# Radio-Electronics

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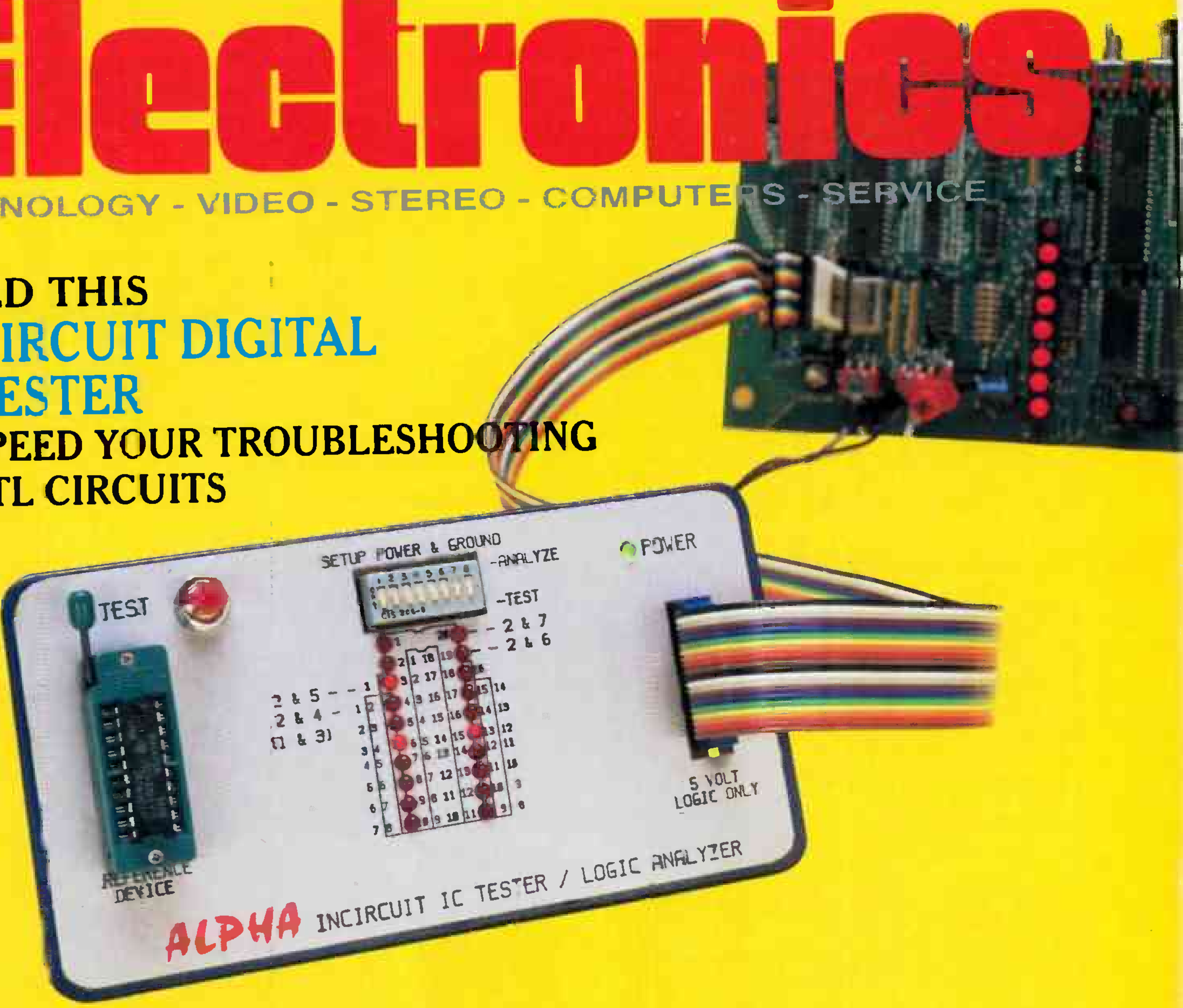
SEPTEMBER 1988

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE

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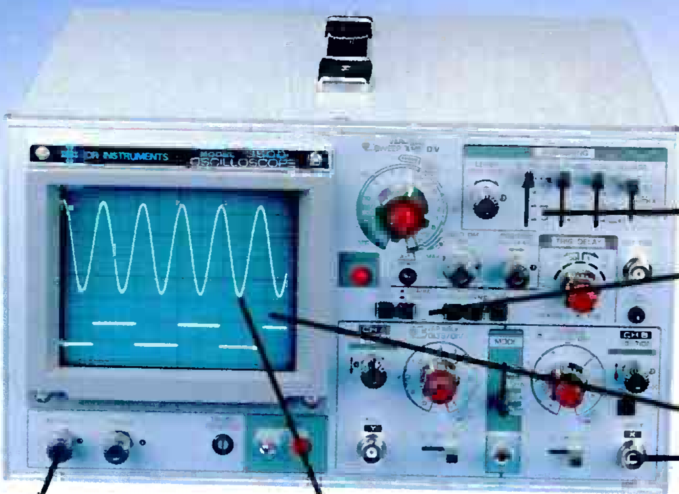


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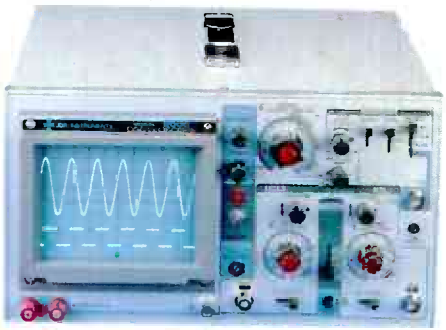

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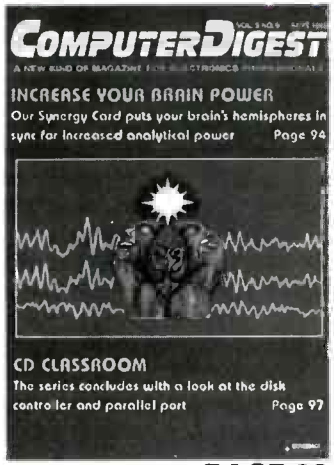
Vol. 59 No. 9






**PAGE 89**


**PAGE 49**

# ON THE COVER


One of the advantages of integrated circuits is that they are much more reliable than the discrete components that they replace. Unfortunately, however, when an IC fails, the problem can be rather difficult—or very expensive—to trace.

Our digital IC tester makes it easy to find problem IC's, and it can be built for around $100. It lets you compare a known-good IC to a questionable one. You can even test IC's as they're operating in a circuit! The IC tester can also be used as a 19-channel logic probe. The story begins on page 37.

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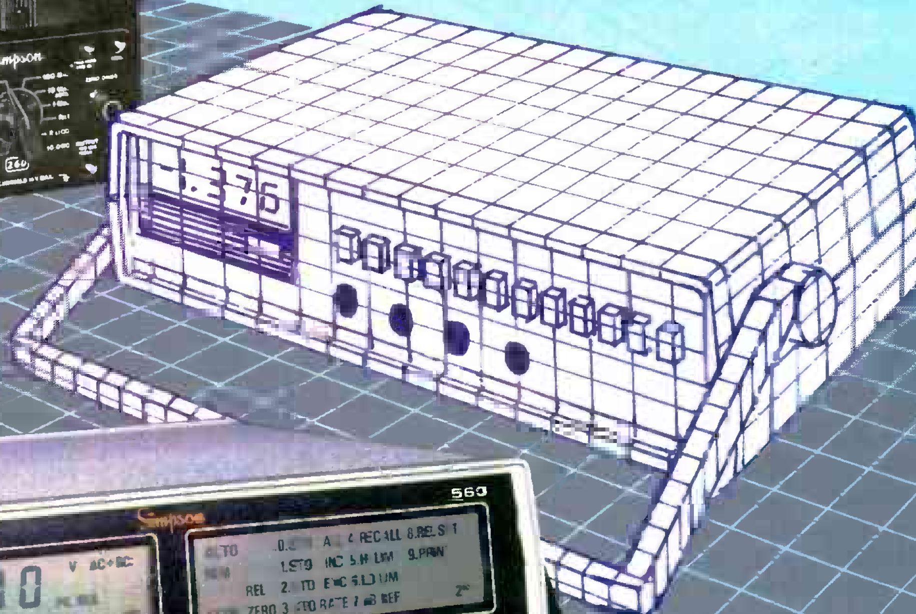


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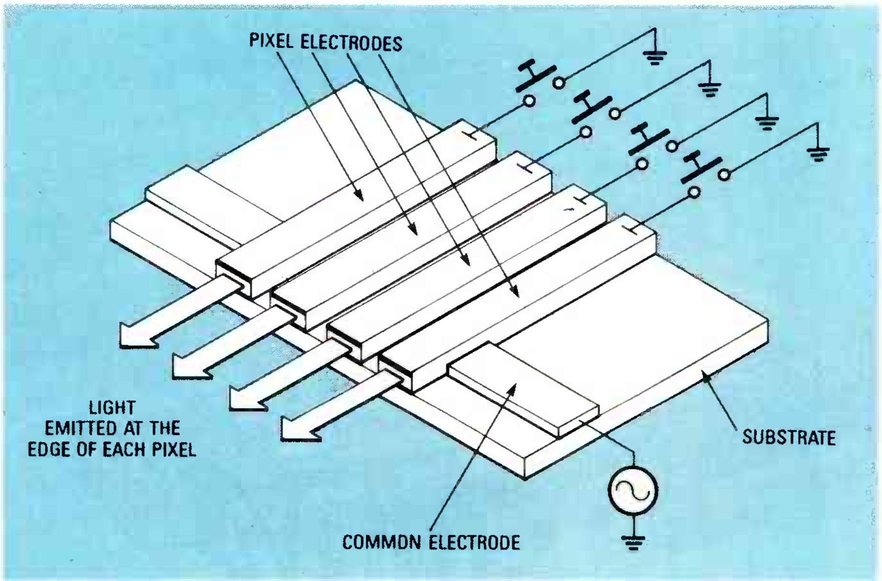
# WHAT'S NEWS




**AN ELECTROLUMINESCENT ARRAY is a new economical light source for laser printers, according to scientists at Westinghouse.**

## Edge-emitter light source improves laser printers

Westinghouse scientists have demonstrated a light source which they believe may be a "low-cost alternative to laser printers." Unlike the laser-light sources in most of todays's non-impact printers, the new source has no scanning mirrors or other moving parts, and it is smaller and more rugged.

Called a *T*hin-*F*ilm *E*lectro*L*uminescent (TFEL) edge emitter, the new light source is based on a discovery that light emitted from the edge of a thin film of zinc sulfide is up to 100 times brighter than light from the face of the film.

The new edge emitter was demonstrated with a specially built test station—a 10 page-per-minute laser printer with a 300 dots-per-inch printing capability was operated with a 400 dots-per-inch TFEL

**A CHARACTER GENERATED BY THE TFEL EDGE EMITTER (left), is clearer than that from a laser-light source (right). Both images are magnified 50 times.**

edge emitter replacing the laser. Even though not all parts were properly matched in the temporary setup, the edge emitter produced superior letters. By simply replacing the laser-matched photoreceptor of the laser printer with one matched to the TFEL edge-emitter wavelength, the printing speed could be doubled to 20 pages per minute, Westinghouse scientists said. **R-E**

## Ion damage improves semiconductor quality

A new technique, known as *ion-damage-controlled photochemical dry etching,* may improve the quality of computer chips and similar items, and save processing time and money.

In conventional semiconductors, complex circuits are etched out by covering parts of the surface with photoresist and etching out the parts that are not covered by that protective material. Complex integrated circuits require multiple masks and etchings. It is difficult to align the masks perfectly with the structures already etched in the wafer, and where misalignment occurs, performance is degraded.

Scientists at Sandia National Laboratories (Albuquerque, NM) have developed the new technique that reduces the need for multiple masks. The semiconductor surfaces that would have surviving masks are bombarded with ions, damaging the exposed areas. That damage makes those areas relatively inert.

The masks that protected the other areas is then stripped away, and the surface is etched with a reactive chemical under strong light. The ion-damage forms an unshiftable mask for subsequent etching processes—the material will not be etched where the surface has been ion-damaged.

## Wallet-sized cards hold a library of information.

The Optical Recording Corporation of Toronto, Canada has developed a wallet-sized optical-storage card capable of storing up to 200 megabytes. That is the equivalent of an optical memory disc, but the card costs as little as $1.00 when purchased in quantities of 100,000. One of the first applications for the card will be to store personal-health records.

Information is placed on the cards in arc-shaped tracks on 2-micron centers. Data is stored on 1-micron diameter spots on 1-micron centers along the line of the tracks. A rotating multi-lens laser scanner is used to write or read four tracks per revolution. The card itself is held stationary during writes and reads. **R-E**

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# VIDEO NEWS

**DAVID LACHENBRUCH,**
CONTRIBUTING EDITOR

• **Sony Adds VHS.** Fourteen years after introducing the first successful home videotape recorder, Sony has finally conceded to the popular taste and added VHS recorders in the United States and Japan. Sony's VHS recorders, the first made in its own factories, are deluxe in every way. A mono recorder listing at $600 and a stereo hi-fi version at $1,100, have such features as "Digital Edit Monitor," which puts two small pictures on the screen for editing—one showing the edit source and the other the tape to be edited and the actual result. The recorders also have front-mounted input jacks for easy attachment of camcorders for editing, LCD remote controls for simple programming, flying erase heads, digital special effects such as picture-in-picture and other top-of-the-line features. In addition to the two recorders, Sony introduced a VHS *V*ideo *C*assette *P*layer (VCP), the first such major-brand play-only unit with hi-fi stereo—designed, presumably, for Beta owners who need a VHS machine to play rented tapes.

• **Video Walkman.** That's the name Sony has given its book-sized combination VCR and TV, obviously in hope of repeating the success of the audio Walkman. The little tote-along combines a complete color-TV set with 3-inch backlit LCD with a complete 8mm videocassette recorder in a neat package weighing just 2.4 pounds. List-priced at $1,300, the Video Walkman is designed for viewing in almost any situation—it can be powered by rechargeable battery, dry cell, car battery, or AC adaptor, and has a loudspeaker as well as earphones for its PCM audio track. It can be used for watching TV, of course, as well as viewing tapes, which can play up to four hours.

• **Fancy New Brandnames.** What do Dimensia, Prism, Optonica, and HPX have in common? No they're not diseases; they're new lines being fielded by major color-TV brands in order to emphasize top-of-the-line features. Dimensia is the tippy-top line of the RCA brand; Prism belongs to Panasonic, Optonica is Sharp's dress-up label, and HPX is Hitachi's high end.

• **Introducing IDTV.** IDTV stands for "*I*mproved *D*efinition *TV*," and Philips and Toshiba share the honors of introducing the new initials to these shores. The first two IDTV sets vary in their features, so there's no real definition of what IDTV actually is. But what the Philips and Toshiba IDTV's share is digital memory—systems that double the number of horizontal lines and motion compensation to avoid blurring.

The Philips IDTV sets, available in either 27- or 31-inch sizes, derive new scanning lines to insert between the existing lines, resulting in 525 lines in each field. The derived lines constitute the median of the line above, the line below and the corresponding line from the preceding field. In addition, the sets have a noise-reduction circuit that remarkably improves snowy pictures. They have two tuners to make it possible to watch two different stations using the picture-in-picture feature. They also let you freeze and store either the main or the subsidiary picture, among other features. Toshiba's IDTV has a 28-inch picture and claims "advance double scanning." It also has picture-in-picture and a full-field memory, as opposed to the Philips' frame memory.

• **"Digital Paper."** Billed as the world's cheapest recording medium—so disposable that its developers call it "digital paper"—a new type of recording tape has been demonstrated by ICI, Britain's largest chemical company. It could make an excellent storage medium for digital-video recording as well as for computer data. The system uses low-cost polyester film with a layer of polymer dye. Recording is done by burning the dye layer with an infrared laser.

The medium can store one terabyte (one thousand billion bytes) on a strip of tape 35mm wide by 1,640 feet long, at a cost of about 5 cents per megabyte, according to ICI. It's a record-once system because it can't be erased. The "digital paper" can be used in several forms—tape, disc, sheet, and so forth. Several companies are working to commercialize it for various uses, and hardware for the system could be shown as early as next year. **R-E**

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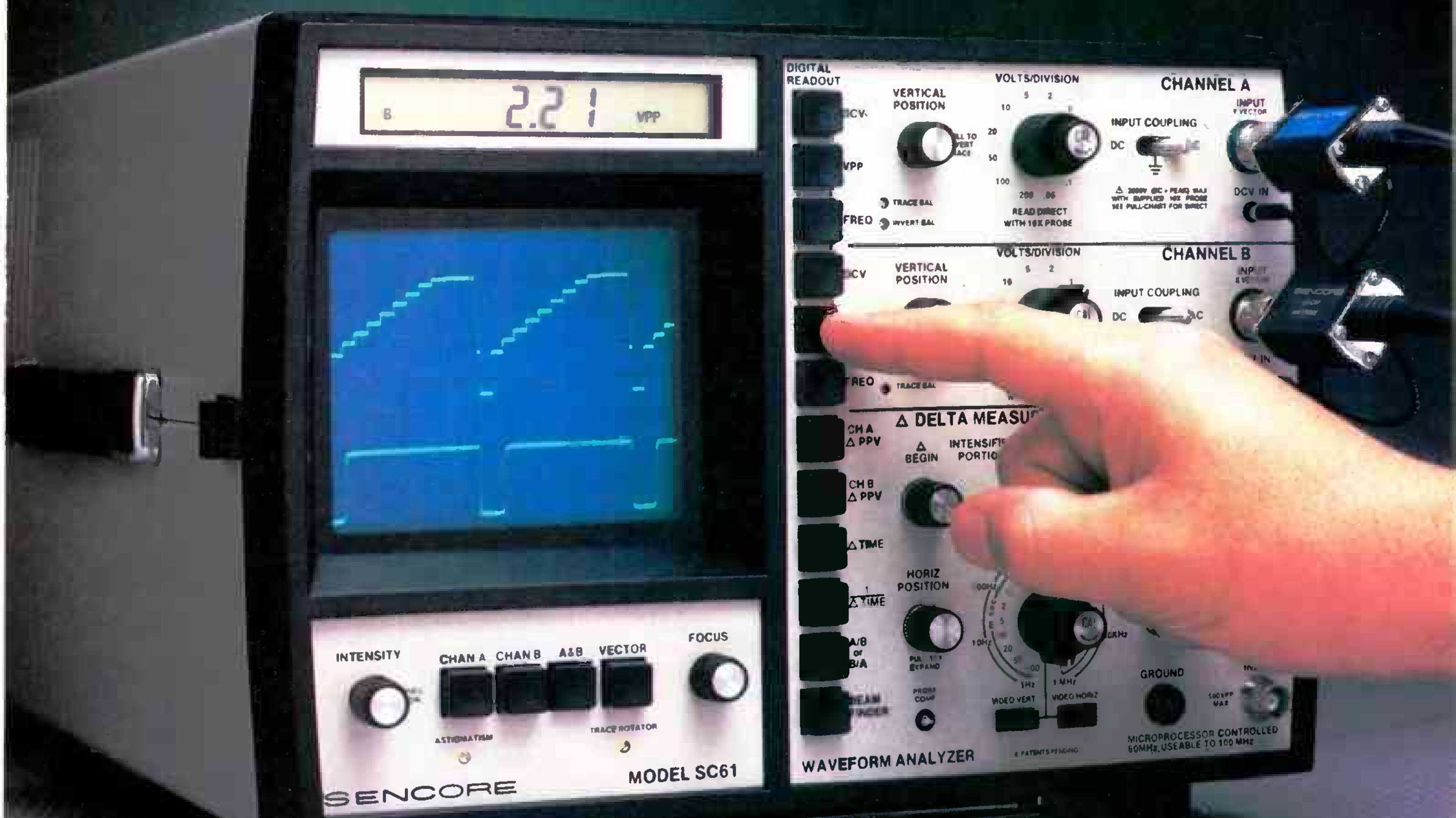


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## WHERE IS TRUE NORTH?

**Some months ago (Radio Electronics, October 1986) you showed us how to use the stars to locate True North to use as an aid in setting up a satellite dish. In my area, smog and bright lights on the northern horizon make locating and identifying stars almost impossible. Is there any way that I can use the sun to locate True North?—G.S.R., Duluth, MN.**

There are several ways to use the sun to establish a true North-South reference line. All are based on the fact that the sun is exactly due south at high noon and the shadow of a vertical pole lies along a true North-South line. The drawing in Fig. 1 shows a method learned in the Boy Scouts.

All that you need is some string, sticks and pegs, and a plumb bob or Scout's knife. Place the crossed sticks as shown in Fig. 1 so that the longer one points in a general northerly direction. Anchor the lower end with a large stone or tie it to a stake driven into the ground. Tie the plumb line to the tip of the pole so that the weight is almost touching the ground. Drive a small stake directly beneath the plumb bob or the point of the knife at point A. About an hour before noon (local time), drive a stake at point B, the exact end of the leaning pole's shadow.

Tie a string to the stake at point A and extend it so its length is AB. Tie a sharpened stick to the string at point B and use it to scribe the arc BCD on the ground.

At about an hour and fifteen minutes *after* noontime, the pole's shadow will cross the scribed arc at point D. Mark that point with a stake and tie a string from B to D. A

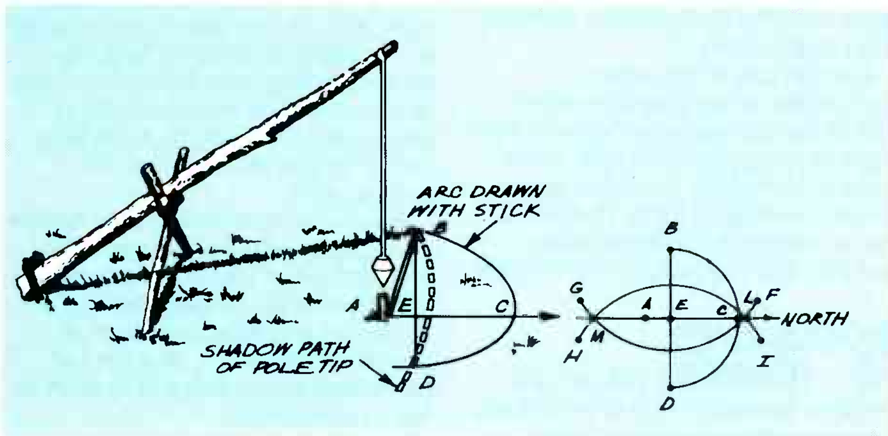


FIG. 1

perpendicular bisector of line BD actually lies in a true North-South direction.

To find the perpendicular bisector, either drive a stake at point E, the mid-point of line BD, or at point C, the mid-point of arc BCD. Line AE or AEC indicates the direction of true north.

If you don't have a tape measure or ruler for locating either E or C, use the scheme, derived from geometric principles, illustrated in Fig. 1. Cut a piece of string to about three-fourths the length of BD. At one end, make a loop that will fit loosely around the stakes at B and D. Tie the other end to a pointed stick that you will use as a scribe. Use the string and stick as a compass to draw arc FG from point B and HI from point D. The straight line passing through points L and M also passes through A, and lies in a true North-South direction.

## TELEPHONE BELL SUBSTITUTE

**I'm looking for the circuit of an electronic warbling telephone ringer that I can substitute for the conventional bell. I can't seem to find one. Can You help?—R.W.K., Kenilworth, NJ.**

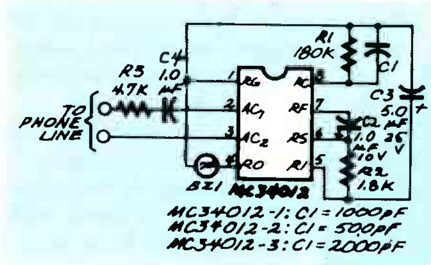


FIG. 2

The circuit in Fig. 2 shows how the Motorola MC34012-series telephone ringers are used. The IC is powered by the ring voltage from the phone line. The ring voltage is nominally 60–80 volts at 20 Hz, but may be anywhere in the range of 40V/16Hz to 150V/68Hz depending on the TELCO system. That voltage is rectified by an internal bridge rectifier and it is then used to power the tone generators and also drive the ceramic piezo-electric buzzer (BZ1).

The base frequency of the relaxation oscillator controlling the high- and low-frequency notes

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along with the warble rate is set by resistor R1 and capacitor C1 connected to pin 8. The base frequency can range between 1 kHz and 10 kHz when R1 is between 150K and 330K, and C1 is between 400 pF and 2000 pF. The tone that is fed to the buzzer at pin 4 switches between the two frequencies at a 12.5-Hz warble rate.

The MC34012-series device is available in three frequency ranges, and they can easily be identified by suffixes 1, 2, and 3. The tone frequencies in Hz are 822/1040 for the MC34012-1, 1664/2080 for the MC34012-2 and 416/520 for the MC34012-3.

Check with Motorola Semiconductor Products, PO Box 52073, Phoenix, AZ for sources and availability of the MC34012. The buzzer can be a Mallory PT-7, PT-8, or other similar ceramic piezoelectric device.

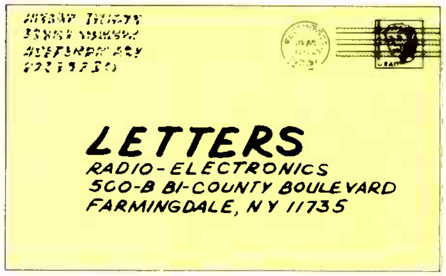
## SOLID-STATE REPLACEMENT FOR AN OLD TUBE

**I would like to have an oscillator circuit using some type of power transistor to replace the oscillator in a Boonton *160-A* Q meter. The oscillator has a type-45 tube in an Armstrong circuit with a grid, plate, and output coils. The output coil delivers 0.5 volt at 500 mA along with the RF signal that heats the thermocouple element. I need help! Otherwise, it's back to the ancient 45.—J.C.M., Baldwin, NY.**

You didn't say why you want to replace the original oscillator. If the instrument is operating properly, you should definitely leave it alone. It is a high-quality instrument and I doubt that you can improve it by simply replacing the oscillator circuit. "If it ain't broke, don't fix it." You'll only be creating unnecessary work for yourself.

If the 45 is weak, you may be able to purchase a replacement through Radio Shack or one of the tube suppliers that advertise in the Market Center. If you can't find a 45, try a 2A3; that tube is a plug-in replacement with somewhat similar characteristics. You may have to "juggle" the grid bias in order to to adjust the output voltage and current to "specs." For the 2A3, one place that you can try is Edlie Electronics, 2700 Hempstead Turnpike, Levittown, NY 11756.

# LETTERS



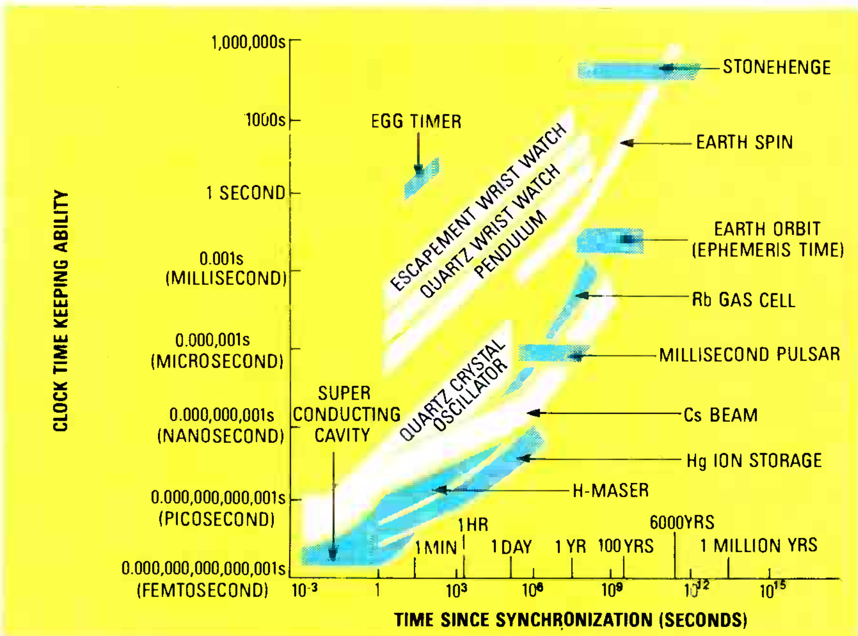




FIG. 1

### KEEPING TIME

"All About Calibration" (**Radio-Electronics**, June 1988) contains some errors in relation to time standards. The article states, as a general rule, that "universal time (UTO, UT1, UT2) is accurate to within 3 ms in 1 day." That yields a factor of about $3.5 \times 10^{-8}$ accuracy. The Ephemeris time value of 50 ms in 9 years yields a factor of about $1.8 \times 10^{-10}$ accuracy. That is OK too. However, the atomic time of 0.1 µs in 1 minute only yields a factor of $16.7 \times 10^{-10}$. That is less than what is stated for Ephemeris time. I believe that what you wanted was something like 0.1 µs in 1 day, which yields a factor of $1.16 \times 10^{-12}$.

STEPHEN L. COAN
*Beaverton, OR*

*Mr. Coan, you are absolutely correct. As the Time Chart shows, some Cesium-beam atomic clocks are accurate to 1 ns in 1 day, or an accuracy factor of* $1.16 \times 10^{-14}$. *See Fig. 1.*—Editor

### RS-232 CORRECTION

*It has come to our attention that there were a couple of errors in the article "RS-232 Monitor/Control System" (**ComputerDigest**, August 1988). The voltage supplied to IC3 can range from 4.5–18.0 volts, not 4.5–8.0 volts, as the article indicated. The equation for the time it takes to transmit data from the same node twice should read: (1/4800) × 11 bits/byte × 8 bytes. We apologize for any inconvenience caused by those mistakes.*—Editor

### VERSATILE FUNCTION GENERATOR

If you are building the "Versatile Function Generator" (**Radio-Electronics**, May 1988), please note that the timing IC (IC6) **must** have an "A" suffix. Do not try to use an ICM7207IPD in place of an ICM7207AIPD. Someone has been advertising the IC with the "A" suffix, but sending the wrong one, so check carefully before using it.

A few minor errors appeared in the article. On the Parts Placement diagram, IC9, the negative regulator, is oriented backward. The tab side should face the middle of the board—just the opposite of the two positive regulators. The ramp output and the pulse output are reversed. In the schematics, R23 should be a 2K linear potentiometer, C8 should be 100 pF, and C9 should be 10µF, 25 volts. The two rectifier diodes, D4 and D5, should have been labeled 1N4001, not 1N4401. Any diode with at least 1-amp/50- volt rating will do. In the Parts List, R36 should be 2.7K, and R13 and R43–R47 should be 4.7K instead of 47K.

JOHN WANNAMAKER
*Orangeburg, SC*

### AMATEUR COMPUTERISTS CLUB

In May 1966, Stephen B. Gray formed the Amateur Computer Society for people who were interested in building their own computers. By sharing their experiences and problems, Gray believed that hobbyists could reduce the frustration and isolation of working on their own to build a computer. Ned Wadsworth's *Scelbi-8H*, Jonathan Titus' *Mark-8*, and Ed Roberts' *Altair 8800* were the practical results of many years of effort to develop a personal computer.

While personal computers are now readily available, there is an increasing emphasis on business uses and software appropriate for

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businesses. There is a need for support and exchange among non-business users. To that end, we are announcing the publication of the first issue of the *Amateur Computerist Newsletter*, named in honor of Stephen Gray's pioneering interchange.

We want to encourage amateur computer users to write and share what they are doing with their computers—their successes and achievements, and their problems. We will try to support and encourage amateur use of computers, and to facilitate communication between users.

We recognize the important role **Radio-Electronics** has played in the history of the personal computer, by publishing Jonathan Titus' Mark-8 in July 1974. (*Editor's Note: H. Edward Roberts, M.D., author of the "*__Radio-Electronics__ Advanced Control System" *series, is the same Ed Roberts of Altair 8800 fame.*) We're sure that many **Radio-Electronics** readers will be interested in the *Amateur Computerist Newsletter*, and we hope they will write to us giving details of how they are using their computers; what uses they are most proud of, which programs are most useful, problems they've encountered, and programs they've created.

RONDA HAUBEN
*Amateur Computerist Newsletter*
*P. O. Box 4344*
*Dearborn, MI 48126*

### NON-CLONE COVERAGE

"Do it yourself"—I can't believe I read that in **Radio-Electronics**! Although you have some very valid points about budgeting your efforts to cover computers for the greatest return, you may have really frosted some of your readers with your response to Carl Kona. ("Letters," July 1988.)

I, too, own a non-clone home-computer system, and I, too, get miffed at seeing virtually all the technical journals ignoring any system that is not IBM-PC compatible. It is heartwarming to see Apple's MAC's making serious inroads into the PC jungle, and frightening to see that **Radio-Electronics** is not.

It is especially frustrating to see that tunnel-vision attitude in a journal such as **Radio-Electronics**. I

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NRI is accredited by the Accrediting Commission of the National Home Study Council 10-098 always thought that "diversity" and "ingenuity" were two of the buzzwords in your editors' vocabularies. I guess not, if their excuse for not investigating Atari's and CoCo's is that they "grew up on CP/M and later moved to MS-DOS systems" and that's all they know. Thank goodness the computer/electronics industry as a whole does not operate on that same kind of philosophy! We'd still be using tubes and analog computers if it did.

I fully respect the amount of time, effort, and money that goes into just keeping up, never mind diversifying into low-popularity areas. However, as a leading reference journal for so many novice (and expert) computer users and technicians, shouldn't **Radio-Electronics** give space to some of the "other guys" in the world of non-compatible systems? I was shocked at the strength of your rejection in your reply to Mr. Kona. Go away, kid, you bother me! I honestly cannot believe that that is really your policy.

After all, does a good tech know only one class of electronics? No, a good tech diversifies to learn analog, digital, radio, and computer (not just MS-DOS).

It would benefit us all—editors and readers alike—if you could diversify a little. Your surveys show that 80% of your readers use clones. Too bad the other 20% can't get equal time, proportionally. How much of your resources would it take to publish an article or series on non-clones once a quarter?

Come on guys, let's get with it!
RAY LaBRECQUE JR.
*Huntington, MA*

## MORE ON NON-CLONES

I wish to express my disappointment with the editorial policy of the *ComputerDigest* section of **Radio-Electronics**. It seems locked in with the IBM and the Commodore. Out here in the West, quite a number of Apples are being used, especially in the schools.

I hope you will abandon that myopic approach.
ED GILLIS
*Central Valley, CA*

## ANTIQUE-RADIO REPAIR

In the July 1988 issue of **Radio-Electronics**, Mr. Fitch gave some pointers on the repair of antique automobile radios in his "Antique Radio" column. Regarding the repair of vibrators, that service is advertised regularly in the publication *Hemmings Motor News* (P. O. Box 100, Bennington, VT 05201.) Other services advertised are speaker rebuilding, transistorized vibrator substitutes, complete radio rebuilding, and FM conversion is also available.

I have no experience with any of those advertisers, so I cannot vouch for their workmanship. I hope this information will be of some help to the readers of **Radio-Electronics**.
ROGER RAVENSBORG
*St. Paul, MN*

## RADIATION SCARE TACTICS

As a subscriber to **Radio-Electronics** since 1949, I have appreciated the technical quality of the articles. I am writing now because of the articles on the radiation monitor (June and July 1988).

While I could not fault the electronics aspects, the discussion of health effects smacks of yellow journalism. For those readers unfamiliar with the biological effects of radiation, such comments could be alarming—and I suspect that that is why they were made.

You are probably unaware that there is a negative correlation between the presence of radon and lung cancer. In other words, those areas with the highest concentration of radon have a lower incidence of lung cancer. The EPA set the radon standard by measuring the radon content in uranium mines without regard for the dust particles containing radioisotopes that are deposited in the lungs. The guideline of 4 picocuries per liter of air is a number that the EPA pulled out of thin air. There is nothing to support that.

It is unfortunate that John Gofman was chosen as an authority on the hazards of radiation, as he is at odds with most authorities on the effects of radiation. After Gofman testified at one hearing, the judge commented, "This court does find that Dr. Gofman's dramatic conflict with all the world's radiation experts creates a bias in him which destroys his credibility as an objective witness in radiation cases. His obsession blinds his objectivity."

The July article states that there are "differences of opinion on the ability of Geiger counters to detect radon." I don't know what the window of the GM1 tube is made of, but I can guess that alpha particles do not penetrate it. A Geiger counter can measure some of the radon daughters, but I doubt that it measures radon.

In the future, I would suggest that you stay with what is technically correct, and stay away from scare tactics. The *Journal of Health Physics* can handle the biological effect of radiation considerably better than you can.

LESLIE P. McCARTY, Ph.D., DABT
*Midland, MI 48640*

### THE MUSIC LIBRARY

I'm sure that **Radio-Electronics**' readers will be interested in the National Music Library, a nonprofit organization established in February 1988. High-quality compact discs, cassette tapes, sheet music, and other musical items can be taken out free of charge, by mail, through the National Music Library organization.

The library's circulation contains a large selection of compact discs and tapes of all types of music, including rock, classical, country, and jazz.

For library card-information, write to the National Music Library, 1994-A202 Woodward Ave., Bloomfield Hills, MI 48013.

ALAN FOXX
*Chairman, National Music Library*

### LEGAL LISTENING

Regarding Forrest Mims III's letter in the May 1988 issue of **Radio-Electronics**: If Mr. Mims had his way, possessing an ordinary pencil would be against federal law as it could be used as a weapon to kill. It would be "assuming a fact not yet in evidence" to prohibit a device simply because it *could* be used in the commission of a violation of the law.

Section 2511 2 (d) of the U.S. Federal Title 18 states "It shall not be unlawful under this chapter for a person not acting under the color of law to intercept a wire or oral communication where such person is a party to the communication or where one of the parties to the communication has given prior consent to such interception unless such communication is intercepted for the purpose of committing any criminal or tortuous act in violation of the Constitution or laws of the United States or of any State or for the purpose of committing any other injurious act."

The word "intercept" is defined in section 2510 (4) as "the aural acquisition of the contents of any wire or oral communication through the use of any electronic, mechanical, or other device."

Just for the record, there are many devices on the market that are specifically designed for "listening and/or recording purposes" that are legally sold and registered with the FCC.

RICHARD A. BOWEN
*Hudson, NH* R-E

# EQUIPMENT REPORTS

## Psion Organiser II Handheld Computer

*A "lifestyle compatible" pocket computer*

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ONE OF THE MOST INTERESTING PRODucts displayed at this summer's CES (Consumer Electronics Show) was a handheld computer called the *Organiser II* from Psion Incorporated (320 Sylvan Lake Road, Watertown, CT 06779).

The computer, which its manufacturer likes to call "lifestyle compatible," is designed to replace address books, phone books, appointment books, diaries, Rolodexes, calculators, expense logs, message pads, and so on. But emphasizing those capabilities is selling the computer short. The *Organiser* can become a versatile and powerful tool if it is so programmed. In fact, prior to this year, the *Organiser* was available in the U.S. only to OEM's and VAR's, who custom-programmed the powerful computer for their clients. (The *Organiser* was introduced in Europe in mid-1986, where it has since been the best-selling new consumer-electronics product.)

Before we look at any applications for which the computer can be programmed by the user, we should point out that right out of the box, the computer's built-in functions are impressive. Also, several applications programs are now available from Psion and others.

### Technical specifications

The *Organiser's* microprocessor is an 8-bit CMOS 6303 running at a speed of 1 MHz. (The 6303 is in the 6800 family.) The computer's internal RAM is 16K on the model *XP*, which we evaluated, and 8K on the less-powerful model *CM*. The built-in ROM, which contains the operating system and programming language, is 32K on both models. Two "solid-state drives" are built in to the computer.

The drives accept up to two special "solid-state disks"—up to a total of 128K on the *XP*, or up to 64K on the *CM*. Those solid-state disks are either special EPROM's, or battery-backed RAM modules. Software for the *Organiser* is distributed in pre-programmed PROM's. Blank EPROM's are also available for data storage. As shown in Fig. 1, the EPROM modules plug into the side of the computer. They are flush with the case when fully installed, and are protected by the slide-up protective case when the cover is closed.

The computer includes an interface port. While the port isn't standard, it can be made so with the addition of the *Comms Link*, an optional RS-232 interface that allows the *Organiser* to communicate with other computers, printers, modems, etc. Other peripherals, including a bar-code reader and a magnetic card reader, are available.

The *Organiser* is powered by a standard 9-volt alkaline battery, and an optional AC adapter is available. The computer consumes from 50 microamps to 100 milliamps depending on its operating mode. Expected battery life is from 2 to 6 months. When the battery is removed for replacement (the computer tells you when it's time), RAM-stored data are protected for more than half a minute.

The computer has some limited audio capabilities. Under software control, it can output tones from 11 Hz to 10 kHz with durations from 1 millisecond to 30 seconds

The *Organiser*, including its protective case is about 6×3×1 inches and weighs about half a pound. Its display is a 2-line by 16-character dot-matrix LCD, and its keyboard had 36 keys arranged in an ABC sequence.

### Using the Organiser

Right out of the box, the *Organiser* is ready to help you get organized. Its menu at power up is: FIND, SAVE, DIARY, CALC, PROG, and ERASE. Scrolling down through the menu yields the further choices: TIME, INFO, ALARM, COPY, RESET, and OFF. All menu choices can be run by moving the cursor over the appropriate word and pressing the EXE key. When you become familiar with the system, you can take shortcuts by simply entering the first letter of any menu choice whether or not it is displayed.

While many of the functions are

more-or-less self explanatory, some require a bit of explanation. FIND retrieves records that have been previously saved; SAVE writes a record to memory—either internal RAM or to a Datapack. DIARY is a sort of appointment book with alarms. CALC turns the *Organiser* into a full-function calculator. PROG puts the *Organiser* into the programming mode. Programs are written in a specialized procedure-based language called OPL (Organizer Programming Language). ALARM allows you to set up to eight alarms, each of which can be set to ring once, hourly, daily, or weekly. INFO gives memory-status information.

FIG. 1

With those basic built-in functions, the *Organiser* can become a replacement for appointment books, address books, and the like. With plug-in *Software Paks* (pre-programmed ROM's) it can become much more. Currently available *Paks* include *Pocket Spreadsheet* (which allows up to 26 columns by 99 rows and accepts Lotus worksheets) a bank-account program, a spelling checker, *Maths Pak* (which can solve Bessel functions, polynomial equations, matrices, and the like), and *Travel-Pak* (which does some language translation, provides international dialing assistance, metric conversions, etc.). We're sure that many additional program packs will become available as well.

Of course, since the *Organiser* contains its own programming language, OPL you its potential applications are almost endless. For example, an Alabama company created a program that calculates the impact of the sugar in various foods on a diabetic's blood system. The diabetic patient need only punch in the type of food he plans to eat, and the *Organiser* will then calculate the amount of insulin the diabetic should take. Other real-world dedicated programming examples include programs that calculate—based on input measurements—the amount of material needed for the flooring and wall-covering of a room. With the addition of a bar-code reader, the *Organiser* can become a portable inventory logger.

In Britain, a drug smuggler used the *Organiser* to record his transactions, and the names of his associates. He was tipped off that the police were set to grab him, and was erasing the last *Datapak* as he was seized. (Unfortunately for him, he didn't realize when data is erased from the *Datapak* EPROM, it's only removed from the display as a housekeeping chore. It's still programmed into the EPROM.) Now, RAM *Datapaks*—backed up by an internal battery— are also available.

We've had a lot of fun putting the *Organiser* through its paces. For the most part, the *Organiser*, although powerful, is easy to use, and its manuals are well written, although we did find the *Comms Link* manual to be a bit convoluted.

The *Organiser* model *XP* is priced at $249.99, while the less powerful model *CM* is priced at $179.99. The RS-232 link costs $99, and program paks range from $49.99 to $129.99. **R-E**

# READER-HELP-READER

• SAMUEL DA ROCHA FONSECA FILHO was happy with his Marantz *4400* receiver, until the filament of the cathode ray tube broke down. He needs a new one, but can't locate the 50TB1, 3-inch, 14-pin cathode ray oscilloscope tube anywhere. Send any information to *Rua Dias da Cruz, 417; 20720 - Rio de Janeiro, Brazil.*

• IVAN RODRIGUEZ has a single-trace, 5-MHz triggering oscilloscope. He wants a schematic with components and values for converting it into a dual-trace scope. Can you help? He's at *325 East 106th St., #13-F, New York, NY 10029-4808.*

• Any assistance you can give RAY MARTIN would be greatly appreciated. He's looking for a vibrator/chopper for a 1956 Plymouth car radio, MOPAR model *916-HR*. He doesn't have any specs on it (no schematic), and the part number on the old one is no longer readable. The radio is an original and works otherwise. It has three vacuum tubes (a 12AX4 and two 12AB5's) that must draw some power. If you can help him locate the vibrator/chopper—or a solid-state replacement for it—write to Ray at *2531 Melrose Dr., Wooster, OH 44691.*

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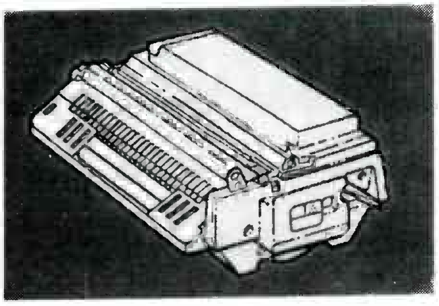

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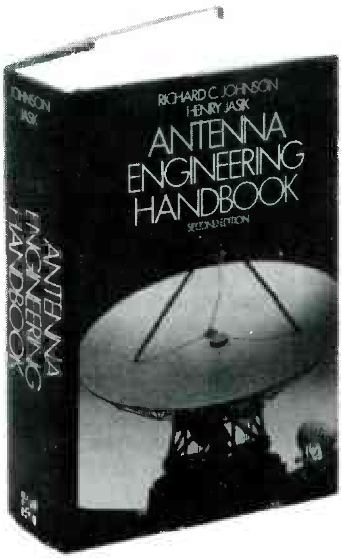


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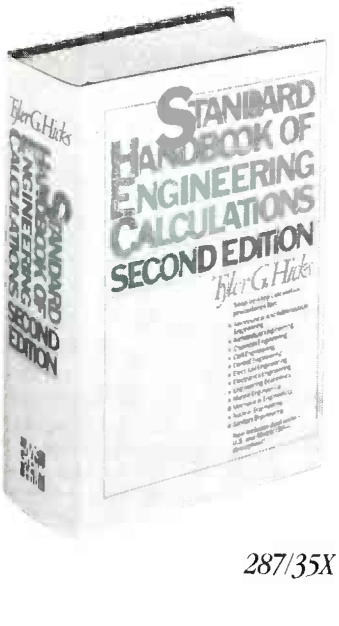


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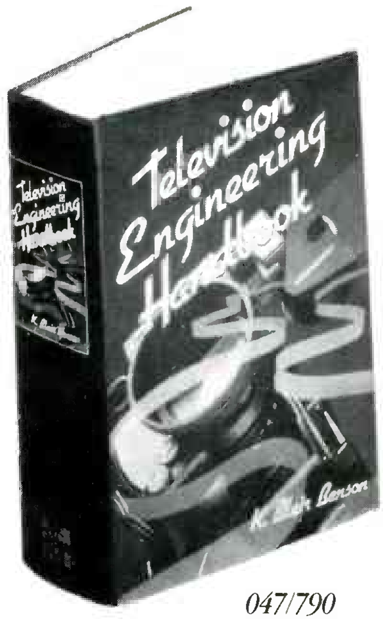


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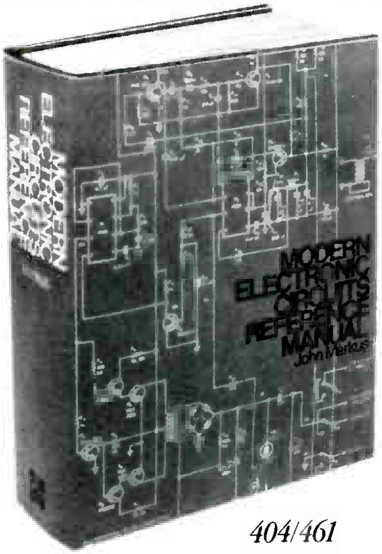


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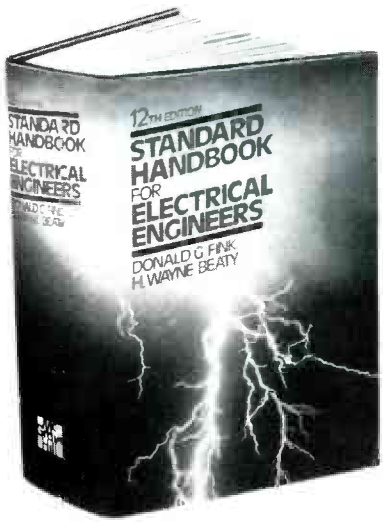


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# NEW PRODUCTS

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**PERSONAL VIDEO.** Sony introduces the concept of "Personal Video" with the *GV-8 Video Walkman* TV/VCR-combination. A portable hand-held unit, about the size of a paperback book, the *GV-8* contains a 3-inch diagonal color-TV screen and a complete VCR. With it, viewers can use and enjoy video virtually anywhere—while waiting for appointments, riding in the car, cooking in the kitchen, or at the beach or park.

Sony predicts that the *Video Walkman* will have the same affect on the video market as personal stereo had on the audio market, and expects consumer demand to precipitate a boom in prerecorded 8mm-tape production. Other companies have already announced production plans for do-it-yourself instructional tapes, children's videos, full-length feature films, and video magazines called "videodicals"—all compatible with the *GV-8*. Sony's ultra-miniature *CCD-G1* color-video camera can also be used with the *Video Walkman*.

The *Video Walkman* measures 5 × 2½ × 8 inches and weighs about 2½ pounds. The color-LCD screen has an active-matrix system for superior sharpness, contrast, and color purity. A back-light built in behind the screen provides a brighter picture and easier viewing in sunlight. The VCR has playback and recording capabilities of up to four hours on a single high-performance 8mm videocassette, in the extended-play mode.

The *GV-8's* VCR component features a high-speed picture search to scan recordings quickly, a one-day/one-event timer, a sleep timer, and a built-in TV tuner with full VHF and UHF channel reception. A linear time counter displays the tape position in hours, minutes, and seconds. Despite its compact size, the 8mm format yields a high-quality video image and high-fidelity sound. The *Video Walkman* has a built-in high-performance speaker for clear audio reproduction.

Although designed for personal use, the *GV-8* can be connected to a monitor for viewing by groups. Audio/video-input and output connectors allow for connection to another VCR—of any format.

The *Video Walkman's* telescoping antenna allows TV viewing in many locations. There is also an external-antenna connector for improved reception outdoors, or while travelling in a car. For indoor/outdoor flexibility, the *Video Walkman* unit operates on AC or DC current, rechargeable nickel-cadmium batteries, or alkaline batteries, when used with an optional external battery case.

The *GV-8*, complete with soft carrying case, will be available in late 1988 at a suggested retail price of $1300.00.—**Sony Corporation of America**, Corporate Communications Department, 9 West 57th Street, New York, NY 10019.

**UNIVERSAL REMOTE CONTROL.** Onkyo has introduced a second-generation, lower-cost model of the *Unifier* universal programmable remote control. The *RC-AV10* has enough memory functions to control at least one of each unit found in a typical audio/video entertainment system.

CIRCLE 11 ON FREE INFORMATION CARD

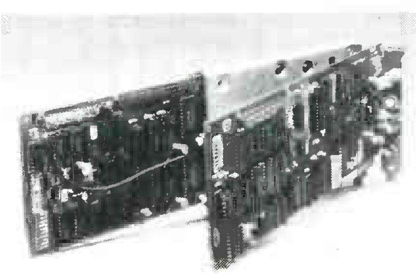
The *RC-AV10* has 55 programmable keys, clearly marked to control a television or cable box, two VCR's, two cassette decks, a compact disc player, and a full array of amplifier or receiver functions. Function keys for each component are in separate, clearly marked areas on the keypad. Programming is simplified by lighted displays that indicate the necessary procedures, step-by-step.

The suggested retail price for the *RC-AV10* universal remote control is $79.95.—**Onkyo**, 200 Williams Drive, Ramsey, NJ 07446.

**DIGITAL-STORAGE SCOPE.** Heath/Zenith's model *SDS-5000* comes complete with menu-driven software. It plugs directly into a PC, or can be mounted in an instrument chassis, so it can be working within a few minutes after its arrival.

Dual analog-to-digital converters capture two channels simultaneously, without reducing the digitizing rate. The *SDS-5000* has a real-time mode which samples data at up to 20 MHz with 4K memory depth, and 16K memory is available with the optional *SDS-5000-16 Memory Upgrade*. The digital-storage scope also has software-controlled 10-step attenuators for scaling input voltages from 40-mV to 40-volts full scale.

Users can examine both pre- and post-trigger events, zoom in on trouble spots, and make cursor movements. Signal averaging, delayed sweep, infinite persistence, signal addition and subtraction, and file-saving retrieval can also be performed. The *SDS-5000* Digital Storage Oscilloscope is priced at $1995.00.—**Heath/Zenith Computer-Based Instruments Group**, Hilltop Road, St. Joseph, MI 49085.



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**IN-FLIGHT HEADPHONES.** Air travelers can now enjoy music, movies, and other in-flight entertainment on lightweight stereo headphones with premium-quality stereo sound. Lotus Developments Ltd.'s *Jetset* portable audio system provides an alternative—with increased comfort and better sound quality—to the standard airline headsets.

The *Jetset* system consists of a patented *Airdapter* amplifier which plugs into the plane's seat jack, and a set of lightweight headphones. The *Airdapter* features a pair of sensitive condenser microphones mounted in a specially designed seat connector, and acoustic "correction baffles" to filter excess hiss and sibilance from the sound source. Those microphones convert the airline's piped sounds to stereo electronic signals, which are amplified and then reconverted to sound by the stereo headphones. The stereo amplifier has a 30–20,000-Hz response and is protected from short circuits and reverse polarity.

Measuring only 3 × 2⅜ × ½ inches, the *Airdapter* module is small enough to fit into a shirt pocket. It can be used on any plane fitted with the standard air-pipe audio connector, in any seating class, when in-flight entertainment is provided. The headphones can also be used with *Walkman*-style tape players.

The *Jetset* is powered by two AAA batteries. Power is automatically switched off when the headset is disconnected. It is priced at $19.95, plus $3.00 shipping and handling. (Illinois residents must add 8% sales tax.)—**Executive Travelware**, P. O. Box 59387, Chicago, IL 60659.


CIRCLE 13 ON FREE INFORMATION CARD

**SOUND-MIXING SYSTEM.** Designed for all "would-be" disc jockeys, the *Studio 4* sound-mixing system from Bondwell combines an audio console, sound mixer, and computerized-effect generator in one package.

The system features a built-in four-channel mixer, 6-function control cassette-deck recorder, microphone, and 3-inch speaker.

CIRCLE 14 ON FREE INFORMATION CARD

*Studio 4* can be used to record music; to create sound effects, voice-overs, and dialogue; and to mix all the recorded elements together into a customized track.

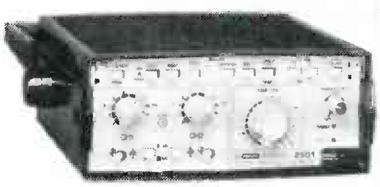
The sound-mixing system also has plug-ins for a second cassette deck, status lights and record-level indicators, an AC/DC power transformer, and a headset.

*Studio 4* retails for $59.95; a stereo version is available for $79.95.—

**Bondwell**, 47358 Fremont Blvd., Fremont, CA 94538.

**A-D SCOPE CONVERTER.** The *Model 2501 Digital Storage Adapter* adds the features of a true digital-storage oscilloscope to almost any analog oscilloscope. It provides dual-channel operation, an output connector for a hard-copy plotter, and 10-MHz per second sampling rate.

The *Model 2501* connects to the oscilloscope with a simple three-lead hook-up. It is easy to operate, even for those who have never used a digital-storage oscilloscope before. By adding the adapter, even a simple analog scope can be used to capture single-shot events, to store and magnify waveforms for analysis, and to view pre-trigger information at either zero, 50%, or 100%.



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The digital-storage memory is 2048 × 8; vertical resolution is 8-bits; and sampling rate is from 10-MHz per second to 2.5-MHz per second. The *Model 2501* has a suggested retail price of $795.00.—**B&K Precision**, Division of Maxtec International Corp., 6470 West Cortland St., Chicago, IL 60635.

**HOME-OFFICE FAX MACHINE.** Sharp has introduced a "no-frills" facsimile, designed for use in

CIRCLE 16 ON FREE INFORMATION CARD

home offices by those who need fax capabilities but don't want to pay for extra features that they don't really need. The compact unit, *Model UX-50*, has an integrated telephone handset and also has the ability to transmit and receive standard-size documents.

The *UX-50* measures 13.7 × 9.9 × 3.3 inches, and weighs 9 pounds, so it won't take up too much space. Its features include automatic reduction, on-hook dialing, contrast control, manual/automatic receiving selection, and redialing/pause function. The user can also signal the receiving party and instruct them to pick up the phone to talk after the transmission is complete. The *UX-50* facsimile is equipped with a 50-second transmission speed, and it also has a fine mode to increase the resolution of transmissions, for documents that require it.

The *UX-50* is priced at $1399.00.—**Sharp Electronics Corporation**, Personal Home Office Electronics Division, Sharp Plaza, Mahwah, NJ 07430. **R-E**



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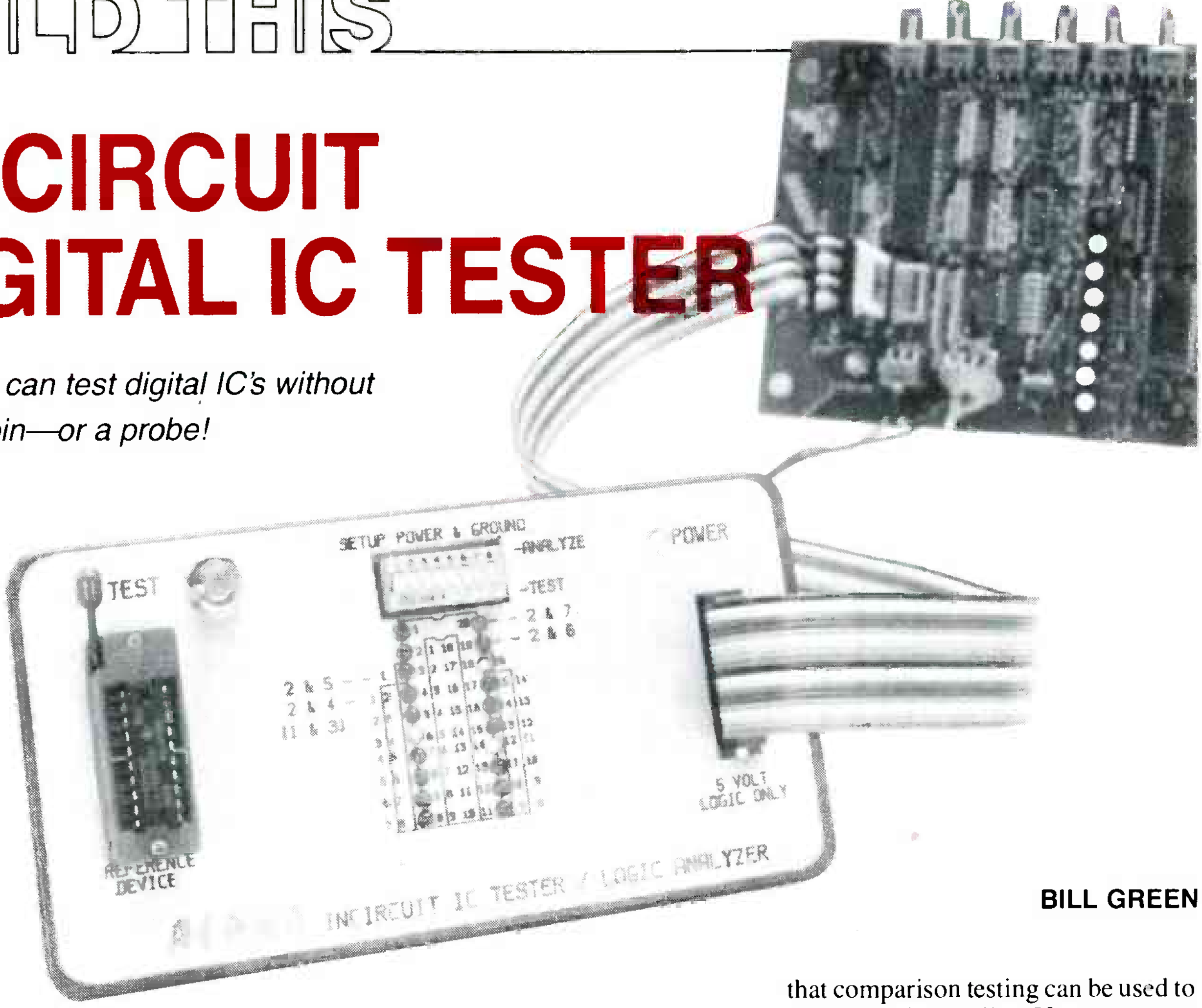
# IN-CIRCUIT DIGITAL IC TESTER

*Now you can test digital IC's without lifting a pin—or a probe!*

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ARE YOU TIRED OF HAVING TO CHECK EACH pin of a digital IC using some kind of probe? Do you hate having to look up truth tables in order to compare the inputs and outputs of IC's? Well, now you can stop wasting time troubleshooting IC's that are working in the first place. By using our in-circuit tester, you can check out the whole IC—while it's still on the board and operating—without having to investigate each pin separately. And our tester can do more than check IC's. It can also function as a 19-channel logic monitor.

There are several types of in-circuit IC testers that are now available. Some come equipped with a library of IC parameters stored in their memories, while others require the user to enter the testing parameters. Still others merely compare a known-good IC with an identical one that is operating in a circuit.

The first two types, although expensive and complex, do a superior job. The comparator-type tester, has the important advantage of being less expensive—ours can be built for under $100! But it also has a disadvantage: Because it is passive, it does not provide any stimulation to the IC being tested. As a result, a defective IC may appear to be good. An inverter with an output stuck low will appear bad only when its input is low.

While our tester is of the comparator type, it has both monitoring and testing capabilities. By selectively using its compare and monitor functions, we can determine whether the inputs of an IC are being exercised sufficiently—that is, in a way such that comparison testing can be used to determine its quality. If not, we can move through the circuit using the tried-and-true methods of circuit tracing, along with comparison testing, until we can sort the good IC's from the questionable and obviously bad ones.

## Circuit description

The in-circuit IC tester is based on four custom AE013 IC's. Custom IC's were used to make the tester as easy to build as possible. When you consider that each AE013 contains 5 independent comparator/latch/LED-driver

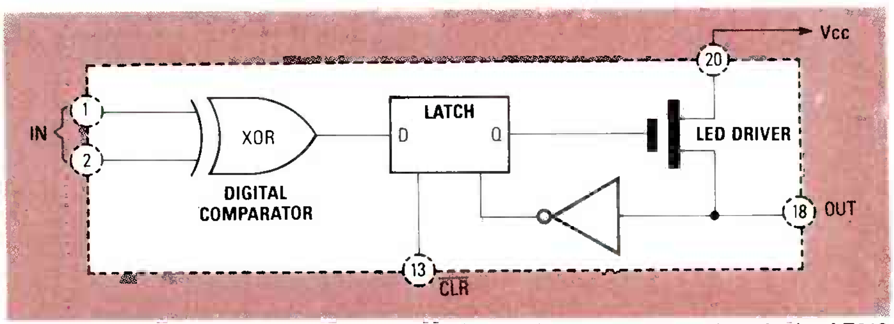



**FIG. 1—ONE OF THE DIGITAL-COMPARATOR/LATCH/LED-DRIVER sections in the AE013 custom logic IC. Each IC contains four of these circuits.**

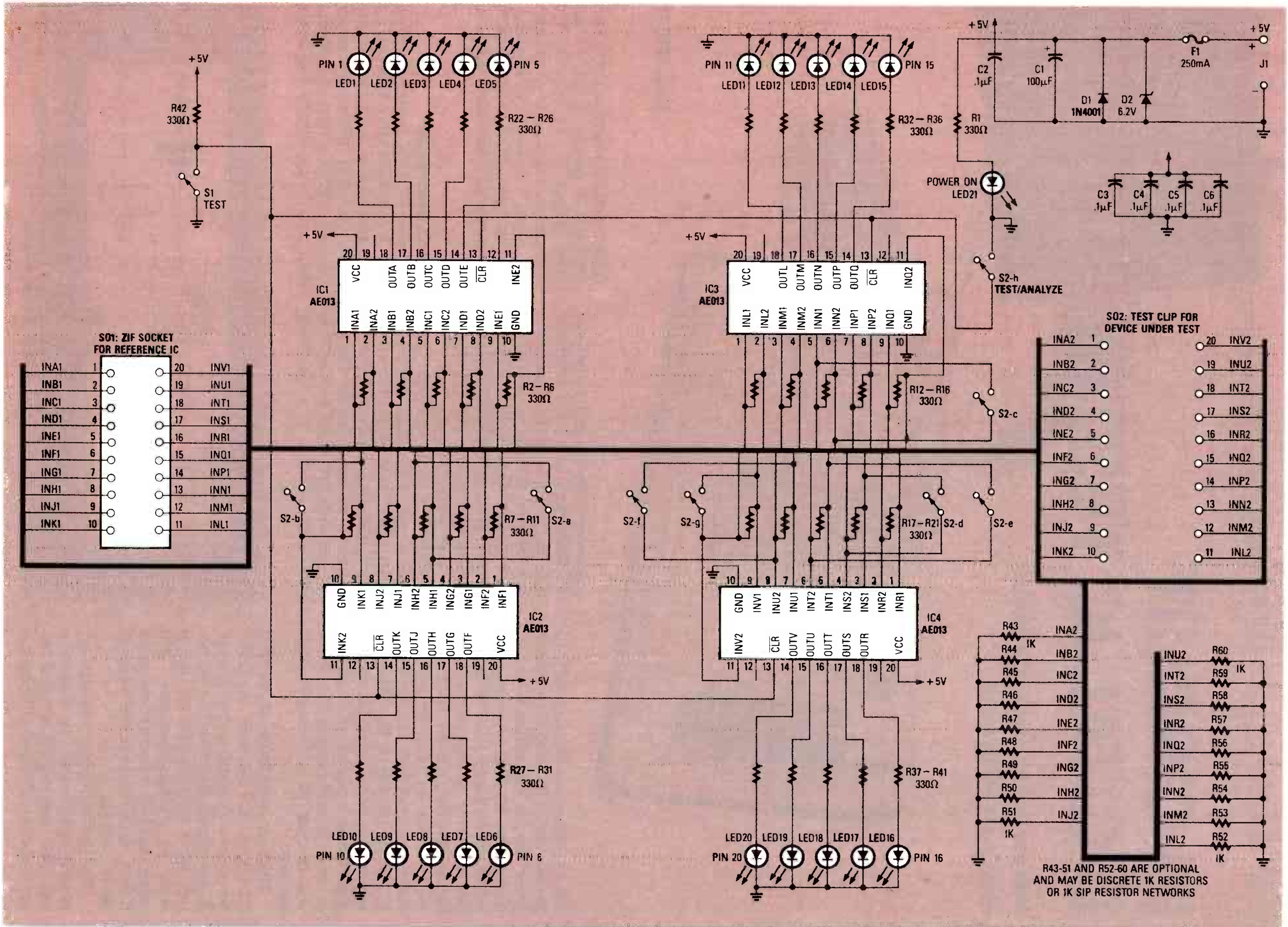



**FIG. 2—THE COMPLETE IC TESTER.** The reference IC is pluged into the ZIF (*Z*ero *I*nsertion *F*orce) socket, SO1, while the test clip, SO2, is attached to the device under test.

## PARTS LIST

**All resistors are ¼-watt, 5%, unless otherwise noted.**
R1–R42—330 ohms, carbon film
R43–R60—1000 ohms, or 9-pack SIP network
**Capacitors**
C1—100µF, 10 volts, electrolytic
C2–C6—1µF, 10 volts, ceramic monolithic
**Semiconductors**
IC1–IC4—AE013 Custom Comparator/Latch/LED Driver
D1—1N4001 rectifier diode
D2—6.2 volt, 1-watt Zener diode
LED1–20—T-1 size, red
LED21—T-1 size, green
**Other Components**
F1—250 mA, pigtail fuse
SO2—20-pin straight male header
SO1—20-pin wire wrap socket
P1—20-pin DIP header
S1—Normally-open pushbutton
S2—8-section DIP switch
**Micsellaneous:** PC board, test cables and clips, power cord and clips, IC sockets, 20-pin ZIF socket, and any kind of suitable cabinet and front panel.

**Note: The following items are available from W.L. Green, ALPHA Electronics, P.O. Box 541005, Merritt Island, FL 32954-1005, (407) 453-3534. In-Circuit IC Tester kit (does not include DIP header, cables, test clips and ZIF socket): $100.00 plus $5.00 postage and handling. Fully assembled IC Tester with IC test cable, 20-pin and 16-pin DIP clips included, (does not include DIP header, ZIF socket, monitor cable and clips): $169.00 plus $5.00 postage and handling. AE013 custom IC: $18.00 each plus $1.00 postage and handling. PC board and four AE013 IC's: $80.00 plus $4.00 postage and handling. Florida residents must add state sales tax. Canadian sales must add $2.00 additional postage and handling to each order. Foreign sales add appropriate amount for air shipping and insurance.**

sections, you can appreciate how much the custom IC's simplify the unit's construction.

A single section of an AE013 is shown in Fig. 1. When both inputs of the comparator are at the same logic level, the driver output will be low, and the LED will be off. When there is a logical difference at the inputs, the driver output will be high, and the connected LED will be on. Therefore, an LED will light when the logic level on a given pin of the DUT (*D*evice *U*nder *T*est) doesn't match the level on the RIC (*R*eference *IC*).

Figure 2 shows the complete schematic for the tester. As we describe the operation of the tester in the test mode, we will assume that the DUT has 20 pins. Since all twenty of the sections are used in essentially the same manner, we will describe only one and point out any exceptions.

Resistor R2 is connected across the input of one of the comparators of IC1. If pin 1 of the RIC is an input, then R2 provides a path for an input signal to flow from pin 1 of the DUT to pin 1 of the RIC. On the other hand, if pin 1 of the RIC is an output, then R2 is unnecessary. When both inputs of the comparator are at the same logic level, a low will be on the driver output and the LED will be off. When a logical difference is present at the inputs, the output and the LED will be on. As explained previously, a lit LED is an indication of a defective IC. The LED indicates at which pin the problem exists.

The $\overline{\text{CLR}}$ pin of IC1 is common to all sections of the IC. When it is high, the latch between the comparator's output and the LED driver's input is active; any disparity at the comparator's inputs will be latched. When low, the latch will be cleared and will appear transparent, meaning that the logic

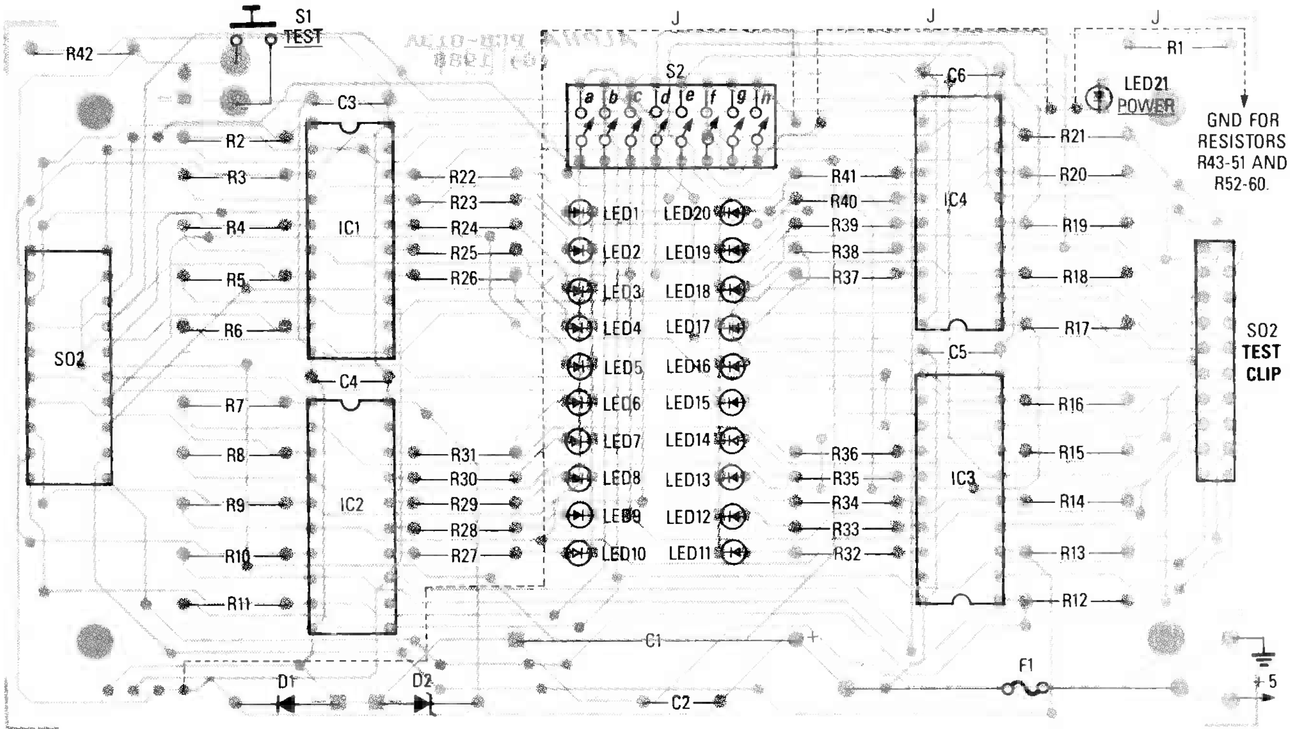



**FIG. 3—PARTS-PLACEMENT DIAGRAM. Notice how IC1 and IC2 are facing in the oposite direction of IC3 and IC4.**

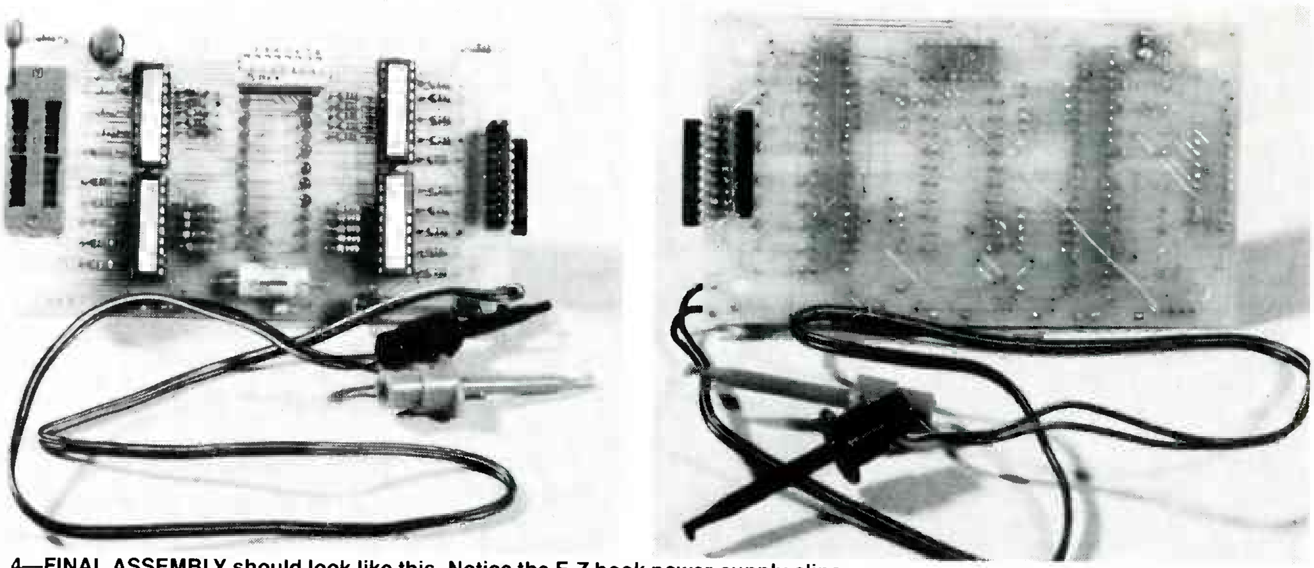


**FIG. 4—FINAL ASSEMBLY should look like this. Notice the E-Z hook power-supply clips and the ZIF socket on the left.**

level at the latch's input will appear at its output. When test-button S1 is pressed, the $\overline{CLR}$ input of each AE013 is grounded; that clears all latches in preparation for a new test.

IC's can have 14, 16, 18,or 20 pins. Notice that each switch contained in S2 (DIP switch) is connected in parallel with an input resistor. Depending on how many pins the DUT has, and which pins are power and ground, the appropriate switches should be closed. In other words, we will short out two of the resistors to provide a direct path for power and ground from the DUT to the RIC.

Resistors R1, and R22–R41 limit the current through the LED's to less than 10 mA. LED's 1–20 indicate the level at the output of the drivers, and the green LED (LED21) is the power indicator. All capacitors are used to filter the power bus. Rectifier-diode D1, Zener-diode D2, and fuse F1, provide power-supply polarity and short-circuit protection. Because power for the tester is supplied from an external source—usually the circuit board under test—you must protect it against overvoltage and reverse voltage. Rectifier-diode D1 will conduct with reverse polarity and blow the fuse because there's no current limiter. Also, Zener-diode D2 will conduct at greater than +6.2 volts and also cause the fuse to blow.

When the tester is used as an analyzer/monitor, one side of all of the comparators are connected to ground. The other side of the comparators are connected through the test cable to various points in the circuit that we wish to analyze. When any one of those points is high, the corresponding LED will light. Whether S1 is open or closed will determine if those LED's will be latched or non-latched, respectively.

## Assembly

Refer to the parts-placement diagram in Fig. 3 for correct orientation of all components on the PC board. (Space does not allow us to print the board pattern in this month's issue. It will appear in next month's PC Service section. We apologize for the inconvenience.)

Begin by installing resistors R1–R42 on the board. Next, install the two diodes D1 and D2, and filter-capacitors C2–C6. Install the sockets for the IC's and switch S2, noting that IC1 and IC2 face one direction while IC3 and IC4 face in the other direction. Install C1 with its negative lead in the hole marked by a "–," and then install the fuse F1.

In the author's model, the LED's are installed with their bottom edges spaced ⅜-inches from the board; that way each LED will protrude through the front panel when the PC board is installed. Of course, the amount that the LED's will protrude above the front panel depends on the length of the stand-offs that you use to mount the PC board. As with most LED's, the cathode lead is shorter than the anode lead, however, our experience tells us that it's a good idea to check each LED before installing it—especially if you're using "grab-bag" parts. Each LED is installed so that the cathode lead is soldered to the square pads, which are the ground points.

Use a 20-pin wire-wrap socket for SO1 so that the socket will be flush with the top of the case when the board is installed. If you fail to do that, you will never be able to plug the ZIF socket into SO1. Seat a socket for DIP-switch S2 against the board and solder it in. (Use a wire-wrap socket as a pin extender if necessary.) Next, install connector SO2, a 20-pin double-row straight male header strip.

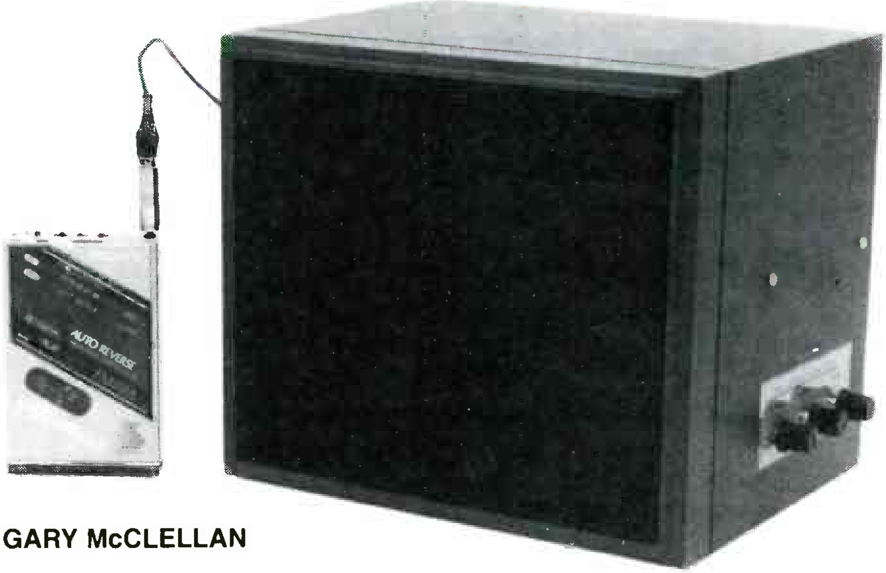
For the power cord, use a piece of zip-cord, about 18–24 inches long. On the free end of that cord, attach a red and a black hook clip. The black clip goes to the ground side of J1,

*continued on page 86*

**TABLE 1—IN-CIRCUIT IC TESTER**

| Number of IC Pins | DIP-Switch S2 Sections Turned-On |
|---|---|
| 20 pins | a and g |
| 18 pins | b and f |
| 16 pins | b and e |
| 14 pins (pin-7 ground, pin-14 power) | b and d |
| 14 pins (pin-10 ground, pin-5 power) | a and c |

# AMPLIFIED SPEAKER




GARY McCLELLAN

*You can build this low-cost amplified speaker system that is useful for testing audio components, or to amplify a walkman-type stereo for "ears-free" listening pleasure.*

IF YOU WORK WITH AUDIO, THERE MUST BE times when you wish you had an amplifier and speaker system handy. If so, the amplified speaker described in this article is the answer to your needs. It is a low-cost, wide-range amplified-sound system complete with loudness, bass, and treble controls. Just connect power, and a line-level audio source and you're in business! Here are some common uses for the project:

If you would like to share the sound of your headphone stereo with your friends, all you have to do is connect the amplified speaker system. The project provides over 5 watts into an internal speaker, and the sound quality is great.

The amplified speaker system is also a great addition to your workshop because you'll no longer have to drag out your stereo and speakers just to check a tuner, tape deck, or other audio component. You'll be able to troubleshoot an audio component on your workbench rather than where your stereo is located.

Another possible use for the amplified speaker system is as an amplifier for an electric guitar or other musical instrument. And, because the project can be powered from a 12-volt car battery (we'll explain how later), you can even use it outdoors.

You should enjoy building the project almost as much as you'll enjoy using it. And, perhaps best of all, it's not going to break your bank account; ours only cost $17.00 to build. Of course, your cost will be determined by the state of your junkbox, and your ability to track down bargains.

## How it works

The amplifier is based on a high-quality audio-amplifier IC made by Sanyo. That particular part was chosen because of its low distortion, high power output, and relatively low noise. Additional circuitry is included for loudness, bass, and treble controls, which are always included in a high-quality audio amplifier.

The schematic of the amplified-speaker project is shown in Fig. 1. Input signals to the audio-input terminals drive volume-control R2. Capacitor C2, resistor R1, and a tap on R2 are a loudness-compensation network, which boosts bass tones at low-volume levels. That circuitry corrects for human hearing deficiencies at low volume.

From R2, the audio signal is amplified by transistor Q1, which is a high-gain, low-noise device. That stage compensates for losses in the tone-control circuitry. Bias-resistor R3 further reduces noise by providing negative feedback. Capacitor C4 is included to prevent RF pickup and to roll off high-frequency noise.

Basically, the circuit connected between capacitor C6 and resistor R12 is a 20-dB resistive attenuator network combined with adjustable low-pass (bass) and high-pass (treble) filters. The potentiometers increase or decrease the capacitive reactance across various resistors, boosting or cutting bass and treble tones. Bass-control R7 is part of a voltage divider consisting of R6 and R8. Turning the potentiometer clockwise puts more of the reactance of capacitor C8 across the potentiometer and R8, shunting most of the high frequencies to ground, and boosting the lows. Turning the potentiometer counterclockwise puts more reactance of C7 across the potentiometer and R6, boosting most of the high frequencies and cutting the lows.

The output from the bass potentiometer (R7) goes to resistor R10, which reduces control interaction, and then it goes to treble-control R11. That potentiometer is in a series voltage divider with capacitors C9 and C10. Turning R11 clockwise puts more of the reactance of C9 in the circuit, shunting high frequencies around the bass control, boosting tre-

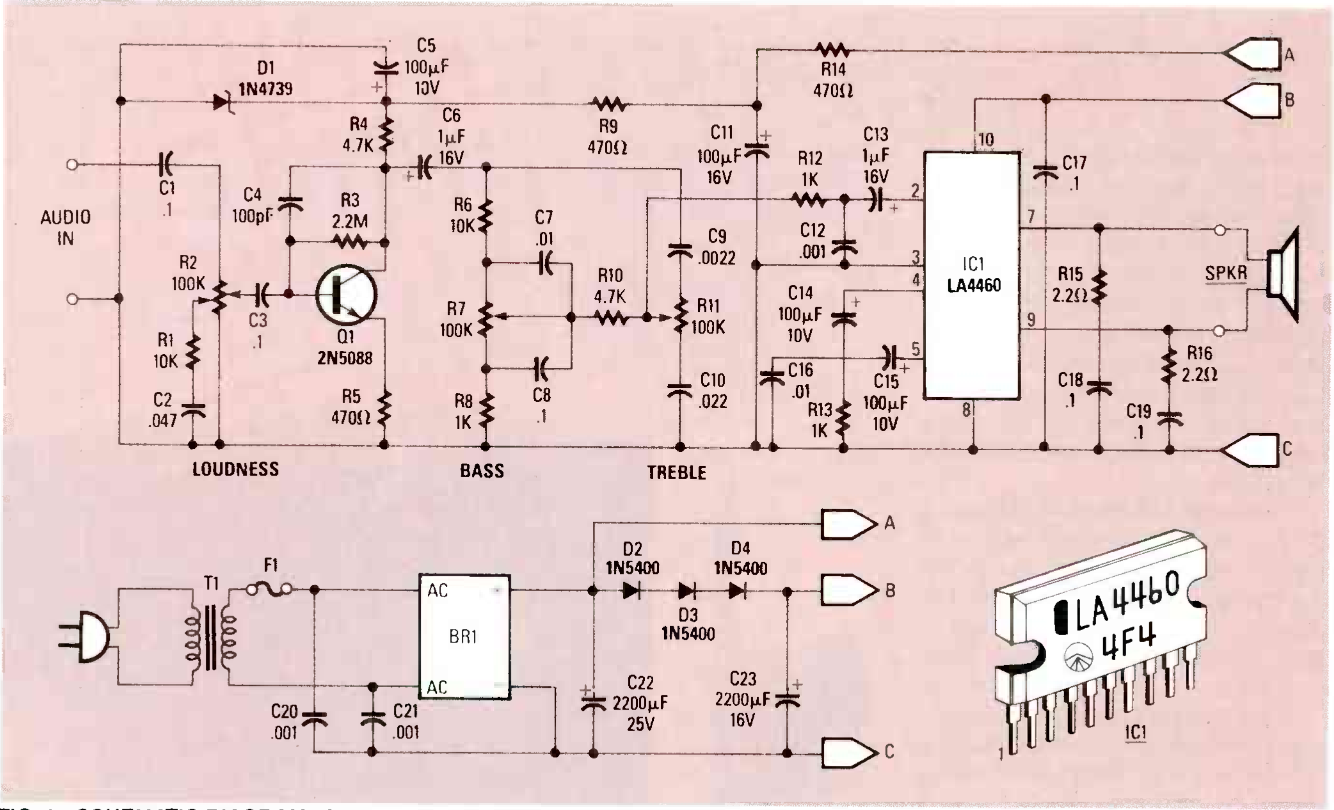



**FIG. 1—SCHEMATIC DIAGRAM of the amplifier board and its power supply.**

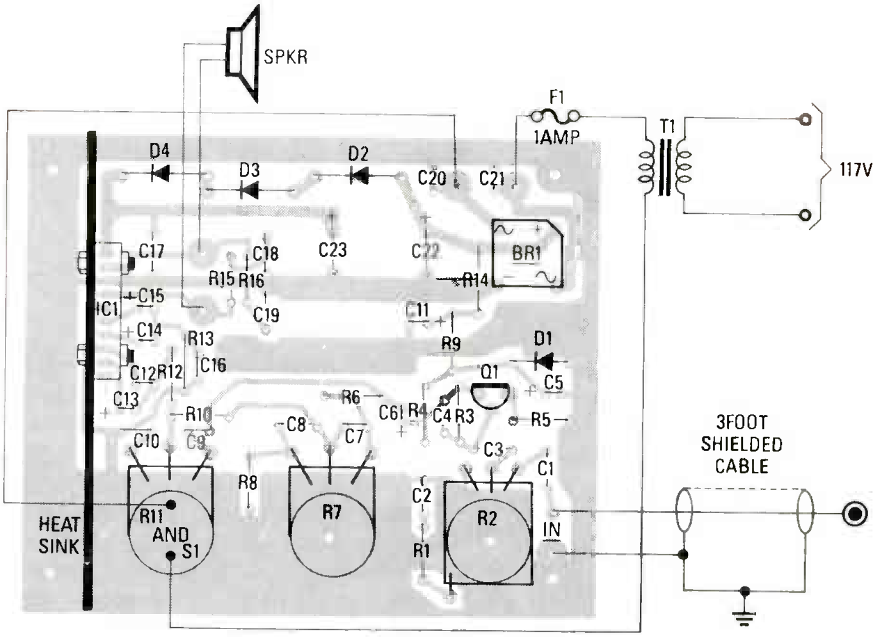



**FIG. 2—PARTS PLACEMENT DIAGRAM for the PC board. Close attention should be paid to the polarities of the electrolytic capacitors.**

ble. Likewise, turning R11 counterclockwise shunts high frequencies away from the bass control to ground, cutting treble tones. The tone-control output drives resistor R12 and capacitor C12, which serve as a low-pass filter. That circuitry is included to prevent oscillation in power-amplifier IC1.

Power-amplifier IC1 is a bridging-type amplifier. That means that there are two power amplifiers inside the package that drive the speaker in a push-pull configuration for double the power output. The input signal to pin 2 is amplified and then drives the speaker from the pin-7 output. A phase-inverted output appears at pin 4 and is coupled through capacitors C14 and C13 to the second amplifier in IC1. After being amplified, the phase-inverted output drives the speaker from pin 9. Resistors R15 and R16, and capacitors C18 and C19, are included at the output of IC1 to prevent high-frequency oscillation. Note that if you can't find the 2.2-ohm resistors specified for R15 and R16, 10-ohm units may be substituted. The exact value isn't critical, although 2.2 ohms is preferred.

Rounding out the circuitry is a fairly conventional power supply, consisting of bridge rectifier BR1; capacitors C22 and C23; and diodes D2, D3, and D4. Since the supply voltage, after being rectified, is at about 17 volts, D2, D3, and D4 are required in order to drop it down to about 15 volts. Note that power is also tapped off capacitor C22 for Q1. That extra

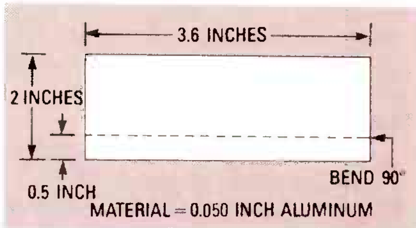



**FIG. 3—YOU CAN MAKE A HEAT SINK for IC1 from a piece of scrap aluminum.**

**All resistors are ¼-watt, 5% unless noted**

R1, R6—10,000 ohms
R2—100,000 ohms, potentiometer, 40% loudness contour tap (Radio Shack 271-1732)
R3—2.2 megohms
R4, R10—4700 ohms
R5, R9, R14—470 ohms
R7, R11—100,000 ohms, potentiometer, audio taper (Radio Shack 271-1722)
R8, R12, R13—1000 ohms
R15, R16—2.2 ohms

**Capacitors**

C1, C3, C8, C17, C18, C19—0.1 µF, 50 volts, radial-lead polyester
C2—0.047 µF, 50 volts, radial-lead polyester
C4—100-pF, 500 volts, ceramic disc
C5, C14, C15—100 µF, 10 volts, radial-electrolytic
C6, C13—1 µF, 16 volts, radial-electrolytic
C7, C16—0.01 µF, 50 volts, radial-lead polyester
C9—0.0022 µF, 50 volts, radial-lead polyester
C10—0.022 µF, 50 volts, radial-lead polyester
C11—100 µF, 16 volts, radial-electrolytic
C12, C20, C21—0.001 µF, 50 volts, ceramic disc
C22—2200 µF, 25 volts, radial-electrolytic
C23—2200 µF, 16 volts, radial-electrolytic

**Semiconductors**

IC1—LA4460 linear power amplifier (Sanyo)
Q1—2N5088 NPN transistor
D1—1N4739 9.1-volt, 1-watt, Zener diode
D2–D4—1N5400 3 amp, 50 PIV, silicon diode
BR1—6 amp, 50 PIV, bridge rectifier

**Other components**

S1—SPST potentiometer switch for R11 (Radio Shack 271-1740)
T1—Plug in transformer, 12 volts AC, 1 amp (Jamenco AC1000 or equivalent)
PL1—RCA plug
F1-1 amp, slow-blow, 3AG fuse and holder
**Miscellaneous**—speaker, PC board, 3 knobs, 3 feet of shielded wire, scrap aluminum for heatsink, hardware. **Note: A PC board is available from E²VSI, P.O. Box 72100, Roselle, IL 60172, for $9.95 plus $0.50 shipping.**

power-supply circuitry is required to ensure amplifier stability, as it would otherwise *motorboat* (low-frequency self-oscillation). Resistors R14 and R9 provide current limiting, while capacitors C11 and C5 provide extra filtering. Zener diode D1 ensures that the supply voltage is stabilized at 9.1 volts, as required by transistor Q1.

## Part selection

Now that we have covered the circuit details, let's discuss the parts.

The speaker system may be any decent-sounding unit you can find. Chances are you will want to build two amplified-speaker systems, so it would be wise to get two identical units for balanced sound. The Panasonic two-way unit used for our prototype was purchased at a flea market for $1.50; perhaps you can do better. If possible, test out the speaker system you are considering, as you don't want to waste time on a unit that is defective, or has poor sound quality.

You may have some trouble finding a tapped potentiometer that is required for R2. One alternative is the ganged unit mentioned in the Parts List. That unit consists of two ganged potentiometers, but only one of them is used. Of course, if you can find a single-unit substitute with same specifications, you should use that.

The semiconductors are available from a wide variety of sources. Many Japanese TV/stereo replacement-parts suppliers carry the Sanyo LA4460 for IC1. And any 3-amp diodes can be used for D2, D3, and D4. The bridge rectifier specified is a standard 6-amp, 0.6-inch square-cube unit. You can also cross-reference those semiconductors with the Philips-ECG replacement line, as well as many others.

Finally, transformer T1 is a plug-in 12-volt AC 1-amp unit. It is available from several sources. If you prefer, a standard 12.6-volt AC, 1-amp or better, filament transformer may be used. If you go with a standard filament transformer, remember to pick up a line cord and a ¼-amp fuse for F1.

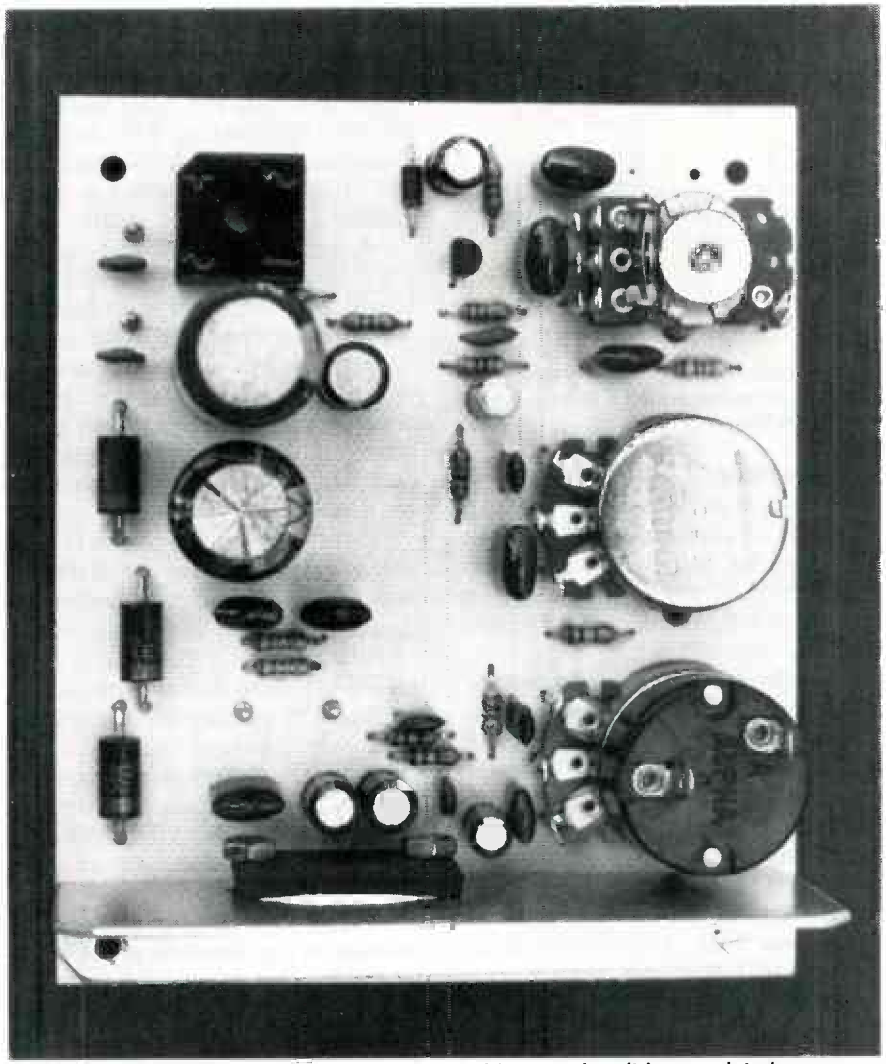


FIG. 4—YOUR BOARD SHOULD look similar to this one when it is completed.

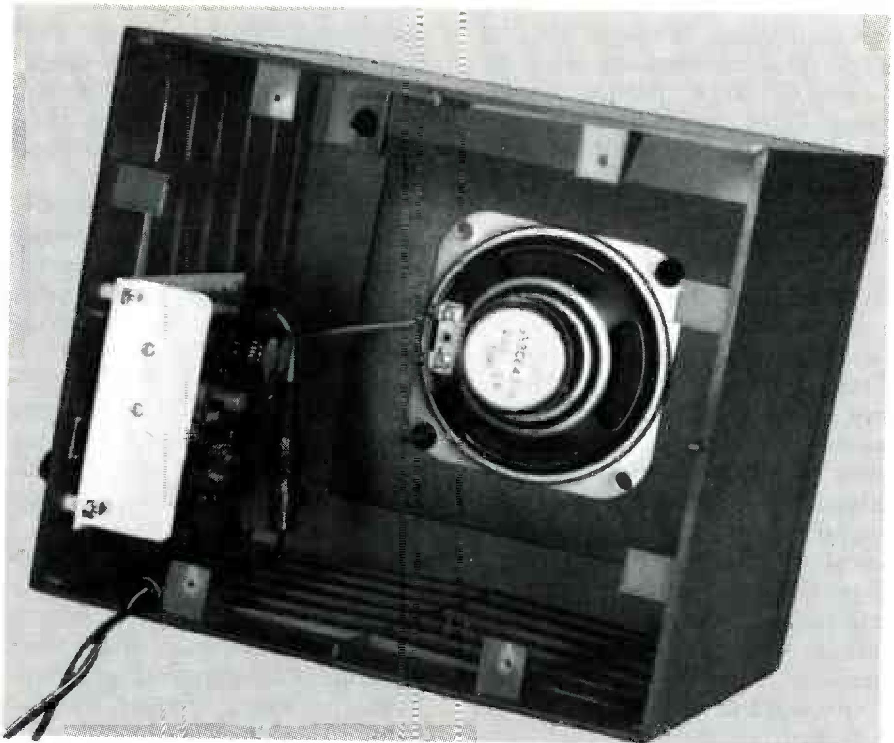


FIG. 5—A GOOD PLACE TO MOUNT the board is on the side of the cabinet, near the rear. Note the spacers that are used between the board and the cabinet

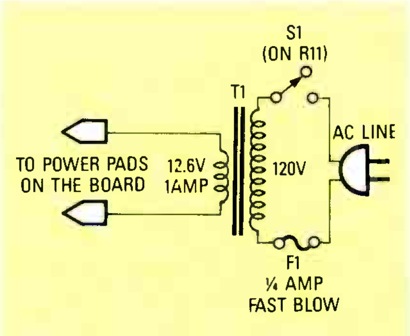



FIG. 6—ALTERNATE TRANSFORMER details should be followed if a standard filament transformer is used.

## Construction

The amplifier should be built on a PC board for best results. Either make one using the pattern in the PC Service section of this magazine or you can buy one from the source given in the Parts List.

Start the assembly by stuffing the amplifier PC board. Refer to Fig. 2 for component locations and the Parts List for values. Starting with the diodes, install bridge-rectifier BR1 with the case, notch, or positive terminal as shown. Then install 3-amp diodes at D2, D3, and D4 as indicated. Finally, install the 1N4739 Zener diode at D1 near BR1. Double-check all parts before continuing.

Next comes the resistors. Install 470-ohm resistors at R14, R9, and R5 as indicated. Then install a 2.2-megohm resistor at R3 and a 4.7K resistor at R4. Next, install 10K resistors at R1 and R6. After that install 2.2-ohm resistors at R15 and R16. Continue by installing 1K resistors at R12, R13, and R8. Finish up by installing a 4.7K resistor at R10.

Modify the three potentiometers next. If necessary cut the shafts to length. Measure 1 inch from the bushing, mark it, and cut it off with a hacksaw, and then smooth the edges with a file. We suggest using a potentiometer switch for S1, and an appropriate unit is listed in the Parts List. The switch, by the way, should be installed on R11.

Install the potentiometer and switch combination at the R11 location, and the tapped potentiometer in the R2 location. Then install the last potentiometer in location R7. Connect the potentiometer terminals to the board by passing short lengths of solid wire through the board and through each potentiometer terminal. Leftover resistor leads are good for that. Make sure that all connections are soldered, and check for mistakes before continuing.

Next comes the capacitors. Remember to pay attention to the polarities of the electrolytics as you install them. Start by installing the 2200-µF, 25-volt capacitor at C22. Then install the 2200-µF, 16-volt capacitor at C23. Continue by installing 0.1-µF capacitors at C17, C18 and C19. Now move over to the righthand side of the board and install 0.1-µF capacitors at C1 and C3. Next, install a 0.047-µF capacitor at C2 and install a 100-pF disc at C4. Now install 1-µF capacitors at C6 and C13, and a 0.01-µF capacitor at C7. Next to that, install a 0.1-µF capacitor at C8. Now install a 0.0022-µF capacitor at C9, and install a 0.022-µF capacitor next to it at C10. Finish up by installing 100µF capacitors at C14 and C15, and check everything before continuing.

Next, Q1 and IC1 are installed. Place the 2N5088 as shown at Q1, and then install the LA4460 at IC1. Insert the part with the metal side to your left. Also, note that the pin-1 marking on the board matches the pin-1 stripe on the IC package. Double check before soldering the connections.

Continue by fabricating a heat sink for IC1. Details are shown in Fig. 3. We used a piece of aluminum salvaged from an old chassis for the heat sink, as it conveniently already had a ½-inch lip on it.

Install the heat sink. Place it against IC1 with the lip over the board's mounting holes. Then mark and drill the two mounting holes for IC1. Also, mark and drill the board's mounting holes. Put a dab of silicon grease on the metal surface of IC1 and secure the heat sink to IC1 with 4-40 × ½-inch screws. Tighten the screws just enough to hold IC1 in place, as overtightening may damage it. The board is now complete, and it should look like the one shown in Fig. 4.

Set the assembled board aside for a moment and work on the speaker cabinet. Determine a suitable location to mount the board. A good location is on the side of the cabinet, toward the rear, as shown in Fig. 5. Using the board as a guide, measure, and mark the holes for the four mounting screws, and the three knob shafts. Do that carefully, as mistakes will be hard to fix later on. Note that the holes for the screws must be smaller than the holes for the knob shafts. Drill all holes and make sure the board fits. You can, if you like, use rub-on lettering to label the controls for a professional appearance.

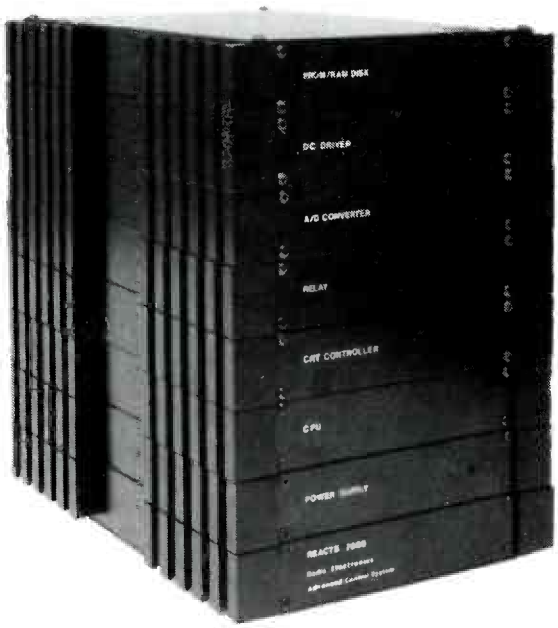
Return to the assembled board and refer back to Fig. 2 for final assembly details. Start by wiring a shielded cable to the IN pads on the board as

*continued on page 104*

# Build REACTS:

## THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

*This month we're going to show you how to build and program the terminal interface for your REACTS system.*




MICHAEL A. TUCKER

**Part 8** LAST MONTH we didn't get a chance to discuss the data registers. So, we'll start with that, and then build the interface.

By writing an eight (00001000) to the address register, the top-of-screen register is selected. That register contains the RAM address of the first character displayed at the top of the video screen.

The cursor-low register is addressed by writing a nine (00001001) to the address register. The cursor-low register holds the lower eight bits of the 11-bit RAM-cursor address, and the upper three bits of the cursor address are in the cursor high register.

As was mentioned, the upper three bits of the RAM-cursor address are located in the cursor-high register. The other five bits of the cursor-high register select the smooth-scroll offset value and disable/enable the non-scrolling 25th status line. That register is located at address ten (00001010).

The fill-address register is selected by writing an eleven (00001011) to the address register. That register is used to obtain the fill-screen feature. The fill-address register contains the memory-RAM address of the character following the last address to be filled. After writing to the fill-address register, the next character placed into the character register will be placed in each display-memory-RAM location between the address specified by the cursor-low and cursor-high register (the cursor address), and the address preceding the one in the fill-address register.

The screen attribute data register is at address twelve (00001100). The most-significant bit (bit 7) of the register determines whether the EVTLC is in the 9×28-graphics or 9×28-alphanumerics mode. If the alphanumerics mode is enabled, the other seven bits of the register will select the type of attribute to be exhibited by the "tagged" screen characters. Remember that in the 9×28 mode, only one attribute per screen is possible. If the EVTLC is in the graphics mode, no attributes are permitted; however, a combination of graphics and alphanumeric characters can be displayed on a single screen. In the graphics mode, a character is determined to be a graphics or alphanumerics character by the most-significant bit of the character byte. That is the same bit that determines whether or not an alphanumeric character is "tagged" in the 9×28 alphanumeric mode.

Only the most-significant bit (bit 7) of the mode-1 register is used. It is called the auto-increment bit and it determines whether or not the display-memory character address is automatically incremented by the EVTLC after every read/write of the character register. The mode-1 register is at address fourteen (00001110).

A fifteen (00001111) output to the address register will select the EVTLC's mode-2 register. Bit 0 places the EVTLC in either the 9×28 or 9×53 mode. Bit 1 enables or disables the cursor blink, and the other bits are not used.

The last register to be discussed is at register-address thirteen (00001101), and it is called the character register. All screen characters are written to and read from the display memory via that register. It should be noted that the register is accessible when the done-bit (bit 7 of the status register) is high. Tables 1, 2, and 3 show the assignments of each bit of the character register in the various programmable modes.

### Control software

If you purchase the CRT-controller kit from the source listed in this article, you will receive a PROM with a CRT-controller program already loaded. We strongly recommend that you

**TABLE 1—9 × 28 GRAPHICS MODE**

| Character-register bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Character | 1 | ------------------- Character Data ------------------- | | | | | | |
| Thin Graphics | 0 | 0 | X | X | SEG4 | SEG3 | SEG2 | SEG1 |
| Wide Graphics | 0 | 1 | SEG6 | SEG5 | SEG4 | SEG3 | SEG2 | SEG1 |

**TABLE 2—9 × 28 ALPHANUMERICS MODE**

| Character-register bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Character (Attr. enabled) | 1 | ------------------- Character Data ------------------- | | | | | | |
| Character (No attribute) | 0 | ------------------- Character Data ------------------- | | | | | | |

**TABLE 3—9 × 53 OPERATION MODE**

| Character-register bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Character | 0 | ------------------- Character Data ------------------- | | | | | | |
| Attribute Character | 1 | 0 | 0 | Blank | Blink | Int | UL | RV |
| Thin Graphics | 1 | 0 | 1 | X | SEG4 | SEG3 | SEG2 | SEG1 |
| Wide Graphics | 1 | 1 | SEG6 | SEG5 | SEG4 | SEG3 | SEG2 | SEG1 |

Ul = Underline Attribute
RV = Reverse Video Attribute

start with the preprogrammed PROM even if you decide to develop your own.

The software that you can purchase works in the following manner: When a key is pressed the DR (*D*ata-*R*eady) output of the 82C52 UART, which is connected to the maskable interrupt (INT) of the Z80, goes high notifying the CRT microprocessor that it has received a character. The Z80 will read that character from the UART and determine whether the character is alphanumeric or a special function. If the character is alphanumeric, the CRT's CPU will send it to the system CPU. The system CPU, after placing the character in the file or program currently called up, will then send it back to the CRT controller to be displayed. A special function can be one that is performed by the system's CPU such as CTRL-C, ESC, and CTRL-S, or one sent to the EVTLC to disable or enable a screen attribute such as reverse video, character blink, or move the screen cursor.

## Programming the CRT controller

Before programming the CRT controller, various registers of the controller's IC's must first be initialized. All but one of the IC's of the CRT controller are hardwired to the I/O ports of the onboard Z80. The only one that is not addressed by the on-board Z80 is one of the 82C55 PPI's; it is addressed by four of the I/O ports of the CPU's Z80. The following list shows the addressable CRT controller IC's and their assigned I/O ports. All addresses are in decimal form:

- 82C52 UART—Ports 64–67
- Page register—Port 68
- 82C55 PPI (addressed by the on-board Z80)—Ports 72–75
- EVTLC—Ports 76 and 77
- 82C55 PPI (addressed by the CPU's Z80)—User selectable (uses 4 ports)

Those ports are selected by the on-board CRT-controller address switches. If the operating system is used, the switches should be set to 252. The address set by the switches will be the first of four, with the others following in consecutive, incrementing order. For example, if the switches are set to address 252, the first address used by the 82C55 will be 252 and then 253, 254, and 255.

The 82C52 UART is initialized by the on-board Z80 sending a 62 to I/O-port 65, a 34 to I/O-port 67, and a 35 to I/O-port 66, in that order. I/O-port 64 is the data port, and the control program should read the byte from there when the INT (maskable interrupt) input of the Z80 goes active (high), such as when a keyboard character has been received.

The CRT controller can display a maximum of two thousand characters on the monitor at one time. Each character being displayed uses one byte of the display RAM's memory. You will notice that the display memory is an 8K × 8 RAM IC. That is four times the amount of RAM needed to display one screen. Therefore the memory-page register allows the storing of four different screens within the display RAM. That is, the display

**PARTS LIST**

**All resistors ¼-watt, 5%, unless otherwise noted.**
R1—1 megohm
R2—68 ohms
R3—330 ohms
R5—70 ohms
R6, R7—9-into-1, 10,000 ohms, SIP resistor pack
**Capacitors**
C1–C20—0.47 µF, 25 volts, ceramic disc
C21, C22—22 µF, 25 volts, ceramic disc
C23—47 µF, 16 volts, electrolytic
**Semiconductors**
IC1, IC17—8K × 8-bit CMOS static RAM
IC2—74HC573 tri-state D-Type latch
IC3, IC18—74HC245 octal tri-state transceiver
IC4–IC6—74HC04 hex inverter
IC7—9053 enhanced video terminal logic controller
IC8, IC11—82C55 programmable peripheral interface
IC9—74HC02 quad 2-input NOR gate
IC10—Z80 8-megahertz CMOS IC microprocessor
*IC12—32K × 8-bit CMOS PROM with controller software
IC13—82C52 UART
IC14, IC15—74HC688 8-bit magnitude comparator
*IC16—CRT32—16 programmable array logic (PAL)
IC19—74HC273 octal D-type flip-flops
*IC20—CRT32—20 programmable array logic (PAL)
LED1—right angle PC-mount red LED
**NOTE:** Components that are marked with a * are customized parts that can be obtained from the source listed in last month's article.
**Other components**
SO1, SO2—60-pin male and female bus-connector set
SO3—6-circuit telephone jack
SO4—9-pin female D-sub printer connector
SO5—25-pin female D-sub connector
X1—16.4 MHz crystal
SW1, SW2—6-position DIP switch
**Miscellaneous:** 1 PC board, extruded aluminum case, 4 14-pin IC sockets, 8 20-pin IC sockets, 4 28-pin IC sockets, 4 40-pin IC sockets

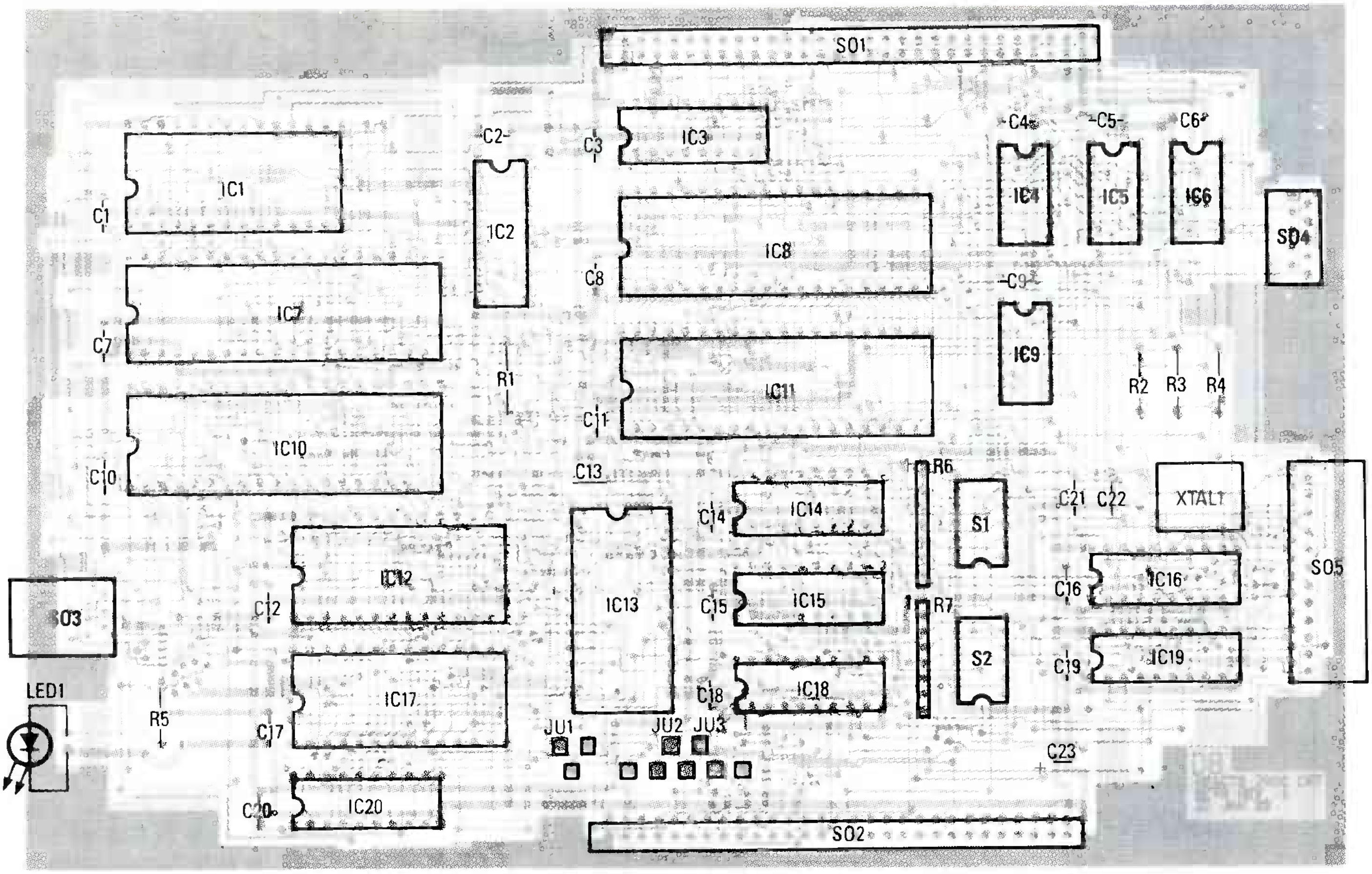



**FIG. 1—PARTS-PLACEMENT DIAGRAM. The parts for the CRT controller/keyboard interface module are installed on the double-sided board as shown.**

memory is divided into four pages with each page occupying 2 kilobytes. The memory page is changed by writing a 0, 1, 2, or 3 to the I/O port at address 68. Normally a 0 should be written to the display-memory paging register, to display the same screen all the time. However, when customizing your CRT controller, you may wish to use that feature in one way or another.

The 82C55 addressed by the onboard Z80 (IC11) is initialized by writing a 98 to I/O-port 75. That sets I/O-port 72 as an input port and I/O-port 73 as an output port, and also configures I/O-port 74 as a status or handshaking port.

The other 82C55 (IC8) is configured by writing a 166 to the highest I/O port used by IC8 (the I/O-port address selected by the switches + 3). The REACTS operating system, if used, will do that for you, and in addition, will handle the transfers between the PPI and the CPU. All you need to do is set the CRT controller's address switches to address 252. Remember that IC8 is controlled by the Z80 on the CPU.

The address and status registers of the EVTLC are accessed by writing to (to enter a data-register address) or reading from (to access the status register) I/O-port address 77. The EVTLC's data registers are selected by I/O-port 76.

After initialization, the CRT-controller program should be set to poll the status register, I/O-port 74, constantly checking for a character from the system CPU. If a character is received, it should be retrieved from I/O port 72, and the program should determine if it is a character to be displayed or one to change one of the screen's attributes or the EVTLC's operating mode. If an interrupt is received from the 82C52 (which means a character from the keyboard has been sent), the interrupt routine should fetch the keyboard character from I/O-port 64 and, depending on the type, send it to either the system CPU or the EVTLC. Customizing the CRT software can include using special keyboard or program inputs to change the EVTLC operating modes, change memory-display pages, perform graphics, etc.

## Printer interface

The printer-interface design is straightforward. The magnitude comparator (IC14) enables the printer-interface portion of the module when the correct I/O address is on the address bus. Note that address signals A0 and A1 are not connected to IC14, and changing the least-significant switch on the addressing switch increments or decrements the first I/O port used by the printer interface by four. If we built a module that required eight I/O ports to operate, we would use the A2 signal along with the A0 and A1 signals to obtain them.

If you purchased the REACTS operating system (ARTDOS) containing the printer-interface driver, using the printer port after building the module is as simple as setting the module-addressing switches to 248 and connecting a parallel printer to the module's 25-pin port. If you didn't, you will have to design your own driver routine to use the interface.

## Construction

The patterns for the double-sided PC board can be found in the PC-Service section of next month's magazine. Unfortunately, space does not permit our showing them this month. The board can also be purchased separately, as was mentioned in the "Sources" box that appeared last month.

When assembling the module, follow the parts-placement diagram shown in Fig. 4. And, we recommend that you use sockets for all the IC's. First Solder in all the components, then check all of the connections. Then double-check them.

## Checkout

Before installing the CRT controller/printer module onto the REACTS CPU, make sure the system is off. If you are using the REACTS operating system, set the CRT controller's I/O-addressing switches to I/O-port 252 (all switches up). Also, set the printer-interface addressing switches to I/O-port address 248 (the rightmost switch down and the rest up). The fourth switch from the right on the row of CPU switches should be placed in the down position; that switch should be up if a terminal is being used as the console and is connected to the CPU's serial port.

Make sure that none of the pins of the CPU connectors are obstructed or bent. To install the module, align the female connectors on the bottom of the CRT/printer module with the male connectors on the top module of your system, making sure the modules are parallel to each other. Press the CRT/printer module onto the system (extreme force is not necessary). Using common sense and following proper procedures, the connectors will last indefinitely.

After the CRT/printer module has been properly installed, connect the monitor to the 9-pin D-type port on the rear of the module and the keyboard to the connector on the front. Turn on the power, and if everything is in order, the opening menu should be displayed.

If that does not occur, check your switch settings. Also, make sure the correct switches for the CRT controller were set and not confused with the ones for the printer-interface I/O-address selection. Connect a parallel printer to the printer port to check out the printer interface. If you are using the REACTS operating system you can enter a CTRL-P, and any data entered afterwards will be printed. To get out of that mode, simply re-type CTRL-P.

In the next REACTS installment we will discuss the operation and construction of a module that will allow REACTS to remotely-control appliances, lights, etc., using the existing AC-power lines in your home, and inexpensive, easy-to-get control modules. **R-E**

# NANOELECTRONICS

## THE NEW SCIENCE OF MINIATURIZATION

*Every year, improvements in manufacturing technology allow us to squeeze more and more circuitry onto a silicon wafer. However, it is physics, not manufacturing technology, that ultimately determines how small the features of an integrated circuit can be made before the circuit will no longer function—and technology is rapidly approaching that limit. Therefore, if our quest for the miniaturization of integrated-circuits is to continue beyond that limit, a whole new breed of semiconductors must be developed.*

**JOSEF BERNARD***

AS MORE AND MORE COMPONENTS ARE crammed on the small chip of silicon that is the basis for an integrated circuit, it becomes necessary to make those components, and the paths that connect them and carry electrical signals between them, smaller and smaller. As feature sizes decrease, some interesting things begin to happen. Some of those effects are useful, others less so.

Miniaturization certainly makes for compactness, that much is evident to the eye. Smaller features on an IC, and an increase in their proximity to one another also means that switching operations can take place more rapidly due to the fact that the electrons do not have so far to travel—the shorter the distance they have to travel, the faster an IC will operate. The small feature size and dense architecture of today's LSI and VLSI integrated circuits is what make possible their high speed and throughput.

*Thanks to everyone at Texas Instruments, especially Robert Bate for their help in preparing this article.

Small size brings with it another benefit—fewer electrons to be moved shorter distances means that less power is required. In an IC with several hundred thousand active elements that is important. Even so, with that large number of components, a lot of energy is used (and lost) in getting electrons from one point to another. Just try to keep your finger on top of a 80386 microprocessor running at full tilt. A lot of energy is dissipated as heat and wasted just in pushing those electrons through the equivalent of microscopic wires.

Small feature size brings with it another problem, too. While tiny features mean that power consumption is lower, there is a phenomenon in transistors known as leakage current. A transistor is never fully, one-hundred-percent, off. There is always some current passing through it. At the discrete component level, and even in most integrated circuits, that leakage current is so small compared with that used to differentiate "on" from "off," that it can be ignored. As switching currents become lower, however (something that goes hand-in-hand with small size and is, in fact, something to be desired—up to a point) they come to approach the value of the leakage current, and the point at which a device can be said to be on or off starts to become vague. As you might imagine, vagueness is not a desirable quality in digital logic circuits.

And, on really *small* small-scale devices, another, and much more disturbing, phenomenon occurs. Present-day technology allows us to manufacture integrated circuits with features as small as .3 micron—three hundred-millionths of a meter. And technologies are under development that will allow even smaller feature sizes—perhaps as small as .05 micron by the mid 1990's (see Fig. 1).

On that submicroscopic scale, strange things begin to happen. As we enter the realm of dimensions approaching billionths of a meter ($10^{-9}$ meter) we begin to encounter a world unlike any that we have experienced

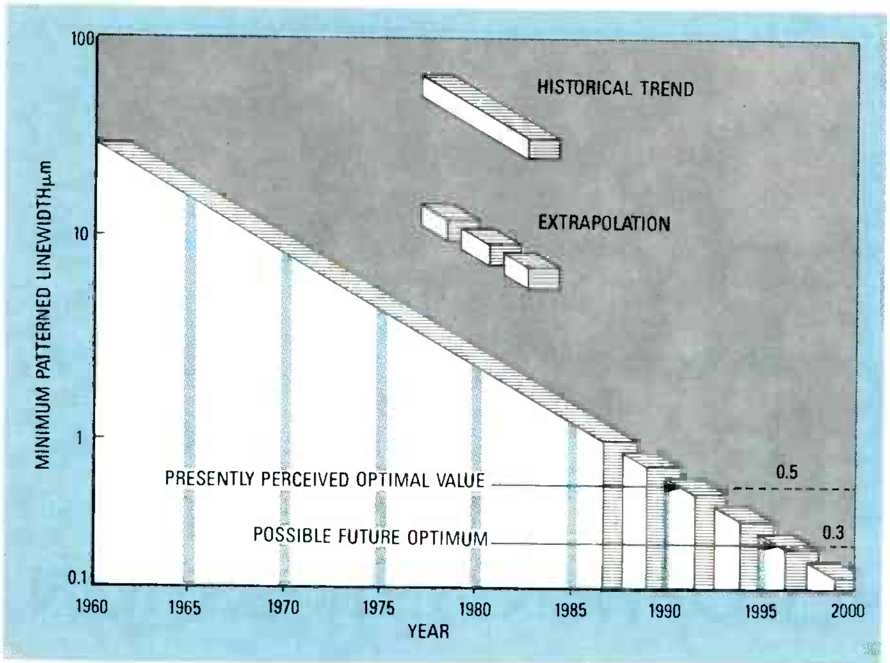



**FIG. 1—EVERY YEAR INTEGRATED-CIRCUIT feature sizes shrink. Shortly they'll reach physical limits.**

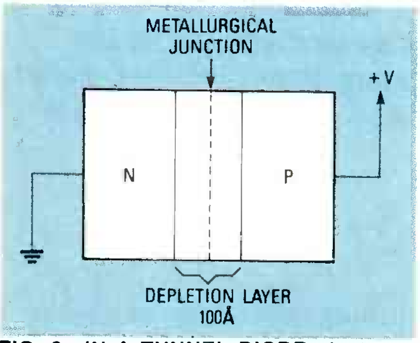



**FIG. 2—IN A TUNNEL DIODE electrons burrow through a barrier layer only about 100 angstroms thick.**

in our lives. On that scale the nature of matter becomes completely different.

## Particles and waves

Way before the time of Isaac Newton (as far back as ancient Greece) there was argument as to the nature of light. Some said it was made up of particles, and some said it was a series of waves in the *luminiferous aether* (the ether, as it later was called). One theory worked better for some of the observed characteristics of light, the other better for others. Eventually the concept of a *wavicle*—a wave that acted like a particle (or a particle that acted like a wave) evolved. And it is still with us today.

Up to a point, the behavior of matter can be explained by treating it as solid particles. That extends down even to electrons and below, hence the concept of electron shells and orbits.

At a certain point, though, we have to begin to think of electrons and other subatomic particles as exhibiting the type of behavior we associate with waves. That becomes more and more the case as we approach dimensions close to those of the electron itself.

When we do approach those dimensions, a curious thing happens. The minimum feature size of the integrated circuit begins to approach the size of the electron. Using present-day optical manufacturing techniques, the feature size of an integrated circuit can be made as small as 0.3 micron, or $3 \times 10^{-7}$ meter (feature sizes as small as 0.1 micron have been achieved in the laboratory). The size of an electron is about 200 billionths of a meter, or $2 \times 10^{-7}$ meter. The electron and its environment are almost the same size!

## Now what happens?

To explain the behavior of things at that level, a science called quantum mechanics has evolved (actually, the quantum theory was expounded by Max Planck in 1900). You're probably familiar with the expression "quantum leap," as in "a quantum leap forward." Many people think that that means a huge leap, but it doesn't (especially if you're talking about things as minuscule as electrons). It refers to the behavior of things at the level where they lose their "particle" characteristics and start behaving more like waves.

At the quantum scale, energy travels in packets or bunches. Depending on their nature and wavelength, those packets of energy may be photons, electrons, or other types of particles. Furthermore, they seem to go from here to there, or from one state to another, without entering or passing through the space, or states, in between.

In a semiconductor, that "passing through states" takes the form of an effect known as tunneling. If two adjacent layers of a semiconductor device are separated by an extremely thin (about the wavelength of an electron) depletion layer containing neither electrons nor holes, under the right conditions electrons can "tunnel" through that depletion layer as if it presented no barrier (see Fig. 2).

(While the idea of quantum-effect semiconductors is just now getting under way, tunneling devices have been known for some time. In the late 1950s and early 1960s a device known as a tunnel diode gained some degree of popularity. It even showed up in a Heathkit grid-dip meter, used for measuring antenna performance.)

## Quantum dots, wires, and wells

In an ordinary semiconductor, electrons, that act like particles rather than waves, are confined in a material such as one of the layers of doped silicon making up the device. In a quantum-effect device, however, the barriers that confine the electrons are made of energy.

Electrons occupy what are known in quantum physics as energy levels or energy bands. That is the quantum-theory equivalent of electron orbits in the more conventional model of atomic theory. A higher orbit represents a higher energy band. Under certain conditions, some materials, such as the doped gallium arsenide (GaAs) and aluminum gallium arsenide (AlGaAs) that have been contemplated for use in quantum-effect devices, have energy bands that are different. And unless the two different materials have energy bands that overlap, electrons cannot be transferred from one to the other. That discontinuity prevents electron movement from one material to the other.

In order to overcome that barrier, a semiconductor "sandwich" is made, consisting of a very thin layer (200 angstroms—about the same size as an electron's wavelength) of AlGaAs between two layers of GaAs. Then, under certain conditions, the wave nature of electrons make it possible for them to tunnel through the middle barrier layer as if it were not there.

If we take advantage of the barrier effects of differing materials, we can construct several types of quantum-effect devices. There are quantum dots, quantum wires, and quantum wells, depending on whether confinement is to zero, one, or two dimensions (see Fig. 3). The energy bands in one- and two-dimensional quantum structures are somewhat continuous, meaning that there can be some degree of electron transfer between them by conventional means. In a quantum dot, though, the energy bands become discrete and electron transfer, in a physical sense, is effectively blocked.

Another aspect of the wave nature of electrons becomes apparent in confinement. Standing waves, like those in systems involving sound (the way your voice sounds so great when you sing in the shower) or radio-frequency (affecting an antenna's efficiency) can occur. The quantum structure becomes resonant at a certain frequency. At resonance, where the standing waves reinforce rather than cancel each other, a small amount of energy has a great effect. A specific voltage will easily cause tunneling; other voltage levels, both higher and lower, will not. That, in effect, enables us to turn a quantum-device switch on or off.

Thus, the quantum effect, which at first appeared to be rather disconcerting, and perhaps to present a barrier to the further miniaturization of electronic components and circuits, now appears to present a way out of the situation. It may eventually allow us to produce complex semiconductor devices that will be perhaps one one-hundredth the size of current devices.

Furthermore, while current semiconductor devices have a theoretical switching-speed limit in the picosecond ($10^{-12}$ second) range, quantum-effect devices can have switching speeds up to 100 femtoseconds ($10^{-13}$ second)—ten times faster. The way in which such a device might be constructed is shown in Fig. 4, and an experimental array of quantum-dot diodes is shown in Fig. 5.

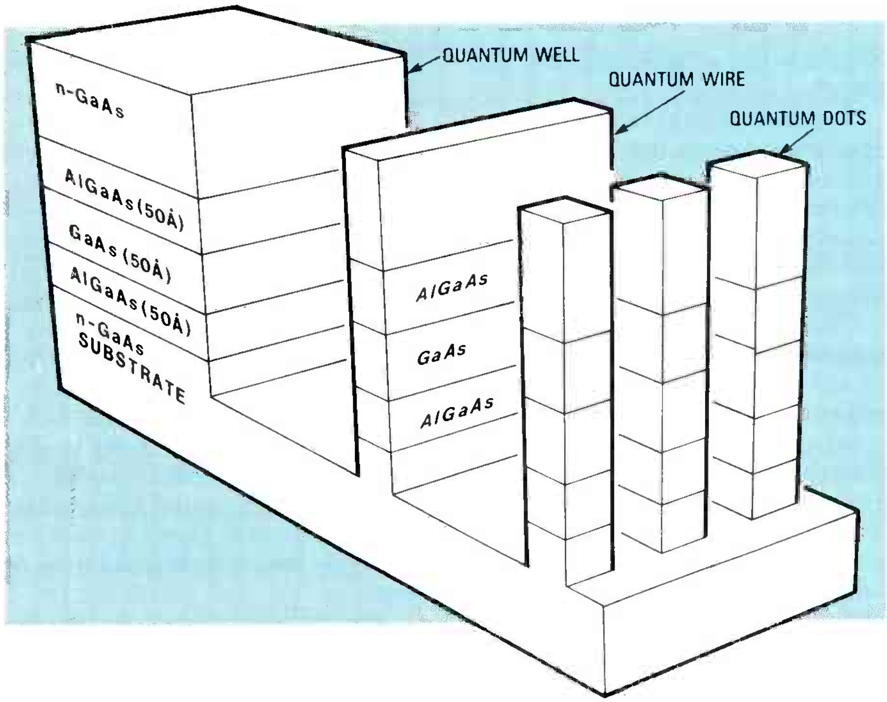



**FIG. 3—DEPENDING ON THE DEGREE of confinement of electron travel, a quantum device may be defined as a quantum well, wire, or dot.**

## Getting things down to size

It is unfortunate that this new science of nanoelectronics (from the Greek nanos, meaning "dwarf") is not yet a reality. There are still many difficulties to overcome before you'll

### EXPONENTIAL NOTATION

To express extremely large or extremely small numbers, a method known as exponential notation is frequently used. For example, the number $10^6$ represents one million—a one followed by six zeros. The exponent, 6, tells us how many times ten must be multiplied by itself to reach that magnitude, and indicates how many zeros to put after the one if the number is written out.

For numbers smaller than one, a negative exponent is used: $10^{-6}$ represents one millionth (1/1,000,000), or ten divided by itself six times.

Numbers that are not exact multiples of ten can be represented as follows:

$6 \times 10^6$ = 6,000,000 (six times one million)

$4.5 \times 10^6$ = 4,500,000 (four-and-a-half times one million)

$3.14 \times 10^{-4}$ = 0.000314 (3.14 times one ten-thousandth)

The table below is a guide to the exponential system for representing values. Each time the exponent changes by one, the value of the number changes by an order of ten.

TABLE 1

| | | | |
|---|---|---|---|
| $10^{12}$ | 1,000,000,000,000 | trillion | tera- |
| $10^9$ | 1,000,000,000 | billion | giga- |
| $10^6$ | 1,000,000 | million | mega- |
| $10^3$ | 1,000 | thousand | kilo- |
| $10^2$ | 100 | hundred | hecto- |
| $10^1$ | 10 | ten | deca- |
| $10^0$ | 1 | unit | - |
| $10^{-1}$ | 1/10 | tenth | deci- |
| $10^{-2}$ | 1/100 | hundredth | centi- |
| $10^{-3}$ | 1/1,000 | thousandth | milli- |
| $10^{-6}$ | 1/1,000,000 | millionth | micro- |
| $10^{-9}$ | 1/1,000,000,000 | billionth | nano- |
| $10^{-12}$ | 1/1,000,000,000,000 | trillionth | pico- |
| $10^{-15}$ | 1/1,000,000,000,000,000 | quadrillionth | femto- |

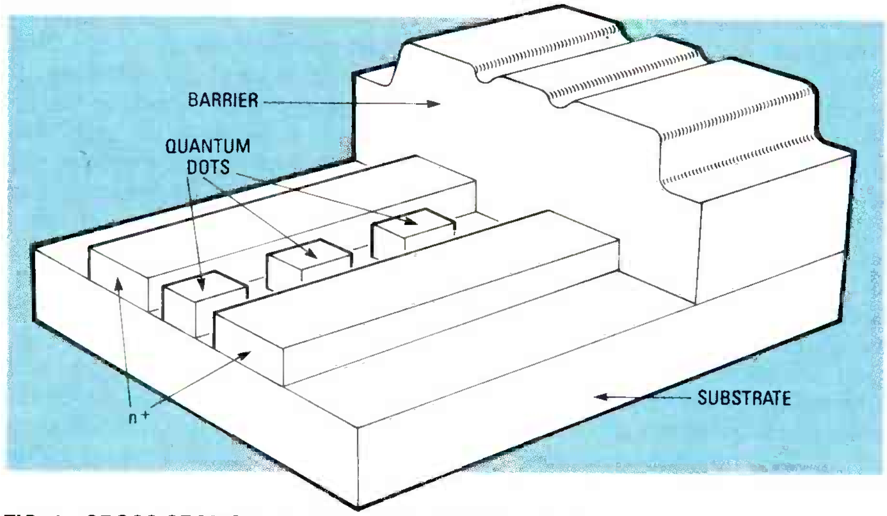



**FIG. 4—CROSS SECTION of a theoretical quantum-dot device.**

be able to buy a "supercomputer on a chip."

The first difficulty in making semiconductor devices that small lies in getting the pattern for the IC from its original size (perhaps several dozen square feet) down to a quarter-inch or so—the size of the square piece of silicon for which it is intended.

Conventional integrated circuits are produced in much the same way as an enlargement from a photographic negative, only in reverse. Simply speaking, a large negative of the IC pattern is projected onto the sensitized surface of the small silicon wafer that will eventually become the integrated circuit. It is an optical process, where a beam of light does the work. The main difference is that the image is reduced in size rather than blown up.

In quantum-effect IC's, though, we are dealing with extremely small dimensions. So small, in fact, that light is too crude a medium to achieve the precision required. The wavelength of light is measured in angstroms, one angstrom being one ten-thousandth of a micron, or $10^{-10}$ meter. Blue light has a wavelength of approximately 4500 angstroms, or $4.5 \times 10^{-7}$ meters. The feature size of our intended quantum-effect IC, however, is less than $3 \times 10^{-7}$ meters, which is smaller than the wavelength of the light that we would use to project the image.

Obviously, that method won't work. It would be like trying to slice an olive with a sledgehammer! To achieve smaller feature sizes, something smaller than photons (with their relatively long wavelengths) must be used.

The current solution to the size problem is a technique called electron-beam lithography, where electrons, rather than photons, are used. With their smaller wavelengths, electrons afford a much greater definition than photons. (That is why electron microscopes can enable us to see things that are much smaller than we can see using conventional optical microscopes.)

Electron-beam lithography, however, is an impractical method for mass-production. At present, the most promising answer lies in *M*asked *I*on-*B*eam *L*ithography (MIBL), a technique now under investigation at the University of Houston. Instead of using photons or electrons to project the IC pattern onto the surface of a silicon wafer, MIBL uses ions of hydrogen. The wavelength of those ions is even smaller than that of electrons, making it possible to achieve the feature size required by quantum-effect devices.

The next problem comes in the interconnection of the components on the surface of the integrated circuit. In ordinary-scale IC's, the components are connected by thin strips of conductive material deposited on the silicon surface. At the quantum-effect scale, however, such a method is impractical. Not only does electrical resistance and current leakage cause problems, but we also run into the problem of how to contain the electrons in the microscopic conductors that would have to be used.

One solution is to make the interconnects as large as, if not larger than, the components they join–not a very practical answer. A more elegant solution involves what is called limited-interconnect architecture. Using computer assistance, the IC pattern is laid out so that parts of the circuit that are electrically adjacent to one another are physically adjacent as well. Where one ends, the next begins, and electrons move from one to the other directly. Using that approach, at least a good deal of the interconnections can be eliminated.

Other difficulties arise from the extremely small feature size of quantum-effect devices. A quantum dot can contain only a few electrons—not enough to make it possible to discriminate between a legitimate signal and random noise. Several quantum dots have to be ganged together to overcome the noise threshold.

Also, getting signals out of a quantum-effect integrated circuit and into the real world is not a simple matter. The voltages and currents present in quantum-effect devices are much

*continued on page 104*

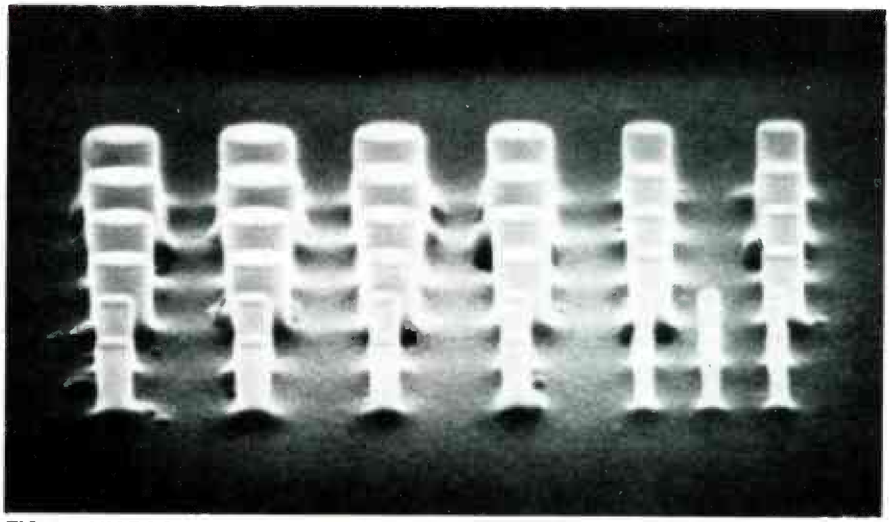


**FIG. 5—MICROGRAPH of an experimental array of quantum-dot diodes. The smallest feature here is just 1000 angstroms, or 10-7 meters. (Photo courtesy of Texas Instruments)**

# VCR SERVICING BASICS

*This quick six-step approach can help you to isolate VCR failures.*

BRIAN PHELPS

PEOPLE OFTEN HAVE QUESTIONS DEALING with VCR problems. One of the most frequent is: "How can I tell which circuit in my VCR is causing the symptoms I see on my TV or monitor?" This article will provide some of the answers to that question, and also discuss some valuable servicing tips.

One reason why it's sometimes so difficult to isolate a VCR failure is that almost any circuit can cause many different problems, and, quite often, the symptoms are misleading. Sometimes something unusual, such as a shorted switching transistor or a capstan- or cylinder-servo problem, may confuse a servicer into replacing a good component. Therefore, to avoid any unnecessary procedures, some kind of step-by-step process is required.

### A step-by-step method

One way to isolate problems is by checking out the unit in the following order:

1—Visual inspection
2—Check microprocessor
3—Servos (cylinder and capstan)
4—Luminance
5—Chrominance
6—Audio

### Visual inspection

Looking for the obvious includes things such as foreign objects that may be jammed inside the VCR. (You would be surprised what children might manage to stick inside an appliance). The tracking control may be out of the center-detent position, or the consumer may have locked-up their VCR in a program mode. At any rate, failure to check for the obvious problems first can send you on a wild goose chase.

### Microprocessor analysis

There are some very basic things to check that concern the microprocessor.

- The B+ supply for DC level, ripple, and any high-frequency glitches.
- The clock input for any DC voltage that should be there, the amplitude of the clock signal, and the frequency.
- The data inputs and outputs. We're mostly concerned that there is activity on those lines, and that the activity changes when different functions of the VCR are selected, rather than how the actual signals look.
- The reset pulse; it usually occurs between 0.5 and 1 second after B+ is applied to the microprocessor. If the reset pulse is absent, the microprocessor may start its routine at any point, yielding some strange symptoms—if anything at all.

### Servos

When troubleshooting servos, it is often helpful to use a block diagram (see Fig. 1). Before you start, however, you must decide which servo or servos you should be looking at.

You can determine if the problem is caused from the capstan or the cylinder servos by listening to the audio. The audio quality is dependent upon the rate at which the tape is being pulled by the capstan across the audio head. If the speed is incorrect, the

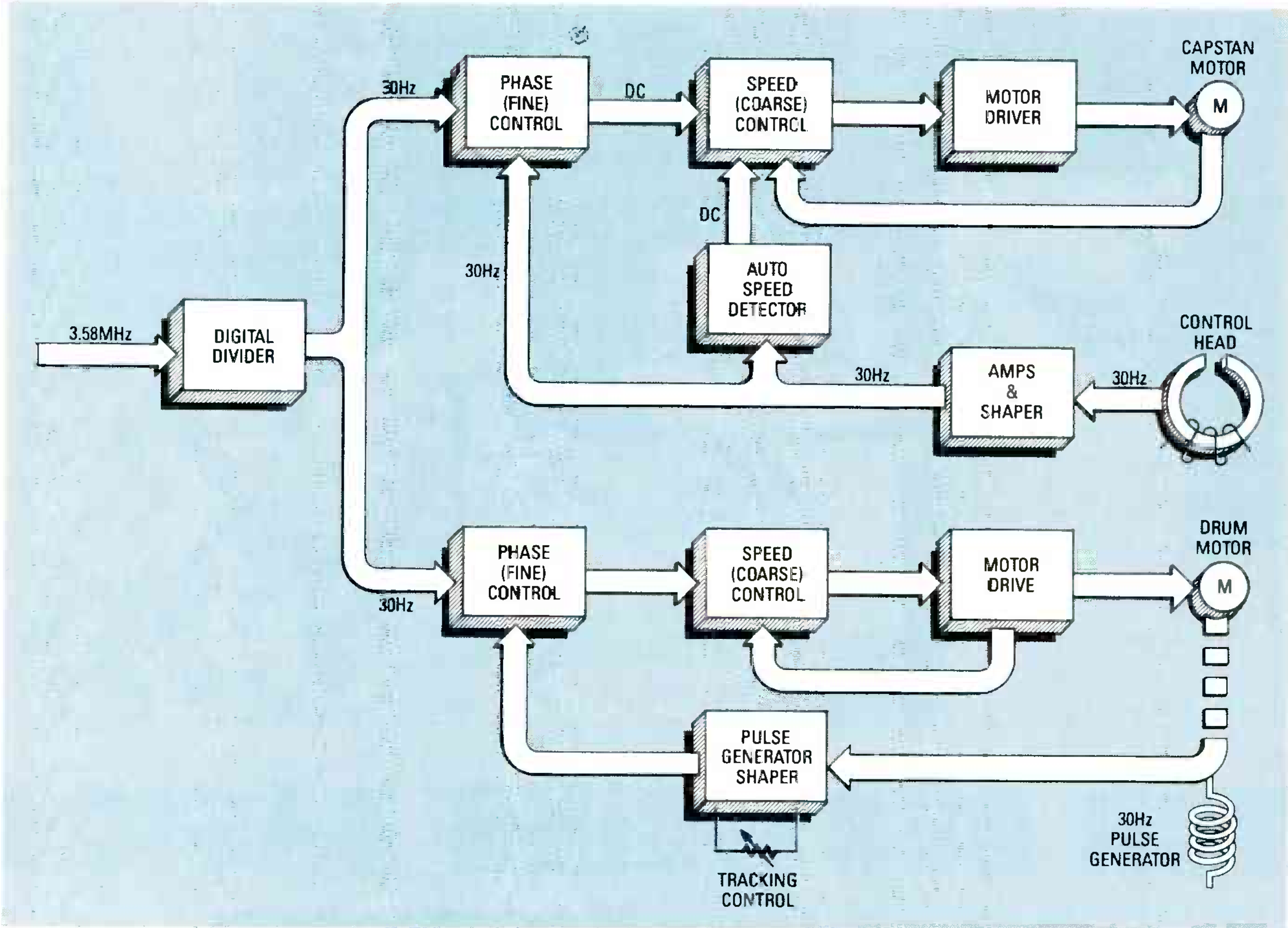



**FIG. 1—THE BLOCK DIAGRAM** of the servo circuits inside a VCR. A block diagram is often very helpful in troubleshooting because it shows you how the different sections of a circuit are interconnected.

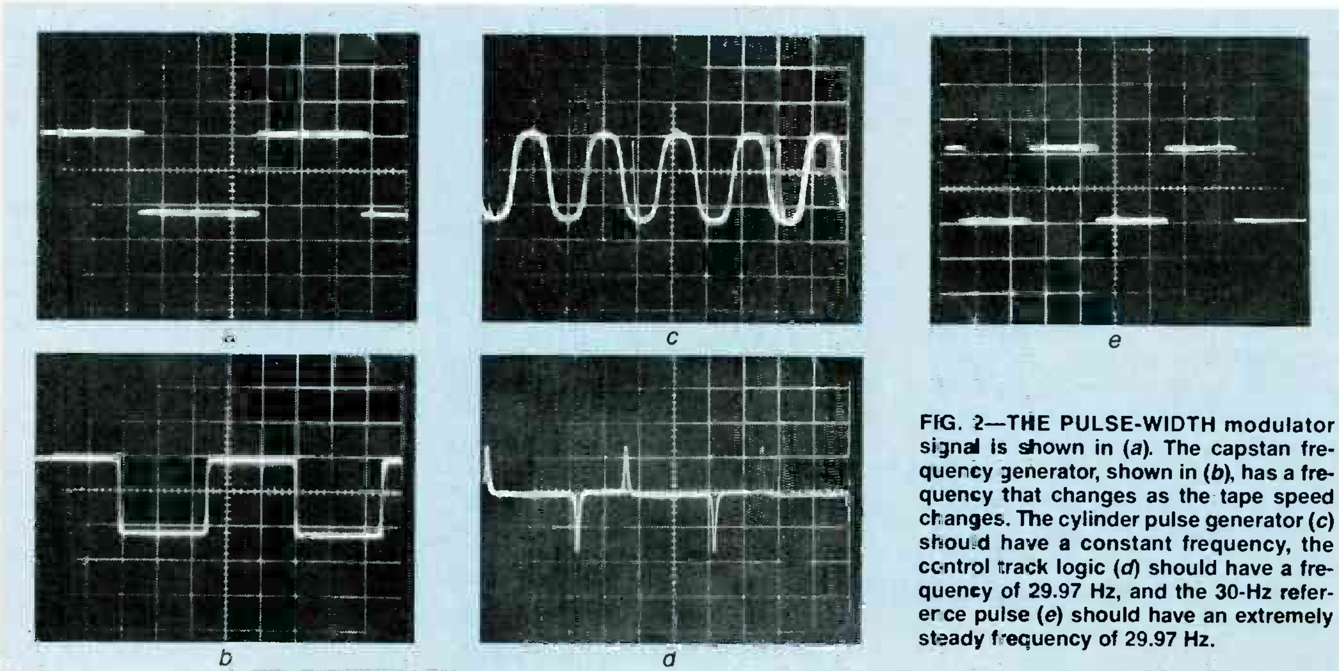



**FIG. 2—THE PULSE-WIDTH modulator** signal is shown in (*a*). The capstan frequency generator, shown in (*b*), has a frequency that changes as the tape speed changes. The cylinder pulse generator (*c*) should have a constant frequency, the control track logic (*d*) should have a frequency of 29.97 Hz, and the 30-Hz reference pulse (*e*) should have an extremely steady frequency of 29.97 Hz.

audio will sound distorted. But, if the audio sounds good, you should look at the cylinder servo circuitry.

When analyzing the servo circuits, there are some key signals to check. Those include the pulse-width modulator signal (PWM), the capstan frequency-generator signal (FG), the cylinder pulse-generator signal (PG),

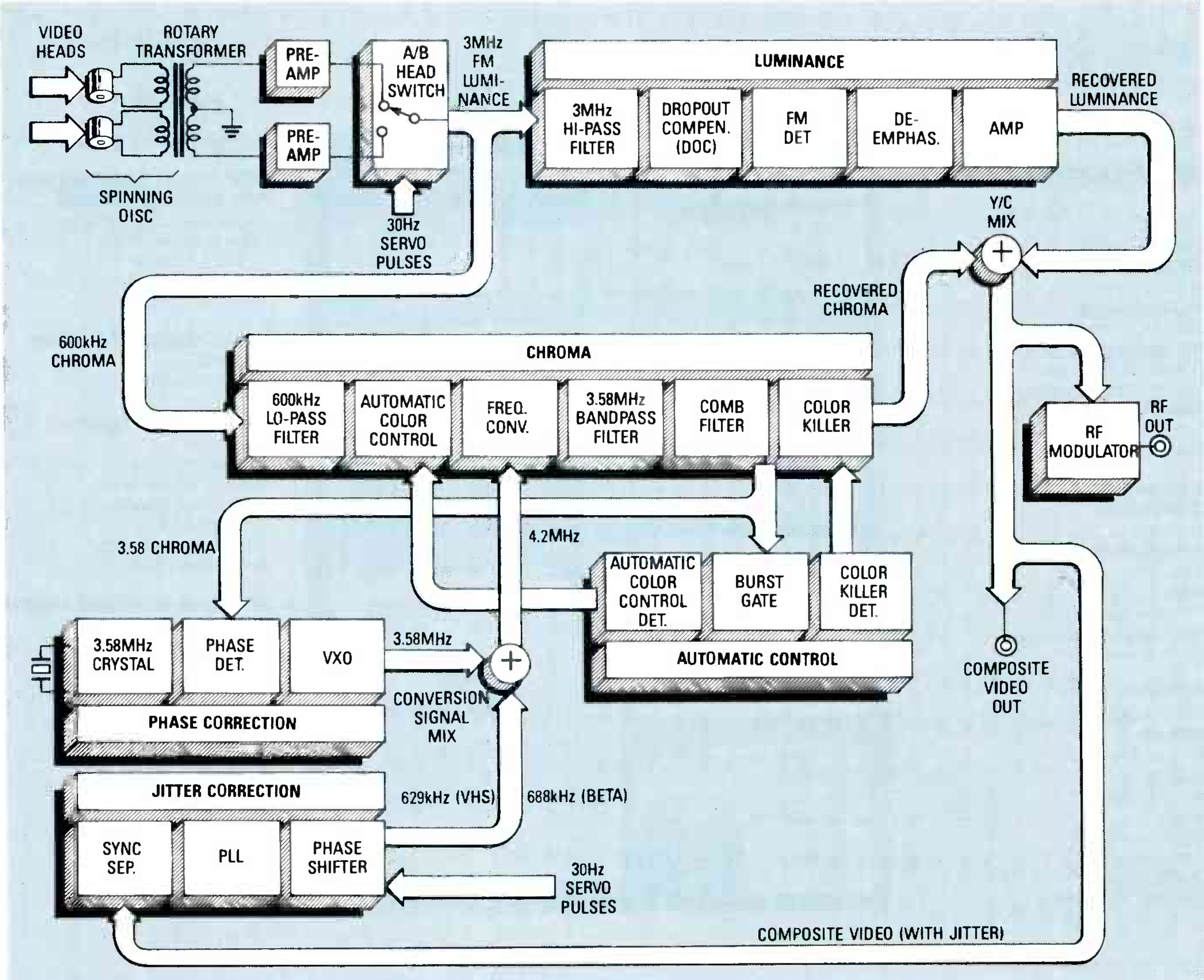



**FIG. 3—THIS BLOCK DIAGRAM shows the video-processing circuitry inside a VCR. The circuitry inside all VCR's is similar.**

the control-track logic pulse (CTL), and the 30-Hz reference signal. Figure 2 shows how those signals should look for proper servo operation.

## Luminance circuitry

The luminance circuits typically produce failures ranging from noisy video to a lack of video. However, failures such as those can also be caused by anything from the video-head circuitry to the RF modulator.

A good approach to troubleshooting luminance circuits is to inject a signal that would be present at various test points if the VCR were operating properly. That way you can determine which circuits are and aren't working by checking every point where the signal is supposed to appear.

One example of troubleshooting by using signal injection is substituting a known good signal in place of the one coming from the video heads (see Fig. 3). Sencore's *VC63* VCR test accessory provides a signal to inject into the video preamps. (You should use equal levels for both preamp inputs and if one of the inputs needs a greater signal level, that's the path to follow.) That simple procedure tells you whether or not the preamps were receiving a good signal from the video heads. If everything checks out after the signal is injected, that would probably indicate a bad video head.

If, after injecting a signal into the preamps, there is still a problem, the chances are good that the video heads are all right. For example, suppose that one of the playback/record switching transistors has a short. That would put 10 ohms between the playback path for one of the heads and ground. The resulting picture on the monitor is similar to that of a bad video head, and many repairmen would prematurely clean and/or replace the video heads—a procedure that is costly and time-consuming.

## Chrominance

Defects in the chrominance and audio circuits can be detected by looking at the color or listening to the audio. Quick checks for the chrominance include testing the 3.58-MHz oscillator, the 4.2-MHz conversion signal, the 30-Hz and 15-kHz reference signals, and the 629-kHz VHS color subcarrier.

If you troubleshoot a VCR following the procedures in the correct order, you can quickly and accurately isolate defective stages in the circuitry. After a couple of trial runs on known-good VCR's, you should be able to tackle the "Tough Dog" problems that you may come across. Just be sure that you learn any new techniques and procedures on a known good unit, so that you are not led astray by erroneous readings and strange results. **R-E**

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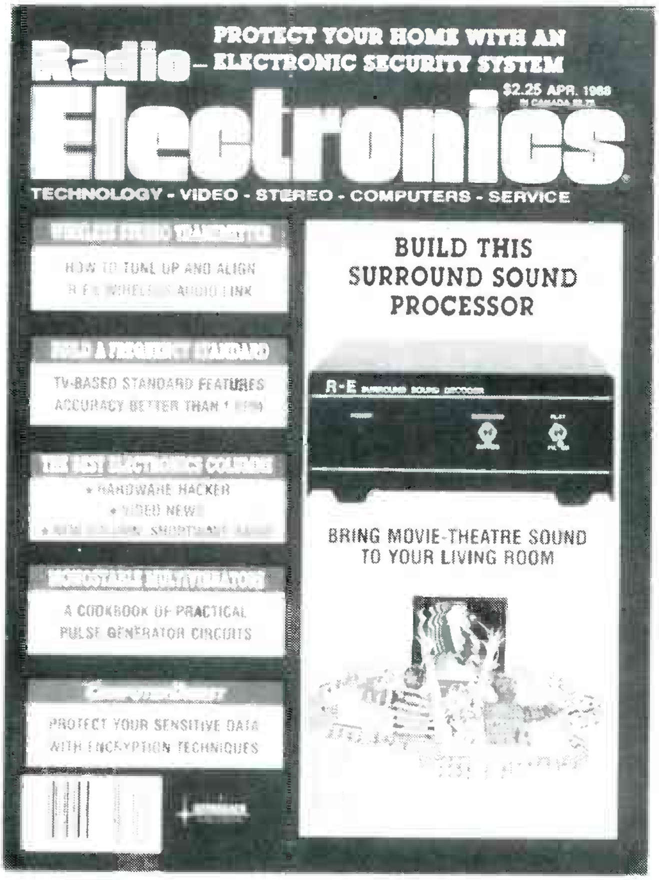


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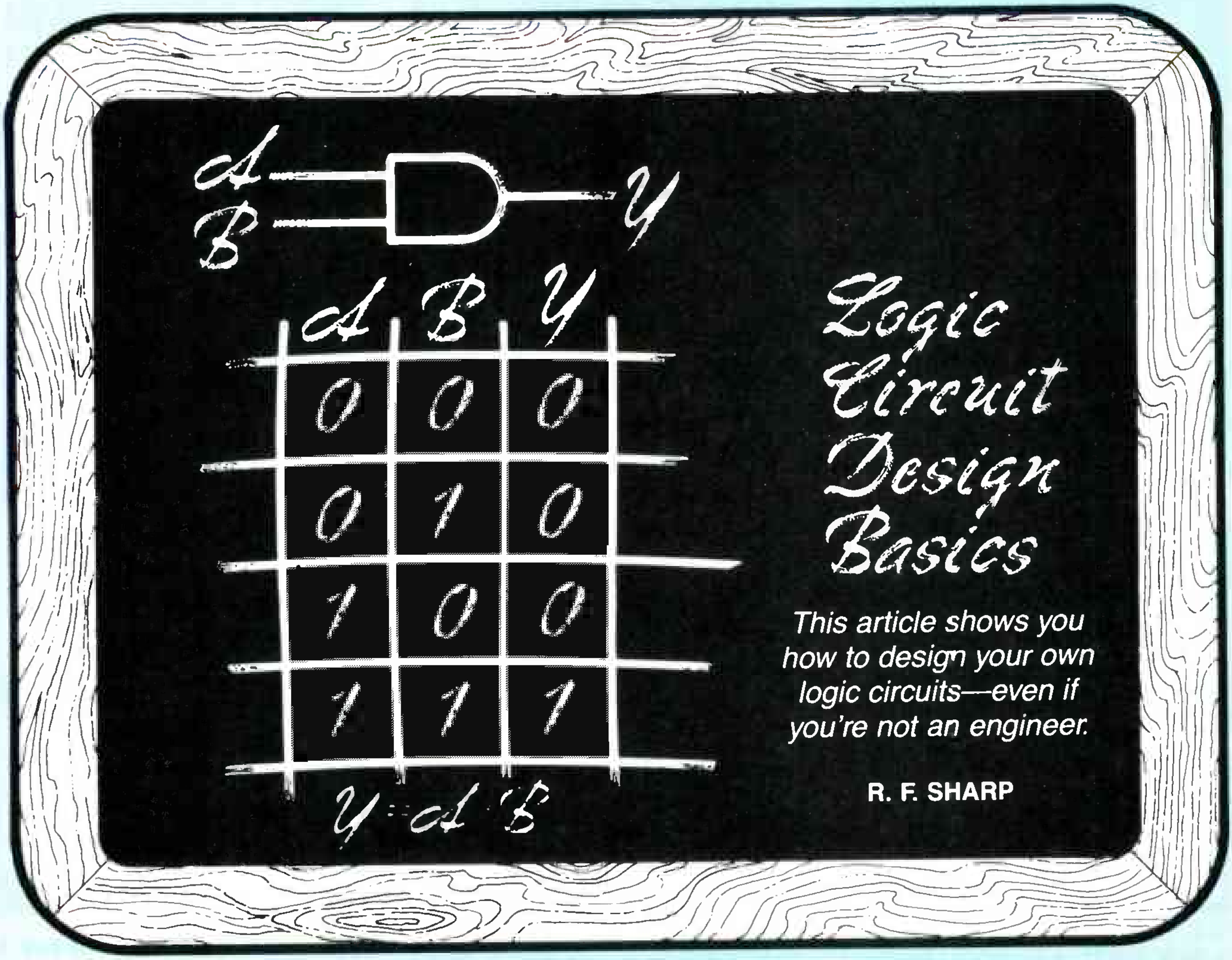



# Logic Circuit Design Basics

*This article shows you how to design your own logic circuits—even if you're not an engineer.*

R. F. SHARP

NOT LONG AGO, PEOPLE WHO WERE INvolved in electronics as a hobby more than likely worked in the electronics field as well. As a result, those people quite often had a strong background in circuit design. Nowadays, however, many people dabble with all sorts of do-it-yourself electronic gadgets. Unfortunately, when you build a ready-to-assemble kit, or if you assemble a circuit according to someone else's schematic, you learn very little in the way of actual circuit-design and engineering techniques.

In this article we will show you a systematic approach that is used by circuit designers to create switching circuits. And although circuit design is a broad topic, and cannot be covered in detail in the space we have available, you should still be able to acquire enough knowledge from reading this article to get a good head start when you set out to design a logic circuit of your own.

We will begin with the fundamentals and, although the subject of circuit design requires some familiarity with algebra, we will try to avoid mathematics as much as possible. Those of you who are already familiar with digital circuitry may find some parts of this article too elementary and will want to skip over them. Even so, it might be a good idea to read along just as a refresher.

## Number bases

The most elemental language of computers or digital circuits is the base-2 (or binary) number system. The reason for that is because all digital circuitry is basically a collection of on/off switches, electronic or mechanical. And since a switch has only two states it can therefore be represented using the digits 0 or 1 in the binary number system. Other number systems, such as *B*inary *C*oded *D*ecimal (BCD) and hexadecimal (base 16) are natural outgrowths of base 2. Our everyday number system, decimal, was originally chosen as base 10 to correspond to the number of fingers (digits) we have. Perhaps there are some computer scientists who at one time or another have wished that humans had eight fingers on each hand so that we would be more familiar with hexadecimal!

To help explain how the binary number system works, let us first analyze the decimal number system. The base-10 number system works like this: The number 1234 means $4 \times 1 + 3 \times 10 + 2 \times 100 + 1 \times 1000$. Each successive position to the left of the decimal point represents the next highest power of 10. So, the number 1234 could also be represented as $4 \times 10^0 + 3 \times 10^1 + 2 \times 10^2 + 1 \times 10^3$. (Note that any number raised to the power of 0 is equal to 1 and any number raised to the power of 1 is equal to the number itself.)

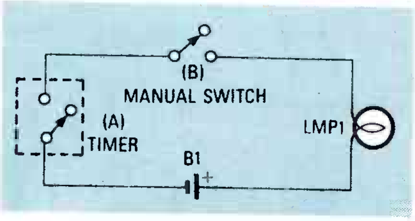



**FIG. 1—IN THIS CIRCUIT, the lamp will turn on if both the timer AND the switch are closed.**

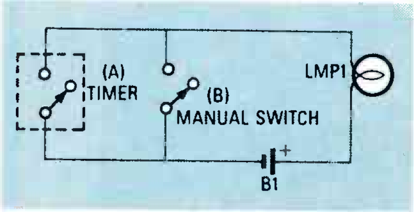



**FIG. 2—THIS CIRCUIT REQUIRES that either the timer OR the switch must be closed for the lamp to be on.**

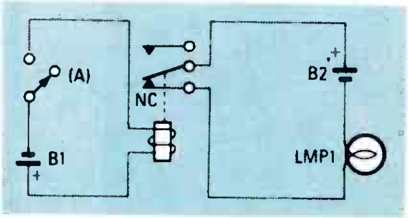



**FIG. 3—IF THE SWITCH (A) is open, the lamp is on, and if the switch is closed, the lamp is off. The relay inverts the switch's action.**

Base-2 numbers use powers of 2 instead of 10. For example, the number 111011 in base 2 translates as $1 \times 1 + 1 \times 2 + 0 \times 4 + 1 \times 8 + 1 \times 16 + 1 \times 32$. It could also be written as $1 \times 2^0 + 1 \times 2^1 + 0 \times 2^2 + 1 \times 2^3 + 1 \times 2^4 + 1 \times 2^5$. Notice that the base number of any given number system never appears as a single character. For example, base 10 only has the characters 0–9, while base 2 only has the characters, 0 and 1. Counting in binary is actually very easy, for example, 000, 001, 010, 011, 100, 101, 110, 111, 1000, 1001, etc.

## Logic

When it comes to switching circuits, there are two types of logic: positive and negative. Positive logic assigns the digit "1" to represent a high output and "0" to represent a low output. Negative Logic is much less common and works just the opposite (1 = low output and 0 = high output). For our purposes we'll say that a high output is 5 volts and a low output is 0 volt. We can also say that a "1" means true and that a "0" means false.

So why, you wonder, is all that of interest? As an example, suppose we want to design a circuit that will turn on a lamp at 7:00 pm. We would also like to have an override switch so that we can manually turn the lamp off regardless of the time.

The circuit in Fig. 1 turns on the lamp if both the timer AND the manual switch is closed. Using positive logic we can say that LMP1 is true only if A AND B are closed. Alternately, we might want to turn the lamp on even if the timer has not reached its set time. The circuit in Fig. 2 will light the bulb if either the timer OR the manual switch is closed. Again, using positive logic we can say that LMP1 is true if either A OR B is closed.

While those two circuits are trivial, and are very easy to design, we have nonetheless introduced some concepts that will eventually allow us to create much more complicated circuits. The two key words that we used were AND and OR, our basic tools. When we talk about AND and OR in electronics, we are referring to devices called logic gates (switches that control electron flow).

Our last basic building block is the NOT gate, better known as an inverter. Figure 3 shows a way of implementing the NOT function by using a normally closed relay to invert the switch's action. Logically, LMP1 is true only when switch A is open.

Logic gates can be made using diodes and resistors, known as *D*iode *R*esistor *L*ogic (DRL). Figure 4-*a* is a DRL OR gate and it works as follows: If both inputs (A and B) are low, the output ($V_{OUT}$) is low. However, if either input is high, the diode that corresponds to the high input conducts, providing a path for current to flow to ground. As the current flows, most of the voltage is dropped across R3, and a high is measured at $V_{OUT}$. The output is the same if both inputs are high.

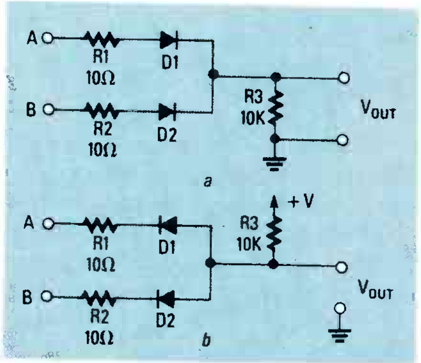
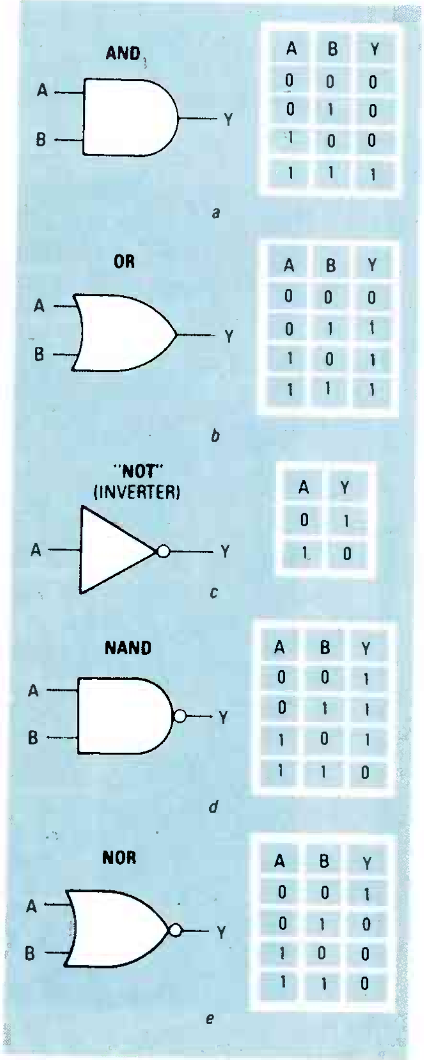



**FIG. 4—THESE TWO CIRCUITS use diode-resistor logic (DRL). The one in *a* is an OR gate, and the one in *b* is an AND gate.**

Figure 4-*b* is a DRL AND gate and it works as follows: If both inputs are low, both diodes are conducting and $V_{OUT}$ will be low. If only one input is high, the other input is still conducting and there is still a low at the output. It is only when *both* inputs are high, that neither diode is conducting and a high is measured at the output.

Two other useful gates can be made by adding an inverter at the output of an AND gate and an OR gate. An AND gate becomes a NAND gate (meaning NOT AND) and an OR gate becomes a NOR gate (meaning NOT OR).




| A | B | Y (AND) |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

| A | B | Y (OR) |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

| A | Y (NOT) |
|---|---|
| 0 | 1 |
| 1 | 0 |

| A | B | Y (NAND) |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

| A | B | Y (NOR) |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

**FIG. 5—SHOWN HERE ARE the truth tables and schematic symbols for the five basic logic gates.**

## Truth tables

A truth table is a method of summarizing the operation of a gate or combination of gates. Circuits are said to have equal functions if their truth tables are the same. In general, the inputs to a logic gate are labeled "A", "B", "C", etc., and the output is labeled "Y." A truth table usually has those designations, uses positive logic, and 1's and 0's to represent highs and lows. You may also come across a truth table using "T" and "F"(true and false), or "H" and "L" (high and low).

A truth table lists all possible combinations of inputs and their corresponding outputs. Figure 5 shows the truth tables for the gates that we have discussed, along with the schematic symbols for each one. Note that although we have shown only two inputs for the AND, OR, NAND, and NOR gates, they often have several inputs.

Listing all possible combinations of inputs can be a very painstaking process, especially for a circuit having ten inputs. That would require that you recognize 1024 different combinations. The simplest way to figure out how many possible combinations of inputs there are is to count the number of inputs to the device or circuit, and then raise 2 to that power. For example, a circuit having ten inputs would have $2^{10}$, or 1024 possible combinations of inputs.

Figure 6 shows a partial truth table for a 5-input AND gate. Although the table is incomplete, you should see a pattern there. Notice that the five inputs (A–E) are actually counting in binary from zero to thirty one (there are a total of 32 possible combinations of inputs). For example, input number 4 corresponds to the binary number 4 (00100). Notice that the

| | INPUTS | | | | | OUTPUT |
|---|---|---|---|---|---|---|
| | 16's | 8's | 4's | 2's | 1's | |
| | A | B | C | D | E | Y |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2 | 0 | 0 | 0 | 1 | 0 | 0 |
| 3 | 0 | 0 | 0 | 1 | 1 | 0 |
| 4 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5 | 0 | 0 | 1 | 0 | 1 | 0 |
| 6 | 0 | 0 | 1 | 1 | 0 | 0 |
| 7 | 0 | 0 | 1 | 1 | 1 | 0 |
| 8 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9 | 0 | 1 | 0 | 0 | 1 | 0 |
| 10 | 0 | 1 | 0 | 1 | 0 | 0 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 |

FIG. 6—THIS IS A PARTIAL truth table for a five-input AND gate.

only time the output of the 5-input AND gate is a "1" is when all the inputs are 1.

Suppose you had a device with seven inputs and you had to list all the possible combinations of inputs. To make a truth table you would first have to calculate: $2^7 = 128$. That means that there are 128 possible combinations of inputs. Then you would have to count in binary from 0 to 127, and that would be the list of all the different inputs. Data sheets supplied with logic components usually list truth tables.

## Boolean algebra

So far we have developed most of the tools we will need for circuit design. However, the last subject that you must become familiar with, Boolean algebra, is at the very heart of circuit design.

Boolean algebra is named in honor of George Boole, an English mathematician, who was underappreciated during his own times. His developments of the "algebra of logic" had little practical use in 1847 when it was introduced. However in 1938, Claude E. Shannon of M. I. T. presented a paper outlining how Boolean algebra could be adapted to represent switching circuits.

If you are familiar with ordinary algebra you'll notice some similarities between that and Boolean algebra. The main difference is that the variables (the unknown quantities) of algebra can represent any value, while the constraints of logic (that a statement is either true or false) insist that variables of Boolean algebra have only one of two values.

## Rules

Certain rules must be followed in Boolean algebra. We will not offer any proof of these rules, we will simply list them for later use. **In Boolean algebra you must be aware that:** the symbol "·" means AND (the "·" can be dropped: A·B can also be written as AB), the symbol " + " means OR, and when something has a bar over it, the term is negated; for example, "$\overline{A}$" means "A NOT."

**1**—A, B, C, etc., can either be 1 or 0 (true or false)
**2**—0·0 = 0
**3**—0·1 = 0
**4**—1·0 = 0
**5**—1·1 = 1
**5**—0 + 0 = 0

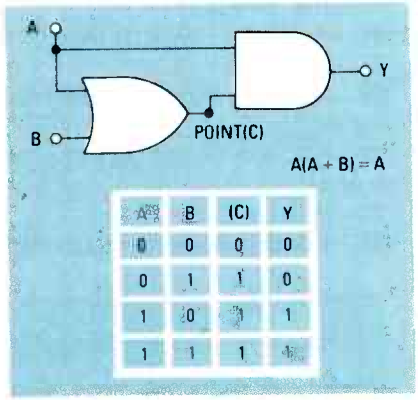



FIG. 7—THIS CIRCUIT PROVES that A(A + B) = A because the columns for A and Y in the truth table are the same.

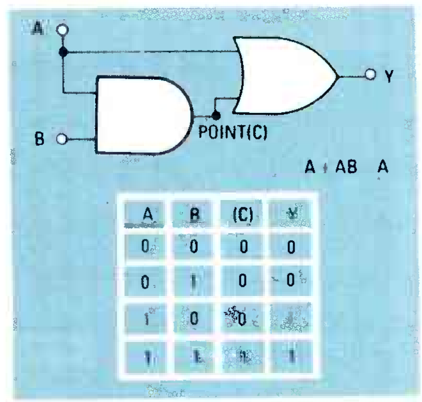



FIG. 8—A + AB = A. That can be proven by comparing columns A and Y.

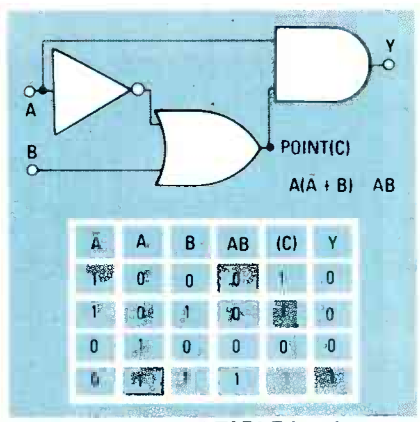



FIG. 9—THE TRUTH TABLE has been expanded to include other points in the circuit. It proves that $A(\overline{A} + B) = AB$.

**6**—0 + 1 = 1
**7**—1 + 0 = 1
**8**—1 + 1 = 1
**9**—$\overline{1}$ = 0
**10**—$\overline{0}$ = 1
**11**—AB = BA (the commutative property)
**12**—A + B = B + A
**13**—A(BC) = AB(C) (grouping is also commutative)
**14**—A + (B + C) = (A + B) + C

**15**—A(B + C) = AB + AC (the distributive property)
**16**—A + BC = (A + B) (A + C)
**17**—A·0 = 0
**18**—A·1 = A (depends solely on A's value)
**19**—AA = A (A can only be equal to 0 or 1)
**20**—$A\cdot\overline{A} = 0$
**21**—a double negative equals itself

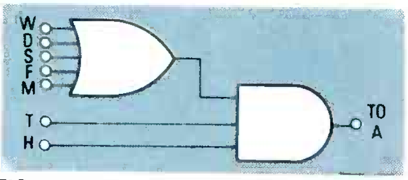



**FIG. 10—OUR BURGLAR-ALARM system can be represented using logic gates.**

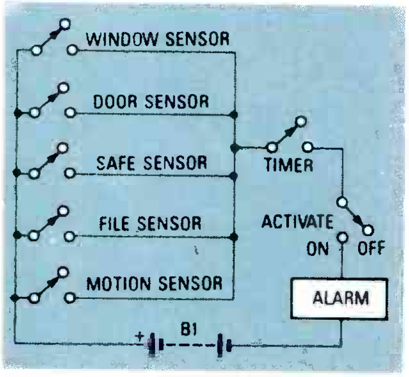



**FIG. 11—HERE IS THE ACTUAL CIRCUITRY for our office burglar-alarm system.**

**22**—A + 0 = A
**23**—A + 1 = 1 (1 is always true)
**24**—A + A = A
**25**—$A + \overline{A} = 1$

DeMorgan's theorems can often be used to simplify a Boolean expression. The theorems are as follows:

$$\overline{A}\cdot\overline{B}\cdot\overline{C} = \overline{A+B+C}$$

and

$$\overline{A}+\overline{B}+\overline{C} = \overline{ABC}$$

We will not prove the validity of those equations; however, the three steps for using them are:

1—Change all the "·"to "+" and vice versa

2—Replace all variables with their complements. (A would become $\overline{A}$, B would become $\overline{B}$, etc.)

3—Negate the entire expression.

Figures 7–9 show some interesting ways of simplifying Boolean expressions. The relationships can be derived from DeMorgan's theorems, however, there is no need to go into those derivations.

The circuit in Fig. 7 proves that: A(A + B) = A. In that circuit Y is true if A is true AND A OR B is true. Obviously Y is equal to A. The truth table demonstrates that equivalence. The circuit in Fig. 8 proves that A + AB = A. You can see that by looking at the truth table and comparing A to Y. That whole circuit can therefore be replaced by A alone. The circuit in Fig. 9 is a bit more tricky, proving that $A(\overline{A} + B) = AB$. The truth table has been extended to include $\overline{A}$ and AB. Since the truth table shows that AB and Y are equal, the expression is true.

In the beginning of this article we agreed to go lightly on mathematics, and by now you probably suspect that we have strayed from that promise. Take heart, you now have all the equipment you need to design a workable switching circuit. Of course you must observe the parameters given in the data that is included with the components you plan to use in your designs. Those include power-consumption, loading, and timing constraints, that we are not going to get into.

## Circuits

Before we apply the techniques we have learned to designing an actual circuit, let us first list the steps we must follow when designing a circuit from scratch:

1—State the problem in logical and concise sentences, using the logical operators OR, AND, and NOT.

2—List the input variables and assign a letter to each.

3—Determine the desired output for the circuit.

4—Translate the words into a Boolean equation.

5—Represent the Boolean expression using gate symbols.

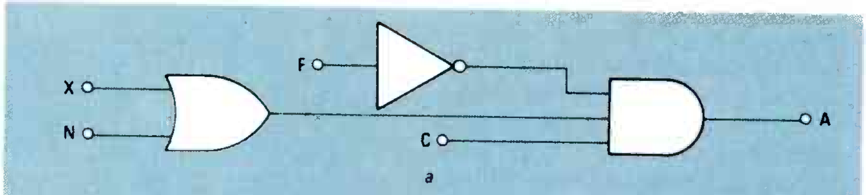
6—Redraw the schematic using real components.

As our first test of that approach we will design a security system for an office.

Let's suppose that the office has a window and a door that are potential entrances for a burglar. We also want to guard the contents of a safe and a file cabinet. As an added measure of security we will add a motion sensor to cover the entire room. Since no one is authorized to enter the room except during working hours, we can power the alarm system from a timer that activates the system from 5:30 pm until 8:30 am. We will also need some sort of disable switch in case an authorized person must enter during non-working hours.

### Step one:

The alarm will sound if the timer is on AND the on/off switch is on AND the window sensor OR the door sensor OR

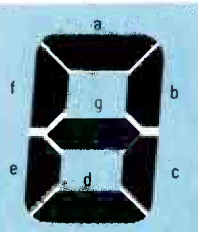



| F | $\overline{F}$ | X | N | C | $CX\overline{F}$ | $CN\overline{F}$ | $CNX\overline{F}$ | $CX\overline{F} + CN\overline{F} + CNX\overline{F}$ | $C\overline{F}$ | X + N | $C\overline{F}(X + N)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

THESE ARE EQUAL

*b*

**FIG. 12—THIS CIRCUIT WILL PREVENT our farmer from loosing any of his goods.**




*a*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | a | b | c | d | e | f | |
| 1 | | b | c | | | | |
| 2 | a | b | | d | e | | g |
| 3 | a | b | c | d | | | g |
| 4 | | b | c | | | f | g |
| 5 | a | | c | d | | f | g |
| 6 | | | c | d | e | f | g |
| 7 | a | b | c | | | | |
| 8 | a | b | c | d | e | f | g |
| 9 | a | b | c | | | f | g |

*b*

| | BOOLEAN EXPRESSION | INPUTS | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 0 | $\bar{A}\bar{B}\bar{C}\bar{D}$ | 0 | 0 | 0 | 0 |
| 1 | $\bar{A}\bar{B}\bar{C}D$ | 0 | 0 | 0 | 1 |
| 2 | $\bar{A}\bar{B}C\bar{D}$ | 0 | 0 | 1 | 0 |
| 3 | $\bar{A}\bar{B}CD$ | 0 | 0 | 1 | 1 |
| 4 | $\bar{A}B\bar{C}\bar{D}$ | 0 | 1 | 0 | 0 |
| 5 | $\bar{A}B\bar{C}D$ | 0 | 1 | 0 | 1 |
| 6 | $\bar{A}BC\bar{D}$ | 0 | 1 | 1 | 0 |
| 7 | $\bar{A}BCD$ | 0 | 1 | 1 | 1 |
| 8 | $A\bar{B}\bar{C}\bar{D}$ | 1 | 0 | 0 | 0 |
| 9 | $A\bar{B}\bar{C}D$ | 1 | 0 | 0 | 1 |

*c*

**FIG. 13—A 7-SEGMENT DISPLAY (*a*) is labeled as shown. In order for it to display a number correctly, the segments shown in *b* must be lit. The table in *c* shows the Boolean expressions that must be decoded in order to display the corresponding decimal number.**

the safe sensor OR the file sensor OR the motion sensor are on (or triggered by an intruder).

**Step two:**

We will represent our variables with the following letters:

Window sensor—W
Door sensor—D
Safe sensor—S
File sensor—F
Motion sensor—M
Timer—T
On/off switch—H

**Step three:**

Our output will be something like a bell or siren and we will represent it with the letter "A"

**Step four:**

Our Boolean expression is:
$A = TH(W+D+S+F+M)$

**Step five:**

Figure 10 shows our Boolean expression being implemented with gate symbols.

**Step six:**

The easiest way to implement our alarm system is to use switches to detect an open or closed window, door, safe, or file cabinet. The motion sensor can be considered as a switch that closes when motion is detected in the room. The circuit in Fig. 11 illustrates our alarm system.

## The chicken and the fox

Our first circuit was fairly simple. Let us now turn to a classic example, a variation on what appears in nearly all logic texts. This time we will design an electronic version of an old word puzzle:

There was once a farmer who was taking to market a fox, a chicken, and a basket of corn. To get to market the farmer had to cross a stream. His boat could carry only the farmer and one other item. The farmer found himself in a dilemma. If he left the chicken and the corn together while he took the fox across the stream, the chicken would feast on the corn. Alternately, if the chicken and the fox were left alone, that would cost the farmer a hen. Short of wringing a few necks, what was the farmer to do? We're sure everyone has heard this one, but as a refresher; first the chicken is taken across and left alone on the market side of the stream. The farmer returns across the stream and picks up the fox which he then carries across. The farmer returns the chicken to the original side where he exchanges it for the corn. The corn is taken across and left with its safe companion, the fox. The farmer returns for the chicken and, on recrossing, is on his way to market; all products intact and healthy, though a bit confused.

Now we want to construct an electronic game around that old scenario.

**Step 1:**

We want to sound an alarm if the fox AND chicken are together but NOT the farmer, OR if the corn AND chicken are together but NOT the farmer, OR if the corn AND the chicken AND the fox are together but NOT the farmer (that last situation could leave the farmer with only a very fat fox!).

**Step 2:**

We'll use the following letters:

Farmer—F
Fox—X
Corn—N
Chicken—C

**Step 3:**

Our output will be a buzzer or light represented by the letter "A"

**Step 4:**

Our Boolean expression is: $A = CX\bar{F} + CN\bar{F} + CNX\bar{F}$

We will now attempt to simplify that expression using Boolean algebra, and then we will check our results with a truth table.

$A = CX\bar{F} + CN\bar{F} + CNX\bar{F}$ (original expression)
$A = C\bar{F}(X+N+NX)$ (rule 15)
$A = C\bar{F}(X+N(1+X))$ (rules 15 and 18)
$A = C\bar{F}(X+N)$(rule 23)

**Step 5:**

Figure 12 shows our circuit and also the truth table confirming that our simplification was correct.

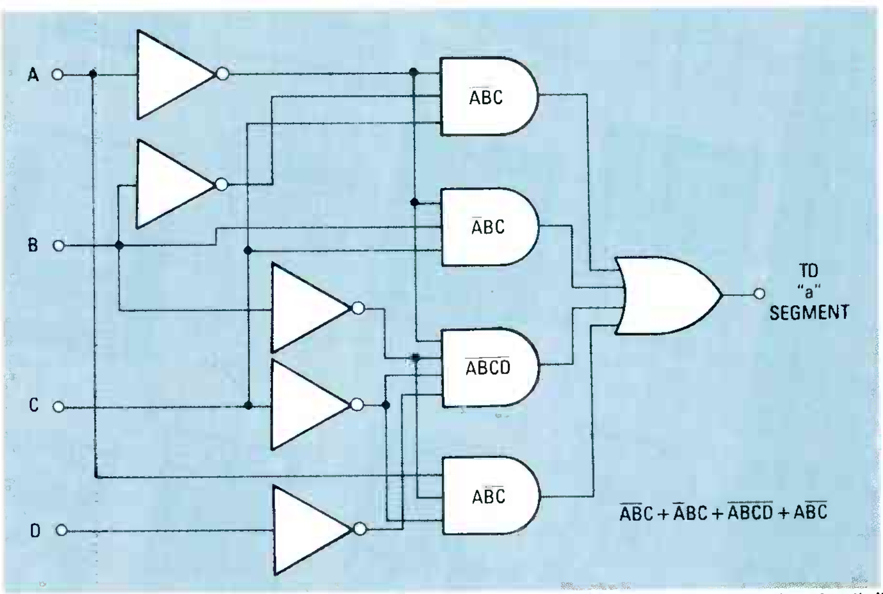



**FIG. 14—HERE IS OUR FINAL CIRCUIT. It will decode the BCD information for the "a" segment.**

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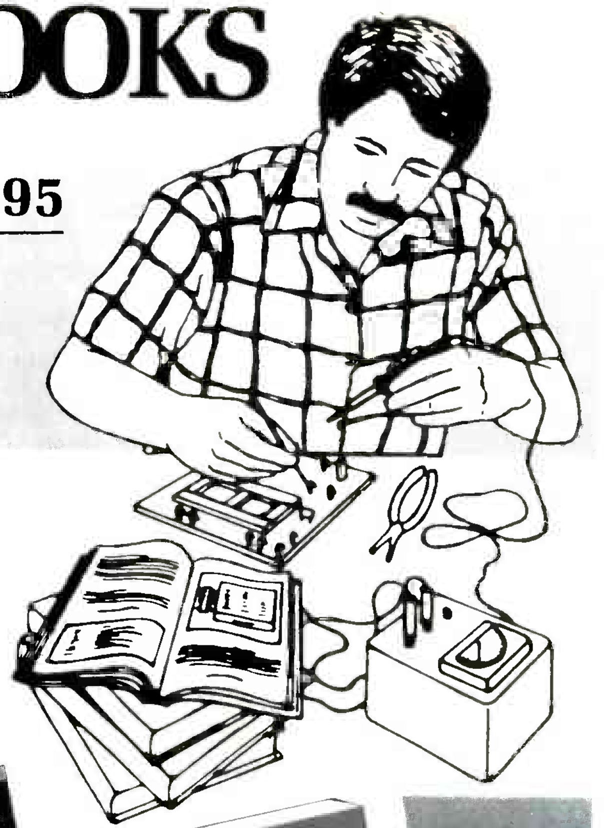


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## 7-segment decoder

By now you should be able to see how Boolean algebra allows for an orderly design procedure. As a final example we will construct part of a 7-segment decoder. Such a device is used to translate BCD (*B*inary *C*oded *D*ecimal) information into a familiar base-10 digit to be displayed on an LED or LCD 7-segment display. Figure 13-*a* outlines the segment designations for that type of display. For example, to display the numeral 3 we would light segments a, b, c, d and g.

**Step 1:**

We want to be able to display the digits 0–9 so we'll need at least ten different combinations of inputs. That's because in binary, if we have three inputs (A,B,C), we would only have eight possible combinations ($2^3 = 8$). Therefore we need four inputs (A,B,C,D). Let A represent the most-significant digit, B the next, and so on. For example, if the BCD number is 0011, D=1, C=1, B=0, and A=0. That is the code for the number "3" in base-10. We want our display to show a:

"0" if NOT D AND NOT C AND NOT B AND NOT A
"1" if D AND NOT C AND NOT B AND NOT A
"2" if NOT D AND C AND NOT B AND NOT A
"3" if D AND C AND NOT B AND NOT A
"4" if NOT D AND NOT C AND B AND NOT A
"5" if D AND NOT C AND B AND NOT A
"6" if NOT D AND C AND B AND NOT A
"7" if D AND C AND B AND NOT A
"8" if NOT D AND NOT C AND NOT B AND A
"9" if D AND NOT C AND NOT B AND A

**Step 2:**

Input variables are A, B, C and D.

**Step 3:**

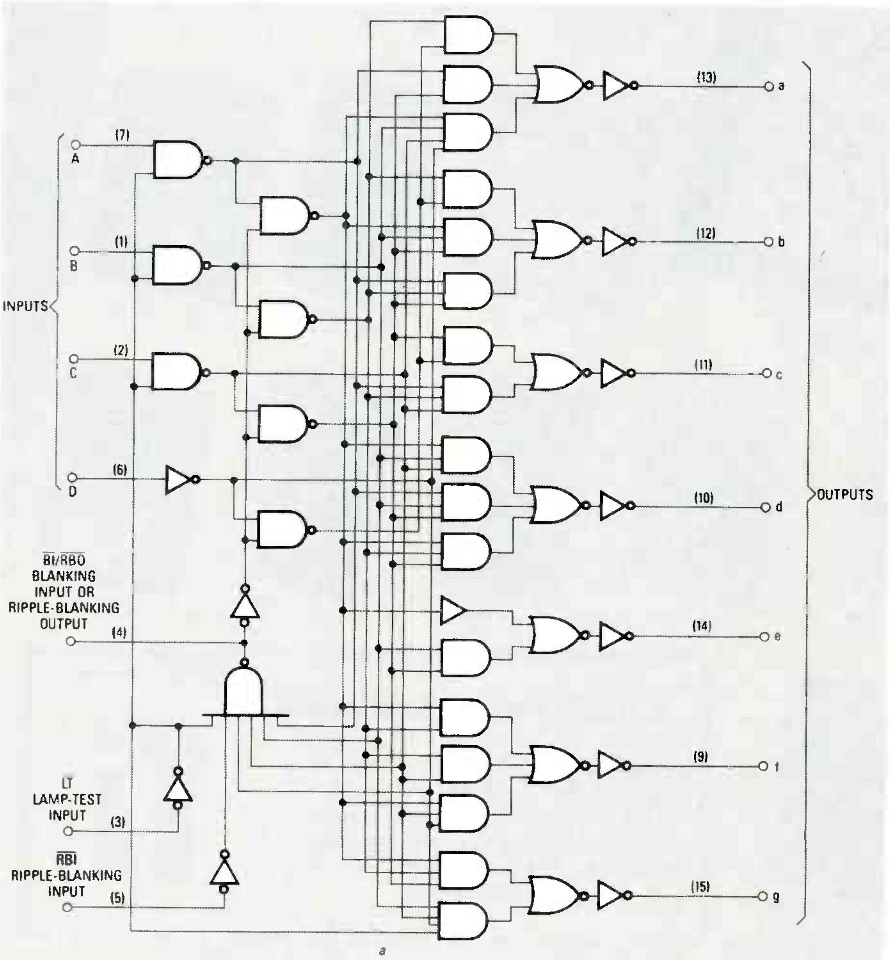
Figure 13-*b* shows which segments must be lit according to the number to be displayed.

**Step 4:**

Figure 13-*c* shows what the Boolean expressions for our inputs look like, and also the corresponding hi/low (1/0) input values.

**Step 5:**

We now have to do some thinking. Each segment of our display needs a circuit that can decode the BCD information so that the segment will light *only* when it is supposed to. Let's work on the "a" segment. Figure 13-*b* shows that segment "a" is supposed to light when displaying 0, 2, 3, 5, 7, 8, and 9. From the information in Fig.




| DECIMAL OR FUNCTION | INPUTS | | | | OUTPUTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D | C | B | A | a | b | c | d | e | f | g |
| 0 | L | L | L | L | ON | ON | ON | ON | ON | ON | OFF |
| 1 | L | L | L | H | OFF | ON | ON | OFF | OFF | OFF | OFF |
| 2 | L | L | H | L | ON | ON | OFF | ON | ON | OFF | ON |
| 3 | L | L | H | H | ON | ON | ON | ON | OFF | OFF | ON |
| 4 | L | H | L | L | OFF | ON | ON | OFF | OFF | ON | ON |
| 5 | L | H | L | H | ON | OFF | ON | ON | OFF | ON | ON |
| 6 | L | H | H | L | OFF | OFF | ON | ON | ON | ON | ON |
| 7 | L | H | H | H | ON | ON | ON | OFF | OFF | OFF | OFF |
| 8 | H | L | L | L | ON | ON | ON | ON | ON | ON | ON |
| 9 | H | L | L | H | ON | ON | ON | OFF | OFF | ON | ON |
| 10 | H | L | H | L | OFF | OFF | OFF | ON | ON | OFF | ON |
| 11 | H | L | H | H | OFF | OFF | ON | ON | OFF | OFF | ON |
| 12 | H | H | L | L | OFF | ON | OFF | OFF | OFF | ON | ON |
| 13 | H | H | L | H | ON | OFF | OFF | ON | OFF | ON | ON |
| 14 | H | H | H | L | OFF | OFF | OFF | ON | ON | ON | ON |
| 15 | H | H | H | H | OFF | OFF | OFF | OFF | OFF | OFF | OFF |

*b*

**FIG. 15—THIS IS A COMPLETE 7-SEGMENT decoder. The device is made by Texas Instruments.**

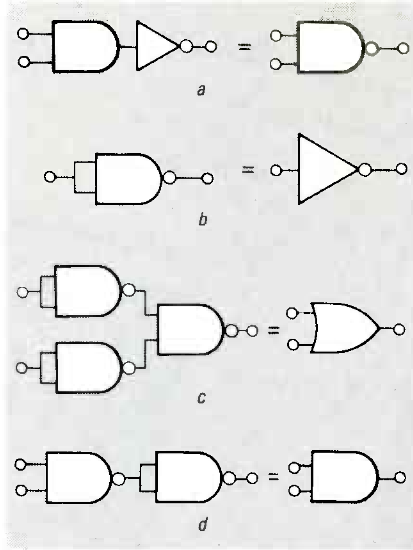



**FIG. 16—THE CIRCUITS ON THE LEFT are functionally equivalent to the ones on the right.**

13-*c* we can come up with the following expression:

$a = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}D + \bar{A}BCD + A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D$

Using the rules we have learned we will simplify that expression.

$a = (\bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}D + \bar{A}BCD) + (\bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D)$ (rule 12)

We will work it out in two halves:

$(\bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}D + \bar{A}BCD)$

$=$

$(\bar{A}\bar{B}C(D + \bar{D})) + (\bar{A}BD(C + \bar{C}))$

(rule 15)

$= (\bar{A}\bar{B}C) + (\bar{A}BD)$ (rule 25)

Now the second half:

$(\bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D) =$

$\bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}(D + \bar{D}) =$

$\bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}$

Now we recombine the two halves to form our final expression:

$\bar{A}\bar{B}C + \bar{A}BD + \bar{A}\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}$

Figure 14 shows our final circuit. That circuitry will turn on the "a" segment whenever a BCD input requires it. By now, you should be able to design the circuitry to decode BCD for all the other segments.

Figure 15 shows a complete BCD-to-7-segment decoder, Texas Instruments' 74LS47. Right away you should notice that the circuitry for the "a" segment is different from what we came up with. One of the reasons for that is because ours only decoded digits 0–9. The one made by Texas Instruments will display six additional characters that we made no provisions for. However, the techniques that were used in designing Texas Instruments' decoder are similar to ours. Texas Instruments has also added some extra features to their decoder, such as a means to test of all of the segments of the display simultaneously.

So far we haven't said anything about reducing the number of components in your circuit design. However, by properly applying the rules of Boolean algebra, many unnecessary components can be eliminated. We can, if necessary, change an expression so that we can use components that we have on hand. Also, most logic components contain several of the same gates in a single package, so you should make full use of all gates available whenever possible. For example, notice the substitutions you can make shown in Fig. 16. Those substitutions are quite often very useful, should you have any unused gates in your circuit. **R-E**

# HARDWARE HACKER

Electronic references
16-bit converter chips
Synchronous inverters
A/D conversion secrets
Apple computing books

## A/D and D/A conversion

DON LANCASTER

CONGRATULATIONS TO RICK STANLEY of Bloomsburg, Pennsylvania for his winning of our grand prize tinaja quest in the pneumatic-valve-hacker applications contest. Rick's Air-Dale automatic dog-watering mechanism won paws down, while his Air-O-Smith guitar-playing machine was in a special class by itself.

As per usual, this is your column and you can get both tech help and off-the-wall networking by calling up the Guru hisself per the "Need Help?" box. The best calling times are weekdays, 8–5, mountain-standard time.

Also as per usual, we've again gathered all of those names and numbers together for you into one single table. That's where you go for further tech info on any and all of the items mentioned.

One correction. The real phone number is (812) 339-7305 to reach Speleonics. You might call Frank Reid there on most any weekday evening. Many thanks to the Indiana University Chem Department Machine Shop (the wrong number previously listed) for forwarding the zillions of calls they got.

A bunch of positively ridiculous breakthroughs in the hacker A/D converter pricing, availability, and performance have happened in the last few weeks. The rule seems to be this: If the ink on your A/D data sheet is not still wet, then you are dealing with a very overpriced and obsolete part.

The best place to start on all this is with some....

### A/D conversion fundamentals

An *A/D* Converter (ADC) is most any electronic device for changing varying or analog inputs into digital pulses or numbers. The two most important specifications of an ADC are its resolution and its conversion speed.

The resolution will determine the best possible output accuracy and is usually expressed in bits. An 8-bit ADC can resolve up to one part in 256. A 10-bit ADC can resolve one part in 1024. 12-, 14-, and 16-bit ADC's can resolve 4096, 16384, and 65514 separate analog levels.

But note that a 16-bit ADC will only give you a 16-bit result for a full-scale input, and then only if the input signal has not been corrupted by noise or any kind of frequency limitations.

For instance, a 16-bit ADC with a four-volt reference will give sixteen bits of resolution for a four-volt input, twelve bits of resolution for a one-volt input, only eight bits of resolution for a quarter-volt input, and so on. The minimum input signal that can be converted is often set by the quantization noise of the A/D process itself.

The conversion speed is simply how many conversions per second the ADC is capable of. Examples include instrument circuits that can very accurately handle only a few to a few hundred conversions per second, telephone chips that work in the three- to six-kHz range, CD audio converters that run near 40 kHz, video A/D circuits that operate at 15–25 MHz, and the pricey radar A/D converters that extend beyond 200 MHz.

**NEED HELP?**

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
**Synergetics**
Box 809
Thatcher, AZ 85552
(602) 428-4073.

There are a number of different ways of doing an A/D conversion. The fastest is called a brute-force or flash-converter type, in which a pile of comparators is put to use, having one for each input level. A variation on flash converters uses the new feedforward conversion process, where one-half of the bits are flash converted, and the remainder error is calculated. The remaining half of the bits are then flash converted and combined with the previous conversion. Feedforward converters run at one-half or less of flash-converter speeds, but will use far fewer comparators to do the job.

Most video converters are either the flash or the feedforward type. Radar converters of necessity must use flash conversion. They can be insanely expensive.

One of the very common older conversion methods is known as successive approximation. In that, one-half of the reference is subtracted from the input so long as a positive result remains. Then one-quarter of the reference is subtracted, which is followed by one-eighth, one-sixteenth, and so on down the bits. Those successive-approximation converters are fairly simple and fairly cheap. Uses are typically in the medium-speed and medium-resolution areas.

Telephone A/D converters are sometimes also called companders. They do a non-linear conversion where the small signal levels are sliced finer than larger ones. That way, you can digitally represent a 12-bit range with only an 8-bit non-linear output.

Those instrument A/D converters normally run much slower than the others while providing a considerably higher accuracy. The classic conversion schemes here include the dual-slope and multiple-slope conversions, where the input will linearly charge up an integrating capacitor and a precision reference then discharges it. By measurement of the discharge time, you end up with a number equal to the input analog voltage or current.

One very important feature of most instrument converters lies in their ability to reject power-line frequency noise or hum. That is done by converting exactly at the power-line rate or a submultiple.

Other A/D conversion schemes do include the voltage-to-frequency converters and charge balancers. In a charge balancer, the input will continually add charge to an integrating capacitor, while the output will remove the charge in discrete current-line packets. The number of packets removed is proportional to the input voltage or current.

But the latest, and certainly the most bizarre, of A/D converters are called oversampling converters that use an elaborate decimation and digitalfiltering process. An oversampling converter makes all of its measurements at an extremely high sampling frequency.

They're also known as delta-sigma A/D converters. They are new and they are hot.

The theory here is that the only "little thing" wrong with one-bit A/D is that its quantization noise is totally gruesome. By taking that quantization noise and spreading it out over a much wider bandwidth than the input signal and by then rejecting most of the noise with a filtering process, you can actually reduce the noise to below that of a 16-bit converter!

The Crystal Semiconductor folks are a leading developer of those exciting new low-cost oversampling converters.

A fairly good background book on A/D conversion in general is *Analog to Digital Conversion*, now available from Analog Devices for $32. Some of the fundamentals of computer A/D interface appear in my *Micro Cookbooks*, both volumes I and II.

## The rest of the story

Unfortunately, though, your A/D converter chip is only a tiny part of the hardware that you will really need to do an A/D conversion. Figure 1 shows you some of the rude surprises that you are going to have to work around to get a complete analog-to-digital conversion system.

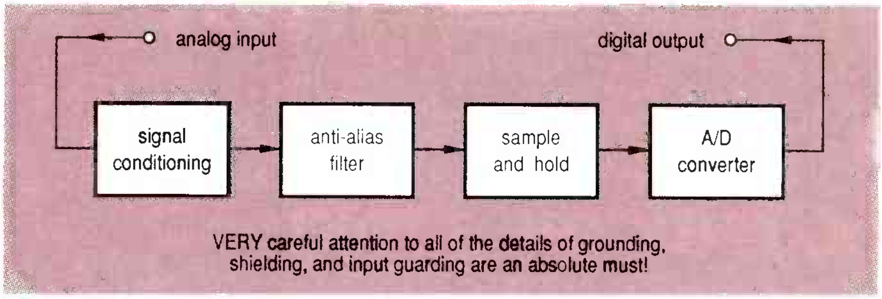



**FIG. 1—AN ANALOG-TO-DIGITAL conversion system normally will need all of the areas shown here. Often, the A/D converter chip itself will be the least of your worries.**

You first need some input-signal conditioning. That will accept your input signal and amplify it enough so that its maximum value equals the converter's reference voltage.

Signal conditioning can also do such things as subtracting out an offset value, filtering, rejection of noise, temperature compensation, or calibration.

The latest of A/D converter chips allow you to use lower or floating-point reference voltages or else can have enough bits that you might work at reduced resolution and are able to end up with useful results. Nonetheless, signal conditioning is always a very sticky design area.

After all of your initial signal conditioning, you must provide an anti-aliasing filter, and a darn good one. There is a fundamental rule that says that any A/D converter must never be fed any signal that is greater than one-half of its sampling frequency.

Figure 2 shows you what an alias is and how it is created. Say you were on a long commuter airline flight and you are very sleepy. You briefly open your eyes and see a green service truck on the runway. You fall asleep, and wake up an hour later at a new airport. This time the green service truck is ten feet further along. You repeat the process a third time, and now, the green truck is yet another ten feet further away. You then wrongly conclude that the green truck is traveling at ten feet per hour.

In exactly the same manner, an alias gets created if you sample any frequency near the sample rate of an A/D converter. For instance, if you employ a 40,000-Hz sample rate, and then sample a 40,100-Hz

## NAMES AND NUMBERS

**Analog Devices**
One Technology Way
Norwood, MA 02062
(617) 329-4700
**Burr-Brown**
P.O. Box 11400
Tucson, AZ 85734
(602) 746-1111
**C & H Sales**
2176 East Colorado Blvd.
Pasadena, CA 91107
(800) 325-9465
**Crystal Semiconductor**
4210 South Industrial Drive
Austin, TX 78744
(512) 445-7222
**Exar Corp./Literature**
2222 Qume Drive
San Jose, CA 95161
(408) 732-7970
**Harris Publishing Co.**
2057-2 Aurora Rd.
Twinsburg, OH 44087
(216) 425-9000
**Interlink Electronics**
535 E. Montecito
Santa Barbara, CA 93103
(805) 965-5155
**ISL Corp.**
4354 Olive St.
St. Louis, MO 63108
(314) 535-5760
**Linear Technology**
1630 McCarthy Blvd.
Milpitas, CA 95035
(408) 432-1900
**Motorola**
PO Box 20912
Phoenix, AZ 85036
(602) 244-6900
**National Semiconductor**
2900 Semiconductor Dr.
Santa Clara, CA 95052
(408) 721-5000
**Plessey Semiconductors**
9 Parker
Irvine, CA 92719
(714) 472-0303
**Samsung Semiconductor**
3725 North First St.
San Jose, CA 95134
(408) 434-5400
**Solar Age**
Church Hill
Harrisville, NH 03450
(603) 924-9641
**Solar and Wind Technology**
Fairview Park
Elmsford, NY 01523
(914) 592-7700
**Solar Energy**
Fairview Park
Elmsford, NY 01523
(914) 592-7700
**Solar Engineering**
Box 3600
Troy, MI 48007
(313) 362-3700
**Standard Microsystems**
35 Marcus Blvd.
Hauppauge, NY 11788
(516) 273-3100
**Speleonics**
PO Box 5283
Bloomington, IN 47407
(812) 339-7305
**Texas Instruments**
Box 655303
Dallas, TX 75265
(214) 995-3821

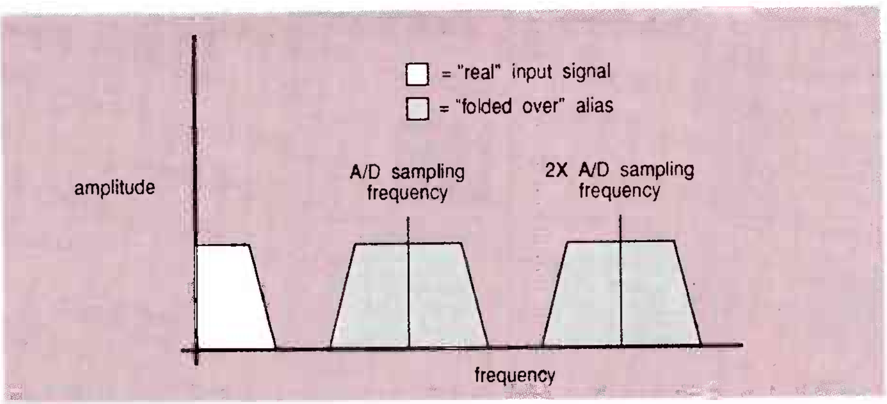



**FIG. 2—A ANTI-ALIASING filter absolutely must be used with any A/D converter so as to sharply reject any and all frequencies above one-half of the sampling frequency. Should any higher frequencies remain present, they will "fold over" and form aliases that end up looking just like "real" input signals.**

signal, you will apparently get a 100-Hz signal digitized that you simply cannot tell from a "real" 100-Hz signal. That's an alias, and you absolutely must not ever let that happen.

One big advantage of the new oversampling converters is that the anti-aliasing filter is both simpler and cheaper to build.

After filtering, you normally must do a sample and hold, as shown in Fig. 3. If your input signal is allowed to change during the measurement interval, you can get wild inaccuracies since you are now measuring a different amplitude at the end than you were at the beginning.

A sample and hold is normally done with an electronic switch that charges up a capacitor during the sampling, or the aperture time. The charge is kept during the time a conversion gets completed.

At high resolutions, the penalty for leaving off a sample and hold is severe. Figure 4 shows you the differences in the full accuracy input frequency response you will get with or without using a sample-and-hold circuit.

Fortunately, most of the newer chips do have their own internal sample-and-hold circuits on board. But you have to be absolutely certain that you understand how the sampling process works.

Your actual A/D converter will follow the input conditioning, the anti-aliasing, and the sample and hold. That final circuit area is often the least of your problems.

Along the bottom, we also have shown you some guarding and shielding. It is trivially easy to let digital noise and even power-line hum totally trash out any accuracy from your A/D system. Ferinstance, a typical hacker digital circuit will be very lucky to hold the digital-logic ground noise down below 300,000 microvolts.

On a typical 16-bit A/D converter circuit, any input noise greater than 15 microvolts or so might bobble the bits and give you all sorts of nasty jitter and errors.

If so much as a hint of a whiff of a few of the fumes of your ground noise ends up referenced to the input of your high-resolution A/D, then all is lost.

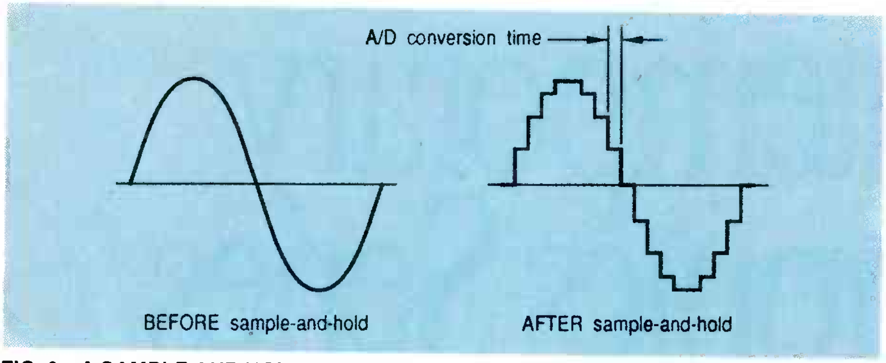



**FIG. 3—A SAMPLE AND HOLD is needed to hold the analog input signal constant during the conversion time, or serious errors are certain to result.**

Proper grounding and shielding techniques, including the use of ground planes, guarding, and careful separation of digital and analog grounds, are, or course, an absolute must.

It is all part of the black art of analog-circuit design.

The bottom line? Unless you have successfully gotten a low-resolution, low-speed A/D converter to work, there is not a snowball's chance in a rather unpleasant locale that you will ever be able to accomplish anything at all useful at higher speed and resolution.

So, as an initial prequalification entrance exam that you must pass before you can even think about doing any fancy A/D stuff, Fig. 5 is an ancient 8-channel 8-bit A/D circuit that you can build and test. The chip is available from either National or Analog Devices for a few dollars. It will interface simply with most any parallel port on most any microcomputer.

## New A/D chips

What are the new A/D chips and where can you get them? Last month we looked at the LTC1092 10-bit chip from the Linear Technology people. There is a fancier "big brother" to that device called the LTC1090 that includes multiple channels, variable formatting, and lots of other goodies.

The big breakthroughs are found in the new oversampling A/D chips that are newly available from Crystal Semiconductor. In particular, do check out their instrument CS-5501 and their hi-fi audio CSZ-5116. Yes, they are both 16-bit chips. And at insanely low prices.

The major supplier of A/D converters to all the Japanese CD ROM manufacturers is the company called Burr Brown.

And, Texas Instruments has now announced a new combined 14-bit telephone-speed A/D and D/A for $26. It's intended for digital-signal processing, but should also be an absolutely outstanding hacker chip. But half a dozen very expensive phone calls have proven that device to be pure vaporware, at least for now.

| number of bits | max frequency WITH a S/H | max frequency WITHOUT a S/H | speed penalty WITHOUT a S/H |
|---|---|---|---|
| 2 | 20,000 | 3120 | 13 |
| 4 | 20,000 | 795 | 50 |
| 6 | 20,000 | 199 | 201 |
| 8 | 20,000 | 50 | 804 |
| 10 | 20,000 | 12 | 3216 |
| 12 | 20,000 | 3.1 | 12,868 |
| 14 | 20,000 | 0.8 | 57,472 |
| 16 | 20,000 | 0.2 | 205,887 |

**FIG. 4—A RIDICULOUSLY SEVERE speed penalty must be paid if you omit the sample and hold from your A/D converter. The examples here are for a 40-kHz conversion rate.**

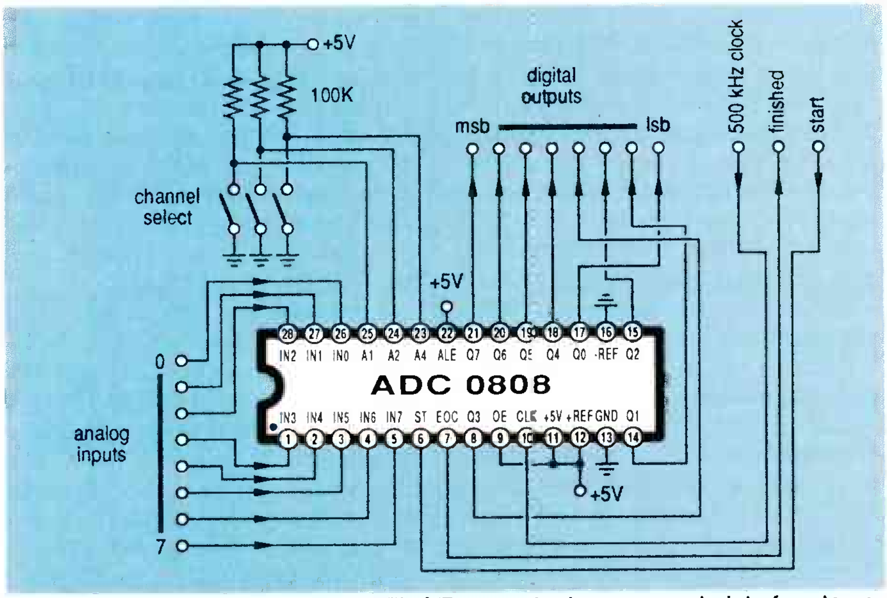



**FIG. 5—THIS OLDER 8-BIT, 8-CHANNEL A/D converter is very easy to interface to any parallel input port on most any personal computer**

As an interesting entry in video-rate A/D conversions, do check out Samsung. They now have a dozen different combined 8-bit A/D and 10-bit D/A chips. Their KVS3110N-7 should be a good starting point.

For the contest this month, just dream up an unusual use for A/D or D/A converters. A paper design is just fine. There will be the usual Incredible Secret Money Machine prizes for the best twenty entries, and a great all-expense-paid (FOB Thatcher, AZ) tinaja quest for the best entry of all.

## Finding names and numbers

How do you find out where to buy a Maxim integrated circuit? Or how do you get a National Semiconductor data sheet? Who makes solid-state gyroscopes? Electronic inclinometers?

Finding sane answers to those and other similar questions is what hardware hacking is all about.

Naturally, you start with our own Names and Numbers section, and by reading all of our great **Radio-Electronics** ads. And, yes, a master names and numbers directory will soon be available. Call or write for full details.

But where to from there?

Let us start out with the only electronics directory that I actually pay cash for out of my own pocket. That is the *Electronic Industry Telephone Directory*, and costs $40 per year from Harris Publishing.

An excellent list of many local distributors for electronic goodies appears monthly in the *E.E. Times* magazine. But for some strange reason, that otherwise great list seems to be strictly limited to their current advertisers.

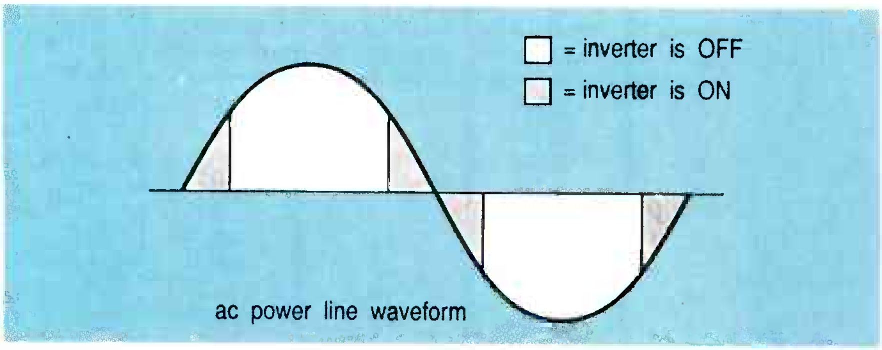



**FIG. 6—A SYNCHRONOUS INVERTER can be used to feed surplus energy from a solar panel or other alternate energy source back into the power line. Here is one possible waveform.**

Most of those electronics trade journals publish yearly directories that are extremely useful for pinning down names and numbers. I especially like the *Gold Book* from Electronic Design, the *Electronics Buyers Guide* from Electronics, and the *EEM Master* from the Electronic Products people.

Various "focus" tech stories in EDN are also quite handy reference sources for needed names and numbers.

You can get a list of all of the trade journals from that *Uhlricht's Periodicals Dictionary* over on the reference shelf at your local library. Also at your favorite library will be the *Thomas Registry of Manufacturers*, and possibly the *Electronic Representatives Association* (ERA) Directory.

Asking for help from an engineer or a technician working for a larger electronics company will sometimes work, as might a ham-radio operator, our technical helpline, the editor of a trade journal, or an electronic bulletin board.

Naturally, it is best to build up your library of useful names and numbers ahead of time, rather than waiting until you desperately need some hard-to-get part. Your own resource library should always be the first place to check.

As a second contest this month to test your source-finding abilities, just tell me the cheapest source of 64 pin, 70 mil shrink dip IC sockets that you know of. That component is desperately needed for an upcoming **Radio-Electronics** project or two.

## Synchronous inverters

I've been getting a lot of calls and letters from hardware hackers who have heard somewhere that, if you have a few solar panels or other alternate energy source up, then your local power company is required by law to buy all of your surplus power from you.

Well, in this day and age, most of the power companies are fairly enlightened and would be most happy to buy power from most any alternate energy source that is both local and reliable.

But there are several very big gotchas here.

First, a power company will sell power to you at retail and buy it back from you at their wholesale avoided cost. Avoided cost is the price of the most expensive power they are currently buying or generating. Thus, you do not simply swap energy, since one of their kilowatt hours may be worth five or more of yours.

Secondly, a very special device called a synchronous inverter is needed to meter your energy back into the power line. As Fig. 6 shows us, a waveform is carefully crafted that feeds your power back in phase with the existing AC-line waveforms.

Synchronous inverters and all of the metering that goes with them are not cheap. The bottom line is an economic one. The time value of the money used to pay for the synchronous inverter and all of its metering will often insanely exceed the total value of all the power you are able to generate.

Thus, many smaller solar-power installations are never able to reach cost breakeven, let alone show a profit. But I certainly encourage all of you dedicated hackers out there to keep on trying. The situation is certain to improve in the future.

*continued on page 87*

# AUDIO UPDATE

## Can You Hear the Difference?—Pt. II

**LARRY KLEIN,**
AUDIO EDITOR

LAST MONTH I PROBABLY ALIENATED some readers and invalidated my ears by maintaining that amplifiers that measure well and are operated within their power ratings almost always sound alike. Note that I'm *not* saying flatly that all amplifiers sound alike—they don't—but I do believe that there are no mysterious forces, factors, or formulas, that cause one amplifier to sound better or worse than another. The use of gold-plated linear-crystal AC line cords, special capacitors, vacuum tubes, a bandwidth extending from DC to light, plus the ear of a bat and the eye of a newt, may or may not have audible consequences—but when they do, their influence is readily measurable by conventional methods.

The "readily measurable" performance parameters I'm referring to go far beyond the FTC-mandated specifications on power, bandwidth, and distortion, that you see in every amplifier or receiver advertisement. Nobody believes that the FTC power statements come close to totally defining the comparative performance and sound of any two amplifiers. For example, the dynamic headroom and current capabilities of an amplifier, although they are ignored by the required FTC statement, can still significantly affect its sonic performance.

I'm aware that *my* beliefs about what is audible, inaudible, or measurable don't carry much weight with those who believe in the special sonic wonders produced by the designs and designers of their chosen and usually costly amplifiers. My claim that scientifically constructed double-blind listening tests regularly fail to confirm the existence of mysterious differences is pooh-poohed by those who hear such differences every time they switch on their equipment. Is there any way out of the impasse?

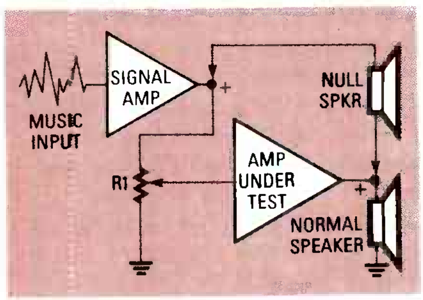



FIG. 1

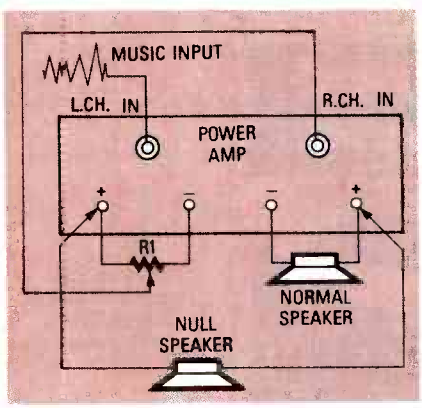



FIG. 2

### Listening tests

There are two popular types of listening-comparison tests: 1—"Do you prefer A or B?" and 2—"Can you hear a difference between A and B?" Obviously, question 1 includes question 2, but they are really quite different in several ways. Question 1 is appropriate when comparing components in a showroom and is likely to reveal as much about the taste of a listener as it will about the performance of a component. Laboratory listening tests, on the other hand, usually ask a type-2 question because it leaves out the confusing "better or worse" element—which can be addressed later if desired.

But the type-2 question has its own problems. Because of psychoacoustic masking and other reasons it is not always easy to *hear* distortion in program material even when the amplifier aberration producing it can be easily measured. (It is well-documented that impedance-matching problems and harmonic distortions in complex wide-band program material have to reach the 6-percent level before becoming perceptible. Musical energy at the frequencies of the distortion products tends to have a masking effect.) If we could convert the type-2 question from "Do you hear a difference?" to "Do you hear something—or nothing?" many of the psychoacoustic and other subjectivity problems would be avoided. David Hafler of The Hafler Company has long been concerned with such matters and has recently come up with a very clever type-3 test configuration that should help resolve many of those questions.

### The Hafler differential test

Many years ago Hafler invented a sort of poor man's quadraphonic system. It consisted essentially of an additional speaker (or a pair of series-connected speakers) connected directly across the two *hot* (positive) terminals of the amplifier in use. Connecting a speaker in such a fashion feeds it a signal which contains *only* the differences (including those of amplitude and phase) between the two stereo channels. Because on many recordings, out-of-phase "hall-ambience" sound is a good part of that difference, feeding it to separate speakers located toward the rear of the listening room provides a worthwhile listening enhancement at a very low cost. For our present discussion, keep in mind that the additional "ambience" speakers are silent when there is no difference between the channels—such as would occur if a mono signal were fed simultaneously to the two channels of a perfectly balanced amplifier.

At some point it occurred to Hafler that the ability to nullify identical signals by a "hot-to-hot" speaker connection could be useful in amplifier testing. A circuit (see Fig. 1) was devised that, in effect, *electrically* subtracts the original signal (from a signal-source amplifier) fed into an amplifier under test from the signal coming out of it. After adjustment for level differences and phase shift (using R1), any residual sound that's heard in the *null* speaker represents the difference between the input and output signals. By definition, such a difference is considered to be distortion. Because the distortion-signal level at the null speaker is always much lower than the normal program sound—even if the distortion is severe—the normal speaker has to be moved out of listening range to keep it from overwhelming the null speaker.

Figure 2 shows a practical connection of the Hafler test circuit (which he refers to as the "straight-wire differential test" or SWDT). The left channel of a stereo power amp serves as the low-impedance/power signal source and the right channel is the amplification section under test. Potentiometer R1 is used to adjust the signal level fed to the right-channel input so that the signal voltages appearing at the right and left channels' hot speaker terminals are as close as possible.

All that technical work has not been done in the cause of pure science. Hafler's new power amplifier, the XL-280, has been developed using the SWDT test technique. The new amplifier also includes trimmer adjustments on each channel to compensate for speaker impedance characteristics and thereby enhance the amp's performance on the SWDT test. SWDT testing of the Hafler—and most other amplifier brands—is facilitated by a switching/adjustment test box available from The Hafler Company. Note that amplifiers with bridged and polarity-inverting output circuits are not suitable for SWDT testing.

## Final thoughts

The Hafler difference-signal test is sensitive enough so that it will easily show up any conceivably audible difference between an amplifier's input and output signals. As a matter of fact, I would guess that the test is so sensitive that the null speaker will reproduce "distortion" that under normal stereo music playback conditions would never be heard—no matter how golden the listener's ears. I certainly do not fault the Hafler test for excessive sensitivity, but I could see it sending some engineering-type audiophiles in pursuit of ever deeper nulls—a pursuit which would have no audible benefit.

Incidentally, a variation on the null test can easily be used to test the alleged benefits of special capacitors, wires, and so forth. All that is necessary, is to install the special parts in one channel, leaving the other unaltered. If a speaker connected across the two hot terminals indicates a difference between the channels, the SWDT test can then be used to determine which channel has less distortion.

I don't really expect that this new test will end the debates among the audio critics. The problem is that you can't really argue convincingly with those who state calmly that their ears consistently reveal things that your tests don't, despite all the science and logic you bring to bear. Or worse, that the very quality that your test reveals as distortion is really the magic ingredient that makes the equipment sound so good. One would hope that the inner realities of all audio critics would be in accord with objective reality; but when it isn't, there is no way that I know of to force them to agree. **R-E**

**NEXT MONTH watch for a feature article that will show you how to build a Hafler differential test box.**

# DRAWING BOARD

## Copy protection and a Z-80 reset

**ROBERT GROSSBLATT,**
CIRCUITS EDITOR

A FEW MONTHS AGO I WROTE SOME articles on disk storage and copy protection—what it is, how it's done, and why it works. At the end of the series, I decided to see how many of you found the subject as interesting as I did. In order to make things a bit juicier, I threw in a short listing I found in a protected Apple game a few years ago and figured that only a few of you would be able to work it out.

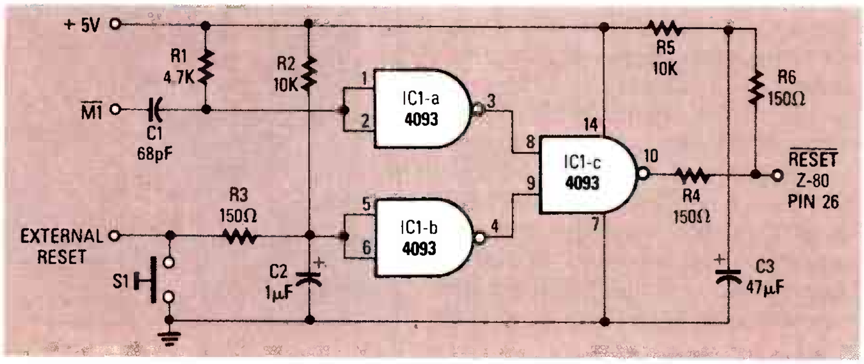



FIG. 1

**LISTING 1**

```
59E4   CE E7 59   DEC $59E7
59E7   CF         ???
59E8   EA         NOP
59E9   59 EF EA   EOR $EAEF,Y
59EC   59 AD 51   EOR, $51AD,Y
59EF   C0 AD      CPY #$AD
59F1   54         ???
59F2   C0 AD      CPY #$AD
59F4   57         ???
59F5   C0 AD      CPY #$AD
59F7   52         ???
59F8   C0 20      CPY#$20
59FA   60         RTS
59FB   5B         ???
59FC   20 C5 5B   JSR $5BC5
59FF   20 4E 5B   JSR $5B4E
5A02   A9 04      LDA #$04
5A04   8D EC B7   STA $B7EC
5A07   A9 00      LDA #$00
5A09   8D EB B7   STA $B7EB
5A0C   A9 00      LDA #$00
5A0E   8D F0 B7   STA $B7F0
5A11   A9 60      LDA #$60
5A13   8D F1 B7   STA $B7F1
5A16   A9 40      LDA #$40
5A18   20 45 5A   JSR $5A45
5A1B   10 01      BPL $5AIE
5A1D   A9 20      LDA #$20
5A1F   91 5A      STA ($5A),Y
5A21   AD 50 C0   LDA $C050
5A24   A9 09      LDA #$09
Etc., etc., etc.
```

Boy, was I wrong!

It seems that not only are there loads of Apple freaks out there but a lot of you have spent some time code-snooping. However difficult it is to follow uncommented machine code, protected code is twice as hard to understand. The listing in the article was an example of a self-modifying code—a particularly nasty piece of business that shows up every once in a while in low-end software, like games. The original and commented disassembly are shown in listings 1 and 2 respectively. As you can see, once you figure out what's going on, the correct code stares you right in the face.

The only interesting part of the listing is the first three lines of the original code. If you don't catch that, there's absolutely no way you'll be able to make sense out of the rest of it. I'm not going to talk about all of the code, but it's worth some time to go through the protection scheme. Like many other things, it's really simple when you see it.

The first three lines of the original code disassembled like:

```
----> 59E4  CE E7 59  DEC $59E7
      59E7  CF        ???
      59E8  EA        NOP
      59E9  59 EF EA  EOR $EAEF,Y
      59EC  59 AD 51  EOR $51AD,Y
      59EF  etc., etc.
```

That looks exactly like the kind of junk you usually see when you try to disassemble data, graphics, or look-up tables. In actual fact, that is the kernel of the method used by the programmer—more than once, I might add—to keep people from following his code. All you have to do to figure it out is exactly what's shown in the first instruction. After decrementing the $CF at $59E7, the code changes and looks like this:

```
      59E4  CE E7 59  DEC $59E7
----> 59E7  CF EA 59  DEC $59EA
      59EA  EF        ???
      59EB  EA        NOP
      59EC  59 AD 51  EOR $51AD,Y
      59EF  etc., etc.
```

By now, a bit of light should be peeking through the window. And as soon as you execute the second instruction at $59E7, the whole

## LISTING 2

```
                ****************************************
                *                                      *
                * COMMENTED LISTING OF THE SELF MODIFYING *
                *  CODE FROM THE COPY PROTECTION ARTICLE  *
                *                                      *
                ****************************************
                *
                *         ORG   $59ED
                *
                *
                *   Set the screen display switches
                *
59ED: AD 51 C0  SETUP     LDA   $C051      ;Set screen to text
59F0: AD 54 C0            LDA   $C054      ;Set Page 1
59F3: AD 57 C0            LDA   $C057      ;Set HiRES graphics
59F6: AD 52 C0            LDA   $C052      ;Set full screen
                *
                *
                *   Run several subroutines
                *
59F9: 20 60 5B            JSR   $5B60      ;Jump to subroutine #1
59FC: 20 C5 5B            JSR   $5BC5      ;Jump to subroutine #2
59FF: 20 4E 5B            JSR   $5B4E      ;Jump to subroutine #3
                *
                *
                *  Set several DOS parameters
                *
5A02: A9 04               LDA   #$04       ;Make track #4 the
5A04: 8D EC B7            STA   $B7EC      ;current disk track
5A07: A9 00               LDA   #$00       ;Make 00 the current
5A09: 8D EB B7            STA   $B7EB      ;disk volume number
5A0C: A9 00               LDA   #$00       ;Set the active DOS
5A0E: 8D F0 B7            STA   $B7F0      ;buffer to the one
5A11: A9 60               LDA   #$60       ;that's located at
5A13: 8D F1 B7            STA   $B7F1      ;address $6000
                *
                *
                *  Run another subroutine
                *
5A16: A9 40               LDA   #$40       ;Set up accumulator
5A18: 20 45 5A            JSR   $5A45      ;jump to subroutine #4
                *
                *
                *  The next instruction makes the program
                *  bypass the byte at $5A1D, (an $A9).  The
                *  A9 is put there only to confuse the
                *  disassembly since there's absolutely no
                *  way it can be reached and executed.  This
                *  is an example of another protection method
                *  called `FALSE DISASSEMBLY' and is used by
                *  some programmers to hide sensitive code.
                *
                *  It can be VERY hard to detect!!
                *
5A1B: 10 01               BPL   $5A1E      ;Skip over next byte
5A1D: A9                                   ;False disassembly
                *
                *
                *  Run another subroutine
                *
5A1E: 20 91 5A            JSR   $5A91      ;Jump to subroutine #5
                *
                *
                *  Switch the screen to graphics
                *
5A21: AD 50 C0  START     LDA   $C050      ;Set graphics screen
                *
                *
                *  Continue with the rest of the program
                *
5A24: A9 09               LDA   #$09       ;etc., etc........
```

thing becomes clear since what you get is:

```
      59E4  CE E7 59  DEC $59E7
      59E7  CE EA 59  DEC $59EA
----> 59EA  EE EA 59  INC  $59EA
      59ED  AD 51 etc. LDA  $??51
```

The final instruction at $59EA changes the $EE back to $EF—but not until after the instruction executes! That means the instruction at $59EA modifies itself and location $59EA only contains an $EE for as long as it takes the instruction to execute. Unless you work it out you'll never get it.

*continued on page 86*

# COMMUNICATIONS CORNER

A new way to communicate!

**HERB FRIEDMAN,**
COMMUNICATIONS EDITOR

THE ENCODING OF NON-MILITARY communications originated as a need to conceal commercial transactions from accidental discovery. Almost anyone could eavesdrop on short-wave Morse-code cable traffic, and so the five-group commercial code was developed as a way to pass international traffic without a casual listener discovering that a boatload of bananas had just left Central America, or that a rust-bucket pulling into Pago-Pago had gold bars concealed in the salted fish.

Those who required maximum secrecy—spies, international bankers, merchants of death, and other nefarious schemers—used encoding that might take hours to decode by those having the key; weeks, months, years, or never by those not having a key, or a spy or a mole with the opposition.

Non-military encoding was also used to reduce the amount of time and effort needed to send a commercial message, and there were various national and international message codes for that purpose. The familiar 73's (goodbye, or best regards) and 88's (love and kisses) used by the amateur radio operators are from an old international message code in which two-digit numbers represented complete sentences. Radio operators also had the international Q-signal code, in which 3-letter groups starting with the letter Q represented a thought, a sentence, or a particular situation.

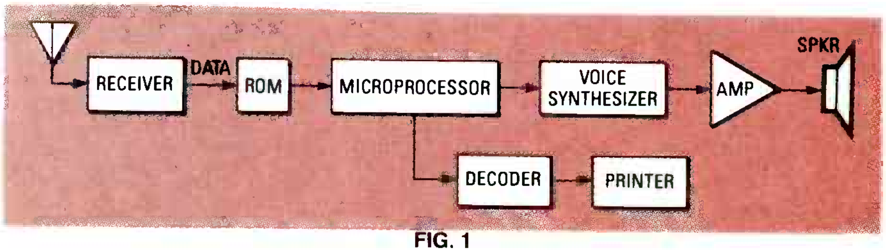



FIG. 1

## Digitize

In the context of using encoding to save time—not for concealment, espionage, nor military use, although it provides security even superior to the famed enigma code machine—we have combined the modern microprocessor with the old concept of an alpha or a numeric commercial code to create the fastest, most secure means of sending a message from one place to another.

For example, assume we have a data-exchange system running at 1200 baud. The transmission of the digitized message *22 96 16*—which at 1200 baud would sound exactly like a blip of static—would produce a printout at the receiver of "CONGRATULATIONS ON YOUR WINNING THE LOTTERY FROM YOUR LONG LOST FAMILY IN CALIFORNIA." Or perhaps a digitized blip of *13 87 23 POLE 15 MALAMUTE 17* would result in a telegram reading "SORRY WE CAN'T BE WITH YOU ON YOUR MOST JOYOUS OCCASION. CONGRATULATIONS ON YOUR REACHING THE POLE. THE BOYS AT THE MALAMUTE SALOON."

Not only would the blips of what sounds like static to the human ear result in complex messages; they would also be automatically translated into the language and grammar of the people at the receiving facility.

## Done in memory

Sound farfetched? Not so! Just such a system is being introduced in Europe for—would you believe?—the common automobile radio, and **Radio-Electronics** will have a feature article on the European system in a future issue. Meanwhile, let's take a quick-and-dirty look at how it's done.

The key to the system is the same idea used in the *Digital L/C Meter* project in the July '88 issue of **Radio-Electronics**. If you recall, the results of thousands of calculations were stored in a ROM. A capacitor or inductor connected to the meter's input terminals created a specific voltage condition. Instead of going through all the calculations and interpretations needed to determine the L or C value represented by the condition, the meter simply compared the condition to the calculated results stored in the ROM. Almost instantly, a match was found; and the meter displayed the L or C value that corresponded to the stored ROM data. (Yes, that's a gross oversimplification. Read the original article if you want an in-depth explanation.)

Using the functional block diagram shown in Fig. 1 as the reference, let's apply the L/C meter's use of ROM memory to communications. Notice that we have a receiver feeding a data output to a ROM, which, in turn, feeds a microprocessor, a voice synthesizer, an audio amplifier, and a speaker. A second output channel from the microprocessor feeds a decoder and a printer.

The ROM is like a giant CD-ROM, or even a Compact Disc, in that it contains a digitized representation of thousands of words and phrases; much like the "human" voice the telephone company uses for its information service to give telephone numbers. Each word or phrase can be keyed only by a specific input data code. For the sake of discussion, let's assume that a number represented by binary data represents a digitized word, or a string of digital data represents a phrase.

Assume that the receiver outputs data representing the number 13. The 13 is the ROM-address key for digitization of "SORRY WE CAN'T BE WITH YOU ON YOUR MOST JOYOUS OCCASION." That digitized message is fed to the voice synthesizer, which outputs the complete phrase in a "human voice." Alternately, the digitized data from the ROM could also feed the decoder and printer, thereby printing the message.

Now I have the message represented by a 13 written in English. In actual use, the equipment used in each country would have a ROM whose messages are digitized in its own language. In that way, an international communications code of 13 could produce the same message in any language.

What's that? You claim that the system would provide unbreakable encryption. You betcha! If the ROM data were uncovered by a spy, it would only be necessary for the user(s) to plug a different ROM into each receiver. If the ROM exchange was time-coordinated, a communications service, country, or whomever could change all their encoding equipment in a matter of minutes. It would even be possible to bank-switch various ROM's in order to accommodate specific services.

## Rolling code

In the event that the ROM could not contain certain data, such as the name of a city, state, or person, that information for ordinary communication traffic could be sent in clear text—as we showed with *POLE* and *MALAMUTE*, or digital data could be used to represent individual characters. Were full secrecy necessary, the character encoding could be done on a rolling basis, in the same manner as used for the enigma machine. That is, the first time a 12 might represent the letter P, while the second time a 12 would represent a Z while a 26 represented E, etc., etc., etc. A 4-bit microprocessor is really all that's required to accommodate a rolling code.

The only real limitations for ROM'ized communications are the practical limitations on the size of the ROM and the kind of messages we intend to exchange. But the way that technology is going, in a couple of years a $2 ROM might well contain the digitized data for every word and phrase known both on Earth and in the nearest inhabitable galaxy.

The applications for such a system are endless. For example, imagine that you're driving in your car somewhere out of state, and you don't know what stations are broadcasting classical music, which you enjoy. All you would have to do is program your car radio to tune in to any station that happens to be broadcasting classical music, and your car radio would then tune in to only those stations. In fact, there is just such a system in use today. You should keep an eye out for a feature article on that system in an upcoming issue. **R-E**

## DRAWING BOARD

*continued from page 83*

In actual fact, that is really sloppy programming. The game it was protecting (no names) is a really slick piece of work and is obviously that of a gifted programmer. Finding that kind of garbage in the middle of it is evidence that someone else modified the source code in order to make it difficult for people like us to examine and understand.

If you go through the corrected listing carefully, you'll realize that the second programmer forgot to put everything back the way it was in the beginning, because executing the instruction at $59EA will leave the listing looking like:

```
     59E4  CE E7 59  DEC $59E7
     59E7  CE EA 59  DEC $59EA
     59EA  EF        ???
     59EB  EA        NOP
     59EC  59 AD 51  EOR $51AD,Y
---> 59EF  etc., etc.
```

That's not the same as the original listing. In order to do the job properly, the code should have looked like:

```
     59E4  CE E7 59  DEC $59E7
     59E7  CE EA 59  DEC $59EA
     59EA  EE EA 59  INC $59EA
---> 59ED  EE E7 59  INC $59E7
     59F0  AD 51 etc.LDA $??51
```

The instruction I added at $59ED would make the code go back to its original garbage appearance as soon as it was finished.

Hey, if you want to throw people off the scent at least do the job properly!

Several people who worked out the listing also picked up the fact that there was some unnecessary code as well. It showed up as:

```
     5A07  A9 00     LDA #$00
     5A09  8D EB B7  STA $B7EB
---> 5A0C  A9 00     LDA #$00
     5A0E  8D F0 B7  STA $B7F0
```

You can see that the instruction at $5A0C is a waste of space since the accumulator was already loaded with $00 at $5A07 and hasn't been changed. It's only a couple of bytes and doesn't really mean much in the great scheme of things, but it's surprising to see it there since the game was such a neat bit of programming.

A special thanks to D. H. Evett, Steve Z, James Swindell, Raymond Zapp Jr., Philip Albro, Alan Wilson, Isaac Molho, Michel Kronowit, and David Andrus, for sending in the correct listing. You've all earned 17 cracking points and a gold star.

I was happy to see that a lot of you share my interest in working out puzzles in general and snooping around software in particular. If you'd like to see more of that kind of thing, drop me a note and let me know. The next time I do it, however, I'm going to make it *really tough!*

There isn't really enough room in this column to go into a heavy discussion of copy protection, but I can certainly pass along any tips and suggestions that look interesting. One thing though: Software is machine-specific—an elegant code on an Apple is just garbage to an IBM. If you want to see more on that subject, let me know what kind of computer you have and what peripherals you have connected to it.

In order to deal with copy protection you have to have a working understanding of assembly-language programming. There's no easy way to get into it—you just have to make up your mind and do it.

The more experience you have with dealing with the CPU on a gut machine-code level, the more success you'll have in dealing with the ins and outs of copy protection. When I get a better idea of what kind of computers you own, I'll be able to make some recommendations of programming books and tutorials. If you know of any good ones for your hardware, put them on the note and I'll be sure to pass them along.

### Z-80 Reset

On a completely different subject, John Gruszynski dropped me a note with a question about the Z-80 series we did a few months ago. He wants to know what happens to the registers when the Z-80 is reset. Here it is:

## IC TESTER

*continued from page 40*

while the red clip goes to the positive side. Make or purchase an IC test cable and test clips (one 20-pin and one 16-pin test clip should be adequate), and use a 20-pin cable with multi-colored micro-hook probes for the analyzer cable.

After checking for good solder joints and proper component location, install the four AE013 IC's observing proper handling precautions for CMOS devices. As shown in Fig. 3, pin 1 of IC3 and IC4 is oriented 180 degrees from pin 1 of IC1 and IC2. If the IC's are installed backwards, they will be damaged. Put an 8-section DIP switch in the S2 socket; the switch marked "1" goes toward the pin-1 end of the socket.

### Checkout and final assembly

For the preliminary checkout you will need a +5-volt supply, capable of outputting at least 250 mA. (DO NOT connect the tester to anything greater than +5.5 volts.) Plug the 20-pin header, P1, to SO1, and connect a jumper from any pin of the header to ground. Now wrap a thin piece of bare wire around each pin of the header, so that all of the pins are connected together. Wrap a thin piece of bare wire around each pin of DIP-clip SO2, so that all the pins are connected together. Now connect a jumper from any pin to ground. Turn off all sections of S2, and then connect the power leads to the +5-volt supply and then press and release S1. If the tester is working properly, all of the LED's should be off except LED21.

With S2-h open, connect the P1 header jumper to +5 volts, and then remove it and connect it to ground. All of the LED's should turn on and stay on. Now, with S2-h closed, connect the jumper to +5 volts, and then to ground. All the LED's should turn on when 5 volts is applied, and then go off when the jumper is grounded (holding S1 will have the same effect). Now remove the power, the P1 header from SO1, and the SO2 test clip.

Now get your enclosure, and label the front panel using the photographs as a guide. Drill and/or punch holes as necessary, and be sure to make a hole in the bottom of the case for the power

*continued on page 104*

1—Output control lines become inactive.

2—Data and address buses go tristate.

3—Interrupt mode is set to zero.

4—Interrupt and refresh registers are set to zero.

5—All interrupts, except NMI, are disabled.

6—Program counter is set to zero (execution starts at 0000h).

As you can see, it pretty much starts everything from scratch. A hardware reset is usually generated when you first power-up the system to make sure things start off in a known state.

To answer specifically: The program counter resets to zero as a result of a reset, and program execution starts at location 0000h. If you do a reset at startup, (and you should), it doesn't really matter what else is going on in your circuit because you're just starting out. If, however, you do a reset while your circuit is powered up, there is one circumstance that can cause you some problems.

If you're using dynamic RAM in your circuit and the R register in the Z-80 to handle the refresh, a hardware reset can cause the contents of the RAM to get trashed because the reset signal takes precedence over everything else.

When RESET is brought low, it takes effect irrespective which part of the instruction is being executed. One way around that is to synchronize a reset with the appearance of the M1 signal. The circuit in Fig. 1 will do that for you and also give you a way of having a reset done by either a manual switch or some other kind of logic circuitry.

By synchronizing reset with M1, a reset can never happen while the CPU is talking to memory so there's no chance of a memory glitch due to an erroneous write. Of course, since the R register is reset to zero as well, you'll have to make sure your refresh timing is fast enough to save the data you've already stored—but that is a different problem.

The Z-80 can take the strain out of a lot of design problems. A good designer can mix some hardware with a bit of software and cut the size of the board down to a minimum. But the price you pay for that convenience is that the Z-80 is a complex IC and dealing with software is a whole new can of worms. There's no way you can use the IC successfully without doing your paperwork first.

There are lots of books on the Z-80 that can tell you everything you want to know about the IC. The first place to look is in your local library; if you don't find what you want there, write to the electronics book publishers. And don't forget the people who make the Z-80 (Zilog, 210 Hacienda Ave., Campbell, CA 95008). They all have data books and application notes that are crammed with lots of good information.

We seem to have gotten off the subject of display multiplexing but don't worry, we'll pick it up again next month. I promise. **R-E**

## HARDWARE HACKER

*continued from page 75*

The best sources of design and supplier information on synchronous inverters seem to be several rather expensive trade journals. Visit a large technical library and see if they have *Solar Age, Solar Energy, Solar and Wind Technology*, or, on the more practical side, *Solar Engineering and Contracting*.

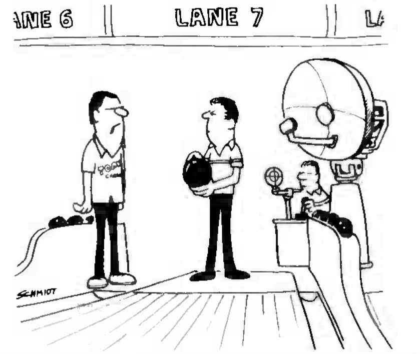
### New tech info

Let's see. There's a free *Thyristor selector guide and cross reference* from Motorola, a *Modem Design Booklet* from Exar, a new *Linear IC Handbook* from Plessey, and the *Standard Products data book* from Standard Microsystems that does include such chips as CRT display circuits and keyboard encoders.

And C & H Sales now has a new surplus catalog full of robotics and other goodies. A free sample force-sensing resistor is obtainable from Interlink Electronics. And, at long last, sanely priced current transformers for energy management and such as described in the *Current Ring* data sheets from ISL.

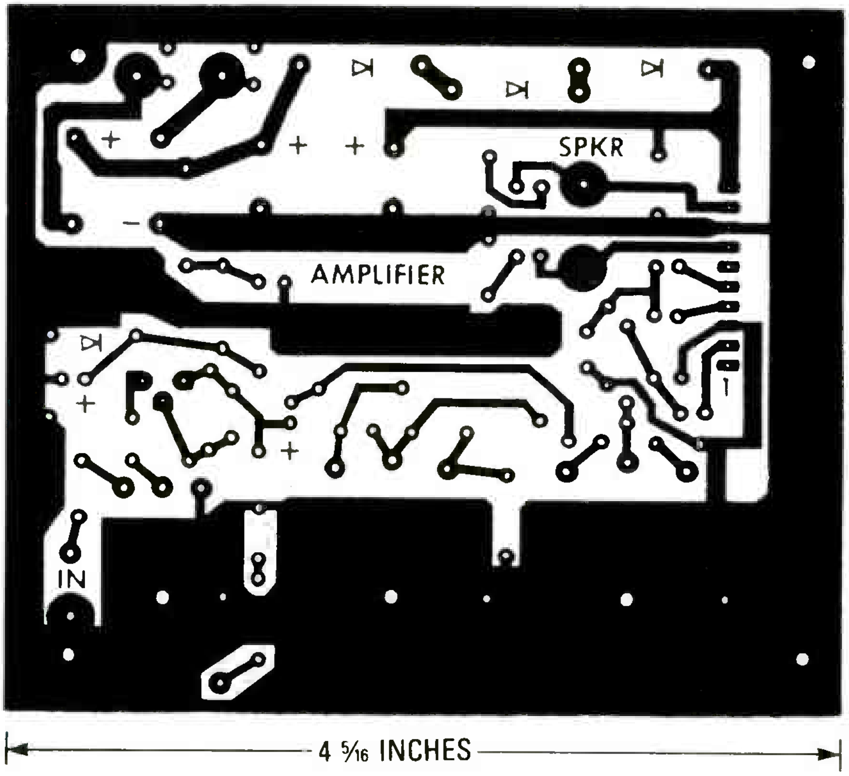
If you are at all interested in any Apple computing, be sure to check into my *Enhancing your Apple IIe*, volumes I and II, my *AppleWriter Cookbook*, and my *Apple Assembly Cookbook*. By one of those absolutely astounding coincidences, I do appear to have several autographed copies on hand here.

Write or call if you are at all interested. Let's hear from you. **R-E**

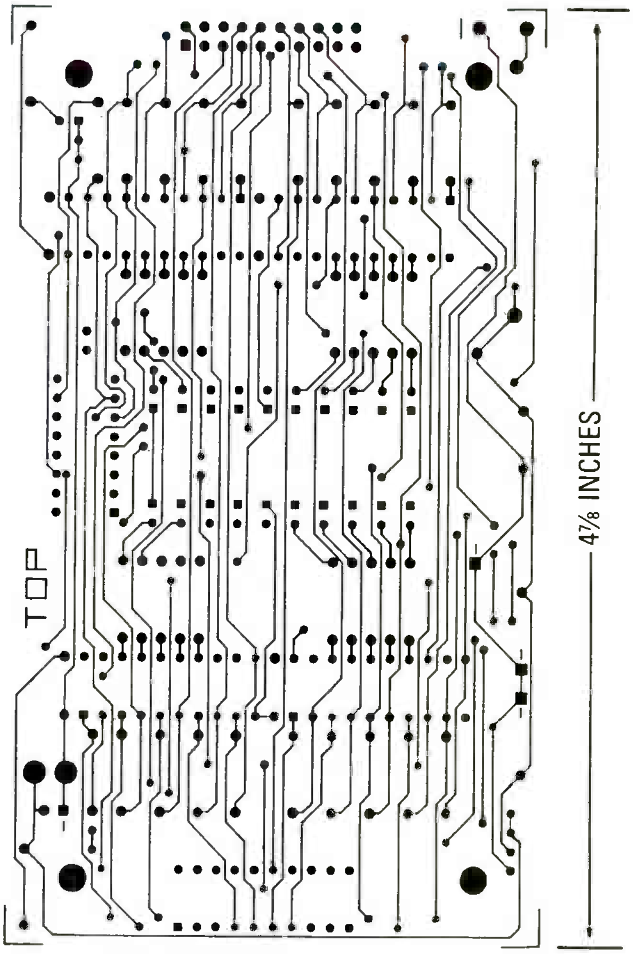



*"There's a rumor around that some of your guys are using an electronically controlled ball..."*

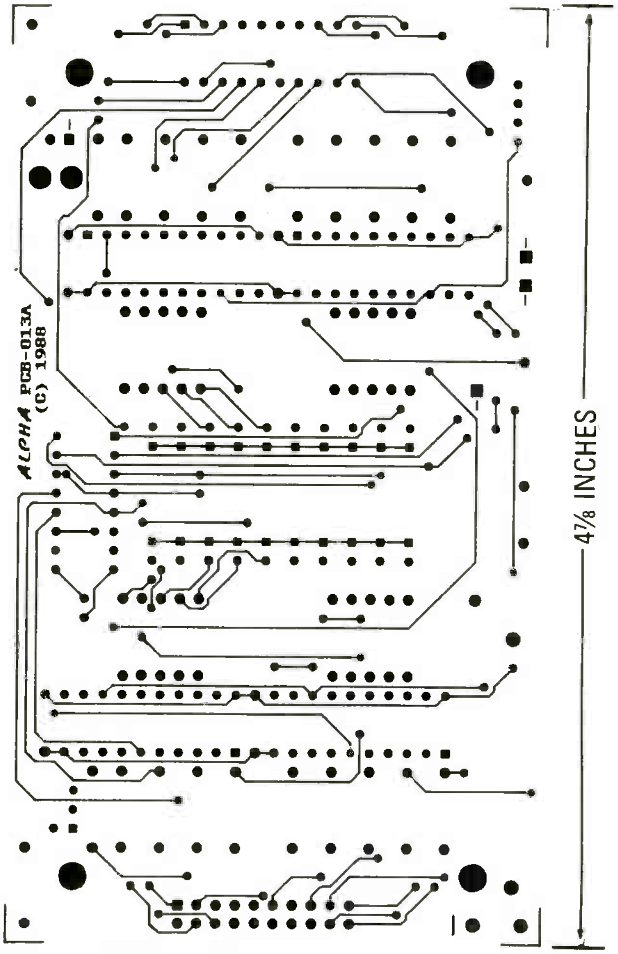
# PC SERVICE




**BUILD THE AMPLIFIED SPEAKER SYSTEM using this pattern.**




**COMPONENT SIDE of the IC tester.**




**SOLDER SIDE of the IC tester.**

VOL. 5 NO. 9 SEPT 1988

# COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

## INCREASE YOUR BRAIN POWER

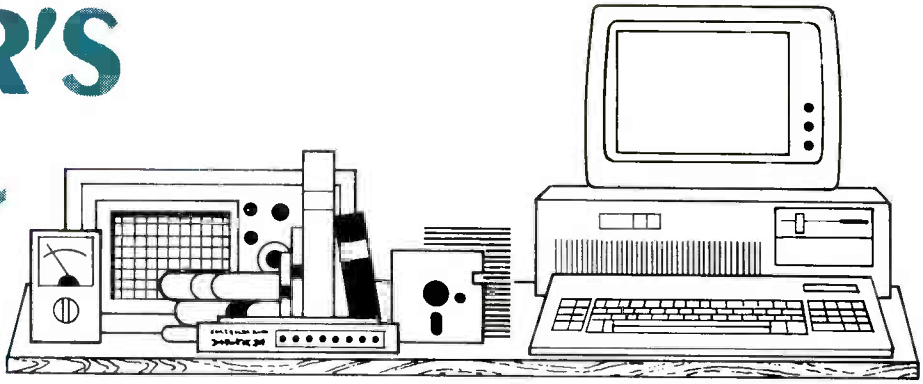
Our Synergy Card puts your brain's hemispheres in sync for increased analytical power Page 94

## CD CLASSROOM

The series concludes with a look at the disk controller and parallel port Page 97

A GERNSBACH PUBLICATION

# EDITOR'S WORK-BENCH




## A Pair From Paradise

Resolution of video adapters and monitors is increasing. For those in fields requiring high resolution (CAD and desktop publishing), that's good news. For the rest of us—those who want it but can't afford it—it's bad news. In fact, a quality EGA adapter and monitor still costs three times or more what a Hercules mono system costs—and a Hercules system actually provides 12% better resolution than an EGA!

To help users at both ends of the scale, Paradise Systems recently introduced a pair of half-length video adapters. The low-cost AutoSwitch Monochrome EGA allows the user to run both CGA and EGA programs on a TTL monochrome monitor. Of course the board can also run standard Hercules monochrome graphics. The VGA Plus Card, on the other hand, requires an analog monitor or a NEC MultiSync (or equivalent), and provides displays of up to 800 × 600 with 16 simultaneous colors.

### The AutoSwitch Monochrome EGA

Many programs are written to support both Hercules and EGA graphics systems—but some aren't. OS/2, for example, requires EGA (or VGA) graphics. However, it's hard to scrap a perfectly good video system, especially when you consider that a standard TTL monochrome monitor has the bandwidth to display images at EGA resolution easily.

Paradise did consider that fact, and decided to build an adapter that takes advantage of it. The AutoSwitch Monochrome EGA Card can run any software designed for CGA, EGA, and Hercules graphics—all on a standard TTL monochrome monitor.

The board works in two modes: *True Monochrome Mode* (TMM) and *Color Simulation Mode* (CSM). In TMM, you run software set up for standard text, Hercules text and graphics, and monochrome EGA text and graphics. In CSM, you run software set up for color CGA and EGA text and graphics. In this mode, colors are represented as different intensity levels. White is bright, black is dark, and the other colors are somewhere in between.

DIP-switch settings allow you to boot the card in either TMM or CSM. You can also change modes at the DOS command line using a utility program (MEGA.EXE). You can even "lock" a mode, so that even if you normally run in TMM, you can lock CSM, reboot, and then run Flight Simulator and other self-booting programs.

In addition to the two modes, the board has a feature called AutoSwitch which is also enabled and disabled by a DIP switch and MEGA.EXE. With AutoSwitch enabled, in TMM, you can run any monochrome software (MDA, Hercules, or mono EGA), and the card will switch into the correct mode automatically without changing switch settings, software drivers, or anything else. Likewise, in CSM, you can run CGA and EGA software at will.

The board's last major feature allows you to run text-mode applications in 132-column width, with either 25 or 43 lines. Paradise supplies software drivers and patches that allow you to do so using Lotus 1-2-3 and Symphony, Framework II, WordPerfect 4.2, and WordStar versions 3.3 and 4.0.

One potential problem with a board of this nature is lack of contrast. Color combinations that are perfectly legible on a color monitor may be illegible on a monochrome monitor. So Paradise supplies an additional utility that allows you to modify, save, and load "palettes"; maps that show how various colors are translated into different levels of intensity. You can have different palettes for different applications, loading them as required at the DOS command line or by batch file.

As for compatibility, the board worked fine in both modes with all software tested, including tough graphics programs such as Windows 2.0, Dr. Halo III, and Broderbund's PrintShop. (By the way, in the past we had run the latter on a Hercules mono card using a public-domain utility called SIMCGA, which is available on the RE-BBS. It looks *much* better on the Paradise card.)

We tested the card in two machines: a new-model IBM PC XT (with a 640K motherboard), and an AST Premium/286 (a 10-MHz AT compatible). The AutoSwitch Monochrome EGA card ran with no problems whatsoever in the AST, but in the IBM, a slight shimmering effect was observable with some color combinations. For example, the bright blue that is used as a background color in PC Outline shows up as a shimmering grey on the AutoSwitch Monochrome EGA. Careful adjustment of the monitor's contrast and brightness controls could reduce the effect, but not eliminate it. Because we've had compatibility problems with that XT before, we suspect it is at fault. Paradise is looking into the problem.

### Enhanced VGA

At the other end of the scale, the VGA Plus is an analog-only card, which means you'll need a NEC MultiSync or compatible, or one of the new IBM analog monitors.

The VGA Plus is compatible with all IBM standard video modes (CGA, EGA, MCGA, and VGA), Hercules monochrome, and three proprietary modes. Like the monochrome EGA card, the VGA Plus supports 132 columns by 25 or 43 lines in text modes. It also supports an 800 × 600 graphics mode. (The latter mode won't run on IBM analog monitors.)

Special drivers are supplied that allow you to run Windows 2.0 (including any program that runs under Windows—PageMaker, Excel, etc.), GEM, AutoCAD, Ventura Publisher, Cadvance, and Framework II in the 800 × 600 graphics mode. Other drivers and patches are available for running Framework II, WordStar 3.3 and 4.0, and WordPerfect 4.2 in 132-column text modes.

Unlike some VGA-compatible boards, the VGA Plus has the "Feature Connector" that is part of the IBM VGA standard. The Feature Connector is designed to allow add-on hardware to provide enhanced video features, but so far there are no commercial products that utilize the Feature Connector.

Like the AutoSwitch Monochrome EGA adapter, the VGA Plus ran all the software we tested it with, without any problems, including Windows 2.0 and AutoCAD Release 9.0.

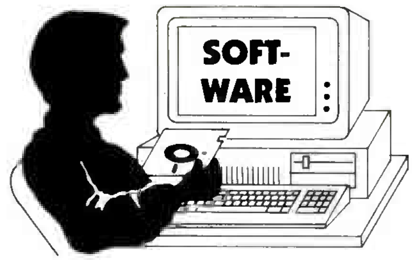
Whether you're looking for an enhanced VGA card for advanced graphics applications, or for an inexpensive way to obtain EGA graphics, Paradise has a solution for you.

## OS/2 on an XT?

If you know anything about OS/2 at all, you know that it requires an 80286 or 80386 microprocessor and at least 1.5MB of extended memory. Therefore, the new operating system can't run on an XT—right? Wrong. SOTA Technology's Mothercard 5.0 (reviewed in the November 1987 issue of Computer Digest) is an accelerator card that provides a complete operating environment for its 80286: it has its own AT-compatible BIOS, its own onboard RAM, its own math coprocessor, etc. Except for I/O circuitry, the Mothercard amounts to an entire AT machine on a card.

The wizards at SOTA have devised a set of drivers that allow IBM's version of OS/2 to run on the card. It works nicely: We tried it.

You'll need a high-density disk drive (1.2M or 1.44M) to install OS/2; because most XT's don't have the proper adapter, SOTA has designed one of their own. We saw an early version of The Floppy I/O Plus, which should be ready by the time you read this. The board will support as many as four internal and external floppy-disk drives in any format (3½ and 5¼, 720K and 1.44M, and 360K and 1.2M, respectively), and also contains a parallel port and one or two serial ports. The company will throw in a free copy of OS/2 and a Floppy I/O Plus to anyone who purchases the 12.5-MHz version of the Mothercard and the two-megabyte daughtercard.




## GrandView

Organization is the key to working efficiently; a new category of software purports to help us get organized. Some programs in that category provide brand-new interfaces and techniques; others build on past types of software (outliners, project managers, free-form databases) to provide capabilities far beyond those of the software type on which they're based. Because of the potential and versatility of these organizers, we'll examine several of the more interesting ones during the next few months.

Living VideoText (a division of Symantec) recently introduced GrandView, a program that comes from the outline tradition. In fact, the program was written by the same person who wrote our favorite (till now) outliner, PC Outline. As you might expect, GrandView resembles PC Outline in many respects, but the program was also influenced by Living VideoText's own ThinkTank. (PC Outline and ThinkTank were examined briefly in the March 1987 and May 1988 editions of **ComputerDigest** respectively.)

The basic user interface strongly resembles that of PC Outline. A series of drop-down menus allows you to load and save files, perform editing functions, change the screen view, reorganize your outline, etc. You can access the menus by pressing F10 or the slash key ("/"), or by using a mouse. Many common menu commands are also accessible through Ctrl- and Alt-key combinations. Alt-S, for example, saves the current outline to disk. A built-in keyboard macro processor allows you to define your own keystrokes to accomplish the tasks you perform most often.

Like PC Outline, you can have as many as nine outlines open on-screen simultaneously. But GrandView gives you quite a bit more flexibility in their on-screen arrangement. They can be tiled (arranged in adjacent, non-overlapping windows) in several ways, overlapping, or in a custom arrangement designed by you. When you hit on the correct format, you can save it to disk and reload it later. And using the Autostart macro, you can even force that window setup to be loaded every time you start GrandView. Those are great improvements over PC Outline.

If you've never used an outliner, nearly all allow you to create headlines, subheadlines, sub-subheadlines, and so forth. Each headline (or subhead) may be just a single line of text, or it may contain several paragraphs of text. To rearrange an outline, you can move a headline (or subhead); all subheads and associated text will move with it. Display options allow you to hide and show various levels of detail—headlines only, headlines and first-level subheads, etc. The ability to "zoom" in and out using the various display options allows you, at different times, to see the overall structure and to zero in on the details.

Of course, GrandView includes the usual complement of editing and outlining functions, as well as advanced features like the ability to mark a disparate group of headlines throughout the outline and gather them together in a new place. Other commands allow you to move and copy a headline or group thereof, join and divide headlines, clone headlines (in which all changes made to one copy of a headline or group are reflected in the other), sort and prioritize headlines. Hoisting a headline hides all of the outline except the current headline, its subheads, and all associated text. That allows you to focus on the subset. Hoisting and cloning are borrowed from ThinkTank.

GrandView also allows extensive print formatting, including headers and footers, specification of fonts and typestyles by outline level, etc. No longer do you have to transfer an outline from an outliner to a word processor for final printing.

### What's new

So far, GrandView sounds like a beefed-up outliner. What gives it the increased organizational abilities mentioned above? Two things: the automation provided by the automatic keyboard macros, and the new ability to view outline entries by category.

In fact, GrandView allows three views of a given document: outline, document, and category. Outline view is the traditional indented hierarchy of headlines and subheads.

Document view shows (and allows you to edit) just the text of a particular headline or subhead.

Category view is more complex. When creating your outline, you can associate each headline and subhead with one or more different categories. You can then use category view to view your outline by category entries.

For example, suppose you're managing the research, engineering, and manufacturing departments of an engineering firm. Suppose further that some people work in more than one department. You might create an outline with research, engineering, and manufacturing as the major headlines. Under each headline you would create a list of current projects. Each project would be categorized according to project leader, monthly expenses, and critical parts.

Then, when Bill comes in and complains that he has too much to do, you could call up your outline, go into category view, and instantly display all the projects he's working on. Once a week you would examine your outline from the critical parts perspective, thereby making sure that a project isn't being delayed because parts aren't available. Once a month, you could update (and justify to your boss!) the expenses category.

GrandView also has numerous small features that make it a joy to use. It is, for example, one of the growing class of text-mode programs that make impeccable use of a mouse to initiate menus and select items from them, mark blocks of text, etc. The program also has an enviable on-line help system, and numerous configuration options that allow you to customize behavior to your tastes.

### Conclusion

Even without the ability to categorize information, GrandView represents a significant improvement in outlining software. In fact, GrandView currently represents the state of the art. So whether you've been considering using an outliner or you're already experienced with another outliner, check out GrandView—you won't be disappointed. Just remember that, like any tool, GrandView is only as effective as the person using it. If you're new to PC-based outlining, you'll probably have to spend some time getting acquainted before you can become productive.

## Excel

Lotus 1-2-3 has reigned as king of the spreadsheet hill (which is rapidly becoming a mountain) for many years now, but several contenders to the throne have arisen recently. Borland's Quattro attempts to out-Lotus Lotus, but Microsoft's Excel takes the spreadsheet metaphor to new heights.

The program runs under Windows 2.0. Excel comes with a run-time version of Windows, but to pass data among Windows applications, you need a regular copy of Windows 2.0. You also need a big, fast machine with a lot of RAM to run Excel. At a minimum, a fast AT with a fast hard disk, 640K of conventional memory, and at least a few hundred K of expanded or extended memory are required. You'll also want a mouse.

Whereas Quattro provides an optional clone of the Lotus interface, Excel has its own user interface. However, in what is without question the best on-line help system we're ever seen, an experienced Lotus user can easily find the equivalent Excel command. A similar capability is provided for Multiplan users. In addition, the help system contains an excellent tutorial and an encyclopedic multi-level indexed and cross-referenced listing of all commands. There is also a separate guide to keyboard commands, and a Feature Guide that functions as a tutorial for intermediate users. The combination of all the help functions makes it possible to learn (or relearn) most of what you need to know about that complex product without ever opening the well-done manual.

Because Excel runs under Windows, you get all of the advantages and disadvantages of that environment. On the plus side, the graphic environment is easy to work with, and provides, with the proper printer, the possibility of high-quality output in a multitude of type faces, as well as high-quality graphics. On the other hand, with anything less than a fast 286, operation is *slow*.

Excel provides three basic kinds of structures: spreadsheets, macros, and charts. Unlike Lotus, each type of structure is stored in a separate file, which helps keep your spreadsheets free of clutter. All three structures provide capabilities that Lotus is only now beginning to incorporate into the latest version of the program (3.0), which is due out about the time you read this. For example, Excel provides more than 40 pre-defined charts, including various types of bar, line, and scatter charts. You can define multiple charts for a single spreadsheet; each chart appears in a separate window. Unfortunately, 3D charting is not implemented. Unlike Lotus, Macros can be recorded as you enter the actual keystrokes; later you can edit your macros in a macro editing window. As for spreadsheets, you can have more than one open at once (limited by the amount of memory you have), and separate spreadsheets can be linked, so that changing data on one spreadsheet is automatically updated on any linked spreadsheet. The list goes on and on.

Excel is a big, powerful program, and it requires a big, powerful machine to run it. But working with it is both fun and productive. And it's also a harbinger of the type of program we'll start seeing soon that run under OS/2.

## Graphics Conversion with Hijaak

Graphics on PC's were once limited to games, but more and more serious uses are cropping up all the time. The problem is that there is no standard file format, so you can't, for example, read images created by Microsoft Paint into Dr. Halo for further editing. And forget about transferring an image from an Amiga or a Macintosh to a PC (or vice versa).

Inset Systems recognized the problem and has started building a solution to it. (The company's first product, Inset, allows you to do desktop publishing within the confines of your own word processor; see the February 1988 issue for a review.)

Hijaak allows you to capture the screen of just about any IBM PC program and then convert it to one of the supported formats, which presently include: Amiga ILBM, Compuserve GIF, Halo CUT, Hewlett-Packard PCL, Inset PIX, Lotus PIC, Macintosh MacPaint, Microsoft Paint, NewsMaster, PC Paintbrush, PrintMaster, Text, TIFF, and PostScript. Or you can convert a disk file created in one format to another. Exceptions presently include the ability to transfer only from (not to) the Lotus PIC format, and only to (not from) PostScript format.

Conversion can be accomplished from a fill-in-the-blanks program or via the DOS command line (or in batch files). In either case, the process is quick and painless.

Supported formats for capturing images directly from screen include C/GA, EGA, VGA, Hercules, AT&T, and Toshiba (T3100).

Hijaak's manual is very well written and laid out, which makes learning and using the program simplicity itself. All software manufacturers should buy a copy of Hijaak just to see the right way to do a manual.

## Optimize Disk Performance with VOPT

It's a fact of PC life that disk files become fragmented over time. By un-fragmenting them, they load faster because the read/write head needn't shuttle back and forth across the surface of the disk. Rather it laps up each sector as it passes beneath the head.

Several un-fragment programs are sold commercially; one of the better is VOPT, by Golden Bow Systems. VOPT is both safer and faster than most comparable programs, because it does not try to account for every single sector. For example, if there is a single unused sector in one of the lower numbered tracks, other programs will shift the entire sector chain—which could comprise many megabytes—down just to reclaim a few K of space. Doing so takes a long time and is dangerous, because if a power line glitch occurred in the middle of the process, one or more files could be hopelessly scrambled.

VOPT, on the other hand, adopts an intelligent approach to reclaiming unused space. Rather than shifting an entire disk down to fill a small space, it will move a small file there, or simply leave it unused. Doing so greatly increases safety and greatly decreases the amount of time required to optimize the disk.

In addition to VOPT, the disk comes with several utility programs, including one (VMAP) that provides a graphic display of your hard disk's sector usage. Figures 1 and 2 show the displays provided before and after running VOPT on a 20-megabyte hard disk (a Seagate ST-225) installed in an IBM PC XT, a process that took about 2.5 minutes, rather than the 25–40 minutes required by other similar programs.

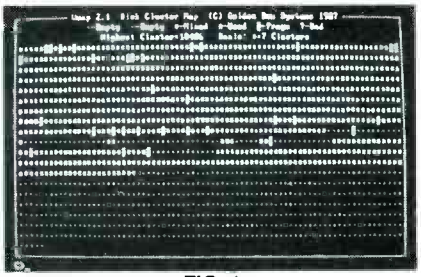


FIG. 1

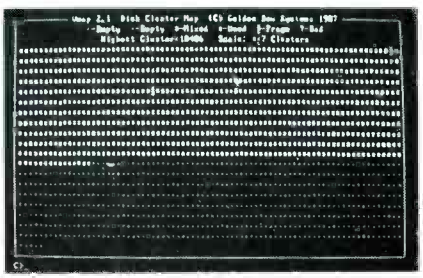


FIG. 2

Golden Bow also markets a quality disk-caching program, VCACHE, and a hard-disk partitioning program called VFEATURE that allows you to create bootable partitions larger than the 32-megabyte limit imposed by DOS.

## BASIC 6.0

Microsoft just released a slew of languages (BASIC, assembler, Pascal, FORTRAN, and C) that allow you to develop programs for both DOS and OS/2. BASIC 6.0 is a complex hybrid product that includes the QuickBASIC 4.0 environment for developing DOS programs interactively, as well as a command-line compiler that both runs under and produces code for both DOS and OS/2 environments. The only problem is that the compiler cannot take full advantage of some of the advanced features of OS/2, such as multiple processes in the same program.

Fortunately, versions of CodeView, Microsoft's windowing debugger, are included for both environments. Unfortunately, however, QuickBASIC doesn't run under OS/2 (yet).

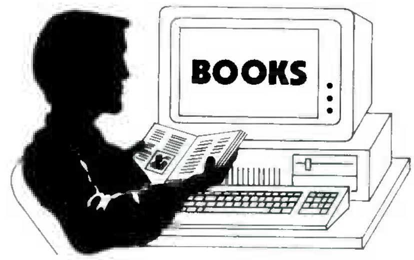
The programs are supplied on nine 360K diskettes, and are accompanied by about six inches of spiral-bound documentation. It's possible to run various portions of the package from a floppy-only system, but you'll really want a hard disk for convenience. To store everything you'll need almost three megabytes of space; you won't need all files if you're just going to use QuickBASIC, for example, or just the OS/2 development tools.

This author gave up on BASIC as a serious programming tool long ago, but QuickBASIC could change his mind. There are several reasons for that. For one, the language doesn't require line numbers, and it allows named procedures (subroutines). In addition, it contains a built-in debugger that allows you, for example, to keep a watch on one or more variables while a program is running. Further, its built-in editor is infinitely better than that supplied with GW-BASIC. An especially nice feature is that, many times, you can modify a program (not just a variable, as in GW-BASIC) and continue running it without recompiling. Last, file facilities that allow for binary records allow you to create Pascal-like records. No more FIELD, LSET, etc!

For use with the command-line compiler (BC.EXE), BASIC 6.0 also includes a configurable text editor (M.EXE) from which other programs—including BC, of course—can be run. That ability is no replacement for the integrated Quick environment, but it helps.

You can buy QuickBASIC separately for considerably less money, but with BASIC 6.0 you also get the command-line compiler and editor, and versions of CodeView for both DOS and OS/2. So you could use QB to develop, say, the interactive portions of programs, and BC to compile (and CodeView to debug) the "meat." Also, don't forget that under OS/2, you can run multiple programs simultaneously, so you could run BC—even several copies of it—in the background, while at the same time editing another file in the foreground.

If you're looking for a simple way (i.e., not with C or assembler) of easing into OS/2 programming, BASIC 6.0 is what you need. It combines a wealth of programming tools for both old and new environments, all at a reasonable price.




## Customizing AutoCAD

AutoCAD has developed a cult following for a number of reasons, not the least of which is its ability to be thoroughly customized. (See the April 1988 issue for a review of the current version.) You can customize the program's on-screen menus to provide you with a subset of commands that fit your particular application. In addition, using AutoCAD's built-in LISP-like language, you can program special functions to do just about anything you like.

The problem is that Autodesk's documentation on customization is sparse. So New Riders Publishing decided to show us how to do it. The result is a big (8½ × 11), thick (600 pages) book written by Joseph Smith and Rusty Gesner that covers just about every imaginable (and several unimaginable) aspect of customizing AutoCAD. The book teaches you all about menu customization and working with LISP. The book does not, however, inundate you with much detail all at once; rather, it presents information to you in well-chosen and easily manageable chunks, gradually building on earlier concepts.

Along the way, it teaches how to best use DOS (subdirectories, etc.), interfacing with Lotus 1-2-3 and dBASE, and more.

In short, if you're seriously into AutoCAD, you need a copy of *Customizing AutoCAD*, to help you get the absolute most from your system.

PRODUCTS REVIEWED

- AutoSwitch Monochrome EGA ($249) and VGA Plus Card ($399), Paradise Systems, Inc., 99 South Hill Drive, Brisbane, CA 94005. (415) 468-7300.
- Mothercard 5.0 (12.5 MHz, $995; 10 MHz, $895), SOTA Technology, 657 N. Pastoria Ave., Sunnyvale, CA 94086. (403) 245-3366.
- GrandView ($295), Symantec Corp., Living VideoText Division, 117 Easy Street, Mountain View, CA 94043. (415) 964-6300.
- Excel ($495), Microsoft 16011 NE 36th Way, Redmond, WA 98073. (206) 882-8080.
- Hijaak ($89), Inset Systems 12 Mill Plain Road, Danbury, CT 06811. (800) 828-8088, (203) 794-0396 (CT).
- VOPT ($49.95), Golden Bow Systems, 2870 Fifth Ave., Suite 201, San Diego, CA 92103. (619) 298-9349.
- BASIC 6.0 ($295), Microsoft Corp., 16011 NE 36th Way, Redmond, WA 98073. (206) 882-8080.
- Customizing AutoCAD ($34.95, disk with AutoLISP routines, $29.90), New Riders Publishing, P.O. Box 4846, Thousand Oaks, CA 91360. (818) 991-5392.

# BUILD A SYNERGY CARD FOR YOUR PC

*Tap your hidden potential!*

**Jeff Wiley & R. D. Warner**

In our society, we tend to over-emphasize analytical, linear thinking, and under-emphasize intuitive, symbolic approaches. However, we short-change ourselves when we do. The best scientific achievements have something "artistic" about them, and the best artistic achievements have something "scientific" (organized or structured) about them. Systems design and analysis, for example, requires one to retain an image of the overall system while simultaneously being able to break that system down into its component parts.

To help you learn to maximize both analytical and intuitive types of skills, we're going to describe the construction of a device, called the Synergy Card, that plugs into any IBM PC or compatible with an eight-bit slot. The Synergy Card works by generating computer-controlled sound waves that put your brain into a state that is more conducive to both learning and creating. The Synergy Card can also be used to create various sound effects. The card can be built for under $100; assembled and tested versions are also available. See the sidebar for more information.

Because of the controversial nature of the technique, we'll spend most of this first article describing basic terms, background research, and philosophy. Next time we'll build the card itself and show you how to use it.

## Background

Research has taught us much about how the human brain works. Using machines such as the ElectroEncephaloGraph (EEG) and the Superconducting QUantum Interference Device (SQUID), researchers have discovered that there is a division of labor between the sides of the brain. The left hemisphere is predominantly analytical, linear, and verbal. By contrast, the right hemisphere is intuitive, creative, visual, and symbolic. Throughout the course of the day, we shift from one hemisphere to the other, depending on the task at hand. When speaking or balancing a checkbook, the highest brainwave amplitudes are in the left side. When painting or listening to music, the right side becomes most active.

Another discovery revealed that certain psychological and physiological states were associated with certain ranges of brain waves. That discovery led to the development of bio-feedback techniques. With the proper techniques, a person could learn to produce alpha or theta brainwaves, and thereby experience the physical and mental states associated with them.

A technique that, unlike biofeedback, requires no learning by the subject has been developed by Robert Monroe, presently of The Monroe Institute (TMI) in Faber, Virginia. In the late 1950's, Monroe began investigating methods of accelerated learning, which led to remarkable discoveries about the nature of human consciousness. For example, Monroe found that regular sound waves at brainwave frequencies could induce the brain to produce brainwaves of a similar frequency. That phenomenon is called a Frequency-Following Response (FFR). The important thing about FFR is that, given the correct frequencies, one could enjoy the physical and mental states associated with those frequencies.

Because most brainwave frequencies are quite low, "beat" frequencies are used to generate them. The way they're generated is unusual, though, because the actual beat frequencies are synthesized by the brain instead of being heard normally. To understand how it works, imagine listening through headphones to two distinct signals. A 200-Hz signal is fed to one side, and a 205-Hz signal to the other. Those signals are not being mixed electrically, nor are they mixing in the air. Nevertheless, you will hear a distinct 5-Hz beat frequency, which is created in your brain. The way it works is that the two brain hemispheres synchronize to synthesize the beat signal. That process was dubbed *Hemi-Sync* (for hemisphere synchroniztion) by Monroe. We'll call it HS.

In that example, if you were being monitored with an EEG, it would trace a 5-Hz brainwave, and the amplitudes of the signals from both hemispheres would gradually become equal.

Which signals produce desirable physiological and psychological responses? TMI was founded in 1971 to answer just that question. Thousands of experiments with volunteers led to the development of certain combinations to produce specific responses. For example, a frequency of about 4 Hz can produce theta waves, which are associated with deep relaxation and high receptivity. By itself, theta waves may produce drowsiness, but when combined with beta waves (which are associated with concentration and alert problem solving), you have an excellent mental state for learning, retention, and problem solving.

**ORDERING INFORMATION**

The following are available from Perceptual Research Ventures, P.O. Box 201516, Missoula, MT 59801: Etched, drilled, tin-plated, and silk-screened PC board (PR-10), $36.00; assembled, tested, and conformal-coated card (PR-48), $319.95 (for research organizations only); custom cabling (PR-8), $28.95; Sleep Lab software, compiled, runs card as a background task, leaving CPU free for other work, (PR-100), $29.95. Add $5 for postage and handling.

## Case studies

A philosophy professor at the Tacoma Community College in Washington has been using HS signals combined with music in his classes since 1978. The professor spends less time on housekeeping and department tasks; students are more relaxed, cooperative, and interested in learning; and student performance is enhanced.

In another study, HS (delta, theta, and beta) was mixed with music and played in 24 second- through fifth-grade classrooms. Teachers reported that students had more highly focused attention, were more interested in learning, and were able to learn more material in a given period of time. The general classroom atmosphere was one of relaxed attentiveness.

## Dream research

HS also looks useful for dream research. In fact, HS was developed mainly as a way to maintain a state conductive to lucid dreaming, so that dreaming could be studied in a more consistent manner. That fascinating phenomenon has potential as a psychological and creativity tool, and as entertainment. In fact, HS has been used to develop techniques that can teach you how to increase dream awareness, and how to dream with finesse.

Sleep research has shown that in REM sleep (the period when most dreams occur) the right hemisphere is much more active than the left. That's understandable based on what we said before, because dreams are usually pictorial, emotional, and illogical, and the right side of the brain is the home of such states.

In order to become lucid in a dream, it is necessary to increase activity in the left hemisphere. The effect of hemisphere synchronization seems to be that it allows one to carry more left-brain critical-analysis functions into dreaming. Much of what we've said about HS and dreaming is speculative, but the authors can personally attest that HS helps induce lucid dreaming.

## Hardware introduction

The Synergy Card is built around two 8255A parallel interfaces, three AY-3-8910 Programmable Sound Generators (PSG's), and a stereo amplifier suitable for driving headphones or the line-level inputs of your stereo system.

Because sound generation is done with hardware rather than software, the control software is easy to write. The hardware approach also provides much greater control over the sound envelope generated by the Synergy Card. In addition, it also frees the CPU for other tasks. For example, the CPU can give the card the necessary parameters, and then go off and monitor biofeedback equipment, altering the signal mix based on the information provided by that equipment.

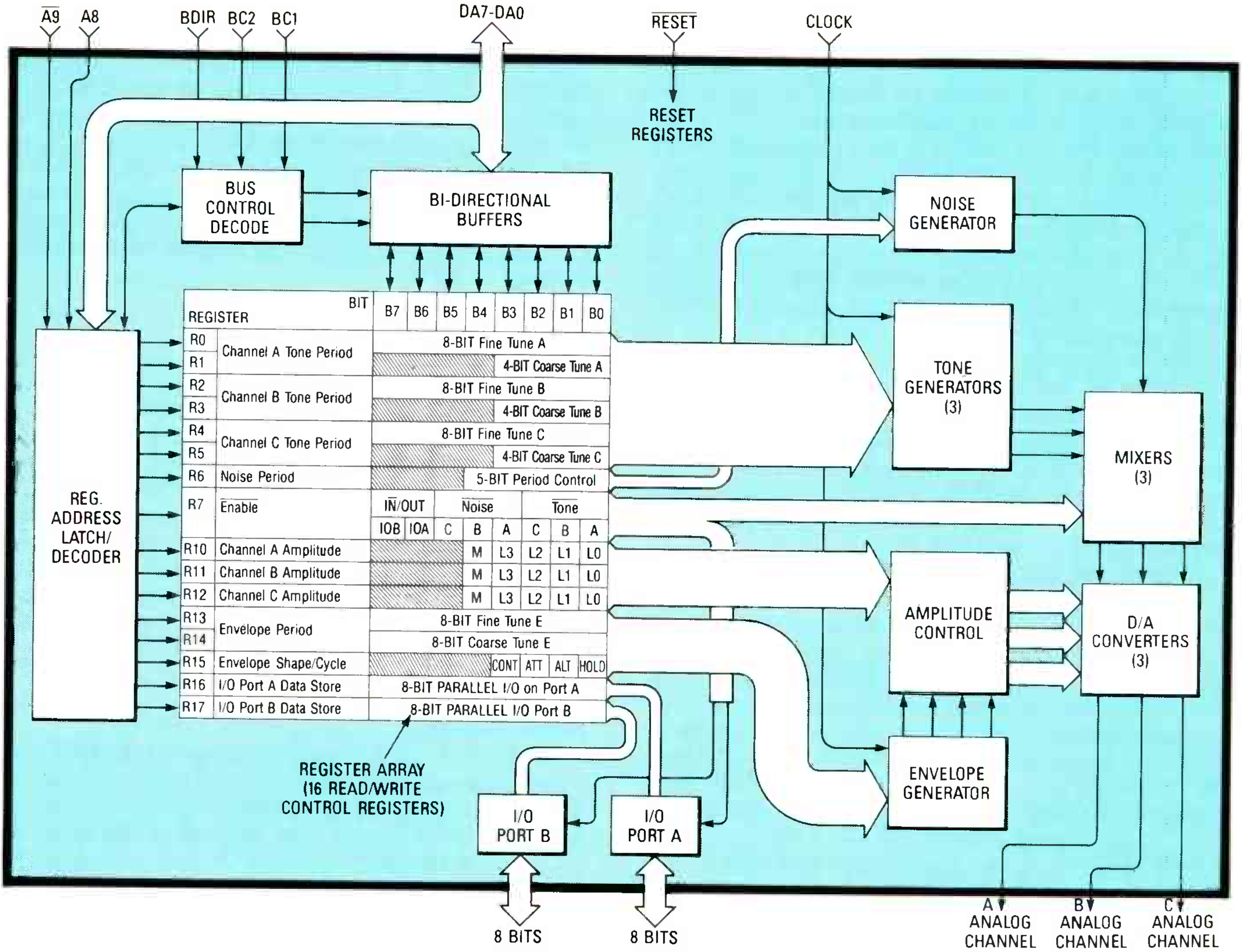



**FIG. 1—THE PROGRAMMABLE SOUND GENERATOR has sixteen registers that control the operation of a noise generator, tone generators, and the frequency and amplitude of the resulting waveforms.**

Figure 1 shows a block diagram of the PSG. As you can see, each PSG has three analog outputs and 16 digital I/O lines. Each of the three analog outputs has its own tone generator; the output of a single noise generator (if enabled) may be mixed with one or more outputs. The amplitude of each output may be fixed or variable, depending on the state of the envelope generator. The output of each mixer is fed through its own four-bit (sixteen-level) D/A convertor. The analog outputs of the IC have maximum amplitudes of 1 volt pk-pk.

All operational parameters are specified by a set of sixteen registers. Output frequency, for example, is determined by the contents of registers R13 and R14, which are the fine and coarse envelope period control registers. Here is the formula for determining output frequency:

$$F_O = F_C/[16 \times (256 \times C_T + F_T)]$$

$F_O$ is the desired frequency, $F_C$ is the clock frequency, $C_T$ is the contents of the coarse-tune register, and $F_T$ is the contents of the fine-tune register.

Control software must be able to calculate $C_T$ and $F_T$, given a desired output frequency ($F_O$). (Clock frequency $F_C$ is set at 1.8432 MHz.) For example, to obtain a 200-Hz tone, plug in the known values and re-arrange the equation as follows:

$$200 \text{ Hz} = 1843200 \text{ Hz}/[16 \times (256 \times C_T + F_T)]$$

$$200 \text{ Hz} = 1843200 \text{ Hz}/(4096C_T + 16 F_T)$$

$$4096C_T + 16F_T = 1843200 \text{ Hz}/200 \text{ Hz}$$

$$4096C_T + 16F_T = 9216$$

$$C_T = 9216/4096 = 2$$

$$F_T = 1024/16 = 64$$

$C_T$ is calculated first, and then $F_T$ is determined from the remainder. The reason is that the PSG views the eight-bit fine-tune register and the four-bit coarse-tune register as representing one twelve-bit number. So you really aren't solving the equation for two unknowns, but one that is broken down into most-significant and least-significant parts that fit into the two registers.

Next time we'll present the complete circuit, discuss how it works and how to build it.

# BUILD THE PT-68K




*This time we install hard- and floppy-disk controllers, and a parallel port.*

**PETER A. STARK**

We tend to look in awe at the floppy-disk circuitry of a computer, but actually it is very simple, mainly because the most complex parts are hidden in a dedicated IC known as the Floppy Disk Controller (FDC).

### Step 21: Floppy-disk controller

Figure 1 shows the floppy-disk circuit used in the PT-68K. The heart of the circuit is the WD1772 FDC, which connects to the lower eight bits of the data bus, to address bits A1 and A2, to the R/$\overline{W}$ line, to the $\overline{\text{RESET}}$ line, to the $\overline{\text{I/O4}}$ select line from the address decoder, and to the 8-MHz clock signal (CLK8).

The $\overline{\text{I/O4}}$ line comes from IC34 in the address decoder (shown in Fig. 3 in the January 1988 installment). It goes low whenever the 68000 accesses any location $FE0100–$FE013F, and thus selects the FDC whenever the 68000 reads or writes any address in that range. However, because only the lower eight bits of the data bus go to the FDC, only odd addresses in that range actually are used to transfer data.

Internally, the CPU-side of the FDC is organized into six byte-size registers, two of which the 68000 can either read or write. Two others can be read but not written, and the remaining two can be written but not read. The 68000 selects which register it is reading or writing by (a) making the R/$\overline{W}$ line high for reading or low for writing, and (b) putting the appropriate bit pattern on address lines A1 and A2.

The values of those two bits depend on the address (in the range from $FE0100 through $FE013F) that the program accesses. For example, writing to location $FE0103 makes R/$\overline{W}$ low and puts the bits 01 on A2 and A1 respectively. (Remember that the 3 at the end of $FE0103 is the bit pattern 0011; the middle two bits of this pattern correspond to A2 and A1, respectively.) The six registers appear at the addresses shown in Table 1.

Each register has a specific job. The Control register, for example, tells the floppy-disk drive to move the read/write head to a specific track, to read or write a specific sector, or to format a track. (See the December 1987 and January 1988 issues for more on tracks and sectors, and the sidebar here entitled "SK*DOS Disk Organization" for information on how SK*DOS stores information on disk.)

The FDC presents the results of various operations in the Status register, where each bit has a function: indicating that the FDC is busy, that it is waiting for data, that the disk is write-protected, or that an error has occurred.

The 68000 tells the FDC where to read or write by placing the track and sector number into the Track and Sector registers.

Last, the 68000 places data to be written on the disk into the Write data register, or reads data from the disk in the Read data register.

Although the FDC handles most of the housekeeping involved with reading and writing floppy disks, there are several tasks it does not handle: choosing one of several drives, choosing a specific side of a double-sided disk, and choosing single- or double- density format. All three tasks are handled by IC11, a quad latch.

As shown in Fig. 1, the four data inputs of IC11 connect to bits 0, 1, 5, and 6 of the data bus, and the IC's CLK input connects to $\overline{\text{I/O3}}$. Like $\overline{\text{I/O4}}$, $\overline{\text{I/O3}}$ comes from IC34 in the address decoder, but $\overline{\text{I/O3}}$ is pulsed whenever the 68000 reads or writes locations $FE00C0—$FE00FF. Specifically, any time the 68000 stores a byte into location $FE00C1, IC11 is clocked and the data present on bits 0, 1, 5, and 6 of the data bus is stored in IC11.

The outputs of IC11 are used as follows: bits 0 and 1 go to IC12, a decoder that selects one of four drives; bit 5 goes to the $\overline{\text{DDEN}}$ input (pin 26) of the FDC to choose single or double density; bit 6 is buffered by IC22-a and is used to select the side.

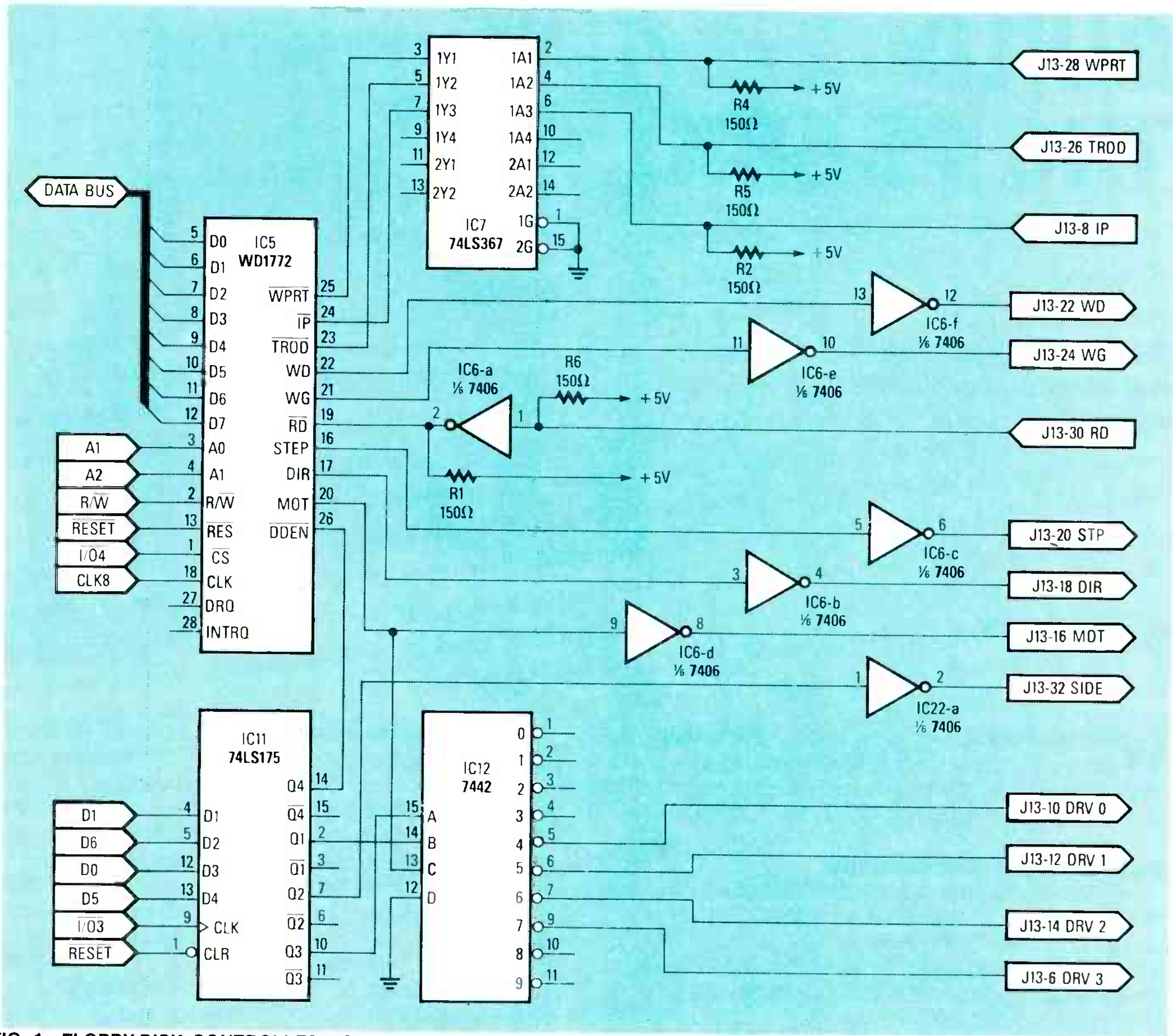



**FIG. 1—FLOPPY-DISK CONTROLLER: IC5 does the real work; IC11 and IC12 select drive, disk side, and disk density.**

**TABLE 1—FDC REGISTERS**

| | |
|---|---|
| $FE0101 | Write only Control register |
| $FE0101 | Read only Status register |
| $FE0103 | Read/Write Track register |
| $FE0105 | Read/Write Sector register |
| $FE0107 | Write only Write data register |
| $FE0107 | Read only Read data register |

Last, let's look at the connections to the disk drives themselves. Disk drives connect to the PT-68K through a 34-wire flat cable that plugs into J13. All odd-numbered pins of the cable are grounded; the even-numbered pins carry signals to and from the drives. Physically, all the odd pins are on one side of the connector, but in the cable, the odd-numbered wires, alternate with the even-numbered wires. Therefore there is a ground between each adjacent pair of signal-carrying wires, reducing noise pickup.

There is only one 34-conductor cable, even when there is more than one disk drive. So each drive receives all signals from the computer. A specific drive is selected through use of the DRV0–DRV3 signals. For example, to access drive 0, the PT-68K places a low on DRV0, meanwhile keeping the other three lines high. In that way, when a command or data is sent down the cable, only the selected drive actually obeys.

The signal wires themselves can be divided into three types: data, control, and status signals. The data lines carry serial data to and from the drives. The computer uses the control lines to tell the drive what to do. And, the status lines tell the computer the results of various operations.

The two data lines are RD for Read Data, and WD for Write Data. Although data on the data bus travels in parallel, the FDC contains shift registers that convert parallel data (that comes from the bus) to serial form (that goes to the drive), and vice versa. The FDC also adds clock pulses to ensure that the data on the disk is properly timed and can be read back correctly. In single density, a clock bit follows every data bit; in double density, clock bits are inserted only between consecutive zero bits. Reducing the number of clock bits is what allows double-density operation to store more bits per track.

Several signals control the operation of the drive. We already discussed the four DRV signals, which select a particular drive; and the SIDE signal, which selects a particular side of the disk. Other control signals include Write Gate (WG), which goes low to tell the drive to switch from reading to writing; (Step STP), which tells it to move the read/write head to the next track; Direction (DIR), which tells it which direction to move the head; and Motor (MOT), which tells it to turn the motor on.

Actually, MOT controls all drives, so even unselected drives turn their motors on and rotate the disk when MOT is asserted.

The STP signal is so named because floppy drives use a *stepper motor* to move the head from track to track. A stepper motor has a ratchet-like motion, whereby the head aligns itself over a track correctly each time the motor clicks into position. In that way, the head is positioned precisely by the motor with no help from other potentially problematic mechanical devices.

Last, there are three status signals, all of which are usually derived from photo-electric sensors in the drive. A drive sends back a low on the Write Protect (WPRT) line when the write-protect notch on the disk is covered. The drive sends back a low on the Track 0 (TR00) line when the head is positioned over Track 0, which is the outermost track on the floppy disk. Note that the FDC has no easy way of knowing which track the head is positioned over—it keeps track of head position by sensing track 0 and then keeping a count of the STP step pulses as the head moves in and out.

The drive senses the beginning of the track by sending a beam of light through a small hole in the disk called the *index hole*. That light is sensed once per revolution. When a disk is rotating, the Index Pulse (IP) goes low every time the beginning of a track comes under the read/write disk-drive head.

The FDC uses the index pulse in several ways. In normal operation, the presence of the signal tells the FDC that there is a disk in the drive and that the door is closed (otherwise the disk would not turn). In addition, when a disk is being formatted, the index hole tells the FDC where to begin and end each track. Also, when the FDC encounters a disk error, it uses IP to count the number of times it retries the failed operation before giving up.

A word or two about 40- and 80-track drives. An 80-track drive can read 40-track disks by a process called double-stepping, in which the drive takes two steps of 1/96" to traverse the 1/48" spacing between tracks on a normal 40-track disk. In fact, SK*DOS automatically tries double-stepping when it encounters a disk error, so reading a 40-track disk in an 80-track drive is totally invisible to the user.

However, the reverse is not true—although SK*DOS can write a 40-track disk in an 80-track drive, it often happens that the disk is unreadable in a 40-track drive. The reason is that the tracks on an 80-track disk are not just closer together, they are also narrower. So when an 80-track drive writes on a 40-track disk, it does not write over the full track width, and some of the original 40-track data may remain around the edges of the track. Then, when a 40-track drive tries to read the disk, it reads the new data as well as some of the old. Depending on the exact track positioning and other factors, it may then misread the disk and fail.

### SK*DOS DISK ORGANIZATION

Although a double-density track can theoretically hold almost 6000 bytes, in practice only 4608 bytes are used for actual data storage; the remaining bytes are wasted. On an IBM disk running MS-DOS, those 4608 bytes are divided into 9 sectors of 512 bytes each; on the PT-68K running SK*DOS, they are divided into 18 sectors of 256 bytes each. Sectors are numbered beginning with 1.

On an SK*DOS disk, track 0 holds system information; the remaining tracks hold program and data files. Sectors 1 and 2 of track 0 hold the superboot program, which is used when starting (booting) the system. Sector 3 is called the System Information Sector (SIS) because it stores system information such as how much of the disk is free. Sector 4 is used for testing purposes, and the disk directory begins with sector 5. If more space is needed for the directory, then it may be continued in other sectors of track 0.

Each file on the disk has an entry in the directory that contains the file's name, size, time and date of creation or last update, location on the disk, and a one-byte attribute that provides further file information. The location of the file is specified by the track and sector where the file begins, and the track and sector where the file ends.

Because only the beginning and ending locations are specified in the directory, additional information indicating where to find the rest of the file is contained within the file itself. The first two bytes of every sector in the file contain a pointer to the next sector of the file, in the form of another track and sector number. The linked sectors form a chain-like structure, so this type of disk organization is called a linked chain system.

The free space on the disk is treated like a file (i.e., as another linked chain of sectors), whose beginning and ending locations, as well as size, are stored in the SIS, sector 3 of track 0.

As SK*DOS creates or deletes files, it simply moves sectors between chains. For example, when a file is deleted, its name is removed from the directory, and its sectors are added to the end of the chain of free sectors. One neat side-effect of this system is that, if there is enough free space on the disk, these sectors may not be overwritten for some time. It is therefore possible to recover a deleted file, sometimes days or weeks later, depending on how the disk has been used. SK*DOS is supplied with such an UNDELETE program.

## Build the floppy controller

Enough theory; let's warm up our soldering irons. Install the following components, using sockets for all IC's: IC5 (WD1772), IC11 (74LS175), IC12 (7442), IC7 (74LS367), IC6 (7406). Then install 150-ohm, 1/4-watt resistors at R1, R2, R4, R5, and R6, and a 0.1-µF ceramic disk at C6 (if it's not already installed). Last, install J13, a 34-pin dual-row header strip.

Just about any 5¼" disk drive will work with the PT-68K, but a double-sided, 80-track drive is preferable, because it holds more data. Note that the SK*DOS disk operating system is normally supplied on 80-track double-sided disks unless you specify otherwise.

The next task is to make sure that the jumpers on the drive are properly set. As described above, selecting one of four possible drives is done by the four DRV lines.

Although all four lines go to each drive, only one DRV signal is actually used by any single drive.

Figure 2 shows a simplified diagram of the jumpers that control drive selection on a typical floppy drive. As you can see, the four DRV signals appear on pins 6, 10, 12, and 14 of the 34-pin connector, and go to a set of jumpers usually called DS0–DS3, although sometimes they are labeled DS1–DS4. When one of those jumpers is installed, the corresponding DRV signal goes to the Drive Select line of the drive itself.

To use a drive with the PT-68K, you must make sure that it has only one Drive Select jumper installed. In some drives, the connections are made through a shorting plug installed in an IC socket; in that case, you may have to break three of the four connections on the shorting plug (or install a small DIP switch instead of the shorting plug). In other cases, you may have to move a jumper from one of the other positions into DS0. Many floppy drives currently sold for use in IBM PC's and compatibles have the DS1 jumper installed, because drive selection in IBM's is done by flipping wires in the 34-pin cable, rather than by moving jumpers on the drive.

In a single-drive system, the jumper would be installed on DS0 (or DS1 if your drive's numbering scheme starts with 1). If you install more than one drive, place each DS jumper in a successively higher position.

In addition to moving the DS jumpers, you should also remove the MICX (or MX) and HM jumpers if installed, and install a jumper in the HS position. MUX is used to select a drive permanently for those computers that don't provide DRV signals. HM and HS jumpers control the Head Load signal in those drives that use a solenoid to move the read/write head against the disk. Installing the HM (Head with Motor) jumper would bring the head against the disk as soon as the motor turned on, whereas installing the HS (Head with Select) jumper only brings the head against the disk if the drive is selected.

A word about terminating resistors. In order to minimize noise, each signal-carrying wire must be terminated at the drive with a resistor. A drive usually has a small

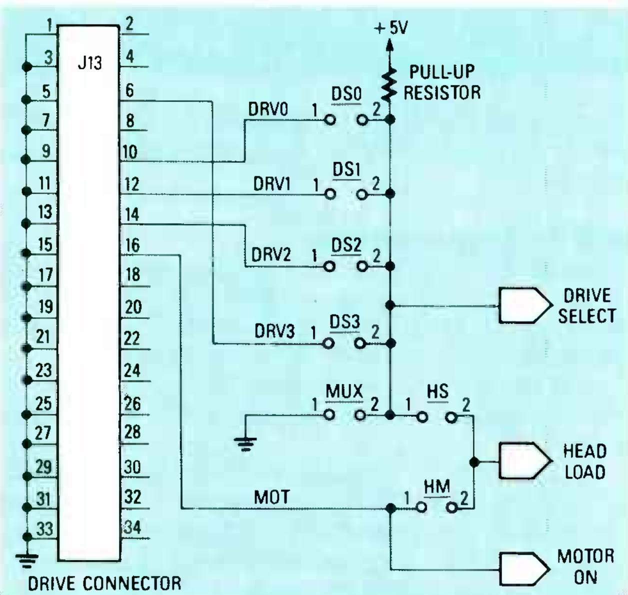



**FIG. 2—DRIVE-SELECT CIRCUITRY: Typical floppy-disk drives have a header block for selecting the disk-drive number that the drive will respond to.**

**FURTHER HELP**

**For further help, contact us through our BBS at (914) 241-3307. Hardware questions can be answered by Peripheral Technology, 1480 Terrell Mill Rd. #870, Marietta GA 30067, (404) 984-0742. Software questions dealing with HUMBUG and SK*DOS can be answered by Star-K Software Systems Corp., P. O. Box 209, Mt. Kisco NY 10549, (914) 241-0287.**

**Ordering Information**

**Complete details were given in Part One (in the October 1987 issue). To summarize: the basic kit (PT1, $200) contains all parts except power supply, case, and video terminal or personal computer to get a small system (ROM monitor, 2K RAM) up and running. The full basic system (PT-68K, currently $530 but the price may vary as DRAM prices change) includes 512K of dynamic RAM, floppy-disk controller, parallel port, battery-backed clock/calendar, three PC-compatible expansion slots, SK*DOS, editor, assembler, and system utilities. To order, or for more information, contact Peripheral Technology, 1480 Terrell Mill Road #870, Marietta GA 30067, (404) 984-0742.**

resistor pack that provides termination. To avoid overloading when more than one drive is installed in a system, only the drive at the end of the cable should have its resistor pack installed. If there is no terminating resistor pack, or if there are two or more, the disk system may be unreliable, so check each drive in your system.

Then connect the four-pin power plug to the power supply, and connect the 34-pin data cable between the computer and disk drive. Pin 1 of J13 is toward the back of the board, and the pin 1 end of the connector is marked on most disk drives with a small notch between pins.

Now insert a blank disk into drive 0 and turn on the power. When HUMBUG is running, examine the disk drive to check that the motor is off and the drive select LED on the face of the drive is off. If either of those is on, the 34-pin cable may be reversed at one end.

Now type the HUMBUG command *FD* (Floppy Disk). The drive still contains a blank disk, so it cannot boot SK*DOS; even so, the drive motor should start and the drive-select LED should light. If the motor comes on but the LED does not, the DS jumpers may not be properly placed. Don't continue on until the motor and the LED behave properly.

When all seems well, reset the computer, remove the blank disk, place a write-protect strip on your SK*DOS system disk, and place it in the drive. Then type *FD* again.

If all goes well, the disk drive should start, the drive select LED should go on, the head should go back and forth a few times, and in a few seconds the SK*DOS sign-on message should appear. Congratulations—your system is working and almost finished!

## Drive debugging

If not, then a bit of debugging is in order. First check the type of disk drive—a single-sided drive cannot read a double-sided disk, a 40-track drive cannot read an 80-track disk. If you are really quick, try to count the disk revolutions per second (rps). The disk should be turning at 5 rps, not 6. If it turns at 6 rps, it may be a 360-rpm 1.2-megabyte drive intended for an AT-type system; if so, you may be able to boot by switching jumpers, because some drives of that type have a jumper to select either 300 or 360 rpm.

If the drive seems correct, use HUMBUG's FM command to fill all of memory from address $0800–$8000 with zeros, and then try the FD command again. After about 15 seconds, reset the system and use the HA command to look at locations $0800–$0900. If those locations still contain zeros, the disk system failed to read the disk. If an oscilloscope or logic probe is available, check that the IP and RD lines are normally high, but have negative-going pulses just after you type *FD*. If not, the disk may be in the drive backward, the disk drive may still not be properly selected, or it may be defective.

An easy way to check the drive is to remove the disk, turn off the power, then manually (and *very* carefully—it might be wise to ask a knowledgeable person for help!) move the drive's head carriage a half-inch toward the center of the disk, and then try again. As soon as you type the FD command, the FDC should step the head carriage outward toward track 0. If it doesn't, then either some of the control signals are not getting to the drive, or else they are being ignored.

If locations $0800 and up are now non-zero, then *something* was read from the disk. Check whether the first few bytes at $0800 are:

60 08 50 54 32

Those are the very first bytes read from track 0, sector 1 of the disk. If that data is correct, then the disk system is almost OK. The data read from this very first sector contains the first half of a program we call the *superboot*, which loads into locations $0800–$08FF. Once loaded via HUMBUG's FD command, FD then begins execution at location $0800. The program loaded there then loads the next sector (track 0 sector 2) into memory beginning at location $0900, so check whether the area from $0900–$09FF still contains zeros. If so, the second sector wasn't loaded.

The combination of those two sectors is supposed to load the SK*DOS.SYS system file into memory at location $1000, and then start execution there. Look at locations $0805 and $0806; those two bytes should contain two non-zero numbers, which tell the program where to find SK*DOS.SYS on the disk.

Next, look at locations $1000–$1100. If those locations still contain zeros, then SK*DOS.SYS was not loaded. If the drive seems able to read the superboot program but fails to read SK*DOS.SYS, there may be a problem with the STP or DIR lines or circuitry such that the drive can read track 0 but not other tracks. The same symptom would also appear if you were using a 40-track drive to read an 80-track disk, or a single-sided drive to read a double-sided disk.

Last, look at locations $4000–$5000 or so. If that area still contains zeros, then an error may have occurred while reading the disk. A common problem is head alignment: The disk head may not be centered over a track. If you suspect that's the case, try a different drive or copy your SK*DOS system disk on another system and try the copy. (You can also copy SK*DOS disks with the Copy II PC Option Board on IBM hardware.) Alternatively, return your SK*DOS disk for exchange to either Peripheral Technology or Star-K Software.

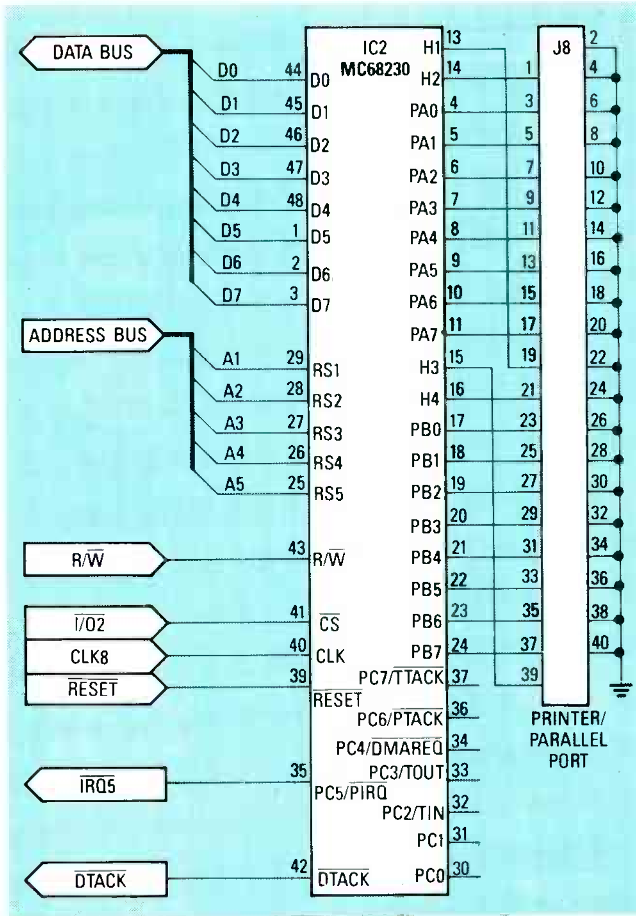



**FIG. 3—PARALLEL PORT: IC2 has two full eight-bit ports and a counter/timer. Port A can drive a printer with standard Centronics parallel interface.**

### Step 22: The parallel printer port

There are several ways to connect a printer to the PT-68K. A serial printer can be connected to the serial port at J21. A parallel printer can be connected to either the printer port on an IBM-type monochrome video card, or directly to J8 on the PT-68K system board. All three are supported by SK*DOS drivers, and it is even possible to connect all three printers at once. Here we'll discusses installing the parallel printer port at J8.

As shown in Fig. 3, there isn't much to the port. In fact, the entire port consists of just IC2, an MC68230 *P*arallel *I*nterface/*T*imer (PI/T), which is part of the Motorola 68000 family.

The 68230 consists of three main sections. Port A is an eight-bit input/output port consisting of the eight pins labeled PA0–PA7, along with two handshaking pins, labeled H1 and H2, that are used for sending control information. When used with a printer, pins 1–20 of J8 connect to a Centronics-compatible parallel-printer connector. The PA lines deliver characters to the printer, H2 tells the printer that a character is ready, and H1 lets the printer tell the PT-68K when it is busy.

Port B is a second eight-bit port that is similar to port A. Its control lines are H3 and H4. Port B is uncommitted, so you are free to use it for whatever you wish. When using port A to drive a parallel printer, don't connect anything to pins 21–40 of J8.

The third part of the 68230 PI/T is a timer consisting of a 24-bit counter that can count either CLK8 clock pulses or

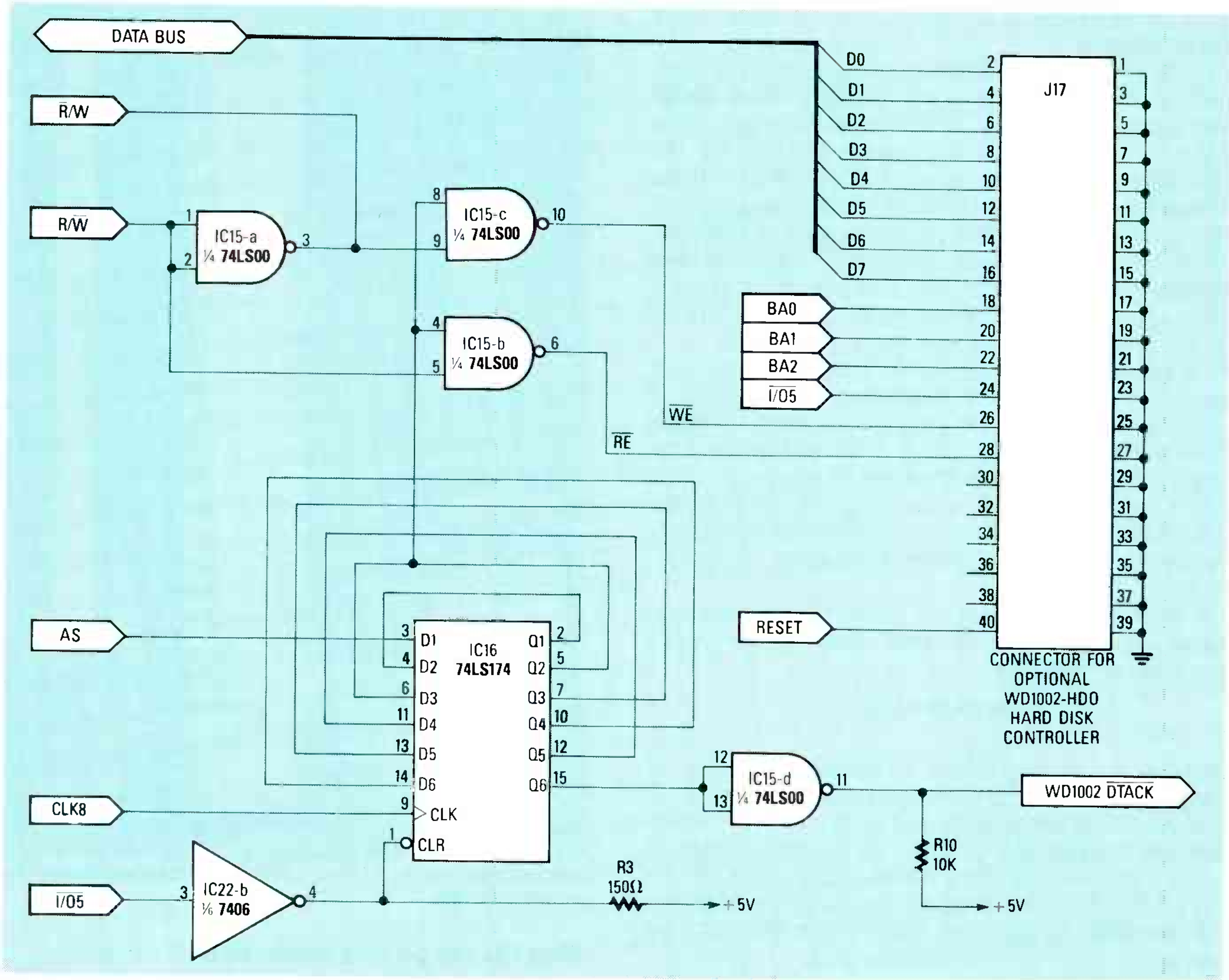



**FIG. 4—HARD DISK INTERFACE: Use this circuit only if you're not using a hard-disk controller in one of the IBM expansion slots.**

external pulses, generate square waves, generate interrupt signals to the computer at fixed time intervals, and various other functions. It is not used by PT-68K software, but it is available for custom applications.

The 68230 connections to the computer are similar to those of the floppy-disk controller. The 68230 receives the $\overline{\text{I/O2}}$ signal from the address decoder, so it is selected whenever an address in the range \$FE0080–\$FE00BF appears on the address bus. Like the FDC, it contains a number of internal registers that are accessed at specific addresses, depending on the states of address lines A1–A5. However, there are too many registers and operating modes to describe here—Motorola publishes a 75-page manual on that IC alone!

Construction is simple; install the following components: IC2 (MC68230) with socket, J8 (40-pin header), and C2 (0.1 µF ceramic disk).

Build the printer cable with 20-conductor flat cable; you may use a 20-pin connector at the computer end if you install it only in the pin 1 end of J8; otherwise, use a 40-pin connector. Place a standard Centronics printer connector at the other end, making sure that pin 1 of the Centronics connector connects to pin 1 of the other connector.

### Step 23: Optional HDO hard disk controller port

The cheapest way to add a hard disk to your PT-68K is with a Western Digital WD1002-WX1 or -WX2 hard-disk controller (used in IBM XT's and compatibles). The controller generally costs about \$90, or can be obtained complete with a 20-megabyte disk and cables for under \$300.

However, to keep all their XT-type slots open for other purposes, some users may wish to use the Western Digital WD1002-HDO controller, which costs about \$250 (without a drive). The HDO hard-disk port is shown in Fig. 4; all others can simply skip this part since the HDO controller has no other advantages. (While both hard disk controllers can be installed at the same time, they require slightly different versions of SK*DOS and therefore cannot be used simultaneously.)

The HDO controller connects to the PT-68K with a 40-pin flat cable connected to J17. The controller needs the data bus and three bits from the address bus to select internal registers. Buffered address lines BA0–BA2, obtained from the XT-type interface connectors, are used. In addition, the controller needs $\overline{\text{I/O5}}$, which selects the port at locations \$FE0140—\$FE017F, $\overline{\text{RESET}}$, and a pair of signals called $\overline{\text{WE}}$ and $\overline{\text{RE}}$ for write enable and read enable. $\overline{\text{WE}}$ and

RE are generated by IC15-b and IC15-c from the R/W signal and a port-select signal derived from IC16.

IC16 is a digital delay that is used to generate DTACK. Each time the HDO port is selected by I/O5 and AS (Address Strobe) arrives, IC16 starts to shift AS from stage to stage. After two CLK8 clock pulses, it clocks IC15-b and IC15-c to generate either WE or RE, depending on the state of R/W. After six clock pulses, IC16 sends a pulse to IC15-d, which generates DTACK.

If you're going to build this portion of the PT-68K, start by removing the jumper between pins 7 and 12 of IC15. When we installed IC15 (in Step 16, as part of the XT-bus connector circuitry), we connected the jumper to prevent IC15-d from generating a continual DTACK, which would prevent the rest of the computer from working properly.

Then install the following parts: IC16 (74LS174) with socket, R3 (150 ohms, ¼ watt), J17 (40-pin header). The other components (R10, IC15, and IC22) were installed in previous steps, so installation is complete.

Unless you have the HDO controller, there is no easy way for you to test this circuit, so we will leave it as is, and hope for the best.

### Step 24: Loose ends

If you still have a test wire connected to pin 1 of J14, cut it very short and use it to jumper pin 1 to pin 2. We won't need the LED logic probe any longer; cutting that jumper restores the circuitry feeding the LED, thereby restoring the LED's operation.

Way back in Step 4, we installed three LED's at J15, J16, and J17. If you're planning to install the PT-68K in a cabinet with cutouts for LED's on the front panel, you may wish to replace the board-mounted LED's with those on the front panel. Since the DISK LED at J16 is only used with the HDO hard disk controller, you will probably choose to leave it on the motherboard, but the POWER LED at J15 and the HALT LED at J17 might be useful on the front panel. If so, cut off the two LED's, leaving about ½" of each lead sticking up above the board. The two-pin connectors that most cabinets are supplied with for the LED connections will slip right over the LED stubs. If the LED's do not light, all you have to do is reverse the connectors.

Before mounting the motherboard in the case, examine it carefully to make sure that all solder joints are good, and that there are no suspicious joints that might cause problems a few months from now. Also make sure that all components are installed; look especially for capacitors or resistors you may have missed. The computer might work without a particular resistor or capacitor, but it might not be as reliable as it should be.

### Conclusion

That brings us to the end of this series. Keep in mind that hundreds of other readers have built this project, and that they're all interested in learning more about the 68000 microprocessor and the PT-68K computer. If you come up with an unusual application for the computer, or with an interesting add-on to make it more useful or more powerful, let the editors know. They may ask you to write an article based on your idea.

If you built a PT-68K, send your name and address to Star-K Software Systems to be placed on their mailing list. A newsletter is mailed occasionally with information about improvements and updates.

Above all, enjoy using your 68000 system.

## AMPLIFIER

*continued from page 44*

shown. After that, install an RCA plug on the other end for PL1. Then install two short wires at the pads marked SPKR for the speaker. Continue by connecting a 6-inch wire between S1 and the power pads (unmarked). Finish up by connecting transformer T1 and fuseholder between S1 and the other unmarked pad. Snap a 1-amp slow-blow fuse into the holder when you are finished.

Note that if you substitute a standard filament transformer for T1, the wiring is a somewhat different, as shown in Fig. 6. Wire the transformer's secondary directly to the unmarked pads, then wire the primary to S1 and F1 as shown. Also, be sure to use a ¼-amp fast-blow fuse for F1.

All that is left to do now is to install the board in the cabinet with 4-40 hardware, using spacers between the cabinet and the board, as shown in Fig. 5. Now connect the speaker wires, attach the knobs.

### Operation

Now set all controls fully counterclockwise. Plug the unit into a nearby AC outlet, then turn it on by advancing the treble control. You will hear a brief "pop" from the speaker, then silence if all is well. Turn up the volume and touch the center terminal of PL1. You should hear a hum. If you are successful so far, you should connect a signal source, such as a tuner, and adjust the controls.

If you have any problems, check some voltages. From ground, you should read about 17 volts on C22, 15 volts on C23, and 9.1 volts on D1. The collector of Q1 should read about 4.9 volts. Start troubleshooting where the voltages are seriously off. Integrated circuit IC1 is more difficult to check, but start by measuring the voltages on the SPKR pads with the speaker disconnected; expect 7.5 volts on each pad, and if that voltage is not present, try replacing IC1.

The project also works well from a 12-volt battery. Simply short out diodes D2, D3, and D4 with a jumper wire, and then connect the +12 volts through fuse F1 and switch S1 directly to the positive terminal of BR1. Wire the negative side of the battery to the negative terminal of BR1. **R-E**

## NANOELECTRONICS

*continued from page 52*

lower than those used in conventional logic circuits. Therefore, quantum-effect devices will have to have current- and voltage-translation devices built into them to make the signal levels compatible with more conventional devices. Similarly, signals input to a quantum-effect device will have to be reduced to levels compatible with its operation. And, presumably, signals routed from one quantum-effect device through a PC trace to another quantum-effect device on the same board will also have to go through a translation process to push them along.

Tooling up for a new generation of quantum-effect devices will not be easy or cheap. However, in the end, the benefits will outweigh whatever obstacles may presently stand in the way. Future integrated circuits will permit us to place as many as a hundred switching devices in the space that is now required for just one. Power requirements will be reduced significantly, and switching speeds will increase. Indeed, sometime in the next decade, we may truly see the advent of the "supercomputer on a chip." **R-E**

## IC TESTER

*continued from page 86*

cord. Install the completed board in the case, and make sure that the wire with the black clip goes to the "−" pad of J1.

### Tester operation

Table 1 shows the settings of S2a–h. The settings depend on the pinout of the IC being tested, and whether the in-circuit tester is in the testing or analyzing mode.

Connect the power leads to the power supply of the board to be tested. Set the DIP switches to the in-circuit test position, as shown in Table 1. Install a known-good reference IC in SO1, and connect the IC test clip to the DUT. Now, press and release S1; if any LED's light, the IC is bad. Remove and replace any bad IC's that you find, and then observe the board's operation. If the board works properly, we are now finished, and if not, we will need to use the monitor/analyzer feature to check the circuit.

To set the tester for analyzing, set S2-b on, and S2-h either on or off as your experience dictates. Also, install the 20-pin header in SO1 (with all pins shorted together). Closing S2-b provides a ground to the header in most cases. If, however, you are analyzing an IC with pin 10 grounded, open S2-b, and close S2-c.

Let's call upon your experience and knowledge of logic circuits to determine which IC's would be most likely to cause the symptoms that the circuit exhibits. A schematic and IC data sheets would, at this time, be helpful. The in-circuit tester is an instrument that can separate IC's that are definitely good from those that might not be. Remove and replace suspected IC's as necessary, but keep in mind, that it may be something other than an IC that's causing the problem.

As mentioned earlier, resistors R43–R60 may or may not be necessary. It depends on the type of circuit that is being tested. They may be needed when testing circuits with three-state outputs connected to a common bus, such as the data bus of a microprocessor, but not always. In fact, those resistors are so rarely required, that they are optional. LED's on the tester corresponding to these outputs may turn on during the time when the bus is floating. If that occurs, it can be overcome by using the resistors, or by holding S1 down during testing. If needed, they can be discrete resistors or resistor networks. Mount them on the pins of SO2 on the bottom side of the PC board. The ground for those resistors is provided by the jumpers through S2-h.

To use the tester as a logic monitor/analyzer, plug the 20-pin DIP header into SO1, and close S2-b. Connect the cable with the hook probes to SO2. The hook probe connected to pin 10 of SO1 is to be connected to a ground point on the board we are monitoring. That connects one side of all the comparators to ground. Now, connect the other probes to the points in the circuit that you wish to examine.

As mentioned earlier, S2-h will select the latched or non-latched mode. Generally, use the non-latched (S2-b closed) mode because the latched mode is used mostly to capture very short pulses. **R-E**

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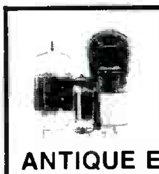

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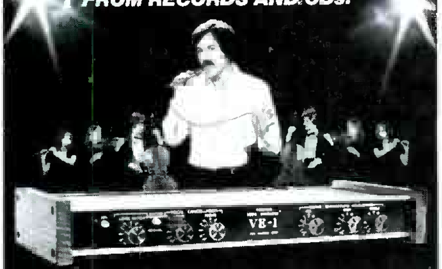

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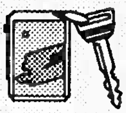

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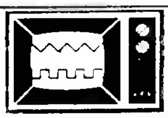

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Made in U.S.A.

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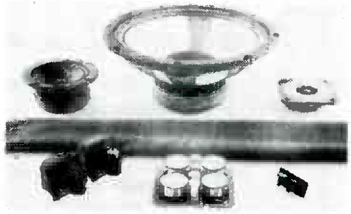

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PIONEER

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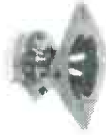

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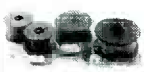

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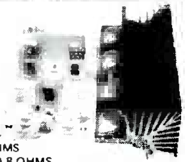

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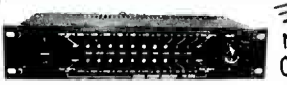

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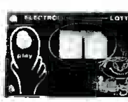

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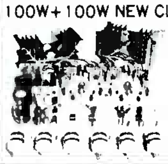

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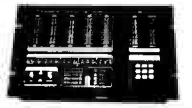

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This processor employs the most updated IC at its heart. It is also equipped with a "DNR" DYNAMIC NOISE REDUCTION SYSTEM IC made by NATIONAL SEMICONDUCTOR to particularly filter out the annoying noise that is commonly found on tapes or CD disk. In addition, there is six LOW NOISE OP—AMPS and all in one board design, no other external connections connect to the main board.

SPECIFICATIONS:
Frequency Response. 20Hz—20KHz ( ± 5dB). Total Harmonic. Distortion: 0.06% 20Hz—20KHz (front channel), < 0.25% (surround channel). Input Voltage: 0.1V—3.5V. Output Voltage: 0.1V—3.5V (front channel), 8.6V Max (surround channel). Delay Time: 5ms—50ms. Input Impedance 47K Ohms. Power: AC 110V 60Hz. Dimensions: 4 3/16in. (W) X 4 13/16in. (D) X 2 1/16in. (H).
KIT/ASSM WITH TESTED ........ $72/93

### 0-15V 2A REGULATED DC POWER SUPPLY TR-100A

ESSENTIAL FOR FACTORIES, PROFESSIONALS & ENTHUSIASTIC AMATEURS!

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Ass. with tested ........ $69.50

- Output voltage is adjustable from 0-15V DC, two current limit range are available for selection: 200mA or 2A.
- An elaborated protection system is specially designed, a 'BB' sound and a sparkling light will appear when the output is overloaded.
- High stability and reliability is resulted by employing high quality voltage regulated IC.
- King-size meter makes the reading of voltage and current more clearly and accurately.
- A refined case, meter and all accessory are enclosed for both kit and assembled form. It is most suitable for professional or amateur use.

### 8 Digit 1GHz Multifunctional Counter FC—1000A ☆

A versatile laboratory bench digital counter with FIVE FUNCTION performance FREQUENCY, PERIOD, UNIT (TOTALIZE) DATA HOLD & SELF CHECK. The period function makes the instrument outstanding for video tape recorder service applications. 0.5" Bright LED display assure easy readability of values. High stabilized dual crystal oscillators are used to ensure the accuracy in measurement. Durable alloy cabinet with a fancy looking panel. Comes complete with test lead and owners manual.

FEATURES:
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Input sensitivity 10Hz - 100MHz (10mV - 32mV)
100MHz - 1.2GHz (5mV - 20mV)
Period range 0.5uS—10S
Unit counting capacity 99999999.
Accuracy ±1 count, ±time base accuracy
Hold function Hold the last input signal (Max 8 digits).
Power source 117V AC ±10% 50—60Hz.
Dimensions 9.69" (W) X 7.87" (D) X 3" (H)
ASSM WITH TESTED & CAL ........ $192.00

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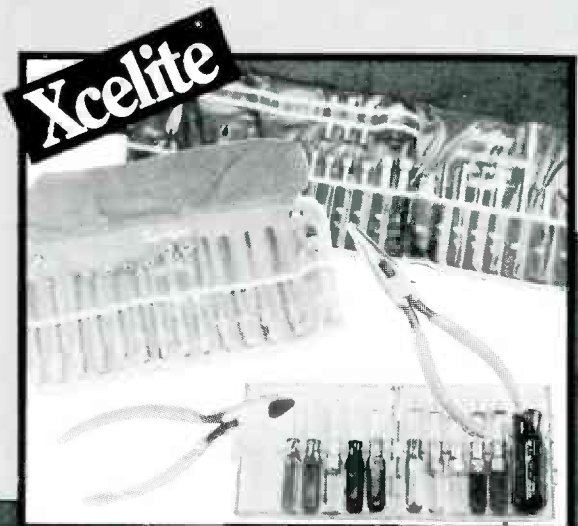


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## STATIC RAMS

| | | | |
|---|---|---|---|
| 2112 | 256x4 | (450ns) | 2.99 |
| 2114 | 1024x4 | (450ns) | .99 |
| 2114L-2 | 1024x4 | (200ns)(LOW POWER) | 1.49 |
| TMM2016-100 | 2048x8 | (100ns) | 1.95 |
| HM6116-4 | 2048x8 | (200ns)(CMOS) | 3.29 |
| HM6116-3 | 2048x8 | (150ns)(CMOS) | 3.95 |
| HM6116LP-4 | 2048x8 | (200ns)(CMOS)(LP) | 4.29 |
| HM6116LP-3 | 2048x8 | (150ns)(CMOS)(LP) | 4.95 |
| HM6116LP-2 | 2048x8 | (120ns)(CMOS)(LP) | 5.49 |
| HM6264LP-15 | 8192x8 | (150ns)(CMOS)(LP) | 6.49 |
| HM6264LP-12 | 8192x8 | (120ns)(CMOS)(LP) | 6.99 |
| HM43256LP-15 | 32768x8 | (150ns)(CMOS)(LP) | 12.95 |
| HM43256LP-12 | 32768x8 | (120ns)(CMOS)(LP) | 14.95 |
| HM43256LP-10 | 32768x8 | (100ns)(CMOS)(LP) | 19.95 |

## DYNAMIC RAMS

| | | | |
|---|---|---|---|
| 4116-250 | 16384x1 | (250ns) | .49 |
| 4116-200 | 16384x1 | (200ns) | .89 |
| 4116-150 | 16384x1 | (150ns) | .99 |
| 4116-120 | 16384x1 | (120ns) | 1.49 |
| MK4332 | 32768x1 | (200ns) | 6.95 |
| 4164-150 | 65536x1 | (150ns) | 2.89 |
| 4164-120 | 65536x1 | (120ns) | 3.19 |
| MCM6665 | 65536x1 | (200ns) | 1.95 |
| TMS4164 | 65536x1 | (150ns) | 1.95 |
| 4164-REFRESH | 65536x1 | (150ns)(PIN 1 REFRESH) | 2.95 |
| TMS4416 | 16384x4 | (150ns) | 3.75 |
| 41128-150 | 131072x1 | (150ns) | 5.95 |
| TMS4464-15 | 65536x4 | (150ns) | 7.95 |
| 41256-150 | 262144x1 | (150ns) | 12.45 |
| 41256-120 | 262144x1 | (120ns) | 12.95 |
| 41256-100 | 262144x1 | (100ns) | 13.45 |
| HM51258-100 | 262144x1 | (100ns)(CMOS) | 6.95 |
| 1 MB-120 | 1048576x1 | (120ns) | 34.95 |
| 1 MB-100 | 1048576x1 | (100ns) | 37.95 |

## EPROMS

| | | | |
|---|---|---|---|
| 2708 | 1024x8 | (450ns)(25V) | 4.95 |
| 2716 | 2048x8 | (450ns)(25V) | 3.49 |
| 2716-1 | 2048x8 | (350ns)(25V) | 3.95 |
| TMS2532 | 4096x8 | (450ns)(25V) | 5.95 |
| 2732 | 4096x8 | (450ns)(25V) | 3.95 |
| 2732A | 4096x8 | (250ns)(21V) | 3.95 |
| 2732A-2 | 4096x8 | (200ns)(21V) | 4.25 |
| 27C64 | 8192x8 | (250ns)(12.5V CMOS) | 4.95 |
| 2764 | 8192x8 | (450ns)(12.5V) | 3.49 |
| 2764-250 | 8192x8 | (250ns)(12.5V) | 3.69 |
| 2764-200 | 8192x8 | (200ns)(12.5V) | 4.25 |
| MCM68766 | 8192x8 | (350ns)(21V)(24 PIN) | 15.95 |
| 27128 | 16384x8 | (250ns)(12.5V) | 4.25 |
| 27C256 | 32768x8 | (250ns)(12.5V CMOS) | 7.95 |
| 27256 | 32768x8 | (250ns)(12.5V) | 5.95 |
| 27512 | 65536x8 | (250ns)(12.5V) | 11.95 |
| 27C512 | 65536x8 | (250ns)(12.5V CMOS) | 12.95 |

xxV=Program Voltage

MEMORY PRICES SUBJECT TO CHANGE DUE TO MARKET CONDITIONS. PLEASE CALL TO CONFIRM PRICES.

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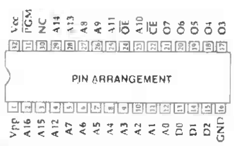
- 200 NS
- CMOS DESIGN FOR LOW POWER




**$34.95**

## 8000

| | |
|---|---|
| 8031 | 3.95 |
| 8035 | 1.49 |
| 8039 | 1.95 |
| 8052AH BASIC | 34.95 |
| 8080 | 2.49 |
| 8085 | 1.95 |
| 8086 | 6.49 |
| 8088 | 5.99 |
| 8088-2 | 7.95 |
| 8155 | 2.49 |
| 8155-2 | 3.95 |
| 8741 | 9.95 |
| 8748 | 7.95 |
| 8749 | 9.95 |
| 8755 | 14.95 |

## 8200

| | | | |
|---|---|---|---|
| 8203 | 14.95 | 8255-5 | 1.59 |
| 8205 | 3.29 | 8259 | 1.95 |
| 8212 | 1.49 | 8259-5 | 2.29 |
| 8216 | 1.49 | 8257 | 2.25 |
| 8224 | 2.25 | 8272 | 4.39 |
| 8228 | 2.25 | 8274 | 4.95 |
| 8237 | 3.95 | 8275 | 16.95 |
| 8237-5 | 4.75 | 8279 | 2.49 |
| 8243 | 1.95 | 8279-5 | 2.95 |
| 8250 | 6.95 | 8282 | 3.95 |
| 8251 | 1.29 | 8283 | 3.95 |
| 8251A | 1.69 | 8284 | 2.25 |
| 8253 | 1.59 | 8286 | 3.95 |
| 8253-5 | 1.95 | 8287 | 3.95 |
| 8255 | 1.49 | 8288 | 4.95 |

## MATH COPROCESSORS


| | | |
|---|---|---|
| 8087 | 5 MHz | $99.95 |
| 8087-2 | 8 MHz | $159.95 |
| 8087-1 | 10 MHz | $229.95 |
| 80287 | 6 MHz | $179.95 |
| 80287-8 | 8 MHz | $249.95 |
| 80287-10 | 10 MHz | $309.95 |
| 80387-16 | 16 MHz | $499.95 |
| 80387-20 | 20 MHz | $799.95 |

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## 74LS00

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .16 | 74LS112 | .29 | 74LS241 | .69 |
| 74LS01 | .18 | 74LS122 | .45 | 74LS242 | .69 |
| 74LS02 | .17 | 74LS123 | .49 | 74LS243 | .69 |
| 74LS03 | .18 | 74LS124 | 2.75 | 74LS244 | .69 |
| 74LS04 | .16 | 74LS125 | .39 | 74LS245 | .79 |
| 74LS05 | .18 | 74LS126 | .39 | 74LS251 | .49 |
| 74LS08 | .18 | 74LS132 | .39 | 74LS253 | .49 |
| 74LS09 | .18 | 74LS133 | .49 | 74LS257 | .39 |
| 74LS10 | .16 | 74LS136 | .39 | 74LS258 | .49 |
| 74LS11 | .22 | 74LS138 | .39 | 74LS259 | 1.29 |
| 74LS12 | .22 | 74LS139 | .39 | 74LS260 | .49 |
| 74LS13 | .26 | 74LS145 | .99 | 74LS266 | .39 |
| 74LS14 | .39 | 74LS147 | .99 | 74LS273 | .79 |
| 74LS15 | .26 | 74LS148 | .99 | 74LS279 | .39 |
| 74LS20 | .17 | 74LS151 | .39 | 74LS280 | 1.98 |
| 74LS21 | .22 | 74LS153 | .39 | 74LS283 | .59 |
| 74LS22 | .22 | 74LS154 | 1.49 | 74LS290 | .89 |
| 74LS27 | .23 | 74LS155 | .59 | 74LS293 | .89 |
| 74LS28 | .26 | 74LS156 | .49 | 74LS299 | 1.49 |
| 74LS30 | .17 | 74LS157 | .35 | 74LS322 | 3.95 |
| 74LS32 | .18 | 74LS158 | .29 | 74LS323 | 2.49 |
| 74LS33 | .28 | 74LS160 | .29 | 74LS365 | .39 |
| 74LS37 | .26 | 74LS161 | .39 | 74LS367 | .39 |
| 74LS38 | .26 | 74LS162 | .49 | 74LS368 | .39 |
| 74LS42 | .39 | 74LS163 | .39 | 74LS373 | .79 |
| 74LS47 | .75 | 74LS164 | .49 | 74LS374 | .79 |
| 74LS48 | .85 | 74LS165 | .65 | 74LS375 | .95 |
| 74LS51 | .17 | 74LS166 | .95 | 74LS377 | .79 |
| 74LS73 | .29 | 74LS169 | .95 | 74LS390 | 1.19 |
| 74LS74 | .24 | 74LS173 | .49 | 74LS393 | .79 |
| 74LS75 | .29 | 74LS174 | .39 | 74LS541 | 1.49 |
| 74LS76 | .29 | 74LS175 | .39 | 74LS624 | 1.95 |
| 74LS83 | .49 | 74LS191 | .49 | 74LS640 | .99 |
| 74LS85 | .49 | 74LS192 | .69 | 74LS645 | .99 |
| 74LS86 | .22 | 74LS193 | .69 | 74LS670 | .89 |
| 74LS90 | .39 | 74LS194 | .69 | 74LS682 | 3.20 |
| 74LS92 | .49 | 74LS195 | .69 | 74LS688 | 2.40 |
| 74LS93 | .39 | 74LS196 | .59 | 74LS783 | 22.95 |
| 74LS95 | .49 | 74LS197 | .59 | 25LS2521 | 2.80 |
| 74LS107 | .34 | 74LS221 | .59 | 26LS31 | 1.95 |
| 74LS109 | .36 | 74LS240 | .69 | 26LS32 | 1.95 |

## 7400

| | |
|---|---|
| 7400 | .19 |
| 7402 | .19 |
| 7404 | .19 |
| 7406 | .29 |
| 7407 | .29 |
| 7408 | .24 |
| 7410 | .19 |
| 7411 | .25 |
| 7414 | .49 |
| 7416 | .25 |
| 7417 | .25 |
| 7420 | .19 |
| 7430 | .19 |
| 7432 | .29 |
| 7438 | .29 |
| 7442 | .49 |
| 7445 | .69 |
| 7447 | .89 |
| 7473 | .34 |
| 7474 | .33 |
| 7475 | .45 |
| 7476 | .35 |
| 7483 | .50 |
| 7485 | .59 |
| 7486 | .35 |
| 7489 | 2.15 |
| 7490 | .39 |
| 7493 | .35 |
| 74121 | .29 |
| 74123 | .49 |
| 74125 | .45 |
| 74150 | 1.35 |
| 74151 | .55 |
| 74153 | .55 |
| 74154 | 1.49 |
| 74157 | .55 |
| 74159 | 1.65 |
| 74161 | .69 |
| 74164 | .85 |
| 74166 | 1.00 |
| 74175 | .89 |
| 74367 | .65 |

## LINEAR

| | | | |
|---|---|---|---|
| TL071 | .69 | LM567 | .79 |
| TL072 | 1.09 | NE570 | 2.95 |
| TL074 | 1.95 | NE592 | .98 |
| TL082 | .99 | LM723 | .49 |
| TL084 | 1.49 | LM733 | .98 |
| LM301 | .34 | LM741 | .29 |
| LM309K | 1.25 | LM747 | .69 |
| LM311 | .59 | MC1330 | 1.69 |
| LM311H | .89 | MC1350 | 1.19 |
| LM317K | 3.49 | LM1458 | .35 |
| LM317T | .69 | LM1488 | .49 |
| LM318 | 1.49 | LM1489 | .49 |
| LM319 | 1.25 | LM1496 | .85 |
| LM320 see7900 | | ULN2003 | .79 |
| LM323K | 3.49 | XR2206 | 3.95 |
| LM324 | .34 | XR2211 | 2.95 |
| LM331 | 3.95 | LM2917 | 1.95 |
| LM334 | 1.19 | CA3046 | .89 |
| LM335 | 1.79 | CA3146 | 1.29 |
| LM336 | 1.75 | MC3373 | 1.29 |
| LM338K | 4.49 | MC3470 | 1.95 |
| LM339 | .59 | MC3480 | 8.95 |
| LM340 see7800 | | MC3487 | 2.95 |
| LF353 | .59 | LM3900 | .49 |
| LF356 | .99 | LM3911 | 2.25 |
| LF357 | .99 | LM3909 | .98 |
| LM358 | .59 | LM3914 | 1.89 |
| LM380 | .89 | MC4024 | 3.49 |
| LM383 | 1.95 | MC4044 | 3.99 |
| LM386 | .89 | RC4136 | 1.25 |
| LM393 | .45 | RC4558 | .69 |
| LM394H | 5.95 | LM13600 | 1.49 |
| TL494 | 4.20 | 75107 | 1.49 |
| TL497 | 3.25 | 75110 | 1.95 |
| NE555 | .29 | 75150 | 1.95 |
| NE556 | .49 | 75154 | 1.95 |
| NE558 | .79 | 75188 | 1.25 |
| NE564 | 1.95 | 75189 | 1.25 |
| LM565 | .95 | 75451 | .39 |
| LM566 | 1.49 | 75452 | .39 |
| NE590 | 2.50 | 75477 | 1.29 |

H=TO-5 CAN, K=TO-3, T=TO-220

## 6500

**1.0 MHz**

| | |
|---|---|
| 6502 | 2.25 |
| 65C02 (CMOS) | 7.95 |
| 6520 | 1.65 |
| 6522 | 2.95 |
| 6526 | 13.95 |
| 6532 | 5.95 |
| 6545 | 2.95 |
| 6551 | 2.95 |

**2.0 MHz**

| | |
|---|---|
| 6502A | 2.69 |
| 6520A | 2.95 |
| 6522A | 5.95 |
| 6532A | 11.95 |
| 6545A | 3.95 |
| 6551A | 6.95 |

**3.0 MHz**

| | |
|---|---|
| 6502B | 4.25 |

## Z-80

**2.5 MHz**

| | |
|---|---|
| Z80-CPU | 1.25 |

**4.0 MHz**

| | |
|---|---|
| Z80A-CPU | 1.29 |
| Z80A-CTC | 1.69 |
| Z80A-DART | 5.95 |
| Z80A-DMA | 5.95 |
| Z80A-PIO | 1.89 |
| Z80A-SIO 0 | 5.95 |
| Z80A-SIO 1 | 5.95 |
| Z80A-SIO 2 | 5.95 |

**6.0 MHz**

| | |
|---|---|
| Z80B-CPU | 2.75 |
| Z80B-CTC | 4.25 |
| Z80B-PIO | 4.25 |
| Z80B-DART | 6.95 |
| Z80B-SIO 0 | 12.95 |
| Z80B-SIO 2 | 12.95 |
| Z8671 ZILOG | 9.95 |

## DISK CONTROLLERS

| | |
|---|---|
| 1771 | 4.95 |
| 1791 | 9.95 |
| 1793 | 9.95 |
| 1795 | 12.95 |
| 1797 | 12.95 |
| 2791 | 19.95 |
| 2793 | 19.95 |
| 2797 | 29.95 |
| 8272 | 4.39 |
| UPD765 | 4.39 |
| MB8876 | 12.95 |
| MB8877 | 12.95 |
| 1691 | 6.95 |
| 2143 | 6.95 |
| 9216 | 6.29 |

## V 20 SERIES

| | | |
|---|---|---|
| V20* | 5 MHz | 8.95 |
| V20* | 8 MHz | 10.95 |
| V20* | 10 MHz | 12.95 |
| V30 | 8 MHz | 13.95 |

*Replaces 8088 to speed up PC 10-40%

## PALS

| | |
|---|---|
| 16L8 | $2.95 |
| 16R8 | $2.95 |
| 16R6 | $2.95 |
| 16R4 | $2.95 |

## CRYSTALS

| | |
|---|---|
| 32.768 KHz | .95 |
| 1.0 MHz | 2.95 |
| 1.8432 | 2.95 |
| 2.0 | 1.95 |
| 2.4576 | 1.95 |
| 3.579545 | 1.95 |
| 4.0 | 1.95 |
| 5.0 | 1.95 |
| 5.0688 | 1.95 |
| 6.0 | 1.95 |
| 6.144 | 1.95 |
| 8.0 | 1.95 |
| 10.0 | 1.95 |
| 10.738635 | 1.95 |
| 12.0 | 1.95 |
| 14.31818 | 1.95 |
| 16.0 | 1.95 |
| 18.0 | 1.95 |
| 18.432 | 1.95 |
| 20.0 | 1.95 |
| 22.1184 | 1.95 |
| 24.0 | 1.95 |
| 32.0 | 1.95 |

## OSCILLATORS

| | |
|---|---|
| 1.0MHz | 5.95 |
| 1.8432 | 5.95 |
| 2.0 | 5.95 |
| 2.4576 | 5.95 |
| 2.5 | 5.95 |
| 4.0 | 4.95 |
| 5.0688 | 4.95 |
| 6.0 | 4.95 |
| 6.144 | 4.95 |
| 8.0 | 4.95 |
| 10.0 | 4.95 |
| 12.0 | 4.95 |
| 16.0 | 4.95 |
| 18.432 | 4.95 |
| 20.0 | 4.95 |
| 24.0 | 4.95 |

## 74F/74S

| | |
|---|---|
| 74F00 | .35 |
| 74F02 | .35 |
| 74F04 | .35 |
| 74F08 | .35 |
| 74F10 | .35 |
| 74F32 | .35 |
| 74F64 | .55 |
| 74F74 | .39 |
| 74F86 | .55 |
| 74F138 | .79 |
| 74F139 | .79 |
| 74F253 | .89 |
| 74F157 | .89 |
| 74F240 | 1.29 |
| 74S00 | .29 |
| 74S02 | .29 |
| 74S04 | .29 |
| 74S08 | .35 |
| 74S10 | .29 |
| 74S32 | .35 |
| 74S74 | .49 |
| 74S86 | .35 |
| 74S112 | .50 |
| 74S124 | 2.75 |
| 74S138 | .79 |
| 74S153 | .79 |
| 74S157 | .79 |
| 74S158 | .95 |
| 74S163 | 1.29 |
| 74S175 | .79 |
| 74S195 | 1.49 |
| 74S240 | 1.49 |
| 74S241 | 1.49 |
| 74S244 | 1.49 |
| 74S280 | 1.95 |
| 74S287 | 1.69 |
| 74S288 | 1.69 |
| 74S299 | 2.95 |
| 74S373 | 1.69 |
| 74S374 | 1.69 |
| 74S471 | 4.95 |
| 74S571 | 2.95 |

## UARTS

| | |
|---|---|
| AY5-1013 | 3.95 |
| AY3-1015 | 4.95 |
| TR1602 | 3.95 |
| 2651 | 4.95 |
| IM6402 | 3.95 |
| IM6403 | 9.95 |
| INS8250 | 6.95 |
| NS16450 | 10.95 |

## 6800

**1.0 MHz**

| | |
|---|---|
| 6800 | 1.95 |
| 6802 | 2.95 |
| 6803 | 3.95 |
| 6809 | 2.95 |
| 6809E | 2.95 |
| 6810 | 1.95 |
| 6820 | 2.95 |
| 6821 | 1.25 |
| 6840 | 3.95 |
| 6843 | 4.95 |
| 6844 | 6.95 |
| 6845 | 2.75 |
| 6847 | 4.75 |
| 6850 | 1.95 |
| 6883 | 22.95 |

**2.0 MHz**

| | |
|---|---|
| 68B00 | 2.95 |
| 68B02 | 3.95 |
| 68B09E | 5.49 |
| 68B09 | 5.99 |
| 68B21 | 1.85 |
| 68B45 | 4.95 |
| 68B50 | 1.75 |
| 68000 | 9.95 |

## CLOCK CIRCUITS

| | |
|---|---|
| MM58167 | 9.95 |
| MM58174 | 9.95 |
| MSM5832 | 2.95 |

## BIT RATE GENERATORS

| | |
|---|---|
| MC14411 | 9.95 |
| BR1941 | 4.95 |
| 4702 | 9.95 |
| COM8116 | 8.95 |

## INTERSIL

| | |
|---|---|
| ICL7106 | 9.95 |
| ICL7107 | 10.95 |
| ICL7660 | 1.99 |
| ICL8038 | 3.85 |
| ICM7207A | 5.95 |
| ICM7208 | 15.95 |

## MISC.

| | |
|---|---|
| ADC0804 | 2.99 |
| ADC0809 | 3.85 |
| DAC0800 | 3.29 |
| DAC0808 | 1.95 |
| DAC1022 | 5.95 |
| MC1408L8 | 1.95 |
| 8T28 | 1.29 |
| 8T97 | .59 |
| DP8304 | 2.29 |
| 9334 | 1.75 |
| 9368 | 2.85 |
| 9602 | .69 |
| ULN2003 | .79 |
| MAX232 | 7.95 |
| MC3470 | 1.95 |
| MC3487 | 2.95 |
| AY5-3600 PRO | 11.95 |

## CMOS/HIGH SPEED CMOS

| | | | | | |
|---|---|---|---|---|---|
| 4001 | .19 | 4066 | .29 | 74HC154 | 1.09 |
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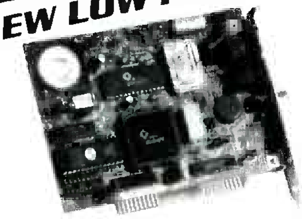

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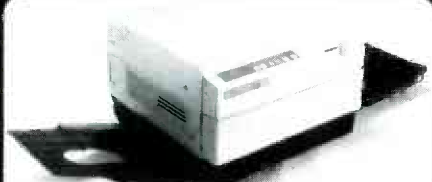

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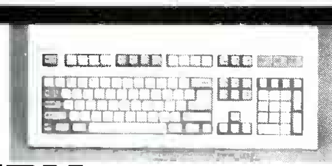

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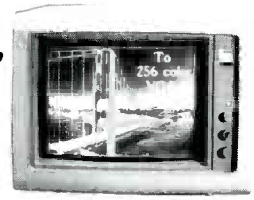

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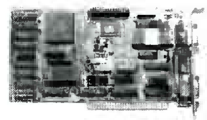

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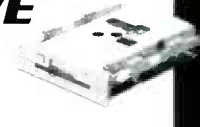

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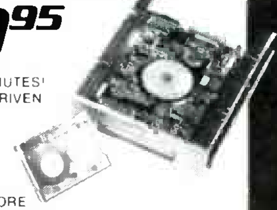

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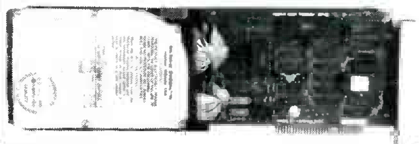

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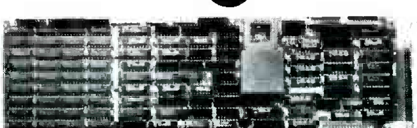

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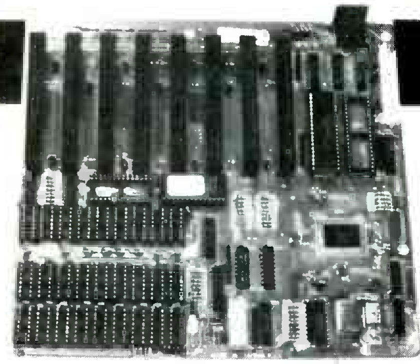

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MCT-TURBO-10

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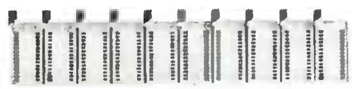

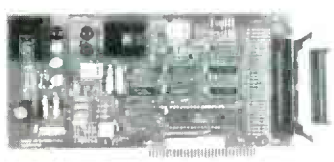

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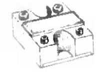
## TRANSISTORS

| CAT# | TYPE | CASE | PRICE |
|---|---|---|---|
| PN2222 | NPN | TO-92 | 5 for .75 |
| 2N2904 | PNP | TO-5 | 3 for $1.00 |
| 2N2906 | PNP | T0-18 | 3 for $1.00 |
| PN2907 | PNP | TO-92 | 5 for .75 |
| 2N3055 | NPN | TO-3 | $1.00 each |
| PN3569 | NPN | TO-92 | 5 for .50 |
| 2N3904 | NPN | TO-92 | 5 for .75 |
| 2N3906 | PNP | TO-92 | 5 for .75 |
| 2N4400 | NPN | TO-92 | 5 for .75 |
| 2N4402 | PNP | TO-92 | 5 for .75 |
| 2N5400 | PNP | TO-92 | 4 for $1.00 |
| 2N5880 | PNP | TO-3 | $2.00 each |
| 2N5882 | NPN | TO-3 | $2.00 each |
| MJ2955 | PNP | TO-3 | 1.50 each |
| MJE2955T | PNP | TO-220 | .75 each |
| MJE3055T | NPN | TO-220 | .75 each |
| TIP30 | NPN | TO-220 | .75 each |
| TIP31 | NPN | TO-220 | .75 each |
| TIP32 | PNP | TO-220 | .75 each |
| TIP41 | NPN | TO-220 | .75 each |
| TIP42 | PNP | TO-220 | .75 each |
| TIP121 | NPN | TO-220 | .75each |
| TIP126 | PNP | TO-220 | .75each |

## 10 AMP SOLID STATE RELAYS



ELECTROL# S2181
CONTROL:
Rated 5.5 to 10 Vdc
(will operate on 3-32 Vdc)
LOAD:
10 Amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8"
**CAT# SSRLY-10B**
$9.50 each
*QUANTITY DISCOUNT!*
10 for $85.00
25 for $175.00
50 for $300.00
100 for $500.00

## SWITCHES

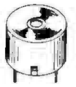
MINIATURE TOGGLE SWITCHES
all rated 5 Amps

**S.P.D.T.(on-on)**
Solder lug terminals.
**CAT# MTS-4**
$1.00 each
10 for $9.00

**S.P.D.T.(on-on)**
Non threaded bushing.
P.C. mount.
**CAT# MTS-40PC**
75¢ each
10 for $7.00

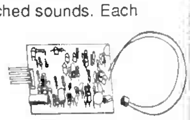
**D.P.D.T.(on-on)**
Solder lug terminals.
**CAT# MTS-8**
$2.00 each
10 for $19.00

## PIEZO WARNING DEVICE



Murata Erie # PKB8-4A0
High pitched audible alarm.
Operates on 3 - 20 Vdc @ 20 ma. 1" high X 7/8" dia. P.C. board mount.
**CAT# PBZ-84** $1.75 each

## SOUND ACTIVATED BOARD



Designed to react to high pitched sounds. Each board contains many useful parts including a condenser mike.
Operates on 6 Vdc.
Instructions included.
**CAT# SAB** $2.50 each

## 24 VOLT D.C. SOLENOID

Intermittent duty cycle. 240 ohm coil.
Mounting flange is 1 1/8" wide.
Solenoid body 11/2" X 1/2" X 1/2".
**CAT# SOL-34** $1.00 each • 10 for $8.50
100 for $75.00 *Large Quantity Available*

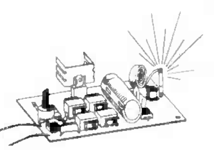
## MINI PUSH BUTTON

S. P. S. T. momentary.
Push to make. 1/4" threaded bushing.
Red button.
**CAT# MPB-1**
35¢ each • 10 for $3.25

## XENON TUBE

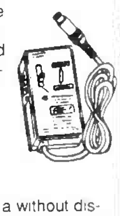
1" long flashtube prepped with 3 1/2" red and black leads. Ideal for electronic flash or strobe projects.
**CAT# FLT-3** 2 for $1.00

## *NEW!* STROBE KIT



Variable rate strobe kit, flashes between 60 to 120 times per minute. Will operate on either 6 or 12 Vdc depending upon how you wire the circuit. Comes complete with P.C. board and instructions for easy assembly.
**CAT# STROBE-1** $7.50 each

## SOUND & VIDEO MODULATOR



TI# UM1381-1.
Designed for use with T.I. computers. Can be used with video cameras, games, or other audio/ video sources. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.
**CAT# AVMOD** $5.00 each

## GRAB BAGS $1.00 EACH

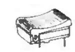
**50 ASSORTED DISC CAPS.**
Cut leads. Many common values, some are 500 volts.
**CAT# GRABDC**

**ASSORTED 1/4 WATT RESISTORS**
Approximately 200 pieces of assorted values, some cut leads.
**CAT# GRES**

**ASSORTED PARTS**
Strips of 100 assorted parts. Each strip contains an assortemt of resistors, capacitors, diodes, coils, etc. 100 pieces.
**CAT# GRABTR**

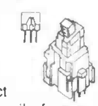
**15 VALUES OF ELECTROLYTICS**
Assortment contains 15 values of 1 mfd and up. Some cut leads.
**CAT# GRABCP**

## ITT PUSH BUTTON



ITT MDPL series. 3/4" X 1/2" gray rectangular key cap.
S.P.S.T. N.O. Push to close.
RATED:
0.1amp switching,
0.25 amp carry current. P.C. mount
**CAT# PB-8** 65¢ each
10 for $6.00 • 100 for $50.00

## HALL EFFECT SWITCH

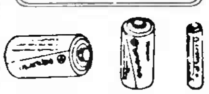


MICROSWITCH #4BE3
Slanted keyboard switch with hall effect sensor. Snaps into 5/8" square chassis hole. Hall effect sensor slides easily from switch and can be used in other applications.
**CAT# HESW** 4 for $1.00
10 for $2.00
100 for $15.00

## NICKEL-CAD (RECHARGEABLE) BATTERIES

### SPECIAL

**AAA SIZE**
Panasonic # P-18AAA
1.2 volt @ 180 mAh
**CAT# NCB-AAAX**
$1.50 each
10 for $13.50
100 for $125.00
LARGE QUANTITIES



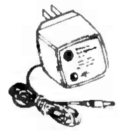
**AA SIZE** $2.00 each
1.25 Volts 500 mAh
**CAT# NCB-AA**

**AA SIZE** $2.20 each
**WITH SOLDER TABS**
**CAT# NCB-SAA**

**C SIZE** $4.25 each
1.2 Volts 1200 mAh
**CAT# NCB-C**

**D SIZE** $4.50 each
1.2 Volts 1200 mAh
**CAT# NCB-D**

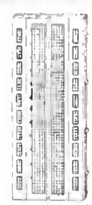
## WALL TRANSFORMERS



*ALL PLUG DIRECTLY INTO 120 VAC OUTLET*

6 Vdc @ 200 ma. $2.25
**CAT# DCTX-620**
6 Vdc @ 750 ma. $3.50
**CAT# DCTX-675**
9 Vdc @ 250 ma. $2.50
**CAT# DCTX-925**
12 Vac @ 930 ma. $3.50
**CAT# ACTX-1293**
18 Vac @ 1 Amp. $3.50
**CAT#ACTX-1885**

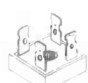
## PROTO BOARD



Large enough to design most experimental circuits. This proto board measures 6 3/4" X 2 1/2". Contains main board and two power buss strips.
**CAT# PB-101**
$9.00 each

## FULL WAVE BRIDGE RECTIFIERS

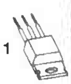
**10 AMP 200 P.I.V.**
5/8" SQUARE
**CAT# FWB-1020**
$1.00 each • 10 for $9.00



**25 AMP RATING**
1 1/8" SQUARE
metal epoxy filled case

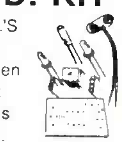
200 P.I.V. $2.50 each
**CAT# FWB-252**
400 P.I.V. $3.00 each
**CAT# FWB-254**
600 P.I.V. $3.50 each
**CAT# FWB-256**

## N-CHANNEL MOSFET



IRF-511
TO-220 case
**CAT# IRF 511**
$1.00 each
10 for $9.00
*LARGE QUANTITY AVAILABLE...*

## FLASHING L.E.D. KIT



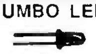
Two L.E.D.'S flash in unison when a 9 volt battery is attached. Requires easy assembly, you solder the parts to the circuit board.
**CAT# LEDKIT**
$1.50 each

## WATER TIGHT ENCLOSURE

ROSE# 02081905
Molded fiberglass enclosure with neoprene gasket.
2" X 3" X 7 1/2". Light blue.
**CAT# WP-905** $7.50 each

## LIGHT EMITTING DIODES (L.E.D.)

**STANDARD JUMBO LED**



DIFFUSED
T 1-3/4 size

RED 10 for $1.50
**CAT# LED-1** 100 for $13.00
1000 for $110.00

GREEN 10 for $2.00
**CAT# LED-2** 100 for $17.00
1000 for $150.00

YELLOW 10 for $2.00
**CAT# LED-3** 100 for $17.00
1000 for $150.00

**FLASHING LED**

with built in flashing circuit.
operates on 5 volts...
RED $1.00 each
**CAT# LED-4** 10 for $9.50
GREEN $1.00 each
**CAT# LED-4G** 10 for $9.50

**BI-POLAR LED**

Lights RED one direction, GREEN the other. Two leads.
**CAT# LED-6** 2 for $1.70

**LED HOLDER**

Two piece holder.
**CAT# HLED**
10 for 65¢

**CLIPLITE LED HOLDER**

Makes a L.E.D. look like a fancy indicator. Fits T 1-3/4 size LED.
CLEAR **CAT# HLDCL-C**
RED **CAT# HLDCL-R**
GREEN **CAT# HLDCL-G**
YELLOW **CAT# HLDCL-Y**

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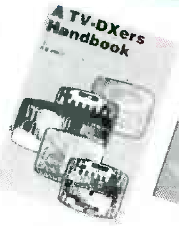


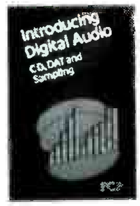
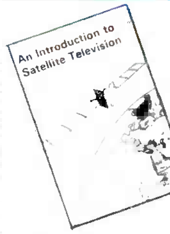
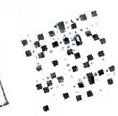
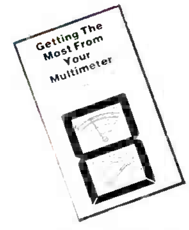

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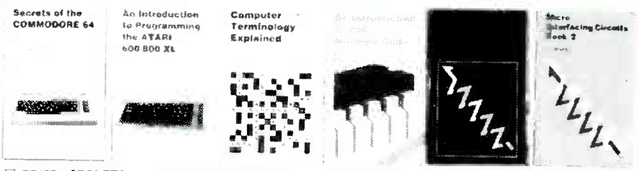
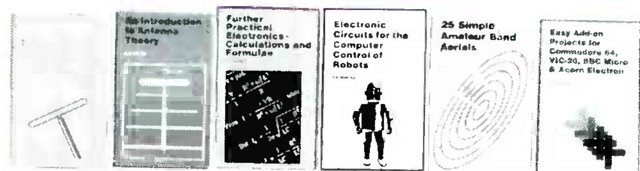

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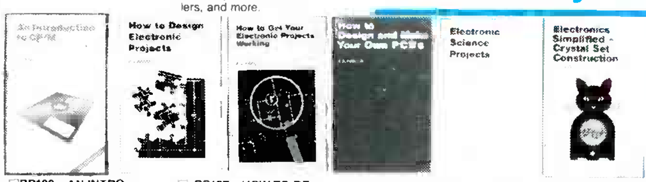
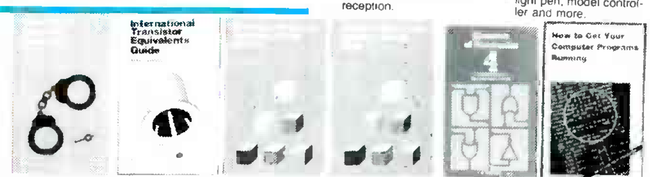

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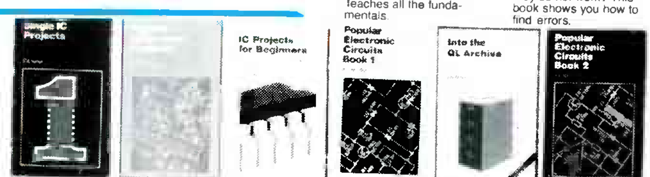

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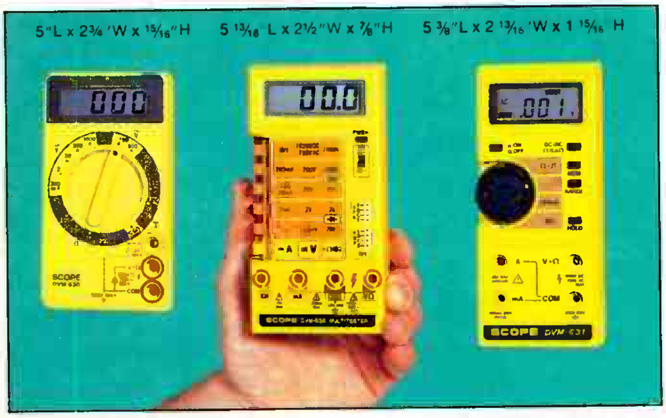


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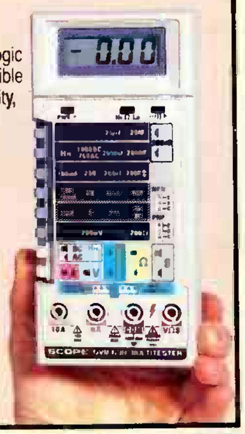

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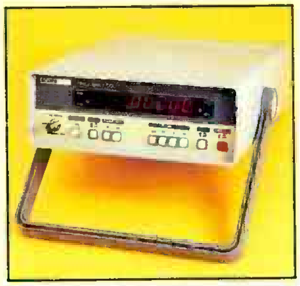

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