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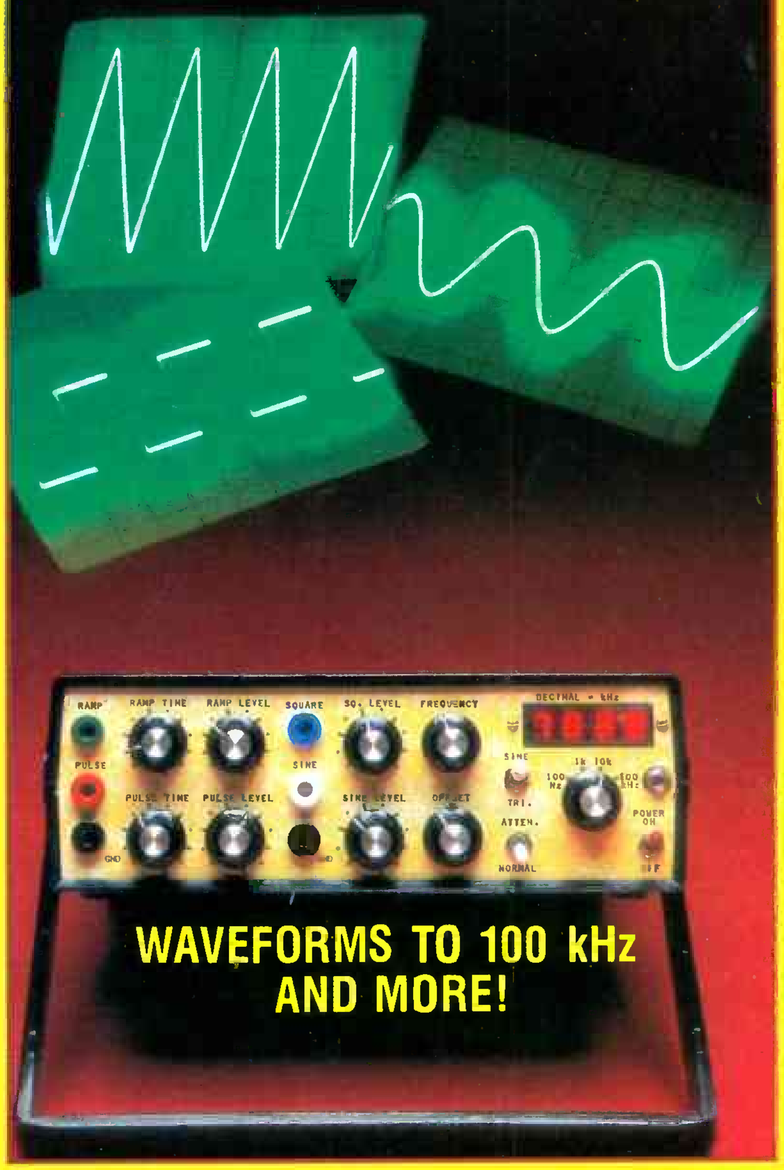

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Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
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Price	$4995	$3995	$2995

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May 1988

Radio-Electronics
Vol. 59 No. 5

BUILD THIS

TECHNOLOGY

CIRCUITS AND COMPONENTS

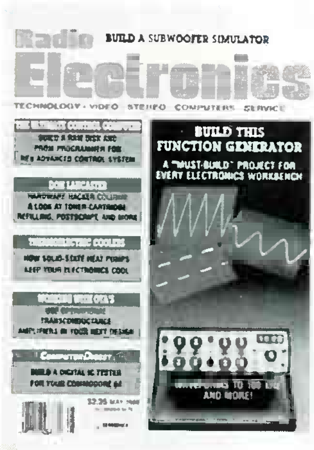
DEPARTMENTS

PAGE 85

PAGE 57

AND MORE

ON THE COVER



Gone are the days when a simple sine or square wave was sufficient to test electronic equipment. The diverse nature of today's electronics equipment demands more kinds of test signals, and control over their duration, size, and duty cycles. In short, what is needed is a laboratory-grade, multifunction signal generator, like the one we show you how to build on page 39. It delivers simultaneous square/triangle or square/sine output signals, as well as variable duty-cycle pulses and a linear-sawtooth ramp. With a built-in frequency counter, it is a truly versatile piece of test equipment.

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WHAT'S NEWS

Higher quality signals via CD radio system?

Digital Radio Labs, of Lomita, CA, has proposed a new music-broadcast service: 16 stereo channels of CD-quality digital music, 24 hours daily. Digital signals will be transmitted by satellite to local cable TV, MDS, and UHF-TV outlets for re-transmission to their customers as a premium pay-radio service for a low additional fee.

The special in-home receivers resemble FM tuners, and are expected to retail in the $150 to $200 range. Each contains a graphics/text generator, which connects to a normal TV set, and can carry information about the music, or other text or art material.

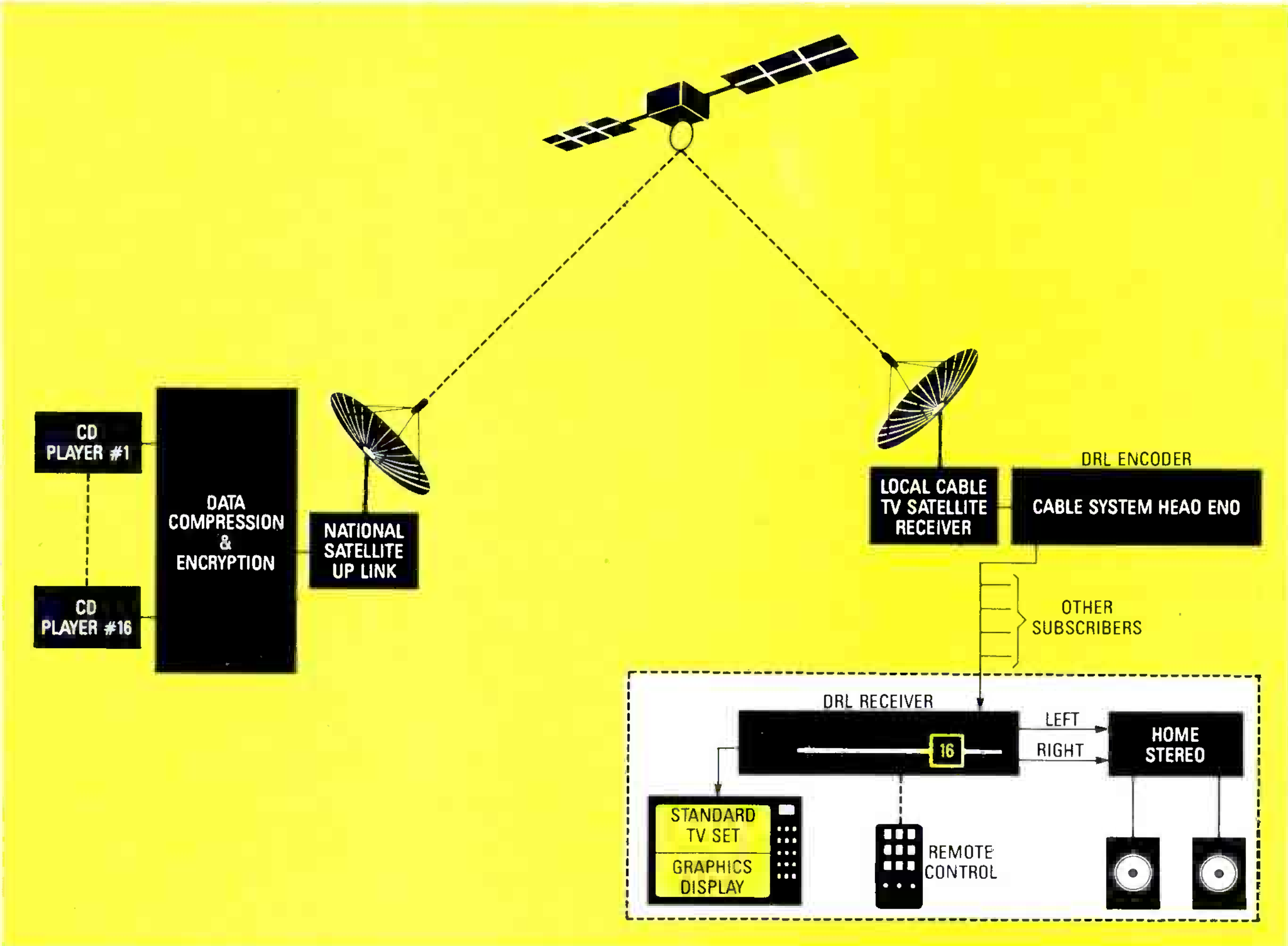
The company expects the system to be fully operational by late 1988. For further information, contact Digital Radio Labs, P.O. Box 1256, Lomita, CA 90717.

Multi-kilowatt fuel cells are operating in Japan

The first of Westinghouse's new solid-oxide fuel generators to be sent overseas have been put into operational research use by Tokyo Gas and Osaka Gas companies. Those third-generation *Solid-Oxide Fuel Cells* (SOFC's) are rated at about 3 kilowatts and operate at a temperature of 1000°C.

The modules are 2.1 meters high by 2.4 meters wide by 0.8 meters deep, and weigh 1.3 tons. They consist of 144 single cells, each of which generates about 20 watts. Solid-oxide fuel cells operate by the reaction of coal-derived or natural gas fuel with the oxygen of the air.

Tokyo and Osada Gas are also operating first-generation fuel cells based on phosphoric acid, and second-generation cells using molten carbonate. R-E



A CD MUSIC BY SATELLITE SYSTEM is shown here in block diagram form. The proposed system will broadcast 16 channels of music and text 24 hours a day.

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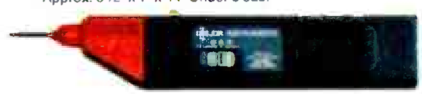

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* AC/DC current: 200μA–20A, 6 ranges
* Input impedance: 10M ohm
* Fully overload protected
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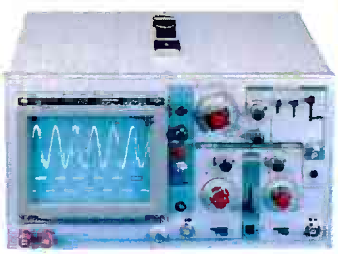

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Stereoscopic TV.** The subject of stereoscopic, or 3D TV continues to carry an aura of fascination, even though: (1) 3D movies have failed in every attempt to foist them on the public. (2) Stereoscopic 35-mm still photography, which reached the craze stage shortly after World-War II, abruptly ended in dismal failure. (3) No one has yet devised a practical system of 3D photography or cinematography that doesn't require the use of viewing glasses (holography, which holds out hope for the future, can't yet be considered a practical system). (4) Every system ever demonstrated has the potential for creating nausea and headaches for viewers.

With those qualifications, we are pleased to report the following developments:

• **3D TV on the air.** As of our deadline, the first network-TV program broadcast in 3D is scheduled to air this month. It is the season's finale of *Moonlighting*, on ABC-TV. That program will use a stereoscopic process that developers claim is completely compatible; that is, those without viewing glasses don't see the customary double image.

Called *Nuoptix*, the system exploits a new variation of a technique that has been proposed many times for stereoscopic television. That is the *Pulfrich effect*, which combines a time delay between left and right images with movement on the screen to produce a "compatible" 3D effect. In the system, each eye sees a slightly different image as the result of camera panning or lateral movement of objects on the screen, and the brain translates that into a depth effect.

The glasses used for Nuoptix have one deep purple filter and one pale green filter to provide the unequal time delays to the eyes. The TV picture is on film, shot with a high-speed camera using a single lens and a proprietary film-to-video transfer system. Coca-Cola, the sponsor of the final program, says that it will distribute some 40,000,000 pairs of glasses in 40,000 retail outlets. Nuoptix says that the process has potential uses in home video.

• **And another one.** Another claimed compatible system, called *Aspex*, has been developed in England. Although Aspex's developers say that it's not based on the Pulfrich effect, that system also depends upon motion on the screen. Aspex is filmed using a Panavision camera whose rotary shutter is modified so that two side-by-side openings replace the single opening that normally exposes the film. One opening is covered by a red filter, the other by a cyan filter, and those are used to expose film frames sequentially.

The viewer uses glasses with one red filter and one cyan filter to observe a subtle effect of separation of foreground from background objects. As in the Nuoptix system, the stereo effect disappears when the foreground object or the camera is stationary. Unlike the Nuoptix system, there is a noticeable color-fringing effect around moving objects when the picture is viewed without the glasses.

And about the glasses: Those currently use glass lenses and are expected to sell for perhaps $15 to $45 a pair. The British developers of the system expect them to become a much-wanted "fashion item" for the youth market, and say that the glasses will be useful for 3D billboards and magazines.

Some day, television pictures will produce a true depth illusion without resorting to cumbersome glasses. Unfortunately, it appears that that day is hardly here.

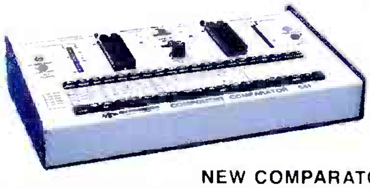
• **Coals to Newcastle.** Two Japanese TV manufacturers with American assembly plants have announced they'll soon start exporting color sets from the U.S. to Japan. Toshiba says that starting April 1 it will ship about 100,000 color TV sets from its Lebanon, TN factory to its home country, and, beginning next year, Matsushita plans to ship 25- and 31-inch sets across the Pacific from its facility in Franklin Park, IL. Sony, which already ships U.S.-made Trinitron picture tubes from San Diego to Japan, says complete sets may follow in 1989.

HANDHELD DIGITAL IC COMPARATOR/TESTERS FEATURE 20 CHANNEL LOGIC MONITOR

B&K-PRECISION's Model 550 and 552 IC Comparator Tester/Logic Monitors test IC's by comparison to a known good reference in one simple operation. As logic monitors, they simultaneously indicate the logic states of up to 20 IC pins. They test most 14 to 20 pin, 54 and 74 Series TTL (Model 550) or 4000 and 74C Series CMOS (Model 552) devices. Both models are available from distributors at $395. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

LOGIC/PULSER PROBES HELP LOCATE DIGITAL FAULTS IN LAB OR IN FIELD SERVICE

B&K-PRECISION now offers logic and pulser probes to fill the needs of engineers and technicians. The DP-21 is a 20 MHz probe that also displays pulse presence and logic status. Both LED and audible logic state indicators are featured. The DP-31 pulser probe can be used alone or with a logic probe or scope. It produces a 10μS pulse at 0.5 or 400 PPS rates and features an external square wave and synchronizing terminal. Both probes are multi-family compatible. The DP-21 is $32. The DP-31 is $33. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.



NEW COMPARATOR ADDS IC/COMPONENT TESTING TO SCOPE

Test virtually any type of passive or active component or module with B&K-PRECISION's new 541 Component Comparator. The 541 is designed for use with the 540 component tester or virtually any x-y oscilloscope. It is well suited for both in-circuit and out-of-circuit tests. It's fast and easy to use. Unlike single function testing, the 541 can be used on series, parallel or series/parallel circuits. $395. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

NEW COMPONENT TESTER LOCATES FAULTS ON UNPOWERED BOARDS IN FIELD OR PLANT

The new Model 540 component tester is an extremely cost effective, highly flexible trouble-shooting aid that can assist in rapidly locating faults on unpowered boards. Faults can be traced to the component level without specific circuit knowledge. Individual components can also be tested. Test results are displayed as a curve on a built-in CRT display. Curve tracing allows matching of components. Two channels allow production testing against known good boards. Ideal for field service or production testing. $995. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

PROGRAMMABLE IC TESTER TESTS TTL, CMOS, RAM AND ROM IC'S, IN OR OUT-OF-CIRCUIT

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LED VU METER

Is there any simple circuit I could use to have a series of LED's light in response to the volume of an incoming audio signal? The circuit should be battery powered and have a small amplifier in it to handle a variety of input signals.—J.K., Altoona, IA

What you're really talking about building is an LED VU meter. You could put one together with discreet parts but it's a lot smarter to use an LM3915. That IC has the buffers, drivers, and precision voltage reference on board to do the job. Best of all, they're not expensive and you can probably find one at your local supplier.

A circuit that does what you ask is shown in Fig. 1. You didn't say what kind of audio signal would be used as the input, but, as you can see from the schematic, the circuit has both a microphone and line-level input.

You only need two of the four op-amps in the LM3900 package implement the basic circuit. You can use the extra amps to provide more gain, more inputs, etc. As shown in Fig. 1, I've elected to use them tor additional inputs, but you can change that and use them for anything else you have in mind.

Switch S2 is used to change the display from a dot to a bargraph. You can use any construction technique you want. The circuit doesn't draw much current, so a nine-volt battery will keep the circuit going for a long time.

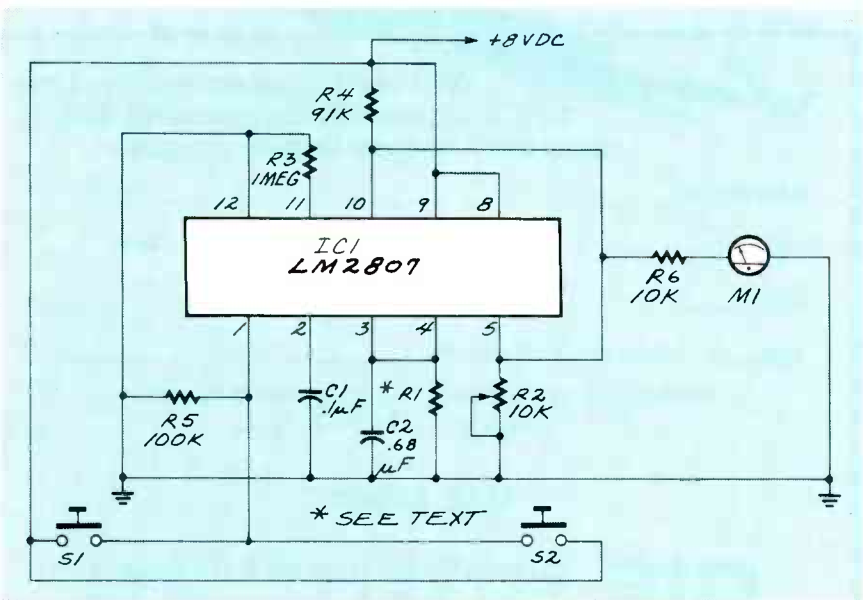


FIG. 1

NiCd CHARGING

I have a personal CD player that uses a 4-cell NiCd battery pack marked "140 mA, 8 hours." An LED lets me know that it's time to recharge the batteries by lighting up when, under load, the voltage falls to 4.5. Is there a "volts-per-cell" figure I can look for so I don't have to go through the full 8-hour charge cycle?—G.D., San Rafael, CA

The answer is a resounding yes, and no! One of the nicest features of NiCd batteries is that they have a pretty flat voltage-over-time curve. The voltage won't drop much below 1.1 until its stored energy is just about gone. The charging curve is the same. The voltage will rise to 1.2, or more, near the beginning of the charge cycle and stay there. The bottom line is that cell voltage isn't a reliable indicator of the state of charge.

The best way to determine whether a battery is fully charged is to monitor the charging current. That may or may not be possible in your case, since it depends on the design of the charger. If your charger is a variable-current type, you can get an idea of the state of charge by watching the current—the lower the draw, the closer the cell is to a full charge.

You haven't told me enough for me to know what kind of charger you have, but the "8-hour" figure is a clue. The safest charging rate for a NiCd cell is the "C10" rate, where the charging current is limited to 1/10th the cell capacity. That *trickle rate* usually calls for a charging time of 14 or 15 hours. In your case, the 8-hour figure seems to indicate a higher charging rate—probably C6 or so—and a charger like that has to have some provision to drop the charging current as the cell accumulates energy. If it didn't, the internal cell chemistry would produce oxygen faster than it could be absorbed by the electrolyte, and the internal pressure would rupture the cell. Consumer units aren't designed like that.

Put an ammeter between the

charger and a completely discharged battery pack. The initial charging current will be high and rapidly fall off. Sometime during the 8-hour charge, the current draw will stabilize at one rate as the cell goes into a trickle charge. As soon as that happens, it's a safe assumption that the battery is fully charged.

Keep a log of the charging current over time for the complete 8-hour cycle; 15-minute increments are good. I know it's a drag but you only have to do it once. Graph the results and you'll be able to figure out exactly when the charger dropped to a trickle charge rate. Since the trickle charge is probably just maintaining the charge rather than adding energy, you can end the charge cycle there.

HELP WITH HEARING-AID PROBLEM

Can you help me with the design of a hearing aid? The units I've found aren't made with the bass boost and mid-range attenuation that I need.—J.B.C., McLeansville, NC

I have a personal interest in hearing problems so I'm surprised that you can't find a hearing-aid or have one especially tailored to give you the frequency response that you require. I contacted several otolarynogologists (ear, nose, and throat specialists), two of whom are specialists in audiology. They agreed that hearing aids can be made with response curves that complement the exact hearing curves of the user's ears.

Off-the-shelf hearing aids are made with a large variety of response curves. Until recently, most attention was paid to the high end of the hearing range, and designers made no effort to shape the low end to the user's needs. Now, most makers have some models with low-end boost. If you are going to a "hearing-aid center," be sure to select one that will permit you to try and wear several models until you find one that is satisfactory.

If you can't be fitted at a center, ask your physician to recommend an otolarynologist who specializes in audiology. He, or she, should be able to fit you with a suitable hearing aid.

SPEAKER OVERLOAD

I have a new pair of 4-ohm B.S.M. speakers that can handle up to 200 watts. The stereo amplifier is a Yamaha *CR-44* that delivers up to 50 watts into 8 ohms. The problem: Each time that I bring the volume up to about half scale, distortion begins and then the speaker's thermal circuit breakers trip. The amplifier indicates only about 30 watts peak when the breakers open.—M.B., Opasatika, Ont., Canada

The trouble may be due to the fact that the amplifier is working into 4-ohm loads instead of the 8 ohms it is designed for. Some amplifiers can become unstable and develop inaudible oscillations, either below or above the normal audio spectrum, when driven hard while only lightly loaded.

The amplitude of those oscillations can be high enough to overload the amplifier and/or the speakers. You should be thankful that your speakers are protected by thermal circuit breakers. Otherwise, you would have to replace the speakers or have them repaired without finding and eliminating the cause of the problem.

Try working the amplifier into 8 ohms and see how it performs. Try connecting a 4-ohm, non-inductive power resistor in series with each speaker. A pair of 8-ohm, 20-watt non-inductive resistors (Radio Shack No. 271-120 or equal) connected in parallel will serve as the 4-ohm series resistor. If the system works OK without tripping the breakers, you've probably found the trouble. Your amplifier may be particularly sensitive to loads lower than their design center, or to loads having the characteristics of your 4-ohm speakers.

HUM FROM CABLE-TV CONVERTER

I have trouble with the Zenith *Z1000* converter supplied by the cable-TV company. I hear a 60-Hz hum coming from the TV speaker when the incoming TV signal passes through the converter. The hum is not present when the signal comes directly from the cable or from a VHF or UHF antenna. A service "technician," sent by the cable company, at first claimed that he didn't hear the hum. Finally, when he did hear it, he said that nothing can be done about it. Is there anything that I can do, short of modifying the company's converter, to eliminate the hum?—B.B., W. Henrietta, NY

My guess is that trouble in the converter's power supply is allowing a 60-Hz hum voltage to modulate the TV signal being fed to the TV set. However, there is a remote possibility that the trouble is originating in the TV set but does not show up until the converter is connected to it. To eliminate that possibility, substitute another TV set and see if the hum is still present.

Try reversing the AC-line plug in the receptacle and see if that affects the hum level. Also, try another patch cable between the converter output and the antenna terminals on the TV set. Sometimes, an open ground (shield) can cause hum to develop.

If you can't locate the hum source, take the converter to the company's office and ask them to exchange it for another. **R-E**

NEW LIT

TEST- AND MEASUREMENT-INSTRUMENTS CATALOG. The 1988 **Transcat** catalog is a comprehensive, 226-page book, divided into five categories of equipment: Electrical, Temperature, Pressure, Plant Maintenance, and Temperature Sensors. A small sample of the products mentioned includes multimeters, oscilloscopes, frequency generators, data-communications test equipment, logic probes and analyzers, digital temperature indicators and probes, pressure gauges, digital pressure indicators, tachometers and stroboscopes, analytical instruments, and thermocouples. The description of each instrument includes full specifications. The catalog is indexed by product and by manufacturer. It can be ordered, free of charge, by calling 800-828-1470; in New York, 716-458-4801.—**Transcat,** Box D-1, Rochester, NY 14606.

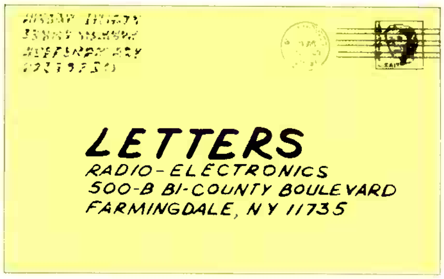
CIRCLE 20 ON FREE INFORMATION CARD

PRECISION SWITCHES CATALOG. Cherry Electrical Products' line of switches is described in catalog *CE1287*. It includes subminiature, sub-subminiature, ultra-subminiature, waterproof, international miniature, miniature panel-mount pushbutton, and general-purpose styles. Catalog descriptions include cut-away drawings of snap-action switches, engineering specifications, and operating characteristics. A selector/locator chart, plus alphabetical listing of all switch series, make it easy to find the type, size, and rated switch required. *Catalog CE1287* is free.—**Cherry Electrical Products,** 3600 Sunset Ave., Waukegan, IL 60087. **R-E**

CIRCLE 21 ON FREE INFORMATION CARD

continued on page 33

LETTERS



SAY "NO" TO CENSORSHIP

Everyone keeps writing to you about how good your magazine is, and you can add my name to the list. I've enjoyed **Radio-Electronics** through the years, and look forward to it each month. Your overall view of all electronics, with computers added, is just the right touch. Don't change the format.

On the other hand, what ever happened to your pieces on satellite receivers? I've followed this subject with much interest, and would like to keep up with the latest information. Reading between the lines, a person could think that those articles have been dropped because of threats about lawsuits. I hope this is not the case.

I am apprehensive about censorship, and the censoring of technological ideas is particularly frightening. Several letters in recent months have argued against some articles you've printed, and I couldn't disagree more. **Radio-Electronics** is not showing "how to" evade radar speed traps, or break VideoCipher, but is giving *information* on how the technology works—two entirely separate concepts.

If we block the practice of technology exchange and discussion, how can we teach future generations? In the March 1988 "Letters" column, a young man gives thanks to **Radio-Electronics** for his education, training, and future. Can we stifle the future of others, because someone wants to curtail our exchange of ideas?

TOM KNIERIM
Rock Port, MO

LASER LISTENER

A letter I wrote appeared in **Radio-Electronics**' November 1987 "Letters" column. In it, I made two key points. First, federal law prohibits the assembly, possession and use of electronic eavesdropping devices. Second, **Radio-Electronics** erred in publishing plans for an electronic eavesdropping device and encouraging its readers to build and use it.

Please note that I did not chastise **Radio-Electronics** for publishing plans for a "Laser Listener"(October 1987). I did criticize the publication of such plans within the same article that encouraged the use of the device for illegal purposes.

Nevertheless, readers John Williams ("Letters," January 1988) and William Ritz ("Letters," February 1988) have criticized my letter. Mr. Williams implied that I oppose the Constitution's guarantee of freedom of the press. Mr. Ritz agreed with my contention that **Radio-Electronics** should warn its readers "...of the consequences of illegal usage..." But he incorrectly characterized me as wanting the magazine to withhold information. He implies that I also criticized the publication of "...detailed plans for various descramblers, decoders, transmitters..."—subjects not even mentioned in my letter. I'm offended that **Radio-Electronics** published letters criticizing my original letter for views it doesn't even contain.

As for the legal questions raised, thus far I've not seen **Radio-Electronics** take a stand. I believe, at this point, the magazine owes its readers an explanation of its position on the matter. Now that **Radio-Electronics** has been informed about the federal electronic eavesdropping law, does the magazine stand by the Richard Pearson's statement in the "Laser Listener" article that "A better and safer way to bug a room is to use a laser beam to eavesdrop..."? Does the magazine stand by the article's subtitle, "Use a light beam to listen in to anything, anywhere, anytime," and the Table of Contents teaser, "Eavesdrop using a beam of light"?

Each of those quotes recommends that readers commit acts defined as felonies under state and federal statutes. It is entirely possible that **Radio-Electronics**, and Mr. Williams and Mr. Ritz, do not agree with those laws. I don't happen to agree with all aspects of them myself. On the other hand, I seriously doubt that your readers would want their homes monitored by a neighbor with a laser listener. Nor would **Radio-Electronics** want a competing publication to determine confidential publishing schedules with the help of such a device.

In recent years, the term "computer hacker" has been misapplied by the popular press to widely publicized computer criminals. That might happen to electronics experimenters if our magazines encourage us to build and use such illegal equipment as the Laser Listener.

FORREST M. MIMS, III

AES AWARDS PROGRAM

The Audio Engineering Society Educational Foundation has announced the opening of its 1988 educational grant program for university studies with emphasis on audio topics. The awards—for graduate students only—are made annually. Successful applicants may request a one-time renewal of their grants.

Completed applications must be received by June 1 to be consid-

ered for the 1988-89 academic year. Additional information, and application forms, are available from:
AES EDUCATIONAL FOUNDATION
60 East 42nd Street
New York, NY 10165

DESKTOP PUBLISHING/ PUBLISHING MANUALS

In his article, "Desktop Publishing,"(**ComputerDigest**, March 1988) Josef Bernard reports a problem in *Ventura Publisher* relating to line positioning and spacing. He states, in the caption for Fig. 6, that there was no precise control of the free graphic horizontal line that was being placed over a mathematical symbol.

In both versions 1.0 and 1.1, the degree of control is set in the graphics-grid settings box. The grid resolution can be set as fine as .001 inch, or can be turned off entirely. That information is extremely difficult to locate in the Ventura user's guide.

It seems that the number of second-party manuals available for a given product is dependent upon two major variables: market penetration and the quality of original documentation. Although alternate manuals provide a much-needed resource, why can't software vendors simply hire someone who has actually used the program to write the manual?

I'm sure there are many other people who have spent hours trying to decipher what the manual says, when what is actually needed is: Information which should have been translated from "programese;" information placed in a "convenient" (i.e., "somewhere else") appendix; information placed in a previous, or subsequent, section—like in another volume; or information not necessary because it is "self evident."

How about an article on both vendor-supplied and second-source user guides for some popular software? I suggest an evaluation based on such things as legibility, accuracy, completeness, and organization of material.

Thanks for a good article. I've been reading **Radio-Electronics** since I could afford a subscription.
STEVE RUSSELL
Redwood City, CA

SPEAKER-LEAD RESISTANCE

In "Ask R-E"(**Radio-Electronics**, February 1988) the question on speaker-lead resistance was answered correctly, but not really completely.

Your answer addressed the problem of losses in the wiring, but there are two other effects that are more important in audio reproduction systems—frequency-response variations and damping reduction. The impedance of most speakers varies considerably over their operating range. A nominally 4-ohm speaker will go from perhaps 2 to 20 ohms over its part of the frequency spectrum. That impedance will typically contain large and varying reactive components also. If that were in series with as much as 1 ohm of wire, that effect alone would cause a frequency-response variation of

3.1dB—not an attractive prospect for anyone who has spent money to squeeze down such variations in his system.

The damping effect pertains to rise and hangover of transient sounds. That can be demonstrated with pulsed sine-wave tests. For a few years, those were a standard part of the tests done by audio magazines, but they had difficulty correlating the results with the sound. Since those tests are not part of any industry-standard test regimen, the magazines dropped them. (I think that they should try harder!)

High-fidelity speakers are designed to give proper response when driven from a zero-impedance ("constant-voltage") source. The cone position, or velocity, should correspond exactly with the voltage input. If a resistance, such as the 1 ohm mentioned above, is in series with the speaker, increased rise time and hangover of intrinsic speaker resonances will blur and color the sound. Power amplifiers are designed to have very low output impedances, usually on the order of hundredths or thousandths of an ohm, for just that reason.

There are a few rare amplifiers that run a feedback wire directly from the speaker to get the wiring in the loop, making only the losses important. However, as far as I know, none of those is available for autos.

Thus, the proper policy is to keep the wiring in series with a speaker at, say, a tenth of the lowest speaker impedance or less. For most auto-speaker runs, I would guess 14- or 16-gauge wire would suffice. At home I use 12-gauge for 20- to 25-foot runs. It's hard to find nice fine-stranded wire larger than 12-gauge for less than a king's ransom. Of course, two or more 12-gauge wires can be paralleled.

W.J. NEWELL
Richardson, TX

DIGITAL TACHOMETER

I recently built the Digital Tachometer that appeared in the June 1987 issue of **Radio-Electronics**, and it works very well. It is the only digital tachometer circuit I've ever seen that offers accurate tachometer readings without calibration. That is accomplished by the use of a built-in 60-Hz crystal-controlled time base. The author is to be congratulated on that fine project.

It worked perfectly on several standard and Capacitive-Discharge (C-D) ignition systems. However, the tachometer will not work on some C-D systems that use input-triggering circuits that generate extremely low pulse levels across the ignition points. On one such system, which incorporates an unusual triggering network designed primarily to eliminate point "bounce" or "flutter" at high engine speed, the pulse obtained across the ignition points was far too small for tachometer pickup.

To eliminate that problem, I used a miniature broadband amplifier between the ignition points and the tachometer input. I chose the broadband amplifier described by Earl "Doc" Savage in "Hobby Corner" in the April 1980 issue of **Radio-Electronics**. It is small enough to fit easily within the tachometer enclosure. I added a switch to allow the amplifier to be switched in or out of the circuit.

I hope that my solution may prove useful to other readers experiencing similar difficulties. Many thanks for a fine magazine.

PAUL SCHULTZ
Carmichael, CA

CALIBRATING VCR COUNTERS

I thought Fred Blechman's article, "Calibrating VCR Counters," (**Radio-Electronics**, January 1988) was interesting—but for cable subscribers there's a technique that's even easier.

Most cable systems use one channel as a 24-hour menu that shows program listings. At the top corner of the screen the day, date, and exact time are displayed. Just set your VCR to record for six hours, starting at any convenient on-the-hour time, and you will have accomplished the same thing Mr. Blechman did with a camera. Of course, that procedure must be repeated for each speed, plotting the results described in the article.

GEORGE BERNSTEIN
Tamarac, FL

continued on page 79

EQUIPMENT REPORTS

Fluke 90 Series Microprocessor Board Tester

Speed your testing of microprocessor-based systems.

CIRCLE 49 ON FREE INFORMATION CARD

IF YOU'VE EVER HAD TO DIAGNOSE problems in a microprocessor-based system, you know that finding the source of a problem can give you quite a headache. But put yourself in the place of an electronics technician who has to trace and repair several such systems each day!

The only logical course of action is to get some help from a microprocessor-based tester, like the *90 Series* microprocessor-board testers from the John Fluke Mfg. Co., Inc. (P.O. Box C9090, Everett, WA 98206) and N.V. Philips.

The *90 Series* is available for the Z80, 6809, and 8085 microprocessors, and it is likely that future models will handle other microprocessors. We examined the tester for the Z80.

The tester is housed in an 11×6×3-inch package and weighs just over two pounds. A 2-line, 32-character LCD and 24-key keypad dominates the front panel. Sixteen of the keys form a hex keypad; the other eight are used to initiate and control various tests. Despite its powerful capabilities, the *Fluke 90* is surprisingly easy to use. But don't think that the tester is going to do all your work for you—it won't. It will make your work a lot easier by taking out some of the drudgery; but you have to know what you're doing. (You still make the decisions and the diagnoses.)

Setting up the tester consists of merely connecting its 40-pin test clip to the microprocessor you want to test, and plugging a supplied probe into the rear of the tester. The microprocessor to be tested is not removed from the circuit. To the contrary, the tester allows you to check some of the microprocessor's circuitry, such as buffers, decoders, RAM, and ROM. In use, the tester emulates a DMA (*D*irect *M*emory *A*ccess) device, and forces the DMA and WAIT lines of the microprocessor under test, taking control of the bus from the microprocessor.

Bus tests

Assuming that your power supply and clock are working correctly, the first thing to check if you have a problem in a microprocessor system is the integrity of the bus lines. The *Fluke 90* offers several bus tests.

The primary use of the simple bus test is to check for bus lines that are shorted together, or for bus lines tied to the ground and supply lines. The test determines whether the data, address, and control lines can be driven by trying to force each line to a given state and then sensing whether that state was actually achieved. At the same time, it checks for shorts by making sure that nothing else on the bus changes state at the same time as the line being tested.

The simple bus test is a useful first test but, unfortunately, shorted bus lines are not the most likely problem to occur on a microprocessor board. What's more, they are among the easiest problems to diagnose, even without a dedicated tester. A second test, called the *ramp test*, allows you to make tests on the other side of address decoders and buffers. The test performs a memory write to each address in the microprocessor's memory space. That should, of course, enable all address decoders. The output of the decoders—or the CHIP-SELECT inputs of any memory IC's—can be monitored using an oscilloscope, a logic analyzer, or the probe supplied with the tester. Any lack of activity indicates a probable faulty component.

Shorted lines can be checked for during the ramp test by watching the frequency of each address line. As the complete address space is stepped through, the frequency of each line should be different—one half of the previous line's frequency. (Remember, the state of address line AØ changes each time the address is incremented. A1 changes every second increment, A2 changes every fourth increment, and so on.) The tester outputs a similar pattern on the data lines making data-bus shorts easy to find. A third bus test, called the *shift test*, is a variation of the ramp test. Only one address and data line is high at a time. That can make detecting some shorted lines easier. All of the bus tests can be made to cycle once, or to loop continuously.

Memory and I/O tests

Once you're satisfied that your computer's bus lines are doing what you expect, the next step is to test the system's RAM. The first memory test reads the contents of each memory location in the user-selected range, then writes two patterns and verifies that each pattern was written correctly. Finally, it restores the original contents. The system under test can be operating normally during the memory test.

If the RAM checks out, the checksum of the ROM in the system can be tested. The tester reads the data from the user-specified range, and accumulates the 16-bit sum (which is the checksum generated by most EPROM programming equipment). All memory locations in the selected range are accessed, so faulty address decoders and shorted chip-select lines can be found.

The tester's memory-examine function allows you to easily examine the contents of any specific memory location in the address space. The *Fluke 90* makes it easy to increment one location at a time. A memory-verify test lets you verify a particular location by writing the bit pattern of your choice to the location of your choice. A read operation is then performed immediately. A separate memory-write test is also available.

The final memory test of the *Fluke 90* is *memory soak*, which checks that static RAM retains its memory for a user-specified length of time. It can also be used to fill memory with a given bit pattern.

I/O examine, *I/O verify* and *I/O write* tests are available on the *Fluke 90*, and are performed just as the similar memory tests are.

Using the probe

We mentioned previously how the probe supplied with the tester could be used as a simple logic probe to check the state of data and address lines, and the like. In the *QuickTrace* mode, it can also be used to identify and trace bus lines. In that mode, the tester continually searches for the signal line being probed. When the probed line is identified, the probe's green LED lights, and the tester's display shows the line's name. The *QuickTrace* identification feature is ideal for getting your bearings on a tightly packed board, and it can also help you find shorted lines.

The *probe-address* test lets you indicate a line you're trying to find, say the microprocessor's WRITE line. You can then hunt around your board to find the line. (Should that be on pin 20 of the PROM or on pin 19?) When you do find it, the green LED on the probe lights, and the LCD readout also indicates that the signal was found. Similar functions are available to find data and control lines.

Communications port

An RS-232 is available on the tester for control from a remote computer, or for uploading to and downloading from the memory of the system under test. The RS-232 jack is a 6-pin RJ-12 connector on the rear of the tester. A compatible cable is supplied. Communication rates from 300 to 9600 baud are supported.

The communication port lets you enter command strings for complex tests such as break-point. When a user-defined event occurs, the microprocessor under test is halted, and the states of its address and data lines are output to the terminal. Frame-point tests—where the status of the address and data lines are displayed without the halting of the processor—are also available. The tester can also be programmed to output a trigger pulse (from a rear-panel connector) when a specified event occurs.

All commands that can be entered from the tester's keypad can also be entered remotely. That can be a great convenience if your communications program or terminal allows you to define macro strings. It also allows some degree of automated testing.

Fluke's *90 Series* microprocessor board testers are obviously special-purpose tools, and are not designed for casual use. If you test microprocessor systems on a regular basis, however, the tester can greatly increase your productivity. The hours it will save you will quickly make up for its $995 price. ($1395 after June 30, 1988). **R-E**

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CIRCLE 71 ON FREE INFORMATION CARD

New Products

CIRCLE 10 ON FREE INFORMATION CARD

HOME SCANNER. Regency Electronics introduces the model *R2060* featuring "TurboScan," which allows the device to scan at a rate of up to 50 channels per second. A special WEATHER-ALERT key provides instant awareness of severe weather: At the touch of a button, the *R2060* silently monitors the weather frequencies, broadcasting alerts in plenty of time for listeners to take safety precautions.

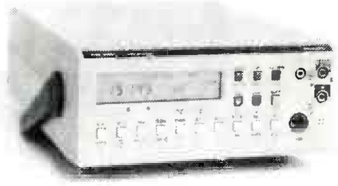
The unit covers seven of the most popular bands, including VHF low band, 30–50 MHz; VHF amateur, 140–148 MHz; VHF high band, 148–174 MHz; UHF low band, 406–440 MHz; UHF amateur, 440–450 MHz; UHF standard, 450–470 MHz; and UHF extended, 470–522 MHz.

Its 60-channel programmability provides instant access to favorite frequencies, either directly or in the scan mode. Bank scanning provides easy access to four groups of consecutive channels. A separate set of non-programmable channels provides exclusive scanning of NOAA weather frequencies in the U.S. and Canada. Additional features include priority, lockout, delay, and hold.

The model *R2060* has a suggested retail price of $249.95.—**Regency Electronics,** 7707 Records St., Indianapolis, IN 46226.

DIGITAL MULTIMETER. The Philips model *PM 2525* is a general-purpose instrument with many extra functions. Eighteen measurement functions are standard, including volts AC/DC, amps AC/DC, both four-wire and two-wire resistance, capacitance, frequency, time, temperature, dB, and continuity check. There are five voltage ranges, eight current ranges, and seven resistance ranges.

The model *PM 2525* also provides three functions, min/max, zero-set, and dBm, to enhance understanding of measured values. For example, measurements such as volts and min/max, or capacitance and zero-set, can be combined to reduce manual calculations.



CIRCLE 11 ON FREE INFORMATION CARD

The model *PM 2525* has 4½-digit resolution with a 21,000-count display, or a 5½-digit resolution with a 210,000-count display in the high-resolution mode. In addition, a high-resolution analog bar-graph display gives a clear indication of signal trends. The bandwidth is up to 100 kHz.

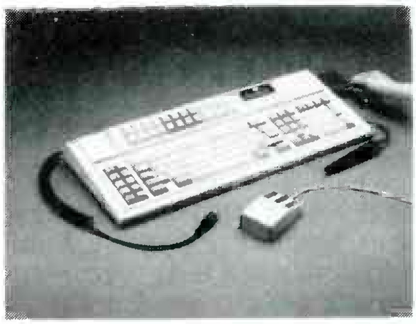
The *PM 2525* is available in three versions: A benchtop model for general-purpose use in lab, workshop, and production-line environments; a portable model with battery power pack for field use; and a version with a choice of three built-in interfaces—GPIB, RS-232 for system applications, or analog output for use with hard-copy devices.

The *PM 2525* is priced at $795.00.—**John Fluke Mfg. Co., Inc.,** PO Box C9090, Everest, WA 98206.

MULTI-OPTION KEYBOARD. Cherry's model *G80-2000* is IBM-compatible and has a card reader, mouse, and remote bar-code reader available as options.

The keyboard has a layout that is identical to IBM's *3270* with 24 function keys arranged in two rows along the top, in addition to ten at the left. The extra function keys are especially useful for rapid data entry, allowing input of lengthy product descriptions or codes with just a few keystrokes.

The additional function keys are normally only recognized by software written for the *3270* PC, but Cherry has also made provisions for PC-XT and AT users. The enhanced versions of *SmartKey* software is bundled with the keyboard, giving it an extra 96 functions because each of the keys can function alone, shifted, CTRL-shifted, or ALT-shifted. An on-board LCD readout provides operator guidance. Also available are N-Key rollover, LED-actuation indicators, and programmable auto-repeat. The keyboard can be supplied with or without low-profile housing in order to conform to DIN standard.

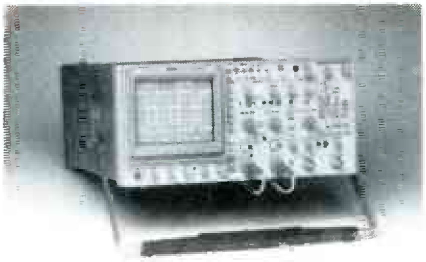


CIRCLE 12 ON FREE INFORMATION CARD

The *G80-2000* 123-key keyboard, completely assembled and electronically equipped for bar-code reading, mouse, and magnetic-card reader is priced at $765.00. The bar-code-reader light pen ($170.00) and mouse ($45.00) are sold separately. The keyboard completely assembled and electronically equipped for bar-code reading only is $680.00, and equipped for magnetic-card reading only, including the card-reader itself, is also $680.00.—**Cherry Electrical Products**, 3600 Sunset Avenue, Waukegan, IL 60087.

OSCILLOSCOPES. Tektronix has introduced two oscilloscopes that offer automated-measurement features normally found only on more expensive oscilloscopes: The model *2245A* and the model *2246A* (shown).

The *2246A* is the first 100-MHz scope to offer 20 store/recall setups, 4-channel testing capability, cursors, readout and automatic setup. It is priced at $2395.00. The *2245A* has almost all the features of

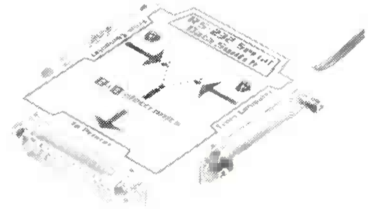


CIRCLE 13 ON FREE INFORMATION CARD

the *2246A*, but not the 20 store/recall feature. It is priced at $1795.—**Tektronix, Inc.**, PO Box 500, Beaverton, OH 97077.

SERIAL SCANNING SWITCH. B & B Electronics' model *232SSS* automatically scans two RS-232C serial ports waiting for data to be sent. Upon receipt of the data from either RD (pin 3) port, the switch then selects that port and passes all RS-232 data on pins 2–7, 8 and 20. Approximately 15 seconds after the data has stopped flowing on pin 3, the switch then resumes scanning.

During the time that the switch is locked on to one port, the other port outputs (pins 2, 4, and 20) will be low to prevent the computer from outputting data.



CIRCLE 14 ON FREE INFORMATION CARD

The model *232SSS* comes complete with a 117-volt AC power supply. The two input-port connectors are female and the main connector is a male DB25P. The Scanning Switch is priced at $119.95.—**B & B Electronics,** 1500P Boyce Memorial Drive, PO Box 1040, Ottawa, IL 61350.

WIRE ANALYZER. Polytronics presents *SureTest,* a portable hand-held device that tests for current-carrying capacity using a built-in 15-ampere load. The multi-function analyzer applies the load and determines if the voltage drop is less than 5%, as recommended by the National Electric Code.

CIRCLE 15 ON FREE INFORMATION CARD

SureTest also checks circuits for voltage level, wiring connections, and operation of a ground fault circuit interrupter, thus saving any need on the owner's part to have or use separate testers.

SureTest is priced at $89.95.—**Polytronics,** 2100 Old Union Road, Buffalo, NY 14227.

continued on page 28

Simpson

Announces 9 NEW PRODUCTS!

NEW · Models 422 and 421 5 MHz Sweep/Function Generators that offer low distortion, harmonic-free sine, triangle and square wave outputs. TTL output will drive up to 10 TTL loads for logic and digital circuit testing. Selectable sweep frequencies (.05 Hz to 5.0 MHz), rates and sweep times. Model 422 features 6-digit LED display and frequency counter capability for circuit monitoring.

Model 421, 120 VAC, Cat. #12731 . . . .
220 VAC, Cat. #12733 . . . . $535.00
Model 422, 120 VAC, Cat. #12732 . . . .
220 VAC, Cat. #12734 . . . . $650.00

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NEW - Model 159 AC/DC Clamp-On Probe

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Model 159, Cat. #12120 . . . . $169.00

CIRCLE 251

CIRCLE 253

NEW · Model 460-6 DMM

High accuracy bench DMM with extended measurement capability. It is completely portable with a built-in, ni-cad battery pack and includes true rms measurement, pulse detection, selectable dB reference level and a 4-1/2 digit LCD readout with 22-segment bar graph. Designed to meet UL 1244 requirements.

Model 460-6, 120 VAC, Cat. #12538 . . . .
240 VAC, Cat. #12539 . . . . $425.00

NEW · Models 713 and 712 Universal Frequency Counters

Model 713 (to 520 MHz) and 712 (to 200 MHz) provide period, frequency, ratio, time interval and totalize functions for a wide range of applications from radio servicing to logic and control circuit testing and monitoring. Both feature an 8-digit, high visibility, orange LED display, selectable attenuation and self-check of the 10 MHz time base.

Model 712, 120 VAC, Cat. #12722 . . . .
220 VAC, Cat. #12723 . . . . $525.00
Model 713, 120 VAC, Cat. #12724 . . . .
220 VAC, Cat. #12725 . . . . $675.00

CIRCLE 250

NEW · Models 488 and 487 Digital Multimeters

These new handheld DMMs feature autoranging and data/peak hold, and a 3-1/2 digit LCD plus 71-segment analog display. Housed in a shock resistant case for rugged use. AC and DC current measurements; 300 μA to 20 A; 1000 VDC, 750 VAC (rms); diode check; and resistance to 30 MΩ. The Model 488 features true rms measurements.

Model 487, Cat. #48700 . . . . $219.00
Model 488, Cat. #48800 . . . . $275.00

CIRCLE 252

CIRCLE 254

NEW · Model 464-4 DMM

Provides true rms voltage and current readings. Big, orange 3-1/2 digit LED display for easy reading. 100 kHz frequency response. Designed to meet UL 1244 requirements.

Model 464-4, 120 VAC, Cat. #12677 . . . .
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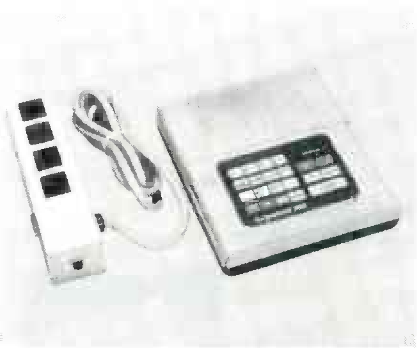
CIRCLE 191 ON FREE INFORMATION CARD

MONITORING SYSTEM. The Phonetics model *1100 Sensaphone* communicates over phone lines to help avoid catastrophic loss or damage to your valuable property, products, or operating facilities. If any monitored condition changes, the model *1100* will automatically sound an alert, call you by phone, and deliver its message in English. You can also check on actual operating conditions by calling your *Sensaphone* from any phone worldwide to hear a complete status report.

In addition to its built-in electrical-power, temperature-level, and high-sound-level (from a smoke or fire alarm) sensing capabilities, you can configure your model *1100* to monitor other environmental conditions that are critical to you.



CIRCLE 16 ON FREE INFORMATION CARD

When an alert condition occurs, *Sensaphone* will immediately dial out up to four phone numbers in sequence, to warn key personnel that a problem or emergency exists. A prompt return call to acknowledge the alert stops the continuous call-out.

The model *1100 Sensaphone* is priced at $300.00.—**Phonetics, Inc.**, 101 State Road, Media, PA 19063.

FREQUENCY COUNTERS. From Simpson Electric Company comes the model *712* and the model *713* (shown in photo).

Both models are designed for service, production, laboratory, and training operations. The model *712* has a range up to 200 MHz and the model *713* has a range up to 520 MHz. They both provide period (10 Hz to 2.5 MHz), channel A/channel B frequency-ratio (10 Hz to 2.5 MHz/10 Hz to 10 MHz), time-interval (0.5 μs to 200,000 μs) and totalize (10 Hz to 10 MHz) functions.

CIRCLE 17 ON FREE INFORMATION CARD

Additional features of both models include self-check with display of internal time-base frequency (10 MHz), a 1-MHz lowpass filter, and selectable attenuation. The display for both models is an easy-to-read 0.56-inch orange LED. It has 8 digits with overflow, gate, and μs indicators.

Prices are $525.00 for the model *712* and $675.00 for the the model *713*—**Simpson Electric Company,**

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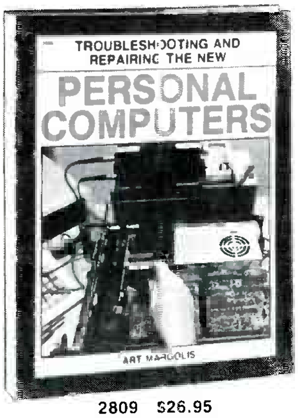

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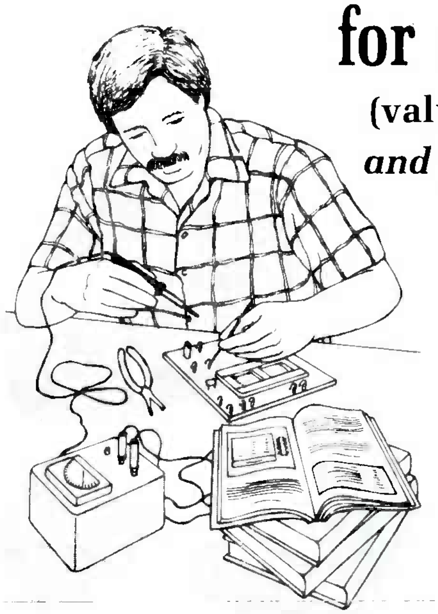
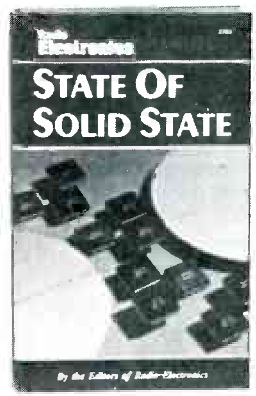
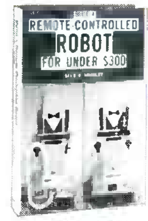




2733 $14.95

2660P $17.95



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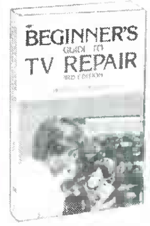

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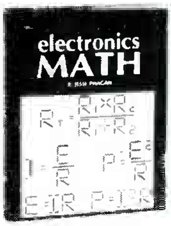

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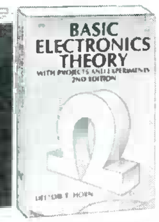

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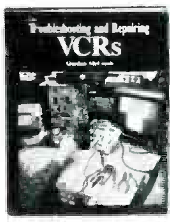

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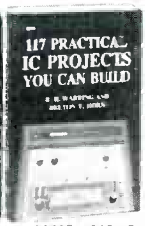

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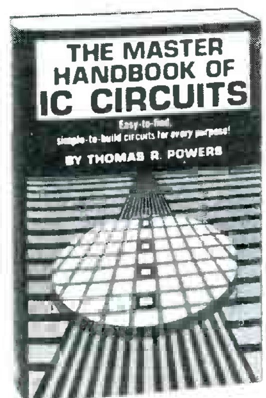

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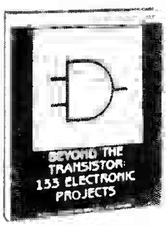

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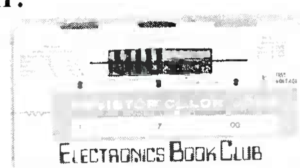

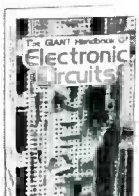

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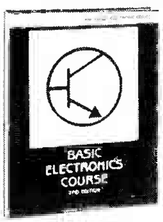

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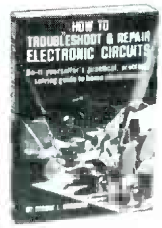

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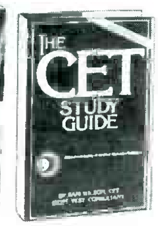

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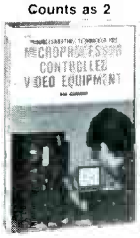

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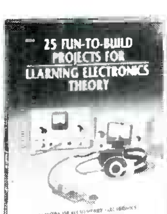

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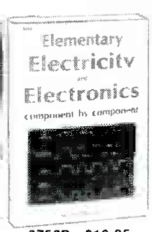

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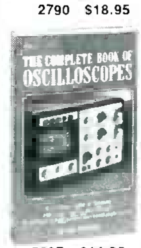

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853 Dundee Avenue, Elgin IL 60120-3090.

DESK BATTERY CHARGER. MFJ Enterprises offers the model *MFJ-290*, a drop-in, rapid, desktop battery charger. It is designed for all ICOM rechargeable battery packs. (The IC-μ2 series battery packs require the ICOM AD-10 charger adapter.)

CIRCLE 18 ON FREE INFORMATION CARD

The model *MFJ-290* is made of high-impact plastic with ample ventilation holes to ensure cool operation; it measures 7 × 4 × 3 inches. It has an ON/OFF switch, power-on and charging indicators, and operates from 117 VAC. The unit is covered by an unconditional 1-year warranty.

The model *MFJ-290* is priced at $59.95.—**MFJ Enterprises, Inc.,** 921 Louisville Road, Starkville, MS 39759.

AM/FM STEREO CASSETTE PLAYER. The Sparkomatic *SR37* features an illuminated dial, and AM/FM, mono/stereo, and local/distance pushbutton selection. Other features include LED stereo and play indicators, tuning and balance controls, and a fast-forward/eject pushbutton. The radio/cassette player comes complete with mounting hardware.

CIRCLE 19 ON FREE INFORMATION CARD

Audio power specifications are 9 watts (RMS) at 10% THD, and 7.5 watts (RMS) at 1% THD. The model *SR37* is priced at $69.965—**Sparkomatic Corporation,** Milford, PA 18337. **R-E**

SERVICE CLINIC

Ghost busting

JACK DARR
SERVICE EDITOR

MOST OF US ARE FAMILIAR WITH ghosting. It's when the primary image on the screen is accompanied by one or more secondary images. The effect is most often caused by a reception problem, such as when the antenna receives signals both directly and via a time-delayed reflection from a building, hilltop, etc.

But ghosting can have other sources. A defect in the video-IF amplifier strip could cause regenerative feedback to occur. If that feedback's frequency falls within the amp's pass band, it will show up on the picture as ghosting. If fine tuning affects that ghosting, that's further conformation that the video IF is indeed the culprit.

But what if fine tuning has no effect? Then, assuming the TV set is a color model, you should look to the delay line.

In color receivers, the video leaving the first video amp is split into luminance (brightness) and chrominance (color) information. Each signal is processed and then fed to the picture tube for display. However, the brightness information has fewer stages to pass through during processing. Hence, it tends to arrive at the picture tube slightly ahead of its related color information. If uncorrected, the result would be a picture where the color information is offset to the right of the black-and-white information.

The purpose of the delay line, then, is to slow down the brightness signal so that all the components of an image arrive at the picture tube at the same time. The delay line is inserted between two of the stages of the video amplifier. A typical setup is shown in Fig. 1.

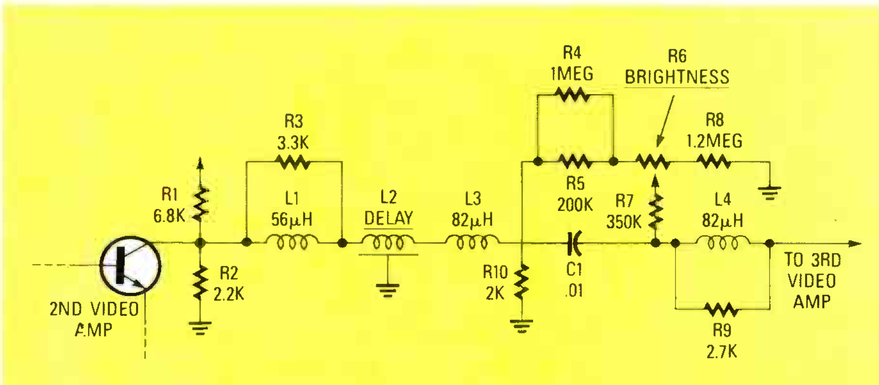

FIG. 1

A delay line is essentially a long inductor wound on a metal form. That form is lined with foil along its entire length, and the foil is tied to ground creating a ground plane, which causes a capacitance to exist between each turn of the coil and ground. That capacitance, along with the inductance of the delay line, introduces a time delay because it takes time for the capacitance to build a charge and the coil to produce its magnetic field.

Two types of delay-line failures could cause ghosting to occur. One is if the delay line is improperly terminated. Typically, that happens when a resistor changes value or the peaking coil becomes open. The other common cause is an open ground plane.

In short, then, a ghosting problem caused by the set itself is most likely the result of regenerative feedback or ringing in the video IF or video amps. If fiddling with the fine tuning affects the ghosting, look to the video IF; if fiddling with the fine tuning has no effect, look to the delay line.

Tracking intermittents

Anyone who has spent any length of time servicing TV sets has had some experience with intermittents. Sometimes the problem crops up rather quickly. Other times the TV set may seem fine for several weeks before cutting out; shortly thereafter, the set once again seems to be fine, for a while.

TV sets suffering from the latter symptoms can be a real pain to troubleshoot. Often, the best course to take is to force the intermittent to show up. There are several ways to go about doing that.

The simplest technique is to jar the chassis with the heel of your hand, or a small rubber mallet. You'd be surprised how often that does the trick.

If tapping the chassis fails, you'll have to apply more stringent methods. Hook up a Variac and drop the line voltage. If that fails, use a hair dryer or other heat source to warm up individual circuit components until the intermittent appears.

An old troubleshooter's trick for tracking down stubborn intermittents was to rig up a tapping tool and attack individual components. The tool was little more than a rubber washer slipped over an end of an alignment tool; the result was a miniature rubber mallet that was light enough to allow tapping without the fear of breakage, but heavy enough to send a noticeable shock through a component. Start tapping away at the components until one of those taps makes the intermittent appear.

While you're at it, don't overlook the solder joints. It doesn't matter how "perfect" the joint looks on the outside; inside that joint it could be a whole different story.

In one set, I had tracked the intermittent to a particular junction in the circuit. But the joint there looked textbook clean. Deciding that I had probably overlooked something, I wasted hours of time checking everything else in the vicinity of that joint. Finally, out of frustration I attacked that "clean" looking joint itself. Of course, I found that the wires beneath the solder were completely corroded! Rewiring and resoldering the connection restored proper operation, and the set has worked fine ever since.

If jarring the TV set makes the intermittent show up, then you should suspect bypass or coupling capacitors in the affected circuits. Attack each of those with your "mini-mallet" until the the intermittent reveals itself.

Sometimes, irritation can be a helpful ally. In one particular instance, no matter what I did, including light tapping, the intermittent would not show up. In desperation, I drew back and gave the chassis a relatively healthy shot—strong enough to knock it about six inches. Apparently, that "scared" the intermittent enough to force it to show up. The moral is to not be afraid to use brute force—in moderation. Picking up a TV set and heaving it across the room is never a recommended servicing strategy! **R-E**

NEW LIT

continued from page 15

TOOL CATALOG. Jensen's full-color *Winter 1988* catalog features pliers, screwdrivers, and other handtools; power tools; test and measurement instruments; and tool kits and cases. Test equipment for computers and telecommunications devices is also presented. An updated supplement is also available; both are free of charge upon request.—**Jensen Tools Inc.**, P. O. Box 50020, Phoenix, AZ 85076-0020.

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FULL-LINE CATALOG. The 1988 catalog from **Parts Express** contains VCR parts, speakers, semiconductors, CATV products, tools, test equipment, chemicals, and cables. Also featured are computer accessories, and hardware. There is no charge for the catalog, which can be ordered by calling (800) 338-0531.—**Parts Express International Inc.**, 340 E. First St., Dayton, OH 45402.

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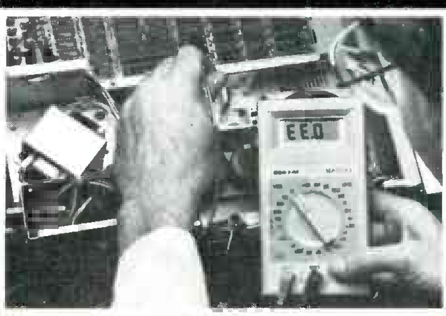
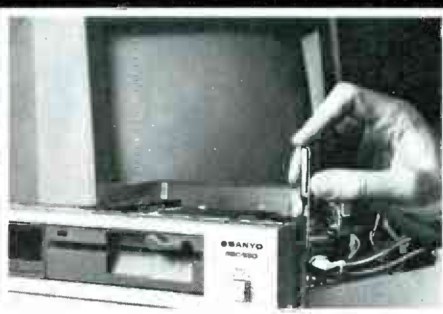


The power supply is assembled in the main unit of the computer. You check out keyboard connections and circuits with the digital multimeter included for training and field use.



Next, you install the 5¼" floppy disk drive, learning disk drive operation and adjustment. Later, you increase your data storage capacity dramatically by installing a 20 meg hard disk drive.

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VERSATILE FUNCTION GENERATOR

JOHN WANNAMAKER

THERE WAS A TIME WHEN A SIMPLE SINE OR square wave signal was all that was needed to test electronic equipment. Today, we need many more kinds of test signals, as well as specific control over such things as their duration, shape, and duty cycle. Basically, what's needed is a laboratory-grade multifunction signal generator, such as the one described in this article. Using readily available parts, the signal generator provides a square wave output, with simultaneous triangle, and sine wave outputs; it can also supply variable duty-cycle pulses and a more-or-less conventional linear-sawtooth ramp.

All outputs have level controls, and the sine/triangle function makes provision for a fixed amount of attenuation. There's also a front-panel OFFSET control for the sine and triangle waveforms that provides ±1.5 volts into a 600-ohm load, or 3 volts into an open load. Other waveforms are unipolar and may be used with CMOS and TTL circuits.

The variable duty-cycle output pulse, which has a timing value of 1–50 ms can sink more than 20 TTL loads. The linear output ramp is similarly variable. A built-in frequency counter monitors the output frequency using four decaded ranges of 100, 1000, 10,000, and 100k Hz.

Although the time-base accuracy and stability of the internal counter are exceptionally good, it would be fairly easy to add an external jack that switches out the internal monitoring and accepts a signal from the outside world. A 0–1-volt pulse is adequate input from 5 Hz to 2 MHz, but the four-digit counter and display can only handle up to 99.99 kHz.

The circuits

The signal generator is divided into three sections: (1) the sine/triangle/square wave generator; (2) the counter; (3) the pulse/ramp.

As shown in Fig. 1, IC3, an Exar *XR2206* Function Generator integrated circuit, provides the sine, triangle, and square waves. Normally, IC3's frequency adjustment is a 0.2–2-megohm variable resistor connected from pin 7 to ground, but that kind of adjustment often proves to be critical because only conventional single-turn potentiometers are normally available in such large values. In our prototype, however, the *XR2206* is used as a voltage-controlled oscillator, and frequency-adjustment control R25 is a 10K 10-turn potentiometer. Adjusting the output frequency to within one cycle out of a thousand takes only a modest degree of dexterity.

Values other than 10K may be used if fixed-resistor R16 is changed. For a 2K potentiometer, R16 = 4.7K. For 5K, R16 = 20K. For 20K, R16 = 82K. Try to stay within that range, or the low-frequency adjustment trimmer may become ineffective.

The sine/triangle circuit is also unusual in that, unlike some commercial circuits, attenuation switch S3 affects only the signal amplitude and not the value of any offset voltage. You decide how much fixed attenuation the circuit is to have (up to -20 dB; a 10:1 voltage ratio) by making R26 larger than necessary, and then trimming its value by connecting another fixed resistor (R27) in parallel. If that method is too cumbersome, the two resistors can be replaced by a multi-turn trimmer resistor. (Although the trimmer is more costly, it's a great deal easier to use.)

Output impedance

A sine or triangle output is selected by switch S2. Emitter-follower Q8 has an output impedance of about 20 ohms, which can supply a 1.5-volt p-p waveform into an 8-ohm speaker, or about twice that amount into 16 ohms. That holds true from 10 Hz to frequencies that are far above the audio range. (It's important to adjust for zero offset if testing speakers in that manner.)

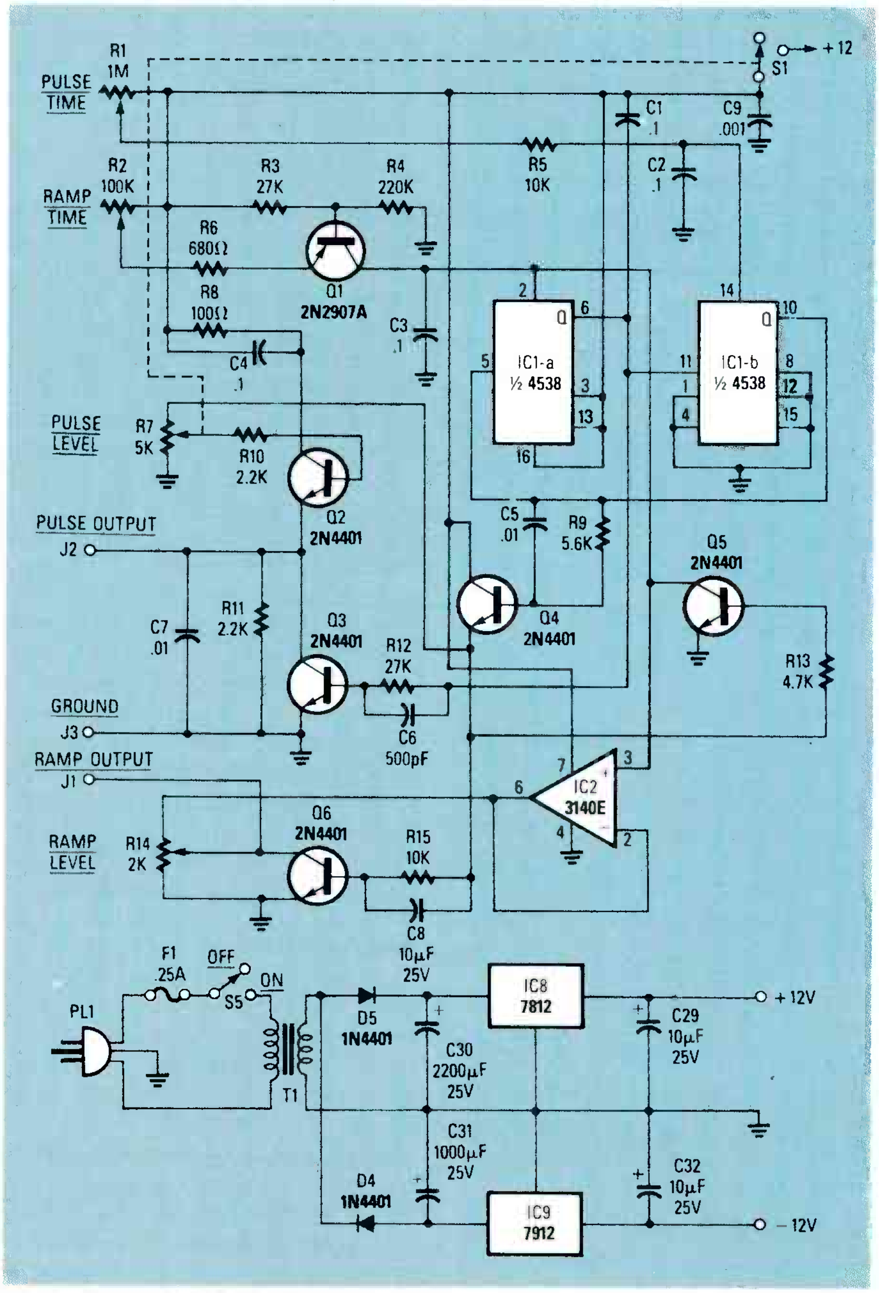

FIG. 3—THE RAMP/PULSE SECTION can be disabled by switch S1, which is part of PULSE-LEVEL control R7.

in a different way might increase noise on the sine-wave output.

Since the sine-wave output can be adjusted to a very low level, it is important to minimize the resident noise level on the output line. The use of wide foil in the power-supply circuit, plus a short length of hookup wire used as a supplemental ground bus, keeps powerline-related noise to about 200 µV p-p. We found that grounding the resistor in the OFFSET circuit to the front panel instead of to the ground foil on the PC-board made a significant reduction in random noise, again proving that all grounds are not equal. Noise spikes caused by the counter's multiplexing (or pulse transitions) are suppressed by either removing power or reducing power to the offending area. The counter/display current is reduced by one section of attenuator-switch S3. Although that causes the readout to dim, it is still usable. The pulse/ramp circuitry may be switched off entirely by switch S1, which is part of PULSE LEVEL control R7. The overall noise is about 250 µV p-p into a 600-ohm load, and about twice that value into an open circuit.

Low distortion

The sine-wave output's harmonic distortion can be reduced to as little as 0.5% by adjusting trimmer potentiometers R18 and R19. However, the sine-wave output also contains a low-level distortion that appears in the form of a tenacious little blip that appears near the peaks of the sine and triangle waveforms during the transitions of the square wave. Although hardly noticeable when the sine-wave amplitude is high, the blip refuses to lose amplitude at the same rate as the sine wave when the sine-wave output level is reduced. Capacitors C18–21 minimize that blip to about 0.5-µs duration, and to a peak amplitude of 400 µV.

The user can very nearly eliminate the blip altogether by adding capaci-

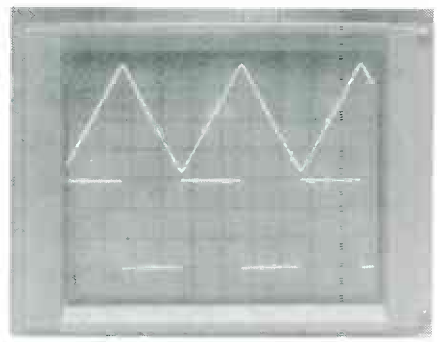

FIG. 4—THE SQUARE AND TRIANGLE WAVEFORMS are simultaneously available at independent output jacks. Note that the waveforms are in-phase.

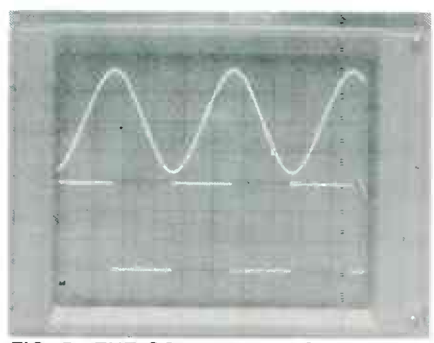

FIG. 5—THE SQUARE AND SINE WAVEFORMS are also in-phase and simultaneously available at independent output jacks.

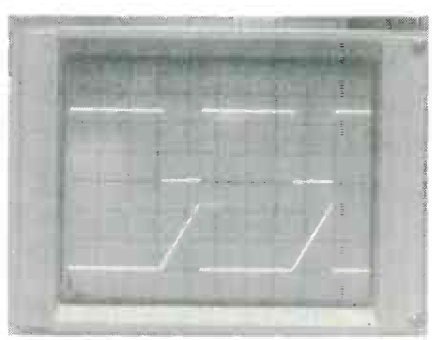

FIG. 6—THE RAMP OUTPUT OCCURS during the negative-going part of the square-wave's duty-cycle.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—1 megohm, linear potentiometer
R2—100,000 ohm, linear potentiometer
R3, R12, R30—27,000 ohms
R4—220,000 ohms
R5, R15, R21, R22, R32, R55—10,000 ohms
R6—680 ohms
R7—5000 ohm, potentiometer with switch
R8—100 ohms, 2 watts
R9—5600 ohms
R10, R11—2200 ohms
R13, R43–47—47000 ohms
R14, R23, R28—2000 ohm, linear potentiometer
R16—33,000 ohms
R17—10,000-ohm trimmer potentiometer
R18—500 or 1000 ohm, trimmer potentiometer
R19—50,000 ohm, trimmer potentiometer
R20, R57—1000 ohms
R24—9100 ohms
R25—10,000 ohms, 10-turn potentiometer (see text)
R26, R27—selected, see text
R29—10,000 ohms, linear potentiometer
R31, R59—47,000 ohms
R33—22,000 ohms
R34—50,000 ohms, trimmer potentiometer
R35, R52, R54, R56, R58—100,000 ohms
R36—27,000 ohms
R37, R38—1500 ohms
R39–42, R49–51—150 ohms
R48—100 ohms
R53—10 megohms
R60—330 ohms

Capacitors
C1, C4—0.1 µF, ceramic disc
C2, C3—0.1 µF, Mylar
C5, C7, C23—0.01 µF, ceramic disc
C6, C18, C20—500 pF, ceramic disc
C8, C24—100 pF, ceramic disc
C9, C10, C16, C17, C29, C32—10 µF, 25-volts, electrolytic
C11, C27—47 µF, 25 volts, electrolytic
C12—.001 µF, Mylar, 1%
C13—.01 µF, Mylar, 1%
C14—0.1 µF, Mylar, 1%
C15—1 µF,, 50 volts, electrolytic
C19, C21, C22, C28—.001 µF, ceramic disc
C25, C26—22 pF, ceramic disc
C30—2200 µF, 25 volts, electrolytic
C31—1000 µF, 25 volt, electrolytic

Semiconductors
IC1—CD4538 or MC14538 dual monostable
IC2, IC4—CA314OE op-amp
IC3—XR2206 function generator
IC5—74C926 counter
IC6—ICM7207A time base
Q1—2N2907A PNP transistor
Q2–Q15—2N4401 NPN transistor
D1–3—1N914 small signal diode
D4, D5—1N4401 silicon rectifier

Other components
F1—0.25-amp fuse
DSP1—NSB3881 Four-Digit display (National)
J1–J6—Insulated banana jack
J7—Miniature phone jack
PL1—Powerline plug
S1—SPST, part of R7
S2, S5—SPST switch
S3—DPST switch
S4—3–pole, 4–position rotary switch
T1—Power transformer; 117-volt primary; 12.6-volt, 1-amp secondary
XTAL1—5.24288-MHz crystal
Miscellaneous: PC-board, IC sockets, enclosure, wire, solder, etc.
Note: An etched and drilled printed-circuit board is available for $17 postpaid (includes postage and handling) from John Wannamaker, Route 4, Box 550, Orangeburg, SC 29115. South Carolina residents must add appropriate sales tax.

tance between the terminal and ground, although the cost of the extra capacitance is a rounding of the triangle-waveform's peaks. (With the built-in capacitors, that becomes objectionable only on the highest range.) The capacitance also causes 4-dB attenuation at 100 kHz. If that seems too stiff a price to pay for a clean low-level signal, simply remove the aforementioned capacitors, but expect a little rounding of the high-frequency triangle peaks anyway.

Since it is known that the square-wave output contributes significantly to the unwanted blip on the sine wave, the square-wave's output line should be kept short, and (it really hurts to say this) it should be shielded.

The 330-ohm current-limiting resistor for the counter section, R60, should be mounted directly between the terminals of the appropriate section of the DPST (or DPDT) ATTENUATE switch. Other front-panel mounted components are C20 (500 pF), which should be soldered across the outboard terminals of the SINE-LEVEL potentiometer, and C21 (.001 µF), which should be soldered between the SINE output jack and the nearby front-panel GROUND jack. (Separate GROUND jacks should be provided for the pulse/ramp signals and the sine/triangle signals.)

If the SINE output is to provide maximum current, wire it directly to its PC-board solder pad. If a 600-ohm output is desired, use a string of ¼-watt resistors with a nominal resistance of about 580 ohms in place of the direct wire connection. When the resistance value is just right, an open-circuit sine wave of any value will drop to exactly half of that value when a precise 600-ohm load is connected between the SINE and GROUND jacks.

Even though the PC board has two foils connecting the power-supply ground to the long ground foil on the "output" side of the board, there is sufficient inherent impedance to create some hum at the SINE output. To minimize the induced hum, solder a short—approximately 3 inches—insulated jumper between the ground foils, under the board. Solder one end to the wide foil where C30 is grounded; solder the other end to the foil near the two ground pads on the opposite side of the board.

Mounting

Each corner of the board has room for a 4–40 machine screw mounting hole. Be careful to not let a metal spacer under the board short to a nearby foil; or even better, use insulated spacers. It would be wise to pass the screws through the bottom of the cabinet so that the retaining nuts are on top of the board.

The LED-display assembly can be held in place by either 2–56 or 4–40 machine screws that extend through the front panel on each side of the display. They should pass through some kind of improvised insulated retaining bar across the back of the display. Take care, when installing the display, that its solder terminals do not short to the panel. Since the recommended display has a built-in red filter, no additional filter is necessary.

When mounting the power transformer, make provision for two lugs under one of the mounting screws.

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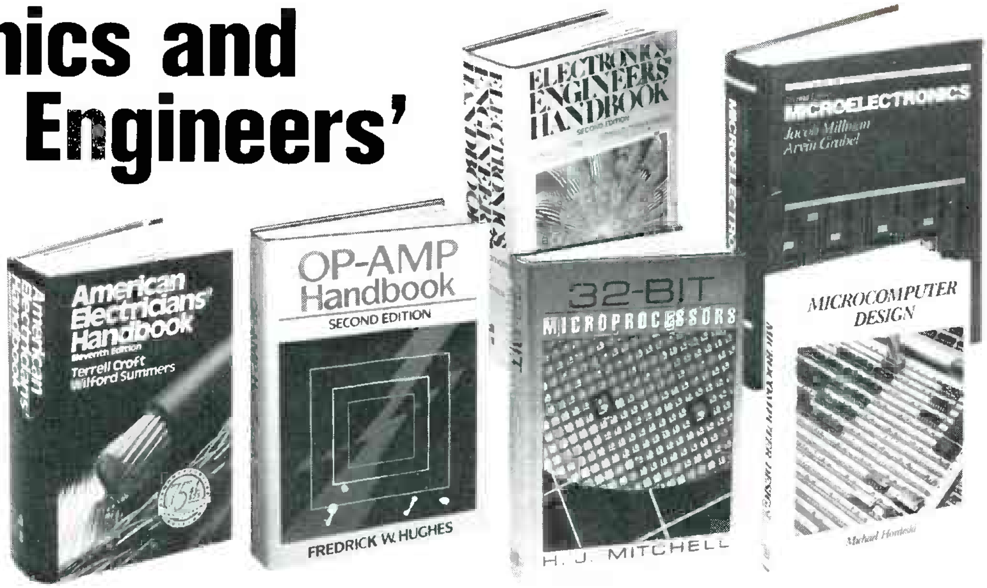

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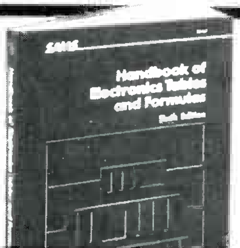

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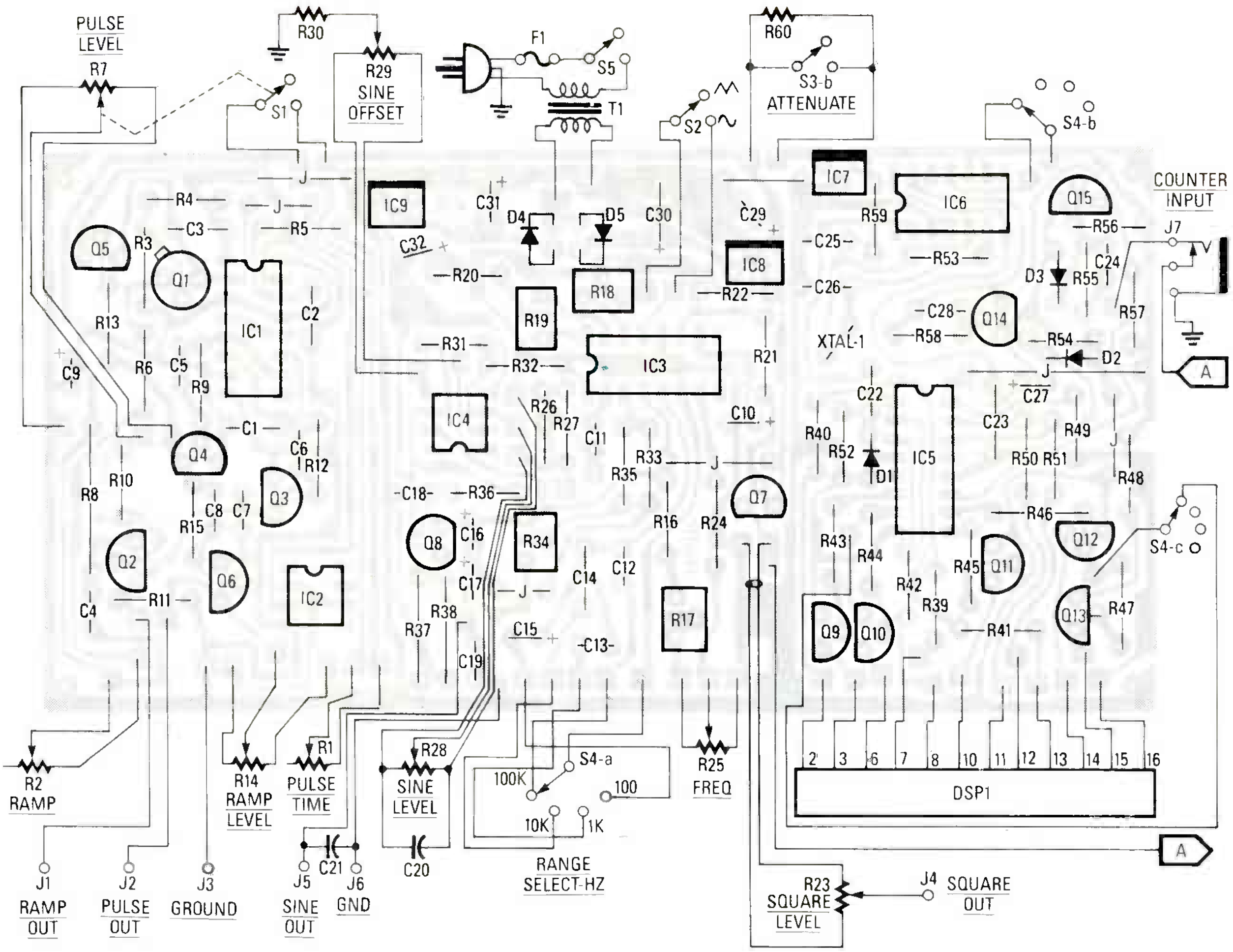


FIG. 7—THE PARTS PLACEMENT FOR THE PRINTED-CIRCUIT BOARD. Notice that not all of the 16 connections on display DSP1 are used.

Attach one to the green ground wire of the three-conductor line cord. The other should attach to an insulated wire to the PC-board's ground in the power-supply area. That has to be brought out from beneath the board and may be fairly long to allow the board to be turned over. Use stranded wire for its flexibility.

Jack J7, which is shown in Fig. 2, is needed only if you want to be able to measure the frequency of an externally generated external to the signal generator. If the feature isn't needed, using Fig. 4 as a reference, simply eliminate the jack and connect the wire going to J7's "hot" terminal to the PC-board terminal having the A-flag, which actually is a connection to the top of R23.

Checkout

Don't install the IC's. Begin with the soldered-in voltage regulators. Using an oscilloscope, check each power source for proper voltage and polarity. Looking at the plastic front of the regulators, the rightmost pin is the regulated output of both the positive and negative units. There should be no ripple. If everything checks out, unplug the power cord and let the voltages decay before inserting any IC's.

Plug in the IC5 and IC6 and apply power. The display should indicate 0000 for the three lowest frequency positions of the range switch, and 00.00 for the highest position. If counter is set for SINE ATTENUATE, the display will be very dim. Without any attenuation all digits will be bright.

A single dim digit can be due to insufficient multiplexing drive; check the 4700-ohm resistors at the bases of Q9–Q13. If the same segment of all digits is dim or will not light, check connections through to the display, particularly the 150-ohm resistors. At this point, of course, the middle bar cannot light. Once checked out, unplug power and allow time for voltages to decay.

To check out and adjust the sine/triangle/square circuit, initially adjust all trimmer resistors and the front-panel potentiometers to mid position. The FREQUENCY control should be rotated five turns into its range. Select the highest frequency range with the RANGE switch and turn off any attenuation. Insert IC3 and IC4, then apply power. The counter should indicate a frequency of approximately 40 kHz. If not, check pin 11 of IC3 with an oscilloscope: You should measure a 12-volt square wave, which means that the IC is oscillating. Trace the signal through to the counter's input. If no problem is found along the route, the problem is most likely to be in the counter.

Adjust the FREQUENCY control to observe that the readout changes, updating every 0.2 seconds (2 seconds on the three lower ranges). Adjust for the lowest frequency on a particular range. Observe the readout while adjusting the low-end trimmer, R17, for a reading of approximately 9.40 kHz. You can then check each range for at

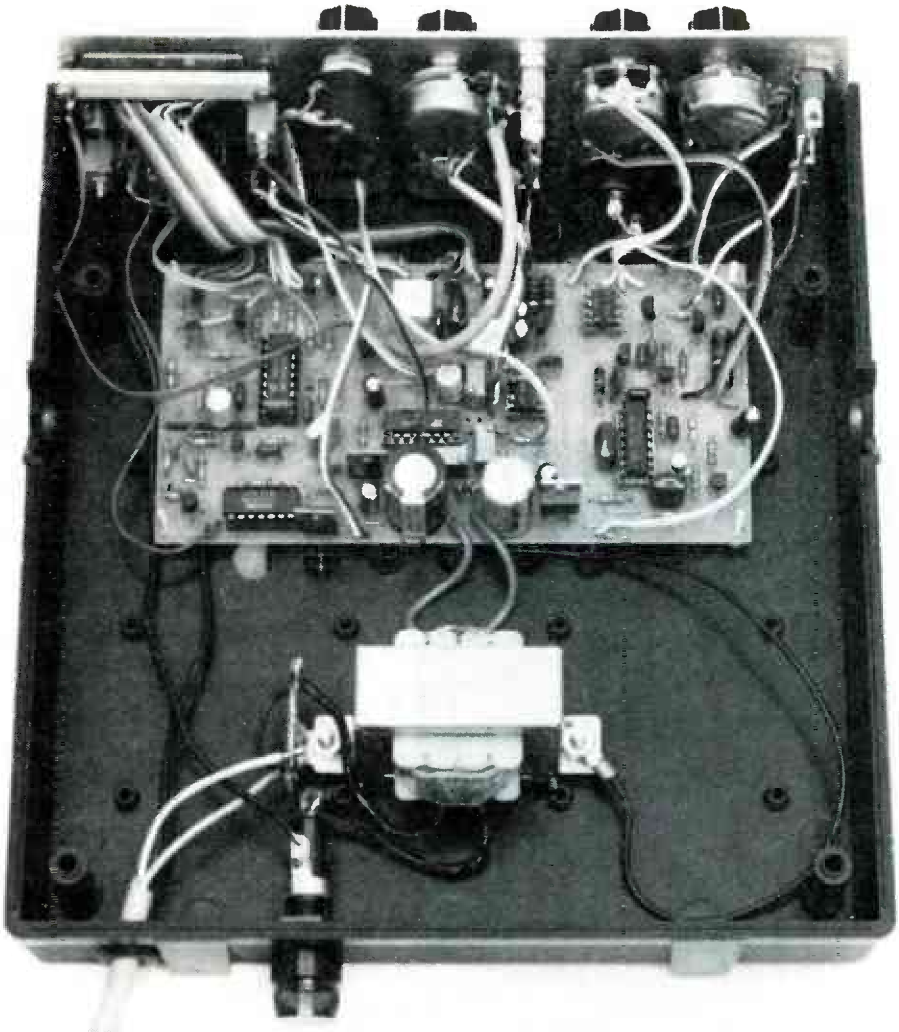


FIG. 8—THE COMPLETED PROTOTYPE. To reduce the possibility of hum pickup, the power transformer, T1, is located a considerable distance from the printed-circuit board. The ribbon cable at the upper left connect the display unit to the PC board.

least a 1:10 frequency variation: 10 Hz to 100 Hz; 100 Hz to 1000 Hz, etc. Of course, where a five-digit figure is given, the most significant digit is missing from the display. Correct the adjustment of R17 on any range that does not go down to, or below, the expected low value. If the highest range will not quite reach 100 kHz, it will be due to stray capacitance that parallels C12. You might try finding a capacitor with a slightly lower value, but a quick fix is to insert a 470-ohm resistor at the RANGE switch in series with the wire from S4 to C12.

Use the scope to check the square-wave output at J4. The SQUARE LEVEL control should vary the amplitude from near zero to 10 volts p-p. If there is a problem, trace the signal from pin 11 of IC3.

Set the frequency to 1000 Hz and select the triangle waveform. Observe the output at the SINE OUTPUT, J5. Adjust the SINE-LEVEL control for minimum (zero) output. Set the scope for measuring 2-volts DC per division and a time base of 0.2-ms/division. Position the trace so that the zero-volt line is across the center of the CRT. The front panel OFFSET adjustment should be able to create a variable output of approximately ±3 volts.

Adjust the SINE-LEVEL control to mid-position and check for a triangle-like waveform of approximately 8 volts p-p (no attenuation). Either the top or the bottom of the waveform may be clipped. Adjust the internal OFFSET trimmer potentiometer, R34, to remove the clipping. Continue increasing the sine level and adjusting R34 until you get the maximum non-clipped waveform. A clean 16 volts p-p should be possible.

Sine shaping

Select and observe the SINE output. When the sine-shaping adjustments are completed, the sine wave's amplitude will be about half of that of the triangle wave. Shaping trimmers R18 and R19 interact, so alternate between the two until the scope displays the best shape. Consider that a perfect sine wave has equal areas above and below the zero line, and both peaks should have the same amount of rounding. Low distortion is definitely possible and if not attained, check your circuit, especially for improper trimmer values.

If you substitute a trimmer potentiometer for attenuating resistors R26 and R27, make the adjustment this way: With no attenuation, adjust the front panel SINE-LEVEL control for an output of precisely 8 volts p-p. Switch the attenuation in and adjust the trimmer potentiometer for whatever loss you want, up to −20 dB (10:1).

If you decided to use the fixed attenuating resistors, then solder in a value for R26 based on the following: 4.7K = −6 dB (2:1), 10K = −12 dB (4:1), 27K = −20dB (10:1). Resistor R27 is used as a fixed-value trimmer to bring the attenuation more nearly on target, and its value is either selected by trial and error, or it is "empirically" selected, depending on your particular view of reality. Start with a value ten times that of R26. The trimmer resistor must be tack soldered in place when determining its value to avoid introducing hum.

The ramp

The remaining task is to check out the pulse/ramp circuit. Unplug the unit's power cord, insert IC1 and IC2, and set all pulse/ramp controls to mid range; then apply power.

View the pulse output at J2 with the scope's time-base initially at 20-ms/division. The pulse amplitude should be more than 3 volts p-p.

The PULSE-LEVEL control should allow varying the amplitude from near zero to more than 7 volts p-p. The PULSE-TIME control should vary the pulse width from 1 ms to more than 50 ms. The RAMP-TIME control determines the pulse's off time.

Observe the ramp output at J1. The RAMP LEVEL varies the ramp output from zero to +7 volts. The RAMP-TIME control adjusts the duration of the ramp, which is equal to the off-time of pulse output. Switch S1, which is part of the PULSE-LEVEL control should kill both the pulse and ramp outputs. **R-E**

Build REACTS: THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

This month, we add a way to store your programs and data.

H. EDWARD ROBERTS, M.D.

Part 4 LAST TIME, WE promised to show you a battery back-up system for the REACTS system. Well we will—but not this month! Instead, we will show you a powerful high-speed semiconductor-disk system for the control computer. That module will allow us to expand the size of our disk storage from the 20K provided by the CPU board to virtually any size desired, and to add read/write (RAM) storage to the disk system. And best of all, it will operate at speeds that are up to 1000 times faster than magnetic-disk systems.

Using semiconductor disks

To the computer programmer/user, semiconductor disks are manipulated in the same way as floppies or hard drives. That is, all commands that are used with floppies or hard drives (DIR, ERA, etc.) work the same way with semiconductor disks, only much quicker.

For many reasons, semiconductor memory is ideal for process-control applications. It is low in cost compared to magnetic storage, except for applications requiring huge amounts of memory. It is much more tolerant of temperature and vibration extremes than magnetic memory. Power consumption is only a fraction of what typical magnetic-disk systems require. The size of a small semiconductor-disk system is much less than that of a conventional disk drive. The only real disadvantage of that type of disk is that the read/write portion of the disk is volatile; that means that it must be powered continually. That's really not much of a problem, and it can be made even simpler when you build the battery-backed switching power supply that will be discussed in a future article. For now, it only means that you will have to keep your computer powered up if you want to save the contents of the RAM memory permanently.

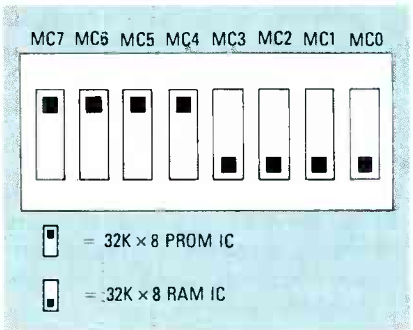


FIG. 1—THE SYSTEM IS CONFIGURED for RAM, PROM, or a combination of memory IC's using an 8-position DIP switch, S2.

The soft/hardware concept that we previously introduced is very evident in this module. For instance, you can configure the system to appear as 1 to 8 disk drives by simply setting switches on the back of the module. Also, multiple modules may be combined to increase the size of a single disk to over 2 megabytes. Any number of disks may be added to the system. By leaving out memory IC's, the cost of the disk system can be minimized in cost-sensitive applications. Once the hardware is customized as desired, the operating system can be changed using a configuration utility (more on that shortly). That will provide a truly customized system.

The REACTS drives

The PROM/RAM disk portion of this month's module provides 256K of PROM and/or RAM space. It contains 8 IC sockets into which either 32K RAM or PROM IC's can be inserted; any 32K × 8-bit RAM or PROM can be used. You let the system know which type of memory each socket location contains by setting a DIP switch. As shown in Fig. 1, a PROM/RAM location is configured for a PROM if its corresponding switch is up, and configured for a RAM if the switch is down.

Throughout the rest of this article, we will refer to the disk system as a drive or drives. That allows us to follow the accepted convention used in most operating systems. For instance, the first floppy in a conventional PC is known as drive A: and the hard disk is usually labeled drive C. Our system will support up to 16 drives, identified

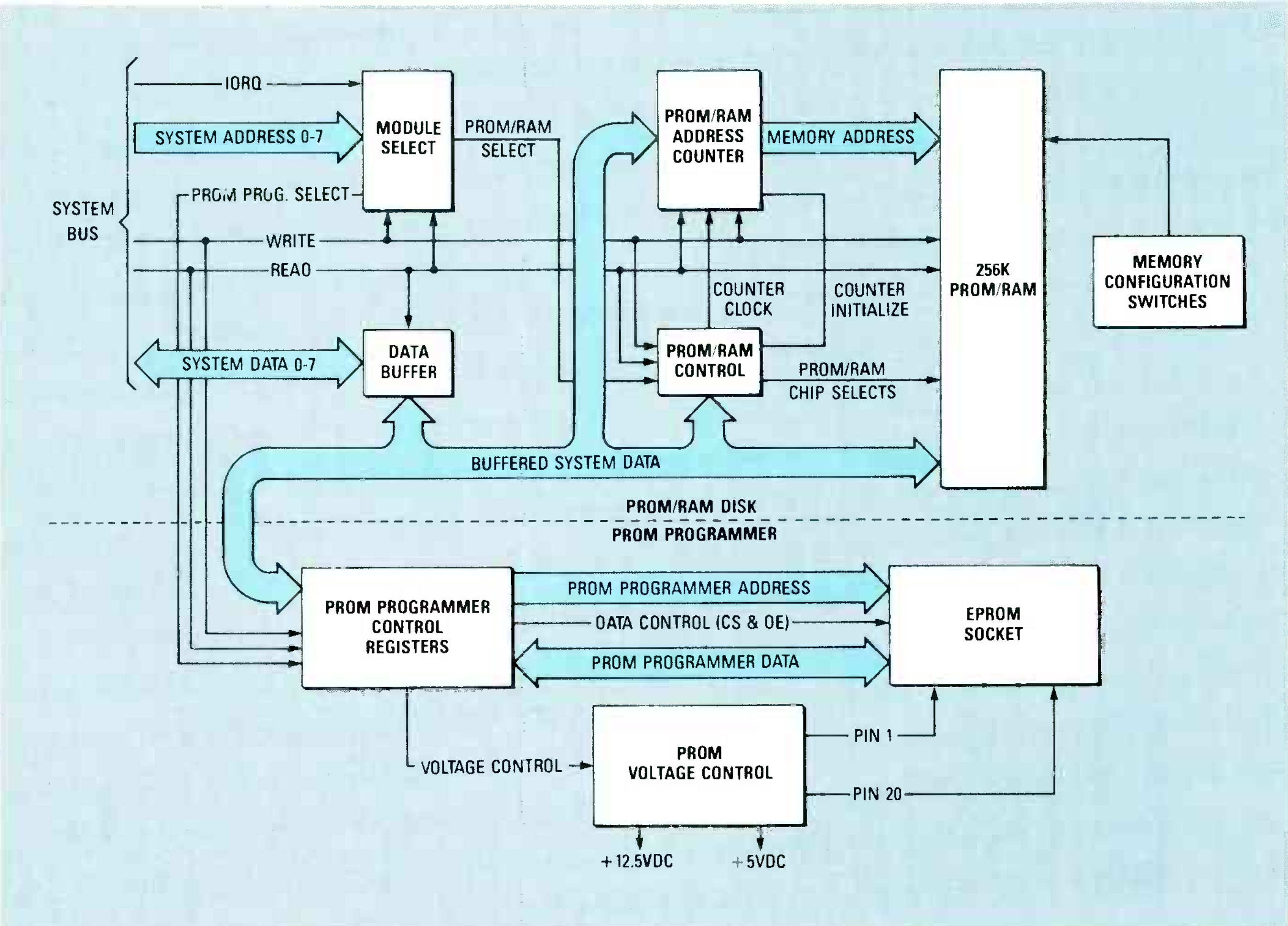


FIG. 2—THE PROM/RAM DISK and optional PROM Programmer are shown here in block-diagram form.

as drives A:–P:. Further, the REACTS operating system has been designed to divide the PROM or RAM disks into tracks and sectors, with each track made up of 8 sectors of 128 bytes each. That compares with the tracks and sectors of a floppy or hard disk.

Certain drives are reserved by the system for special operations; specifically, drive P: is reserved as the boot drive on the CPU. Future articles will provide the information necessary to add floppy and hard disk drives to the system. Those drives will be labeled in exactly the same manner. Indeed, a random mixture of floppies, hard disks, RAM and PROM disks is perfectly satisfactory from the system's standpoint.

It is not necessary to have all of the PROM or RAM space of a module designated as one drive. Up to 8 separate drives may be specified on one module; the only constraint is that the memory allocated to each drive must be a multiple of 32K (the size of a single memory IC). As an example, you could configure the system to have 128K of PROM memory set up as drive A: and 128K memory set up as drive B:. Another option would be to have two 64K drives of PROM and two 64K drives of RAM; the four could be designated as drives A:, B:, C:, and D:, where A: and B: would be RAM drives and C: and D: PROM drives.

It is even possible to have eight different drives on one PROM/RAM module, each containing 32K of PROM or RAM memory. At the other extreme it is possible to have more than two megabytes of PROM or

Sources

The following items are available from DataBlocks,Inc.,579 Snowhill Road, Glenwood, GA. 30428; 800 652-1336 (in Georgia call 912 568-7101

DP-P/R/PP: Design package of schematics and instructions; $10.00

PC-P/R/PP: PC Board for PROM/RAM/PROM Programmer module, includes design package; $37.00

PROM/RAM: Complete set of parts, PC board, IC's for PROM/RAM portion of module (excluding PROM and RAM memory IC's); $114.00

PROM PROG: Parts needed to add PROM Programming capabilities to module; $59.95

MEMORY IC's: 32K × 8 bit UV EPROM's; $10.50. 32K × 8 bit RAM IC's $12.50.

SOFTWARE: Software is available on UVEPROMs as well as on 5¼-inch floppies for downloading from an IBM PC, XT, AT or compatible. Please call for prices on the different software packages.

Other REACTS systems and components are available; please call for information and prices.

Please add $10 shipping and handling per order. Georgia Residents must add sales tax.

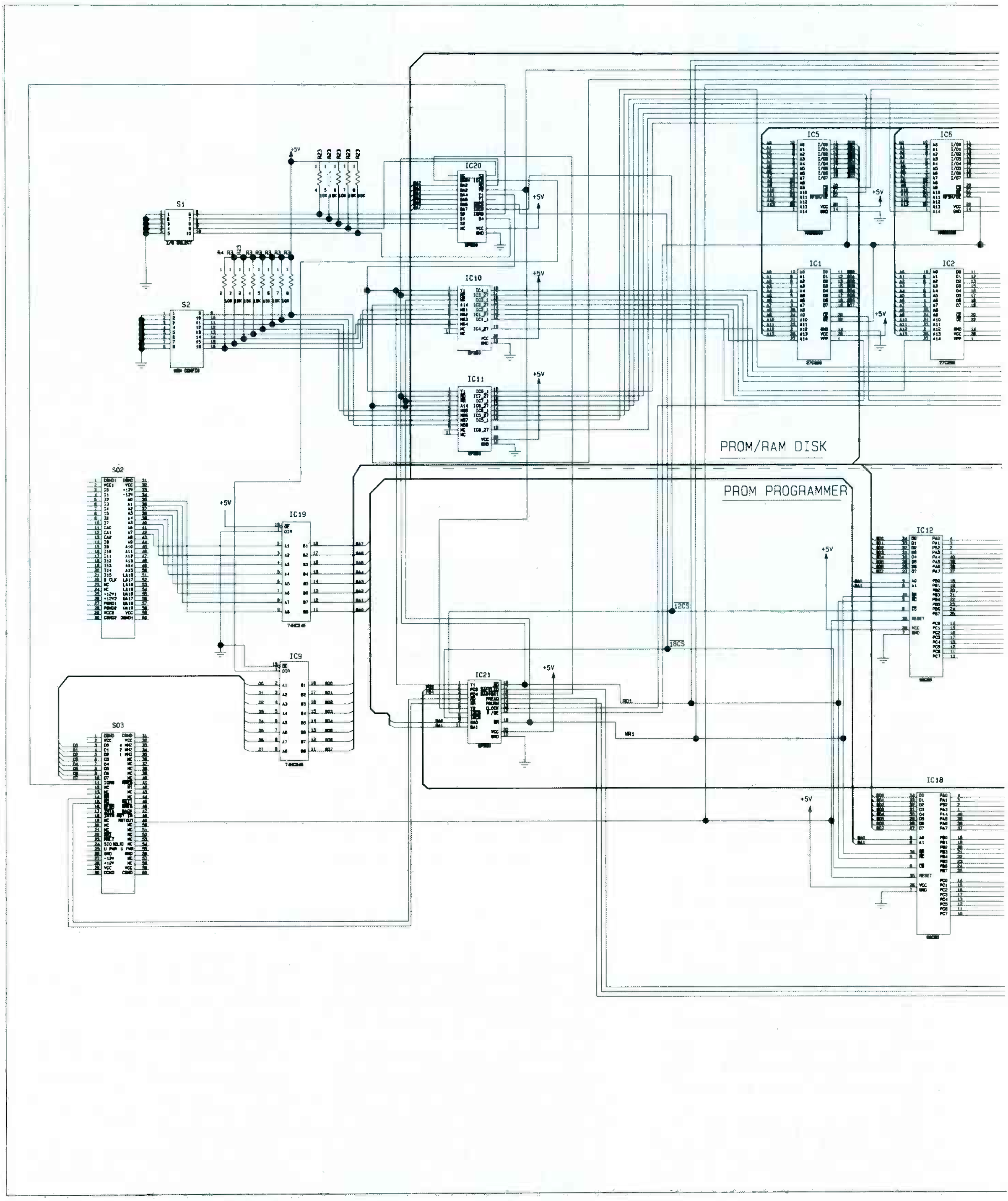
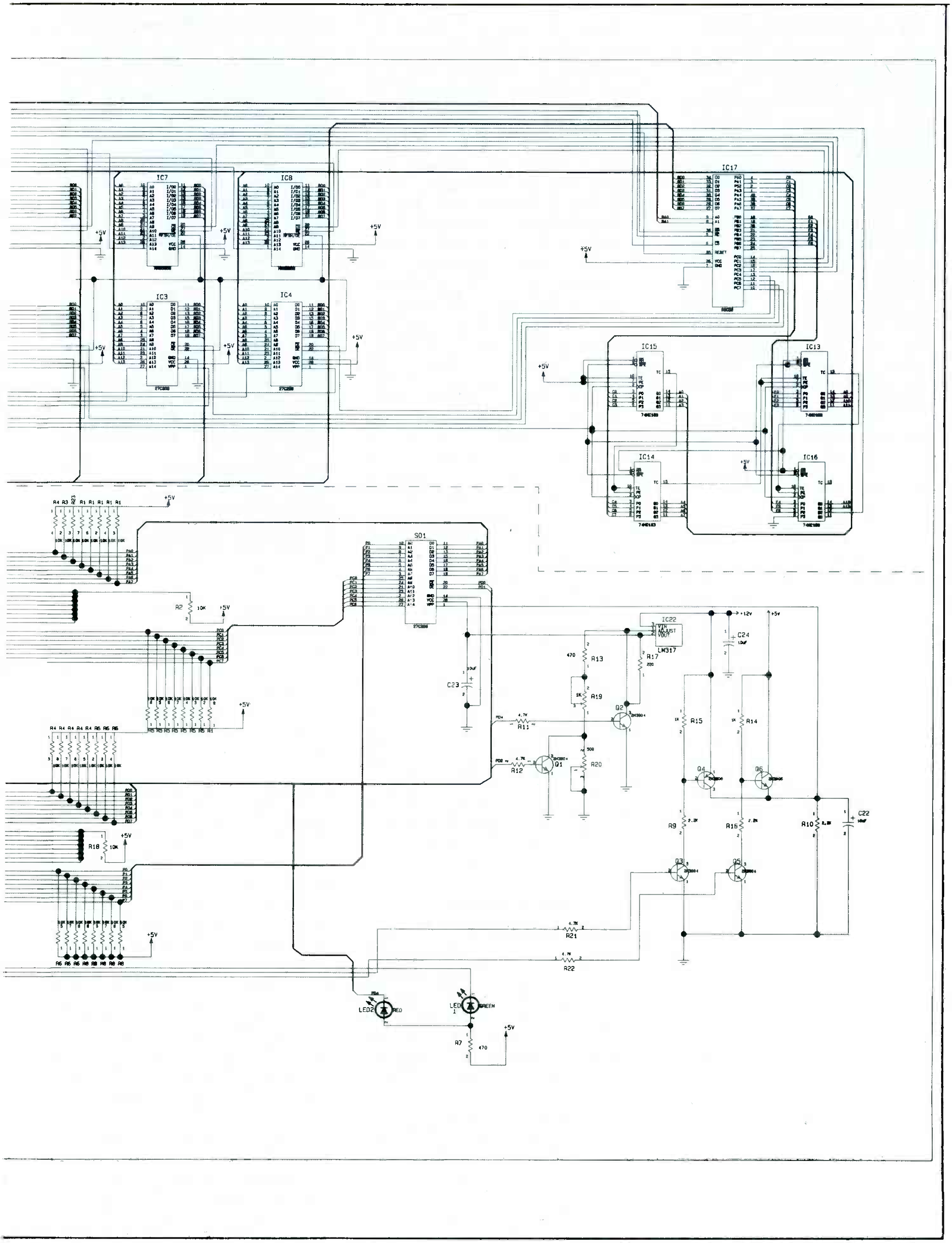


FIG. 3—THE MODULE'S CIRCUIT DETAILS are shown in this schematic.


IC7
IC8
IC17
IC3
IC4
IC15
IC13
IC14
IC16
S01
IC22
LM317
+5V
+12V
R2
R7
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
C22
C23
C24
Q1
Q2
Q3
Q4
Q5
Q6
LED2
RED
GREEN

Parts List—PROM/RAM Drive

All resistors ¼ watt, 5% unless otherwise noted
R3, R4, R23—10,000 ohms, 10-into-1 SIP
R7—470 ohms
Capacitors
C1–C11, C13–C17, C19–C21—0.47 μF, ceramic disc
C25—47 μF, 16 volts, electrolytic
C26—47 μF, 10 volts, electrolytic
Semiconductors
IC1–IC8—32K × 8 RAM or EPROM, see text
IC9, IC19—74HC245 octal three-state transceiver
IC10, IC11, IC20, IC21—Programmable array logic IC's, custom components, see text
IC13–IC16—74HC163 synchronous binary counter
IC17—82C55 programmable peripheral interface
D2—Red LED, right-angle PC-mount
Other components
S1—5-position DIP switch
S2—8-position DIP switch
SO2, SO3—60-pin male and female bus connector set
Miscellaneous:PC board, IC sockets, hardware, case, wire, solder, etc.

RAM memory configured as one drive. In that case, each module is only ⅛ of the total drive (8 PROM/RAM disk modules times 256K per module = 2048K). The ability to custom design the PROM/RAM configuration of the disk drives fits in nicely with the concept of soft-hardware in that it allows the user to select the optimum disk size for a particular application.

(As discussed in the Feb. 1988 installment, soft-hardware is system hardware that can be changed as easily as software.)

After setting the memory configuration switches and installing the correct memory IC's (RAM or PROM) into their appropriate sockets, the operating system must be "told" about the current configuration of disks. The REACTS operating system handles that with a configuration utility called CONFIG. If the new configuration is to be permanent, which will usually be the case, it should be "burned" onto a boot PROM, using the PROM programmer, and that PROM then placed in the appropriate socket on CPU-module board.

PROM/RAM disk operation

Referring to Fig. 2, a block diagram of the PROM/RAM disk and the optional PROM programmer, will help in following the discussion of the operation of the PROM/RAM portion of the module. Complete circuit details are shown in Fig. 3.

The REACTS CPU communicates with the PROM/RAM module via I/O ports. The system I/O ports used by the PROM/RAM module are user-selectable. The MODULE SELECT and PROM/RAM CONTROL blocks of Fig. 2 are implemented using PAL (*P*rogrammable *A*rray *L*ogic) IC's; those custom components are available from the supplier mentioned in the Sources box. PAL's are used in the PROM/RAM disk module, as they were in the CPU module, to reduce circuit cost and complexity. The I/O address of the module can be changed by resetting a 5-position DIP switch, S1. That allows you to use multiple PROM/RAM modules per system for greater storage capacity.

Basic operation of the PROM/RAM portion of the module calls for reading or writing to the correct PROM or RAM IC. That is done by the PROM/RAM CONTROL block. After selecting the correct type of memory IC (as determined by S2, the 8-position DIP switch previously discussed), the PROM/RAM ADDRESS COUNTER is loaded with the starting memory address of the file to be read, or in the case of a write to a RAM drive, the first unoccupied memory location. As each memory byte is read or written, the address counter is incremented to point to the next byte in memory so that that location can be read from or written to.

The PROM programmer

If you are going to make full use of PROM memory, you need some way to get your programs into them. To that end, we have included an PROM programmer on the PROM/RAM disk module. (In order to accommodate cost-sensitive applications, the programmer has been made optional and can be omitted where it is not needed.)

In addition to being able to program 32K UV EPROM's (*U*ltra *V*iolet *E*rasable *P*rogrammable *R*ead *O*nly *M*emory), the programming socket can be used as an independent disk drive. To the REACTS operating system, a PROM in the PROM programmer's easily accessible ZIF (*Z*ero *I*nsertion *F*orce) socket looks like a 32K disk drive. (The use of a ZIF socket allows you to insert and remove IC's many times without damage.) You will find that attribute to be a useful tool when developing software.

Parts List—PROM Programmer

All resistors ¼-watt, 5%, unless otherwise noted
R1, R5, R6, R8—10,000 ohms, 9-into-1 SIP
R2, R18—10,000 ohms
R9, R10, R16—2200 ohms
R11, R12, R21, R22—4700 ohms
R13—470 ohms
R14, R15—1000 ohms
R17—220 ohms
R19—1000 ohms, potentiometer
R20—500 ohms, potentiometer
Capacitors
C12, C18—0.47 μF, ceramic disc
C22–C24—10 μF, 16 volts, tantalum
Semiconductors
IC12, IC18—82C55 programmable peripheral interface
IC22—LM317 voltage regulator
Q1–Q3, Q5—2N3904 NPN transistor
Q4, Q6—2N3906 PNP transistor
D1—Green LED, right-angle PC mount
Other components
SO1—28-pin ZIF socket
Miscelaneous:PC board, IC sockets, 28-pin hi-rise socket, hardware, wire, solder, etc.

PROM-programmer operation

The PROM programmer programs EPROM's one byte at a time. Referring to the PROM programmer portion of Fig. 2, the address of the memory location to be programmed is placed on the PROM programmer's address bus and the data to be programmed is placed on the data bus. To do the actual programming, 12 volts is placed on pin 1 of the EPROM, 5 volts on pin 28, and the EPROM's CE (*C*HIP *E*NABLE) input is brought low for a specified period of time. After a location is programmed, the address is incremented and the next byte to be programmed is placed on the PROM data bus.

Reading an EPROM (or PROM) is essentially done in the same manner as programming one, except that 5 volts are placed on both pin 1 and pin 28, and both the CE and OE (*O*UTPUT *E*NABLE) pins are brought low. Once

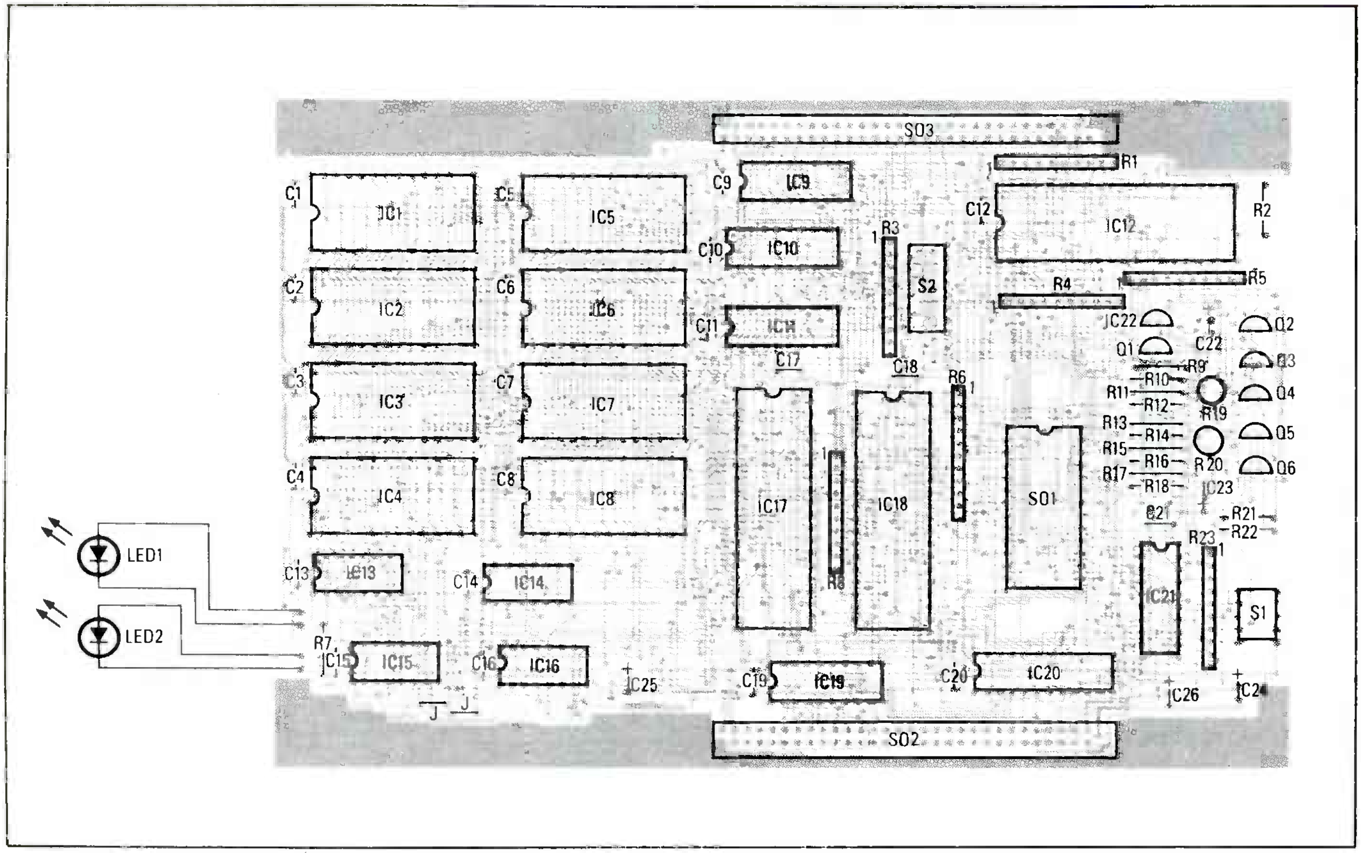


FIG. 4—CONSTRUCTION OF THE MODULE is fairly straightforward. Use this Parts-Placement diagram when mounting the components.

again, to keep circuit complexity and cost as low as possible, much of the programmer's circuitry is incorporated in a custom PAL. (That IC is available from the supplier.)

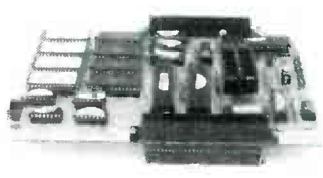
The REACTS operating system contains a utility called RBURN that makes programming EPROM's easy. That utility uses prompts to allow the user to select the file to be programmed, the drive that the file is located on, and the number of kilobytes to be programmed. In addition to burning EPROM's, the RBURN utility can be used to check an EPROM for complete erasure (i.e. to make absolutely sure that a PROM is blank before programming).

Two LED's are used by the module to display the state (idle or busy) of the PROM programmer. If the red LED is illuminated, the EPROM is either in the process of being burned or read and should not be disturbed. To avoid damaging the device, EPROM's should be placed in or removed from the programming socket only when the green LED is on.

When handling EPROM's, remember that they are CMOS components and all of the usual precautions regarding static electricity should be followed to avoid inadvertently zapping them. Also, be sure that any EPROM's are oriented correctly in the socket before attempting to burn or read them otherwise, the device may be damaged.

Building the module

Building the combination PROM/RAM disk and PROM programmer is basically a straightforward operation. Follow the parts-placement diagram shown in Fig. 4 when mounting the components. The pattern for that board can be found in PC Service; a pre-etched board is available from the supplier that is mentioned in the Sources box.



THE FINISHED PROM/RAM DISK. Note the ZIF socket near the center of the unit.

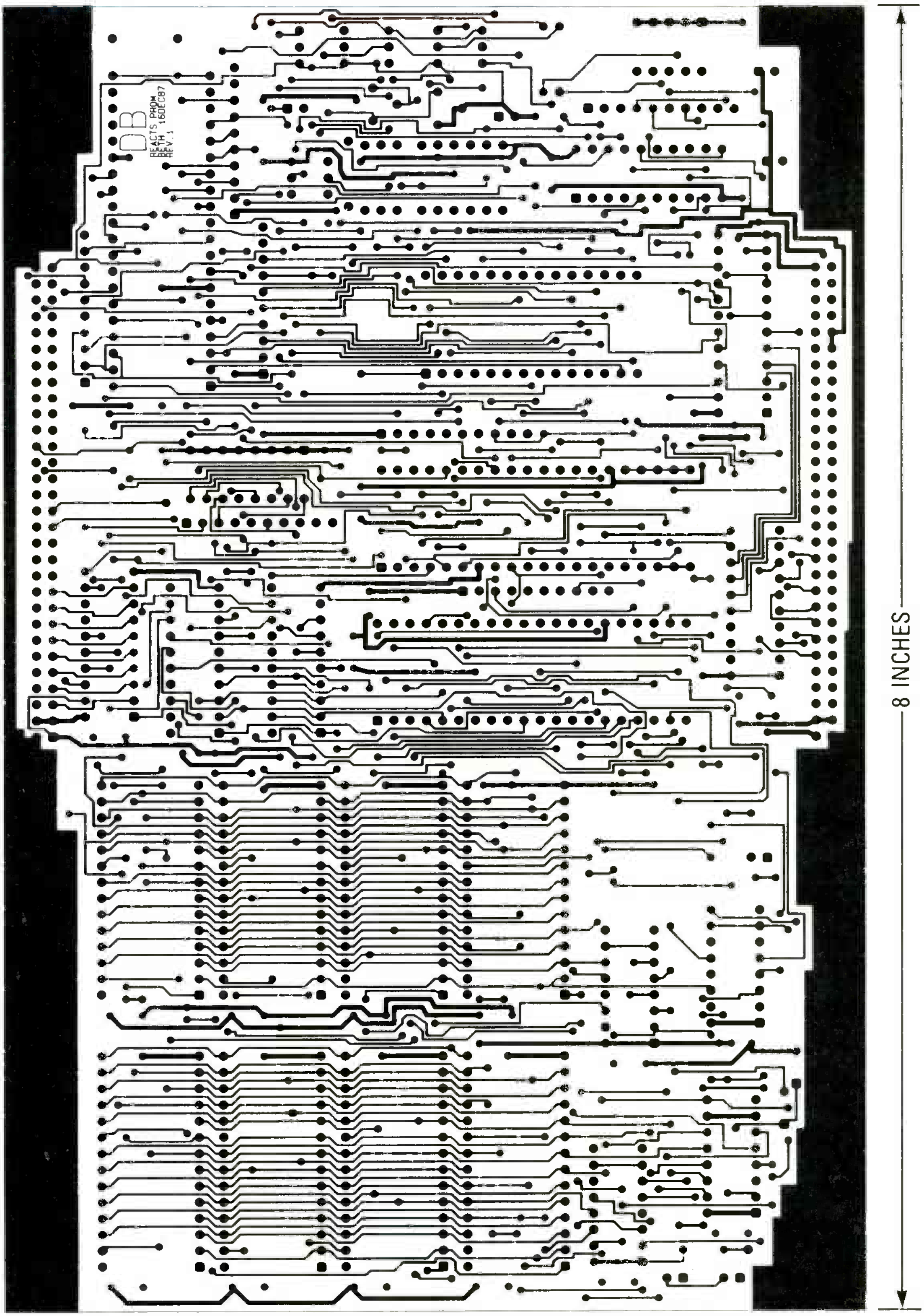
Be sure to observe the cautions outlined last time when installing the two 60-pin PC-board connectors. (Though they are rugged units once assembled, they can be easily damaged during assembly.) Also, take the usual precautions when handling the CMOS IC's. Finally, because we are putting so much circuitry in a small area, we have chosen to use *S*ingle *I*nline *P*ackage (SIP) resistors where applicable. Those are reasonably new components and you may not have used them before. However, SIP resistors are becoming more commonplace so they should not be to difficult to locate.

Software

Although we have not yet built any actual process-control modules, we can now start program development. We have a central processing unit, a means of communicating with it (a dedicated terminal or an IBM or compatible configured to act as a terminal; see the April issue for more on that), and at least one way of saving programs, that being the PROM-programmer/semiconductor-disk module. In order to create any programs

continued on page 82

PC SERVICE

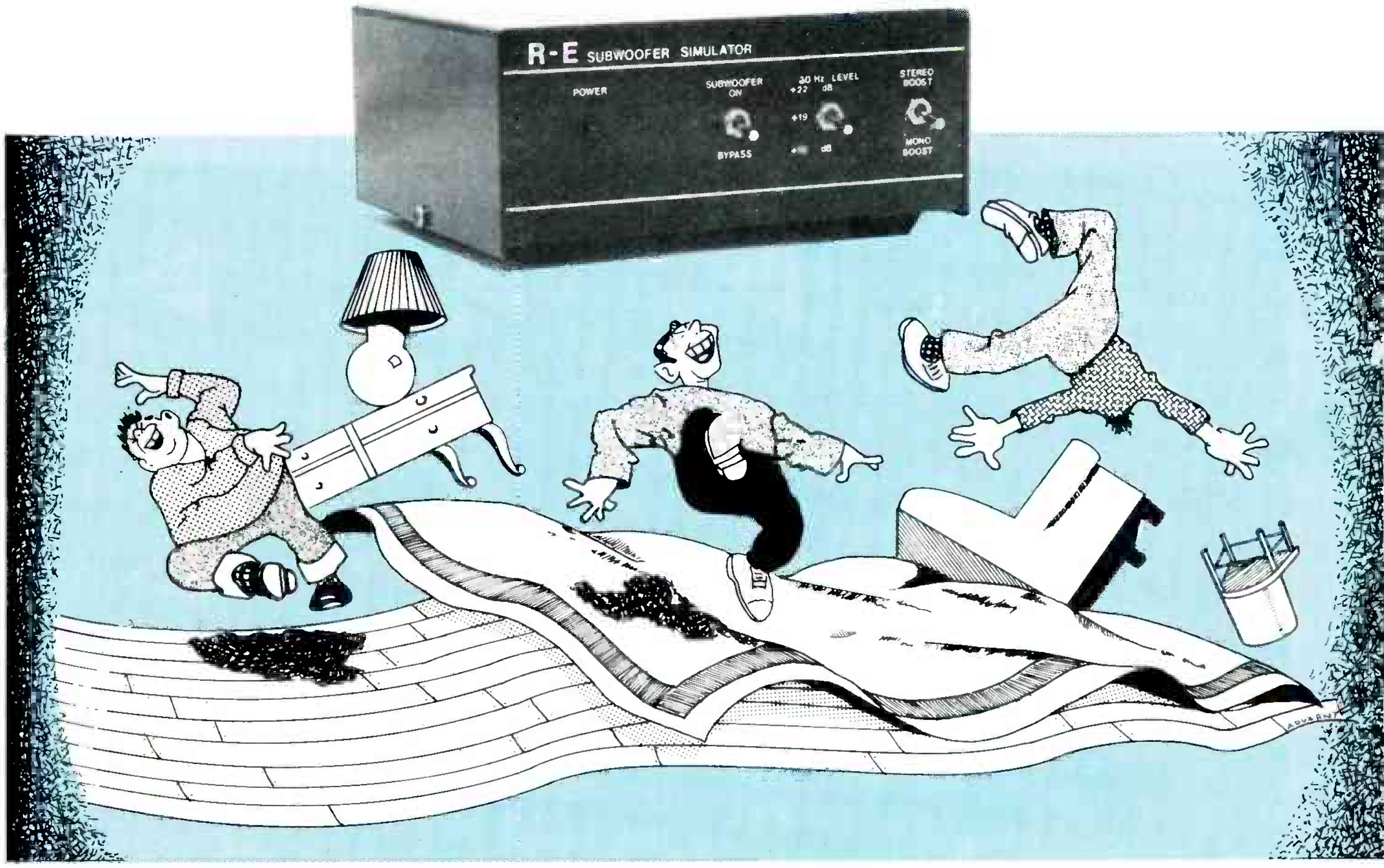


COMPONENT SIDE for the REACTS RAM/PROM Disk and PROM Programmer. The solder side will appear next time. See page 100 for more PC patterns.

BUILD THIS

SUBWOOFER SIMULATOR

NORM HILL



Build a subwoofer simulator and fill your living room with movie-theater sound you can actually feel.

A MOVIE THEATER CREATES REALISM BY projecting a large picture, using surround sound, and by extending the sound's low-frequency response with subwoofers so that the viewer can actually feel the special-effects. When a movie contains explosions, jet rumble, thunder, galloping horses, or other heavy-duty action, the subwoofer adds realism by literally shaking the floor.

Although it is generally accepted that a healthy ear can hear a frequency range of 20 Hz to 20 kHz, in fact, some of that range is not so much heard, but sensed. For example, many people cannot hear frequencies higher than 15 kHz, although they can sense that they exist. It's the same thing for frequencies in the deep-bass range of 20–50 Hz; many persons cannot hear frequencies within that range, although they can feel and sense them as vibrations.

In a theater, special effects are often exploited by enhancing the deep-bass frequencies, so that when the jets rumble, they rumble so powerfully that you can actually feel the runway vibrating under your feet. (And a flat frequency response ceases to be desirable once your feet become the listening transducers.) Below 20 Hz, sound is neither felt nor heard; at best there is a strange sensation of changing air pressure.

But although most people can perceive sounds in the 20–50 Hz range, because conventional woofers, even 12-inch and larger, roll off below 50 Hz, deep bass sounds are rarely heard unless some kind of deep-bass compensation is provided. The usual solution to providing deep bass in both theaters and the home is to add a monaural subwoofer that is driven off the front channels by an active filter and a separate amplifier.

Not that perfect

Unfortunately, there are some drawbacks to using a monaural subwoofer. It is commonly assumed that deep-bass information has such a long wavelength that it will be summed by the room to a mono signal, and that therefore a single transducer can be

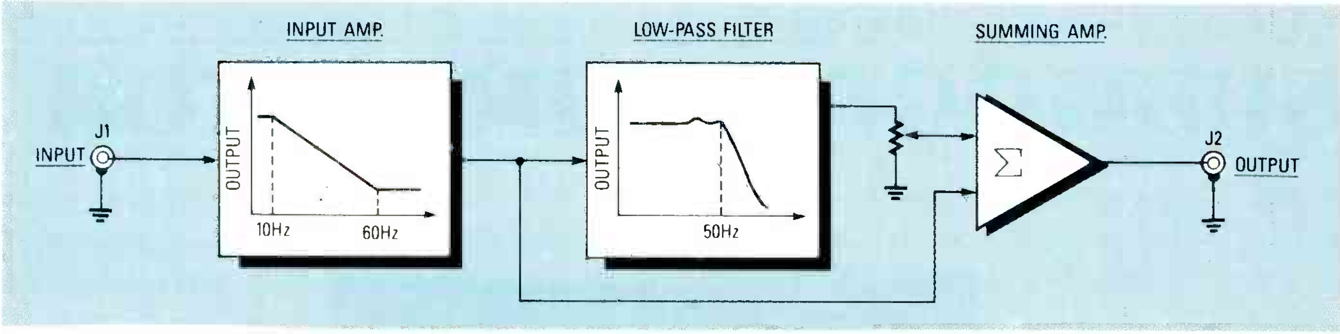


FIG. 1—TO ENSURE THAT ONLY THE DEEP-BASS FREQUENCIES are enhanced, the simulator's first stage amplifies the frequencies below 60 Hz before the low-pass filter attenuates all signals above 50 Hz.

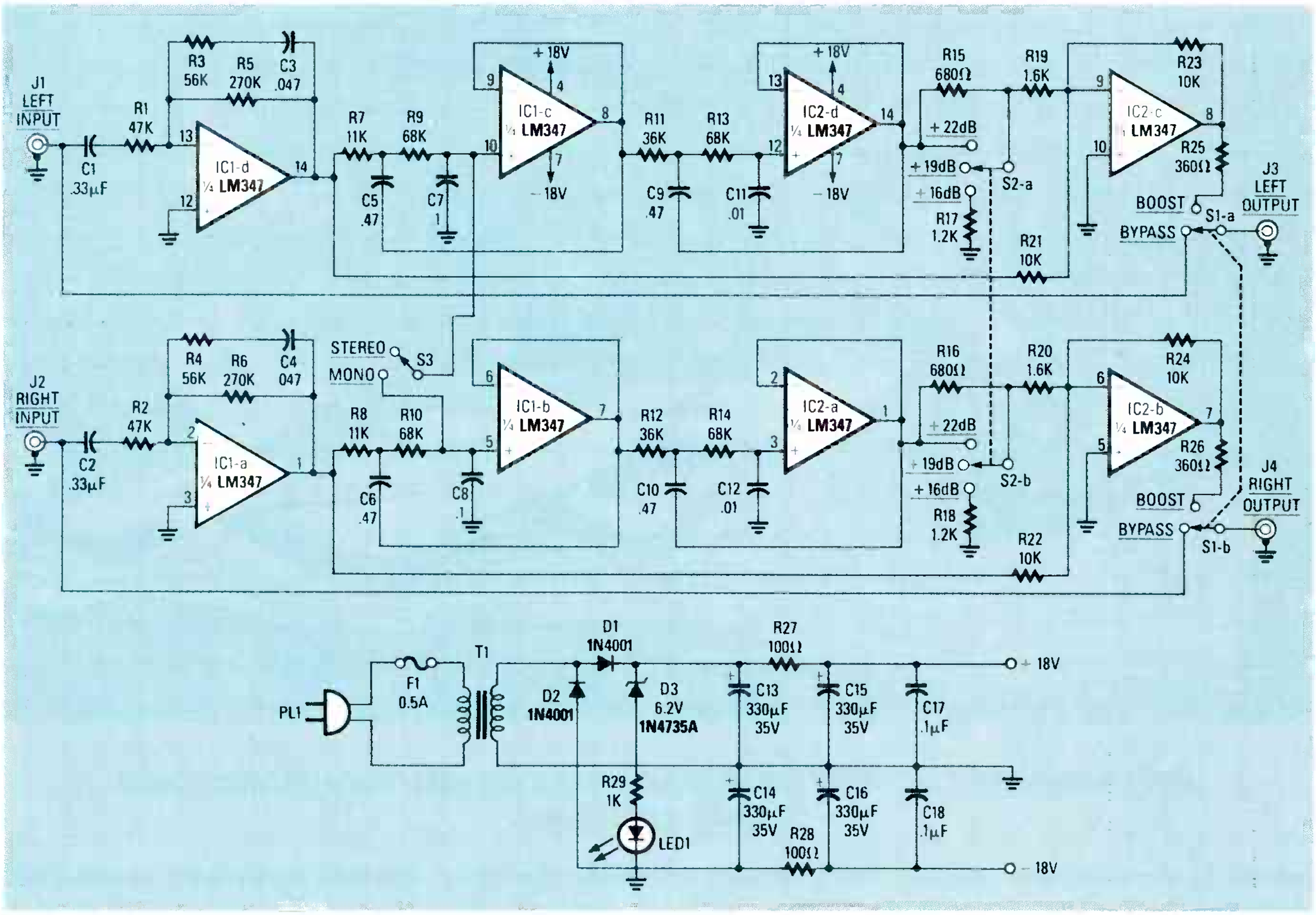


FIG. 2—THE LEFT AND RIGHT CHANNELS ARE IDENTICAL. Switch S3 blends the two channels when only mono deep-bass sounds are wanted. Switch S2 provides three levels of deep-bass amplification.

used. A simple comparison of mono and stereo bass-boosting calls that into question. Jet rumble, such as in the movie *Top Gun*, takes on a flatter, quieter, less spacious sound when boosted monaurally instead of stereophonically. A quick check of the low-frequency information (measured using a dual-trace scope and active 50-Hz stereo filters) shows that the two channels have little in common during jet rumble or numerous other situations. Only in music are the two channels similar.

Another concern is the type of filter used to feed the subwoofer. All filters have substantial phase shift at the roll-off frequencies. It can easily turn out that the high-band and low-band speaker cones will end up out of phase during the transition region, causing a loss of response over, say 60–90 Hz, which will produce a peculiar bass quality. It is likely that many subwoofer systems suffer that problem, especially those using simple passive crossovers for which 180° is a common roll-off phase angle.

Price is another objection to a mono-subwoofer system that includes a filter and separate amplifier: You'll have to spend a lot before your floor starts to shake, rattle, and roll.

A cheaper way

A less expensive way to simulate the "feelie" effect of the movie theater's deep-bass system is to simply boost the bass signal delivered to your existing front speakers. (Most home-stereo systems are overbuilt, at least when listening to a video movie at the

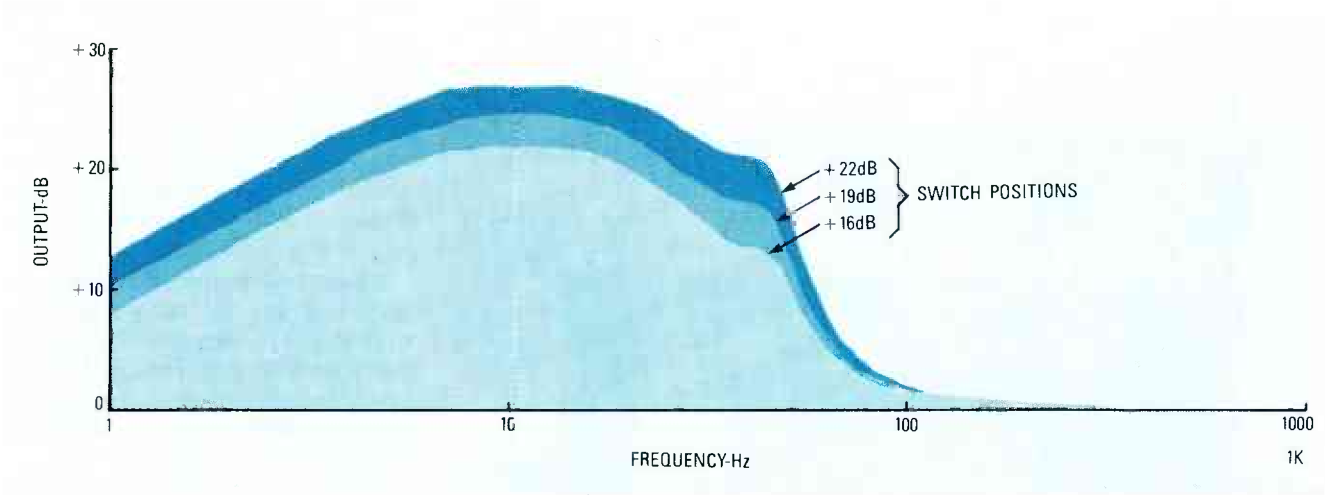


FIG. 3—MAXIMUM DEEP-BASS BOOST IS ATTAINED AT approximately 12 Hz. Note that the curves shown are unattainable with conventional tone controls.

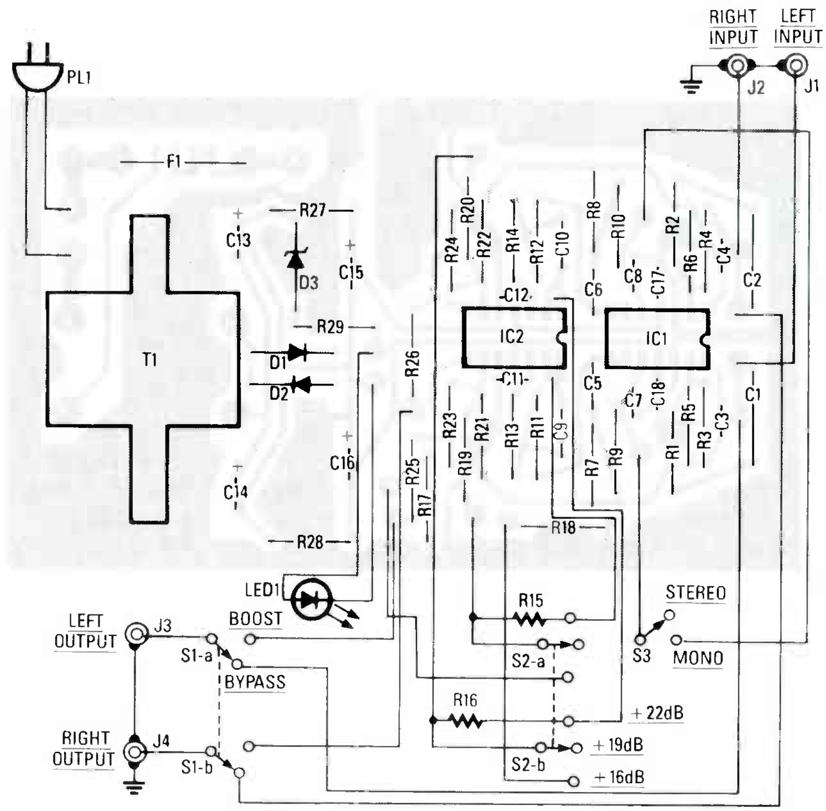


FIG. 4—THIS IS THE PARTS LAYOUT for the printed-circuit board. Take note that resistors R15 and R16 are mounted on switch S2, not on the board.

usual living-room volume level.) Although home-speaker systems having a 10- or 12-inch woofer may be rolling off between 20–50-Hz, that doesn't mean that they can't radiate energy in that range. We merely need to provide compensation so that they get more power in the deep-bass frequency range. An analogy is hitting the loudness switch or turning up the bass, except that the boost must be more selective to create the illusion of a subwoofer's sound & feel.

Figure 1 shows the block diagram of a subwoofer simulator that can be used for either the left or right channel. The first stage is a buffer-amplifier that provides gain below 60 Hz to compensate for the fact that most speakers roll off in that range. The buffer is followed by an active low-pass filter that removes everything except the deep-bass frequencies. The output from the filter is summed with its input so that the total bandwidth is at a substantially higher level than it

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R2—47,000 ohms
R3, R4—56,000 ohms
R5, R6—270,000 ohms
R7, R8—11,000 ohms
R9, R10, R13, R14—68,000 ohms
R11, R12—36,000 ohms
R15, R16—680 ohms
R17, R18—1200 ohms
R19, R20—1600 ohms
R21–R24—10,000 ohms
R26, R26—360 ohms
R27, R28—100 ohms
R29—1000 ohms
Capacitors
C1, C2—0.33 µF, 100 volts
C3, C4—0.047 µF, 50 volts
C5, C6, C9, C10—0.47 µF, 50 volts
C7, C8, C17, C18—0.1 µF, 50 volts
C11, C12—0.01 µF, 50 volts
C13–C16—330 µF, 35 volts, electrolytic
Semiconductors
IC1, IC2—LF347N, Quad JFET op-amp
D1, D2—1N4001 rectifier diode
D3—1N4735A, Zener diode, 6.2 volts,
LED1—Light-emitting diode
Other components
F1—½-amp slo-blo fuse
J1–J4—Phono jack
S1—Switch, DPDT
S2—Switch, DPDT, center off
S3—Switch, SPST
T1—Power transformer, 117 volt primary; 12.6-volt, 300-mA secondary.
Miscellaneous: PC-board materials, fuse clips, wire, linecord, solder, enclosure, etc.

An etched and drilled PC board is available for $10.25 postpaid from Fen-Tek, P.O. Box 5012, Babylon, NY 11702-0012. NY residents must add appropriate sales tax.

diately before your front power amplifier—after any surround-sound decoder. If you have a receiver, your only option is to connect the simulator before the receiver's AUX input, or within the tape-monitor loop—which isn't quite ideal because the simulator will be receiving a line-level 1-volt rms signal

Since the bass boost can exceed a factor of 10, the subwoofer simulator may occasionally output more than 10-volts rms, so to avoid blowing out your speakers, be careful when first trying the subwoofer simulator.

Increase the amplifier's gain slowly. Back off the amplifier's output power if you hear distortion. The author developed the circuit using a 200-watt-per-channel amplifier and speakers rated for 250 watts. If your system is more modestly powered, you may not want to use S2's higher boost positions. Also, if your amplifier is rated for less than 60 watts per channel, or if your woofers are smaller than 10-inches, you may not attain sufficient deep-bass output to create the sense of feeling.

Clipping within the simulator is possible, although we have seen no problems because of the device's relatively high DC supply voltage. A bigger concern is an audio amplifier that wasn't built to handle an unusually large deep-bass signal. For example, one time we absent-mindedly installed the simulator between a VCR and a *Trinitron* monitor, which has an audio switching function. It took quite a while to figure out that the sound's distortion was caused by the *Trinitron* monitor's inability to handle more than a few volts of input. Moving the simulator so that it was installed after the monitor, between the TV and preamplifier, completely resolved the problem.

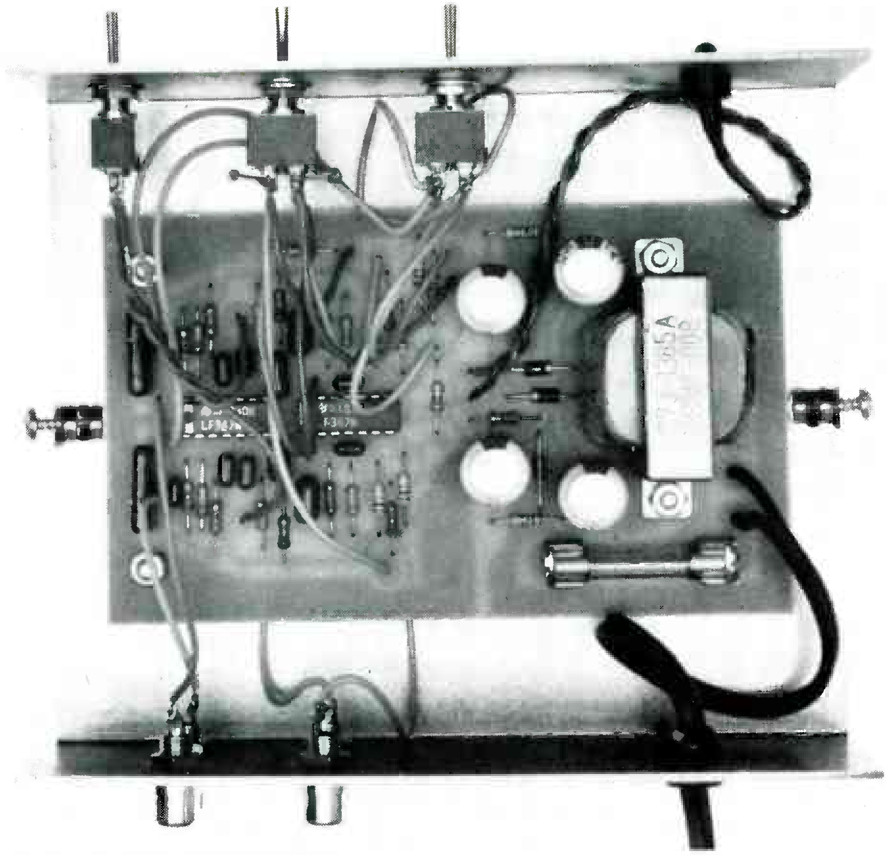


FIG. 5—TO AVOID NOISE PICKUP the simulator should be enclosed in a metal cabinet. Cabinets that are partially metal and partially plastic aren't suitable.

would be if only the deep-bass frequencies were filtered.

Figure 2 shows how the block diagram becomes the schematic for our stereo-subwoofer simulator.

How it works

Both channels are identical. Buffer amplifier IC1-a has unity gain above 60 Hz, and a rising gain characteristic below 60 Hz to compensate for the speaker's deficiency in the deep-bass range. Active low-pass filters, IC1-b and IC2-a, pass the frequency components below 50 Hz. Amplifier IC2-b sums the input and output signals of the filters. Switch S2-a provides three levels of bass summation—a fancy way of saying "bass boost." The subwoofer simulator's frequency-response curves for the three switch positions are shown in Fig. 3.

Construction

The project should use printed-circuit assembly to avoid introducing noise. A foil template for the PC board is provided in PC Service. You'll find that the template has holes to accommodate either a pigtail-lead fuse (F1), or individual fuse clips (which take two holes per clip) Use whatever is most convenient for you.

The parts layout for the PC-board and the connections for the panel-mounted components are shown in Fig. 4. For simplicity, an on/off power switch was not included so that the unit would be switched on and off by the master power switch for the entire system. If you want separate power control for the subwoofer simulator, simply install a SPST switch in series with one leg of the power cord.

Although the circuit will accept conventional part tolerances for the resistors and capacitors, for best results we suggest you use 5% capacitors for the active-filter components. As shown in Fig. 5, the prototype is mounted in a metal enclosure; do not use a cabinet that is part metal and part plastic.

Hookup

If your sound system has a separate pre-amp and power-amp, the subwoofer simulator connects imme-

The payoff

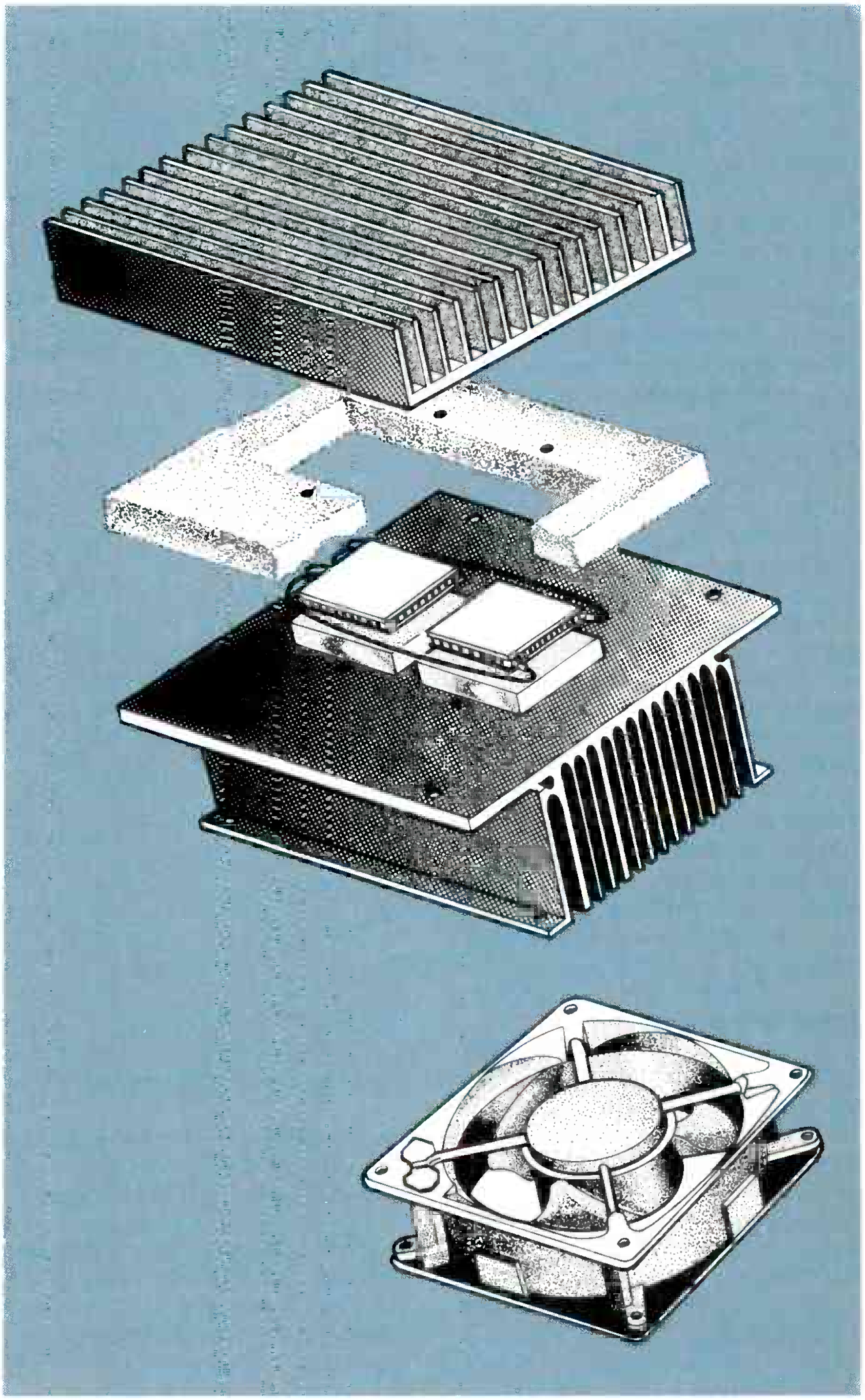
Once your system is wired for surround sound you'll discover that some movies have effects that you can literally feel, while others don't. There is a wide variation in the quality of the effects, usually from one studio to the next, not from one movie to the next. Some outfits put in plenty of enjoyable, surround-sound and "feelie" effects, while others put in few sound effects. Unfortunately, the only way to find which is which is through trial and error. R-E

ALL ABOUT

Thermoelectric Coolers

Here's a look at Peltier devices—tiny solid-state heat pumps that can be used in a wide variety of cooling or heating applications.

JOHN POTTER SHIELDS



SINCE THE LAST CENTURY WE'VE KNOWN that when you form a closed circuit of two dissimilar metals and two junctions, a current may flow between the junctions. That happens when there is a temperature difference between the junctions, or when the metals have different temperatures.

The phenomenon is known as the *Seebeck effect*, and is the fundamental principal behind the thermocouple. Generally speaking, the greater the temperature differences, the higher the current. Also, the combination of metals that are used will affect the current flow.

The reverse of the Seebeck effect was discovered in 1834 by James C. Peltier. He found that passing an electric current through a junction formed by certain types of dissimilar materials could cause an increase or decrease in temperature. Peltier also found that the direction of current flow dictated whether heating or cooling occurred, and that the amount of temperature change was determined by the type of material and the size of the junction. In his honor, that effect is called the *Peltier effect*, and it is the fundamental principal behind Peltier devices. In this article, we'll examine Peltier devices, and how they are used, in more detail.

Semiconductor thermoelectric devices

Since the discovery of the Seebeck and Peltier effects, we've discovered that they are not necessarily limited to metals. In fact, they are seen strongly in semiconductors. Figure 1 shows the arrangement of a simple semiconductor Peltier device. It consists of two pieces of semiconductor material; one is p-type, and the other is n-type.

When current is applied, charge carriers move through the two materials; causing cooling of the top surface and heating of the bottom surface. That action is basically that of a heat pump—heat is pumped from the top to the bottom of the device. If the applied current is reversed, then the top surface will be heated, and the bottom surface cooled. The device is then a heater. Most practical thermoelectric devices, like the Marlow (10351 Vista Park Road, Dallas, TX 75238) MI 1069 shown in Fig. 2, consist of many such elements. In those, the elements are connected in series electrically, and in parallel thermally.

The tiny devices are capable of putting out great quantities of cold and heat, regardless of whether they are used as a cooler or heater. Therefore, a practical semiconductor cooler or heater absolutely requires a heat sink. Otherwise, the device would overheat and fail within seconds.

Applications

One of the most interesting applications, especially for the electronics experimenter, is localized cooling of electronic components. For that, the cold side of the Peltier device is mounted directly to component using thermal epoxy, solder, or thermal grease. When power is applied to the Peltier device, heat is drawn away from the component being protected. Those components can include IC's, power transistors, laser diodes IR detectors, and solid-state imaging devices.

Peltier devices can also be used to cool moderate volumes of air or other gasses. In that application, a finned heat sink is attached to the cold side of the Peltier device. That heat sink thus becomes a *cold sink*. The Peltier device cools the cold sink; when air passes over the cold sink, a small air conditioner is created. The cold sink serves the same function as the evaporator coil in a conventional air-conditioner design.

Likewise, Peltier devices can be used to cool liquids. In that application, liquid is pumped through the cold sink and is cooled to the desired temperature.

Power generators

One interesting, and little-discussed application of Peltier devices is as power generators.

The circuit shown in Fig. 1 can be used as a power generator by simply replacing the DC power source with a load and applying heat to the top surface of the Peltier device. Note that the delivered power will have a polarity that's the opposite of the battery polarity shown.

One consideration when using a Peltier device as a power generator is that the solders used in most devices melt at about 138°C (although some units use solders that are designed to withstand short term exposure to temperatures as high as 200°). That limits the maximum efficiency of Peltier devices, but it is still possible to use a solar collector to heat a Peltier device and achieve outputs and efficiencies that rival those of solar cells.

Thermoelectric coolers are available in single-stage configurations at prices that range from about $15 to $50. For applications where a high degree of cooling is required, single-stage units can be ganged; that is the hot side of one unit is attached to the cold side of the other. Commercial units with up to six stages are available. **R-E**

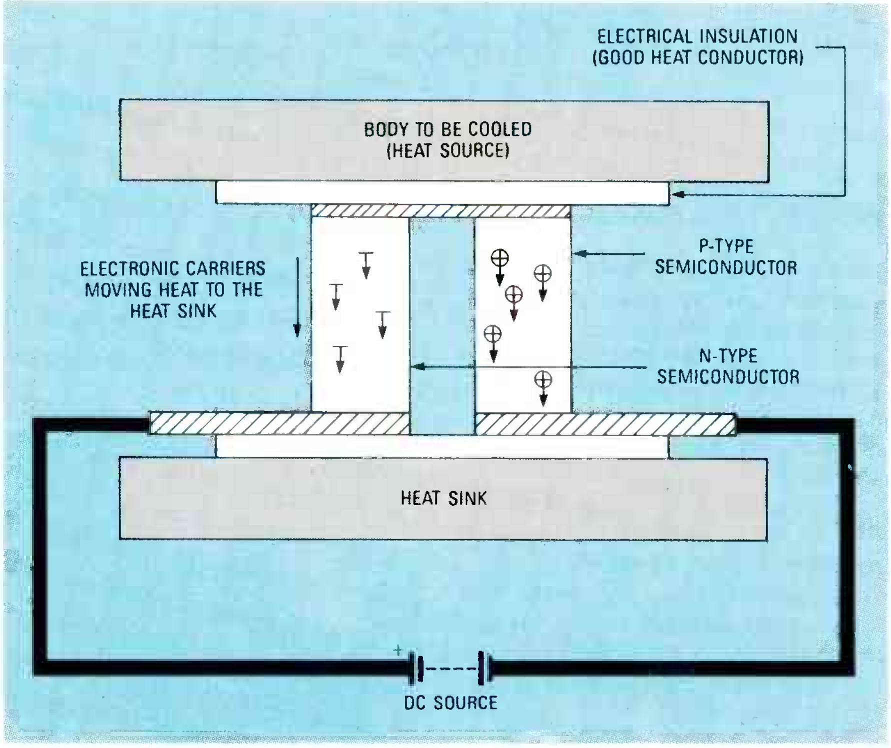


FIG. 1—A BASIC THERMOELECTRIC COOLER. The action is similar to that of a heat pump, conducting heat away from the cold side to the hot side.

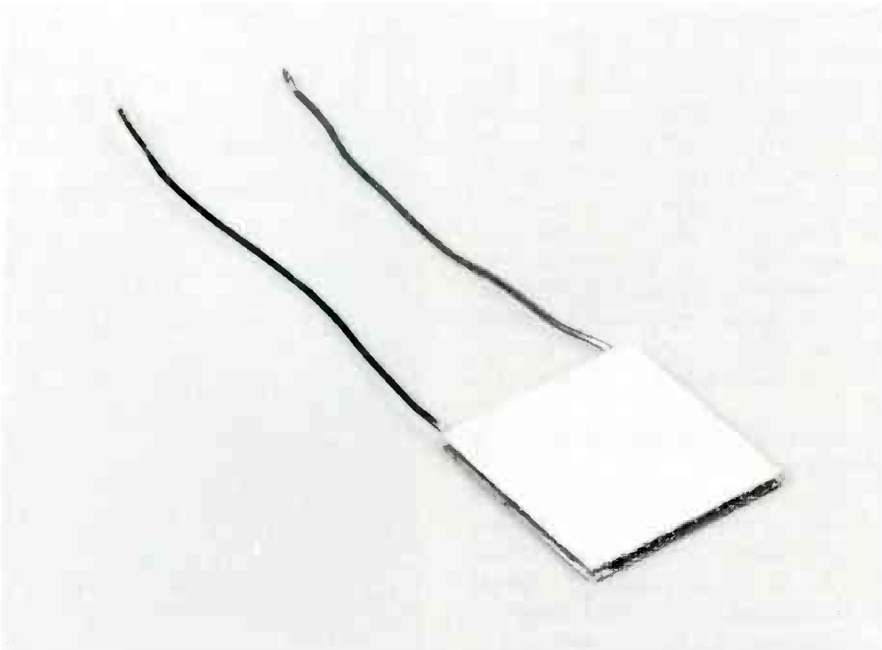


FIG. 2—A COMMERCIAL PELTIER DEVICE. This single-stage unit is the Marlow MI 1069.

WORKING WITH OTA's

How to use operational transconductance amplifiers in your designs and projects.

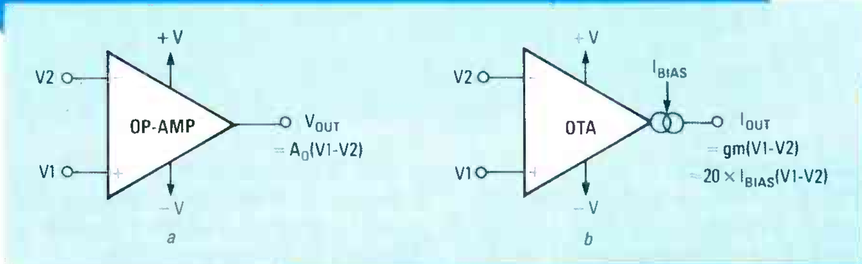


FIG. 1—A CONVENTIONAL OP-AMP (*a*) is a fixed-gain voltage-amplifying device, whereas an OTA (*b*) is a variable-gain voltage-to-current amplifier..

RAY MARSTON

THERE ARE MANY DIFFERENT TYPES OF operational amplifiers in use today, but an *O*perational *T*ransconductance *A*mplifier, or OTA, is one that you may not be familiar with. This month we'll introduce you to the CA3080 OTA.

Op-amps and OTA's

Conventional op-amps are essentially voltage-amplifying devices. As figure 1-*a* shows, a conventional op-amp has differential input terminals and produces an output voltage of $A_O \times (V1 - V2)$, where A_O is the open-loop voltage gain (that gain is typically 100,000), V1 is the signal voltage at the non-inverting input, and V2 is the signal voltage at the inverting input. Also, a conventional op-amp has a fixed open-loop voltage gain, a high input impedance, and a low output impedance.

Like a standard op-amp, an OTA has differential input terminals, but, as shown in figure 1-*b* it is a voltage-to-current amplifier, as indicated by the constant-current symbol at its output. The input voltages produce an output in the form of a high-impedance current with a value of $gm \times (V1 - V2)$, where gm is the transconductance in mhos, or the *voltage-to-current gain* of the device. The transconductance is directly proportional to an external bias current (I_{BIAS}) fed into the amplifier's bias input. In an OTA, that current can be varied from 0.1 μA to 1 mA, providing a 10,000:1 gain-control range.

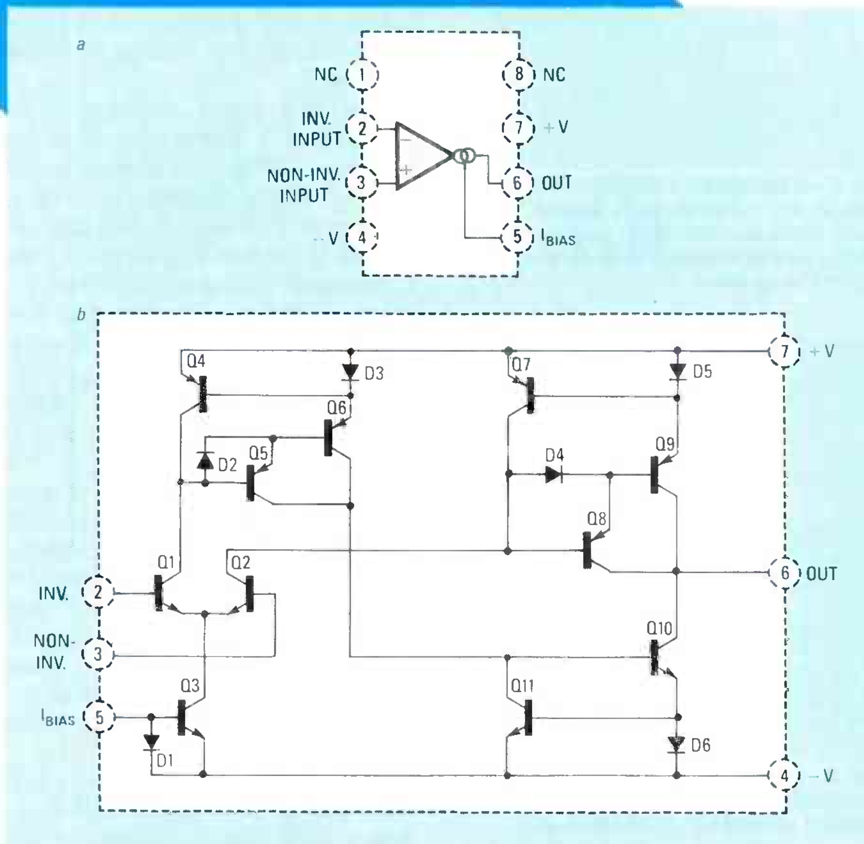


Fig. 2—THE PIN CONNECTIONS of the 8-pin dip version of the CA3080 are shown in (*a*), and the internal circuitry is shown in (*b*).

An OTA can be made to operate like a conventional voltage-amplifying op-amp by connecting a suitable load resistance to its output terminal so that its output current is converted to a proportional voltage. The total current consumed by an OTA is double the value of I_{BIAS}, which may be as low as 0.1 μA. That means that the device can be used in true micropower applications. The amount of I_{BIAS} can be controlled easily using an external voltage and a series resistor. An OTA can be used as a *V*oltage-*C*ontrolled *A*mplifier (VCA), *V*oltage *C*ontrolled *O*scillator (VCO), or *V*oltage *C*ontrolled *F*ilter (VCF).

One of the best known OTA's is the CA3080. Figure 2-*a* shows its pin connections, and Fig. 2-*b* shows its internal circuitry. Table 1 lists the basic parameters of the device.

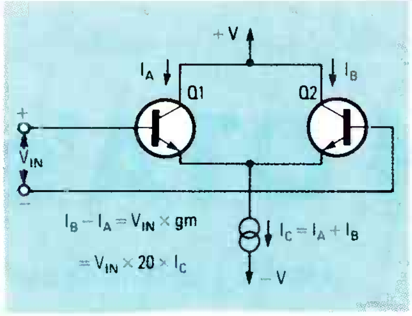


FIG. 3—A DIFFERENTIAL AMPLIFIER is at the heart of the CA3080.

TABLE 1

CHARACTERISTIC	LIMITS
Supply Voltage Range	+4V to +30V DC or ±2V to ±15V
Max Differential Input Voltage	±15V
Power Dissipation	125 mW MAX
Input Signal Current	1 mA MAX
Amplifier Bias Current	2 mA MAX
Output Short-Circuit Duration	INDEFINITE
Forward Transconductance, gm	9600 μmho typ
Open Loop Bandwidth	2 MHz
Unity-Gain Slew Rate	50 V/μs
Common-Mode Rejection Ratio	110 dB typ

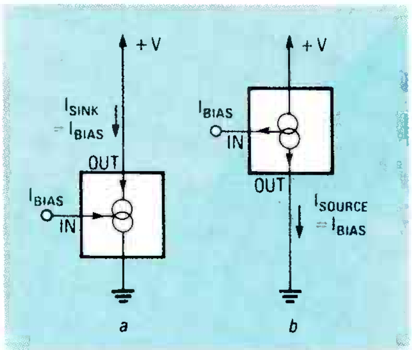


Fig. 4—A CURRENT-MIRROR SINK (*a*) will sink as much current as is applied to its input, and a current-mirror source (*b*) will supply as much current at its output, as is applied to its input.

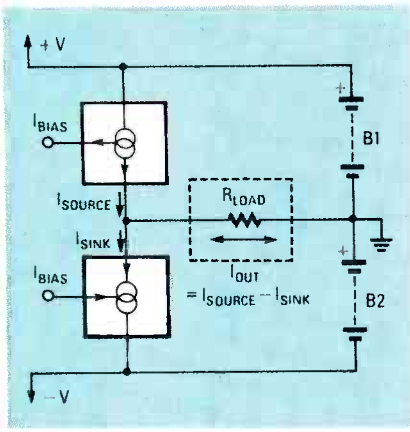


FIG. 5—WHEN TWO CURRENT MIRRORS are wired as shown, they generate a differential current in an external load.

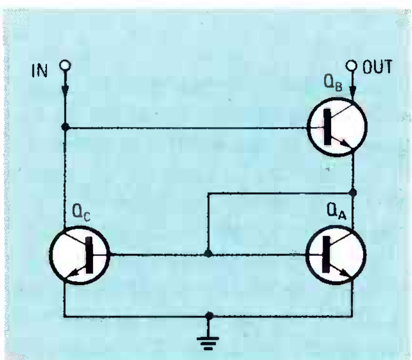


FIG. 6—A SINK-TYPE CURRENT MIRROR is made up of the circuitry shown here.

CA3080 operation

The CA3080 consists of one differential amplifier and four *C*urrent *M*irrors (CM). A current mirror is a 3-terminal circuit that, when an external bias current is provided at its input terminal, will produce an in-phase current of identical value at its output terminal.

The basic circuit and formulas for the CA3080's differential amplifier are shown in Fig. 3. The emitter current (I_C) of the amplifier is equal to the sum of the two collector currents (I_A and I_B). When V_{IN} is zero, I_A and I_B are equal and have a value of $I_C/2$. When V_{IN} has a value other than zero (±25 mV maximum), I_A and I_B differ and produce an $I_B - I_A$ value of $V_{IN} \times$ gm. The transconductance value is directly proportional to I_C, and at 25°C roughly equals $20 \times I_C$.

By itself, the circuit in Fig. 3 is not very useful. However, in an OTA such as the CA3080, the circuit is useful because by using a current mirror to externally control I_C, the amplifier's transconductance can then be controlled. By using three more current mirrors, the difference current between I_A and I_B can be made externally available.

There are two types of current mirrors. Some are current sinks, as shown in Fig. 4-*a*, and others are current sources, as shown in Fig. 4-*b*. When a current mirror source and current mirror sink are connected as shown in Fig. 5, and powered from a bi-polar power supply, they generate a differential current ($I_{SOURCE} - I_{SINK}$) in any load that is connected between the junction point and the circuit ground.

Figure 6 shows the actual circuit of a sinking-type current mirror. Transistor Q_A, which operates like a diode, is wired across the base-emitter junction of a second, closely-matched transistor. The mirror accuracy of that circuit is less sensitive to the current gains of the transistors, and has improved (greater) output impedance than in a more-simple circuit.

Figure 7 shows how the differential amplifier and four current mirrors are connected in the CA3080 to make a practical OTA. Bias current (I_{BIAS}) controls the emitter current, and thus the transconductance of the Q1/Q2 differential amplifier via current-mirror C. The collector current of Q1 is mirrored by current-mirror A and fed to the bias terminal of current-mirror D, and the collector current of Q2 is mirrored by current-mirror B and fed to the sink terminal of current-mirror D, so that the externally available output current is equal to $I_B - I_A$.

If you refer back to Fig. 2-*b*, you will notice that Q1 and Q2 form the differential amplifier, D1 and Q3 make up current-mirror C, and current-mirror D is comprised of D6, Q10, and Q11. Current-mirror A (Q4–Q6, D2, and D3), and current-mirror B (Q7–Q9, D4, and D5) are slightly more complex than the others, using Darlington pairs of transistors and speed-up diodes to improve their performance.

Some finer points

All of the major operating parameters of the CA3080 are adjustable and depend on the value of I_{BIAS}. The maximum output current is equal to I_{BIAS}, and the total operating current of the IC is double the I_{BIAS} value. The input bias currents drawn by pins 2 and 3 when the IC is operating in the linear mode are each equal to approximately $I_{BIAS}/200$, with the actual values depending on the current gains of Q1 and Q2 within the chip.

The transconductance (Fig. 8-*a*) and the input and output impedances (Fig. 8-*b*) vary with I_{BIAS}. Figure 8 shows typical parameter values when the IC is driven from a bi-polar 15-volt

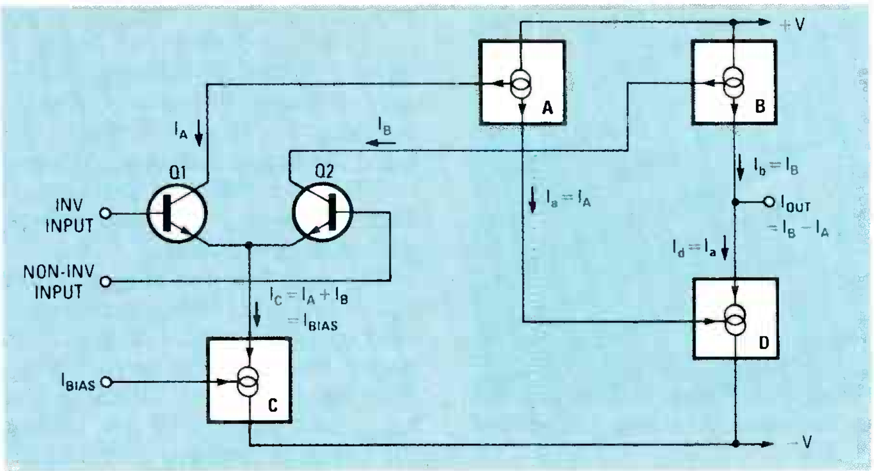


FIG. 7—THE CA3080 IS COMPRISED of one differential amplifier and four current mirrors.

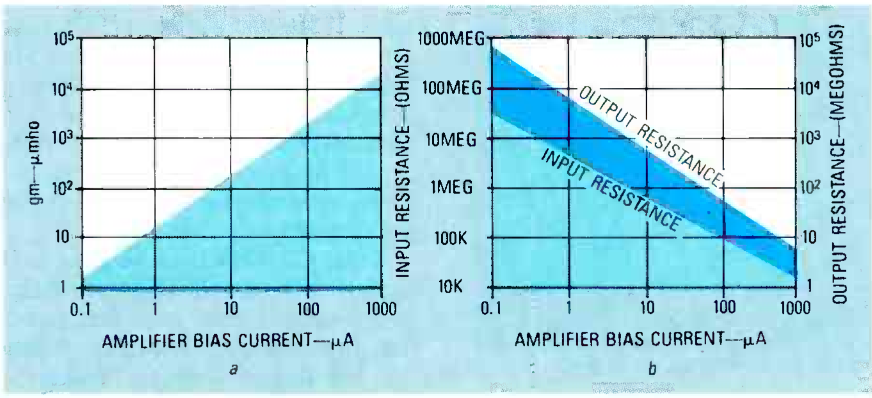


FIG. 8—THE TRANSCONDUCTANCE (*a*) and the input and output resistances (*b*) of the CA3080 vary with the bias current.

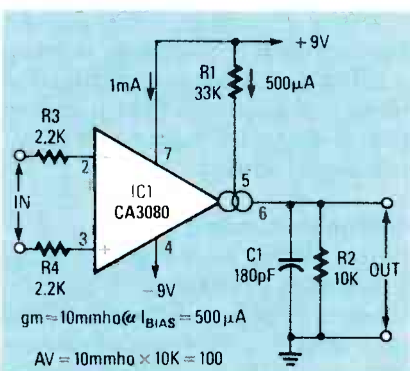


FIG. 9—THIS DIFFERENTIAL AMPLIFIER has 40-dB voltage gain.

supply at an ambient temperature of 25°C. Therefore, at a bias current of 10µA, gm is typically 200 µmho, with an input resistance of 800K and an output resistance of 700 megohms. At 1-mA bias current, those values change to 20 mmho, 15K, and 7 megohms respectively.

The output voltage of the IC depends on the values of I_{BIAS} and an external load resistor connected to the output (pin 6) of the device. If the load impedance is infinite, the output can swing to within 1.5 volts of the positive supply and within 0.5 volt of the negative supply. If the impedance is not infinite, the peak output swing is limited to $I_{BIAS} \times R_L$. Thus at a 10-µA bias with a 100K load, the output swing is 1 volt.

The slew rate and bandwidth of the IC depend on the value of I_{BIAS} and any external loading capacitor connected to pin 6. The slew-rate value, in V/µs, equals I_{BIAS}/C_L, where C_L is the loading capacitance value in pF, and I_{BIAS} is in µA. With no external loading capacitor connected, the maximum slew rate of the CA3080 is about 50V/µs.

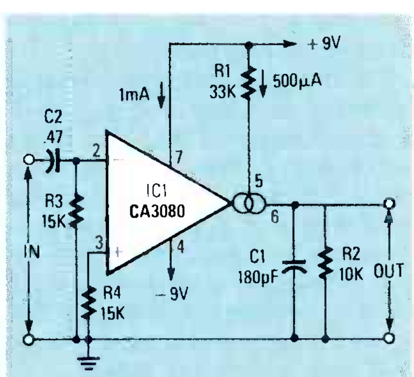


FIG. 10—AN AC-COUPLED 40-dB inverting amplifier.

Basic circuits

The CA3080 is very easy to use. Its I_{BIAS} terminal (pin 5) is internally connected to the negative supply (pin 4) by a base-emitter junction, so the biased voltage of the terminal is about 600 mV above that of pin 4. I_{BIAS} can be obtained by connecting pin 5 to either the ground line or the positive supply via a current-limiting resistor of suitable value.

Figures 9 and 10 show two ways of using the CA3080 as a linear amplifier with a voltage gain of about 40 dB. The circuit in Fig. 9 is a direct-coupled differential amplifier, and Fig. 10 shows an AC-coupled inverting amplifier. Both designs operate from bi-polar 9-volt supplies, so 17.4 volts is generated across bias-resistor R1, which feeds about 500 µA into pin 5 causing each IC to draw another 1 mA from their supply.

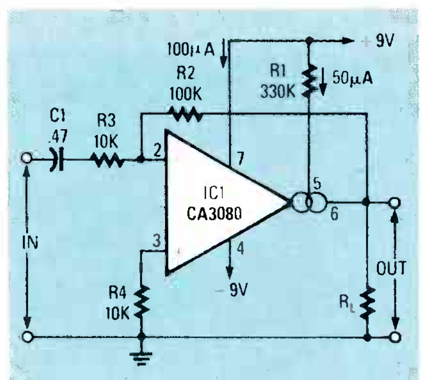


FIG. 11—THIS 20-dB MICRO-POWER inverting amplifier consumes very little power.

At a bias current of 500 µA, the transconductance of the CA3080 is approximately 10 mmho. The outputs of Figs. 9 and 10 are loaded by a 10K resistor (R2), and therefore provide an overall voltage gain of 10 mmho × 10K = 100, or 40 dB. The peak current that can flow into the 10K load is 500 µA (equal to I_{BIAS}), so the peak output is 5 volts. The output is also loaded by a 180-pF capacitor (C1), giving the circuit a slew-rate limit of 500 µA/180pF = 2.8V/µs. The output impedance of each circuit equals the R2 value of 10K. Note that in those two circuits the IC is used in the

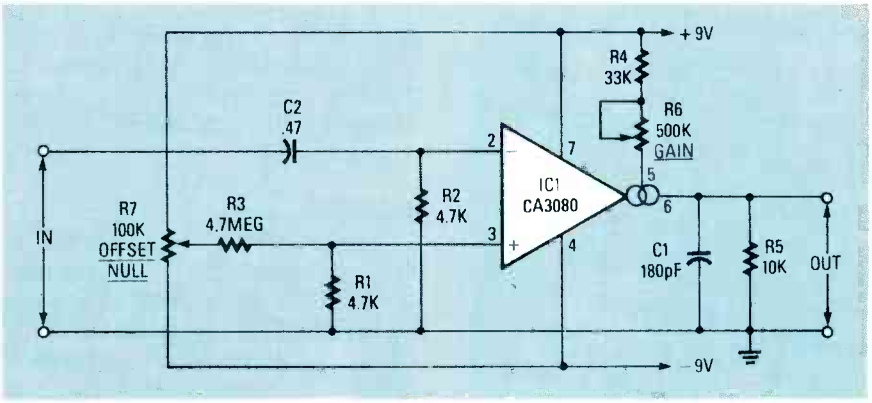


FIG. 12—A VARIABLE-GAIN AC amplifier has a gain that can range between × 5 and × 100.

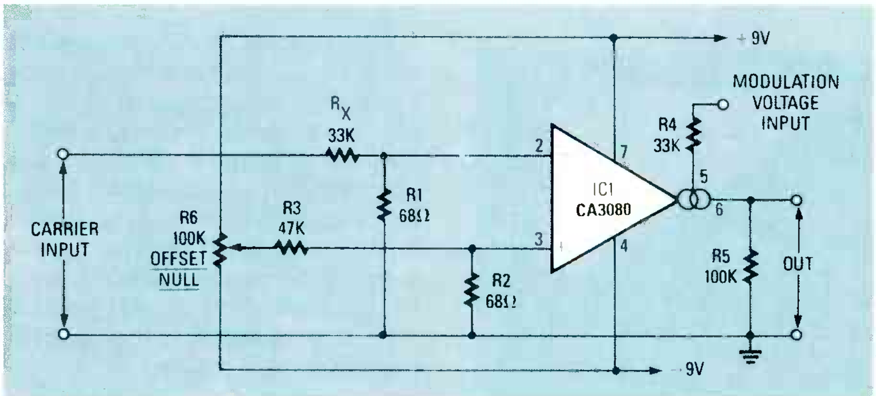


FIG. 13—AN AMPLITUDE MODULATOR or 2-quadrant multiplier has unity gain.

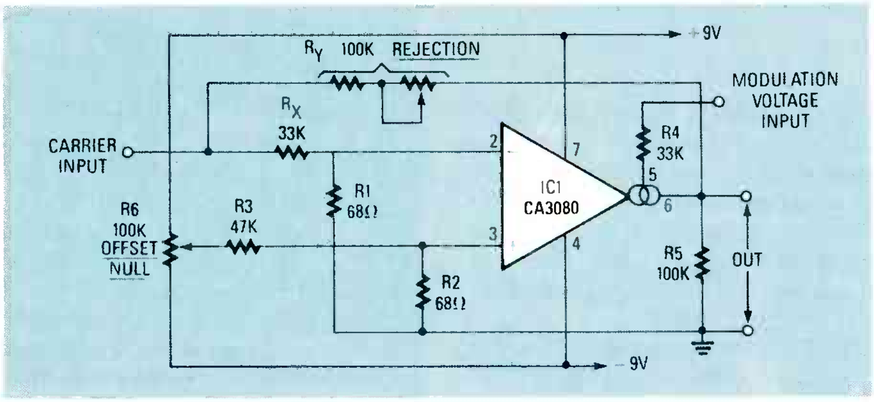


FIG. 14—BOTH PHASE AND AMPLITUDE can be controlled by the modulation signal in this ring modulator or 4-quadrant multiplier.

open-loop mode, and that if the slew rate is not externally limited by C1, the IC will operate at its maximum bandwidth and slew rate. Under those conditions the CA3080 may be excessively noisy.

In the circuit in Fig. 9, the differential inputs are applied via series resistors R3 and R4, which help equalize the source impedances of the two signals and maintain the DC balance of the IC. The circuit in Fig. 10 has both inputs tied to ground via 15K resistors and the input signal applied to one terminal only. With the input connected to pin 2, the circuit is a 40-dB inverting amplifier.

The voltage gains in Figs. 9 and 10 depend on the value of I_{BIAS}, which in turn depends on the value of the supply voltage. The voltage gain of the CA3080 can be made almost independent of the I_{BIAS} and supply-voltage values by using conventional op-amp techniques, as shown by the 20-dB AC-coupled inverter circuit of Fig. 11, which consumes a mere 150 μA from its bi-polar 9-volt supply.

The circuit in Fig. 11 is wired like a conventional inverting amplifier, with its voltage gain (A_V) determined primarily by the R2/R3 ratio (equal to 10, or 20-dB). The gain equation is only valid when the value of an external load, R_L, is infinite. That's because the output impedance is equal to $R2/A_V$, or 10K, and any external load lessens that value and reduces the output of the circuit.

The main function of I_{BIAS} in the circuit of Fig. 11 is to determine the total operating current of the circuit and/or the maximum output swing. With the component values shown, I_{BIAS} has a value of 50 μA, causing the circuit to consume a total of 150 μA. When R_L is infinite, the output is loaded only by R2, which has a value of 100K, so the maximum output is 5 volts. If R_L has a value of 10K, the maximum output voltage is limited to 0.5 volt. That circuit can therefore be designed to have any desired voltage gain and peak output, and since the IC is used in the closed-loop mode, external slew-rate limiting is therefore not required.

If the CA3080 is to be used as a high-gain DC amplifier, or as a wide-range variable-gain amplifier, input-bias levels must be balanced to ensure that the output correctly tracks the input signals at all values of I_{BIAS}. Figure 12 shows how to bias an inverting AC amplifier in which the voltage gain is variable from roughly ×5 to ×100 via R6, and the offset balance is pre-set via R7. The circuit is set up by adjusting R6 to its minimum value (maximum gain) and then trimming R7 to give zero DC output with no AC input signal applied.

Voltage-controlled gain

Some of the most useful applications for the CA3080 are in true micropower amplifier and oscillator circuits, and when important parameters are controlled by an external voltage. In the latter category, one major application is as a VCA or amplitude modulator, in which a carrier signal is fed to the input of the amplifier, and the output amplitude is controlled or modulated by another signal fed to the I_{BIAS} terminal. Figure 13 shows a practical version of such a circuit.

The circuit in Fig. 13 is a variable-gain inverting amplifier. Input-bias resistors R1 and R2 have low values to minimize the noise levels of the IC and eliminate the need for external slew-rate limiting. Offset biasing is applied to the non-inverting input via

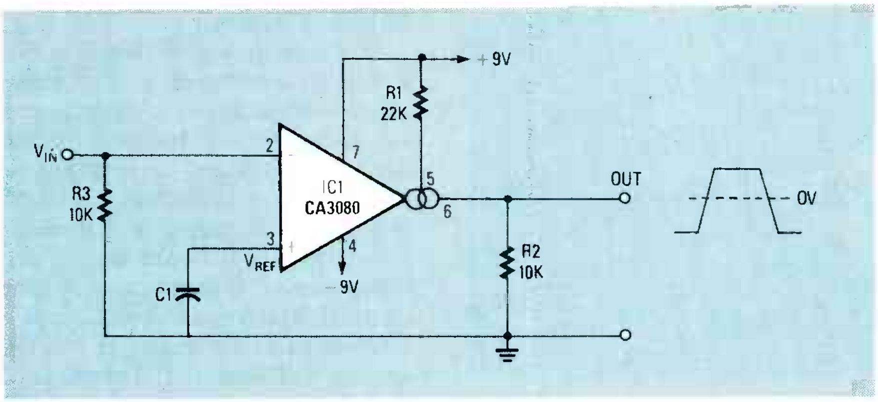


FIG. 15—A FAST INVERTING VOLTAGE comparator has a high output when its input falls below V_{REF}.

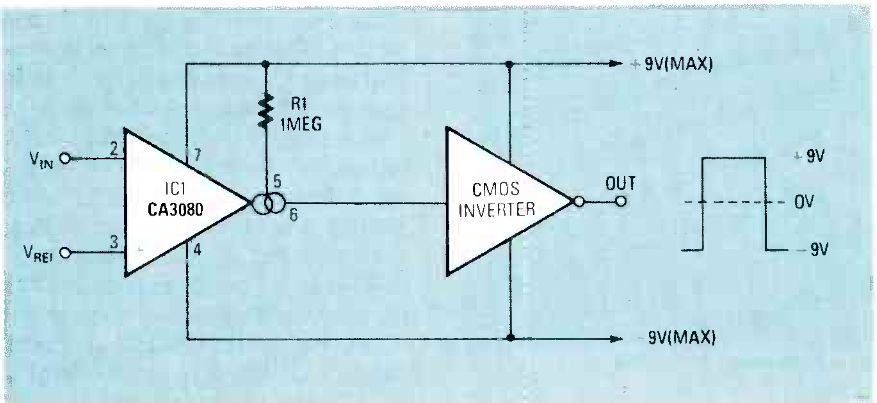


FIG. 16—A NON-INVERTING micropower voltage comparator has inputs that are sensitive to small changes.

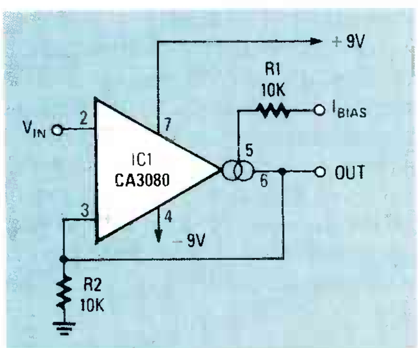


FIG. 17—THIS SCHMITT-TRIGGER circuit has programmable trigger-thresholds and peak-output.

R3/R6. The carrier signal is applied to the inverting pin of the CA3080 by the voltage divider Rx/R1. When R_X has a value of 33K as shown, and the modulation input terminal is tied to ground, the circuit basically has unity gain. The gain doubles when the modulation terminal is tied to +9 volts (+V), and when the modulation terminal is tied to −9 volts (−V) the circuit has roughly 80 dB of signal rejection.

The instantaneous polarity of the output signal of the circuit in Fig. 13 is determined entirely by the instantaneous polarity of the input signal. The amplitude of the output signal is determined by the product of the input and the gain-control values. That type of circuit is known as a 2-quadrant multiplier.

Figure 14 shows how the circuit in Fig. 13 can be modified so that it can be used as a ring-modulator or 4-quadrant multiplier, in which the output-signal polarity depends on the polarities of both the input signal and the modulation signal.

The circuits of Figs. 13 and 14 are identical, except that in Fig. 14, resistor-network R_Y is connected between the input and output terminals. When the modulator input is tied to ground, the inverted signal flowing into R5 from the OTA's output is balanced by the non-inverted signal flowing into R5 from the input signal via R_Y. Therefore, zero volts is generated across R5. If the modulation input goes to +V, the output of the OTA exceeds the current of the R_Y network, and an inverted gain-controlled output is obtained. If the modulation input is −V, on the other hand, the output current of R_Y exceeds that of the OTA, and a non-inverted gain-controlled output is obtained. So, both the phase and the amplitude of the output signal of the 4-quadrant multiplier circuit are controlled by the modulation signal. The circuit can be used as a ring modulator by feeding independent AC signals to the two inputs, or as a frequency doubler by feeding identical sine-wave signals to the two inputs.

Note that with the R_X and R_Y values shown in Fig. 14, the circuit has a voltage gain of 0.5 when the modulation terminal is tied to +V or −V. The gain doubles if the values of R_X and R_Y are halved. Also note that the Fig. 13 and Fig. 14 circuits each have a high output impedance, and that in practice an output buffer must be added between the output terminal and the outside world.

Comparator circuits

The CA3080 can easily be used as a programmable or micropower voltage comparator. Figure 15 shows the basic circuit of a fast, programmable, inverting comparator, in which a reference voltage (V_{REF}) is applied to the non-inverting terminal and the test input is applied to the inverting terminal. The circuit's operation is such that the output is driven high when the test input is below V_{REF}, and is driven low when the test input is above V_{REF}. The circuit can be used as a non-inverting comparator by reversing the input connections of the IC.

With the component values shown in Fig. 15, the I_{BIAS} current is several hundred µA, so the device has a slew rate of about 20V/µs, and operates as a fast comparator. When the test voltage and V_{REF} are almost identical, the IC operates as a linear amplifier with a voltage gain of gm × R2 or about 200. When the two input voltages are significantly different, the output voltage is limited to values determined by the values of I_{BIAS} and R2. In Fig. 15, the output is limited to about 7 volts when R2 has a value of 10K, or about 700 mV when R2 has a value of 1K.

The circuit in Fig. 15 can be modified so that it is an ultra-sensitive micropower comparator, as shown in Fig. 16. That circuit typically consumes only 50 µA but has an output that fully swings between the +V supply and the −V supply, and can provide drive currents of several mA. In Fig. 16 the CA3080 is biased at about 18 µA via R1 but has its output fed to the near-infinite input impedance of a CMOS inverter stage. That

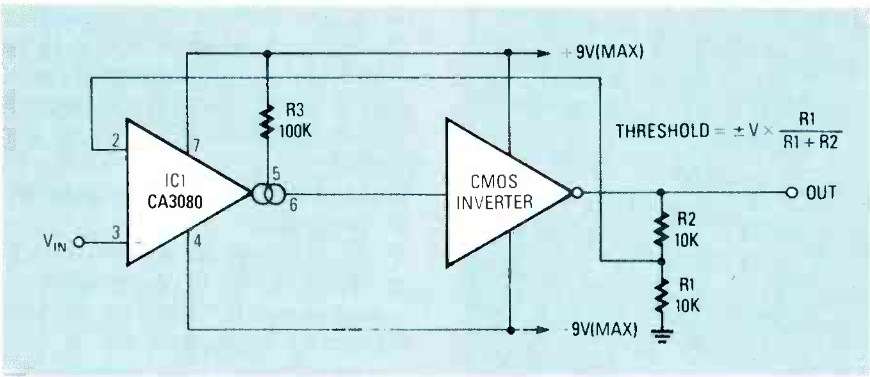


FIG. 18—A MICRO-POWER Schmitt trigger is shown here.

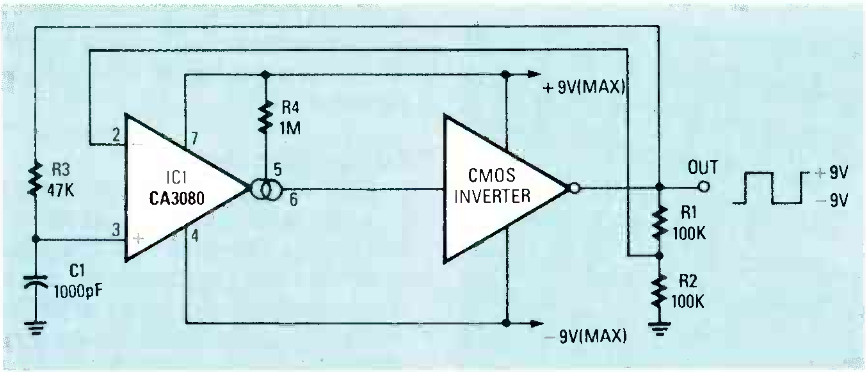


FIG. 19—A LOW-POWER astable multivibrator or square-wave generator.

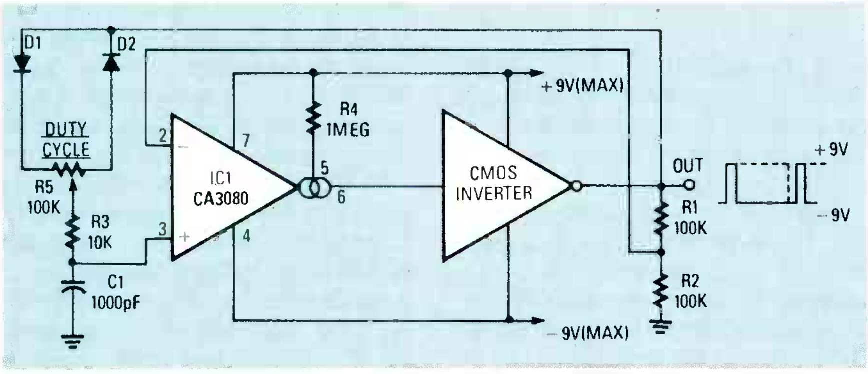


FIG. 20—THIS VARIABLE DUTY-CYCLE oscillator has an output that can be varied from 10:1 to 1:10. D

combination gives the circuit an overall voltage gain of about 130 dB, so that input-voltage changes of only a few μV are enough to switch the output from one supply level to the other.

Schmitt-trigger circuits

The voltage comparator circuit of Fig. 15 can be used as a programmable Schmitt trigger by connecting the non-inverting reference terminal directly to the output of the CA3080, as shown in Fig. 17. In that case, when the output is high, a positive reference value of $I_{BIAS} \times R2$ is generated. When V_{IN} exceeds that value, the output regeneratively switches low and generates a negative reference voltage of $I_{BIAS} \times R2$, and when V_{IN} falls below that value, the output is regeneratively switched high and once more generates a positive reference voltage of $I_{BIAS} \times R2$. Therefore, the trigger thresholds, and also the peak output voltages of the Schmitt circuit, can be precisely controlled or programmed by changing the value of either I_{BIAS} or R2.

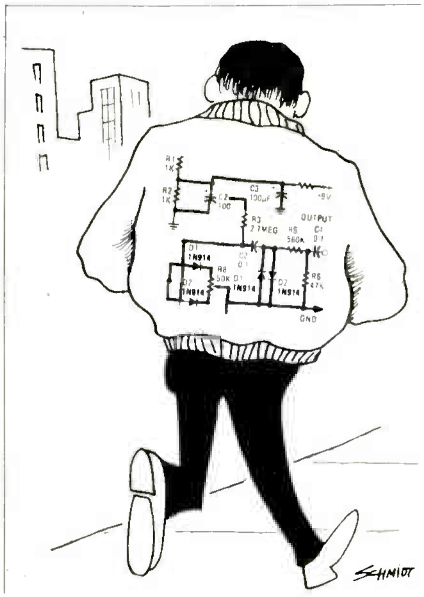
Figure 18 shows an another type of Schmitt trigger, in which the output fully switches between the supply-voltage values. The switching-threshold values are determined by the R1/R2 ratio and the supply-voltage values, and is equal to $+V \times R1/(R1+R2)$.

Astable circuits

The Schmitt-trigger circuit in Fig. 18 can be used as an astable multivibrator or square-wave generator circuit by connecting its output to the non-inverting input terminal via an RC time-constant network, as shown in Fig. 19. The output of that circuit fully switches between the supply-voltage values, is approximately symmetrical, and has a frequency that is determined by the values of R3, C1, and the R1/R2 ratio. The operation is such that, when the output is high, C1 charges via R3 until the C1 voltage reaches the positive reference-voltage value determined by the R1/R2 ratio. At that value the output switches low. Capacitor C1 then discharges via R3 until the C1 voltage reaches the negative reference-voltage value determined by the R1/R2 ratio. at that value the output switches high again, and the whole process then repeats.

Finally, Fig. 20 shows how the circuit in Fig. 19 can be modified to have an output waveform with a variable duty cycle. In that case, C1 alternately charges via D1, R3, and the left half of R5, and discharges via D2, R3, and the right half of R5, to provide a duty-cycle ratio that is fully variable from 10:1 to 1:10 via R5.

Note that in the two astable circuits of Figs. 19 and 20, the CA3080 is biased at only a few μA, and the total current consumption of each design is determined primarily by the series values of R1 and R2, and by the value of R3. In practice, total current consumption of only a few tens of μA can easily be achieved. R-E



HARDWARE HACKER

A new A/D converter
The PostScript language
Telephone ring detectors
Toner cartridge reloading
Replacement semiconductors

DON LANCASTER

Refilling toner cartridges, and more!

I JUST GOT WIND OF A STUNNING NEW mid-level hacker integrated circuit that should cheaply and elegantly solve a lot of sensing and analog interface problems for you. That IC is the new LTC1092A by Linear Technology. While I don't yet have any samples or even any complete data, some preliminary technical info did appear over in *Electronic Design* for December 10, 1987.

That little $12, 8-pin mini-DIP gem is a one-piece 10-bit low-level and high-speed analog-to-digital converter. What it does all by itself is take a small analog signal sitting on a large or even a slowly varying offset voltage and convert it into an 0.1-percent accurate 0–1023 digital numeric value.

The LTC1092A should serially interface beautifully with most any personal computer. It does appear especially good for talking through Apple's game ports.

Unlike previous A/D converters, that is a floating point unit that can have its maximum full-scale value set anywhere from 150 millivolts(!) on up to 10 volts. Which gives you a mind-numbing dynamic range of nearly 97 decibels. The same IC can measure anything from a mere 150 microvolts up to 10 volts.

The potential hacker uses boggle the mind. A recent help-line caller wanted an expanded scale voltmeter. Another asked for a way to accurately measure the charging voltage of a large industrial battery, since you can detect the end of charge when the voltage starts to rise suddenly.

You are able to directly input such things as "raw" data from a strain gauge, pressure transducer, thermocouple, or other temperature sensor, and in one step get a numeric result. No more instrument amplifiers, voltage references, awkward board layouts, precision resistors, and all of the hassles that go with them.

And, yes, that IC is fast enough for almost any high-quality audio use. You can even digitize 19-kHz audio at a 38-kHz sampling rate.

Operation could not be simpler. There are two supply pins that can work from a single +5- or a +10-volt supply and ground. You have two differential input pins and a reference input that sets the full-scale amplitude. A precision reference is not needed, since you can get that signal from the same source that is driving your sensor or whatever.

The remaining three pins are digital. You'll find a clock input, a "start-converting" input, and a serial output. Which all should be able to interface quite well with just about anything.

We'll be seeing lots more on that beauty here. Yes, there definitely will be one of our usual contests. To get a head start, just pick up some data sheets, samples, and "ap" notes, and see what you can come up with.

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

This is your column, and tech help is available per the help line. Let's start off with a great business idea...

Tell me all about toner cartridge reloading

Toner cartridges, such as those used in all of the Canon personal copiers, in those Hewlett Packard *LaserJets* or the Apple *LaserWriters*, cost as much as $124 each and are good for only a maximum of 2500 or so copies.

Yet, with a simple two minute operation, you can reload all those empty cartridges three or more times with new toner at a cost of only $7.50. At the same time, you will get better and blacker images, since the rest of that cartridge mechanism does not even begin to get up to its maximum blackness until after its second reload, and since the refill toner materials are much blacker than the original toner.

If you now own one of those machines, you could dramatically reduce your operating costs and improve the quality of your output by doing your own refilling. If you do not, chances are others in your neighborhood will be glad to pay you as much as $24 for a local and custom refilling.

One good source of refill toner is Lazer Products, while one reliable, independent, toner-refill testing and reporting service is now available through Thompson and Thompson. Note that the refill toner must be exactly matched to its target cartridge. Copier toner won't work in a laser printer, and vice versa.

Let us look at how you can refill a Canon *CX* cartridge. The details will vary with other systems. You can get your empty cartridges by accepting exchanges or else by putting an ad in the local paper. The current street price of empty but virgin cartridges is $5 in urban areas and $10 in small towns.

In fact, there is never any point at all in buying a brand new *CX* cartridge. You might as well let someone else condition the drum and get rid of the less-than-perfect factory toner for you.

There's usually no good reason to completely tear down a cartridge. All that does is introduce more problems than it solves. I will show you the "punch and go" method here, since that is far more cost effective. However, if you absolutely insist on tearing one apart, the magic tamperproof *Torx* bit is available as EVCO part #945B700 from Jensen Tools.

With the punch-and-go method, you have to make two holes in the cartridge, as shown in Figs. 1 and 2. The easiest way to make those holes is to melt them using a

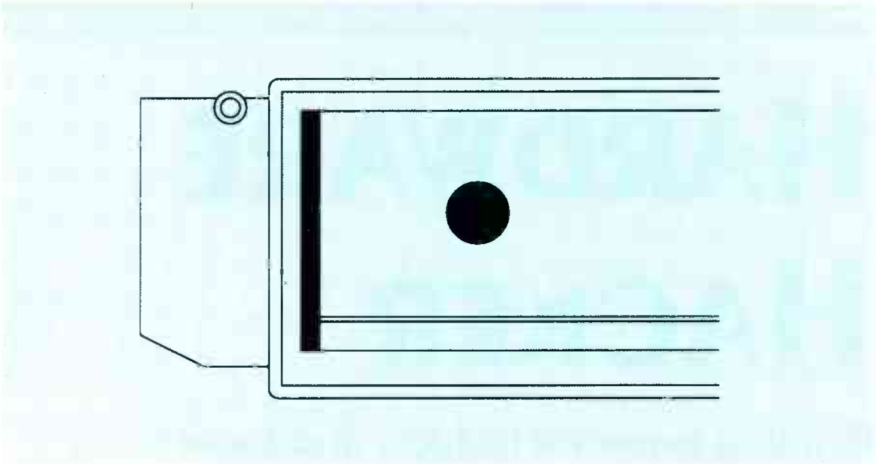


FIG. 1—A CANNON *CX* TONER CARTRIDGE has to be modified before it can be refilled. First, remove the large cardboard label (not shown here) by lifting it up from each end. Then, melt a clean ½-inch hole in the fresh-toner tank.

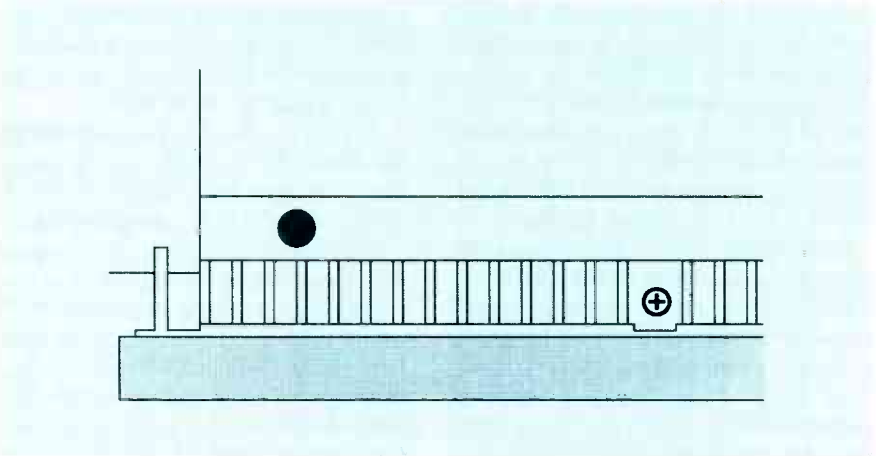


FIG. 2—CONTINUE MODIFYING THE *CX* CARTRIDGE by melting this ¼-inch hole in the spent-toner holding tank beneath the cartridge. When finished reloading, seal up both holes with a very aggressive tape. Replace the cardboard label and the fuser wiper pad after refilling.

small soldering iron. You can also make them with a heated-up, spent 0.45-caliber cartridge shell or with a special *Unibit* drill intended for thin plastic.

One ½-inch hole is placed in the toner filling tank, and another ¼-inch one is placed in the spent-toner holding tank, as shown. The holes should both be trimmed flush, being very careful to get no scraps of plastic inside the tanks themselves.

The toner filling tank is reached by popping off the large cardboard label. Do that from the ends, and not from the sides.

Suitable tape, such as the metal tape used in some floppy-disk write-protect tabs, is used as a seal. It is of the utmost importance that your sealing tape is both aggressive and secure.

To actually refill a cartridge, first open the holding tank hole and drain out the old toner. Do that outdoors and avoid breathing the toner. Then reseal the holding tank. Next, use a plastic funnel to dump one bottle (typically 400 grams) of toner into the filling tank via the ½-inch hole. Then reseal.

Follow that up with a stick-on label that holds the refilling history of the cartridge. Finally, replace the original cardboard label and clean the corona wire with the usual little green tool.

When you refill the cartridge, you should also replace the wiper pad that tracks the fusion rollers. Those pads contain a small amount of a special silicon oil, so they must be replaced, rather than just cleaned or recycled.

Wiper pads are usually included

free when you order toner. Simply scrape the original pad out of its holder and secure the new one with a drop or two of glue.

Refilled cartridges must be hand carried. They cannot be shipped without adding an additional and specialized sealing strip. Thus, cartridge reloading is best done as a local service.

More details on doing cartridge reloading appear in my *Ask The Guru* reprints, while a step-by-step toner-reloading demonstration is included in my *Introduction to Postscript* video.

What is *PostScript*?

Several help-line callers have now complimented me on the technical illustrations for this column and have wondered just who the artist is. Well, the artist is not a he or a she. It is an it.

All of the artwork you see in this column is prepared in camera-ready form using nothing but the *AppleWriter* word processor on a *IIe*, printing onto a *LaserWriter* Plus. That is all made possible by a unique graphics and typesetting language that is known as *PostScript*.

PostScript is new industry-standard page-description language that is also making strong bids to become a screen-description standard, a fax standard, a BBS graphics-interchange standard, a signmaking and engraving standard, and even a printed-circuit layout standard.

The good news about *PostScript* is that you can simply and quickly use any old world processor on any old computer and create graphics that can meet and often ridiculously exceed the finest graphics output available from the most expensive custom programs running on the fanciest of computer systems.

The bad news is that *PostScript* only works on premium printers and typesetters that have

FIG. 3—AN ORDINARY WORD PROCESSOR is all that is needed with the *PostScript* language to create graphics that look this good. These examples show you several of *PostScript's* powerful curve tracing and cubic spline abilities. Any personal computer can be used.

NAMES AND NUMBERS

Adobe Systems
1585 Charleston Rd.
Mountain, View, CA 94039
(415) 961-4400

Computer Shopper
Box F
Tutusville, FL 32781
(305) 269-3211

EGC
70 Empire Dr.
West Seneca, NY 14224
(716) 325-2620

EVCO
3451 Lorna Road
Birmingham, AL 35236
(205) 822-5381

General Electric
Electronics Park Bldg 7
Syracuse, NY 13221
(800) 626-2001

General Instruments
2355 W Chandler Blvd.
Chandler, AZ 85224
(602) 963-7373

Jensen Tools
7815 South 46th St.
Phoenix, AZ 85044
(602) 968-6231

Lazer Products
PO Box 4947
Englewood, CO 80155
(303) 721-9990

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035
(408) 432-1900

Mini-Circuits
PO Box 350166
Brooklyn, NY 11235
(718) 934-4500

NTE
44 Farrand St.
Bloomfield, NJ 07003
(201) 748-5089

PostScript BBS
2504 Sycamore
Bay City, TX 77414
(409) 244-4704

Speleonics
Box 5283
Bloomington, IN 47402
(812) 335-7305

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

TecSpec
3 Mine Mountain Rd
Cornwall Bridge, CT 06754
(203) 672-0123

Texas Instruments
Box 5012
Dallas, TX 75265
(214) 995-3821

Thompson & Thompson
23072 Mullin Dr.
El Toro, CA 92630
(714) 855-3838

Thomson Semiconducteurs
43, Avenue De L'europe
78140 Velizy-Villacoublay
FRANCE
(1) 3946-9719

PostScript capabilities already built into them. Current examples are the Apple *LaserWriter* and *LaserWriter Plus* printers and the Linotron *100* and *300* phototypesetters. Those are still a tad on the pricey side.

Some important advantages of *PostScript* include its device independence, which means that the very same code and very same text file can be used for 300 DPI personal laser printing or for 2560 DPI commercial typesetting.

PostScript can be used to do professional-quality typesetting, and its fonts can be set to any size from two points up to 40,000 points or even higher, and may be independently rotated, translated, scaled, or have any of hundreds of other special treatments applied to them.

Thousands of different *PostScript* fonts are now available, and each of these individual fonts can be shown in a nearly infinite number of variations.

Full page *PostScript* text and graphics can be freely intermixed in any combination in most any direction in most any manner.

PostScript, like its second cousin (three times removed and five times disowned) Forth, is a threaded and extensible language. Which means that you can add anything you like to the language anytime, creating custom and reusable code.

One of the neatest features of *PostScript* is its ability to handle a powerful means of drawing smooth curves that go by the name of *cubic splines*. Figure 3 shows a few of the awesome things you can do with *PostScript's* cubic spline capabilities.

And, yes, *PostScript* is incredibly easy to learn. In fact, it becomes downright addictive. Off-the-street students in my beginning *PostScript* courses are doing their own superb custom letterheads, business cards, badges, forms, ads, line art, decals, and bumper stickers after as little as three hours of instruction.

Those of you hackers that have also been following me over in *Computer Shopper* know that I am into *PostScript* in a very big way. You can get started in all this on your own by calling our free *PostScript* voice help line at (602) 428-4073, by calling our free *PostScript* BBS at (409) 244-4704, by getting a free subscription to the *Colophon* magazine from Adobe Systems, or by picking up any of my other Postscript goodies that are mentioned at the end of this column.

Where can I get replacement entertainment semiconductors?

While nearly all transistors and integrated circuits are made in the same way by the same people, there are several different ways those devices are sold. If you are a manufacturer of, say, television sets, you will buy them direct in huge-quantity lots, already custom numbered for you per your own internal needs.

If you are a hacker, designer, or developer, you won't do that; instead you'll buy your standard-numbered parts from any of the usual industrial or new-age distributors, including many of our

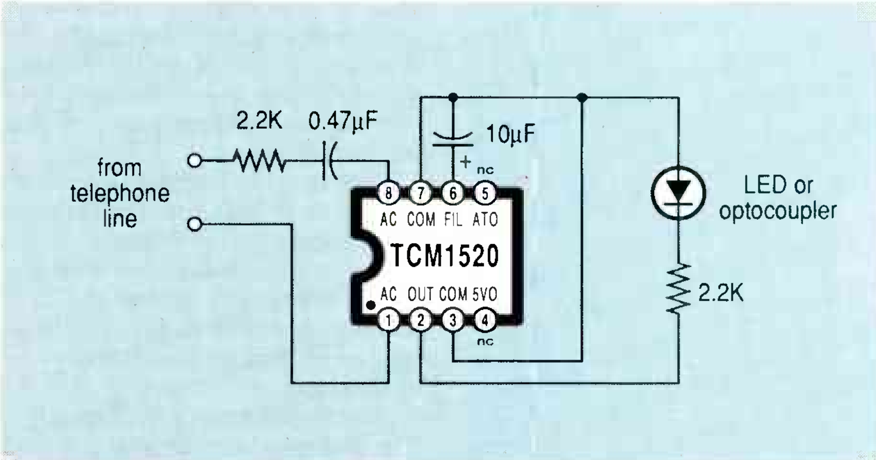


FIG. 4—THIS TELEPHONE-RING DETECTOR might be used to light an LED, or to power an LED optocoupler to create an isolated "the phone is ringing" optical signal.

Radio-Electronics advertisers.

Finally, you will find yet a third distribution channel. That one is intended specifically for technical training, for maintenance services, and consumer-electronics repair. Those sources stock small quantities of the house-numbered devices specifically for service and warranty-repair uses.

As a hacker, you'll want to tune into both of the standard-numbered parts sources as well as the service and warranty-replacement sources. More often than not, what you get from one distribution channel is totally unheard of by the other.

Two of the leading sources of replacement semiconductors are the ECG people and the competing folks over at TCE. Both sources have fat and low-cost technical guide directions that list and then cross reference zillions of house part-numbers. Package details, pin-outs, and limited technical data is also included.

No hacker can afford to be without current copies of those.

Show me a telephone-ring detector.

A typical home-telephone line normally consists of a 48-volt DC supply that drops to half of that when you are off-hook. That DC supply is amplitude modulated in order to provide voice or data communications.

Ringing is separately done by superimposing a very strong AC ringing signal. That is typically a sinewave of 40 to 150 volts rms at a frequency of 16 to 68 Hz.

Traditionally, the ringing voltage would be capacitor coupled to a mechanical bell whose resonant frequency matched that of the ringing signal. Some older party lines used several different resonating frequencies for the bells, so that each party could be selected by changing the ring frequency.

You might like to build your own ring detector, possibly as an aide for the deaf, for use as a modem or answering-machine actuator, for automated computer communications, or simply for an outside, a remote, or a super-loud or a super-quiet way to tell when your phone is ringing.

One way to do that is with a plain old neon lamp. Take a NE-2 and put it in series with a 470K resistor and a 0.47-µF, 400-volt capacitor, and hang in across the phone line. Or use a neon night light instead. The neon lamp lights whenever the phone is ringing.

To get a safety isolated ringing signal, just tape a photoconductive cell or phototransistor to the neon lamp, and input the photodetector into your whatever.

These days, though, you will find simple, low cost, and sophisticated integrated circuits that you can use to detect ringing and directly drive a piezotransducer or a speaker.

Many of those are described in the new *Telecommunications Data Book* by Texas Instruments. Let us look at two different examples.

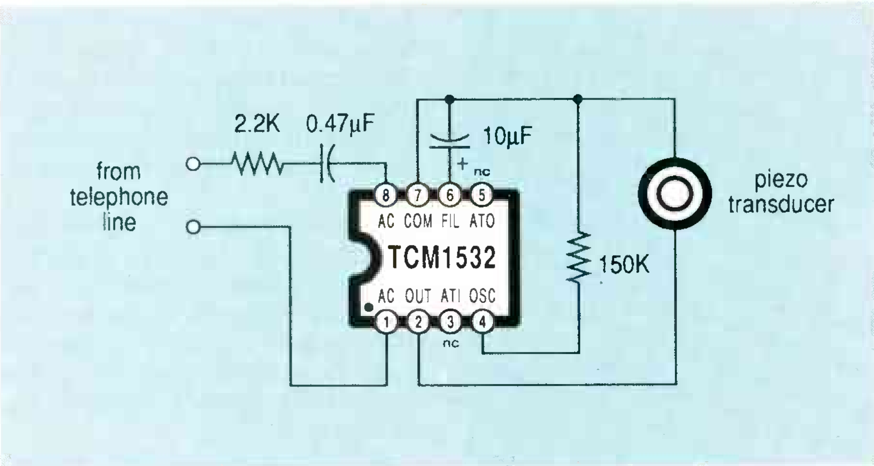


FIG. 5—A COMBINED RING DETECTOR AND DRIVER that directly powers a piezotransducer. Speakers or external amplifiers can be driven by transformer coupling. Note that all of the needed power is derived directly from the AC ring signal. Use a 400-volt input capacitor.

Figure 4 shows you a detect-only circuit that uses a TCM1520A to light an LED or drive the input of an LED optocoupler. The output is a pulsed DC signal that is present when the phone is ringing and absent otherwise.

Figure 5 shows you a detect-and-drive circuit that uses a TCM1532 to directly drive a piezotransducer, or else lets you transformer couple to a speaker or an external and isolated amplifier.

To get a decent-sounding ring, you really want to pick a pair of frequencies and warble between them. Further, you will want to match those frequencies to whatever you are driving. That is done automatically for you inside the IC. A number of different part numbers are available that give you various ring frequencies and warble rates.

Note that the second circuit can also drive an LED, and the LED will even appear to light continuously on a ring. But remember that the actual waveform across the LED will be a complex audio signal that may need further treatment if you optocouple it.

There's other uses for those IC's that include burglar and process alarms, or even low-power, direct line-operated power supplies. See the data book for more details.

Any new tech lit this month?

Newsletters are often a very high-energy source of hacker ideas. One new one is called *TecSpec*, and is quite strong on lasers and optical communications. The coverage is all very hacker oriented. The cost is $1.50 per issue.

My favorite technical newsletter

of all, though, is *Speleonics*, which weights in at a budget-breaking $6 per year. That newsletter is written by and for spelunking cavers who have a technical bent. Topics of special interest to electronics hackers include underground location finding, low-frequency radio communications, laser mapping and geophysical exploration, and innovations in lighting.

General Instrument Microelectronics has a short-form product portfolio out. Among the products included are sound generation integrated circuits, character generators, some keyboard encoders, and even credit-card size memory devices.

There is a new and free *Triac Applications Handbook* you can get from Thomson Semiconductors. While full of good ideas, it is poorly written and the translation is even worse. To this day, the best reference book on power-control semiconductors remains the ancient GE *SCR Manual*. I'm not even sure that the book is still in print, though.

The Mini-Circuits people have a new how-to-use guide for their *MAR* drop-in amplifiers. Those are a series of very low-cost, ultra high-frequency transistor-amplifier IC's that are usable as high as 2 GHz.

Turning to my own products, if you want to know more about the *PostScript* language, I have scads of *PostScript* stuff for anyone from a rank beginner on up through some testing, development, and leading-edge advisory services for even the most gonzo of advanced *PostScript* developers.

For beginners just getting started who do not yet own a *Postscript* printer, I would suggest my new *Introduction to Postscript* videotape and Adobe's *PostScript Cookbook*. If you already do own a *PostScript* printer, there's my *PostScript Show and Tell*, my *PostScript Technical Illustrations*, and my *PostScript* BBS Stuff, available for all of the major personal computers.

Write or call (see the box on the first page of this article), and I'll be most happy to send you a brochure on all of this and lots more; some free, and some not. **R-E**

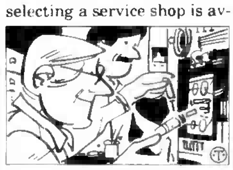
New solid-state and digital TV sets, stereos, and videorecorders are tougher to repair than old-fashioned tube type sets and require special training for the service technician who works on them.

Only a few states have laws requiring competency tests for licensing technicians who repair consumer electronics, but fifteen years ago the International Society of Certified Electronic Technicians (CET) began its own certification program to qualify these technicians and those in industry. To carry the CET designation, technicians must have four years experience and pass a rigid examination on general electronics and a specific area of expertise such as audio or radio-TV.

Many consumers look for a Certified Electronic Technician in the shop when they need any electronic item repaired.

Free Consumer Checklist

A consumer checklist for selecting a service shop is available free by sending a stamped, self-addressed envelope to: Checklist, ISCET, 2708 West Berry, Fort Worth, TX 76109. The list reminds consumers to check such items as "Does the business have the parts for your particular brand?", "Did you get an estimated price?", and "Did you check this company with the Better Business Bureau?"



Modern electronic equipment such as digital TVs or stereos should be repaired by specially trained people.

AUDIO UPDATE

Some thoughts on predicting the audio future

LARRY KLEIN,
AUDIO EDITOR

BEFORE WE LOOK AHEAD AT THE FUTURE of audio, let's finish up the backward look that we began in last month's column.

By 1959 a new type of component—the tuner-amplifier—had appeared and was gaining popularity; it would be several years before it was called a "receiver." Transistorized equipment also began to appear at that time. Audiophiles incautious enough to invest in the new technology found themselves with tuners having front-end overload problems and low sensitivity, and amplifiers that suffered from crossover distortion, overload, and other repeated failures.

Although a few early starters among the manufacturers had dropped out, the total number of audio manufacturers had grown significantly over a 10-year period. And, in fact, some of them were beginning to make model changes every couple of years.

The stereo sixties

I shouldn't leave the 1950's without acknowledging the introduction of the first acoustic-suspension speaker in 1955. The development by Edgar Villchur of a speaker system with remarkable bass *and* compact dimensions would ultimately dovetail neatly with stereo's need for two speakers. In the 1960's, the company he founded—Acoustic Research—managed to take over a third of the speaker market with various models that they were producing.

In 1963 Philips introduced their Compact Cassette system. I don't think anybody (including Philips) would have predicted that the book-size, low-fi portable unit introduced as a "sound camera" 25 years ago would one day evolve into a product that at its best would provide performance equivalent to that heard from the finest LP's—and that would virtually wipe out the home open-reel tape machine.

FIG. 1

In 1967 the first Dolby-A mastered discs appeared. Several years later, Advent incorporated a heavily modified version of the studio A system into a cassette machine. Referred to as the B system, it ultimately became a necessary part of virtually every cassette machine. But it didn't happen instantly or easily. Ray Dolby spent years in licensing negotiations with the Japanese (and Philips, who weren't all that sure that Dolby encoding didn't circumvent the compatibility requirement in the Philips licensing agreement). Philips ultimately gave tacit approval, and one by one the Japanese signed up.

By now I've reached a time period probably familiar to most of my readers—and I'm running out of space. One final thought: In the summer of 1970 I wrote a prophetically titled article "The Four-Channel Follies." A year later, when I followed up with "The Four-Channel Follies: Act 2", I could see the handwriting on the wall—all four of them. Quadraphonics was killed by a combination of inept promotion and marketing, the presence of three competing incompatible systems, and off-target engineering. However, when writing about the death of quad in early 1978, I predicted that multi-channel sound in some format would one day reappear. It appears that that day is now here with components such as the new Dolby Stereo sound-track processors and sound-field synthesizers such as Yamaha's DSP-1 digital processor. I'm looking forward to *re*converting my system to the new formats.

Into the future

In the years that i've been playing audio oracle, my crystal ball, shown in Fig. 1, has usually provided relatively clear reception, albeit with an occasional glitch to remind me that marketplace prediction is a tricky business. When I call a wrong turn as a journalist, I'm embarrassed; but when a manufacturer misjudges the potential demand for a product, millions of dollars and many people's jobs may be at risk.

Why are the twists and turns of the audio marketplace so hard to anticipate even by experienced marketeers? Probably because the public's reaction to a particular new format or product is based on a difficult-to-sort-out mix of elements. Those include satisfaction of a real or imagined need, personal taste, and what I call the "oh-wow!" factor. And we shouldn't overlook the importance of effective promotion and marketing know-how.

Is it possible to tell in advance what will be *hot* and what will *not*? Not infallibly; but here are some thoughts and case histories that should provide insights into the social, psychological, economic, and technical factors that determine whether a particular audio product will fly—or never get off the ground.

Taste factors

Some audio features, such as product cosmetics, are essentially a matter of taste. About 10 years ago, Yamaha bucked then-current design trends by producing a line of receivers with very clean, almost sterile looking, matte-silver front panels. When they asked my opinion of their new look, I said that *I* liked it, but that I didn't think it would be attractive to an audio public conditioned to visual pizzazz. Not only was I wrong, but Yamaha's cosmetic approach established a styling trend that lasted for years. Today, black is considered beautiful. Why? Your guess is as good as mine.

Technological trends

Can an inside knowledge of upcoming technical developments be helpful in predicting product trends? Sometimes, but not always. For example: Perhaps a dozen years ago I heard about Hall-effect magnetic-sensing heads. (Unlike conventional tape heads that depend on tape movement to generate a signal, Hall-effect heads produce a signal proportional to a stationary magnetic field.) At the time, I wrote a short piece extolling the virtues of Hall-effect heads for wide-range slow-speed recording, and predicted that they would shortly be found in a large variety of home recorders. In truth, Hall-effect heads did become popular, but only for credit-card readers and similar non-audio applications. I've never pursued the matter to find out where I went wrong, but I certainly proved to myself that a *little* technical knowledge can be terribly misleading.

On the other hand, I correctly predicted that the well-publicized and well-promoted Elcassette-tape format would fail. The projected audience were those who found open-reel tapes too inconvenient and regular cassettes too low in fidelity. It was clear to me—if not to the manufacturers—that the targeted market was just too small. The Elcassette turned out to be a very expensive fiasco for a number of major Japanese recorder and tape manufacturers.

At the press conference where Sony introduced their *Walkman* format, I judged it an instant winner based on the excited "Oh wow!" reactions of the normally blase magazine editors that were present. And it didn't hurt the *Walkman's* sales that at about the time it was introduced, prerecorded cassettes were on the verge of outselling LP's.

The Japanese influence

There are several factors, aside from the particular technologies involved, that make it difficult to

predict the success or failure of Japanese audio innovations. For example, their marketing plans in the U.S. are sometimes inappropriately based on early enthusiastic reactions in Japan. And when things do not go according to plan, Japanese companies will usually persist in their marketing efforts long after the usual U.S. company would have thrown in the towel. Sources of capital in Japan are much more supportive than in the U.S., and the tendency is to invest for the long haul rather than fast return for stockholders. In that regard, it's instructive to contrast RCA's videodisc pullout with JVC's continuing support of their VHD disc format in Japan and Pioneer's ongoing backing of the *LaserDisc* both here and in Japan.

The Japanese tendency to support a format or product, despite disappointing initial sales, sometimes appears to be based on ego or face-saving, and at other times is the direct result of their enlightened business/social philosophy. For example, when times are rough, the upper executives of major Japanese companies are likely to take a salary cut and reduce profit margins—sometimes to the break-even level or below—in order to avoid layoffs and keep the factory wheels turning. How un-American can you get!

The CD situation

During a series of annual trips to Japan, I had an opportunity to closely monitor the technical development of the compact-disc format from its very beginnings. I was terribly impressed both by the complexity of the technology and by the sonic potential. But I felt that the format was inherently too expensive to be widely popular and that the price of CD units would not readily come down because of the astronomical development costs.

I guessed that perhaps 50,000 machines would be snapped up by those well-heeled first-on-the-block U.S. buyers who will go for any new and apparently improved format. But after the supply caught up with the initial demand, I expected sales to plummet—and then take considerable time to recover. I was right about the post-50,000 depression, but I was very wrong about the recovery time. I forgot that Japanese companies are willing to go for the long haul, operating from the supportive ground rules previously mentioned.

As soon as player sales began to fall, so did the prices. And obviously when a CD player is available for a price that's the same or lower than that of a reasonable turntable and phono cartridge, then a new and larger group of mainstream audio consumers will become instantly interested in the product. However, after that new group is saturated, and the initial 50,000 have traded in their first players for new and improved high-end models, I see another slowdown in CD-player sales, perhaps occurring as you read this. CD sales are still being moderated by the relatively high cost of discs, and the hard-to-face fact that the general public is not terribly concerned with ultimate sonic quality.

Consider this: Several years ago, prerecorded-cassette sales for the first time exceeded those of LP's, even though most LP's had better fidelity and lower noise than cassettes. To me that meant that the major concern of the mass consumers of music were convenience and durability, *not* fidelity. If I'm right, that will certainly have bearing on the progress of the CD format. Automobile CD players won't make it since they are less convenient than cassettes, and the sonic virtues of a CD will almost all be obscured by road noise. In fact, the wide dynamic range of CD is an annoyance rather than an advantage in a car. (Soft passages will be lost in the road noise unless the volume is turned up, in which case the loud passages will be *much* too loud.) If I'm right about the importance of the convenience factor, cassettes will continue to win out for car use.

The DAT dilemma

Here's a chance to really stick my neck out. It seems to me that the new Digital Audio Tape (DAT) format is a technological tour-de-force that is the answer to a question no one has asked. When DAT finally comes to market, I expect that—at best—it will go through the same 50,000 sales and subsequent plummet experienced by CD's. But unlike CD's, I don't expect a strong recovery even if the price comes down, simply because the mainstream audio consumers won't be sufficiently interested to stimulate demand.

And, if I'm right about convenience being a stronger buying motivation for the mass market than fidelity, DAT has no advantage over cassettes except its near-instant program access and a somewhat longer playing time. Offsetting that small advantage is the fact that prerecorded DAT tapes in automobile use will suffer from the same excessive dynamics as CD's, unless the player manufacturers provide built-in switchable compression circuits.

Today it's possible to copy a CD with sufficient fidelity on a top-model cassette deck that even an audiophile would have difficulty telling the dub from the original during playback. Given that fact, I think that it's going to be very difficult to convince even sound-conscious consumers that the extra cost of the DAT format buys advantages they simply *must* have. It seems to me that the major accomplishment of the Japanese in introducing the DAT format has been to confuse the high-end CD and cassette marketplace. In light of all that, the current brouhaha about the installation of copy-prevention circuits in DAT machines is pure silliness.

A year from now, or less, we will all know to what extent I'm right, or wrong! R-E

LETTERS

continued from page 18

SPEAKER REPAIR

I'd like to pass along a tip on an area of audio electronics that is seldom touched—fixing tears and holes in old-fashioned paper-cone speakers.

If the damage is on the flat area of the cone, try coating the rip with black nail polish about ¼ to ½ inch to each side. Place a piece of single-ply tissue, trimmed to size, over the area. Then give another coating of nail polish, extending at least ¼ inch beyond the edges of the tissue. Let it dry thoroughly before sending the driver a signal.

Of course, if the corrugated suspension has been torn, that won't do, since it must remain flexible. In that case, cover the damage with a generous coating of rubber cement. Again, let it dry completely before cranking the tunes.

MATT ION
Vancouver, BC

A WELCOME ADDITION

I am delighted to find that Don Lancaster has become one of your regular contributors. I've been a fan of his since I discovered his book *The TTL Cookbook*.

He manages to inject an invigorating irreverence into his work, without the "here's how to steal from the phone company" stuff that seems so prevalent today. I'm glad to find Don among your editorial ranks.

ART HANSEN
Oak Park, IL

SURFACE-MOUNT COMPONENTS SERVICING

I've owned an electronics-service business for many years, and I've adjusted to the changes in technology from the days of tube sets to today's microprocessors. But there is one horror that I really fear—the repair of circuits using *Surface Mount Components*.

After some nightmare experiences with products using that technology, I refuse to service anything that uses them anymore. If it gets to the point where everything is using them, I'll get out of the business.

Those components have no lead slack. They cannot tolerate circuit-board flexing as lead components can. That will lead to a new batch of intermittent problems—the worst type of service problem. I've spent many hours trying to track down intermittent problems caused by those little monsters, and, in every case, it was a separation—invisible to the naked eye—of the end of the component from its tab.

JOHN AUGUSTINE
Reading, PA R-E

COMMUNICATIONS CORNER

When a shield isn't a shield

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

WHETHER WE'RE DEALING WITH DIGITAL or analog circuits, shielding often seems to resemble a kind of magical force that works in its own mysterious way. Quite possibly, had electronics existed back in the days of the Salem witchcraft trials, Cotton Mather would have condemned a piece of metal to be dunked in the river until drowned.

My first introduction to the mysteries of shielding came about with the introduction of the aluminum chassis and cabinet. Prior to aluminum, all audio circuits were assembled on and/or in an iron or steel chassis or enclosure because iron was a magnetic shield. It kept the 60-Hz hum radiated by adjacent powerlines from entering the unshielded wires that interconnected the high-impedance vacuum-tube audio circuits. Quite often, it was necessary to place an iron shield between a power transformer and audio-circuit wiring in order to "shield" the wiring from the transformer's radiated hum field.

I have no idea how many Greenlee punches I wore out punching socket holes in No. 16- and 18-gauge steel chassis and cabinets, but I do remember much of my allowance being spent on Greenlee punches.

I think it was out of pure desperation—meaning I had run out of funds for Greenlee punches—that I built a tubed dynamic noise suppressor on an aluminum chassis and used an aluminum cabinet (I think it was a Budd *Minibox*). Wonders of wonders: the Sun did not stand still, rivers did not stop flowing, and the multi-tubed project (it seemed more as if it were mega-tubed) worked without any hum. I don't think I ever built another project on, or in, iron or steel again, although I have used iron as transformer shields, just as I have used aluminum for transformer shields. But regardless what I used for the chassis, the one thing I did know was that the entire circuit had to be shielded. If I left off a chassis bottom plate, and the project wasn't *totally* shielded, I was just asking for hum or RF-radiation problems.

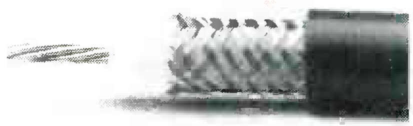


FIG. 1

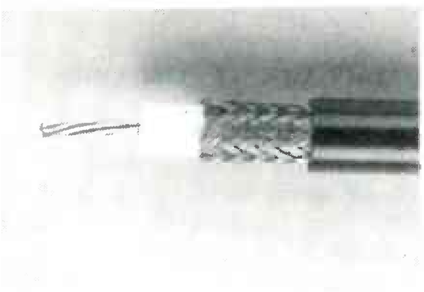


FIG. 2

Percentage shielding

On the other hand, I have had more than my share of troubles with "total" transmission-line shields that weren't. When I first started out in electronics, the metal braid of any kind of shielded wire—audio, RF, powerline, whatever—was wound so tightly around the center conductor that I remember having to pick away at the shielding braid for what seemed like hours in order to make a "shield pigtail" for circuit or socket connections. The magic number that sticks in my mind was 95%. In other words, as I understand it (and I'm certain someone will write in with a college-level thesis on why I am wrong), the shield could reduce radiation into or out of the center conductor by 95%. (As I recall, the surplus military cables used by my first employers were rated at almost 100% shielding; 95% was the minimum acceptable value for non-military industrial shielded cable.)

When I got into both SWL and amateur radio I discovered that some of my antenna systems were fantastic, while others of the exact same design suffered from local noise pickup on reception, or radiated RF from what was supposed to be a "flat" (non-radiating) transmission line.

In virtually every instance the problem was traced to a manufacturer's greed. In order to undersell their competition, some manufacturers were reducing the number of strands in the shield wrap, or stretching the wrap, actually creating "holes" in the shield through which energy could radiate into or out of the center conductor. An example of "stretched" shielding is shown in Fig. 1. Use that stuff for a high-impedance audio signal running adjacent to, or through a powerful 60-Hz field, and I will guarantee the signal will pick up hum. Similarly, if used as an antenna's transmission line, and you run the cable through a strong RFI or EMI field, I'll give you an odds-on bet that you'll hear interference you never expected.

Keep it tight

In many instances, it doesn't matter what kind of metal the braid is made of as long as it is tightly wound. For example, Fig. 2 shows the new Radio Shack coaxial cable, which is rated for at least 95% shielding. Notice that you cannot see the insulation under the braid, which is probably the best visual test you can make on any kind of shielded cable. Comparing Fig. 2 with Fig. 1 gives you a good idea of what to look for as far as the shield itself is concerned. (In fact, much professional shielded audio cable no longer uses braid at all. Instead, the shield is actually a wrapped foil with a drain wire running its entire length.)

A tight braid is particularly important when handling digital signals. You've probably experienced the RF interference on a radio or telephone that is in close proximity to a personal computer. Those of you who have a shortwave receiver may have experienced RFI from a computer in the next house. Often, the interference is caused by RFI leaking through "shielded" cables.

The RFI is created because digital signals are squarewaves, and squarewaves generate at least five harmonics if they're to retain their square shape. Let's assume that you have an early computer having a slow clock of approximately 2 MHz. Since the clock signal is a square wave, you really are generating strong harmonics up to at least 10 MHz. If any of it radiates into a shielded wire that leads from the computer to a peripheral, and the shield isn't too efficient or if the braid is stretched, the RF is going to radiate right through the shield just as if it were broadcast by an antenna. **R-E**

REACTS

continued from page 55

though, we must have a programming language.

One of the simplest and most universal languages is BASIC. A version of BASIC called ZBASIC is available from the Supplier listed in the Sources box. If you have programmed with BASIC in the past, you'll have no trouble at all using ZBASIC. The ZBASIC language is especially geared for use in a process-control environment.

For most applications, ZBASIC should suffice; however, if more speed is needed, you may want to consider purchasing a C compiler and/or Z80 assembler and linker for use with the REACTS system. Those, too, are available from supplier listed in the Sources box. If you are using an IBM machine, or a compatible, you can get the software on a 5¼-inch floppy and download it from the computer to REACTS. If you do not have access to an IBM PC (or compatible), you can purchase the software on 32K PROM's. The PROM's can either be loaded into the PROM programmer, and the software can be loaded from there, or they can be mounted in the PROM/RAM module and accessed. Because of the much greater speed of the PROM/RAM drives, even if you purchase your software in floppy format, you may want to eventually burn the software onto PROM's and place them in the PROM/RAM module as a PROM drive.

Coming soon

Now that we have built the two modules necessary for program development, we are ready to start building more of the actual process-control modules. The particular application will determine the types of process control modules you will need. That is, not all of the modules discussed and constructed in the months to come will be required for every application. You only build the modules that you need. We'll also be building some support modules, including a dedicated CRT-terminal/printer-interface module, and the previously promised battery-backed-up switching power supply.

Next time, we'll look at a universal input/output module. **R-E**

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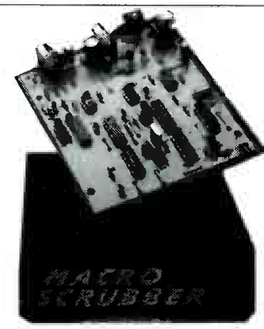

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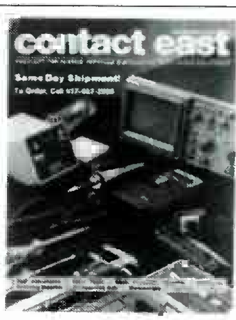

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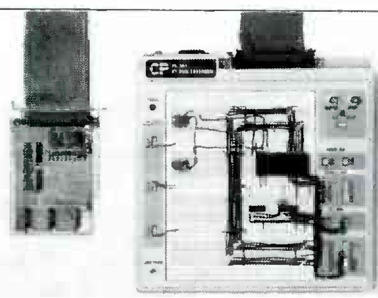

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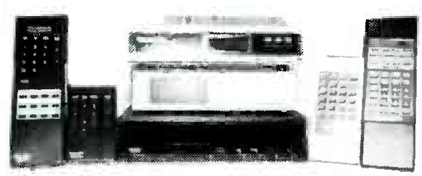

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USING THE RE-BBS

To access the RE-BBS, you need a personal computer and a modem capable of communicating at 300 or 1200 baud. Set the modem for 8 data bits, 1 stop bit, and no parity. (Other formats will work, but you may be unable to upload and download files.) You'll also need a communications program that runs on your computer and can control your modem. If you have an IBM-PC and a modem, but no communications program, get a friend to download the QMODEM.ARC file for you. It contains a user-supported communications program and complete documentation.

The BBS runs 24 hours a day, seven days a week. To sign on the first time, dial 516-293-2283. If your system is working properly, you'll be presented with an identifying message. Type in the requested information. At that point you'll be able to access some, but not all of the BBS. After the Sysop verifies your account, you'll be able to access all relevant areas of the BBS.

You can do several things on the RE-BBS: send and receive messages, and upload and download files. Sending messages is simple, and only requires you to type at your keyboard. Receiving messages is also simple, but to save messages, your communications program must allow you to set up a capture buffer.

Uploading and downloading files is easy after you get the hang of it; just follow directions, and remember always to start the transmitter before starting the receiver—whichever end is transmitting or receiving.

Because of our background and interests, the RE-BBS will be oriented toward IBM-PC's and compatibles. But you can access the RE-BBS with any computer (or ASCII terminal) and modem, so if your interest lies in Apples, Ataris, Commodores, Sinclairs, etc., feel free to participate. If you have public-domain software of interest to other owners of your type of machine, feel free to upload it. The contents of the BBS will in large part be determined by what you post there, so if you feel your machine is being neglected, do something about it!

On the RE-BBS, any file whose name ends in the three letters ARC is an archive file. An archive file is a group of related files that are collected together and compressed in order to save space and download time. Archive files are useful only to owners of IBM-PC's or compatibles. You use a program called ARC.EXE to add to, delete or extract from, list the contents of, etc., an archive.

Similar to archive files are library files, which have the file type .LBR (e. g., HIDDEN.LBR). Like archive files, libraries are also composed of compressed, inter-related programs and data files, but they are incompatible with .ARC files. So an additional utility is necessary to process library files; one such utility is LSWEEP, for Library SWEEP. Library files are used on both CP/M and IBM BBS's, and versions of LSWEEP are available for both types of system. And, although you can unpack a CP/M library file on an IBM-PC, you can't run the .COM files! Nor can you run .COM files from a CP/M library on an IBM!

A method of compressing files is popular on CP/M and some IBM BBS's. On IBM BBS's the file-compression program is usually called SQ.COM (for squeezing) or something similar, and the de-compression program is usually USQ.EXE (for unsqueezing). *SQ and USQ work only on individual files;* a squeezed file always has a *Q* in the second position of the file type (e. g. RIDDLES.TQT). USQ automatically restores the proper file name.

For maximum flexibility, you'll need copies of ARC.EXE, SQ.COM, USQ.EXE, and LSWEEP.EXE. A version of each has been posted on the RE-BBS. If you can't find programs with those exact names, check the directory listing carefully; many of those programs also contain version numbers in their names (e. g., LSWP103.EXE).

A related utility for IBM's, which is based on a popular public-domain CP/M utility, is called PCSWEEP. It allows multi-file copying, deleting, etc. In addition, it can squeeze and unsqueeze files, and process library files. Its biggest limitation is that it can't process archive files.

We've posted much public-domain and user-supported software on the RE-BBS. Feel free to download it and try it out. If you use it, please send the requested donation to the author of the program.

Don't hesitate to upload your own programs, and don't hesitate to participate in the various conferences we've set up. If you're working on a project of general interest, share your thoughts. If you need help—ask!

RE-BBS

VOL. 5 NO. 5 MAY 1988

COMPUTER DIGEST

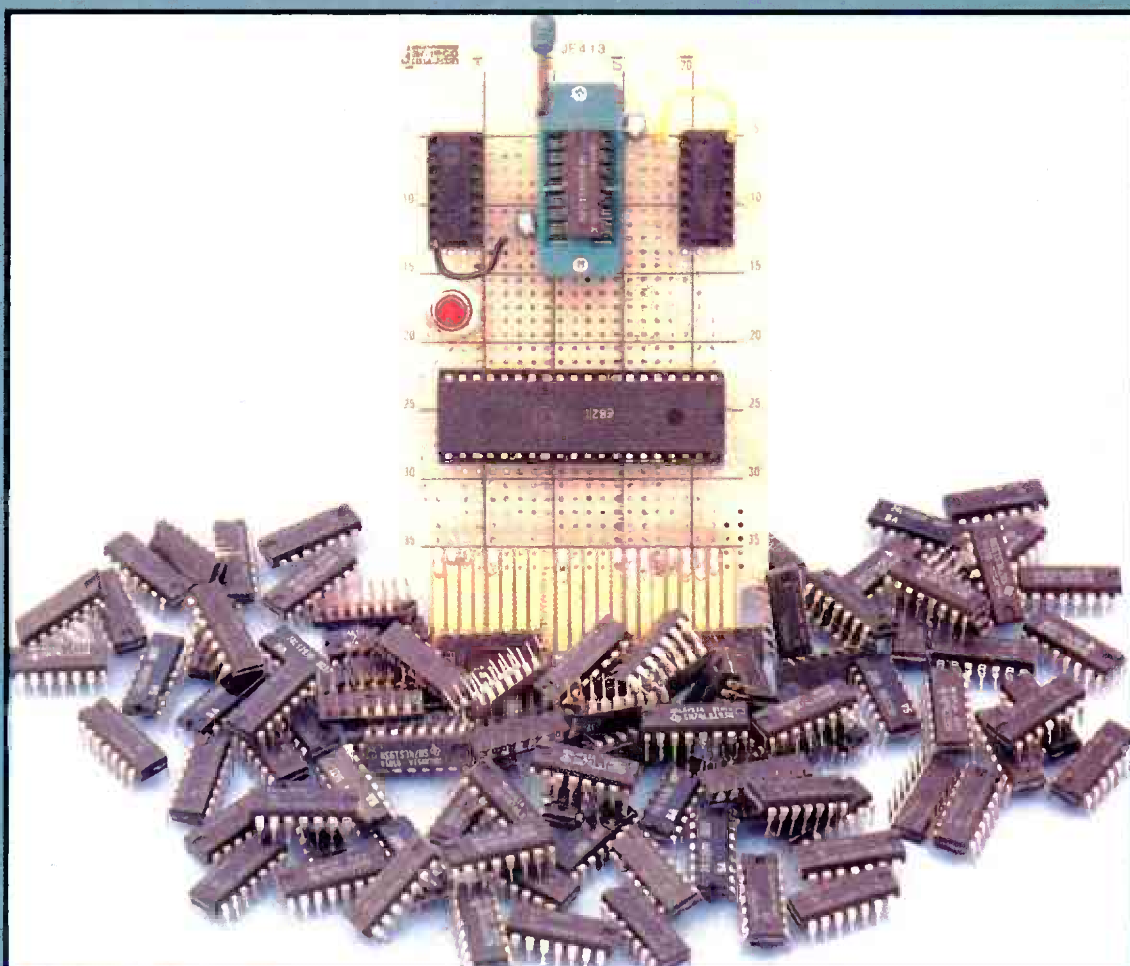
A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

A GERNSBACK PUBLICATION

BUILD A DIGITAL IC TESTER

For your Commodore 64

Page 89



CD CLASSROOM

Troubleshooting your PT-68K

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MULTITASKING

With OS/2, DESQview and TaskView

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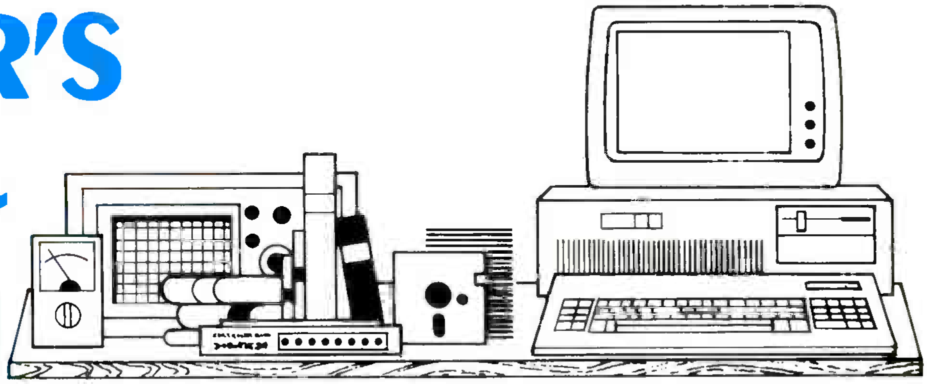
EDITOR'S WORK-BENCH



Multi-tasking with DESQview, TaskView, and OS/2

How do you do two things at once on a PC? You don't—not under DOS anyway. Either get a second PC, or switch to Unix or Xenix.

That used to be true, but not any more. Now there are several ways to get multi-tasking on a PC. DESQview and TaskView allow limited multi-tasking, along with highly useful task swapping; OS/2 allows true multi-tasking.

DESQview and TaskView run on any PC-compatible computer (PC, XT, AT, 80386, or compatible); OS/2 requires an 80286 or 80386 microprocessor that runs in its own address space (i.e., it won't run on most accelerator cards, but see note below), and it requires at least 1.5 megabytes of extended RAM. DESQview and TaskView also function much better with extra RAM, either extended (AT) or expanded (EMS or EEMS).

What's so good about multi-tasking and task swapping? With a large system, you could, for example, sort a database or compile a program in the background while you worked on a spreadsheet or in an editor in the foreground.

With a small system, you could format disks or copy files in the background while you worked in your editor or spreadsheet.

Plain task swapping—wherein the background task does no useful work, and which requires the least hardware investment—can also be highly useful. Suppose you're writing a report and constantly need to refer to data in a spreadsheet. With task swapping, you could switch between the two instantly, without having to quit one application, load the other, quit it, and re-load the first.

OS/2

For test purposes, IBM's version of OS/2 was installed on an AST Premium/286 (a 10-MHz 0-wait state AT compatible) with 640K of conventional RAM, 1.5M of extended RAM, a 40M hard disk, and a NEC MultiSync monitor and EGA adapter. The operating system was supplied on four high-density (1.44M) 3½ floppy disks; the Premium/286's BIOS directly supports that format, so it was simple to configure the micro disk drive as drive A and run the installation there.

OS/2 comes with an automated installation program that automatically copies the appropriate files—about 2.5 megabytes worth—to your hard disk. In doing so, some of your DOS system files are overwritten, so to run your machine in DOS mode, you'll have to boot from floppy. (Other OEM versions of OS/2, from AST and Zenith, for example, will allow you to choose either DOS or OS/2 when booting.)

OS/2 runs in two modes: OS/2 and DOS compatible. The latter is not an actual copy of DOS, but a compatibility mode, so software incompatibilities are sure to surface. In fact, although we had

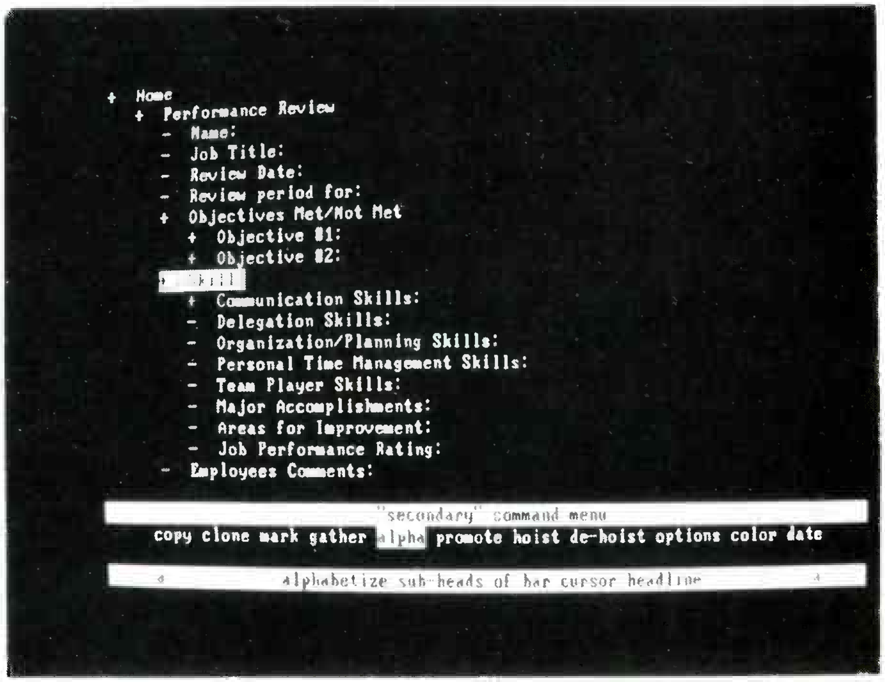


FIG. 1

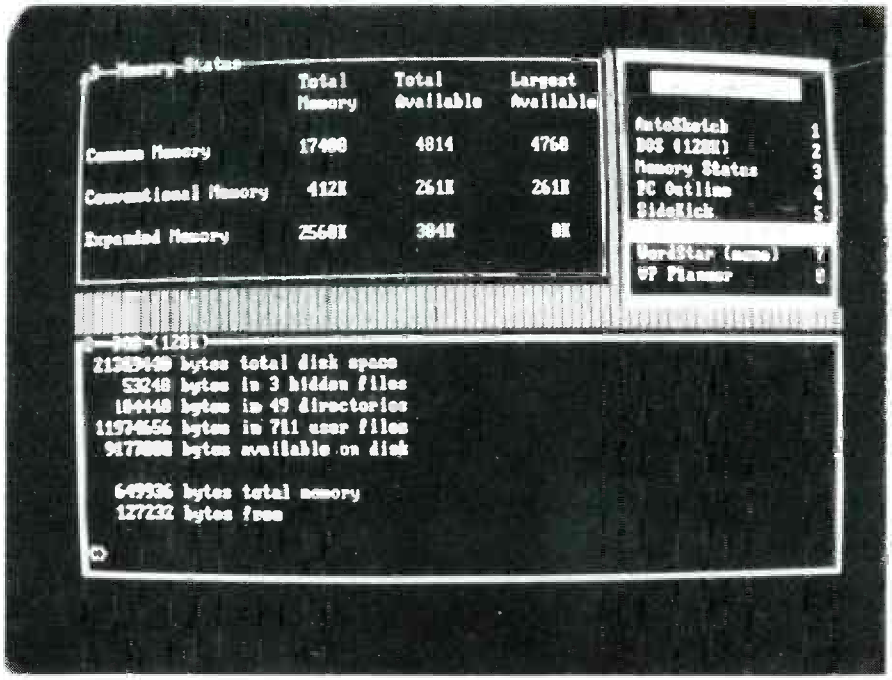


FIG. 2

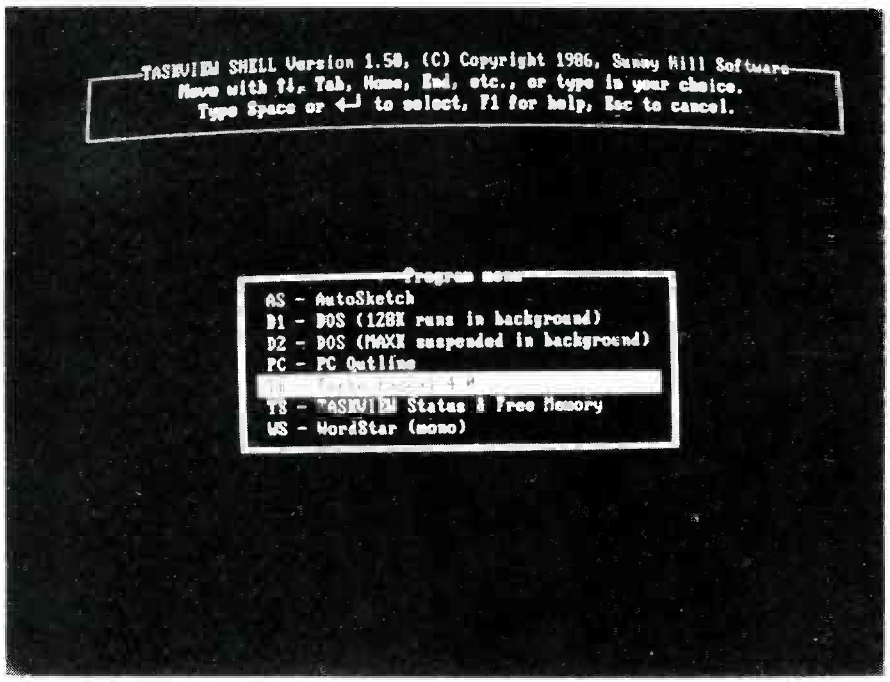


FIG. 3

no trouble running some fairly tough software (Windows 2.0 and PageMaker, among others) the DOS mode repeatedly crashed when bringing up SideKick's calculator. In addition, even with 640K of RAM allocated for the compatibility mode, only about 520K is available for running programs.

Those are not serious problems, because eventually, anyway, you won't run OS/2 for the compatibility box, but for OS/2 applications. However, currently OS/2 is more promise than presence. In fact, as this is written (early February) only one OS/2 application is actually shipping: Living VideoText's excellent outline processor, ThinkTank. The program is a straight port of the DOS version, and in fact operates identically to it. The OS/2 version doesn't take advantage of any OS/2 features (other than the fact that you can run more than one copy of it at a time). Almost unbelievably, ThinkTank comes with both DOS and OS/2 versions—at no extra cost. See Fig. 1.

When you first start OS/2, you're presented with the Program Selector Screen. There you can start a program running, switch to a currently running program (including the DOS box, as well as one or more copies of the OS/2 command line), add a program to OS/2's list, and obtain help in the form of a simple tutorial. To save disk space, the tutorial can be deleted later.

After starting a program, you can return to the Program Selector at any time by pressing Ctrl-Esc; you can cycle among currently running programs without going through the Program Selector by pressing Alt-Esc.

At the command line, OS/2 is quite similar to DOS. Nearly all commands function the same in both environments, except that many OS/2 commands provide more powerful options (TYPE *.TXT, for example).

Both OS/2 and DOS device drivers are specified in the same CONFIG.SYS file, and many more options can be specified in OS/2's CONFIG.SYS file than in DOS's. Many of those options will allow a great deal of customizability for systems integrators when real applications become available.

You can't do much with OS/2 right now. But all major software vendors are scrambling both to port current DOS applications and to write new ones specifically for OS/2. Complicating the scenario (and delaying eventual applications) is the fact that a Windows-like graphical user interface is due to be released sometime this fall. The so-called Presentation Manager (which is reputedly identical to the user interface in Windows 2.0 and Windows/386) provides a completely different programming interface, so it is highly unlikely that we'll see ports of existing applications that run under the Presentation Manager. In fact, new applications must be written from scratch, which is a slow process, due to the complexity of the interface.

IBM and Microsoft are to be commended for introducing OS/2 at this time. Compromises were made (the slow and buggy DOS box, the 32-megabyte file and disk size limit, no inherent 80386 support), but those compromises provide an upgrade path so that current users simply weren't abandoned. We eagerly await the new applications that will justify our patience, and that will, over the next few years, make us regard DOS much as we now regard CP/M: useful in its day, but outmoded by advances in both hardware and software.

As for running OS/2 on an accelerator card, it is claimed that both SOTA Technology's MotherCard 5.0 and Microsoft's much-delayed Mach 20 will run OS/2. We hope to be able to verify those claims next time.

Multi-tasking today

Don't want to wait for OS/2? With DESQview (shown in Fig. 2) or TaskView (shown in Fig. 3) you'll be able to achieve one of the main benefits of a true multi-tasking operating system: the ability to run several programs simultaneously.

Even without expensive hardware, you can still do task swapping, which can provide a tremendous boost in overall productivity.

Your microprocessor, type(s) of memory, and control software will determine your ability to multi-task and task swap. On an 80386-based machine with several megabytes of memory and a special memory manager that takes advantage of the 80386's ability to re-map physical memory, you can run several very large programs (about 550K each) simultaneously. DESQview's 80386 memory manager is called QEMM; other companies market similar products.

On 80286 and lesser machines with EEMS (Enhanced EMS) or EMS 4.0 memory, you can run several medium-sized programs (about 400K, depending on how your computer's memory is configured) simultaneously.

On 80286 and lesser machines with plain EMS (i.e., version 3.2) memory, extended memory, or no non-DOS memory at all, you can multi-task whatever you can fit into the first 640K of memory. Inactive tasks will be swapped to mass storage: either directly to EMS memory, to a RAM disk in EMS or extended memory, or, with no extra memory, to disk, a relatively slow process that negates most of the advantage of the software.

That's not to imply that you need a huge 80386 system to benefit from DESQview or TaskView; if you can get by with simple task swapping, an inexpensive EMS board is sufficient.

To run either TaskView or DESQview, you'll want to unload all but the basic necessities from your AUTOEXEC.BAT and CONFIG.SYS files. The reason is that the larger the initial chunk of memory you have available after loading DV or TV, the larger will be the largest partition you can allocate.

For example, on a standard IBM PC XT (with a Hercules monochrome adapters) that has about 590K of DOS memory after booting and loading an EMS driver and a mouse driver, the largest DOS partition under DESQview is about 415K. Adding the ability to display text and graphics simultaneously drops that figure to about 400K. On an AT, you can load part of DESQview in extended memory and save an additional 50K or so of memory.

On the other hand, in its default state TaskView uses quite a bit less memory than DESQview—about 100K, leaving about 490K as the largest partition—but TaskView unbundles some features that are standard with DESQview (an auto-dialer, a keyboard macro processor, and better support for graphics programs.) You can also load part of TaskView in expanded memory, leaving a maximum partition of almost 540K.

Both programs allow you to start programs running, switch among them, and set up special parameters that determine how each program runs (in graphics mode, with direct screen writing, use of a math co-processor, etc.) using several easy to navigate menus. In addition, you can set up TaskView so that you can control operations at the command line, rather than through the menus. On the test system, that left a maximum partition of about 510K.

In a system without EMS memory, you'd want to give serious consideration to mastering command-line operation. At the command line, you can open a program (which loads it and makes it the current program), spawn a program (which loads it and leaves it in the background or swapped to mass storage), and switch to a currently running program using either hotkeys or an executable file. The latter option allows you to use DOS batch files for switching among tasks. The only disadvantage to command-line operation is that you must master use of a number of poorly documented "switches" that specify how a program should run.

TaskView comes with a powerful keyboard macro processor that, in addition to allowing you to create macros, allows you to cut and paste data among programs running in different partitions. Also, a simple cut and paste program that uses less RAM is included.

TaskView's main weakness is difficulty in handling graphics programs. On an EGA, colors aren't always restored right, and on a Hercules monochrome screen, the program has trouble switching between text and graphics modes. However, the company is aware of those problems, and fixes are expected by the time you read this. In addition, new versions of the program that make full use of EMS 4.0 memory and the 386's hardware address-mapping capabilities are also due to be released before you read this.

DESQview

Quarterdeck Office Systems' DESQview has been on the market quite a bit longer than TaskView, so the company has already been able to meet some of the challenges that TaskView still faces. (Mainly, its graphics handling is impeccable.) DESQview doesn't include a command-line version, and, whereas TaskView can load part of itself only in expanded memory, DESQview can load part of itself only in extended memory. Therefore, an AT is required to get a RAM partition greater than about 420K. On an 80386 system, by adding Quarterdeck's memory manager (QEMM), you can obtain a much larger partition.

In its default configuration, DESQview uses more RAM than TaskView. There are several reasons for that. One is a built-in keyboard macro processor. Also, DESQview provides more of a Windows-like environment than TaskView; that may or may not be useful to you. For example, you can define a "window" for running each of your applications. As long as your application uses the BIOS for display, it can run in that window.

The problem is that the vast majority of programs do write directly to video memory, so DESQview's windowing capability goes unused. However, some programs can be configured to use the BIOS. WordStar 4.0, for example, can be configured to use BIOS output routines, and when it is, the program runs in a DESQview window nicely. The problem is less severe on 386 machines, again because of hardware re-addressing.

Both TaskView and DESQview contain memory-status programs that show total, used, and unused amounts of various types of memory. DESQview's program is slightly better in that in runs in the background and constantly maintains updated information.

DESQview also includes a DOS services program that aids file and disk maintenance, but it's no match for any half-decent DOS shell. Other desktop accessories are available at extra cost.

Documentation for both products is somewhat problematic; TaskView's manual is brief, and DESQview's manual is poorly organized. To get either program running with your applications, count on spending some time reading and experimenting. As for on-line help, DESQview has a definite advantage.

Conclusions

I like both programs; choosing between them is difficult, especially because new versions of both will be released soon. DESQview does more hand holding, but uses more memory; TaskView uses less memory, but has problems with graphics. TaskView's cost is about two-thirds that of DESQview, but it only does 90% as much.

If you've run out of room trying to cram RAM-resident programs (SideKick, CED, etc.) in your machine, either TaskView or DESQview can help. You won't gain all the advantages of a true multi-tasking operating system, but both products offer a good interim solution.

PRODUCTS REVIEWED

- OS/2, Microsoft Corporation, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717.
- DESQview ($130), Quarterdeck Office Systems, 150 Pico Blvd., Santa Monica, CA 90405 (213) 392-9701.
- TaskView ($80), Sunny Hill Software, P.O. Box 33711, Seattle, WA 98133-3711 (206) 367-0650.
- ThinkTank ($195), Living VideoText, 117 Easy Street, Mountain View, CA 94043 (415) 964-6300.

DIGITAL IC TESTER

An Accessory For Your Commodore 64

Your Commodore C64 computer can pretest digital components.

JIM BARBARELLO

An important part of building a digital project is to make sure that all the active components work properly before they're installed. That is even more critical when you deal with sensitive devices like CMOS integrated circuits. Unfortunately, few of us do pre-installation tests because it's somewhat difficult to routinely test digital devices of any kind. We simply solder the parts into the circuit, cross our fingers, and apply power. If the circuit doesn't work, we poke around until we find the bad part. Then we replace it, hoping we don't damage the PC board, or install another defective component. Clearly, a better way is to test each part (especially IC's) before using it.

If you're fortunate enough to own a Commodore *C64* computer you can easily and inexpensively assemble a special kind of tester that will automatically perform up to 100 user-programmed tests on most TTL and CMOS 14- and 16-pin digital IC's; and it is also a simple matter to use the tester to check the switching action of transistors and diodes.

The tester, whose schematic is shown in Fig. 1, is a simple device that actually depends on special software to run the tests. That software allows you to specify how you want a specific TTL or CMOS device tested, and then tests as many units of that device as you like, one after the other, with each complete test taking less than five seconds. If the device doesn't function properly, the software stops the test and tells you specifically how the device failed.

To avoid creating damage where none existed before, the DUT (*D*evice *U*nder *T*est) is installed in a ZIF (*Z*ero *I*nsertion *F*orce) socket; a special kind of IC socket that applies virtually no strain or force to the pins of the DUT.

As an added bonus, the tester includes a hardware reset switch (S1) that resets the computer at the push of a button (no more powering down and then up again). No external power supply is required to use the unit because the tester gets its power directly from the computer's expansion port.

The circuit

As shown in Fig. 1, the tester consists mainly of IC1, a 6821 PIA (*P*eripheral *I*nterface *A*daptor), two resistors, and ZIF-socket SO3. In addition, two 16-pin DIP sockets (SO1 and SO2) are used as terminal blocks to apply power to the DUT. Switch S1 connects between the computer's RESET line and ground: pressing S1 brings the RESET line low and restarts the system without actually having to re-power the computer.

PIA IC1 receives its power, timing, addressing, and data from the computer's expansion port. The sixteen individual peripheral lines are programmed as inputs or outputs by software. IC1 is addressed at decimal memory locations 57100 to 57103. Output lines remain in the previously set state until changed. Input lines are not latched, and therefore show the momentary status of any device connected to them.

Two halves

Since the computer has an 8-bit data bus and the PIA has 16 data lines, the PIA is divided into two halves: side A with PA0–PA7, and side B with PB0–PB7. There are individual control, data direction, and peripheral registers for each side. The control registers allow you to select either the data-direction register (for configuring the peripheral lines as input or output), or the peripheral register (for sending and receiving data). The peripheral registers (when selected as data- direction registers) are located at decimal memory locations 57100 (side A) and 57102 (side B). The control registers are located at 57101 (side A) and 57103 (side B).

Construction

The tester is assembled on a Jameco *JE413* or similar wiring board using wire-wrap connections. Because the edge of the board also serves as plug P1, Fig. 1 shows the connections to both sides of P1 as they actually appear on the board. The half of P1 indicated as TOP are the gold-plated finger connections on the component side of the

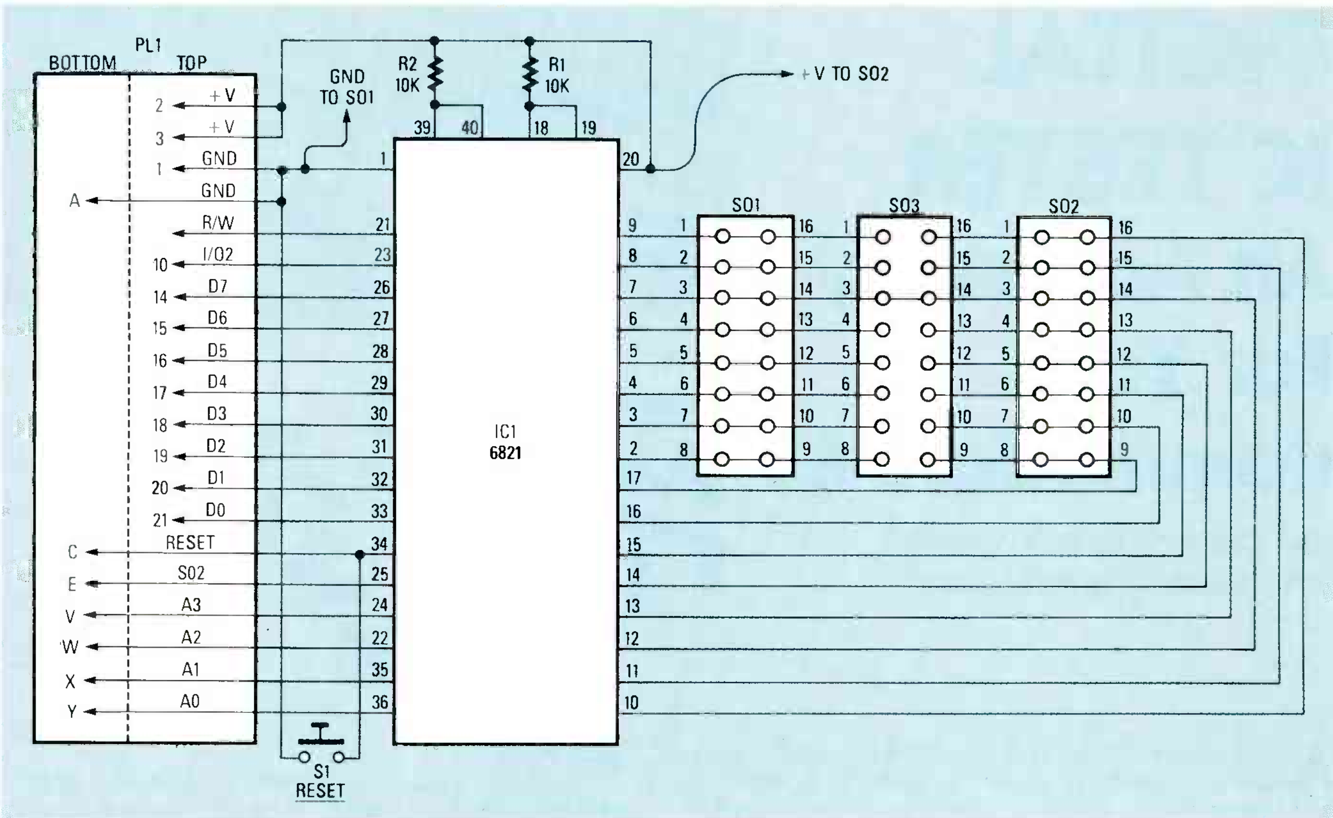


FIG.1—THE SOCKET TERMINALS are specially wired to provide almost automatic selection of the ground and power terminals.

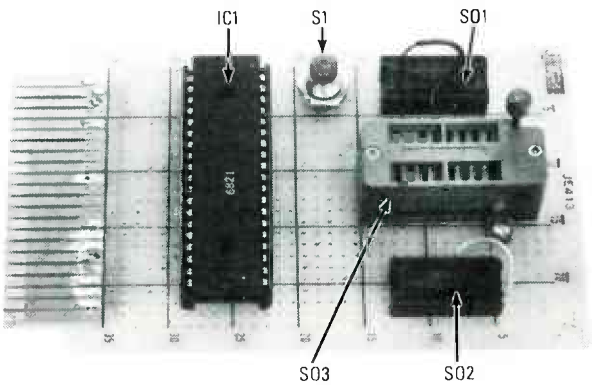


FIG. 2—THE PARTS WILL FIT WITHOUT CROWDING on a Jameco *JE413* board. Wire-wrap is used for all connections except those soldered to the fingers.

board. The half of P1 indicated as BOTTOM are the gold-plated finger connections on the wiring side of the board.

However, the connections to both sides of the board are made from the bottom side. The bottom connections have obvious solder pads that extend from the fingers. The connections to the top fingers are made by passing wires through the appropriate holes on the board. Although wire-wrap connections are used to interconnect the components, those to the fingers should be soldered; don't use stake-on or wire-wrap terminals at the fingers.

The general parts layout isn't critical, although operation will be somewhat more convenient if you follow the one shown in Fig. 2. Make certain you install SO3 so that its lever faces the back edge of the board. Drill two ⅙-inch holes near SO1 and SO2 for the power leads.

Wire across

As shown in Fig. 1, the pins on SO1 and SO2 are wired straight across: pin 1 connects to pin 16, pin 2 connects to pin 15, etc. That is done so you don't have to figure out the convolution of the pins when inserting the +V and ground wires in SO1 and SO2. To determine the power connections to the DUT, simply count from 0–14 or 0–16 starting on either row of pins and you'll automatically end up on the correct connections. (It might appear confusing

PARTS LIST

R1, R2—10,000-ohms, ¼-watt, 10%
IC1—6821 PIA (Jameco 68B21)
SO1, SO2—16 pin wire-wrap socket
SO3—16 Pin ZIF socket
S1—Momentary N.O. pushbutton switch
Miscellaneous: Wiring board Jameco JE413 , No. 24, solid wire (black and red), wire-wrap wire, wire-wrap tool, solder, etc.
NOTE: The following are available from J. J. Barbarello, RD#3, Box 241H, Tennent Road, Manalapan, NJ 07726. IC Tester program (No. IC64) on Commodore *C64* disk (IC64): $5.00. Enhanced program (No. (TTLDB) with TTL library of the most commonly used TTL IC's on a Commodore *C64* disk, along with instructions for use: $20.00. Enhanced program (No. CMOSDB) with CMOS library of the most commonly used CMOS IC's on disk, along with instructions for use (CMOSDB): $20.00. Enhanced program with both CMOS and TTL libraries and instructions: $30.00. Please include $2.00 shipping with each order. New Jersey residents must add appropriate sales tax.

```
1 REM ********************************
2 REM **  IC64 TESTING SOFTWARE       **
3 REM **  NAME:  IC64   V870605       **
4 REM **  (C) 1987, J.J. BARBARELLO  ** 5 REM **  MANALAPAN, NJ  07726        **
6 REM ********************************
8 GOSUB 5000:PRINTCHR$(147):RCS=CHR$(18)+CHR$(158):NC$=CHR$(146)+CHR$(5)
10 DIM I1(100),I2(100),O1(100),O2(100),OO$(16),LS$(16):RC$=CHR$(18)+CHR$(158)
15 PRINTCHR$(147):RO=4:CO=4:FORI=1TO8:T(I)=2^(I-1):NEXT
16 T1$="     "+RC$+"  THE IC64 INTEGRATED CIRCUIT  "+NC$
17 T2$="     "+RC$+"      AUTOMATED TEST SYSTEM     "+NC$:PRINTT1$:PRINTT2$
18 GOSUB5050:PRINTBL$:GOSUB5050:INPUT"WHICH SIZE IC (14 OR 16 PINS)";IC
19 IF IC<>14 AND IC<>16 THEN 18
20 PRINT"     WAIT...":CM$="+-NIOE"+CHR$(29)+CHR$(157)
25 LO$="SETUP PHASE: DEFINE SOCKET PINS   "
30 IFIC=16THENL1$="     0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1    ":GOTO 40
35 L1$="     0 0 0 0 0 0 0     0 0 1 1 1 1 1    ":GOTO 40
40 IFIC=16THENL2$="     1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6    ":GOTO 50
45 L2$="     1 2 3 4 5 6 7 N N 8 9 0 1 2 3 4    "
50 L3$="     C C C C C C C C C C C C C C C C    "
60 GOSUB5050:PRINTLO$:PRINTL1$:PRINTL2$:PRINTL3$
70 RO=16:CO=4:GOSUB5050:PRINT RC$;" SETUP COMMANDS: ";NC$:PRINT
80 PRINT"     I = INPUT PIN";TAB(22);"O = OUTPUT PIN"
90 PRINT"     ";"- = VSS (GND)"TAB(22);"+ = VDD (PWR)
100 PRINT"     N = NOT USED"TAB(22)"E = END DEFINE":PRINT"     "CHR$(60)"-";
110 PRINT"CRSR = LEFT"TAB(22)"-"CHR$(62)"CRSR = RIGHT"
120 RO=9:CO=4:GOSUB 5050:SS$=CM$:PT=1
130 GOSUB 6100:GOSUB6000
140 ON SS GOSUB 150,160,170,180,190,230,210,220:GOSUB5050:GOTO130
150 PRINT"+":OO$(PT)="+":RETURN
160 PRINT"-":OO$(PT)="-":RETURN
170 PRINT"N":OO$(PT)="N":RETURN
180 PRINT"I":OO$(PT)="I":RETURN
190 PRINT"O":OO$(PT)="O":RETURN
210 IF PT=16 THEN RETURN
212 IF IC=14 AND PT=7 THEN PT=9:CO=CO+4
215 PRINTCHR$(157);"{SS}":PT=PT+1:CO=CO+2:RETURN
220 IF PT=1 THEN RETURN
222 IF IC=14 AND PT=10 THEN PT=8:CO=CO-4
225 PRINTCHR$(157);"{SS}":PT=PT-1:CO=CO-2:RETURN
230 PRINTCHR$(157)"{SS}"
235 RO=10:CO=14:GOSUB5050:PRINTRC$" W A I T ..."NC$
236 FORI=1TO16
237 IFOO$(I)<>"I"ANDOO$(I)<>"O"ANDOO$(I)<>"+"ANDOO$(I)<>"-"THENOO$(I)="N"
238 NEXT
240 FORI=1 TO 8:IF OO$(I)="I" THEN PA=PA+T(I)
245 IF OO$(I)="N" THEN MA=MA+T(I)
250 NEXT:MA=255-MA
260 FORI=1 TO 8:IF OO$(I+8)="I" THEN PB=PB+T(I)
265 IF OO$(I+8)="N" THEN MB=MB+T(I)
270 NEXT:MB=255-MB
280 POKE SA+1,0:POKE SA,PA:POKE SA+1,4:POKE SB+1,0:POKE SB,PB:POKE SB+1,4
285 POKE SA,0:POKE SB,0
290 RO=4:CO=4:GOSUB5050:PRINT"      I.C.  INITIALIZATION          "
300 RO=16:CO=2:GOSUB5050:PRINT"DIRECTIONS:  MOVE CURSOR WITH LEFT/"
310 PRINT"     RIGHT CURSOR KEY.  CHANGE INPUTS   "
320 PRINT"     BY TYPING 1 OR 0.  BRING IC TO     "
330 PRINT"     INITIALIZED STATE, THEN PRESS ";RC$;" E ";NC$:PRINTBL$:PRINTBL$
340 PRINT"     STEP: 0"TAB(22)"(MAX STEPS=100)":NS=1:PH=0
345 RO=9:CO=4:GOSUB5050:FORI=1TO16:PRINTOO$(I)"{SS}";:NEXT:PRINT:PRINT"    ";
350 FOR I=1TO16:IF OO$(I)="I" THEN PRINT"Z ";:PU=I:GOTO 370
360 PRINT"{SS}{SS}";
370 NEXT:CM$="01E"+CHR$(29)+CHR$(157):RO=11:CO=3:GOSUB5050:PH=0
380 SS$=CM$:PT=1:N=PEEK(SA) AND MA:GOSUB3000:PRINTA$;:N=PEEK(SB) AND MB
385 GOSUB 3000:PRINTA$
390 FORPT=1TO16:IFOO$(PT)<>"I"THEN NEXT:GOTO 7000
400 CO=4+(PT-1)*2:GOSUB 5050:PX=PT
410 GOSUB6100:GOSUB6000:IF SS=0 THEN 410
420 ON SS GOSUB 430,440,530,450,460:GOSUB5050:GOTO410
430 PRINT"0";:LS$(PT)="0":GOTO 470
440 PRINT"1";:LS$(PT)="1":GOTO 470
450 IF PT=PUTHENRETURN
453 PT=PT+1:IFOO$(PT)<>"I" THEN 450
456 PRINTCHR$(157);"{SS}":CO=4+(PT-1)*2:RETURN
460 IFPT=PXTHENRETURN
463 PT=PT-1:IFOO$(PT)<>"I"THEN460
466 PRINTCHR$(157);"{SS}":CO=4+(PT-1)*2:RETURN
470 PRINTCHR$(157);CHR$(157);RC$">"NC$:C=CO
475 N1=0:FORI=1TO8:IFLS$(I)="1"THENN1=N1+T(I)
480 NEXT:N2=0:FORI=9TO16:IFLS$(I)="1"THENN2=N2+T(I-8)
490 NEXT:O1(NS)=N1:O2(NS)=N2:POKE SA,N1:POKE SB,N2:RO=11:CO=3
495 IF PH=0 THEN I1(NS)=999:I2(NS)=999
500 IF PH=1 THEN I1(NS)=PEEK(SA) AND MA:I2(NS)=PEEK(SB) AND MB
505 GOSUB5050:N=PEEK(SA) AND MA:GOSUB3000:PRINTA$;:N=PEEK(SB) AND MB
507 GOSUB 3000:PRINTA$
510 IF NS=100 THEN SS$="YN":GOTO 570
520 RO=22:CO=9:GOSUB5050:PRINTNS:RO=11:CO=C:GOSUB5050:NS=NS+1:RETURN
530 IF PH=1 THEN SS$="YN":NS=NS-1:GOTO 570
535 PH=1:C=CO:RO=4:CO=4:GOSUB5050:PRINT"       I.C. TESTING PHASE
540 RO=15:CO=0:GOSUB5050:PRINTRC$;BL$;NC$:RO=18:CO=23:GOSUB5050
550 PRINT"PRESS "RC$" E "NC$" TO END ";RC$;BL$;NC$
560 RO=11:CO=C:RETURN
570 PRINTCHR$(147):PRINTT1$:PRINTT2$:PRINT:PRINT"    TEST ANOTHER IC (Y/N)..";
580 GET A$:IF A$="" THEN 580
590 GOSUB 6000:IF SS=0 THEN580
600 IF SS=2 THEN 900
610 RO=4:CO=4:GOSUB5050:PRINT"     <<< TESTING PHASE >>>"
620 PRINT:PRINT"   INSERT NEXT DEVICE TO BE TESTED."
630 PRINT:PRINT"   PRESS ";RC$" F1 "NC$" WHEN READY...";
640 GET A$:IF A$="" THEN 640
650 IF ASC(A$)<>133 THEN 640
660 RO=4:CO=4:GOSUB5050:PRINTBL$;BL$;BL$;BL$:RO=4:CO=4:GOSUB5050
670 PRINT"TESTING. STEP:":CO=19
680 FORI=1TO NS:IF I1(I)<>999 THEN 690
685 POKE SA,O1(I):POKE SB,O2(I):GOSUB 5050:PRINTI:NEXT
690 S=I:FORI=S TO NS:GOSUB5050:PRINTI:POKE SA,O1(I):POKE SB,O2(I)
700 IF(PEEK(SA) AND MA)<>I1(I) OR(PEEK(SB) AND MB)<>I2(I) THEN 730
710 NEXT
720 PRINT:PRINT"    PASS. IC PERFORMS AS EXPECTED"
723 PRINT"    PRESS ANY KEY..."
725 GET A$:IF A$="" THEN 725
726 GOTO 570
730 CO=4:GOSUB5050:F=I:PRINT"      IC FAILS AT STEP";F
735 PRINT"         PIN #{SS}(I=INPUT, O=OUTPUT)"
740 PRINTL1$:PRINTL2$:PRINTL3$:PRINT"    ";:FOR Q=1TO16:PRINTOO$(Q)"{SS}";:NEXT:PRINT
750 PRINT:PRINT"             EXPECTED RESPONSE"
760 N=I1(F):GOSUB 3000:PRINT"   ";A$;:N=I2(F):GOSUB 3000:PRINT A$
765 IF IC=14 THEN RO=14:CO=18:GOSUB5050:PRINT"   "
770 PRINT:PRINT"             OBSERVED RESPONSE"
780 N=PEEK(SA) AND MA:GOSUB 3000:PRINT"   ";A$;:N=PEEK(SB) AND MB
790 GOSUB3000:PRINTA$:PRINT:IF IC=14 THENRO=17:CO=18:GOSUB5050:PRINT"   ":PRINT
795 GOTO 723
900 PRINTA$:RO=12:CO=12:GOSUB5050:PRINT"PROGRAM ENDED.":PRINT:PRINT:END
2999 END
3000 REM** CONVERT TO BASE2
3010 A$="":FOR I=8 TO 1STEP-1:IF T(I)>N THENA$=" 0"+A$:GOTO 3030
3020 N=N-T(I):A$=" 1"+A$
3030 NEXT:RETURN
5000 REM* CURSOR CONTROL USING PLOT               KERNEL ($FFF0)
5005 SA=57100:SB=SA+2:POKE SA+1,0:POKE SA,0:POKE SA+1,4:POKE SB+1,0:POKE SB,0
5008 POKE SB+1,4
5010 DATA 162,0,160,0,24,32,240,255,96,999
5020 A=49300:SC=A
5030 READ B:IF B<>999 THEN POKE A,B:A=A+1:GOTO 5030
5040 POKE53280,6:POKE53281,6:RETURN
5050 POKE SC+3,COL:POKE SC+1,ROW:SYS SC
5060 BL$="                                        ":RETURN
6000 REM** INSTR ,SEARCH=SS$,IN=A$
6010 FOR SS=1 TO LEN(SS$)
6020 IF A$=MID$(SS$,SS,1) THEN RETURN
6030 NEXT SS:SS=0:RETURN
6100 REM** CURSOR BLINK
6110 PRINTCHR$(157)">";
6120 GET A$:IF A$="" THEN 6140
6130 RETURN
6140 PRINTCHR$(157);" ";:GOTO 6110
7000 REM** NO DEFINITIONS
7010 PRINTCHR$(147):PRINT:PRINT
7020 PRINT"  NO DEFINITIONS MADE. PROGRAM ABORTED":PRINT:PRINT:END

READY.
```

at first glance, but if you study Fig. 1 a few times you'll understand how it works out automatically.)

Connect R1 and R2 after all the wire-wrap connections are made. Solder R1 to IC1 pins 18 and 20. Similarly, solder R2 to pins 20 and 39. Cut 6-inch lengths of red and black No. 24 solid wire. Solder one end of the black wire to S1. Solder one end of the red wire to the junction of R1 and R2. Bring each wire through the board to the component side through drilled holes after first making a knot in each wire to serve as a mechanical stop. Make two additional stop-knots on the component side of the board, then strip ¼-inch of insulation from the end of each wire. The uninsulated ends will remain free for later use in applying power (red) and ground (black) to the DUT.

As with all wire-wrapped projects, check for wire nicks or other faults. You may want to do a continuity check on each connection to ensure proper wiring.

Using the tester

Insert the tester into the computer's expansion port before applying power to the computer. Enter the program shown in Table 1 (the program is available on disk —see the Parts List) and save it using the filename "IC64." Run the program by typing LOAD "IC64", 8 (notice that the comma is after the close-quotation mark), and then press the RETURN key. Then type RUN and press RETURN. Then install the DUT in the ZIF socket.

As shown in Fig. 3, 16-pin IC's just fit the ZIF socket. However, 14-pin IC's must be positioned towards the front of the socket because the rear two ZIF pins aren't used when testing 14-pin IC's. Take particular note from Fig. 3 how the pin numbering of the ZIF socket is modified for 14-pin IC's.

The program begins by asking you to specify whether the IC you'll be testing has 14 or 16 pins. Next, the program enters the Setup Phase and displays the screen shown in Fig. 4. Under the pin labeled 01 (meaning pin 1), is a blinking cursor that resembles the greater-than (>) symbol. (You can move the cursor with the right or left arrow keys). Note from Fig. 4 that when a 14-pin test is selected the two center positions are marked "N," meaning that the two lower pins in the ZIF socket (SO3) aren't used. The cursor will automatically skip over the unused pins as the data is entered.

The bottom of the Fig. 4 screen defines the setup commands. As shown in Fig. 5, you identify each pin as an input (I) to the IC, an output (O) from the IC, a ground pin (–), or a voltage-supply pin (+). A pin that will not be used, or a pin where you do not particularly care what happens, is identified with an N or left blank. As an example, the pin identification for a 7408 TTL quad 2-input AND gate would be:

IIOIIO– OIIOII+

For pins 1 through 7, pins 1 and 2 are identified as gate inputs with pin 3 being an output; pins 4 and 5 are inputs with pin 6 an output; pin 7 is ground (–). Similarly, we see that pins 8 and 11 are outputs, pin 14 is where the power

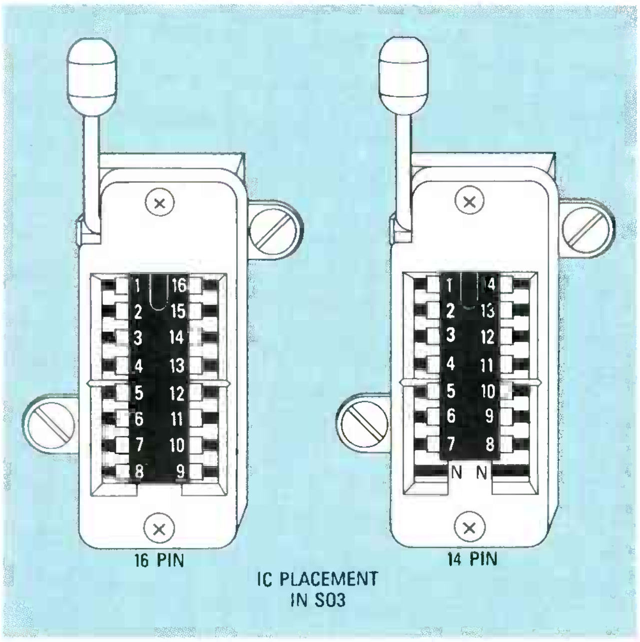


FIG. 3—ALTHOUGH A 16-PIN IC FITS the entire ZIF socket, a 14-pin IC must be positioned forward, so that the rear two ZIF pins aren't used.

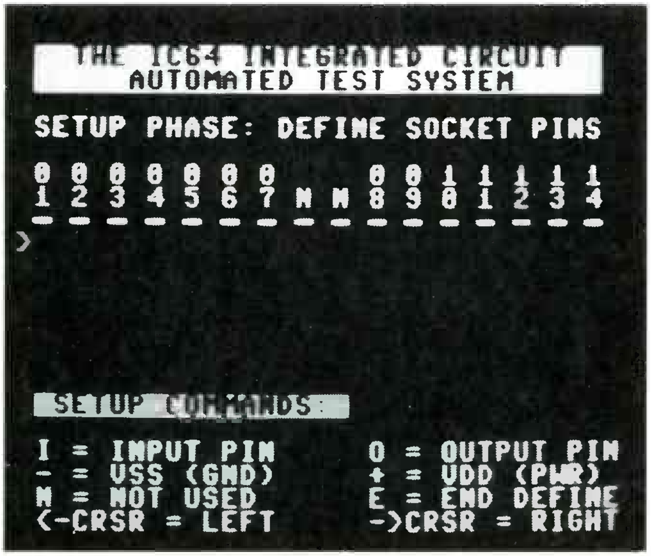


FIG. 4—IF YOU SELECT 14-PIN IC'S FOR TESTING the setup screen will indicate an N for the two unused ZIF socket terminals. The actual IC terminals are indicated as 01–14.

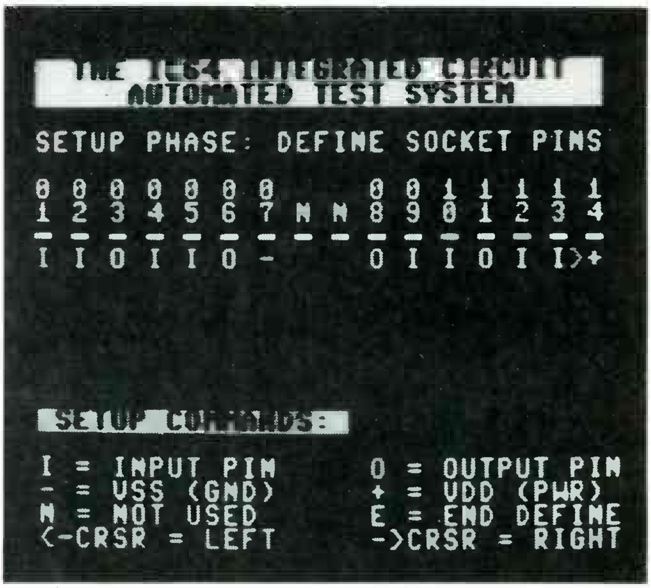


FIG. 5—FIRST STEP IN ANY TEST is to define the function of each socket pin, including the ground and +V connections.

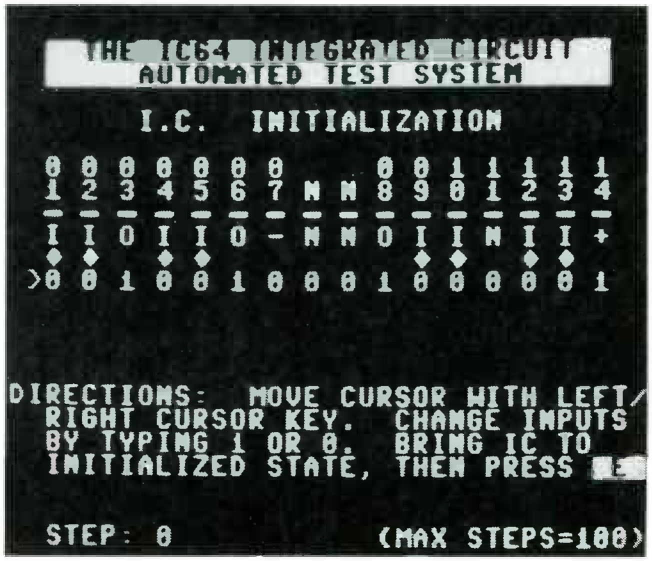


FIG. 6—THE FIRST TEST INITIALIZES each IC to a standard setup. The N shown for pin 11 indicates we don't care what the result will be on that particular pin.

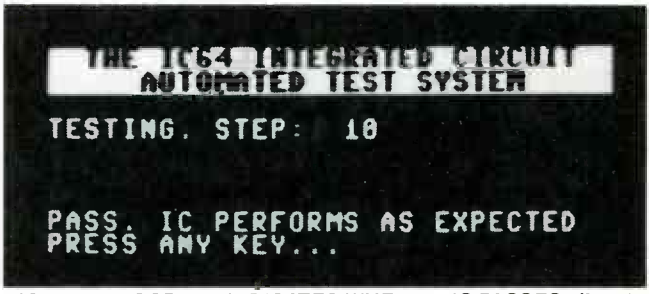


FIG. 7—THE SCREEN INDICATES WHEN the IC PASSES all tests that were established by the user.

(+ V) is applied, and the remaining pins are inputs. The space between the – and the O indicate that the two lower pins in the ZIF socket are not used for the 14 pin device. To make any corrections, position the cursor and enter the desired data. Once the IC's I/O definition has been completed, press E to end the setup phase.

The next screen, IC Initialization, shows the definitions

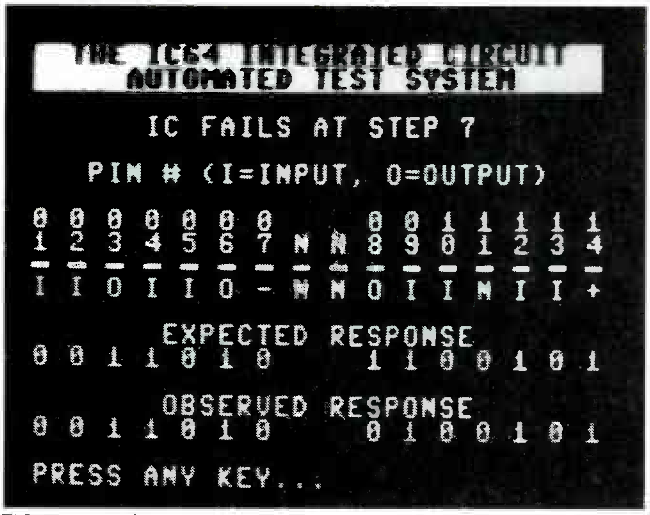


FIG. 8—THE SCREEN NOT ONLY INDICATES AN IC HAS FAILED, but it also shows what test (step) it failed and the and the manner in which it failed.

with each input pin marked with a diamond. During initialization the cursor will only move to the defined input pins. To illustrate the power of the tester, we will deliberately attempt to fool it by entering false data. As shown in Fig. 6, the definition for a NAND gate, we have defined output pin 11 with an N; meaning that we aren't interested in its result. It automatically displays a 0 even though its inputs, pins 12 and 13, should produce a high output. If you haven't done so yet, insert a known-good NAND GATE IC into the ZIF socket. Insert the black ground wire into position 7 or 10 of SO1 to apply ground to pin 7 of the DUT. Insert the red power wire into position 1 or 16 of SO2 to apply power to pin 14 of the DUT.

You want to initialize the IC to insure that all DUT's start out in the same state. As shown in Fig. 6, we'll change all the inputs to a low (0): Start by positioning the cursor at pin 1 and enter 0; then move the cursor to pin 2 and press 0. Since both inputs to the AND gate are now a 0, note that pin 3 changes to 1.

Continue the procedure, changing all inputs to a 0. It is important to note that you can initialize the IC in any way you want. For instance, you could have made pin 1 a 0, pin 2 a 1, pin 4 a 1, pin 5 a 0, and so on. The only rule for a valid test is to make sure your initialization values allow the test for each IC to begin in the same condition. But notice that pin 11, which we defined with an N, incorrectly indicates 0 because it's a "don't care" value.

When you press E to end the initialization phase, the title changes to the IC Testing Phase. As you did during the initialization phase, change the outputs one at a time to exercise all of the functions of the DUT. The number of test steps that you have defined are shown at the bottom left of the screen (you can define up to 100 steps, including initialization). As you change each input you will see its output change as per the IC's logic.

After performing all the steps necessary to exercise the IC, press E to end the testing phase. The program has now stored all conditions and responses of how you expect the IC to perform. The next screen, Auto Testing Phase, allows you to test as many IC's of this type as you desire. In answer to the question TEST ANOTHER DEVICE (Y/N)?, press the Y (Yes) key. As requested by the next message to appear, insert the next device to be tested into the ZIF socket and press any key to begin testing. The program will begin counting through the test steps. If the device is good, you'll see the screen display shown in Fig. 7. If the device does not perform as expected, the sequence will stop, and as shown in Fig. 8, the display will show what was expected and what was actually observed. You can then press a key to return to the auto-testing phase.

Additional capabilities

You can leave the tester connected when it's not being used. During that time, if you need to perform a complete (cold) reset of the computer, simply press the RESET button momentarily and then release it. As shown in Fig. 9, the computer will reset as if you had powered down and then up again.

FIG. 9—THE RESET BUTTON ACCOMPLISHES THE SAME THING as if the computer was powered down up again. It makes a reset easier.

Since the tester can determine digital transitions of any device, you can also test the switching action of diodes and transistors. For example, place a 1,000-ohm resistor between pins 1 and 3, a 10,000-ohm resistor between pins 2 and the base of an NPN transistor, the collector of the transistor to pin 3, and the base of the transistor to pin 4. To accomplish that, you may wish to use a 16 pin DIP jumper cable with one end inserted into the ZIF socket and the other end attached to a solderless breadboard (Radio Shack parts 276-1976 and 276-175 respectively, or their equivalents). You can then make the connections on the breadboard.

Back on the tester, position the +V wire to pin 1 and the ground lead to pin 4. Using the program, define pin 1 as +, pin 2 as I (Input), pin 3 as O (Output) and pin 4 as − (ground). Initialize by changing pin 2 to 0. For the test, change pin 2 to 1, noting that pin 3 will change to 0. Change pin 2 back to 0 and note that pin 3 changes back to 1. That tests the digital switching action under a reasonable load and ensures the device will switch properly in a circuit. A similar setup can be used for a switching diodes such as the 1N914 and 1N4148.

You can also expand the program to allow saving of device setups and responses in a disk file, so you would not have to set them up manually each time. You could then build a library of files for devices. (A CMOS and a TTL library, along with an enhanced program is available. See the Parts List).

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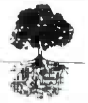

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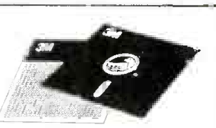

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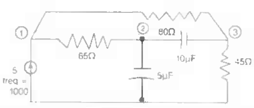

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C 2 3 10E-6			
R 1 3 80	ect.		
R 0 3 45			
FO 1000	set frequency		
SV	solve		

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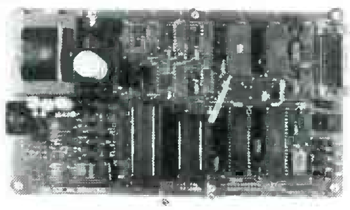

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BUILD THE PT-68K

Troubleshooting hints, with a step-by-step checklist of everything installed so far.

PETER A. STARK,
STARK SOFTWARE SYSTEMS CORPORATION

Part 7 last time we stopped after installing enough input/output circuitry to let us communicate with the computer via keyboard and video screen. This month we'll pause to learn some troubleshooting tricks that you'll want to study even if your system is working fine, because the tips we'll present will deepen your understanding of how both the 68000 microprocessor and the PT-68K computer system work.

Step 17. Troubleshooting tricks

If your computer worked properly at the end of step 16, you could skip this step, but it is recommended reading. On the other hand, if your system isn't working properly, this section will help you locate and fix the problem.

In the last installment, we covered the two ways of talking to the PT-68K computer:

- In Step 14, we discussed the serial RS-232C port, which allows us to connect the PT-68K either to a serial terminal, or to another computer with a serial port and a terminal-emulation program. For the remainder of this article, we'll refer to either option as *serial terminal.*
- In Steps 15 and 16, we discussed the circuit that allows us to connect a PC-compatible keyboard, and the interface connectors that allow us to plug in a PC-compatible monochrome or color video adapter and matching monitor (or possibly both simultaneously).

Because the MC68681 DUART used in the serial port is not used just for serial interfacing, but for other functions as well (to generate the speaker tones, for example), the serial port circuitry must be installed on every PT-68K system. The PC interface circuitry, on the other hand, is an option and may not be present on your board.

Before discussing troubleshooting techniques, first let's discuss what should happen when everything is working correctly, and how the computer decides which I/O devices to use. To summarize, there are five basic ways of talking to the PT-68K:

- With a serial terminal operating at any baud rate from 300 to 9600.
- With a PC-compatible keyboard, a monochrome or color video adapter, and a matching monitor.
- With a serial keyboard (connected to the RS-232C port) for input, but a video board and monitor for output.
- With PC-compatible keyboard for input, but a serial terminal for output (set to 2400 baud).
- Several of the above simultaneously.

When you turn on the power (or short the reset pins at J23), HUMBUG (the PT-68K's ROM-based monitor program) tries to initialize the input and output ports, makes a list of installed options, and sounds the "beep-boop" from the speaker. If HUMBUG detects that a PC-compatible video board is installed, it then displays the message "Please press Enter" in the upper left corner of the screen. HUMBUG does not, however, display that message on a serial terminal, because it doesn't yet know what baud rate to use.

Now HUMBUG monitors both the serial input and the keyboard connector, waiting for you to press the Enter key

Ordering Information

Complete details were given in part one (in the October 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 (PT68K, $460) includes 512K of dynamic RAM, floppy-disk controller, parallel port, battery-backed clock/calendar, and three PC-compatible expansion slots. To order, or for more information, contact Peripheral Technology, 1480 Terrell Mill Road #870, Marietta, GA 30067, (404) 984-0742.

TABLE 1—HUMBUG COMMANDS

AD	— ASCII Dump	LO	— LOAD S1–S9 FORMAT
AI	— ASCII Input FCC	MC	— Memory Compare
AO	— ASCII Output	ME	— Memory Examine
BA	— BASIC	MO	— MOve memory
BP	— Breakpoint Print	MS	— Memory Store
BR	— BReakpoint set/ reset	MT	— Memory Test
CO	— COntinue	RC	— Register Change
CS	— CheckSum	RD	— Return to DOS
FD	— Boot SK*DOS / Floppy Disk	RE	— Register Examine
FI	— FInd 1-5 bytes	SS	— Single Step
FM	— Fill Memory	ST	— STart single-step
HA	— Hex and ASCII dump	WA	— Boot SK*DOS / Winchester WX1
HD	— Hex memory Dump	WB	— Boot SK*DOS / Winchester HDO
HE	— HElp	X1	— eXtra option 1
JS	— Jump to System program	X2	— eXtra option 2
JU	— Jump to User program	!!	— Force reset

(also called Return or CR), so it can determine (a) which keyboard you are using, and (b) the baud rate if you're using the serial keyboard. Both keyboards can be connected electrically; whichever one receives a keypress first will be chosen as the input device. (In order to make sure the correct baud rate is chosen, you may have to press Enter several times on a serial keyboard.)

After the Enter is received, HUMBUG displays its sign-on message,

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the prompt (*), and a cursor.

Whichever keyboard you use, that message will go to the video board(s), if any. If you use a serial keyboard, then it will also go out the serial port to the terminal (at the same baud rate as the keyboard). After the prompt is displayed, you may type in and execute any of the 32 HUMBUG commands, shown in Table 1. We'll discuss further use of them in a moment. For now, try typing anything to see whether it appears on your screen. If so, then the computer is in working condition.

If your computer doesn't function as described above, then some troubleshooting is in order. We'll start with the obvious possibilities.

First, using a good magnifying glass, carefully examine all solder joints to make sure all connections are soldered, but no shorts exist between adjacent lands on the board. Ensure that all IC socket pins really go through the board to the bottom side—sometimes a pin bends under the socket and never makes it through the board. Make sure that all IC's point in the same direction—pin 1 toward the left rear corner of the board—and that each socket contains the correct IC. Also make sure that all capacitors and resistors are in the correct places. It may also be a good idea to check power-supply voltages.

Speaking of power-supply voltages, note that the wide copper strip around the edge on the bottom of the board is electrical ground, but the strip on the top of the board is +5 volts. **If you mount the board with metal hardware, you will short +5 volts to ground. You'll do the same thing if you attach the ground clip of an oscilloscope or voltmeter to the edge of the board.**

Another warning: Some early PC boards were shipped with a note regarding two possibly defective traces; if you have an early board, make sure you followed the directions to correct those problems.

Next, make sure that all the correct components are installed, but no others. Table 2 lists all components installed so far, in the order we installed them. It includes all connections, including the two jumpers and Molex pins installed in step 7 that were later removed in steps 9, 11, and 12; hence they should no longer be on your board. Extra oscillators, resistors and capacitors can stay, but any extra IC's (i.e., those not listed in the Table) should be removed during the following troubleshooting procedure, as they can cause undesirable results.

Also check all jumpers and other connections. The speaker should be connected to the two outer pins of J18; J25 should connect the center pin to pin 2; J24 should connect the center pin to pin 1; both J19 and J20 should connect the center pin to pin 2 for EPROM's shipped by Peripheral Technology (27256's). Incidentally, should you want to re-program those EPROM's, they require 12.5 volts for programming, and—as I have discovered—will be damaged at the more common 21 or 25 volts.

If all the simple tests reveal no problems, then it's time for more drastic action. Let's break the situation down into two types: either the speaker beeps or it doesn't.

If the speaker beeps

If the speaker does beep, then the system works, more or less, so troubleshooting will be easier. Regardless of which keyboard you ultimately intend to use, for now connect a serial terminal to J22 and perform the tests in Step 14 (see the last installment for details)—there are very few things that can go wrong between the beep-boop (Step 13) and the operation of the serial port (in Step 14), so the serial port should be checked before continuing with the PC-compatible keyboard and video interfaces.

If the serial port works and a video board is installed, output should go to both. If the HUMBUG messages go to the serial port but not to the video board, then examine the PC interface-connector circuitry closely. One problem that has shown up with some clone CGA color boards is a slight amount of noise on the $\overline{\text{BRESET}}$ line, which prevents the board from working. A simple fix is to place a 0.1 µF disk capacitor right on the CGA board, from pin B2 to pin B1 (ground). Don't solder to the edge connector; find a nearby solder pad or feedthrough. (The pins on the right side of the connector are labeled A1–A31; the pins on the left side are B1–B31; in both cases, pin 1 is toward the rear of the board.)

If both the serial board and the video board work correctly, the last item to check is the PC-compatible keyboard. Make sure you press Enter on this keyboard as soon as the "Please press Enter" message appears, so that HUMBUG uses the PC keyboard, rather than the serial terminal. If the keyboard still does not work, make sure that the XT/AT switch (present on the bottom of many clone keyboards) is in the XT position, and try again. Then borrow a keyboard from a friend's PC or XT, and try it.

TABLE 2—PARTS INSTALLED SO FAR

Step 3. The Power Connector

J10A, J10B	Power connectors
C65	10 μF tantalum (near J9)
C3, C4, C5	47 pF
C6	0.1 μF

Step 4. LED Indicators

R14, R15, R16	320 ohms
R24	2200 ohms
C11	0.1 μF
IC32	7406
R25	33 ohms
J18	4-pin header
LED's	J15, J16, and J17

Step 5. The Reset Circuit

R22, R23	1 megohm
R20, R21	2200 ohms
C57, C61, C62, C64	0.1 μF
C63	1 μF, 16 volts, tantalum
IC91	555
IC22	7406
IC66	74LS04
J23	Two-pin single header
unmarked	Two 0.1 μF capacitors to the left of IC66

Step 6. The Master Clock Circuit

IC78	16 MHz oscillator (no socket)
IC77	74ALS74
J24	3-pin header, jumper center to 1
C58, C59, C60	0.1 μF

Step 7. The 68000

IC47	68000
IC37	74LS10 triple 3-input NAND
IC89	74LS148 priority encoder
R19	10K SIP resistor (no socket)
C14, C48	0.1 μF
Jumper	IC47-22 to IC47-14 to negate $\overline{\text{BERR}}$
Jumper	IC66-1 to IC166-14 to assert $\overline{\text{TACK}}$
Sockets	IC27 and IC21
Molex pins	Short pins 9-17 of IC21 socket
Molex pins	Short pins 11-19 of IC27 socket

Step 8. The MAP circuit

IC90	74LS164
J25	Three-pin header, jumper center to 1

Step 9. The Bus Error Circuit

Remove jumper	between IC47 pins 14 and 22
IC76	74LS175

Step 10. The Address Decoder

IC63	16L8 PAL
R17, R18	33-ohm resistor packs (no sockets)
IC64	74LS139 dual decoder
IC34	74LS138 decoder
C13, C67, C70	0.1 μF
Jumper	J25 center to pin 1
C68	33 pF, not 0.1 μF

Step 11. The DTACK Circuit

Remove jumper	Between IC66 pins 1 and 14
IC33	74LS175
IC36	74LS30
Jumper	J25 center to pin 2

Step 12. ROM and RAM

Remove Molex pins	from the IC21 and IC27 sockets
IC26	74LS32
C12, C66	0.1 μF
IC20	EPROM marked "UPPER"
IC27	EPROM marked "LOWER"
IC21	6116 SRAM
IC28	6116 SRAM or MK48T02 clock
J19, J20	three-pin headers; set both jumpers on position two for 27256 EPROM's.

Step 13. Running at Last!

IC3	3.6864-MHz oscillator (no socket)
IC10	MC68681 DUART
R9, R10, R12, R13	10K
Speaker	To two outer pins of J18

Step 14. The Serial Ports

IC30	1488 TTL-to-RS232C converter
IC29	1489 RS232C-to-TTL converter
J21, J22	Six-pin header strips

Step 15. The PC-Compatible Keyboard

R7	4.7K
R8	10K
IC23	74S74
IC24	74LS175
IC25	74LS322
IC17	74LS373
IC19	74S373
C7, C8, C9, C10	0.1 μF
C65	0.1 μF (near IC16)
J9	Keyboard connector

Step 16. The PC-compatible Bus Connectors

J1–J6	62-pin card edge connectors
IC18	74LS373
IC15	74LS00
IC14	74LS32
IC1	74LS245
IC48	74LS08
IC35	74LS00
IC51	74LS32
IC31	74LS175
IC13	74LS74
IC92	14.31818-MHz oscillator (no socket)
R26	2.2K
C1	0.1 μF
Jumper	From IC15 pin 12 to pin 7

If you use a modern CGA board (with surface-mounted components), then

IC65	74LS390
Cut Trace	Between IC76-9 and IC47-20
Jumper	IC65-9 to IC76-9.

TABLE 3—ROM CONTENTS

Address	Data
00000000	00FF0FEA
00000004	00F800C0

If the Speaker Doesn't Beep

If the speaker doesn't beep, then the going is a bit tougher. Still, start with the obvious: check the speaker connections.

If you are using a color (CGA) video board, then note that, as pointed out last time, some new CGA boards have a *very* long wait period after some operations, and that causes the Bus-Error timer to time out; the result is that the system may not work at all, so the microprocessor will halt, and the HALT LED will light. Refer to Fig. 8 in the February issue for a solution to that problem.

At this point, there are two ways to go. The brute-force method is to return to Step 7 and try to retrace our steps. But there is another, more elegant method that lets us use the 68000 itself to help us debug the problem.

Let's review how the 68000 works. When it wants to access memory or I/O, it outputs an address on the address bus, along with the appropriate control signals on $\overline{\text{UDS}}$, $\overline{\text{LDS}}$, etc. When the memory or I/O is finished with the requested operation, it returns a $\overline{\text{DTACK}}$ (data transfer acknowledge) signal, which tells the 68000 that the operation is finished. If, for any reason, an operation cannot be completed within a specified time, then the bus error circuit sends a $\overline{\text{BERR}}$ signal to the 68000, which attempts to recover. If the recovery procedure results in another bus error, then the 68000 simply halts and the HALT LED goes on.

To proceed, disable the $\overline{\text{BERR}}$ circuit by removing IC76 and connecting a 10K resistor from pin 14 to pin 16 of the vacant socket. Doing so forces $\overline{\text{BERR}}$ high, so the 68000 will never receive a bus error. (Solder Molex pins to the leads of the resistor; don't force the naked leads of the resistor into the socket, because they could stretch the socket pins.)

Next, disable the $\overline{\text{DTACK}}$ circuit by removing IC36 and connecting a 330-ohm resistor from pin 8 to pin 7 of the socket. Because IC66 is still installed, the $\overline{\text{DTACK}}$ input to the 68000 is forced high, so the microprocessor will never receive a $\overline{\text{DTACK}}$.

Now apply power. The first thing the 68000 tries to do is to obtain two addresses (where to locate the stack and where to start execution) from locations 000000 through 000007, which at power up are at the very beginning of the ROM. Their contents are shown in Table 3.

Some explanation is in order. Although addresses inside the 68000 consist of 32 bits, the actual address bus consists of only 24 lines (counting A0, even though it only exists internally within the 68000). Thus the first two hex digits of any address in the PT-68K are generally 00.

Furthermore, the 32-bit address for the stack (00FF0FEA) can not fit into an eight-bit memory location. Therefore, it is stored in four consecutive locations, 00000000–00000003. That explains why the second address in Table 3 is 00000004.

TABLE 4—68000 SIGNALS WAITING FOR DTACK

Pin	State	Signal	Description	Comment
1-5	High	D4-D0	Data bus	FF
6	Low	AS*	Address strobe	On
7	Low	UDS*	Upper data strobe	On
8	Low	LDS*	Lower data strobe	On
9	High	R/W*	Read/Write*	Read
10	High	DTACK*	Data Xfer acknowledge	Forced to off
11	High	BG*	Bus granted	Off
12	High	BGACK*	BG acknowledge	Off
13	High	BR*	Bus request	Off
14	High	V_{CC}	+5 volts	
15	Pulses	CLK	8 MHz clock	Clock pulses
16	Low	GND	Ground	
17	High	HALT*	Halt	Not halted
18	High	RESET*	Reset	Not reset
19	High	VMA*	Valid Memory Address	Off
20	Pulses	E	E clock	Clock pulses
21	High	VPA*	Valid Peripheral addr	Off
22	High	BERR*	Bus Error	Forced to off
23	High	IPL2*	Interrupt input 2	No interrupts
24	High	IPL1*	Interrupt input 1	No interrupts
25	High	IPL0*	Interrupt input 0	No interrupts
26	High	FC2	Function Code 2	Currently in
27	High	FC1	Function Code 1	supervisor
28	Low	FC0	Function Code 0	program mode
29-48	Low	A1-A20	Address bus	000000
49	High	V_{CC}	+5 volts	
50-52	Low	A21-A23	Address bus	000000
53	Low	GND	Ground	
54-61	Low	D15-D8	Data bus	00
62-64	High	D7-D5	Data bus	FF

Last, although a four-byte address is stored in four one-byte locations, the 68000 can read or write two bytes at a time via its sixteen-bit data bus. Therefore the microprocessor must read the four-byte address in two chunks.

In detail, what happens is this: when the 68000 tries to read the stack address from memory, it outputs address 000000 on the address bus, asserts both $\overline{UDS}$ and $\overline{LDS}$ to signal that it is trying to access both an upper byte and a lower byte, asserts $\overline{AS}$ to activate the address decoder, and releases R/$\overline{W}$ to indicate that memory is being read.

The address decoder then decodes address 000000 and sends a low to both EPROM's to enable them. The EPROM's, in turn, output the contents of the first two bytes (the number $00FF, the upper half of the $00FF0FEA stack address) to the data bus, which sends this data to the 68000. The 68000 receives the data, and now waits for $\overline{DTACK}$ so it can continue.

But we've disabled $\overline{DTACK}$! So the microprocessor just sits there. Take a scope or logic probe and examine some of the important signals. You'll see address 000000 on the address bus, 00FF on the data bus, both $\overline{UDS}$ and $\overline{LDS}$ low, $\overline{AS}$ low, and R/$\overline{W}$ high. You will also see lows on the $\overline{CE}$ and $\overline{OE}$ pins of both EPROM's, and a low on pin 4 of IC64-a.

So, even with fairly simple test equipment, it's easy to check the circuit and make sure the right signals are there. Table 4 is a complete list of what you should find on every pin of the 68000 at this point. Make sure they're all there at the appropriate levels, and trace the signals if not. Remember, a high should be +3 volts or more; a low should 0.4 volt or less. If you see any voltages between those levels, suspect a short.

Here are several examples of how to interpret "strange" results. Suppose all the signals on the 68000 are correct except for the sixteen data-bus lines. If the data bus reads $FF00 instead of $00FF, are the EPROM's interchanged? Or if the data bus is completely different than expected, are the EPROM's selected (lows on their $\overline{OE}$ and $\overline{CE}$ inputs)? If yes, are they getting the correct address? Is pin 4 of IC64 low? If not, are the select inputs (pins 1–3) of IC64 low?

If everything seems normal, the next step is to pulse $\overline{DTACK}$ low so the 68000 will proceed to the next step. The pulse must be wide enough so the 68000 will recognize it, yet narrow enough so that the 68000 will only go forward one step and no more. The timing is touchy, but I have found that momentarily connecting a discharged 0.001 μF capacitor from pin 8 to pin 14 of IC36 works quite well. Pin 8 is held low by the 330-ohm resistor added above, but the 0.001 μF capacitor pulls it high for about a quarter of a microsecond. That signal is inverted by IC66-a into a low $\overline{DTACK}$ pulse.

As a result, the 68000 now tries to read the next two bytes of the stack address from memory, so the address bus should contain 000002, and the data bus should have

TABLE 5—ADDRESS AND DATA BUS CONTENTS DURING THE FIRST FEW MEMORY ACCESSES

Address	Data	Explanation
000000	00FF	Initial stack address = $00FF0FEA
000002	0FEA	
000004	00F8	HUMBUG starting address = $00F800C0
000006	00C0	
F800C0	4EF9	JUMP (op code 4EF9) to $00F80126 instruction
F800C2	00F8	
F800C4	0126	
F80126	4239	A CLR.B instruction
F80128	00FF	
F8012A	002D	
F8012C	4239	Another CLR.B instruction
F8012E	00FF	
F80130	0C85	
F80132	48F9	A MOVEM instruction
F80134	7FFF	
F80136	00FF	
F80138	0C0E	

0FEA—the lower half of stack address 00FF0FEA. It's possible that the pulse from the capacitor may be too wide or too narrow, or that more than one pulse may be generated, in which case you may either stay at the same step, or may skip ahead several steps. In that case, refer to Table 5, which is a list of the information on the address and data busses during the first dozen or so steps.

Assuming nothing turns up from those tests, remove the 330-ohm resistor, replace IC36, and restart the system. The computer will now start executing at high speed the steps we were just tracing one-by-one. However, whenever the 68000 tries to access a memory or I/O address that either doesn't exist or that is not working properly, it will fail to get $\overline{DTACK}$. We're still forcing $\overline{BERR}$ high with a 10K resistor, so the 68000 will stop and we can examine the address bus to see where the 68000 got stuck.

HUMBUG tries to compile a list of installed hardware, so it intentionally tries to access addresses that may not yet exist on your system. Those addresses include $FE0089 (68230), $FE000B (DUART1), $FE004B (DUART2), and either $C00001 or $D60001 (PC-compatible connectors). So the first address you see on the bus should be $FE0089. Of course, you cannot see A0. Instead, $\overline{LDS}$ will be low or on, and $\overline{UDS}$ will be high or off, to signify that the address is $FE0089 and not $FE0088. If there is any other address on the address bus, the 68000 is trying to access a location that does not work or does not exist.

Once you see the $FE0089 address of the 68230, you may pulse $\overline{BERR}$ low once to get the 68000 to continue until the next bus error. That can be done with the same 0.001-μF capacitor as before, except this time connect it between pin 8 and pin 14 of IC76. As before, you may skip ahead a few extra steps if the pulses introduced by the capacitor are not quite right. In that case, to view each step, just start over by resetting.

Note that your computer should not stop at address $FE000B, because you have already installed DUART1 at IC10. If it does stop, then there is something wrong with the DUART1 circuit.

Next time we'll install the dynamic RAM.

FURTHER HELP

If you need further help, contact us through our BBS at (914) 241-3307. If that is not possible, hardware questions can be answered by Peripheral Technology, 1480 Terrell Mill Rd., No. 870, Marietta, GA 30067, (404) 984-0742. Software questions dealing with HUMBUG or SK*DOS can be answered by Star-K Software Systems Corp., P.O. Box 209, Mt. Kisco, NY 10549, (914) 241-0287.

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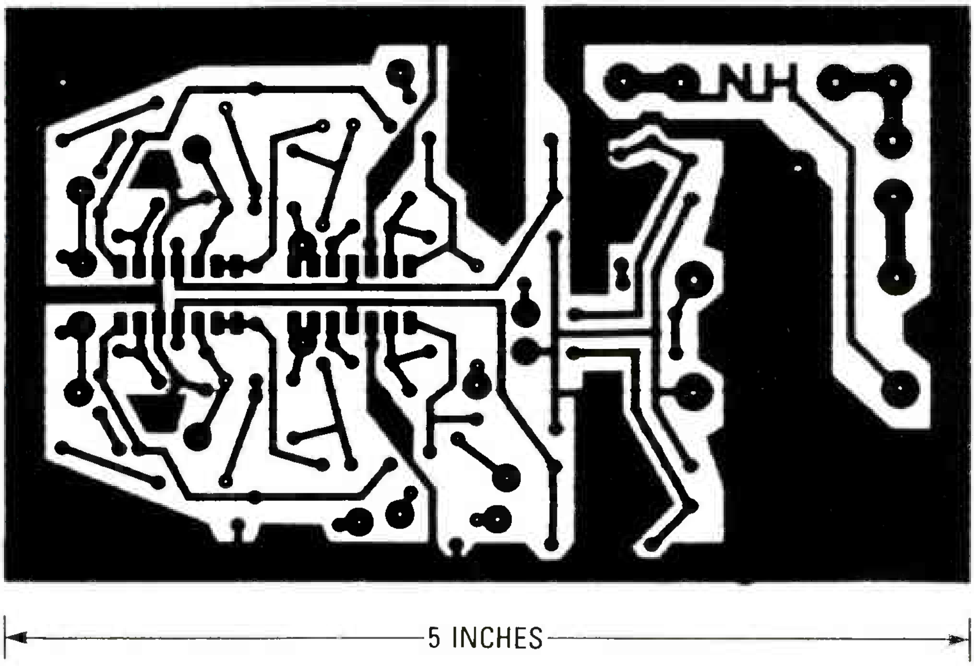

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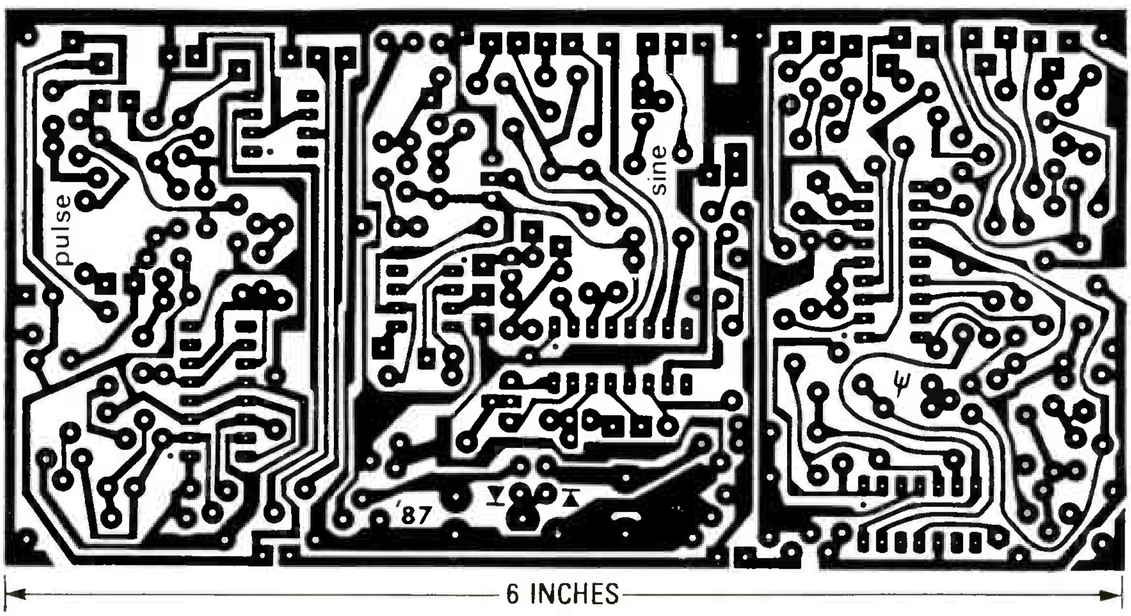

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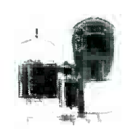

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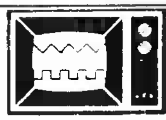

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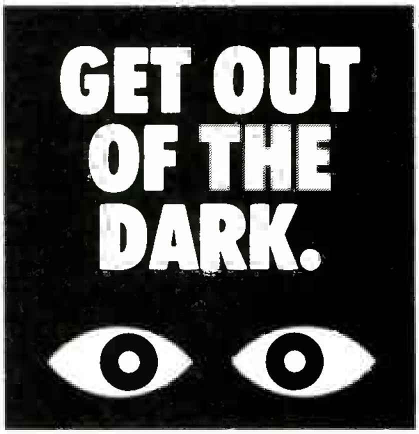

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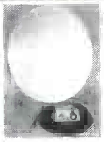

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how would you like to earn $60,000 to $80,000 in 3yrs with potential for over $100,000 per year. Video and electronics now paying top salaries for technical and nontechnical people. Some jobs work right from home in your home town. Find out more in this **New Industry Report and Career Guide.** Send check or MO for $12.95 plus $1.25 shipping and handling to: **AMERICAN BUSINESS AND VENTURE PUBLISHINGS,** 114-41 Queens Blvd., Suite 189-R, Forest Hills, NY 11375. Hurry! Order today, limited quantity in print.

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THE POSITRAP Cookbook: Build 50-60dB filters for pennies. Construction, alignment, fixed, tunable, trimable. Comprehensive **Cable TV scrambling and descrambling** theory and practice. Identifying various systems $9.95. **CLEARVIEW CABLE COMPANY,** PO Box 207, Sterling Heights, MI 48311.

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300W HQ HI-FI POWER AMPLIFIER (MONO) TA-3600 △△△

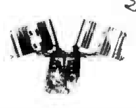
QUASI-COMPLEMENTARY-SYMMETRY WITH PARALLEL HIGH OUTPUT TRANSISTORS'
SPECIFICATIONS
*POWER OUTPUT 300W (RMS) INTO 8 OHMS
2450W (P.M.P.O.) INTO 8 OHMS
540W (MUSIC POWER) INTO 8 OHMS
*LOAD IMPEDANCE 4 OHMS OR 8 OHMS
*FREQUENCY RESPONSE : 10Hz-200,00 Hz
*TOTAL HARMONIC DISTORTION LESS THAN 0.05%
*INPUT SENSITIVITY AND IMPEDANCE AT 1KHz 1V-1.4V 47K OHMS
*SUPPLY VOLTAGE DC ± 75V OR AC 53V × 2.8A
KIT/ASSM WITH TESTED $80/92
X'FORMER (WEIGHT: 15 lb.) $38.00

NEW FOR 1988

120W MOSFET POWER AMPLIFIER

TA-477 △△

BUILD A PROFESSIONAL AMP BY YOURSELF



KIT $61.28
Metal Cabinet/X'Former (Optional) .... $26.00/$19.88

STATE OF ARTS HQ FET ST. PRE—AMP

TA-377A △△△

0.007% T.H.D

- This Pre-emplifier employs 18 pairs of HIGH QUALITY N channel and P channel FET and 1% metal film resistor to form a state of arts full complementary symmetric mirror circuit
- It uses "CR" RIAA EQ pre-amplifier to minimize TIM distortion and to obtain high fidelity
- The power supply is besed on by pass coupling DC stabilizer which uses class A design to obtain low internal impedence at high frequency and to greatly reduce transient distortion
- Professional ralay delay circuit prevents noise which may occur during power on and off
- All FETs were tested and paired in the factory so no problem is likely to occured during building
- It can be directly connected to any power amplifier. The best partner is TA-477 120W MOS FET power amplifier & TA 3600

KIT/ASS WITH TESTED $55/
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8 Digit 1 GHz Multifunctional Counter SM/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
Frequency range 10Hz—1GHz GUARANTEED, 5Hz 1.2GHz typically
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) X3" (H)
ASSM WITH TESTED & CAL $188.00

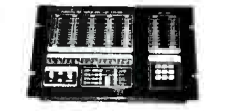
NEW

4½ HI-PRECISION D.P.M. SM-48A △△△

NEW

SPECIFICATIONS:
*4½ digit 14mm red large display with overload flash.
*Multi-functions including BCD, BUSY, STROBE output, very suitable for micro computer
*MEMORY STYSTEM CAN HOLD the input reading for comparison and monitor.
*Range: DC voltage DC±1mV-±2000A
DC current DC±1uA-±20A
*Accuracy: DC+0.025% ± 2 digit
*Power DC5-6V at 200mA
DIMENSIONS 3 3/4" (W) × 1 7/8" (H) × 4 1/16" (D)
(MEET WITH DIN STANDARD OF W. GERMANY.)
KIT/ASSM. WITH TESTED & CAL. $41/51

PROFESSIONAL COLOR LIGHT CONTROLLER SM—328 ☆



FEATURES
1 FOUR GROUPS OF INDEPENDENT OUTPUT SYSTEM 1000W/CH MAX 4680W (100 117V) 2 PROFESSIONAL COLOR CONTROL SYSTEM (KEY BOARD TYPE) 3 INDEPENDENT INPUT SIGNAL ADJUSTMENT 4 FOUR GROUPS OF INDEPENDENT DIMMER CONTROL 5 SPEED CONTROL CHASER 6 AUTOMATIC CHASING CONTROL SYSTEM 7 FOUR KINDS OF SPECIAL CHASING PROGRAM 8 COMBINATION OF PROGRAM AND MUSIC CHASING EFFECT 9 FORWARD/BACKWARD CHASING CONTROL SM-328 color light controlller is specialized for ballroom, night club disco and advertisement lighting. It consorts with several color control characteristics, which employ professional color control system and keyboard program selection. Therefore, it is capable of producing lighting effects by using chasing program and fluctuating music signal. There are two kinds of lighting effects. The first type is controlled by 'music' signal. In order to adjust the brightness of four groups of lightings, each music signal will be separated into high, medium low A and low B frequency range. Furthermore, each group of lightings is incorporated with an independent signal adjustment. The second kind is composed of electrical circuits and this is the main part for creating a special lighting effect. It has four chasing programme
Dimensions 14 5/16" × 8 15/16" × 3 3/16"
Ass with tested $150.00

ONLY

MULTIFUNCTIONAL LED D.P.M. △△

LARGE 3½ DIGIT 0.6" LED DISPLAY

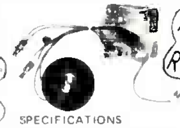
MEASUREMENT RANGE
D.C VOLTAGE 1mV — 1000V
A.C VOLTAGE 1mV — 1000V
DIGITAL THERMOMETER 0°C — 100°C
D.C CURRENT 1uA — 2A
CAPACITOR METER 1pF — 2uF
DIMENSIONS 3 3/4" × 1 7/8" × 4 1/16"

FREE GOLD-PLATED EDGE CONNECTOR

SM-43 ONLY
Kit $30.00
ASSM WITH TESTED & CAL $36.00

We've rated our goods with a △ indicating the level of difficulty for kit assembly
△ beginner level,
△△ intermediate level,
△△△ advanced level.
A ★ indicates the product has already been assembled

DIGITAL MENO TA-28 △



NO TAPE REQUIRED

NEW FOR 1988

SPECIFICATIONS
16 SEC RECORD TIME * LED FUNCTION INDICATOR * AUTO RECORD CIRCUIT * INTERNAL 256K DRAM MEMORY * INTERNAL MIC AMPLIFIER * ONE PUSH ON/OFF POWER * TWO RECORD FUNCTION TALK-BACK MODE & MESSAGE MODE * LOW POWER CONSUMPTION * SUPPLY VOLTAGE 9V 20MA D.C.
KIT $20.00

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TA-2400A

REMIX RECORDS W/ ECHO EFFECT YOURSELF!

Ass with tested $99.85

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With our full 90-day warranty, any purchase can be returned for any reason for full credit or refund.

3½", 20 Mb, HALF HT. HARD DISK DRIVE

Fits standard 5¼" spacing. High speed, low power. Comes w/both full-ht. and half-ht. face plates. Mfr – Lapine #LT200/2000
Item #15853 **$199.00** New

5¼" FULL HEIGHT DISK DRIVES –

48 TPI (IBM® Compatible) DS/DD, 40 Track
Tandon #TM100-2 or equiv.
Item #7928 **$79.00** New
2 for **$150.00** New

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$79.00; 2 for **$150.00**

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$39.50; 2 for **$75.00**

96 TPI, DS/Quad Density
CDC #9409T
Item #1893 **$89.00**

EXTERNAL DISK DRIVE CHASSIS

With 60W power supply (fan cooled).
Can accommodate:
2 full ht. drives *our item* #7928
2 floppy drives #1904
1 hard drive & 1 floppy #13250
Input: 115/230V, 50/60 Hz.
Originally for Burroughs computer.
Dim.: 11"W x 8"H x 12" deep
Item #14541 **$59.50**

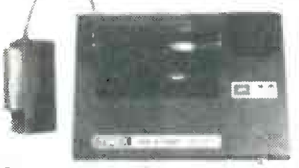
22" COMPOSITE MONITOR

Black & White, Raster Scan

Standard TV grade monitor, originally used in arcade games, ignition systems, etc. 115VAC, 60Hz. Mfr – Wells Gardner 22V1003A
Item #16579 **$49.95** New

★ ★ ★ ★ ★ ★ ★

TIMEX-SINCLAIR. . . 2040 PRINTER



32 column – compatible w/all Timex-Sinclair computers, as well as our PC8300 Computer. Uses standard 4½" thermal paper.
Item #15851 *New* – **$39.95**

115 CFM MUFFIN® FANS

115VAC 60Hz, 21W, 28A., 3100 RPM, 5-blade model, aluminum housing. Can be mounted for blowing or exhaust.
Dimensions: 4¹¹⁄₁₆"sq. x 1½" deep
NEW – Mfr: IMC
Item #1864 **$9.95**
USED – Mfr: Centaur/Howard
Item #5345 **$5.95**

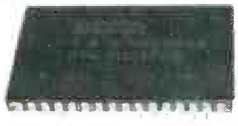
27 CFM MINI FANS

50/60Hz.; 12W. Low noise-level fans. Can be mounted for blowing or exhaust.

1" Thin –
Contains 9 plastic blades.
Dimensions: 3⅛" sq. x 1" deep
Mfr – Tobishi #U9201B
Item #10960 **$7.95** RFE

1½" Standard –
Contains 7 metal blades.
Mfr – Rotron #SU2A1
Item #5970 **$7.95** New

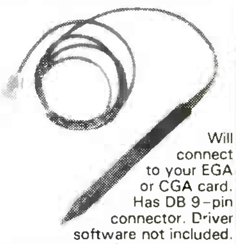
ANALOG to DIGITAL CONVERTER



Binary output: 12 bit; Conversion time: 8 microseconds; Linearity: 8 ms. ± 1/2 lbs. Parallel and series outputs; internal reference.
Mfr – Datel ADC-HZ-12BGC
Item #7052 (RFE – tested good!)
Originally ~~$130.00~~
Special – **$39.95**

LIGHT PEN

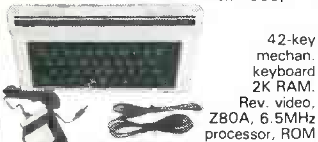
IBM® PC Compatible...



Will connect to your EGA or CGA card. Has DB 9-pin connector. Driver software not included. Originally used w/AT&T computers.
Item #16454 **$39.95** New

PC8300 HOME COMPUTER

(Advanced version of the Timex 1000)

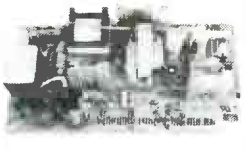


42-key mechan. keyboard 2K RAM. Rev. video, Z80A, 6.5MHz processor, ROM 8K BASIC. Graphics cap./sound–music, TV or monitor. Joystick input. 115VAC. AC adapt, TV cable & cass. cables. Runs tapes for Sinclair/Timex 1000-ZX85. Mfr-Power 3000. In orig. boxes
Item #10336 *New* **$29.95**

★ **16K RAMPACK upgrade**
Item #10337 *New* – **$9.95**

★ **32K RAMPACK upgrade**
Item #12148 *New* – **$19.95**

SWITCHING POWER SUPPLY



DC Output +5V @ 8A
+12V @ 500ma
–12V @ 200ma
+24V @ 2.0A
Input: 115/230VAC, 50/60Hz.
Dimensions: 8¾" x 4⅝" x 2"H
Mfr – Power Systems #PS1547
Item #16585 **$19.95**

STEPPING MOTORS for ROBOTICS . . .

Precision steppers with increments from 1 to 7.5°. Speeds up to 5,000 steps.

Fig. 1

Fig. 2

Item No.	Step Angle	Volts DC	Stall Torque (oz/in)	Type	Mfr. & Part No.	Fig	Price
5431	1	5	17	PM	N.A. Phillips A82310-M2	1	$9.95 ea. 2/$14.95
5275	1.8	1.8	72	PM	Superior Electric M061-FF-6201B	2	$19.95 ea. 2/$37.50
6671	3.7	1.2	18	–	Mitsubishi 42SH-32KOA	2	$9.95 ea. 2/$14.95
7630	1.8	3.0	200	PM	Superior Electric M092-FT-402	2	$34.50 ea. 2/$59.50

GELL CELL/LEAD ACID BATTERIES . . .

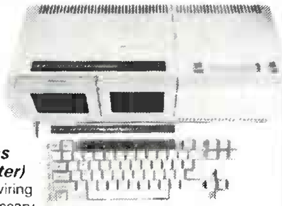
RECHARGEABLE – Used for solar energy storage, alarm systems, model boats, planes, cars, trains, etc.

6V @ 9.5AH
Dim.: 5½"H x 4⅛"W x 2⅝"D
Mfr – Elpower
Item #7039 **$14.95**

6V @ 4.0AH
Dim.: 4"H x 2⅝"W x 1¾"D
Major Manufacturers
Item #15757 **$7.95**

INTEGRATED CIRCUITS – POWER SUPPLIES MOTORS – ELECTRONIC COMPONENTS – TIMERS

ADAM COMPUTER



(Less printer) No wiring necessary (just plugs together). Hook-up diagram incl. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply & one cassette. Capable of running CP/M, has built-in word processor.
Item #7410 *Complete* – **$99.00**

ADAM Accessories. . .

DATA DRIVE –
Item #6641 **$19.95**

PRINTER POWER SUPPLY –
Item #6642 **$14.95**

ASCII KEYBOARD –
Item #6643 **$19.95**

CONTROLLERS –
Set of 4 Item #7013 **$9.95** RFE

ADAM CASSETTES –
(Consisting of Smart Basic, Buck Rogers & blank cassette.) Item #7786
BAKER'S DOZEN – **$19.95**

ADAM LINK MODEM –
Software included.
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DISK DRIVE POWER SUPPLY –
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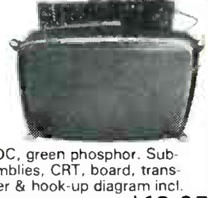
ADAM DAISY PRINT WHEEL –
Item #13305 **$3.95**

COMPUTER GRADE POWER SUPPLY

Other uses–runs CB & car radios. Comes ready to plug in!
DC Output: –5V @ .5 amp.
+5V @ 3 amp.
+12V @ 6 amp.
Input: 115V/60Hz. Dimensions: 9¼"W x 3¾"H. (Rubber ft. incl.)
Item #9501 **$24.95** New

High-Resolution TTL MONITORS . . . *(Open Frame)*



12"
12VDC, green phosphor. Subassemblies, CRT, board, transformer & hook-up diagram incl.
Item #6811 *New* – **$19.95**

15" Data Display/Monitor Kit
Alphanumeric & graphics display. Green phosphor. Input power reg. 24VDC. Bandwidth: 22-72Khz. Consists of 2 subassemblies (monitor & board). Hook-up diagram incl. Mfr – Wells Gardner #15V7025
Item #16171 *New* – **$24.95**

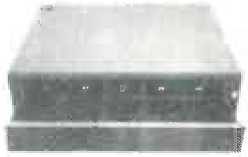
Call or Write with Your Requirements

VOICE-ACTIVATED SWITCH

"Activate 'on' or 'off' with the sound of your voice, a whistle or clap. . ."
Ideal for robotics, lights, etc. Turns on with the first sound & off with the second. Solid-state units with adjust. sensitivity control & pick-up microphone attached to PC board. Dim.: 2¾" x 3⅛" x ⅞".
VOX input: 6–9VDC; can be used with any standard battery.
Item #16440
3 switches/ **$9.95**

ELECTRONIC CASH REGISTER DRAWER . . .

CAN BE COMPUTER OPERATED!



Fits right under your PC. Comes w/removable cash drawer; & security switch w/keys, which allows you to open or lock the drawer manually. Brown cabinet; mtd. on rubber feet. OA dim.: 18¾"W x 4"H x 15" deep
Item #12265 **$59.50** New

AMERICAN DESIGN COMPONENTS, 62 JOSEPH STREET, MOONACHIE, N.J. 07074

MINIMUM ORDER $15.

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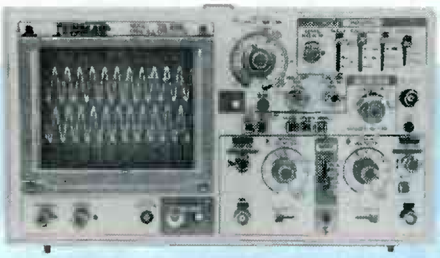
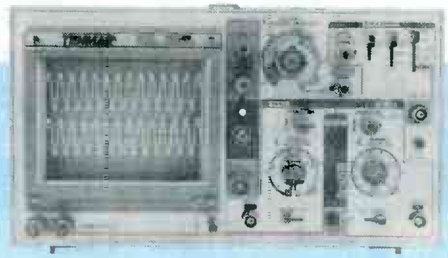


TENMA 35MHz Dual Trace Oscilloscope

- Two high quality 10:1 probes included
- For additional specification see MCM Catalog #17

#72-330

2 YEAR LIMITED WARRANTY



TENMA 20MHz Dual Trace Oscilloscope

- Two high quality 10:1 probes included
- For additional specification see MCM Catalog # 17

#72-320

2 YEAR LIMITED WARRANTY

1 YEAR LIMITED WARRANTY

TENMA 3½ Digit LCD Multimeter

- Measures resistance, AC-DC voltage and current
- Diode and hFe transistor tests
- Overload protection
- 10Mohm input impedance
- Carrying case included

#72-050

2 YEAR LIMITED WARRANTY

TENMA 30A Power Supply

- Output voltage: 1-15VDC
- Lighted cross needle meter: Displays voltage, current and power simultaneously
- Output current: 30A, 22A continuous
- Fan cooled

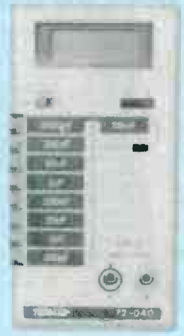
#72-035

1 YEAR LIMITED WARRANTY

TENMA 0-18V 3A Power Supply

- Regulated outputs — constant volt or constant current, both are continuously variable
- Can be connected in series or parallel for more voltage or current output
- Reverse polarity and overload protected
- Isolated output

#72-420

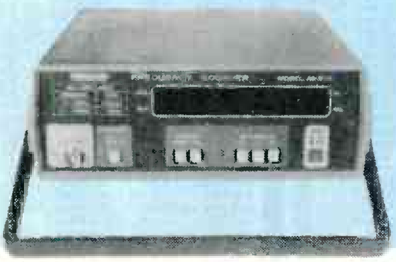


1 YEAR LIMITED WARRANTY

TENMA Digital Capacitance Meter

- Measurement range from 0.1pF to 19,999μF
- Sampling time: .5 seconds
- Accuracy: ± 1% full scale
- Checks capacitors in or out of circuit
- Carrying case included

#72-040

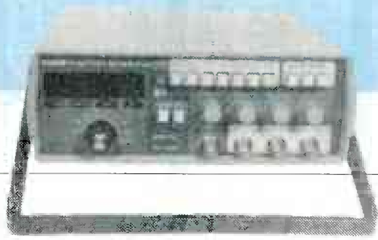


1 YEAR LIMITED WARRANTY

TENMA Frequency Counter

- 8 digit LED display
- Measurement range: 1Hz-120MHz
- High input sensitivity of 20mV RMS

#72-375

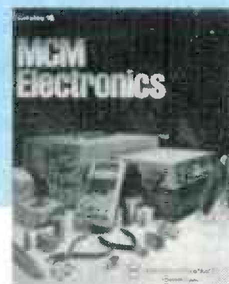


1 YEAR LIMITED WARRANTY

TENMA Combination Function Generator and Frequency Counter

- 6 digit display
- Output range: 2Hz-2MHz: seven ranges
- Counter range: .1Hz-10MHz
- 5-15V TTL and CMOS output
- Wave forms: sine, triangle, square, pulse, and ramp.

#72-380



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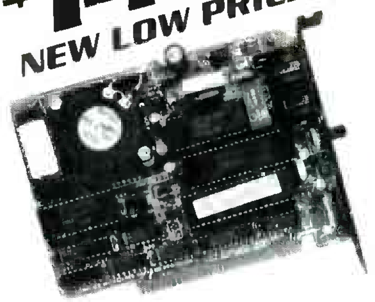

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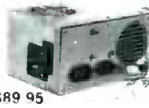

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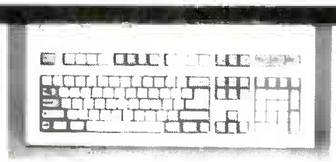

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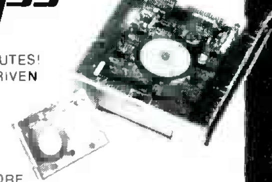

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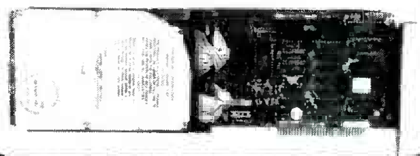

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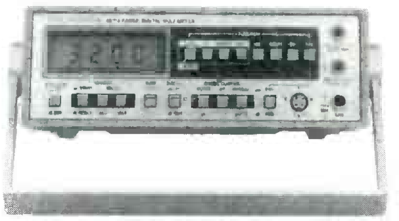

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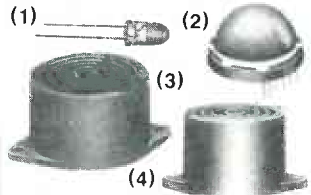

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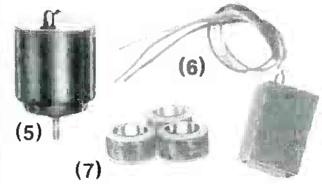

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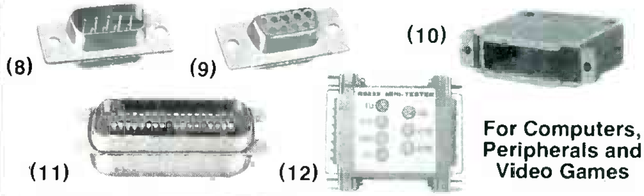

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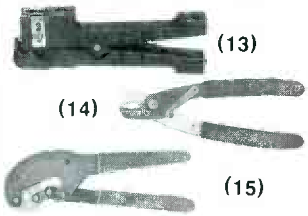

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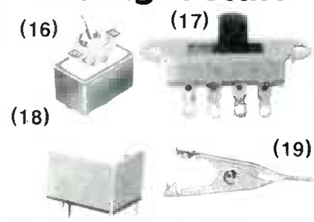

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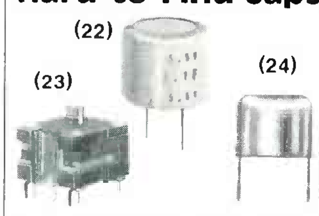

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7400

Part No.	1-9	10+	Part No.	1-9	10+
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7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	2.05	1.95
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.55	.45
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.69	.59
7416	.39	.29	74143	3.95	3.85
7417	.39	.29	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.59	.49
7442	.55	.45	74175	.59	.49
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	2.05	1.95	74193	.79	.69
7472	.89	.79	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.65	.55
7476	.45	.35	74367	.65	.55

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.69	.59
74LS30	.29	.19	74LS243	.69	.59
74LS32	.35	.25	74LS244	.69	.59
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
74LS151	1.09	.99	74LS629	2.95	2.85
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.39	2.29

74S/PROMS*

74S00	.29	74S188*	1.49
74S04	.29	74S189	1.69
74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.49	74S288*	1.49
74S124	2.75	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74F

74F00	.29	74F139	.69
74F04	.29	74F157	.69
74F08	.29	74F193	2.95
74F10	.29	74F240	.99
74F32	.29	74F244	.99
74F74	.39	74F253	.69
74F86	.39	74F373	.99
74F138	.69	74F374	.99

CD—CMOS

CD4001	.19	CD4076	.59
CD4008	.69	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	2.49
CD4018	.59	CD40107	.49
CD4020	.59	CD40109	.79
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.25	CD4538	.79
CD4050	.29	CD4541	.89
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	4.95
CD4053	.59	CD4555	.79
CD4063	1.49	CD4559	7.95
CD4066	.29	CD4566	2.49
CD4067	1.29	CD4583	.89
CD4069	.25	CD4584	.39
CD4070	.25	CD4585	.89
CD4071	.25	MC14411P	8.95
CD4072	.25	MC14490P	4.49

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.	Price
D765AC	~~4.95~~ 3.95
WD9216	6.95
95H90	~~9.95~~ 5.95
Z80, Z80A, Z80B SERIES	
Z80	~~1.25~~ .99
Z80-CTC	~~1.79~~ .99
Z80-DART	4.95
Z80-PIO	~~1.79~~ .99
Z80A	1.69
Z80A-CTC	1.79
Z80A-DART	4.95
Z80A-PIO	1.69
Z80A-SIO/0	5.75
Z80B	3.49
Z80B CTC	3.95
Z80B PIO	~~4.29~~ 3.95
6500/6800/68000 SER.	
6502	2.65
65C02 (CMOS)	~~8.95~~ 7.75
6520	1.95
6522	3.95
6532	~~6.49~~ 5.49
6551	~~4.49~~ 2.95
65C802 (CMOS)	17.95
6800	1.95
6802	3.95
6810	1.25
6821	1.75
6840	3.95

6500/6800/68000 Cont.

Part No.	Price
6845	~~3.95~~ 2.95
6850	1.95
6852	1.49
MC68000L8	11.95
MC68000L10	13.95
MC68010L10	49.95
MC68020RC12B	169.95
MC68881RC12A	149.95
8000 SERIES	
8031	3.95
80C31	9.95
8035	1.95
8073	9.95
8080A	~~2.95~~ 2.49
8085A	2.49
8086	5.95
8086-2	6.95
8087 (5MHz)	129.95
8087-1 (10MHz)	229.95
8087-2 (8MHz)	159.95
8088	~~6.49~~ 5.75
8088-2	~~8.95~~ 7.75
8116	4.95
8155	2.49
8155-2	3.49
8156	3.95
8202	5.95
8203	9.95
8212	2.29
8224	2.25

8000 SERIES Cont.

Part No.	Price
8228	2.95
8237-5	~~4.95~~ 4.49
8243	~~2.25~~ 1.75
8250A	6.49
8250B (For IBM)	6.95
8251A	1.89
8253-5	1.95
8254	4.95
8255A-5	1.89
8257-5	1.95
8259-5	2.25
8272	~~4.95~~ 3.95
8279-5	2.95
8741	9.95
8742	~~29.95~~ 22.95
8748 (25V)	7.95
8748H (HMOS) (21V)	9.95
8749	9.95
8751	39.95
8755	14.95
DATA ACQUISITION	
ADC0804LCN	~~3.19~~ 2.79
ADC0808CCN	5.95
ADC0809CCN	~~3.95~~ 3.69
ADC0816CCN	11.95
ADC1205CCJ-1	19.95
DAC0808LCN	1.95
DAC1008LCN	4.95
AY-3-1015D	4.95
AY-5-1013A	2.95

MICROPROCESSOR SALE!

Part No.		Price
8052AHBASIC	CPU w/BASIC Interpreter	$ 29.95
MC68008L8	32-Bit MPU (8-Bit Data Bus) ~~19.95~~	$ 16.95
MC68701	8-Bit EPROM Microcomputer	$ 14.95
MC68705P3S	8-Bit EPROM Microcomputer	$ 14.95
MC68705U3L	8-Bit EPROM Microcomputer	$ 10.95
80286-10	16-Bit Hi Performance MPU	$ 99.95
80287-8	Math Co-processor (8MHz)	$259.95
80287-10	Math Co-processor (10MHz)	$309.95
80387-16	Math Co-processor (16MHz) GRID ARRAY	$494.95
80387-20	Math Co-processor (20MHz) GRID ARRAY	$895.95

DYNAMIC RAMS

Part No.			Price
*4116-15	16,384 x 1	(150ns)	1.09
*4128-20	131,072 x 1	(200ns) (Piggyback)	~~9.25~~ 2.75
*4164-120	65,536 x 1	(120ns)	2.75
*4164-150	65,536 x 1	(150ns)	2.49
*4164-200	65,536 x 1	(200ns)	1.95
*TMS4416-12	16,384 x 4	(120ns)	4.95
8118	16,384 x 1	(120ns)	~~.49~~ .39
*41256-100	262,144 x 1	(100ns)	8.49
*41256-120	262,144 x 1	(120ns)	7.95
*41256-150	262,144 x 1	(150ns)	7.75
*50464-15	65,536 x 4	(150ns) (4464)	5.95
*511000P-10	1,048,576 x 1	(100ns) 1 Meg	49.95
*514256P-10	262,144 x 4	(100ns) 1 Meg	89.95
STATIC RAMS			
2016-12	2048 x 8	(120ns)	1.69
2018-45	2048 x 8	(45ns)	~~6.95~~ 5.49
2102-2L	1024 x 1	(250ns) Low Power	1.95
2114N	1024 x 4	(450ns)	.99
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	2.49
5101	256 x 4	(450ns) CMOS	1.95
6116P-3	2048 x 8	(150ns) CMOS	2.49
6116LP-3	2048 x 8	(150ns) LP CMOS	2.59
6264LP-12	8192 x 8	(120ns) LP CMOS	~~4.25~~ 3.95
6264P-15	8192 x 8	(150ns) CMOS	3.49
6264LP-15	8192 x 8	(150ns) LP CMOS	~~3.75~~ 3.49
6514	1024 x 4	(350ns) CMOS	3.49
43256-15L	32,768 x 8	(150ns) Low Power	11.95
EPROMS			
TMS2516	2048 x 8	(450ns) 25V	6.95
TMS2532	4096 x 8	(450ns) 25V	6.95
TMS2532A	4096 x 8	(450ns) 21V	5.95
TMS2564	8192 x 8	(450ns) 25V	9.95
TMS2716	2048 x 8	(450ns) 3 Voltage	~~9.95~~ 6.95
1702A	256 x 8	(1µs)	~~6.95~~ 4.95
2708	1024 x 8	(450ns)	4.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	5.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	5.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	3.95
2764-45	8192 x 8	(450ns) 21V	2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	7.95
27512-20	65,536 x 8	(200ns) 12.5V	13.49
27512-25	65,536 x 8	(250ns) 12.5V	11.95
68764	8192 x 8	(450ns) 25V	13.95
EEPROMS			
2816A	2048 x 8	(350ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A	8192 x 8	(250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
LAG570	~~10.95~~ 9.95
WD1770	11.95
SI3052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	~~4.95~~ 3.49
6526	~~14.95~~ 12.95
6529	2.95
6532	~~6.49~~ 5.49
6545-1	~~4.95~~ 3.25
6551	~~4.49~~ 2.95
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	~~14.95~~ 9.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
8721	14.95
8722	9.95
*251104-04	10.95
310654-05	9.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
325572-01	14.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

*No specs. available
**Note: 82S100PLA U17 (C-64)

SPECIALS!

SMP81FY	Prec. Sample & Hold Amp	7.95
MAX232CPE	Dual RS232 Rec./Trans.	5.19
LM306P	Dual Comparator	.79
6116P-1	16K CMOS SRAM (100ns)	3.95
27128-45	128K EPROM (450ns) 21V	4.95
74LS612	Memory Mapper, Tri-State	11.95

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	~~.25~~ .19	74HC175	~~.69~~ .49
74HC02	~~.25~~ .19	74HC221	~~1.19~~ .89
74HC04	~~.29~~ .19	74HC240	~~.99~~ .69
74HC08	~~.29~~ .19	74HC244	~~.99~~ .69
74HC10	~~.29~~ .19	74HC245	~~.99~~ .79
74HC14	~~.49~~ .29	74HC253	~~.59~~ .49
74HC30	~~.29~~ .19	74HC259	~~.89~~ .49
74HC32	~~.29~~ .25	74HC273	~~.99~~ .69
74HC74	~~.39~~ .29	74HC373	~~.99~~ .65
74HC75	~~.39~~ .35	74HC374	~~.99~~ .65
74HC76	~~.45~~ .35	74HC595	~~1.29~~ 1.09
74HC85	~~.79~~ .55	74HC688	~~.99~~ .79
74HC86	~~.39~~ .35	74HC943	8.95
74HC123	~~.89~~ .69	74HC4040	~~.99~~ .79
74HC125	~~.49~~ .39	74HC4049	~~.59~~ .49
74HC132	~~.69~~ .39	74HC4050	~~.59~~ .49
74HC138	~~.69~~ .39	74HC4060	~~.99~~ .89
74HC139	~~.49~~ .39	74HC4511	~~1.29~~ 1.09
74HC154	~~1.49~~ 1.19	74HC4514	~~1.79~~ 1.09
74HC163	~~.65~~ .39	74HC4538	.89
74HC174	~~.69~~ .49	74HC4543	~~1.19~~ .89

74HCT — CMOS TTL

74HCT00	~~.29~~ .17	74HCT139	~~.59~~ .35
74HCT02	~~.29~~ .17	74HCT157	~~.69~~ .35
74HCT04	~~.29~~ .17	74HCT174	~~.69~~ .35
74HCT08	~~.29~~ .17	74HCT175	~~.69~~ .39
74HCT10	~~.29~~ .17	74HCT240	~~.99~~ .89
74HCT32	~~.29~~ .21	74HCT244	~~.99~~ .59
74HCT74	~~.49~~ .25	74HCT245	~~1.19~~ .79
74HCT86	~~.49~~ .29	74HCT373	~~1.19~~ .55
74HCT138	~~.59~~ .35	74HCT374	~~1.19~~ .49

74C — CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.79
74C08	.35	74C240	1.79
74C10	.35	74C244	1.79
74C14	.59	74C373	1.95
74C32	.35	74C374	1.95
74C74	.59	74C912	8.95
74C85	1.49	74C915	1.39
74C86	.35	74C920	6.95
74C89	5.49	74C921	6.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	1.19	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.89
LM311N	.45	MC1648P	3.49
LM317T	.79	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	~~1.49~~ .79
LM323K	3.95	ULN2003A	.79
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	26LS29	3.95
LM348N	.69	26LS31	1.19
LM350T	2.95	26LS32	1.19
LF351N	.39	26LS33	1.49
LF353N	.49	LM2901N	~~.39~~ .25
LF355N	.79	LM2907N	1.29
LF356N	.89	LM2917N (8 pin)	1.95
LF357N	1.09	MC3419CL	6.95
LM358N	.49	MC3446N	1.69
LM360N	2.19	MC3450P	1.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	1.95
LM386N-3	.89	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	1.49	LM3909N	.99
NE540H (C540H)	2.29	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XRL555	.59	NE5532	.69
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.79	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350P	1.09	7905K (LM320K-5)	1.35
MC1372P	1.95	7905T (LM320T-5)	.59
MC1377P	2.29	75472	.59
MC1398P	8.95	75477	.89
LM1414N	1.29	MC145106P	~~3.25~~ 2.49
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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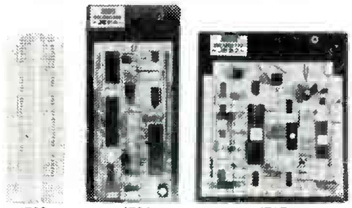
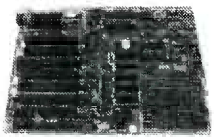


JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5¾	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

Jameco's IBM PC/XT/AT Compatible Motherboards

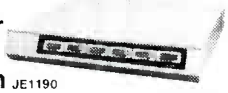
· Award BIOS ROMs included



JE1001

JE1000	4.77MHz (PC/XT)	$ 84.95
JE1001	4.77/8MHz (PC/XT)	$ 99.95
JE1002	4.77/10MHz (PC/XT)	$119.95
JE1007	6/8/10/12MHz (AT)	$349.95

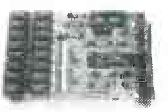
Jameco Computer Power Protection



JE1190

JE1190	Power Base	$29.95
JE1191	6-Outlet Power Strip	$11.95
JE1192	300 Watt Back-Up	$269.95
JE1193	500 Watt Back-Up	$349.95

Zuckerboard TANDY 1000 Expansion Memory Half Card



Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TE512	Includes 512K RAM	$199.95
TANC	Plug-in Clock option chip (only)	$39.95

30Meg Hard Disk Drive Board for Tandy 1000, 1000A, 1000SX, 1200, 3000 and 3000HL

T30MB	30MB Hard Disk Drive Board	$599.95

DATA BOOKS

30005	Logic Data Book - Vol. II (84)	$19.95
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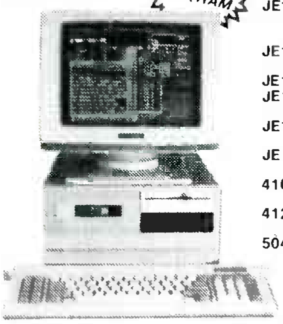
JE1059...$499.95 (EGA Monitor and Card not included)

Total 640K RAM



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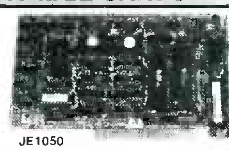

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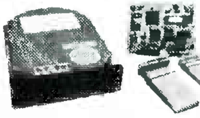

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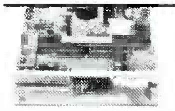

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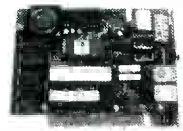

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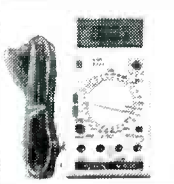

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1N4005	600 PIV	DO 41		1 00	9 00	74 00
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5 Watt	32	2 90	24 00	90 00	160 00
10 Watt	35	3 20	27 00	100 00	180 00

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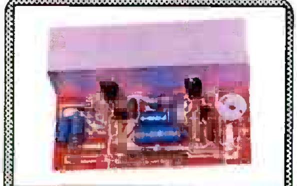

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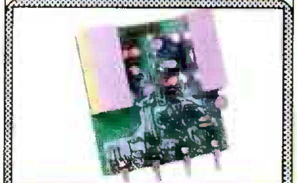

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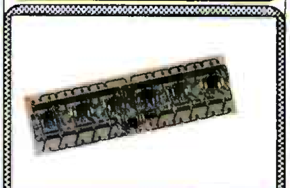

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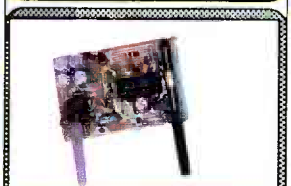

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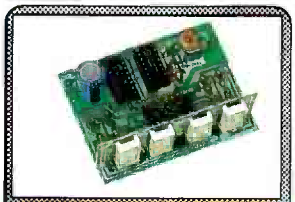

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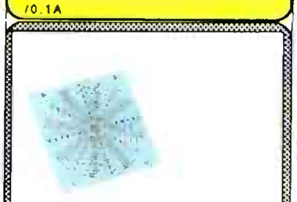

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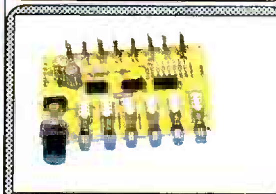

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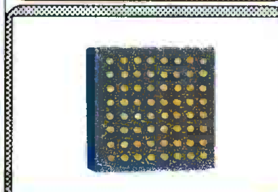

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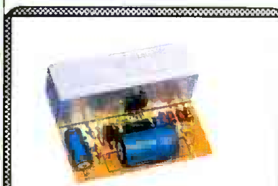

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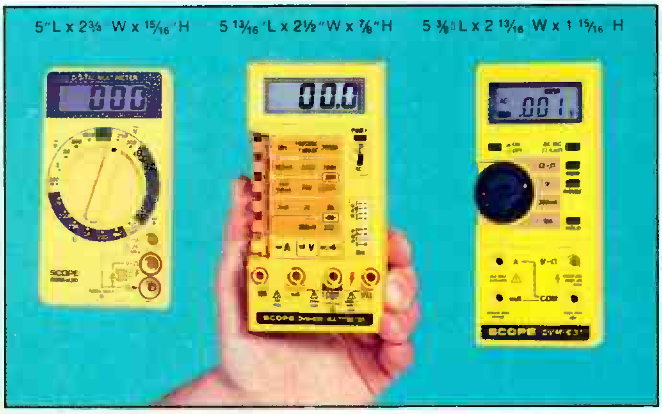

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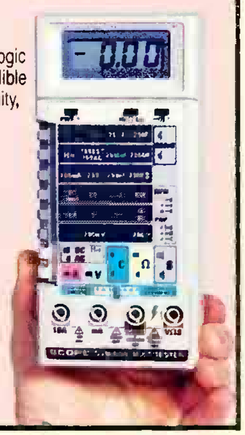

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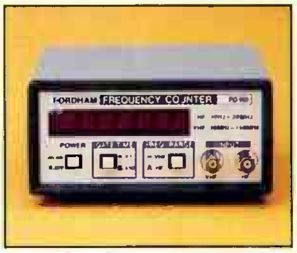

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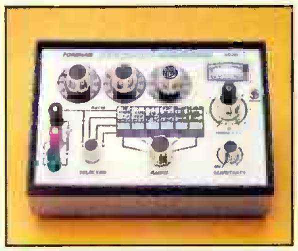

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