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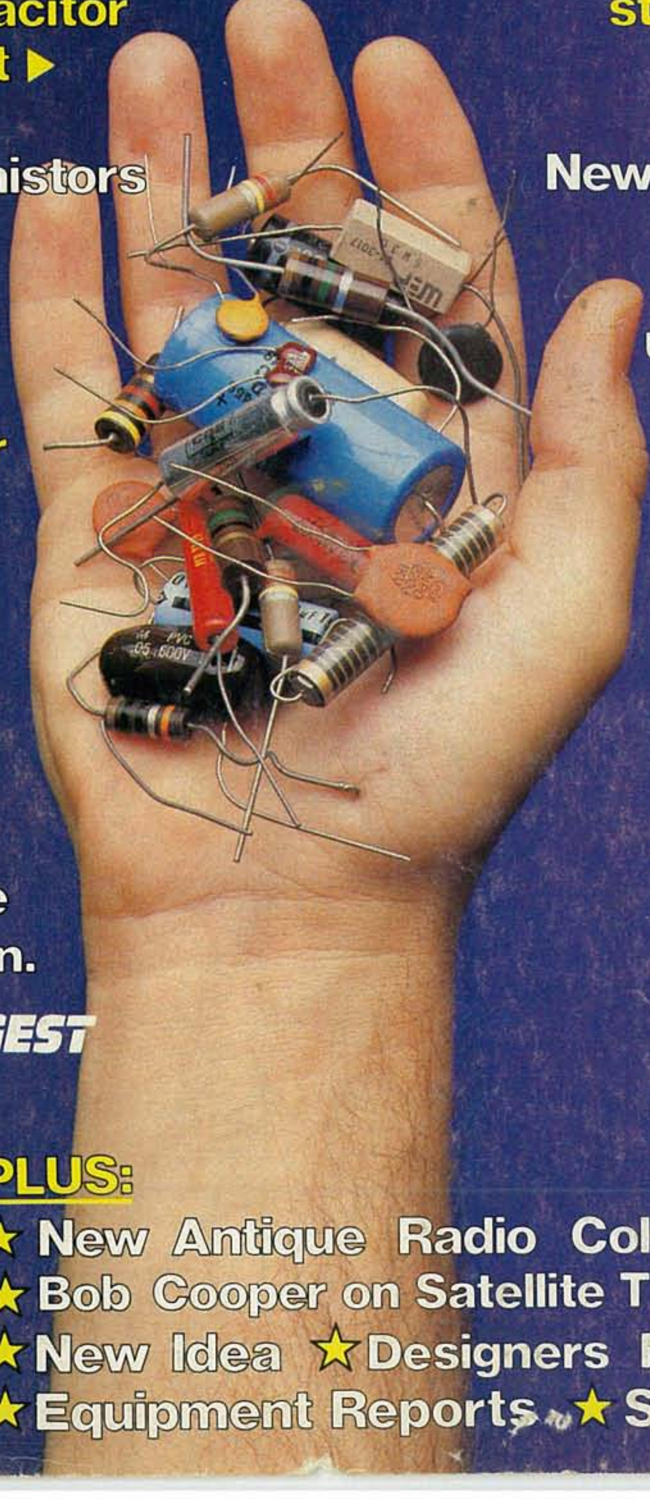

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All about thermistors and their applications

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Reduce wear and tear of your VCR heads with the AC powered circuit protected rewinders, LED power-on indicators.

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List price $599.95/**CE price $359.00**
Multi-Band, 20 Channel • No-crystal scanner
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Selectable AM-FM modes • LCD display
World's first continuous coverage scanner
Frequency range: 25-550 MHz. continuous coverage.
Never before have so many features come in such a small package. The *Regency* MX5000 mobile or home scanner has continuous coverage from 25 to 550 MHz. That means you can hear CB, Television audio, FM broadcast stations, all aircraft bands including military and the normal scanner bands, all on your choice of 20 programmable channels.

Regency® MX3000-E

List price $319.95/**CE price $179.00**
6-Band, 30 Channel • No-crystal scanner
Search • Lockout • Priority • AC/DC
Bands: 30-50, 144-174, 440-512 MHz.
The *Regency* Touch MX3000 provides the ease of computer controlled, touch-entry programming in a compact-sized scanner for use at home or on the road. Enter your favorite public service frequencies by simply touching the numbered pressure pads. You'll even hear a "beep" tone that lets you know you've made contact.

In addition to scanning the programmed channels, the MX3000 has the ability to search through as much as an entire band for an active frequency. The MX3000 includes channel 1 priority, dual scan speeds, scan or search delay and a brightness switch for day or night operation.

Regency® Z30-E

List price $279.95/**CE price $169.00**
6-Band, 30 Channel • No-crystal scanner
Bands: 30-50, 144-174, 440-512 MHz.
Cover your choice of over 15,000 frequencies on 30 channels at the touch of your finger.

Regency® C403-E

List price $99.95/**CE price $59.00**
5-Band, 4 Channel • Crystal scanner
Channel indicator LED • AC only • Low cost
Bands: 30-50, 148-174, 450-470 MHz.
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List price $329.95/**CE price $209.00**
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Frequency range: 30-50, 144-174, 440-512 MHz.
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List price $159.95/**CE price $92.00**
5-Band, 10 Channel • Crystal scanner • AC/DC
Frequency range: 30-50, 146-174, 450-512 MHz.
A versatile scanner, The *Regency* R-106 is built to provide maximum reception at home or on the road. Rugged cabinet protects the advanced design circuitry allowing you years of dependable listening.

NEW! Regency® R1050-E

List price $179.95/**CE price $109.00**
6-Band, 10 Channel • Crystalless • AC only
Frequency range: 30-50, 144-174, 440-512 MHz.
Now you can enjoy computerized scanner versatility at a price that's less than some crystal units. The *Regency* R1050 lets you in on all the action of police, fire, and emergency calls. You'll even hear mobile telephones.

Programming the R1050 is easy. Merely touch the keyboard and enter any of over 15,000 frequencies on your choice of 10 channels.

Regency® HX650-E

List price $129.95/**CE price $79.00**
5-Band, 6 Channel • Handheld crystal scanner
Bands: 30-50, 146-174, 450-512 MHz.
Now you can tune in to any emergency around town, from wherever you are, the second it happens. Advanced circuitry gives you the world's smallest scanner. Our low CE price includes battery charger/A.C. adapter.

NEW! Regency® HX-650P-E

List Price $189.95/**CE price $104.00**
Now, Communications Electronics offers a special packaged price on the *Regency* HX-650 scanner and the following items for only $104.00. You get the *Regency* HX-650 scanner, a set of 4 AAA ni-cad batteries, the MA-506 carrying case, six crystal certificates, AC adapter/charger and flexible rubber antenna for only $104.00 per package plus $10.00 shipping/handling. To order this special package, use CE special order number HX-650P-E.

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Order two scanners at the same time and deduct 1%, for three scanners deduct 2%, four scanners deduct 3%, five scanners deduct 4% and six or more scanners purchased at the same time earns you a 5% discount off our super low single unit price.

NEW! Regency® MX7000-E

List price $699.95/**CE price $449.00**
10-Band, 20 Channel • Crystalless • AC/DC
Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.2 GHz. continuous coverage
In addition to normal scanner listening, the MX7000 offers CB, VHF, and UHF TV audio, FM Broadcast, all aircraft bands (civil and military), 800 MHz communications, cellular telephone, and when connected to a printer or CRT, satellite weather pictures.

The *Regency* Touch MX7000 provides the ease of computer controlled, touch-entry programming in a compact-sized scanner for use at home or on the road. Enter your favorite frequencies by simply touching the numbered pressure pads. You'll even hear a "beep" tone that lets you know you've made contact.

In addition to scanning the programmed channels, the MX7000 has the ability to search through as much as an entire band for an active frequency. When a call is received, the frequency will appear on the digital display.

Regency® Z10-E

List price $239.95/**CE price $138.00**
6-Band, 10 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Bands: 30-50, 140-174, 440-512 MHz.
Cover your choice of over 15,000 frequencies on 10 channels at the touch of your finger.

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B-4-E 1.2 V AAA Ni-Cad batteries (set of four) $9.00
A-135C-E Crystal certificate $3.00
A60-E Magnet mount mobile antenna $35.00
A70-E Base station antenna.......................... $35.00
Add $3.00 shipping for all *accessories* ordered at the same time.
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COVER 1

Choosing the right component values for your circuit designs can be difficult. But that task can pale in comparison to choosing the proper component types!

If you've ever wondered about the differences between wirewound and carbon resistors, or ceramic and tantalum capacitors, then this article is for you. This month, we'll tell you about resistors—carbon, film, wirewound, cermet, etc. The story begins on page 47.

NEXT MONTH

ON SALE FEBRUARY 14

TEST EQUIPMENT
Two information-packed articles to help you choose the oscilloscope and digital multimeter that's best for you.

UNIVERSAL CASSETTE INTERFACE
In Part 2, we'll show you how to build the high-speed tape streamer.

RESISTOR/CAPACITOR SECTION
Next month, we'll look at different capacitor types and how to pick the right one for your circuit designs.

DIGITAL IC's
Our back-to-school series continues with a look at CMOS technology.

AND LOTS MORE!

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Radio-Electronics is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature*.

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Advertising Sales Offices listed on page 122.

WHAT'S NEWS

PROTECTION FOR A COMPUTER

A ROOM AS BIG AS A BASKETBALL COURT is needed to hold the 1,840 storage batteries at the Boeing Computer Services data center in Bellevue, Washington. The 1,840 Allied C & D batteries, with an output equal to that of 3,300 standard car batteries, are part of a fail-safe plan to provide instantaneous backup power in case of electrical failure. Protection is temporary only—the batteries are intended to provide 4,100 kilowatts of power for 15 minutes, while the company's diesel generators can be started. The center is designed to withstand natural disasters, and the batteries are installed on earthquake-resistant racks.

American company locates in Japan

Last October, Applied Materials Japan, a subsidiary of Applied Materials, Inc., of Santa Clara, CA, dedicated a new Technology Center in Marita, Japan, just outside of Tokyo. Applied Materials calls it "the first major research and development facility in Japan established by an American semiconductor production systems manufacturer."

The 57,000-square-foot facility was built at a cost of $9.2 million, part of which was provided by a $3.4 million loan from the Japanese Development Bank, an agency of the Japanese government.

New lab investigates silicon-on-sapphire IC's

The Marconi Co. is establishing a fully-equipped Silicon Systems Laboratory in Lincoln, England. It will provide advanced processing facilities for 1.5-micron silicon-on-sapphire technology IC's.

The advantages of silicon-on-sapphire are improved speed or reduced power, combined with high packing density and proven radiation resistance. A particularly important application is for electronics in satellites, where the cost of providing electrical power is high, and where the circuits are exposed to continuous natural radiation for years.

NASA contracts for advanced space system

NASA's Lewis Research Center, Cleveland, OH, has awarded a $260 million contract to a team of electronics manufacturers headed by RCA's Astro-Electronics Group of Princeton, NJ, for design, development and fabrication of an Advanced Communications Technology Satellite (ACTS). That is expected to be the most advanced and complex space-communications system known. It is scheduled for launch by the Space Shuttle in 1989.

The contract specifications call for a flight spacecraft, ground systems, and operations. The work will be split among the several contractors. Lewis has project-management responsibility for the program; RCA Astro-Electronics will be responsible for construction of the spacecraft and integration and testing of the ACTS system. COMSAT will take care of the design and development of a master control station, a NASA ground station, and operations and maintenance, and TRW will develop the multibeam communications package.

The technologies to be tested in the ACTS program, says a NASA spokesman, could lead to at least a five-fold increase in satellite-communications capabilities in the 1990's. Those include multiple spot beam transmission, message switching on board the satellite, and use of a new higher-frequency band between 20 and 30 GHz. **R-E**

New protection—especially in stormy weather—for the electronics you use, sell or service!

A brief, high voltage surge – or spike – can occur in any AC line system and, at amplitudes lower than 600V, cause little or no damage.

But at greater amplitudes, a spike can do real damage. And the greater the high voltage surge – resulting from nearby lightning, for example – the greater the risk of harm, especially to solid-state devices.

That's why Zenith now announces the availability of two Spike Suppressors – one with a grounding plug and the other without.

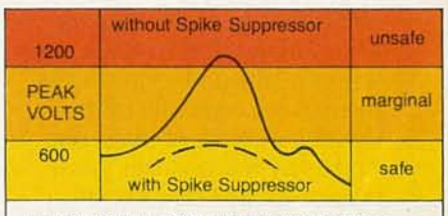
Both are designed to provide susceptible TV receivers, household appliances and other electronics with two-way protection from high-voltage surges.

First, a Zenith Spike Suppressor absorbs a wide range of voltage spikes so only a safe voltage level reaches the protected equipment.

Second, heavy or prolonged voltage surges cause a Zenith Spike Suppressor to cut off power completely to protected equipment thereby signaling the need for a replacement Spike Suppressor.

That's double-duty protection against spikes for the electronics you use, sell or service. And ample reason for you to lay in a supply of Zenith Spike Suppressors soon.

Chances are they're available at your Zenith dealer's now. Call and pick up several before the next storm hits!



In this graph, the solid curve represents the excess voltage or "spike" imposed on an electric system and, represented by the dotted line, the protection provided household appliances as the Zenith Spike Suppressor absorbs the excess voltage and prevents it from surging thru the system.

ZENITH®
The quality goes in before the name goes on.®

Train for the Fastest Growing Job Skill in America

Only NRI teaches you to service and repair all computers as you build your own 16-bit IBM-compatible micro

As computers move into offices and homes by the millions, the demand for trained computer service technicians surges forward. The Department of Labor estimates that computer service jobs will actually *double* in the next ten years—a faster growth than any other occupation.

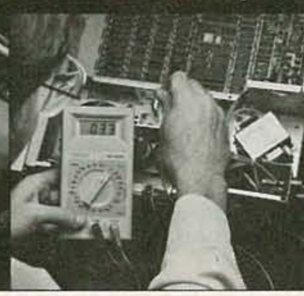
Total System Training

As an NRI student, you'll get total hands-on training as you actually build your own Sanyo MBC-550-2 computer from the keyboard up. Only a person who knows *all* the underlying fundamentals can cope with *all* the significant brands of computers. And as an NRI graduate, you'll possess the up-to-the-minute combination of theory and practical experience that will lead you to success on the job.

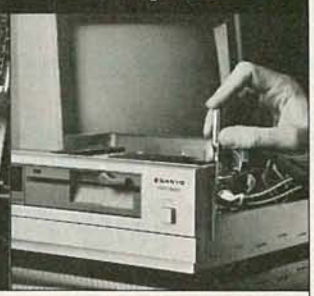
You learn at your own convenience, in your own home, at your own comfortable pace. Without classroom pressures, without rigid night-school schedules, without wasted time. Your own personal NRI instructor and NRI's complete technical staff will answer your questions, give you guidance and special help whenever you may need it.

New from NRI—the only home study course that trains you as you assemble a top-brand computer!

After you construct this digital logic probe, you'll install the "intelligent" Sanyo detached keyboard, with its dedicated microprocessor.



You next assemble the power supply into the main unit of the computer. Using the digital multimeter, you check all keyboard connections and circuits.



After you install the disk drive and monitor, you'll make a backup copy of the MS-DOS operating disk, explore the 8088 microchip and additional circuits.

The Exciting Sanyo MBC-550-2—Yours To Keep

Critics hail the new Sanyo as the "most intriguing" of all the IBM-PC compatible computers. It uses the same 8088 microprocessor as the IBM-PC and the MS/DOS operating system. So, you'll be able to choose thousands of off-the-shelf software programs to run on your completed Sanyo.

As you build the Sanyo from the keyboard up, you'll perform demonstrations and experiments that will give you a total mastery of computer operations and servicing techniques. You'll do programming in BASIC language. You'll prepare interfaces for peripherals such as printers and joysticks. Using utility programs, you'll check out 8088 functioning. NRI's easy step-by-step instructions will guide you all the way right into one of today's fastest growing fields as a computer

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **German Flat-Screen Color TV.** Siemens of Germany, with government backing, has developed a plasma color display less than 2½ inches thick, providing a 12-inch picture on a panel measuring 14-inches diagonally, which the German government says is ready for production. The system uses a plasma cathode, no electron gun, and is addressed by a matrix system. The phosphor screen is said to be a conventional type, currently with 288 lines, each made up of 720 phosphor points, or 240 sets of three colors. The tube reportedly is scheduled for production in an ITT German plant. However, the matrix system currently is very expensive and development of special VLSI IC's is required to bring costs down. Germany claims the flat tube is the most advanced such display device ever built.

• **All-in-One.** Pioneer has introduced a combination Laservision videodisc player and CD compact digital audiodisc player. To be priced at more than $1,000, it automatically adjusts itself to play back 4½-inch CD discs, or 8- or 12-inch LV videodiscs, and the solid-state laser automatically changes in intensity to read either the audio or video disc. With the introduction of the combination player, Pioneer also is adding a digital-audio track to its new Laservision videodiscs. The analog track is also preserved for compatibility with old model players. As it introduced its new model, Pioneer cut the list price of its older videodisc player to $300.

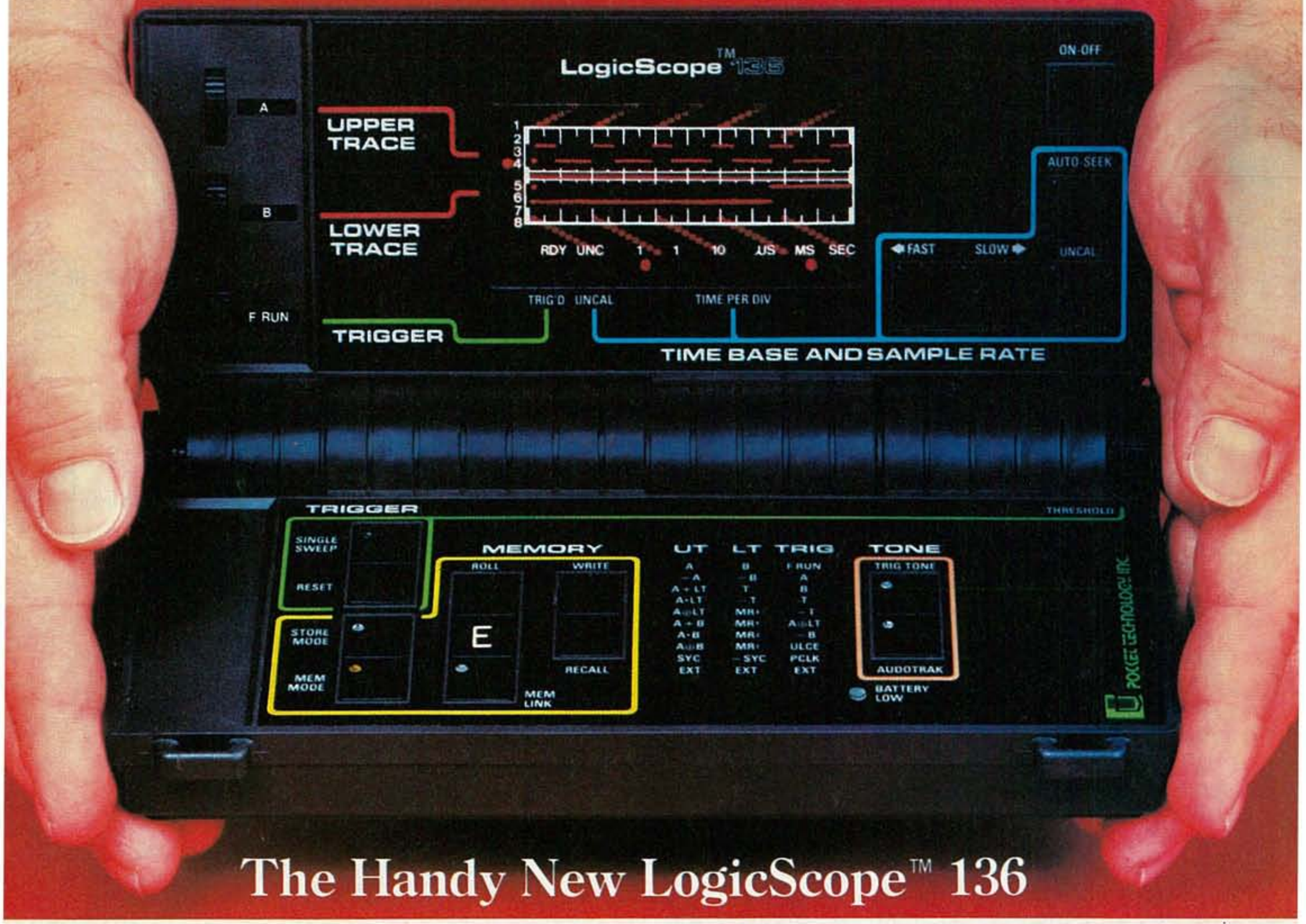
• **Camcorder update.** The all-in-one camera-VCR, or camcorder, is coming into its own, and the three formats now in production will be joined by a fourth in 1985. Currently available or on the way are 8mm camcorders by Kodak, Polaroid, and GE; Betamovie camcorders by the Beta group, including Sony, Sanyo, Toshiba, and NEC, and VHS-C VideoMovie camcorders using the 20-minute compatible mini-VHS cassette by JVC, Zenith, and the European Thomson Group.

The VHS group has been accelerating development of a camcorder combining the advantages of all three systems without the disadvantages, and both Matsushita (Panasonic and Quasar) and Hitachi (which also manufactures for RCA) have come up with units combining a full-sized VHS cassette with a video camera. The aim is to produce a basic camcorder model to sell in the U.S. for less than $1,000. The companies believe they have overcome the disadvantages of the three other systems introduced to date—unlike the 8mm models, they will use standard cassettes; unlike Betamovie, they'll be able to play back as well as record, and unlike VideoMovie (and currently 8mm), they'll be able to record a full two hours on a cassette.

• **Multichannel TV Sound.** Stereophonic sound will be added to the television signal of more than 100 TV stations in 1985, according to a recent survey. The survey, conducted by the trade newsletter, *Television Digest*, indicated that the stations would be located in most major metropolitan areas. The new multichannel TV sound (MTS) system also provides for transmission of a *S*econd *A*udio *P*rogram, or SAP, in addition to stereo. The survey found that SAP transmissions would be much slower than stereo in starting up. Only 19 percent of the stations planning to broadcast in stereo indicated they would also originate such program-related SAP transmission as second-language translation, while 3.5 percent planned to originate non-program-related SAP's. Under the FCC rules, stations may originate virtually any non-program-related audio material they wish—anything from paging service to radio-type programming for the public.

A survey of set manufacturers by the EIA, meanwhile, indicates that they expect multichannel sound sets to comprise 10 percent of color-TV shipments by mid-1986, rising to 30 percent by mid-1987 and leveling off at 45 percent in mid-1988. MTS adaptor jacks should be in 10 percent of sets sold by mid-1985, in 20 percent by mid-1986, and peaking at 30 percent in mid-1988. (See story on page 51.) **R-E**

Here's The Savvy-est True Dual Trace 10 MHz Digital Storage Scope You Ever Saw . . . At The Saving-est Price. Only $595.



The Handy New LogicScope™ 136

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SATELLITE TV

LNA's and downconverters

BOB COOPER, JR.*
SATELLITE EDITOR

THE PAST FEW MONTHS, WE'VE LOOKED at the evolution of the home TVRO. This time, let's continue with a look at how LNA's and downconverters have changed.

LNA changes

A *L*ow-*N*oise *A*mplifier (LNA) has always been a substantial part of the home-TVRO system. Since 1979, that portion of the system has seen the most dramatic change in pricing. In 1979, the basic LNA had a 120-degree noise temperature (figure) with 50 dB of circuit gain at a cost of over $1500 per unit; but by year's end, prices had dropped to around $1195. Not only that, but its original function and use has been significantly modified by creative system designers, as well.

In 1979, an LNA was simply a "low-noise gain block" designed to provide a suitable low-noise front-end for the receiver that followed. Its job was to supply enough RF signal-gain to overcome the coaxial cable's line losses between the LNA and the receiver. It was powered by a DC supply that ranged from 15–25 volts. Power was fed to the LNA through a pair of weather-proof wires from a power connector located on or at the receiver. Back then, the basic LNA was virtually the only one offered.

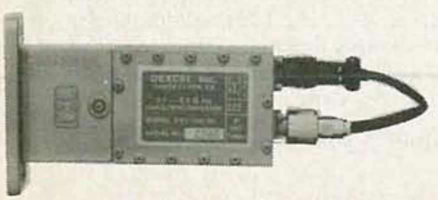

FIG. 1

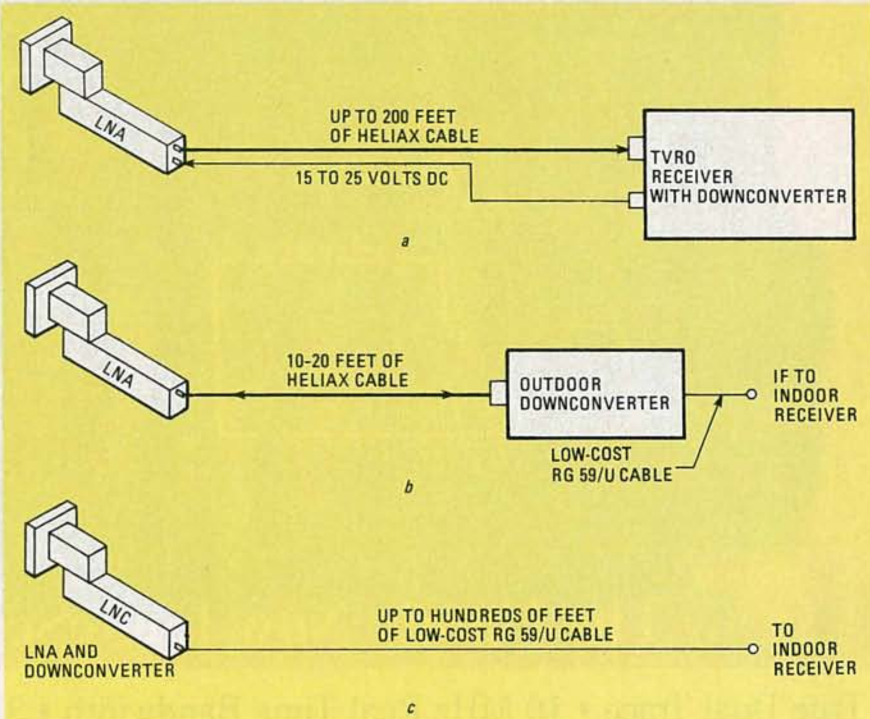

FIG. 2

Today, however, the dealer has a wide list of options available: Virtually any noise temperature from 120 degrees down to 60 degrees; almost any gain from 30–55 dB, and models with or without isolators. Also, the price of an LNA has dropped significantly. Now dealers are paying under $100 for an LNA.

The basic LNA (see Fig. 1) now has a 100-degree or lower noise figure. (Lower noise temperature means lower noise contribution, hence, improved system sensitivity.) In addition, the unit is now powered through the same coaxial cable that connects the LNA to the downconverter portion of the receiver.

Downconverters

In 1979, the 3.7–4.2 GHz output of the LNA had to be driven indoors through (relatively) "lossy" cable—sometimes as much as 200 feet of the stuff—to the downconverter located inside the receiver, as shown in Fig. 2-a. In those days, *bulk gain* in an LNA was important because immediately after the LNA was *bulk loss* because of the interconnecting cable. (What was lossy cable at 4 GHz was probably not lossy at 70 or even 1200 MHz.) However, that situation soon changed.

First, downconverters were taken out of the receivers (see Fig. 2-b) and installed in their own weather-resistant housings, allow-

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ing them to be mounted right at the dish (usually to the rear). Now the microwave energy had to travel only about 10 to 20 feet through lossy cable before it was downconverted to a lower frequency (i.e. the IF), which meant less signal loss.

With less signal loss expected, the gain of the LNA could be scaled down to the 30–45 dB region. That helped reduce the price of LNA's (fewer gain stages equals lower cost). Next, prices for GaAs FET's, used in LNA's, dropped dramatically—from \$500 each in 1978 under to \$5 in 1984—as volume went up.

Then some clever engineers found that the isolator portion of the LNA could be eliminated if you were extremely careful about how you designed the balance of the LNA, and were equally careful about how you installed and used the unit. (The isolator cost \$30 and up and also added circuit noise to the LNA in front of the GaAs-FET amplifier stages.) Seemingly, that was the best of both worlds—lower cost and better performance!

Finally, firms such as Dexcel/Gould created hybrid units that combined the LNA plus the downconverter into a single container (see Fig. 2-c), eliminating the short section of coax between the LNA and the downconverter. Those packages, called *L*ow-*N*oise *C*onverter (LNC), reduced by 1 the number of pieces in a typical TVRO system, thus, simplifying dealer installation.

Synopsis of trends

As we enter 1985, LNA prices have come down dramatically, while quality (performance and reliability) has gone up. Many had predicted that the development of LNC's would doom LNA's. After all, who'd want to install an LNA plus downconverter when one LNC could replace the pair? However, things didn't quite work out that way because LNC's are designed (typically) to work with one model receiver.

The dealer has learned or believes, that his maximum flexibility occurs when he can separate the LNA or LNC from the receiver so you can "mix-and-match" to get

continued on page 120

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.

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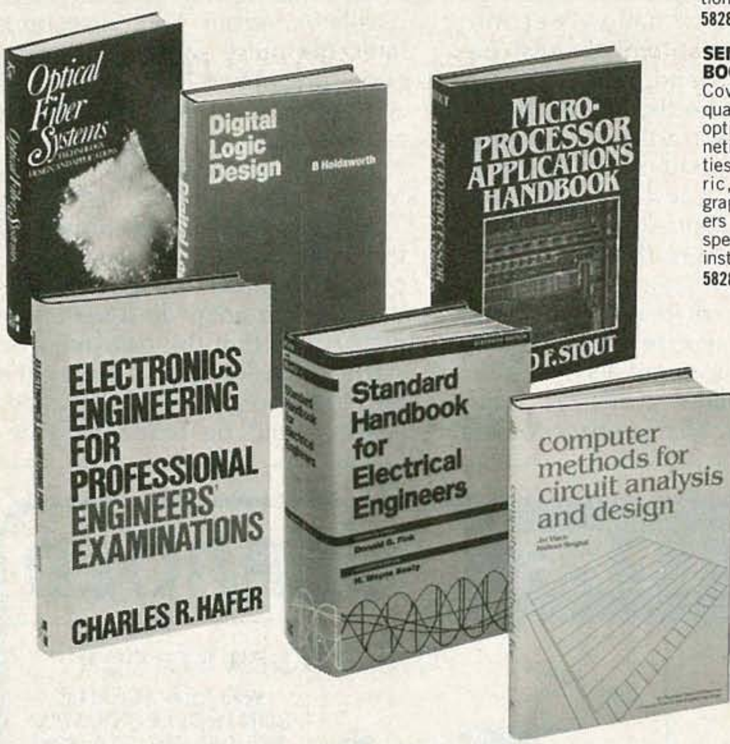

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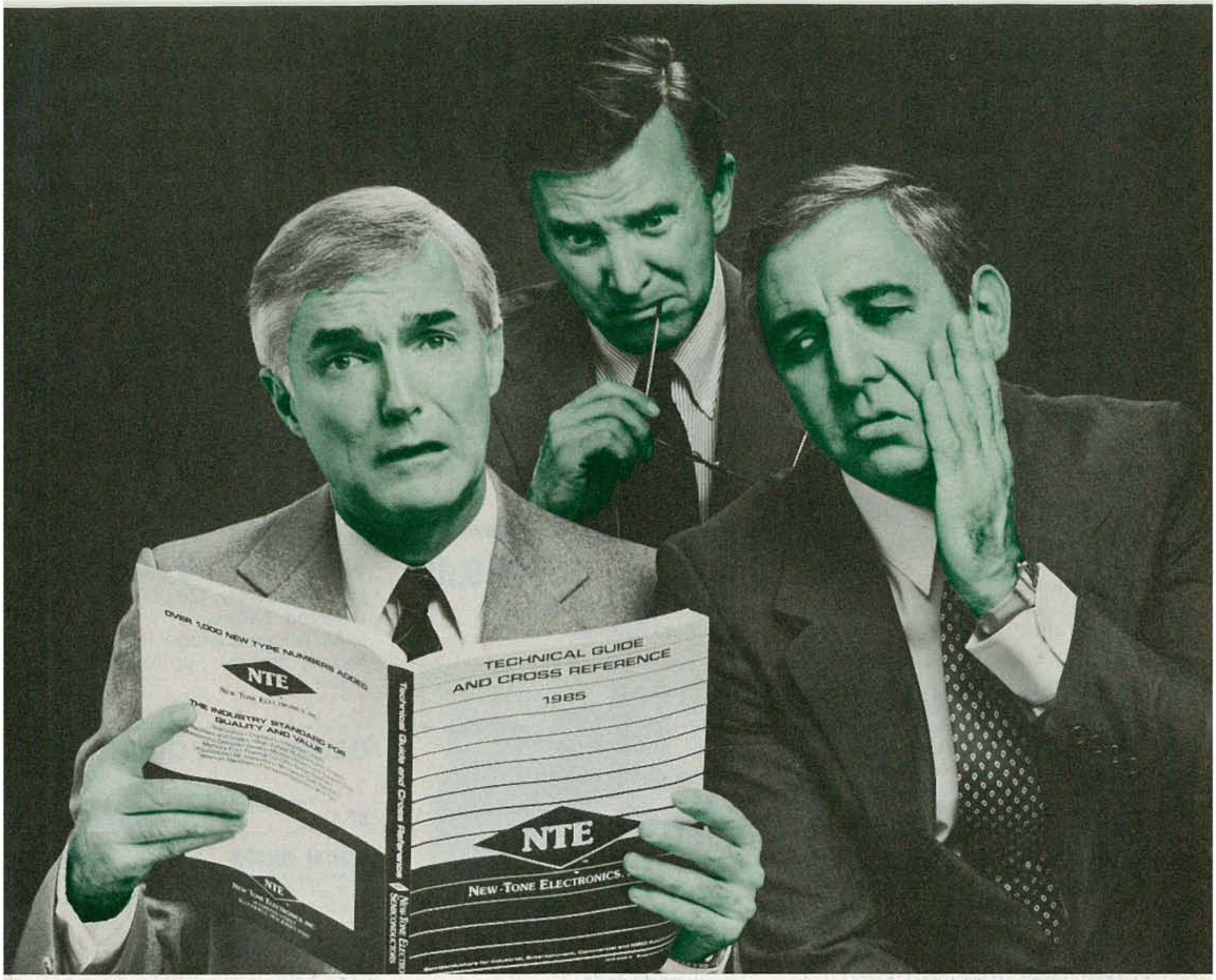
CLOSED-CAPTION TV SIGNALS

Perhaps we can provide some of the information John Bunting asked for in the August 1984, "Letters" column relative to closed caption TV signals. PBS stations helped pioneer the process, first with the National Bureau of Standards system in the 70's, and then with the current system.

In theory, it should be relatively easy to extract the transmitted characters, but one will not be able to obtain the full caption function with "a few dollars worth of chips." First, it is necessary to look in the right place for the caption signal: line 21, the last line of vertical blanking before the start of picture information. Second, the decoder has to distinguish between field 1 and field 2 of each frame, because the actual characters are only transmitted during field 1. (Only half of line 21 can be used in field 2, and that is reserved for a framing code that determines when and where the text will appear on the screen.)

The format of field 1, line 21, is as follows: 10 microseconds after the start of the horizontal-sync pulse, exactly 7 cycles of 503 kHz sinewave appear. That is phase-locked to horizontal sync, and is used for synchronizing the decoder clock oscillator. About 4 microseconds later, the pulse sequence begins, consisting of two 7-bit (plus parity) ASCII characters in non-return-to-zero (NRZ) format. The two characters occupy a little under 34 microseconds. That is true for only 7 consecutive frames, however; the eighth is used for a reference pulse that allows the commercial decoders to adapt to a variety of distortions that the transmission system may induce. Neither the framing code nor the equalizer pulse would be feasible to de-



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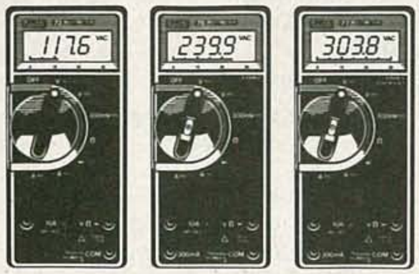

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- CH1 signal output
- Beam finder
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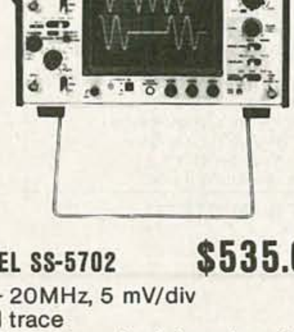

MODEL SS-5702 $535.00

DC – 20MHz, 5 mV/div
Dual trace
6 inch rectangular internal graticule CRT.
Includes 2 each x1/x10 probes and full factory warranty; 2 years on parts, labor and CRT.

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- 10 Hz to 1 MHz

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- Sine, square and triangle output
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- Typical distortion under 0.5% from 1 Hz to 100 kHz
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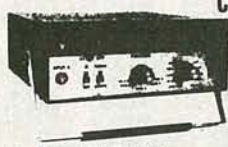
VIZ MULTI-FUNCTION COUNTER



MODEL WD-755
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- 5 Hz to 125 MHz
- 8 Digit LED Display
- Period Measurement 5 Hz to 2 MHz
- Totalizes to 99,999,999 Plus Overflow
- Frequency Ratio Mode
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MODEL WV-532A
- Fast relay opens input circuit on overload
- Lamp indicates when relay is open
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VARIABLE TRANSFORMER

$145.00 MODEL 3PN1010V

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PROBE MASTER Polaroid Shimpo Simpson PRIMELINE STACO ENERGY PRODUCTS CO. VIZ code, so the experimenter would probably want to display the data stream on a separate monitor.

It would appear that teletext and closed-caption signals are quite different, which is reasonable considering the difference in targeted audiences. The closed-caption signal transmits data at a much slower rate and might appear to be less efficient. It is still capable of transmission faster than most people can read, though, and the slower rate enables reliable data recovery even at the outer regions of a station's coverage.

Teletext, on the other hand, must be more things to more people, so it necessarily must be faster. That is accomplished by higher baud rates and use of more lines. Mr. Bunting might be interested to know that lines 10–13 are not in general use, but according to the FCC's timetable (Section 73.682, Schedule 1) will become available in 1988. Lines 14–18 and 20 (both fields) are currently used, although some stations still use certain of those lines for test signals.

We hope that information will be useful to Mr. Bunting and any others interested in this new area of TV technology.

JOHN H. DAVIS
WJSP-TV
Warm Springs, GA

ANOTHER ONE JOINS THE RANKS

You can add my name to the list of those who joined your ranks from *Computer & Electronics*, (formerly *Popular Electronics*.)

I had been reading and/or subscribing to *Popular Electronics* since 1964, but no more once they became *Computer & Electronics*.

By the way I've got nothing against computers, since I design PC boards using a CAD (computer-aided design) system and have a Radio Shack *TRS-80 Color Computer* at home. But everything has its place, and changing their format to one that covered computers almost entirely was a bad move. I had always looked forward to building the various projects they (and also your magazine) published.

Before I sign off, maybe you or your readers can help me. I need a schematic and parts list for a Southwest Technical Products Corp. project called *Psychedelia III*, a color organ kit that needs repair. I hope you can help.

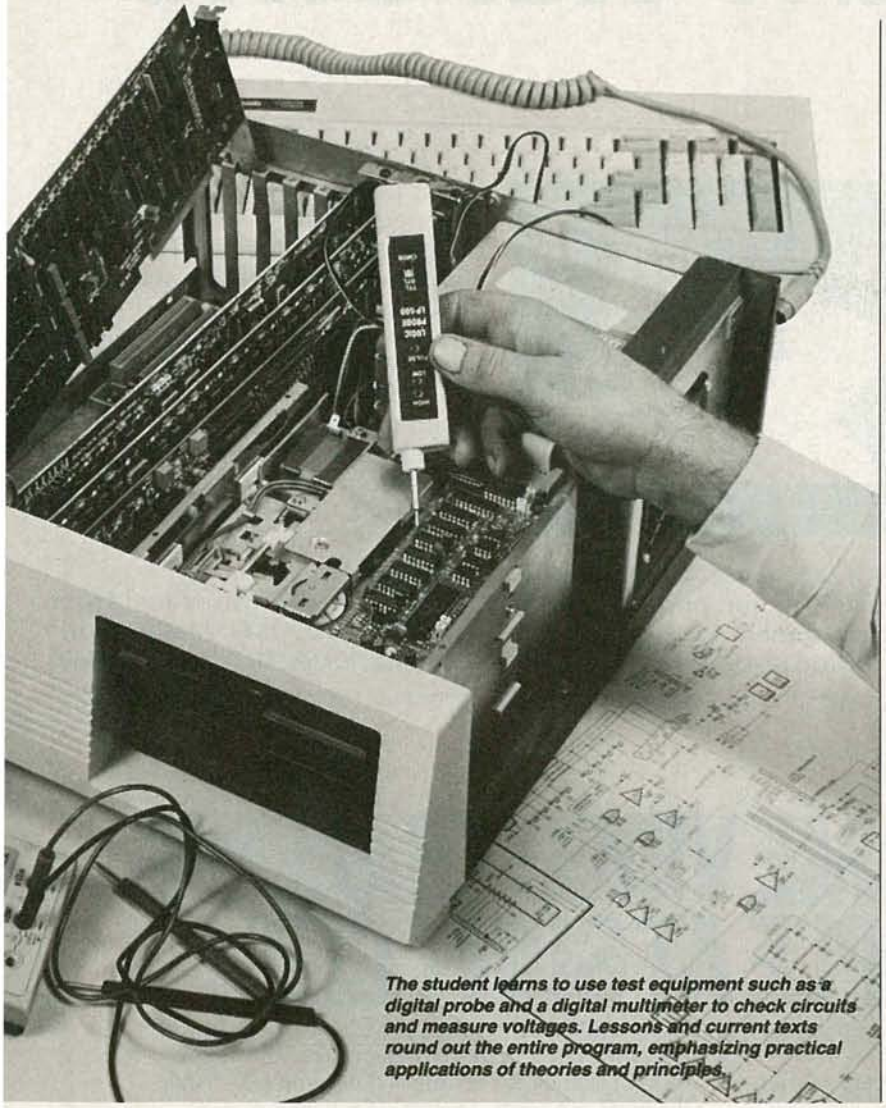
RICHARD C. POLK
Streamwood, IL

ZX81 OWNERS ALIVE AND WELL

Thanks to you for running the article on "Interfacing the *ZX81*." I just received my July issue of **Radio-Electronics**, (the mail takes a while) and I am delighted with the article. Also appreciated was the previous article by Paul W.W. Hunter on the 8K transparent memory for the *ZX81*. I estimate that there are on the order of two million *ZX81* and Timex *1000* owners scattered about, and although our prime supplier (Timex) and prime publication (Sync) have bitten the dust, we remain alive and well.

JESS PEELER
Costa Rica, Central America **R-E**

NTO PC SERVICING
A MICROCOMPUTER



The student learns to use test equipment such as a digital probe and a digital multimeter to check circuits and measure voltages. Lessons and current texts round out the entire program, emphasizing practical applications of theories and principles.

Installing the disk-drive in the PC is one of the final stages in the assembly of the microcomputer. Learning the use of test equipment to check circuits is an integral part of the training which, with field experience, develops invaluable career skills.

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EQUIPMENT REPORTS

Cardco Card/? Universal Printer Interface

This interface lets you use almost any printer with your Commodore 64.

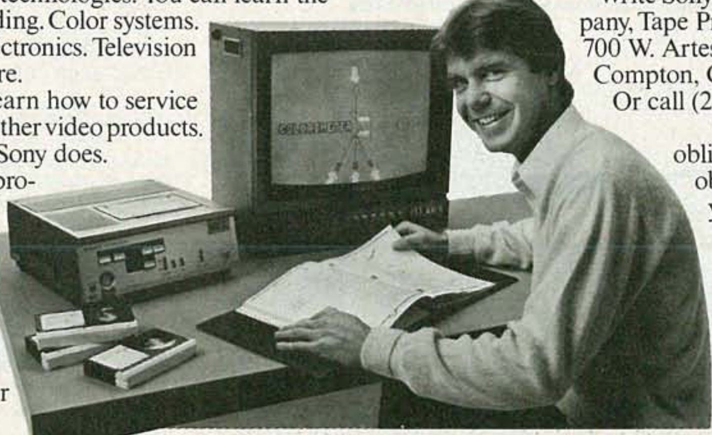
CIRCLE 5 ON FREE INFORMATION CARD

BECAUSE OF ITS HIGH PERFORMANCE and low cost, the *Commodore 64* has become one of the most popular computers for home-and-family and school use. Unfortunately, its matching line printer leaves a lot to be desired when it comes to word processing of any kind. In fact, there is no low cost formed-character (daisy-wheel type) or high-quality dot-matrix printer presently available for that computer.

The way to get high quality printouts from the *Commodore 64* (or *VIC-20*) is to use one of the better printers and a *Card/?* interface, a device that lets you use a Centronics-type parallel printer in place of a Commodore printer.

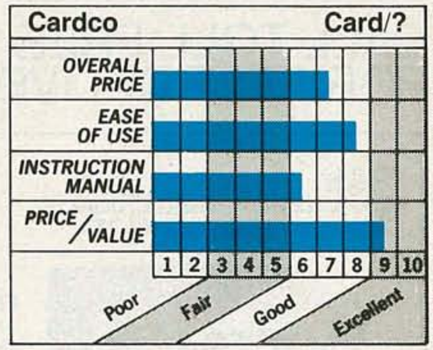
The *Card/?*

The *Card/?* interface from Cardco, Inc. (313 Mathewson, Wichita, KS 67214) is priced at $69.



The unit consists of a small, lightweight plastic box that measures approximately 3⅛ × 3 × ⅞ inches with a Centronics-type connector on one end and a cable on the other end that terminates in a DIN connector that matches the serial output connector on the Commodore computer or its disk drive. (When using a disk drive, the printer connection is moved from the computer to the disk drive.) A single wire trailing from the *Card/?'s* DIN connector is attached to an adapter that slips over the computer's edge connector that provides power and signal I/O for the Commodore *Datassette* (cassette) tape recorder. The wire provides the 5-volt power supply for the interface and still allows the *Datassette* to be used.

The interface plugs directly into the Centronics type connector on the printer. (An earlier version of the *Card/?* interface—called the Model A; the model we are describing is the Model B—was larger and had a ribbon connector between the cabinet and the printer connector.) Its operation is completely automatic. When the computer is told to output to the printer, the interface converts the Commodore's unusual ASCII output to the standard ASCII of the printer. As far as the computer is concerned, it "sees" a simulated Commodore printer.



To avoid problems caused by differences in response to ASCII control codes between the computer and the printer, the interface automatically makes the required conversions. For example, when listing a program, the Commodore's CHR$(19) "home cursor" command would stop an Epson printer dead in its tracks because CHR$(19) is the Epson-printer command for "stop printing." To avoid that hassle, the interface automatically changes the listing from CHR$(19) to an "[HM]" (home cursor). Other ASCII codes from 1 to 31 and 128 to 160, that might be inconsistent with the non-Commodore printer commands, are similarly designated within brackets. For example, CHR$(150), which is the Commodore command for the color "light red," is listed as "[LR]".

The interface normally defaults to the "normal printing mode," which is upper case only with automatic linefeed after carriage return. A short software command can be used to temporarily or "permanently" lock (until power reset) the interface to provide upper case only with no line feed, upper and lower case with no line feed, upper and lower case with automatic linefeed, graphics mode with line feed, or graphics mode with no line feed.

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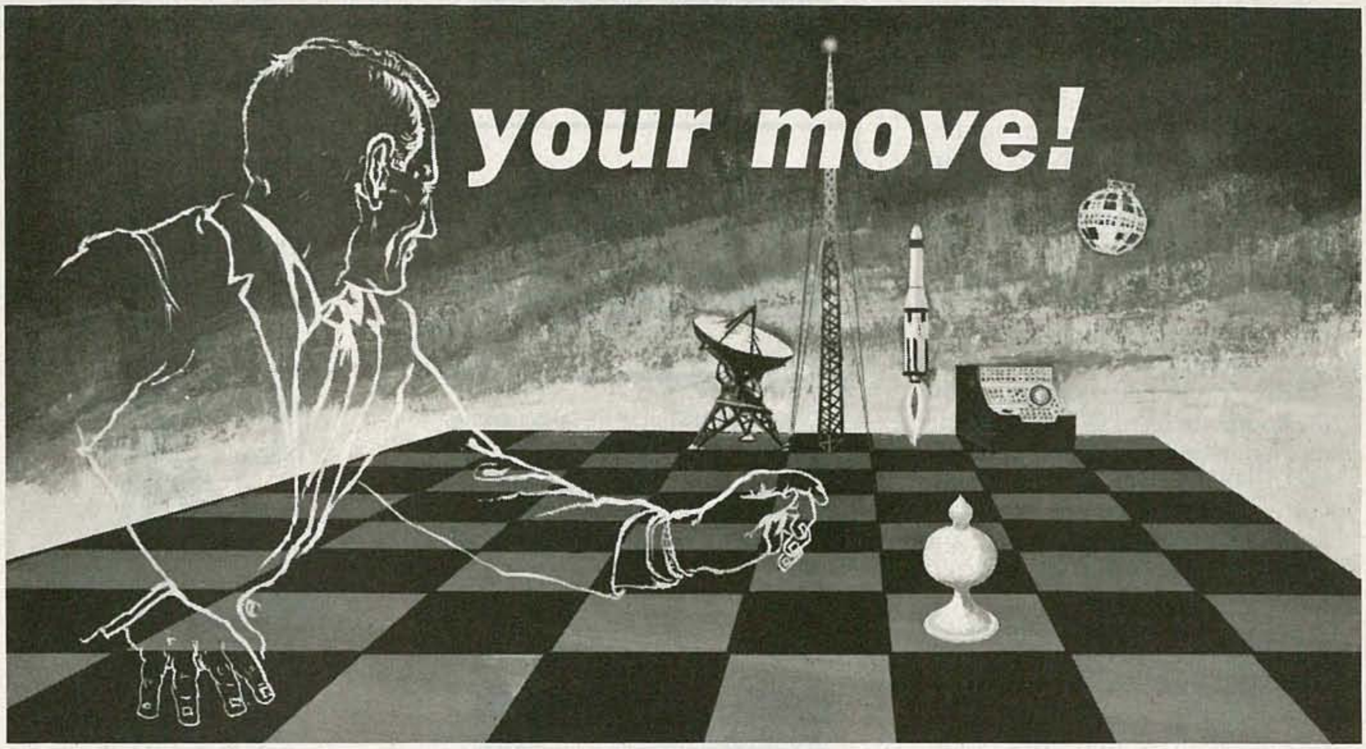

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The graphics mode has the ability to pass any character string to the printer unchanged. It's primarily intended for use with word processors and other programs that can function with non-Commodore printers, and that can access the advanced graphics features of certain printers. A semipermanent selection of the graphics mode can be made by an internal DIP-switch on the printed-circuit board.

Three other DIP switches on the PC board are used to automatically exchange the function of CHR$(15) and CHR$(20); enable or disable software selection of automatic linefeed after carriage return, and enable or disable the ASCII correction described above.

The reason for the automatic exchange of the CHR$(20) and CHR$(15) functions is because Commodore uses CHR$(15) to cancel the expanded print mode, but other printers use CHR$(15) for condensed print with CHR$(20) used to cancel the expanded mode. By automatically swapping CHR$(15) for CHR$(20), the Commodore command to "cancel expanded print mode" will work properly with just about any non-Commodore printer currently on the market.

For listings, user written programs, and word processing, the *Card/?* works as claimed, doing an effective job of emulating a Commodore printer, while providing the enhancements of the higher-performance printers. The few problems that arise, such as dropped spaces between words and stepping of the printer through each blank space (no character) on a line comes about through some off-the-wall programming used in some commercial programs—even some better quality software. Fortunately, programs for the Commodore computers are in BASIC, so it's possible to get into the listings and make whatever changes are necessary to provide rational printer operation.

Overall, the *Card/?* interface is the way to go for "professional quality" printouts from the *Commodore 64* and *VIC-20* computers. **R-E**

continued on page 81

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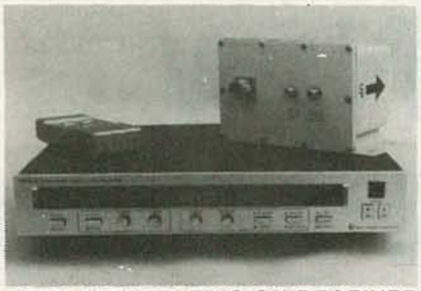

SATELLITE TELEVISION RECEIVER SEMIKIT with dual conversion downconverter. Features infrared remote control tuning, AFC, SAW filter, RF or video output, stereo output, Polorator controls, LED channel & tuning indicators. Install six factory assembled circuit boards to complete. **Semikit $400.00.** Completed downconverter add **$100.** Completed receiver and downconverter add **$150. JAMES WALTER SATELLITE RECEIVER, 2697 Nickel, San Pablo, CA 94806. Tel 415-724-0587.**

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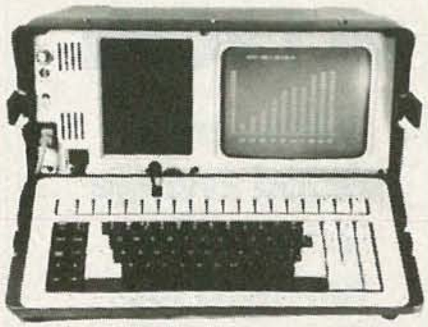

ZORBA 64K PORTABLE COMPUTER 9" Green or Amber CRT. Two 400 K DSDD Drives. CP/M 2.2 Operating System. **$799.00. Gemini Electronics, Inc., 130 Baywood Ave., Longwood, FL 32750. 1-800-327-7182, 305-830-8886.**

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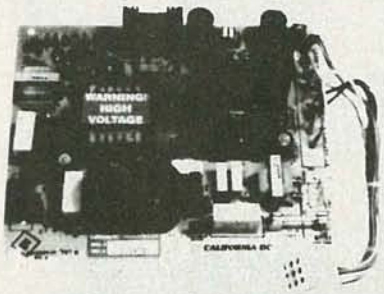

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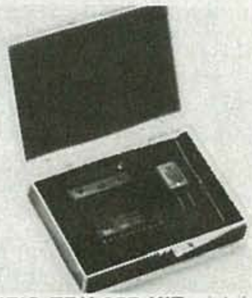

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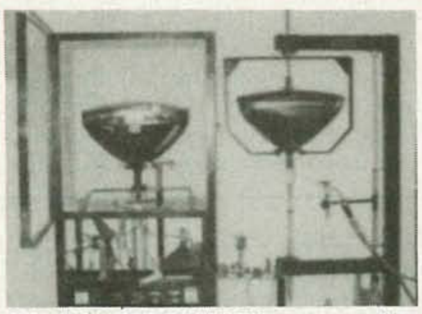

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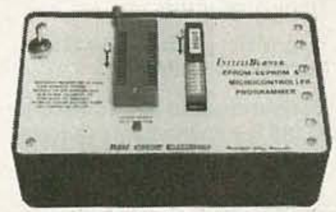

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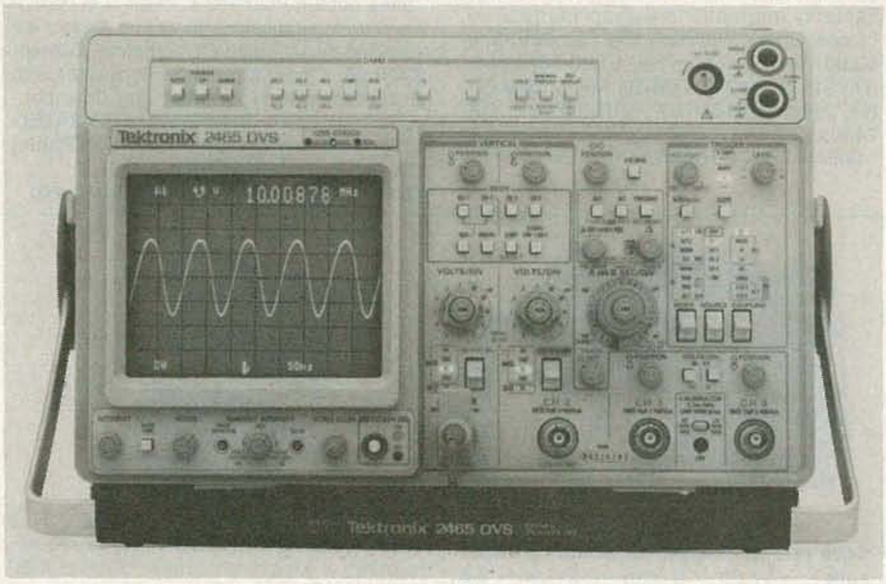
NEW PRODUCTS



CIRCLE 11 ON FREE INFORMATION CARD

OSCILLOSCOPES, the *2465 DVS* (Digital Video System) Special Edition (shown in photo); the *2465 DMS* (Digital Multimeter System), Special Edition, and the *2465 CTS* (Counter-Timer System) Special Edition. All three are programmable using the IEEE-488 GPIB.

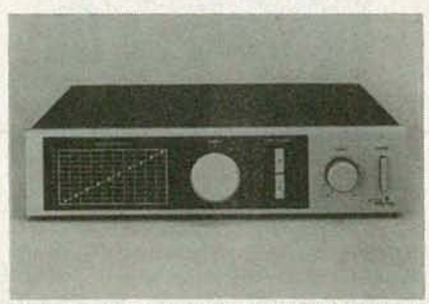
The *2465 DVS* has five new measurement capabilities. It incoporates: 1. a talker/listener IEEE-488 GPIB; 2. a counter/timer/trigger; 3. a word recognizer; 4. an auto-ranging digital multimeter, and 5. comprehensive televsion-waveform measurement capability. That oscilloscope is priced at $8550.

The *2465 DMS* incoporates all of the above features except the TV capability. It is priced at $7850.

The *2465 CTS* has all the above features except the TV and digital multimeter capability. It is priced at $6650.—**Tektronix, Inc.,** PO Box 500, Beaverton, OR 97077.

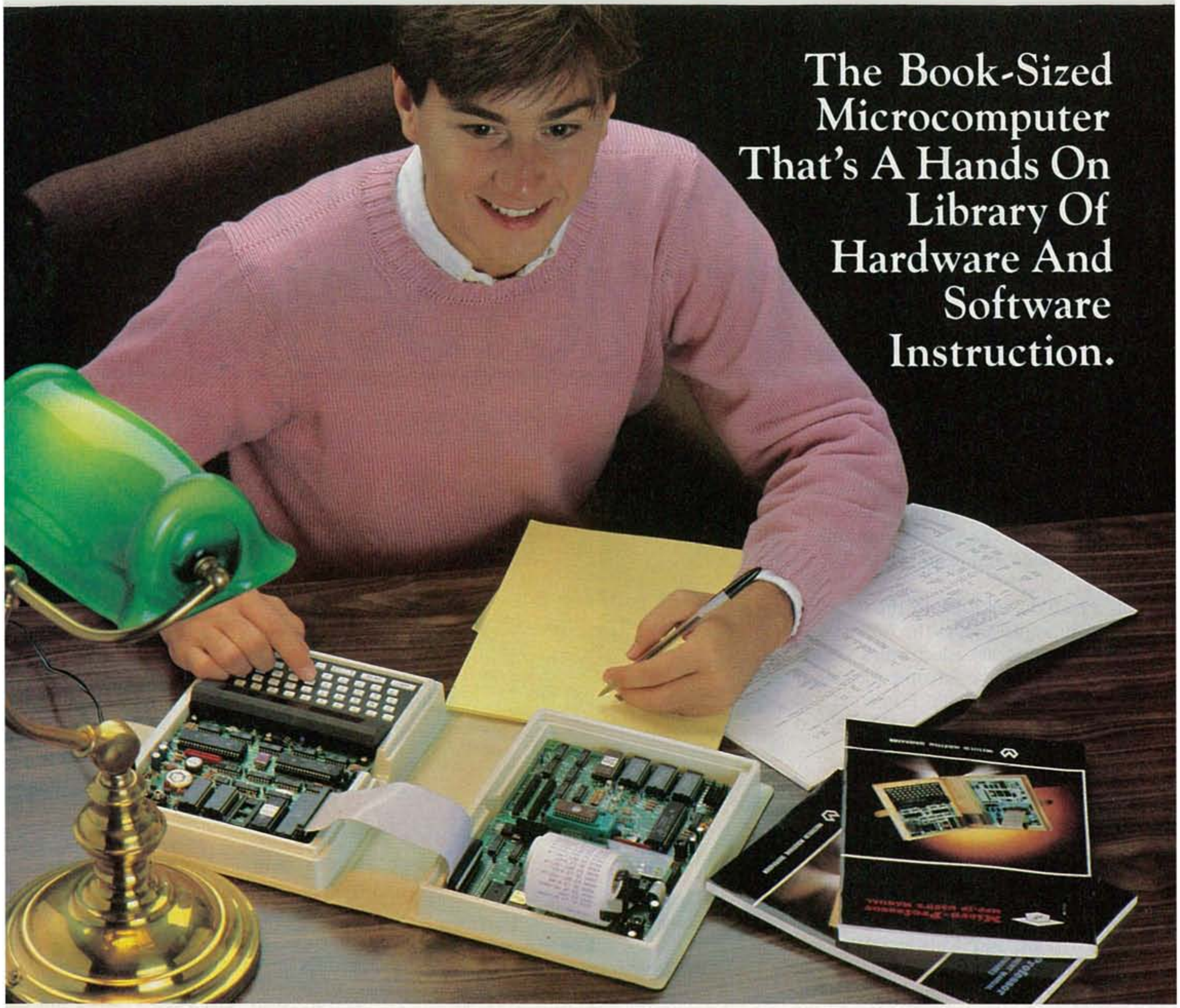
SATELLITE TV RECEIVER, model *SR-1000* has three variable controls for video and audio tuning, dual threshhold extension switches, and an LED "climbing" bar-graph tuning meter. A front-mounted Chapparal *Polarator* control helps optimize reception for the desired satellite, and helps reject interference from adjacent satellites.

A composite baseband output provides optimum signal quality



CIRCLE 12 ON FREE INFORMATION CARD

continued on page 43


The Book-Sized Microcomputer That's A Hands On Library Of Hardware And Software Instruction.

NEW PRODUCTS

continued from page 38

for equipment capable of using it (including upcoming stereo decoders); for use with standard TV sets, a built-in modulator puts the signal on Channel 3 or 4. The model *SR-1000* is priced at $499.00. — **Regency Electronics, Inc.,** 7707 Records Street, Indianapolis, IN 46226-9989.

COMPONENT GRIPPER, model *E-90,* lets you remove IC's from boards or sockets safely. It grips on high-density circuits, and eliminates strain and breakage on IC bodies because it grips from the pin centers rather than from the ends. The *Little Gripper* is effective on IC's, as well as on ZIF sockets. It can be adjusted for package tolerances, and can be safely used on static-sensitive devices.

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The Little Gripper, model *E-90,* comes with a lifetime guarantee. There are no springs, knobs, or screws to break or wear. It is priced at $29.95.—**Techni-Tool, Inc.,** 5 Apollo Road, PO Box 368, Plymouth Meeting, PA 19462.

AUDIO OSCILLATOR, model *1100,* features low distortion, fixed and variable output levels, and frequency coverage from 20 Hz to 50 kHz. Total harmonic distortion measures 0.01% at 1 kHz and is specified as less than 0.03% from 400 Hz to 25 kHz. A fixed 1-volt


CIRCLE 14 ON FREE INFORMATION CARD

output and a variable 10-millivolt to 8-volt output are both accurate to 0.5%, with a typical flatness of 0.2% from 20 Hz to 20 kHz.

Manual control is by means of front-panel numeric and function keys. Entries are shown on a 4-digit display, and functions indicated by appropriate annunciators. The entire status of instrument functions can be stored in any one of 190 nonvolatile memory locations for later recall. GPIB control provides full talk and listen capability, including return of values in the talk mode and recall of memory contents. A free-form number-entry system, triggering in immediate or wait modes, choice of end-of-string terminators, SRQ function, and front-panel return to local control all contribute to bus versatility.

The model *1100* is priced at $1795.00.—**Boonton Electronics Corporation,** 791 Route 10, Randolph, NJ 07869.

PRECISION TRIMMER POTENTIOMETERS, the *ME323-422* series lets the user see the wiper setting. These rectangular trimmers are housed in transparent nylon. The user can see exactly where the wiper is positioned for quick adjustments at a glance. The cermet element has an essentially infinite resolution output. It is precision-adjustable over a wide resistance


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range. It features a screwdriver-adjusted mechanism (20 turns nominal), ±10% tolerance, and a miniature size that saves board space.

These potentiometers are

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power-rated at 0.75 watt at 40°C and come in values from 500 ohms to 1 megohm. Their operating power is 300 volts; dielectric strength is 350-volts AC, and insulation resistance is 100 megohms.

The unit price of the *ME323-422* series is 80 cents in quantities of 500.—**Mouser Electronics,** 11433 Woodside Ave., Santee, CA 92071.

HAND-HELD TERMINALS, the *DATA-MAC 8* and the *DATA-MAC 16* (shown) are small, light-weight, and calculator-shaped "data collectors." Their 40-key keyboards include 10-key numeric keypads, and letters arranged in alphabetic order. Each key can be defined with a second, 10-character function

CIRCLE 16 ON FREE INFORMATION CARD

The *DATA-MAC 8* has an 8,000 character data storage, includes carrying case and battery pack. It is priced at $1,295.00.

The *DATA-MAC 16* has a 16,000 character data storage, and includes carrying case and battery pack. The unit is priced at $1,495.00.—**Definable Data Devices, Inc.,** PO Box 769, Wilsonville, OR 97070-0769.

WAVEFORM ANALYZER, the model *SC61,* brings wideband peak-to-peak voltage readings to the IEEE bus. That allows the designer to feed signals to the IEEE bus that agree directly with conventional oscilloscope readings.

The model *SC61's* includes the following features: Its autoranging DC voltage circuits read to a full 2000 volts from two different test

CIRCLE 17 ON FREE INFORMATION CARD

points. Its autoranging frequency counter reads from 10 Hz (with 0.01-Hz resolution) to 100 MHz (with 6-digit resolution) from either of two channels. Its ratio function automatically calculates the ratio of two frequencies; that function is handy for testing multiplier or divider stages.

The model *SC61* is priced at $3275.—**Sencore,** 3200 Sencore Drive, Sioux Falls, SD 57107. **R-E**

VICTOR MEELDIJK

SELECTING THE BEST RESISTOR/CAPACITOR

There's much more to selecting components for your designs and projects than meets the eye. In this article, we'll look at the various types of resistors and capacitors, and what factors you should consider when selecting which type to use.

DID YOU KNOW THAT:

Polystyrene foil capacitors may be better for timing circuits than polycabonate types?

Tantalum capacitors are not recommended for any application where current spikes are present?

A hybrid potentiometer consisting of a wirewound element and a conductive plastic track will have a life span that is 10 times greater than that of a wirewound potentiometer?

Power wirewound resistors can be operated with a body temperature of 275°C, and that some can operated at body temperatures of as high as 500°C?

From the above, it should be clear that there's a lot to know about the many different types of resistors and capacitors available. That's because each type has its own unique characteristics, and those characteristics make some types of resistors and capacitors far better for certain applications than others. Selecting the proper component for a particular application is vital in order to ensure the reliability of your design. In this article, we'll look at the various factors that you should consider when selecting resistors and capacitors for your projects.

Resistors

When selecting a resistor, consider stability, noise, power dissipation, environment, AC requirements, and resistance. Actual resistance value is a function of tolerance, voltage coefficient, temperature coefficient, and drift with time. The power rating is based upon ambient temperature and derating. Derating, which is the operation of a component at something less than 100% of its specified rating, may be necessary because of environmental conditions.

Resistor compositions include carbon, film, and wirewound for fixed resistance units, and cermet and conductive plastic for variable resistors. Figure 1 shows many of the types of resistors available.

Carbon resistors

Carbon-composition units have a resistive element that is molded from carbon powder that has been mixed with a phenolic binder to from a uniform resistive body. That device, molded with end leads, is a general purpose resistor capable of withstanding temperature and electrical transient shocks. The carbon-composition resistor is used in applications where initial tolerance need not be closer than ±5% with long term stability no better than ±20%.

For variable resistors, one problem is that the carbon element requires a high contact force to ensure that any variation in the contact resistance remains within acceptable limits. That results in high shaft-torque and poor adjustability.

Carbon elements are susceptible to moisture absorption and such moisture absorption can cause the resistance to change by as much as 20%. That resistance shift can be reversed if the device is baked at high temperatures (100°C).

Film resistors

Metal-film devices are used in applications requiring higher stability and precision than available from carbon devices. In addition, metal-film resistors should be used in applications where AC is present. Operation is satisfactory from DC to the MHz range. Metal-film units have low temperature coefficients and suffer little degradation to ambient temperatures of 125°C and higher. Film resistors can be classified according to the techniques used in their manufacture.

One such technique is vacuum deposition, which is also known as evaporated metal film. In it, a nickel-chromium alloy is superheated in a vacuum. The alloy vaporizes and is deposited on a ceramic substrate. Small quantities of contami-

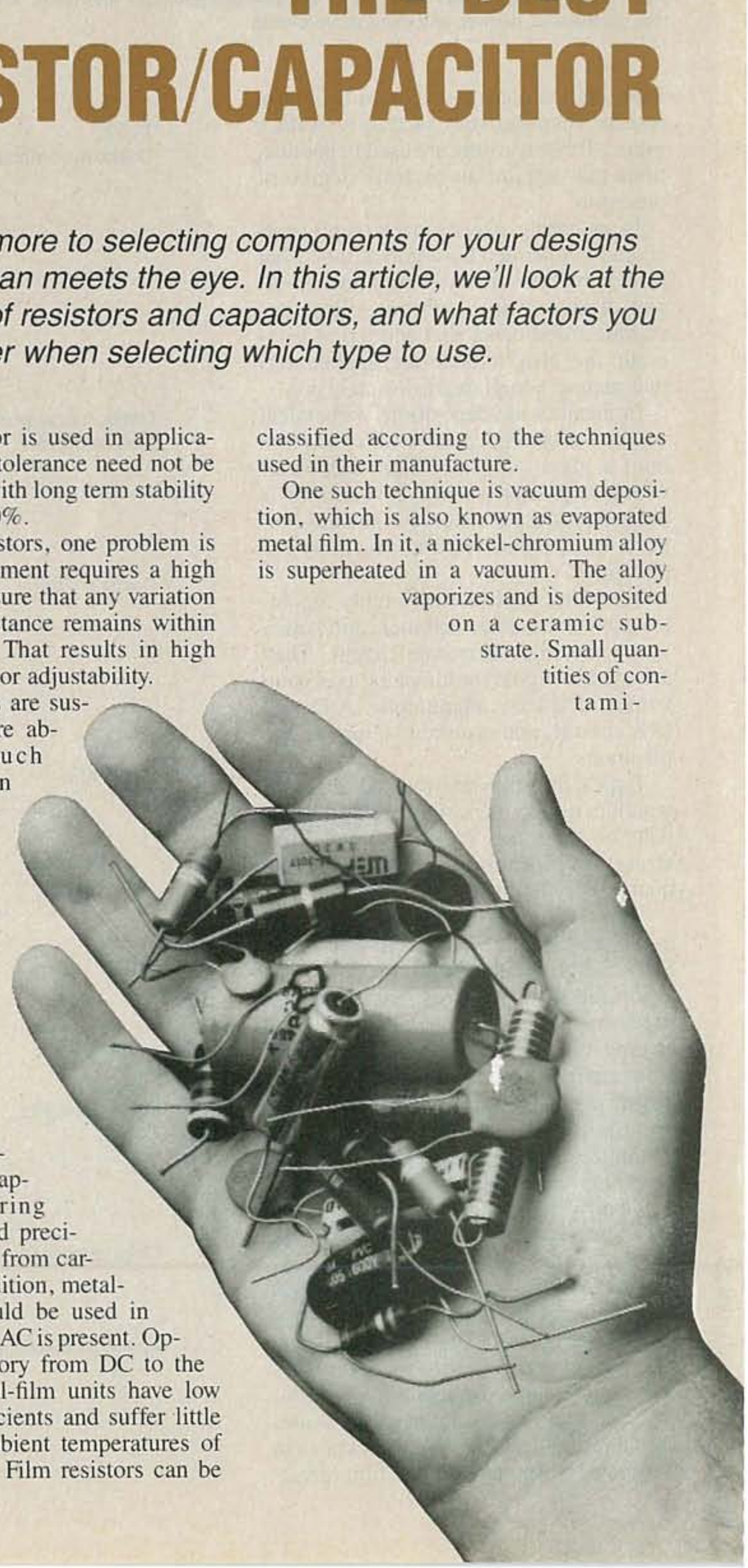


FIG. 1—THERE ARE MANY DIFFERENT resistor compositions and types. Among them are carbon, film, wirewound, cermet, and conductive plastic.

nants, called dopants, are used to control resistor characteristics such as resistance range. Those resistors are used in applications that require an extreme degree of precision.

In sputtering, a nichrome target is heated and bombarded by argon atoms. That results in metal atoms being knocked off and deposited on a substrate. Resistors manufactured using that sputtering technique are also suitable for applications that require a high degree of precision.

In metal-oxide deposition, a chemical vapor is used to deposit a tin-oxide film onto a glass substrate. That technique, which is primarily used by Corning is used to produce resistors for general-purpose, semi-precision, and precision applications.

Thin-film resistors are highly stable, have low-noise characteristics, and have a very low temperature-coefficient. They are used in digital multimeters, precision voltage-dividers, attenuators, A/D and D/A circuits, and in current-summing applications.

Typical thin-film resistors are sputtered tantalum nitride, deposited chromium cobalt, or nichrome, on a substrate. Substrates of alumina, sapphire, glass, quartz, beryllia or silicon are used.

Thin-film resistor networks are also available; those are housed in DIP's and SIP's (*S*ingle *I*nline *P*ackage).

In individual resistors, the terminals used may be either surface or wrap-around types. Wrap-around terminals wrap around the side of the substrate allowing connections to the underside. Terminals of solder, silver over nickel, platinum, or platinum gold are available. Trimming of the resistor is done either mechanically or by using a laser.

In thick-film resistors, a ceramic substrate is coated (silk screened—a mechanized stenciling process) with a glass-metal material and then fired (to cure it) at a high temperature. The glass-metal materials include nichrome, silver palladium, platinum, ruthenium, rhodium, gold and a tantalum-modified tin oxide. That film is up to 100 times thicker than evaporated or sputtered metal film (greater than .0001 inches thick) and is used in applications requiring high power density or the capability of surviving power spikes or overloads. Those units are suitable for some precision applications, but not those requiring an extremely high degree of precision.

Bulk metal resistors, made in a process that is properietary to the Vishay Corporation, metal foil is laminated to a substrate and then chemically etched to produce a conductive path. The flat element is used exclusively for high-precision applications and has tight tolerances and an excellent temperature coefficient.

TABLE 1—RESISTOR SELECTION GUIDELINES

TYPE	SPECIFICATIONS AND NOTES
Carbon composition	**Resistance range:** 2.7 ohms to 100 megohms **Power rating:** to 2 watts **Tolerance:** 5% to 20% **Temperature coefficient:** −200 to −8000 PPM/°C **Noise:** less than 6 μV/V **Derating factors:** 50% power, 80% voltage **Notes:** General purpose. Excellent transient and surge handling capabilities. RF produces capacitive effects end to end, and operation at VHF or higher frequencies reduces effective resistance due to dielectric losses. Resistance increases by 20% during storage under humid conditions.
Carbon composition potentiometer	**Resistance range:** 50 ohms to 10 megohms **Power rating:** to 5 watts **Temperature coefficient:** 1000 PPM/°C **Derating factors:** 50% power, 80% voltage **Life expectancy:** 5,000,000 rotations **Failure mode:** noise **Notes:** High shaft torque causes poor adjustability
Carbon Film	**Resistance range:** 10 ohms to 25 megohms **Power rating:** 0.1 to 10 watts **Tolerance:** 2% to 10% **Temperature coefficient:** −200 to −1000 PPM/°C **Noise:** less than 10 μV/V **Derating factors:** 50% power, 80% voltage **Notes:** General purpose, cost less than carbon-composition units
Metal film	**Resistance range:** 10 ohms to 3 megohms (high voltage types: 1 kilohm to 30 gigohms) **Power rating:** to 10 watts (high voltage types: to 6 watts) **Tolerance:** 0.1% to 2% **Temperature coefficient:** ±25 to ±175 PPM/°C **Noise:** less than 0.1 μV/V **Life expectancy** (potentiometers): 100,000 rotations **Failure mode:** resistance change or catastrophic failure **Derating factors:** 50% power, 80% voltage **Notes:** Fair degree of precision in lower value units. High stability, long life, and excellent high-frequency performance. Resistance values stable to about 100 MHz; begin to decrease beyond that frequency. Used in high-frequency tuning circuits, measuring circuits, filters, etc.
Film networks	**Resistance range:** 10 ohms to 33 megohms **Power rating:** to 0.2 watts per element, to 1.6 watts per network **Tolerance:** 0.1% to 5% **Operating temperature range:** −55 to +125°C **Temperature coefficient:** ±25 to ±300 PPM/°C **Notes:** Tracking between resistors 5 PPM/°C
Chip resistors	**Resistance range:** 1 ohm to 100 megohms **Power rating:** to 2 watts **Tolerance: 1% to 20%** **Operating temperature range:** −55 to +125°C
Power wirewound	**Resistance range:** 0.1 ohm to 180 kilohms **Power rating:** to greater than 225 watts **Tolerance:** 5% to 10% **Temperature coefficient:** less than ±260 PPM/°C **Noise:** low static, high dynamic noise levels **Derating factors:** 50% power, 80% voltage

Carbon-film resistors were introduced to perform the same basic functions as carbon-composition resistors, but at a lower price. Just like composition types, they lack the ability to withstand transient voltage spikes and have a poor temperature coefficient.

An axial-lead, carbon-film resistor is made by screening carbon based resistive inks on a ceramic rod and then firing the assembly. Alternate techniques include depositing pure carbon by cracking a hydrocarbon gas or by depositing a nickel film for resistor values of less than 10 ohms. The resistive element may also be sprayed on, applied with a transfer wheel, or dipped on.

The rod is then cut to size, leaded end caps are attached, and the unit is trimmed to a precise value. The resistor is then coated with an insulating material. Carbon-film resistors are available in the same resistance values as carbon-composition units and have a typical tolerance of ±5%.

Wirewound resistors

Wirewound resistors are used where large power dissipation is required and where AC performance is relatively unimportant. Those devices are generally satisfactory for use at frequencies up to 20kHz. They are available with various insulating/moisture preventative coatings such as vitreous enamel, cement, molded phenolic, glass sleeves, or silicone.

Vitreous enamel units have excellent moisture-resistance properties and will not burn (although they may melt) under high overload conditions since they are made from a glass type material.

Silicone, which also has excellent moisture-resistance characteristics, is an organic material and is more flammable at lower overload conditions than vitreous enamel. It will also emit gases under overload conditions leaving deposits on electrical contacts.

Cement coatings are composed of inorganic materials. Those coatings are essentially flameproof but can be made to burn if subjected to high overloads for long periods. Resistors coated with that material are also subject to changes in value with exposure to moisture.

Aluminum and water-cooled housings are also available. Those housings facilitate the transfer of heat away from the resistive element.

In wirewound resistors, three alloys are commonly used for the resistive element. They are nickel-chromium, Copper-nickel, and gold-platinum. Nickel-chromium is the most common due to its excellent temperature coefficient (less than ±5 PPM/°C) and its availability in many different diameters. Copper-nickel is the next most popular, with a temperature coefficient of ±20 PPM/°C. The gold-platinum alloy, that is actually a complex alloy of gold, platinum with small amounts of copper and silver has a high temperature coefficient of ±650 PPM/°C, but has low resistance. That resistance is 85 ohms/cmf (cmf is a circular mil foot, a hypothetical quantity equivalent to one foot of wire that is .001 inches in diameter) while nickel-chromium has a resistivity of 800 ohms/cmf. The gold-platinum alloy can also withstand harsh environments.

The ceramic core of a wirewound resistor is either beryllium oxide, which has a high cooling capability, alumina (aluminum oxide) or steatite, which has the lowest thermal conductivity of the three materials but is low cost. Figure 2 shows some steatite cores.

Wirewound resistors are most often used in voltage divider circuits, as power-supply bleeder resistors, or as series dropping resistors. Variable devices are used where voltage and current variations are expected, such as motor-speed and heater controls. Precision variable types are used in servo systems requiring precise electrical and mechanical performance.

Other resistor types

For low resistance/high current applications, edgewound ribbon type power

TABLE 1 CONTINUED

TYPE	SPECIFICATIONS AND NOTES
Precision wirewound	**Resistance range:** 0.1 ohm to 800 kilohms **Power rating:** to 15 watts **Tolerance:** .01% to 1% **Temperature coefficient:** varies with resistance **Noise:** low static, high dynamic noise levels **Life expectancy (potentiometers):** 200,000 to 1,000,000 rotations **Failure mode:** Catastrophic failure **Derating factors:** 50% power, 80% voltage **Notes:** Wirewound resistors are used in low-tolerance, high-power dissipation applications where AC performance is not critical. Power dissipation depends on heat sink or air flow around the device. When mounting on a PC board, standoffs should be used to prevent charring the board. Not suitable for use at frequencies above 50 kHz. Wirewound potentiometers do not suffer from contact resistance variations. The units can be manufactured with low temperature coefficients and tight tolerances. Applications include motor speed controls, lamp dimmers, heater controls, etc. Precision types are used in servo mechanisms.
Cermet	**Resistance range:** 50 ohms to 5 megohms **Power rating:** to 2 watts **Life expectancy (potentiometers):** 50 to 500,000 rotations **Failure mode:** noise **Derating factors:** 50% power, 80% voltage **Notes:** Very stable under humid conditions. Low temperature coefficients. Low end resistance (2 ohms). Short life expectancy. High resolution of the resistive element allows for more precise trimmer settings. Less reactance in high-frequency applications than wirewound units, and are lower in price. Cermet is also the thick film used in resistor networks and chip resistors.
Conductive plastic potentiometers	**Resistance range:** 150 ohms to 5 megohms **Power rating:** to 1 watt **Temperature coefficient:** −600 to −300 PPM/°C **Life expectancy:** 100,000 to 4,000,000 rotations **Failure mode:** Noise **Derating factors:** 50% power, 80% voltage
General purpose conductive plastic potentiometers	**Resistance range:** 1 ohm to 15 kilohms, depending on power rating **Power rating:** to 1000 watts
Precision conductive plastic potentiometer	**Resistance range:** 100 ohms to 500 kilohms **Power rating:** to 7 watts **Tolerance:** 3% **Temperature coefficients:** less than 70 PPM/°C **Life expectancy:** Greater than 2,000,000 rotations
Conductive plastic trimmers	**Resistance range:** 10 ohms to 100,000 ohms **Power rating:** to 1 watt **Notes:** Conductive plastic potentiometers have a long life expectancy and low-noise characteristics. Resistance will shift if exposed to humidity.
Hybrid potentiometers	**Resistance range:** 200 ohms to 250,000 ohms **Power rating:** to 7 watts **Tolerance:** 5% **Temperature coefficient:** less than ±100 PPM/°C **Life expectancy:** 10,000,000 rotations

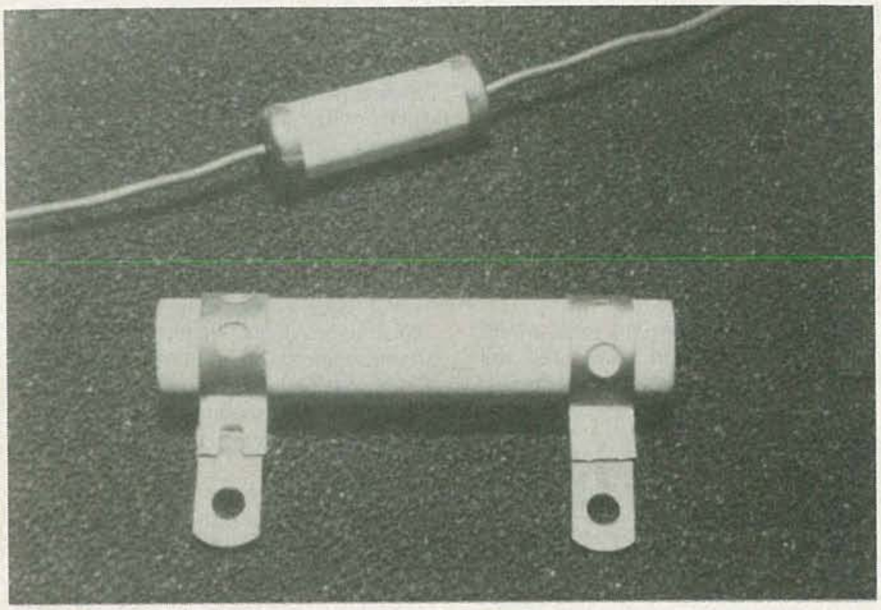


FIG. 2—**MANY WIREWOUND RESISTORS** use Steatite cores, such as the ones shown here.

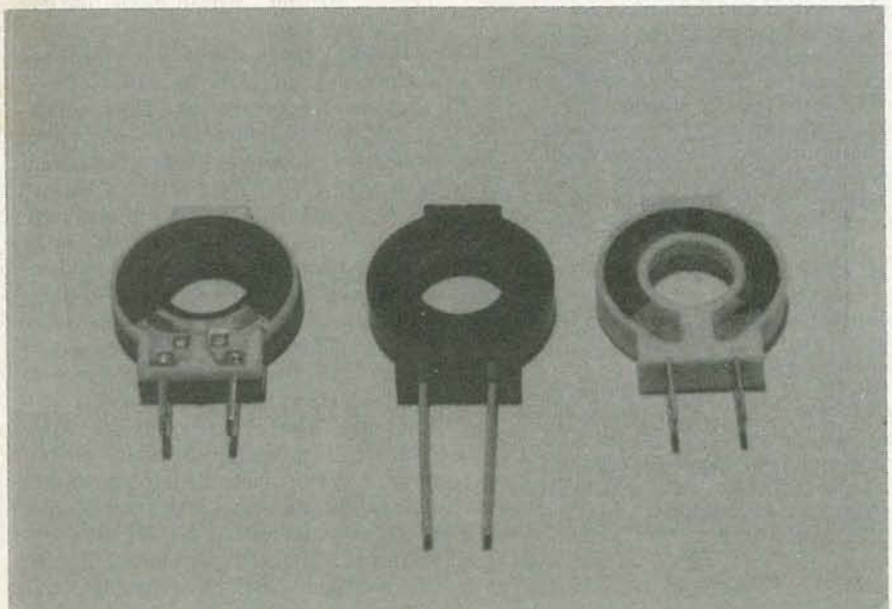


FIG. 3—**POTENTIOMETERS** can use resistive elements made of many different materials. Three such materials, shown above from left to right, are cermet, carbon, and conductive plastic.

resistors are available. Designed for power handling up to 1000 watts (at currents up to 100 amps) these devices are made up of steel ribbons wound into a coil and supported by ceramic insulators. They are generally rated for normal operation with a temperature rise of 375°C. Those units are used in power-supply testing and in motor-breaking systems. (You may have seen them underneath subway cars, especially the older trains in New York City.)

Cermet devices have a resistive element made by combining very fine particles of ceramic, or glass, with precious metals. Cermet devices are very stable under humid conditions and have low temperature coefficients of ±100 PPM/°C. Conductive-plastic or hot-molded carbon potentiometers, for example, have an average temperature coefficient of ±1000 PPM/°C. In variable resistors, however, the cermet element is abrasive and long periods of rotational cycling will wear out the wiper long before similar use would wear out the wiper in resistive-film or conductive-plastic units. Cermet potentiometers are available in low resistance values, which makes them useful in many audio applications.

Cermet is also the thick film used in resistor networks and in chip resistors.

Conductive plastic potentiometers have a resistive element consisting of a blend of resin (epoxy, polyester, phenolics, or polyamides) and a carbon powder applied to a plastic or ceramic substrate. The plastic substrate results in a better temperature coefficient due to greater compatability between the ink and the substrate. Those devices have a long rotational life and excellent contact resistance variation, or low noise. End resistance is low, two ohms maximum.

Conductive plastic units are suitable for use in applications that require a consistent temperature coefficient over a limited temperature range, such as −25°C to 75°C. Temperature coefficient values of −200 PPM/°C may be attained by special processing of the carbon material or by incorporating metal powders, or flakes, into the element. Nickel, silver, and copper are frequently used in low-resistance devices. Conductive-plastic elements, like carbon units, vary in resistance when exposed to humid conditions. Figure 3 shows cermet, carbon, and conductive plastic units.

Hybrid potentiometers are wirewound units with a conductive-plastic track deposited along the contact path of the resistive element. That results in a device that has a better resolution and a longer life, by a factor of 10, over wirewound types. Compared to conductive-plastic units, hybrid devices have a higher power handling capability, due to the wirewound element. Like wirewound units however, they have stray capacitance at higher frequencies and have high contact resistance and marginal output smoothness when drawing current through the wiper contact.

Table 1 summarizes the resistor types available, their characteristics, recommended applications, and suggested derating factor. Use of a derating factor is an effective means to decrease the failure rate of most devices since device life is stress and temperature dependent. Derating is accomplished by either decreasing part stresses such as power/voltage or current or by selecting a higher rated part. Optimum derating occurs at or below the point where an increase in stress or operating temperature results in a large increase in the device failure rate.

One note about Table 1: The values and rating shown are provided as guidelines. While they apply to the most commonly found units, it is not impossible to find units with slightly, or greatly, different specifications.

While that concludes our look at resistors, our look at component selection is far from over. In the next part of this article, we'll turn our attention to the factors that should be considered when selecting capacitors. **R-E**

ALL ABOUT

STEREO Audio For TV

BRIAN C. FENTON, TECHNICAL EDITOR

A recent FCC decision has set the stage for multichannel television sound. Here's a look at that decision, its technical aspects, and the new dimension in TV sound that it makes possible.

STEREO TV IS FINALLY HERE! IT'S THE most exciting development in television since the introduction of the videodisc player and VCR. Interestingly enough, while the idea of stereo television has been on the minds of the industry for some time, it was the *consumer's* interest—stimulated by videodisc players and VCR's—that was the driving force behind making it a reality. But *M*ultichannel *T*elevision *S*ound (MTS) is not just stereo TV—it's a completely new way of using television's audio signal.

The FCC decision

The Federal Communications Commission authorized multichannel TV sound in late March 1984 by adopting new, very general rules regarding TV audio signals. As a result of that action, stereo TV sound, as well as second-language programming and many other services, are now possible.

As has been the the FCC's policy of late, the Commission did not adopt a single system as a stereo TV standard. Remember the FCC's "let the marketplace decide" decision on AM stereo, and the uncertainty and inaction in the marketplace that it caused. (AM stereo is yet to really get off the ground.) But thanks to the television industry, that's not about to happen to stereo TV!

The main difference between the two cases is that the industry—with the knowledge of what happened with AM stereo—presented a single proposal to the FCC for adoption. Both broadcasters and equipment manufacturers worked together through the EIA (Electronic Industries Association) whose Broadcast Television Systems Committee (BTSC) worked 5 years selecting a system as a standard. The transmission system that was chosen by the BTSC was developed by Zenith, and the noise reduction system was developed by dbx Corporation. (Those were selected over transmission systems developed by the Electronic Industries Association of Japan and Telesonics Systems, Inc. and noise-reduction systems developed by Dolby and CBS Laboratories.)

Together, the Zenith transmission system and the dbx-TV noise reduction system make up the BTSC multichannel television sound or MTS system. We'll take a close look at both systems a little later on in this article.

Even though the FCC was presented with a proposal for a single MTS system, the Commission's decision still followed an "open marketplace" policy. That was based on the (correct) belief that MTS technology will continue to advance beyond the BTSC system. However, because the FCC was aware both of what happened with AM stereo and the industry's proven desire for a single standard, they endorsed the BTSC system by protecting its *pilot tone*. That means that the pilot frequency may be used only by broadcasters using the BTSC system. By restricting the use of the pilot frequency, BTSC-type receivers are protected from falsely detecting other MTS formats, but any other MTS system can be used *if the marketplace calls for it*.

The BTSC system

Before late March, 1984, the TV-audio baseband—the band of frequencies from 0 to 120 kHz that contains a TV signal's audio information—was limited to carrying only audio in the *main channel* (the portion of the baseband from 50 Hz to 15 kHz). Now, thanks to the FCC decision, the audio baseband is virtually unregulated. For most of us, that means that we can now listen to TV in stereo or in a second language. But for broadcasters, it means a number of options.

Figure 1 shows a "fully loaded" MTS audio baseband. We'll call it stereo + SAP service. The frequency-modulated main-channel audio is contained from 50 to 15 kHz, just as it is in any TV broadcast. What is different from conventional TV signals is that the baseband also includes an amplitude-modulated *stereo-difference* subcarrier, a pilot signal, a SAP (*S*econd-*A*udio-*P*rogram) channel, and a *professional channel*. But that is only *one* of the possible configurations. Figure 2 shows three other possible configurations: stereo service without SAP capability, mono service with SAP capability, and mono service without SAP capability. Note that each configuration leaves room for a professional channel.

The professional channel can be used for a wide variety of non-program-related uses. A TV station can use it to relay broadcast materials to other stations, to communicate with remote crews, etc. But the professional channel could also be used to transmit signals to *you*—or, to be more precise—to your TV receiver. For

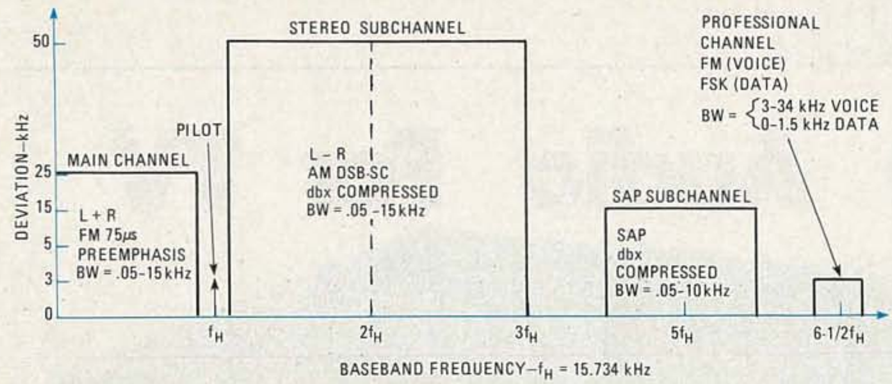


FIG. 1—THE "FULLY LOADED" AUDIO BASEBAND for multichannel television sound contains the frequency-modulated main channel, amplitude-modulated stereo subchannel, an amplitude-modulated SAP subchannel, and a professional channel.

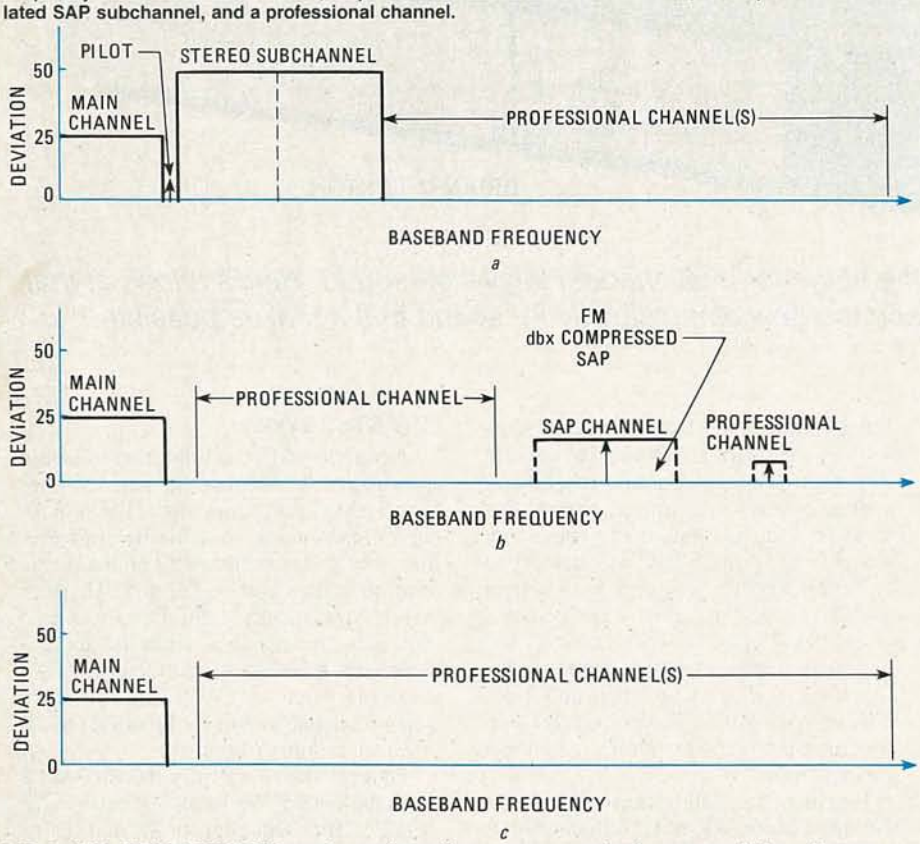


FIG. 2—THE AUDIO BASEBAND can be configured in many ways under the new regulations. Here we see stereo-only service (*a*), mono service with SAP (*b*), and mono service (*c*). Note that each configuration leaves room for a professional channel. That professional channel can be used for a variety of non-program related applications.

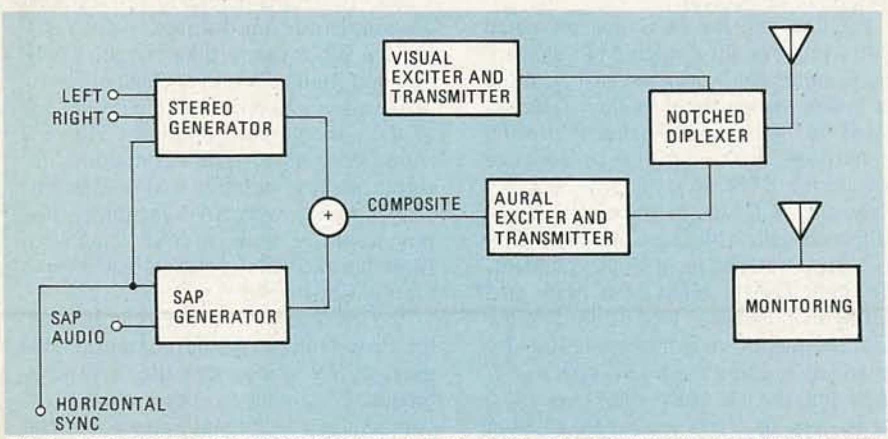


FIG. 3—BTSC TRANSMISSION SYSTEM. The signal that drives the audio (aural) transmitter is the sum of the stereo-and SAP-generator outputs. A diplexer is used so that the video transmitter and audio transmitter can use the same antenna. The notch filter at 4.5 MHz reduces one source of audio buzz: the direct spillover of video sideband components into the audio carrier spectrum.

example, a signal could be sent to turn on receiver noise-reduction circuitry. Another—though unlikely—possibility is that a TV station could transmit control signals to your VCR so that it wouldn't record commercials.

The professional channel is not restricted to carrying TV-related signals; it can also be used for subsidiary communications services (much like the broadcast FM SCA services).

It's really here!

Before we go into some of the theory behind MTS, let us emphasize that stereo television and multichannel TV sound are here for real. The first commercial television broadcast with stereo sound took place during coverage of the 1984 Summer Olympics in Los Angeles. Television digest, the industry newsletter, notes that as of November 1, 1984, 7 stations were on the air with almost 200 others either testing or planning MTS. Table 1 is a list of those stations.

The Zenith transmission system

The MTS system that was chosen by the industry and endorsed by the FCC is made up of a transmission system and a noise-reduction system. The transmission system selected was developed by Zentih.

An important aspect of the Zenith system is that it is compatibile with the existing NTSC standard. That is important because any MTS system not compatible with existing TV's would be useless—neither the broadcasters nor the equipment manufacturers would support it.

In order for MTS signals to be compatible with conventional signals, the main channel must be compatible. Therefore, the main channel of the Zenith system signal contains the monaural signal, which is the sum of the left- and right-channel signals. (We'll refer to the monaural signal as the *stereo sum* or L + R signal). That L + R signal frequency-modulates the TV carrier in the same way that a conventional mono signal does.

The the *stereo difference* signal (L − R) amplitude-modulates a subcarrier centered at a 31.468 MHz—twice the horizontal scanning frequency, $2f_H$. A pilot signal, which is used by the receiver to decode the stereo information, is located in the audio baseband at the horizontal scanning frequency, f_H (15,734 kHz). As we mentioned previously, while the rest of the audio baseband is virtually unregulated, that pilot frequency is protected under FCC rules.

A standard (mono) TV set will ignore everything but the main channel and will recover the L + R audio just as it would any mono signal. A stereo-capable set, however, will use the pilot signal both to recognize that a stereo signal is present and to generate a carrier for decoding the L − R component.

TABLE 1—MTS BROADCASTERS

All stations stereo, non-SAP, unless otherwise indicated in footnote.

Now broadcasting regularly in stereo:

WTTW	Chicago, IL	(PBS)
WTIC-TV	Hartford, CT	(ind.)
KTLA	Los Angeles, CA	(ind.)[a]
KIRO-TV	Seattle, WA	(CBS)
KOMO-TV	Seattle, WA	(ABC)
WDBB-TV	Tuscaloosa, AL	(ind.)
WTXX	Waterbury, CT	(ind.)

Planning fall 1984 start:

WZTZ-TV	Boston, MA	(ind.)
WEDH	Hartford, CT	(PBS)
WFSB	Hartford, CT	(CBS)
WTLV	Jacksonville, FL	(ABC))
KABC-TV	Los Angeles, CA	(ABC)
KTLA	Los Angeles, CA	(ind.)[a]
KMSO-TV	Missoula, MT*	(CBS)[f]
WNET	N.Y.-Newark	(PBS)
KATU	Portland, MT	(ABC)
KRBK-TV	Sacramento, CA	(ind.)
KPLR-TV	St. Louis, MO	(ind.)
KSL-TV	Salt Lake City, MO	(CBS)
WMHT	Schenectady-Albany-Troy, NY	(PBS)
WTVG	Toledo, OH	(NBC)
WNJT	Trenton, NJ	(PBS)[b]
KPOL	Tucson, AZ*	(ind.)[f]

Planning winter 1984-85 start:

KTVA	Anchorage, AK	(CBS)
WGNX-TV	Atlanta, GA	(ind.)
WBZ-TV	Boston, MA	(NBC)
WVIZ-TV	Cleveland, OH	(PBS)
KERA-TV	Dallas, TX	(PBS)[a]
KOOD	Hays-Russell-Gt. Bend, KS	(PBS)
KVVU-TV	Henderson-Las Vegas, NV	(ind.)
WIUD	Lakeland, FL*	(ind.)
WMFP	Lawrence, MA*	(ind.)
WPBT	Miami, FL	(PBS)
WYES-TV	New Orleans, LA	(PBS)
WEDN	Norwich, CT	(PBS)
KTIE-TV	Oxnard, CA*	(ind.)
WPSD-TV	Paducah, KY	(NBC)
WEEK-TV	Peoria, IL	(NBC)
KPHO-TV	Phoenix, AZ	(ind.)
KSBW-TV	Salinas-Monterey, CA	(NBC)
KUED	Salt Lake City, UT	(PBS)[a]
KSAT-TV	San Antonio, TX	(ABC)[c]
KOVR-TV	Sacramento, CA	(ABC)
WFSU-TV	Tallahassee, TN	(PBS)

Planning spring 1985 start:

WTBS	Atlanta, GA	(ind.)
WJZ-TV	Baltimore, MD	(ABC)[a]
WTTO	Birmingham, AL	(ind.)
KWHP	Boise, ID*	(ind.)
new,	Cedar City, UT*	
WMAQ-TV	Chicago, IL	(NBC)
WCET	Cincinnati, OH	(PBS)[a]
KHBS	Ft. Smith, AR	(ABC)[e]
KMSG	Fresno (Sanger), CA*	(ind.)
WXII	Greensboro-High Point-Winston-Salem, NC	(NBC)
WITF-TV	Harrisburg, PA	(PBS)
new,	Idaho Falls, ID*	(ind.)
WFYI	Indianapolis, IN	(ind.)
WRLR	Las Vegas, NV*	(ind.)
WIYE	Leesburg, FL	(ind.)
KNBC-TV	Los Angeles, CA	(NBC)
KWHY-TV	Los Angeles, CA	(ind.)
WBFS-TV	Miami, FL*	(ind.)[a]
WMVS	Milwaukee, WI	(PBS)[a]
WMVT	Milwaukee, WI	(PBS)[a]
WLCT	New London*	(ind.)
WNOL-TV	New Orleans, LA	(ind.)
WNBC-TV	New York, NY	(NBC)[a]
WCFE-TV	Plattsburg, NY	(PBS)[a]
WXXI	Rochester, NY	(PBS)
KCRA-TV	Sacramento, CA	(NBC)
KETC	St. Louis, MO	(PBS)
WOIO	Shaker Heights, OH*	(ind.)
KSMW	Spokane, WA*	(ind.)
WACO	Waco, TX*	(ind.)
WRC-TV	Washington, DC	(NBC)
WHYY-TV	Wilmington-Phila., PA	(PBS)

Planning start in late 1985:

KNME-TV	Albuquerque, NM	(PBS)[f]
KOAT-TV	Albuquerque, NM	(ABC)
KTUU-TV	Anchorage, AK	(NBC)
WATL-TV	Atlanta, GA	(ind.)
WCBB	Augusta-Lewiston-Portland, ME	(PBS)
WSKG	Binghamton, NY	(PBS)[a]
WGBH-TV	Boston, MA	(PBS)[a]
WNEV-TV	Boston, MA	(CBS)
WNJS	Camden, NJ	(PBS)[e]
WKYC-TV	Cleveland, OH	(NBC)
KLBY	Colby, KS*	(ind.)
WCMH-TV	Columbus, OH	(NBC)
WOSU-TV	Columbus, OH	(PBS)
WTVN-TV	Columbus, OH	(ABC)
WJBK-TV	Detroit, MI	(CBS)[a]
WKBD-TV	Detroit, MI	(ind.)
WTVS	Detroit, MI	(PBS)[f]
WXYZ-TV	Detroit, MI	(ABC)
KTSM-TV	El Paso, TX	(NBC)
KVIA-TV	El Paso, TX	(ABC)[a]
KJEO	Fresno, CA	(ABC)[c]
WLRE	Green Bay	(ind.)
KHOU-TV	Houston, TX	(CBS)[a]
WVSN-TV	Humacao, PR*	(ind.)
KIFI-TV	Idaho Falls, ID	(NBC)[e]
WJXT	Jacksonville, FL	(CBS)
KATV	Little Rock, AR	(ABC)
KHJ-TV	Los Angeles, CA	(ind.)[a]
WMAZ-TV	Macon, GA	(CBS)
WCIX-TV	Miami, FL	(ind.)
WCCO-TV	Minneapolis-St. Paul, MN	(CBS)[f]
WNJM	Montclair, NJ	(PBS)[e]
WNJB	New Brunswick, NJ	(PBS)[e]
WEDY	New Haven, CT	(PBS)
WNYC-TV	NY	(PBS)
KETV	Omaha, NE	(ABC)
WOFL	Orlando, FL	(ind.)[a]
WXEX-TV	Richm'd-Petersb'g, VA	(ABC)
KTSP-TV	Phoenix, AZ	(CBS)
WPBO-TV	Portsmouth, OH	(PBS)
KBYU-TV	Provo, UT	(PBS)
KTSL	Sacramento, CA	(ind.)[a]
KSDK	St. Louis, MO	(NBC)[e]
KRON-TV	San Francisco, CA	(NBC)[f]
KTEH	San Jose, CA	(PBS)[e]
WSJU	San Juan, PR*	(ind.)[e]
WMHT	Schenectady-Albany-Troy, NY	(PBS)
WVIA-TV	Scranton-Wilkes Barre-Hazleton, PA	(PBS)
KTBS-TV	Shreveport, LA	(ABC)[e]
KREM-TV	Spokane, WA	(CBS)
KSCH-TV	Stockton-Sacramento*	(ind.)
WEDU	Tampa-St. Petersburg, FL	(PBS)
KCEN-TV	Temple-Waco, TX	(NBC)[a]
WNJT	Trenton, NJ	(PBS)[d]
KUAT-TV	Tucson, AZ	(PBS)
WILL-TV	Urbana-Champaign, IL	(PBS)[e]
KMPH	Visalia-Fresno, CA	(ind.)
WPEC	West Palm Beach, FL	(ABC)[a]

Planning 1986 start:

WSBK	Boston, MA	(ind.)
WUFT	Gainesville, FL	(PBS)
WJKS-TV	Jacksonville, FL	(NBC)
WFMY-TV	Greensboro-High Point-Winston-Salem, NC	(CBS)
KSHB-TV	Kansas City	(ind.)
WHA-TV	Madison, WI	(PBS)
WFTV	Orlando, FL	(ABC)
KDNL-TV	St. Louis, MO	(ind.)
WGGB-TV	Spfld.-Holyoke, MA	(ABC)

Planning start after 1986:

KMTF	Fresno, CA	(PBS)
WLFI-TV	Lafayette-Kokomo, IN	(CBS)
WNMU-TV	Marquette, MI	(PBS)
WITI-TV	Milwaukee, WI	(CBS)
WTSP-TV	St. Petersburg-Tampa, FL	(ABC)
KVIE	Sacramento, CA	(PBS)[a]
KCTS-TV	Seattle, WA	(PBS)

Planning MTS, no date:

WNUV-TV	Baltimore, MD	(ind.)
WRBT	Baton Rouge, LA	(NBC)
WBNG-TV	Binghamton, NY	(CBS)[e]
WBMG	Birmingham, AL	(CBS)
KFYR-TV	Bismarck, ND	(NBC)
KTVB	Boise, ID	(NBC)
KMGH-TV	Denver, CO	(CBS)[a]
WGPR-TV	Detroit, MI	(ind.)
WFIQ	Florence, AL	(PBS)
WSWP-TV	Grandview, WV	(PBS)
KHON-TV	Honolulu, HI	(NBC)
WISH-TV	Indianapolis, IN	(CBS)
WJCT	Jacksonville, FL	(PBS)
KHGI-TV	Kearney-Hastings, NE	(ABC)
KARK-TV	Little Rock, AR	(NBC)
KTHV	Little Rock, AR	(CBS)[e]
KCET	Los Angeles, CA	(PBS)
WISN-TV	Milwaukee, WI	(ABC)
WTVF	Nashville, TN	(CBS)
WDSU-TV	New Orleans, LA	(NBC)
WJTC	Pensacola, FL*	(ind.)
KAET	Phoenix, AZ	(PBS)
KOLO-TV	Reno, NV	(ABC)
KXTV	Sacramento, CA	(CBS)
KPBS-TV	San Diego, CA	(PBS)[a]
KPIX	San Francisco, CA	(CBS)
KSAF-TV	Santa Fe, NM	(ind.)
WAKA	Selma, AL	(CBS)
KOLR-TV	Springfield, MO	(CBS)
WTOV-TV	Steubenville, OH-Wheeling, WV	(NBC, ABC)
KAII-TV	Wailuku, HI	(NBC)
KAUZ-TV	Wichita Falls, TX	(CBS)

* Construction permit, not on air.
[a] Stereo & program-related SAP
[b] Non-program-related SAP only
[c] Program-related SAP only
[d] Adding stereo to SAP
[e] Stereo and non-program-related SAP
[f] Stereo, program and non-program SAP

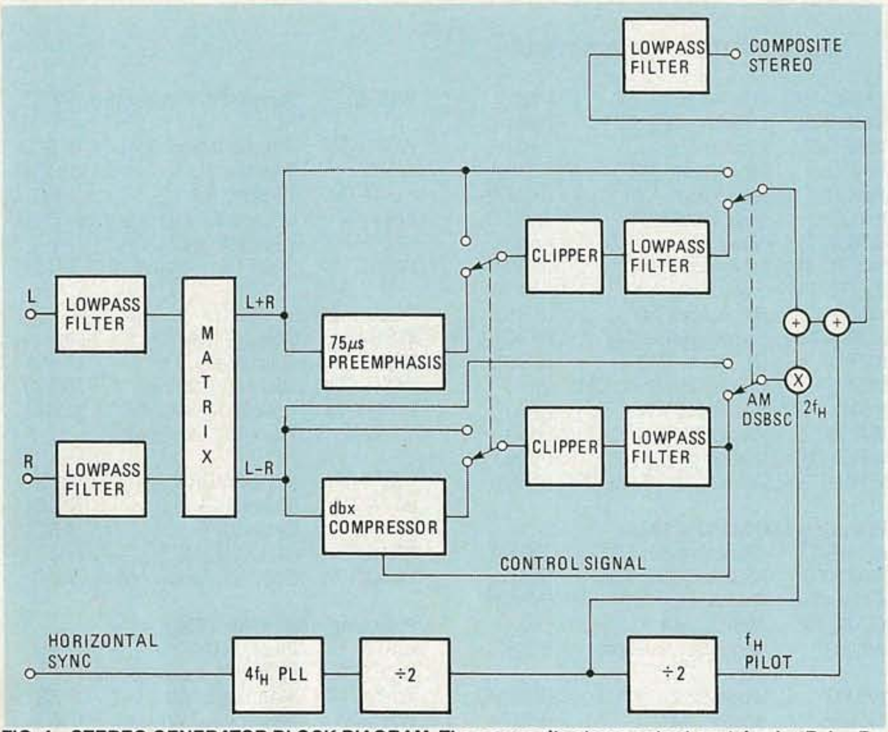


FIG. 4—STEREO GENERATOR BLOCK DIAGRAM. The composite stereo output contains L + R, L − R, and pilot signals.

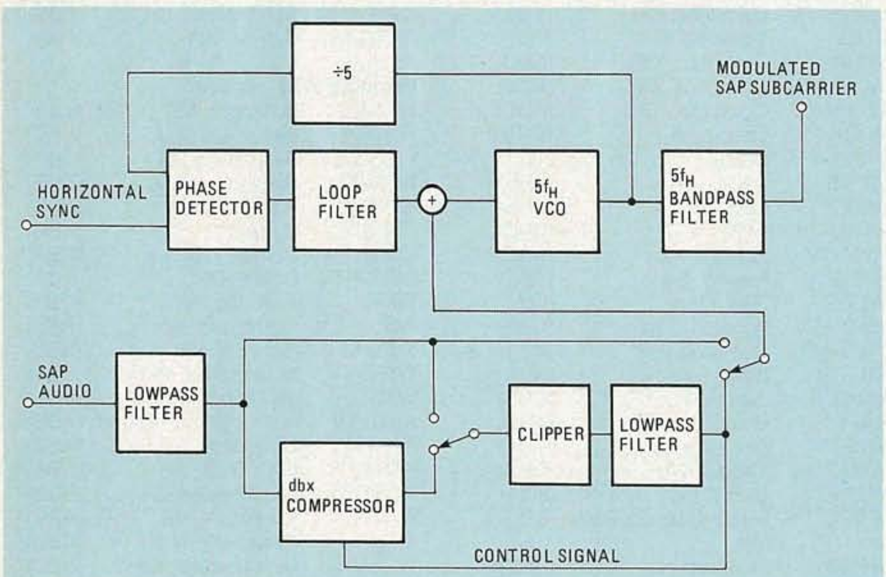


FIG. 5—SAP GENERATOR BLOCK DIAGRAM. The SAP generator can use the same compressor that is used in the stereo-signal generator.

By combining the stereo sum and difference signals in-phase and out-of-phase, the stereo decoder can reconstruct the individual left- and right-channel signals. That can be seen by the following equations:

$$(L+R)+(L-R) = 2L$$
$$(L+R)-(L-R) = 2R$$

If you're familiar with broadcast FM stereo, you've probably noticed that stereo TV uses a somewhat similar encoding method. There are some differences. The most important—which we'll describe in detail—is that the AM stereo-difference subcarrier is compressed.

A block diagram of the Zenith transmission system is shown in Fig. 3. Note that the Zenith composite signal that drives the aural (audio) transmitter is the sum of two signals—the stereo-generator and SAP-generator outputs.

The stereo generator

The input to the stereo-generator, as shown in Fig. 4, is made up of three signals: the left- and right-channel signals and the horizontal-sync signal. The L and R signals are first fed through lowpass filters to remove out-of-band components that could cause crosstalk and intermodulation. The L and R signals are then fed to a matrix circuit that forms the stereo-sum (L + R) and -difference (L − R) signals. Note that the L + R signal undergoes a 75μs preemphasis (as FM radio signals and mono TV-audio signals normally do) while the L − R signal undergoes a variable compression (the amount of compression is determined by the dbx compressor). We'll look at preemphasis and compression circuitry next month.

To prevent overmodulation and interference with other portions of the baseband (including the pilot and SAP channel), both signals are fed through clippers and lowpass filters.

Although not shown in Fig. 4, equalizers are normally included in one or both of the L + R and L − R paths. They are placed there to help ensure proper stereo separation.

Because the dbx-compressor output may contain a large amount of noise, it may be difficult to measure such things as stereo separation. To overcome that, as shown in Fig. 4, switches are provided to take the compressor and/or the clippers and lowpass filters out of the circuit.

A subcarrier at $2f_H$, twice the horizontal line frequency, is AM-DSBSC (AM double-sideband, suppressed carrier) modulated by the compressed L − R signal and is summed with the preemphasized L + R signal. The $2f_H$ subcarrier signal is also divided by two to supply the pilot tone. The composite stereo signal that is output from the stereo generator contains the stereo sum (mono) signal, the stereo difference signal, and the pilot tone.

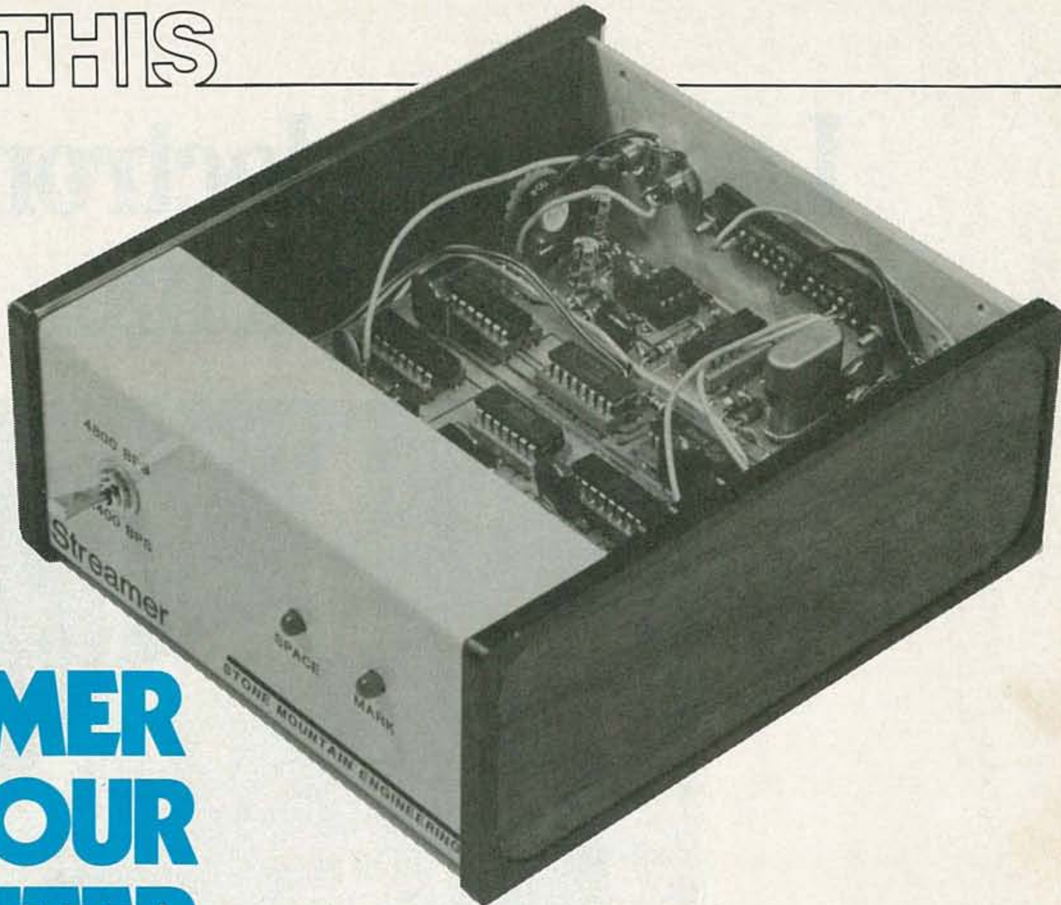
The SAP generator

A block diagram of the other major component of the Zenith transmission system—the SAP generator—is shown in Fig. 5. The SAP audio is processed in much the same way that the stereo-difference signal is. A lowpass filter is used to remove high-frequency components that could overload the compressor, and a clipper is used to prevent overmodulation of the SAP subcarrier and thus prevent interference with the rest of the audio baseband. Equalization, which was used in the stereo generator to preserve stereo separation, is not needed here.

Note the $5f_H$ phase-locked loop in Fig. 5. The compressed audio is added to the PLL control voltage and thus frequency-modulates the VCO (voltage controlled oscillator). The frequency modulated subcarrier is then passed through a bandpass filter to protect the other audio signals from SAP spillover interference.

Now, if we look back to the block diagram of the Zenith transmission system (Fig. 3), we see that the outputs of the stereo generator and SAP generator are added together to form the composite signal, which frequency-modulates the TV audio carrier.

Next time, we'll look at the noise reduction techniques used in the BTSC system and why it's so important. **R-E**



TAPE STREAMER FOR YOUR COMPUTER

MIKE HUDDLESTON

Are incompatible disk formats keeping you from transferring files from one computer to another? This universal cassette interface can solve that problem. And at 4800 baud, it can do it in a hurry!

THE COST OF MICROCOMPUTER COMPONENTS seems destined to continue to drop. Now you can build or buy computers at prices that seemed unbelievable just a few years ago. But when you add floppy-disk drives, the picture changes. Disk drives haven't dropped in price like other computer hardware has—and it seems likely that disk-drive prices will stay high. Is there a low-cost alternative?

Many of you probably have answered, "audio cassettes." Yes, they can be used but—when compared to disk drives—their slow and unreliable performance leaves much to be desired. We'll show you, however, an easy-to-build cassette interface that may change all that.

That interface, which we'll call a Streamer, is a very fast, highly reliable *universal* audio cassette interface designed to be a low-cost alternative to floppy disks. If your computer has an RS-232 port, you can use the Streamer to transfer data to any other computer similarly equipped. You can transfer *any* program, written on *any* computer, to *any other* computer using a compatible language. For example, the author routinely writes and debugs assembly-language programs at work on an Intel development system, and brings them home on a cassette so that they can be run on his "homebrew" 8080-based computer. He has also transferred BASIC listings from a 6502-based system to cassette so that the programs could be run on his system. (Of course, while the BASIC implementation may vary from one system to another, those differences are usually easy to work around.)

The same thing can be done with other high-level language programs, like FORTRAN or Pascal: The listings can be transferred from one computer to cassette tape and then they can be loaded into your next computer, without worry of disk compatibility. Obviously, doing the same thing in these days of endless 5¼-inch disk formats would be virtually impossible if the systems were not identical.

Streamer basics

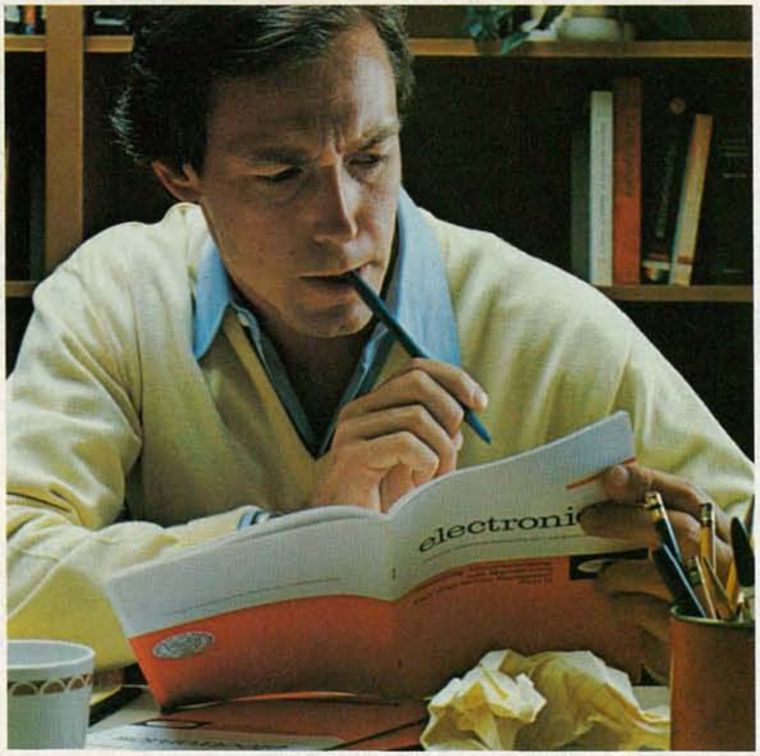
The name "Streamer" is computer-shop talk for "streaming tape interface," a term normally used to refer to magnetic-tape systems that are used for disk backup. If you're looking for something to *replace* floppy-disk drives, you should first understand that a streamer is *not* a random-access drive like a floppy disk—the tape moves in one direction only, and files must be accessed sequentially.

The Streamer has no provisions for motor controls, which greatly simplifies its construction and interfacing, but restricts its operation to the manual mode. If you use short (5-minute) cassettes, and put only one program or one file on each, the interface will be easier to use. The cassettes are cheap and reliable, but their random accessibility is limited by the time it takes me to remove one cassette and replace it with another.

In the course of designing of the Streamer, several encoding techniques—from Kansas City Standard to FSK and PWM—were tried. The method chosen was *Manchester encoding*, which we'll look at in some detail next month. Methods of data recovery evolved from the use of filters and phase-locked loops to digital timing. The result is a low-cost but high-performance cassette interface.

Just what do we mean by "high performance?" The data-transfer rate is 4800 baud or bps (*B*its *P*er *S*econd). What that means is that a 16-kilobyte program can be loaded in as little as 38 seconds. The

Learning electronics is no picnic.



At any level it takes work and a few sacrifices. But with CIE, it's worth it.

Streamer is reliable, too—the cassette deck is the limiting factor, so a high-fidelity type deck is recommended. (The author has used a $69 stereo unit for over a year, and has had no permanent errors. When a read error occurs, a simple cleaning of the heads and capstan eliminates the problem.)

Along with its speed and universality, the cassette streamer has another attractive feature: It can be built for about $60. All the electronic parts are standard, and all are available from the vendors who regularly advertise in **Radio-Electronics.**

The Streamer circuit

Figure 1 is a schematic of the interface circuit—we'll start our look at it with the power supply. The circuit requires a voltage supply between 8 and 16 volts DC at a typical current drain of only about 30 mA. That can be supplied by an external wall plug DC supply or it may be "stolen" from the computer or the tape deck. If the computer supply is to be used, the power can be run through pin 25 of the the DB25 connector. If you use a miniature closed-circuit phone jack (J3) and wire it as shown in the schematic, then you can conveniently have your choice of either.

Electrolytic capacitor C14 provides filtering for the raw DC (which powers the RS-232 interface and is the input to the five-volt regulator, IC15). The negative voltage required for RS-232 is furnished by a charge pump: Transistor Q1 is alternately turned on and off by a 76.6-kHz clocking signal provided by IC3, and charges developed across C16 are transferred to C15 through D3. A negative voltage of slightly less magnitude than the positive supply voltage will be developed across C15 for use by the RS-232 output stage.

The circuit's clock is made up of a 2.4576-MHz crystal (XTAL1), and an EXCLUSIVE-OR gate (IC2-d) that's connected as an inverter. The clock's output is divided by IC3, a 4040 ripple counter, for the various frequencies needed by the rest of the circuit. The outputs at pins 2, 3, and 5 of IC3 are baud-rate clocks for the UART (*U*niversal *A*synchronous *R*eceiver/*T*ransmitter).

The UART uses a clock at 16 times the data rate, so the signals at pins 5, 3, and 2 (which are 153.6 76.8, and 38.4 kHz) correspond to UART baud rates of 9600, 4800, and 2400 bits per second, respectively. The UART transmitter (which sends data back to the computer) always runs at 9600 baud, so its TRANSMITTER REGISTER CLOCK, (pin 40) is directly connected to pin 5 of IC3. However, since data from the computer to the Streamer may be either 2400 or 4800 baud, a switch is provided to select different RECEIVER REGISTER CLOCK (pin 17) connections.

RS-232 interfaces are usually crystal controlled. Fortunately, UART's are forgiving of small differences between clocking frequencies. That's important because an RS-232 data stream is continuous—that is, the stop bit of one word is followed immediately by the start bit of the next. Although it would seem there is no margin for error, UART's do allow for some timing variations by accepting stop bits that are either short or long, then re-synchronizing on the following start bit.

The Streamer extends that idea by sending bits to the cassette tape at a slightly faster rate than its UART receives them. (For an RS-232 input with a data-rate of 4800 bps, the output sent to the tape is at 5486 bps, allowing a timing mismatch of 12.5%.) If the computers baud-rate clock is a little too fast, the Streamer's UART will be overrun. As we mentioned previously, RS-232 can accept stops bits that are either long or short (1½ bits for example). But there is no way to represent a half bit in Manchester encoding. (That will become obvious when we discuss the encoding next month.) So, when the Streamer UART is overrun, it fills its idle bit times with marks (which is the convention), and inserts them as needed to make up an integral number of stop bits.

That accounts for the difference in speed from UART-to-UART, but not for the (typically worse) cassette-playback variations. Tape timing is reliably recovered by timing each bit (Manchester encoding is bit-synchronous), but since the data may play back faster than it was recorded, it may be returned to the computer at a still faster rate. To keep things compatible with RS-232 standards, the bits from the tape are gathered in one at a time, grouped into 8-bit words, and returned to the computer at 9600 bps.

Synchronous counter IC4 provides the Streamer with the tape-data rates. For an RS-232 rate of 4800 bps, the tape, as mentioned earlier, is recorded at 5486 bps; while at 2400 bps, the tape-data rate is 2560 bps. IC4 and IC2-c form a counter that divides by either 7 or 15, depending on the bit rate selected by S1. Since its input is 614.4 kHz, its output will be either 87.77 kHz or 40.96 kHz, sixteen times the tape bit rate. That 16× bit rate will be used by both the receiver and the transmitter sections.

The receiver

The CMOS UART, IC11, has two separate functional sections; an NRZ receiver with parallel output, and a parallel-input NRZ transmitter. (We'll discuss NRZ encoding—and compare it to the Manchester coding that this interface uses—later on in this article.) The receiver section of the UART, in conjunction with IC12, IC13, IC14-d, IC5-b, IC8-b, and IC7-d comprise the RS-232-to-Manchester converter. Comparator IC14-d, along with its associated discrete components, converts incoming RS-232 data to TTL-level NRZ code. That code is applied to the serial input (pin 20) of the UART receiver section, which is clocked (on pin 17) at the appropriate rate for RS-232 standard compatibility.

An 8-bit shift register (IC13) and a flip-flop (IC12-b) are connected together to

PARTS LIST

All resistors ¼ watt, 10% unless otherwise noted
R1—1000 ohms, PC-mount, trimmer potentiometer
R2, R5, R6, R11, R16, R17, R20, R28, R29—1000 ohms
R3, R4, R7, R8, R13, R14, R18, R19, R22, R23, R25, R26, R30—10, 000 ohms
R9—1 Megohm
R10—100,000 ohms
R12, R21, R27—47,000 ohms
R15—10 Megohms
R24—2200 ohms
R31—330 ohms
Capacitors
C1, C4, C13—10 µF, 25 volts, electrolytic
C2, C21—0.001 µF, ceramic disc
C3, C12, C16—0.1 µF ceramic disc
C5, C7, C17, C18, C20, C22, C23, C24—0.01 or .1 µF bypass capacitors (not shown in schematic)
C6, C10—20 pF, ceramic disc
C8, C9—250 pF ceramic disc
C11—5 pF, ceramic disc
C14—100-330 µF, 25 volts, electrolytic
C15—47-220 µF, 25 volts, electrolytic
C19—0.01 µF, ceramic disc
Semiconductors
IC1—LM392 or LM2924 op-amp/comparator
IC2—4070 or 74C86 quad XOR gate
IC3—4040 12-stage binary ripple counter
IC4,IC6—4029 presettable up/down counter
IC5—4520 dual 4-bit synchronous counter
IC7—4011 quad 2-input NAND gate
IC8—4027 dual J-K flip-flop
IC9, IC12—74C74 dual D-type flip-flop
IC10—4015 dual 4-bit static shift register
IC11—6402 CMOS UART (Intersil)
IC13—4021 8-stage static shift register
IC14—LM339 quad comparator
IC15—78L05 low power 5-volt regulator
D1-D5—1N914 or similar
D6, D7—standard red LED
Q1, Q3—2N3904
Q2, Q4—2N3906
XTAL1—2.4576 MHz crystal
MISCELLANEOUS: PC board, enclosure, DPDT switch, DB25 connector, phono jacks for tape deck connectors, hardware, solder, etc.
The following are available from Stone Mountain Engineering Co., PO Box 1573, Stone Mountain, GA, 30086: Printed circuit board, double-sided with plated-through holes, solder masked and silkscreened, for $28; Enclosure, with all holes punched and legends silkscreened, $16; Both PC board and enclosure for $40. All orders must include $1.50 shipping and handling, and Georgia residents please enclose 3% sales tax.

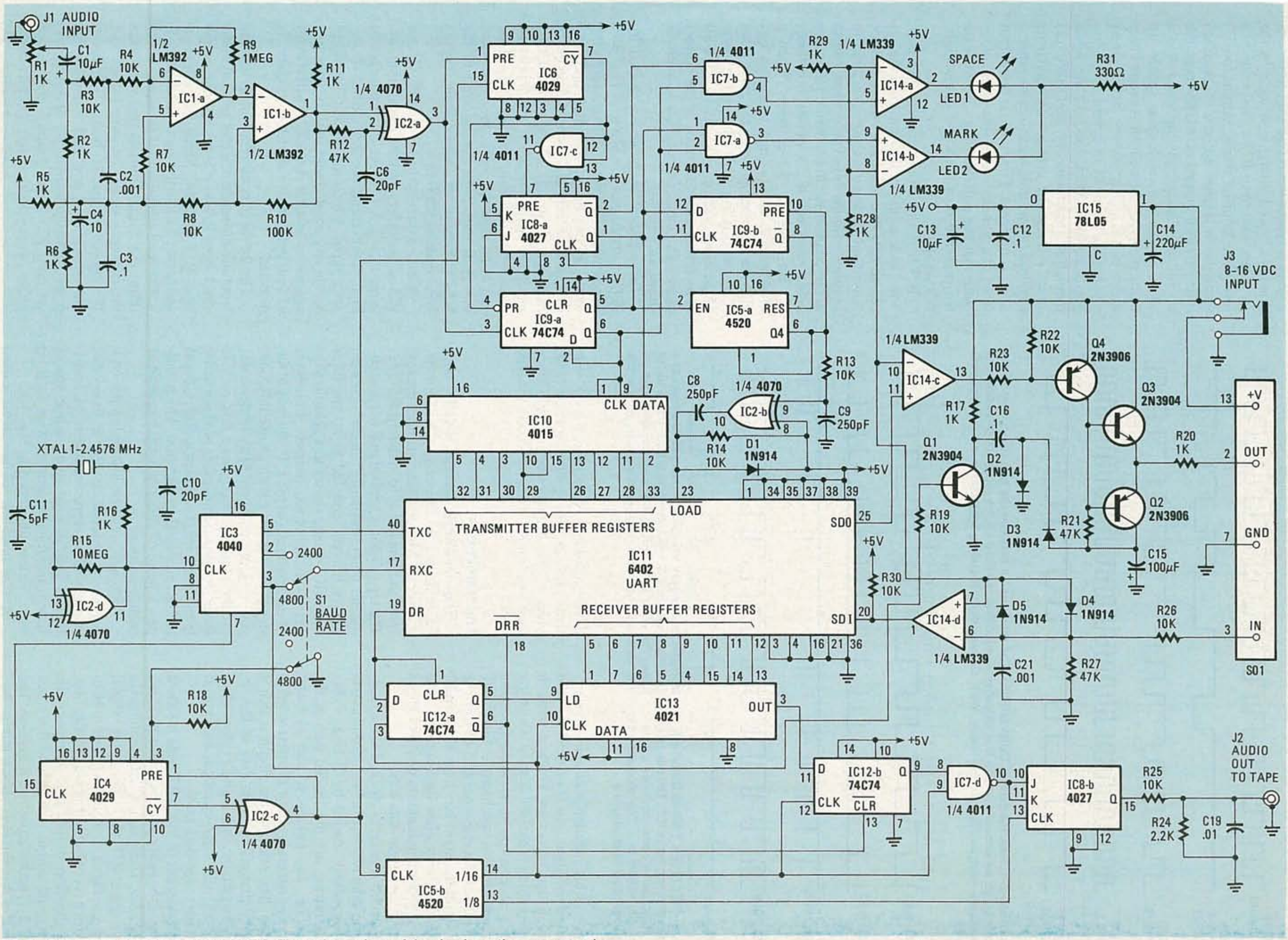


FIG. 1—CASSETTE INTERFACE SCHEMATIC. The main sections of the circuit are the power supply, crystal-controlled clock, RS-232-to-Manchester converter, and the Manchester-to-RS-232 converter. Although not shown, bypass capacitors (0.1 or 0.01 μF) should be located at some of the IC's.

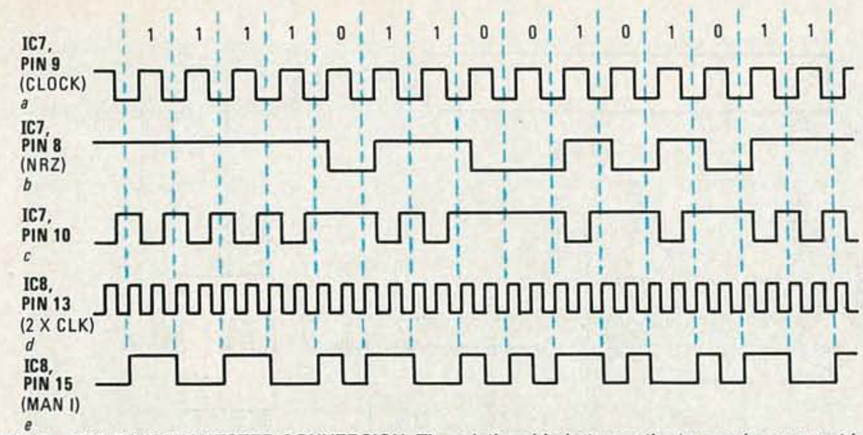


FIG. 2—NRZ-TO-MANCHESTER CONVERSION. The relationship between the two codes may not be apparent, so we should mention that Manchester encoding is based on the presence or absence of transitions—not on high or low levels. We'll discuss both encoding methods in more detail next month.

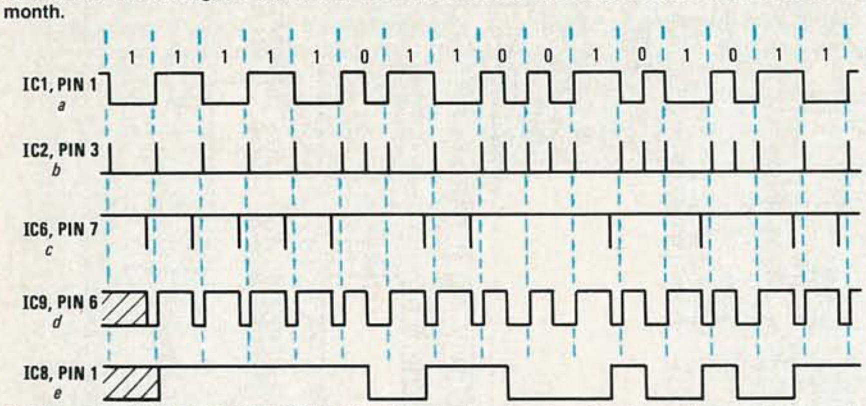


FIG. 3—RECEIVER TIMING DIAGRAM. The Manchester signal received from the tape is shown in *a* (after conditioning by IC1). The output of the transition detector (IC2-a) is shown in *b*. Each transition of the Manchester code produces a positive pulse. The carry output from IC6 (used to determine bit sense) is shown in *c*. The recovered clock is shown in *d*, while the reconstructed NRZ code at the output of IC8-a is shown in *e*.

form a 9-bit parallel-load shift register. Their serial input, pin 11 on IC13, is held high so that marks are clocked through when nothing is parallel-loaded. Once the UART receives a serial word from the computer, IC12-a synchronizes the UART to the tape-data rate from IC5-b, loading IC13 with the eight bits from the UART, and IC12-b with a low for a start bit. The 9-bit register combination now includes a start bit and eight data bits.

The shift register is clocked at the tape-bit rate from IC5-b, pin 14. As soon as it is synchronously loaded by IC12-a, it begins shifting out the loaded data at the tape rate, and follows it with as many marks as necessary until the next word is loaded. The effect of the circuit is that it simply changes the data rate of the received word; the shift register output from IC12-b is still NRZ-encoded, but now at the faster tape-data rate.

An example of this NRZ code is shown in Fig. 2-*b*, along with the tape rate clock in Fig. 2-*a*. Those signals are combined in NAND gate IC7 to produce the signal shown in Fig. 2-*c*. This is applied to IC8-b, which is configured as a toggle flip flop. The flip-flop will toggle whenever the NAND gate output is high and the clock (Fig. 2-*d*) makes a positive transition. The output of this flip flop, shown in Fig, 2-*e*, is the resulting Manchester code. Resistors R24 and R25, with capacitor C19, round off the Manchester bits and reduce their amplitude for application to the tape deck.

The transmitter

The transmitter section of IC11, with the remainder of the circuit components, recover the Manchester code from the cassette and convert it to standard RS-232. The tape signal is applied to R1, a potentiometer that is normally full on. It is then lightly filtered, coupled to an amplifier stage (IC1-a) and passes to a Schmitt trigger (IC1-b), which outputs TTL-level Manchester data at pin 1. If you look at the signal on IC1 pin 1 with an oscilloscope, you'll see the recovered Manchester code, as shown in Fig. 3-*a*. Since that code is sensitive only to transitions (and not to the level), the signal is applied to R12, C6 and IC2-a, a transition detector, which outputs a pulse of about one-microsecond at each transition.

Although we'll be discussing the coding format in detail, for now let us say that marks will be represented here by transitions a full bit time apart, while spaces have transitions occurring twice each bit time. That is illustrated in Fig. 3-*b*.

A 4-bit up/down counter (IC6) is used here as a synchronous one-shot. It is continually clocked at its COUNT input by the 16× tape rate from IC2-c, and outputs a low pulse from its CARRY output (pin 7) whenever it reaches a count of 15. Each time a transition is received, however, the output of IC2-a presets the counter to a value of four. So, as long as spaces are being received, the counter is preset every eight or so clock pulses, so it never reaches the count of 15 before it is again preset to four. Mark bits, on the other hand, have transitions only half as often as space bits, so the counter will reach its terminal count, and output a carry, when a mark is received. Figure 3-*c* is the output from the synchronous one-shot, IC6. Note that the pulses in Fig. 3-*c* indicate the presence of a mark; no output indicates a space.

IC9-a is the clock-recovery flip-flop. The clock signal is derived from the received data; the Streamer's internal clock is used only to test the sense of each bit, in keeping with the bit-synchronous nature of this Manchester code. While spaces are being received, IC2-a pulses two times per bit, toggling IC9-a twice. When a mark is received, its single transition toggles the flip-flop, and then the carry from IC6 presets IC9-a. That corrects the phase of the clock so that, as soon as a mark bit is received, the clock runs in the correct phase. The clock output, IC9-a, pin 6, is shown in Fig. 3-*d*.

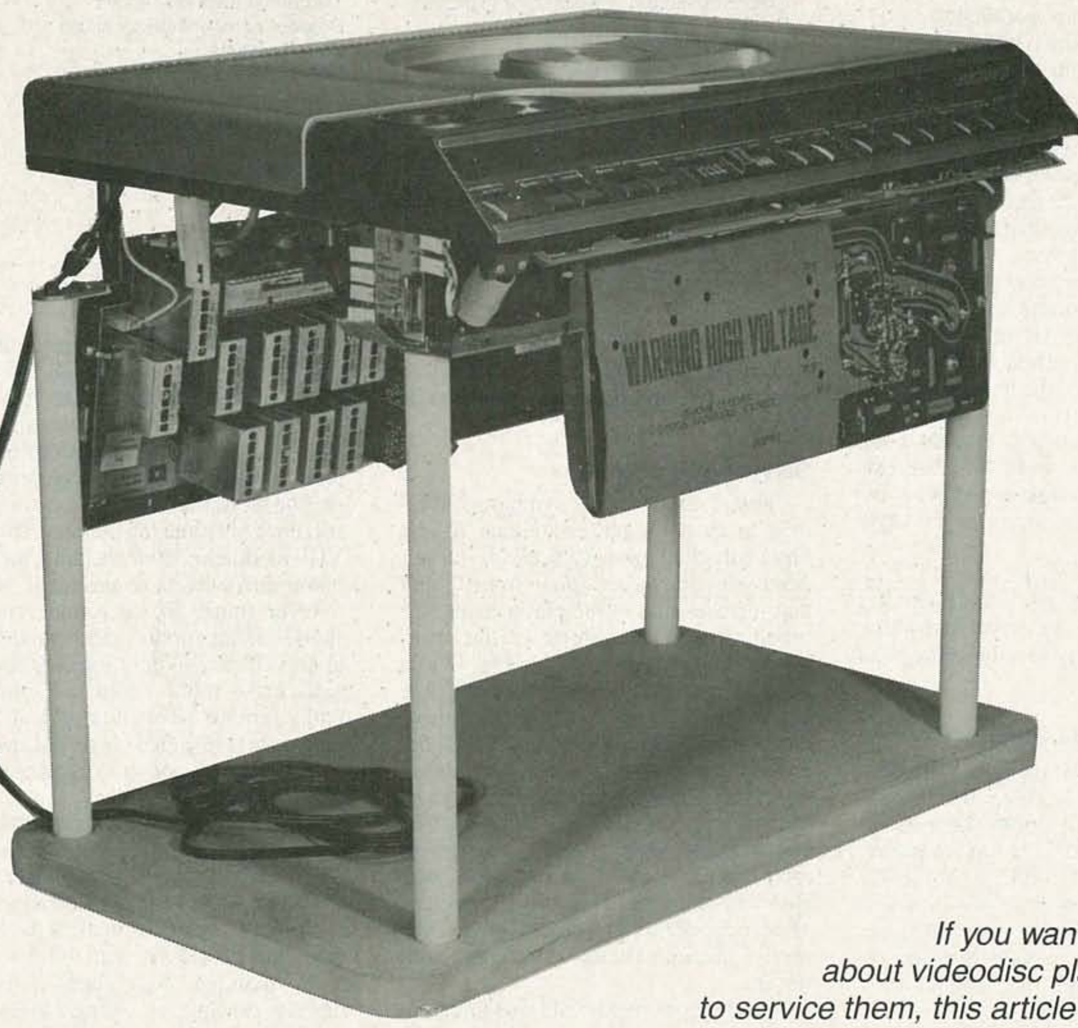
The sense of each bit is detected by IC8-a—its output is shown in Fig. 3-*e*. Wired as a R-S flip-flop, IC8-a is set by the mark-detector output from IC6, and reset by clocking from the inverted data clock from IC9-a, pin 5. The clock and data inputs are applied to IC10, which is wired as an 8-bit serial-load shift register. At the end of an eight-bit word, the contents of this shift register are transferred to the UART transmitter, which then outputs NRZ code at 9600 bps.

A bit counter is made up of IC9-b and IC5-a. To understand their operation, assume that IC5-a has its Q4 output (pin 6) high. That output is connected to its ENABLE input, which means that it will not accept any input clocks until Q4 goes low again (i.e., until it is reset). It will remain in that state until a start bit, a space, is detected.

On the next occurrence of a start bit from the bit-sense detector (IC8-a) and a clock from IC9-a, IC9-b's inverted output (pin 8) goes high. Since that output is connected back to the RESET input on IC5-a, the reset operation takes place, which drops the output from Q4 and re-enables the counter. As the Q4 output goes low, IC9-b becomes preset, bringing its inverted output back low and removing the reset command from IC5-a. It is held preset until IC5-a has counted eight clock pulses, corresponding to eight bits being

continued on page 116

Servicing Videodisc Players



JOHN LENK

If you want to learn more about videodisc players and how to service them, this article is for you. In it we cover both LV and CED players.

NOW THAT WE'VE SEEN HOW THE LV AND CED systems work, we are ready to turn our attention to our main topics—how to properly troubleshoot and service videodisc players.

Tools

Although there is no standardization, most videodisc players require some form of special tools for full service. Study the service literature and use the recommended tools. If the tools appear in the literature, they should be available from the manufacturer. Of course, there are factory assembly tools that may not be available for field service (not even to factory service-centers, in some cases). That is the manufacturer's subtle way of telling service technicians that they should not attempt any adjustment (electrical or mechanical) not recommended in the service literature. Take that hint! The author has heard many horror stories about "disaster area" players brought in to factory service people after "a few simple adjustments." Also keep in mind that most players are manufactured to *metric standards* and your tools must match.

Checkout and preliminary troubleshooting

Before concluding that the player is out of order, run through the following notes and make sure that there is not a simple remedy for the problem.

If the lid does not open on an LV player, check that power is on. Try pressing the STOP/EJECT button to release the lid latch.

If the caddy entry door on a CED player does not open, make sure the FUNCTION lever is in load (for manual players), or that power is applied and the operation switch is set to on (for automatic load players).

If the disc does not appear to rotate (you can't hear the disc motor running), check that power is on. On LV players, check that the lid is properly closed (to close the interlocks).

If the disc stops rotating soon after starting, it is possible that you are playing an unrecorded side of the disc. Try turning the disc over.

If the disc rotates, but there is no picture check the following: Are the connections between player and set correct? Are the player and TV set on the same channel? Is the player in pause mode?

If the picture quality is bad (with proper connections and both the player and the TV set on the same channel), check the fine tuning on the TV set. The player output is on an inactive TV channel and, since that channel is not ordinarily used, fine tuning may not be precisely adjusted. If picture quality is still bad, try a different disc (a known good disc).

If the TV no longer receives other channels after being connected to the player, make sure that the antenna cable is connected to the player. Then check that the player is off (FUNCTION lever set to off, power switch off, etc.)

If a particular part of a disc does not produce a good picture, the disc is possibly damaged. Try pressing the SCAN (or similar) buttons to skip over the damaged portion.

If the remote control does not work, try replacing the batteries (on those remotes that do not have direct wiring). Also check for obstructions between the player and remote.

Servicing videodisc players

If none of the above cures the problem, you must go inside the player. It is impossible to describe full troubleshooting or service procedures for any type of player within the limits of this article. You must read the service literature. But we will, in the balance of this article, give you some service notes that can make the job of servicing either a CED or LV player a lot easier.

As a starting point for either type of player, insert a known good disc and run through all operating procedures. If one or more of the operating features is absent or abnormal, install the recommended test disc and run through the adjustment procedures. That can often lead to the source of the problem, since the adjustment procedures usually require that you monitor the inputs and/or outputs of all circuits and sections in the player.

If the player is still not functioning properly, go through the following service notes, and compare them to any procedures recommended in the service literature. Keep in mind that the circuits referenced in the following are "typical" for a cross-section of videodisc players. You must check at the corresponding points on the circuits of the player you are servicing.

TABLE 1—LV TROUBLESHOOTING GUIDE

Symptom	Circuits To Check
Power on indicator does not light	Low-voltage power supply circuits
Power on; picture, sound not muted	Mute circuits
No picture, no sound, disc does not spin	low-voltage power supply circuits, and start-up sequence-motor accelerator circuits
No picture, no sound, disc speeds up and slows	Low-voltage power supply, laser power supply, and start-up sequence-focus circuits
No picture, no sound, objective lens focused	Signal processing circuits
No picture, sound is normal	Signal processing circuits
Erratic picture, picture shakes and skips	Radial tracking circuits
Picture loses sync, picture jitters, disc speed varies	Turntable motor circuits
Color streaking or loss of color in picture	Tangential tracking circuits
Excessive dropout in picture	Dropout compensation circuits
No sound, picture is normal	Sound circuits
Distorted sound, picture is normal	Sound circuits
Either sound channel does not nute	Sound circuits
Picture sticks and repeats (disc known to be good)	Slide drive and search circuits
No search forward or reverse	Slide drive and search circuits
Index numbers missing or incorrect, index number background missing	Index circuits
No special effects, erratic special effects, skips during special effects	Track jumping circuits

Servicing LV players

Table 1 lists various symptoms common to most LV players. Figure 13 is a block diagram of a typical LV player. After selecting the symptom from Table 1 that matches that of the player being serviced, follow the steps in the troubleshooting procedures using Fig. 13 as a guide. The procedures described help isolate the problem to a defective module or component. Keep in mind that a high degree of integration is used in videodisc players and, thus, defective sections must usually be replaced in their entirety. The adjustments listed at the beginning of each procedure are those usually associated with the related circuit. If possible, always check the adjustments (using the service literature) before proceeding with service.

Prior to replacing the slide assembly, or making any substantial mechanical adjustments, always check for any purely mechanical problems that can affect player operation. If the picture skips or repeats, check for a misadjusted slide drive, poor lead dress, misadjusted slide rails, or anything that can inhibit slide movement. The slide must move freely beneath the disc. If a "ratcheting" noise is heard, it is possible that the slide is adjusted too loosely.

Low-voltage power-supply circuits. Monitor all of the supply output voltages. Typically, that includes ± 12- and ± 24 volt outputs, and possibly ± 5-volts for microprocessor or other control logic.

Mute circuits. When power is first applied, both sound and picture should mute (dark screen, low volume). If the picture does not mute, check to see if a video-mute signal to the video processor is missing; if so, replace the mode control. If it is present, try grounding the composite-video line from the video processor. If that still does not mute the picture, replace the VHF modulator, after checking for proper power and antenna connections.

If the sound does not mute, check for sound-muting inputs to the sound demodulators. If they are missing at either input, replace the mode control. If present at both, remove demodulator I. If sound then mutes replace demodulator I. If sound still does not mute, replace demodulator II.

Laser power-supply circuits. First check the laser adjustments (if any), and then check for 5-volts at the laser supply test point. Most LV players provide such a test point for a quick check of the laser so that a direct measurement of high voltage is not required. Also check if the laser tube is glowing. A strong glow usually indicates that the high-voltage is present and the laser is good.

Start-up sequence-motor accelerator circuits. If the disc does not spin after the lid is closed, check connections between the lid switch and motor drive. If that is fine, ground the motor-acceleration line from the sequence logic to the motor drive. If the disc starts spinning, remove the ground and check the motor-speed signal to the sequence logic. If the signal is present, replace the sequence logic. If missing, replace the search adaptor. If the disc does not spin when the motor acceleration line is grounded, remove the ground and check the lid switch and turntable motor.

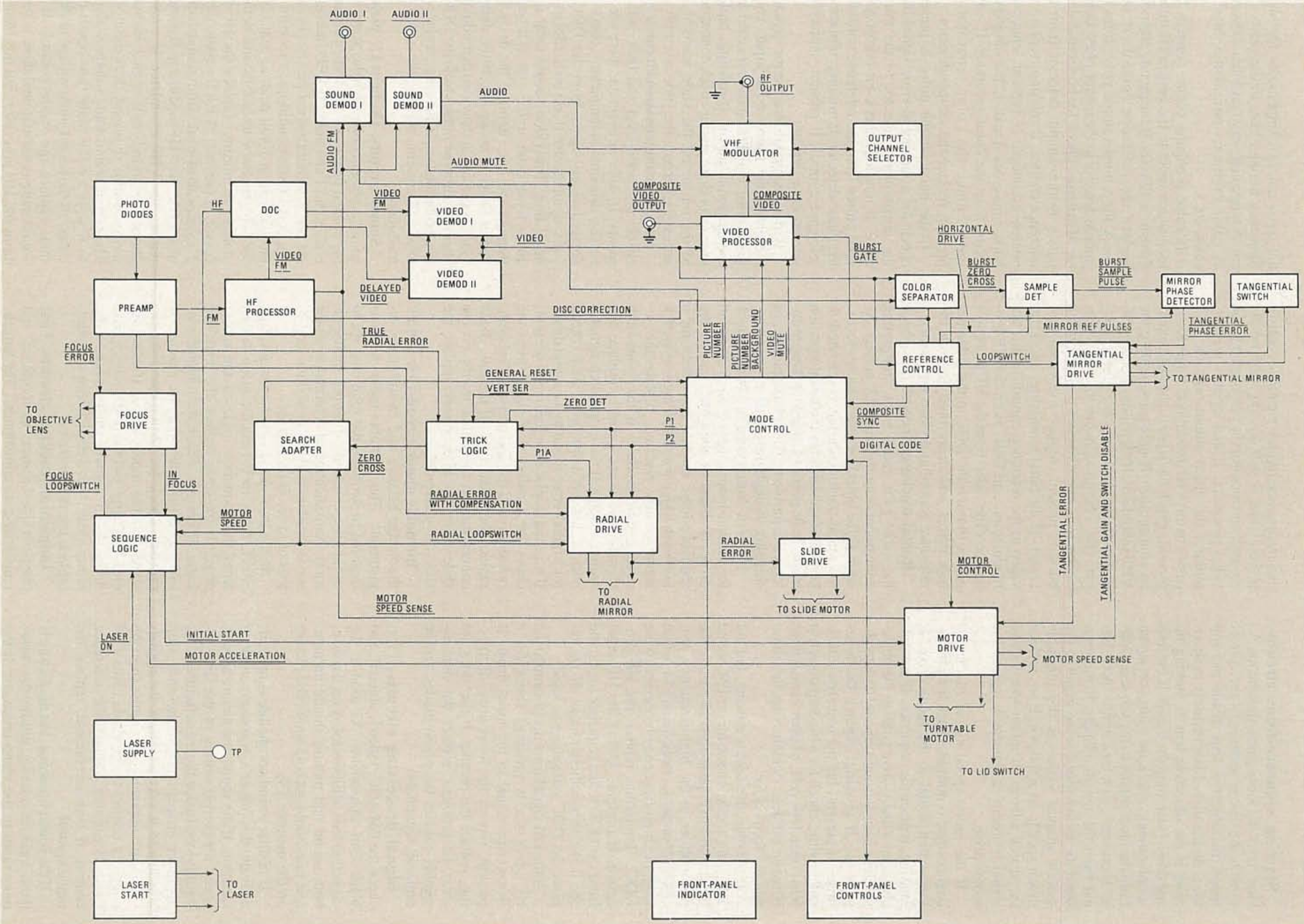


FIG 13—BLOCK DIAGRAM of the electronic and mechanical systems in an LV videodisc player.

Start-up sequence-focus circuits. First check the focus gain adjustments. As soon as the disc is spinning at the correct speed, the objective lens should rise and focus on the disc. Listen closely to determine if the objective lens is moving up and down (searching for focus). If the lens is not moving, check for a laser-on signal from the laser supply to the sequence logic. If present check for a motor-speed signal from the search adapter. If missing, see if the motor-speed-sense signal to the search adapter varies as the turntable motor speeds up and down. If so, replace the search adapter. If motor-speed-sense signal is absent or abnormal, replace the motor drive.

If the motor-speed signal to the sequence logic is normal, check for a focus-loopswitch signal to the focus drive. If missing, replace the sequence. If present, check for a focus-drive pulse to the objective lens (that is usually about 1-volt peak-to-peak). If missing, replace the focus drive. If present, but the objective lens is not moving, check for a binding objective lens, open lens coil, or poor connections between the lens (which is on the slide) and the focus drive.

If the objective lens is moving, but not achieving focus, check for an FM signal (about 100-mV peak-to-peak) from the preamplifier to the high-frequency processor. If present, check for an FM output from the high-frequency processor to the DOC. If missing, replace the HF processor. If present, ground the HF input from the DOC to the sequence logic, and see if the lens achieves focus. If not replace the DOC and sequence logic.

If the FM signal from the preamp to the HF processor is missing, check for a focus-error signal to the focus drive. If present, replace the focus drive. If missing, replace the preamp. If that does not clear the problem, replace the slide assembly (unless the photo-diodes can be replaced separately).

Signal-processing circuits. First check the FM AGC, video I, video II, and black-level adjustments. As soon as the objective lens achieves focus on the disc, both sound and picture should unmute, and you should get both sound and picture on the monitor TV.

If neither sound nor picture is present, activate the player's FORWARD SEARCH function. If the sound and picture appear, check for correct setting of the slide-assembly stop (using the manufacturer's adjustment procedures). If the slide-stop adjustment is correct, check for digital-code and composite-sync signals from the reference control to the mode control. If either is missing, replace the reference control. If both are present, replace the mode control.

If the sound is normal, but the picture is dark, weak, or missing, ground the video-mute input to the video processor. If the picture appears, replace the mode control. If the picture is still missing, remove the ground, and monitor the video input to the video processor. If that input is present, monitor the video output from the processor to the VHF modulator. If that too is present, check the signal cable and antenna connections. If necessary, replace the VHF modulator. If there is no video signal to the VHF modulator, check for a burst-gate (DC-clamp) signal to the video processor from the reference control. If the burst is present, replace the video processor. If the burst is missing, check for video to the reference control, video demodulators, and DOC from the HF processor. (The video from the HF processor passes through the DOC to the video demodulators and delay lines to both the reference control and video processor).

Radial-tracking circuits. First check the radial gain, radial limit, and grating adjustments found on most LV players. As soon as the objective lens achieves focus, the radial-tracking circuit is activated to keep the focused beam on the information track. Indications of radial tracking problems are: garbled sound, shaky picture, or skipping through the picture.

If any of those symptoms occur, check for a radial-loopswitch signal to the radial drive. If absent or abnormal, remove the sequence-logic module and check for a loopswitch signal again. If the loopswitch signal is now restored, replace the sequence-logic module. If the loopswitch signal is still not correct, replace the search adapter. If the loopswitch signal is normal, but the symptoms remain, check for a radial-error signal to the radial drive. If missing, replace the preamp. If present, check for a radial-error signal from the radial drive to the slide drive. If missing, replace the radial drive. If present, check connections to the radial mirror on the slide assembly. If necessary, replace the slide-drive assembly.

Turntable motor circuits. First check the bridge-balance and motor-phase adjustments. The turntable-motor servo is required to maintain the rotational speed of the disc constant (to reduce timing errors). An indication of a turntable-motor servo problem is horizontal jitter (and/or loss of sync) in the picture.

If the disc speed is not constant, first check for a motor-acceleration signal from the sequence logic to the motor drive. If missing, replace the sequence logic. If present, check for a motor-control signal from the reference control. If present, check for motor-speed-sample signals to the motor drive. If missing, check wiring between the motor and drive. If all signals are present to the motor drive, but speed is not constant, replace the motor drive.

Tangential-tracking circuits. First check bridge-balance, motor-phase, and tangential-gain adjustments. The tangential-servo circuit compensates for high-frequency timing errors in the video signal. A tangential-servo problem shows up as color problems (streaking, loss of color, etc.).

If color problems occur, connect the loopswitch input to the tangential-mirror drive to + 12 volts. If the picture clears up, replace the reference control. If not, check for a burst-sample pulse from the sample detector to the mirror-phase detector. If missing, check for horizontal-drive pulses to the sample detector from the reference control. If missing, replace the reference control. If present, check for burst-zero-cross signals to the sample detector from the color separator. If missing, replace the color separator. If present, replace the sample detector.

If the burst-sample pulse is present, check for a tangential-error signal from the mirror-phase detector to the mirror drive. If missing, check for mirror-reference pulses from the reference control to the phase detector. If missing, replace the reference control. If present, replace the mirror-phase detector.

If the tangential-phase-error signal is present at the mirror-drive input, check for an error signal from the mirror drive to the tangential mirror. If missing, replace the mirror drive and/or check connections to the mirror on the slide assembly. If necessary, replace the slide assembly.

Dropout compensation circuits. First check any video-level and DOC adjustments. If, after adjustment, there are excessive dropouts in the picture, check the delayed-video signal from the DOC to video demodulator II, on both sides of the delay line. The video should drop from about 1-volt down to 0.3-volt as it passes through the line. Replace the delay line and/or DOC as necessary. If the delayed video is present at the video demodulator, check for dropout pulses from the DOC to the demodulator. If missing, replace the DOC. If present, replace the video demodulator.

Sound circuits. On most LV players, sound is present only when the player is in the normal play mode, and when either or both audio I and audio II LED indicators are on. If sound (but not picture) is missing under those conditions, check for audio FM (about 1-volt peak-to-peak) from the HF processor to both sound demodulators. If missing, replace the HF processor. If present, check for audio (about 2-volts peak-to-peak) from sound demodulator II to the VHF modulator. If present, replace the VHF modulator. If missing, check the sound-mute signal from the mode control to sound demodulator II. The normal sound-mute voltage is about 5 to 6 volts for the mute (no sound) condition. If the sound-mute voltage is abnormal, replace the mode control. If the sound mute is normal, and there is sound from the HF processor, but not from the

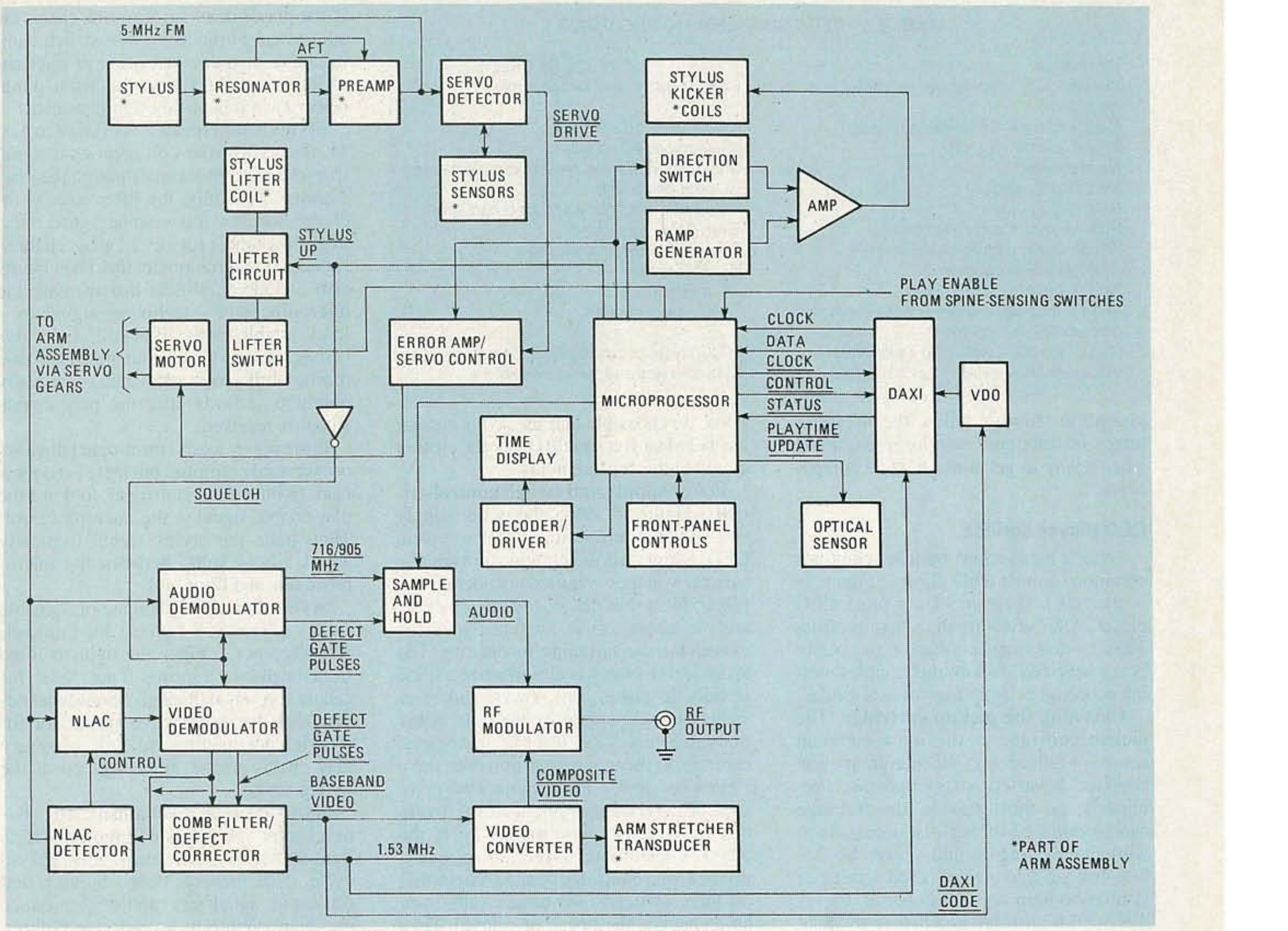


FIG. 14—BLOCK DIAGRAM of the electronic and mechanical systems in a CED videodisc player. The blocks noted with an asterisk are located in the player's arm.

sound demodulators to the VHF modulator, replace the sound demodulators (starting with demodulator II).

If sound is distorted, first check if the distortion is on one or both audio channels. Then replace the corresponding sound demodulator (I, II, or both). If that does not clear the problem, replace the VHF modulator. On most players, it is possible to monitor the sound via the rear panel audio connectors (left and right).

Slide drive and search circuits. The slide-drive servo is responsible for moving the slide assembly radially beneath the disc. A problem in the slide-drive servo can cause the repeating of sections of the disc. If the player sticks or repeats, check for drive signals to the slide motor from the drive. Generally, the drive signals are on the order of 1 to 8 volts, and the polarity of that voltage is positive in forward and negative in reverse. If the voltages are absent or abnormal, replace the slide drive.

If the SEARCH functions (forward or reverse) are not normal, try grounding the corresponding inputs (from the SEARCH controls) to the mode control. If that produces correct operation, replace the SEARCH control and/or wiring. If not, check the search signal from the mode control to the slide drive. If absent or abnormal, replace the mode control. If normal, but there is no search, replace the slide drive and/or check the wiring between the drive and slide motor.

Index circuits. First check any video level adjustments. If the index numbers are present on the TV screen, but the background blanking is missing, check for a picture-number background signal from the mode control. If present, replace the video processor. If the background blanking is present, but the index numbers are missing, check for a picture-number signal from the mode control to the video processor. If missing, replace the mode control, If present, replace the video processor. If both numbers and background are missing, check the INDEX switch and the connections to the mode control.

Track jumping circuits. First check any jump-pulse adjustments. The track-jumping circuit is used only when a special mode of operation is selected (still, slow motion, fast forward, fast reverse, etc.). A malfunction in the track-jumping circuit can cause loss of special modes (tricks), erratic special modes, or skipping through sections of the disc.

First press the play-reverse button and check for vertical-sync-serration pulses from the mode control to the trick logic. If missing, replace the mode control. If present, check for a PIA pulse from the trick logic to the radial drive. If missing, replace the trick logic. If present, check for a zero-detect pulse from the trick logic to the mode control. If missing, replace the mode control and/or trick logic. If present, replace the radial drive.

Mechanical adjustments. Mechanical adjustments should only be made using the manufacturer's procedures, and (generally) only after there has been major replacement of mechanical parts (such as manufacturer's replacement of the slide

TABLE 2—CED TROUBLESHOOTING GUIDE

Symptom	Circuits To Check
Player totally inoperative, or turntable on but no picture	Power supply and switch control
Caddy can not be loaded/unloaded	Mechanical adjustments
Player will not turn off	Mechanical adjustments
No playback	Stylus lifter/cleaner and pickup electronics
No or noisy audio	Audio demodulator
No or noisy video	Video demodulator and video converter
Picture and/or color instability	Time-base corrector
Wrong color, picture not in sync	Comb filter/defect corrected
Soundbeats in picture	NLAC circuits
No RF output	RF modulator
Picture and audio repeat, visual search inoperative or incorrect	DAXI signal circuits
Rapid access inoperative or incorrect	DAXI, system control, time display
VISUAL SEARCH or RAPID ACCESS problems	Stylus kicker and servo control

assembly). Always follow the manufacturer's instructions, even for disassembly when trying to get at mechanical components.

CED player service

Table 2 lists various trouble symptoms common to most CED players. Figure 14 is the block diagram of a typical CED player. After selecting the symptom from Table 2 that matches that of the player being serviced, follow the troubleshooting procedures using Fig. 14 as a guide.

Checking the pickup cartridge. The pickup cartridge is the most common source of failure in a CED player, and can produce a variety of symptoms. Fortunately, on most players, the cartridge can be replaced through an access door, without removing the unit's cover. So, before you get into any involved service or troubleshooting on a CED player, try replacing the cartridge as a first step. Make sure you use a known good cartridge. Also, it is possible that the stylus cleaner has failed so you should check the cleaner circuits after replacements.

Power supply and switch control-circuits. Figure 15 shows the power supply and switch control-circuits for a typical CED player. Those circuits provide the various voltages required to operate the player. Note that the AC POWER, AC PLAY, and AC SPINE-SENSE switches must be closed for the turntable to operate. The SPINE SENSE switch is closed when a spine is fully in place. The POWER and PLAY switches are operated by the user, either through a FUNCTION lever or front-panel controls. If the unit in question does use a FUNCTION lever, the POWER and PLAY switches are usually operated by a cam that may require adjustment. So if the player is dead (with power available, disc in place, and controls operated) check that all three switches are closed (after you have checked the fuses, of course). Then monitor all of the power-supply voltages.

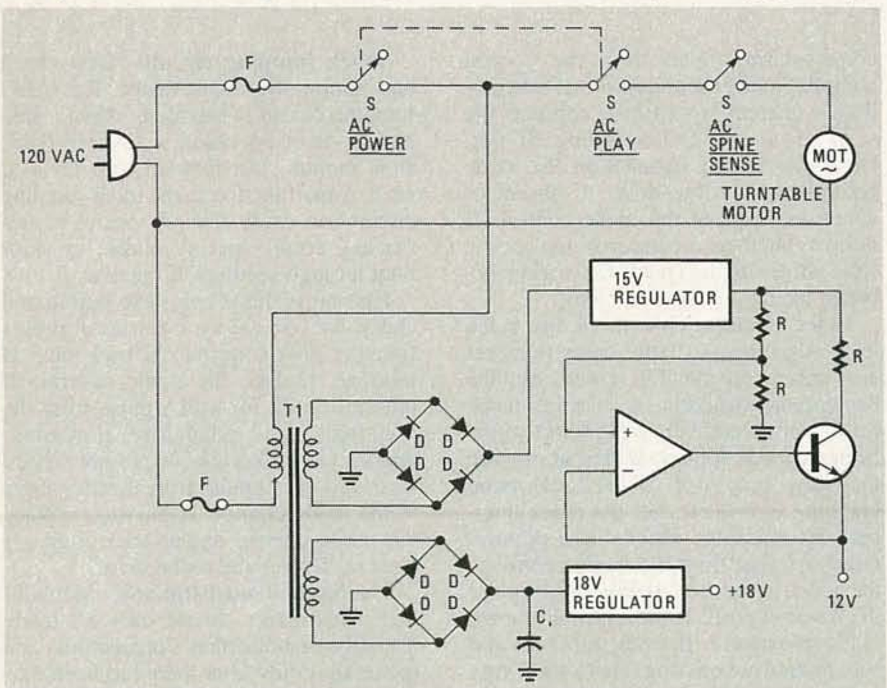


FIG 15—THE POWER SUPPLY and AC switch controls in a typical CED player. Note that the AC POWER, AC PLAY, and AC SPINE-SENSE switches must all be closed for the turntable motor to receive power.

If the player does not turn off, check the adjustment of the AC POWER switch cam. (That problem does not occur in automatic-load models where the front-panel power switch is pushbutton-operated.)

Stylus lifter circuits. As shown in Fig. 14, the stylus lifter coil receives a signal from the microprocessor through the lifter circuits. Generally, the lifter circuits include switches (play, spine sense, etc.) that close and provide a "play enable" signal to the microprocessor. The circuits also include amplifiers that increase the microprocessor's stylus-up signal to a level suitable for the lifter coil. The stylus is lowered onto the disc after the turntable reaches full speed (450 rpm), generally within 6 seconds after the play enable signal is received.

If the player loads (front-panel displays on, turntable running) but there is no playback (with a good cartridge), look for the play-enable signal to the microprocessor. Then trace the stylus signal (typically about 3 or 4 volts) between the microprocessor and lifter coil.

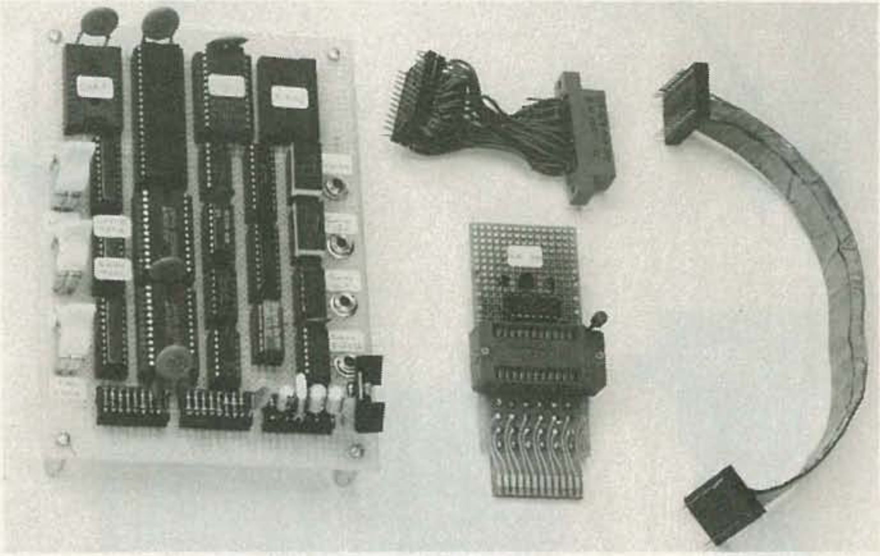
Stylus damage. When the play enable signal is removed (during load/unload, and when not in play), the stylus is lifted from the disc by a spring. If not, the stylus can be severely damaged. Should that occur, look for a defective spring, or for switches not opening and, thus, causing a play enable signal to be applied at the wrong time.

Stylus-cleaner mechanism. The stylus cleaner mechanism removes debris from the stylus during each caddy-unload cycle. That prevents debris buildup that can cause signal loss (and often produce the same symptoms as cartridge failure). So if a cartridge is replaced, and trouble symptoms disappear temporarily only to reappear shortly afterwards, check the stylus-cleaner mechanism. Also, if you find a defective cleaner, "clean" the original cartridge by loading and unloading the disc several times, then check player operation.

It is possible to check cleaner operation through the cartridge access door on some models. Open the door and remove the cartridge. Load and unload a disc while viewing operation of the lifter plate and cleaner (which is usually viewable through the bottom of the pickup arm). As the caddy is removed past the spindle, the stylus lifter-plate should lower, and the cleaner pad should move across the bottom of the arm (where the stylus is located if the cartridge were left in the player). After the pad as moved, the lifter plate should again rise as the caddy is completely removed. If not, you have problems with the stylus lifter and/or cleaner.

There's a lot more to servicing videodisc players. But, unfortunately, that's all the room we have for now. Next time, we'll finish up by showing you more on the CED player. **R-E**

BUILD THIS



ATARI Game Recorder

GUY VACHON and DAVID A. CHAN

You can record the contents of your Atari 2600 videogame cartridges on audio cassette tape! This month, in the conclusion of this article, we'll show you how to build the game recorder and how to put it to use.

Part 3 WHEN WE LEFT OFF last time, we were describing the memory mapping technique that the game recorder uses. The last thing that we want to mention on that subject is that, for simplicity's sake, all ROM's were treated as if they were 4K × 8. That doesn't present any problems with 2K × 8 ROM's because they ignore the most-significant address bit. However, we end up with two copies of the cartridge in the 4K × 8 space—the top and bottom halves are identical. For the time being, remember that all 2K × 8 and 4K × 8 ROM's can be read by inputting to the ROM 4096 addresses (all that can be obtained from all possible combinations of 12 address bits), and saving the data patterns that the ROM returns.

One of the goals of the design of the game recorder was to keep the IC count down. Therefore, the extra memory IC's that would be required to make room for the system stack were not added. That conflicted with our desire to use subroutines (whose return addresses are usually stored in the stack). To get around that conflict, return addresses are kept in the Z80's internal registers. Thus, before a subroutine is called, the return address desired is stored in an internal register; the particular register is determined by which subroutine is to be called. The number of Z80 registers allows for up to three levels of subroutines. Besides that "trick," the software that we showed you last month is quite straightforward.

Building the game recorder

The author's prototype, shown in Fig. 6, was built on perforated construction board. Most of the connections were wire-wrapped. (Even the discrete components were wire-wrapped by first installing them in DIP headers, and then installing the header in a wire-wrap socket.) Eighth-inch phone jacks were used for cassette I/O and power connections, and 24-pin DIP sockets were used for connections to the Atari *2600* and to the game cartridge. Note that a simple power supply, whose schematic is shown in Fig. 7, was also mounted on board. The input to the supply is from a 9-volt, 500-mA DC wall transformer—similar to the transformer that the Atari *2600* itself uses.

Turning to Fig. 8, we see the connectors we need to connect the main board to the game cartridge and to the Atari *2600*. At the top left is the cartridge connector. In the author's prototype, that was basically a DIP-to-card-edge converter: One side plugs into the 24-pin DIP socket on the main board, while the other side is a 24-pin card-edge connector with standard 0.1-inch spacing. Note that to make wiring the connector easier, two 12-pin jumper headers are used to plug into the 24-pin socket. The wires from the headers then connect to the 24-pin edge connector. If you look closely at the photograph, you might note that an inverter is mounted between the socket and the card-edge connector. That's needed to invert the ENABLE line because the program ROM in the cartridge—as opposed to a 4K EPROM—is active high. The foil patterns that we'll show you shortly incorporate the inverter on the board.

Below the cartridge connector is a second board—which we'll call the *adapter board*—that is needed to connect the

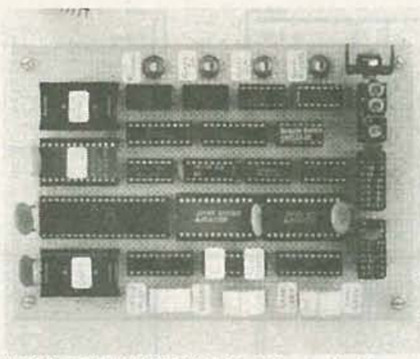


FIG. 6—THE MAIN BOARD of the author's prototype. Three SPDT switches, two 24-pin sockets, and 3¼-inch phone jacks are used for input/output. The fourth jack is used for connection to a wall transformer.

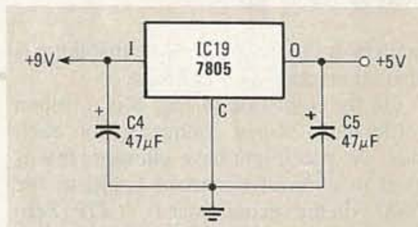


FIG. 7—A SIMPLE VOLTAGE REGULATOR circuit can be mounted on the main board.

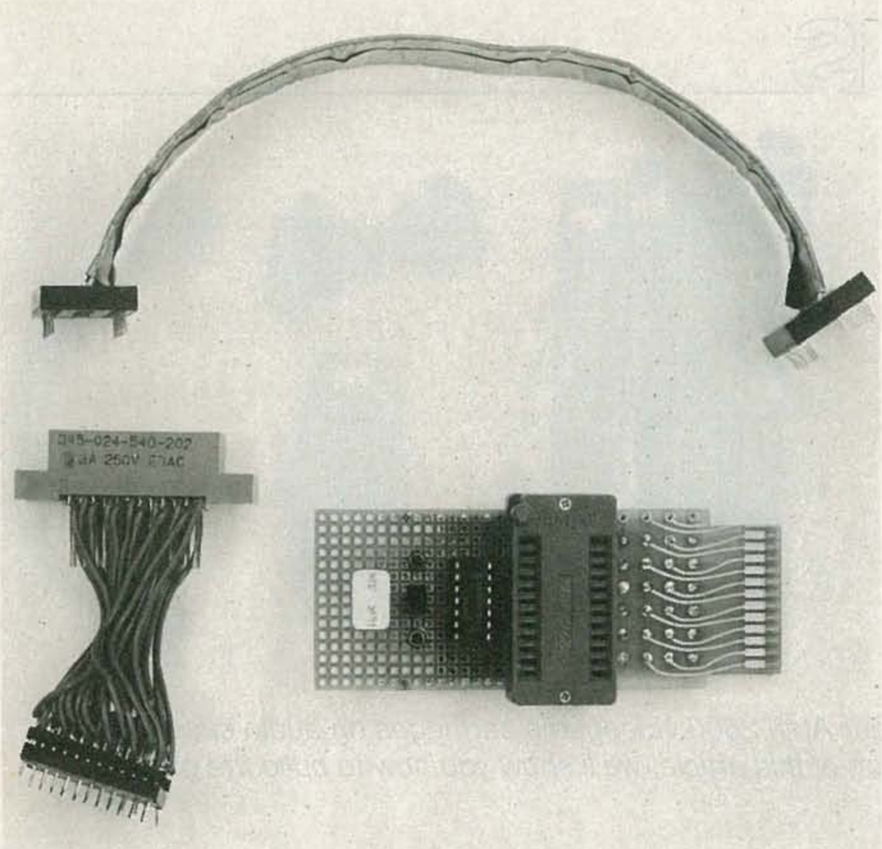


FIG. 8—TO CONNECT THE MAIN BOARD to the Atari *2600* and to the game cartridges, you need to make up special connectors.

main board to the *2600*. Note that there is also an inverter on that board.

On the right side of Fig. 8 is a ribbon cable with 24-pin connectors on each side. As you might have guessed, that is used to connect the main board to the *2600* (via the second board). A ZIF (Zero *I*nsertion *F*orce) socket is mounted on the second board for convenience. Note that the ribbon cable is shielded by copper foil. You will most likely find that shielding the cable will be necessary.

Wire-wrapping a circuit of this complexity is possible but, since wire wrapping sometimes leads to problems in troubleshooting and in mechanical integrity, a printed-circuit board is a desirable alternative. Foil patterns for the component and solder sides of the main board are shown in Figs. 9 and 10 respectively. A supplier of that board is available: See the parts list for information.

The parts-placement diagram for the main board is shown in Fig. 11. Note that there are a few differences between the PC board and the author's prototype. For example, while all the switches and jacks were mounted on the main board of the prototype, the PC board is meant to be used with panel-mounted components. Also, the inverters that were mounted on the prototype's connectors are now located on the board. Note that pull-up resistors for some of the switches are locted off-board. Those resistors, which were not shown in the schematic, are shown in Fig. 11.

You will still need an adapter board to connect main board to the *2600*, and you will have to wire up special cables to connect the main board to both the *2600* and to the game cartridge. The foil patterns for the adapter are shown in Figs. 12 and 13. Figure 14 shows the card-edge pinout of a game cartridge. That, along with Figs. 11–13 should help you wire your cables correctly.

When you build the game recorder—or any other device that uses IC's—be sure to use IC sockets. Start by installing those sockets, followed by the discrete components. Don't install any of the IC's except the voltage regulator. If you use a wall-mounted transformer, install an 1/8-inch phone jack off the board for power connections. Apply power to that jack and check for +5 volts at the appropriate IC pins. Remove power and double check the board for shorts between traces (solder bridges) or for any other potential problems. When you're confident that the board is in good shape, install the IC's, the two displays, and the relay.

Next, you'll have to install the other jacks and the switches. Since those are meant to be panel-mounted, you'll have to cut wires to the appropriate length. Once that is done, you're ready to test the unit out.

Using the game recorder

Throughout this article, we've referred to the various switches and displays that are used on the game recorder. Now it's time to tell you how to use them.

Six switches, two seven-segment displays, and three phone jacks are used for input and output to the game recorder. If you look at the photo in Fig. 6, you'll see only three switches—each single-pole, double-throw switch is used for two functions. You may want to follow the same setup: After all, you can't read and write to the cassette tape at the same time!

Let's give a brief overview of what the switches and displays do. Then we'll go

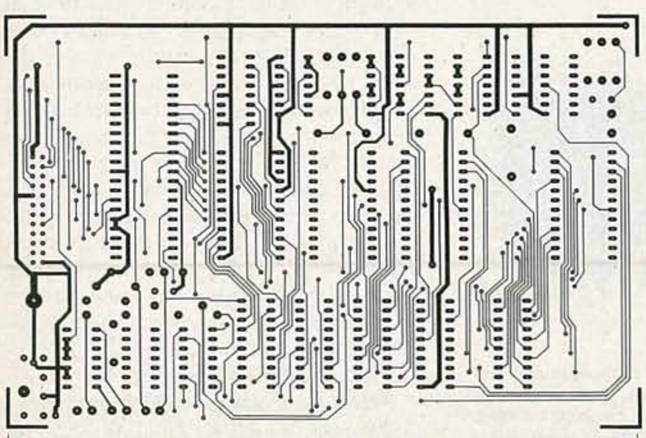


FIG. 9—THE COMPONENT SIDE of a PC board for the Atari game recorder.

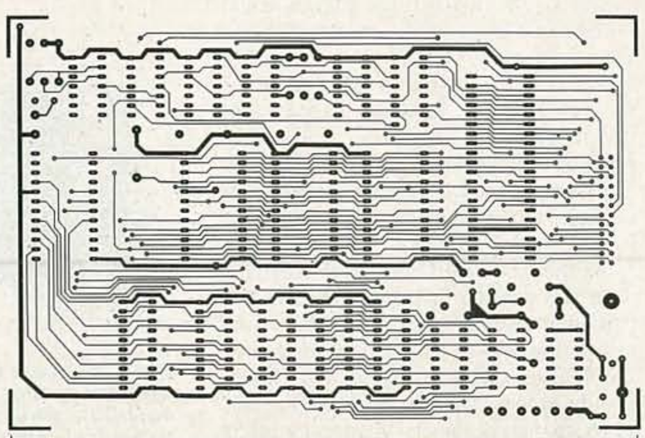


FIG. 10—THE SOLDER SIDE of the game recorder board.

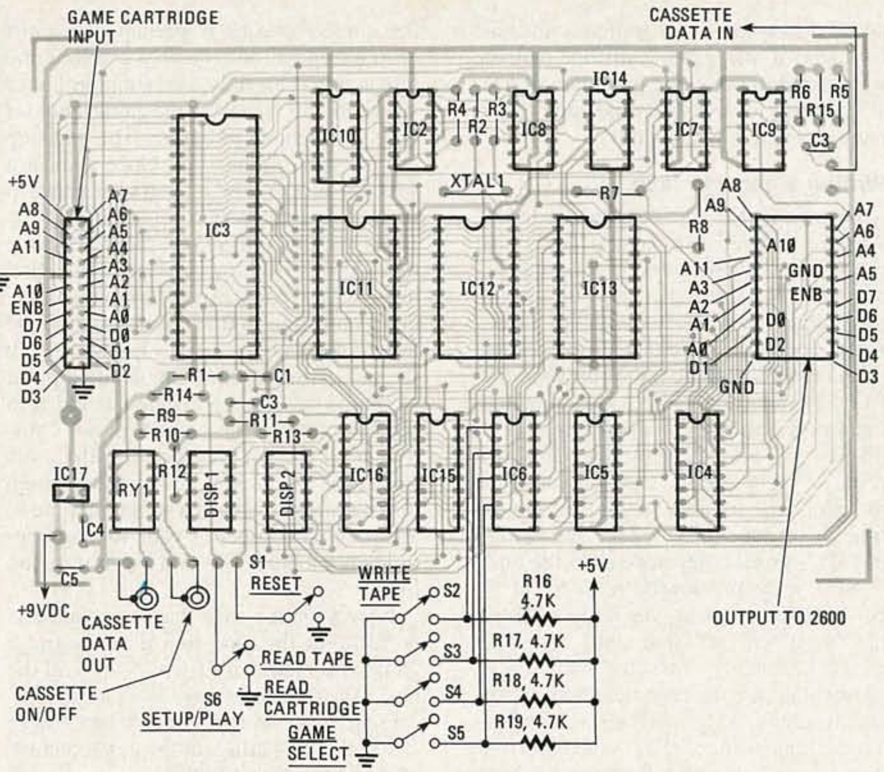


FIG. 11—PARTS-PLACEMENT DIAGRAM for the main board. Note the connector pinouts. You will have to wire up a cable to connect the main board to game cartridges and to the adapter board.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise specified.
R1—220,000 ohms
R2, R3—1000 ohms
R4—330 ohms
R5, R7–R9—10,000 ohms
R6, R15—100,000 ohms
R10—3300 ohms
R11—47,000 ohms
R12, R13—120 ohms
R14—4700 ohms

Capacitors
C1—1 μF, 10 volts, electrolytic
C2, C3—.01 μF, ceramic disc
C4, C5—47 μF, 10 volts, electrolytic

Semiconductors
IC1, IC8, IC14—74LS00 quad 2-input NAND gate
IC2—74LS74 dual D-type flip-flop
IC3—Z80 microprocessor
IC4–IC6—74LS244 octal buffer
IC7—74LS125 quad bus buffer
IC9—LM3900 quad op-amp
IC10—74LS138 3-to-8 line decoder
IC11—2716 EPROM containing the computer's operating system
IC12, IC13—2016 2K × 8 static RAM
IC15, IC16—74LS273 octal D-type flip-flop
IC17—7805 5-volt regulator
DISP1, DISP2—MAN74A or similar seven-segment display

Other components
S1–S5—SPST momentary switch
S6—SPST toggle switch
Miscellaneous: 12/24 card-edge connector, ZIF socket, wiring harnesses to connect main board to *2600* and cartridge, etc.

An EPROM containing the game-recorder program is available for $15 postpaid from J&L Associates, 1133 Broadway Room 906, New York, NY 10010. New York residents must add sales tax.

A set of two etched, drilled, and plated-through boards are available from E²VSI, PO Box 72100, Roselle, IL 60172 for $32.50 postpaid.

into detail on each function. The first switch we'll consider is the GAME SELECT switch, S1, which is used to reset the game recorder in case of failure. The WRITE TAPE switch, S2, is used to initiate the transfer of data from the game recorder's RAM to a cassette tape. Switch S3, READ TAPE, does just the opposite: It initiates data transfer from cassette tape to the game recorder's RAM. The READ CARTRIDGE switch, S4, initiates the transfer of data from the game cartridge to the game recorder's RAM. Switch S5, GAME SELECT, is used to select the name of the game that you want to save on tape, or the name of the game you want to find on a tape. You have 16 choices for a name: the hexadecimal digits Ø–F. The final switch, S6, is the SETUP/PLAY switch which is used to put the game recorder in the mode to play a game on the *2600*.

The first of the two displays, GAME SELECT, shows the name of the game that you want to save or the one you are trying to find on a tape. The name is selected by the GAME SELECT switch. The LAST GAME FOUND display is used to indicate the name of the game that the recorder is "listening to" on the tape. We'll see that the decimal points of those displays serve another important function.

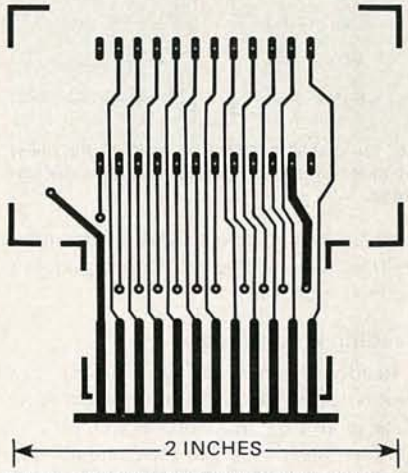


FIG. 12—THIS ADAPTER BOARD is used to connect the main board to the Atari *2600*. We recommend that you use a DIP socket for convenience.

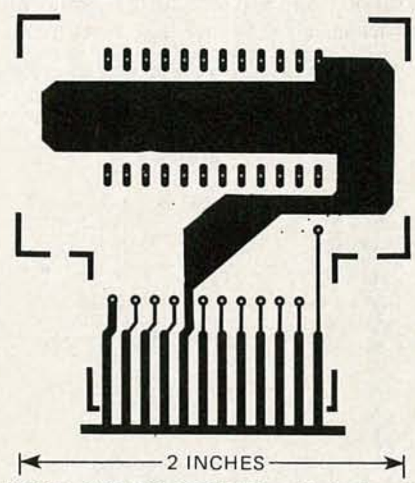


FIG. 13—THE FOIL SIDE OF the adapter board.

There is one cassette input to the game recorder (CASSETTE DATA IN) and two cassette outputs (CASSETTE DATA OUT and CASSETTE ON/OFF). Note that the schematic does not show the CASSETTE ON/OFF output. Instead, the output of IC7-c is labeled "TO CASSETTE-CONTROL RELAY." Although the relay is not shown on the schematic, the board has provision for a DIP mounted relay that can be controlled by the output of IC7-c.

Before you use your game recorder, keep the following notes of caution in mind: **NEVER** plug a game cartridge in while the game recorder is on. The *2600* should be turned **OFF** before the game

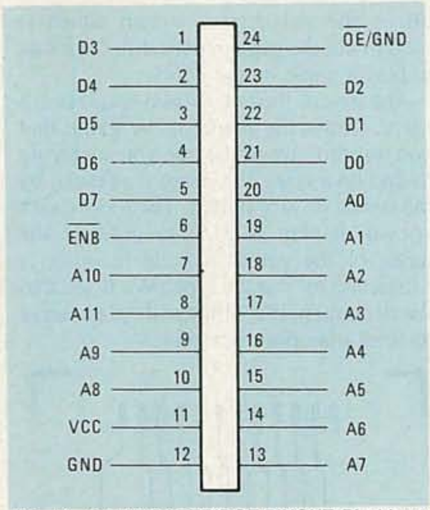


FIG. 14—GAME CARTRIDGE PINOUT. Pin 1 is at the lower left of the front (label side) of the cartridge.

recorder is connected. **NEVER** turn the *2600* on while the game recorder is not in the PLAY position.

Reading a cartridge

Reading a game cartridge is perhaps the easiest task that the game recorder has. It's also an easy function for you to initiate. First make sure that the game recorder's power is off and that it is properly hooked up to the *2600*. Then make sure that the SETUP/PLAY switch is in its SETUP position. Apply power to the game recorder and close S4, the READ CARTRIDGE switch. In a matter of milliseconds, the contents of the game cartridge will be transferred to the game recorder's RAM. If you want to verify that the copy is correct, you can play the game.

Writing a game to tape

Once you have a game stored in RAM, you can transfer it to cassette tape. First make sure that the game is set up as before. If you're using a cassette control relay, attach the cassette output to the REMOTE jack of the cassette recorder. Select the name of the game (a hex digit from Ø-F) by pushing the GAME SELECT switch. Each time you push it, the GAME SELECT display will increment by one. That will place a "label" on the tape that the game recorder will be able to find at another time. It's a good idea to name your games in the order that they appear on the tape.

Next set your cassette recorder to record. (If you are using the remote control option, it will not start until the game recorder is ready. Push the WRITE TAPE switch; the cassette recorder should start, and the data transfer will begin. Note that the decimal point of the GAME SELECTED display will light. After the game has been transferred, the decimal point will again go dark. That's your signal to stop your cassette recorder if you're not using the remote control option.

Reading a tape

Loading a game from cassette tape to the game recorder is perhaps the most difficult operation. But if you follow the instructions carefully, you shouldn't have any problems. Hook up the game recorder in its setup mode as before. The first step is to set the volume level. Once you learn what the proper level is, you won't have to repeat this step every time.

Set your tape to play a recorded game (which you can recognize by the high- and low-pitched tones). Then turn the volume down and connect the cassette's earphone jack to the CASSETTE-DATA IN input. Push the READ TAPE button; the decimal point of the GAME SELECT display should turn on. Now turn up the cassette player's volume until the decimal point of the LAST GAME FOUND display just turns on. Then turn the volume up just a slight bit more—about a half number, if your volume control is numbered. But don't turn it up too loud.

Now to make sure that the volume is correct, set the tape to a place before a game you recorded. Then try to read the tape. The LAST GAME FOUND should indicate the name of the game. When you're finished with setting up the game recorder, press the RESET button.

Now try to load back a game you recorded by selecting its name, setting up the recorder, and hitting the read tape button. The LAST GAME FOUND display will indicate the name of each game the game recorder finds. When it finds the selected game, it will read it and stop the cassette player when it's finished (if the remote option is used).

Playing a game

Now that you have a game in the game recorder's memory—either from a tape or from a game cartridge—you can play it on the *2600*. Just move the SETUP/PLAY switch to the PLAY position and turn the *2600* on. Your game should be ready to play. Be sure to turn the *2600* off before moving the SETUP/PLAY switch back to SETUP.

Expanding the game recorder

As a final note, we should note that many new games for the Atari *2600* are 8K long. The basic ideas of this game recorder can be used to record those games on cassette tape. However, you will have to make both hardware and software modifications. We won't go into detail on how those modifications are made, but we will give you a head start.

Figure 15 shows one way of adding to the the address decoder to obtain bankswitching ability. The software would have to be written to turn the memory-mapped bankswitching mechanism on and off (by setting and resetting a flip-flop, for example). The software should include some way to detect and record the ROM size. The last two bits of the header could be used for that purpose. **R-E**

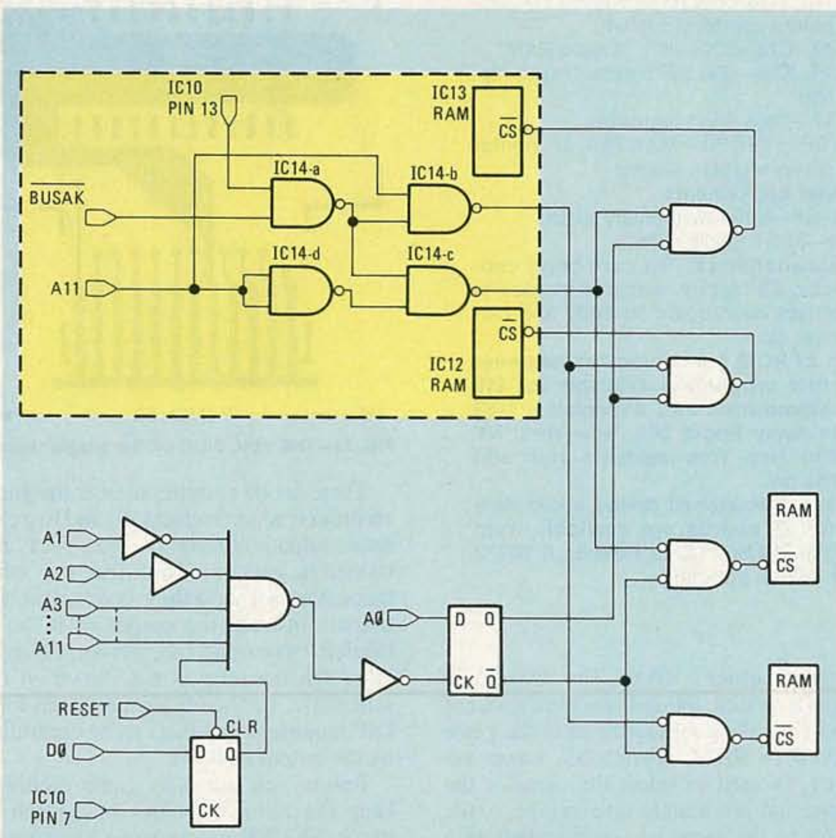


FIG. 15—EXPANDING THE RECORDER to record larger games is possible. The software will have to be changed, as will the address decoder. Here is a possible decoder scheme to use for bankswitching.

ALL ABOUT THERMISTORS

HARRY L. TRIETLEY

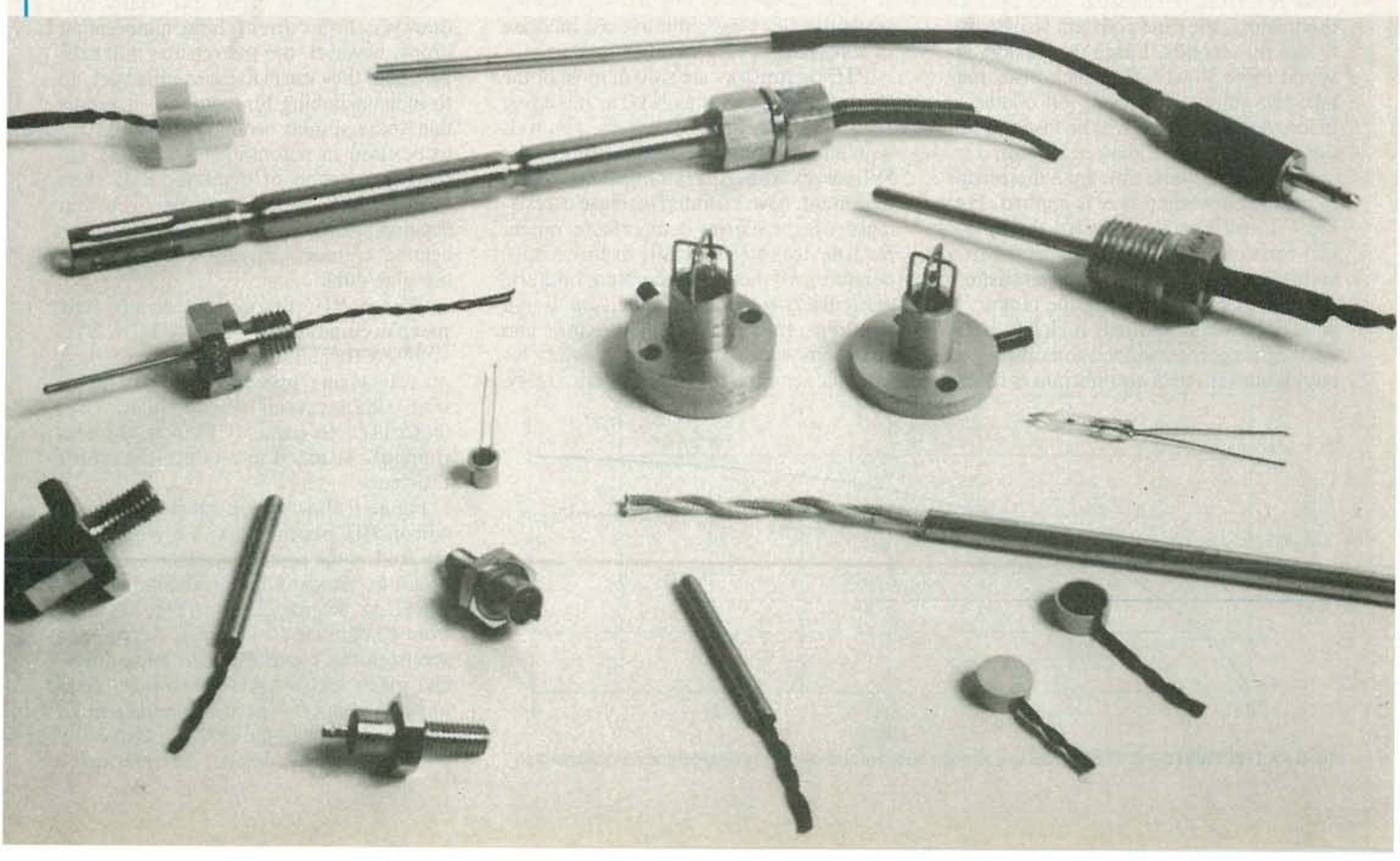
Last month we studied thermistor basics—what they are, how they behave, etc. This month, we'll finish our look at the basics, and then we'll show you design techniques so that put thermistors to work in your circuits.

Part 2

BEFORE WE GET TO circuit applications for thermistors, we have some basic points to mention about thermal runaway PTC thermistors, and probe assemblies.

The negative-resistance behavior makes it possible for a thermistor to go into thermal runaway and destroy itself. Figure 5 shows one of the lines from Fig. 4 (see the January 1985 issue of **Radio-Electronics** page 50) replotted with voltage on the horizontal axis, current vertical. From that plot you can see that if you connect the thermistor to a voltage source, the current will increase more rapidly than the voltage due to the thermistor's decreasing resistance. When the voltage becomes high enough to enter the negative-resistance part of the curve, the resistance will decrease because the thermistor is getting hotter. That results in increased current, heating the thermistor even more, increasing the current more, etc. If there is no current limiting, the thermistor will continue to heat until it destroys itself. Always be careful, when connecting a thermistor to a voltage source, to either limit the voltage to safe values or else provide some means to limit the current. We would point out that the curves we've just described depend very much on the application and must be determined experimentally. Changing the surrounding temperature, connecting the thermistor to a heat sink, changing the air flow, or putting it in an enclosure will create a new set of curves.

The fact that a thermistor heats itself when power is applied is a drawback when measuring temperature—the power must be kept well below a milliwatt to avoid errors. In other uses, however, thermistors are purposely self-heated. For example, if you self-heat a thermistor well above the surrounding air temperature and then increase the air flow, its temperature will drop, increasing its resistance. You now have a sensor to detect wind or air cur-



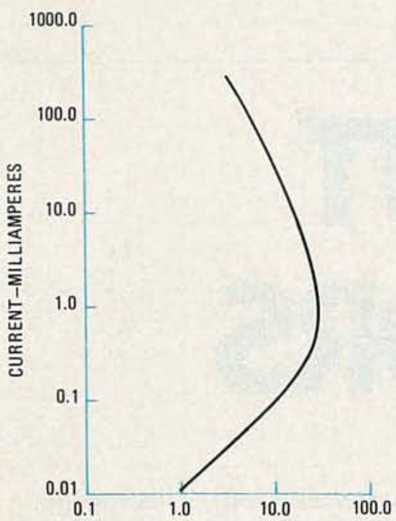


FIG. 5—A THERMISTOR MAY ENTER THERMAL RUNAWAY if neither voltage nor current are limited.

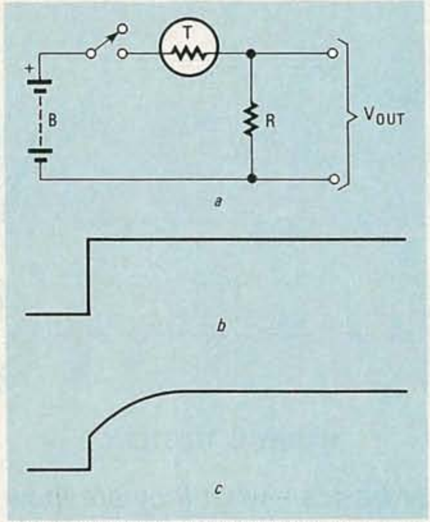


FIG. 7—CREATING A TIME DELAY is one popular use for thermistors.

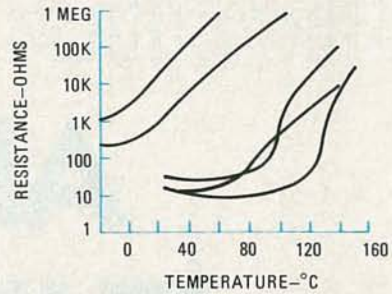


FIG. 8—RESISTANCE-TEMPERATURE CURVES for five typical PTC thermistors.

rents. Likewise, a self-heated thermistor's temperature will drop when it comes in contact with liquid, making it useful as a liquid-level sensor.

Response time

Suppose you suddenly move a thermistor from one temperature to another. Like any thermometer, it will take a while to respond. The mass of the thermistor must heat up or cool down to match the surrounding temperature. The response will look fairly much like an exponential R-C time response as shown in Fig. 6, with the 63% response time indicated by time constant, τ. For small disc or bead thermistors, the time constant will be one to several seconds. Large thermistors respond more slowly: One-inch discs may take two minutes or more. Of course, a thermistor's response will be faster in liquid or in moving air than in still air.

It also takes some time for a thermistor to heat itself when power is applied. Figure 7 shows what happens if a thermistor and resistor in series are connected to a voltage source. At first, the thermistor's resistance is high, limiting the output. If enough power is applied, it slowly heats up, dropping its resistance and raising the output until thermal equilibrium is reached. Thermistors are often used in this way to create delay times or to protect against sudden inrush currents. We will study such applications in more detail a bit further on in this article.

PTC thermistors

As we mentioned at the beginning of this article, there are two distinctly different types of positive temperatures coefficient (PTC) thermistors: those sintered from powdered metal compounds and those made from silicon. The most common of the sintered types are those made from barium titanate, with various doping materials added. Thermistors of that type have resistances that increase with temperature as shown in Fig. 8. Note that the vertical scale is logarithmic—the increase in resistance is very rapid.

PTC thermistors are sold in most of the same configurations as NTC's, including small and large discs, washers, and rods with and without leads and coatings. The R-T curves are highly nonlinear and, more important, have a sudden increase in resistance over a narrow temperature range. Such devices are especially useful as temperature switches or temperature limiters, particularly when high precision is not required. Larger PTC thermistors can switch moderate amounts of power; for example, enough to control a series relay. Simply place the relay and PTC thermistor in series with a voltage source and the relay will drop out somewhere along the steep portion of the curve. The switching point is controlled by varying the doping used in the thermistor.

PTC thermistors also can be used as current limiters. When their current becomes too large they will self-heat to the point where their resistance increases rapidly.

An interesting use of larger PTC thermistors is as self-regulating heaters. When power is applied, the thermistor will heat itself until it reaches the steep portion of the curve, at which point the current will decrease rapidly. A fairly constant temperature will be maintained regardless of changes in the ambient temperature or thermal load. One manufacturer has created a heater for liquid-crystal displays by epoxying several PTC thermistors to a metal strip. The strip is glued or clamped to the back of an LCD and connected to a 24-volt power source. When the LCD is warm, the heater will draw very little current. If the temperature drops, however, the thermistors will self-heat until they warm the assembly back up to their switching temperature. It seems that some similar arrangement will have to be used in automobiles if LCD's are used for dashboard displays. PTC thermistor material is also formed into custom designed shapes to form self-regulating heating elements in appliances such as hot-glue guns.

Silicon PTC thermistors do not have much in common with either PTC or NTC sintered thermistors—at least in their manufacturing process. They are made from single-crystal silicon wafers (like those used to make IC's) with dopants (impurities) added to produce the proper resistance.

Figure 9 shows a typical R-T curve for silicon PTC thermistors. They generally are sold in the same resistance values (at 25°C) as standard 10% resistors; that is, 10, 12, 15, 18, and 22 ohms etc, in values from 10 ohms to 10 kilohms. As you can see from the curve they are fairly linear and much less sensitive than other thermistors, about 0.7 percent per degree C. The exact shape of the curve is affected by the dopant added; hence, different resis-

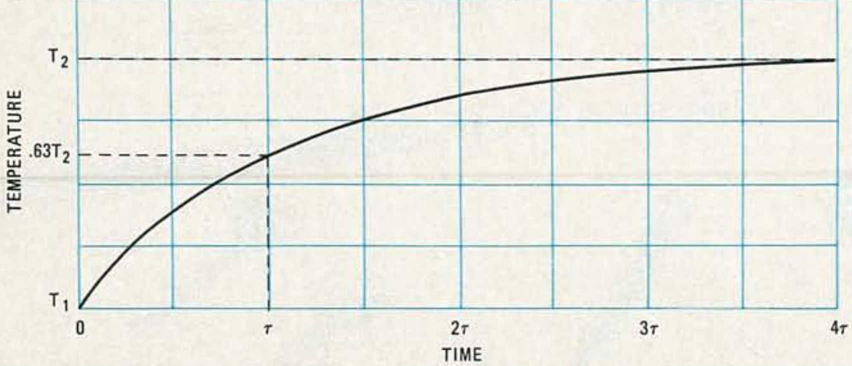


FIG. 6—A THERMISTOR'S RESPONSE to a sudden temperature change is approximately exponential.

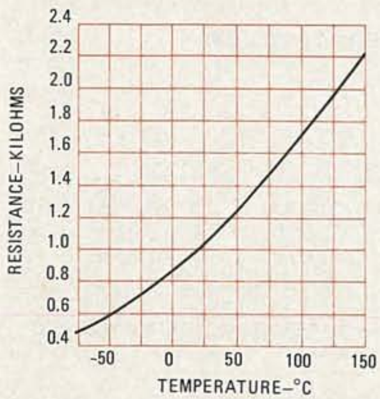


FIG. 9—SILICON PTC THERMISTORS have nearly linear resistance-temperature characteristics.

tance values have slightly different curves.

The operating range of silicon PTC thermistors runs from around −80°C (−112°F) to +150 or 200°C (+302 to 392°F), depending on the style and manufacturer. Tolerances are generally ±10% to ±20% (at 25°C) although tolerances to ±1% are available. Keep in mind that that is poorer than similarly specified NTC thermistors: Their 0.7%/°C sensitivity means that a ten percent error equals 14°C (as opposed to 2.5°C for a 4%/°C NTC thermistor). Again, the tolerance is wider at higher and lower temperatures.

Silicon PTC thermistors are most often sold in diode or transistor-type packages. They also are available mounted on two parallel leads and covered with epoxy, similar to small disc thermistors.

Thermistor probe assemblies

An unprotected thermistor is poorly suited to most temperature measurements. You can't dip it in water or any other conducting liquid since the liquid will shunt the leads, producing false readings. Also, except for hermetically sealed glass units, the liquid will eventually creep into the thermistor, most likely finding a path in minute voids between the leads and the epoxy coating. Nonconductive liquids may attack or soften the epoxy; corrosive liquids may destroy the leads. Even continued exposure to high-humidity air may eventually produce electrical leakage inside the thermistor. Sealing the thermistor can also provide protection for mechanical ruggedness.

Thermistors are often mounted inside temperature probes, such as those seen in Fig. 10. Usually, the probe consists of a length of stainless steel, glass or other tubing welded closed at the measurement end. The thermistor is soldered to a length of wire or cable and inserted into the probe, generally with a bit of epoxy in the probe tip to give mechanical strength and to create better thermal contact with the probe. Additional epoxy is used to seal the back end. A probe may be simply a "straight stick" for laboratory use, or it may be welded to pipe-threaded fittings or other mountings for permanent installation.

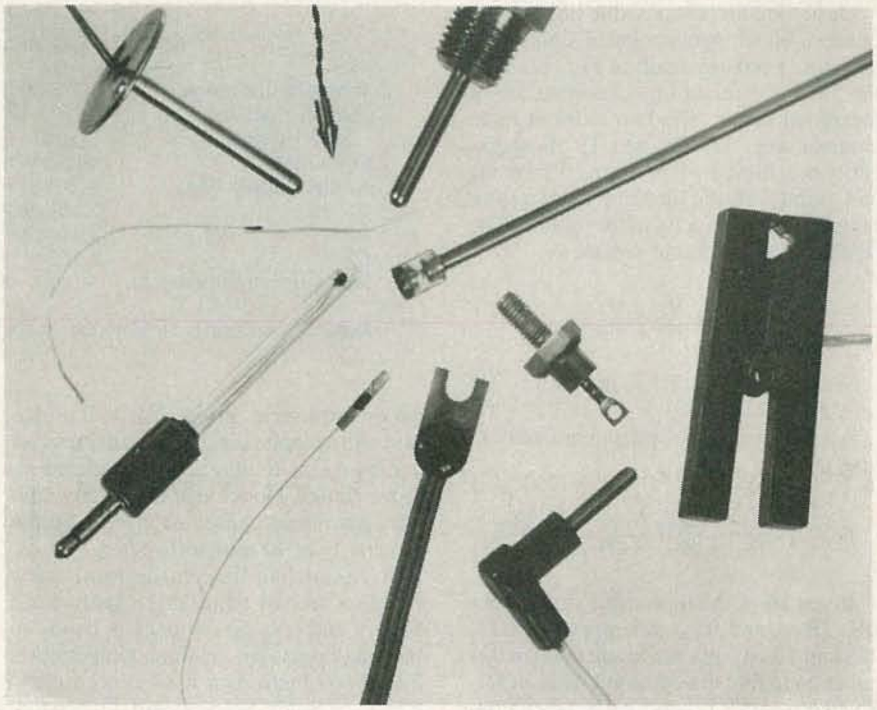


FIG. 10—A WIDE VARIETY OF THERMISTOR mountings and assemblies are available.

Of course, thermistors may be mounted in other ways. For example, they may be epoxied into a drilled-out bolt for installation into a tapped hole. The possibilities are limited only by your imagination. For commercial and OEM customers, many thermistor manufacturers will build their thermistors into probes or other assemblies to meet users' needs.

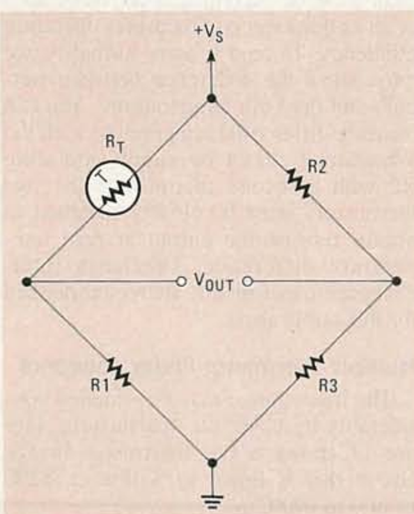


FIG. 11—A WHEATSTONE BRIDGE with a thermistor arm will produce an output that increases with temperature.

Bridge circuits

If we connect an NTC (*N*egative *T*emperature *C*oefficient) thermistor in a Wheatstone bridge as shown in Fig. 11, we can generate a voltage that increases with temperature. If we choose our resistors properly, we can insure that the voltage will vary fairly linearly with respect to temperature (if only over a narrow temperature range).

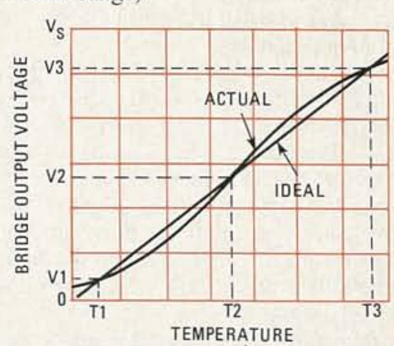


FIG. 12—THE WHEATSTONE BRIDGE OUTPUT is fairly linear near the middle of its range.

Figure 12 shows the output voltage of a Wheatstone bridge as a function of temperature. Note that the curve is S-shaped, approaching—but never reaching—the supply voltage at high temperatures (low thermistor resistance). The sensitivity is highest near the midrange, where the thermistor resistance is close to the resistance of R1.

While it is not possible to change the basic shape of this curve, you can choose R1 so that the center of your temperature range is on the most linear (center) portion of it. For narrow temperature ranges (not more than about 20 °C), you can achieve a quite linear output by making R1 equal to the thermistor's resistance at the center of the temperature range. Linearity becomes poorer as the temperature range gets wider.

Designing for best possible linearity requires a bit of algebra, but it's not at all difficult. Looking again at Fig. 12, note the "ideal" straight line drawn on top of the actual curve. The two cross at three temperatures, T1, T2, and T3. Best linearity is achieved when T1 and T3 are the end points of the desired temperature range and T2 is exactly in the middle. The equation for the output voltage is:

$$V_{OUT} = \frac{Vs \times R1}{R1 + R_T}$$

We wish to select R1 so that: V3 − V2 = V2 − V1 when T3 − T2 = T2 − T1

All this may be solved algebraically to give us:

$$R1 = \frac{R_{T1}\,R_{T2} + R_{T2}\,R_{T3} - 2R_{T1}\,R_{T3}}{R_{T1} + R_{T3} - 2R_{T2}}$$

If you know the thermistor's resistance (R_{T1}, R_{T2}, and R_{T3}) at temperatures T1, T2, and T3, simply substitute them in this equation to find the optimum value of R1. The thermistor's values may be taken from the manufacturer's data or by measurement at the three temperatures.

You still need to choose R2, R3, and the supply voltage, V_S. Choosing the resistors is easy—set R3 equal to R1, then make R2 equal to the thermistor's resistance at the temperature where you want zero output voltage from the bridge. You may want to make R2 adjustable for calibration purposes.

The supply voltage, V_S, determines the output sensitivity (millivolts-per-degree). You may need to do some trial-and-error here. Choose a reasonable voltage—say, one volt—and calculate the output voltage from the bridge at T1 and T3. This will give you a sensitivity for that particular supply voltage. Next, raise or lower V_S in proportion to the increase or decrease in sensitivity needed.

Remember that making the supply voltage too high will cause the thermistor to self-heat, causing measurement errors. For a typical small thermistor in air, one milliwatt of dissipation will cause a 1°C error. The power dissipation will be highest when the thermistor equals R1 and will be:

$$P_D = \frac{(0.5V_s)^2}{R1}$$

where P_D is in watts. For precise work you will want to keep the power dissipation to 0.1 milliwatt or less.

Table 2 lists the calculated resistor and supply-voltage values for three different temperature ranges. Notice that linearity is very good for narrow ranges, but gets worse rapidly as the temperature range widens. The thermistor used in this design is a Yellow Springs Instrument Co. (Box 465, Yellow Springs, OH 45387) model

TABLE 2—EXAMPLES OF BRIDGE DESIGNS

Temperature range	10 to 30°C	0 to 50°C	0 to 70°C
Temperature for zero output	10°C	0°C	0°C
Sensitivity	10 mV/°C	10mV/°C	10 mV/°C
Bridge supply (V_s)	916.2 mV	1017.3 mV	1147.0 mV
R1	2,168 ohms	1,763 ohms	1,164 ohms
R2	4,482 ohms	7,355 ohms	7,355 ohms
R3	2,168 ohms	1,763 ohms	1,164 ohms
Maximum nonlinearity	+0.07 −0.06°C	+0.85 −0.95°C	+2.0 −2.3°C

Note: Thermistor is a YSI 44004, 400 series probe or equivalent, 2,252 ohms at 25°C.

44004, 400-series probe. You will probably have to create series or parallel resistor combinations to obtain the calculated resistor values. Notice that the supply voltages have been chosen to give an output sensitivity of 10 millivolts-per-°C.

A circuit like this, made from a few resistors and an adjustable supply (or a battery and voltage divider), is handy in the laboratory for reading temperature. The *44004* thermistor itself is accurate to 0.2 °C or better. Since sensitivity is about 4%-per-°C, a resistor or supply error of one percent causes a temperature error of only 0.25%. The bridge output may be read directly on a DVM, or fed into a high-impedance differential amplifier for other instrumentation needs. Calibration may be checked by substituting a precision decade box for the thermistor and, if need be, changed by adjusting R2 or R3 to set the zero point. The supply voltage can also be adjusted to set sensitivity.

Differential temperature, the difference between two temperatures, is often useful. For example, the difference between the inlet an outlet temperatures of a solar collector, heat exchanger, heat pump or air-conditioner coil measures operating efficiency. To read relative humidity, we must know the difference between wet-bulb and dry-bulb temperatures. You can measure differential temperature with the Wheatstone circuit by simply replacing R2 with a second thermistor. The two thermistors must be closely matched to obtain zero-bridge output at zero temperature difference. Precision interchangeable thermistors are recommended for this application.

Multiple-thermistor linear networks

The linear range may be widened considerably by using two thermistors. Figure 13 shows a two-thermistor bridge circuit that is linear to within ±.22°C from 0 to 100°C.

At very low temperatures, the resistance of thermistor R_{T2} is so large (95K at 0 °C) that it has very little effect on the circuit. The circuit behaves much like a 6K thermistor in series with a 6.25K fixed resistor, which has a linear range centered around 15°C. As the temperature increases, the resistance of thermistor R_{T2}

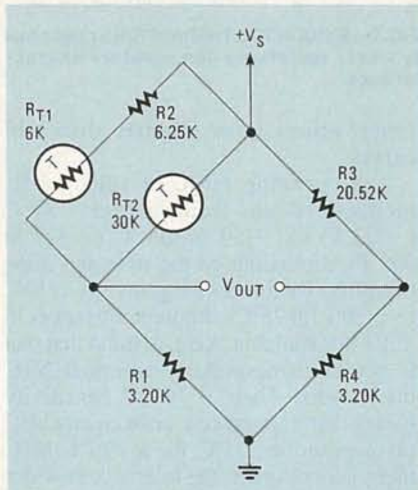


FIG. 13—A THERMISTOR-PAIR can be used in a Wheatstone bridge to improve the output linearity. This circuit is linear to within ±0.216°C from 0–100°C.

drops and begins to shunt the R_{T1}-R2 combination. Thus, while the output sensitivity provided by R_{T1} is dropping off (the high end of the S curve in Fig. 12), R_{T2} begins providing an additional "boost". In the middle of the temperature range, both thermistors are influencing the output.

At higher temperatures, R_{T1} becomes so much smaller than the 6.25K resistor (408 ohms at 100 °C) that its effect is unimportant. Now the circuit behaves as if thermistor R_{T2} was in parallel only with R2. This combination has a linear region near 100 °C. Overall, as we raise the temperature from 0 to 100 °C, the influence of R_{T1} gradually decreases while the influence of R_{T2} increases, providing a linear output over a much wider range.

Selection of an optimum set of resistors and thermistors for the circuit shown in Fig. 13 is not easy. A lot of trial-and-error calculation is needed to find the best values, and it helps to use a computer program with the circuit equations and thermistor tables (or the Steinhart and Hart equation, discussed last month) built in. Fortunately, you don't have to do this. That's because at least two manufacturers sell preselected sets of resistors. We'll tell you who, and look at some more thermistor topics, next time. **R-E**

DESIGNING WITH DIGITAL IC'S

A look at logic families, logic levels, and other digital electronics basics.

JOSEPH J. CARR

IT DOESN'T TAKE A LOT OF INSIGHT TO SEE that digital electronics has really come into its own over the past ten years. Where that field was once the sole province of a few wild-eyed computer "hackers" stuffed into the backrooms of corporate engineering departments, digital electronics now seems to be "a game for all." Unfortunately, training has not kept pace with demand, and there are many out there who would benefit from some basic material on the subject. So much of what is published these days, especially in magazines dedicated to microcomputers, seems to assume prior knowledge; beginners are left out in the cold.

Digital electronics

Unlike analog circuits, voltages in digital circuits are constrained to be one of two values. Those values are referred to as logic high and logic low; other names for those two values are logic 0 and logic 1, and, even more simply, on and off. In most practical IC logic circuits, the high and low states are voltage ranges that are separated by an "invalid" or undefined zone. That is shown in Fig. 1. In that figure, the valid low is the voltage range between zero and V1, while a valid high is any voltage from V2 to V3. Of course, voltages greater than V3 represent a dangerous condition. If such voltages are applied to the IC, its life expectancy would likely be shortened.

The invalid logic-level zone between V2 and V3 is critical. In that area, the IC does not know what to do. You may even find, for any given type number, different responses according to the manufacturer of the device. Three alternatives are possible: the invalid logic level is seen as a valid high, a valid low, or it will create no change in the output from the previous state.

Common Logic Levels

Logic levels vary according to the logic "family" that a device belongs to. Transistor-transistor-logic (TTL or T^2L), is probably the most common single family. Those devices bear type numbers in the 74xx and 74xxx series for commercial devices, and 54xx/54xxx in military quality devices.

The TTL family operates from a monopolar regulated DC-supply of +5 volts. The low logic-level is represented by a voltage of 0 to 0.8 volt, while the high is represented by a voltage that is greater than +2.4 volts (but less than the TTL maximum supply voltage). Reverse voltages (negative), or voltages greater than +5 volts, are dangerous to the TTL device. In most cases, a TTL device output will be less than 4 volts, so this is no problem.

CMOS devices work from power supplies of ±4.5-volts DC to ±15-volts DC. In many cases, we find CMOS devices operating from TTL power supplies, especially where a circuit contains mixed TTL and CMOS devices. In most cases, we can use a 12-volt DC bipolar power supply for CMOS circuits. Since CMOS devices draw considerably less current than TTL, we can use current levels of ±100 mA to ±1 ampere.

A variable output-voltage, DC power supply may seem like something nice to have, but they have a hidden potential for disaster. If the output voltage-level is adjusted too high, especially for a TTL device, the IC can be ruined.

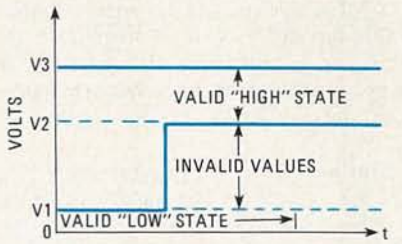


FIG. 1—IN MOST LOGIC IC's, the high and low states are separated by an invalid or undefined zone.

A breadboard can prove to be very useful, especially if it contains built-in DC power-supplies. Heath offers several, of which the *ET-3300* is a good choice. Also recommended is the AP Products *Powerace-102*. That breadboard contains a +5-volt DC power supply, a squarewave clock (1 to 100 kHz), a pulse source, logic level sources, and logic level detectors.

The breadboard may look expensive on first glance, but is well worth the price if you plan to go into digital electronics in any depth. With the breadboard you can build, modify, and troubleshoot digital circuits before committing them to more permanent configurations such as wire wrap or printed circuit boards. You will find that breadboard circuits are a lot easier to modify.

Perhaps the principal advantage of logic breadboards is that they contain one or more multi-dozen pin IC socket blocks that can be used to mount components. Interconnections are made with No. 22 to No. 28 solid hook-up wire pushed into socket holes. The somewhat less than permanent nature of such connections is one reason circuits built on breadboards are so easy to modify.

Another nice to have (and highly recommended) device is a logic probe. Those probes are used to detect either high or low states. In addition, some models can detect whether or not a pulse has occurred or generate pulses of their own at the push of a button. Such probes are exceptionally useful for troubleshooting and debugging circuits. The cost may be high, but the usefulness is a compensating factor.

An oscilloscope is also nice to have, even though high cost tends to limit the number of hobbyists who can own such an instrument. The selected model should have a wide bandwidth. We recommend bandwidth of 4.5 MHz or better as a minimum—but get one with as wide a bandwidth as possible.

A voltmeter is always useful. Since digital circuits operate on pulses, however, the meter will only be useful during the static tests of logic levels, and DC power-supply voltages. Use any electronic voltmeter (digital or analog), or VOM with a sensitivity of 30,000 ohms/volt or more.

CMOS devices can be operated from either bipolar (−V, 0, +V) power supplies, or, a monopolar (0, +V) power supply. In most cases of monopolar operation, the −V-power supply is set to zero (−V = 0).

The high logic-level is represented by a voltage close to the V+ supply, while the low by a voltage close to the −V supply. The transition between states occurs near the mid-point between −V and +V (or, where monopolar supply is used, at ½ +V. The value of −V and +V can be any voltage between ±4.5 volts and ±15 volts; the two voltages do not have to be equal.

High noise immunity logic (HNIL) devices, like TTL, are made using bipolar transistors. The difference is that it takes larger voltages (+12 in one series, +15 in another) to supply HNIL, and, consequently, higher voltage logic levels. Those higher voltages are what creates the improved noise immunity.

We'll look a bit more at these and the other logic families a bit later in this article.

Positive vs. negative logic

The terms "positive logic" and "negative logic" tend to confuse the newcomer to digital electronics. It becomes especially unnerving when you see the same devices designated both ways. The TTL 7400 NAND gate, for example, is listed some places as a NAND/NOR gate. That designation means that that device is both a positive logic NAND gate and a negative logic NOR gate.

The difference between positive and negative logic is as follows: Positive logic uses a positive voltage for high (i.e. logic 1), and either zero or a negative voltage for low (i.e. logic 0). Negative logic, on the other hand, uses a negative voltage for high (logic 1) and either zero or a negative voltage for low (logic 0).

Unless otherwise specified by the manufacturer, IC logic device function names reflect positive logic. Thus, the 7400 is generally called a NAND gate.

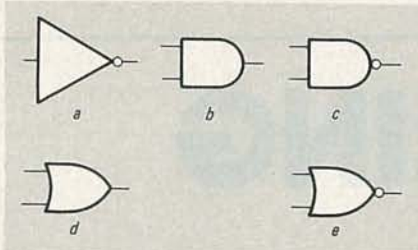


FIG. 2—THESE SYMBOLS are used to represent logic devices in schematic diagrams. A NOT gate (inverter) is shown in *a*, an AND gate in *b*, a NAND gate is shown in *c*, an OR gate in *d*, and a NOR gate in *e*.

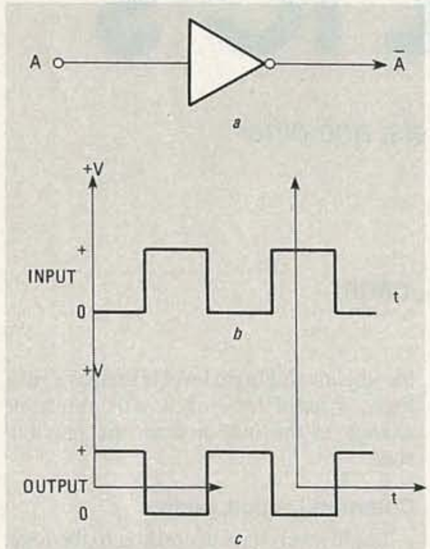


FIG. 3—AN INVERTER is shown in *a*, the timing diagram for that device in *b*.

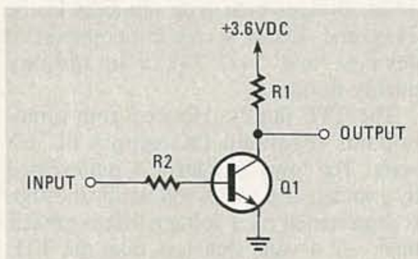


FIG. 4—AN RTL INVERTER. Note that RTL technology is now obsolete.

Logic symbols

Each type of logic device has its own schematic symbol, and those will be used in the rest of this series (as well as in all other articles on digital electronics). They are shown in Fig. 2. While different symbols have been used in the past, the ones shown in the figure are the ones that are now considered standard.

Some practical matters

If you wish to perform experiments or build projects with digital devices, then you will need certain pieces of equipment. Not all of the equipment listed here will be absolutely necessary all the time, but their availability will make things considerably easier.

You will, of course, require one or more DC power-supplies that are compatible with the digital IC logic families that you intend using. For TTL devices, which are probably the most common, you will need at least one +5-volt DC, regulated power-supply. Since TTL devices tend to use high currents (10–30 mA per device), plan on a DC supply of at least 1 amp at +5-volts DC; it is not unreasonable to obtain supplies of 1 to 5 amperes.

Logic families

An IC logic family is a group of digital logic devices that share a common fabrication technology and are matched as to input and output voltage and current levels. Thus, interconnection of logic devices within any one family is grossly simplified. A TTL device, for example, can drive up to ten TTL devices without the need for impedance matching and other niceties that plague analog circuits.

In the remainder of this article we will look at the common IC logic families. For purposes of comparing the families, we will center our discussions around a single device, the simple inverter. That device is also called a NOT-gate. Figure 3-*a* shows the usual logic symbol for inverters as used in schematics. The circle at the output is the standard way an inversion function is noted.

An inverter is a circuit that will produce an output level that is the opposite of its input signal level (See Fig. 3-*b*). In other words, a high at the input produces a low output, while a low input produces a high output. We consider inverters in our discussions of logic families because they are simple circuits that easily demonstrate the differences between families.

Resistor-transistor logic (RTL))

The RTL family was one of the earliest to become commercially available in IC form. It is, however, now completely obsolete. RTL is not used in new designs, and is currently stocked only for replacement purposes in repairs. Figure 4 shows the standard RTL inverter circuit. This device operates from a monopolar DC power supply; the largest power supply that can safely be used is +4 volts DC, with +3.6-volts DC being more common.

Note in Fig. 4 that there are resistors in both input (i.e. base) and power supply (i.e. collector) leads. An advantage of RTL is that no combination of opens or shorts will destroy the device, provided that no voltage greater than +4 (DC) exists on the circuit board. A disadvantage of RTL, however, is that the operating frequency is limited to 4 or 5 MHz.

Diode-transistor logic (DTL)

The DTL family was also among the earliest types available in IC form. Figure

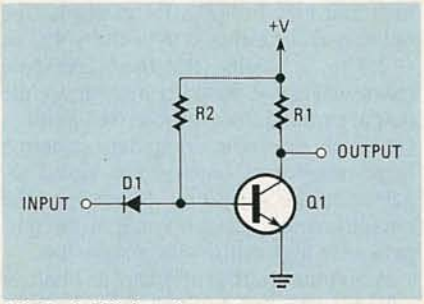


FIG. 5—A DTL inverter.

5 shows a typical DTL inverter circuit. Like the RTL inverter, DTL inverters use a single transistor in the common-emitter configuration. The main difference between the two is the diode (Dl) connecting the input to the base of the transistor.

If the input is high, diode Dl is reverse biased, so it does not affect the circuit. Under that condition, resistor R2 forward biases transistor Q2 forcing it into saturation and the output of the circuit is low. If, on the other hand, the input is low diode Dl will be forward biased by R2, which keeps the base of the transistor unbiased. Under that condition, the transistor is cut off, so its collector voltage rises to +V and the output is high.

DTL devices operate from DC voltages of 5 to 6, and are now regarded obsolete expect for repair purposes.

Transistor-transistor logic (TTL)

The transistor-transistor-logic family is, perhaps, the most common of all digital IC logic families. These are the devices that carry type numbers of 74xx and 74xxx.

A principal advantage of TTL devices is speed of operation. Almost all TTL devices operate to 18 or 20 MHz, while some trip along nicely at 80 MHz or so. A disadvantage that goes along with high speed, however, is high power dissipation and high current requirements.

Logic levels of TTL devices are 0 to +0.8 volt for low, and +2.4 to +5 volts for high. TTL devices typically require 10–40 mA of current per device from the DC supply. All TTL devices must operate from a regulated 5-volt (nominal) DC power supply. Officially, the +5-volt supply must provide a voltage between +4.75 and +5.25 volts DC. Our experience, however, suggests that narrower limits are sometimes prudent. If the voltage is greater than about +5.05-volts DC, then reliability is reduced. Under about +4.80-volts DC, on the other hand, certain TTL devices operate in a flakey manner.

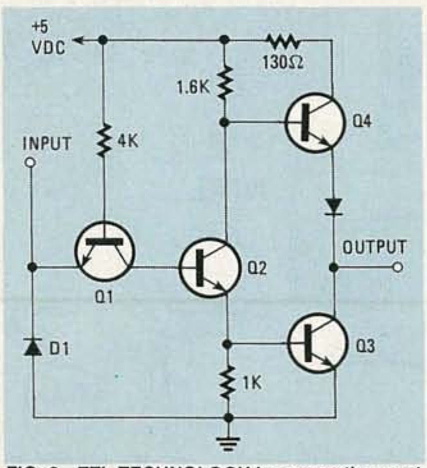


FIG. 6—TTL TECHNOLOGY is among the most popular used for logic circuitry. Here, a TTL inverter is shown.

A typical TTL inverter stage is shown in Fig. 6. Note that NPN bipolar transistors are used. A TTL output operates as a current sink. In the high-output condition, Q3 is cut off and Q4 is turned on, connecting the output terminal to +V. When the output is low, however, Q4 is turned off, and Q3 is turned on. In that condition, the output line is connected to ground through the saturated collector-emitter path of Q3.

The input of a TTL device is a current source formed of emitter follower Q1. The standard TTL input will source 1.6 mA of current.

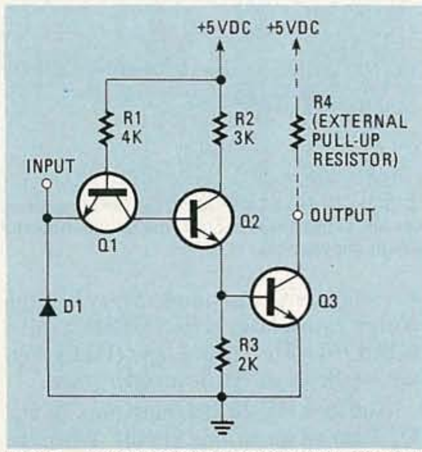


FIG. 7—AN OPEN-COLLECTOR TTL inverter. Note the addition of an external resistor between the output and +V.

Normally, electronic amplifier circuits can be cascaded only by considering matters such as drive power and impedance matching. IN TTL, however, cascade interfacing is greatly simplified by standardizing input/output conditions. An implication of that is that we can standardize loads ("fan-in") and output drive capacity ("fan-out"). Thus, the standard 1.6 mA at 5-volts DC, TTL current-source input is defined as a fan-in of 1. Every output can be specified as to fan-out rating, which is the number of standard TTL inputs the device will drive. The standard TTL output on 74xx/74xxx devices has a fan-out of ten. That means that it will drive up to ten standard TTL inputs. A fan-out of ten means that the output will sink 10 × 1.6 mA, or 16 mA.

Figure 7 shows an alternate form of TTL output called an open-collector TTL output. The output transistor, Q3, does not have a collector load. An external "pull-up" resistor (R4), or other pull-up load, must be connected between the output terminal and +V.

TABLE 1

Device	Maximum Current (mA)	Maximum Voltage (VDC)
7405	16	5
7406	30	30
7407	30	30
7416	40	15
7417	40	15

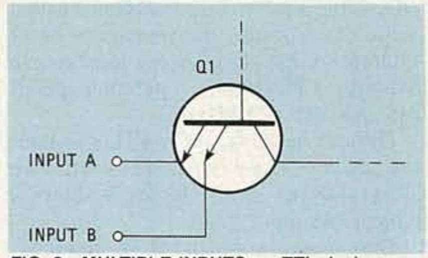


FIG. 8—MULTIPLE INPUTS on TTL devices are created by using input transistors with multiple emitters.

There are several different TTL open-collector devices. The 7405, 7406, 7407, 7416, and 7417 devices are open-collector hex inverters. Table 1 shows the output specifications for those devices. Note that several of those devices can handle voltages higher than the +5-volts DC used on other TTL devices. These devices must be connected to +5 volts DC at the package +V terminal. We can, however, use the output stage to drive higher voltage loads than +5-volts DC. Those limits are, once again, shown in Table 1.

Figure 8 shows how TTL devices accommodate multiple inputs. The input transistor (Ql) is essentially the same, except that there are two or more emitters, each of which is an input.

There are several sub-families of TTL devices: high-power, low-power, Schottky, and low-power Schottky. Those differ a little from ordinary TTL, but generally can interface with standard TTL and each other. The sub-families use variations on the 74xx/74xxx numbering.

High-power TTL devices carry part numbers in the 74Hxxx series. High-power TTL fan-out ratings are typically 10–12, but the fan-in is 1.3 or so. That means that a 74H device input sources 2.08 mA. In general, a regular TTL output can use its fan-out of 10 to drive 6–7 74H inputs.

The power consumption of the 74H-series devices is approximately twice that of regular TTL. The operating speed is also about twice than of regular TTL. Thus, counters and flip-flops typically operate to speeds in the 40–60 MHz region. High-power TTL devices have less noisy outputs than regular TTL, so they are particularly useful for data converters and other such applications.

Low-power TTL devices carry type numbers in the 74Lxx/74Lxxx series. The power consumption is roughly one-tenth that of regular TTL, but that advantage costs us a reduction in operating speed. Thus, 74L counters and flip-flops operate only to about 3 MHz.

One of the factors that inhibits the operating speed of a logic device is the minimum storage time of the electric charge in a saturated transistor. In Schottky TTL devices there are special "Schottky diodes" connected across the inputs. Those diodes have a voltage drop of 0.3-volts DC, so the input voltage is clamped to that value. As a result, the transistors never saturate so operating speeds increase. In Schottky TTL devices, operating speeds can approach 125 MHz.

Devices in the schottky-TTL sub-family carry type numbers in the 74Sxx/74Sxxx series. Figure 9 shows a typical 74S input stage.

Low-power schottky TTL devices, which carry part numbers in the 74LSxx//74LSxxx series, sacrifice some of the blistering speed of the Schottky sub-family in favor of lower operating power. Typically, 74LS devices consume about one-fourth to one-sixth the power of 74S devices.

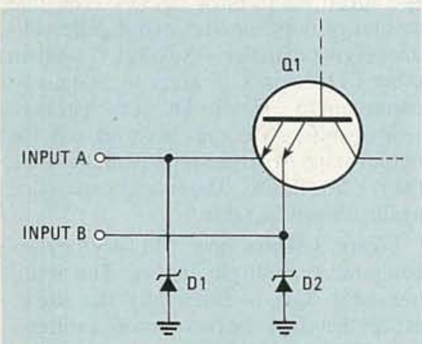


FIG. 9—INPUT CIRCUIT for a Schottky inverter (74S series). The balance of the inverter is standard TTL, as shown in Fig. 6.

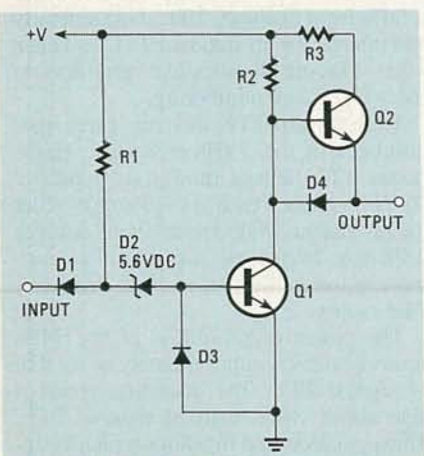


FIG. 10—FOR IMPROVED noise immunity, HNIL circuitry can be used.

TABLE 2

CS	Input	Output
H	H	X
H	L	X
L	H	L
L	L	H

H = High
L = Low
X = Disconnected

High-noise-immunity logic (HNIL)

A problem sometimes seen in TTL logic is lack of noise immunity. The difference between high and low thresholds is so small that noise impulses riding on the signal can drive a device to the incorrect logic level. For example, a low TTL level with noise can be made to appear during the noise impulse as if it were high. Similarly, a noisy high may look low.

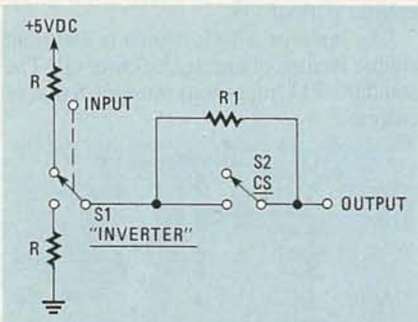


FIG. 11—IN TRI-STATE DEVICES, the output may be one of three states: high, low, or unconnected (high impedance).

A solution to that problem may be *H*igh *N*oise *I*mmunity *L*ogic (HNIL), also called *H*igh *T*hreshold *L*ogic (HTL). Figure 10 shows an HNIL inverter stage.

Notice in Fig. 10 that transistors Q1 and Q2 form an interesting circuit. When the base of Q1 is high, its collector is low, so Q2 is turned off. A current-source input (similar to TTL) will allow current to flow to ground through D4 and the saturated collector-emitter path of transistor Q1. If the base of Q1 is low, on the other hand, its collector is high, so D4 is turned off and Q2 is turned on. In that case, the output terminal is connected to +V through R3 and the saturated collector-emitter path of Q2—forming a high.

The high threshold required to turn on Q1 (which is what gives this device its high noise immunity) is a function of D2, a 5.6-volt Zener. Other than that, the circuit is similar to the DTL logic family.

There are two general classes of HNIL logic. One uses logic levels of 0 and +12 volts DC, while the other uses 1 and +15 volts DC.

Tri-state logic

Digital logic is said to be "binary" because it responds to two input states—high and low. In TTL, for example, the output will be either 0 to +0.8 volts, or +2.4 to +5 volts. But there are some cases where we want to disconnect the output terminal from the internal circuitry. One such case is in computers, where a large number of outputs are bused together on the same line. Damage to the circuitry could occur if some of the outputs were high while others were low.

A solution to that problem is what we call tri-state logic. Such devices have three states—high, low, and disconnected (i.e. high impedance).

In the "third state," the output terminal sees a high impedance to both +V and ground. That state is entered upon the receipt by the device of a $\overline{CS}$ signal at the appropriate terminal. Figure 11 shows how a tri-state inverter works. Switch S1 represents the inverter. When the input is low, S1 will be in the position shown—the output is connected to +V (i.e. high) through a low resistance. Similarly, if the input is high, S1 will be in the other position so the output is connected to ground through a low resistance.

The "tri-state" function is provided by switch S2. When S2 is closed, the output terminal is connected to the S1 circuitry. Alternatively, if S2 is open, then the output terminal is disconnected (that's because the value of R1 is, of course, extremely high). The output state is controlled by an active-low chip select terminal ($\overline{CS}$). When $\overline{CS}$ is high, the output is floating (disconnected). If $\overline{CS}$ is low, on the other hand, S2 is closed and the output is connected to the S1 circuit.

A tri-state inverter will follow the truth table shown in Table 2. Examples of tri-state devices are the 74125 and 74126.

Next time, we'll take a look at CMOS devices **R-E**

"That siren was a test. We wanted to determine whether you are awake and watching our program."

EQUIPMENT REPORTS

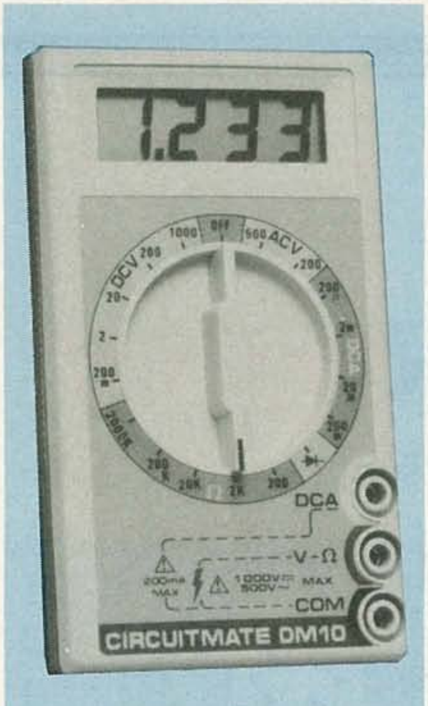
continued from page 36

Beckman DM10 Multimeter

Here's a low-priced multimeter that's made for electronics hobbyists.

MOST "POCKET" DIGITAL MULTIMETERS won't fit in your pocket. We've recently come across one that will: the *DM10* from Beckman Industrial Corporation (630 Puente Street, Brea, CA 92621). Despite its small size, the *DM10* has many of the features you'd expect only in a bigger meter.

The *DM10* is part of Beckman's *Circuitmate* series of multimeters. It can be used to measure DC volts in five ranges (200 mV to 1000 V) and AC volts in two ranges (200 V and 500 V). There are five resistance ranges (200 ohms to 2 megohms) and 4 DC-current ranges (200 μA to 200 mA). The meter also features a handy diode-test function.



CIRCLE 6 ON FREE INFORMATION CARD

We mentioned that the *DM10* is small—it's approximately 5×3×1 inches. That means that it really will fit in your shirt pocket. And because it weighs only 5½ ounces (with battery!), carrying it there should not prove to be at all uncomfortable.

The *DM10* features a 3½-digit liquid-crystal display with easy-to-read ½-inch high digits and automatic negative-polarity indication. Overranging is indicated by a display of only a leading "1," and a LOW-BATT annunciator tells you when to replace the 9-volt battery (which has an expected lifetime of 150–200 hours).

As is common with many meters, the function/range selector switch is a rotary type that dominates the front of the unit. Three input jacks (COM, V-Ω, and DCA) also share the front panel. (You have to switch a test lead to measure current.)

When measuring DC volts, you can expect an accuracy of ±0.8%, +1 digit. With an input impedance

continued on page 100

HOBBY CORNER

Building a simple power supply

EARL "DOC" SAVAGE,
HOBBY EDITOR

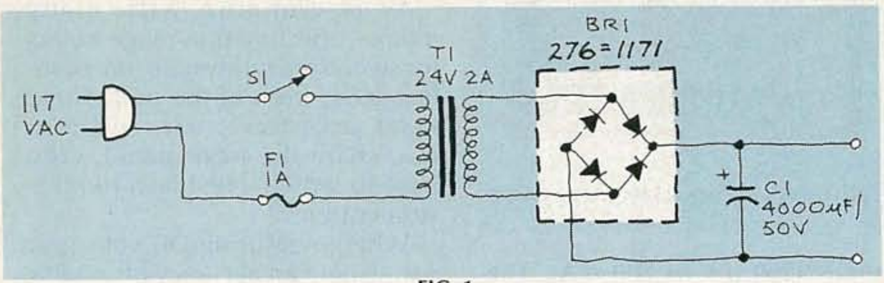


FIG. 1

THE MOST IMPORTANT PART OF ANY electronic device is the power supply—ranging from the simple to the elaborate. After all, without power, electronic circuits serve no useful purpose. Although power supplies are available commercially, it is just as easy to build one and better yet, it's often cheaper!

One of our readers, Carl Muller (CA), is looking for a power supply to operate a 24-volt, 2-amp DC motor. He specifies that the circuit contain a full-wave bridge rectifier. Well, Carl, because the voltage and regulation do not appear to be critical, the circuit in Fig. 1 should fill the bill.

Note the ratings given for the components. If you can't find those values, use the next largest values you can find (except the fuse, of course). The bridge itself can be made of individual diodes (arranged in the same way) or you may prefer the packaged type (which is nothing more than a four-diode arrangement sealed in a plastic case). In the latter category, a 4-amp, 100-PIV (*P*eak *I*nverse *V*oltage) full-wave bridge like the Radio Shack 276-1171 shown in Fig. 1, will probably work all right. But we'd prefer the extra margin of safety provided by 6-amp diodes.

AC-operated devices

Dexter Kalloo (West Indies), you are exactly right: most electronic devices *do* operate on direct current (DC), while alternating current (AC) *does* come out of the wall socket. Therefore, it is necessary to convert the AC to DC before it is applied to an electronic circuit.

That conversion is called "rectification." There are several rectifier arrangements that may be used—*half-wave*, *full-wave*, and *full-wave bridge*. The power supply shown in Fig. 1 is a good example; it uses the full-wave bridge arrangement. Note that the circuit does two jobs: First, the transformer reduces the 117-volt AC to 24 volts. Second, the bridge rectifier takes in that lower AC and "spits out" a proportionate DC voltage. The capacitor simply smoothes (filters) out the ripple a bit.

Where you mount the power supply is up to you. You can mount it externally with wire running to the device it is to power or it may be built right into the device so that you don't even know it's there! Be warned that circuits requiring a DC voltage can be ruined if AC is applied, and the same holds true if DC is applied in reverse (i.e., the positive lead connected to the negative terminal). That is true whether the supply is a battery or a rectifier circuit.

One diode in the power lead of the device will protect it from reverse-voltage damage. Figure 2 shows how the diode should be inserted in the line. It is a good practice to put a diode in the supply line of each device you build, whether it uses a battery or external power supply. Doing so is really cheap insurance and can save you headaches in the future.

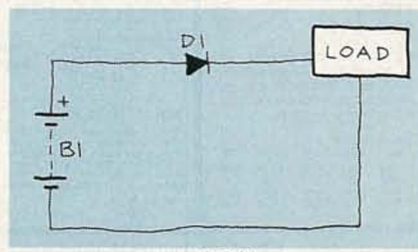


FIG. 2

A new service

As the new year starts, it's appropriate that we take a look at where we are and where we want to go. My thoughts along that line have led me to the point of suggesting a new service for our readers. After all, the entire point of "Hobby Corner" is to help you. Judging from the letters we've received, that job is getting done in a reasonable manner. But, as we all know, there always room for improvement—"Hobby Corner" definitely included!

I am very much aware that there is one group of readers who could be getting a great deal more. They are the ones asking for help in learning about electronics, transistors, IC's, or some other phase of our hobby. Sorry to say, there is no way I can correspond with everyone who needs a bit of special attention. There simply isn't enough time in the day. I regret it, I wish that I could do more, but that's the way it is.

Therefore, my proposal is to list the names and addresses of readers who need help, and would like to correspond with others who are a little farther along in our hobby. I'll try to find space to list a name or two each month and when you see someone who wants information that you have, drop him or her a line and offer to share your knowledge. Of course, the success or failure, and the value of the program depends entirely on your willingness to share what you've already learned with someone who has hit a snag.

Remember when you needed help and someone provided it just in time to boost your interest even higher? Well, now it's your turn to return the favor. I'm reminded of a fellow years ago who pulled me out of the ditch in the wee hours of the morning. (Boy, was I desperate.)

While traveling cross-country with the family, my car ran into a ditch. Two hours went by without any response from a wrecker in either direction. Finally someone came by and offered his assistance. As we put the chain back in his car, I offered to pay him for his trouble. "Oh no," he replied, "I'll be paid when you do the same for someone else some day." (That unknown gentlemen might be surprised to know that I still carry a tow line in my trunk.)

We in ham radio used to call the guys on whom we leaned when the going got rough as our "Elmers." I've had several "Elmers," and, in turn, I've been an "Elmer" to many others. What we need is more "Elmers." I am sure that many of you will be willing to be an "Elmer" by mail to another reader.

All you have to do is to pick a name next month, or the month after, and offer to help. Those of you who would like to have an "Elmer," write and tell me the general area in which you need help getting started. But because our policy is not to print a name and complete address without permission, be sure to give that permission in your letter.

There is, however, one slight catch: I would like one or both of the learning partners to let me know how the process is working.

Voice-activated switch

M. Kuszniaj (NY) wants a circuit for a voice-activated switch to control his recorder by sound from a police scanner. Well, that is no great problem, but I surely would not build one today!

Several suppliers advertising in this publication have been offering such devices for just a few dollars. At such a low cost for something already built and ready to use, I would spend my construction time making the interconnections and building another project. **R-E**

COMMUNICATIONS CORNER

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

Computers and communications

THE WAYS IN WHICH WE COMMUNICATE have changed dramatically over the years. For instance, I grew up in an era when radiotelephone was replacing CW (*C*ontinuous *W*ave) for communications. In those days, almost everyone, including children, could recognize an S-O-S when listening to the radio, or while watching a movie in which the ship's operator pounds out his S-O-S on a brass key. There was no fractured French to produce a "mayday." An S-O-S was an S-O-S—even when spoken into a microphone.

Back then, I sat through endless ham-radio club meetings, while "old timers" argued—and proved—that radiotelephone would never replace CW. Similarly, I've sat through numerous meetings as the *new* "old timers" argued and proved that SSB (*S*ingle *S*ide*B*and) would never replace AM. But today, I sit through seemingly endless seminars listening to arguments proving that digital will never replace voice communications.

In reality, we are probably the last generation that will ever use voice communications for anything other than low-cost local traffic. (That does not include the police and fire departments—they are local.) For long-path communications, or when there is no room for error or misinterpretation, digital is the modern way to go.

Then there's the questions of convenience, time zones, and Ma Bell. With businesses and families spread out across the world, there's a good chance that the person with whom you want to communicate is asleep, out to lunch, or on holiday. And with Ma Bell planning to start charging for long-distance calls that are never completed (even if the line is busy or there's no one at home, etc.), communication costs are going to skyrocket even though you never complete a single exchange of information.

For many years, businesses have handled hard-copy convenience and the moderate cost aspects of communications through teletype or terminals connected to a Telex network; a dial-up communications system that either communicates in real-time with another Telex terminal or uses a store-and-forward technique. (By "store-and-forward" we mean that the message or document is stored in a computer for automatic transmittal at a predetermined time, or when reliable circuits are available.)

With the boom in personal computing, we've seen adaptations of Teletype communications evolve

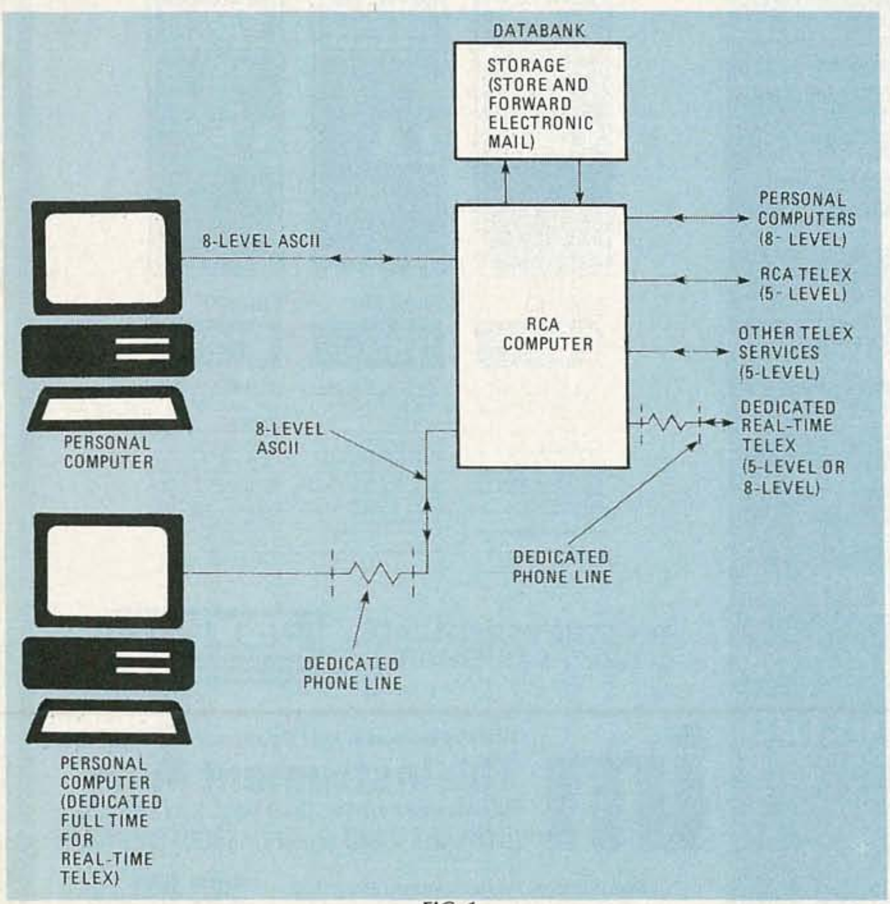


FIG. 1

into a kind of everyman's (or everywoman's) electronic mail system. For example, CompuServe has a computer-to-computer electronic mail system for its subscribers. Unfortunately, there are less than 100,000 CompuServe subscribers—so it's a safe bet that the person or business with whom you want communicate is not using CompuServe's electronic mail-service. Although you could get a special program to convert your computer's 8-level ASCII code to 5-level Baudot for standard Telex use, you'd have to subscribe to a Telex service to communicate with other Telex-connected stations.

Fortunately, there is always someone who sees the next horizon before he really gets to it. In this instance, it's RCA or, to be more precise, RCA Global Communications (which just happens to run a Telex network). Of course, there are other systems as well—Western Union, ITT, and MCI are among the most recognizable names. Having more-or-less anticipated the need for digital communications, RCA has instituted a special Telex service for personal computers—*all* personal computers, not just a few well-known brands or models. Not surprisingly, it's called the RCA Computer-Originated Telex Service.

Computer-originated Telex

Figure 1 shows most of the services provided by RCA's personal-computer Telex service. The key to everything is RCA's computer, which provides the electronic mailbox, store-and-forward, the intersystem Telex interconnect, and the 8-level to 5-level conversion. Basically, RCA automatically converts the normal 8-level ASCII code from a personal computer into 5-level Baudot. It then transmits the message to its own or some other Telex system, stores and forwards, or provides an electronic mailbox for personal-computers connected to their Telex service.

The electronic mailbox works this way: Let's assume you transmit a message via 8-level ASCII to the RCA system and direct it to another personal computer station by entering the RCA-assigned Telex number. Once a day, that person (or station) can dial into RCA and get the electronic mail. If the receiving station replies to your message, you will find the message waiting when you call into your mailbox. When you access your mail, RCA automatically converts the message to 8-level ASCII code for your personal computer.

Alternately, RCA will convert your 8-level computer signal to 5-level Baudot for transmittal to standard Telex stations using RCA or other Telex networks; and will reverse the process, converting their 5-level to 8-level. (Yes, you can direct communicate, via RCA, with Western Union, ITT, etc.)

Whether you're originating a message or accessing your mailbox, the call to RCA is toll-free both ways; the only charge is for the length of messages input from you to RCA. If you get tangled up in the protocol—which is as simple as one can imagine—you are not charged for connect- or use-time. In addition, there is at this time no charge of any kind for accessing your mailbox, or for spesocial software. Plus another bonus is that any ASCII communications software that you may already be using will work.

Note: *At the time this article was prepared* there were no charges for RCA registration, minimum fee, or use other than for the Telex message itself. But, as with all other successful communication enterprises, we can fully expect that some charges will creep in along the way.

With 10-million personal computers already in use in the U.S. alone, it seems that here is the way that personal and small-business communications will be handled in the immediate future. Even now, through RCA, you can send an error-free Telex message that was originated on a personal computer to California for less money than it would cost to accomplish the same thing by voice. Plus, you don't have to wait three hours for the California office to open—and what would be more convenient than that? **R-E**

COMPUTER CORNER

LOU FRENZEL
CONTRIBUTING EDITOR

Printer literacy

THE MOST POPULAR PERIPHERAL DEVICE used with personal computers is a printer. (You may argue that video monitors and disk drives are more popular, but they are so essential that it's hard to consider them to be add-on peripherals.) Because so many computer applications require a hardcopy output, most personal computers in use today are linked to a printer.

Businesses deal with large volumes of paper; and without printers, everything would grind to a halt. But even hobby- and home-computer applications often require a printer. Though a computer may be a great "tool" for storing and retrieving information, or for processing data, the final output almost always has to be in printed form. And even though you can sometimes get by without a printer, it is always more convenient and desirable to have one.

The great demand for personal computers has created an equally large need for printers. As the demand has grown, so has the number of printer manufacturers and types of printers available. The competition in the marketplace and several significant technological developments have given us some extremely high-quality, good-performance, and low-cost printers.

While that may be great for the consumer, it has only served to make the job of selecting a printer more difficult. Given all the choices and complexities of printers, it is just about as difficult to select one as it is to make your first personal-computer purchase. What you need is some kind of "printer literacy" before you go searching for your first printer.

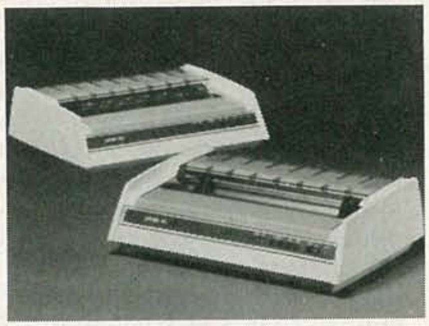


FIG. 1

Printer classification

Printers are classified by the way they put copy onto paper. First, there's the impact type, in which a print element(s) of some kind strikes an inked ribbon to imprint a character (like a typewriter). Then there are the thermal units that use a heat-sensitive paper. Here, the characters are formed by increasing the temperature of a particular area on the paper. Next we have electrostatic printers: This type uses a special electro-sensitive paper to form characters by burning them into the paper. And finally, ink-jet printers, which, as the name implies, spray ink onto the paper.

By far, the most popular type is the impact printer. Impact printers are fast, and the print quality can be outstanding. And better still, no special paper is required. About the only disadvantage of impact printers is that they are noisy. While a significant amount of engineering goes into noise reduction, the noise has not been (and never will be) eliminated.

In contrast, thermal and electrostatic printers are almost silent and low in cost. But they require special paper and the print contrast is usually poor. The output of many of the low-cost types is not truly suitable for professional applications; therefore, the impact type is generally preferred. Their speeds are reasonably high and the output print-quality is excellent. Even multiple copies can be made when carbon paper is used. For most applications, an impact printer is the way to go!

Impact printers

There are two basic types of impact printers: dot-matrix and formed-character printers (such as daisywheel types). A dot-matrix printer forms characters on a page by printing them as patterns of tiny multiple dots. The characters are created with a grid (matrix) of dots that are printed on the paper. The greater the number of dots used, the higher the definition and the better the quality of the printed character. The big advantage of dot-matrix printers is their high speed and low cost. When a small dot matrix (5×7, 7×9, or 9×9) is used, character quality is only moderate. Larger dot grids (9×18, 9×24, 18×48) give superb definition and print quality.

A relatively new type of impact printer, called *N*ear *L*etter *Q*uality (NLQ) printer, is really a dot-matrix machine that is capable of creating a letter-quality output. Figure 1 shows an example an NLQ type printer—the Printek (1515 Towline Road, Benton Harbor, Michigan 49022) models *910* and *920*. Dot-matrix printer technology now permits printing with far more dots in the matrix. In addition to using more dots, the dots are printed twice and are also slightly overlapped.

The result is an exceptionally high-quality character that is often hard to distinguish from the characters printed by a daisywheel unit. Of course, there is a price to pay for the high quality of the print: the speed is reduced when compared to other dot-matrix units—although it's still much faster than a formed-character printer. However, most NLQ printers allow you to print in several modes. For example, a draft mode will print with a less-dense matrix, but at higher speeds than the denser "letter-quality" mode. While such printers are higher in price than more conventional dot-matrix units, you get so much more for your money. And most of those printers also have graphics-output capabilities as well.

The highest quality printers available today are the formed-character printers, or Letter-Quality Printers (LQP). These devices work in much the same manner as a typewriter, in that a fully-formed character is printed on the paper (no dots). Each character is formed on one leaf or petal of a *print wheel, thimble,* or *daisywheel.* (We should not neglect to note that the daisywheel is usually interchangable—it can be replaced with a wheel that prints a different *font.*) The daisywheel (or thimble) rotates to select the desired character, while an electrically driven solenoid hammer taps the appropriate petal against the ribbon, which then contacts the paper. The result is a high-quality typewriter-like output. But, while the print quality is exceptional, the speed is not. It takes time to rotate the daisywheel into position and print the character. As a result, formed-character printers are significantly slower than dot-matrix types.

However, formed-character printers are widely used in business where a high-quality output is required. The choice between a dot-matrix or a formed-character printer will largely depend on your needs. If you are going to use the printer for word-processing applications, where you must create letters, memos, reports and other such documents, a letter-quality printer is probably your best choice. But remember, you pay for the quality in lower speeds and higher prices.

If your application does not require maximum print quality, you can probably get by with a dot-matrix machine. For example, if your output is mostly numerical in nature, a dot-matrix printer is more than adequate. Its lower cost and higher speed are ideal for printing large volumes of tabular numerical data.

There are, of course, other factors that may influence your choice of printers. For instance, there's the type of printer interface, either serial or parallel, that your computer uses. Make sure that the printer you select is equipped to communicate through that type of interface. Otherwise, you'll get nowhere. **R-E**

ANTIQUE RADIOS

RICHARD D. FITCH

Collecting antique radios

COLLECTING OBJECTS FROM A BYGONE era is as old as time itself. Such objects are often referred to as either *antiques* or *junk*—depending, of course, on whether you're buying or selling. Since World War II, all kinds of collectables have come into their own—coins and stamps, for instance, are old favorites. But that's not what we're going to talk about—after all, this is an *electronics* magazine!

The antique-radio hobby is different from other "collecting" hobbies. With radios, unlike other collectables, you are not as likely to get ripped off by unscrupulous characters who deal in "fakes." While making an authentic-looking reproduction of an antique-radio cabinet is possible, the same does not hold true for the tubes and other chassis components!

American antiques are objects considered by knowledgeable collectors to be over a hundred years old. Clearly, if that time frame were applied to old radios, there would be slim pickings for collectors. Even the set used by Marconi in 1888 won't be considered a true antique for a few years!

Many antiquaries—those who deal in or study antiques—divide the items into categories: *antiques*, *semi-antiques* and *collectables*. (Although there are no hundred year-old radios in my limited collection, there are a few that can be called semi-antiques!)

A look at early radios

It wasn't until the mid-1920's that complete radios, like the Crosley *Model 51* shown in Fig. 1, became available to the general public. Corporate contention seemed to hamper the growth of the industry. Designs, innovations, and patents were not generously shared by the early radio manufacturers—huge lawsuits, which tied up production for months, were not uncommon in the early days of radio.

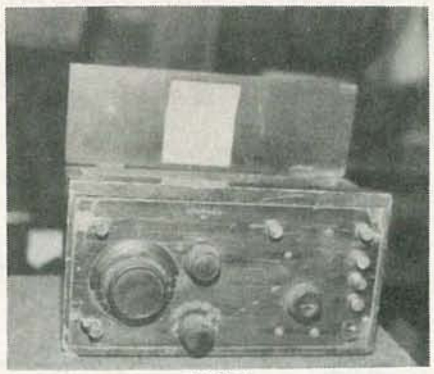


FIG. 1

Improvements and new inventions came fast in those early pioneer days. Back then, the average person had a better working knowledge of radios than now. Those people who got in at the beginning were able to follow advances in the industry. Any radio receiver was pretty much a do-it-yourself project; anyone interested in radio could read a schematic in those developing days.

The early enthusiast knew if he wanted to hear what was "on the air," he would have to build his own set. Therefore, what he wound up with was a custom-built set. A wealth of information and parts was available in early radio publications. And as radio progressed, complete information and schematics were offered.

In the early 1900's there was little commercial interest in radio—despite the development of the two- and three-element tubes (diodes and triodes).

After World War I, there were a number of production portables on the market that came complete with cabinet and tubes (two WD11 tubes). While those sets appeared to be small portables, their portability was certainly limited. The aerial, ground, as well as batteries and earphones, were connected to terminals on the front panel. The Crosley *Model 51*, (shown in Fig. 1) was one such set. That boxy-looking radio (with a cabinet that measured about ten inches across) contained 1.5-volt DC tubes and was battery-operated. Even at that time, only about a quarter of the homes in America were "wired." So the need for battery operated sets prevailed through most of the late 1920's and well into the 1930's!

The stock market crash and great depression of that era had little effect on the evolution of radio. By 1929, most new homes and many old ones were being wired. And with the licensing of more and more broadcast stations, the sale of commercially-built radios began to grow. The big corporations settled many of their differences (Some went all the way to the Supreme Court.)

By 1920, Grigsby Grunow, for example, sold 1,000,000 *Majestics* (see Fig. 2). Most old radios, as well as other manufactured products, had character right through the 1930's. (Civilian radio-production was reduced during the early 1940's—the years of World War II).

There were small AC-powered models with cabinets less than a foot wide that could fit on top of a bread box (fine collectors' items or

FIG. 2

conversation pieces). Those small antique radios, called "midget receivers" are much in demand—the small cabinets are relatively easy to restore.

During the 1930's the midget radio was the industry's answer to the depression. While fidelity may have been sacrificed in those models (with their smaller speakers), by today's standards, their sound quality is above average. The midget radio is the forerunner of the modern table models.

The radio industry in the early 1930's hoped the midget radio would replace the millions of "antique" radios of that era. (But with its cost of around $100.00, listeners were holding on to their older models.) Those custom mail-order or kit radios that were considered antiques in the early thirties will be hard to come by today. The set shown in Fig. 3 is an early antique radio. However, unlike the set in Fig. 1, its terminals for connecting the batteries, earphones, etc, are inside the box.

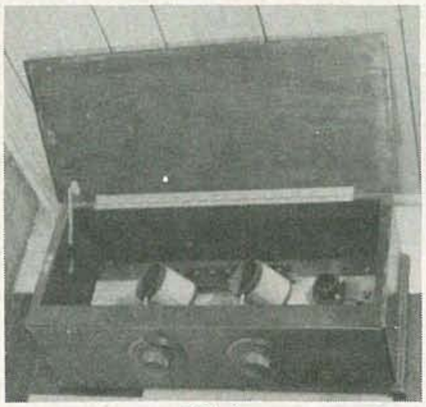


FIG. 3

The radio industry hoped to induce those not enjoying modern radio to discard their obsolete equipment, and join the listeners of modern radio. For radio dealers, the big profit was in the console. At least half of the market still wanted, or could afford the big-console radios. The massive cabinet with huge dynamic speakers and two shortwave bands was a prestigious addition to the home in the thirties. (How many tubes you had in your radio became as important as how many cylinders you had in your car!)

Buying antique radios

Old radios that can be called antiques can be bought for as little as $5.00! You might even find a free

continued on page 112

NEW IDEAS

Musical telephone ringer

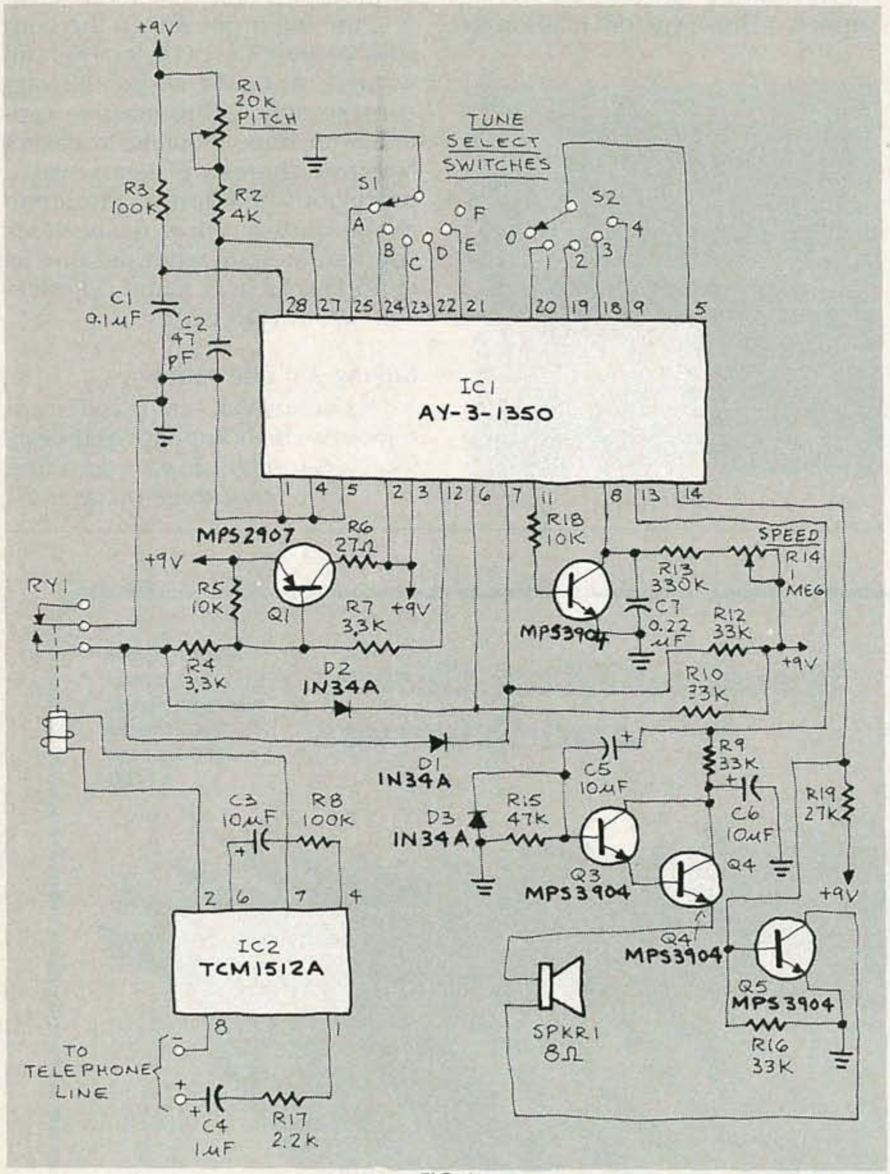


FIG. 1

THE DEVELOPMENT OF IC'S HAS brought with it many novelty circuits and gadgets. And often those circuits serve no purpose other than to entertain. Although this telephone-ringer circuit is a novelty, it doesn't fall into that category. The melody ringer can be used in place of, or as an extension to, your present ringer system.

When the phone rings, the circuit will play one of twenty-eight tunes (as selected by the user). The tunes are certainly a step above the old clanging bell—which at times can be quite startling. Some of the tunes, which are listed in Table 1, are ideal for special occasions, adding another dimension to the circuit's many uses.

VOL. 2 No. 2 February 1985

COMPUTER DIGEST

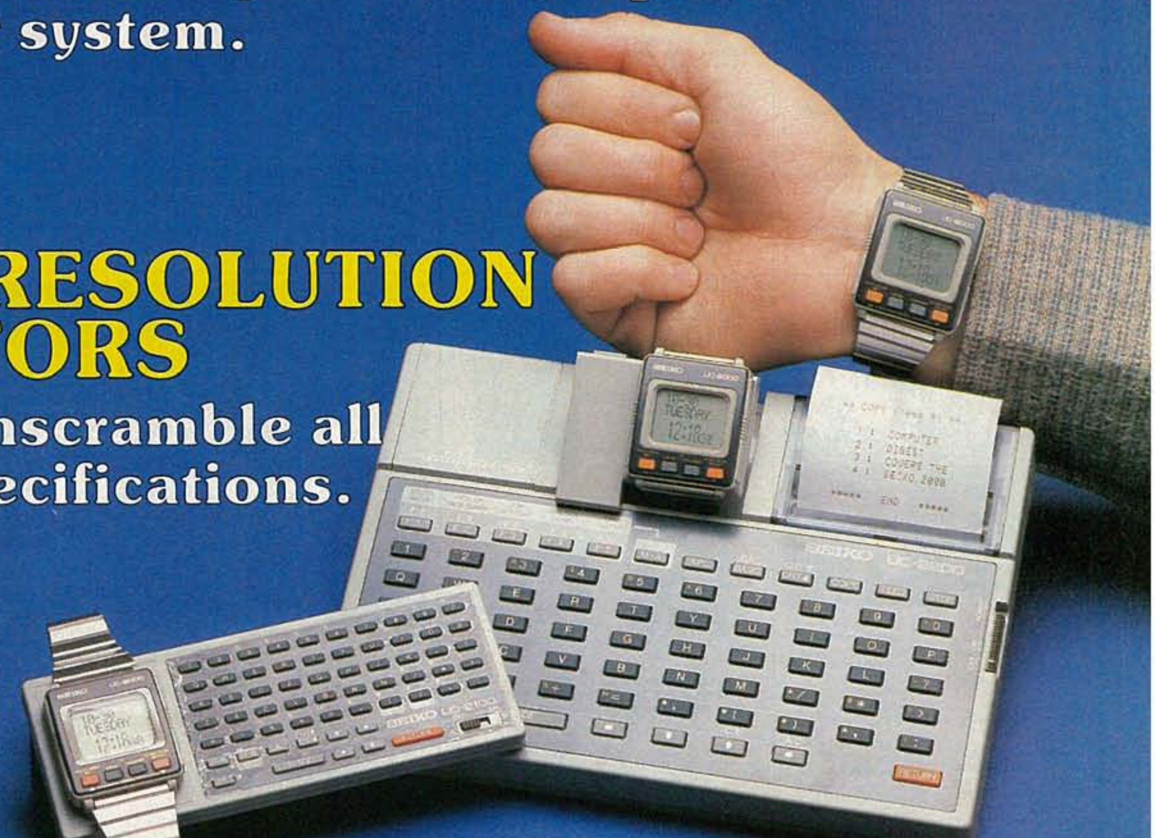
NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

SEIKO'S NEW WRIST-WATCH COMPUTER SYSTEM

An in-depth look at the world's first wrist-watch that forms part of a complete computer system.

HIGH-RESOLUTION MONITORS

How to unscramble all those specifications.



A GERNSBACK PUBLICATION

RECEIVING COMPUTER PROGRAMS VIA BROADCAST RADIO

Standards are being proposed that will enable you to receive computer programs from your radio receiver.

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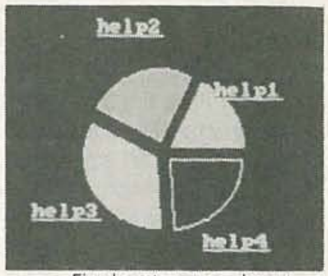
Vol. 2 No. 2 February 1985



Find out more about high-resolution displays, low-resolution displays, and everything in between. The story begins on **page 13.**

The conclusion of Machine Code Development System for the Timex Sinclair *1000* will appear in the March issue of Computer Digest.

ON THE COVER

Just about everyone knows about Dick Tracy's wrist radio. Well, a new innovation from the people of Seiko has left that once speculative device in the dust. The innovation is a tiny "wrist computer" complete with an LCD wrist-watch-like readout, a pocket-sized keyboard, and 2K of RAM. **See page 7.**

ComputerDigest is published monthly as an insert in Radio-Electronics magazine by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class Postage Paid at New York, N.Y. and additional mailing offices. Printed in U.S.A.

LETTERS

NO COMMODORE PRINTER PROBLEMS

Our company, Martec Associates, Inc., sells a dot-matrix printer together with the Cardco, Inc. Card + interface for the Commodore 64 and VIC 20 computers. Naturally, we were very interested by Herb Friedman's article in the September issue of **ComputerDigest**, "Printer Delay for the Commodore 64."

A phone call to Cardco yielded the following information. In 1983, Cardco changed their ROM due to a problem like the one described in the article. However, since then, they have not had any problems. Is it possible that Herb Friedman used an old Cardco CARD?—Arthur Kingsnorth, Vice President, Martec Associates, Elk Grove Village, Illinois

Although both the Commodore computer and Cardco interface were bought shortly before the article was prepared, it is possible that the Cardco interface was sitting around in stock for some time and therefore contained the old ROM. The Customer Service Department at Cardco assures us that all problems have been corrected with the printer adapter. If anyone runs into a situation like the one Herb Friedman did, Cardco will gladly replace the defective interface if it is sent to the Customer Service Department at Cardco (300 S. Topeka, Wichita, KS 67202) along with proof of purchase and a description of the problem.

TI COMPUTERS

You say that you're not "just another computer magazine." Well, so far all you do is talk about the same things that the other computer magazines do.

I have a TI 99/4A, and I haven't seen anything written about it in **ComputerDigest**. For that matter, I haven't seen much written about it in any of the other magazines. That is one of the reasons that I'm writing this letter. I would like to know how to make a phone modem, and a few other things for my computer. I'm sure that there are many more people like me that have a TI 99/4 computer.

I enjoy **Radio-Electronics,** but if **ComputerDigest** is going to be like the rest of the computer magazines, then we can do without it.—Brian E. Sparling, Northfield, IL

If you're a TI owner and think you have an article for publication, consider this an open invitation for you to let us know about it.

PUBLISH YOUR PROGRAMS

The Blacksburg Group writes and produces books about using small computers. Since 1977, we have developed over 60 titles on electronics and computer subjects, and our books are published by major U.S. publishers.

One of our new projects is the collection and publication of useful engineering and scientific routines and subroutines. We know that many people have written interesting programs to solve a specific problem or because they couldn't find a special routine they needed. Our book gives these people a way to share their programs with other scientists and engineers so that others can benefit.

Useful programs include those that do graphing, numerical analysis, statistics, equation solving, 3-D plotting, controlling real-time clocks, controlling analog converters, and so on. We are interested in almost *all* programs that could be used by scientists and engineers to answer specific or general needs. We know from

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200 Park Ave. South
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ADVERTISING SALES 212-777-6400
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LETTERS *continued*

personal experience that most people don't want to become professional programmers just to be able to use a computer, so we strongly feel that a collection of useful program segments will be invaluable.

If readers are interested, they should write or call us first, and we will send them guidelines and other information about submitting a program or subroutine. Our number is 703-951-9030 (which is in the Eastern time zone).

Right now, we're particularly interested in BASIC-language programs for popular desktop computers. This is NOT a vanity publication, and authors retain the copyrights to their material.—Jonathan A. Titus, Ph.D, President, The Blacksburg Group, Inc. PO Box 242, Blacksburg, VA 24060

Thanks for the information—we're happy to pass it along to our readers.

Competition

I'd like to make what I think is an important point that we'd all better understand. I know nothing at all about spectator sports, and could not care less. I think that it was for that reason alone that my young son developed his own interest, and learned to quote the batting averages of every football player in the major leagues. It gave him the opportunity to know something that I didn't. He once challenged me to ask him any question about baseball, so I asked him how far it was between first base and home plate, and he became angry. "What kind of question is *that?*"

Being an old electronics nut myself, he shied away from that field until he realized that my knowledge of computers was miniscule. He jumped on that too. He became an overnight computer "expert" and kept asking questions of a technical nature that he already knew the answers to. I quickly caught on to the game, and began to seriously read—and wonder of wonders—to understand, thanks to

ComputerDigest.

Things are beginning to settle down now around the house. We're starting to learn more together, and we're enjoying it more all of the time. Just thought you'd like to know. Keep up the good work.—J.P., San Francisco, CA.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

PRODUCTIVITY TOOL, *Speed Key*, is designed for business software programs and languages. It makes them easier to learn and to be customized to each user's special needs. *Speed Key* supports the following business-application programs: *Lotus 1-2-3, WordStar, MultiPlan, SuperCalc, VisiCalc, dBASE II*, and IBM's DOS and BASIC programming language.

With *Speed Key* and Koala's touch tablet, a user can bypass the standard computer keyboard to run the leading business-software programs. *Speed Key* converts the Koala touch tablet into a custom keyboard with up to 37 programmable function keys and a cursor controller with the features of a "mouse" pointing device.

Each *Speed Key* overlay has 36 squares, with each square representing a softkey designed to give specific instructions to the IBM PC or IBM PC-XT. When a softkey on the overlay is pressed, the computer and application software will think that the user is typing on the computer keyboard. Thus, the user does not have to remember lengthy commands and multiple keystrokes required by conventional keyboards.

CIRCLE 21 ON FREE INFORMATION CARD

Speed Key has a suggested retail price of $99.00.—**Koala Technologies Corp.,** 3100 Patrick Henry Drive, Santa Clara, CA 95052-8100.

GRAPHICS SUBSYSTEM, the model *DT2750*, is a full-color raster subsystem that allows any Q-Bus processor to generate and display mixed graphics and alphanumerics on a monochrome or standard RGB color monitor.

The model *DT2750* contains a 192K graphics-display memory that organized as two independent display buffers with 512 × 512 × 3 pixels each. The framesize may be jumpered to 512 × 156 × 3 pixels. The 3-bit depth permits display of eight colors at one

CIRCLE 22 ON FREE INFORMATION CARD

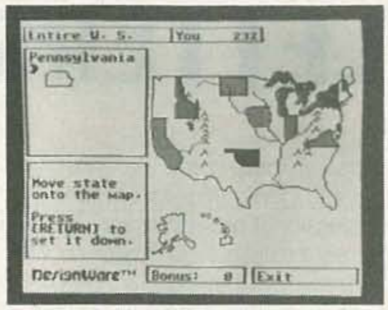
time, selected via a lookup table from a palette of 512 colors. When used with a monochrome monitor, there are eight levels of gray scale available.

Applications for the model *DT1750* graphics board are found in process monitoring and control, medical electronics, business graphics, and visual network control. It is priced at $1995.00.—**Data Translation,** 100 Locke Drive, Marlboro, MA 01752.

EDUCATIONAL SOFTWARE GAME, *States & Traits,* challenges families and children ages nine and above to sharpen their knowledge of United States geography, history, and current trivia.

The map-maker/user has two options: In "states," he or she charts states into their proper locations on a colorful master map. In "traits," the cartographer's challenge is to plot topographical features into their correct geographic positions and to answer questions on U.S. landmarks, history, and trivia.

Players can choose to test their geographic knowledge of the whole United States, or to concentrate on one of four regions. If the player selects "states," the labeled outline of a state appears on the screen next to a map of the total U.S. or region. Using a joystick or keyboard, the player then leads the state to its correct position



CIRCLE 23 ON FREE INFORMATION CARD

on the map. The state appears to "march" across the country as the player moves and charts its course.

In the "traits" portion of the game, a map and a question appear on the screen. State capitals, neighboring states, historical facts, and current events are all fair game. To answer, the user draws an arrow to the correct state. For example: "What state claims fame as the boyhood home of Abraham Lincoln?" The player must point to the state of Illinois. *States & Traits* is priced at $44.95.—**Designware,** 185 Berry Street, San Francisco, CA 94107.

DATA-ACQUISITION BOARD, the *DASH-16,* is a high-speed, plug-in data-acquisition board for the IBM *PC* and other bus-compatible computers.

CIRCLE 24 ON FREE INFORMATION CARD

DASH-16 provdes 12-bit A/D conversion and speeds up to 40,000 samples per second, with transfer to memory at that speed using DMA (level 2 or 3). Sixteen single-ended or eight differential analog input channels are available (switch selectable), as is an instrumentation amplifier with switch-selectable gains of 0.5, 1, 2, 5, 10, and a special "user gain" for specific application gain requirements. Data conversions may be initiated by the program, an internal timer, or by an external trigger. Converted data may be transfered by program interrupt or DMA. The interrupt and DMA modes support background operation. Input-voltage range is ±10 to ±0.5 volts.

The *DASH-16* is priced at $895.00.—**MetraByte Corp.** 254 Tosca Drive, Stoughton, MA 02072.

SEIKO'S NEW WRIST COMPUTER

It had to happen, and Seiko did it... Here's a look at the new Wrist Computer!

Marc Stern

■If you've been following Dick Tracy through the years, you've probably seen him talking to Sam, his sidekick, on his wrist radio. Well, today that can be updated. Instead of talking to Sam on his wrist radio, Dick Tracy will probably use his wrist computer to exchange information with him.

Although that may sound like science fiction, it really isn't because of a recent development from Seiko, the people who normally bring you high-quality watches and mini-televisions, among other things.

Seiko does it

The Seiko *Datagraph* system, which consists of a wrist module, pocket keyboard, and controller is the result of several years of development by the Japanese electronics giant Hattori Corp. It relies on large scale integration (LSI) techniques and the first use of inductive wireless transmission technology in the computer industry.

When you first look at the wrist module, you'll notice that it isn't especially unique-looking. In fact, it looks just like a watch (which is what you'd expect from Seiko). It's what the company has done with technology and how they have managed to squeeze some computing power into a wrist-sized package that sets it apart from all the other wrist watches of the world.

The wrist module

The basic component of the information system is the wrist module. It contains five CMOS LSI IC's that include a four-bit central processing unit; a 2K RAM, and three display drivers for the liquid-crystal display. A block diagram of the wrist module is shown in Fig. 1.

The LCD readout consists of a 10-column by four-row matrix that has a resolution of 1,400-pixels. The LCD not only serves as the display for the computer, but—as you would expect of a watch manufacturer—it also displays all the timekeeping functions, including day, date, chronograph, and alarm. It is powered by a lithium battery that Seiko claims will supply power to the wrist module for 1.5 years.

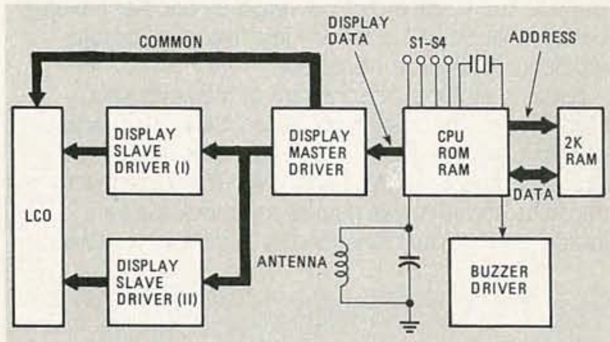


FIG. 1—THE DISPLAY MODULE contains an LCD display, two display drivers, a master display driver, CPU and 2K of RAM, a loop antenna and a buzzer.

The keyboard module

Data is entered into the wrist module by a pocket-sized keyboard unit. The keyboard measures only 5½ × 2¼ × 5/16 inches, and contains 61-keys through which data is input to the wrist module. The wrist module itself has only four buttons that are used to access pre-programmed functions. So, as you can see, the keyboard is an important device. You can use the keyboard unit to input notes, calculations, etc. into the wrist module. You can even store telephone numbers, appointments, and just about anything else in the device.

Data is transferred from the keyboard unit to the

THIS IS NOT a wrist watch! It is the display module for the Seiko *Datagraph* computer.

wrist module through induction. The wrist module fits on a small plate at the left of the keyboard and communicates with the controller at a rate of 2048 baud (bits per second). The communications is duplex. The keyboard is powered by another lithium battery that Seiko claims will last five years before replacement will be necessary.

Looking at the block diagram of the keyboard module shown in Fig. 2, you'll see it is really made up of two parts. The first is the keyboard circuit and the second is the inductive transceiver The transceiver both transmits and receives data as the block diagram indicates. That dual functionality is built into a CMOS

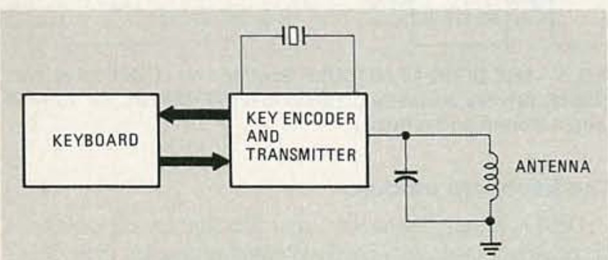


FIG. 2—THE KEYBOARD MODULE contains the keyboard, a keyboard encoder and transmitter, and a loop antenna.

LSI IC that handles not only key scan, but also character generation, as well as wireless transmission. It runs at a clock rate of 32.768 kHz.

Master control

Rounding out the *Datagraph* system is the module that turns this system into a true 8-bit microcomputer, the *UC-2200* controller. Communicating inductively, the controller uses the wrist module as its display device. As shown in Fig. 3, the *UC-2200* controller contains an 8-bit CMOS Z80-equivalent microprocessor. It boasts not only a complete, typewriter-style QWERTY keyboard with function keys, but also a dot-matrix mini-printer. The controller also features 4K of RAM

THE *UC-2200* CONTROLLER turns the display module into an 8-bit micro-computer. The controller is shown here with an application ROM pack in place.

memory and a ROM applications pack that includes scheduling, a 26K BASIC interpreter, as well as other programs. The ROM can contain as much as 32K. The entire unit measures only 5 × 7-inches and it can be powered by alkaline batteries.

The importance of the Seiko *Datagraph* system lies equally in its size and capability, as well as its method of transferring data from one device to another. It is the first system in the industry to employ inductive transmission and reception techniques.

It brings major computer capability to a unit whose key part—the wrist module—is intended to be worn

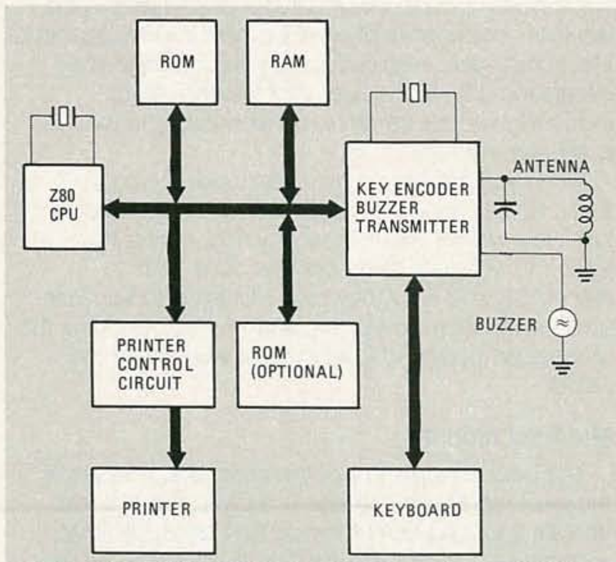


FIG. 3—THE CONTROLLER MODULE contains a CPU, RAM, ROM, an optional ROM containing applications software, a keyboard encoder, buzzer driver and transmitter, a keyboard, printer controller, printer, buzzer, and loop antenna.

on your your wrist. And, the system itself is small enough that it can be easily used by the "man on the go." Ten years ago, when the first microcomputers were making their appearance, it was impossible to have a computer at your fingertips wherever you went. Of course, that situation changed about four years ago with the introduction of such transportable computers as the Osborne I and the Kaypro. But, let's face it, those computers were far from conveniently sized for hauling. Briefcase computers did put true computing power at your fingertips wherever you went, but they were still fairly large. However, the Seiko *Datagraph* system now puts computing power on your *wrist*—a very convenient package.

Inductive coupling

Rather than relying on traditional radio transmission techniques, Seiko chose to use inductive coupling to transfer data between the various modules. Figure 4 shows the basic approach.

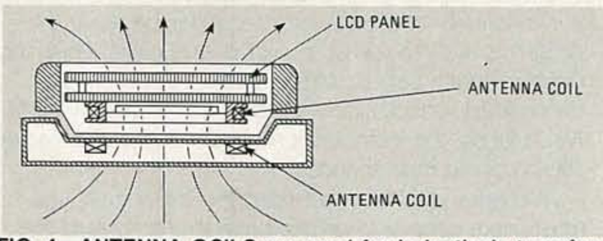


FIG. 4—ANTENNA COILS are used for inductively transferring data between the various modules.

Each module contains an antenna coil that resonates at 32 kHz. That frequency was chosen because the other clock frequencies contained within each of the modules could be easily filtered out. The bit stream modulates a 32-kHz signal that is applied to the transmitting antenna. If the bit is at a logic 1 level, then the 32-kHz signal is applied to the antenna, if the bit is at a logic 0 level, then no signal is applied to to the transmitting antenna. The magnetic field produced by the transmitting antenna cuts across the windings in the receiving antenna. The receiving antenna produces a current in response to the magnetic field. The output of the receiving antenna is an exact duplicate of the original signal applied to the transmitting antenna. The 32-kHz signal is filtered out of the received signal and the original bit stream is recovered.

An eight-bit digital word is transferred in very much the same format that is used when two computers communicate via a modem. The actual transfer of the eight-bit digital word consists of a start bit, followed by eight data bits, a parity bit and finally, a stop bit.

Seiko chose inductive technology for several reasons. First, it could keep everything inside a hermetically sealed unit so it is humidity resistant. Second, it helps to keep the unit portable because of its small size. Next, the company chose this method because of the ease of interfacing the units. There are no cables to worry about and it allows duplex communication through one loop. Last, but not least, the technique is easy to implement and since the circuitry needed to accomplish it is simple, few parts are needed. In fact, the data transmission and receiving circuits can be connected to one antenna coil.

Packaging

None of this would have been possible without developments in LSI packaging. For instance, all parts of the transmitting-receiving circuits, other than the coils and tuning capacitors, are located on a single integrated circuit.

Look at Fig. 5 and you'll see how the wrist module is put together. The main substrate—epoxy glass resin—contains three LSI packages. In turn, a ceramic substrate, which contains the wrist module's 4-bit CPU and 2K RAM, is soldered to the rear. In other words,

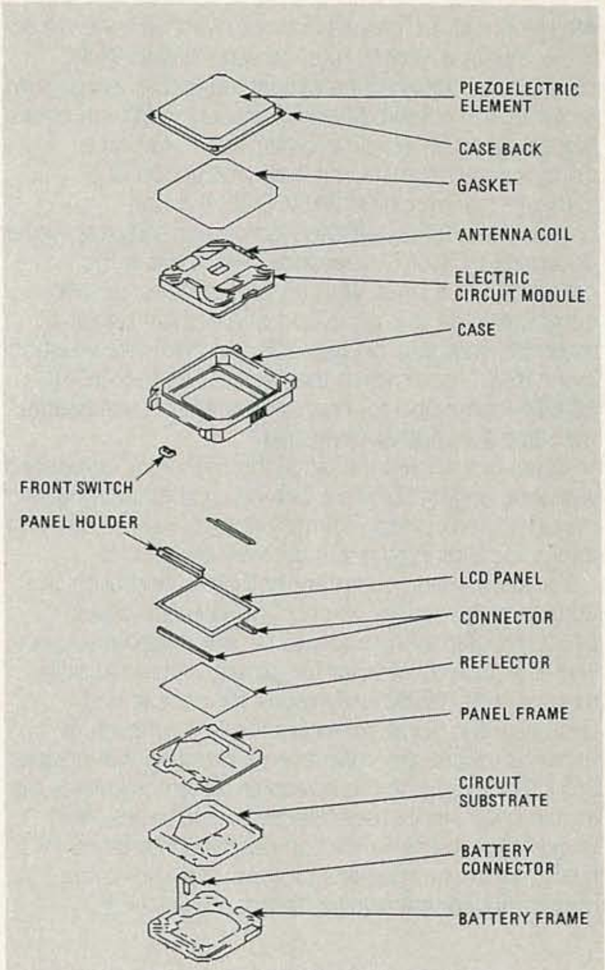


FIG. 5—CONSTRUCTION OF THE WRIST MODULE.

two substrates contain the five LSI chips needed for the entire module. This was made possible by a breakthrough that allowed Seiko to combine two display and control functions onto an individual substrate.

Even the pickup loops have been carefully merged into this plan. They are wound around the battery frame, eliminating the need for extra space.

With all this, the day of the wrist information system has dawned and just like Dick Tracy, we can now have our own "wrist radios," but they're really computers, of course.

BASICODE

You can get free software via shortwave radio.

HERB FRIEDMAN

■Some things are carved in stone. For example, we all know that as a general rule, cassette-based BASIC computer programs aren't interchangeable. A program recorded on a Radio Shack computer won't run on an Apple, while an Apple program won't run on a Commodore 64, etc. Until the introduction of a software system called BASICODE, the non-compatibility of tape-based computer software was an accepted fact for two reasons: First, there is the cassette tape format. With few exceptions, no two computers use the same kind of electrical signals to store the programs or data. Second, there are variations in the BASIC commands themselves; ie., the CLEAR SCREEN command for one computer isn't necessarily the same for another computer.

When one knows the facts, the problems associated with exchanging software between different computer models often appear insurmountable. But as with many things, facts tend to get in the way of real life.

For many years, computer hobbyists and users in Europe have routinely exchanged cassette-based BASIC programs on almost every imagineable subject. These included software for games, arithmetic skills, reading skills (particularly useful for people with dyslexia), and some rather high-level stuff such as titrations (chemistry), and even a program that creates a 555 timer circuit on the screen and then calculates the required values for user-selected frequencies. And there's even software for computerists interested in music, such as a graphics program that shows the correct fingering for guitar chords. (The screen photographs that appear later in this article illustrate two of the typical exhange programs.)

"Aha!," you say, "This is too good to be true. There must be a catch!" Yes, there is a catch. Here in the U.S. you can't exchange software unless you have a short-wave receiver and a cassette recorder, because the programs are broadcast as part of an English language radio program called "Media Network,"which is transmitted worldwide via short-wave radio by *Radio Nederlands*, the independent international short-wave station of the Netherlands.

And after you have recorded the broadcast, you must use a special *translator* program to convert the broadcast into the hardware and software format required by your computer.

Difficult? No. It only appears to be difficult. For most commonly-used computers, it's as simple as pressing the PLAY button on the cassette machine. The translator program—which is available for many popular computers—works on two distinct levels; hardware and software. It processes the received electrical signals into the format required by your computer, and then interprets the handful of non-standard BASIC statements into the format required by your computer's particular version of BASIC.

Hobbyscoop

The translator software is part of a system called NOS-BASICODE, which was developed by Dutch and other European hobbyists for the "Hobbyscoop" (Hobbyscope) radio program NOS—the Dutch

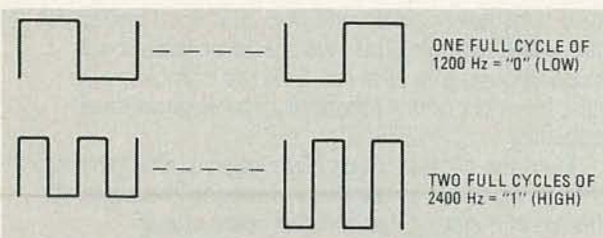


FIG. 1—REPRESENTING ONE FULL CYCLE of 1200 Hz, is a "0" (low), while a "1" (high) is represented by two full cycles of 2400 Hz. A byte of data uses standard teletypewriter format of 1 start bit (logic 0), 8 data bits (logic 1), 2 stop bits (logic 1).

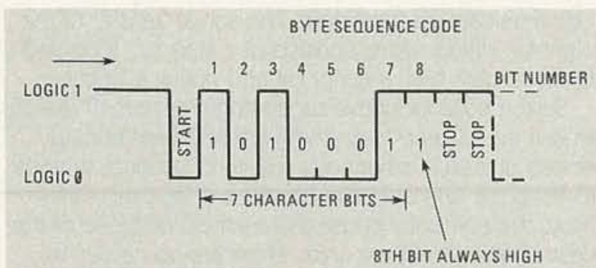


FIG. 2—THE LETTER 'E" shows the byte sequence code. You'll find a start bit, seven character bits, the eighth bit and two start bits, a total of eleven bits.

Broadcasting Corporation. Hobbyscoop features news of new and unusual developments in electronics which would be of interest to hobbyists. When personal computers came along in 1977, it was natural for Hobbyscoop to cover the subject and to broadcast software for the few home/hobby computers available at that time.

Originally, Hobbyscoop broadcast indvidual computer programs. A single program for three different computers required three separate broadcasts. As more computer models were introduced, the amount of time needed to broadcast a single program for the various computers became burdensome, and so a "universal language" called BASICODE, which incorporated a *translator*, was developed. The purpose of the BASICODE system was to use a single broadcast to transmit a program to many different computers, all having different electrical and software requirements. Eventually, BASICODE would translate for 20 different computers.

The broadest tones

Transmitted at 1200 baud, the tone frequencies of 1200 Hz and 2400 Hz are used to broadcast the software to the receiver/cassette recorder. As shown in Figure 1, a "0" (low) is represented by one full cycle of 1200 Hz, while a "1" (high) is represented by two full cycles of 2400 Hz. A byte of data uses the standard teletypewriter format of 1 start bit (logic 0), 8 data bits (logic 1), and 2 stop bits (logic 1).

All characters are represented in ASCII (American Standard Code for Information Interchange). Since only seven bits are used to represent an ASCII character, the eighth bit is always automatically set high (1). The complete character consists of a start bit, seven character bits, the eighth bit, and two start bits. A total of eleven bits; exactly the same format as used for a standard 110 baud teletypewriter. Figure 2 shows how the character "E" would be transmitted. Figure 3 shows the tone sequence used for the actual broadcast transmission, which is eventually recorded by the user. The complete off-the-air signal consists of: Leader, 5 seconds of 2400 Hz; Start text, ASCII "Start Text" (Hex 82); Program, BASIC in ASCII; Checksum, and Trailer, 5 seconds of 2400Hz. The checksum at the end is derived from the bit indication of exclusive-OR of the previous bytes, and is expressed as an 8-bit term. The purpose of the Checksum is to allow the user to test whether the program has been read from the tape without error. Even if the Checksum is not correct—indicating an error—BASICODE will load the program and permit a listing of what has been read. Since the program is in BASIC and not op code (binary), the user can correct the errors and then SAVE the program in the usual way.

The translator converts

Since no computer reads the the transmitted cassette format directly, the user must first load the translator program into his or her computer. (The translator is written in the precise software and hardware format required by the computer.) Then the BASICODE cassette program is loaded. The translator, which is already in the computer, causes the computer to read the BASICODE cassette signals, and then converts the BASICODE into the format required by the computer.

Obviously, not all BASICODE cassette programs can be loaded in the usual way because some of the cassette interfaces used in home computers are going to reject anything that isn't precisely formatted, and the translator can't do anything until the signals get into the computer.

Generally, if the computer refuses to load non-conforming cassette signals, a hardware accessory will get the received cassette signal into the computer. For example, while the BASICODE cassette tape can be fed directly into an Apple or Commodore computer, a TRS-80 requires a simple interface such as the one shown in Figure 4. On the other hand, an OSI *Model 1P* computer (an early hobbyist model) requires only the the addition of a three-way switch and a wire jumper, while for CP/M computers, the BASICODE signal is fed into what is normally the computer's parallel printer output.

A few computers require a somewhat extensive accessory interface. Circuits for those computers that require accessory interfaces are given in the BASICODE Handbook. We'll tell you how to get one later in this article.

Once the BASICODE program has been loaded into the computer and translated it can be SAVED as a standard cassette file—even as a disk file. As far as the computer is concerned, the translated program is a "standard" program for that particular computer and can be used on any similar computer without need for the translator.

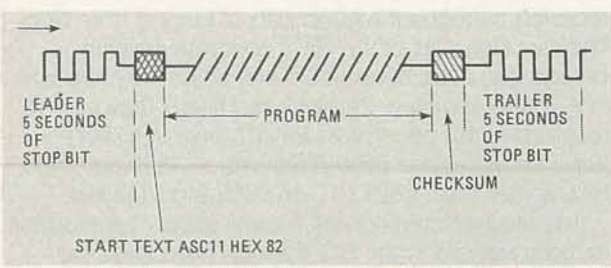


FIG. 3—THE TONE SEQUENCE used for the actual broadcast transmission, which is eventually recorded by the user.

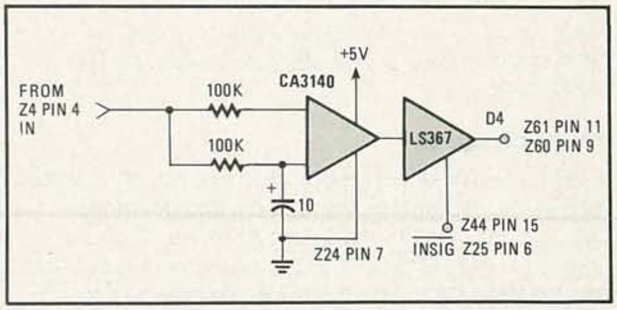


FIG. 4—A SAMPLE INTERFACE for the TRS Model I/III as shown in the BASICODE Handbook.

Universal basic

BASICODE is not an "...all bells and whistles" version of BASIC; instead, BASICODE is more like the high-performance *time-share* BASIC from the era when schools used teletypewriter terminals connected via the telephone system to mainframe computers. The supported statements in BASICODE are: ABS, AND, ASC, ATN, CHR$, COS, DATA, DIM, END, EXP, FOR, GOSUB (GO SUB), GOTO, IF, INPUT, INT, LEFT$, LEN, LET, LOG, MID$, NEXT, NOT, ON, OR, PRINT, READ, REM, RESTORE, RETURN, RIGHT$, RUN, SGN, SIN, SQR, STEP, STOP, TAB, TAN, THEN, TO, and VAL.

The translator automatically accommodates the various ideosyncracies of BASIC through special BASICODE software routines located in the reserved area of program lines 0-999. (Since lines 0-999 are reserved for the translator, user written code starts at line 1010.)

The program translation works this way: Assume you want to write a program that will be used by others having different computers and a BASICODE translator. You want your program to clear the screen first. Since the CLEAR SCREEN statement varies from computer to computer. A BASICODE program would not use the "normal" CLEAR SCREEN command for your computer, instead, the program would use the statement GOSUB 100.

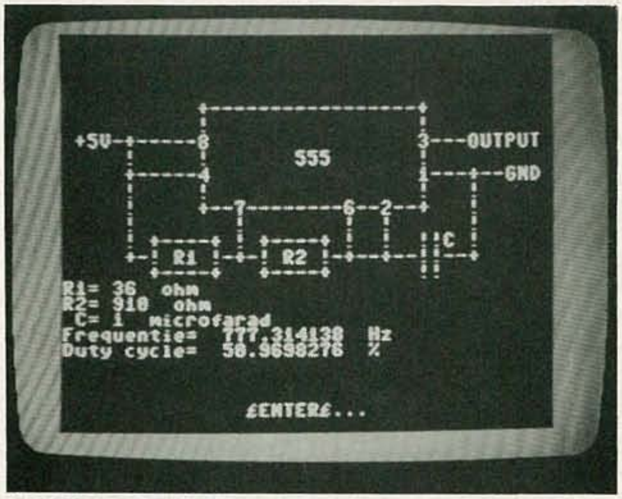
Each translator program has the correct CLEAR SCREEN routine for a specific computer at line 100. The GOSUB command sends the program to line 100 for the correct CLEAR SCREEN statement, and then returns to the program. Another example is a random number variable. That's a GOSUB 260, which the translator uses to generate the correct "random" statement for each computer. Actually, there's not more than a handful of conversions. Having lines 0-999 available insures that BASICODE has room to grow.

It's all in a kit

A kit consisting of the BASICODE handbook (with English translation) and an English-language cassette of translators for 17 popular or commonly-used computers (the ZX-81 is not one of them) is available (sent airmail) for f 38,- (f = Dutch guilders), payment in an international money order (IMO). The kit can be ordered from: BASICODE, Administratie Algemeen Secretariaat, NOS, P.O. Box 10, 1200 JB Hilversum, The Netherlands. Since the translators are updated periodically, information regarding the availability of specific translators should be addressed to: Jonathan Marks, Media Network, English Section, Radio Netherlands, P.O. Box 222, 1200 JG Hilversum, The Netherlands.

You're on the air

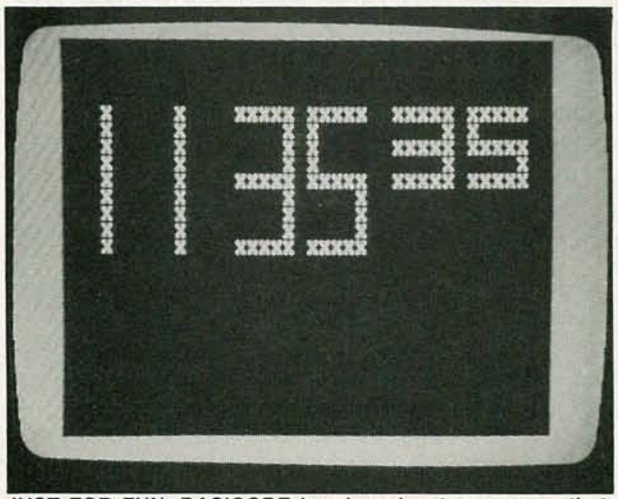
All programs broadcast by Hobbyscoop and Media Network are submitted by listeners and are in the public domain. Many programs are in Dutch and/or English, or only English. It depends on who submitted the program. While you might not be able to read the Dutch labels of non-English programs, you can certainly understand or figure out what's going on. You can also



A BASICODE PROGRAM created this schematic of a 555 timer and then asked for the desired frequency and duty cycle. In the blink of an eye, part values were displayed for the nearest standard values. The requested frequency was 800Hz.

rewrite the listed programs because the BASIC function statements—not necessarily the PRINT statements—are usually in English.

If you have some favorite programs you would like to share with others around the world you can submit them to Media Network, or Hobbyscoop for consideration. The BASICODE programs are presently



JUST FOR FUN, BASICODE has broadcast a program that creates a video clock.

received throughout a good part of Europe from NOS. They are also part of the BBC's computer-training broadcasts. Local transmitters broadcast the programs in Australia and New Zealand; and finally, they can be received in this country via English language short-wave broadcasts at 0230-0325 UTC on 9590 and 6165 kHz, and at 0530-0625 UTC on 9715 and 6165 kHz.

The Media Network program will shortly be available to radio stations in the U.S. for local broadcast, but until then, you'll have to get your "free" software via shortwave.

HIGH RESOLUTION COLOR MONITORS

There's more to computer-display resolution than meets the eye!

HERB FRIEDMAN

■Almost from the beginning of personal computing, we have referred to color displays in terms of resolution; there is low resolution, medium resolution, and high resolution. The individual picture elements that make up the display have been described in terms of dots, pixels, PELS, and total resolution of dots × lines.

What is resolution?

In fact, the picture resolution—meaning the number of individual picture elements that can be displayed—is relative to the existing technology: Yesterday's "high resolution" is today's "medium resolution" while today's "high resolution" is tomorrow's "low resolution."

Unlike a monochrome monitor, whose *apparent* visual sharpness depends almost entirely on the unit's bandwidth, color-monitor resolution is presently a combination of several variables, the most important being the size of the triad (a triad is made up of one red, one green, and one blue phosphor), the number of triads in a picture element, and the size of the displayed characters in terms of the number of active scanned lines. "Active lines" are those lines used for the computer display; it does not include the lines left unused to compensate for overscanning.

For multi-color reproduction, approximately 320 individual horizontal picture-elements per line is about the best we can do under normal circumstances. (That used to be considered *high-res*, but today, it's medium resolution.) The primary limitation on the number of horizontal elements is the size of a single dot of a character's matrix on standard color CRT's used for personal computer monitors, which translates into the maximum number of horizontal characters.

For example, characters for the so-called 80 × 25 screen are usually formed from an 8 × 8 dot matrix. In non-technical terms, it means each character is 7 dots high and 6 or 7 dots wide; the unused dots providing the spacing between characters and rows. Therefore, 80 columns of characters require 80 × 8 or 640 dots per horizontal line. A 40-character display requires 40 × 8 or 320 dot resolution.

It is the same thing going vertically. 25 lines requires 25 × 8 or 200 horizontal lines. (Aha! Now you see how screen resolution values are derived.)

Therefore, a high-res screen—80 characters × 25 lines—requires 640 × 200 resolution. A medium-res screen—40 characters × 25 lines—requires 320 × 200 resolution. Anything less, such as 32 characters × 16 lines is low resolution.

Standards

How did we come to more or less standardize on 32 × 16, 40 × 25, etc.? Mostly, to accommodate existing monitor equipment such as overscanned TV sets; sometimes because it's the most that can be safely put on the screen. To increase the size of the characters by going to a 9 × 9 or 10 × 10 matrix would reduce the number of columns or rows, or would require special monitors if the display wasn't to be "stretched" right off the top, bottom, and sides of the screen.

TV is a compromise

Until very recently, personal computer color displays were intended to be viewed on a TV receiver (through an RF modulator), or on a composite monitor originally intended for TV viewing; hence, the computer's color resolution was designed to function within the limitations of TV equipment, for which a resolution of 240 elements (dots) per line was—and still is—excellent. In relative terms, however, it is "low resolution."

Also, a computer's vertical resolution is designed for approximately 100–200 lines, depending on whether it "full frame" the display; that is, the monitor's scanning is adjusted so the actual corners of the display barely touches the sides of the CRT, creating a complete picture rectangle on the CRT with dark (no picture) areas at the top, bottom and sides. If you turn up the monitor's brightness or contrast controls, you will actually see a complete rectangle on the CRT, right down to the corners. (Try this on a modern Radio Shack or IBM monitor—you'll see why their displays are uniformly sharp from corner to corner.)

By keeping the color guns away from the circumference of the CRT, the focusing and overall convergence error is reduced. And while the display might be smaller in size than an overscan on the same CRT, the overall definition is higher.

By the way, the 200-line non-interlaced scanning is how one form of "highlighting" is created. Imagine for a moment a screen display of a word processing document. The normal character intensity is produced by scanning the characters for two fields per frame. For "highlighting"—actually reduced intensity—the highlighted characters are only scanned for one field. Simple but effective.

Good but not great

While the lower-cost computers—those usually called "home and family"—use TV sets or composite-video monitors for the computer's display, the business computers, almost without exception, provide for the so-called RGB monitor, even if they also have a composite video output connection. The problem with using composite monitors with computers is that they use analog video signals. While they can do a good job of creating computer displays, they are not the equal of an RGB monitor whose three color guns are controlled individually by the computer.

The RGB monitor

As shown in Figure 1—a block diagram of the RGB high-performance, high-resolution Princeton *SR-12* monitor—the computer outputs digital data for each individual color gun along with a digital signal representing intensity. A matrix interpolates the digital data into individual R, G, and B drive signals, which produce 8 colors: black, green, red, blue, brown, cyan, magenta and white. (There's no error in the preceeding. While RGB should produce yellow, not brown, in a high-performance monitor such as an IBM, a Quadram *HX-12*, or a Princeton *SR-12*, the base color is brown, and the intensity-modified brown is yellow.)

When the intensity bit is combined with the computer's RGB data in the monitor's color matrixing circuit, the resultant colors are: dark grey (intensified black), light blue, light green, light cyan, light red (which is the only red provided by some monitors), light magenta, yellow (a true yellow), and pure white (a super white). Altogether, 16 colors.

Tiny dots

But whether the monitor is mono or color, the average monitor is still 200 lines, so the apparent sharpness is determined by the size of each dot, and the smaller the dot, the sharper the appare

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400 lines

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Since the computer's normal character and graphics generators produce 200 lines per field, we obtain 400 lines by generating artificial lines of information. The "extra" lines are positioned directly between the normal scanning lines in the normal "interlace" location. The inherent "bloom" of each dot blends the lines together, and the eye sees a continuous character.

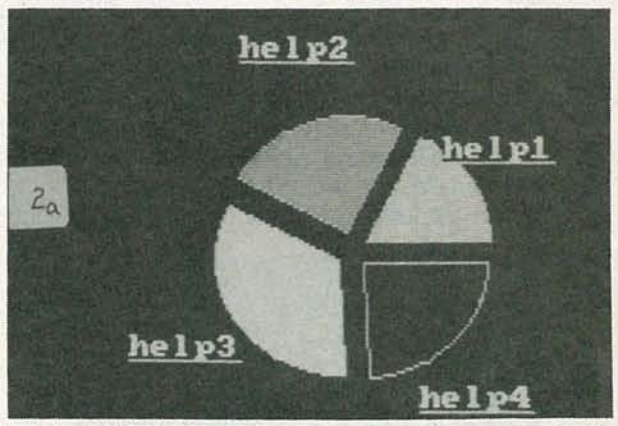

FIG. 2—A DISPLAY as seen on the screen of a Quadram *HX-12* 640 × 200 high-performance monitor shows that though the characters are "sharp as a tack" (for a color monitor) there is an illusion of unsharpness because of the space between the scanning lines.

Figures 2 and 3, photographs from two high-performance, moderate-cost monitors, show how it's done. Figure 2 is from a Quadram *HX-12*, one of the highest performance 200-line monitors: By any standards, it is sharp! Figure 3 is the same display from the Princeton *SR-12*. Note that no scanning lines can be seen. While the edges of the characters displayed on the *SR-12* are not as sharp as those of the *HX-12*, the *SR-12*'s *apparent* sharpness is greater because the normal scanning lines are "filled in."

A good question

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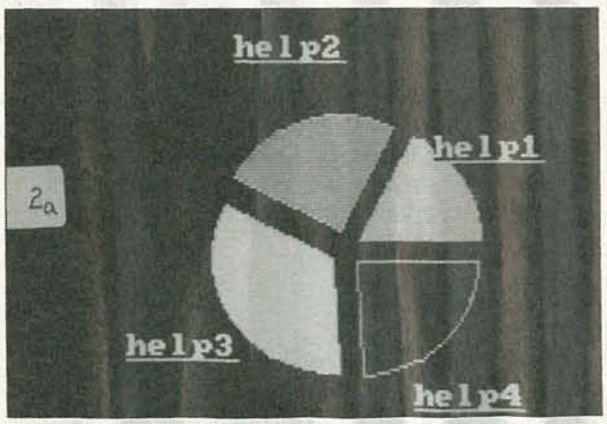

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A good question at this point, is "How can the *SR-12*

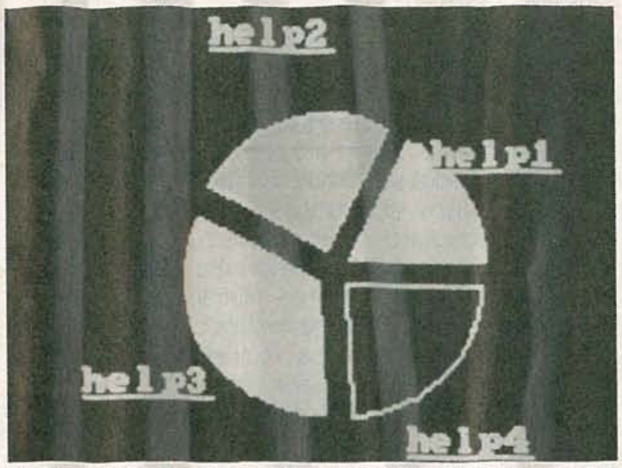

FIG. 3—THE SAME DISPLAY from a Princeton *SR12* 640 × 400 high-performance monitor shows no spaces because an additional 200 lines repeating the same data has been interleaved with the original 200 lines. While the edges of the characters are not as sharp as those on the 200-line monitor, visually the display appears sharper and seems to have greater resolution because there are no spaces between the scanning lines.

get sufficient time to scan two lines in the conventional horizontal scanning period?" By using a device known as a *scan doubler*—A plug-in adapter board for IBM-compatible computers (see Fig. 4).

It works this way. The horizontal scan rate of the *SR-12* monitor runs at a nominal 31.4 kHz, which is twice the conventional horizontal scanning rate of 15.75 kHz. During the conventional horizontal scan period, the *SR-12* scans two lines. But the computer still puts out its signal at 15.75 kHz: If fed directly to the *SR-12*, the single-line display would be spread over two lines and the screen would be a scramble of "garbage."

That's where the scan doubler comes in. Instead of the computer's RGB signal being fed to the monitor, it is fed to the scan doubler, which contains two memory banks and an output switcher. The computer's first line

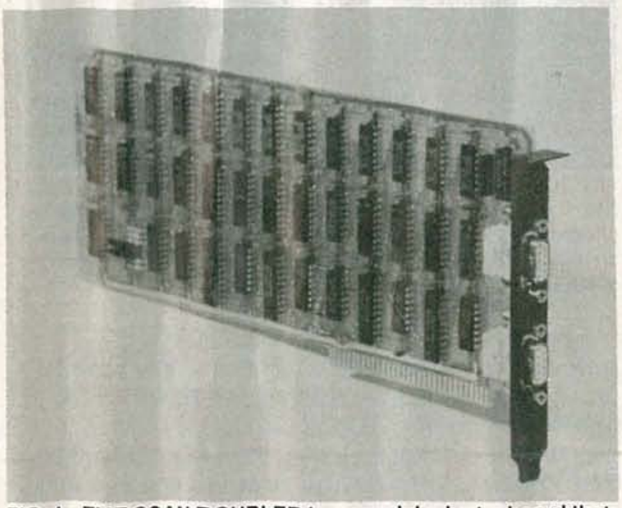

FIG. 4—THE SCAN DOUBLER is a special adapter board that generates 400 lines of display from what is normally a 200-line screen. The computer's normal signal is fed into the lower jack instead of to a monitor. The synthesized 400-line display exits at the top connector to the monitor.

of data is stored in the scan doubler's first memory bank. When memory is full, its data is output twice to the *SR-12* at twice the normal horizontal scanning frequency, so two complete lines are scanned in the same time period of one standard scan; hence, the computer's first display line is scanned on two sequential monitor lines—scan line 1, and what we will call scan line R1—for repeat line 1.

While the monitor is scanning line 1 and R1—each of which corresponds to a single line of data from the computer—the scan doubler's second memory bank is being filled by the computer with the second line of data. When the monitor is finished scanning the first line of data for the second time, the scan doubler switches its output to its second memory bank, which provides the data for monitor lines 2 and R2.

As the scan doubler's second memory bank is being dumped into the monitor, the first memory bank is overwritten by the computer with the data for line 3 and R3.

By continuously switching its output between memories 1 and 2, the scan doubler creates a 400-line monitor display from only 200 lines of data.

The visual effect is spectacular. The display has no visible lines; it is continuous.

Voodoo resolution

Nothing stands still. If equipment has reached the stage beyond which there is no improvement in performance, then someone will invent improvements.

For reasons we have mentioned earlier, a business computer display is more or less standardized at a maximum of 640 dots × 200 lines in order to put everything on the screen within the area of maximum definition. Naturally, if it were possible to fill each complete horizontal line end-to-end, and if it were possible to use the unused vertical lines at the top and bottom of the screen, theoretically, the screen would resolve more dots. And that's precisely the assumption being used to create the illusion of even greater monitor resolution. Manufacturers are now starting to include the "phantom" data in the overall screen specifications, and we get claimed resolutions of 690 dots, 900 dots, 360 lines, 480 lines.

Yes, all that is possible, but not with conventional "business" computer equipment. Some specially-designed graphics and "text" adapters are capable of generating those seemingly unbelievable displays, but their common use is somewhere down the road. We'll cover them when they are generally available and cost-effective. Meanwhile, keep those *magic figures* in mind: *640 × 200 and 320 × 200*. For "medium resolution," multi-color displays, a 320 × 200 resolution is required. And though we call that "medium" resolution, it is actually high resolution for color, because the so-called high resolution display of 640 × 200 is used for only two colors, which happens to be monochrome (black-and-white is two colors, as is any monochrome display). Presently, within the constraints of moderate costs, we cannot generate higher multi-color resolution than approximately 320 × 200 lines unless we artificially create a 400-line display through the use of a scan doubler.

TABLE 1

A0—Toreador
B0—William Tell
C0—Hallelujah Chorus
D0—Star Spangled Banner
E0—Yankee Dookle
A1—John Brown's Body
B1—Clementine
C1—God Save the Queen
D1—Colonel Bogey
E1—Marseillaise
A2—America, America
B2—Deutschland Leid
C2—Wedding March
D2—Beethoven's 5th
E2—Augustine
A3—O Solo Mio
B3—Santa Lucia
C3—The End
D3—Blue Danube
E3—Brahms' Lullaby
A4—Hell's Bells
B4—Jingle Bells
C4—La Vie en Rose
D4—Star Wars
E4—Beethoven's 9th
F1—Westminster Chime
F2—Simple Chime
F3—Descending Octave Chime

How it works

As we can see from the ringer schematic in Fig. 1, the heart of circuit is IC1, General Instrument's AY-3-1350 melody-synthesizer IC. Since power consumption is extremely low in the standby mode, the entire circuit can be powered by a single 9-volt transistor-radio type battery. IC2 is a TCM1512 telephone ring detector IC that is powered by the telephone line.

The circuit's operation begins when IC2 senses a ring pulse on the telephone line. The detector (internally) rectifies the ring signal and then outputs a voltage to relay RY1 (a SPST reed-type relay with 5-volt contacts), causing its contacts to close. That pulls pin 12 (the ON/OFF control) of IC1 low (logic "0"), causing it to output a signal—the selected tune—to transistor amplifier Q2. The amplified signal is then fed to the speaker.

The melody continues to play either until the tune is finished (at which time IC1 returns to the standby mode), or until someone takes the phone off the hook. Taking the phone of the hook discontinues the ring pulses to IC2, which opens RY1. When the relay contacts open, pin 12 of IC1 goes high, returning the circuit to the standby mode to wait for the next incoming phone call.

When connecting the circuit to the telephone line, it's a good idea to use a meter to distinguish the positive side of the line from the negative. That's important for proper operation. Pin 1 is the positive (tip) input and pin 8 is the negative (ring) input, as shown in Fig. 1.

The desired tune is selected using two double-pole, 6-position switches, S1 and S2. Each tune is assigned a letter/number combination. To select a tune, dial the switches to the combination that corresponds to the tune desired as shown in Table 1. For instance, if the theme from Star Wars is desired, S1 is dialed to "D" and S2, to "4."

All components are available from a wide range of sources (including Radio Shack). Potentiometer R1 controls the pitch of each note, while R2 is used to set the speed at which the tune is played. Therefore, each can be set to satisfy personal taste (which is what the circuit is all about).—*John P. Keyerleber* R-E

DRAWING BOARD

Understanding memory IC's

ROBERT GROSSBLATT

THERE'S NO DOUBT THAT THE ELECtronic superstar of the 1980's is the computer. People are buying them like umbrellas in a rainstorm, whether they need them or not. In what has to be the classic case of consumer brainwashing, the public has been convinced that the list of life's basic necessities now includes a 64K memory. Well, it just ain't so!

There's a lot more to electronics than just computers. Died in the wool "hardware hackers" like you and me should look at computers the same way we look at any other piece of electronic equipment—as "hardwired databooks."

Understanding a few of the techniques used in putting those machines together can go a long way in solving problems that show up in our own designs. The nice part about dealing with computers on that level is that you don't have to buy one. All you really need is a good databook that describes computer circuitry and explains its operation.

Computers are heavily memory-dependent machines, and plenty of design time has gone into developing memory techniques that are as efficient as possible. Memory can make your life on the bench a lot easier as well, so it's definitely worth the time to take a good look at memory devices.

Computers use both ROM, (*R*ead-*O*nly *M*emory) and RAM (*R*andom-*A*ccess *M*emory). We'll start with the RAM since it's a lot more fun to play around with your own data. (We'll talk about ROM in a future discussion.)

RAM comes in two flavors—*static* and *dynamic*. The difference between the two has to do with how data is stored. Static RAM will hold data as long as its powered up, while dynamic RAM must be refreshed every so often. But before we get into the details, take a look at Fig. 1, a block diagram of a typical static RAM.

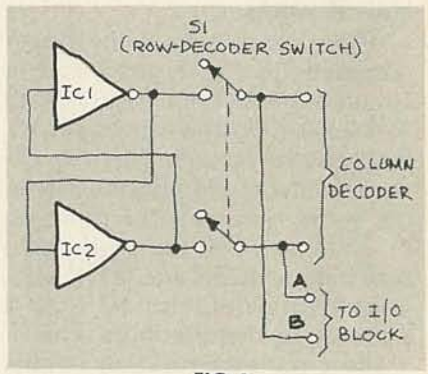

FIG. 2

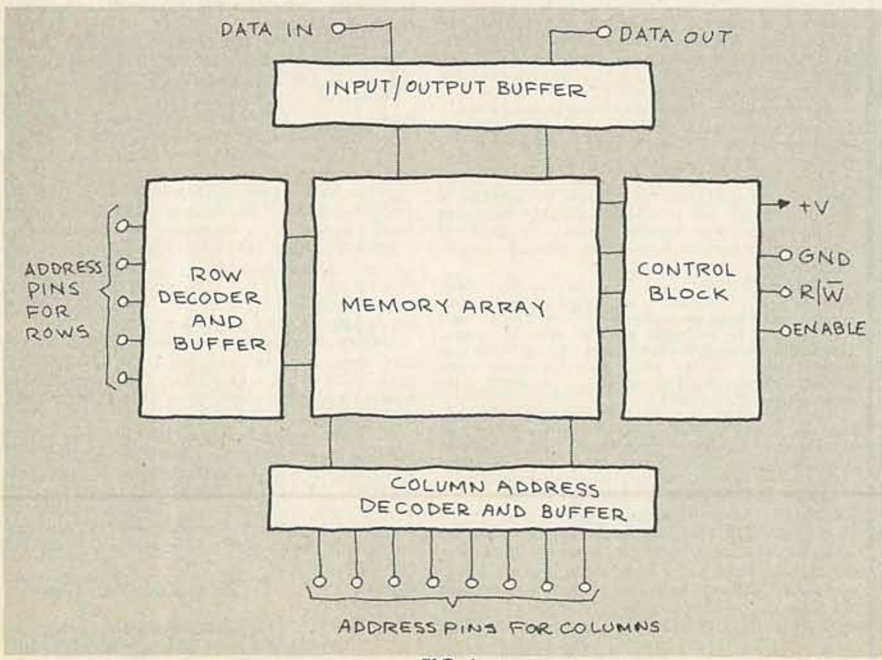

FIG. 1

Static RAM

There are three main parts to the static RAM IC: The memory-cell array; the address decoders, and the input/output (I/O) block. The heart of the device is the memory array (a matrix of storage cells). Each cell is capable of storing one bit of data (either a one or a zero). The actual construction of the cell depends on the logic being used, but the basic idea is the same for all families.

Figure 2 shows the basic storage principle; two inverters are set up as a simple latch with switches at the outputs to control read and write operations. The cells are arranged in a matrix. The number of rows and columns in the matrix are what determine the size of the memory.

When you want to do something to one cell, you put the address on the address bus, and the row and column decoders are used to close the switches surrounding the cell you've selected. The thing to note here is that as long as any cell remains unselected, it's not connected to anything; and whatever data you have there will stay there.

The same operation that picks a particular cell also connects it to the I/O logic in the IC, giving you the option of reading or writing data to that cell. Reading is simple because merely selecting the cell connects it to the I/O block and the data that's there to be read.

Of course, the data from that cell has to be conditioned before it can be used in the real world, since the inverters used in each cell won't have enough punch. That conditioning takes the form of an amplifier called, naturally enough, the *sense amplifier*. That amplifier has a very high input-impedance so it doesn't load down the cell and run the risk of glitching the data that's already stored there.

Writing new data into memory is just as simple; select the location, set up the data, and then flash a write pulse to the IC. The "nuts and bolts" of it is really no different from writing to a home-made latch. Since the two outputs of the storage cell will always be opposite in sense (remember that it's just a simple latch), a write operation is accomplished by grounding the column decode lines.

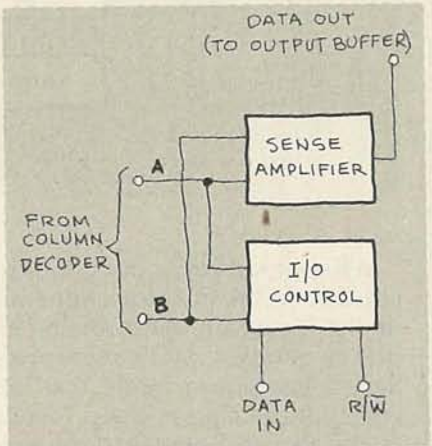

FIG. 3

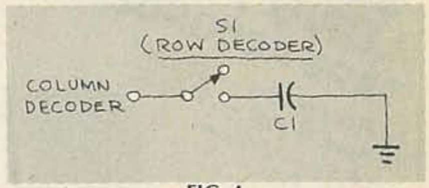

FIG. 4

Figure 3 is a simplified representation of what happens. To keep the design of the device as simple as possible, the column lines are used to carry the cell outputs to the I/O block. Data is read off one line, but both lines are needed to write. If you want to store a zero, you ground the A line and for a one, ground the B line.

The I/O block has a few other jobs to do as well. It selects the line that is to be grounded during a write, and it also has the circuitry that controls the overall status of the IC. How extensive the block is depends on the particular memory you're using. Most RAM's have a CHIP ENABLE pin that will let the outputs be three-stated. That is important if you have several memories sharing the same data.

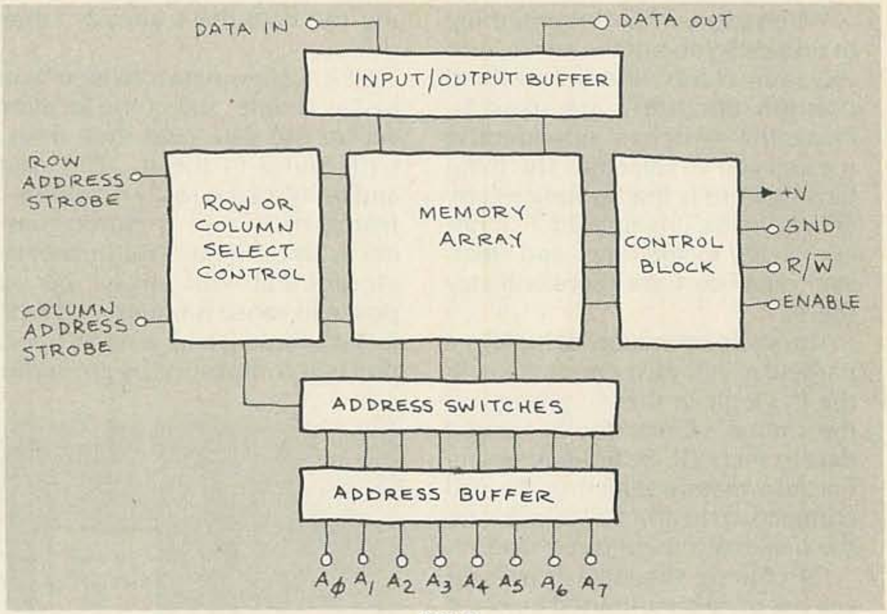

FIG. 5

What other kinds of "goodies" you find in the I/O block depends on the logic technology the memory is using. CMOS memories have a low-power mode that lets you "put the chip to sleep," while saving all data. Some of the memories we'll be looking at need as little as 1 μA (or less) to save data! That should bring all sorts of battery-backup schemes to mind. (You can be sure that we'll get into that in some detail in a future discussion, but for now, let's stick to memories.)

Memories that are organized to handle more than one bit at a time (256 × 4, 512 × 8, etc.) have to have a separate memory matrix for each data line. A 256 × 4 memory will be four arrays deep, and each of them will have its own set of I/O circuits. When you get to the point where you are stacking things eight layers deep, the design is getting really hairy and, as you would expect, it shows up in the price. That's why a 2048 × 1 memory is a lot cheaper than a 256 × 4. The total storage is the same but the complication of the internal design is much greater.

Static RAM's are easy to use; most modern designs are really forgiving of the screw-ups that always manage to show up during breadboarding. When you start talking about dynamic RAM, however, all notions of friendliness have to be thrown out the window.

Dynamic RAM

Because of the way a dynamic RAM stores data, it can be a nightmare to use: Instead of nice stable inverters, it uses a single capacitor...and nothing else! (See Fig. 4.) Since the leakage time is usually measured in microseconds, some scheme is necessary to make sure that the data stored in memory stays put. That problem is solved is by periodically rewriting the data in each cell. That process, called *refresh*, is handled by the sense amplifier that's connected to each column.

When a row and column are selected, the first thing the sense amplifier does is to read the data from each cell in the row and then write it back in. Since only one column is selected, only that cell has its output channeled to the data bus. Every read, then, refreshes the entire row. Modern RAM has built-in circuitry to refresh the entire IC during a read, and a whole row can be refreshed by just addressing it. However, that doesn't make refreshing any better—just a little bit easier!

Many popular dynamic RAM's use the same pin for both row and column addressing. Two control pins—the row and column strobes—are used to tell the RAM which addresses are on the bus. It's still up to us, however, to make sure that the right stuff is at the right place at the right time.

Figure 5 is a block diagram of a

dynamic RAM and if you study it you'll be able to see how its pins relate to each other. Keep in mind that there's plenty of detail in the IC that has not been drawn in. If you're morbid enough to want to get into the anatomy of a dynamic RAM, you can find a complete diagram in any good databook. (You might also drop me a line and give me your reason.)

The question that should come to mind at this time, however, is: Why in the world would anybody decide to use dynamic, rather than static, RAM? The answer is simple—it makes more economic sense: Because the cells are smaller, you can stuff more of them into the same size IC. That means that more memory is available for a lot less money.

By now you probably know more than you ever wanted to know about what goes on inside RAM...and believe me when I tell you that there's a lot more we could talk about. But, being practical minded, let's end the whole discussion here. After all, what we're interested in is not so much how those things work, but how we can use them.

Over the next few months we'll see how memory IC's can cut "brain-blasting" circuit hassles down to nothing, and we'll also design some circuits that you can adapt for your own purposes. You'll find that memories are good for a lot more than just remembering! And if you want to use huge amounts of memory, we'll design refresh circuitry that can not only handle any amount of memory you want, but is completely transparent as well.

So that you can get ready for it, let me remind you of a short corollary to Grossblatt's 18th rule: Get it in writing. In other words, pick up a databook containing the specifications for both *static* and *dynamic* RAM. The timing diagrams are invaluable design aids and are sure to prove their worth since there won't be room to print them in the column. You'll find that having well-drawn timing diagrams in front of you as you're working is the only known cure for the dreaded memory disease known as "electronic amnesia" or, more technically, "silicon senility." **R-E**

STATE OF SOLID STATE

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

High power FET's

UNTIL A FEW YEARS AGO, FET'S COULD handle only about 1 watt and, therefore, could not compete with SCR's or bipolar power devices. That's because, as shown in Fig. 1, the planar technology used has the drain, gate, and source on the top surface of the die.

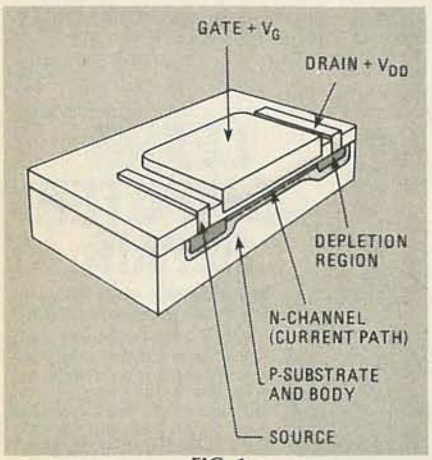

FIG. 1

High-power devices require relatively large metalized terminals to handle the high drain and source currents. Therefore, for increased power-handling capacity, the die size must be increased. Unfortunately, increasing the size results in high inter-electrode capacitances that severely limit the high-frequency response of the device. Further, the high current traveling through the narrow lateral channel develops a significant voltage drop (producing a correspondingly high ON resistance).

However, about seven or eight years ago, a new technology aimed at increasing the current density of the MOSFET was developed. In that structure (dubbed VMOS), the gate and source are side-by-side on the top surface of the die, while the drain is on the bottom.

Impurities are added (by a process called *doping*) to an epitaxial (single crystal) layer of silicon to promote vertical current flow. In addition, some versions of the VMOS device have a V-shaped notch etched through the source and channel regions to enhance vertical current flow.

Enter TMOS

The TMOS name identifies the technology of Motorola's vertical-channel MOSFET's. Its structure is illustrated in Fig. 2. The unique TMOS design, with thousands of "source" sites connected in parallel on a single die, makes possible a very short vertical channel that carries heavy currents, but still has a low ON-state voltage drop. A polysilicon gate material enhances switching speed, while an oxide layer electrically isolates the gate from the source.

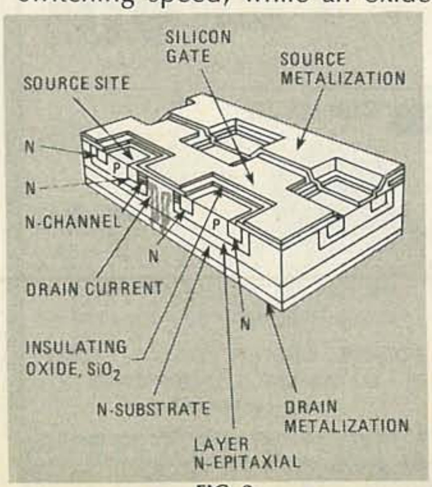

FIG. 2

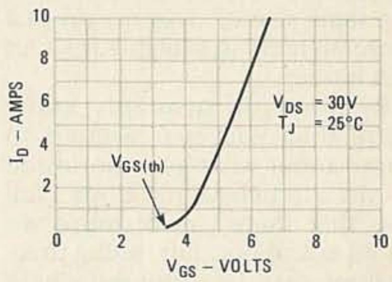

FIG. 3

The input resistance of TMOS devices is extremely high—10^9 ohms—resulting in a leakage current of only a few nanoamperes. Source-to-drain current is controlled by applying a positive voltage to the gate that's just slightly higher than the gate-to-source threshold voltage, $V_{GS(th)}$. The graph in Fig. 3 shows the transfer characteristics for Motorola's MTM5N35/40 devices, which is typical of N-channel, enhancement-mode FET's.

The extremely high input-impedance and the relatively low gate-drive voltage requirement make the TMOS ideally suited for control of high-power directly from low-level CMOS and TTL logic circuits, if enough current is supplied to charge the input capacitance, C_{iss}.

The TMOS FET has inter-electrode capacitances—gate-to-drain (C_{gd}), drain-to-source (C_{ds}), and gate-to-source (C_{gs})—similar to those of a triode vacuum tube. The input capacitance is $C_{iss} = C_{gd} + C_{gs}$; output capacitance, $C_{oss} = C_{gd} + C_{ds}$; and the reverse trans-

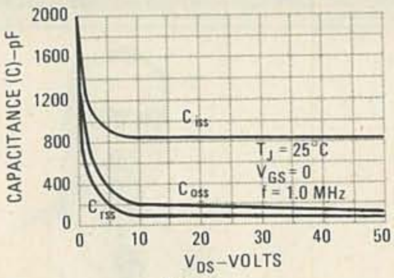

FIG. 4

fer capacitance, $C_{rss} = C_{gd}$. Figure 4 shows the relationship between those capacitances, which are a function of the drain voltage.

The input capacitance of a MOSFET is important and must be considered in circuit design. On a transient basis, gate current flows to charge C_{iss} before the gate gains control over drain current. The driving (or generator) impedance, R_{gen}, and C_{iss} affect the switching speed. The lower R_{gen} the faster the switching speed.

For additional information on TMOS technology and device characteristics, refer to Motorola's 20-page *Power MOSFET Selector Guide and Cross-Reference* (SG56, Rev. 5). Request your copy from **Motorola Semiconductor Products**, PO Box 20912, Phoenix, AZ 85036.

RCA Solid-state product guide

The Solid-State Devices Product Guide is a new 56-page publication covering basic descriptions of RCA's extensive product line of solid-state devices. It includes power MOSFET transistors and ultra-fast recovery rectifiers (two new additions to RCA's family of semiconductors).

Other selections include bipolar power-transistors, thyristors, IR emitters, injection lasers, linear and digital logic IC's, microprocessors, and numerous other devices. The guide summarizes the devices in each product category and highlights their pertinent features and applications.

Single copies of the Solid-State Devices Product Guide (No. SPG-201M) are available from RCA distributors and from **RCA, Solid State Div.**, Route 202, Somerville, NJ 08876 or by calling toll-free number (800) 526-2177.

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Available in TO-99 packages, the 1346 and 1347 are specified over a temperature range of 0°C to +75°C, while the 1346-01 and 1347-01 are specified for the −55°C to +125°C temperature range. Each unit features ± 250 mA bias current, ± 0.5 millivolt maximum offset, 2µs settling to ± 0.1%, and 300 millivolt maximum power consumption.—**Teledyne Philbrick, Microcircuits**, Allied Drive at Route 128, Dedham, MA 02026. **R-E**

SERVICE CLINIC

Servicing electronic test equipment

JACK DARR,
SERVICE EDITOR

EVERY NOW AND THEN, WE ALL FEEL THE need to check up on some of our test equipment. (Nagging doubts about the accuracy of test instruments are bound to crop up ever so often.) Contrary to what you've been led to believe, verifying the accuracy of test instruments is really a simple task—although that can't always be said for repairing them.

Perhaps the easiest measuring devices to check and repair are VOM's (volt-ohmmeters) and DVM's (digital voltmeters)—the most basic and widely use test instruments in any collection. Once you know that your basic instruments are working accurately, you can go a long way in repairing other equipment as well, so let's start there.

Meter repair

There are several ways to verify voltmeter accuracy. The quickest is with a known voltage source (batteries). A new battery, even the common Leclanche (dry cell), has a relatively stable voltage—close to 1.56 volts—if it hasn't been used. A mercury cell is a better voltage source in test procedures where a reference is needed; it will hold its open-circuit voltage for an amazingly long time. Various voltages are available in mercury cells, so check to make sure that you're getting exactly what you want.

Let's assume that we are using a standard dry cell, whose voltage is usually around 1.56 volts. In checking your meter's accuracy, set it to the voltage range and apply the dry-cell voltage directly to the meter's input. If the meter indication agrees with the reference (1.56V), then it's a safe bet that range is OK! If not, then you'll have to find the voltage-divider network, locate the resistor that's causing the problem, and replace it.

FIG. 1

A word of warning: The resistive elements in a meter are wirewound, precision types—so replacements should be the exact values specified. Also, the resistors called for are usually not standard values; that can be handled by paralleling several resistors to obtain the value needed.

You can also check the higher meter ranges to make sure that the resistors in the voltage-divider network have not changed in value. To check higher ranges, remove the back of the meter and locate the divider network, using the schematic of your unit. Change the meter setting to the next higher range and apply the reference voltage to the point that corresponds to the input of to that range.

If your unit is a DVM, the reading will be about .156, because of its 10× ratio. Analog meters, on the other hand, may show a slightly reduced voltage. However, a difference of a few microvolts in both cases is OK.

In checking the resistance ranges, set the switch to ohms and check the swing of the needle to see that it travels all the way over past zero and then swings back freely. If it sticks anywhere, look out; you've got a problem!

One thing that makes the needle stick is "foreign matter," a small piece of iron, for example, lodged in the small gap between the coil and the core. Such objects physically impair the swing of the needle, or block it by getting caught up in the field around the movement's magnetic core. Carefully take the face plate off the meter and look inside the gap with a jeweler's loupe or strong magnifying glass.

The chances are you will be able to spot the obstruction. If so, take a small piece of tape, and carefully slip it into the gap; you should be able to catch particles on the sticky side. Caution: Never use a high-pressure air hose to remove tiny particles around the movement. A high-pressure air hose will scatter parts all over the bench and the meter will never be the same.

Signal-generator repair

Signal generators are probably the easiest instruments to check (and the hardest to fix). To check them, all you need is a radio! Simply zero-beat the signal generator with a broadcast station's carrier: Connect the signal generator to the receiver's antenna terminals and set the unit's attenuator to a low output. Tune the receiver to a station of known frequency.

Now vary the generator frequency in the direction of the stations carrier frequency. You should hear a descending or ascending tone, depending on whether you're headed toward or away from the carrier frequency. As the generator frequency nears that of the carrier, the tone will fade and, at some point, completely disappear. The tolerance of the calibration should be held to within ±5 cycles of the assigned carrier frequency. (I've had to wrestle with a few that wouldn't reach that tolerance.)

If you can get your hands on a communication-type receiver, you can check several other things. By tuning to the fundamental frequency, you can use the second harmonic, 1250 kHz, 2950 kHz, and so on, to get a more accurate indication.

Similarly, a TV station's video carrier may be used. Here the object is to set the generator for the lowest number of "bars" on the screen. Simply follow the same hookup procedure used with the radio receiver, and watch the number of bars on the screen. When you reach the point where the least number of bars are shown, you're right on the station's frequency.

Often, signal generators (like the one in Fig. 1) have a built-in crystal, sometimes on 4.5 MHz, etc, which can be used for checking. Others have 1,000 kHz (1.0 MHz) crystals, which can be used by checking for "birdies" every 1.0 MHz. If a signal generator is badly off, (which seldom happens) you can reset it. Look in the owner's manual for the location of the trimmer capacitors for the different bands.

You can also tune in WWV (the standard time and frequency station) on 2.5, 5.0, 10.0, and 15.0 MHz. For audio checks, the tone modulation is the standard 440 Hz, which can be very handy. Follow the calibration procedure to the letter, especially the adjustment sequence. Doing so will make the job a breeze.

In addition, lower frequencies can be checked using harmonics. For example, you can check 1.25 MHz (1250 kHz) by beating its second harmonic against 2.5 MHz from WWV, or some other source.

Oscilloscope repair

Oscilliscopes can be checked using a squarewave audio signal. That is done by feeding the squarewave signal to the input of the vertical amplifiers, and watching the display for signs of rounding corners, or any other distortion. If the display shows a good clean squarewave, those stages are all OK. But if they're not, the trouble is most likely in the coupling capacitors! I speak with the voice of experience. (I've fixed many old scopes in the past.) **R-E**

SERVICE QUESTIONS

INTERMITTENT STARTING

I've got an RCA CTC 68 that's giving me the fits. Sometimes it starts, sometimes it doesn't. When it fails to start, I hear a squeal, and then the circuit breaker trips. I've changed the two SCR's and diodes CR401 and CR402.—C.M., Franklyn, KY

The solder connections under T401, 402, and 405, especially T405, have been known to give a great deal of intermittent problems. I would also not overlook the possibility of an intermittently open filter capacitor.

HOT SET

On a GE 10HD chassis, I have bottom foldover and poor linearity. The vertical tube and the linearity control both run too hot. The oscillator grid reads −25 volts instead of the −35 volts I should have.—R.D., Greenville, SC

I would be more interested in the reading on the output grid. If that is too low, the output section of the twin-triode tube will draw too heavily, accounting for all that heat. My first suspect would have to be the coupling capacitor, C203, followed by the grid return resistors. R-E

EQUIPMENT REPORTS

continued from page 81

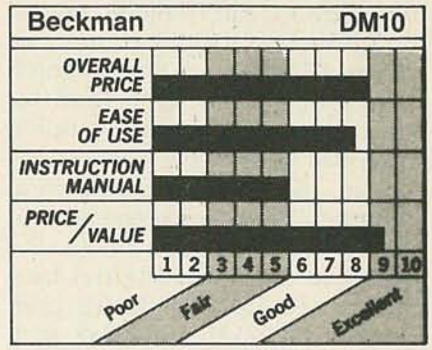
of 1 megohm, circuit loading should be minimal in most cases. The *DM-10* is protected against excessive voltage to 500 volts DC and 350 volts AC on the 200 mV range. On the higher ranges, the protection ratings are twice those figures.

The AC voltage accuracy specification is ±1.2%, +1 digit. The input impedance is 450 kilohms in the AC-volts mode, and the meter is protected up to 500 volts AC or DC.

The accuracy specifications for the resistance mode should also please any hobbyist: ± 1%, +3 digits is the worst-case specification. The open-circuit voltage is less than that needed to turn on a semiconductor junction, so you can make some in-circuit measurements without sacrificing accuracy.

The accuracy of the meter in the DC current mode is ±1.2%, +1 digit. Overload protection is provided by a 800-mA, 250-volt fuse in that mode, and the voltage burden is 325 mV.

The final mode of the *DM-10* is its diode-test mode, which lets you quickly test semiconductor p-n junctions. The maximum open-circuit voltage is 3.2 volts, and the maximum current is 1.2 mA—just enough to dimly light a standard LED.



The manual

The manual we received with the *DM10* was not what we'd normally expect from Beckman. While that manual did contain acceptable operating instructions and a specifications sheet, it did not have any calibration instructions, parts list, or circuit schematic. In fairness, we should point out that our manual was only a preliminary copy. We hope that the finished manual is much more informative.

The *DM10* may not have all the features you want: It does not include an audible continuity beeper, a high-current range, a tilt stand, or autoranging, for example. However, even without those features, it is a good, basic meter for most hobbyists. The meter should also be at home in a technicians toolbox—its small size makes it ideal for field work. Perhaps the best feature of the *DM10*, however, is its price, which is just $39.95. Beckman was able to keep the price down by not including the "extra" features that we mentioned. They also kept manufacturing costs down: Most of the circuitry is contained on a VLSI analog-to-digital converter chip, and all of the circuitry—including the switch contacts—is contained on a single PC board. **R-E**

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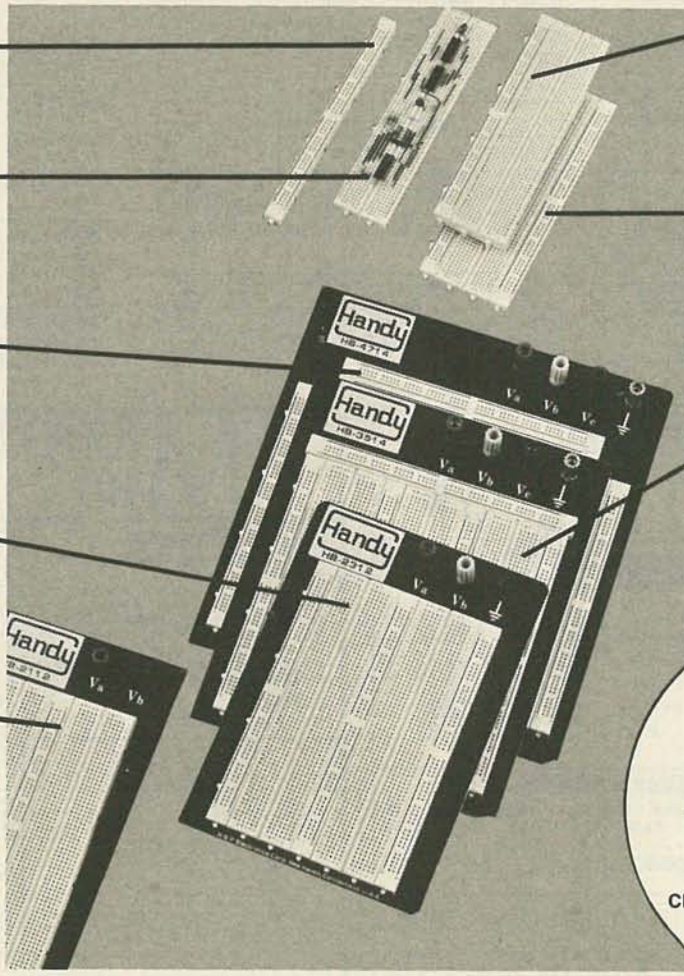

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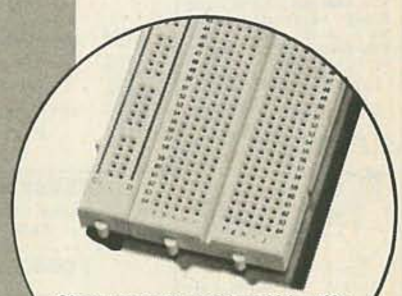

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2.2k	271-1325
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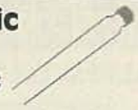

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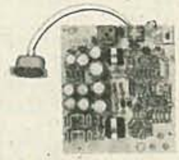

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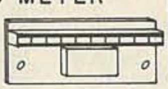

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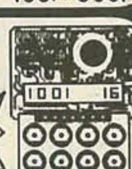

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SN7402N	14	.29	SN7476N	16	.39	SN74161N	16	.59
SN7403N	14	.29	SN7479N	14	4.95	SN74162N	16	.59
SN7404N	14	.35	SN7480N	14	.89	SN74163N	16	.59
SN7405N	14	.49	SN7482N	14	1.49	SN74164N	14	.69
SN7406N	14	.59	SN7483N	16	.55	SN74165N	16	.69
SN7407N	14	.59	SN7485N	16	.59	SN74166N	16	.69
SN7408N	14	.29	SN7486N	14	.39	SN74167N	16	2.95
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SN7412N	14	.49	SN7492N	14	.45	SN74174N	16	.59
SN7413N	14	.39	SN7493N	14	.45	SN74175N	16	.59
SN7414N	14	.49	SN7494N	14	.89	SN74176N	14	.79
SN7416N	14	.49	SN7495N	14	.49	SN74177N	14	.79
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SN7420N	14	.19	SN7497N	16	3.25	SN74180N	14	.69
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SN7430N	14	.35	SN74123N	16	.55	SN74193N	16	.69
SN7432N	14	.39	SN74125N	14	.49	SN74194N	16	.69
SN7433N	14	.49	SN74126N	14	.49	SN74195N	16	.49
SN7437N	14	.25	SN74128N	14	.79	SN74196N	14	.75
SN7438N	14	.49	SN74132N	14	.59	SN74197N	14	.75
SN7439N	14	.79	SN74136N	14	.69	SN74198N	24	1.19
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SN7459N	14	.35	SN74153N	16	.99	SN74366N	16	.55
SN7460N	14	.39	SN74154N	24	1.49	SN74367N	16	.55
SN7470N	14	.39	SN74155N	16	.49	SN74368N	16	.55
SN7472N	14	.39	SN74156N	16	.59	SN74390N	16	1.49
SN7473N	14	.39	SN74157N	16	.49	SN74393N	14	1.49

74LS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74LS00	14	.29	74LS132	14	.65	74LS244	20	1.29
74LS01	14	.29	74LS133	16	.59	74LS245	20	1.49
74LS02	14	.35	74LS136	14	.39	74LS251	16	.59
74LS03	14	.29	74LS138	16	.59	74LS253	16	.59
74LS04	14	.39	74LS139	16	.59	74LS257	16	.59
74LS05	14	.35	74LS145	16	1.19	74LS258	16	.59
74LS08	14	.35	74LS147	16	1.95	74LS260	14	.59
74LS09	14	.35	[illegible]			74LS266	14	.49
74LS10	14	.35	[illegible]			74LS273	20	1.49
[illegible]								

74S/PROMS*

[illegible]

CA—LINEAR

[illegible]

CD—CMOS

[illegible]

(More in Catalog)

74F00 NEW 74ALS00

Part No.	Pins	Function	Price
74F00	14	Quad 2-Input NAND Gate	.69
74F02	14	Quad 2-Input NOR Gate	.75
74F04	14	Hex Inverter	.89
74F08	14	Quad 2-Input AND Gate	.75
74F10	14	Triple 3-Input NAND Gate	.75
74F32	14	Quad 2-Input OR Gate	.79
74F74	14	Dual D Flip-Flop	.85
74F86	14	Quad Exclusive OR Gate	1.15
74F109	16	Dual JK Positive Edge Flip-Flop	.95
74F138	16	Expandable 3/8 Decoder	1.69
74F157	16	Quad 2-Input Multiplexer	1.69
74F158	16	Quad 2-Input Multiplexer (Inv.)	1.69
74F193	16	4-Bit Up/Down Binary Counter	5.29
74F240	20	Tri-State Octal Line Driver (Inverting)	3.75
74F244	20	Tri-State Octal Line Driver	3.49
74F257	16	Tri-State Quad 2-Input Multiplexer	1.79
74F373	20	Tri-State Octal Latch	4.89
74F374	20	Tri-State Octal D Flip-Flop	4.59

Part No.	Pins	Function	Price
74ALS00	14	Quad 2-Input NAND Gate	.59
74ALS02	14	Quad 2-Input NOR Gate	.59
74ALS04	14	Hex Inverter	.59
74ALS08	14	Quad 2-Input AND Gate	.59
74ALS10	14	Triple 3-Input NAND Gate	.59
74ALS30	14	8-Input NAND Gate	.59
74ALS32	14	Quad 2-Input OR Gate	.65
74ALS74	14	Dual D Flip-Flop	.79
74ALS109	16	Dual JK Pos. Edge Flip-Flop	.79
74ALS138	16	Expandable 3/8 Decoder	1.25
74ALS240	20	Tri-State Octal Line Driver (Inverting)	2.25
74ALS244	20	Tri-State Octal Line Driver	2.25
74ALS245	20	Octal Bus Transceiver (Non-Inv.)	2.59
74ALS373	20	Tri-State Octal Latch	2.59
74ALS374	20	Tri-State Octal D Flip-Flop	2.59

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MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	19.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
Z80, Z80A, Z80B, Z8000 SERIES			
Z80	40	CPU (MK3880N) (780C) 2.5MHz	2.95
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	3.49
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4) (780C-1) 4MHz	3.49
Z80A-CTC	28	Counter Timer Circuit	4.49
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
Z8001B	48	CPU Segmented (10MHz)	79.95
Z8002B	40	CPU Non-Segmented (10MHz)	59.95
6500/6800/68000 SERIES			
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	4.95
6502B	40	MPU with Clock (3MHz)	8.95
6520	40	Peripheral Inter. Adapter	3.95
6522	40	Peripheral Inter. Adapter	5.49
6551	28	Async. Comm. Interface Adapter	10.95
6800	40	MPU	2.95
6802CP	40	MPU with Clock and RAM	7.95
6809	40	CPU — 8-Bit (On-Chip Oscillator)	8.95
6809E	40	CPU — 8-Bit (External Clocking)	9.95
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	14.95
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.95
68B21	40	Peripheral Interface Adapter (2MHz)	5.95
6845	40	CRT Controller (CRTC)	14.95
68B45	40	CRT Controller (CRTC) 2MHz	19.95
6850	24	Asynchronous Comm. Adapter	3.95
6860	24	0-600bps Digital MODEM	7.95
68000L8	64	MPU 16-Bit (8MHz)	39.95
68488P	40	General Purpose Int. Adapter	9.95
8000/80000 SERIES			
8031	40	Control Oriented CPU w/RAM & I/O	14.95
8035	40	MPU — 8-Bit	5.95
8039	40	CPU—Sgl. Chip 8-Bit (128bts. RAM)	5.95
8040N-6	40	CPU (256 bytes RAM)	9.95
8060	40	CPU — 8-Bit NMOS	14.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	4.95
8085A-2	40	CPU — 8-Bit N-Channel (5MHz)	11.95
8086-2	40	CPU 16-bit 8MHz	24.95
8087	40	Arithmetic Processor	189.95
8088	40	CPU 8/16-Bit	19.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8156	40	RAM with I/O Port and Timer	8.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.95
8224	16	Clock Generator/Driver	2.95
8228	28	System Cont./Bus Driver (74S428)	4.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	19.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	4.95
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8279	40	Prog. Keyboard/Display Interface	6.95
8282	20	Octal Latch	8.95
8284	18	Clock Generator/Driver	6.95
8286	20	Octal Bus Transceiver	7.95
8287	20	Octal Bus Transceiver (Inverted)	7.95
8288	20	Bus Controller	19.95
8303	20	8-Bit Tri-State Bi-Directional Trans.	3.49
8304	20	8-Bit Bi-Directional Receiver	3.49
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80186-6	68	High Integration 16-Bit MPU	99.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	89.95
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INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	24.95
FD1793	40	Single/Double Density (True)	26.95
FD1795	40	Dual Density/Side Select (Inv.)	26.95
FD1797	40	Dual Density/Side Select (True)	29.95
SPECIAL FUNCTION			
DS0026CN	8	Dual MOS Clock Driver (5MHz)	1.95
INS2651	28	Communication Chip	7.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM54240N	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
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MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

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Part No.	Pins	Function	Price
1103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	1.49
4116N-2	16	16,384x1 (150ns)	1.39 — 8/10.95
4116N-3	16	16,384x1 (200ns)	1.15 — 8/8.95
4116N-4	16	16,384x1 (250ns)	.89 — 8/6.95
4164N-150	16	65,536x1 (150ns)	5.19 — 8/40.95
4164N-200	16	65,536x1 (200ns)	4.95 — 8/38.95
MM5261	18	1024x1 (300ns)	.35 — 8/1.95
MM5262	22	2048x1 (300ns)	.35 — 8/1.95
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5298-3	16	8192x1 (200ns)	.59
41256-150	16	262,144x1 (150ns)	34.95
41256-200	16	262,144x1 (200ns)	31.95
48128	16	131,072x1 (200ns)	24.95
STATIC RAMS			
2101	22	256x4 (450ns) 8101	1.95
2102	16	1024x1 (350ns)	.89
2102-2L	16	1024x1 (250ns) L.P. (91L02)	1.49
2111	18	256x4 (450ns) 8111	2.49
2112	16	256x4 (450ns) MOS	2.49
2114N	18	1024x4 (450ns)	1.29 — 8/9.95
2114N-L	18	1024x4 (450ns) L.P.	1.95 — 8/13.95
2114N-2	18	1024x4 (200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4 (200ns) L.P.	1.69 — 8/13.49
2147HN	18	4096x1 (70ns)	4.49
2148HN	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	1.95
5101	22	256x4 (450ns) CMOS	3.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-2	24	2048x8 (120ns) CMOS	7.95
HM6116LP-2	24	2048x8 (120ns) L.P. CMOS	8.95
HM6116P-3	24	2048x8 (150ns) CMOS	4.95
HM6116LP-3	24	2048x8 (150ns) L.P. CMOS	6.49
HM6116P-4	24	2048x8 (200ns) CMOS	4.75
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	5.49
HM6264P-12	28	8192x8 (120ns) CMOS	37.95
HM6264LP-12	28	8192x8 (120ns) L.P. CMOS	39.95
HM6264P-15	28	8192x8 (150ns) CMOS	34.95
HM6264LP-15	28	8192x8 (150ns) L.P. CMOS	37.95
27LS00	16	256x1 (80ns) L.P.	3.95
7489	16	16x4 (50ns) 3101	2.25
74C921	18	256x4 (250ns) CMOS	5.95
74C930	18	1024x1 (250ns) CMOS (6518)	5.95
74S189	16	16x4 (35ns) 93405	2.95
74S289	16	16x4 (35ns) 3101	2.95
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25
PROMS/EPROMS			
1702A	24	256x8 (1μs)	3.95
2708	24	1024x8 (450ns)	3.95
TMS2516	24	2048x8 (450ns) 2716	4.95
TMS2532	24	4096x8 (450ns) NMC2532	5.49
TMS2564	28	8192x8 (450ns)	10.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	3.95
27C16	24	2048x8 CMOS	14.95
2716-1	24	2048x8 (350ns)	5.49
27160-5	24	2048x8 (550ns)	3.75
2732	24	4096x8 (450ns)	4.95
2732A-20	24	4096x8 (200ns) 21V	11.49
2732A-25	24	4096x8 (250ns) 21V	7.19
2732A-45	24	4096x8 (450ns) 21V	6.49
27C32	24	4096x8 CMOS	19.95
27C32A-30	24	4096x8 (300ns) 21V (CMOS)	22.95
2764-20	28	8192x8 (200ns) 21V	14.95
2764-25	28	8192x8 (250ns) 21V	7.19
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MCM68764	24	8192x8 (450ns) 21V	24.95
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74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	4.95
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74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
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82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
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DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
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DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	14.95
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DC10		Mostek DC/DC Converter +5V to −9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
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DAC1022	16	10-Bit D/A Conv. (0.20% Lin.)	5.95
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DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-5-1013A	40	30K Baud UART (TR1602)	3.95

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Part No.	1-9	10-99	100-up
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14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
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16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

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16 pin HC	.19	.17	.15
24 pin HC	.29	.25	.22

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DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ .... $34.95 ea.
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IBM PC AT

Each kit comes complete with nine 128K dynamic RAMs and documentation for conversion.

IBM128K (Nine 200ns 128K RAMs). $199.95

APPLE //e

Extended 80-Column/64K RAM Card. Expands memory by 64K to give 128K when used with programs like VisiCalc™. Fully assembled and tested.

JE864. . . . . $99.95

TRS-80 MODEL I, III

Each Kit comes complete with eight MM5290 (UPD416/4116) 16K Dynamic RAMs and documentation for conversion. Model 1: 16K equipped with Expansion Interface can be expanded to 48K with 2 Kits. Model III: Can be expanded from 16K to 48K using 2 Kits. Each Kit will expand computer by 16K increments.

TRS-16K3 200ns (Model III). $8.95
TRS-16K4 250ns (Model 1). $6.95

TRS-80 MODEL IV & 4P

Easy to install Kit comes complete with 8 ea. 4164N-20 (200ns) 64K Dynamic RAMs and conversion documentation. Converts TRS-80 Model IV computers from 16K to 64K. Also expands Model 4P from 64K to 128K.

TRS-64K-2. . . . . $38.95
(Converts the Model IV from 16K to 64K or will expand the Model 4P from 64K to 128K)

TRS-64K2PAL (Model IV only). $59.95
(8 - 4164's with PAL Chip to expand from 64K to 128K)

TRS-80 COLOR AND COLOR II

Easy to install Kit comes complete with 8 each 4164N-20 (200ns) 64K Dynamic RAMs and documentation for conversion. Converts TRS-80 Color Computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 Color Computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K-2. . . . . $38.95

INDUSTRIES *Protect Yourself...*

DATASHIELD® Surge Protector

· Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss · 6 month warranty · Power dissipation (100 microseconds): 1,000,000 watts · 6 sockets · 6 foot power cord · Normal line voltage indicator light · Brown out/black out reset switch

Model 100. . . . . $69.95

Protect Yourself...

DATASHIELD® Back-Up Power Source

Provides up to 30 minutes of continuous 120 VAC 60Hz power to your computer system (load dependent) when you have a black out or voltage sag · Six month warranty · Weight (PC200): 24 lbs.–(XT300): 37.5 lbs.

PC200 (Output rating: 200 watts). **$299.95**
XT300 (Output rating: 300 watts). **$399.95**

ProModem 1200 and Options

PROMETHEUS

Intelligent 300/1200 Baud Telephone Modem with Real Time Clock/Calendar

The ProModem™ is a Bell 212A (300/1200 baud) intelligent stand-alone modem · Full featured expandable modem · Standard features include Auto Answer and Auto Dial, Help Commands, Programmable Intelligent Dialing, Touch Tone™ and Pulse Dialing & More · Hayes command set compatible plus an additional extended command set · Shown w/alphanumeric display option.

Part No.	Description	Price
PM1200	RS-232 Stand Alone Unit	$349.95
PM1200A	Apple II, II+ and //e Internal Unit	$369.95
PM1200B	IBM PC and Compatible Internal Unit	$269.95
PM1200BS	IBM PC & Comp. Int. Unit w/ProCom Software	$319.95
MAC PAC	Macintosh Package (Includes PM1200, Cable, & ProCom Software)	$399.95

OPTIONS FOR ProModem 1200

PM-COM	(ProCom Communication Software). Please specify Operating System.	$79.95
PM-OP	(Options Processor)	$79.95
PMO-16K	(Options Processor Memory – 16K)	$10.95
PMO-32K	(Options Processor Memory – 32K)	$20.95
PMO-64K	(Options Processor Memory – 64K)	$39.95
PM-ALP	(Alphanumeric Display)	$79.95
PM-Special	(Includes Options Processor, 64K Memory and Alphanumeric Display)	**$189.95**

KEYBOARDS

13⅛"L x 4¼"W x ¾"H

Mitsumi 54-Key Unencoded All-Purpose Keyboard

· SPST keyswitches · 20 pin ribbon cable connection · Low profile keys · Features: cursor controls, control, caps (lock), function, enter and shift keys · Color (keycaps): grey · Wt.: 1 lb. · Pinout included

KB54. . . . . $14.95

New!

16-9/16"L x 6⅜"W x 1⅝"H

76-Key Serial ASCII Keyboard

· Simple serial interface · SPST mechanical switching · Operates in upper and lower case · Five user function keys: F1-F5 · Six finger edge card connection · Color (keys): tan · Weight: 2 lbs. · Data incl.

KB76. . . . . $29.95

Apple Owners! NEW!

Apple Keyboard and Case for Apple II and II+

· Keyboard: Direct connection with 16-pin ribbon connector · 26 special functions · Size: 14½"L x 5½"W x 1½"H

· Case: Accommodates KB-A68 · Pop-up lid for easy access · Size: 15½"W x 18"D x 4¾"H

Part No.	Description	Price
KB-EA1	Apple Keyboard and Case (pictured above)	$134.95
KB-A68	68-Key Apple Keyboard only	$ 79.95
EAEC-1	Expanded Apple Enclosure Case only	$ 59.95

POWER SUPPLIES

TRANSACTION TECHNOLOGY, INC. 5VDC @ 1 AMP Regulated Power Supply

· Output: +5VDC @ 1.0 amp (also +30VDC regulated) · Input: 115VAC, 60 Hz · Two-tone (black/beige) self-enclosed case · 6 foot, 3-conductor black power cord · Size: 6½" L x 7" W x 2¼" H · Weight: 3 lbs.

PS51194. . . . . $14.95

Power/Mate Corp. REGULATED POWER SUPPLY

· Input: 105-125/210-250 VAC at 47-63 Hz · Line regulation: ±0.05% · Three mounting surfaces · Overvoltage protection · UL recognized · CSA certified

Part No.	Output	Size	Weight	Price
EMA5/6B	5V@3A/6V@2.5A	4⅞"L x 4"W x 2⅛"H	2 lbs.	$29.95
EMA5/6C	5V@6A/6V@5A	5⅝"L x 4⅞"W x 2⅞"H	4 lbs.	$39.95

KEPCO/TDK 4-OUTPUT SWITCHING POWER SUPPLY

· Ideal for disk drive needs of CRT terminals, microcomputers and video games · Input: 115/230VAC, 50/60Hz · Output: +5V @ 5 Amp, +12V @ 1.8 Amp, +12V @ 2 Amp, -12V @ 0.5 Amp · UL recognized · CSA certified · Size: 7¾"L x 6-3/16"W x 1⅝"H · Weight: 2 lbs.

$59.95 each or
MRM 174KF. . . . . 2 for $99.95

Switching Power Supply for APPLE II, II+ & //e™

· Can drive four floppy disk drives and up to eight expansion cards
· Short circuit and overload protection · Fits inside Apple computer
· Fully regulated +5V @ 5A, +12V @ 1.5A, -5V @ .5A, -12V @ .5A
· Direct plug-in power cord included · Size: 9⅞"L x 3½"W x 2¼"H
· Weight: 2 lbs.

KHP4007 (SPS-109). $59.95

4-CHANNEL SWITCHING POWER SUPPLY

· Microprocessor, mini-computer, terminal, medical equipment and process control applications · Input: 90-130VAC, 47-440Hz · Output: +5VDC @ 5A, -5VDC @ 1 A; +12VDC @ 1A, -12VDC @ 1A · Line regulations: ±0.2% · Ripple: 30mV p-p · Load regulation: ±1% · Overcurrent protection · Adj: 5V main output ±10% · Size: 6¾"L x 1⅞"W x 4-15/16"H · Weight: 1½ lbs.

FCS-604A. $69.95

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

Spec Sheets — 30¢ each
Send $1.00 Postage for your
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5¼" APPLE™ Direct Plug-In Compatible Disk Drive and Controller Card

The ADD-514 Disk Drive uses Shugart SA390 mechanics–143K formatted storage · 35 tracks · Compatible with Apple Controller & ACC-1 Controller · The drive comes complete with connector and cable – just plug into your disk controller card · Size: 6"L x 3½"W x 8-9/16"D · Weight: 4½ lbs.

ADD-514 (Disk Drive). $169.95
ACC-1 (Controller Card). . . . . $ 49.95

More Apple Compatible Add-Ons...

APF-1	(Cooling Fan with surge protection)	$39.95
KHP4007	(Switching Power Supply)	$59.95
JE614	(Numeric/Aux. Keypad for //e)	$59.95
KB-A68	(Keyboard w/Keypad for II & II+)	$79.95
MON-12G	(12" Green Monitor for II,II+, //e, //c)	$99.95
JE864	(80 Col. +64K RAM for //e)	$99.95
ADD-12	(5¼" Half-Height Disk Drive)	$179.95

DISK DRIVES

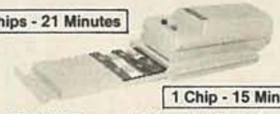
Documentation Included

Best Buys!

MPI51S	(MPI 5¼" SS full-ht.)	$ 89.95
RFD480	(Remex 5¼" DS full-ht.)	$129.95
TM100-2	(Tandon 5¼" DS full-ht.)	$159.95
FD55B	(Teac 5¼" DS half-ht.)	$149.95
SA455	(Shugart 5¼" DS half-ht.)	$159.95
FDD100-8	(Siemens 8" SS full-ht.)	$139.95
PCK-5	(5¼" Power Cable Kit)	$2.95
PCK-8	(8" Power Cable Kit)	$3.95

UV-EPROM Eraser

8 Chips - 21 Minutes



1 Chip - 15 Minutes

Erases all EPROMs. Erases up to 8 chips within 21 minutes (1 chip in 15 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00"L x 3.70"W x 2.60"H. Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser. $74.95
UVS-11EL Replacement Bulb. $16.95

NEW! Software & Documentation for CP/M Computers

JE664 EPROM PROGRAMMER

8K to 64K EPROMS – 24 & 28 Pin Packages

Completely Self-Contained — Requires No Additional Systems for Operation

· Programs and validates EPROMs · Checks for properly erased EPROMs · Emulates PROMs or EPROMs · RS232C Computer Interface for editing and program loading · Loads data into RAM by keyboard · Changes data in RAM by keyboard · Loads RAM from an EPROM · Compares EPROMs for content differences · Copies EPROMs · Power Input: 115VAC, 60Hz, less than 10W power consumption · Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown · Size: 15⅝"L x 8¾"D x 3½"H · Weight: 5¾ lbs.

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM, (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below)

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity with 2 stop bits.

EPROM Programmer w/JE665 Option

JE664-ARS. $1195.00
Assembled & Tested (Includes JM16A Module)

EPROM JUMPER MODULES – The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, Nat., Intel, TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Nat., NEC, TI, AMD, Hitachi, Mostek	$14.95
JM16B	TMS2716 (3-V's)	-5V, +5V, +12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95

CIRCLE 114 ON FREE INFORMATION CARD

ANTIQUE RADIOS

continued from page 89

one if you're in the right place at the right time. (The right place at the right time is when someone is cleaning out old junk.) The price you pay depends on how much you want to pay, how badly do you want the set, and the radio's age, condition, and classic value.

Antique-radio collectors will have more in common with each other than most other collectors. Many (or most) will have some formal electronics training. Besides being able to repair and restore the chassis, they will have to learn how to restore cabinets. (Some radio and TV servicemen may have at least some ability in this area. Repairing minor scratches or marks often went with being able to repair a chassis.)

Bringing back the deep rich tone of an antique radio will be a satisfying experience. While everything has its price, a collector will find it difficult to part with a set that he as spent many tedious hours restoring. That's true even with a handsome profit in sight. And those who do a good professional restoring job can ask their own prices.

If you are going to have only one antique radio, the console is the only way to go. Of course it will take up some room. But like expensive cars, most of those large sets had better care and less misuse than their cheaper counterparts of the same era.

There is a market developing for antique radios for those other than collectors. Homeowners who want to decorate their houses in a 1930's motif need all the furnishings from that era. Restoring an antique radio is not something the average home decorator can do. An expertly restored antique radio is a fine addition to the rest of the decor.

There is really no age bracket for antique-radio collectors. I have often seen antique radios go to young persons who get to a sale before me. And older folks, of course, will feel nostalgic about having an antique radio that they might have owned or had at a younger age. **R-E**

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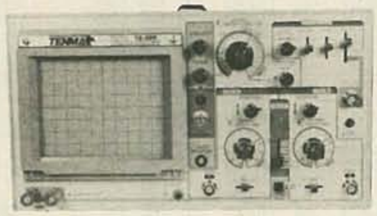
TENMA® 3½ DIGIT LCD MULTIMETER

■ DC input impedance 10M ohm ■ Diode and HFE Transistor tests ■ Overload protection ■ Auto polarity ■ 2 year limited Warranty

#72-050 **$36.80** (10-up)

$39.80 (1-9)



TENMA® 20MHZ DUAL TRACE OSCILLOSCOPE

Two High Quality 10:1 probes included. Backed by our 2 year limited warranty. For specifications see MCM Catalog #9 page 118

#72-320 **$389.95**

TENMA® COMBINATION DMM/ CAPACITANCE METER

(With Transistor Gain Tester)

■ User can easily read Voltage, AC and DC current, resistance up to 20M ohms, capacitance up to 20 microfarad, and HFE on a clear ½ inch, 3½ digit LCD display ■ 2 year limited Warranty

#72-045 **$69.95** (2 or more)

$74.95 each

LOGIC PROBE WITH MEMORY

■ Multi-family compatibility—DTL/TTL/HTL/CMOSIC ■ Detects pulses as short as 50 nanoseconds

#72-190 **$19.95**

2-WAY SPLITTER

■ Zinc diecast construction ■ Power passive ■ 5-900MHZ

#33-070 **89¢** (min 10)

6½" POLYPROPYLENE WOOFER

■ Magnet Weight: 15 oz. ■ Structure Weight: 3 lbs. ■ Voice Coil: 1.5" ■ Impedance: 8 ohms ■ Power Handling: RMS/PEAK 45w/80w ■ Free Air Res: 30 Hz ■ Freq. Response: 35-2500 Hz ■ Sensitivity SPL 1 WATT/1 METER:

#55-055

$15.90 (1-3)

$14.90 (4-19)

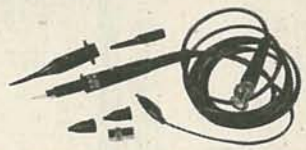
$13.90 (20-up)

10" PYLE WOOFER

■ Magnet Weight: 16 oz. ■ Structure Weight: 4.5 lbs. ■ Voice Coil: 1.5" ■ Impedance: 8 ohms ■ Power Handling: RMS/PEAK 75w/150w ■ Free Air Res: 40 Hz ■ Freq. Response: 30-5500Hz ■ Sensitivity SPL 1 WATT/1 METER: 95dB ■ Manufacturer: #W10C170-F

#55-100 **$19.90** each

OSCILLOSCOPE PROBE KIT



■ Bandwidth: 10:1 position: 100MHZ at—3dB into 20pF ■ Rise Time: 10:1 position less than 3.5_{NS} nominal ■ Kit contains: 10" earth lead, retractable hook, Ic test tip, insulator, BNC adaptor and trimming tool.

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$24.95 (5-up)

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■ Phenolic ring design used in hundreds of domestic speaker systems ■ Trim profile for easy mounting in tight spaces ■ 4¼" diameter ■ 10 watt power handling capacity ■ 3 oz. magnet ■ 2K-20K ■ 8 ohms

#53-020 $4.20 (1-3) **$2.90** (20-up)

150 WATT CROSSOVER (With protection circuit)

■ Build your own high-quality 5-way speaker system. ■ These units can handle 150 watts RMS and feature a built-in protection circuit. ■ Same crossover used in Jensen's System B ■ Crossover points: 0-300HZ, 300-1800HZ, 1800-7KHZ, 7KHZ-up; rear hi frequency 7KHZ-up. ■ Two L-pad controls included for upper mid frequency and high frequency. ■ 12 dB octave. ■ Comes complete with hook-up wire and instructions.

#50-170 **$19.95** each

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AUDIO TECHNICA CARTRIDGE AT11E

■ Bi-Radial (elliptical) diamond stylus ■ Thin-wall tubular stylus cantilever ■ Excellent replacement for older cartridges ■ Frequency response 15 to 25,000Hz ■ Tracking force 1½ to 2½ grams ■ Audio Technica No. AT11E

#39-020 $9.95 (1-9) **$9.45** (10-up)

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- Orders shipped UPS C.O.D.
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STATIC RAMS

2101	256 x 4 (450ns)	1.90
5101	256 x 4 (450ns) (cmos)	3.90
2102-1	1024 x 1 (450ns)	.88
2102L-4	1024 x 1 (450ns) (LP)	.98
2102L-2	1024 x 1 (250ns) (LP)	1.45
2111	256 x 4 (450ns)	2.45
2112	256 x 4 (450ns)	2.95
2114	1024 x 4 (450ns)	.99
2114-25	1024 x 4 (250ns)	1.10
2114L-4	1024 x 4 (450ns) (LP)	1.20
2114L-3	1024 x 4 (300ns) (LP)	1.30
2114L-2	1024 x 4 (200ns) (LP)	1.40
2125	1024 x 1	2.49
2147	4096 x 1 (55ns)	4.90
TMS4044-4	4096 x 1 (450ns)	3.45
TMS4044-3	4096 x 1 (300ns)	3.95
TMS4044-2	4096 x 1 (200ns)	4.45
MK4118	1024 x 8 (250ns)	9.90
TMM2016-200	2048 x 8 (200ns)	4.10
TMM2016-150	2048 x 8 (150ns)	4.90
TMM2016-100	2048 x 8 (100ns)	6.10
HM6116-4	2048 x 8 (200ns) (cmos)	4.70
HM6116-3	2048 x 8 (150ns) (cmos)	4.90
HM6116-2	2048 x 8 (120ns) (cmos)	8.90
HM6116LP-4	2048 x 8 (200ns) (cmos)	5.90
HM6116LP-3	2048 x 8 (150ns) (cmos) (LP)	6.90
HM6116LP-2	2048 x 8 (120ns) (cmos) (LP)	9.95
Z-6132	4096 x 8 (300ns) (Qstat)	33.95
HM6264P-15	8192 x 8 (150ns) (cmos)	38.95
HM6264LP-15	8192 x 8 (150ns) (cmos)	48.95

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.95
UPD411	4096 x 1 (300ns)	1.95
MM5280	4096 x 1 (300ns)	1.95
MK4108	8192 x 1 (200ns)	1.90
MM5298	8192 x 1 (250ns)	1.80
4116-200	16384 x 1 (200ns)	.79
4116-150	16384 x 1 (150ns)	1.20
2118	16384 x 1 (150ns) (5v)	4.90
4164-250	65536 x 1 (250ns)	4.45
4164-200	65536 x 1 (200ns) (5v)	5.00
4164-150	65536 x 1 (150ns) (5v)	5.00

5V = Single 5 Volt Supply

EPROMS

1702	256 x 8 (1us)	4.45
2708	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	2.95
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	6.95
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	4.45
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5V)	10.95
2764	8192 x 8 (450ns) (5v)	6.45
2764-250	8192 x 8 (250ns) (5v)	7.45
2764-200	8192 x 1 (200ns) (5v)	16.45
TMS2564	8192 x 8 (450ns) (5v)	16.95
MC68764	8192 x 8 (450ns) (5v) (24 pin)	38.95
27128	16384 x 8 Call	24.95

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS125	.48	74LS260	.58
74LS01	.24	74LS126	.48	74LS266	.54
74LS02	.24	74LS132	.58	74LS273	1.45
74LS03	.24	74LS133	.58	74LS275	3.30
74LS04	.23	74LS136	.38	74LS279	.48
74LS05	.24	74LS137	.98	74LS280	1.95
74LS08	.27	74LS138	.54	74LS283	.68
74LS09	.28	74LS139	.54	74LS290	.88
74LS10	.24	74LS145	1.15	74LS293	.88
74LS11	.34	74LS147	2.45	74LS295	.98
74LS12	.34	74LS148	1.30	74LS298	.88
74LS13	.44	74LS151	.54	74LS299	1.70
74LS14	.58	74LS153	.54	74LS323	3.45
74LS15	.34	74LS154	1.85	74LS324	1.70
74LS20	.24	74LS155	.68	74LS352	1.25
74LS21	.28	74LS156	.68	74LS353	1.25
74LS22	.24	74LS157	.64	74LS363	1.30
74LS26	.28	74LS158	.58	74LS364	1.90
74LS27	.28	74LS160	.68	74LS365	.48
74LS28	.34	74LS161	.64	74LS366	.48
74LS30	.24	74LS162	.68	74LS367	.44
74LS32	.28	74LS163	.64	74LS368	.44
74LS33	.54	74LS164	.68	74LS373	1.35
74LS37	.34	74LS165	.94	74LS374	1.35
74LS38	.34	74LS166	1.90	74LS377	1.35
74LS40	.24	74LS168	1.70	74LS378	1.13
74LS42	.48	74LS169	1.70	74LS378	1.30
74LS47	.74	74LS170	1.45	74LS385	1.85
74LS48	.74	74LS173	.68	74LS386	.44
74LS49	.74	74LS174	.54	74LS390	1.15
74LS51	.24	74LS175	.54	74LS393	1.15
74LS54	.28	74LS181	2.10	74LS395	1.15
74LS55	.28	74LS189	8.90	74LS399	1.45
74LS63	1.20	74LS190	.88	74LS424	2.90
74LS73	.38	74LS191	.88	74LS447	.36
74LS74	.34	74LS192	.78	74LS490	1.90
74LS75	.38	74LS193	.78	74LS624	3.95
74LS76	.38	74LS194	.68	74LS640	2.15
74LS78	.48	74LS195	.68	74LS645	2.15
74LS83	.59	74LS196	.78	74LS668	1.65
74LS85	.68	74LS197	.78	74LS669	1.85
74LS86	.38	74LS221	.88	74LS670	1.45
74LS90	.54	74LS240	.94	74LS674	9.60
74LS91	.88	74LS241	.98	74LS682	3.15
74LS92	.54	74LS242	.98	74LS683	3.15
74LS93	.54	74LS243	.98	74LS684	3.15
74LS95	.74	74LS244	1.25	74LS685	3.15
74LS96	.88	74LS245	1.45	74LS688	2.35
74LS107	.38	74LS247	.74	74LS689	3.15
74LS109	.38	74LS248	.98	74LS783	23.95
74LS112	.38	74LS249	.98	81LS95	1.45
74LS113	.38	74LS251	.58	81LS96	1.45
74LS114	.38	74LS253	.58	81LS97	1.45
74LS122	.44	74LS257	.58	81LS98	1.45
74LS123	.78	74LS258	.58	25LS2521	2.75
74LS124	2.85	74LS259	2.70	25LS2569	4.20

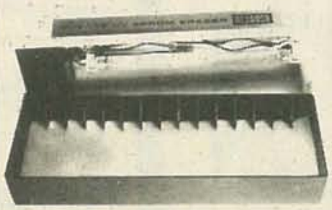
CRT CONTROLLERS

1771	14.95	2797	84.85
1791	23.95	6843	33.95
1793	25.95	8272	38.95
1795	28.95	UPD765	38.95
1797	48.95	MB8876	23.95
2791	79.95	MB8877	25.95
2793	79.95	1691	16.95
2795	84.95	2143	17.95

DISC CONTROLLERS

1771	14.95	2797	84.95
1791	23.95	6843	33.95
1793	25.95	8272	38.95
1795	48.95	UPD765	38.95
1797	48.95	MB8876	28.95
2791	79.95	MB8877	33.95
2793	79.95	1691	16.95
2795	84.95	2143	17.95

QUV-T8/1 EPROM Eraser



QUV-T8/1 Economy Model: Low cost EPROM eraser in plastic enclosure. The UV element is in the lid and you place the EPROMS in the bottom half. No timer or switch option.

- Erases up to 8 EPROMS in 15 - 20 minutes.
- 12,000 uWatts at 1" distance.
- 90-Day Warranty

49.95

6500

1 MHZ		2 MHZ	
6502	4.90	6502A	6.90
6504	6.90	6522A	9.90
6505	8.90	6532A	10.95
6507	9.90	6545A	26.95
6520	4.30	6551A	10.95
6522	6.90	**3 MHZ**	
6532	9.90	6502B	9.90
6545	21.50		
6551	10.85		

6800

68000	58.95	6860	9.90
6800	3.90	6862	10.95
6802	7.90	6875	6.90
6808	12.90	6880	2.20
6809E	18.95	6883	21.95
6809	10.95	68047	23.95
6810	2.90	68488	18.95
6820	4.30		
6821	3.20	**1 MHZ**	
6828	13.95	68B00	9.95
6840	11.95	68B02	21.25
6843	33.95	68B09E	28.95
6844	24.95	68B09	28.95
6845	13.95	68B10	6.90
6847	10.95	68B21	6.90
6850	3.20	68B45	18.95
6852	15.70	68B50	5.90

8000

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8039	6.90	8155	6.90
INS-8060	16.95	8155-2	7.90
INS-8073	49.95	8156	6.90
8080	3.90	8185	28.95
8085	5.90	8185-2	38.95
8085A-2	10.95	8741	38.95
8086	28.95	8748	49.95
8087	199.00	8755	23.95
8088	38.95		

8200

8202	23.95	8255-5	5.20
8203	38.95	8257	7.90
8205	3.45	8257-5	8.90
8212	1.75	8259	6.85
8214	3.80	8259-5	7.45
8216	1.70	8271	75.00
8224	2.20	8272	38.95
8226	1.75	8275	28.95
8228	3.45	8279	8.90
8237	18.95	8279-5	9.00
8237-5	20.95	8282	6.45
8238	4.45	8283	6.45
8243	10.95	8284	14.95
8250	16.95	8286	6.45
8251	4.45	8287	6.45
8253	6.90	8288	24.00
8253-5	7.90	8289	48.95
8255	4.45	8292	16.95

Z-80

2.5 MHZ		4.0 MHZ	
Z80-CPU	3.90	Z80A-CPU	4.29
Z80-CTC	3.95	Z80A-CTC	4.90
Z80-DART	10.95	Z80A-DART	9.95
Z80-DMA	13.95	Z80A-DMA	12.95
Z80-PIO	3.95	Z80A-PIO	4.29
Z80-SIO/0	11.95	Z80A-SIO/0	12.95
Z80-SIO/1	11.95	Z80A-SIO/1	12.95
Z80-SIO/2	11.95	Z80A-SIO/2	12.95
Z80-SIO/9	11.95	Z80A-SIO/9	12.95

6.0 MHZ		ZILOG	
Z80B-CPU	9.95	Z6132	33.95
Z80B-CTC	12.95	Z8671	38.95
Z80B-PIO	12.95		
Z80B-DART	12.95		

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4 POSITION	.84
5 POSITION	.89
6 POSITION	.89
7 POSITION	.94
8 POSITION	.94

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8T26	1.54	8T98	.88
68T28	1.84	DM8131	2.90
8T95	.88	DP8304	2.24
8T96	.88	DS8835	1.94
8T97	.88	DS8836	.98

CRYSTALS

1.0000 MHz	3.69	8.0000 MHz	2.69
1.8432 MHz	3.69	10.0000 MHz	2.69
2.0000 MHz	2.69	10.7386 MHz	2.69
2.0972 MHz	2.69	12.0000 MHz	2.69
2.4576 MHz	2.69	14.3182 MHz	2.69
3.2768 MHz	2.69	15.0000 MHz	2.69
3.5795 MHz	2.69	16.0000 MHz	2.69
4.0000 MHz	2.69	17.4300 MHz	2.69
4.1943 MHz	2.69	18.0000 MHz	2.69
4.9160 MHz	2.69	18.4320 MHz	2.69
5.0000 MHz	2.69	19.6608 MHz	2.69
5.0688 MHz	2.69	20.0000 MHz	2.69
5.1850 MHz	2.69	22.1184 MHz	2.69
5.2429 MHz	2.69	32.0000 MHz	2.69
5.7143 MHz	2.69	36.0000 MHz	2.69
6.0000 MHz	2.69	48.0000 MHz	2.69
6.1440 MHz	2.69	49.4350 MHz	2.69
6.4000 MHz	2.69	49.8900 MHz	2.69
6.5536 MHz	2.69		

32.768 KHz...... 1.69

CRYSTAL CLOCK OSCILLATORS

PART NO.	FREQUENCY	PRICE
1.000	1.0000 MHz	9.95
1.843	1.8432 MHz	9.95
2.000	2.0000 MHz	9.95
4.000	4.0000 MHz	9.95
8.000	8.0000 MHz	9.95
10.000	10.0000 MHz	9.95
16.000	16.0000 MHz	9.95
18.432	18.4320 MHz	9.95
19.660	19.6608 MHz	9.95
20.000	20.0000 MHz	9.95
32.000	32.0000 MHz	9.95

VOLTAGE REGULATORS

7805T	.74	7905T	.84
78M05C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74	7905K	1.44
7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
7824K	1.34	79L05	.7
78L05	.68	79L12	.7
78L12	.68	79L15	.7
78L15	.68	LM323K	4.9
78H05K	9.90	UA78S40	1.9
78H12K	9.90		

C,T = TO-220   K = TO-3   L = TO-92

IC SOCKETS
(1 to 99)

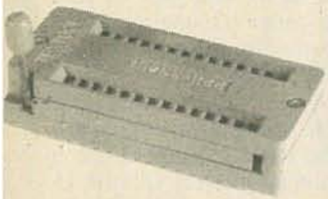
8 pin ST.	.12	8 pin WW.	.58
14 pin ST.	.14	14 pin WW.	.68
16 pin ST.	.16	16 pin WW.	.68
18 pin ST.	.19	18 pin WW.	.98
20 pin ST.	.28	20 pin WW.	1.04
22 pin ST.	.29	22 pin WW.	1.34
24 pin ST.	.29	24 pin WW.	1.44
28 pin ST.	.39	28 pin WW.	1.64
40 pin ST.	.48	40 pin WW.	1.94

ST = Soldertail WW = Wirewrap

ZIF SOCKETS

16 pin ZIF	5.90
24 pin ZIF	7.90
28 pin ZIF	8.90

ZIF = TEXTOOL (Zero Insertion Force)



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- Serial Port
- Clock Calendar
- Software Included
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MEMORY CARD

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- Fully compatible with IBM software
- Fully compatible w/IBM diagnostic utilities
- Serial Port Available
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80 Column Apple II+	149.95
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Z80 Apple II+	89.00
Z80 Apple IIE	89.00
16K Card	39.95
Cooling Fan	38.95
Power Supply	74.95
Joystick	29.95
RF Modulator	13.95
Disk Drive	199.00
Controller Card	59.95
Paddles	7.95

APPLE COMPATIBLE JOYSTICK

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COOLING FAN

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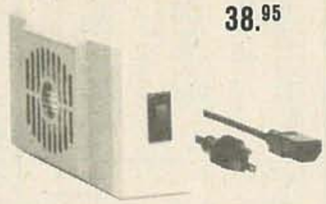
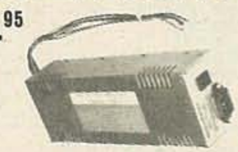


APPLE COMPATIBLE POWER SUPPLY

74.95



- Powers Apple type systems
- +5V @ 5A +12V @ 3A −5V @ .5A −12V @ .5A
- includes instructions

16K RAM Card – Apple II+

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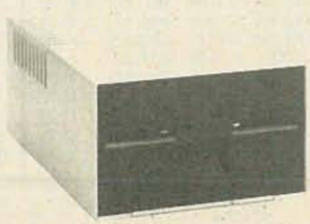

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- Shugart mechanism, made in U.S.A.
- Directly replaces Apple Disk II
- Fully compatible with Apple Controller or other Apple compatible controllers.
- One Year Warranty

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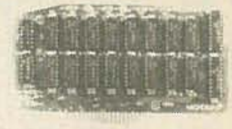
- 80 Col. card for Apple II+
- Video Soft Switch
- Inverse Video
- 2 Year Warranty

VIEWMAX-80e 129.95

- 80 Col. card for Apple IIE
- 64K RAM Expandable to 128K

64K RAM Upgrade 40.00



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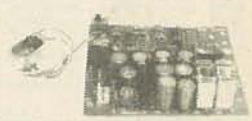

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TAPE STREAMER

continued from page 62

clocked into the shift register. At the terminal count of eight, Q4 again goes high, and the operation described above repeats. The Q4 output is also connected through R13 and C9 to IC2-b, which is connected as an inverter. When the inverter output switches low, it is differentiated by C8 and R14, producing a negative pulse on the UART $\overline{\text{LOAD}}$ input. That causes the transmitter shift register to load the data from IC10, and then to commence its transmission to the computer.

The NRZ output from the UART transmitter is conditioned by IC14-c and transistor Q4 to invert the data (RS-232 is inverted) and to swing positive and negative levels, also required by RS-232 conventions. Emitter followers Q2 and Q3 function in a totem-pole configuration to give current drive without unduly loading the supply when operating into a high impedance.

The indicator LED's are turned on when a bit of either mark or space sense is received from the tape. That's accomplished by AND-ing the data lines from IC8-a with the clock line from IC9-a, assuring that, when an LED is on, a real data stream is being processed. When data is being decoded, both LED's will flicker at a high rate, giving the appearance of both being on. During an idle time, when the NRZ data would be marking, only the MARK LED will be on; if the tape is blank, neither will come on.

While we've talked a bit about NRZ and Manchester encoding, we haven't really explained how they work. We'll do that next time. And once you understand what the circuit does, we can go about building it. We'll present foil patterns and full construction details that will make it easy. **R-E**

"I'm afraid that your comuter has a terminal illness."

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120 volt primaries

5.6 VOLTS @ 750 MA	$3.00
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3 - 2PDT SWITCHES. EACH OPERATES INDEPENDENTLY.
1 3/4" BETWEEN MOUNTING CENTERS.
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3 1/4" BETWEEN MOUNTING CENTERS.
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5 STATION NON-INTERLOCKING
SAME AS ABOVE, EXCEPT EACH SWITCH OPERATES INDEPENDENTLY.
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THIS 2-1/4" SQUARE METER MEASURES 0-15 VDC.
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2K 10 TURN
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4 PDT RELAY
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- 3 amp contacts
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specify coil voltage
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5v = Single 5 Volt Supply
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74LS00	.24	74LS157	.65
74LS01	.25	74LS158	.59
74LS02	.25	74LS160	.69
74LS03	.25	74LS161	.65
74LS04	.24	74LS163	.65
74LS05	.25	74LS164	.69
74LS08	.28	74LS165	.95
74LS09	.29	74LS166	1.95
74LS10	.25	74LS169	1.75
74LS11	.35	74LS173	.69
74LS12	.35	74LS174	.55
74LS13	.45	74LS191	.89
74LS14	.59	74LS192	.79
74LS20	.25	74LS193	.79
74LS21	.29	74LS194	.69
74LS26	.29	74LS195	.69
74LS27	.29	74LS197	.79
74LS32	.29	74LS221	.89
74LS33	.55	74LS240	.95
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74LS75	.39	74LS258	.59
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74LS132	.59	74LS374	1.39
74LS136	.39	74LS377	1.39
74LS138	.55	74LS390	1.19
74LS139	.55	74LS393	1.19
74LS145	1.20	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS670	1.49
74LS153	.55	74LS682	3.20
74LS154	1.90	74LS688	2.40
74LS155	.69	81LS95	1.49
74LS156	.69	25LS2521	2.80

7400

7400	.19	7492	.50
7401	.19	7493	.35
7402	.19	74100	1.75
7403	.19	74107	.30
7404	.19	74116	1.55
7405	.25	74121	.29
7406	.29	74122	.45
7407	.29	74123	.49
7408	.24	74125	.45
7409	.19	74126	.45
7410	.19	74132	.45
7411	.25	74145	.60
7413	.35	74148	1.20
7414	.49	74150	1.35
7416	.25	74151	.55
7417	.25	74153	.55
7420	.19	74154	1.25
7421	.35	74155	.75
7425	.29	74157	.55
7427	.29	74159	1.65
7430	.19	74161	.69
7432	.29	74163	.69
7437	.29	74164	.85
7438	.29	74165	.85
7442	.49	74166	1.00
7445	.69	74173	.75
7447	.69	74174	.89
7448	.69	74175	.89
7473	.34	74185	2.00
7474	.33	74192	.79
7475	.45	74193	.79
7476	.35	74194	.85
7483	.50	74259	2.25
7485	.59	74367	.65
7489	2.15	74368	.65
7490	.35	74393	1.35

74S00

74S00	.32
74S02	.35
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S32	.40
74S37	.88
74S74	.50
74S86	.50
74S112	.50
74S124	2.75
74S132	1.24
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SATELLITE TV

continued from page 16

the best combination of LNA and downconverter, plus receiver. When the LNA and converter are one, mixing components is extremely difficult.

LNA's as stand-alone units have held on, as their use in the American industry has grown to the 50,000-per-month range. American OEM's manufacturing LNA's have raced to keep up with the demand and Japanese manufactures have risen to meet the challenge. By September, the Japanese industry was capable of supplying upward of 40,000 LNA's per month to the North American market at prices that American suppliers are having difficulty in matching.

Since the world market for 4-GHz LNA's is virtually a North-American (only) market, that tremendous production capability cannot be marketed elsewhere effectively. With too many LNA's in so many warehouses, the expected happened—prices tumbled. The price for 120-degree LNA's dipped below $100 in June of this year, and by September, even the higher-grade, 100-degree units dropped below $100 (to dealers, in modest quantities).

Through all that, the dealer is more confused than ever. When prices were in the $250 to $300 region for standard 120-degree units, lower-priced (no-isolator or lower-gain) LNA's seemed like worthwhile alternative components. However, with the price of standard units dropping below $100, the pricing advantage for lower-gain or non-isolator models has eroded.

Of the four major component areas (antenna, LNA, receiver, and motor drive), the motor-drive remains the last area where intense competition and traditional price-cutting has not been applied. That will, of course, change during 1985 since there's significant profit out there for OEM's or importers who are able to reduce costs while not getting the industry back to the "dog-days" of 1981 (when motor-drives were the bane of every dealer's existence). **R-E**

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