuChess's memory, depress FP. Then, to locate the position of, let's say, the white king, depress the key labeled WK. The position of the white king will then be displayed. You can do this for every piece on the keyboard.

You can also start with any board position you'd like. After resetting and entering the level of play, CompuChess responds by displaying BP. Entering A starts a new game with CompuChess playing black. You can also enter B, which blanks the entire board.

By using the EP key, you can locate pieces wherever you'd like on the board and then confirm the location of all the pieces using the FP key. You can force CompuChess to make the first move by depressing PLAY, or you can enter a move by depressing the MD key, enter a move and then depress PLAY.

You can also change the level of play in the middle of a game. First reset CompuChess (never reset while it's calculating a move) and then enter the new level of play. When CompuChess responds by displaying BP, enter C. This instructs CompuChess to continue the game presently in progress (resetting the CompuChess does not change the position of the pieces within its memory). You can now make a move by depressing MD or force CompuChess to calculate a move by depressing PLAY.

In the standard game, CompuChess plays black. You can make CompuChess play white. After selecting the level of play and entering an A in response to the BP display, interchange continued on page 68.

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A host of precision instruments are required by anyone wanting to put high-quality audio equipment through its paces. This test station has everything you'll need. You can build it from a kit.

RAY DAVISON

This is the first in a series of articles describing the operation, design and construction of Fidelity Sound's model 101 Audio Test System. This first article presents the functions that are available and gives detailed information on the power supplies. Subsequent articles will cover the other major circuit blocks. A kit of all components is being offered.

The unit consists of a power supply, two sine/square/triangle function generators, pulse generator, frequency counter and AC voltmeter. In its simplest form it can be thought of as several pieces of independent test equipment in a common cabinet. They are all basically familiar test equipment and can be used in the normal manner. In addition, when the various sections are properly connected to each other and to an X-Y plotter or scope, the system will generate a frequency-response plot.

The controls and the Audio Test System are grouped within solid black lines on the front panel as can be seen in Fig. 1. Each of the areas should be thought of as a separate piece of equipment with the capability of being internally connected. Each section has its own power switch. Figure 2 is a block diagram that shows the various circuits and their interrelationships.

Basic to audio testing is a three-decade, three-function generator. This is contained in the area labeled Audio Sweep Generator. This basic generator has three controls besides the power switch: Slide pots for frequency and amplitude and a toggle switch to select one of the three available waveforms. The amplifier output impedance is less than one ohm and it will supply 15 volts peak-to-peak into 500 ohms or 10 volts peak-to-peak into 8 ohms. By having the output impedance very low the user can add resistance either internally or externally where necessary to match a particular application. The other three toggle switches in the sweep generator section are used to interface to the timebase section that will be discussed next.

The next step of sophistication beyond a basic function generator is generally a sweep generator. This requires some type of second oscillator to generate a sweep signal for the primary generator. Often the secondary oscillator is a simple fixed or possibly selectable frequency ramp generator.

In the case of the model 101 we decided to give you wide latitude in the choice of both sweep and return times. The basic waveform of the timebase is a triangle. The two slide pots (R1 and R2) on the left side of the timebase section control the leading and trailing sides of that triangle independently. A switch (S4) deactivates one of the pots and allows the remaining one to control the frequency of a symmetrical triangular waveform. Use of the two frequency control pots allows the leading or trailing side to be up to 100 times as long as the other side. Rotary switch S3 steps the frequency range. In the slowest setting, with the slide pots at their minimum, the timebase will produce a triangular waveform of three minutes on each ramp. This would be used for maximum resolution for such things as plotting standing waves in an auditorium on an X-Y recorder.

Slide pot R3 is the amplitude adjustment and R4 is a ±5-volt DC offset. Below the DC offset pot there are two toggle switches. The one to the left (S5) selects one of the three waveforms. The timebase is capable of providing the three basic waveforms and hence, rather than merely a secondary oscillator to sweep the audio generator, it is a complete second
function generator. The separate leading and trailing edge frequency controls allow it to produce nonsymmetrical waveforms. Combining the frequency, amplitude and DC offset controls will provide wide latitude in generating a pulse train.

Toggle switch S8 inverts the output, while S9 provides for manual setup of the timebase/sweep generator system.

The triangle output from the timebase generator (independent of the setting of the output waveform switch) sweeps the audio generator through the LOG/LINEAR sweep select switch (S12) of the sweep generator section when SWEEP/MANUAL switch S9 in the timebase section is set on SWEEP. When this switch is set to MANUAL, the DC offset pot replaces the triangle timebase generator. This allows the timebase signal, which would drive the X-axis of a plotter and simultaneously sweep the audio generator, to be manually moved to any point and stopped. While the timebase signal is stopped, the audio generator frequency can be read off the counter. This mode provides for setting of the sweep end points and calibrating the chart paper.

The sweep frequency end points are set by multiturn trimmers with a screwdriver through the four small holes to the left of R6, the sweep generator manual frequency slide pot.

The timebase also triggers the blanking mode of the audio sweep generator. In the blanking mode when the timebase is on the negative-going side of the ramp, the audio oscillator is turned off. Also, the holding capacitors in the AC to DC converters of the voltmeter are discharged. This results in a zero reference line during retrace. The purpose of this

FIG. 1 THE MODEL 101 AUDIO-PLUS SYSTEM consolidates several audio test instruments.

Radio-Electronics

WITH MORE AND MORE AUDIO SERVICE centers, dealers and design laboratories making repetitive and comprehensive measurements of audio equipment (including everything from preamplifiers to loudspeakers and tape decks), their goal is to make such measurements as quickly as possible, with as few pieces of test equipment as practical. For this reason, The Fidelity Sound model 101, shown in Fig. 1, combines various signals and test functions into a single, compact instrument. It won't tell you everything you ever wanted to know about a piece of audio equipment but, when combined with a decent oscilloscope and/or an X-Y plotter, it produces some very excellent response measurements of virtually any kind of audio gear where frequency response is important. Its many signal outputs, built-in frequency counter and built-in audio voltmeter can prove useful in making a variety of other tests besides frequency response.

The model 101 consists of two sine/square/triangle-wave function generators, a pulse generator, a frequency counter and an AC voltmeter. In its simplest form, the unit can be thought of as several pieces of independent equipment in a compact cabinet. In addition, when these various sections are properly interconnected (many of these interconnections are internal, thanks to the front-panel switching arrangements) and if an X-Y plotter or scope is used, the system generates a frequency-response plot. When the unit is combined with an efficient speaker, a quality microphone and a hard-copy plotter, it will produce a written record of room acoustic analysis including standing waves, which, because of their low spectral energy, are often missed by other types of sweep analysis.

There are several applications for which the unit is not suitable. For example, its sinewave output is too high in distortion to be used to check preamplifier or power amplifier distortion, although the amplitude response of the sweep generator, used in either its manual or sweep mode, is certainly flat enough for meaningful frequency-response measurements.

The frequency-counter section, shown in Fig. 2, is a useful addition. The counter reads the repetition rate of whatever signal is selected from the sweep-signal generator section. It would have been more useful if the counter could also read externally connected signal frequencies.

The functions and controls of the different sections are described in the article dealing with the construction of the model 101. Our purpose here was to check out
Tests It

the various specifications of the instrument and to examine some of the output waveforms it is able to deliver. Table 1 summarizes the manufacturer's specifications as well as our own measurements and results. In general, most of the published specifications were either met or exceeded. One notable exception was the total harmonic distortion of the sweep-generator sinewave output. This THD measured 1.8% for a 1-kHz output signal, as opposed to the 1.0% claimed by the manufacturer.

Output signal waveforms

We photographed several types of waveforms that can be taken from the various output terminals of the model 101. Figure 3 shows a sweep-frequency signal output, logarithmically swept from 20 Hz to 20 kHz. The center line seen from left to right is the retrace signal between successive sweeps and is, of course, adjustable as to duration. The total sweep time can be adjusted from its slowest speed of around 3½ minutes for a full sweep to about 4 seconds—the minimum time required to "get all the frequencies in" for at least one cycle of each.

Combined use of the timebase generator and the audio sweep generator operated in its manual mode (under which conditions any frequency within the audio range can be selected and remains fixed).

Figure 5 shows positive- and negative-going sharp pulses. Besides being useful in and of themselves, these pulses are also timed to occur at the start of a timebase ramp generated by the timebase section. Since the ramp voltage generated by the timebase section also sweeps the frequencies generated by the sweep-generator section, these dual-polarity pulses provide a ready means for triggering a scope.
burst and the right-hand pot controls the off-time. The blanking circuit is coordinated with the zero crossing of the sweep generator waveform; therefore, the tone burst produces only integral cycle waveforms, beginning and ending at zero.

To the left of the timebase section is a pulse output and pulse-width control. Each time the timebase begins its positive-going ramp the pulse section provides a single pulse. The width is controlled independently of timebase frequency by range switch S7 and slide pot R5. The outputs are complementary TTL.

An AC voltmeter is in the lower right-hand corner of the unit. Rotary switch S17 under the meter is the range switch. The high-sensitivity ranges (−36 to −72 dB) apply only to the mike connector. Toggle switch S16 selects either the sweep or timebase function generators or the external BNC connector (J5) below it. The other three toggle switches provide fast or slow tracking rate (large or small damping), peak or true RMS, and linear or log scales.

A six-digit frequency counter is above the voltmeter. Toggle switch S21 is the power switch and also selects the signal to be counted. It will count either whatever signal is selected by the voltmeter select switch, or it will count the audio generator internally. This latter selection allows stable counting of the audio generator when the signal coming from the system under test may be very distorted or of very low amplitude. The second toggle switch (S22) selects either a one-second or a one-half-second counter update. The counter is line-triggered and may be programmed for either 50 or 60 Hz.

Next month, we will present an in-depth discussion of the power supply and timebase circuits as well as the construction details for these two circuits.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>PERFORMANCE SPECIFICATIONS</th>
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</thead>
<tbody>
<tr>
<td>Manufacturer's Claim</td>
<td>R-E Measurement</td>
</tr>
<tr>
<td>Timebase frequency range</td>
<td>0.002 Hz–800 kHz</td>
</tr>
<tr>
<td>Vernier control of ± ramp side</td>
<td>100 X</td>
</tr>
<tr>
<td>Sinewave THD</td>
<td>Less than 1.5% at 1 kHz</td>
</tr>
<tr>
<td>Squarewave rise &amp; falltime</td>
<td>0.5 μs, 8 volts P-P</td>
</tr>
<tr>
<td>Timebase amplitude</td>
<td>± 5 volts</td>
</tr>
<tr>
<td>DC offset</td>
<td></td>
</tr>
<tr>
<td>Pulse-section waveform</td>
<td>40 ns–4 seconds</td>
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<tr>
<td>Pulse-width total range</td>
<td>14 X per range</td>
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<tr>
<td>PULSE SECTION</td>
<td></td>
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<tr>
<td>SWEEP-GENERATOR SECTION</td>
<td></td>
</tr>
<tr>
<td>Manual frequency range</td>
<td>20 Hz–20 kHz</td>
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<tr>
<td>Sinewave THD</td>
<td>Less than 1.0%, 8 volts P-P</td>
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<tr>
<td>Squarewave rise &amp; falltime</td>
<td>0.5 μs</td>
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<tr>
<td>Output level</td>
<td>16 volts P-P/500 ohms; 10 volts P-P/8 ohms</td>
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<tr>
<td>AC VOLTZER SECTION</td>
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<tr>
<td>0 dB reference</td>
<td>8.0 volts P-P = 0 dB</td>
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<tr>
<td>Internal or line-in range</td>
<td>+36 dB to −24 dB</td>
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<tr>
<td>Microphone input range</td>
<td>−36 dB to −72 dB</td>
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<td>External input impedance</td>
<td>1 megohm</td>
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<td>Microphone input impedance</td>
<td>600 ohms</td>
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<td>Voltmeter output impedance</td>
<td>100 ohms</td>
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<td>Meter system response</td>
<td>20 Hz–100 kHz, ±0.5% dB</td>
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<td>FREQUENCY-COUNTER SECTION</td>
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<tr>
<td>Sensitivity</td>
<td>10% of selected meter scale</td>
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<tr>
<td>Reading update</td>
<td>0.5 or 1.0 seconds</td>
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<td>GENERAL SPECIFICATIONS</td>
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<tr>
<td>Dimensions</td>
<td>14W X 8 H X 3-inches D</td>
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<td>Shipping weight, assembled</td>
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<tr>
<td>Price</td>
<td>$650</td>
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</table>

sweep or initiating the action of an X–Y plotter in sync with the frequency sweep to be plotted.

Figure 6 shows a 20-kHz squarewave output. This particular squarewave was observed at the output terminal of the timebase generator section, but equally steep squarewaves can be obtained at the sweep-generator output terminals.

Figures 7 and 8 are scope photos taken of the triangular and ramp-shaped waveforms at the output jack of the timebase generator section. A sinusoidal timebase is also available from this output terminal.

Based on our tests and measurements, we conclude that the model 101 Audio-Plus Test System would be a useful addition to anyone’s audio test bench.
CONTINUING ADVANCES IN LARGE-SCALE integrated-circuit (LSI) technology have made possible the development of low-cost, high-performance digital test equipment. The OPTO-7000 Frequency Counter requires only five integrated circuits to achieve its remarkable performance specifications that would have been impossible just a few years ago. An additional benefit of LSI IC's is apparent when you consider that this 7-digit, 600-MHz frequency counter requires only 200 mA of current (at 5V) making battery operation practical. In general the counter’s low cost (about 15c per MHz), high performance, small size and minimal power consumption is a direct result of LSI integrated circuits incorporated into the design.

Figure 1 shows the counter’s excellent sensitivity from 10 Hz to over 600 MHz, covering low-end audio through the UHF amateur and commercial communications bands. These bandwidth/sensitivity specifications compare with those found in state-of-the-art commercial test-bench instruments. A complete listing of the specifications appears in Table 1. The OPTO-7000 will provide you with what amounts to a sophisticated test-bench instrument that is rugged enough and small enough to be carried in a tool box and ready to go anywhere anytime.

How it works

The unit of frequency measurement is the hertz, which is equivalent to cycles-per-second. The basic digital frequency counter uses a pulse with a precisely generated width called a gate interval in conjunction with an electronic counter that counts cycles of the input signal during the time period in which the gate is open. If the gate period is 1 second then the number displayed by the counter is cycles-per-second. If the gate period is 0.1 second then the displayed count is corrected by multiplying by 10 (moving the decimal point one position to the right).

The counter—The OPTO-7000 block diagram is shown in Fig. 2. The gate and the decade counter are contained in the 7208 IC. The gate signal is generated by the 7207-A IC that divides the crystal oscillator frequency to obtain a squarewave with either a 2-second or 0.2-second period. Therefore, gate signal is low for either 1 second or 0.1 second. This opens the gate for the passage of the input signal to the counter. As the gate signal goes from low to high to close the gate, a store pulse—generated by the 7207-A—causes the contents of the counter to be transferred to the latch and then displayed. A reset pulse follows the store pulse to reset the counters to zero to be ready for the next negative gate interval.

Prescaler—The maximum signal frequency that the 7208 can handle is between 6 and 7 MHz. The input signal must be prescaled or divided to count higher frequencies. The 74196 IC generates a BCD output and we use the 2' bit to drive transistor inverter Q5 (see the Fig. 3 schematic) to obtain a 60-40 duty-cycle squarewave suitable for driving the 7208 counter.

In order to count frequencies as high as 600 MHz, the 11C90 UHF divide-by-10 prescaler is used so that input signals above 60 MHz are divided by 100 before reaching the 7208 counter. The decimal point is switched to the correct location by the gate-select switch.

Input amplifiers—Dual inputs and amplifiers are used for the 10-Hz and 60-MHz and 10-600-MHz ranges. Both inputs have back-to-back signal diode clamps for overvoltage protection.
The 1-megohm (60-MHz) input uses an FET/bipolar pair to provide a high input impedance and low output impedance along with a small amount of voltage gain. Resistor Rx is matched with the FET to set the voltage at IC2 pin 9 to 1/2 the supply (2.3 to 2.7 volts). The MC10116 is an ECL (Emitter-Coupled Logic) triple line receiver. The first two stages are connected as differential input/output amplifiers while the third stage has positive feedback to act as a Schmitt trigger to square up the waveform. Transistor Q4 (MPS6516) converts the ECL logic levels to TTL.

Several low-cost frequency counters on the market economize by having a lower than 1-megohm input impedance on their low-frequency (less than 60 MHz) range. The advantages of having a 1-megohm input impedance are well worth the additional parts cost. The counter's input impedance is seen as a load by the circuit being measured. An oscillator may shift frequency or stop when loaded by only a few thousand ohms. Oscilloscope accessories such as 10:1 probes and terminators can be used because most scopes have 1-megohm inputs. This counter's input impedance can always be lowered to match a different source impedance by using a terminator or adding a shunt impedance; but it is not as easily increased.

The 11C90 prescaler has good sensitivity (typically less than 200 mV) without preamplification. However, we decided that the OPTO-7000 should have at least one stage of preamplification in order to meet a wider range of applications. A 2N2857 NPN RF amplifier is used in a common-base configuration to provide voltage gain all the way to 600 MHz. The PC layout is critical at high frequencies and good soldering techniques are important. The ceramic disc capacitors used should have low self-inductance such as the Sprague 5G series. Component leads must be kept as short as possible to prevent attenuation due to lead inductance.

If you don't expect to be counting frequencies above say 450 MHz, then additional sensitivity and significant power savings can be made possible by lowering the supply voltage to the 11C90. Resistor R6 can be increased until the counter will count 450 MHz but no higher. The 11C90 will operate with as little as 3.5 volts and the only sacrifice is bandwidth.

At very high frequencies, a high input impedance cannot be maintained. The internal shunt capacitance in coax input cables at high frequencies reduces the input impedance. A nominal 50-ohm input impedance is therefore used on the

<table>
<thead>
<tr>
<th>Frequency Range:</th>
<th>10 Hz to 60 MHz (65 MHz Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Impedance:</td>
<td>1 meg shunted by 20 pf (60 MHz input)</td>
</tr>
<tr>
<td>Power Protection:</td>
<td>1 meg/60 MHz input—100V up to 10 MHz 50V up to 60 MHz</td>
</tr>
<tr>
<td>Gate Times:</td>
<td>100 millisecond</td>
</tr>
<tr>
<td>Resolution:</td>
<td>1 Hz (10 Hz to 6 MHz) with direct-counting option 10 Hz (10 Hz to 60 MHz) 100 Hz (10 MHz to 600 MHz)</td>
</tr>
<tr>
<td>Sensitivity:</td>
<td>10 MV to 60 MHz 25 MV to 150 MHz 50 MV @ 450 MHz typ. ~75 MV Guaranteed</td>
</tr>
<tr>
<td>Timebase:</td>
<td>Quartz Crystal, 5.24288 MHz, TCXO, first order linear compensation</td>
</tr>
<tr>
<td>Counter Accuracy:</td>
<td>±1 count, temperature stability and aging</td>
</tr>
<tr>
<td>Temp. Stability:</td>
<td>±0.8PPM/C (±1 PPM 20° to 40°C, Typ.)</td>
</tr>
<tr>
<td>Aging:</td>
<td>&lt; PPM/year</td>
</tr>
<tr>
<td>Display:</td>
<td>7, 4&quot; Red LED Digits</td>
</tr>
<tr>
<td>Power Requirement:</td>
<td>1.5 Watts 7.5-15V DC/AC @ &lt;250 MA</td>
</tr>
<tr>
<td>Batteries:</td>
<td>4—AA NiCad, Constant Current Charger</td>
</tr>
<tr>
<td>Size:</td>
<td>1 1/4 x 4 1/4 W x 5 1/8-inches D</td>
</tr>
<tr>
<td>Weight:</td>
<td>14 oz. (17 oz. with batteries &amp; charger)</td>
</tr>
</tbody>
</table>

Note: The OPTO-7000 frequency counter is available as a kit for $99.95 or assembled for $139.95 from Optoelectronics, Inc., 5821 NE 14 Ave., Ft. Lauderdale, FL 33334. A kit, No. 7000-PCB, containing the two circuit boards is available for $14.95. Accessories available for the OPTO-7000 in both the kit and assembled versions: Power pack for 117 VAC line operation, model AC-70, $4.95. Rechargeable battery pack for internal installation; includes NiCad cells, holder, constant-current charger and mounting hardware, model NiCad-70, $19.95. Optional switch for 1-Hz resolution to 6 MHz, model S-4, $4.95. Optional precision crystal oscillator, model TCXO-70 ±0.1 PPM from 17 to 40°C, precalibrated, $79.95.

Add 5% to all orders to cover shipping, handling and insurance. Florida residents add state and local taxes as applicable.
600-MHz input.

Timebase—A frequency counter's accuracy is a function of its timebase stability. The quality of the quartz crystal used is of paramount importance. The inexpensive and readily available color-burst TV crystal (3.59545 MHz) was found unsuitable as a counter timebase. Color-burst crystals are manufactured to loose specifications (in a TV set they are phase-locked to the network signal). While suitable color-burst crystals can be hand-picked from batches they still have what crystal manufacturers refer to as "glitches." When temperature-cycled they behave erratically and depart from a smooth temperature/frequency curve.

The 7207A timebase generator is designed to use a 5.24288-MHz crystal. This frequency falls within the inherently stable 4-10-MHz range for quartz crystals. The crystal used in the OPTO-7000 counter is guaranteed to meet or exceed 5-
ppm stability from 20° to 60°C. Industry specs for the color-burst crystal is 30 ppm from 20° to 60°C. Over the more realistic range of 20° to 40°C, the typical stability of the OPTO-7000's crystal is on the order of 1 ppm and 0.5 ppm close to room temperature. The oscillator uses first-order linear temperature compensation to improve temperature stability over the crystal specs. Each crystal's temperature frequency curve is plotted and a pair of temperature compensating capacitors are selected to provide compensation. Good long-term stability is achieved by pre-aging the crystal. The 7207A in conjunction with the crystal generates all clock signals as well as the display multiplex frequency.

Assembly details
As in any valuable project, each design phase must enhance the other. Especially in sensitive electronic equipment where a good, solid circuit design could either be complemented or destroyed by its physical layout. The mechanical design of this frequency counter has many features that are the result of user considerations.

As a note, the specifications shown in Table 1 are typical for the frequency counter shown in this article, using the PC boards designed with the proper impedance and should not be compared with results obtained from one built by other means.

As for assembling the unit, you couldn't ask for anything simpler. Of course, your best soldering techniques will pay off here. Positions of most components are silk-screened on the boards (if you etch your own boards you'll have to follow Figs. 4, 5, 6, 7 and 8). The two BNC connectors and the power input jack, J1, J2 and J3, are mounted on the rear panel. By referring to Figs. 6 and 8 and the parts list, install all components in the boards, except the three DPDT slide switches. Make sure to orient all diodes and polarized capacitors as indicated by the component layouts. Solder all component leads (top, bottom, or both sides) wherever a pad is provided and trim the excess leads.

There are four pads on the main board, marked with boxes (C), which require a piece of excess resistor lead inserted through each of them and soldered on both sides of the board. Trim the excess leads after soldering. Sockets are provided for all IC's with the exception of IC2, the MC10116, which is exceptionally reliable and performs a little better when not socketed. The voltage regulator is bolted to the top side of the PC board with a mica insulator. The crystal is also mounted on top of the PC board using a double-stick foam pad as an insulator and shock mount over IC4.

Align the display board at right angles to the main board with two pieces of excess resistor lead passing through pads.
FIG. 6—PARTS PLACEMENT DIAGRAM for the main board. When board is installed most parts are toward the inside or bottom side of the case. Ground plane with switches faces upward.

FIG. 7—DISPLAY BOARD foil pattern. You may want to make several and adapt them for use in other digital instruments using the FND357 or similar 7-segment LED displays.

FIG. 8—COMPONENT SIDE of the display board. Leads through pads E9—E10 and E11—E12 form right-angle bracing when display board and main board are mated.

E9–E10 and E11–E12. Make sure the triangle marks on the sides of the display board foil line up with the ground-plane surface of the main board before soldering these two wires. This insures the correct mechanical positioning of the display board for interconnection soldering. Solder the 18 interconnections, being careful not to short any adjacent pads.

Next, install the three DPDT slide switches in the top cover, using six 4-40 X 1/4-inch flat-head machine screws. Place the main board flush over the switches, with the display board facing forward and the switch terminals extending up through the component side of the main board. Solder all switch terminals to the main board. This insures the correct mechanical relationship between the main and display boards, switches and top cover, so there will be no stress on any solder connections during final assembly. Remove this assembly from the top cover by removing the six switch screws.

In preparation for hooking up the rear panel, solder two 1/4-inch pieces of hook-up wire in E17 and E18 on the main board. Next, solder a 1-inch piece of excess resistor lead in E2 and one end of C2 in E1. Install the two BNC connectors and the power input jack on the rear panel. Solder a 1/4-inch piece of excess resistor lead to the solder lugs on J1 and J2. Place the rear panel assembly against the rear edge of the main board. Solder the loose end of the wire, in E2, to the center conductor of J2 above it. Now solder the loose end of C2 to the center conductor of connector J1. Solder the two 1/4-inch pieces of wire on the ground lugs to the ground plane of the main board. Solder the stranded hook-up wire from pad E17 to the center terminal of the power input jack and the wire from pad E18 to the outside terminal of the power input jack.

Install this assembly in the top cover as before, using the six 4-40 X 1/4-inch flat-head machine screws. Carefully place the bottom cover over this assembly so that the press nuts are in the forward position and the rear panel fits outside the corner brackets. Secure the top and bottom covers together with two 4-40 X 1/4-inch machine screws in the rear holes. Attach the rear panel with two 4-40 X 1/4-inch machine screws and the display window with two 4-40 X 1/4-inch machine screws.

Install the bracket/stand using two 6-32 X 1/4-inch machine screws and two rubber washers. Place the washers next to the case. Finally, apply the self-stick rubber feet and you’re ready for check-out and calibration.

Direct counting
If you are going to be doing a lot of audio and low-frequency counting in the 10-Hz to 6-MHz range then there is a simple modification you can make to the OPTO-7000. The 74196 IC can be re-continued on page 90
Video Motorcycle Game

Keep up with the advance in video game sophistication by building this single-player game for lots of fun and excitement.

L. Steven Cheairs

This arcade-quality video game is a follow-up to the "Tank Battle" described in the November and December issues. The heart of this game is one LSI IC that contains a complex audio sound generator, a complete timing circuit (thus allowing for unique point identification anywhere on the television screen), the motion logic, a number of ROM image arrays, chip buffering and color video circuits. The video circuit includes the horizontal and vertical blanking, the horizontal and vertical sync circuits, the color circuits, the field intensity circuit, and logic for both the American NTSC and the European PAL screen format.

It doesn't require much imagination for the operator to find himself or herself upon the back of an iron stallion, with a faint taste of dust and a distant roar of the elated crowd; that sound is only surpassed by the mechanical snorting of the throbbing steed. With but a wrist's twitch the ultimate of freedom and adventure is realized.

This is made possible by another new dedicated IC introduced by General Instruments Corporation. There is as much difference between this game and the common pong-type units as there is between an earthworm and man. This is the second IC in a new generation of video games; the first is GI's AY-3-8710-1 battle game.

This single-player game begins when a mode of play is selected; reset is automatic when power is first turned on. Four games are provided; each with two levels of complexity. The four games are Drag Race, Enduro, Stunt Cycle and Motocross. A single motorcycle and rider is displayed on a tri-segmented road that, in most of the games, contains obstacles that the rider must jump. As with the tank game, realistic engine and crashing sounds are provided. As the motorcycle changes its speed or when it shifts gears, the engine sounds change to reflect these conditions. Realistic wheel rotation is displayed.

FIG. 1—TYPICAL VIDEO IMAGES as they appear on the TV screen. The Drag Race at a, Stunt Cycle at b, Motocross, the easy way at c and the hard way at d. Enduro the easy way (e) has single obstacle on first and second rows; the hard way (f) has two obstacles in the first and second rows.
The games begin with the rider at the top left-hand side of the screen. The cycle begins to move when the throttle pot is turned. The cycle and rider move across the first track from left to right, it exits the screen and reappears on the left side of track number two; it likewise traverses this track in the same direction and exits the screen; only to reappear on the left-hand side of track number three, which again it traverses from left to right. When it exits the screen on track number three, it is replaced at the starting position and remains stationary. The throttle must be reset to the minimum speed position and again increased. See Fig. 1 for typical video images as seen using this game.

About the circuit

The AY-3-8760 was designed for both color and black-and-white operation using a standard domestic 525-line NTSC receiver or 625-line PAL units. The complete game unit is shown schematically in Fig. 2. In addition to automatic reset at turn-on, reset also occurs when any game is selected by pressing one of the four momentary contact SPST pushbutton switches (S2-S4). Also, an SPST switch (S1) is used to select either the pro or amateur skill level; I use a rotary switch that protrudes from the left side of the case—acting as one handle bar. The THROTTLE pot protrudes from the right side of the case, thus, forming another handle bar.

Upon pressing the DRAG RACE select pushbutton the screen takes on the form as seen in Fig. 1-a. The score is automatically reset to zero upon pressing a game select switch. The object of the DRAG Race game is to reach the right side of the third (bottom) track segment in the shortest possible time, the minimum score. At the end of each game return the pot to the slow position; when it is increased again the score will be reset and

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**PARTS LIST**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1</td>
<td>AY-3-8760 video game IC</td>
</tr>
<tr>
<td>IC2-a</td>
<td>1/4 4001</td>
</tr>
<tr>
<td>IC2-b</td>
<td>1/4 4001</td>
</tr>
<tr>
<td>IC2-c</td>
<td>1/4 4001</td>
</tr>
<tr>
<td>IC3</td>
<td>555 timer</td>
</tr>
<tr>
<td>IC4</td>
<td>MC1306 1/4-watt audio amplifier</td>
</tr>
<tr>
<td>IC5</td>
<td>7805 5-volt regulator (TO-220 case)</td>
</tr>
<tr>
<td>T1</td>
<td>power transformer, 12 VAC, 1A secondary</td>
</tr>
<tr>
<td>F1</td>
<td>1 amp fuse</td>
</tr>
<tr>
<td>S1</td>
<td>SPST toggle or rotary switch</td>
</tr>
<tr>
<td>S2</td>
<td>SPST normally open pushbutton switch</td>
</tr>
<tr>
<td>S6</td>
<td>SPST toggle switch</td>
</tr>
<tr>
<td>SPKR</td>
<td>8—16-ohm speaker, 0.25 watt or higher</td>
</tr>
</tbody>
</table>

The following are available from Questar Engineering Co., 50 S. McDonald St., Mesa, AZ 85202: PC board $9.75; AY-3-8760 $25.50; and kit of all parts listed above $61.75. Add $1.75 to all orders for shipping, handling and insurance.
a new game will begin. The score—a three-digit number centered at the top of the screen—is advanced at a fixed rate throughout the game. At the end of each game the score remains static until the beginning of the next game.

This game requires the development of speed-shifting skills in order to minimize one’s score. When the game begins, the motorcycle is in low gear and will move down the track at a fixed rate. The only way the cycle may be accelerated is to shift into the next gear, by returning the throttle to a “slow” position and then turning it back to a “fast” position. The cycle now moves across the screen at a higher rate of speed. If the above process is repeated the motorcycle will shift into third gear, this results in the maximum possible velocity. Thus, a minimum score is obtained when the highest gear is obtained in the shortest period of time.

When the amateur mode is selected by the PRO/AM switch, the game proceeds just as described above. But when the professional mode is chosen, then when the user twists the throttle too rapidly, the motorcycle’s front end raises off the ground and the cycle flips upside down. When a crash occurs a high-pitched screeching sound is generated. At the end of the screech the game is reset with the bike reappearing at the beginning of track 1. No crashes occur in the easy mode. If the game is being displayed on a black-and-white television set then the cycle and score are white; the track is black; and the background is gray. On a color set the cycle and score are also white. Also, the road is black; only the background is changed—it is red. For all games included on the motorcycle-game IC only the background is in color.

Upon pressing the STUNT CYCLE select switch, the screen will be as seen in Fig. 1-b. The score is preset, the left digit is set to zero and the right digit will be an eight. The right digit (or digits as the game proceeds) equals the number of buses between the ramps. The left digit represents the number of crashes; the maximum amount possible depends on the setting of the PRO/AM switch. In the amateur mode a total of seven crashes may occur. But in the professional mode three crashes only are permitted.

Crashes can occur due to a number of factors. As in the Drag Race game, if the motorcycle is accelerated too rapidly it will flip upside down and a screeching sound is generated. Another method of crashing is to have an insufficient speed upon jumping the buses. This causes the cycle to land on either the second ramp or on one of the buses. A collision is also recorded if the cycle lands too far past the end of the last ramp and an appropriate crash sound is generated. Every time an accident occurs the left digit is advanced and the cycle and rider are placed back at

continued on page 69
Part 2—With digital circuitry becoming an increasingly important factor in our everyday lives, it's time that we learn how to design logic circuits.

Here the author discusses digital logic design—
including sequential circuits and multiple output functions.

JERRY WOOLSEY

LAST MONTH WE WENT THROUGH THE BASICS of digital circuit design, using Karnaugh maps and Quine-McCluskey tables. Now, we'll look at multiple-output functions and those where the output depends on sequential input events.

Multiple-output functions

It is often the case that we wish to design a circuit with not only multiple inputs, but also multiple outputs, all of which are dependent on the same inputs. In the truth table of Fig. 17-a, we show such an example, with three inputs, a, b and c, and three outputs, \( f_1 \), \( f_2 \) and \( f_3 \). Each of these functions could be treated separately, and designed using Karnaugh maps, as shown in Figs. 17-b and 17-c. However, this type of design does not lead to optimum gate use. Some gates are repeated, and combinations of gates to perform several functions cannot be taken into account. To resolve this, we resort to a modified Quine-McCluskey method.

The workings are similar to the method described for a single-output function, but all three functions are combined into one table, and each entry is subscripted with the functions \( f_1 \), \( f_2 \) or \( f_3 \) that it covers. Refer to Figs. 17-a and 18-a. Since an input of all zeroes produces no 1-outputs, we have no 0-bit group in the input column of the Q-M table. An input of 1 (abc = 001) causes a 1-output for functions \( f_1 \) and \( f_2 \), so we enter a 1 subscripted with these functions in the 1-bit group. We continue in this manner, filling the input column as we did for a single-output function, subscribing each

We now proceed to form 1-cubes as before, except now we must make sure that at least one subscript is common to each of the lower cubes being combined. (See Fig. 18-b.) Inputs 1 and 3 are adjacent, and also have the same subscripts, so we enter this in the next column as a 1-cube, also entering the subscripts. The 1 and 3 entries in the input column can be checked off, since the 1-cube just formed covers both of these inputs for all outputs. Inputs 1 and 5 are adjacent and have a common subscript, \( f_3 \), so we enter this as a 1-cube, but the subscript is only entered for \( f_3 \), since this is the only common subscript and hence the only function which contains this 1-cube.
We do not yet check the 1 or 5 in the input column, since the higher cube does not cover either input for all functions. The input 5 is checked off when we combine it with input 4, since the cube formed has the same subscripts as 5. We continue as in the case of single-output functions, until there are no more cubes that can be formed. The completed table appears in Fig. 18-b.

<table>
<thead>
<tr>
<th></th>
<th>F₁</th>
<th>F₂</th>
<th>F₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>*2—f₁ f₂</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*4—f₁ f₂ f₃</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*1,3—f₁ f₂</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1,5—f₂</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2,3—f₁</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*4,5—f₂ f₃</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**FIG. 19**—COVERAGE MAP is generated from the table shown in Fig. 18-b.

A cover map is now made as in Fig. 19, which includes the inputs that will produce a 1-output for each separate function as column headers and the unchecked entries of Fig. 18-b as row headers. Since the row labeled 2 is subscripted with f₁ and f₂, we check the columns labeled 2 under f₁ and f₂, and so on for all the rows. Following the covering procedure outlined previously, we find that the rows marked with an asterisk are essential to cover all the columns. The circuit can now be drawn.

A gate is drawn for each row with an asterisk, again with the inputs to the gates corresponding to the nonchanging coordinates of the cube formed by the row header. We then draw three output gates with no input connections, and the result is as in Fig. 20.

Returning to Fig. 19, we now take a minimum cover for each separate function. For f₁, we see we need the rows labeled 2, 4 and (1,3) to cover the columns under that function. The gates corresponding to these rows are thus fed to gate f₁. For f₂, we need only (1,3) and (4,5) to cover all 1-outputs, so we feed these gates to gate f₂. Note that the row labeled 4 is not needed for f₁, even though it is checked in f₂, because this is covered by the 1-cube (4,5). Similarly, f₃ requires rows 2 and (4,5). The completed circuit now appears as in Fig. 21, and is a substantial savings over the circuit shown in Fig. 17-c.

**Sequential Circuits**

Up to this point, we have concerned ourselves only with circuits whose output depends solely on its input at a given time. However, it is often the case that a circuit must produce an output that depends not only on the present inputs to the circuit, but also on previous inputs (or outputs). To perform this, we must make use of a "memory" circuit to hold the previous information. For the experimenter, the simplest type of memory circuit is the flip-flop. When fed a clock pulse, it will store information according to its input, and hold it until the next clock pulse. This implies we must have a clock running the circuit, which we will consider later.

We can thus hold information from one clock pulse to the next. But suppose we need to know not only what happened on the previous clock pulse, but a string of several before that. We could store the entire string in a series of flip-flops, i.e., a shift register, but this could be costly for long strings and wasteful of gates, since we do not really need to look at every bit in the string as it comes in.

Instead, we can assign to each unique string of bits that may appear at the input a state number that corresponds to that string. We know what the string was if we know what the state number is. Thus, the input string 0000 could be assigned a state number of 0, the string 0001 a state number of 1, etc. At first glance, this does not seem to help matters much, since a 4-bit input string can have 16 possible states, which requires 4 bits for saving the state number, which is the same number required to hold the input string. But this is not necessarily so, depending on the function, and if it is so, methods have been devised for reducing the number of states. What we need to do, then, is store the state number, and update it as each bit enters.

In implementing sequential functions, we make use of two tools known as the state diagram and state table. These merely show us the possible states that our function may assume. We start first with the state diagram.

As an example, let us assume that we have a string of bits entering our circuit, and we want to know when the pattern 1101 enters. It may come at any bit time, i.e., it may start at the first bit entered, or the third, etc. We start the state diagram by assuming an initial state which we call state A, and write this down in a circle. See Fig. 22-a. There are two possible occurrences at state A; we may receive either a 0 or a 1. If we receive a 0, we have not detected the start of the string 1101, so we draw an arrow from A back to itself and label it 0/0 (applied input/generated output). This means we follow this arrow if we are at state A and receive a 0-input, and the output of the circuit is to be 0. The arrow, of course, brings us back to state A to look for the first bit of the string.
This loop will continue until a 1-bit is received. At this point, we must "remember" that we have found the first bit of the string, so we draw an arrow to a new state which we name B. The arrow is labeled 1/0, and indicates that if we are at state A and a 1 is received, we are to go to state B and output a 0. Since we have covered both input conditions for state A, we move to state B. If we are at state B, we have received the first 1 of the string. If we now receive a 0, we must go back to state A, and start searching for the beginning of the string again.

If a 1 is received, we have received the first two bits of the desired string, so we could go to a new state, E, which simply ignores the remainder of the incoming data and outputs a constant 1 (or it could output a constant 0 or follow the incoming data). See Fig. 22-c.

Now, using Fig. 22-d, we put the diagram down in a state table, as shown in Fig. 23. The "Present State" (PS) column lists all the states that appear on the state diagram. The "Next State" (NS) column lists the next state to go to when the input is 0 (x = 0) or 1 (x = 1). For example, if we are at state A and receive an input of x = 0, the next state is A. If we receive an input of x = 1, the next state is B. The output column specifies the output to be produced when at the present state and an input of x = 0 or x = 1 is received. For example, the only time a 1 is output is when we are at state D and the input x = 1 is received.

We can now assign numbers to the states, letting A = 0, B = 1, C = 2 and D = 3, and obtain the Transition Table shown in Fig. 24. Note that with only four possible states, we need only two flip-flops to "remember" the 4-bit sequence. This table will be used later to construct the actual circuit.

Multiple input circuits can also be designed using this method. For example, Fig. 25 shows the state diagram for a circuit which is to produce a 1-output only when two input lines simultaneously input the string 1101. The NS and OUTPUT columns of the state table would then have four sub-columns, for inputs x = 00, x = 01, x = 10 and x = 11.

As another example, suppose we wished to design a circuit that would compute odd parity for a 3-bit data word, and set a flag when the parity bit was ready, after which it would compute parity on the next three bits, etc. Figure 26 shows the state diagram for the circuit. The first bit of the output is the parity bit, and the second is a flag indicating when the parity bit is ready to sample. The state table is shown in Fig. 27. Looking at the state table, we see that both states D and G advance to the same state (A) when x = 0 is input, and advance to the same state (A) when x = 1 is input. Also, the outputs of the two states are the same when x = 0 is input and when x = 1 is input.

Since the entire row D (except, of course, the PS column) is identical to G, the two states are equivalent, and we can strike out state D and replace all references to it with state G. States E and F are also equivalent, so we can eliminate state E and replace references to it with state F. Our reduced state table now appears as in Fig. 28, and we number the states to obtain the transition table shown in Fig. 29.

We are now ready to design the actual circuit, using the table of Fig. 29. We will use D-type flip-flops as memory elements, since these have only one input, as opposed to two for the J-K flip-flop. When a clock pulse occurs on a D-type flip-flop, it merely stores the value present at its input at the time of the pulse, and makes this available at the Q-output, while the inverse is available at the Q'.output. Three flip-flops are needed to hold the current state numbers.

Suppose we have the PS = 00 stored in the Q-outputs of flip-flop 1 (FF1), FF2 and FF3, and at the next bit time the input is x = 0. We then wish to set the flip-flops so that the Q-output of FF1 is 0, FF2 is 0, and FF3 is 1, so we know we are now at state 001. From state 001, if x = 1 is applied, we want to set FF1 to 0, FF2 to 1 and FF3 to 1 to indicate the new state, 011, etc.

We need three combinational circuits for this, one for each flip-flop, to place a 0 or a 1 at the input of each flip-flop. The input to the combinational circuits will be...
The outputs of the flip-flops, i.e., the PS, and the input x. We can label the PS-bits as p₁, p₂, and p₃, so a PS of 011 indicates p₁ = 0, p₂ = 1, and p₃ = 1, where pᵢ is the Q-output of FFᵢ. Now we can see that our combinational circuits have four inputs, p₁, p₂, p₃, and x, and one output, which we can label nᵢ to correspond to the bits of the number of the next state.

It is thus an easy matter to draw a Karnaugh map for each flip-flop input. Figure 30-a shows the map for FF₁. If the PS is 000 and x = 0 is applied, then n₁, the first bit of the NS, is to be a 0, so in the box with coordinates p₁p₂p₃x = 0000, we place a 0. Similarly, for a PS of 000 and x = 1 (p₁p₂p₃x = 0001), we must have n₁ = 0, so a 0 is placed in box 0001. When the PS is 001 and x = 0 is applied, n₁, the first bit of the NS, is to be a 1, so a 1 is placed in box 0010. This procedure is repeated up to p₁p₂p₃x = 1001. Since there is no state 101, we can enter a “d” (don’t-care) in boxes 1010 through 1111. Using the d-labeled boxes, we get the resultant equation for n₁, which is also shown in Fig. 30-a. The same procedure is repeated for bits n₂ and n₃ of NS, as shown in Figs. 30-b and 30-c. With these outputs applied to the inputs of the flip-flops, they will assume the correct next state after the next clock pulse.

The output functions are also designed in this way, since they depend on only the PS = p₁p₂p₃ and the input x. Labeling the first output bit o₁ and the second o₂, the equations are written from the Karnaugh maps as shown in Figs. 31-a and 31-b.

Each of the five functions may now be easily implemented, as shown in Fig. 32. The outputs pᵢ of the flip-flops are fed back to the NAND gates as shown. In actual operation, the circuit would be set to the initial state before use by toggling the CLEAR inputs on the flip-flops by a computer command or a manual switch.

This circuit could also be realized using J-K flip-flops, using two input circuits to each flip-flop instead of one. Thus, we would need eight Karnaugh maps, one for each J-input, one for each K-input, and one for each output. These would be derived from the truth table of the J-K flip-flop, shown in Fig. 33.

As an example, referring to Fig. 29, if we wish to find the J-input of FF₁ to obtain the next state (call this J₁), we draw the Karnaugh map as in Fig. 34. For p₁p₂p₃x = 0000, we change the first state bit from 0 to 0, which requires a J-input of 0, so we enter a 0 in box 0000. With the PS = 001 and an input of x = 0, we must change the first bit of the state from a 1 to a 0, which requires a J-input of 1. If the clock pulse occurs as close to the middle of the bit time as possible. The clock pulse must not begin until all gates have had time to settle after the new input bit has arrived and must end before the next data bit arrives.

We have now gone through the basics of logic design, and you should be able to design most common types of circuits using methods that will produce a more efficient circuit.
4-Channel FM

With discrete and matrixed 4-channel tape and phono formats dormant, the fight for 4-channel programming continues on the broadcasting front.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

IT HAS BEEN SOME TIME SINCE WE DISCUSSED QUADRIPHONIC SOUND; INDEED, SUPERFICIALITY AT LEAST, IT WOULD SEEM THAT THE AUDIO INDUSTRY AND CONSUMERS ALIKE HAVE ALL BUT TURNED THEIR BACKS ON 4-CHANNEL SOUND. VERY FEW, IF ANY, 4-CHANNEL RECORDS ARE PRESENTLY BEING RELEASED (ALTHOUGH THE NUMBER OF AVAILABLE RELEASERS IN ALL FORMATS—MATRIX OR DISCRETE—EXCEEDS 1000), AND HI-FI COMPONENT MANUFACTURERS HAVE ALL BUT ABANDONED PRODUCTION OF ANY QUADRIPHONIC REPRODUCING EQUIPMENT.

There is one aspect of the 4-channel scene that is very much alive—4-channel FM broadcasting. Back in March, 1972, when interest in quadrophonics was at its height, the Consumer Electronics Group of the Electronics Industry Association (EIA) voted to sponsor the organization of a National Quadriphonic Radio Committee (NQRC) whose objective was to report to the Federal Communications Commission its final technical conclusions regarding 4-channel FM sound broadcast standards. The FCC endorsed the study project and the NQRC plunged into its complex task of analyzing, evaluating, and, finally, field-testing five proposed systems for discrete 4-channel FM broadcasting.

The work continued until late 1975 and, in November of that year, the final NQRC report was submitted to the FCC. Nearly two years later, on July 6, 1977, the FCC released its formal Notice of Inquiry (Docket 21310) on quadriphonic FM radio broadcasting, in which all interested parties were asked to comment on whether the FCC should adopt standards for 4-channel broadcasting. The Commission said that the purpose of the inquiry was to determine whether there was sufficient public and industry interest to warrant the adoption of standards, and, if so, to assist the FCC in formulating such standards. The comment period, originally scheduled to end on September 15, 1977, was extended to December 15, 1977; and, from all accounts, more than a thousand letters were received by the time the comment period ended.

Several other events occurred almost simultaneously, two of which tended to complicate the issue. First, coincident with issuing the 4-channel FM Notice of Inquiry, the FCC also issued a second Notice of Inquiry (Docket 21313) regarding AM stereophonic broadcasting. A growing interest has been shown on the part of AM broadcast stations for this type of service, largely because of the competitive advantage gained by FM stations over the last decade. This advantage has been attributed by many to the fact that FM stations can transmit stereo program material while AM stations must transmit monophonic programs. Many industry experts feel that the FCC is more likely to pay attention to AM stereo broadcasting before it ever considers the problem of 4-channel FM transmission.

The second event that occurred was sponsored by the FCC itself. The Commission was concerned that the NQRC had only included one matrix system in its report, and had not involved subjective listening evaluations of either the QS matrix system (developed by Sansui Corporation of Japan) or the SQ matrix system (originated by CBS in the U.S.). As they pointed out, since the work of the NQRC was completed, much-improved logic and phase cancellation decoders were designed and developed for the QS- and SQ-systems. As a result, the FCC felt that available test data comparing localization and musical preference for 4-4-4 (discrete), 4-3-4 (semidiscrete, using three channels of transmission to broadcast four channels of information) and 4-2-4 (matrix-encoded using two channels for transmission) quadriphonic systems is not complete with respect to presently available technology.

The FCC Lab decided to conduct its own listening tests, including the best implementation (based upon the listener's choice) of the QS format, SQ format and the British-sponsored BBC Matrix H systems, as well as the discrete 4-channel tapes. The results of these tests were issued by the FCC in August, 1977. In addition to judging quadriphonic performance, listeners were asked to evaluate the compatibility of the different formats—that is, how well the music was reproduced stereophonically and even monophonically—an important criterion in any decision affecting quadriphonic broadcasting standards.

The results of these tests have been interpreted by different listeners in different ways. Since, on an overall basis, listeners agreed that the direct 4-channel

FIG. 1—DISCRETE 4-CHANNEL BROADCAST SYSTEM USES FOUR TRANSMISSION CHANNELS. TO MAINTAIN COMPATIBILITY WITH EXISTING STEREO AND MONO RECEIVERS, THE FOUR CHANNELS ARE ENCODED AT THE TRANSMITTER AND DECODED AT THE RECEIVER.

UPDATE

4 CHANNEL RECORDING

FM TRANSMISSION SIGNALS

M = LF + RF + LB + RB
Y = LF + LB - (RF + RB)
X = LF + RF - (LB + RB)
U = LF + RB - (RF + LB)

4 CHANNEL PLAYBACK

ENCODER NETWORK

DECODER NETWORK

FIG. 1—DISCRETE 4-CHANNEL BROADCAST SYSTEM USES FOUR TRANSMISSION CHANNELS. TO MAINTAIN COMPATIBILITY WITH EXISTING STEREO AND MONO RECEIVERS, THE FOUR CHANNELS ARE ENCODED AT THE TRANSMITTER AND DECODED AT THE RECEIVER.
tape reproduction was the best, supporters of discrete 4-channel broadcasting are claiming a victory. Since, of all matrix systems tested, the CBS-developed SQ system (with its sophisticated logic decoder) was favored, CBS has also claimed a victory and has, in fact, suggested that the FCC not only refrain from enacting discrete 4-channel broadcast standards but actually set quadruphonic standards specifically endorsing the SQ format as the only matrix suitable for broadcast over FM channels.

Before we examine the logic (excuse the pun) of this argument, let's briefly review how the five proposed discrete 4-channel FM systems operate. All five systems are very similar. In fact, insofar as monophonic and stereophonic performance on existing FM tuners is concerned, the systems are identical. This similarity is a basic requirement of any quadruphonic system, since they must present uncompromised FM stereophonic and FM monophonic performance. Where the systems differ slightly is in their treatment of SCA (Subsidiary Communications Authorization) services, such as background music channels now broadcast as piggy-back subcarriers on FM stations on a private, point-to-point subscription basis, which, according to the FCC, should be provided for in any new standards to be proposed.

Monophonic compatibility

Assume that there are four inputs: Left-front (Lr), Right-front (Rf), Left-back (Lb) and Right-back (Rb). To preserve monophonic compatibility, the monophonic channel or baseband of the FM transmission (the region from 30 Hz to 15 kHz) must contain an equal summation of these four input signals designated as M = Lr + Rf + Lb + Rb. For stereo compatibility, the four signals are grouped as follows: Lr = Lr  + Lb and Rf = Rf + Rb. The values of Lr and Rf correspond to the left-total and right-total signals that should be heard in stereo. Just as in stereophonic broadcasting, they are also assigned to a difference subcarrier channel, as follows: Y = (Lr + Lb) - (Rf + Rb). When these two signals are received by a standard stereophonic tuner or receiver, they are decoded as follows:

\[
L_r = \frac{M + Y}{2} = L_r + L_b
\]

\[
R_f = \frac{M - Y}{2} = R_f + R_b.
\]

Because of quadruphonic playback requirements, it is clear that two more transmission channels are needed, since, to solve for four unknowns, you must have four equations. The two additional transmission channels are defined as X and U, in which:

\[
X = (L_r + R_r) - (L_b + R_b)
\]

U = (L_r + R_r) - (R_f + L_b).

We will show how all four signals can be accommodated in a single FM transmission. But, first, let's examine what the 4-channel decoder must do after it has recovered signals M, Y, X and U to solve for the four original, discrete signals:

\[
L_r = \frac{M + Y + X + U}{4}
\]

\[
R_f = \frac{M - Y + X - U}{4}
\]

\[
L_b = \frac{M + Y - X - U}{4}
\]

\[
R_b = \frac{M - Y - X + U}{4}
\]

Figure 1 shows the principle of discrete 4-channel FM broadcasting. The question is where to assign the extra transmission channels X and U, and how to allow for continued SCA transmission. Figure 2 shows the scheme used by two of the five proponents, Quadracast System, Inc., and RCA. The newly required X channel is centered at a frequency of 38 kHz (similar to the older Y channel required for stereo), but it is in quadrature with the Y channel. This means that the X channel will not be detected by a stereophonic receiver but by a properly designed 4-channel receiver having a synchronous detector designed for that quadrature signal. The U channel is transmitted via a new subcarrier signal centered at 76 kHz (four times the 19-kHz pilot-carrier frequency). The QSI format further proposes that the SCA channel be moved from its present frequency of 67 kHz to 95 kHz and that it be band-limited in order not to interfere with adjacent broadcast channels.

RCA proposes an additional scheme that allows the SCA to remain where it presently is. This is the so-called 4-3-4 or semidiscrete system mentioned earlier in this article. This system uses only three transmission channels (the U channel is dropped from its 76-kHz position in the spectrum), leaving room for the SCA channel at a frequency of 67 kHz. In this system, the recovered four channels include the following original signal components:

\[
L_r = L_r + \frac{1}{3} L_b + \frac{1}{3} R_f - \frac{1}{3} R_b
\]

\[
R_f = R_f + \frac{1}{3} L_r + \frac{1}{3} R_b - \frac{1}{3} L_b
\]

\[
L_b = L_b + \frac{1}{3} L_r + \frac{1}{3} R_f - \frac{1}{3} R_b
\]

\[
R_b = R_b + \frac{1}{3} L_r + \frac{1}{3} R_f - \frac{1}{3} L_b
\]

The last three components in each equation are crosstalk terms, but overall separation from one channel to any other channel is still just a bit less than 10 dB. This RCA option would be strictly up to the station owner (who wants to have an SCA subcarrier signal at 67 kHz), and receivers designed for regular 4-4-4 operation would require no modifications for the 4-3-4 system.

Another system, using the same baseband signals as those shown in Fig. 2, is the Cooper-UMX system. This scheme differs from the foregoing explanation in that it uses phasor encoding of the four input signals to create three different playback modes: A 4-2-4 matrix (similar to the QS- or SQ-matrix encoding), a 4-
3-4 playback scheme similar to the RCA optional system, and, finally, a full 4-4-4 discrete mode.

Frequency assignments for the General Electric system are shown in Fig. 3. The fourth X channel is transmitted as a set of vestigial lower sideband signals at a frequency of 76 kHz. This allows an SCA channel at a 95-kHz frequency with a greater guard band between it and the adjacent X channel subcarrier as compared with the RCA option.

Finally, Fig. 4 shows the Zenith proposal. The fourth transmission channel, the X channel, is placed at a 95-kHz frequency and uses lower sideband signals only, allowing for SCA transmission to take place at its currently assigned 67-kHz frequency. The Zenith system also uses an encode/decode noise-reduction system, similar to the Dolby system, in order to maintain a lower overall noise level; this helps to counter in part the signal-to-noise degradation that occurs whenever the spectrum width of a transmission system is increased.

Argument against a matrix standard

Proponents of the matrix system that was favored by the FCC’s panel of listeners believe that this format should be approved as a standard at this time and that no discrete systems should be approved. What would this mean to the listening public? Admittedly, if a listener equipped his or her system with a sophisticated (and expensive) logic decoder such as that used in the FCC tests, results would approximate (but still not equal) those obtained with discrete 4-channel program material. However, if a simple matrix decoder were used, results would be far poorer than those obtainable from expensive one—and first decoding the matrix-encoded source material into four discrete channels before it is transmitted. The home listener would not have reproduction quality determined by his or her financial limitations, since optimum decoding would take place at the station before transmission. This approach would keep the doors open for further improvements in matrix technology and would have many other advantages as well. FM stations could then transmit any and all formats of quadraphonic program material (instead of being limited to one specific matrix approach). Four-channel taped productions could be freely interchanged from one station to another, since no encoders or decoders would be required. Discrete broadcasts have proved to be fully compatible with all existing monophonic or stereophonic receivers. Furthermore, the matrix system still imposes certain artistic limitations upon record producers. A vocalist, for example, cannot be positioned at center-rear in the SQ system if full stereophonic and monophonic compatibility is to be maintained. Such limitations, although of relatively minor significance, are not imposed with discrete systems.

By the time you read this, the dates for filing comments and reply comments with the FCC will have passed. Nevertheless, we suspect that the FCC is not going to make any hasty decisions regarding 4-channel broadcasting. It does seem that by choosing a discrete broadcast standard, the FCC would let the final decision as to which kinds of quadraphonic records sound better remain where it belongs—with the public. A decision in favor of any matrix system as a standard would, we believe, be tantamount to taking away that freedom of choice from the music listeners of this country.

Mobile radio market to double during 1980-1986

The Mobile Radio Market, a study conducted by the market research firm of Frost & Sullivan, Inc., predicts that the mobile radio equipment market will continue to expand and even double over the next 10 years, with a projected annual compounded growth rate during the period 1980–1986. Among the factors involved in this projected growth rate are such innovations as 1) the use of digital instead of voice-generated messages in police mobile radios; 2) the increased use of voice scramblers; 3) a new consumer market in FM scanners monitoring police, fire and other public service departments; 4) the cellular approach to using the 800–900-MHz frequency band on mobile radios; and 5) the use of microprocessors and other LSI circuits in CB radios.

Despite the fact that land mobile radio equipment will be affected by declining unit prices, CB radio is expected to make a strong comeback in the vehicle market. Detroit car manufacturers plan to incorporate many more CB/AM-FM/tape deck combinations into a single passenger car unit. The cellular concept to using the 800–900-MHz frequency band on mobile radios is "likely to be incorporated in leading U.S. cities," according to the study. Companies presently developing the cellular approach are the Bell System, American Radio-Telephone Service, and NTT in Japan.

More information can be obtained from Frost & Sullivan, Inc., Customer Service, 106 Fulton Street, New York, NY 10038.

Motorola’s microwave system is an alternative to land lines

Motorola, Inc., has developed a micro-wave communications system called the Point-to-Point Wireless Visual Communications System that is used with CCTV cameras, lenses and other equipment to transmit a closed-circuit video image wherever installation of land lines is difficult or impossible.

Motorola indicates that the VCS would enable video transmissions to be made up to 10 miles in line of sight just using a single transmitter and receiver. Another advantage cited for the VCS is that users can change the location of transmission or reception sites. Further information can be obtained from Motorola Literature Distribution Center, 2122 North Palmer Dr., Schaumburg, IL 60195.

IHF to set technical standards for turntable/cassette/speaker criteria

In answer to a growing need among high-fidelity manufacturers for acceptable industry measurement standards in differentiating between high- and low-fidelity products, the Institute of High Fidelity (IHF) Board of Directors has organized standards committees to evaluate and discuss criteria for turntables, cassette recorders and speakers.

The first meeting of the IHF Turntable Standards Committee, chaired by Martin Fine of B.I.C./Avnet, set its goals for achieving its industry standard: It would attempt to 1) develop a glossary of technical terms; 2) separate these terms into primary and secondary groups; 3) develop measurement standards for both groups; and 4) devise a set of standard test conditions.

JANUARY 1979

www.americanradiohistory.com
Radio-Electronics
Tests Tandberg TDA-20A
Open-Reel Tape Deck

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

TANDBERG OF AMERICA, INC. (LABRIOLA COURT, Armonk, NY 10505) has developed an open-reel tape deck, the model TD-20A, that incorporates several electronic and mechanical innovations. The tape deck incorporates a new actileanr recording system that offers up to 20-dB improvement in headroom over most conventional systems. In addition, the tape-transport system uses four separate motors, including a motor for the pinch roller and tape guides.

Figure 1 shows that the model TD-20A can handle 10'/inch tape reels. On the front panel, three rectangular pushbuttons to the left below the feed reel handle power, select low or high speed and select the correct tape tension for large or small reels. Below these pushbuttons are rotary left- and right-channel output-level controls, while below them are four toggle switches. The left pair of toggle switches selects playback mode (left channel only stereo or right channel only), and source or tape monitoring. The right-hand pair of toggle switches activates the select-synchronization feature (in multitrack recordings the record head acts as a monitoring playback head when a second track is added in sync with the first recorded track). These same switches also handle the edit-cue function that enables you to hear recorded results as you fast-wind the tape for cueing and editing.

A pair of brightly illuminated VU meters, centered below the tape head assembly, are calibrated from -24 dB to +3 dB. However, it must be emphasized that the 0-dB level on these meters corresponds to a +9-dB level referenced to the standard NAB level of 185 nanowbers. These meters read peak signals, and are positioned in the signal path beyond the record-equalization circuits so that readings (regardless of the signal frequency being recorded) are directly related to the levels of magnetization applied to the tape.

Below the meters are a headphone output jack and two microphone input jacks. Below the takeup reel is a four-digit counter, while lower down, in the light-colored section of the panel, are five rectangular tape-transport pushbuttons: RECORD, REWIND, STOP, WIND (fast-forward) and PLAY. For the tape deck to be in the record mode, you must turn on separate left- and right-channel selector switches located on the bottom right of the panel. When either of these switches is engaged, a standby light above the RECORD switch illuminates, and touching the RECORD pushbutton starts the tape and places the tape deck in the record mode. This arrangement permits so-called "flying start" recording—inserting newly recorded signals on cue, as the machine plays back previously recorded program material.

When the STOP/WIND (fast-forward) pushbuttons are pressed simultaneously, the logic-control transport system completely frees both reels, permitting you to hand-cue the reels to a precise syllable or note in a recording. All transport modes are indicated by LED's above each transport pushbutton.

Below the transport-control pushbuttons are two pairs of input-level controls; the first pair of controls handles Line 2 or microphone input signals, and the second pair adjusts the level of Line 1 inputs. This provides full mixing capability for up to four line inputs, or two line inputs plus two microphone inputs. Once these four controls are properly adjusted, a master level control to the right of the Line 1 controls takes care of the overall level. A socket for connecting an optional remote-control attachment is located above this master level control. A two-position toggle switch at the lower right of the front panel provides selectable 25-dB attenuation for the microphone inputs, in case high-output microphones are used that might necessitate inconvenient and inaccurate settings of the separate microphone record level controls.

Other features
The model TD-20A uses no solenoids or mechanical relays, which results in an unusually quiet and noise-free performance. The drive motor is a phase-locked brushless synchronous motor with a belt-drive flywheel and capstan. A separate motor for the pinch roller and tape guides provides smooth and click-free tape positioning that Tandberg claims provides more precision and gentler tape handling.

PROM electronic speed regulation combined with triac-controlled direct-drive supply-recall and takeup-roller motors facilitate efficient fast-forward and rewind-tape tension. Separate power supplies take care of operational and audio-signal functions. This reduces the possibility of thermal stress in the electronic components and insures that external electrical disturbances do not affect sound quality. Complete logic control allows rapid transition from mode to mode, and assures gentle tape handling with controlled tension.

There are special phase-linearity correction circuits in the signal-handling electronic amplifiers of the model TD-20A. In addition, "echo" and sound-on-sound recording can be performed through external coupling from line outputs to line inputs on the rear panel.

Laboratory measurements
In previous tests on Tandberg audio products, we have noted that this company is extremely conservative when it comes to published specifications. Their tendency to understatement applies no less to the model TD-20A. In actuality, the open-reel deck measured much better than the company's published specifications indicate.

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Tape Speeds: 7'/8 ips and 3'/4 ips, Wow and Flutter: 0.06% at 7'/8 ips; 0.10% at 3'/4 ips, WRMS, Frequency Response (Maxell UD-XL Tape or Equivalent): 20 Hz to 22,000 Hz, ±2.0 dB at 7'/8 ips; 29 kHz to 18,000 Hz, ±2.0 dB at 3'/4 ips. S/N Ratio (A-Weighted): 66 dB at 7'/8 ips, Crosstalk: 60 dB, mono; 50 dB, stereo. Harmonic Distortion: for 0 dB at 7'/8 ips, 2.0%. Input Sensitivity: mke, 0.2 mV; line, 50 mV. Output Level: line, 1.5 volts; headphone, 5 mW into 8-ohm loads. Erase Coefficient: better than 70 dB. Suggested Retail Price: $1300; optional wireless PCM infrared remote-control unit, approximately $200.

Figure 2 shows the frequency response for Maxell UD tape operating at the higher 7'/8 ips speed; it was measured at a -20-dB level (referenced to the standard NAB 0 VU level). This level is actually 29 dB below the 0-dB readings on the VU meters. Response was flat to within ±2 dB from 15 Hz to 32 kHz, and variations within the audio spectrum never
exceeded 1.0 dB above or below the 1-kHz reference level.

Perhaps even more amazing was the frequency response measured for the slower 3½-ips speed, also using the same grade of tape. (See Fig. 3.) In this case, the -2 dB points were observed at 10 Hz and a superaudible 24 kHz. In separate tests, we determined just how "hard" we could record a high-frequency signal onto this tape sample. Increasing the mid-frequency record level for maximum output (the point where further increases in input level do not produce additional linear increases in recorded playback level), we noted that at the higher 7½-ips speed we could record a 10-kHz signal to a level only around 6.5-dB lower than that recordable at mid-frequencies before obtaining maximum output level.

For the slower 3½-ips speed, the maximum recording-output level obtainable at 10 kHz was approximately 14.0 dB below the mid-frequency maximum output level. These values are considerably better than those usually obtained when this tape is used on other decks, and underline the advantages of Tandberg's new recording electronics.

The Fig. 4 chart (supplied by the manufacturer) shows the practical reel-to-reel recording benefits provided by Tandberg's actilinear recording system, and also indicates the added dynamic range available at the slow 3½-ips speed at all frequencies from 333 Hz up. In Fig. 4, the 0-dB reference level is taken as 250 nanowebers per millimaxwell, or approximately 2.6 dB above the standard NAB reference record level. Results of our lab measurements are shown in Table 1.

Summary
Table 2 summarizes our overall product evaluation together with comments.

We spent a great deal of time with the model TD-20A on the lab test bench and used it to record a variety of program material. Playback reproduction is excellent, and it is hard to imagine that any features have been left out.

With so many companies concentrating solely on improved stereo cassette decks these days, it is refreshing to find a manufacturer paying attention to the needs of those who still prefer and need a top-quality open-reel tape deck.

### TABLE 1

**RADIO-ELECTRONICS PRODUCT TEST REPORT**

<table>
<thead>
<tr>
<th>Manufacturer: Tandberg of America, Inc.</th>
<th>Model: TD-20A</th>
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**OPEN-REEL TAPE DECK MEASUREMENTS**

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</thead>
<tbody>
<tr>
<td><strong>STANDARD TAPE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency response at 15 ips (Hz-kHz ± dB)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Frequency response at 7½ ips (Hz-kHz ± dB)</td>
<td>15 -32, -2.0</td>
<td>Superb</td>
</tr>
<tr>
<td>Frequency response at 3½ ips (Hz-kHz ± dB)</td>
<td>10 -24, -2.0</td>
<td>Superb</td>
</tr>
<tr>
<td><strong>CRO. TAPE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency response at 15 ips (Hz-kHz ± dB)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Frequency response at 7½ ips (Hz-kHz ± dB)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Frequency response at 3½ ips (Hz-kHz ± dB)</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

(See Figs. 2, 3)

**DISTORTION MEASUREMENTS (RECORD/PLAY)**

| Harmonic distortion at 3 VU (highest speed) (%) | N/A |
| Harmonic distortion at 3 VU (highest speed) (%) | N/A |
| Harmonic distortion at 0 VU (highest speed) (%) | 1.5 |
| Harmonic distortion at +3 VU (highest speed) (%) | 3.0 |

**SIGNAL-TO-NOISE RATIO MEASUREMENTS**

| Best S/N ratio, standard tape (dB) | 66 |
| Best S/N ratio, CRO tape (dB)       | N/A |

**MECHANICAL PERFORMANCE MEASUREMENTS**

| Wow and flutter at 15 ips (% WRMS) | N/A |
| Wow and flutter at 7½ ips (% WRMS) | 0.012 |
| Wow and flutter at 3½ ips (% WRMS) | 0.04 |
| Rewind time, 2500-foot tape (seconds) | 70 |

**COMPONENT MATCHING CHARACTERISTICS**

| Microphone input sensitivity (mV) | 0.2 |
| Line input sensitivity (mV)       | 42 |
| Line output level (mV)            | 1400 |
| Phone output level (mV or mw)     | 5.0 mW/8 ohms |
| Bias frequency (kHz)              | 125 kHz |

**TRANSPORT MECHANISM EVALUATION**

| Action of transport controls       | Superb |
| Tape guidance system              | Excellent |
| Absence of mechanical noise       | Superb |
| Tape head accessibility           | Excellent |
| Construction and internal layout  | Superb |
| Evaluation of extra features, If any | Superb |

**OVERALL TAPE DECK PERFORMANCE RATING**

<table>
<thead>
<tr>
<th>OVERALL PRODUCT ANALYSIS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail price</td>
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<tr>
<td>Price category</td>
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<tr>
<td>Price/performance ratio</td>
<td>Excellent</td>
</tr>
<tr>
<td>Styling and appearance</td>
<td>Superb</td>
</tr>
<tr>
<td>Sound quality</td>
<td>Superb</td>
</tr>
<tr>
<td>Mechanical performance</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Comments: There are so many new features in this Tandberg open-reel machine that a brief summary can hardly cover all points. Perhaps the most important feature is its capability of accepting new tapes (such as metal-particle tape) that may soon be available for open-reel decks. The bias adjustments on the front panel have sufficient range to handle the higher bias requirements of such future high-coercivity tapes. Additionally, the system's record electronics (called actilinear recording) provides more than enough recording headroom to handle those future tapes.

One of the most welcome new features is the freewheeling tape mode which, with the aid of the auto-cue switch, permits the easy and quickest tape editing we have ever had the pleasure of using. When the sprocket and fast-forward pushbuttons are touched simultaneously, both feed and takeup reels become completely freewheeling.

Tape is handled about as gently as on any machine (home or professional) we have ever tested. The four-motor drive system produces precise and unwavering tape transport, as evidenced by the excellent wow-and-flutter values shown in Table 1 for both its higher and lower tape speeds.

We have always appreciated Tandberg's post-equalization metering system that informs the user what signal intensities are actually reaching the tape. High frequencies, which are subjected to more boost by the equalization constants, show up as higher meter indications on this well-calibrated metering system, which is readable with pinpoint accuracy to better than one-half of 1 dB.

Sound reproduction via tape, even at the lower speed, is virtually indistinguishable from the original program source and that is the ultimate test for any cassette or open-reel tape deck. Although the Tandberg model TD-20A is fairly expensive, it is worth every penny of its price.
Pioneer Model TVX-9500

TV Audio Tuner

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

CONSUMER ELECTRONICS EXPERTS HAVE LONG been predicting the imminent marriage between audio and video. The introduction of the model TVX-9500 TV Audio Tuner by U.S. Pioneer Electronics (750 Oxford Drive, Moonachie, NJ 07074) may well signal the beginning of that union. This tuner’s appearance on the market is particularly timely, in view of some behind-the-scenes technology that has been taking place recently in TV broadcasting.

After many years of relaying the audio portions of a TV program from studio to transmitter via standard telephone lines (rented from A.T. & T. or other phone companies), a method of duplexing audio signals along with the video signals on the wideband coaxial cables is now being used. This new method permits TV broadcasters to transmit a full-fidelity audio signal whose response is identical to that of FM radio broadcasts. Thus, the audio portion of TV programs (long considered an industry “stepchild”) is beginning to take a turn for the better.

For some time, Public Broadcasting Service (which is noncommercial educational television) has been using satellite communications so that in this area, too, high-quality audio transmission has been possible. Still, as we all know too well, the 3-inch-diameter speakers in most TV sets, driven by minimal-quality one-stage mini-wattage amplifiers, severely limit audio quality. Attempting to bypass the poor-quality TV audio is loaded with problems (and dangerous, since most sets have no transformer isolation between power line and chassis).

Figure 1 shows the model TVX-9500, which is really just a good-quality FM tuner, whose range covers TV audio Channels 2 through 13 and UHF Channels 14 through 83.

The slim gold-anodized front panel contains a power on/off switch on the left. The remainder of the panel contains 12 slim pushbuttons labeled with channel numbers 2 to 13, above which are tiny indicator lights. To receive the audio frequencies from UHF TV channels, the UHF pushbutton is depressed, and a continuously variable tuning knob indicates approximate channel numbers in an adjacent window. A green LED indicator lights up when optimum tuning has been achieved.

Although automatic frequency control (AFC) locks desired sound-carrier frequencies for each channel, there are individual screwdriver VHF channel controls on the underside of the unit, along with an AFC defeat switch, for additional tuning adjustment, if necessary. Defeating the AFC also defeats the built-in muting circuit that normally delays sound activation for about two seconds after a given channel button is depressed.

Figure 2 shows the rear-panel layout, as well as how to connect the model TVX-9500 to a typical high-fidelity component system. Although two output jacks are provided, the TV audio signals recovered are, of course, not stereophonic. But connecting the unit to both the left- and right-channel auxiliary or tuner input jacks on your amplifier or receiver enables sound to be heard from both stereo speakers. If a single output connection is made, the same results are obtained by switching the amplifier or receiver mode selector to monophonic. Separate antenna screw-terminals are provided for connecting an outdoor VHF antenna and an outdoor UHF antenna, and are intended for a 300-ohm twin-lead transmission line. A 75-ohm unbalanced line terminal is provided for the VHF antenna only, if you wish to use a coaxial line input from that antenna.

Test procedures and results

As noted, in the model TVX-9500, TV audio is broadcast in FM. While standard 75-µs pre-emphasis and de-emphasis are used, the maximum allowable modulation is only one-third as great as that used in FM radio broadcasting, or ±25 kHz. Compared with an FM

MANUFACTURER’S PUBLISHED SPECIFICATIONS:

50-dB Quieting: 22 µV (32 dB). S/N Ratio at 85 dB: 65 dB. THD at 65 dB: 0.07% at 100 Hz and 1 kHz; 0.2% at 5 kHz. Capture Ratio: 1.0 dB. Alternate Channel Selectivity: 25 dB. Frequency Response: 50 Hz to 10 kHz, +0.5, -1.0 dB. Spurious Response: VHF, 50 dB; UHF, 40 dB. Image Rejection: VHF, 50 dB; UHF, 40 dB. IF Rejection: VHF, 50 dB; UHF, 55 dB. AM Suppression: 50 dB. Muting Threshold: 28 µV (24.1 dB). Output Level: 400 mV (for a 25-kHz deviation). Power Requirements: 120 volts, 60 Hz, 12 watts. Dimensions: 16½” W x 3½” H x 13¼” inches D. Weight: 13 lbs, 7 oz. Suggested Retail Value: $250.
tuner, therefore, there is a built-in penalty of 10-dB insofar as signal-to-noise ratio is concerned. On the other hand, the bandwidth requirements of the IF stages and FM detector stages are not as strict, and you could expect very low audio distortion.

In all other respects, the measurements shown in Table 1 were similar to those of any high-quality FM tuner, although, of course, stereophonic performance measurements were not applicable. We did however measure signal-to-noise ratio at 85 dBf instead of the usual 65 dBf. An 85-dBf value corresponds to approximately 10,000 µV of signal strength, while 65 dBf (generally used when measuring ultimate FM tuner and receiver sensitivity) is more nearly 1000 µV across a 300-ohm input. In addition to correlating our results with those in the manufacturer’s specifications, we justified the higher signal strength because TV transmitter power is ordinarily much greater than the power which FM station broadcasters are permitted to use; therefore, we can assume that if a good outdoor TV antenna is hooked up to the model TVX-9500, signal reception will also be stronger than that for FM tuners and receivers.

The Pioneer “alternate channel selectivity” specification was puzzling since this could not refer to an “alternate channel” 12 MHz away from the desired signal (or the spread between the audio carrier of Channel 7 and Channel 9, for example). We concluded that selectivity was cited as it would be for an FM tuner, and our measurements confirmed this.

Considering the stronger TV audio transmission signals, the Pioneer model TVX-9500 performed remarkably well in sensitivity, 50-dB quieting and, most particularly, in S/N ratio and distortion values. To obtain these low distortion figures, it was necessary to trim the channel tuning slightly. Our measurements were conducted with the tuner set for Channel 6. The audio carrier for this channel is at 87.75 MHz—close enough to the edge of the standard FM band for us to be able to tune our FM signal generator “on frequency.” Listening tests, however, were conducted for all available TV channels in our viewing area and we could not audibly detect any audio distortion for any channel (aside from the obvious deficiencies in the fidelity of the program sources broadcast at that time).

Summary

Our overall product analysis of the model TVX-9500 TV Audio Tuner is given in Table 2, along with our summary comments.

Frequency response was fairly flat out to 10 kHz, but was down about 5 dB at 15 kHz, the theoretical limit of TV audio broadcast capability. Still, it is amazing what TV sound can be like when it is flat even out to 10,000 Hz and is free of the distortion normally heard when such sound is reproduced by standard TV circuitry. If all TV broadcasters would pay some attention to the quality of audio they transmit, products such as the model TVX-9500 should do very well. And, who knows, perhaps the FCC may now reconsider the possibility of stereo-audio transmission on TV as well.

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td><strong>RADIO-ELECTRONICS PRODUCT TEST REPORT</strong></td>
</tr>
<tr>
<td><strong>Model:</strong> TVX-9500</td>
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<tr>
<td><strong>MANUFACTURER:</strong> U.S. Pioneer Electronics</td>
</tr>
<tr>
<td><strong>RF PERFORMANCE MEASUREMENTS</strong></td>
</tr>
<tr>
<td><strong>SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE</strong></td>
</tr>
<tr>
<td><strong>IF Noise figure, mono:</strong> (µV) (dBf)</td>
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<tr>
<td><strong>Sensitivity, stereo:</strong> (µV)</td>
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<tr>
<td><strong>50-dB quieting signal, mono:</strong> (µV)</td>
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<tr>
<td><strong>50-dB quieting signal, stereo:</strong> (µV)</td>
</tr>
<tr>
<td><strong>Maximum S/N ratio, mono:</strong> (dB)</td>
</tr>
<tr>
<td><strong>Maximum S/N ratio, stereo:</strong> (dB)</td>
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<tr>
<td><strong>Capture ratio (dB):</strong></td>
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<td><strong>AM suppression (dB):</strong></td>
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<td><strong>Image rejection (dB):</strong></td>
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<td><strong>IF rejection (dB):</strong></td>
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<td><strong>Spurious rejection (dB):</strong></td>
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<tr>
<td><strong>Alternate channel selectivity (dB):</strong></td>
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<td><strong>FIDELITY AND DISTORTION MEASUREMENTS</strong></td>
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<tr>
<td><strong>Frequency response, 50 Hz to 15 kHz (±dB):</strong></td>
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<tr>
<td><strong>Harmonic distortion, 1 kHz, mono:</strong> (%)</td>
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<tr>
<td><strong>Harmonic distortion, 1 kHz, stereo:</strong> (%)</td>
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<tr>
<td><strong>Harmonic distortion, 100 Hz, mono:</strong> (%)</td>
</tr>
<tr>
<td><strong>Harmonic distortion, 100 Hz, stereo:</strong> (%)</td>
</tr>
<tr>
<td><strong>Harmonic distortion, 6 kHz, mono:</strong> (%)</td>
</tr>
<tr>
<td><strong>Harmonic distortion, 6 kHz, stereo:</strong> (%)</td>
</tr>
<tr>
<td><strong>Distortion at 50-dB quieting, mono:</strong> (%)</td>
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<tr>
<td><strong>Distortion at 50-dB quieting, stereo:</strong> (%)</td>
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<tr>
<td><strong>STEREO PERFORMANCE MEASUREMENTS</strong></td>
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<tr>
<td><strong>Stereo threshold (µV):</strong></td>
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<td><strong>Separation, 1 kHz (dB):</strong></td>
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<td><strong>Separation, 10 kHz (dB):</strong></td>
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<td><strong>MISCELLANEOUS MEASUREMENTS</strong></td>
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<td><strong>Sensitivity (µV):</strong></td>
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<td><strong>S/N ratio (µV):</strong></td>
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<td><strong>Dial calibration accuracy (±kHz at MHz):</strong></td>
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<td><strong>EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION</strong></td>
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<td><strong>Control layout:</strong></td>
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<td><strong>Ease of tuning:</strong></td>
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<td><strong>Accuracy of meters or other tuning aids:</strong></td>
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<td><strong>Usefulness of other controls:</strong></td>
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<td><strong>Construction and internal layout:</strong></td>
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<td><strong>Ease of servicing:</strong></td>
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<td><strong>OVERALL RF PERFORMANCE RATING:</strong></td>
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<table>
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<tr>
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<td><strong>MANUFACTURER:</strong> U.S. Pioneer Electronics</td>
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<td><strong>Price/performance ratio:</strong> Good</td>
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<td><strong>Styling and appearance:</strong> Excellent</td>
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<tr>
<td><strong>Sound quality:</strong> Good</td>
</tr>
<tr>
<td><strong>Mechanical performance:</strong> Very good</td>
</tr>
</tbody>
</table>

**Comments:** For the audiophile who has almost given up trying to find a TV receiver that contains a “high-fidelity” audio section, U.S. Pioneer's innovative model TVX-9500 TV audio tuner will be welcome. However, two points must be kept in mind: First, when you hook this unit to your hi-fi system, don't expect every TV channel to deliver the high-quality audio delivered by your other hi-fi program sources. Much audio programming we listened to with the model TVX-9500 is still of poor “telephone line” quality, even though the potential for full 15-kHz frequency response exists. We particularly noted that the audio quality of many TV commercials is poor and voices are reproduced no better than from a low-cost AM table radio. Obviously, even the model TVX-9500 cannot add to fidelity that was never there originally.

Second, a good outdoor antenna should be used with this tuner. Although lower TV audio modulation levels are partly offset by the higher TV signal strengths (compared with those of FM radio stations), multipath distortion is a problem unless a correctly oriented antenna is used with the tuner. A totally separate antenna is preferable, but if you must use a "splitter" on your regular TV antenna even that will be better than using the indoor dipole supplied with the model TVX-9500. This is especially important since the unit's AM rejection ratio is not nearly as high as on hi-fi FM tuners. The best results were obtained from our commercial-free Public Broadcasting Service station whose audio quality was exceptional.
NOM Card For The 1802

Part 2—Add-on math board for an 1802-based microcomputer. Based on a number-crunching IC, this board speeds execution time, reduces software overhead and saves memory.

L. STEVEN CHEAIRS

LAST MONTH WE LOOKED AT HOW THE NOM card reduces computer memory requirements and increases processing speed by eliminating number-crunching software routines. This month, we present final construction details.

Construction

The components used in this project are all readily available; assembly is straightforward, and the circuit can be wire-wrapped or built on a PC card. Use a double-sided glass epoxy circuit board with 2-ounce copper foil (available from Questar). A heavy plate layer covers all runs, and the holes are plated-through. The card has gold-plated fingers and a solder mask. For those who wish to etch the circuit board themselves, the foil patterns are shown in Figs. 8 and 9.

In assembling the board, pay special attention to component orientation. Figure 10 shows the correct placement and orientation of all the components and Fig. 11 shows the PC board pinout and switch placement. First, install and solder all resistors, capacitors and diodes. Connect the +5-volt and -15-volt leads, (the -4 volts is derived from the -15-volt source) and methodically test all power-supply pads for the proper voltages. If the power levels are OK, disconnect the power and install the IC's; if not, check for possible shorts or faulty components. No calibration is required.

Check-out and operation

Check-out and operation is theoretically very simple. First, enter the first number into the X-register. Follow this with the next number; all numbers enter the X-register. Execute a math operation, such as an ADD. Enter and execute an OUT instruction. If the correct answer is obtained, then 90% of the test is complete, and the only remaining functions to test are error and branch. If you did not receive the correct answer, check to see if...
all the DIP switches were closed; if so, then recheck component placement and orientation. If no mistake was made (and you have programmed the 1802 correctly), then a component failure has occurred. Use normal digital troubleshooting techniques to isolate and solve the problem.

Now, enter a branch instruction to see if the branch outline interrupts the 1802. If this works, proceed to the final test. Enter a zero into the X-register, then execute the 1/X instruction. If an error occurs, you have completed the NOM interface; if not, check the error flip-flop.

The basic operation is outlined in the flowchart shown in Fig. 12. The user program first places the numbers in a FIFO table along with the required mathematical operations. Enter the first number into the X-register, then exchange the X- and Y-registers. Now, enter the next number into the X-register, then perform the desired operations. Enter the next number (if any) and perform the desired operations. Continue until all numbers and operations are completed. Execute an output instruction, store the digits into the user’s FIFO table and return to the user program. The above description implies that the 1802 is tied up 100% of the time with the NOM, but actually a very small percentage of the 1802’s time is spent with the NOM during these operations. The 1802 only moves data/instruction into (and out of) the NOM; most of the time it is used to perform mathematical calculations or to manipulate data inside the NOM. During this time the 1802 is free to perform other tasks.

Programming the NOM

The NOM has 70 instructions that can be classified into seven groups: Digit entry, move, math, clear, branch, input/output, and mode control. Table 3 lists the mnemonics for these instructions and the associated binary code. (A detailed description of what each instruction does; including the mnemonic, octal op-code and execution time; can be obtained by sending a SASE with 28¢ postage to NOM Instructions, Radio-Electronics, 200 Park Ave. South, New York, NY 10003.—Editor)

The first class of instruction—digit entry—has 17 members. The stack is
pushed and the X-register is cleared when a digit, a decimal point, or a π is entered with an AIN, 0-9, DP, or PI instructions. After "initiation of number entry," the digit and future digits are entered into the X-mantissa. Any digits following the eighth mantissa digit are ignored, and any subsequent entry of digits or DP, EE, or CS

exception to the number-entry initiation rule. The stack will not be pushed if the ENTER instruction occurred prior to the entered digit; the X-register, however, is still cleared and the new digit is entered into the X-register.

The IN instruction is used to enter all digits of a number; it does not cause number-entry initiation. However, it does terminate this mode if the NOM is in that mode prior to the IN instruction being executed. Thus, 0-9, AIN and IN instructions can be mixed without performing an ENTER instruction before the IN instruction. The IN instruction always pushes the stack except if the previous instruction was an ENTER, thus allowing multiple IN instructions to be executed without performing an ENTER between them.

Second, the move instruction group has eight parts: ROLL, POP, KEY, XEM, MS, MR, LSH, and RSH. The ROLL instruction simply rolls the stack (X-T, T-Z, Z-Y, Y-X). The POP instruction causes the following sequence: Y-X, Z-Y, T-Z, O-T. The KEY instruction exchanges the X- and Y-registers; while XEM exchanges the X- and M-registers; the MS instruction is memory-store (X→M); MR is memory-recall (M→X); and LSH and RSH are shift mantissa instructions.

Third, the math group is composed of 24 instructions. As mentioned earlier, this instruction set is available from Radio-Electronics Editorial Offices upon receipt of a SASE with 28¢ postage. Fourth, the clear group has only two instructions: MCLR and ECLR. Instruction MCLR is the master clear instruction for all internal registers and memory. It also initializes the I/O control signals—MDc = 8 and MODE = floating point. Instruction ECLR is the error flag clear; it loads the error flip-flop with a zero.

Fifth, the branch instruction has eight instructions divided into two subgroups—test and count. The test group is formed by the JMP, TAC, TERR, TX = 0, TXF, and TLTLTO. The count subgroup contains instructions DBNZ and DBNZ.

Sixth, the input/output group is composed of nine instructions that can be divided into three subgroups: multidigit instructions (IN, OUT), single-digit instructions (AIN), and flags (SF1, PF1, SF2, SF3).
PRW1, PRW2). In the design described here the event flags were not used; therefore, the SF1, PF1, SF2 and PF2 instructions are of no use with this interface.

The last group of instructions is mode control: It contains TOGM, SMDC and INV.

On power-up the mantissa digit count is set at 8, and the mode is set to floating point. Figure 13 shows the initialization routine. After initialization (POR) or the completion of an instruction, the input ready signal goes to a logic high, which tells the external hardware to supply a new instruction.

Sixteen of the 70 instructions are two words long (See Fig. 14.) These instructions are: INV+, INV-, INVX, INV/; INV SIN, INV COS, INV TAN, JMP, TJC, TERR, TX = 0, TXF, TXLTO, IN, OUT, and SMDC. The first word of a two-word instruction is the same format as the one-word instruction. The second word contains the branch address that is to be loaded into the PC (Program Counter) during the branch; or it contains the MDC (Mantissa Digit Count) for SMDC instructions; or it may have the high-order address bits for external RAM on the IN/OUT instructions. The low-order address is placed on the DA lines. This interface does not use an external RAM. Generally, the second word is ignored except for the SMDC instruction. The 14 lines must contain digit data during the AIN and IN instructions. Each two-word instruction generates an input ready twice—one for each word. The first type are the inverse instructions. These require the INV instruction to be executed first (followed by the desired instruction). The second type is the SMDC instruction. The second word of this instruction is the mantissa digit count—a BCD number from 1 to 8. The other types of two-word instructions have adequately been discussed previously.

Since there are software differences between the many 1802 systems involved (primarily in the I/O and memory addresses), the software I used in my system is not included here. As an alternative, the flowcharts in Figs. 12 and 13 can serve as a guide in developing your own software.

FIG. 14—FIRST WORD of 2-word instruction (a), second word (b). Floating-point notation formats and scientific notation formats are illustrated at c and d, respectively.

FIG. 15—SOFTWARE FLOWCHARTS. a) TRANSFER of data to NOM; b) TRANSFER of data from NOM; c) USE OF branch-type instructions.

"While I was waiting, I adjusted your roof antenna, aligned your set and cleaned the tuner."
Learn solid-state circuitry as you build a monophonic music maker.

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THIS MONTH WE'RE GOING TO LEARN HOW to build a music maker or song player. You can set this device up for almost any simple tune and then program it to play automatically. In the process, you'll learn more about solid-state circuits, and end up with a unit that can be used as your doorbell, clock alarm and so on. This versatile circuit has endless possibilities.

Audio oscillator

First, you'll need a tone generator or audio oscillator. Figure 1 shows a very simple instrument. Although it has a minimum of parts, it is difficult to keep it from oscillating. (On the other hand, while the tone probably sounds all right to an untrained ear, it may insult a musician!)

Although in Fig. 1 the transistor is listed as a 2N3904, almost any NPN audio transistor works in this circuit. Any voltage from 1.5 up to the limit imposed by the transistor you select can be used. Figure 1 shows 5 volts because this value represents the power needed to run the IC's. No values are given for R1 and C1, but you can wire in a 100K potentiometer and any 0.01-µF component for testing purposes. As resistor R1 varies, the frequency (tone) changes.

This tone generator is used because it's simple. You can, however, use your own favorite circuit if you can separate out the frequency-determining components, as shown in Fig. 1. You can even add fuzz, attack, or delay if you like.

All you have to do is switch the R-C network or just R1 in and out of the circuit. Other components could be added for additional tones. Of course, you could add a manual switch at point A or point B. For our example, let's choose point A and build an electronic organ, as shown in Fig. 2.

Although manual switches are OK, the tone should really be controlled with electrical pulses. You could use relay switches, but they are expensive, bulky and usually noisy. So, why not use transistor switches?

Figure 3 shows two transistor switches that turn the tone either on or off. Switches Q2 and Q3 can be 2N3904, RS2009, 2N2222 or almost any NPN transistors you have on hand. When the base of the switching transistor is connected to the positive voltage, the switch is on. When the base is grounded, the switch is off.

Now a strange thing happens to the circuit when Q2 and Q3 are added. First, the potentiometer values decrease. With most types of transistors at Q1, the circuit oscillates even when C1 is removed. Therefore, we draw C1 with dashed lines. (You may not need it.) Try your oscillator without using C1. You may have to put it back in (or add one across each pot). This little oscillator is both versatile and fun to experiment with.

You can add as many pots and transistor switches as you want. You need one for each note in the tune to be played. Just add these components out from points X and Y and adjust the pots for the proper tones. Choose a tune with no more than 15 notes (for reasons that are explained later).

Now you need some way to put a positive voltage on the transistor bases, one at a time. Manual switches work, but, again, adding transistor switches activates them automatically. For this task we'll use the 74154 1-of-16 data distributor described in the Hobby Corner article on an IC game roller circuit (Radio-Electronics, March, 1978). And if you use less than 10 notes, a 7442 can be used.

The only problem in using the 74154 is that the outputs are of opposite polarity from what you need. The selected output goes low instead of high as required by the switching transistors. This is why the inverters are used (six with each 7404 IC) shown in Fig. 4. Note that outputs 4, 6 and 8 all play the same tone through a

FIG. 1—BASIC TONE GENERATOR

FIG. 2—MANUAL TWO-TONE ORGAN

FIG. 3—TUNE MAKER CIRCUIT showing transistor on-off switches.

FIG. 4—TONE SELECTOR

www.americanradiohistory.com
gate of a 7410 triple 3-input NAND gate. One gate in a 7400 repeats the same tone on two outputs, while one 7420 gate combines four outputs. Any extra gates you may have can be used for other things, as shown in Fig. 5.

![Gate Equivalences](image)

**FIG. 5—BASIC GATE EQUIVALENCES**

There are several things that you should note about the circuit in Fig. 4. First, four switches were added to the 74154 input (this, however, is only a temporary arrangement). These four switches control the 16 output lines; by using momentary switches, you can "play" any of the 15 notes with only four fingers. If you build two such setups, you can play 30 notes with eight fingers! Of course, these switches count in the binary system.

Second, you only need 7404 gates at the output if you are going to play the device this way. However, automatic play may require a combination of repeat notes depending upon the tune you select.

Third, output line 1 is not used. This means only 15 notes are available, but the output line will be necessary if you add on automatic-play control. If you are not going to add the automatic-play feature, you can put in a 16th note and raise pin 19 from ground to the positive voltage to get an off or no-sound condition.

Here are some programming suggestions: how about using the whole tone for the front door, and just part of the tune for the back door? Or perhaps you could play three notes for the quarter-hour, eight notes for the half-hour, the whole tune for three-quarters of an hour, and the tune twice for the hour?

In a future article, we’ll discuss making additions to this circuit that will cause it to play automatically at the touch of a button.

Old radios, TV’s, etc.

Sometimes a reader writes for help in finding a schematic and other information about an old radio or TV. Here are a few suggestions that may help when you want to recondition or restore an old piece of gear.

First, you must completely identify the equipment. That means finding the model and serial numbers if they are still on the chassis or cabinet. If there are no identifying numbers, make a complete description of the set including the numbers and locations of the tubes. Armed with this information, you are ready to begin your search.

A local service shop may have the information you want in Sam’s Photofacts, in Supreme Publications manuals, or even in a Rider manual. If you live in a large city, you can probably find these publications in the public library. You can also write the manufacturer, but this may not help if the set is very old. Many have gone out of business.

Whether the set is very old or nearly new, Supreme Publications has data on almost any equipment, and a typical charge for such information is only about $3. Just send the complete details on your set to Supreme Publications, Att: M. N. Beitman, Box 46, Highland Park, Ill. 60035. If all else fails write ISCET Technical Library, there is a $10 fee for this service or you might even become a member for an annual $25 fee. The address is 8015 Paseo, Kansas City, Missouri.

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**JANUARY 1979**

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8085 A look at Intel's 8085 µP and the MCS-48 µP family.

WILLIAM BARDEN, JR.

INTEL CORPORATION, DESIGNERS OF THE 8080 and 8080A microprocessors, have developed two new devices. One is the Intel 8085, a microprocessor that is designed to replace the 8080A. It is a larger-scale microprocessor because it is designed to be used in applications that in some cases were only in the realm of minicomputers. The MCS-48 family of microprocessor components, on the other hand, is a minimum-configuration type of microprocessor that will be used to implement low-cost consumer and business computer products.

The 8085

The 8085 is a redesigned 8080A microprocessor. One of the weaknesses of the 8080 microprocessor was that for a basic system it required a dozen or so TTL IC's in addition to the basic CPU. The 8085 requires only a few external components to produce a viable microcomputer. Although the 8085 is not pin-compatible with the 8080, it is software-compatible "downwards"; that is, all software written for the 8080 will run on the 8085, except that which is specifically geared for an existing 8080 microcomputer system, which may differ in I/O addresses, memory cycle times, and the like in a new 8085 system.

Figure 1 shows the pinout of the 8085 microprocessor, which uses only one supply voltage, +5 volts, with the input at Vcc; Vss is the ground reference. The -5 VDC and +12 VDC of the 8080 are eliminated. The 8085 uses an on-chip clock generator, with only an external crystal or R-C network, whereas the 8080 uses a two-phase external clock. The basic clock speed is 3 MHz, and the basic instruction cycle is 1.3 µs, which is an improvement over the 8080's 2-µs instruction cycle.

The 8085 multiplexes the address and data outputs during the instruction cycle. Lines A15 through A8 are the address lines, as in the 8080, but lines AD7 through AD0 are used both as the lower half of the address lines and the data bus. These lines are used as the address bus during the first clock cycle of a machine cycle and as the data bus during the second and third clock cycles. Signal ALE (Address Latch Enable) occurs during the first clock cycle to allow components to latch the address.

In the 8080, status signals needed further decoding to produce read and write signals to memory and I/O. In the 8085, these signals are provided directly by RD, WR, and IO/M; the latter indicates whether the read or write is to memory or I/O. Outputs S0 and S1 provide encoded status of the bus cycle (HALT, WRITE, READ, or FETCH). The READY instruction is used similarly as with the 8080—to interface slow-speed memory or I/O devices by deferring CPU operation. Instructions HOLD and HLDA are also similar to the 8080, allowing external devices to control the CPU buses for direct-memory-access action.

---

**Figure 1**

![Schematic of 8085 Microprocessor](image)

**Figure 2**

![Schematic of 8748 Microprocessor](image)
Interrupt action in the 8085 is more sophisticated than in the 8080. Signals INTR (INTeRrupt Request) and INTA (INTeRrupt Acknowledge) are used as before, but three additional interrupt inputs, RST 5.5, RST 6.5 and RST 7.5 cause predefined internal RESTARTS (rather than an external RESTART response). In addition, a nonmaskable interrupt that cannot be disabled under program control is provided by signal TRAP. A RESET IN input is similar to the 8080's RESET input; the output RESET OUT indicates that the CPU is currently being reset.

One serial-input line and one serial-output line are provided in the 8085; the 8080 had neither. Data on the SID (Serial Input Data) line is loaded into accumulator bit 7 whenever a RIM instruction is executed. The serial-output data line can be set or reset by an SIM instruction. These two lines allow serial I/O devices such as Teletype or audio tape cassettes to be directly interfaced to the CPU. Instructions RIM and SIM are the only two new instructions in the 8085. Internal registers within the 8085 central processor unit remain the same as in the 8080.

A dedicated function microcomputer using the 8085, a 2K-byte EPROM chip (8755), a 256-byte RAM (8155) and six discrete components can be assembled on a 4-inch by 3-inch PC board. This is quite a change from the 8080! Such a single board microcomputer can easily handle many control applications and its small size makes it easier to design into household appliances.

MCS-48 family

Speaking of computers on a chip, the microprocessors in the MCS-48 family certainly fit the description. The 8048 microprocessor IC of this family is the most elaborate of them all. The 8048 provides an 8-bit CPU, 1K-byte ROM, 64-byte RAM, 27 I/O lines (which may be programmed for input and output as required) and an 8-bit timer/event counter, all on one IC! The 8748 microprocessor is identical to the 8048 except that it contains a 1K-byte EPROM (Erasable Programmable Read-Only Memory). Other versions of these two microprocessors contain additional ROM and data (RAM) memory, or no internal memory. A low-cost version, the 8021, contains an instruction subset of the 8048 and fewer hardware features.

Let's take a brief look at the 8748 (EPROM) version. Figure 2 shows a standard 40-pin 8748 package. In this version, only a single +5-volt power supply is required. A crystal clock input is provided, although this may be an L-C network or an external clock rather than a crystal controlled clock.

Input/output port 1 (P10–P17) and I/O port 2 (P20–P27) are two 8-bit ports that can be used either as input or output ports. Input and output on the same pin and a mixture of input and output lines on the same port is permitted. Lines DB7 through DB0 are also an 8-bit port that serves either as a latched output port or a nonlatching input port. Two additional input pins, T0 and T1, are test inputs that can be used under program control by specific instructions. One interrupt input, INT, is implemented so that an interrupt occurs if an internal interrupt-enable flip-flop is set. Various other control signals are provided.

Figure 3 shows the architecture of the 8748. One 8-bit accumulator serves as the main data register for arithmetic and other operations; both binary and decimal arithmetic are implemented in the CPU. Program memory of 1K bytes is provided on the resident EPROM. Locations 0, 3 and 7 of program memory are dedicated to reset, external interrupt and timer/counter interrupt processing routines, respectively. Data memory consists of 64 bytes of RAM, in which two sets of eight locations are designated bank 0 and bank 1 working registers. Either bank 0 or bank 1 can be selected under program control. When one or the other bank is selected, all registers in the bank are directly addressable by several instructions. An eight-level stack and additional user RAM comprise the remainder of the data memory.

The 8748's instructions include both 1- and 2-byte instructions plus the usual complement of arithmetic, logical, data movement, and conditional and unconditional jumps. Since 70% of the instructions are only 1 byte long, the MCS-48 microprocessors provide efficient programming within the limitations of the relatively small RAM storage and program area.
Don't jump to conclusions before obtaining the necessary facts.

A SERVICE CLINIC COLUMN APPEARED A while back containing some fairly elementary material. A reader wrote: “Why? We know all this stuff!” I wrote him back to tell him that it's a good idea to jog your memory once in a while.

This article is another memory jogger. It tells you about the easy way to diagnose troubles in TV sets, and about one of the most "common faults" technicians make in this area. A large amount of Service Clinic mail comes from technicians who know how to do the job, but are simply not using their knowledge in the right way. The common fault in too many cases is jumping to conclusions before you make any tests and obtain the facts.

Here's a typical example: The symptoms are a blank screen, plenty of width and height, the brightness is good, and no sound or picture. The calibrated eyeball tells us that quite a few things are OK: there's plenty of B+ voltage, a good picture tube, etc. Correct reasoning tells us that there is a fault somewhere in the signal path. This involves a lot of stages, starting at the tuner, the IF, detector, and video amplifier. Anything wrong in these stages can cause problems.

The first thing to do is to break these stages up into smaller sections. A good and fast way to do this is to scope the video detector output. If you see a normal signal here, the tuner, video IF and AGC are not at fault. Proceed through the video amp stages until you find where the signal stops.

If there's no signal at this point, the video stages can be eliminated as a source of problems (for now, anyway). Now, check the IF and/or tuner stages. Hook up a tuner subber to the IF input; if you get a picture, you've just eliminated the IF stage as a cause of your problem. If there's no response, you do have an IF problem. As usual, there are multiple causes for the same symptom. It could be caused by a fault in the IF stage, or it could be in the IF control voltage; the AGC (Automatic Gain Control). Here's another simple test. Override the AGC with a bias box. You can read the AGC voltage, but overriding it just is one step less to perform and gives you the same result. If you get a picture with the AGC set to approximately normal (check the unit's schematic for the normal voltage, remembering that the AGC shown is a no-signal voltage or the point of maximum IF gain), then you've eliminated the IF amplifier stages, and you can now check the AGC stage.

At this point, you can take some DC voltage readings; all voltages on this AGC stage are critical. Also don't forget to scope the input for the proper video signal; it won't work without it. Watch out for bias problems in the AGC stages. If one stage is incorrect, it will not chop off the sync pulses to develop an AGC voltage.

If the problem is in the IF stages, here's a quick check. Don't bother reading the IF signal with a demodulator probe; just read the emitter voltages of all IF transistors. Practically all these transistors use a small transistor (bypassed) in the emitter circuit. The DC will run about 1 to 2 volts. Find an IF transistor with zero voltage, and it is probably open. If there's far too much emitter voltage, the transistor is probably shorted. Don't overlook the emitter resistor; check it to make sure. This also works for tube-type IF stages; read the IF tube's cathode voltages.

Another area where reasoning can help is in the sync-separator stage. If you see no vertical sync and the picture slides sideways, go right to the stage that handles both syncs. Do not start checking the vertical oscillator! Scope the composite-sync waveform at the separator output. (Far too many schematics leave out this necessary stage. The typical P-P voltage runs about 50 to 60 for tube stages, and about 20 to 25 for transistor stages; these are just ballpark figures.)

A severe loss of sync amplitude at this point can cause weak vertical sync. The vertical sync depends on amplitude; the horizontal sync works mainly on phase, and quite a lot of sync amplitude can be lost before any horizontal instability shows up. Use your scope to check both syncs.

Checking the horizontal sync can be very tricky; you can lock the picture in, but with even the slightest movement of the horizontal hold control, away it goes. The fact that you can stop it momentarily indicates that the horizontal oscillator stage is quite stable. This is often due to a loss of the horizontal sync to the AFC. For a definite test, pull the AFC diodes and scope the point where the sync goes in—usually at the center terminal of the diode unit. The horizontal sync is picked off the composite sync and fed through a small (50-pF) coupling capacitor (which explains why the vertical sync does not go into the horizontal sync). If this coupling capacitor is open, or if the PC board conductors between the capacitor and sync separator/AGC circuit are broken, this'll cause problems. Check the conductors with an ohmmeter.

If there's plenty of horizontal sync here, then the AFC diode unit is bad and should be replaced. Look out for imbalance in AFC diode units because this can cause some odd problems. You can check this out with an ohmmeter.

The main point is that you must always remember that there's no such thing as a symptom with only one possible cause. Make a mental list of all the things that could cause a problem and then patiently check 'em out one by one. You'll pin down the trouble a lot faster. Use time-saving quick-check tests such as the ones mentioned earlier; these tests can clear up or confirm trouble in a great many stages simultaneously, as for example in the IF stage.

The most important thing to remember is—don't jump to conclusions without any hard facts. Good luck.

Jack Darr, Service Editor

Don't jump to conclusions before obtaining the necessary facts.

FLYBACK SUBSTITUTE WANTED

This National model TR-317U TV set manufactured by Matsushita has a burned flyback circuit. Since my sources just turn blue when I mention National, where can I get this part?—W. S.,enville, N.J.

Tracking this down calls for some part-number crossing. Matsushita manufactures Panasonic, so I checked out Sams on a TR-315, which is as close as they could get. I found a flyback circuit with a "TLF-xxxx" part number which is very close to the flyback part number you gave.

R-E
me (TLF-3605-1DS) Try ordering a flyback with this number from the nearest Panasonic parts depot. The closest depot to you is: Panasonic, 50 Meadowlark Parkwy, Secaucus, NJ, 08004. Good luck!

COILS WITH LOOSE CORES
Louis Supel of Brunswick, O.H., writes:
"If you have a coil with a loose core that won't stay tuned or falls out, try taking the core out and inserting a thin strip of masking tape inside the coil lengthwise so the core fits. Once you still too loose, place another thin strip of tape on the other side of the core. The coil will turn freely without binding. (Thanks, Louis! This helpful hint is much appreciated.)"

HIGH VOLTAGE DROPS
Everything else seems to be OK in this model CTC-31A RCA set, but the high voltage drops to where the raster goes out. I've checked the whole output circuit and found zilch.—K.P., Flitwick, MA.

Here are a couple of hints: Pull the picture tube socket and see if the high voltage comes back. If so, check the cathode and grid voltages on the picture tube. If there is very low voltage on the picture tube cathodes, for example, this will make the grids positive, and the picture tube will pull the high voltage down. The common cause for this: an open winding in the video peaking transformer between the video output and picture tube cathodes causes this voltage to go to 0.

(Redaktion: "Thanks! Your crystal ball is working fine; the video peaking transformer was open.")

RASTER BRIGHTENS
I've got a funny problem with a Sony model KV-1910. The sound and picture are good, but the raster becomes gradually brighter from left to right; at the far right-hand edge of the screen the video wipes out completely to a brilliant white. The brightness control works, but as you turn it down, the raster is gradually wiped out from left to right. What is this?—D.L., Badie Creek, Mi.

I suspect that you've got a blanking problem (along with a lot of other people!). The schematic shows the horizontal blanking is fed to the three grids of the picture tube, tied together, through a pair of neon lights plus another light over the flyback. These lights are not shown on the parts list, but they're probably ordinary NE-2's. Check if any of these bulbs are blackened; if so, they're probably bad. In this application, if one of these lights is aired it acts as a short and upsets the horizontal blanking. I suggest you replace them all just for luck.

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**EQUIPMENT REPORTS continued from page 33**

the location of the white king and queen and black king and queen using the EP key. Then, force CompuChess to make the first move by depressing PLAY.

The well-thought-out keyboard provides a tremendous amount of versatility. You can play handicap chess by initially deleting a piece; in fact, you can delete or add any piece you want at any point during the game. You can perform a castile move by using the MD key and CompuChess will also handle en-passant moves.

During play, you can cancel a move after entering it, provided the PLAY key has not been depressed, by simply re-entering the move. Also during normal play, on levels 3 or 4, when CompuChess sees a threat to any of its more valuable pieces, it will display a flashing hyphen to indicate that it needs more time to calculate its response. If you should lose the game, CompuChess will notify you by displaying its final move and then flashing the display.

CompuChess indicates a stalemate by a king move to its own position. If CompuChess should lose the game, it displays LOST.

CompuChess also has a randomizing feature. If after evaluating its move, CompuChess determines that there are several moves of equal strategic value, it will randomly choose its move from one of these several moves. Because of this, it is almost impossible to duplicate an attack or repeat a game.

**Playing a game**

The best way to evaluate a device such as this is to actually play a game with it. I started a game on level 6 to see just how long the response time for this level would be.

I opened with the traditional opening of P—K4. CompuChess responded within 18 hours. This turned out to be the shortest response time. From here the response times varied between 2 and 4 days. The response time to the 6th move was an absolute surprise—it took between 11 and 13 days to respond.

I don’t feel, however, that the long response time is a big disadvantage. As the owner’s manual states, it’s perhaps better to start play at level 4 and then switch to level 6 after 6 and 12 moves into the game. This should reduce the response time. And then again, not everyone would be comfortable playing a level 6 game.

I have also received a call from Data Cash Systems that they have just introduced an improved version of CompuChess. The newer unit is called CompuChess, The Second Edition. In addition to much quicker response times (level 6 now responds within 2 hours), three new game variations have been introduced along with the standard chess game. The game of Knights is similar to a standard chess game except all the pieces on the first rank are converted to knights. The pawns on the second rank remain pawns. The second new game is called the Amazon Queen. Here all the pieces remain identical as in standard chess except the two queen pieces are given the additional capability to move like knights. The third and final new game is called Survival. This game sets up a randomized mid-game board position. The object is to play a standard chess game from this random board position and mate CompuChess.

CompuChess retails for $169.95, and The Second Edition retails for $209.95.
the start. Every time a successful jump is made the two right-hand digits are increased by 1 and another bus is added to the area between the two ramps; also, a good-jumper sound is generated. The motorcycle reappears at the starting position after each jump. The cycle, score and buses are white; the ramps and track are black. For black-and-white operation, the background is gray, and in color the background is blue.

If the PRO/AM switch is in the easy mode and the MOTORCROSS select switch depressed, then the picture will be like that shown in Fig. 1-c. The cycle moves across the screen, at a rate proportional to the setting of the throttle, as the throttle is advanced from its low-speed setting. No speed shifting exists in this game. As in the Drag Race game, the object of the game is to transverse the three track segments in the minimum amount of time. On each track segment though, there is a blockade. The operator must do a "wheelie" in order to cross over this obstacle.

In the Pro mode, two obstacles per track are displayed; see Fig. 1-d for a typical screen image. The game otherwise functions as the amateur mode did. Again, the cycle, rider, score and block continued on page 76

Don Lancaster's "Cheap Video" concept allows almost unlimited options, including:

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frequency response of 20 Hz to 20 kHz and a minimum 10,000-ohm input impedance. Unit's 6-position selector switch permits 18 different combinations of power levels and speaker impedances. Instantaneous peak-responding green, yellow and red LED's are calibrated from 0 dB to -30 dB in 8 steps for each stereo channel. Optional walnut cabinet is available. Price: $129.95.—Lectrotech, Inc., 5810 N. Western Ave., Chicago, IL 60609.

POWER AMPLIFIER, model 300CC, features low TID (Transient Intermodulation Distortion), a fast slew rate, wide bandwidth and low distortion. It is rated at a minimum RMS of 150 watts-per-channel into 8 ohms, 20 Hz-20 kHz at no more than 0.03% THD. The power transformer has two

secondaries providing independent power for the two channels, and meter range switching provides accurate VU meter readings. Suggested retail price: $629.95.—Marantz Co., Inc., 20525 Nordhoff St., Chatsworth, CA 91311.

DIRECT-DRIVE TURNTABLE, model 621, is an automatic start-stop turntable with an electronic DC motor regulated by digital circuitry. The wow and flutter is rated at less than ±0.03% and rumble better than 70 dB. The tone arm is mounted in a 4-point gimbal, with the counterbal- 

ance containing two anti-resonance filters. Other features include 10% pitch control, illuminated strobe, continuous repeat, damped cueing; anti-skate feature is calibrated for all stylus types. Including base and cover, the model 621 sells for $299.95. A manual start/automatic shutoff model 604 is also available for $259.95.—United Audio Products, 120 S. Columbus Ave., Mt. Vernon, NY 10553.

ERROR-NULLING POWER AMPLIFIER, model Stasis I, is a single-channel audio amplifier that uses feed-forward error-nulling. The amplifier has a rated power output of 175 watts into 8 ohms, 20 Hz-20 kHz; 300 watts into 4 ohms, 20 Hz-2 kHz with less than .002% THD; a maximum slew rate

of 100 volts-per-µs, a frequency bandwidth of +0 dB, -3 dB, 0.01 Hz-250 kHz. Other features include peak-vs.-average output display from +2 dB to -24 dB, on-off switch; and panel displays such as logic-on, amplifier-on, differential waveforms, etc. The model Stasis I measures 19.5 X 5.25 H X 17-inches W. Suggested retail price: $2500.—Threshold Corp., 1832 Tribute Rd., Sacramento, CA 95815.

MOVING-COIL CARTRIDGE & TONE ARM, model 10X and model DV-505 The model 10X is the latest in the Dynavector line of cartridges (manufactured in Japan) and provides a 2-mV output

level, eliminating the need for a preamp or step-up transformer. The unit contains 2 separate 200-turn copper-alloy coils, 11.5 microns in diameter. The model DV-505 tone arm is a bi-axis inertia-controlled balanced tone arm with a vertical subarm useful for tracking warped records. Prices: the model 10X cartridge, $120; the model DV-505 tone arm, approximately $600.—ESS Special Products, Box 15889, Sacramento, CA 95813.
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VIDEO MOTORCYCLE GAME
continued from page 69

ades are white; the track is black. The background is gray for black-and-white operation and green on a color set.

The fourth game, Enduro, in the amateur mode appears like the image seen in Fig. 1-e. As with Motorcross the first two segments contain obstacles; the third segment resembles the Stunt Cycle game in that it contains buses and ramps. For the first two tracks "wheelies" are required to pass the blockades. Before entering the third track the throttle must be adjusted to perform the required jump across the buses. In the professional mode, two additional obstacles are added (see Fig. 1-f).

How it works
The main section is the AY-3-8760 LSI integrated circuit. Section two is a 3.58-MHz crystal clock source. The next section is a set of controls; four game select pushbuttons, one SPST mode select switch, and a 50- to 250-kHz oscillator used as the throttle control. Section four is the power supply—12 volts AC is converted to about 6 volts DC. The next section is the video output summing network. The last block is the audio amplifier.

The throttle oscillator is formed by using an LM555 timer. The frequency is set by the control potentiometer; the output is applied to pin 18 of the AY-3-8760 via a CMOS inverter.

The 1/4-watt audio amplifier is formed from a MC1306P monolithic complementary power preamplifier/amplifier. An 8-16-ohm speaker is driven at the output of this section. A volume control trimmer pot can be adjusted for the desired volume level.

The black video (ramps, track and composite blanking) is summed to the white video (motorcycle, rider, buses, score and obstacles) along with the sync pulses. The color A and B outputs (pins 24 and 25, respectively) are pulled-up to V<sub>C</sub> + 5 volts, then summed together using 20-pF capacitors and fed into the resistor network. The intensity of the white video is reduced when no motion exists on the screen (the game has not been initiated). This will reduce the possibility of the TV screen being burned if the game is left on for extended periods of time. This feature is provided by R11, C11, D1 and CMOS inverter IC2-a. The output of the summing network should be fed directly to a video monitor or to a TV set through an RF modulator.

The power supply takes 12 volts AC from the power transformer secondary and develops the 6-volt DC V<sub>C</sub> supply. Four 1-ampere rectifiers are used in a full-wave bridge. A raised-ground 5-volt linear three-terminal IC voltage regulator is used. One volt is developed across ground resistor R2. Capacitor filtering is used at the input and output of the regulator.

Construction
Before beginning construction you must decide on a method of assembly and wiring—either wire-wrap or a printed circuit. If you select the latter, you can use the foil pattern in Fig. 3.

After etching and drilling your board (or purchasing the board listed in the parts list) begin wiring by installing the five jumpers shown on Fig. 4.

The next step is to install the resistors and capacitors. Also the IC sockets if you elect to use them. Install and solder in the five diodes and the regulator IC. Be sure diode polarity is correct before soldering.

You are now ready to wire the PC board to the switches, control pot and power transformers. After making these connections, apply power to the board and check the voltage at the supply pins of IC1-IC4. If it is lower than 6 or higher than 7 volts, readjust the values of R1 and R2 to obtain the desired voltage.

Now install the IC’s and the circuit should be ready for use. If problems arise, use regular troubleshooting techniques to find and correct them. I’m sure you’ll have a great deal of fun and excitement with this advanced single-player video game.
More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside back cover.

DUAL-TRACE OSCILLOSCOPE, model PM3262, is a 100-MHz, 5-MV (2 mV at 35 MHz) general-purpose instrument designed for many sophisticated lab, computer, telecommunications, and bench and field applications. The unit features an alternate timebase capability that shows both main and delayed timebase displays together across entire screen width; a third channel allows simultaneous viewing of trigger signals. Other features include composite triggering to permit stable display of asynchronous signals; 250-MHz triggering capability; extended X-Y display; cold switching that allows electrical (not mechanical) connections between front-panel controls and internal circuitry. Triggering mode and input controls are pushbutton-selectable. Power consumption is 45 watts. The model PM3262 measures 11 1/2 X 6 1/2 X 7 inches and weighs 21.1 lb. Price: $2345.—Philips Test & Measuring Instruments, Inc., 85 McKee Dr., Mahwah, NJ 07430.

COMPUTER PHONE DIALER, Keymemco. Fully assembled or in kit form, is a solid-state plug-in device that can be connected to any type phone without couplers. The unit holds 15 preset phone numbers (each up to 15 digits) and can hold the last manually dialed number in memory for recall. Touch-tone pad allows manual dialing of unpro-grammed numbers. Unit can be installed via direct-wire coupling; piggyback jack permits plugging both dialer and phone in one outlet. Power is supplied either by 4 NiCad batteries or 110-volt AC/DC adapter from 110 volts, 60 Hz. Optional speaker and volume control are available. Prices: Kit, $129; assembled, $220.—Chung Long Electronics Corp., P.O. Box 18732, Seattle, WA 98118.

EXTENSION CABLE KITS, Sylvania Check-A-Board model KZ-2 and model KRX-5, are designed to troubleshoot Zenith and RCA solid-state TV sets without removing chassis from set. Kits consist of cables made of stranded multicolored wire (color-differentiated for proper

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orientation with female connectors (for TV modules) and mating chassis connectors, plus plated-alloy conductors on glass-fiber PC boards. Suggested retail prices: model KZ-2 (Zenith) $49.50; model KRX-5 (RCA) $54.50.—General Telephone & Electronics Corp., 1 Stamford Forum, Stamford, CT 06904.

3-HOLE LIGHTER OUTLET BOX, model 1140, mounts under-dash and plugs into vehicle’s lighter outlet. Unit accepts three 12-volt devices, such as a CB transceiver, scanner, radar detector, tape deck, etc.; all three devices can be used simultaneously (maximum current draw, 10 amp). Comes with mounting bracket, and sets for a suggested retail price of $19.95.—Gold Line, 992 Danbury Rd., Georgetown, CT 06829.

PHONE PLUGS AND JACKS. A broad line of phone jacks, enclosed phone jacks and matching plugs is available. The line ranges from microminiature to thick-panel size, either two- or three-conductor and open- or closed-circuit format.—National Tel-Tronics, State Road Hill, Medaville, PA 16335.

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simultaneously (maximum current draw, 10 amp). Comes with mounting bracket, and sets for a suggested retail price of $19.95.—Gold Line, 992 Danbury Rd., Georgetown, CT 06829.

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grammed numbers. Unit can be installed via direct-wire coupling; piggyback jack permits plugging both dialer and phone in one outlet. Power is supplied either by 4 NiCad batteries or 11-volt AC/DC adapter from 110 volts, 60 Hz. Optional speaker and volume control are available. Prices: Kit, $129; assembled, $220.—Chung Long Electronics Corp., P.O. Box 18732, Seattle, WA 98118.

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HIGH-SPEED LOGIC TROUBLESHOOTER, model 57008 Scanmaster, is designed for in-circuit testing of digital ICs; front-panel pushbuttons let you probe pins, and a switch selects five logic families. Other features include a built-in dual-threshold logic state analyzer; 3½-digit display; a DVM (useful also for measuring DC voltages in analog circuits); and a universal logic pulser. The

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unit can be interfaced with an oscilloscope, frequency counter, or other test instruments. Price: $1295.—Information Scan Technology, 1725 Rogers Ave., San Jose, CA 95112.

COMPUTER PRINTER INTERFACES, Sol Hytype I and Hytype II, are designed to increase card-copy capability of the Sol computer. Hytype I mounts inside Sol Diablo Series 1200 printer;

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Hytype II interface works with Diablo Series 1300 printer. Both include fully assembled, tested and etched PC board, software, cables and mounting hardware. Driver software on CUTS cassette is included together with a source listing. Suggested retail price for Hytype I and Hytype II, $150.—Processor Technology Corp., 7100 Johnson Industrial Drive, Pleasanton, CA 94566.

GENERAL-PURPOSE BREADBOARD, model 4607 Plugboard, permits convenient assembly of custom circuits for Heath H-11 and DEC LSI-11, PDP-8 and PDP-11 computers. The model 4607 (measuring 8.430 X 5.187 X 0.062 inches) has etched contacts spaced to fit dual 36 pin connectors and contact terminations labeled to fit DEC nomenclature. The 0.042-inch-diameter holes on

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0.1-inch centers allows unrestricted placement of discrete components or DIP sockets.

The boards are made of copper-clad blue epoxy glass with solder-plated pads and gold/nickel-plated edge connectors. The model 4607 Plugboard sells for $15.95 each in quantities of 1 to 4; from 5 to 9 quantities, $14.35; quantities over 10, $12.76.—Vector Electronic Co., Inc., 12450 Gladstone Ave., Sylmar, CA 91342.

FLOPPY DISC SYSTEM, Disk II, is designed for the Apple II personal computer. System provides rapid access to programs and data, and the DOS software uses standard BASIC. The Disk II con-

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sists of an interface card and one or two mini-floppy drives and offers full 116K-bytes-per-diskette in soft-sectored format. Complete bootstrap in ROM and operating system in RAM provide full disc capability for systems with as little as 16K bytes; can load and store files, and allow random and sequential data access. System can be driven solely from Apple II power supply. Price: $495 (includes card and Disc II drive).—Apple Computer, Inc., 10260 Bandley Drive, Cupertino, CA 95014.
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Minimum order $5.00. Add $1.00 postage and handling. Ask for our complete price list when ordering. Overseas buyers, Manufacturers, Distributors or Dealer orders welcome. All parts are guaranteed against factory defects for one year. C.O.D. orders are welcome. 48-hour delivery.

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CIRCLE 60 ON FREE INFORMATION CARD

JanuarY 1979

www.americanradiohistory.com
HOBBYIST give your project the professional look. Printed circuit boards from your sketch or artwork. Affordable prices. Also fun kit projects. Free details. DANOCINTHS, INC., Box 261, Westlind, MI 48185.

BUILD 10.525 GHZ Doppler radar detector. Uses include Intrusion alarm, level sensing, event detection, automatic door opener, etc. Plans include schematic, wiring diagram, and parts list. Etched and drilled PC board available. Send $12.00 plus $1.00 for postage and handling. G/W ATEKITES, P.O. Box 520, Exton, PA 19341.

CIA TOOL KIT. Complete schematics for 30 electronic surveillance devices. $15.00. MICRON RESEARCH, PO Box 118, Woodstown, NJ 08098.

EDUCATION & INSTRUCTION


TELEPHONE buged? Don't be Watagedale! Countermeasures brochure $1.00. NEGEYE LABORATORIES, Box 547-RE, Pennsylwan, WV 16015.

UNIVERSITY degrees by mail. Bachelors, Masters, PhD's. Free revealing details. COUNSELING, Box 317-RE, Tusin, CA 92686.

ASTRONISH your friends with magic. E.S.P., card tricks you can do. Details. JENGEN, Box 191-CA, Downsonview, Ont, M3N 3A3.

FROM KIT TO CAR IN 80 MINUTES!

Electronic ignition is "in." Update your car with the TOPS in power, efficiency and reliability—the TIGER SST capacitive discharge ignition (CD).

The TIGER delivers everything other CD's promise—and more: quicker starting, more power, more gas mileage, tune-ups eliminated, lifetime plugs and points, reduced repairs and pollution. The TIGER can be built and installed in your car in 80 minutes. The TIGER is unique! The TIGER comes with a switch for TIGER or standard ignition for 12V negative ground only.

Simpli-Kit $21.95 POST PAID U.S.A.

WE ACCEPT: Mastercharge or Bank American. Send check or money order with order to:

Tri-Star Corporation DEPT. FF. P.O. Box 1727 Grand Junction, Colorado 81501

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FAIRCHILD RED LED LAMPS

#FLV057. Medium Size Clear Case RED/EMITTING. These are not receiving off-spec units as advertised by some of our competition. These are factory first, quality new units. 10 FOR $1.15

50 FOR $4.95

"WE BOUGHT 250,000 PCS."

COMPUTER KITS

We stock our own line of top quality computer kits.

8K STATIC RAM (S-100) $129
16K STATIC RAM (S-100) $295
16K EPROM (7800) BOARD (S-100) $59.95
16K STATIC RAM (SWTC 6600 SS-SO) BOARD $295

ADDITIONAL DATA ON ANY KIT AVAILABLE ON REQUEST.

16K DYNAMIC RAM CHIP

16K X 1 Bits. 16 Pin Package. Same as 65204-9. 235 NS access. 350 NS cycle time. Our best price yet for this state of the art RAM. 32K and 64K RAM boards using this chip are readily available. These are new, fully guaranteed devices by a major mfg. $14.95 each

8 FOR $89.95

FAIRCHILD "SUPER TRANSISTOR" 2N4304 2N4305 2N4306 2N4307 2N4308

Direct High Current-VECO-40 IC-5 Epc. 2N4301-2N4304 In pups with each order. Special Discount. BEEFED-UP version of the 2N4308.

8 FOR $18

FET SALE!

2N4304 Brand New N-Channels Junction Fet

BvGDO-30V/IDSS-15Ma Typ

1500 uMOS. TO-18 Plastic Case. $6 For $1.

DISC CAPACITORS

1 MFD 16V. P.C. leads. Most popular value by Sprague

20 for $1.00

TIP-30 POWER TRANSISTOR

Prime new units. TO-220 Case. High spec. VICO-60 IC-1AMF FT-3 MHz 30WATS

3 FOR $1.00

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VOLTAGE SUPPRESSORS

By Midwest. H6755010 Silicon Carbone Varistor. These units grab voltage transients, spikes, surges etc. For use on AC or DC in the range of 12 to 28 Volts. Small Size. 5 inch Disc with radial leads. For use across transformer secondaries, relays, etc. More rugged and reliable than silicon devices. Rated at 30 WATT-SEC. 25 WATT CONT. Perfect for use on AC operated boards and instruments.

RCA MICRO-POWER OP. AMP.

RC2051A Metal Can. Also used on many linear OP. Amps. Requires some layout design to operate properly. 75V to 10V. Perfect for battery use. Standing power down to 700 mv. High Gain. 2.5 dB typ. 1.5 Open Loop Gain. Measures zero crossover at compensation. See RCA Linear Data Book for more details. Similar to National LM102 Original cost only $1.25 each.

TERMS: Add $0.30 postage, we pay balance. Orders under $15 add $1.75 handling. No C.O.D. We accept Visa, Master-charge, and American Express cards. Tax Res add 5% Tax. Foreign orders (except Canada) add 20% P & H. 90 Day Money Back Guarantee on all items.
## COMPUTER INTERFACES & PERIPHERALS

For free catalog including parts lists and schematics, send a self-addressed stamped envelope.

### APPLE II SERIAL I/O INTERFACE *

<table>
<thead>
<tr>
<th>Part no. 2</th>
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<tr>
<td>Baud rate is continuously adjustable from 0 to 30,000</td>
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<tr>
<td>Plug into any peripheral connector</td>
</tr>
<tr>
<td>Low current drain</td>
</tr>
<tr>
<td>RS-232 input and output</td>
</tr>
<tr>
<td>On-board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even</td>
</tr>
<tr>
<td>jumper selectable address</td>
</tr>
<tr>
<td>SOFTWARE input and output routine from monitor or BASIC to teletype or other serial printer</td>
</tr>
<tr>
<td>Program for using an Apple I for a video or an intelligent terminal Also can output in correspondence code to interface with some seicenetics. Board only — $15.00 with parts — $42.00 assembled and tested — $52.00</td>
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### T.V. TYPEWRITER

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<td>Stand alone TVT</td>
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<td>32 chart/line, 16 lines modifications for 64 char/line included</td>
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<tr>
<td>Parallel ASCII (TTL) input</td>
</tr>
<tr>
<td>Video output 1K on board memory</td>
</tr>
<tr>
<td>Output for computer-controlled cursor</td>
</tr>
<tr>
<td>Auto scroll</td>
</tr>
<tr>
<td>Non-destructive cursor</td>
</tr>
<tr>
<td>Curser inputs up, down, left, right, home, EOL, EOD Scroll up, down</td>
</tr>
<tr>
<td>Requires +5 volts at 1.5 amperes and +12 volts at 30 mA</td>
</tr>
<tr>
<td>All 7406 TTL chips</td>
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<tr>
<td>Char. gen. 2513</td>
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<tr>
<td>Upper case only</td>
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<tr>
<td>Board only $39.00 with parts $145.00</td>
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### MODEM *

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<td>Type 103</td>
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<tr>
<td>Full or half duplex</td>
</tr>
<tr>
<td>Works up to 300 baud</td>
</tr>
<tr>
<td>Originates or Answer</td>
</tr>
<tr>
<td>No coils, only low cost components</td>
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</tbody>
</table>
| TTL input and output-
| serial |
| Connects 8 ohm speaker |
| and crystal mic. directly to board |
| Uses XR FSK demodulator |
| Requires +5 volts |
| Board $7.60, with parts $27.50 |

### TIDMA *

<table>
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<th>Part no. 112</th>
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<tr>
<td>Tape Interface Direct Memory Access</td>
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<tr>
<td>Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate</td>
</tr>
<tr>
<td>Low cost on-board baud rate generator</td>
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<tr>
<td>Board $7.60, with parts $110.00</td>
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### DC POWER SUPPLY *

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<td>Board supplies a regulated +5 volts at 3 amperes</td>
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<tr>
<td>-12, -15, and -5 volts at 1 amp</td>
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<td>Power required is 8 volts AC at 3 amperes, and 24 volts AC</td>
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<tr>
<td>7 at 1.5 amperes</td>
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<tr>
<td>Board only $12.50, with parts excluding transformers $42.50</td>
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### TAPE INTERFACE *

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<td>Play and record Kansas City Standard tapes</td>
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<tr>
<td>Converts a low cost tape recorder to a digital recorder</td>
</tr>
<tr>
<td>Works up to 1200 baud</td>
</tr>
<tr>
<td>Digital in and out are TTL—serial</td>
</tr>
<tr>
<td>Output of board connects to mic. in of recorder</td>
</tr>
<tr>
<td>Earphone of recorder connects to input on board</td>
</tr>
<tr>
<td>No coils</td>
</tr>
<tr>
<td>Requires +5 volts, low power drain</td>
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<tr>
<td>Board $7.60, with parts $27.50</td>
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### UART & BAUD RATE GENERATOR *

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</tr>
<tr>
<td>Baud rates 110, 150, 300, 600, 1200, and 2400</td>
</tr>
<tr>
<td>Low power drain +5 volts and +12 volts</td>
</tr>
<tr>
<td>TTL compatible</td>
</tr>
<tr>
<td>All characters contain a start bit, 5 to 8 data bits, and stop bits</td>
</tr>
<tr>
<td>Board only $12.00, with parts $35.00 with connector and $3.00</td>
</tr>
</tbody>
</table>

### 8K STATIC RAM

<table>
<thead>
<tr>
<th>Part no. 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>8K Altair bus memory</td>
</tr>
<tr>
<td>Uses 2102 Static memory chips</td>
</tr>
<tr>
<td>Memory protect</td>
</tr>
<tr>
<td>Gold contacts</td>
</tr>
<tr>
<td>Nickel plates</td>
</tr>
<tr>
<td>On-board regulator</td>
</tr>
<tr>
<td>+10 bus compatible</td>
</tr>
<tr>
<td>Vector input option</td>
</tr>
<tr>
<td>BR board buffered</td>
</tr>
<tr>
<td>Board only $21.50, with parts $160.00</td>
</tr>
</tbody>
</table>

### RF MODULATOR *

<table>
<thead>
<tr>
<th>Part no. 107</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converts video to AM modulated RF, Channels 2 or 3</td>
</tr>
<tr>
<td>So powerful almost no tuning is required</td>
</tr>
<tr>
<td>Board regulated power supply makes this extremely stable</td>
</tr>
<tr>
<td>Rated very highly in Doctor Dobbs Journal</td>
</tr>
<tr>
<td>Recommended by Apple</td>
</tr>
<tr>
<td>Power required is 12 volts AC C.T. or +5 volts DC</td>
</tr>
<tr>
<td>Board $7.60, with parts $13.50</td>
</tr>
</tbody>
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### RS 232/TTY *

<table>
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<tr>
<th>INTERFACE</th>
</tr>
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<tbody>
<tr>
<td>Part no. 800</td>
</tr>
<tr>
<td>Converts RS-232 to 20mA current loop, and 20mA current loop to RS-232</td>
</tr>
<tr>
<td>Two separate circuits</td>
</tr>
<tr>
<td>Requires +12 and -12 volts</td>
</tr>
<tr>
<td>Board only $4.50, with parts $7.00</td>
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</table>

### RS 232/TTL *

<table>
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<tr>
<th>INTERFACE</th>
</tr>
</thead>
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<tr>
<td>Part no. 232</td>
</tr>
<tr>
<td>Converts TTL to RS-232, and converts RS-232 to TTL</td>
</tr>
<tr>
<td>Two separate circuits</td>
</tr>
<tr>
<td>Requires +12 and -12 volts</td>
</tr>
<tr>
<td>All connections go to a 10 pin gold plated edge connector</td>
</tr>
<tr>
<td>Board only $4.50, with parts $7.00 with connector add $2.00</td>
</tr>
</tbody>
</table>

---

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<table>
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<tr>
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<th>2SA747</th>
<th>2SA683</th>
</tr>
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<tr>
<td>2SA562</td>
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<tr>
<td>C-2400</td>
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**2PAGE DATA SHEET:**

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| C-1475  | 30    |
| C-1455  | 50    |
| C-1460  | 100   |
| C-1335  | 100   |
| C-1500  | 50    |
| C-1140  | 100   |
| C-3200  | 30    |

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**RAM Memory ICs**

<table>
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<th>Cat. No.</th>
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Resolution: 10 Hz, 0.1 kHz, 1 kHz, 10 kHz
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- Output: 50VAC, 5 A, 100 VAC

FM POWER STAGES:

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Size: 6" x 10", 2 lb, low profile aluminum case, 2 lbs.

ICS: 13 units, all soldered

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Readout: 3 digit, 0.4" high LED, direct readout in MHz
Accuracy: adjustable to ±0.5 ppm
Stability: ±1 ppm over 10 to 40 °C temperature

Controllable
- 10 MHz reference - 50 MHz or CT-650
- Output: 50VAC, 5 A, 100 VAC

FM POWER STAGES:

100 VAC 5 Watts or 12 Vdc 100 ma

Size: 6" x 10", 2 lb, low profile aluminum case, 2 lbs.

ICS: 13 units, all soldered

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Most detailed features on low-cost microcomputer systems
Wide 20-column printout
Versatile 5 x 7 dot matrix format
Complete 64-character ASCII alphanumeric format
Fast: 120 lines per minute
Quiet: True on operation
Proven reliability

Full Size Alphanumeric Keyboard

Print-on-Demand: 8
Standard 54 key terminal-style layout
26 alphanumeric characters
10 numeric characters
22 special characters
8 bidirectional functions
3 user-defined functions

True Alphanumeric Display

Provides legible and lengthy display
20 characters wide
High contrast monolitich characters
Complete 64-character ASCII alphanumeric format

PROVEN R6500 MICROCOMPUTER SYSTEM DEVICE

Relates high performance NMOS technology
R6500 Central Processing Unit (CPU) operating at 1 MHz
Has 65K address capability 13 addressing modes and true index capability Simple but powerful 56 instructions

BASIC Interpreter Module R2114 Static Ram Devices Available in 1K and 4K byte versions

8K Random Program Memory using R232 Static RAM devices Has sockets to accept additional 2332 ROM or 2523 PROM devices to expand on-board Program Memory up to 20K bytes

R6523 RAM-Impedance Output-Tester (ROIT) combination device Multipurpose control for AIM 65 Monitor functions

Two R6522 Versatile Interface Adapter (VIA) devices which support AIM 65 and user functions Each VIA has two parallel and one serial 5-bit bus interface 1 0 ports two 2-bit peripheral handshake control lines and two fully programmable 16-bit universal timer counter events

Built-in Expansion Capability

Add Application Connector for peripheral add-ons
44-pin Expansion Connector has full system
Both connectors are KIM-1 compatible
TTY and Audio Cassette Interfaces

Standard Interface to low-cost peripherals
70 ma current loop TTY interface
Interface for two audio cassette recorders
Two audio cassette formats ASCII KIM-1 compatible and binary blocked like assembler compatible

ROM-Resident Advanced Interactive Monitor

Advanced features found only on larger systems
Monitor-generated prompts
Single keystroke commands
Address-independent data entry
Debug aids
16-bit messages
Options and user interface weaknesses

Advanced Interface Monitor Commands

Memory Management (RESE-Enter Memory)

- ERASE: Erase Memory
- Set-Repeat: Erase Memory
- ERASE: Erase Memory
- Set-Repeat: Erase Memory

Program Memory

- Enter memory instruction entry mode
- Display Assembly Memory

User-Defined Memory

- Enter mnemonic instruction entry mode
- Display Assembly Memory

Call User-Defined Functions

- Call User Function 1
- Call User Function 2
- Call User Function 3

Test Editor Commands

- Read input into text buffer from peripheral device
- Insert line into text buffer from keyboard
- Delete line from text buffer
- Insert line into text buffer from keyboard
- Delete line from text buffer
- Edit line from text buffer
- Insert line into text buffer from keyboard
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- Insert line into text buffer from keyboard
- Delete line from text buffer

Power Supply Specifications

- 5 VDC - 5% regulated to 2.0 amps (max)
- 10 VDC - 10% unregulated to 2.5 amps (peak)
- 0.5 amps (average)

Money Back Guarantee

If you are not convinced that the AIM 65 is the best of its kind in the market, we will refund your money immediately.

Rockwell's AIM 65 Advanced Interactive Microcomputer can get you into the exciting world of microcomputer development and at a lower cost than you may have thought possible. And you'll be working with the 6500 family the advanced state-of-the-art NMOS system that's an servicing favorite for new commercial and hobbyist applications.

As a learning aid the AIM 65 gives you an assembled versatile microcomputer system with a full range of 0-20 character display and uniquely a thermal printer an on-board Advanced Interactive Monitor Program provides extensive control and program development functions. And our AIM 65 User's Manual will help you along each step of the way.

You'll master fundamentals rapidly. Then you'll appreciate the fact that unlike the computer toys on the market the AIM 65 offers the only expandability you would expect to find in a sophisticated microcomputer development system

Thermal printer gives you hard copy - fast and quiet

AIM 65's 20 column THERMAL PRINTER gives you hard copy as you type. It produces all of the standard 64 ASCII characters with a crisp printing five-by-seven dot matrix AIM 65 on-board printer is a unique feature for a low-cost computer

Extended Alphanumeric Display is Built for Understanding, Not Deciphering

AIM 65 comes with a 20-character true Alphanumeric Display Information is displayed with bright magenta 16-segment font monolithic characters. It is both unambiguous and easily readable

Full-size keyboard is Designed for Humans, Not Elves

AIM 65's Terminal-style keyboard frees you from the hassles of juggling around with a tiny calculator-style keypad. And its 54 keys provides 70 different alphanumeric, numeric, control and special functions

On-board Advanced Interactive Monitor Gets Your Programs Up and Running

The ROM-resident AIM 65 Advanced Interactive Monitor Program provides a comprehensive set of easy-to-use single keystroke commands for debugging your program and provides features normally available only in larger expensive microcomputer development systems. And with the AIM 65 Monitor there's no question when the Monitor gives you an error message prompt when it needs information and it will generate a meaningful error message if an error has occurred

The AIM 65 Monitor includes commands to
- Enter and edit programs directly no 'opcode' memorization
- Last programs on Printer orTTY
- Display editing registers and memory
- Set breakpoints trace and debug program execution
- Control the Thermal Printer
- Transfer information to and from attached Cassette Recorders or TTY
- Execute programs in on-board or external RAM ROM or PROM memory
- Interrogate the optional AIM 65 Assembler and BASIC Interpreter

AIM 65's Advanced R6500 NMOS Architecture

The R6500 Central and Wing Unit is the heart of the AIM 65 It provides demonstrated speed and simplicity plus 65K addressability and the power of a 56-command microcomputer-size instruction set

The R6532 RAM/Output-Tester (ROIT) combination device is used by the AIM 65 Monitors for scratchpad memory and Keyboard operations

Two R6522 Versatile Interface Adapter (VIA) devices are provided One device supports AIM 65's Thermal Printer and the TTY and Cassette Interfaces and the other supports two user defined bidirectional I O ports plus an 8-bit serial I O port and access to two 16-bit timer/counter locations, on the already Application Connector

AIM 65 comes with two R2323A 300 baud Only Memory (ROM) devices installed These hold the Advanced Interface Monitor Program Sockets allow the user to expand on-board ROM up to 20K bytes These sockets will accept user programs in ROM32 ROMs or compatible PROMs, or can be used to install the optional AIM 65 Assembler and BASIC Interpreter ROM devices

On-board Read Write RAM Memory modules available in 1K-byte and 4K-byte configurations

AIM 65 Has Expansion Built In

And to allow AIM 65 to grow the way you want to we've provided an Application Connector and an Expansion Connector The Application Connector permits you to plug in a TTY (20 ma current loop) and one or two standard audio cassette recorders It also has the sockets for the VISA 44-pin DIP Interface 1500 The Expansion Connector permits the AIM 65's system bus address and data control output to additional memory, or anything else you might attach

And BASIC high-level language programming is a built-in option

Circle 5 on Free Information Card
moved from its socket and a jumper wire used to connect socket pins 8 and 2. The input will now be applied directly to the 7208 counter without being precased. You can also go a step farther and use a DPDT miniature toggle switch (S4) to open the supply going to the 74196 and short together pins 8 and 2 (see schematic). You will of course have to make allowances for the decimal point being one place to the right in this mode.

Calibration
Before calibration, check the regulated supply voltage at pin 2 of the voltage regulator IC6. The voltage should be between 5.1 and 5.35 referenced to ground. Resistor R1 can be replaced with a higher value to increase or a lower value to decrease the Depression output voltage. Allow the counter to warm up for 30 minutes before calibration.

Calibration is performed by allowing the counter to count an accurately known and stable signal (preferably between 3 MHz and 50 MHz) and adjusting trimmer C14 until the known frequency is displayed. A nonmetallic screwdriver or TV alignment tool should be used when adjusting C14. The 1-megohm/60-MHz input and the 1-second gate position should be used for maximum resolution.

If an accurately calibrated frequency counter is available then allow it and the OPTO-7000 to measure a stable oscillator or signal generator output. Adjust the OPTO-7000 until identical readings are obtained. The reference frequency counter should have at least the same number of digits of resolution as the OPTO-7000.

A signal generator or oscillator (15-MHz if available) can be adjusted for a zero beat against the WWV signal received on a general-purpose communications receiver. When a zero beat or meter null is obtained, read the frequency on the OPTO-7000 and adjust C14 for the correct display. A color TV set that is tuned to a network (CBS, NBC, ABC) color signal is phase-locked to a secondary frequency standard of 3.579545 MHz. The color-burst frequency standard should be used only by those who have experience working with powered-up TV set chassis.

It may be possible to locate a local two-way radio service shop that has suitable frequency calibration equipment and would be willing to calibrate a counter for a reasonable charge.

The Optoelectronics TCXO-70 can be used as a precision 1-ppm timebase for the OPTO-7000 and comes from the factory precalibrated.

SPECIAL: LM317 adjustable (+) regulator, $2.24 (6dqly.)


Please note our kit is guaranteed for 1 yr. Includes DP switches, and price 25 percent off for 4-MHz operation. Upgrades 4-K TRE-85 to 1-KB, or substitutes Memory Expansion Module—no novice level instructions show you how. Also suitable for APPLE computers.

H8 COMPATIBLE 12K X 8 MEMORY BOARD: $200

VHS is the basic, comes with sockets and logic; caps are pre-soldered in place for easy assembly. Assured: 970.

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The SE-01 is a kit that contains all the parts needed to build a programmable sound effects generator. Designed around the new Texas Instruments 76447 Sound Chip, the board provides banks of Mini Dip switches and pots to program the various combinations of the SEF Oscillator, VCO, Noise, One Shot and Envelope Controls. Another IC is used to implement an Adjustable Pulse Generator, Level Comparators and Multiplex Oscillator for even more versatility. The 3½" by 5" plated PC Board features a prototype area to allow for user added circuitry. Easily programmed to duplicate Explosions, Phaser Guns, Steampipes, or an almost infinite number of other sounds, the unit has a multitude of applications. The $16.95 price includes Assembly Manual, Programming Charts, and 76447 Chip specifications (speaker not included). Available from stock.
New 15MHz portable 3" dual-trace scope
- 15MHz bandwidth with smooth non-distorting, wide linear scale
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  - Located at 3/4 stages
  - Check operation of memory
  - RF and local circuits
  - Check stages sequentially
  - Locate series shifts and internal ghosts from RF, mixer
  - Vertical sync output
  - Operations performed internally with master function switch

Television Analyst Model 1077B
- Four instruments in one: sweep generator, marker generator, marker generator, marker scanner, and dual-trace generator
- Complete accessory pack
- All interchanging changes and generator separations accomplished internally with master function switch and front panel control
- Contributes all TV alignment steps

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- Generates 9 voltages and logic functions
- Located at 3/4 stages
- Check operation of memory
- RF and local circuits
- Check stages sequentially
- Locate series shifts and internal ghosts from RF, mixer
- Vertical sync output
- Operations performed internally with master function switch

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- Includes all components, case and transformer
- Size: 3 1/4 x 3 1/4 x 1 1/4”
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- Bright 300 1/2° common cathode display
- Uses MM5034 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 20 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6 3/4 x 3 1/8 x 1 3/4”
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**Jumbo 6-Digit Clock Kit**

- Four 830 1/2° and two 300 1/2° common anode displays
- Uses MM5034 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
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The “Pennywhistle 103” is an all solid-state kit which uses integrated circuit technology to assure easy assembly and operation. Requires minimum electrical experience. Includes a free Order Form. No radiation is possible. No soldering required. Includes complete instructions and parts needed for assembly. Kit includes: NE555 timer IC, 10k, 100k trimmer, 1N4148 diode, 1N914 diode, 1N914 diode, 1N914 diode, and 1N914 diode. Requires: (1) 9V, (2) 9V, (3) 9V, (4) 9V, (5) 9V. Available in 28 case. Kit includes: (1) 9V, (2) 9V, (3) 9V, (4) 9V, (5) 9V.

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- The TRS-80 16K System is a fully automatic digital conversion from analog to digital format. It is compatible with both TTL and CMOS logic and includes a complete set of hardware and software for easy conversion.
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- MOD II is protected by Channel 33 (UHF)
- Includes coaxial cable and antenna transformer

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**System Kits**

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- 25 Pin D Subminiature
- 63-Key Unencoded Keyboard

- 5-key pad includes 1-key to 10-key numbers, ABCDE and 2 optional keys and a shift key.
- **JE732** $19.95

**63-Key Unencoded Keyboard**

- Hexadecimal Unencoded Keypad

- 5-key pad includes 1-key to 10-key numbers, ABCDE and 2 optional keys and a shift key.
- **JE732** $19.95
QUEST Cosmic Super Elf Computer $106.95

Compare features before you decide to buy any other computer. Here is one that is an outstanding buy. This is a small single board computer that does many big things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily expanded with additional memory, Simple Basic, ASCII keyboard, video graphics, etc.

The Super Elf includes a ROM monitor for program loading, editing and execution with SIMPLE STEP forward or backward. Programs are not included in others at the same price. With SINGLE STEP you can see the microprocessor chip operating with the unique Quest address and data bus displays before, during and after executing instructions. Also, CPU mode and instruction cycle are shown on several LED indicators.

An RCA 1961 video graphics chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a speaker system included for writing your own music or any music programs already written with the sound program, which may be used to drive relays for control purposes. A 24 key HEX keyboard includes 16 HEX keys plus Read, Reset, and other memory protect.

Super Expansion Board with Cassette Interface $89.95

This is truly an astonishing value! This board has been designed to allow you to decide how you want it configured. The Super Expansion Board comes with a K 260 RAM only addressable anywhere in 64K with built-in protection. All possible cards have been made for all other options on the same board and it fits nicely into the hardware cabinet along with the Super Elf. The board includes slots for up to 5K of EPROM (2758, 2718, 2716 or TI 2716) and is fully buffered ($17.00 each). EPROM can be used for the monitor and the Text Basic or other purposes.

A 2764 EPROM with 1295 $19.95 is available as an on-board option in 2764 EPROM which has been preprogrammed with a program loader/editing and error checking multi-line cassette file read/write software (relocatable cassette file) another exclusive from Quest. It includes register save and readout, video graphics driver with blinking cursor and block move capability. The Super Monitor is written with substrategies allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done in the monitor if you have the Super Expansion Board and the Super Elf monitor to add and running at the push of a button.

On board options include Parallel I/O Interface and Ports with full handshake. They allow easy connection of an ASCII keyboard to the input port. RS 232 and 20 ma Current Loop to teletype or other device are on board and if you need more memory there are two S-100 slots for static RAM or video boards. A Goodrich 48 RAM board is available for $727. Parallel I/O Ports $9.85, RS 232 $32.50, TTY 20 ma I/F $1.95, S-100 $14.95. A 50 pin connector set with ribbon cable is available at $1.95 for easy connection between the Super Elf and the Super Expansion Board.

The Power Supply for the Super Expansion Board is a large, low noise power supply with 5V = 15V = 10V = 5V. Regulated voltages are +5V +12V $29.95 Deluxe version includes case at $39.95.

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<td>103A (103 w/PCB)</td>
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<td><strong>110 ELECTRONIC WHOOPER SIREN.</strong> Powerful warning sound. Dual oscillator circuit. Use with any alarm circuit. Battery not included.</td>
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<td><strong>117 TUNABLE ELECTRONIC ORGAN.</strong> Tunable 7-note scale. Play sing-a-long favorites. Battery not included.</td>
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<td>117A (117 w/PCB)</td>
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<td><strong>120 SIREN/CODE OSCILLATOR.</strong> Loud, piercing alarm. Practice Morse code. Battery not included.</td>
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<td><strong>104 VARIABLE STROBE LIGHT.</strong> Great for parties and photography. Variable flash rate. AC operated.</td>
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<td>ZSC 1387 4.50</td>
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Transformer
$1.76

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9 Steps 4 Colors

LED VU

Stereo level indicator kit with arc-shape display panel!!! This Mark III LED level indicator is a new design PC board with an arc-shape 4-colors LED display (change color from red-yellow-green and the peak output indicated by red). The power range is very large, from 30dB to 95dB. The Mark III indicator is applicable to 1 watt - 200 watts amplifiers operating voltage is 3V - 9V DC at max 400 MA. The circuit uses 10 LEDs per channel. It is very easy to connect to the amplifier. Just hook up with the speaker output!

IN KIT FORM $17.50

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Cut off when current it shared or over load to protect your amplifier as well as your speakers. An must for OCL circuits.

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It is not a Pack of cigarettes. It is a new FM wireless mic kit! New design PC board fits into a plastic cigarette box. (and included) Uses a condenser microphone to allow you to have a better response in sound pickup. Transmits up to 125 feet with an LED indicator to signal the unit is on.

KIT FORM $7.95

AN AIR HORN!

Good for anything needing sound! This is not electronic, but we bought them with some other deals. They are all brand new in boxes.

$2.50 EA.

WHAT A SAFE WAY TO SHOOT!

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6 positions $1.70
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12V DC POWERED
Lights up to 5 watt Fluorescent light tubes. Ideal for campers, indoor Auto or Boat. Kit includes high voltage coil, power transistor, metal tube, all other electronic parts and P.C. Board, Light tube not included.

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