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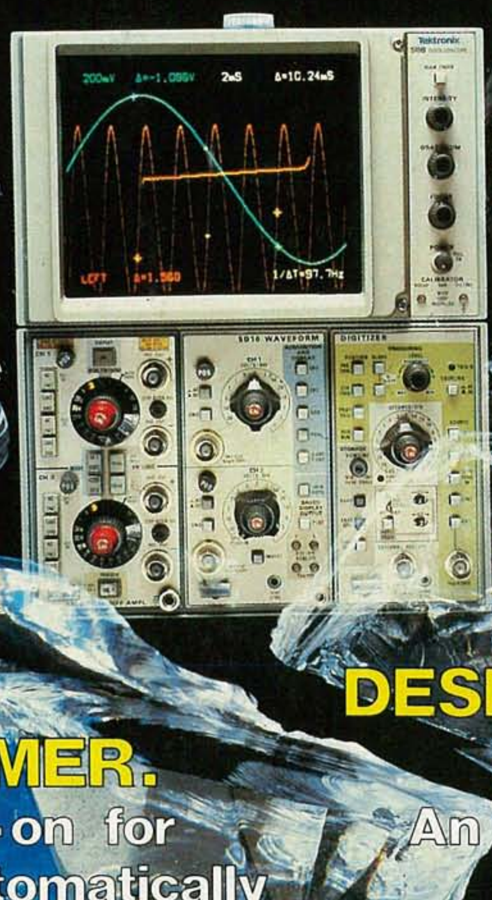

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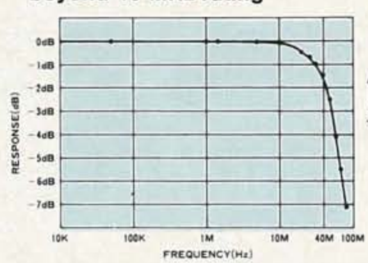
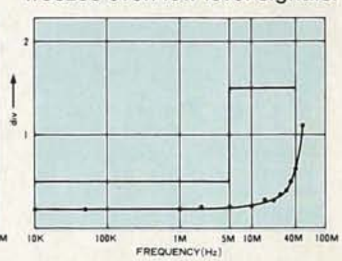


- **Superb trigger sensitivity** freezes even low level signals.



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CIRCLE 51 ON FREE INFORMATION CARD

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R-11

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More information on the Kenwood receivers is available from authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street, Compton, CA 90220.

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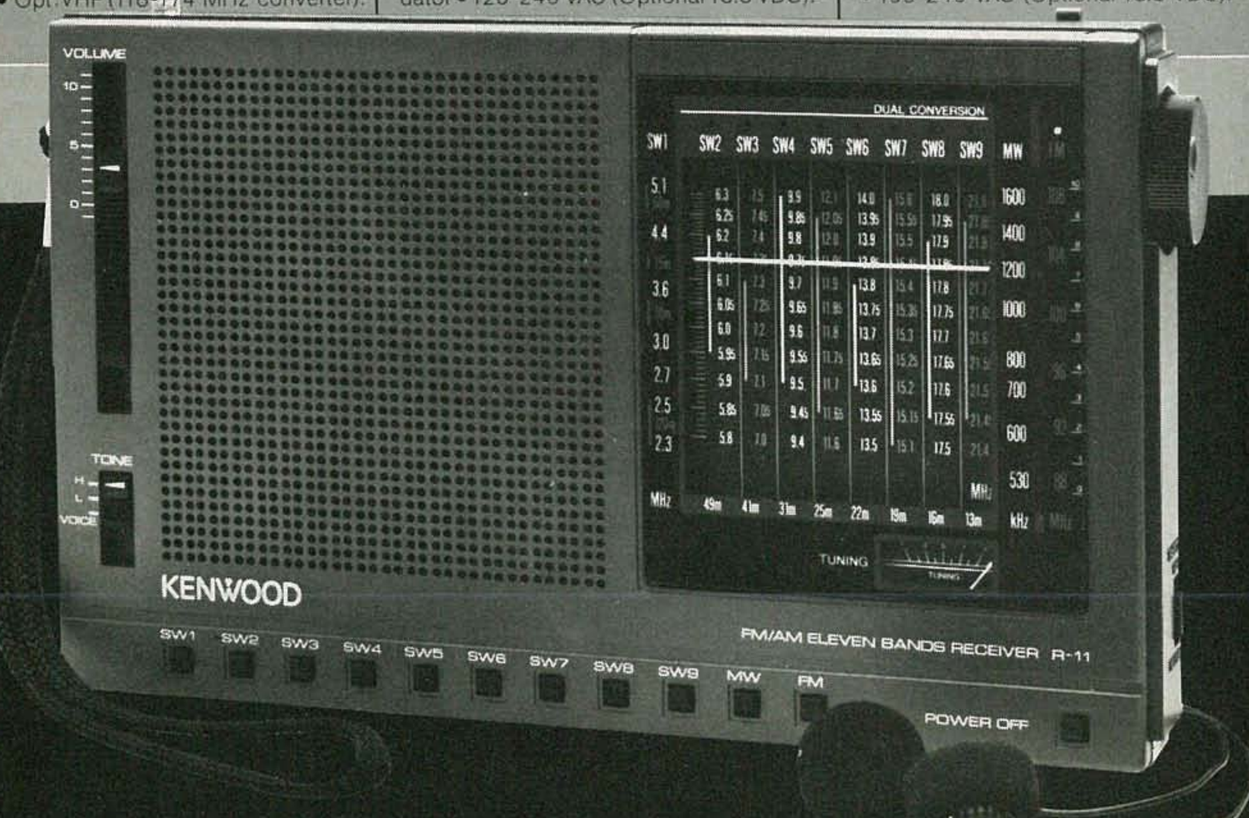
R-600 General coverage receiver • 150 kHz–30 MHz • digital display • 2 IF filters • PLL UP conversion • noise blanker • RF attenuator • front speaker • 100-240 VAC (Optional 13.8 VDC).



CIRCLE 94 ON FREE INFORMATION CARD

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Zenith Sales Company / Service, Parts & Accessories Division / 11000 Seymour Avenue / Franklin Park, Illinois 60131

NOVEMBER 84

Radio-Electronics
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Diskette Users...

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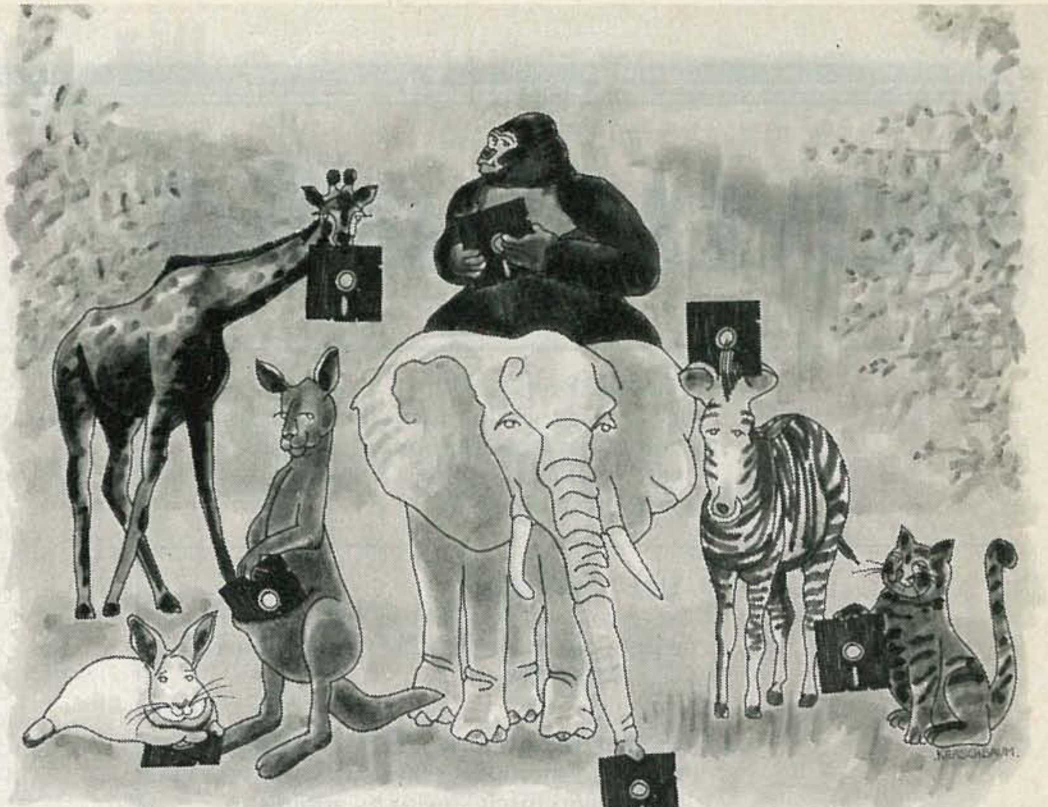

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Choose your brand
Choose your price

Product Description	Super Disk diskettes for as low as $0.94 each — Super Disk Part #	CE quant. 100 price per disk ($)	Wabash diskettes for as low as $0.99 each — Wabash Part #	CE quant. 100 price per disk ($)	BASF diskettes for as low as $1.44 each — BASF Part #	CE quant. 100 price per disk ($)	3M diskettes for as low as $1.44 each — 3M Part #	CE quant. 100 price per disk ($)
8" SSSD IBM Compatible 128B/S, 26 Sector	—	—	F111-P	1.59	—	—	8SSSD-P	1.94
8" SSSD Shugart Compatible, 32 Hard Sector	—	—	F31A-P	1.79	—	—	—	—
8" SSDD IBM Compatible (128 B/S, 26 Sectors)	—	—	F131-P	1.89	—	—	8SSDD-P	2.39
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5¼" DSDD Same as above, but bulk product	6497-P	1.34	M14AB-P	1.39	—	—	—	—
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5¼" DSDD 16 Hard Sector w/Hub Ring	—	—	M54A-P	1.59	—	—	—	—
5¼" DSDD Soft Sector w/Hub Ring (96 TPI)	6501-P	2.44	M16A-P	2.49	54992-P	2.99	5DSDD-96RH-P	3.09
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CIRCLE 35 ON FREE INFORMATION CARD

COVER 1

A color display for an oscilloscope was always considered to be impractical: Even if the need for color was there, shadow-mask CRT's couldn't deliver the necessary resolution.

However, Tektronix—by using their new liquid-crystal shutter in combination with a monochrome CRT—has found a practical way to add color displays to oscilloscopes. And it's a safe bet that we'll be seeing Tektronix's technology used in many, many other products in the near future.

NEXT MONTH

ON SALE NOVEMBER 22

LCD TV
A look at the technology that is bringing the dream of a hang-on-the-wall TV closer to reality.

VIDEO CAMERAS
A look at miniature, portable cameras for your VCR.

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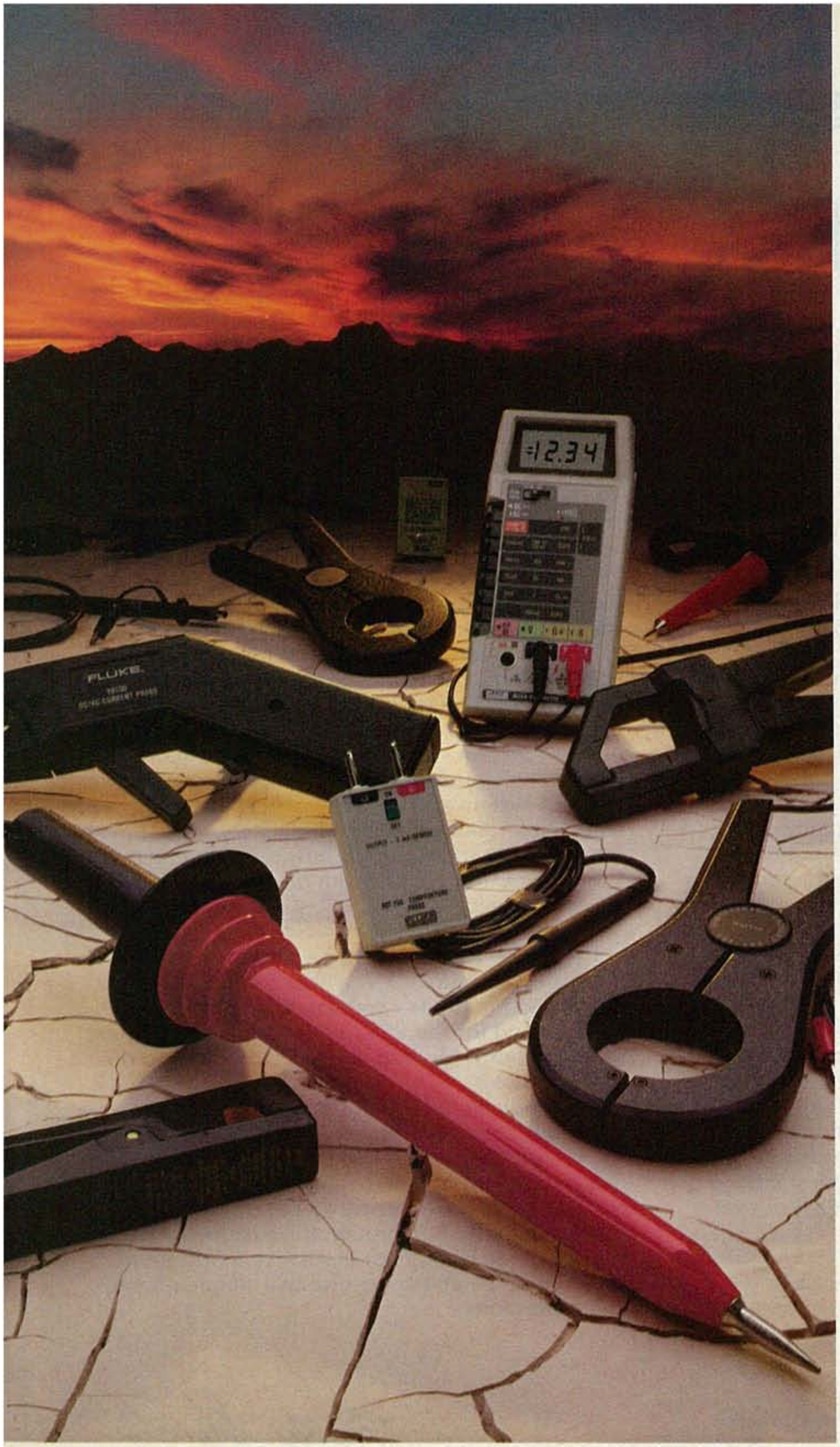

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EDITORIAL

Larry Steckler

Simple Problems are Harder to Solve

Wednesday evening is my time for relaxation. And there I was sitting in my most comfortable chair, videodisc player connected to the TV, and ready to enjoy one of my favorite movies. I reached for the remote for the Pioneer videodisc player, pointed it at the end of the room and pushed PLAY, and at the speed of light my new General Electric TV set changed channels.

A minor annoyance? Yes! A growing problem? Yes! Is it easy to solve? No! The only solutions I had available were to either hard-wire the remote to the videodisc player or to replace the TV set.

The problem was a simple one; both remote-control systems used the same frequencies for different functions.

The solution is also potentially simple—ask the consumer-electronics industry to establish a set of standards for remote control. All that is needed is for *all* the manufacturers to agree that on-off for TV sets is channel 1, while on-off for videodisc is channel 2 and so on. Obviously we'll be smart enough to leave room for devices that haven't yet been invented.

Some individual manufacturers have already taken a step in that direction. RCA, for example, packs a remote unit with some of their new TV's that also has the capability of controlling an RCA videotape recorder. Sony has set up a system where specific frequencies have been reserved for the functions of all of their latest remote-controlled consumer-electronics gear. They even provide a master function so that you can turn everything off with a single push of a button. But the catch is that the RCA system and the Sony systems are not compatible. And while each individual manufacturer tries to do its best to be sure that its system does not conflict with others, they don't always succeed.

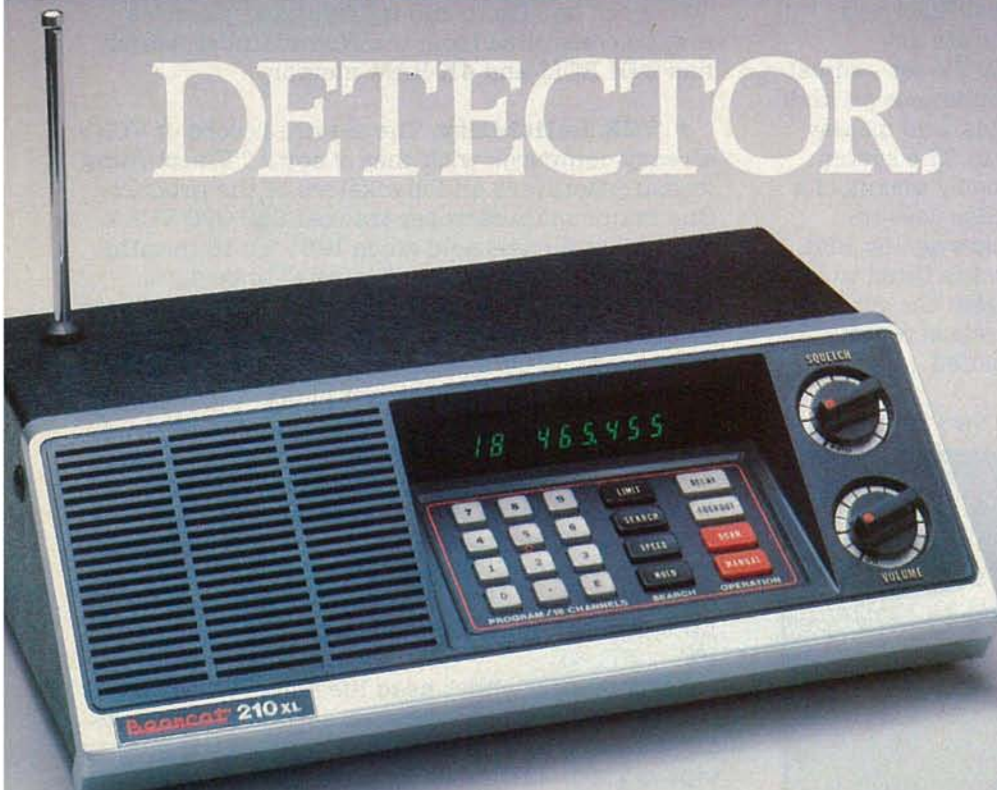
Thus, it is easy to visualize a situation where you are seated surrounded by a host of individual remote-control units—you could have one for the TV, a second for the VCR, a third for your videodisc player, a fourth for your stereo system, and so on.

That's ridiculous! We're smart enough to put communications satellites in space; we've got to be smart enough to cooperate enough to develop a set of standards for remote control of consumer-electronics devices. I know Macy's isn't noted for telling Gimbel's, but through the auspices of the EIA (that's the Electronics Industries Association), we ought to be able to resolve that simple remote-control problem.

Larry Steckler

LARRY STECKLER, EHF, CET
PUBLISHER

CRIME. DETECTOR.



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CIRCLE 99 ON FREE INFORMATION CARD

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Home control by video.** Going on the market before year's end is General Electric's *HomeMinder* system that can operate key household devices from the family TV set—adjust temperatures, dim lights, turn appliances on and off at specific times, store messages, and display important dates and appointments. The system also can be addressed at a distance by means of a pushbutton telephone. *HomeMinder* uses the *X-10* system developed several years ago by BSR. Each appliance or electrical socket is fitted to a module, which may be operated from the central microcomputer by means of a wireless remote control, and all functions are depicted graphically on the TV screen.

HomeMinder initially comes in two versions—a

FIG. 1

$400, set-top system with its own remote control, designed for connecting to any television set, and a 25-inch color monitor-receiver with everything built in and using a single hand-held wireless remote-control unit to operate both the TV set and the *HomeMinder*. The on-screen visuals show diagrams of every room of the house (up to 10 rooms) along with numbered menus of lights and appliances. On-screen prompts (see Fig. 1) help the user to operate the system step by step, such as "What do you want to turn on?" or "Where is it?" Up to 100 lights and appliances may be controlled from the *HomeMinder*, which has 64K ROM and 4K RAM memory.

• **VCR Reliability.** The service record of VCR's already compares with that of color TV, according to manufacturers and marketers of the product. One major manufacturer tracked 665,000 VCR's of 15 of its models sold since 1981 for 18 months and found the "overall defect rate" to be 4.7%. There were service calls on 6.3% of the units over the 18-month period, but 25% of these were found to be unwarranted—due to such causes as battery inserted backwards, deck not plugged in, etc. The same company found that video cameras had only a 2.9% defect rate in 18 months.

Another company listed these top 10 causes of failures during the warranty period: Belts, 21.5%; IC's, 8.8%; tape heads, 4.6%; idlers and pulleys, 4.4%; circuit-board assemblies, 3.9%; motors, 2.5%; switches, 1.5%; tape-loading mechanism, 1.6%; remote-control hand units, 1.3%, and relays, 1%.

Early fears of short head life haven't been borne out by the facts. Manufacturers report their tests show head life of up to 3,000 hours if good-quality tape is used. One major VCR rental firm puts actual life at 1,000 hours and adds: "Head problems always relate to tape quality or tape cleaning." Although some VCR manufacturers recommend one swipe of a head-cleaning cassette when the picture deteriorates, others warn against any consumer head cleaning, and they all agree that here is a major cause of head problems. The worst offenders frequently are audiophiles, who are so accustomed to frequent cleaning of audio-tape recorder heads that they do the same to their VCR's. That can be very damaging because of the speed at which the heads revolve and the delicacy of the heads. The other major cause of head problems—poor-quality tape—results in clogging of heads with flaked off coating. Videotape is one product in which brand name is all-important. **R-E**

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$159.95 MODEL 820
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- 4 digit easy-to-read LED display
- Fuse protected against charged capacitors
- Overrange indication

WHAT'S NEWS

Revolutionary advance in circuit printing

A major new printed-circuit-production process that will give producers of printed circuits savings ranging into millions of dollars has been developed by scientists of the General Electric Research and Development Center at Schenectady, NY.

Secret of the new process is a family of special metallic "inks" consisting of a liquid polymer "loaded" with fine powdered metals—a mixture of iron and nickel. To define the circuit pattern, the ink is transferred to an insulating substrate (circuit board) by screen printing. The board is then run through an oven to harden and cure the ink.

The board is then dipped into a copper-sulfate bath to plate it with copper. While in the bath, some of the metal powder in the cured ink pattern dissolves (going into solution as ferric sulfate) and copper from the bath takes its place. The process takes about five minutes (versus as much as eight hours for older techniques).

With the new process, circuits can be printed on almost any substrate—glass, paper, plastics and even (properly insulated) steel. A new polymer insulation makes steel a highly practical substrate. The insulation has high dielectric strength, and is flexible, enabling the steel to be bent, if desired.

With the new insulation, cost savings of over 10:1 can be achieved by fabricating multi-layer circuits. The single-layer printed circuit is coated with the dielectric layer—leaving holes where layer-to-layer interconnections are desired—and another circuit is laid out on it. The procedure is repeated to form a number of layers.

G.E. SCIENTISTS ROBERT WOJNAROWSKI (right) AND CHARLES W. EICHELBERGER in the final stage of a new printed-circuit process expected to save millions of dollars a year.

DBS applicants alter their plans

Three DBS applicants—CBS, Western Union, and RCA Americom—have altered their plans, leaving only five applicants prepared to commence DBS programming by the end of this decade.

CBS has abandoned its DBS plans, and has dropped out of a possible joint venture with Satellite TV Corporation. Western Union has also decided not to pursue its proposed Ku-band service. Rather than withdrawing completely, RCA Americom has scaled back its plans. They have postponed any possible start-up until at least 1989, and will use just two 16-channel satellites as opposed to their originally proposed four.

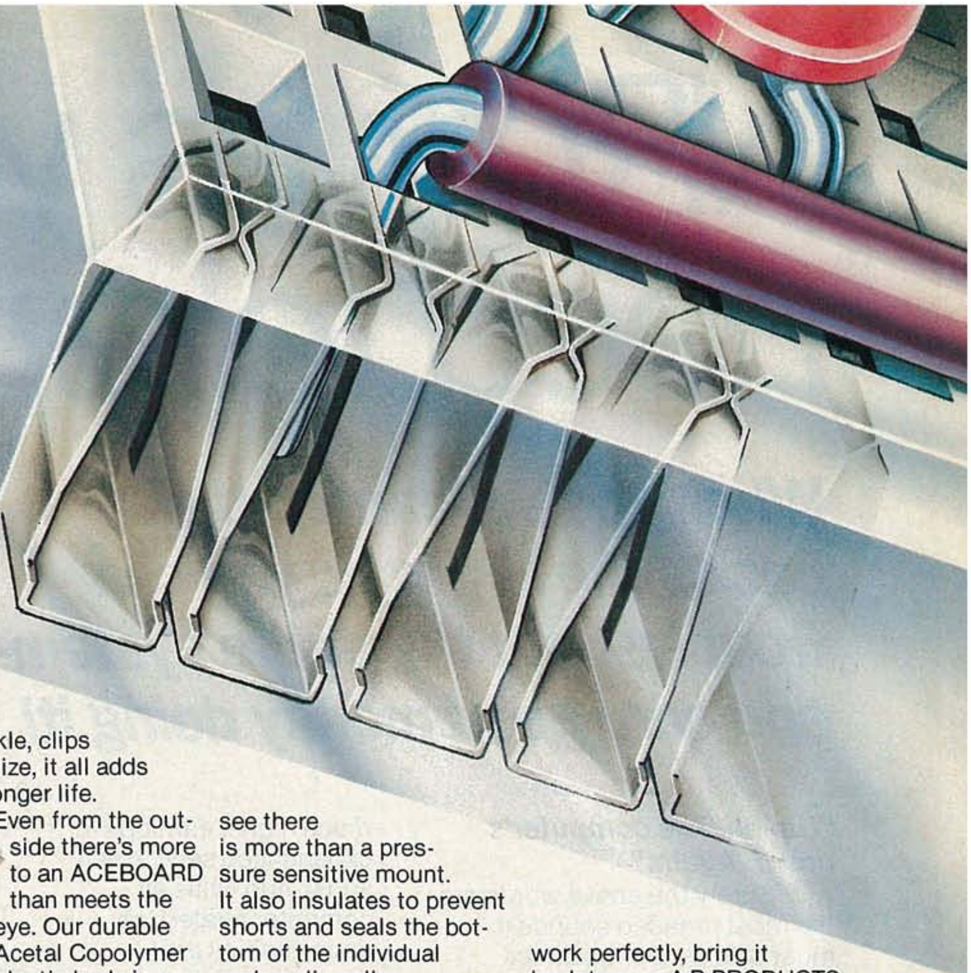
Many of those still proceeding with DBS are altering the details of their proposed services. For example, STC, a subsidiary of Comsat, now is seeking to co-locate two satellites at 110° west longitude instead of their originally proposed 101°. STC also wants to use six channels to cover the entire U.S. upon launch. Originally they planned to start offering service to just the eastern part of the country, with western-U.S. service to commence later.

New infrared detector may be used in space

A new way of making ultrasensitive indium antimonide infrared detectors usable in space satellites should result in an appreciable improvement in the imaging abilities of satellites that are used for weather forecasting and a host of other applications.

Until now, indium antimonide detectors have been limited to land-based equipment or aircraft,

continued on page 21



LITTLE THINGS MEAN A LOT

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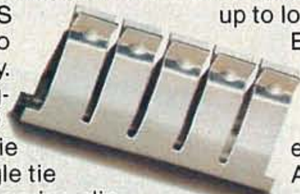

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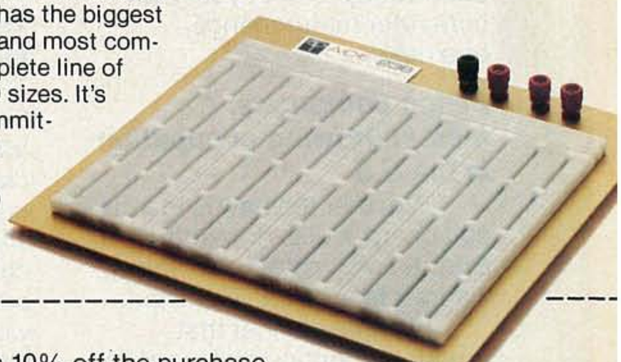

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It's little wonder that America's continuing love affair with the microcomputer has led to growing job opportunities. The U.S. Department of Labor recently projected that the number of computer service jobs will *double* before the year 1995. The same agency also reports median earnings of full-time computer service technicians are $430 per week (with much higher earnings for experienced service persons). And while all computer-related job opportunities are expanding, the computer service technician is the fastest growing job category of all (48% faster than electrical engineers, 92% faster than injection mold machine operators).

Choose from a wide variety of career paths

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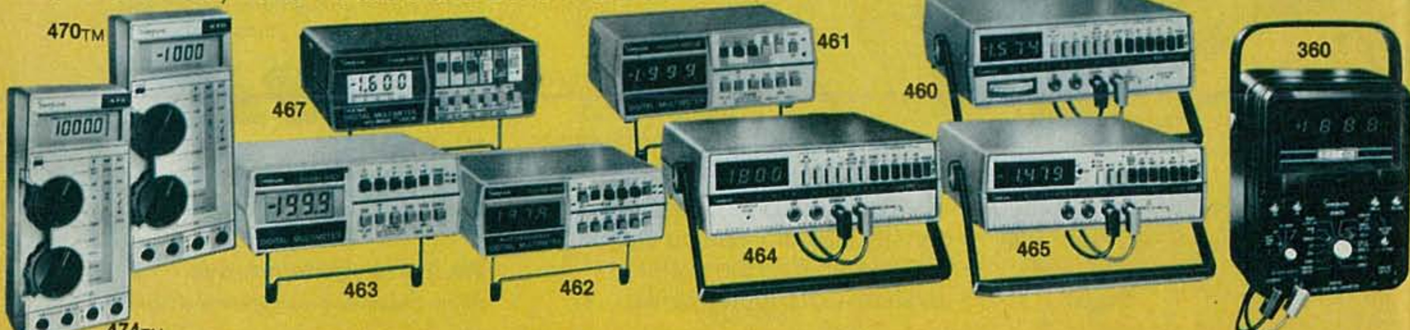

CIRCLE 25 ON FREE INFORMATION CARD

What's News

continued from page 14

because of their extreme cooling requirements. Such detectors must be operated at temperatures below −300 degrees F, making cooling with liquid nitrogen or helium necessary. Those coolants evaporate and must be replenished, ruling them out for unattended space satellites.

The material prepared by General Electric scientist Dr. Wirojana Tantraporn will permit detectors to perform effectively at −240 degrees F. That temperature can be maintained indefinitely by satellite refrigeration systems powered by solar cells.

Dr. Tantraporn determined that certain types of impurities in the material were important in determining its operating temperature, and was able to develop a process that controls the type and amount of impurities. In his process, a conventional indium antimonide wafer is coated with a thin, high-purity overlayer consisting of indium, antimony, and a special impurity, or dopant.

In-office "voice mail" developed by Fujitsu

An intra-office "voice mail" computer system that can log a voice message into a storage unit and forward it to the recipient later is announced by Fujitsu. Message-recording systems are familiar, but previous ones have been able only to record the messages on an auxiliary tape recorder.

With the new voice-mail system (VMS), if the caller finds the extension he has called busy or unattended, he flashes the VMS and repeats his message. The VMS stores the message, then periodically rings the called party until the receiver is picked up.

The VMS provides up to 2,000 extensions with services, and can process up to 24 messages at once, with a storage capacity of 1,400 60-second messages. That capacity is attained by converting the analog phone signals to digital signals, then storing them by "adaptive differential pulse modulation." In that system, a signal is recorded only when it differs from the one preceding it. That results in a great saving of space.

The VMS can be used to connect a number of offices in different locations by connecting the offices with leased telephone circuits.

Parallel recording permits high speeds

A new technique records information onto an optical disc simultaneously from three semiconductor lasers that are on a single IC. The new system, multichannel recording, can store and retrieve vast amounts of information at speeds hitherto impossible. It was developed by scientists of RCA laboratories at Princeton, NJ.

Three high-power semiconductor lasers, mounted on a single IC, are the central feature of the development. They record information by creating tiny pits in a light-absorbing layer on the disc. Each pit is less than thirty millionths of an inch across. The information from the three lasers is simultaneously recorded in three closely spaced parallel grooves. The disc that is used is 14 inches across and can store 100 billion bits. A low-power laser retrieves the information.

"Modern high-speed communications, such as microwave signals from satellites or light pulses in optical fibers, can easily overwhelm single-channel storage systems," says an RCA spokesman. "With multi-track recording, information can now be stored at extremely high data rates. In the future, large computer mainframes that require mass storage of data would also benefit from multi-channel optical recording."

Telex to take over Raytheon Data Systems

Raytheon Co. and Telex Corp. announce an agreement in which Telex Computer Products, Inc. will acquire the assets of the Raytheon Data Systems Division. The purchase price is estimated at more than $200 million.

The companies indicated that about 2,100 employees of Raytheon Data Services and Leasing Co. will be able to transfer to Telex, to service Raytheon customers. Telex has expressed its intention to establish operations in Massachusetts, largely to service the large base of airline users it will obtain as part of the agreement.

Future direct-broadcast satellites to be most powerful

The United States Satellite Broadcasting Co. (USSB) of Minneapolis, has let a contract for two high-powered direct-to-home broadcast satellites (DBS). Both design and construction has been contracted to RCA Astro-Electronics, East Windsor, NJ. Operating at 240 watts-per-channel, they will provide TV pictures and stereo sound of the highest quality to all 50 states, Puerto Rico and the Virgin Islands.

Because of the high power of the satellites—greater than anything yet built or contracted for—home owners will be able to receive their signals on inexpensive 24-inch dishes on their rooftops. The first launch is scheduled for 1988. **R-E**

LETTERS

WRITE TO:

LETTERS
Radio-Electronics
200 Park Ave South
New York, NY 10003

SINCLAIR LIVES

I have been enjoying your magazine for some time now, and I have found your articles informative and accurate. I did spot a comment in the July 1984 issue which bothered me a bit, though. In the article "Interfacing the *ZX81*," by Neil Bungard, one sentence reads in part, "And now that the computer is no longer being produced, you can...."

Not so! While we all know that Timex has stopped producing the *TS1000*, Sinclair is not dead, and in fact has recently signed a deal with an eastern firm (whose name, unfortunately, escapes me at the moment) to produce more *ZX81*'s.

Lest anyone believe that I am in any way detracting from Mr. Bungard's article, let me say that I have every intention of building his circuit or a variant of it, as I have with the last few circuits for the *TS1000/ZX81* that you have printed.

While your publication is not completely dedicated to computers, radio, or any other specialty (a fact I enjoy very much), it may interest you to know that I consider your articles among the very best I have seen.

TIM RUSSELL
Thousand Oaks, CA

VIDEODISC INFERIOR

Your "Video Electronics" column in the July, 1984 issue of **Radio-**

Electronics, contained a reference to RCA's "noble experiement" with CED videodisc, and elsewhere I read that a high RCA official had said, in effect, that the CED debacle was a "technical success but a marketing failure."

Those comments annoy me because the obvious reason that the system failed—as anyone who owned a VCR and a CED system could testify—is that the CED system was significantly inferior in performance to VCR systems. I own about ten CED videodiscs, and have viewed at least twice as many rental tapes. *All* the rental tapes were of obvious higher quality that the *best* of the videodiscs. That reflects comparison between *used* tapes and absolutely *new* discs; the disc deteriorates rapidly with replaying.

All the videodiscs I own arrived with skips (those are just like the similar defect in an audio record; the picture shifts abruptly as a small section of the program is skipped over). Every single one had at least one of those defects; I haven't counted, but my impression is that they invariably had many (five or ten) skips on arrival. Such defects increased with replaying.

I don't mean to beat a dead horse. What I find annoying and disturbing is the apparent inability of American companies and technical observers to distinguish excellence from mediocrity.

GREGOR OWEN
Port Jefferson, NY

PREFERRED CHOICE CLARIFIED

I don't quite understand why Mr. Rich Taylor disagrees with me. (**Radio-Electronics**, "Letters," May 1984.) In the February 1984 issue, I stated that "...I didn't think computer-circuitry articles have been emphasized too heavily." That is evident by the number of people retaining **Radio-Electronics** subscriptions and dropping others like *Computers & Electronics*. I didn't say or imply **Radio-Electronics** should become another computer magazine.

My point was that **Radio-Electronics** shouldn't go out of its way *not* to publish articles that deal with computers. After all, computers most definitely do have a place in what he called, "The last good general-interest electronics magazine..." (I couldn't agree more about that description of your magazine.) It seems to me that Mr. Taylor misunderstood my meaning. I hope that this clarifies it.

EDWARD W. LOXTERKAMP
Cincinnati, OH

NO COMPUTERS—PLEASE

I am writing to emphatically agree with Richard Taylor's letter in the May 1984 issue of **Radio-Electronics**; it is indeed the last good general-interest electronics magazine around. Since *Popular Electronics* changed its emphasis and name, its interest and value to me, and, I'll bet, to many others who formerly subscribed, plunged to zero.

You tell us that your insert, **ComputerDigest**, takes "no editorial

space away'. Well I stopped believing in a free lunch many years ago; maybe it doesn't represent a subtraction, but then it must represent time, energy, and money that could be added to what you are presently offering.

Please continue with the good thing you've got, and maybe add to it with some of the features and authors that that other magazine used to have. You'll be unique, instead of another one of some twenty-odd computer magazines.
SIDNEY F. KAHN, MD
Norwalk, CA

A READER COMMENTS

I received the June issue of **Radio-Electronics** just two days ago, and I have completed the first reading. I am moved to forward my comments immediately.

Your special section "Receiving Satellite Television" was timely, competent, informative, and extremely well done. I am now retired from the electronics field after many active years, so I am not closely in touch. This provides an excellent forum for summarizing the current state of things. Thanks for a job well done.

Although I am not yet active in computer programming, I have hopes for the near future; we have acquired an IBM *PC* and printer in our home. I feel confident that your **ComputerDigest** section will become a valuable and useful resource for me.

I wish I could be as complimentary about Robert Grossblatt and his "Drawing Board" article on page 88. It is a masterful combination of self-adulation, obfuscation, and derision of mathematics, which patronizes his readers, states incorrect information, and fails utterly in explaining how the circuit worked. I knew how it worked until I read the article.

It was gratifying to learn that 36° is $\frac{1}{10}$ of 360° and that the Q outputs of the CD4018 wired decade counter repeats after five counts. Methinks he would find the timing diagram in the specification sheet fascinating reading.

Why did he mention Fibonacci numbers? Is he interested in rabbits? He should be aware that these numbers rarely scare anyone. Most people have never heard of them and could not care less. Those who have, know them to be simple and not very useful.

My enthusiasm remains substantially undaunted. Keep up the good work.
L.D. SMITHEY
Pacific Palisades, CA

ADDRESS NEEDED

Recently I have been asked to repair a model *200* audio amplifier manufactured by Integral Systems. I have tried to obtain a set of schematics for the unit but have been unable to contact the company. The address that I have for the company is 463 Salem Street, North Wilmington, MA 01887. If you or any of your readers could help me to locate the company, I would be grateful for your help. Thank you.
KENNETH MONGELLUZZO
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Newfield, NJ 08344 **R-E**


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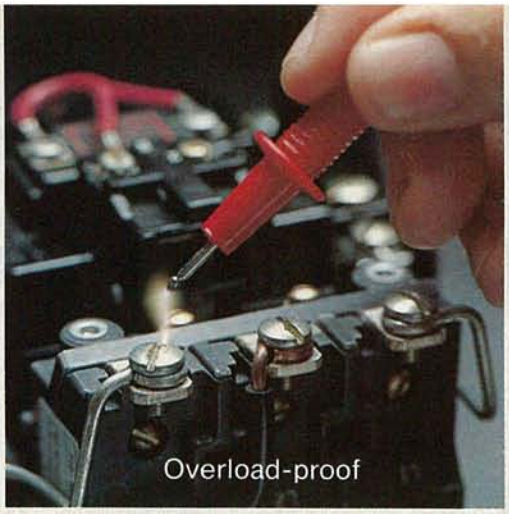
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EQUIPMENT REPORTS

Wersi Pianostar S2000 Electronic Piano

A versatile electronic piano that you can build yourself.

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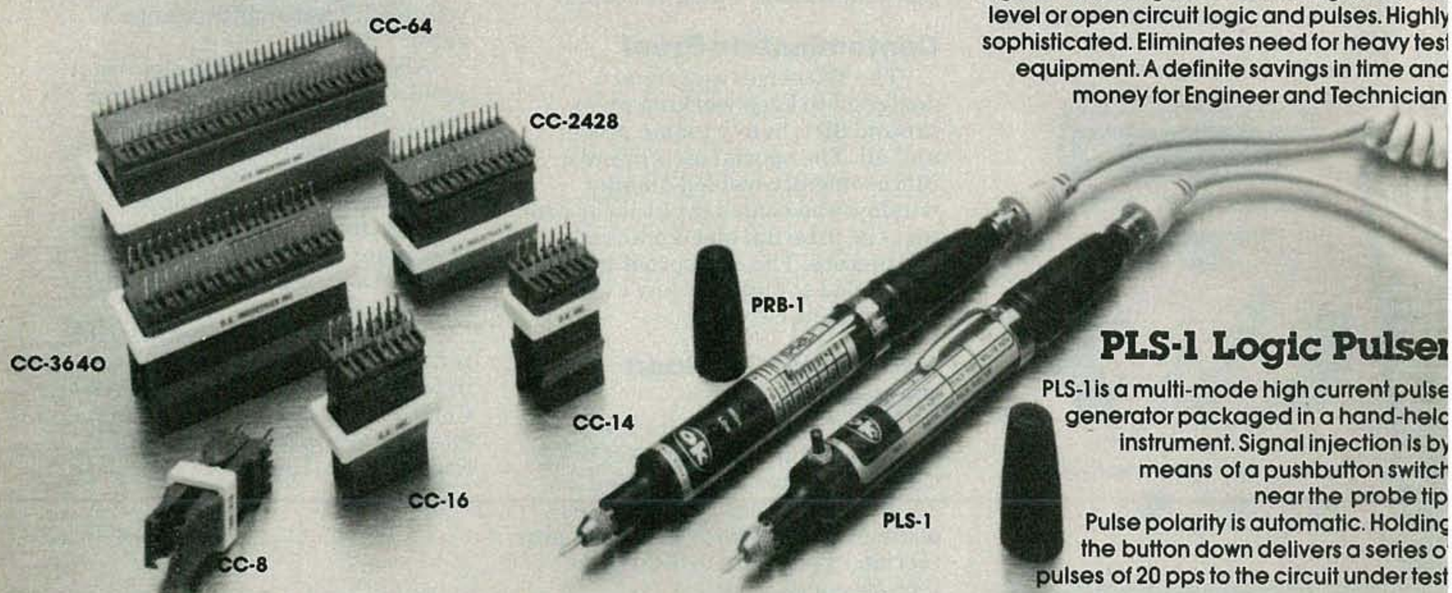
IT IS ESTIMATED THAT THERE ARE SOME 30 million pianos in the united states. Most of those are of the mechanical variety that everyone is familiar with. Some, however, are quite different—they are electronic. In those, advanced electronic circuitry replaces the traditional strings, hammers, etc.

In this review we are going to look at one of those electronic pianos, the *Pianostar S2000* from Wersi (1720 Hempstead Road, Lancaster, PA 17601). An interesting twist is that that piano is one that you can build yourself.

continued on page 30



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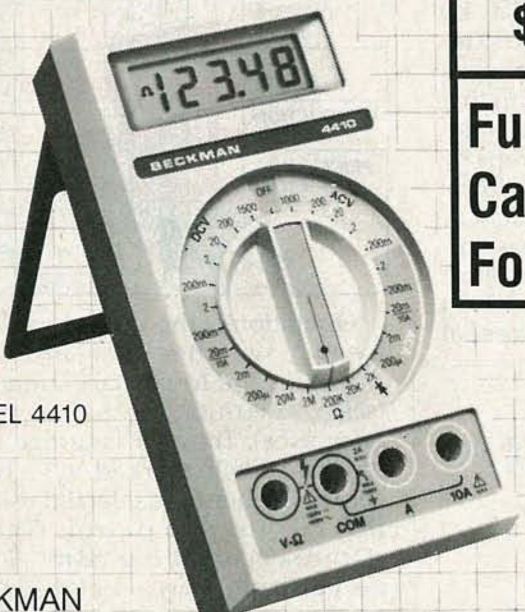

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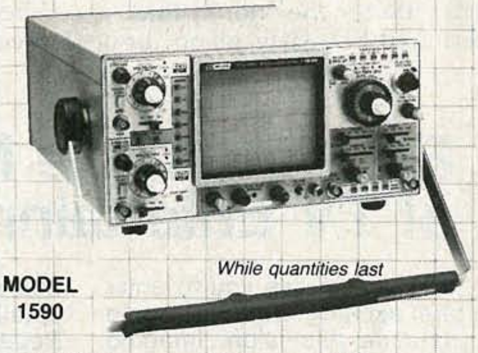

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EQUIPMENT REPORTS

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The *Pianostar*

The *Pianostar S2000* is a versatile electronic musical instrument. It is housed in an attractive wood cabinet and measures 40⅛ × 57⅛ × 22¾ inches. The keyboard has a 7-octave range. The unit boasts two 60-watt RMS audio amplifiers. Sound output is available from three sources: speakers, a headphone jack, and a tape-recorder interface.

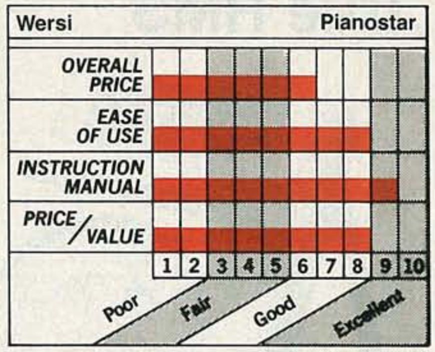
Eight different "voices" or sounds are available from the *Pianostar*. Two or more of those voices can be selected simultaneously for special effects (more on that later), etc. The voices "piano" and "harpsichord" sound just like their familiar mechanical counterparts. The "cembalo" voice sounds much like a harpsichord, except that every key sounds at its normal pitch plus the pitch that's one octave higher. Another name for the "honky-tonk" voice might be player piano, because that voice sounds just like a player piano.

The forerunner of the piano used metal plates instead of strings. The resulting sound is, as you would imagine, rather harsh. That sound is simulated by the unit's "kinura" voice.

The unit's "banjo" voice sounds very much like the instrument for which it is named. Other voices include "rock piano" and "stage piano."

The two foot pedals normally function exactly like their mechanical piano counterparts. The left pedal serves as a damper; the right one adds a sustain. In the *Pianostar*, however, new functions can be assigned to the pedals by simply depressing a switch. Depressing the HAWAII switch assigns a new task to the left pedal. In that mode, each time that pedal is depressed, the overall pitch drops by half a tone and then returns slowly to normal. With some practice, you will be able to accurately simulate a "Hawaiian guitar" sound. When the VIBRATTO PEDAL mode is selected, depressing the left pedal will add vibrato that will start with a certain hesitation and then build up gradually.

An almost limitless number of special effects can be achieved through the use of the unit's voltage-controlled filter (VCF). That filter has a passband that can be varied from wide to narrow. The center frequency is adjustable and can fall anywhere over a wide frequency range. That center frequency can also be made to vary about the nominal center frequency. The amount of variation and the speed of that variation can be set by the user.



Operation of the VCF is handled by two switches (VCF and VCF TRACKING) and four rotary controls (SPEED, AMPLITUDE, RESONANCE, and FREQUENCY). The VCF is turned on by the switch marked VCF. The center frequency is selected using the FREQUENCY control. The RESONANCE control is used to select the passband. AMPLITUDE is used to set the amount of center-frequency variation. The speed of that variation is set by the SPEED control. Normally, as mentioned above, the center frequency is set by the frequency control. When VCF TRACKING is selected, however, the center frequency is pulled up to the frequency of the highest key being played.

Experimenting with those controls and their settings will allow you to simulate a wide variety of sounds for special effects. For example a "wah wah guitar" can be simulated with the following settings: voices, rock piano and kinura; VCF, on; VCF tracking, on; amplitude, 10; speed, center; frequency, center, and resonance, 10.

Construction

Building the *Pianostar* is certainly not a one-night job. On the

other hand, with the proper care and patience, it could be handled by even a beginner. Part of the reason that that's possible are the excellent manuals provided with the kit. Construction details are covered in two of those manuals. (There are four all together; we'll cover the others shortly.) Of particular help to the first-time builder is the one entitled "General Instructions." That book covers such topics as the tools required, general construction techniques (how to solder, etc.), and how to identify and install the various types of components found in the kit. It would be nice if all kits included such complete and helpful information for the beginner.

Actual construction is covered in the assembly manual. That manual does an adequate job of taking you through the building of the device. It is profusely illustrated, provides valuable hints as you move step-by-step through the construction, and provides you with a checklist to help ensure that nothing is missed. The book does not, however, painstakingly outline the installation of each and every component. It's not uncommon for a single step in the manual to cover the installation of several components; indeed, some single "steps" cover the installation of 294 jumpers, 182 resistors, 168 diodes, and the like. Don't let that scare you away, however; as we said, the manual is still good enough so that most builders should have little trouble successfully completing the project.

The third manual of the four covers the technical aspects of the *Pianostar*. Included are schematics, block diagrams, parts-placement diagrams, and the like. Also included are the theories of operation for the various circuits and sections, and a chapter on servicing hints.

The fourth manual is an owner's manual, whose primary purpose is to briefly summarize the use of the instrument.

Our experiences with the *Pianostar S2000* have been exceedingly positive. No troubleshooting was required as the piano worked perfectly upon the completion of the project. For those that do encounter problems, however, Wersi stands behind their products. The *Pianostar S2000* is covered by a one-year limited warranty.

The *Pianostar S2000* is an outstanding product, and one we recommend for those interested in music and electronics. It sells for $2770. **R-E**

continued on page 38

"So we would save 25 cents on the steak. Now, how about the drinks?"

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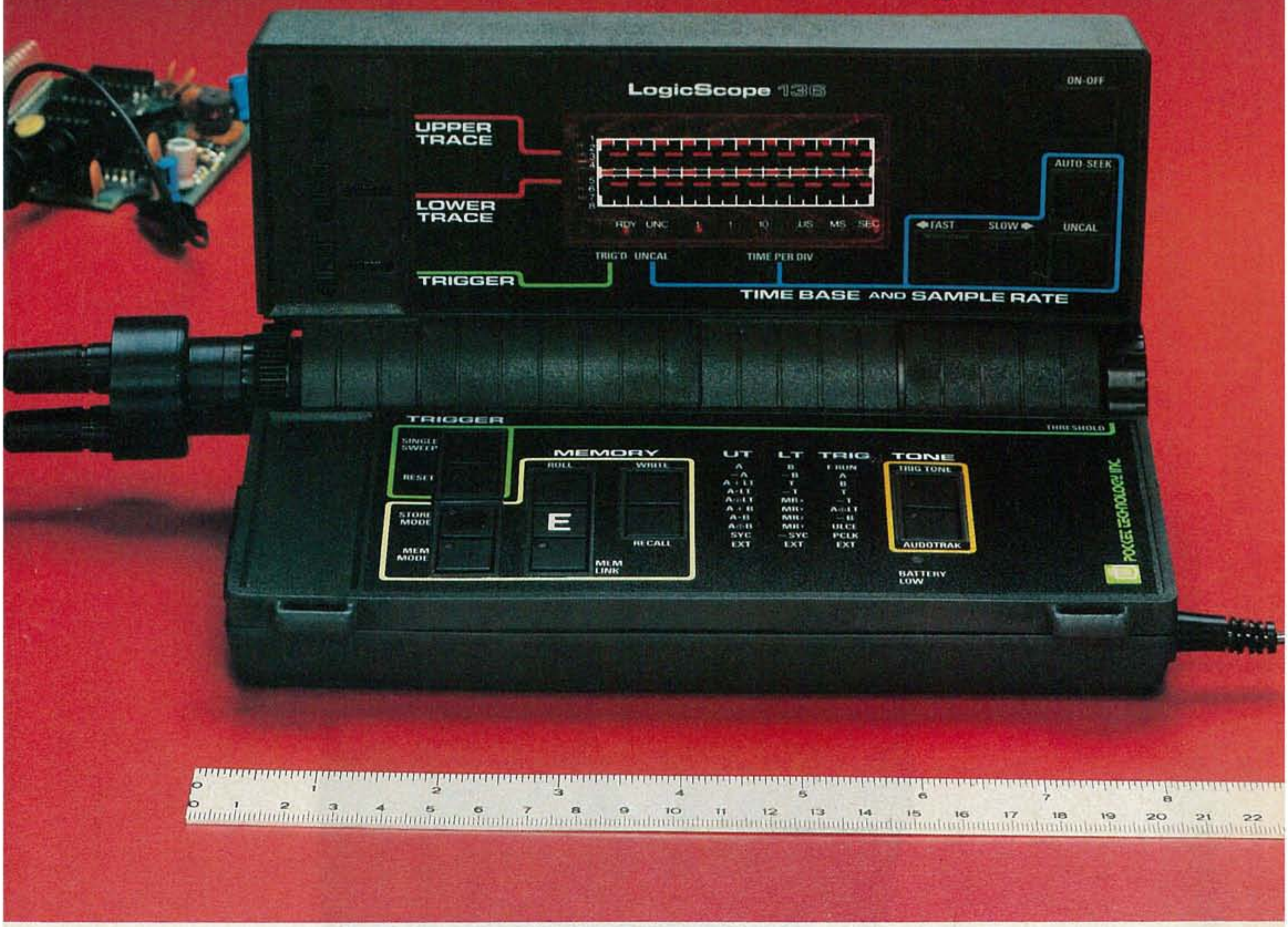

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■ Its very low cost, convenience and ease-of-use make the LogicScope the ideal instrument, for designing, troubleshooting or repairing digital systems.

Consider its Engineering & Field Service Applications:

■ On microprocessor-based systems, check the timing relationship of various parameters relative to the system clock and other key events. Its storage capability allows visual and logical comparison of non-repetitive waveforms to known reference signals. Output in the start-up of the digital device can be compared to reference signals to determine the operating state of the device. Questionable waveforms can be stored for analysis.

■ Its light weight and small size make the LogicScope convenient to take on every service call. The 136 provides much more information for trouble shooting a digital system or peripheral than a logic probe or digital multimeter, without having to lug an oscilloscope or logic analyzer along.

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HOW DO YOU TURN YOUR ON-PAPER electronic circuits into working real-world circuits? How do you take your breadboarded circuit and make a more-permanent version? If it's a complex circuit that uses many IC's, you undoubtedly use a PC board. But what if it's rather simple and uses only a handful of IC's (such as a circuit you read about in "Hobby Corner" or "New Ideas)? For those, making a single PC board probably just isn't worth the effort.

You should know, however, that making a PC board does not have to be a project in itself. It does not have to involve chemicals, etching, and photography—thanks to *E-Z Circuit* printed-circuit copper products from Bishop Graphics (5388 Sterling Center Drive, PO Box 5007E-Z, Westlake Village, CA 91359-5007).

We should say right at the beginning that *E-Z Circuit* cannot *replace* standard PC-board methods—it is not suitable for *all* applications. But when you can use it, the time and trouble you'll save certainly makes it worthwhile. And we should point out that *E-Z Circuit* can be used for other things than making original circuit boards: The copper patterns are ideal for repairing or modifying *existing* PC boards.

The E-Z-Circuit process

With *E-Z Circuit*, you start with a blank board (instead of a copper-clad board) and you put copper on the board where you want it (instead of etching it off where you don't). Therefore, etching (our least-favorite step) is done away with because the only copper on the board is what you put down! Drilling is also done away with because the blank board you use is perforated—as are the foil patterns you place on the board. Camera-ready artwork is also not necessary.

Once you have your layout design finished, you're ready to put the copper patterns on the board. You simply align the adhesive-

NEW! uniden® Bearcat® Products

Communications Electronics,™ the world's largest distributor of radio scanners, is pleased to announce that *Bearcat* brand scanner radios have been acquired by Uniden Corporation of America. Because of this acquisition, Communications Electronics will now carry the complete line of Uniden *Bearcat* scanners, CB radios and Uniden *Bandit*™ radar detectors. To celebrate this acquisition, we have special pricing on the Uniden line of electronic products.

Bearcat®† 300-E
List price $549.95/**CE price $339.00**
7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC
Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz.
The *Bearcat* 300 is the most advanced automatic scanning radio that has ever been offered to the public. The *Bearcat* 300 uses a bright green fluorescent digital display, so it's ideal for mobile applications. The *Bearcat* 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys, Separate Band keys to permit lock-in/lock-out of any band for more efficient service search.

Bearcat® 20/20-E
List price $449.95/**CE price $269.00**
7-Band, 40 Channel • Crystalless • Searches AM Aircraft and Public Service bands • AC/DC Priority Channel • Direct Channel Access • Delay
Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz.
Find an easy chair. Turn on your *Bearcat* 20/20 and you're in an airplane cockpit. Listening to all the air-to-ground conversations. Maybe you'll pick up an exciting search and rescue mission on the Coast Guard channel. In a flash, you're back on the ground listening as news crews report a fast breaking story. Or hearing police and fire calls in your own neighborhood, in plenty of time so you can take precautions. You can even hear ham radio transmission, business phone calls and government intelligence agencies. Without leaving your easy chair. Because you've got a *Bearcat* 20/20 right beside it.

The *Bearcat* 20/20 monitors 40 frequencies from 7 bands, including aircraft. A two-position switch, located on the front panel, allows monitoring of 20 channels at a time.

Bearcat® 210XL-E
List price $349.95/**CE price $209.00**
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Frequency range 32-50, 144-174, 421-512 MHz.
The *Bearcat* 210XL scanning radio is the second generation scanner that replaces the popular *Bearcat* 210 and 211. It has almost twice the scanning capacity of the *Bearcat* 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display. Automatic search finds new frequencies. Features scan delay, single antenna, patented track tuning and more.

Bearcat® 260-E
List price $399.95/**CE price $249.00**
8-Band, 16 Channel • Priority • AC/DC
Frequency range 30-50, 138-174, 406-512 MHz.
Keep up with police and fire calls, ham radio operators and other transmission while you're on the road with a *Bearcat* 260 scanner. Designed with police and fire department cooperation, its unique, practical shape and special two-position mounting bracket makes hump mounted or under dash installation possible in any vehicle. The *Bearcat* 260 is so ruggedly built for mobile use that it meets military standard 810c, curve y for vibration rating. Incorporated in its rugged, all metal case is a specially positioned speaker delivering 3 watts of crisp, clear audio.

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List price $279.95/**CE price $179.00**
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Frequency range 30-50, 118-136 AM, 146-174, 420-512 MHz.
The *Bearcat* 201 performs any scanning function you could possibly want. With push button ease, you can program up to 16 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear.

NEW! Bearcat® 180-E
List price $249.95/**CE price $149.00**
8-Band, 16 Channel • Priority • AC only
Frequency range: 30-50, 138-174, 406-512 MHz.
Police and fire calls. Ham radio transmissions. Business and government undercover operations. You can hear it all on a *Bearcat* 180 scanner radio. Imagine the thrill of hearing a major news event unfold even before the news organizations can report it. And the security of knowing what's happening in your neighborhood by hearing police and fire calls in time to take precautions. There's nothing like scanning to keep you in-the-know, and no better way to get scanner radio performance at a value price than with the *Bearcat* 180.

Bearcat® 100-E
The first no-crystal programmable handheld scanner.
List price $449.95/**CE price $234.00/*SPECIAL!***
8-Band, 16 Channel • Liquid Crystal Display Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 138-174, 406-512 MHz.
The world's first no-crystal handheld scanner has compressed into a 3" x 7" x 1¼" case more scanning power than is found in many base or mobile scanners. The *Bearcat* 100 has a full 16 channels with frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the 2-Meter and 70 cm. Amateur bands, *plus* Military and Federal Government frequencies. It has chrome-plated keys for functions that are user controlled, such as lockout, manual and automatic scan. Even search is provided, both manual and automatic. Wow...what a scanner!

The *Bearcat* 100 produces audio power output of 300 milliwatts, is track-tuned and has selectivity of better than 50 dB down and sensitivity of 0.6 microvolts on VHF and 1.0 microvolts on UHF. Power consumption is kept extremely low by using a liquid crystal display and exclusive low power integrated circuits.

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. The *Bearcat* 100 is in stock for quick shipment, so order your scanner today.

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Frequency range 10 kHz to 30 MHz.
The *Bearcat* DX1000 shortwave radio makes tuning in London as easy as dialing a phone. It features PLL synthesized accuracy, two time zone 24-hour digital quartz clock and a built-in timer to wake you to your favorite shortwave station. It can be programmed to activate peripheral equipment like a tape recorder to record up to five different broadcasts, any frequency, any mode, while you are asleep or at work. It will receive AM, LSB, USB, CW and FM broadcasts.

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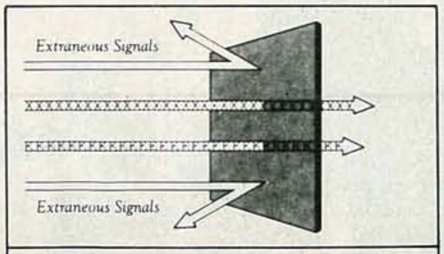
Order two scanners at the same time and deduct 1%, for three scanners deduct 2%, four scanners deduct 3%, five scanners deduct 4% and six or more scanners purchased at the same time earns you a 5% discount off our super low single unit price.



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Uniden® PC33-E
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List price $89.95/**CE price $59.00**
The full featured *Uniden* PC55 front-panel mike connector makes installation easier when space is a factor. It has ANL, PA-CB, Channel 9 and RF Gain switches. LED "S"/RF meter, TX lite, PA & external speaker jacks. Dimensions: 6" W x 6" D x 1⅞" H. ±13.8 VDC.

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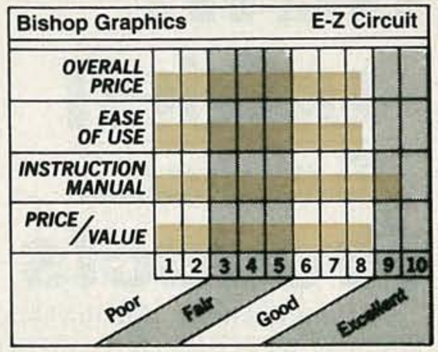
backed copper patterns with the pre-drilled holes, and press in place. If you want to move a pattern, you can—until the adhesive cures. (After that time, the pattern can still be removed if you need to make changes to the board, but it cannot be re-used.

Once you have your component-mounting pads in place, you can interconnect them with copper tape. When traces cross, you have two choices: You can use the supplied insulating polyester tape between the two crossing traces, or you can run one of the traces on the other side of the board.

That ability to make double-sided boards (which, interestingly, is not mentioned in the *E-Z Circuit* instruction manual) is very important. That's because the copper-tape traces are thicker than what you can etch, so you cannot run them between, for example, IC-pin pads. Being able to run traces on both sides of the board helps to compensate for that.



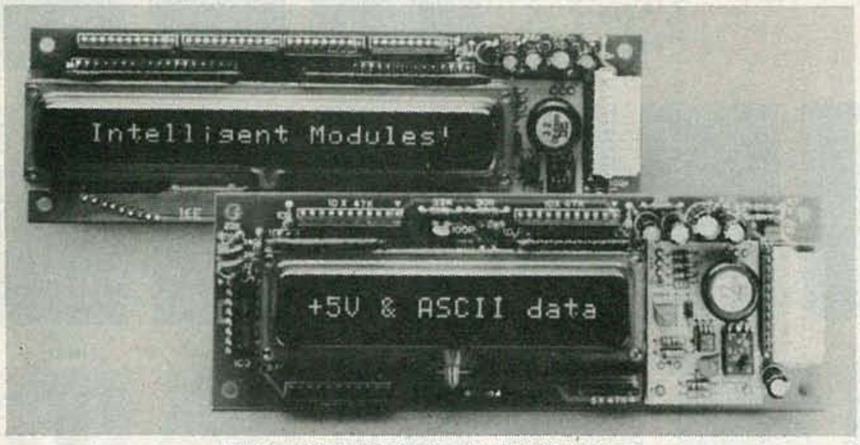
Once all of your pads and interconnecting traces are in place, they must be soldered together. (Even though a trace may be attached to another by the adhesive backing, they are not electrically connected until they are soldered.) The final step, of course, is inserting the components and soldering them to the copper patterns. The component-mounting pads have an epoxy-glass substrate and can be soldered many times. The traces and donut pads, however, do not have that thermal barrier. When they are soldered, the adhesive can soften and the patterns can slide and/or lift from the board. If you solder with that in mind (and you keep your soldering iron in a vertical position), you won't have any trouble. The adhesive regains full strength when it cools.

What's available

While the *E-Z Circuit* patterns are available separately, their kits offer a better value. Four kits, which should fill the needs of most hobbyists, are available. Each kit consists of more than 200 pieces, including such pressure-sensitive copper configurations as donut pads, multi-conductor strips, and power distribution strips, as well as TO-5, power-transistor, SCR, and DIP mounting patterns.

The difference between the kits is the type of boards (and card-edge patterns) they contain. For example, the *AppleKit* contains an *E-Z Bus* board (that is shaped the same as any apple card) and self-adhesive card-edge connections. The S-100 kit includes an S-100 board, the standard-bus kit includes a standard-bus board, and the *Eurokit* contains two eurocard boards. Kit prices vary from about $63 to $68. **R-E**

NEW PRODUCTS



CIRCLE 121 ON FREE INFORMATION CARD

INTELLIGENT MODULES, model *3600-80-016* and model *3600-81-020* are the latest additions to the FLIP family of vacuum fluorescent display modules. Each is a single-board module.

The model *3600-80-016* displays 1 line of 16 characters and measures 6.37″ wide × 2.20″ high × 0.70″ deep. The model *3600-81-020* displays 1 line of 20 characters and measures 6.92″ wide × 2.20″ high × 0.70″ deep.

For the user's convenience, an integral switching power-supply provides all required drive voltages from a single +5-volt DC input. An on-board ASCII interface controller handles all scan, refresh, and data I/O tasks, permitting easy interface to an 8-bit data bus.

The devices display an extended ASCII character set of upper- and lower-case letters, numbers, and symbols using a 0.20" high 5 × 7 dot matrix. Display color is a bright, broad-spectrum emission, which peaks in the blue-green, and is easily filtered to a wide range of colors. Viewing angle is typically 150 degrees.

The model *3600-80-016* is priced at $74.00 each for 100 pieces; the model *3600-80-016* is priced at $79.00 each for 100 pieces.—**Industrial Electronic Engineers, Inc.,** 7740 Lemona Ave., Van Nuys, CA 91405.

DMM, model *8840A,* is a 5½" digit benchtop/system that provides basic accuracy of 0.005% for one year with a 24-hour specifications of 0.002%. Complete software calibration, either manually or over the bus, makes it easy to maintain the 24-hour specifications routinely in those applications requiring optimized accuracy.

CIRCLE 122 ON FREE INFORMATION CARD

At reading rates of 2.5 and 20 readings per second, the model *8840A* has 5½ digit resolution. At the fast rate of 100 readings per second, the resolution is 4½ digits. The model *8840A* is priced at $95.00. It is available with two options for true RMS AC and fully programmable IEEE-*488* interface ($150.00 each). A fully loaded package sells for $995.00. —**John Fluke Mfg. Co., Inc.,** PO Box C9090, Everett, WA 98206.

POWER SUPPLY, model *WP-29A* is designed to provide an isolated AC

CIRCLE 123 ON FREE INFORMATION CARD

output from 0 to 150 volts, 0–2.25 amps continuous at 60 Hz. Input voltage and isolated output voltage can be monitored on a large, taut-band meter.

Secondary leakge is limited to less than 0.1 milliamp—lower than the established ANSI limits in Specification Code C-101. The unit is designed for incoming or outgoing quality control, servicing, or design work where testing circuits at higher or lower than normal voltages is required. The model *WP-29A* is priced at $167.00 — **VIZ Test Equipment,** 335 East Price Street, Philadelphia, PA 19144. **R-E**

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MODEL 1045 $395

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These test instruments cover every possible level of service required for telephone products. They are equally useful for training. The instruction manuals provided offer a comprehensive course of training for service personnel and students. Call your nearest B&K-PRECISION distributor for off-the-shelf-delivery or additional information—or contact B&K-PRECISION.

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CIRCLE 16 ON FREE INFORMATION CARD

An exciting new technology may make it possible to offer color displays in applications where previously they have been impractical or impossible. In this article we'll look at that technology, and its first commercial application.

OSCILLOSCOPES IN COLOR

CARL LARON
ASSOCIATE EDITOR

MOST READERS OF **RADIO-ELECTRONICS** are familiar with shadow-mask CRT's. Those CRT's are used in the vast majority color display applications, including the most familar of all, the color TV. But several breakthroughs in color-display technology have recently occurred, breakthroughs that could eventually make the shadow-mask color CRT obsolete.

One of the most recent of those breakthroughs is the new liquid-crystal color shutter (or switch) from Tektronix (PO Box 500, Beaverton, OR 97077). The color shutter is used in combination with a high-resolution *monochrome* CRT and allows the monochrome CRT to display *color* images. The system developed by Tektronix offers the advantage of high-resolution color—much higher than possible with shadow-mask CRT's—at a reasonable cost. We'll take a closer look at the color shutter in a moment, but first let's take time to review some important LCD basics.

LCD basics

A liquid crystal is an organic compound; that means that it is a compound that consists of carbon, hydrogen, oxygen, and nitrogen. What is different about a liquid-crystal compound is that it is fluid like a liquid, but has the optical properties of a solid.

Another interesting property of a liquid crystal is that its molecules, which are shaped like long rods, act like dipoles in the presence of an electric field. That means that the alignment of molecules in a liquid crystal can be controlled by applying and removing an electric field.

Liquid-crystal displays differ from other types of displays in that they scatter rather than generate light. The type of LCD used in watches and calculators, as well as in the color shutter, consists of a vertical polarizer, a liquid-crystal cell (the cell used in the shutter will be described below), and a horizontal polarizer. When there is no electric field present, the liquid-crystal material is in its relaxed state. In that state, the liquid-crystal molecules nearest the polarizers have their long axes parallel to the polarizers with subsequent layers twisting through the 90° between horizontal and vertical (see Fig. 1-a). Light from the light source passes through the horizontal polarizer, is twisted 90° by the liquid crystal, and passes out through the vertical polarizer. Someone looking at the LCD will see light.

When an electric field is applied, the liquid-crystal material is in its driven state. In that state, the liquid-crystal molecules are oriented parallel to the direction of the field (see Fig. 1-b). Because of that, the natural twist is destroyed, and hence, the light is not rotated by the LCD. Therefore the light is absorbed by the vertical polarizer and a viewer would see a dark area.

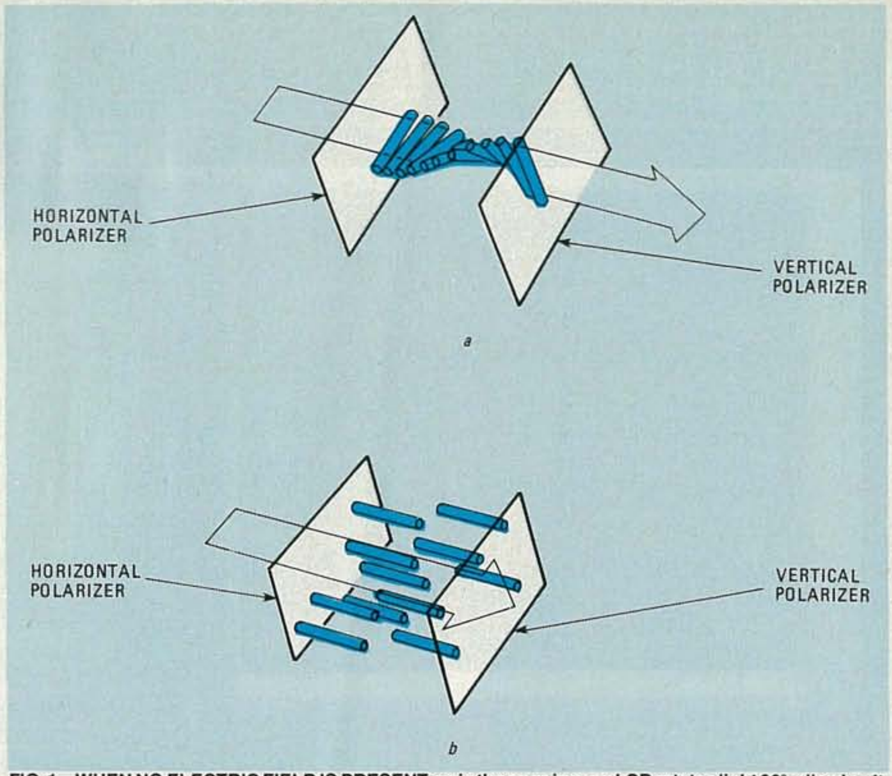


FIG. 1—WHEN NO ELECTRIC FIELD IS PRESENT, as is the case in *a*, an LCD rotates light 90°, allowing it to be seen. When an electric field is present, as is the case in *b*, light is not rotated so it is absorbed by the polarizer.

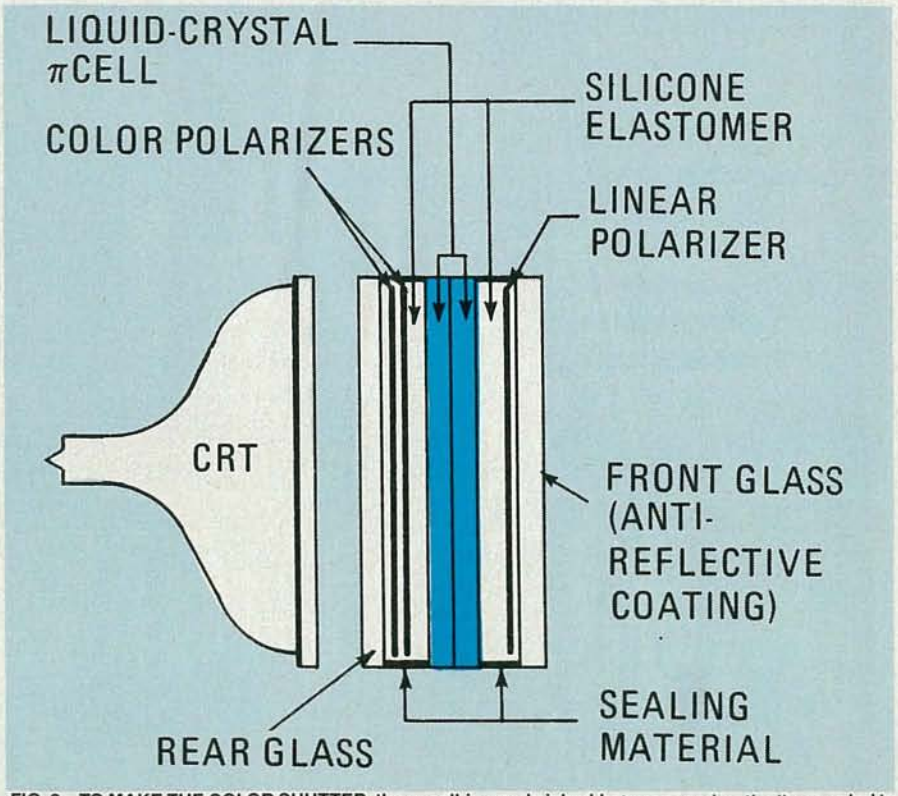


FIG. 2—TO MAKE THE COLOR SHUTTER, the π- cell is sandwiched between, and optically coupled to, a pair of orthogonal color polarizers and a linear polarizer.

The π cell

Tektronix' major accomplishment in developing the color shutter was in devising a liquid-crystal device, called a π cell, with a fast-enough switching time. Most liquid crystals switch (change between a relaxed and a driven state) at rate of 20 to 100 milliseconds. The π cell has a switching time of 1.7 milliseconds.

The π-cell consists of two glass plates coated with indium-tin-oxide, a thin layer of silicon-dioxide (which serves as an insulator), and a special alignment layer. It has a special structure in which the liquid-crystal molecules are arranged so that when the applied electric field is removed, the liquid flow within the cell does not oppose the natural rotation of the liquid-crystal molecules into their relaxed (twisted) orientation. That is the key to the fast switching times.

Another factor in developing the π-cell was the thin cell spacing that Tektronix has achieved. The cell spacing must be very accurate because the switching characteristics described above depend on the cell being very thin and uniform. If the cell is made too thin, however, it will not have the required optical properties. The company has developed techniques for cell spacings of 3 to 10 micrometers with a tolerance of 300 nanometers. Cells with that spacing have been manufactured in sizes ranging from 5 to 40 centimeters, although the actual viewing area is only about 90% of the cell size; that limited viewing area is due to mounting considerations.

The color shutter

To make the color shutter, the π cell is sandwiched between, and optically coupled to, an orthogonal set of color polarizers (orange and blue-green) and a horizontal linear polarizer (see Fig. 2). The "sandwich" is then placed in front of a CRT that uses a phosphor whose emission peaks are in the orange and blue-green portions of the spectrum (see Fig. 3).

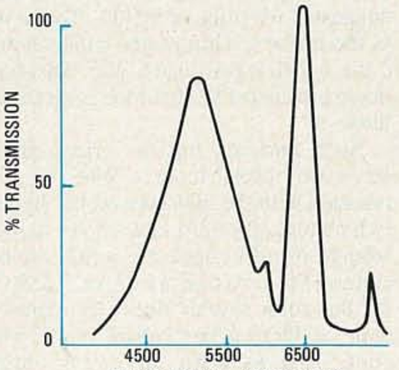


FIG. 3—IN THE CURRENT TEKTRONIX SYSTEM, a CRT with a phosphor whose emission peaks lie in the orange and blue-green regions is used.

To generate a multi-color display, both the screen and the shutter are switched synchronously. A block diagram of the system is shown in Fig. 4. In one frame, all of the information that should appear in orange is displayed. In the next frame, all of the information that should appear in blue-green is displayed.

The role of the π cell in this system is to be sure that only light of the appropriate color will be passed. Orange light entering the shutter is vertically polarized by the orange polarizer; blue-green light entering the shutter is horizontally polarized by the blue-green polarizer. (Note that the color polarizers also polarize white light as indicated in Fig. 4.) During the "orange" frame, the liquid-crystal is in its undriven state. Orange light is thus rotated 90° by the liquid-crystal and passes through the horizontal linear polarizer. The horizontally polarized blue-green light is also rotated, but it is rotated out of the transmission axis of the linear polarizer and is thus absorbed.

During the "blue-green" frame, the liquid-crystal molecules are oriented so that they do not twist light. Thus, the horizontally polarized blue-green light is passed by the horizontal linear polarizer while the vertically-polarized orange light is absorbed.

As the alternate frames are viewed, the eye integrates them to produce a multicolored image. With the phosphor/polarizer combination used in this system, any color that can be created by combining orange and blue-green can be displayed by varying the intensity of the scanning beam. To achieve flicker-free operation, each color (frame) is repeated at a rate of 60 Hz; thus, the two field system will run at a rate of 120 Hz.

Although orange and blue-green are the colors chosen by Tektronix, any two colors could be used through the proper selection of color polarizers and phosphors. For instance, early versions of the color shutter used red and green. The colors chosen for the current shutter were selected because they, and neutral (a color formed by the combination of the two primary colors and used in the first commercial application of the new technology—more on that later), are spectrally separated enough to be easily distinguishable, but close enough to minimize the eye's need to refocus.

As indicated above, only colors that can be generated by combinations of two primary colors can be displayed. Tektronix is continuing with its research in order to develop a shutter capable of displaying colors that could be produced by three primary colors. Such a shutter would be capable of producing a full gamut of colors, with results comparable to, or better than, conventional color displays.

Advantages

The development of the liquid-crystal color shutter is important for a number of reasons. Perhaps most significant is its high resolution. Because a monochrome CRT is used in place of a shadow mask (or other type, such as penetration-phosphor) color CRT, much better resolution is possible than with any other type of color display. That means, of course, much better graphics, and clearer, easier-to-read text.

The use of a monochrome CRT is also a key to a number of other advantages offered by the display. For one thing, adding color capability to a monochrome instrument will not require repackaging the instrument to accommodate the longer color CRT. Also, due to the absence of a fragile shadow-mask or complex electron-gun, monochrome CRT's are inherently more rugged than color CRT's. Use of a monochrome CRT also eliminates the color-convergence problems that plague other types of color displays.

One potential problem with the display arises from the fact that the system is field sequential. In the system, the brightness of a given color will be reduced to a maximum of 25% of the brightness of that color on a continuously rastered CRT. That is due to two factors. One is that since the system is field-sequential, the two colors have a 50% duty cycle (since the frames alternate, each color is displayed only half of the time). The second factor is that an ideal polarizer has a transmission factor of about 50%. We are dealing with real devices here, however. Taking into account factors such as the non-ideal nature of the polarizers, the brightness level of the display is only about 12%–14% of the brightness level of a continuously rastered display.

What offsets that potential problem is a high and controllable contrast-ratio. The combination of color and linear polarizers used in the Tektronix system allows for contrast ratios that can exceed 20:1. The contrast ratio of the display can be varied by varying the intensity of the scanning beam. That high contrast ratio allows the display to be satisfactorily viewed under high ambient-light conditions, even in full sunlight.

Applications

There are, of course, a number of applications where the new Tektronix technology can provide color capability where it has not been practical before. Examples of that include small instrument displays such as oscilloscopes, logic analyzers, and spectrum analyzers. Those instruments require high-resolution displays to adequately convey waveform information. Another area where color would be useful is in system-control displays. In that application, color could be used for highlighting special situations or warnings.

In fact, the display could be used in any application where color is desired, but high-resolution is required. It would be ideal, for example, for word processing. In addition, the display's high contrast is a

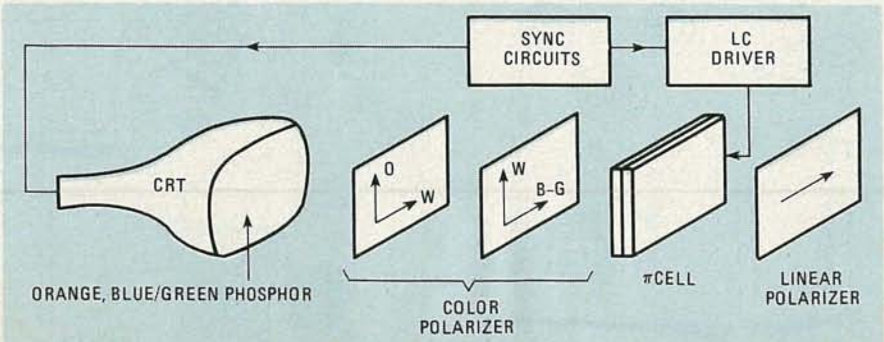


FIG. 4—BLOCK DIAGRAM OF THE liquid-crystal color shutter display system. Information is fed to the CRT in two sequential fields, which are synchronized with the switching of the color shutter.

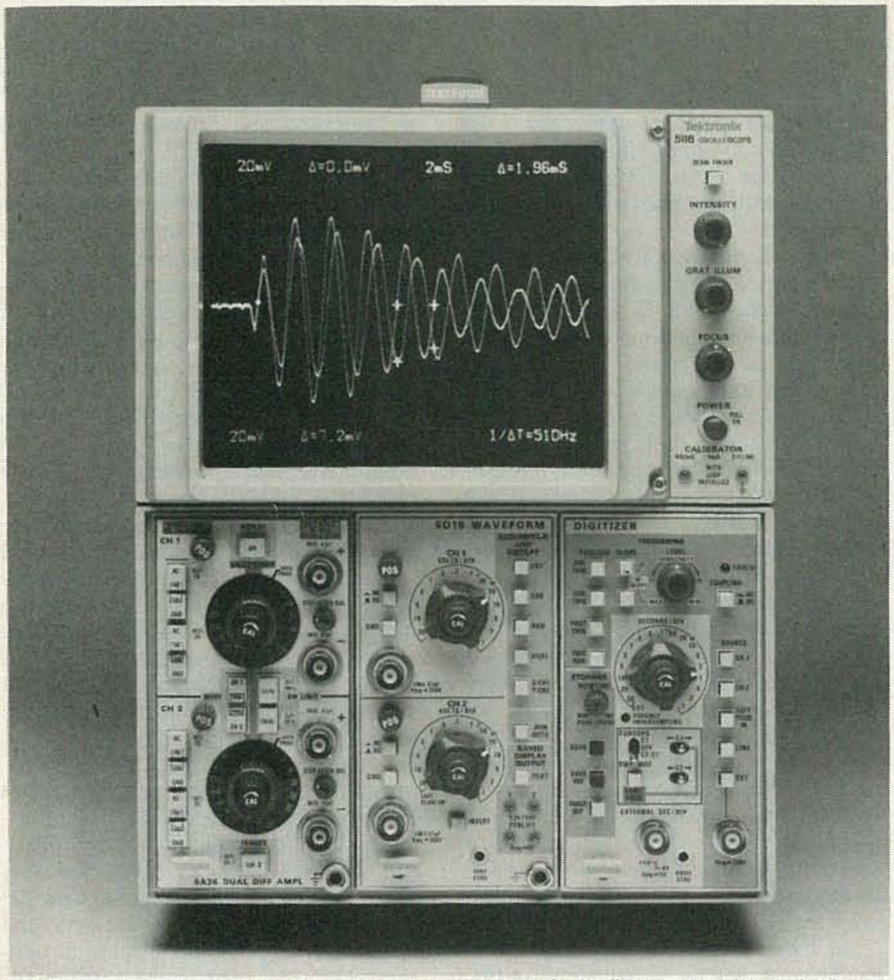


FIG. 5—THE MODEL *5116* from Tektronix. That oscilloscope is the first commercial application of Tektronix' liquid-crystal color shutter technology.

great advantage in the high ambient light of the typical office.

The *5116*

Textronix' first commercial application of the liquid-crystal color shutter was in its *5116* color-display oscilloscope. The usefulness and practicality of the color shutter is clearly illustrated by that device.

In that scope (see Fig. 5), the color traces are used to make it easy to distinguish between channels, for emphasizing certain types of important information, and in general to make the scope easier and more efficient to use.

In the past, oscilloscopes have used a variety of schemes to make them easier to use. Those schemes include highlighting, cursors, and alphanumeric readouts. The addition of color merely takes those schemes one step farther. In the *5116*, for instance, channel 1 data is displayed in blue-green while the channel 2 data is displayed in orange. Further, the alphanumeric readouts are color coded by channel, while the X-Y and time-base measurements are displayed in neutral (off-white).

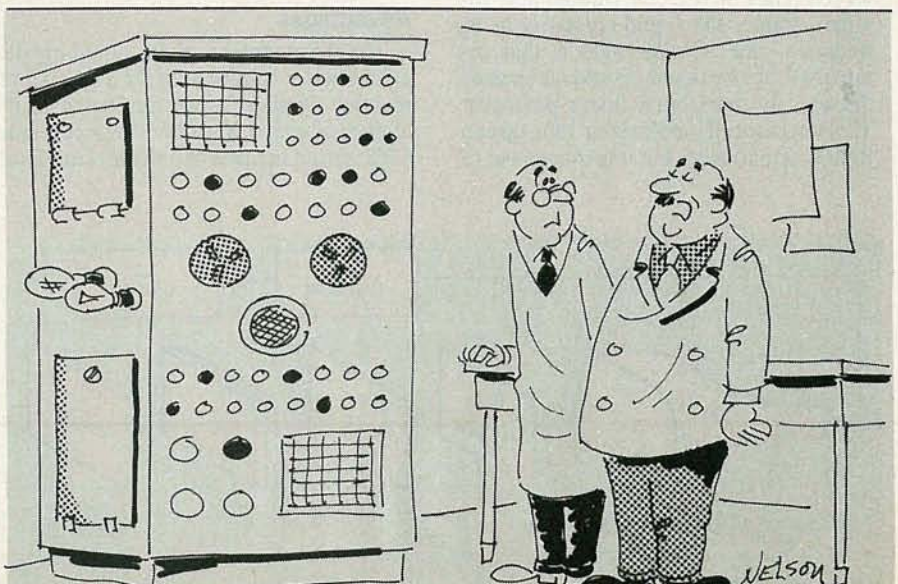
The use of color allows users to overcome many of the shortcomings of traditional oscilloscopes. For instance, in the past, one problem has been how to display multiple traces while taking advantage of the full vertical resolution of the oscilloscope. When the traces are of one color, confusion often arises when those traces are overlaid. In the *5116*, the use of color eliminates that problem. The channel-1 and channel-2 traces are, of course, displayed in their designated colors; with the areas of the waveform overlap shown in neutral.

Of course, one of the key factors in the eventual success or failure of liquid-crystal color shutter technology is its cost to implement. Right now, the only indication of that cost is found in the *5116*. The basic *5116* color oscilloscope carries a suggested list price of $2335. That scope is the color version of the monochrome *5110*, which is priced at $1505. That boils down to a cost of $830 for the color shutter alone.

Note, however, that the prices quoted above are for basic models. When the *5116* is mated with the *5D10* waveform digitzer (which turns the *5116* into a color digital-storage-oscilloscope) the total cost becomes $5185. At that price level, the $830 for the color shutter does not represent quite as large a percentage of the total cost. Just as with any technology, however, it is reasonable to assume that as production picks up, costs will drop, making the color shutter an extremely attractive display option.

As time goes on then, it is reasonable to assume that the color shutter will be used in a wide variety of products and applications. In addition, it is likely that it will be used in a variety of non-Tektronix products. That's because the manufacturer has recently announced that it intends to sell the new technology to other companies for use in their products.

In summary, the liquid-crystal color shutter, with its dual properties of color and high resolution, offers instrument manufacturers an attractive alternative to other types of color displays. It is reasonable to assume that we'll be seeing them in a great number of products before too long. **R-E**



"The audio response should have a deeper—John Barrymore—voice."

WARC 84

The future of shortwave broadcasting is being decided by a pair of international conferences, the first of which was held this year. Here is a report on that first conference, including a look at what was accomplished, and, perhaps more importantly, what was not.

STANLEY LEINWOLL*

ON THE SURFACE, THE WORLD ADMINistrative Radio Conference for the Planning of the Shortwave (High Frequency) BroadCasting Service (WARC-HFBC) was a rousing success. Held under the auspices of the International Telecommunication Union (ITU), the Conference was charged with the task of preparing a report containing a set of technical standards to be used in the planning of the shortwave broadcasting bands.

In addition, the Conference was directed to develop a set of principles and procedures governing the use of the shortwave broadcasting bands, and to decide upon a method of planning those bands.

The report of the first session is to be transmitted to a second session, now scheduled to be held in Geneva for seven weeks during early 1987. That second session is scheduled to carry out the actual planning.

In all, some 575 delegates from 115 countries participated in WARC-HFBC, which was held in Geneva, Switzerland, from January 10–February 11, 1984. In addition to the countries represented, there were 20 observers from various regional and international organizations, including the International Amateur Radio Union (IARU).

When one considers the diversity of interests and cultures represented at the Conference—East, West, and Third World; developed and developing countries; large users of the spectrum and

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THE U.S. DELEGATION to the WARC-HFBC

small, and old, established broadcasters as well as newcomers—it is a miracle that anything at all was accomplished. The basic problems involved polarization between the larger users of the spectrum, those with extensive worldwide or national broadcasting commitments, and the smaller users, who were seeking assurances that their spectrum requirements would be met and guaranteed.

And indeed, during the five gruelling weeks of the Conference, it appeared on more than one occasion that the Conference would fail because of stalemates that developed over seemingly irresolvable issues. Everyone present made monumental efforts to resolve some of those conflicts, and many of the delegates worked fifteen to twenty hours a day during the second half of the Conference in an effort to achieve reasonable solutions.

Finally, however, the Conference was able to complete its report. That report is 101 pages long, and includes over 70 pages of technical standards and procedures. In contrast, the sections dealing with planning principles and procedures, and the planning method itself, are only 9 pages long. Of greater significance is the fact that some of the basic principles and procedures are vaguely worded, others are provisional, and some are confusing.

A careful reader of that report comes quickly to the conclusion that many fundamental problems remain, and that the delegates attending the second session will be required to work long hours with diligence, patience, resourcefulness, and dedication in order to bring that second session to a successful conclusion.

So, although the Conference did complete its report, the document is a caldron bubbling with unresolved issues, procedures that must be clarified, software that is yet to be developed, and principles that are still to be tested.

Between the first and second session of the WARC-HFBC, the *I*nternational *F*requency *R*egistration *B*oard (IFRB), one of the permanent organs of the ITU, has been charged with a number of vital preparatory tasks, including the development of the software necessary to test and implement the planning method adopted at the first session. That method appears to be one of the most complex planning processes ever attempted, and the tasks before the IFRB are indeed formidable.

Some of the major problems facing the IFRB, and the second session will be described shortly. But first, the good news!

Technical standards

One of the most significant accomplishments of the first session was the adoption of some 73 pages of technical standards that cover virtually every aspect of shortwave broadcasting. Those include: double-sideband system specifications; protection ratios; receiver characteristics; required transmitter power; propagation, radio noise, and solar indexes; usable field strength; antenna and transmitter characteristics; reliability; delineation of reception areas; rules dealing with the maximum number of frequencies for broadcasting the same program to the same area, and specifications for and progressive introduction of, a single-sideband (SSB) system.

As just indicated, the Conference adopted a format for the progressive introduction of single-sideband transmissions, including a set of single-sideband system specifications that will allow the number of transmitters to be increased significantly without a corresponding increase in the amount of spectrum space allocated to shortwave broadcasting. Since such a system will render most of the transmitters and receivers in operation today obsolete, the Conference decided that the progressive introduction of SSB, over a period of something like twenty years, was the most effective way of overcoming the technical and economic problems that are sure to arise. The second session of the Conference will determine the precise starting date and the duration of the transition period, but at this writing, it is a virtual certainty that the completion of the conversion will not take place in this century, and in all probability not before the year 2010.

Planning principles

The remainder of the report dealt with the principals and procedures that are to be used in planning the shortwave bands. Those principles include:

- planning of the bands is to be based on the principle of equal rights of all countries, large or small, to equitable access to those bands for use in accordance with the decisions taken by the Conference;
- the planning of the high-frequency broadcasting service shall be based on four seasonal plans;
- the minimum broadcasting requirements submitted by the various nations shall be satisfied on an equal basis at the overall level of broadcasting reliability adopted by the Conference;
- the planning process is to be based on double-sideband transmissions with the possibility for countries so wishing to use single sideband, provided that the level of interference caused to double-sideband transmissions appearing in the plan is not increased;
- whenever possible, only one frequency shall be used to meet a given broadcast requirement,
- and, finally, the highest possible number of submitted broadcasting requirements are to be included in the plan.

Although those principles read very well, it is evident that some may be easier to satisfy then others, and that before they are finally implemented they will have to be tested against a complete set of operational requirements.

Planning method

The planning method adopted by the first session is a highly complex procedure; a block diagram of the procedure is shown in Figure 1. It comprises 11 steps that will be the subject of tests to be conducted by the IFRB during the intersessional period. Steps 3 through 8, and step 10 (indicated by the dashed box) are to be drawn up using the computer at ITU headquarters in Geneva.

That planning method represents a radical departure from the procedure now in effect. Under Article XVII of the Radio Regulations, all broadcasters submit their schedules to the IFRB six months in advance of implementation. The IFRB publishes that information in a book, called the *Tentative Schedule*. Where conflicts arise, it is up to the individual countries involved to solve them. In some instances, the IFRB offers recommendations for resolving the conflicts, but acceptance of these recommendations is not mandatory. The new procedure, in contrast, will leave many of the crucial decisions up to the IFRB.

The software to be used in the planning process has not yet been developed by the ITU, and doing so will be an extremely complex task because of the many variables involved. Those variables include changes in season, sunspot number, time of day, hours of operation, and location of not only the transmitter for which a frequency is being sought, but all other transmitters throughout the world operating on or adjacent to the frequency being used. Other variables include type of antenna as well as transmitter power. Furthermore, the use of a computer to predict optimum frequencies involves risks. In the past, computer-generated propagation models have lacked the accuracy required to produce highly reliable schedules.

Despite those drawbacks, that procedure was supported by the Third World and developing countries because they do not have the technical expertise to choose and evaluate the best possible frequencies for their broadcast services. It was their position that by having the IFRB choose the frequency band and/or frequency, it would provide them with technical assistance they cannot provide for themselves.

Some very major questions, particularly those involving modification procedures, still remain unanswered. The prediction method chosen is based necessarily on simplified propagation models, and there is considerable doubt about the accuracy that will result. In many cases, even using the most sophisticated programs currently available, there are significant differences between the frequency band predicted to be optimum, and the one that actually turns out to be optimum. Where such differences occur, methods will have to be developed for changing bands or frequencies in order to insure the success of the services affected.

That concept shapes up as one of the most troublesome issues to be faced at the second session. The first session was

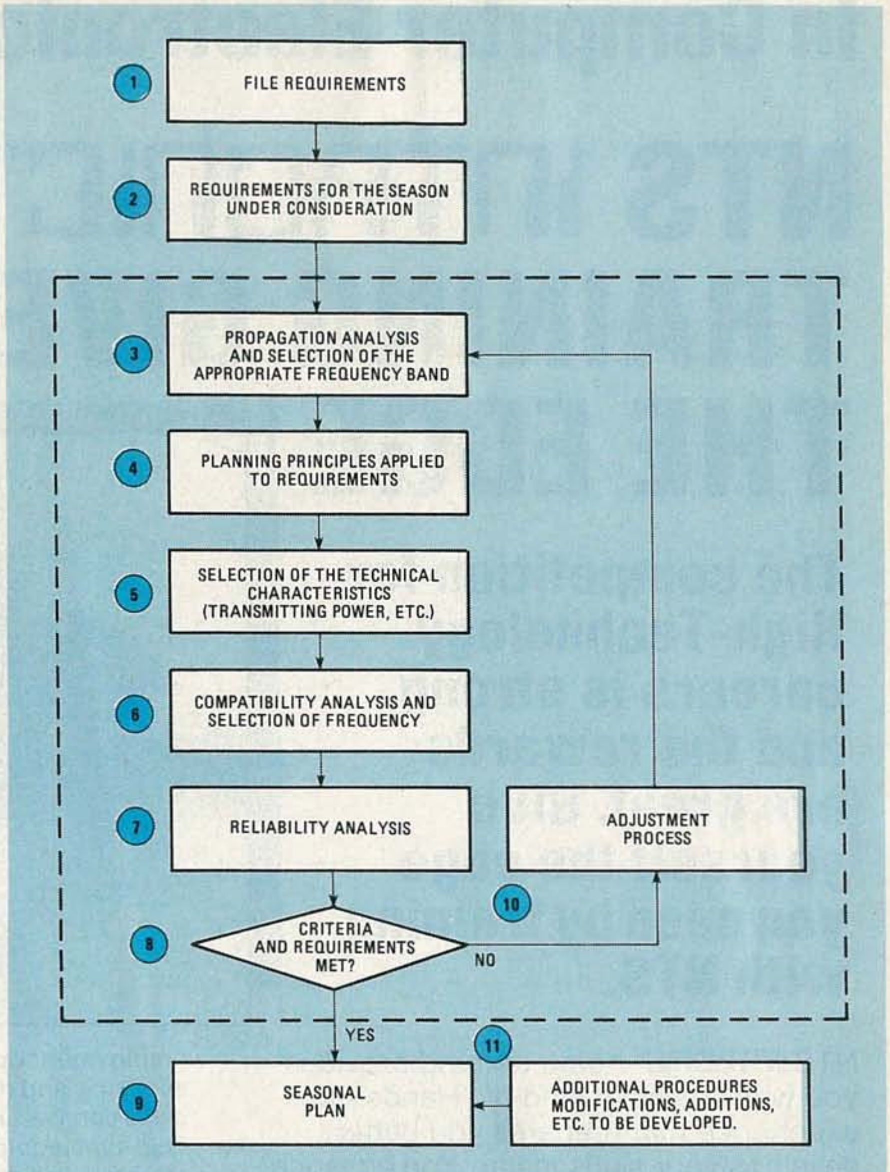

FIG. 1—THIS BLOCK DIAGRAM shows the planning procedure drafted by the first session of the WARC-HFBC. The steps contained within the dashed box are to be performed by computer.

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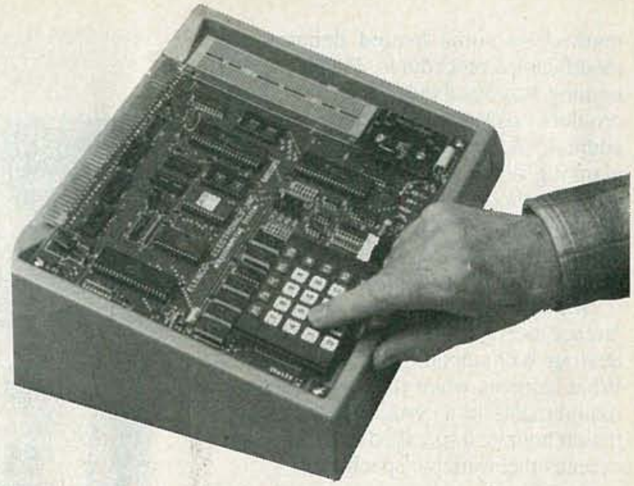

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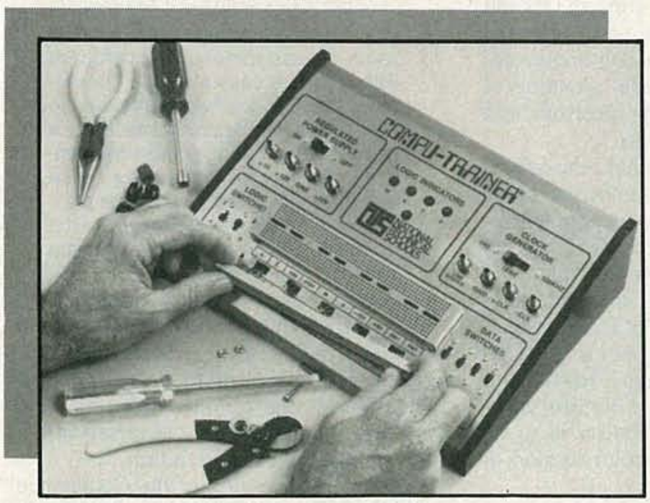

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marked by some heated debates over modification procedures, but in the end, nothing was resolved. Thus, that thorny problem was left for the second session to address. Yet, it remains clear that if the planning procedure is to be successful, some method of modifying assignments must be devised to take care of instances where the predicted optimum frequency differs from the actual one.

But the issue over which the Conference nearly failed was over rules for dealing with incompatibilities. That is: What happens when the total number of requirements in a certain band, at a particular hour, to a specified reception zone, exceeds the available spectrum?

The larger broadcasters held that all requirements should be met, even if that meant accepting lower standards and less protection. It was their position that equality meant literally that all requirements would be treated equally.

The developing countries led by Iran, India, and Algeria, disagreed. They held that there was a difference between equality and equity. Their view was that if there were too many requirements to be satisfied in the existing spectrum, then all countries should be guaranteed a certain minimum number of requirements that would be satisfied at an agreed-upon level of protection. After that, those countries with large numbers of requirements would either have to reduce some of them or accept reduced protection.

With the battle lines drawn early, the issue became more and more acrimonious as the Conference progressed. At the eleventh hour a highly complex three-tier system, which satisfied no one, even those who purported to understand it, was proposed. That compromise also would have failed if it hadn't included the stipulation that during the intersessional period the IFRB would develop the software required to test the proposed method, and report the results of those tests to the second session. The success of the second session will depend, to a great extent, on the ability of the Conference to deal with, and resolve successfully, that key issue.

Perhaps the most sensitive actions to be taken at the WARC-HFBC concerned jamming. The Conference adopted a resolution relating to the avoidance of harmful interference in order to improve the use of the shortwave bands allocated to the broadcasting service. The original resolution, proposed by the Netherlands, contained very strong language, and specifically identified jamming and the extent to which it disrupts shortwave listening. The Dutch found that of 85 broadcasts from stations in the Far East, Middle East, Africa, and the Americas that were monitored, 32 were affected by jamming.

The Dutch resolution further indicated that it feared that that form of harmful interference jeopardized the orderly planning of the high-frequency broadcast bands.

SITE OF THE WARC-HFBC Conference in Geneva.

It further proposed the organization of extensive monitoring programs to identify countries causing harmful interference. The program's findings were to be reported to the second session of the Conference.

It must be emphasized that never in the history of the ITU has the subject of jamming been brought up, because that has been considered a primarily political subject, and not appropriate for discussion at a technical forum. However, the Dutch resolution pointed out, as indicated above, that such harmful interference adversely affected the rational planning of the shortwave broadcasting spectrum, and that it had to be considered.

After some frantic behind-the-scenes maneuvering among a number of countries, a resolution that was acceptable by consensus was agreed upon. That resolution eliminates any reference to the word jamming, or intentional harmful interference, although its intent is unmistakable. It further calls for monitoring efforts to be conducted through the IFRB to identify countries causing that harmful interference, and that information is to be made available at the second session of the WARC-HFBC.

The manner in which that monitoring is performed during the intersessional period, and the extent to which use is made of it, may be of vital importance in assessing the impact of harmful interference, and determining the possibility of rational planning at the second session.

A companion to the resolution on harmful interference did not fare as well. Originally submitted jointly as a planning principle by England and the Netherlands, that principle called upon the Conference to adopt a planning method that included procedures to ensure broadcast reliability for all countries.

That principle was not supported by the big three in the non-aligned/developing country bloc—Algeria, India, and Iran, and it was subsequently diluted considerably. It became a procedural item instead of a principle, and it gives very little to countries whose transmissions suffer from intentional harmful interference. The item now reads in part:

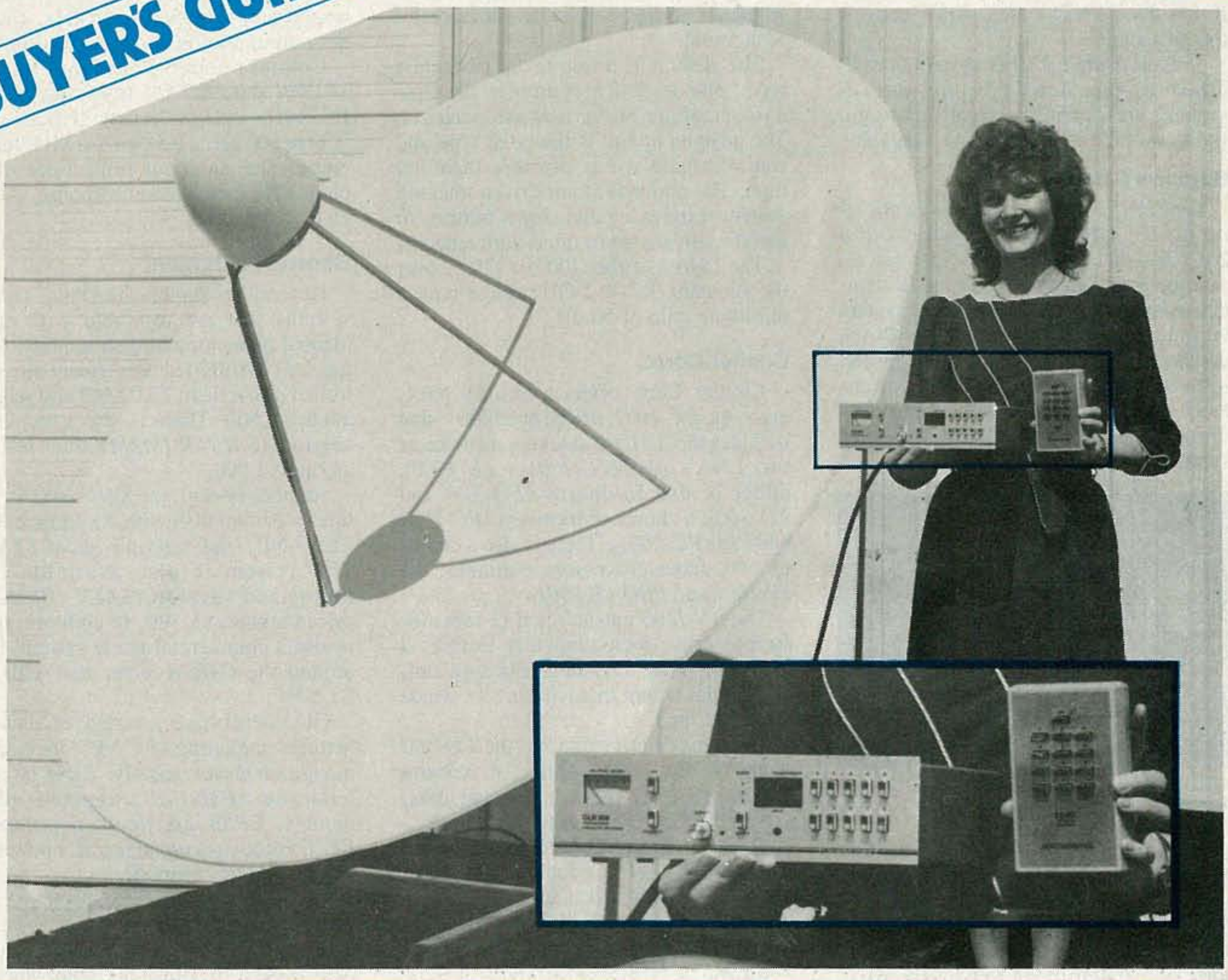
Actions relating to harmful interference

In the event of harmful interference to an HF broadcasting service which is using an assignment in accordance with a current seasonal plan, the Administration concerned shall have the right to request the prompt assistance of the IFRB in finding another frequency to help restore that service to the level of reliability achieved in the plan. Any new frequency proposed by the IFRB shall not adversely affect the seasonal plan in operation...

That procedure offers a country (Administration) whose transmissions are being jammed woefully little in the way of relief. In effect, it gives it the option of substituting one jammed frequency for another, if that does not "adversely affect the seasonal plan in operation."

The second session of the Conference will have many very difficult problems to address, not the least of which is the one dealing with harmful interference, how to cope with it, and how to take it into account in preparing a planning procedure that is to work effectively. In addition, many complex and highly controversial issues have yet to be addressed, both during the intersessional period, and at the second session of the Conference. Because of that, the second session may prove to be quite "interesting." **R-E**

BUYER'S GUIDE



Turnkey Systems

MARC STERN

A TVRO system does not have to be bought and assembled piece-by-piece—turnkey systems offer an attractive alternative.

PUTTING TOGETHER A HOME SATELLITE-TV reception system doesn't have to be a step-by-step, component-by-component process. You *can* do it that way, of course, if you choose. But there is an alternative—the turnkey system.

Typically a turnkey satellite-TV system consists of everything you need—from the antenna to the receiver—to start watching satellite-beamed programming. Some systems also include add-ons such as stereo processors and the like.

In this article, we won't be presenting the specifications of each system in detail. That's because the specifications of many of the components that make up these turnkey systems can be found in the special "Receiving Satellite Television" section in the October issue of **Radio-Electronics**. However, we will be including some of the more important specifications as a guide.

Caveat emptor!

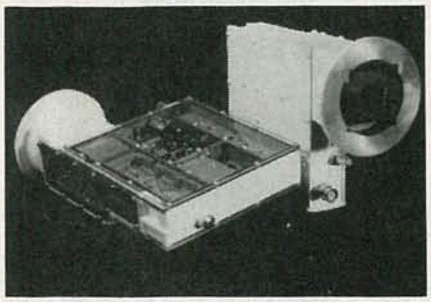
Before we begin our look at complete packages remember that when you buy a turnkey system, you will pay a price for the convenience. At best, you will find turnkey systems to be priced about the same as what you'd expect to pay for the individual components—but it can cost much more. (Especially because some components are discounted, while turnkey systems rarely are.) And keep in mind that the prices that you see here are only approximate. In most cases, it's the dealer—not the manufacturer—that assembles the components into a system and sets the price.

Is convenience the only advantage of a turnkey system? Not really: Buying the system from a single manufacturer gives you reasonable insurance that all the parts that make up the system are properly matched. Further, if the system ever needs servicing, you'll know who to call—even if you don't know which part is causing the problem.

If assembling a TVRO system doesn't appeal to you, don't give up—turnkey systems are certainly a good way to go. Let's now take a look at what's available.

Birdview Satellite

For $2995, Birdview offers a multiple-receiver, satellite-TV system—the *20/20M*—that allows you to have several satellite receivers tuned to separate channels simultaneously. The matched system includes a receiver, *L*ow-*N*oise *B*lock downconverter (LNB), *LS40* line splitter, infrared remote-control, antenna, and antenna-drive control. The system also features stereo capability and digitally synthesized tuning.



BIRDVIEW'S LNB is one of the main components in the multiple-receiver system.

The LNB and the 4-way splitter are the main components in the multiple-receiver system. Using the original Birdview design, the LNB features a 4.7-GHz oscillator with a stability of 2 ppm/°C and a noise temperature of 90° Kelvin (1.17 dB). The LNB has a nominal conversion gain of 70 dB. The unit downconverts the 24 available transponder signals as one block with a range of 500–1000 MHz.

The output of the LNB can be fed to up to four satellite receivers by using the *LS40* line splitter. Then, each receiver can be tuned to a different transponder frequency (but on the same satellite, of course).

Channel Master

Channel Master offers a variety of high-performance satellite-receiving systems. They all feature the same basic electronic components and differ in antenna size and mount (either manual or motorized).

With an 8-foot manually adjusted dish, the *6147* system is available for $1,895 ($2395 for the motorized *6247*). The *6174*, with a 10-foot manually adjusted dish, is priced at $2495 (the motorized version, *6274*, sells for $2995). A system with an 6.8-foot dish is priced at $1695 for the manual version ($2095 for the motorized version).

Those systems include the *6128* receiver, which features 24-channel push-button tuning, automatic polarity-switching, LED channel-display, center fine-tuning meter, and signal-strength meter. A higher grade receiver is available for $300 more.

The dish is a prime-focus fiberglass type. The feedhorn combines the low-noise amplifier, scalar feed and polarizer. The antenna mount is the polar type and can withstand winds of more than 100 mph. The optional motor-driven tracking system features UP and DOWN buttons to aim the antenna and a three-digit readout.

The LNA's, either 100° or 120°, cover the standard 3.7–4.2 GHz range with a minimum gain of 50 dB.

Conifer Corp.

Conifer Corp. offers a turnkey package—the *DE-2001*, priced at $3000—that includes the *AN1200* antenna, a choice of two LNA's (the *LN-1200* or *LN-1000*), either of two feedhorns (*FD-200* and *FD-300*), a choice of receivers (*RC-2001* and *PRO RC-2001*). There is also a choice of two stereo processors available, the *SP-2001* and *PRO SP-2001*.

The *AN-1200* antenna is a 12-foot, 18-section prime-focus unit that features a gain of 42.3 dB, a 1.5-degree beamwidth, and a polar mount that will survive winds up to 100 mph.

The two scalar feedhorns, the *FD-300* and *FD-200*, each offer a maximum VSWR of 1.25:1. They are identical units, except the *FD-200* accepts two LNA's.

The *LN-1200* and *LN-1000* LNA's are mounted in rugged cast aluminum. Each offers a gain of 50 dB, and a noise-rejection minimum of 30 dB. The standard *LN-1200* has a noise figure of 1.5 dB, and a maximum noise temperature of 120° Kelvin. The *LN-1000* LNA offers an improved noise-temperature specification of 100°K maximum with a noise figure of 1.3 dB.

The downconverter supplied with the *RC-2001* and *PRO RC-2001* receivers has a noise figure of 15 dB (nominal), with an image rejection of 25 dB. The downconverter's IF output is at 70 MHz and its voltage requirements vary between 14.5- and 18-volts DC.

The *RC-2001* and *PRO RC-2001* receivers have an input IF of 70 MHz (and a required input level from −35 to −5 dBm). The frequency response of the video section is from 20 Hz to 4.2 MHz with an IF bandwidth of 27 MHz. The units offer tunable audio (5.5–8.5 MHz) and features two preset positions (6.2 and 6.8 MHz). They feature an audio-frequency response of from 50 Hz–15 kHz. The audio-output level is nominally 0 dBm.

CONIFER'S *RC-2001* RECEIVER has many features including tunable audio.

Conifer's stereo processors (models *SP-2001* and *PRO SP-2001*) offer an IF of 10.7 MHz with a selectable IF-bandwidth (150 or 500 kHz), a 5.5 to 8.0 MHz tuning range, and an input impedance of 72 ohms. Their frequency response is from 15 Hz to 15 kHz.

General Instrument

General Instrument has three turnkey systems that are available with either manual or motorized dish mounts. One, the *SATV-081M2* features a manually-controlled 8-foot dish, 120° LNB and sells for about $2,500. There is also a motorized version (*SATV-081M2M*) that sell for around $2,900.

Another system, the *SATV-108M2*, features a 10-foot dish with Az/El mounts, a 120° LNB, and sells for about $2,900. The system is also available in a motorized version (*SATV-108M2M*) priced around $3,500. In addition, there is also a commercial-grade system, built around the *C4R* receiver that sells for $3,500.

GI systems have a variety of standard features including the *NPS-36* manual navigator/power supply, *SPM-08* (tubular) or *SPM-10B* (ruggized) polar mounts, *EPSB* electronic polarizer or *EPSO* solid-state polarizer, *SLA* power dividers, and line amplifiers.

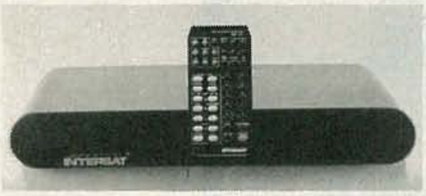
The navigator/power supply (*NPS-36*) features an east-west antenna control, LED antenna-position display, and a built-in delay to protect the motor when its direction is reversed. The *SPM-08* polar mount is designed for eight-foot dishes. It can be manually operated or motorized. The *SPM-10B* mount is designed for 10–12-foot antennas (manual or motorized).

The *EPSB* electronic polarizer shifts the polarization of the antenna electronically. The unit has an insertion loss of less than .06 dB; operates from an 8–15-volt supply, and has no mechanical parts. The *EPSO* solid-state electronic polarizer includes a scalar feed, and offers an insertion loss of 0.2 dB, and a VSWR of 1.35:1.

General Instrument offers systems built around the *CRSF* and *C4R* receivers. (*C4R* systems are commercially oriented.) Both receivers have the following general features: 24-channel tuning, digital tuning meter and display, and an 8-dB threshold. The receivers are also compatible with block downconversion (950–1450 MHz input). They provide DC power for an LNB, or an LNA plus remote downconverter. Audio carriers of 6.8 and 6.2 MHz are standard.

Intersat

Intersat's complete systems range in price from $2,000 to $6,000 and include the Intersat *SR-40* receiver. Among the receiver's features are detent tuning of 24 channels, a tuning meter, fine-tuning and audio-tuning controls; plus remote switching and scanning. The *SR-40* accepts C-band signals with input levels from -25 to -72 dBm. Its image rejection is specified at 30 dB. The IF is 70 MHz with a bandwidth of 30 MHz. Polarity switching is also featured.



THE INTERSAT *IQ-160* RECEIVER is microprocessor controlled and features a real-time clock.

One Intersat system, the *IQ-160*, is microprocessor controlled, and offers a real-time clock interface and a 6-kilobyte memory for program storage. Other features of the system include an infrared remote-control transmitter; mono, matrix-stereo, and direct-stereo capabilities. In addition, it offers selectable wide- or narrow-band filtering with an output of 12-watts RMS per channel at 0.1% THD.

The television screen is used to display a menu of satellite programming, signal strength, and polarity selection. Wide/narrow audio tuning (5 to 9 MHz) is featured along with a user-selectable scan rate, and remote-actuator control.

Another system, called the *Baby Q*, features a built-in modulator for Channels 2–6, as well as composite-video and audio outputs. Other features include a single-conversion downconverter and a polarity control. An optional matching stereo decoder is available as are wired remote controls.

KLM

KLM offers six packages (referred to simply as system 1, 2, etc.), each of which includes the antenna, receiver, low-noise amplifier, control console, polarizer, and feedhorn.

System 1, priced at $2,395, includes the *X-11* antenna (manual mount), *Sky Eye V* receiver, 120° LNA; polarizer and control head, and feedhorn. *System 2*, priced at $2,495, includes the *X-11* (manual mount) antenna, *Sky Eye IV* receiver, 120° LNA, polarizer and control head, and feedhorn.

System 3 includes the *X-11* antenna with motorized mount, *Sky Eye V* receiver, a *Polar-Trak Control Console*, 120° LNA, polarizer and feedhorn. The system is priced at $2,895.

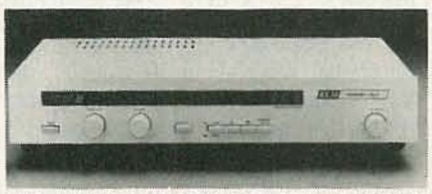
System 4 carries a manufacturer's suggested retail price of $2,995 and includes the *X-11* motorized mount, *Polar-Track Control Console*, *Sky Eye IV* receiver, 120° LNA, polarizer and feedhorn. Yet another package, *System 5*, is priced at $3,495 and includes the *X-11*, motorized mount, *Memory-Track Control Console*, *Sky Eye IV* receiver, 120-degree LNA, polarizer and feedhorn.

The final package—*System 6*, priced at $4,795—includes the *X-16* antenna, motorized mount, *Memory-Trak Control Console*, *Sky Eye IV* receiver, 120-degree LNA, polarizer and feedhorn.

The *X-11* is an 11-foot parabolic dish constructed of mesh panels; it can withstand winds up to 100 mph. The X-16 is a 16-foot, mesh dish with an increased surface area that delivers a substantial boost in gain over the *X-11*. It is built to withstand winds of 100 mph.

The *Sky Eye IV* receiver features slide-rule tuning, fully-tunable audio controls, pushbutton video-inversion, AFC defeat, and an LED bar-graph signal-strength meter. The *Sky Eye V* receiver offers single-knob transponder tuning and audio control, and features an analog signal-strength meter and pushbutton video-polarity control.

The *Polar-Trak* motor drive-control console features pushbutton east-west dish-positioning with meter, pushbutton polarity-control, and a polarity-trim knob.



THE *MEMORY TRACK CONTROL CONSOLE* from KLM features a 50-satellite memory with a digital readout.

The *Memory-Trak* remote dish-control has a programmable memory that can store up to 50-satellite positions with a 0–180° dish-position digital readout. The control console also features full east-west manual dish-control and a single-knob variable polarity-control.

Accessories include a stereo processor, line amplifier, and external polarity-trim unit.

Regency

Regency offers all the components necessary to make-up a complete TVRO system. Among those components are the $595 *SA-9000* Polaris satellite antenna, which uses a deep-dish, short focal length prime-focus parabolic design (made of .090 hard-alloy, marine-grade spun aluminum) in a relatively small antenna with a 38.5-dB gain, and a 95° LNA.

The ($549.95) *SR-3000* receiver offers

REGENCY'S *SR-1000* RECEIVER features separate video and audio tuning controls and a bar-graph LED tuning meter.

24-channel detent tuning with defeatable AFC, signal-strength and center-tune tuning meters, as well as separate audio and video fine-tuning controls. Dynamic noise-reduction circuitry helps improve audio fidelity; unmodulated audio and video outputs are available.

Also available is the $499 *SR-1000* satellite-TV receiver. The unit features separate variable controls for video and audio tuning, dual threshold-extension switches, and an LED bar-graph tuning meter. A front-mounted polarity control helps optimize reception. The *SR-1000* also provides a baseband output.

The ($495) 95° *LNA-95* low-noise amplifier offers a 47-dB gain, image rejection of 20 dB nominal, and an operating temperature of -20–65°C. It accepts input frequencies ranging from 3.7 to 4.2 GHz, has a noise figure of 15 dB, and operates from a supply ranging between 14.5 and 18 volts.

Winegard

Winegard offers a choice of several 8- and 10-foot TVRO packages that are available with either manual or motorized mounts. Each system contains an antenna, LNA, receiver, and the *Polarotor 1*.

The key difference between the 8- and 10-foot packages offered by Winegard is the dish size. The 8-foot packages are priced at about $2450 for the manual *SC5001* version and $2,995 for the motorized *SC-5001S*.

The 10-foot packages are priced at $3,081 for the manual version (*SC-5020*) and $3,624 (*SC5020S*) for the motorized version. The system contains the *SC-1018* antenna, which provides a gain of 39.5 dB and can withstand winds of up to 125 mph. Each package (both 8 and 10 foot versions) contains the same basic components, receiver, LNA, etc.

The manually operated systems use the *SC-7035* receiver, which features a digital channel-readout, fine-tuning control, variable audio-tuning, and automatic polarity-switching.

The *SC-7035S* receiver (used with motorized mounts) is almost identical to the *SC-7035*, except it provides the added feature of a built-in satellite-selector control circuit for use with the *SC-7705S* actuator.

The *SC8101* 120° LNA is a 3.7–4.2 GHz GaAs FET amplifier with a minimum gain of 50 dB. The downconverter is a single-conversion unit. **R-E**

BUILD THIS

Tele-Toll Timer

GARY McCLELLEN

Saving a buck on your phone bill is not an easy job—especially with rates constantly going up. But this automatic call-timer can help you get a grip on your skyrocketing bills.

IF YOU'RE INTERESTED IN SAVING MONEY on your phone bills (And who isn't?), you don't have to stop making phone calls—but making shorter ones would help (especially if you make lots of toll calls). The simple timing device that we'll describe in this article can help you start saving money right away: It will tell you just how much time you spend on the phone—and it will, we hope, remind you to shorten your calls.

Since the timer will monitor all calls made on a line—even on an extension phone—it's easy to keep tabs on the calls made by your high-school kids as well as your own calls! But don't think that the timer is limited to use around the home; it can also be very useful in the business world—especially for those who use a WATS line (800 numbers).

Inefficient use of a WATS line can cost a business an awful lot of money. And without some type of timer, improving phone-use habits is a hit-or-miss proposition. But with this timer, you can determine how long an employee stays on the phone. Then his or her telephone procedure can be "fine-tuned" for greater efficiency.

Ease-of-use is one of the timer's greatest features. For starters, there are no controls. Any time the phone is picked up, the display lights and the count begins. And when you've hung up, the elapsed time is automatically frozen on the display, so that you know how long you've been on the phone. After about 20 seconds, the project then resets itself and blanks (turns off) the display. Now that is true hands-off operation!

Not only is the device simple to use—it is easy to build, too. All parts are mounted on two printed-circuit boards, so construction time is reduced to a few hours (once you have the boards, of course). All the parts are easily available, so not only will you have little trouble in obtaining the parts, you'll also have the opportunity to shop for the best prices.

Before we go any further, we should mention a few words about the FCC and your friendly telephone company. The timer, if assembled properly, should meet the FCC's requirements (namely Parts 15 and 68). However, local phone companies may have their own restrictions. Therefore, we suggest that you contact them for their requirements before you begin building this project.

Circuit operation

As shown in the block diagram in Fig. 1, the timer consists of an input-conditioning circuit, a comparator, a 20-second timer, and an inverter. In addition, there are three divide-by-60 counters (IC5–IC7), three BCD (*B*inary *C*oded *D*ecimal) decoder/drivers, three seven-segment displays, and, of course, a power supply.

The conditioning circuit, which is connected to the telephone line, isolates the device from the line and protects the unit from line transients. When the phone is in its cradle, 48 volts appears across the line. Picking up the handset reduces that value to about 9 volts. The conditioning circuit reduces the telephone's line voltage to about 2.1 volts when the phone is hung up and 0.4 volt when it's off the hook.

The output of the conditioning circuit is fed to comparator IC1-a, which compares that output to a 1.4-volt reference. When the handset is picked up, the input immediately drops below the reference and triggers the comparator. That activates the rest of the circuit.

The comparator output drives inverters that, in turn, are used to blank the displays and reset the counters. Three counters, IC5–IC7, generate the timing function: A 60-Hz signal is fed to IC5 and is divided down to 1 Hz for use by IC6 and IC7, which count the 1-Hz pulses. The count is divided internally and then output in BCD (*B*inary *C*oded *D*ecimal) form. That BCD output is sent to three BCD-to-seven-segment display drivers, IC2–IC4, which drive the displays, DISP1–DISP3. (Note

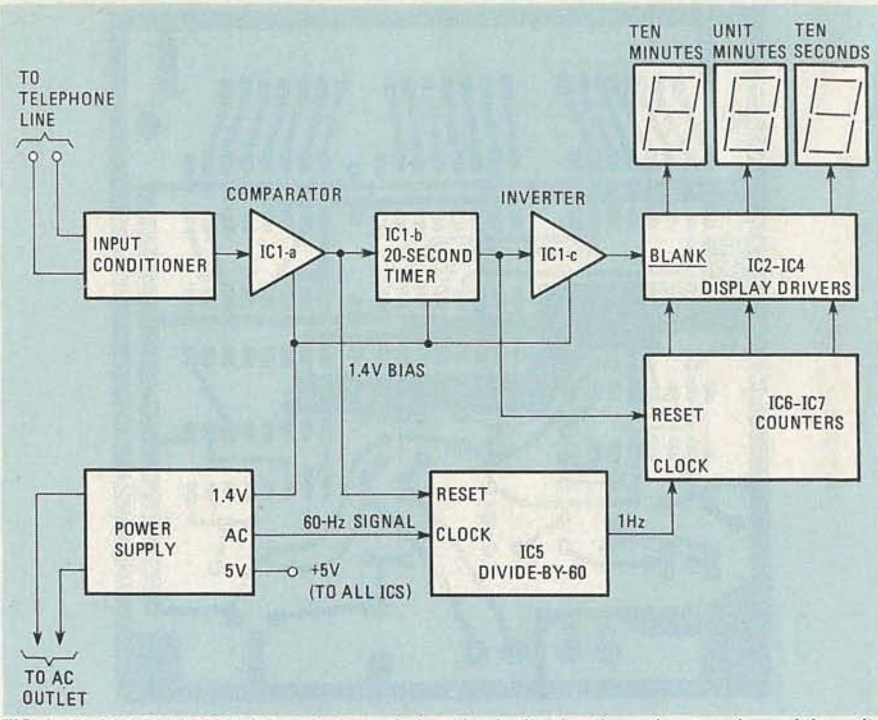


FIG. 1—BLOCK DIAGRAM of the telephone timing circuit showing the various sections of the unit.

that the unit displays tens of minutes, minutes, and tens of seconds. It does not display seconds—that amount of precision is not needed.

When the phone is hung up, the output of IC1-a goes high. That resets IC5 and freezes the elapsed time on the display for 20 seconds. (After the 20 seconds, the timer is reset automatically.) Now, refer to the schematic in Fig. 2 for a more detailed look at the circuit's operation.

In Fig. 2, we see that the input-conditioning circuit consists of diodes D1–D4, capacitors C1–C3, and resistors R1–R3. Diodes D1–D4 form a full-wave bridge rectifier, whose output is filtered by capacitors C1–C3. That's done to prevent damage to the circuit caused by transients (such as those that might be generated by a nearby storm). Resistors R1–R3 provide a high input-impedance to the circuit.

The comparator, 20-second timer, and inverter functions are handled by an LM339 quad-comparator. A voltage-divider circuit in the supply provides the reference voltage for IC1-a. When the phone is picked up, the output of the conditioning circuit drops below the reference voltage and triggers IC1-a, causing its output to go low, and capacitor C4 to begin charging through diode D5. That causes IC1-b's output to go low, removing the reset from counters IC6 and IC7, and causing the display to light and the timers to begin counting.

When the phone is hung up, the output of IC1-a goes high. That resets IC5 and freezes the time displayed. Capacitor C4 now begins to discharge through resistor R5. When C4 has discharged sufficiently (after about 20 seconds), IC1-b is again

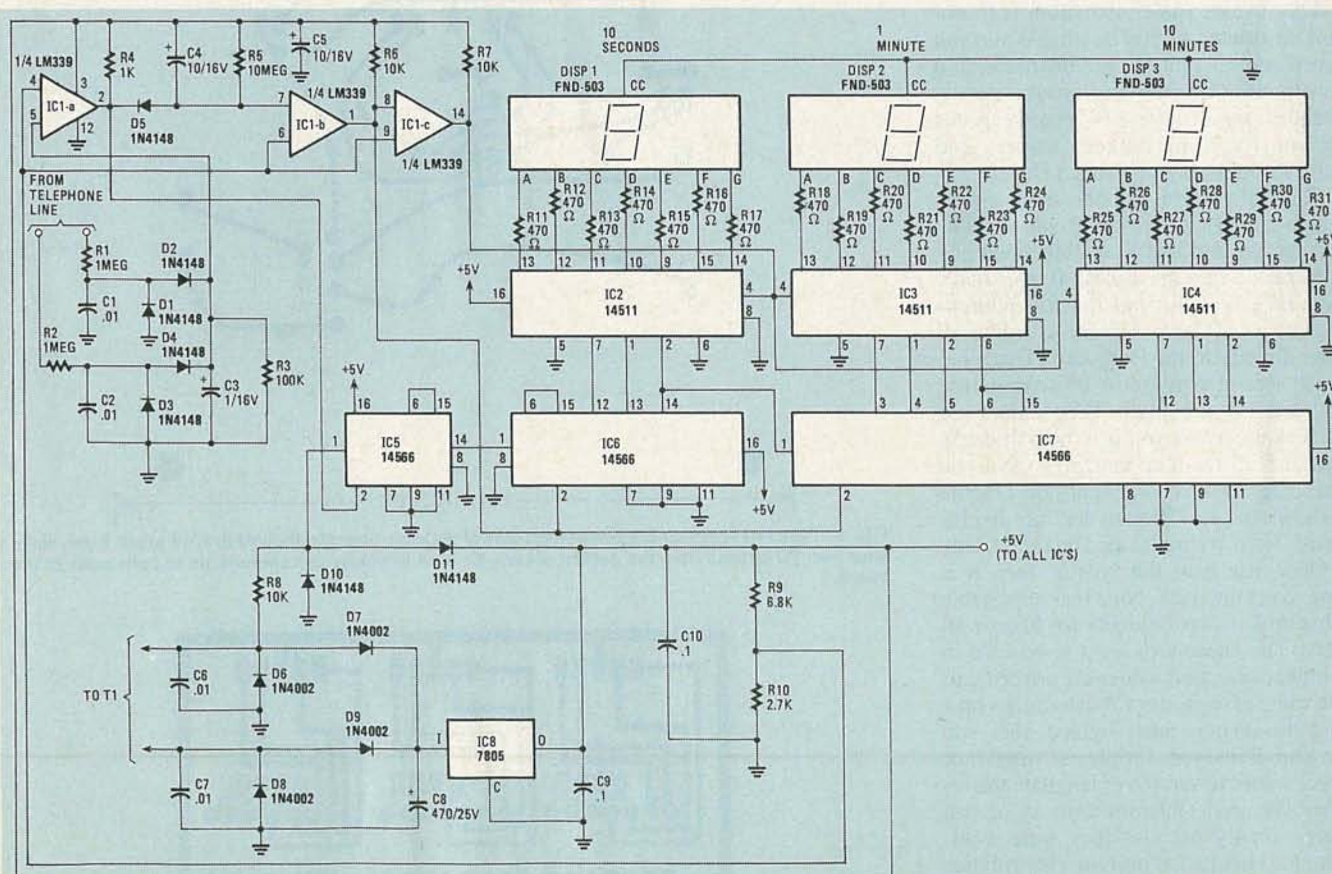


FIG. 2—A DETAILED SCHEMATIC of the timing circuit with all components and their values shown. Note that the comparator, 20-second timer, and inverter functions are handled by an LM339 quad-comparator IC1.

triggered. Its high output resets the counters. Its output is also inverted by IC1-c and fed to the pin 4 terminals of IC2–IC4 to blank the display.

Diodes D10, D11, and resistor R8 condition the 60-Hz output from the power supply by clipping the peaks off the output waveform to produce the squarewave signal. That signal is applied to the CLOCK input of IC5, divided down to 1 Hz and fed to IC6 and IC7.

The BCD outputs of IC6 and IC7 are fed to three decoder/drivers, IC2–IC4. Resistors R11–R31 (at the output of the display drivers) limit the display current to about 10 mA per segment.

The power supply consists of a 9-volt AC wall transformer and diodes D6–D9, (which are configured as a full-wave bridge rectifier). The rectifier output is filtered by C8 and regulated to 5 volts by IC8, a standard LM7805 three-terminal regulator.

The reference voltage that sets the trip point for comparator IC1-a is obtained by dividing the output of the regulator with R9 and R10. The 60-Hz squarewave signal for the timing circuitry is also derived from the power supply.

Now that we have a good idea about how the timer works, it's time to put it together!

Construction

The first step in construction is to obtain the printed-circuit boards. While you can assemble the circuit on perforated construction-board (parts layout is not especially critical), using PC boards speeds up construction, reduces errors, and makes troubleshooting much easier.

The foil patterns for the main circuit board are shown in Figs. 3 and 4. Note that the main board is double-sided and uses plated-through holes. If you make your own boards from the foil patterns shown, it will be necessary to solder all parts directly to the PC board. That's because several parts must be soldered on both sides of the board. (You cannot use IC sockets unless you use the wire-wrap type and lift them up enough so that you can solder on the component side.) Figure 5 shows the foil pattern for the display board. Here, a single-sided board is used.

Once you have the boards, then it is time to get the parts. Note that reasonable substitutions can be made for almost all parts. The capacitors are a good case in point because their values are not critical. The value of capacitor C4 determines how long the display stays lighted after you hang up. If desired, simply use smaller or larger values to shorten or lengthen the ON time. We used tantalum units in several places simply because they were available, but standard aluminum electrolytics should work fine.

As for the resistors, all are quarter-watt units, except for R1 and R2. The reason

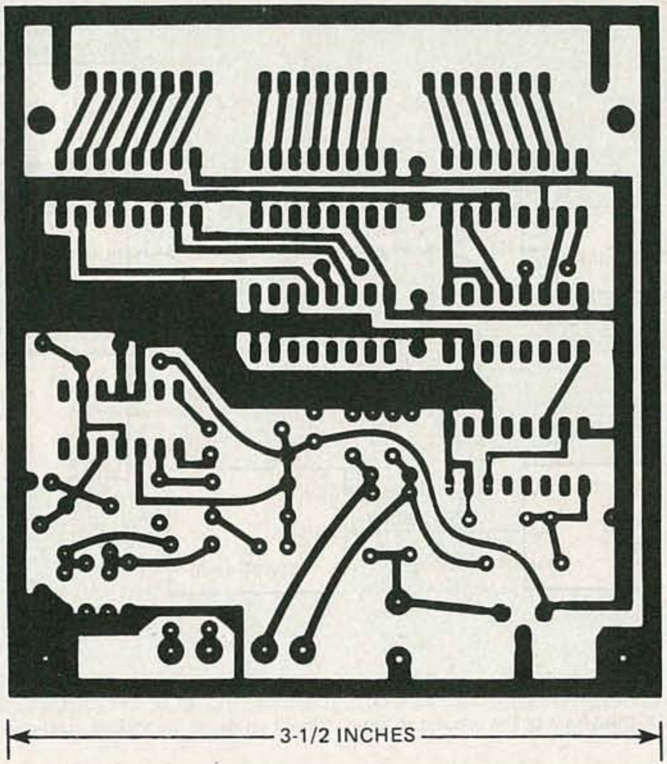


FIG. 3—THE FOIL PATTERN for the underside of main circuit board is shown here full-scale.

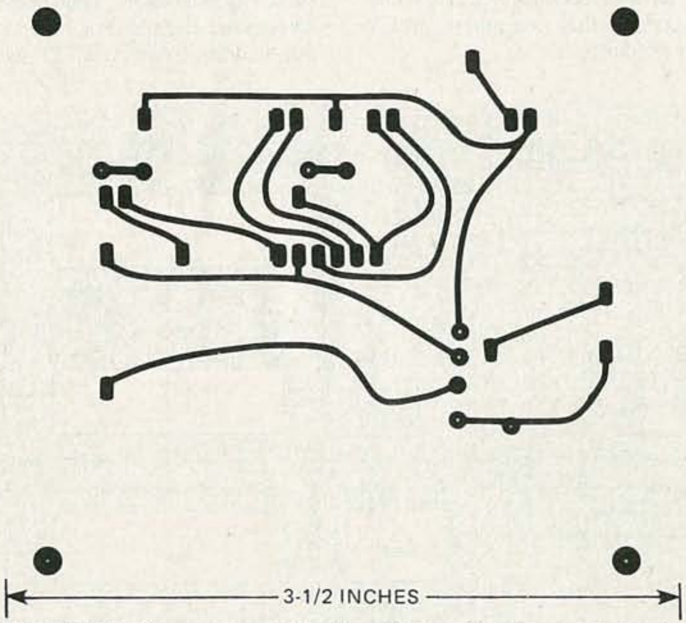


FIG. 4—FOIL PATTERN for the component side of the main board is shown here full-scale. If you make your own PC boards from the pattern shown, be sure to solder all components to both sides of the board.

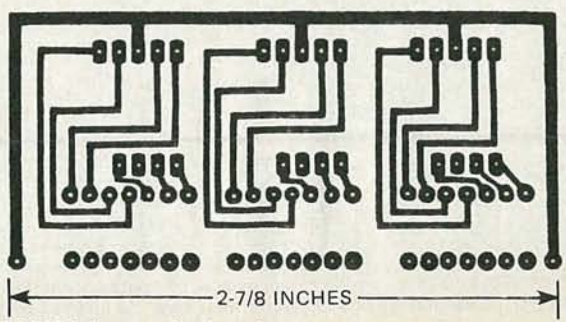


FIG. 5—DISPLAY BOARD foil pattern is shown here.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted.
R1, R2—1 megohm, ½-watt
R3—100,000 ohms
R4—1000 ohms
R5—10 megohms
R6–R8—10,000 ohms
R9—6800 ohms
R10—2700 ohms
R11–R31—470 ohms
Capacitors
C1, C2, C6, C7—0.01 µF, 50 volts, ceramic disc or polyester
C3—1 µF, 16 volts, radial-lead tantalum
C4, C5—10 µF, 16 volts, radial-lead tantalum
C8—470 µF, 25 volts, radial-lead electrolytic
C9, C10—0.1 µF, 16 volts, ceramic disc
Semiconductors
IC1—LM339N linear quad comparator
IC2–IC4—MC14511, BCD to seven-segment latch/decoder/driver
IC5–IC7—MC14566BCP, timebase generator
IC8—LM7805CT, 5 volt, 1 amp regulator
D1–D5, D10, D11—1N4148
D6–D9—1N4002
DISP1–DISP3—FND-503 (Fairchild), 0.5-inch, common cathode, seven-segment display
Other Components
F1—0.25-amp, 3AG fuse
T1—9 volt, 250 mA (or greater) wall-mount transformer (Jameco AC-9004 or equivalent)
Miscellaneous—Circuit boards, cabinet, IC sockets, modular telephone cable, fuse holder, 4×1-inch piece of red display filter (see text), mounting hardware, etc..

The following is available from Mendakota Products LTD., P.O. Box 20HC, 1920 W. Commonwealth Ave., Fullerton, CA 92633: Set of the two etched, predrilled printed-circuit boards, part No. TTT-1, 15.00 postage paid. California residents add 6% sales tax. Allow 6–8 weeks for delivery.

half-watt units are used here is to avoid resistor breakdown and telephone-line problems: Quarter-watt resistors are rated at 100 volts; that value is likely to be exceeded when the phone rings.

There are many possible substitutions for transformer T1. If you can't find a 9-volt AC unit with a current rating of 250 mA or greater, try a surplus outlet. Many calculator-type battery chargers contain 9-volt transformers. To use that type, you'll have to pry open the case and remove the rectifier and filter capacitor. Just be sure not to use a 9-volt DC charger, because the timer won't count if you do! (Remember that the 60-Hz signal from the power supply is used as the clock input.)

The red-plastic display filter used on the front panel (to improve contrast) is available from many sources. A quick look through the ads in the back of the magazine should prove that to you. You can also try to get the filter material from a surplus outlet, or you might want to use red cut-and-peel drafting film over a piece of clear plastic (try a drafting-supply house for the film). Just remember that you need only a 4×1-inch piece.

The display board

Once you have the parts, you can start putting the timer together. We'll start with the display board: Refer to Fig. 6 and the parts-placement diagram in Fig. 7. First, pick up one seven-segment display and turn it over so that the pins are facing you; make sure that the ribbed side is on the top as shown. Cut the decimal-point lead off each display; that's the one at the lower left corner of the module with the pins facing you. Now insert the units and solder them in place as shown in the parts-placement diagram.

Next install twenty-one 470-ohm resistors (R11–R31) below the displays (again refer to Figs. 6 and 7) and bend the lower leads straight down before soldering. After soldering, clip off *only the upper leads. Allow the bottom leads to remain*—the resistor leads are used to make the connections to the main board. Now install two pieces of leftover component lead in the holes at each corner of the display board and bend them down to match the resistor leads. (See Fig. 6.) That completes the display board. Set it aside for now.

The main board

As we discuss the main-board assembly, refer to the parts-placement diagram in Fig. 8. Start by installing the IC sockets, making sure that pin 1 is correctly oriented. (Note that all sockets are installed so that their pin-1 notches point in the same direction.) Install a 14-pin socket at IC1 first. Then install six 16-pin sockets at IC2–IC7. Check your work for shorts and solder bridges; make any necessary corrections before continuing. *Do not* install the IC's at this point.

Now we'll install the diodes. Be careful not to get the 1N4148 and 1N4002 types mixed up. Also be sure to install them with the banded-ends (cathodes) positioned as shown. First go to the IC5 socket and install two 1N4148 diodes (D11 and

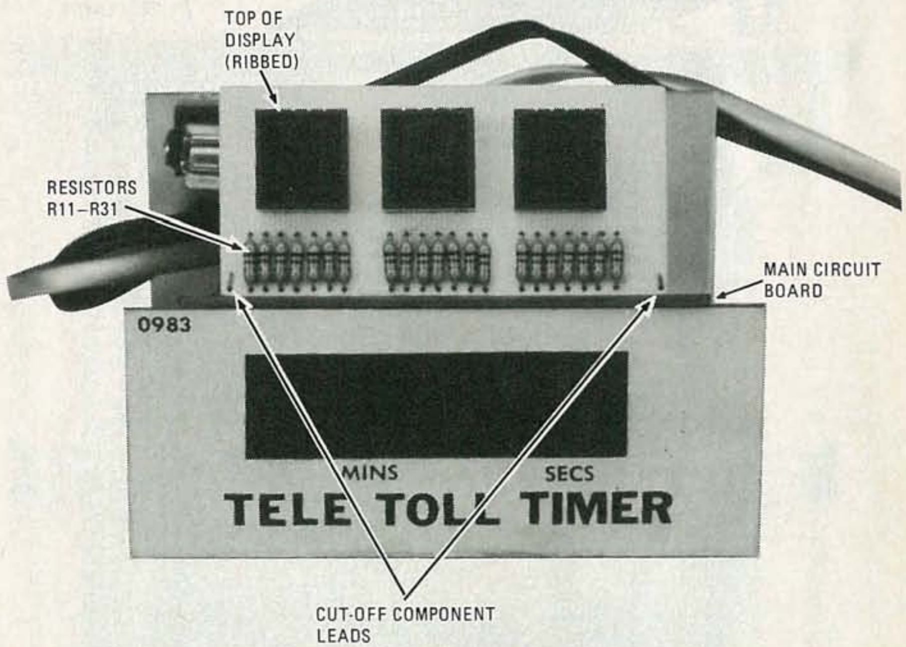


FIG. 6—THE DISPLAY BOARD installed in the main board. Note: The ribbed surface marks the top of the seven-segment displays. Resistor leads are use to make connection between the main and display boards. The leads are also used for mounting support.

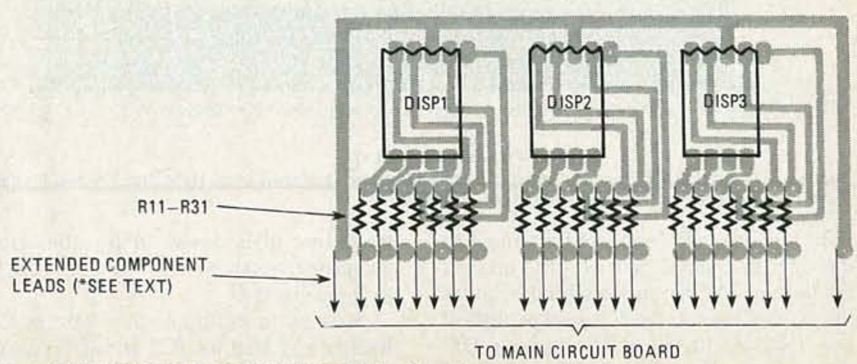


FIG. 7—THE PARTS-PLACEMENT DIAGRAM for the display board is shown here.

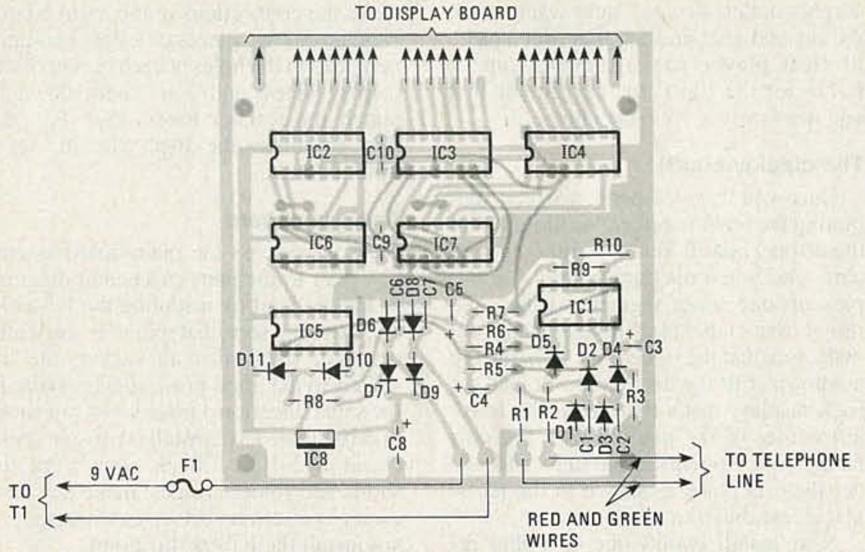


FIG. 8—THE MAIN BOARD's parts-placement diagram. Note that all pin-1 notches of the IC's face in the same direction.

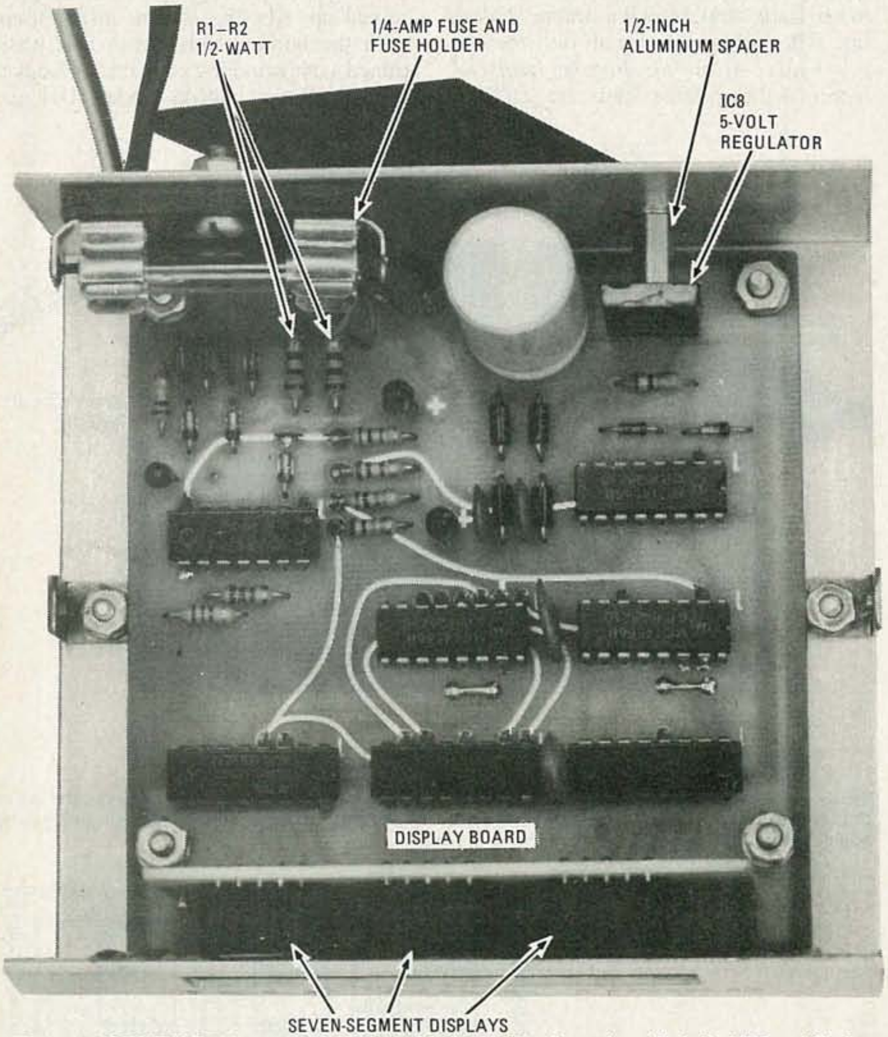


FIG. 9—A TOP VIEW OF the completely assembled circuit is shown here. Note that IC8 and the fuse holder are secured to the rear panel of the cabinet.

D10) just below the socket. Then move to the right and install four 1N4002 units at D6 through D9. Continue with the diodes by moving over to the IC1 socket. Install five 1N4148 diodes at D1 through D5. When done, check your work carefully to make sure all diodes are in the right places and properly oriented. Now, let's move on to the capacitors.

Start by installing a 0.1-F disc at C10 located between the IC2 and IC3 sockets and another at C9, directly below as shown. Next install a 470-µF electrolytic capacitor at C8 (at the bottom of the board). Be sure to double-check the polarity of that capacitor. After that, install two 0.01-µF units at C6 and C7 to the right of the IC5 socket.

Continue by installing a 10-µF tantalum unit at C5, again double-checking that the positive lead is correctly oriented. Likewise, install another 10-µF tantalum at C4. Moving to the right, install 0.01-µF capacitors at C1 and C2 (between the diodes). Then finish up the capacitors by installing a 1-µF tantalum unit at C3. Next we'll install the resistors.

Start by installing a 10,000-ohm unit at R8 (below the IC5 socket). Then move over to the socket for IC1 and install a couple of 10,000-ohm units at R6 and R7. After that, install a 1000-ohm resistor at R4. Finish the row by installing a 10-megohm unit at R5. Next install a 2700-ohm unit at R10 and a 6800-ohm resistor at R9. Move to the right edge of the board and install a 100,000-ohm resistor at R3. Then finish up the resistors by installing two 1-megohm, ½-watt units at R1 and R2.

Next install the LM7805 voltage regulator at IC8. Note that the IC is soldered directly to the board. Be sure to position it so that the metal tab is facing toward you (or to the nearest edge of the board).

With that done, it's time to double-check your work. Once you are sure that you have no solder bridges or other errors, you can install the assembled display board.

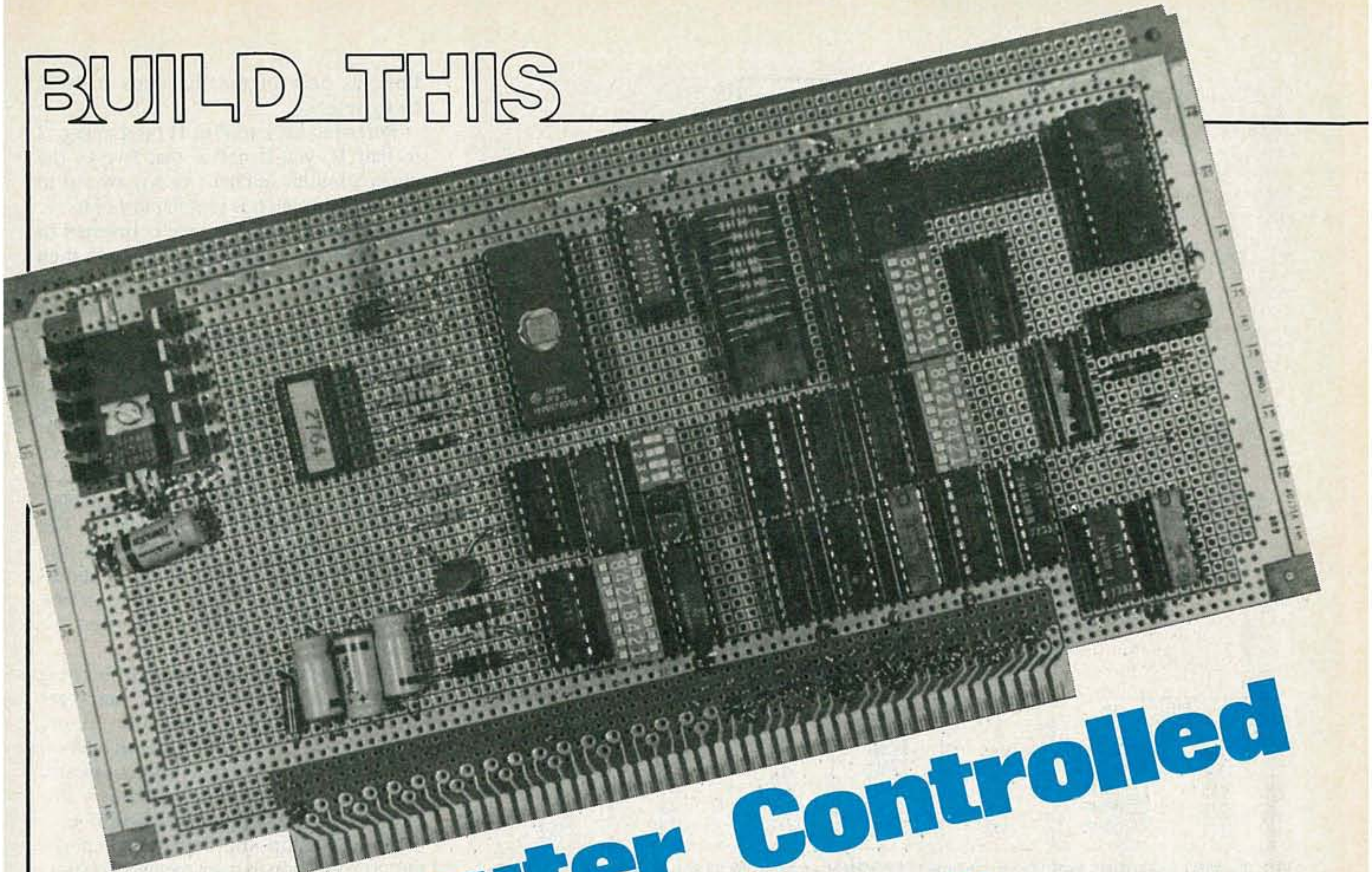
Installing the display board takes a little patience. Make sure that all the resistor leads on the display board are bent straight down and then slide them through the holes on the main board. When the two boards touch, solder in place and trim all leads.

Install the IC's next. Be sure to install them in the right places with pin 1 oriented as shown. Install three MC14511 BCD decoder/drivers at IC2, IC3, and IC4. Then install three MC14566 counters at IC5–IC7. Lastly, install an LM339 quad-comparator at IC1. That completes the main-board assembly.

Prepare the cabinet by making a 2½ by ¾ inch cutout for the display, and drilling a ⅜ inch hole at the rear of the case to feed the line and telephone cords through. It's a good idea to use a strain relief (or grommet) to prevent stripping the wires accidentally. If you use a grommet, you can secure the cords to the case with a small cable-clamp. That will prevent the wires from pulling free of the board. Drill screw holes at the rear of the case for mounting hardware (see Fig. 9.) The size of those holes depend on your mounting hardware.

Next mount the display filter in place. (We taped the edges first and then ran a bead of silicone sealer around the exposed

continued on page 87



Computer Controlled IC Tester

FLOYD L. OATS

We've already seen that the IC tester we've been building can be used for more than just testing digital IC's. This month we'll add an EPROM programmer.

Part 3 IN THE FIRST TWO parts of this article, we looked at a circuit that could be used—along with your computer—to test digital IC's. We then added a low-budget logic analyzer to the tester: It worked by allowing you to view 16 digital signals on a single-trace oscilloscope. This month, we'll expand the circuit even further by adding EPROM-programming capability.

Before we go on, we should add some cautions: The circuit was designed to be used with an S-100 bus computer. With modifications, it can be used with essentially any computer. In either case, some programming experience is essential: While the software that is required is described, the actual, complete programs are not presented.

EPROM programmer

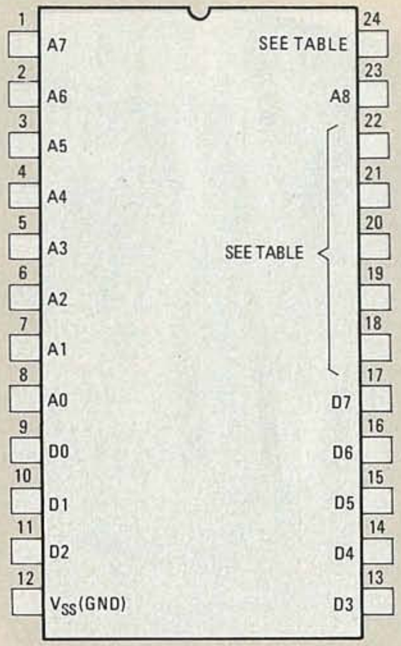
The digital IC tester—along with your computer—can be used to program and verify virtually any 24-pin member of the 2700 EPROM family. That includes everything from the original 2704/2708 through and including the 2732. Although the circuit can be modified to program 28-pin devices such as the 2764, we will not cover that here.

Figure 10 shows the pinouts for some of the various styles of 24-pin EPROM's. You'll want to refer to it as we talk about the different types of EPROM's available. We should add one more caution, though: Before you try to program any EPROM, make sure you have the manufacturer's data sheets. Pinouts, voltage requirements, and programming sequences can vary from one manufacturer to another, and from older devices to newer ones. Double checking is the safest and surest way to avoid problems.

Before we can discuss the EPROM programmer circuit, we have to know what we want it to do. So let's first consider how the 2708—a typical three-supply EPROM—is programmed. (Note that when we say "three-supply" or "single-supply," we are referring to the number of power supplies required for READ operation—we do not include the programming-voltage supply.)

To program the 2708, its $\overline{CS}$/WE pin is brought to +12 volts and is held at that voltage throughout the programming operation. (That causes the eight data lines to become input-data lines). An EPROM address, and the data to be stored in that address, are then presented to the EPROM. Both the address and data lines must be held in their valid state while a program pulse is applied to the program pin.

That +25-volt program pulse has a pulse width between 100 microseconds and 1 millisecond. After the pulse is terminated, the next (sequential) address, along with the contents to be stored there, are sent to the EPROM and another program pulse is issued. After all addresses have been pulsed, we say we have com-



TYPE \ PIN	18	19	20	21	22	24
2704	PROGRAM	V_{DD}	$\overline{CS}$/WE	V_{BB}	V_{SS}	V_{CC}
2708	PROGRAM	V_{DD}	CS/WE	V_{BB}	A9	V_{CC}
2758	$\overline{CE}$/(PGM)	A_R	$\overline{OE}$	V_{PP}	A9	V_{CC}
2716	$\overline{CE}$/(PGM)	A1Ø	$\overline{OE}$	V_{PP}	A9	V_{CC}
2732	$\overline{CE}$/(PGM)	A1Ø	$\overline{OE}/V_{PP}$	A11	A9	V_{CC}

FIG. 10—PIN FUNCTIONS VARY from one type of EPROM to another. While you can use this as a guide, make sure you have the manufacturer's data sheet for any EPROM you want to program.

pleted a single *pass*.

It is necessary to make enough passes to bring the total program-pulse time to at least 100 milliseconds per address. That means that if your pulse width is, say, 500 microseconds, then at least two hundred passes must be made.

The 2708 is only one kind of EPROM—a three-supply type. Now we'll look at the programming procedure for a typical single-supply EPROM: the 2716.

To enter the 2716's programming mode, pin 20, the output-enable pin ($\overline{OE}$, pin 18) is brought to +5 volts, and the programming-voltage pin (V_{PP}, pin 21) is brought to +25 volts. The address and corresponding data are presented to the IC and held valid while a fifty-millisecond high-level TTL pulse is sent to the $\overline{CE}$/PGM pin. (Note that, as opposed to the 2708, we program with a TTL-level pulse—the programming voltage applied to pin 21 remains constant at 25 volts. We should note, however, that the programming voltage *can* be switched, if desired.)

Only a single pulse is required to completely program a location. Unlike the 2708, sequential addressing is not necessary and only the addresses being written need be pulsed. Therefore, since all of the address locations in new (or erased) EPROM's are set to 1, to program a 2716, only the addresses that need to be changed to zero bits are "burned in." Those addresses that need to be set to one are programmed by simply passing over the location.

The EPROM-programmer circuit

Because the EPROM programmer (whose schematic is shown in Fig. 11) is being built as an add-on to the digital IC tester, we have to map up to four kilobytes of EPROM address into 256 memory-mapped locations. (You will recall that the IC tester uses eight address lines to carry stimulus information and thus occupies 256 memory locations.)

We overcome that problem by using a D-type flip-flop (IC15) to store the most-significant bits of the EPROM address, and by implementing a three-phase program/verify cycle (which we'll describe in more detail shortly). When we combine IC15 with the sixteen stimulus latches (IC1–IC4), we obtain thirteen address lines and eight data lines. That's enough to accommodate up to 8K of EPROM space.

The three-phase cycle is shown in Fig. 12. In the first phase, enabled by A5 being high, the EPROM upper address (A8–A12) is loaded into IC15. In the second phase, the eight least-significant address bits (AØ–A7) along with eight data bits (DØ–D8) are loaded into the stimulus latches (IC1–IC4, Fig. 2)) and a "burn" interval is initiated. In the third phase, the burn interval is terminated and the programmer is restored to its idle state (which is defined as both of the flip-flops in IC16 being reset).

Referring back to Fig. 11 (and to Fig. 3 in Part 1), you'll notice that five of the upper stimulus latches (A0–A4) are fed to IC15. The A5 latch is sent to pin 1 of IC17. The STIMULUS LOAD signal is inverted to an active-low pulse by IC17-f and then applied to both flip-flops of IC16 as a clock.

Assume the programmer to be in the idle state, awaiting a phase-one load. If A5 is high ($\overline{A5}$ low), pin 2 of IC16 is conditioned to set one of its flip-flops on the trailing edge of the stimulus-load pulse. (We'll call that flip-flop, IC16-a, the LOAD flip-flop.) When the LOAD flip-flop sets, it will clock pin nine of IC15, thereby capturing the EPROM upper address. The LOAD flip-flop primes the second flip-flop of IC16 to set and, through IC17-b, conditions its own reset. (We'll call the second flip-flop, IC16-b, the TTLP flip-flop for *TTL P*ulse.)

The second phase starts with the next stimulus load pulse, which will now reset the LOAD flip-flop and set the second (TTLP) flip-flop to initiate the burn interval (see Fig. 12). TTLP activates the program/verify controls and also maintains a low into the LOAD flip-flop through IC17-e.

The LOAD flip-flop being reset causes the TTLP flip-flop to reset on the next stimulus load (phase three). The burn interval is terminated and the programmer is returned to its idle state. We should note that IC15 still retains the bits captured during phase one.

During a program cycle, the TTLP flip-flop supplies a TTL pulse for programming those EPROM's that require only a TTL-level pulse. The signal also controls the high-voltage pulse needed by many EPROM's. For example, the TTLP signal controls the base of Q1 through IC17-c and IC17-d. Transistor Q1 controls V_{PP}, the programming voltage. When Q1 is turned on, it will drop about two volts and pass the remaining 26 volts to the EPROM. When pin 6 of IC3 is low, diode D3 returns the program pin to ground. Capacitor C4 limits the overshoot on the emitter of Q1 to acceptable levels.

Switch S24 is useful in testing and troubleshooting Q1 and associated circuitry—when closed, it will hold V_{PP} high without regard to the state of TTLP.

Closing switch S25 will unconditionally hold the programmer in the idle state thereby disabling the entire circuit. A quick-arming power-on reset function is provided by C1, R15, and R16.

Personality module

As shown in Fig. 11, the signals and voltages developed are sent to the EPROM socket (SO5) through a switching and distribution network (S18–S24, and S04). Socket SO4, the *personality module* socket, accepts a personality

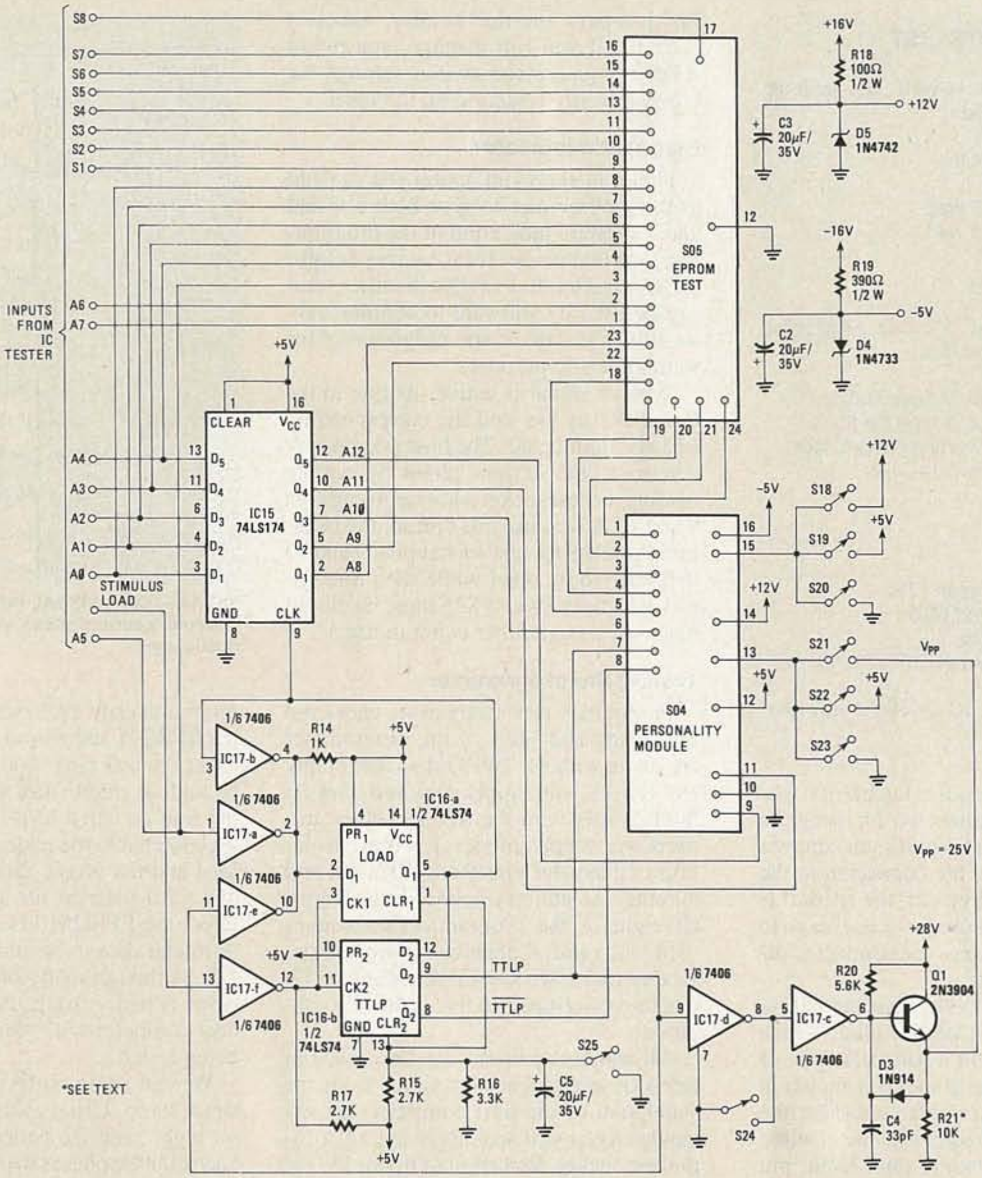


FIG. 11—EPROM PROGRAMMER SCHEMATIC. Note that some EPROM's require a 21-volt (instead of 25–26 volt) programming voltage. When programming such devices, you can either use a variable power-supply, or you can substitute a voltage divider (or trimmer potentiometer) for R21.

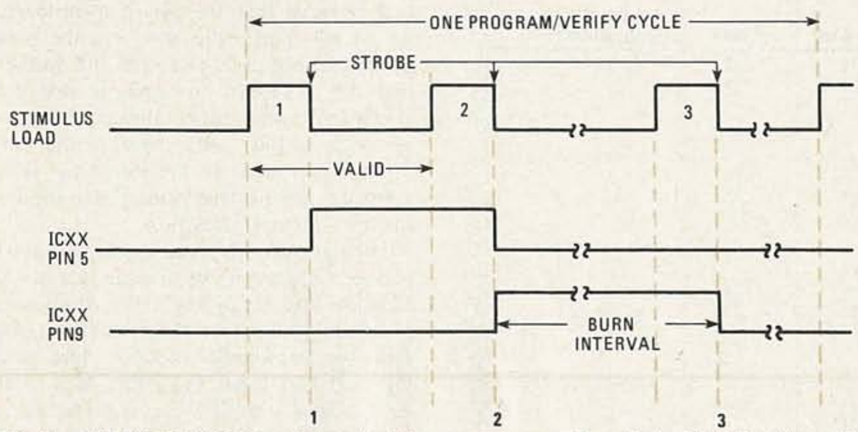


FIG. 12—THE THREE-PHASE cycle required to program or verify a single EPROM address. The program or verify function is selected by the programmer's switches. (See Fig. 13.)

module that is custom made for each style of EPROM. (The personality module can be made on a DIP header, and consists of appropriate jumpers. We'll get to the specifics of the jumpers shortly.) The switches (S18–S23) are configured to select either a program or verify function.

The personality-module outputs (pins 1–5) feed what may be termed the "variable" EPROM pins. Figure 13 defines the personality module and the program/verify configuration needed for each EPROM. We'll discuss those configurations in more detail later.

Construction

It is recommended—but not essential—that the programmer be built on the same board with the IC tester. Component placement, general signal routing, and construction method are not critical and are therefore left to your discretion. Don't forget that the EPROM programmer needs an external source of +28 volts at about 100 mA. (A variable power supply is preferred.)

Most of the signal connections to the IC tester can be seen in Fig. 11. The EPROM socket data-lines are connected to the isolation side (test-socket side) of the isolation switches so that they may be

PARTS LIST

All resistors are ¼-watt, 5% unless stated otherwise
R14—1000 ohms
R15, R17—2700 ohms
R16—3300 ohms
R18—100 ohms, ½ watt
R19—390 ohms, ½ watt
R20—5600 ohms
R21—10,000 ohms
Capacitors
C2, C3, C5—20 µF, 35 volts, electrolytic
C4—33 pF, ceramic disc
Semiconductors
IC15—74LS174 hex D-type flip-flop
IC16—74LS74 dual D-type flip-flop
IC17—7406 hex inverting buffer/driver
IC18—74LS367 hex bus driver
Q1—2N3904
D3—1N914
D4—1N4733
D5—1N4742
LED1—standard green LED
LED2—standard red LED
Other components
S18–25—SPST switch (DIP switches preferred)
Miscellaneous: IC sockets, jumper header, etc.

connected to the stimulus latches for programming or disconnected for program verifying. The least-significant address bits, A0 through A7, are connected to the most-significant byte of the stimulus latches and five of those (A0–A4), also go to IC15. The address lines are connected directly to the latches.

The personality-module socket (SO4) will accept a 16-pin header plug, which must be pre-wired for a particular type of EPROM (according to the data shown in Fig. 13.) As an example, consider the 2732 entry in that figure: Pin one is wired to pin twelve, pin two to pin eleven, pin three to pin thirteen, etc. Once you install the jumpers on the header, label it "2732." If you can manage, you might want to squeeze the switch settings for program/verify selection on the label.

Diagnostic indicator

Figure 14 shows an option you can add to the programmer to give both a visual and a software indication of the programmer's current phase. It can be very helpful for debugging and troubleshooting, and can be used by software to continuously monitor the state of the programmer for self-diagnostic purposes.

When a signal is active, its line to the test socket is low and the corresponding LED is illuminated. The host system may determine the current phase by simply reading the test socket and examining pins 9 and 10.(If you use this option, the isolation switches for test socket pins 9 and 10 will have to be open while the programmer is in use. Switch S25 must be closed when the programmer is not in use.)

Testing the programmer

Preliminary tests designed to check out the wiring and logic of the programmer are made with the EPROM socket empty and the 28-volt supply removed. Set up the IC tester with the test socket vacant, the power-supply jumpers removed, isolation switches for pins 9 and 10 open, and all other isolation switches closed. Open all eight of the programmer's switches (S18–S25) and, if practical, power the device up and down several times and verify that the power-on reset forces the idle condition.

All stimulus patterns can be viewed in terms of test-socket pins since, from the standpoint of the host computer, the expanded tester still appears as merely a 16-pin test socket. Referring to figure 15, the first stimulus pattern of the three-phase program/verify cycle will contain the upper EPROM address on the lines assigned to test-socket pins 9–13. The A5 bit must be high to enable this phase-one load, so the line assigned to pin 14 must also be high to enable the address-register (IC15) load and the phase advance. The second and third patterns are identical and will direct the EPROM lower address to pins 9–16 and data to be programmed to pins 1–8. Although many of the patterns may never actually reach the test socket, the host computer will "think" that an IC is being tested.

We can begin by testing the phase-advance logic. Using a stimulus with the A5 bit high, send the pattern repeatedly and check for the phases to progress according to Fig. 15. Starting in the idle condition, send the same stimulus once more and then change the pattern so that A5 is low. Send this new pattern ten or twelve times and observe that the phase is properly advanced to the idle state but the new pattern is not able to cause any further activity. It should be apparent that the issuance of two or more consecutive stimuli with A5 low will guarantee that the programmer goes to the idle state. The software can use that principle to implement a "restore" function.

For the remaining tests, you will need to insert a personality module for a 4K EPROM and set up the DIP switches to program. Make sure the switches agree with the personality-module style (see Fig. 13) and leave the EPROM socket empty. Send stimuli which will load various bit patterns into the address register and check the appropriate bits on the EPROM socket itself. Make the phase-two and -three bit patterns different from the first to be certain that the upper address bits are captured only during phase

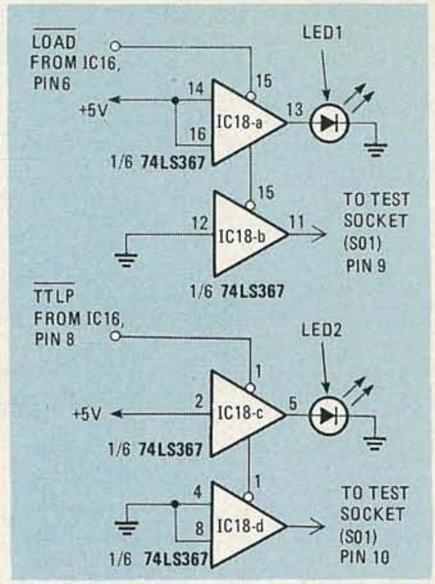


FIG. 14—FOR A VISUAL INDICATION of the programmer's current phase, you can add this diagnostic logic.

EPROM TYPE	PERSONALITY MODULE JUMPERS	PROGRAM	VERIFY	VERIFY PROCEDURE
2704, 2708	1 – 12 2 – 16 3 – 15 4 – 14 5 – 13	S18 S21	S20 S23	V1 OR V2
2758	1 – 12 2 – 13 3 – 15 4 – 10 5 – 7	S19 S21 S24	S20 S21 S24	V1
2716	1 – 12 2 – 13 3 – 15 5 – 7	S19 S21 S24	S20 S21 5 – 10*	V1 OR V2
2732 *2732A	1 – 12 3 – 13 5 – 10	S21 S24	S23	V2

*YOU MAY WANT TO ADD A SWITCH TO AVOID CHANGING JUMPERS

FIG. 13—PERSONALITY MODULE AND SWITCH configurations for various EPROM's. See the text for more information on verify procedures V1 (load, load, load, read) and V2 (load, load, read, load).

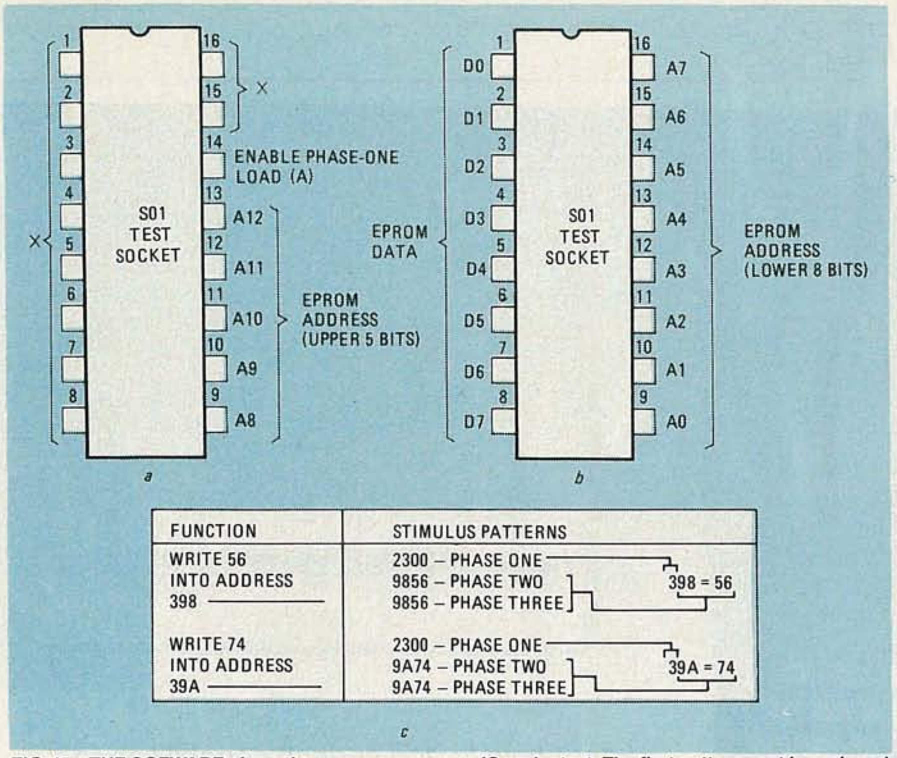


FIG. 15—THE SOFWARE views the programmer as an IC under test. The first pattern sent is assigned to the EPROM lines as shown in *a*, while the second and third patterns are assigned to the lines shown in *b*. Sample bit patterns (in hexadecimal form) used to program two EPROM address locations are shown in *c*.

one. Next, vary the phase-two and -three patterns and check the data and lower-address bits, again on the EPROM socket. By testing the bits on the socket, the wiring is checked out as well as the source logic.

For the next test, an 820-ohm, 2-watt resistor is needed. (If you don't have that unusual item you can combine four 3300-ohm ½-watt resistors in parallel.) In either case, take notice that the resistor(s) will become very warm to the touch.

With the programmer in the idle condition, apply +28 volts to the collector of Q1 and observe Q1's emitter for a voltage near ground potential. Close switch S24, and the emitter should go to about 27 volts. Now connect the resistor, which constitutes a typical load, from the emitter to ground and look for a voltage of 25 or 26 volts. If Q1 has been substituted for, and is dropping four volts or more, the substitution is not acceptable.

Leave S24 closed and the load connected for ten minutes or longer and then open S7. The emitter should return to near ground potential. With switch S7 open, cycle the device through the phases and confirm that transistor Q1's emitter is controlled by TTLP.

For the final hardware test, close switch S8 and make sure that the programmer is locked into the idle condition regardless of attempts to cycle it from the host computer. Now, with S8 closed and the EPROM socket empty, make sure the IC tester and any other expansion devices still function properly.

Using the programmer

Before you can use the programmer, you'll have to write some software to control it. A relatively simple (and popular) method is to store the intended EPROM contents in a main memory area and use software to transfer that data to the programmer (while keeping the address and data bits properly distributed and maintaining good program-pulse width).

The program will have to send the proper set of bits to the device during each phase and must control the program pulse width by means of a delay between phase two and phase three. Programming is more complex for the three-supply EPROM's because the source data is transferred to the EPROM a number of times as multiple passes are made. Don't forget that only a single pulse per address is permitted with single-supply EPROM types and the pulse width must be 50 milliseconds, ± 10%.

Figure 15 may be helpful in determining the address- and data-bit distribution among the three phases. Examples of exact stimuli for programming two locations are shown. Using that figure, you can develop software that will create and issue the appropriate patterns. You can leave the delay between phases two and three at a very low value for now. Check that the programmer is in the idle state when the software is initiated and that the software leaves the programmer in the idle state at completion. If your program doesn't do that, it is not observing the three-phase cycle requirements.

Once the raw program is developed to your satisfaction, you can work on adjusting the pulse width. You can do that easily with the aid of an oscilloscope by simply measuring TTLP and changing the software delay accordingly.

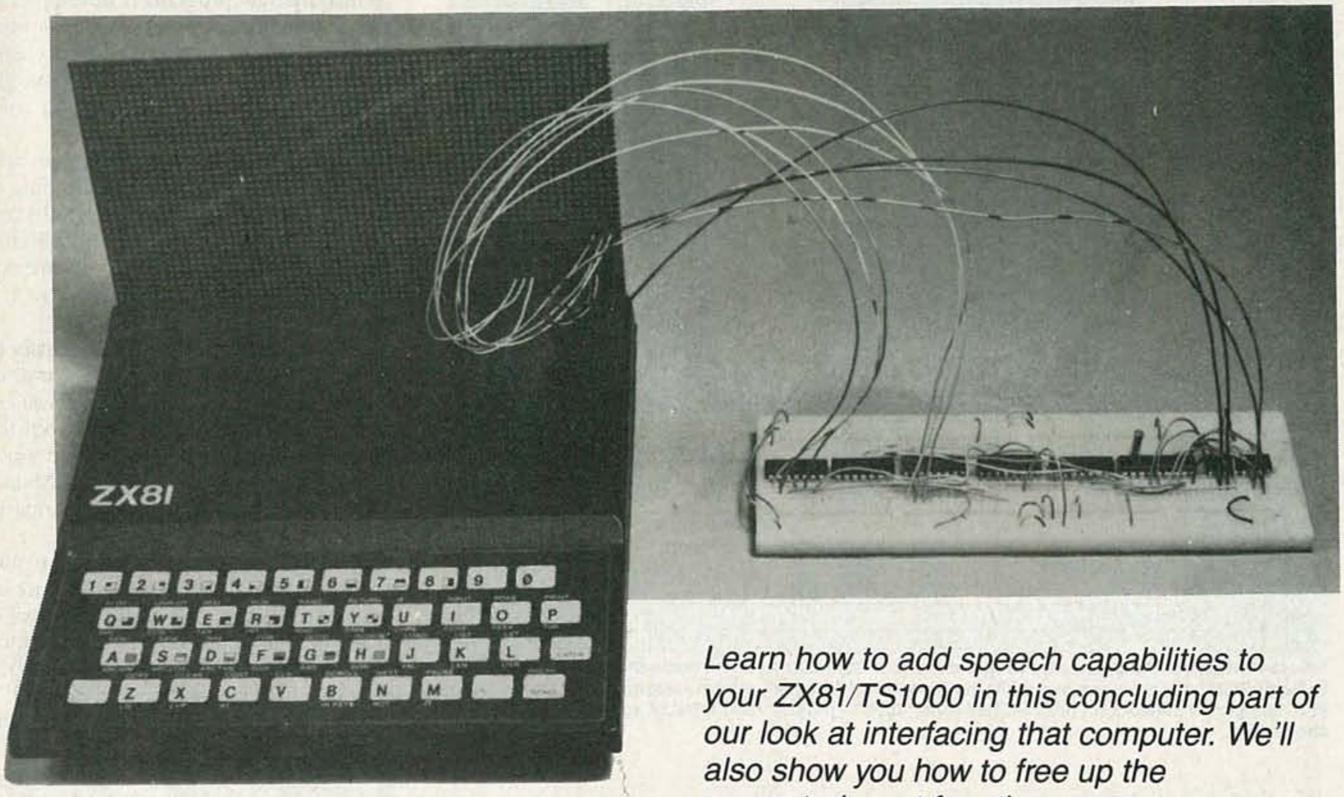
If you don't have an oscilloscope, use a clock or watch to measure the time it takes to transfer one or two kilobytes. Run the program with the EPROM socket empty, and adjust the software delay until the run time is 100 seconds, ±3 seconds.

The EPROM verify software is easier to create because there are no delays or multiple passes involved. The three-phase cycle is used to load the addresses, but the data patterns have no significance since the isolation switches to the EPROM data lines will be open during the verify operation.

There are two verify procedures, V1 and V2 specified in Fig. 13: In the V1 process, the host reads pins 1–8 of the test socket during the idle state after having executed the three-phase cycle to load the EPROM address. In the V2 process, the read is performed during phase three, and one more load is done to complete the cycle. Normally, the contents of the EPROM is either read into a main memory area for examination or compared with a memory area to verify the EPROM contents.

When you have the hardware and software debugged, you are ready to test the programmer with an EPROM in the socket and the V_{PP} supply connected. The first thing you'll want to check is that the EPROM is erased. Power the programmer down, insert an EPROM and the associated personality module, set up the DIP switches for verify (using Fig. 13), and open the isolation switches for test socket pins one through eight. Power the programmer up and run the verify software, checking for FFH patterns in all addresses.

Power may be removed from the programmer while the DIP switches are changed between program and verify, but be careful that V_{PP} is not applied to the EPROM while the five volt supply is removed. Set up the programmer switches for the program function and close the isolation switches for pins one through eight of the test socket. With the desired EPROM data loaded into the main memory source-area and the programmer in the idle condition, bring up the 28-volt supply and execute the EPROM program software. After the program runs, remove the 28-volt supply and set up the DIP and isolation switches for verify. Run the verify software and if the EPROM contents prove to be good, you have now successfully programmed an EPROM and the project has passed its final test. **R-E**



Learn how to add speech capabilities to your ZX81/TS1000 in this concluding part of our look at interfacing that computer. We'll also show you how to free up the computer's port for other uses.

Interfacing the ZX81

NEIL BUNGARD

Part 4 THIS MONTH, WE'LL finish up our look at interfacing the *ZX81/TS1000* by showing you how you can add speech capabilities to that machine.

Adding speech capabilities

A *Digitalker* speech synthesizer is the last of the external circuits that we'll be adding to our interface. The *Digitalker*, which is manufactured by National Semiconductor, consists of a speech processor IC (SPC) and ROM that contains the synthesizer's vocabulary. (For more information on the *Digitalker*, see the July 1982 issue of **Radio-Electronics**.)

We'll be using a set of three IC's (the SPC and two 8 × 8K ROM IC's) called the DT1050. It sells for about $35 and is available from a number of suppliers, including Jameco Electronics.

The complete synthesizer is not difficult to build: All that's required is to add simple filter and amplifier circuits to the DT1050 IC set.

As we mentioned before, the synthesizer's vocabulary (which consists of 137 separate "words," 2 tones, and 5 different silence durations) is contained in two ROM IC's (MM52164SSR1 and MM52164SSR2). The vocabulary is listed in Table 21. (That is the most popular vocabulary set, although other ROM's with different, and larger, vocabularies are available.)

The synthesizer circuit, as shown in Fig. 11, consists of a digital and an analog section. The digital section consists of the speech-processor IC22, two ROM's, IC23 and IC24, and two 7400-series IC's for control-signal decoding.

The analog section of the circuit consists of IC25 and IC26. IC25 is an LM346 op-amp that is configured as a lowpass filter with a rolloff frequency of about 200 Hz. The filter is required to take out the high-frequency noise generated by the *Digitalker*'s speech-synthesis technique. IC26 is an LM386 audio-amplifier IC that is used to drive a small 8-ohm speaker.

To use the *Digitalker* with the *ZX81*, 8 data-bus and 3 control-line connections are required. The data bus carries information to the SPC (telling it which word to speak). The control signals are used to time the information transfer and start the speech sequence. Figure 12 shows the control-signal timing necessary to write information to the SPC.

That control-signal timing is accomplished with 3 output device-code pulses (18, 14, and 1C) and a IC20. When pin 2 of the IC20 sees a low-going pulse accomplished with an "OUT 14" device-code pulse, its output (pin 12) goes to a logic Ø. (That's the negative-going edge of the pulse generated on the CS input of the SPC in the waveform shown in Fig. 12.) Next an "OUT 18" device-code pulse is generated to the $\overline{WR}$ input of the SPC. That pulse initiates the data transfer into the SPC, and starts the speech sequence. The final device-code pulse that is generated is "OUT 1C", which sets the output of the 74LS73 (pin 12) back to a logic 1 and deselects the SPC. (That's the rising edge of the pulse in the top waveform in Fig. 12.)

As long as the *Digitalker* is speaking, its INTR output (pin 6) is at logic Ø. At the end of a speech sequence however, the INTR line goes to a logic 1.

The status of INTR is checked by using an "IN ØC" device-code pulse which is

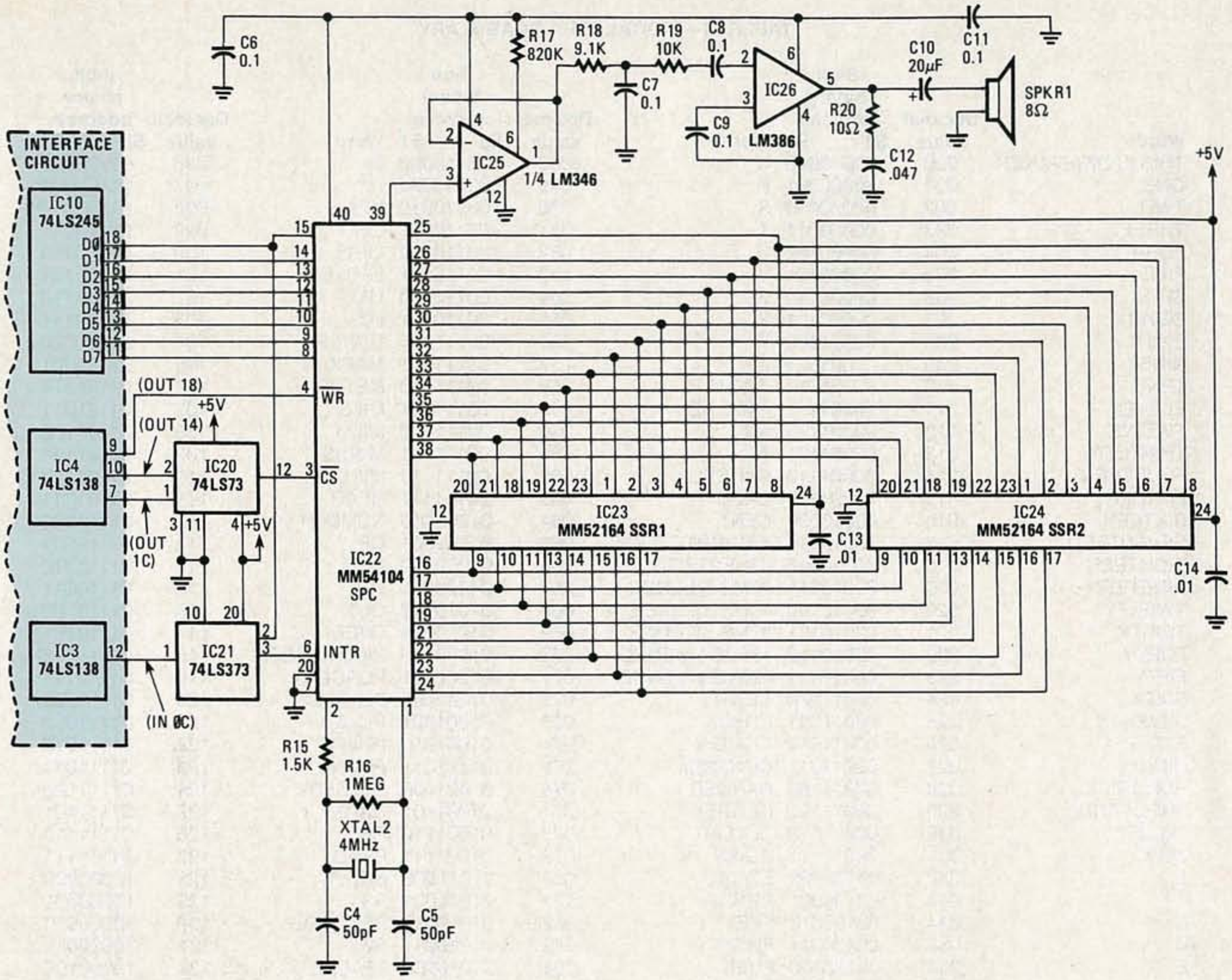


FIG. 11—THE SPEECH SYNTHESIZER circuit, thanks to large-scale integration, is not as complex as you might think. For best voice quality, don't use a very small speaker for SPKR1.

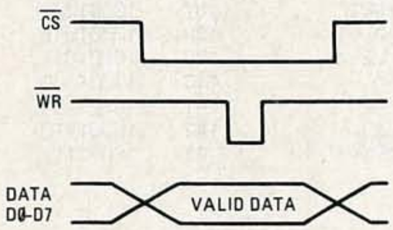


FIG. 12—THREE Z80 CONTROL SIGNALS are needed to generate the timing shown here.

connected to the ENABLE pin of IC21, a 74LS373 three-state latch. When IN ØC is generated, the status of the INTR output of the SPC is sent through IC10 to the Z80 accumulator on data-bus bit DØ. If DØ is a logic Ø, the speech sequence is still in progress. If DØ is a logic 1, then the speech sequence has ended, and the next word can be sent to the SPC.

We will demonstrate the capabilities of the *Digitalker* by using a machine-language routine and two BASIC programs. Remember that the programs we'll use are only a starting point. You are encouraged to modify the programs. For example, you might want to use the *Digitalker* with any of the other interface projects presented in this series.

To begin, first reserve the required space for the machine-language program which operates the *Digitalker*'s circuitry. A 20-character REM statement accomplishes that task. Then load the machine-language subroutine listed in Table 22. When the machine code has been entered, erase the loader program (if you used one) and load the BASIC program in Table 23.

Let's follow the two programs to see what they accomplish. Beginning in line 20 of the BASIC program, the variable "A" (which represents the numerical value of the word that the *Digitalker* will be asked to speak) is set to zero. (A complete listing of the *Digitalker*'s 144-word vocabulary and each word's associated numerical value is shown in Table 21.) Line 30 places the value of "A" into a memory location where it will later be retrieved by the machine-language subroutine that is called by line 40.

The first three instructions of the machine-language program repeatedly check the INTR output of the SPC to determine if a speech sequence has ended. As we mentioned previously, that's done by generating an input device-code pulse (IN ØC), setting all bits of the accumulator to a logic Ø except bit DØ (AND Ø1), and asking if DØ is a logic 1 or a logic Ø (JZ 82 40). If DØ is a logic Ø, program execution returns to the beginning of the machine-language routine. If DØ is a logic 1, which means the speech sequence has ended, the numerical value of the next word to be spoken is retrieved from memory location 4095H (16533), where it was previously stored by the BASIC routine. That's accomplished with the instructions: LD B,40, LD C,95, and LD A,(BC). Once the numerical value of the next word to be spoken is in the accumulator of the Z80, it is transferred to the SPC by a series of output instructions (OUT 14, OUT 18, and OUT 1C).

With the data transferred to the SPC, the speech sequence starts automatically. Program execution returns to the BASIC

TABLE 21—DIGITALKER VOCABULARY

Word	Decimal value	8-bit binary address S8 S1	Word	Decimal value	8-bit binary address S8 S1	Word	Decimal value	8-bit binary address S8 S1
THIS IS DIGITALKER	ØØØ	ØØØØØØØØ	Q	Ø48	ØØ11ØØØØ	IS	Ø96	Ø11ØØØØØ
ONE	ØØ1	ØØØØØØØ1	R	Ø49	ØØ11ØØØ1	IT	Ø97	Ø11ØØØØ1
TWO	ØØ2	ØØØØØØ1Ø	S	Ø5Ø	ØØ11ØØ1Ø	KILO	Ø98	Ø11ØØØ1Ø
THREE	ØØ3	ØØØØØØ11	T	Ø51	ØØ11ØØ11	LEFT	Ø99	Ø11ØØØ11
FOUR	ØØ4	ØØØØØ1ØØ	U	Ø52	ØØ11Ø1ØØ	LESS	1ØØ	Ø11ØØ1ØØ
FIVE	ØØ5	ØØØØØ1Ø1	V	Ø53	ØØ11Ø1Ø1	LESSER	1Ø1	Ø11ØØ1Ø1
SIX	ØØ6	ØØØØØ11Ø	W	Ø54	ØØ11Ø11Ø	LIMIT	1Ø2	Ø11ØØ11Ø
SEVEN	ØØ7	ØØØØØ111	X	Ø55	ØØ11Ø111	LOW	1Ø3	Ø11ØØ111
EIGHT	ØØ8	ØØØØ1ØØØ	Y	Ø56	ØØ111ØØØ	LOWER	1Ø4	Ø11Ø1ØØØ
NINE	ØØ9	ØØØØ1ØØ1	Z	Ø57	ØØ111ØØ1	MARK	1Ø5	Ø11Ø1ØØ1
TEN	Ø1Ø	ØØØØ1Ø1Ø	AGAIN	Ø58	ØØ111Ø1Ø	METER	1Ø6	Ø11Ø1Ø1Ø
ELEVEN	Ø11	ØØØØ1Ø11	AMPERE	Ø59	ØØ111Ø11	MILE	1Ø7	Ø11Ø1Ø11
TWELVE	Ø12	ØØØØ11ØØ	AND	Ø6Ø	ØØ1111ØØ	MILLI	1Ø8	Ø11Ø11ØØ
THIRTEEN	Ø13	ØØØØ11Ø1	AT	Ø61	ØØ1111Ø1	MINUS	1Ø9	Ø11Ø11Ø1
FOURTEEN	Ø14	ØØØØ111Ø	CANCEL	Ø62	ØØ11111Ø	MINUTE	11Ø	Ø11Ø111Ø
FIFTEEN	Ø15	ØØØØ1111	CASE	Ø63	ØØ111111	NEAR	111	Ø11Ø1111
SIXTEEN	Ø16	ØØØ1ØØØØ	CENT	Ø64	Ø1ØØØØØØ	NUMBER	112	Ø111ØØØØ
SEVENTEEN	Ø17	ØØØ1ØØØ1	4ØØHERTZ TONE	Ø65	Ø1ØØØØØ1	OF	113	Ø111ØØØ1
EIGHTEEN	Ø18	ØØØ1ØØ1Ø	8ØHERTZ TONE	Ø66	Ø1ØØØØ1Ø	OFF	114	Ø111ØØ1Ø
NINETEEN	Ø19	ØØØ1ØØ11	2ØMS SILENCE	Ø67	Ø1ØØØØ11	ON	115	Ø111ØØ11
TWENTY	Ø2Ø	ØØØ1Ø1ØØ	4ØMS SILENCE	Ø68	Ø1ØØØ1ØØ	OUT	116	Ø111Ø1ØØ
THIRTY	Ø21	ØØØ1Ø1Ø1	8ØMS SILENCE	Ø69	Ø1ØØØ1Ø1	OVER	117	Ø111Ø1Ø1
FORTY	Ø22	ØØØ1Ø11Ø	16ØMS SILENCE	Ø7Ø	Ø1ØØØ11Ø	PARENTHESIS	118	Ø111Ø11Ø
FIFTY	Ø23	ØØØ1Ø111	32ØMS SILENCE	Ø71	Ø1ØØØ111	PERCENT	119	Ø111Ø111
SIXTY	Ø24	ØØØ11ØØØ	CENTI	Ø72	Ø1ØØ1ØØØ	PLEASE	12Ø	Ø1111ØØØ
SEVENTY	Ø25	ØØØ11ØØ1	CHECK	Ø73	Ø1ØØ1ØØ1	PLUS	121	Ø1111ØØ1
EIGHTY	Ø26	ØØØ11Ø1Ø	COMMA	Ø74	Ø1ØØ1Ø1Ø	POINT	122	Ø1111Ø1Ø
NINETY	Ø27	ØØØ11Ø11	CONTROL	Ø75	Ø1ØØ1Ø11	POUND	123	Ø1111Ø11
HUNDRED	Ø28	ØØØ111ØØ	DANGER	Ø76	Ø1ØØ11ØØ	PULSES	124	Ø11111ØØ
THOUSAND	Ø29	ØØØ111Ø1	DEGREE	Ø77	Ø1ØØ11Ø1	RATE	125	Ø11111Ø1
MILLION	Ø3Ø	ØØØ1111Ø	DOLLAR	Ø78	Ø1ØØ111Ø	RE	126	Ø111111Ø
ZERO	Ø31	ØØØ11111	DOWN	Ø79	Ø1ØØ1111	READY	127	Ø1111111
A	Ø32	ØØ1ØØØØØ	EQUAL	Ø8Ø	Ø1Ø1ØØØØ	RIGHT	128	1ØØØØØØØ
B	Ø33	ØØ1ØØØØ1	ERROR	Ø81	Ø1Ø1ØØØ1	SS	129	1ØØØØØØ1
C	Ø34	ØØ1ØØØ1Ø	FEET	Ø82	Ø1Ø1ØØ1Ø	SECOND	13Ø	1ØØØØØ1Ø
D	Ø35	ØØ1ØØØ11	FLOW	Ø83	Ø1Ø1ØØ11	SET	131	1ØØØØØ11
E	Ø36	ØØ1ØØ1ØØ	FUEL	Ø84	Ø1Ø1Ø1ØØ	SPACE	132	1ØØØØ1ØØ
F	Ø37	ØØ1ØØ1Ø1	GALLON	Ø85	Ø1Ø1Ø1Ø1	SPEED	133	1ØØØØ1Ø1
G	Ø38	ØØ1ØØ11Ø	GO	Ø86	Ø1Ø1Ø11Ø	STAR	134	1ØØØØ11Ø
H	Ø39	ØØ1ØØ111	GRAM	Ø87	Ø1Ø1Ø111	START	135	1ØØØØ111
I	Ø4Ø	ØØ1Ø1ØØØ	GREAT	Ø88	Ø1Ø11ØØØ	STOP	136	1ØØØ1ØØØ
J	Ø41	ØØ1Ø1ØØ1	GREATER	Ø89	Ø1Ø11ØØ1	THAN	137	1ØØØ1ØØ1
K	Ø42	ØØ1Ø1Ø1Ø	HAVE	Ø9Ø	Ø1Ø11Ø1Ø	THE	138	1ØØØ1Ø1Ø
L	Ø43	ØØ1Ø1Ø11	HIGH	Ø91	Ø1Ø11Ø11	TIME	139	1ØØØ1Ø11
M	Ø44	ØØ1Ø11ØØ	HIGHER	Ø92	Ø1Ø111ØØ	TRY	14Ø	1ØØØ11ØØ
N	Ø45	ØØ1Ø11Ø1	HOUR	Ø93	Ø1Ø111Ø1	UP	141	1ØØØ11Ø1
O	Ø46	ØØ1Ø111Ø	IN	Ø94	Ø1Ø1111Ø	VOLT	142	1ØØØ111Ø
P	Ø47	ØØ1Ø1111	INCHES	Ø95	Ø1Ø11111	WEIGHT	143	1ØØØ1111

TABLE 22—DIGITALKER CONTROL

DB ØC	IN ØC
E6 Ø1	AND Ø1
CA 82 Ø1	JZ 82 4Ø
Ø6 4Ø	LD B,4Ø
ØE 95	LD C,95
ØA	LD A,(BC)
D3 14	OUT 14
D3 18	OUT 18
D3 IC	OUT 1C
C9	RET

program in line 50, which increments the variable "A" by 1. Line 60 sends program execution back to line 30 where the new value will be sent to the SPC and the next word in Table 21 will be spoken by the *Digitalker*.

When the synthesizer is controlled by the programs we have just discussed, it will speak, starting with the first word in the listing in Table 21, and say all of the words sequentially. You'll notice that although the last valid word has a numerical value of 143, the program sequences through 255—there are 112 undefined values which are spoken. Those undefined values generate some garbled sounds. But

continued on page 82

TABLE 23—AUTOMATIC DIGITALKER OPERATION

```
2Ø LET A=Ø
3Ø POKE 16533, A
4Ø LET B=USR 16514
5Ø LET A=A+1
6Ø GOTO 3Ø
```

TABLE 24—MANUAL DIGITALKER OPERATION

```
2Ø LET A$=""
3Ø IF A$="" THEN INPUT A$
4Ø LET B$=A$(TO 3)
5Ø LET A$=A$(4 TO)
6Ø LET A=VAL B$
7Ø POKE 16514,A
8Ø LET B=USR 16514
9Ø GOTO 3Ø
```

DESIGNING WITH LINEAR IC'S

A look at two lesser known but still powerful devices—the logarithmic and isolation amplifiers.

JOSEPH J. CARR

Part 6 THIS MONTH, WE WILL look at two lesser-known linear devices: logarithmic and isolation amplifiers. Let's start with the logarithmic amplifier.

A logarithmic amplifier produces an output voltage that is proportional to the log of the input voltage. We can build a logarithmic amplifier by combining an ordinary op-amp and an NPN silicon transistor, as shown in Fig. 1. Transistor Q1 is connected in the negative feedback loop such that the op-amp output voltage, V_O, is also the transistor's base-emitter voltage, V_{BE}, and the transistor's collector current, I_C, is also the feedback current applied to the summing junction. From the above discussion and basic transistor theory we know the following:

$$V_{BE} = \frac{KT}{Q} \text{ IN} \left(\frac{I_C}{I_S}\right) \quad (1)$$

$$V_O = V_{BE} \quad (2)$$

From basic op-amp theory we also know:

$$I_C = -I1 \quad (3)$$

and

$$I1 = V_I/R1 \quad (4)$$

so we are justified in writing Equation 1 as:

$$V_O = \frac{KT}{Q} \text{ IN} \left(\frac{V_I/R1}{I_S}\right) \quad (5)$$

where: K is Boltzmann's constant, Q is the electronic charge, T is the temperature in degrees Kelvin, V_I is the input voltage, R1 is the input resistor, and I_S is the transistor's reverse-saturation current. The terms K, Q, R1, and I_S are constants, and T can be made constant. In essence, therefore, Equation 5 tells us that output voltage V_O is a function of input voltage V_I and some constants. We are justified, therefore, in calling the circuit shown in Fig. 1 a logarithmic amplifier.

There is still a problem, however, which makes Fig. 1 a little too simple for practical application: temperature, T. It is not likely that the temperature of Q1 will remain constant, so the output signal will contain a variable term that is independent of the input voltage, V_I; in other words, there is an error associated with temperature.

Eliminating the temperature error requires the use of thermistors or PN junctions connected so that the effects of temperature are counteracted. For many circuit designers the best solution to that hassle is to buy an IC or hybrid logarithmic-amplifier device.

So what use is the log amp? Rarely will some instrument need to take the logarithm of the input signal, but there are cases where that is desirable, for instance for input-data compression. Many instruments will see analog signals that have an extremely wide dynamic range. Yet we find that amplifier gains that give us adequate low-level resolution will cause saturation on high-level signals. But if the gain is low enough to prevent saturation, then we lose the ability to resolve changes in low-level signals. The solution to that problem is to use a logarithmic amplifier

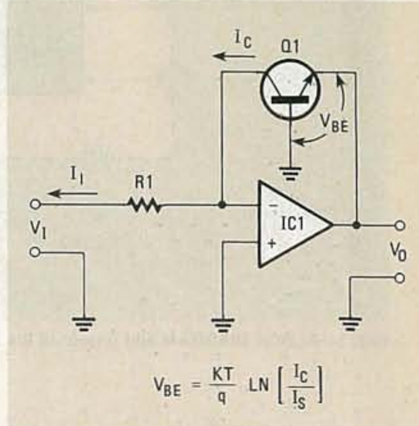


FIG. 1—A LOGARITHMIC AMPLIFIER can be formed by combining an ordinary op-amp with an NPN transistor.

that has a different gain at different input-signal levels.

If we want to decompress the analog data, or take the antilog of an analog signal for any other reason, then we may want to use an antilog amplifier (see Fig. 2). To make that type of amplifier is simple: We merely reverse the positions of R1 and Q1 in the log amp. The antilog amplifier of Fig. 2 also requires temperature

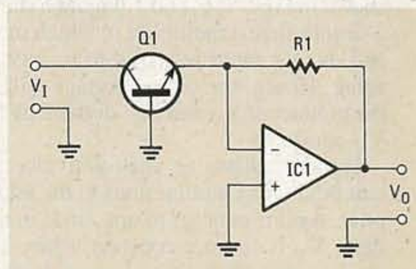


FIG. 2—AN ANTI-LOG AMPLIFIER circuit resembles the log-amp circuit. Only the circuit positions of Q1 and R1 have been swapped.

compensation.

Figure 3 shows the block diagram for the Burr-Brown 4301 and 4302 hybrid amplifiers. Those two devices are essentially the same except for package style (plastic-vs-metal) and temperature range. The 4301/02 contains logarithmic amplifiers and a summing network. The device accepts three input voltages (V_X, V_Y and V_Z) that produces an output voltage according to the transfer function:

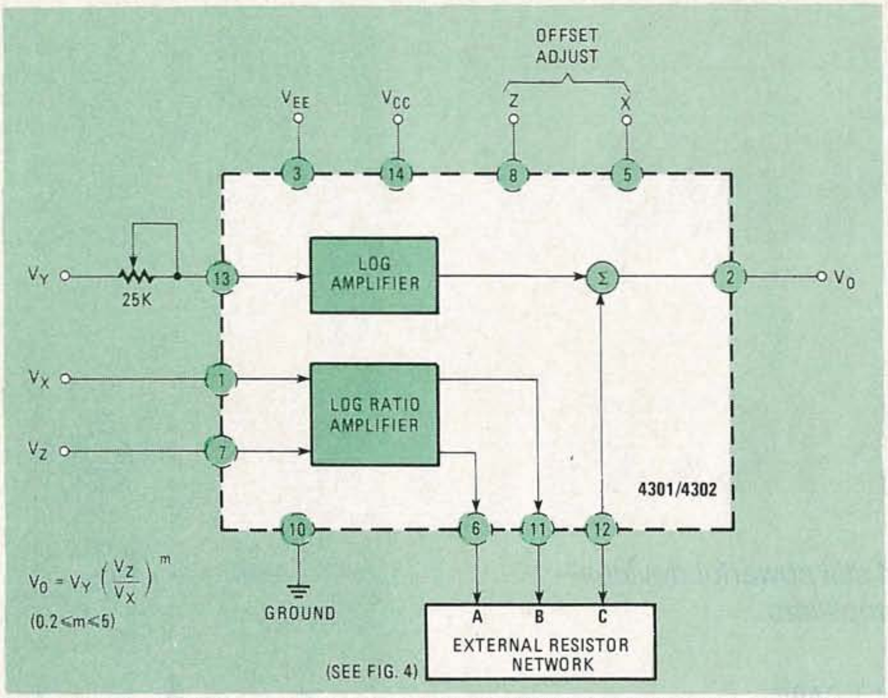


FIG. 3—BLOCK DIAGRAM and pinout of the Burr-Brown 4301/4302 hybrid logarithmic amplifiers.

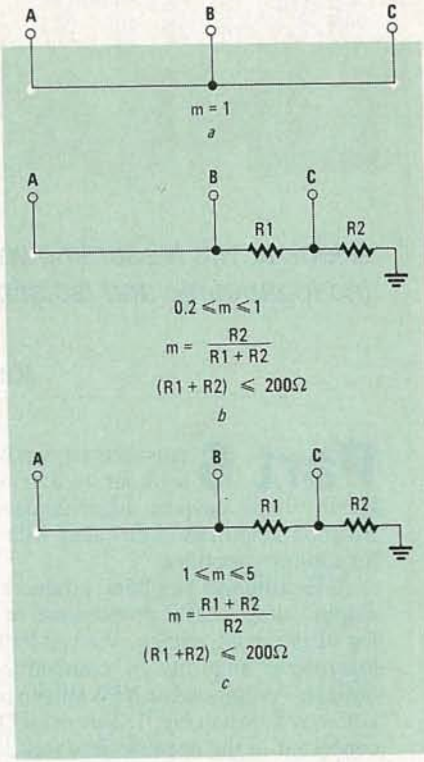


FIG. 4—THESE SIMPLE RESISTOR NETWORKS are used to set the value of m. The one in *a* is for the m = 1 case, the one in *b* is for the m<1 case, and the one in *c* is for the m>1 case.

$$V_O = V_Y \left(\frac{V_Z}{V_X}\right)^m \qquad (6)$$

where V_O is the output voltage; V_X, V_Y, and V_Z are input voltages, and m has a value between 0.2 and 5.0. The value of m is set by a simple resistor network. Because of that, the 4301/02 allows us to create transfer functions that would otherwise be difficult to achieve with simple circuitry. Figures 4-a through 4-c show the resistor networks for three cases: $m = 1$, $m < 1$, and $m > 1$, respectively.

Typical applications for the 4301/02 are shown in Figs. 5, 6, and 7. Figure 5 shows a simple analog multiplier in which $m = 1$ and the V_X input is biased to a constant value. Hence, the output voltage will be the product of V_Y and V_Z, divided by the V_X constant.

Figure 6 shows an analog-divider circuit built along similar lines to the multiplier. Again, m is set to one, and, in this case, V_Y is set to a constant value. The result is an output voltage $V_O = 10V_Z/V_X$.

Figure 7 shows a circuit that might be called an exponentiator, and has a transfer function of $V_O = 10(V_Z)^m$, where m is set by R4, as shown in Fig. 7-b and Fig. 7-c. Of course, each potentiometer can be replaced with a pair of resistors selected according to the equations shown in Figs. 4-b and 4-c.

Isolation amplifiers

There are certain cases where it is desirable to maintain a very high degree of isolation between the inputs and outputs of an amplifier. If there is some factor in one environment that is dangerous to the other, then the use of an isolation amplifier is justified. Biomedical instruments are a case in point. It is believed that the maximum safe exposure to 60-Hz AC for certain patients is about 10 microamperes. Normal leakage currents can exceed that value by a couple orders of magnitude, so medical equipment designers usually specify an isolated input amplifier stage. For medical applications it is common to find the degree of isolation expressed as 10^{12} ohms between inputs and the power terminals of the nonisolated side of the circuit.

Previously, isolation amplifiers were built from discrete components. Today, however, we can buy hybrid isolation amplifiers from several sources. At least two methods are now being used to achieve isolation: transformer coupling and optical coupling.

Figure 8 shows the transformer-coupling method in block-diagram form. A high-frequency (50 to 500 kHz) signal is generated in a power oscillator on the nonisolated side of the circuit. The use of such high frequencies allows the construction of transformers (T1 and T2) that easily pass the signal but severely attenuate the low-frequency 60-Hz AC leakage.

The oscillator output signal (200 kHz in this example) is coupled to the isolated side of the circuit via transformer T1. The oscillator signal is used for two purposes. Those are to provide 200-kHz AC to the rectifier/filter isolated DC power-supply, and to provide a 200-kHz carrier to the modulator stage.

The purpose of the isolated DC power-supply is to completely divorce the power for the isolation amplifier from the power for the nonisolated "outside world." Since the current level is very low, the rectifiers used in that circuit are often ordinary signal diodes rather than rectifier diodes. Also, the high frequency of the AC, 200 kHz, allows use of very low-value filter capacitors in the isolated DC-supply; we don't need large, high-value electrolytic capacitors.

Amplifier IC1 is connected to the signal source (a patient in biomedical applications, for instance). That stage usually has a medium level-gain that is a healthy fraction of the total gain. The signal from the output of IC1 is fed to the input of a modulator stage. The modulator output is an AM signal with a carrier frequency of 200 kHz. The AM signal is coupled to the nonisolated side of the circuit via transformer T2.

The original signal (V_I) is recovered by demodulating the AM signal. While some designs use simple envelope detectors (as in AM radios), others use a phase-sensitive detector (also called a synchronous detector) for the demodulator stage. That type of AM detector requires a sample of the carrier, so a 200-kHz signal is provided by the power oscillator.

Following the demodulator will be an output buffer-amplifier (IC2). That stage may or may not provide variable gain, depending on design.

Optically-coupled isolation amplifiers (see Fig. 9), as their name would imply, use light to carry the signal from isolated to nonisolated sides of the circuit. Most isolation amplifiers are of the optoisolator variety. That device should be familiar to most **Radio-Electronics** readers. It consists of a light-emitting diode (LED) and a phototransistor housed in an IC package. Although many people are aware of the digital applications of the optoisolator, it is also possible to use that device in linear applications. For instance, if we modulate the LED light, the pattern of modulation is reproduced at the transistor output.

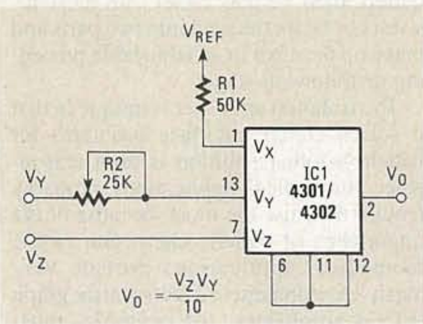


FIG. 5—IN THIS APPLICATION, an analog multiplier, the output is the product of V_Y and V_Z, multiplied by V_X.

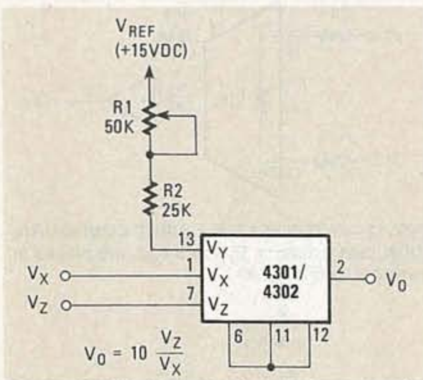


FIG. 6—IN THIS ANALOG DIVIDER, the output is equal to $10V_Z$ divided by V_X.

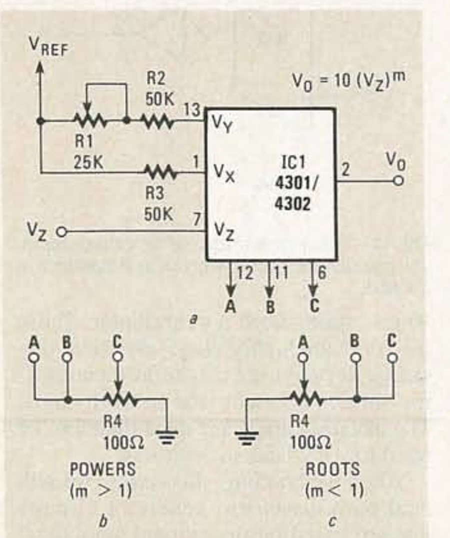


FIG. 7—IN THE CIRCUIT SHOWN IN *a*, the value of m is set by R4 as shown in *b* and *c*.

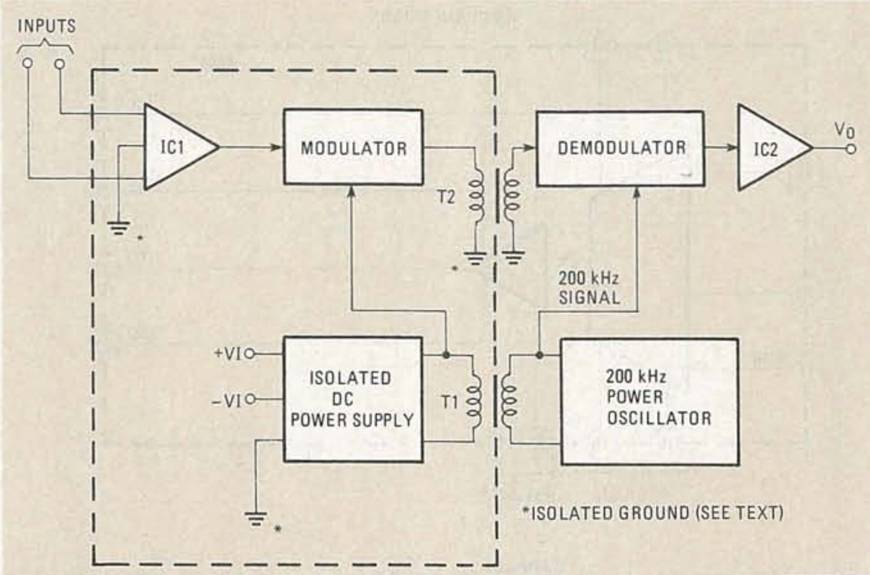


FIG. 8—BLOCK DIAGRAM of a transformer-coupled isolation amplifier. The transformers used are designed to pass the high-frequency signals but sharply attenuate any 60-Hz leakage current.

Note in Fig. 9 the use of an isolated ground for the input stage. If isolation is to be achieved, the input-stage ground must be kept separate from the ground used by the balance of the circuit.

Figure 10 shows the pinouts and block diagram for the Burr-Brown 3650 and 3652 isolation amplifiers. The two devices differ from each other in that the 3650 is a current-input amplifier and the 3652 can be configured for either a current or voltage input. Both the 3650 and 3652 are optically coupled and use a unique Burr-Brown circuit that tends to cancel the drift problems seen on certain other optically-coupled designs.

The 3650/52 devices do not contain a built-in isolated power supply. The +V and −V voltages to the nonisolated side can be supplied from the regular DC supply used in the rest of the circuit. The voltages for the isolated stages must come from a source that is isolated from the AC power lines. That requirement usually means batteries (not while connected to the charging circuit!) or an external, isolated power-supply. Burr-Brown makes several suitable DC-to-DC converters including single-port (710), dual-port (722) and quad-port (724) versions. The dual- and quad-port versions will supply power for two or four isolation amplifiers, respectively.

Figure 11 shows a 3650 with differential current-source inputs (I1 and I2). The gain of the isolation amplifier is 10^6 volts per ampere, so the output voltage is given by:

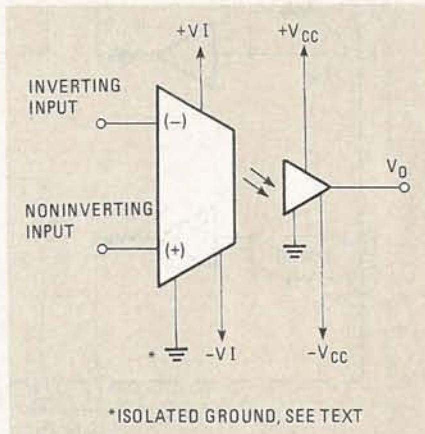


FIG. 9—OPTICALLY COUPLED isolation amplifiers require the use of a separate, isolated ground for the input stage.

$$V_O = (I1 - I2)(10^6 \text{ V/A}) \quad (7)$$

where: I1 and I2 are the input currents in amperes.

A voltage-input configuration for the 3650 is shown in Fig. 12. In that circuit, two input resistors (R_G1 and R_G2) are in series with the input terminals of the 3650. The gain is given by:

$$V_O = \frac{10^6}{R_G1 + R_G2 + R_{IN} + R9} (V1\text{-}V2) \quad (8)$$

where: R_G1 and R_G2 are the external resistors shown in Fig. 12, R_{IN} is the nominal input resistance of the 3650, and R_O is the output resistance of the driving signal-source. In many practical cases we find it possible to lump R_{IN} and R_O together into one term of approximately 115 ohms. That action makes the gain dependent solely upon R_G1 and R_G2. The resultant simplification will break down only when using a signal source with an excessive output resistance.

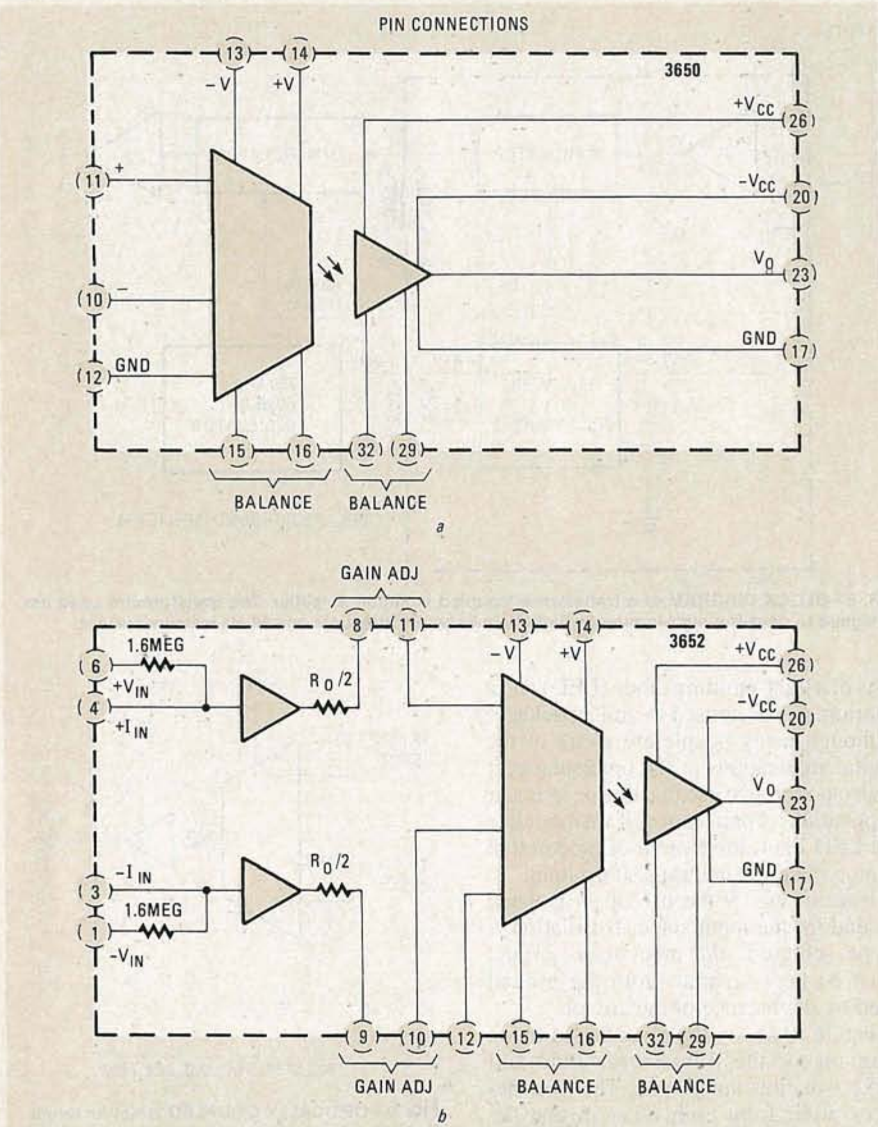


FIG. 10—BLOCK DIAGRAM and pinout of the Burr-Brown 3650 is shown in *a*; the block diagram and pinout of the Burr-Brown 3652 is shown in *b*.

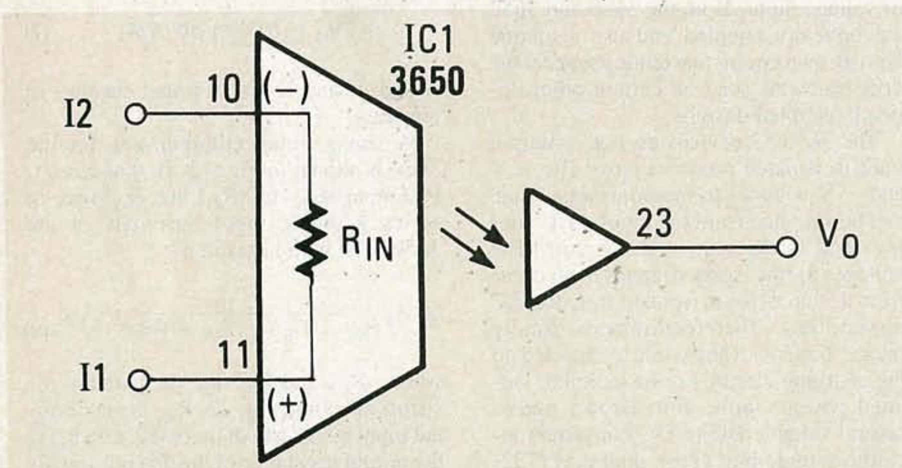


FIG. 11—HERE, THE 3650 is configured with differential current-inputs.

The configuration for the voltage-input 3652 is shown in Fig. 13. As in the previous case, the gain is set by Eq. 8 with $R_O + R_{IN}$ lumped together as 115 ohms. Let's rewrite Eq. 8 in simplified form to solve for R_G1 and R_G2 when the gain is known. As a basic assumption $R_G1 = R_G2 = R_G1$, so Eq. 8 becomes:

$$R_G = \frac{1}{2}\left(\frac{10^6}{A_V} - 115\right) \quad (9)$$

Let's look at an example: Calculate R_G1 and R_G2 for an amplifier with a gain (A_V) of 1000 (10^3). Assume a 3652 isolation amplifier and $R_G1 = R_G2$. Then:

$$R_G = \frac{1}{2}\left(\frac{10^6}{10^3} - 115\right)$$

$$= \frac{1}{2}(1000 - 115)$$

$$= 442.5 \text{ ohms}$$

In a practical case we would accept a tiny gain error by using $R_G = 440$ ohms (a standard value). If precise gain is required, then we may either trim those resistors or factor the gain into two parts and make up the error in an adjustable preceding or following stage.

The isolation amplifier is unique in that it solves certain interface problems for which no other solution is even reasonable. Biomedical applications probably require their use the most, because of the importance of patient safety. But, some biomedical applications provide very harsh environments. Electrocardiograph (ECG) amplifiers, for example, must sometimes withstand a 2000–3000 volt,

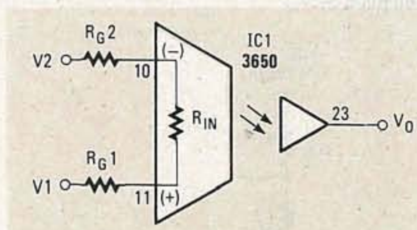


FIG. 12—IN THE VOLTAGE-INPUT CONFIGURATION, two resistors, R_G1 and R_G2, are placed in series with the inputs.

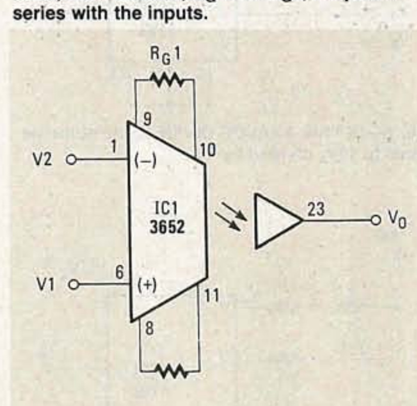


FIG. 13—THE 3652 configured for voltage input. The gain for the circuit is given by Equation 8 in the text.

10-ms, shock from a defibrillator. Those machines are high-voltage, electrical-discharge devices used to administer an electric shock to correct fatal heart rhythms. The isolation amplifier must therefore be rated to withstand such shocks.

When we continue this series, we will deal with waveform-generator circuits that are based on operational amplifiers. We will include sinewave, squarewave, and pulse generators, and more! **R-E**

ALL ABOUT

CMOS CLOCK CIRCUITS

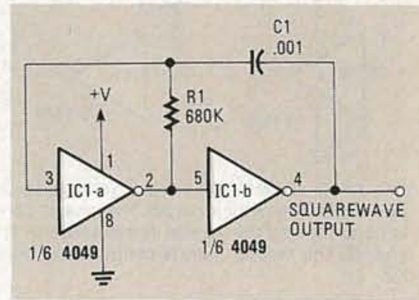


FIG. 1—THIS 2-GATE CMOS ASTABLE operates at 1 kHz with the component values shown.

The next time you need a clock generator, pick out one of these CMOS-based designs.

RAY MARSTON

IN THE SEPTEMBER ISSUE, WE TOOK A look at squarewave-generator circuits. This month, we'll take another look. However, instead of using transistors, op-amps and 555 timer IC's, we'll deal only with designs based on CMOS IC's.

CMOS logic IC's can easily be used to make squarewave-generator or "clock" circuits that are both inexpensive and highly versatile. The outputs can be symmetrical or non-symmetrical, and the oscillators can be either free-running or gated. The gated oscillators can be designed to turn on with either logic-0 or logic-1 signals, and to give either a logic-0 or a logic-1 output when in the "off" mode. You can even use those "cheapo" circuits as simple VCO's (*V*oltage-*C*ontrolled *O*scillators) or as frequency-modulated oscillators.

If you want VCO operation with excellent linearity and versatility, then you have to be slightly more particular about the IC you use. We'll get to that in just a little while. But first, the basics: 2-gate CMOS squarewave-generator or astable circuits.

Two-gate astable oscillators

The simplest way to make an astable circuit is to wire two CMOS inverter stages in series and use the R-C feedback network shown in Fig. 1. That circuit generates a decent squarewave output and operates at about 1 kHz with the component values shown. The frequency is inversely proportional to the R-C time constant, so it can be raised by lowering the values of either C1 or R1. Capacitor C1 must be a non-polarized type; it can have any value from a few tens of pF to several µF. Resistor R1 can have any value from about 47 kilohms to 22 megohms. With those ranges of values, the operating frequency can vary from below 1 Hz to about 1 MHz. For variable-frequency operation, R1 should be replaced by a series combination of a fixed and a variable resistor.

The output of the astable circuit in Fig. 1 switches (when lightly loaded) almost fully between the zero and positive supply rail values. But the R1-C1 junction is prevented from swinging below zero or above the positive rail levels by on-chip clamping diodes at the input of IC1-a. That characteristic causes the operating frequency of the circuit to be somewhat dependent on the supply: Typically, the frequency falls by about 0.8% for a 10% rise in supply voltage. If the frequency is normalized with a 10-volt supply, the frequency falls by 4% at 15 volts or rises by 8% at 5 volts.

The operating frequency of the circuit shown in Fig. 1 is also influenced by the individual gates that are used. You can expect the frequency to vary by as much as 10% between individual IC's. The output symmetry of the waveform also depends on the particular IC used and, in most cases, the circuit will give a non-symmetrical output. In most "hobby" or other non-precision applications, those defects of the basic astable circuit are of little practical importance.

We should note here that for the circuit in Fig. 1—and all of the others that we'll present this month—the supply voltage indicated by "+V" can be anywhere from 3 to 18 volts DC. Also, the CMOS IC's used are all of the "B-series" type (with improved gate-oxide protection.)

Figure 2 shows an improved, "compensated" astable circuit in which R2 is wired in series with the input of IC1-a. That resistor must have a value that is large relative to R1; its main purpose is to allow the R1-C1 junction to swing freely below the zero and above the positive supply rail voltages during circuit operation and thus improve the frequency stability of the circuit. Typically, when R2 is ten times the value of R1, the frequency varies by only 0.5% when the supply voltage is varied between 5 and 15 volts. An incidental benefit of R2 is that it gives a slight improvement in the symmetry of the output of the astable.

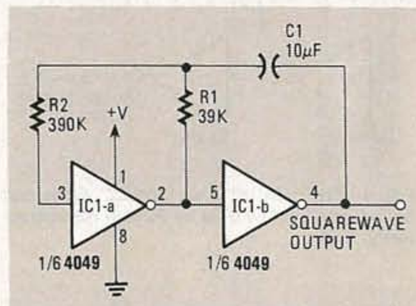


FIG. 2—THE "COMPENSATED" VERSION of the 2-gate astable oscillator has excellent frequency stability with variations in supply voltage.

The basic and compensated astable circuits of Figs. 1 and 2 can be built with a good number of detail variations, as shown in Figs. 3 to 5. In the basic astable circuit, for example, C1 alternately charges and discharges via R1 and thus has a fixed symmetry. Figures 3 to 5 show how the basic circuit can be modified to give alternate charge and discharge paths for C1 and thus to allow the symmetry to be varied at will.

The circuit in Fig. 3 is useful if you need a highly non-symmetrical waveform (such as a pulse). Capacitor C1 charges in one direction via R2 in parallel with R1, to generate the *mark* (or pulse) part of the waveform. It charges in the reverse direc-

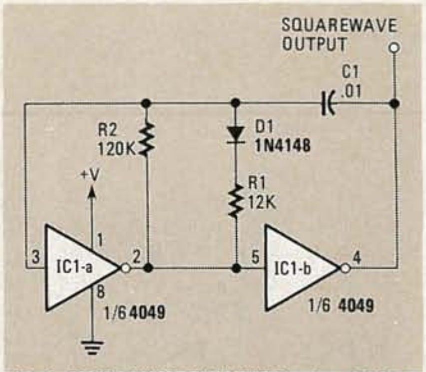


FIG. 3—YOU CAN MODIFY THE 2-gate astable to give a non-symmetrical output. The "mark" time is controlled by the parallel combination of R1 and R2. The "space" time is controlled by only R2.

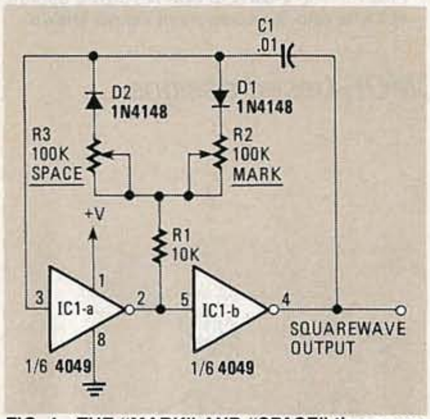


FIG. 4—THE "MARK" AND "SPACE" times can be independently varied by R2 and R3 respectively.

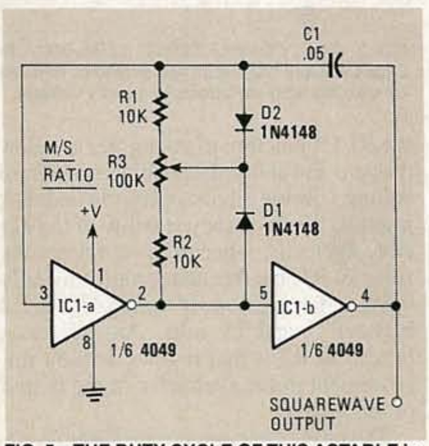


FIG. 5—THE DUTY CYCLE OF THIS ASTABLE is fully variable from 1:11 to 11:1.

tion via R2 only, to give the *space* between the pulses.

Figure 4 shows the modifications for generating a waveform with independently variable mark and space times; the mark time is controlled by R1, R2, and D1, and the space time is controlled by R1, R3, and D2.

Figure 5 shows the modifications to give a variable duty-cycle (or mark/space ratio) output while maintaining a near-constant frequency. Here, C1 charges in one direction via D2 and the lower half of R3 and R2, and in the other direction via D1 and the upper half of R3 and R1. The duty cycle can be varied over a range of 1:11 to 11:1 via R3.

Figure 6 shows a couple of ways of using the basic astable circuit as a very simple VCO. The circuit in Fig. 6-a can be used to vary the operating frequency over a limited range via an external voltage. For satisfactory operation, R2 must be at least twice as large as R1. Its actual value depends on the required frequency-shift range: A low R2 value gives a large frequency-shift range, and a larger R2 value gives a small frequency-shift range. The circuit in Fig. 6-b acts as a special-effects VCO in which the oscillator frequency rises with input voltage, but switches off completely when the input voltage falls below a value preset by R3.

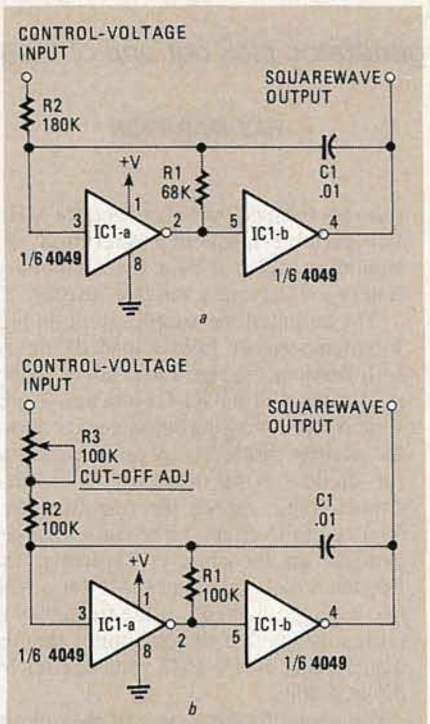


FIG. 6—A SIMPLE VOLTAGE-CONTROLLED OSCILLATOR or VCO is shown in *a*. Shown in *b* is a VCO that cuts off when V_{IN} falls below a value that is preset by R3.

Gated astable circuits

All of the astable circuits of Figs. 1 to 6 can be made using NAND or NOR gates instead of inverters. Simply replace the inverters with one of the gates as shown in Fig. 7.

Using NAND and NOR gates instead of inverters has a practical advantage—it lets you modify all of the circuits in Figs. 1–6 for gated operation. In other words, the astables can be turned on and off by external signals. All you have to do is to use a 2-input NAND (4011B) or NOR (4001B) gate in place of the inverter in the IC1-a position, and apply a control signal to one of the gate input terminals. By choosing the appropriate gate, you can control your astable by either a high or a low gate signal. That is shown by the two basic versions of the gated astable multivibrator in Figs. 8 and 9.

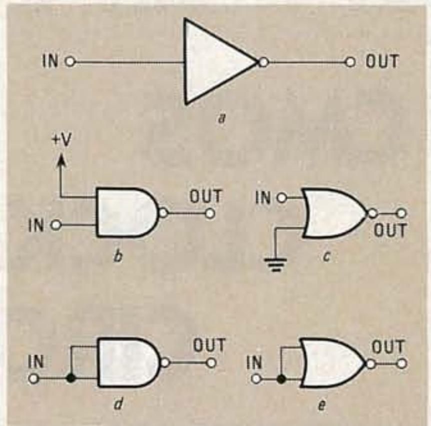


FIG. 7— TWO-INPUT NAND OR NOR gates can be used as inverters. As we'll see, they permit gated operation. As with any other CMOS IC, be sure to tie all unused inputs to one of the supply rails.

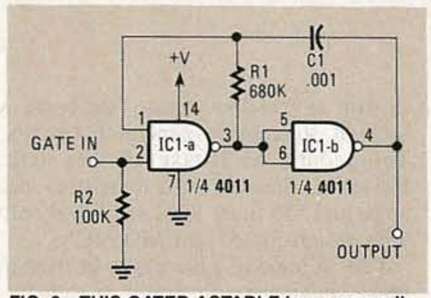


FIG. 8—THIS GATED ASTABLE has a normally-low output. It is gated on by a high input.

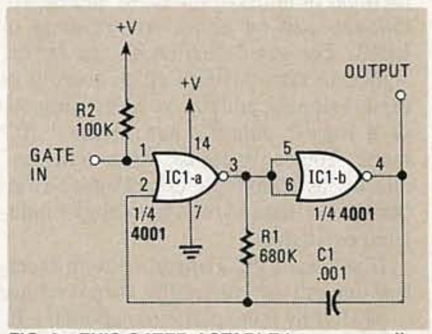


FIG. 9—THIS GATED ASTABLE has a normally-high output. It is gated on by a low input.

Note specifically from those two circuits that the NAND version is gated on by a logic-1 input and has a normally-low output, while the NOR version is gated on by a logic-0 input and has a normally high output. Pull-up (or pull-down) resistor R2 can be eliminated from the circuits if IC1-a is direct-coupled from the output of a preceding CMOS logic stage.

In the basic gated astable circuits of Figs. 8 and 9, the output signal terminates as soon as the gate drive signal is removed. Consequently, any noise present at the gate terminal also appears at the outputs of those circuits. Figures 10 and 11 show how to modify the circuits to over-

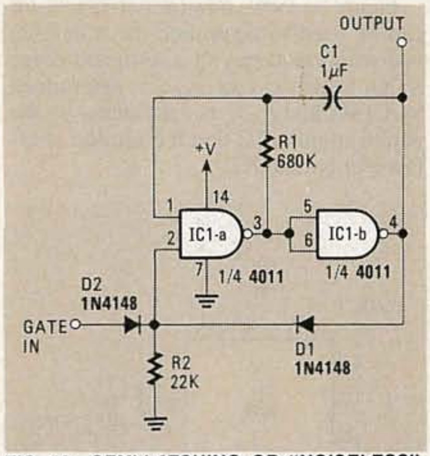


FIG. 10—SEMI-LATCHING OR "NOISELESS" gated astable has a normally-low output and is gated on by a high input.

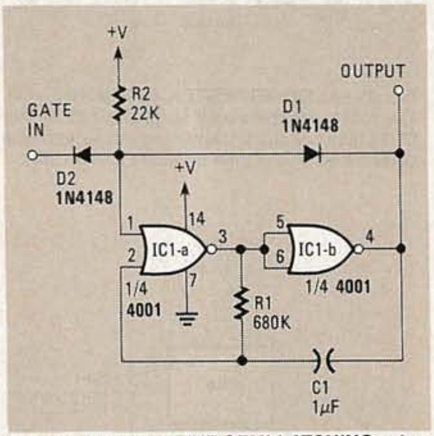


FIG. 11—ALTERNATIVE SEMI-LATCHING astable has a normally-high output and is gated on by a low input.

come that problem. There, the gate signal of IC1-a is derived from both the "outside world" and from the output of IC1-b via the diode OR gate (D1, D2, and R2). As soon as the circuit is gated from an external signal applied via D2, the output of IC1-b reinforces or self-latches the gating via D1 for the duration of one-half astable cycle. That eliminates any effects of a noisy external gate signal. The outputs of the "semi-latching" gated astable circuits are thus always complete numbers of half cycles.

Ring-of-three circuits

The 2-gate astable circuit is not generally suitable for direct use as a "clock" generator with fast-acting counting and dividing circuits. That's because it tends to pick up and amplify any supply-line noise during the "transitioning" parts of its operating cycle and to thus produce squarewaves with "glitchy" leading and trailing edges. A far better type of clock generator circuit is the *ring-of-three* astable that is shown in Fig. 12.

The Fig. 12 ring-of-three circuit is similar to the basic 2-gate astable, except that its "input" stage (IC1-a–IC1-b) acts as an ultra-high-gain non-inverting amplifier and its main timing components (R1-C1) are transposed (relative to the 2-gate astable). Because of the very high overall gain of the circuit, it produces an excellent and glitch-free squarewave output, ideal for clock-generator use.

The basic ring-of-three astable can be subjected to all the design modifications that we've already looked at for the basic

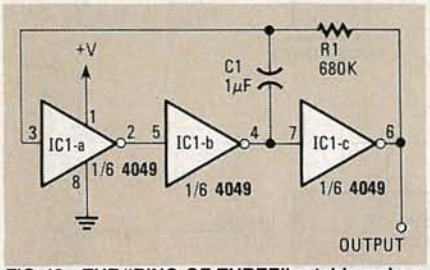


FIG. 12—THE "RING-OF-THREE" astable makes an excellent clock generator.

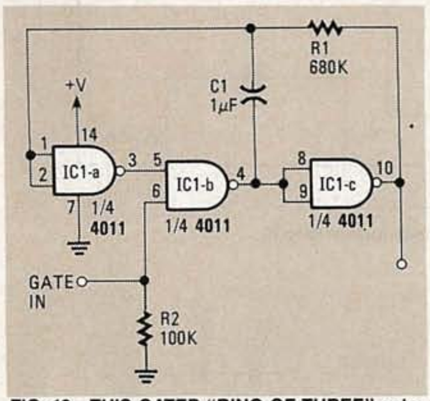


FIG. 13—THIS GATED "RING-OF-THREE" astable has a normally-low output and is gated on by a logic-1 signal.

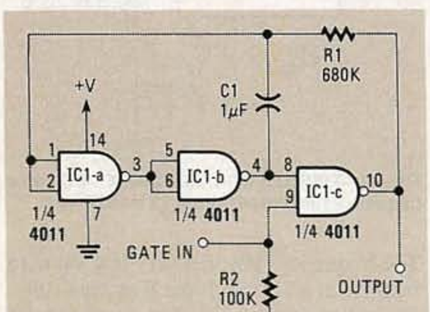


FIG. 14—THIS GATED "RING-OF-THREE" astable has a normally-high output and is gated on by a logic-1 signal.

2-gate astable—it can be used in either basic or compensated form and can give either a symmetrical or non-symmetrical output, etc. The most interesting variations of the circuit occur, however, when it is used in the gated mode, since it can be gated via either the IC1-b or IC1-c stages. Figures 13 to 16 show four variations on that gating theme.

The circuits in Figs. 13 and 14 are both gated on by a logic-1 input signal, but the

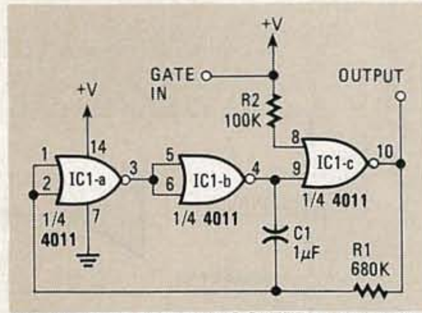


FIG. 15—THIS ASTABLE IS GATED on by a logic-0 signal and has a normally low output.

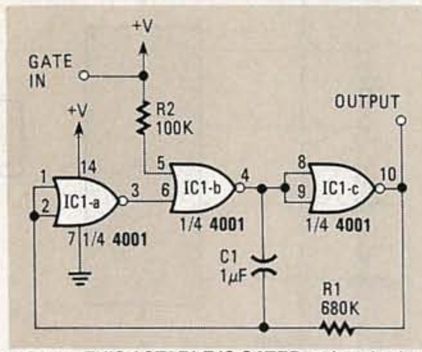


FIG. 16—THIS ASTABLE IS GATED on by a logic-0 signal and has a normally high output.

circuit in Fig. 13 has a normally-low output, while that of Fig. 14 is normally-high. Similarly, the circuits in Fig. 15 and 16 are both gated on by a logic-0 signal, but the output of the circuit in Fig. 15 is normally-low, while that of Fig. 16 is normally-high.

4046 VCO circuits

To close this look at CMOS squarewave generator circuits, let's consider some practical VCO applications of the 4046 phase-locked loop (PLL) IC. Figure 17 shows the internal block diagram and pinout of the 4046, which contains a couple of phase comparators, a VCO, a Zener diode, and a few other bits and pieces.

For our present purpose, the most important part of the chip is the VCO section. That VCO is a highly versatile device: It produces a well-shaped symmetrical squarewave output, has a top-end frequency limit in excess of 1 MHz, has a voltage-to-frequency linearity of about 1%, and can easily be "scanned" through a 1,000,000:1 range by an external voltage applied to the VCO input terminal. The frequency of the oscillator is governed by the value of a capacitor (minimum value 50 pF) connected between pins 6 and 7, by the value of a resistor (minimum value 10K) wired between pin 11 and ground, and by the voltage (any value from zero to the supply voltage) applied to VCO-input pin 9.

Figure 18 shows the simplest possible way of using the 4046 VCO as a voltage-controlled squarewave generator. In that circuit, the C1-R1 combination deter-

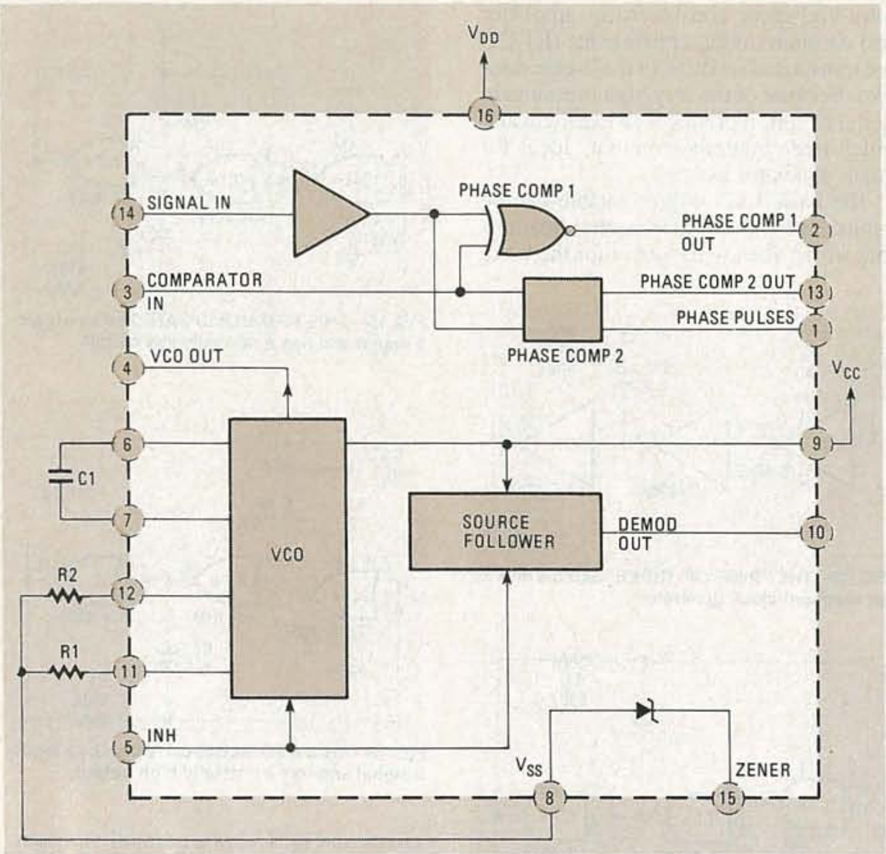


FIG. 17—INTERNAL BLOCK DIAGRAM of the 4046 phase-locked loop IC.

mines the maximum frequency that can be obtained (with the pin 9 voltage at maximum) and R2 controls the actual frequency by applying a control voltage to pin 9:

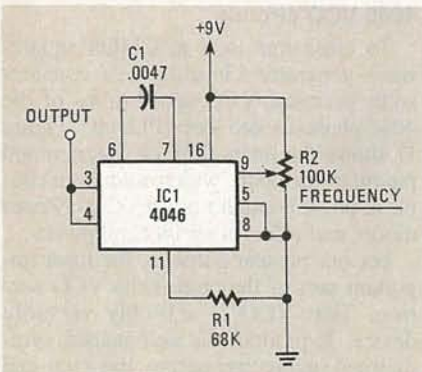


FIG. 18—A BASIC WIDE-RANGE VCO spanning from about zero to about 5 kHz (determined by R2).

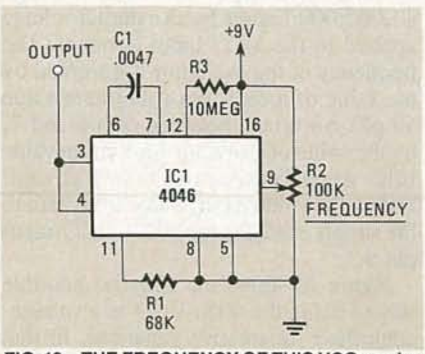


FIG. 19—THE FREQUENCY OF THIS VCO can be varied all the way down to zero.

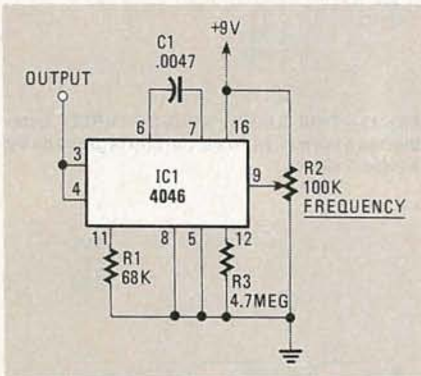


FIG. 20—THIS RESTRICTED-RANGE VCO has a frequency range from about 72 Hz to 5 kHz.

The frequency falls to a very low value (a fraction of a Hz) with pin 9 at zero volts. The effective control-voltage range of pin 9 varies from roughly 1 volt below the supply value to about 1 volt above ground, and gives a frequency span of about 1,000,000:1. Ideally, the supply voltage to the circuit should be regulated.

We've said above that the frequency of the circuit shown in Fig. 18 falls to *near*-zero when the input voltage is reduced to zero. Figure 19 shows how the circuit can be modified so that the frequency falls all the way to zero—all that's needed is a high-value resistor (R3) between pins 12 and 16. Note here that, when the frequency is reduced to zero, the VCO output randomly settles in either a logic 0 or a logic 1 state.

Figure 20 shows how the pin-12 resistor can be used to determine the minimum operating frequency of a restricted-range VCO. In that circuit, f_{MIN} is determined by C1-R2 and f_{MAX} is determined by the combination of C1 and the parallel resistance of R1 and R2.

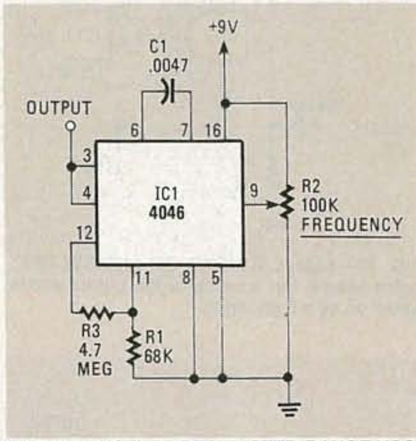


FIG. 21—ANOTHER RESTRICTED-RANGE VCO. The maximum frequency is determined by the C1-R1 time constant; the minumum frequency is determined by the time constant C1(R1 + R3).

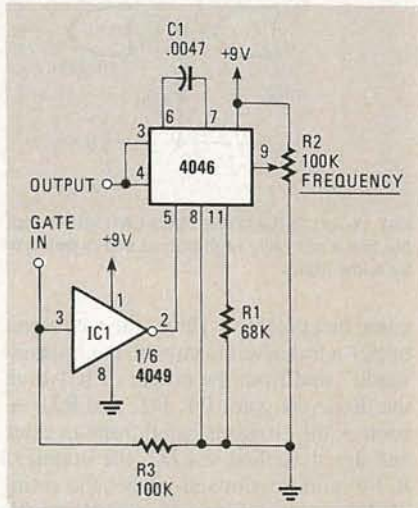


FIG. 22—THIS GATED WIDE-RANGE VCO uses an external inverter.

Figure 21 shows an alternative version of the restricted-range VCO, in which f_{MAX} is controlled by C1-R1 and f_{MIN} is determined by C1 and the series combination of R1 and R2. Note that, by making a suitable choice of the R1 and R2 values, the circuit can be made to "span" any desired frequency range from 1:1 to near-infinity.

Finally, it should be noted that the VCO section of the 4046B can be disabled by taking pin 5 of the package high (to logic 1 level) or enabled by taking pin 5 low. That feature makes it possible to gate the VCO on and off by external signals. Figure 22 illustrates that feature and shows how the basic voltage-controlled oscillator circuit can be gated via a signal applied to an external inverted stage. **R-E**

BOOKS

DIGITAL ELECTRONICS, by David Casasent; Quantum Publishers, Inc., c/o Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 7¼ × 9½ inches; softcover; 259 pages, including appendix, bibliography, and index; $9.95.

The design of digital circuits involves three somewhat separate disciplines: logic design, applications, and hardware. This text is intended primarily for a junior or senior electrical-engineering course in digital electronics; no prior knowledge of Boolean algebra, logic design, or transistor theory is required. Both differential and integral equations and determinants are avoided; the one and only mathematical prerequisite is algebra.

The emphasis is on hardware—that is, the actual design and analysis of individual logic circuits rather than the interconnection of them (logic design). That hardware flavoring is even more pronounced in the treatment of the individual gates and regenerative-logic circuits in which designs using discrete (individual) transistors, etc., are emphasized. Liberal and ample coverage of IC logic devices is included in the text. To help you understand how they work, most of the IC's are treated in rather complete detail, as if they were constructed from discrete components.

A thorough treatment of the principles and techniques covered should enable the reader to design basic special-purpose digital circuits and to use the multitude of commercially available digital integrated-circuits. **R-E**

ZX81 INTERFACE

continued from page 72

try them anyway—we're sure you'll find some of them amusing.

For initial testing, you'll want the *Digitalker* to speak all of the words in its vocabulary. But if you want to use the synthesizer for serious applications, you'll need control over exactly what it says. The next program allows you to command the *Digitalker* to speak any sequence of words from the list in Table 21 so that you can program phrases or sentences. Enter the BASIC program in Table 24. Using that program, you can enter a word sequence as a series of three-digit values. All words must be represented by three digits: Any numerical value less than 100 must be padded with leading zeros. (For example, a 1 must be represented as a Ø Ø1.) The digits are entered in a series, and delimiters are not required between the three-digit groups. For example, if you want the *Digitalker* to say "The time is 1:30," the sequence you enter is:

138139096001021

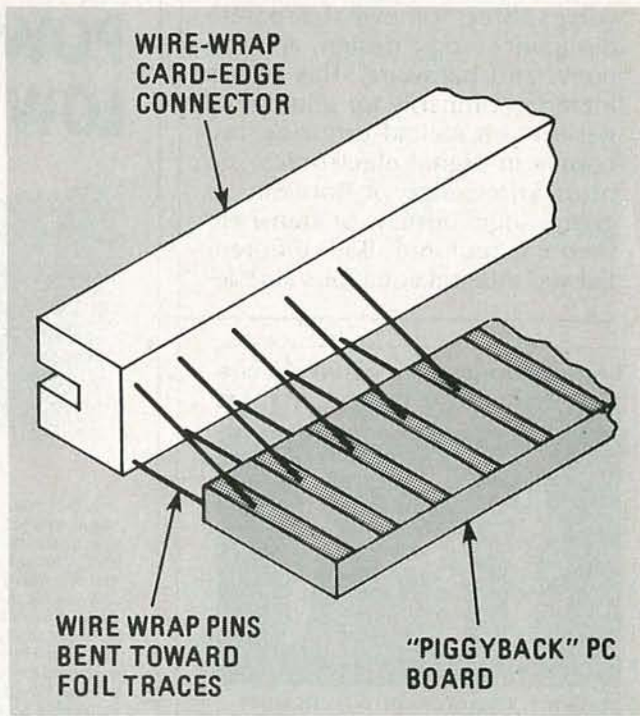


FIG. 13—THE INTERFACE CIRCUIT does not have to tie up your ZX81's port. An "extender" board will allow you to piggyback other devices to the interface.

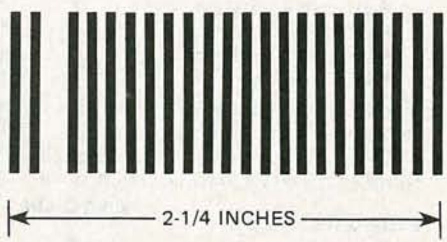


FIG. 14—THE FOIL PATTERN for the double-sided piggyback extender board. Note that only one pattern is shown. The other side is, of course, the same.

The BASIC program divides the sequence into its three-digit word representations and sends them to the machine-language routine where the *Digitalker* is commanded to sequentially speak each word.

A piggyback connector

As you complete the interface projects we're sure that you'll discover that the 1K or 2K memory in your computer really limits

PARTS LIST—SPEECH SYNTHESIZER

Resistors, ¼-watt, 5% unless otherwise noted
R15—1500 ohms
R16—1 megohm
R17—820,000 ohms
R18—9100 ohms
R19—10,000 ohms
R20—10 ohms, ½ watt

Capacitors
C4, C5—50 pF, ceramic disc
C6–C9, C11—0.1 μF, ceramic disc
C10—20 μF, 10 volts, electrolytic
C12—0.047 μF, ceramic disc
C13, C14—.01 μF, ceramic disc

Semiconductors
IC20—74LS73 dual J-K flip-flop
IC21—74LS373 octal D-type latch
IC22—MM54104 speech processor IC
IC23—MM52164 SSR1 speech ROM
IC24—MM52164 SSR2 speech ROM
IC25—LM346 quad op-amp
IC26—LM386 audio amplifier

Other components
XTAL2—4 MHz
SPKR1—8 ohms

what you can do. To eliminate that problem, you might want to add a 16K or 64K memory pack. Both are commercially available for the Sinclair. The problem is that the interface circuit is plugged into the same slot that the memory pack must plug into. That problem can be solved by soldering a set of card-edge fingers onto the wire-wrap socket so that a memory pack can be piggybacked onto the interface circuit. Figure 13 shows how the card-edge fingers are attached to the wire-wrap socket. Figure 14 is the foil pattern for one side of the board. (The pattern for the other side is, of course, the same.)

The author of this four-part article would like to hear from any readers with interesting circuits to share, or anyone with questions regarding interfacing the *ZX81* or Timex Sinclair 1000. You can contact Neil Bungard directly at PO Box 493, Blacksburg, VA 24060 **R-E**

"We'veaddedtheacceleratorcardtothecomputer.Whydoyouask?"

SATELLITE TV

Then and now

BOB COOPER, JR.*

WITH THE INTELLIGENCE OF HINDSIGHT, it is amusing and even instructive to look back on the rapid development of the TVRO industry since it all began in October of 1979. It was on October 18, 1979 that the FCC held a meeting and decided that TVRO (*T*elevision-*R*eceive-*O*nly) "terminals" would no longer be required to file for and receive a federal license. Until that decision, many of us had been operating our TVRO's "extra-legally:" We had them, we used them, and we at least suspected we were breaking some obscure regulation or law. When the FCC decided, with great wisdom, that no further licenses would be required, a major legal impediment to owning and operating a TVRO was done away with. The industry has never looked back from that event.

But perhaps we should. Having just celebrated five years of TVRO's, I suspect there are many readers of **Radio-Electronics** who have had the opportunity to consider expanding their own sales and/or service business to include TVRO-system hardware. I also suspect, and in fact know, that many of the best and most qualified electronic equipment shops in the country have, in the past, elected to pass TVRO's by because of a frightening array of equipment problems and potential equipment liabilities. That will, for the next few issues of this column, be our editorial thrust; we will look at "then" and "now." Or, the way that TVRO hardware has changed since all of this began in late 1979 and early 1980, to give you both a feel for the rapid strides TVRO hardware has made in that five-year span, and to perhaps introduce you to the potentially profitable business of handling TVRO equipment as an adjunct (or featured part) to your present electronics business interests. Consumers interested in TVRO's will also find the following discussions a useful and informative way to learn about the equipment that is part of such a setup.

*Publisher, CSD Magazine

The basics

The basic TVRO system of 1984 differs somewhat from the basic TVRO system of 1979/80 because of the number of subtle (and not so subtle) advances in technology. But the elements of the system have not changed.

For example:

1) Satellite microwave energy is radiated from a satellite some 22,300 miles above the earth. That energy is usually (but not always) "directed" at a specific portion of the earth (known as the *boresight*).

2) On the earth, the TVRO must have a clear (not obstructed) view of the satellites of interest.

3) The TVRO dish is some form of parabolic (usually) reflector. It acts like a giant (well, large) collector, capturing the satellite's (weak) signals and re-directing them into a tight *focal point* in front of the dish.

4) There, a small antenna called a *feed* picks up the focused energy and couples it directly into a special signal-booster called an *LNA* (*L*ow *N*oise *A*mplifier).

5) The LNA amplifies the signal and sends it through a short length of "premium-grade" cable (typically RG-213/U or 214/U) to a rear-of-antenna mounted box called a *downconverter*.

6) The downconverter has a local oscillator, a mixer, and some amplifier stages inside a typically semi-weatherproofed metal enclosure. The downconverter takes the 4-GHz (3.7 to 4.2 GHz) signal and shifts it "down" to a lower frequency; 70 MHz is typical.

7) That IF signal is now transported inside (the home, office, etc.) using relatively low-cost RG-59/U or RG-6/U cable.

8) Inside, the IF signal is connected to a *demodulator* that filters and amplifies the signal and then demodulates it (turning it into pure video and pure audio).

9) The video and audio can now be used to re-modulate a low-power RF modulator with an output on (NTSC) Channel 2–6. That signal, usually under +10 dBmV (3,000 microvolts) is now connected to a standard TV receiver and you have satellite TV.

That's the basic system; then, and now. There are many, many variations to that system and we'll touch on the primary variations as we work our way through the elements.

Basically, this is what we will find. The 1979/80 TVRO was big, bulky, and expensive. The pictures were not bad by 1984 standards (some will say they may have been better than today) but the equipment was designed by the technically oriented for the technically oriented. In other words, it was not consumer-friendly. You had to be very much "into the technology" to appreciate the six to eight steps you had to follow just to change channels (*transponders* in satellite talk), or horror-of-horrors, switch from one satellite to another. Little old ladies in Dubuque were not able to operate the unsophisticated systems of five years ago.

Big has gotten small (we'll see some 4.5- and 5-foot antennas that work exceedingly well in the months ahead); bulky has gotten tiny (full receivers fit into the plam of your hand); and expensive has gotten less so, thanks to modern, often off-shore, high-production technologies. It is, certainly, an entire new ballgame for everyone involved.

But perhaps something else has happened that is even more significant, especially if you are involved in the operation of an electronics retail or service outlet. There is a new recognition that professionalism in sales and installation is perhaps more important than all of the technology advances and price declines. Customer support—always important with new technology—is starting to be seen as essential. Dealers, through a trade association and through regional groups, have finally figured out that cut-throat price cutting and selling $100 over cost is a sure path to failure. Those who have survived that recent (and still on-going) shake-out are now aware that being a TVRO dealer, or selling TVRO systems, is one of those "long-pull" businesses that rewards best those who plan for a multi-yeared future. It has finally gotten past the lure of being a get-rich-quick scheme and that may be more important to established electronic sales and service centers than all of the technology advances combined.

And much of that is due, of course, to volume. Going into the start of the summer, there were between 475,000 and 500,000 TVRO's operating in North America (including Canada). The present fall selling season was expected to see numbers such as 50,000 per month during the traditionally "up" September/November period. Some of us recall when selling 50,000 VCR's in America was big news for a single month.

Next time, we'll continue our comparison of the past and present states of satellite TV. **R-E**

TVRO dealer "Starter Kit" available

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

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

NEW IDEAS

Continuity tester

MAKING CONTINUITY CHECKS CAN BE A tedious undertaking, especially if you happen to be working with wire-wrap circuits. Of course, you could use an ohmeter to do the job, but continuously turning your head back and forth to read the meter can be a real pain in the neck! There is, however, a way that you can check continuity (and make sure that the resistance is less than about one ohm) without "twisting your head off." All you need do is rig up some sort of audible continuity tester, like the one shown in Fig. 1.

How it works

Power for the circuit is provided by a single 9-volt, transistor-radio type battery. At the heart of the circuit are two LF411 op-amp IC's: One op-amp, IC1, is used along with resistors R1 and R2 to form a ground reference for the circuit; in effect, producing a 4.5-volt split supply. The other op-amp (IC2) is configured as a comparator whose output used is to source current for the buzzer.

Resistors R4 and R5 form a voltage-divider that provides a reference voltage that is applied to pin 2 of IC2. The circuit to be tested is connected between points A and B via jumpers. The resistance offered by that circuit along with resistor R3 forms a second voltage divider. That leg of the circuit provides the voltage that's presented to the non-inverting input (pin 3) of IC2.

When a non-continious (open) circuit is connected across points A and B, the voltage appearing at pin 3 of IC2 will be high; therefore, its output will be high and no current flows through buzzer BZ1. However, when a continious circuit is connected to points A and B, the input to pin 3 will be low, thereby causing the output of IC2 to go low. That completes the current path for BZ1, and causes the buzzer to sound indicating a complete circuit.

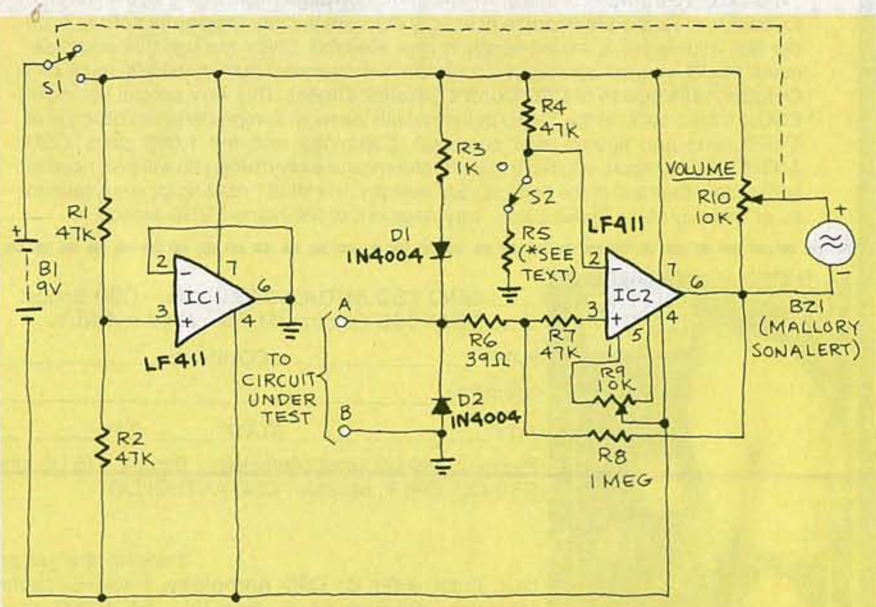


FIG. 1

Diodes D1 and D2 along with resistor R7 provide protection for the unit in the event that it is accidentally connected to a live circuit.

To calibrate the unit, connect a 47-ohm resistor at R5 and a 1-ohm unit at across points A and B. Now adjust potentiometer R5 until the buzzer just comes on. Resistor R9, which adjusts the circuit's sensitivity, should be a multi-turn, trimmer potentiometer. The maximum current through the circuit being tested will be about 4.5 milliamps.—*Ron McCabe*

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

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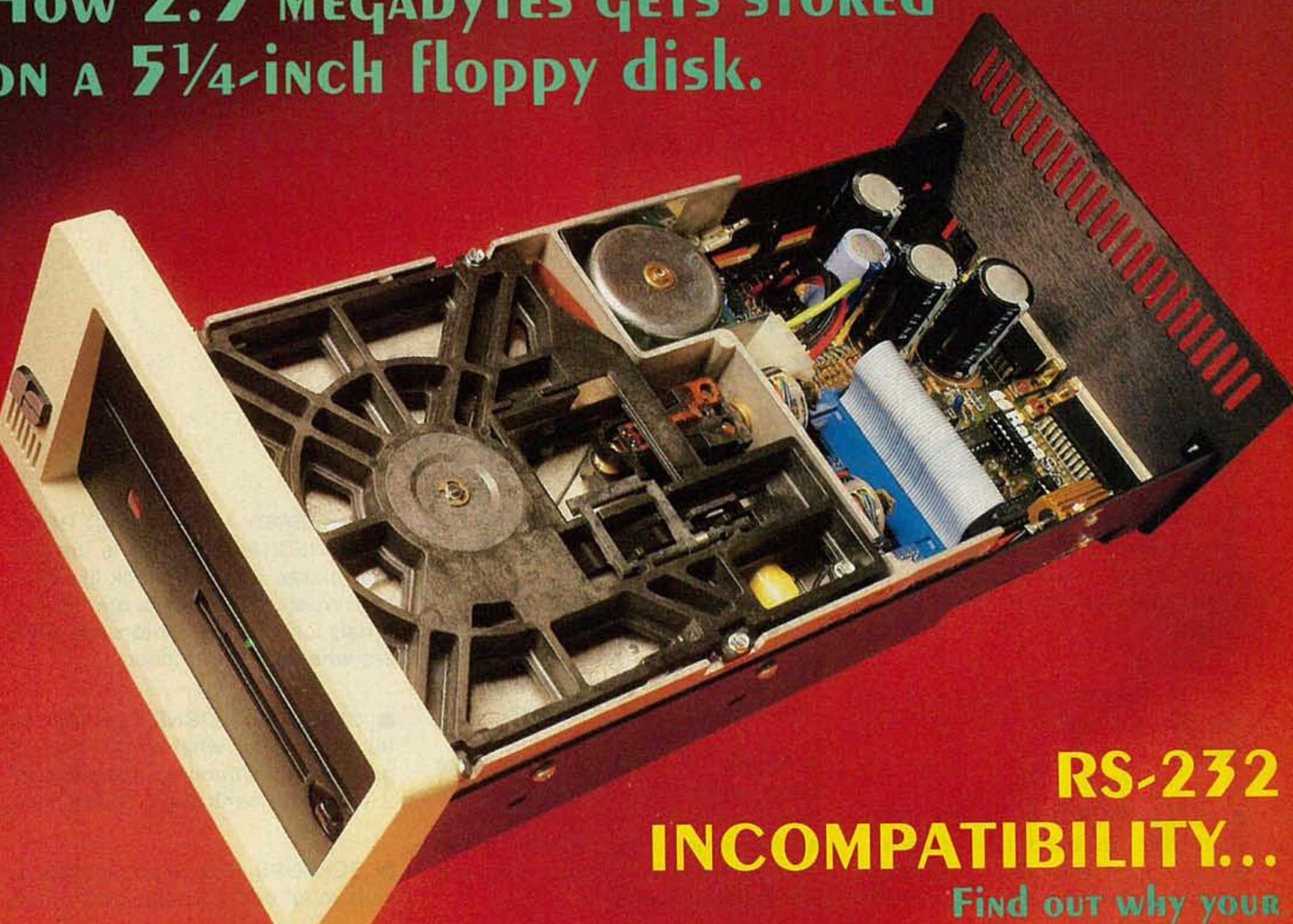
VOL. 1 No. 7 November 1984

COMPUTER DIGEST

NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

SUPER-HIGH DENSITY FLOPPY DISK DRIVES...

How 2.5 megabytes gets stored on a 5¼-inch floppy disk.



RS-232 INCOMPATIBILITY...

Find out why your computer won't talk to your serial printer.

COMPUTER-AIDED DESIGN...

Put your computer to work designing audio networks.

A GERNSBACK PUBLICATION

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The evoluation of the floppy disk is fascinating. We've gone from single-sided, single density to two-sided, double density, and now RANA introduces what appears to be the ultimate... A disk that can cram 2.5 megabytes of information into the same amount of space. To find out how they do it; **see page 5.**

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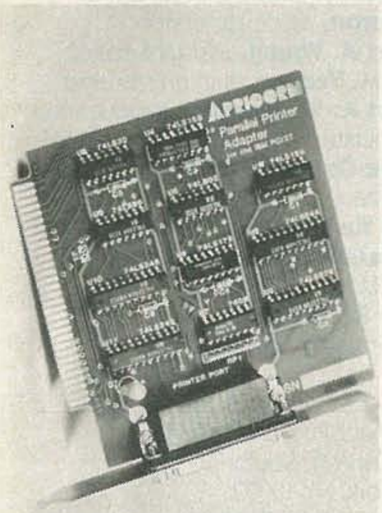
COMPUTER PRODUCTS

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

PLUG-IN INTERFACE ADAPTERS, the Apricorn *Parallel Interface Adapter* (shown in photo) and the Apricorn *Asynchronous Communications Adapter* are compatible with the IBM *PC/XT* and work with all operating



CIRCLE 111 ON FREE INFORMATION CARD

systems and software packages available for the IBM-PC and IBM-XT. Each card is fully burned-in and tested, and is backed by a lifetime warranty.

The *Parallel Interface Adapter* creates a parallel I/O interface accessible through a connector at the rear panel of the computer system, providing control of numerous printers with parallel (or Centronics) type interfaces.

The *Asynchronous Communications Adapter* provides a fully programmable RS-232 serial interface for communication with a variety of devices, including printers, modems, terminals, other computers, and plotters.

Both boards carry a suggested list price of $119.00.—**Apricorn,** 7050 Convoy Court, San Diego, CA 92111.

MULTI-CHANNEL SWITCH/SPOOLER, model *SX-60* serves up to four computers and feeds two printers simultaneously. Any of the four input computers can direct its outputs to either of the printers. All switching is under software control.

Spooler buffer sizes of 8, 32, or 64K store from 2.5 to 20 pages of dense, single-spaced text. For busy installations, an expansion board can increase the spooler's buffer capacity to 384K, 120 pages. Standard configuration is four computers in, two printers out, or two printers in, four printers out. Using jumpers, the model *SX-60* may be configured for 5 in, 1 out; 3 in, 3 out; or 1 in, 5 out.

The model *SX-60* will accept serial data on each channel from 150 to 19,200 baud with each computer at a different baud rate. Printers also may be set from 150 to 19,200 baud with each printer at a different baud rate—for example: a letter-quality printer at 2400 baud and a dot-matrix printer at 1200 baud. A variety of serial-serial

CIRCLE 112 ON FREE INFORMATION CARD

and parallel-serial combinations are available. All conections are made through 25-pin D connectors at the rear. A copy function is provided for multiple copies of documents.

Prices for the model *SX-60* start at $469.00.—**Kearsarge Industries, Inc.,** Reston, VA 22091.

CIRCLE 68 ON FREE INFORMATION CARD

NEW HIGH DENSITY DISC DRIVE

Fig. 1—THE RANA 2.5 SUPER FLOPPY-DISK SYSTEM is capable of storing 2.5 megabytes on a 5¼ inch floppy diskette. It ushers in a new era in high-density storage devices.

Here's more storage power for your computer.

MARC STERN

At last, a floppy-disk-drive manufacturer has broken the 2-megabyte barrier. Rana Systems has developed a floppy-disk-drive that interfaces with the IBM *Personal Computer* and IBM-*PC XT*. Called the Rana *2.5 Super Floppy Disk System*, this super high-density storage device is capable of storing 2.5-megabytes of formatted data (3.3 megabytes unformatted) on a single 5-1/4-inch floppy diskette.

The *Super Floppy*, which, according to Rana has been in development for 2½ years, takes advantage of microprocessor control and LSI (*Large-Scale-Integration*) techniques. The head-movement commands are under the control of a closed-loop servo system.

The Rana drive

Rana developed their *Super Floppy* system in conjunction with Drivetec. The read-write heads—there are two—are made of manganese zinc ferrite and are mounted on a carriage which is located on precision guide rods that insure accurate radial motion. Head positioning is accomplished on a closed-loop basis, using servo data recorded between each sector of the (pre-formatted) diskette.

A special disk-controller card, which fits into one of the IBM-PC's expansion slots, is required. It communicates with the microprocessor via the IBM system bus and replaces the standard IBM disk-controller cards. This card will support up to four drives. For instance, a PC user can have two standard, 360K floppy-disk drives installed and 2 Rana *Super Floppy* drives.

The drive itself uses two stepper motors, which work in concert with the drive's controller circuitry, to correctly position the read-write heads. The first motor is a coarse stepper and finds the particular track—there are 160 per side—while the second motor is a fine stepper which brings the read-write head to the correct sector. It must maintain an accuracy of 200-microinches.

The direct DC drive motor is on continuously. The acquisition time for data loading is 35 milliseconds; track-to-track access time is 0.3 ms. The direct-DC drive motors "come up" much more quickly than AC units.

A brief walkthrough

A standalone unit, the *Super Floppy*, is a good example of the super high-density units now appearing

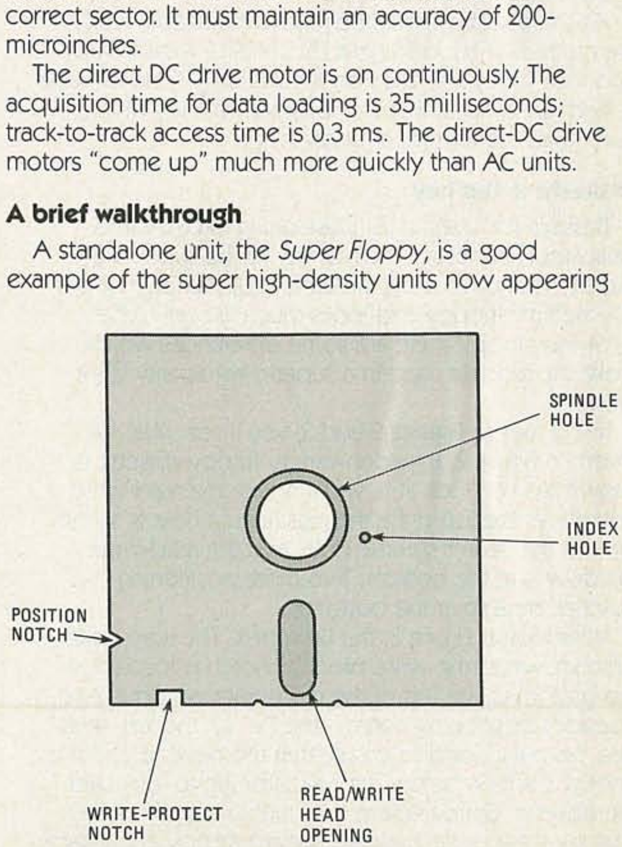


Fig. 2—AN ORDINARY DISKETTE shows the notching that we are all familiar with. Compare this with Fig. 3.

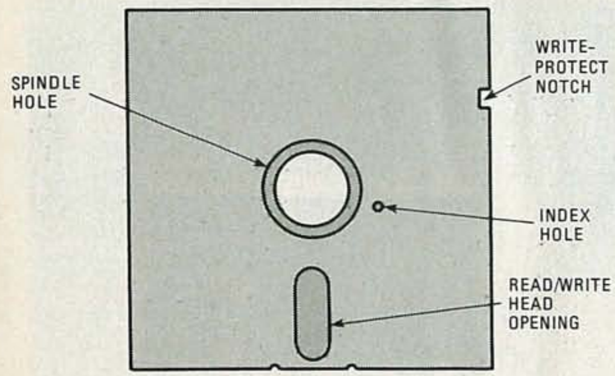


Fig. 3—THE RANA DISKETTE has entirely different notching. This means that you cannot substitute an ordinary diskette in the Rana drive.

on the market. When the power is turned on, the drive remains inactive until a diskette is inserted and a special latch at the front is closed, at which time, the drive's center spindle comes up and centers the diskette. A cone drops as the motor comes on and runs continuously at 360 rpm (the standard 8-inch floppy-disk rate). Optoelectronic circuitry reads a special notch in the diskette to ensure that it has been positioned properly (See Figure 3) and the drive further checks other position-sensing circuitry at the spindle to ensure that the diskette remains centered. A user can't remove the diskette because the latch locks the diskette into place. The latch must be opened before the diskette can be removed.

As the diskette spins, the read-write heads, which are controlled by intelligent LSI circuitry, look for Track 0 and look for bad sectors on the diskette. If the diskette is bad, it indicates that to the system board, which, in turn, gives the user an error message.

Diskette is the key

Besides the special LSI positioning circuitry and dual-stepper motors, the real key to the super high-density disk drive is the diskette itself. Although it is a 5¼-inch minifloppy and looks much like any other 5-1.4-inch foppy, there are some differences which make the diskette used in a super-high-density drive unique.

If you look at Figures 2 and 3, you'll see what we mean. In Figure 2, a garden-variety floppy diskette is shown. As you look at it, you'll notice the read-write notch is at the top right; the positioning hole is to the right of the center spindle hole, and the read-write window is at the bottom. Two more positioning notches are also at the bottom.

Now look at Figure 3, the Rana disk. The read-write (also known as the write-protect) notch is located at the bottom to the left of the read-write window. And, a special positioning notch—the "V" on the left—has also been included to ensure that the diskette is in the correct position before the heads begin to look over the diskette. Optoelectronic circuitry reads this notch. That means you can't use a standard floppy in the Rana drive. Instead, you must use one supplied by Rana, which costs about $15, at the moment. (Rana officials expect the price to drop to about $8, when more super high-density drives appear on the market.

In reality, these super high-density disks are quad-density storage diskettes. Using modified frequency modulation (MFM), as many as 160 tracks of information can be laid down per side. (Single-density disks use one recording head and 36 to 40 tracks. Double-density disks use one recording head, modified frequency modulation, and effectively double the amount of information capability, and quad-density disks use both sides and double the number of tracks per side. Double-sided, double-density disks use both sides, but have only 40 tracks per side, while quad-density disks have 80 tracks, effectively doubling the amount of information capability. The key to the ability to double the information capacity with recording technique relies on the type of modulation used. With standard FM techniques, a certain amount of timing and address data is stored along with the digital data. Each byte of data on the disk not only has digital information, but also timing and address information. With MFM, only digital and address information is stored, effectively freeing a great deal of space for further information storage. Timing is supplied by read-write head intelligence.)

Servo information

Equally as important as the disk media and recording technique is a method of storing positioning information on each super high-density disk. Rana calls this information the "servo" information and stores it in between each sector along a track. (Rana uses 17 sectors per track.)

In operation, the disk read-write head interacts with this servo information for precise head positioning. It reads the positioning data in each sector and finds the ones which hold the file of data or program the user asks for.

The servo information is preformatted on each diskette supplied by Rana and this is the reason you must buy the diskettes from them or their dealers. The servo information, which acts as header data for the read-write head, lies before the sector ID header on each track (See Fig. 4.)

In operation, the read data is decoded and the servo data is presented to two electronic devices. The first does a digital identification of the servo patterns, while the second compares the amplitude of the left and right servo signals and repositions the stepper motor toward the center line of the recorded data.

The read-write head constantly looks for servo data on the disk and constantly updates itself and repositions itself. Special circuitry also compensates for thermal and humidity-related expansion or contraction of the diskette and for other mechanical tolerances of the drive.

A little history

If you've been a personal computer user for more than a couple of years, you probably remember the first disk drive you purchased. Think about it for a couple of minutes. When you purchased that first disk drive for your first personal computer, it was probably a "state-of-the-art" storage device, capable of holding about 90K of data. It made no difference whether your system was an Apple, a CP/M machine, or one of the Radio Shack computers: The amount of storage was probably about the same, give or take a few thousand bytes.

It all seems an age-and-a-half ago, but it really wasn't. Single-sided, single-density disk drives were the standards of the industry as recently as three to four years ago. That type of disk drive—still used by many computer owners—had a storage capacity that was limited not only by its format, typically 36 to 40 tracks, but also by the method used to store data on the disk.

With a single-density disk drive, each range of frequencies that's recorded represents not only the data, but also certain timing and address information which enables the computer to find specific files or data on the disk. That manner of encoding data on the disk effectively limited the amount of data which could be stored to about 90,000 bytes of usable space.

However, new ways to cram more data onto storage disks were found. An example is modified frequency modulation or MFM. Using that technique, which strips away the necessity of using a constant clock pulse for timing information, the amount of data that could be stored on a diskette was effectively doubled.

Still designers weren't content and they saw a vast wasteland on the unused side of the disk. So they included a second read-write head opposite the already-existing read-write head and effectively doubled the disk capacity again.

However, the number of tracks remained the same. Each side of the disk had only 40 tracks, or 80 tracks total. The reason this number remained the same is because the technology didn't exist to increase the number of tracks and add even more storage. Like the car industry's downsizing program where the first gains—cutting weight—were easy because all they had to do was substitute materials, the early gains in mass storage were fairly easy because all that had to be modified was read-write technology. When it came to further gains,more-elaborate circuitry, some of which hadn't been developed in 1981, had to be created.

Until this time, there was a fair amount of leeway in read-write head positioning because the requirements weren't as critical as might be. Potentially, a 5¼-inch floppy disk could store far more than just 360K but any increase in the amount of storage couldn't be reached

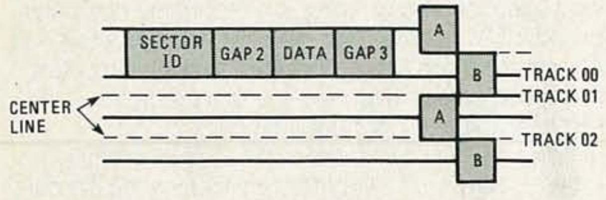


Fig. 4—SERVO INFORMATION acts as header data for the read-write head. It lies before the sector ID header on each track.

because the head positioning required was far too critical.

But, disk drive designers weren't about to let that stand in their way. They continued their work until they were able to lay down double or more the number of storage tracks on the disk. Thus, the 40-track disk became the 80 to 96-track disk and, as a result, the amount of information that could be stored increased by a factor of two and disks could store as much as 720K of data. These quad density disks were state-of-the-art until disk drive developers moved toward the 1 megabyte barrier.

Disk drives from such companies as Amlyn, Tandon and Rana use precise positioning servos and super-precise positioning circuitry to achieve information densities as high as 2.5 megabytes of storage, and have reached a new plateau in floppy disk storage technology.

What it means

The advent of the super high-density disk has several advantages for the microcomputer user. First it is a good way point in the seemingly inevitable trek to a hard disk and, second, when you reach the hard disk, it is a good backup device.

At one point or another in the life of every microcomputer user, there comes a day when ordinary floppy disk drives just aren't enough, for whatever reasons, whether business, professional or personal. Quite likely, this point is reached where several programs are used frequently and different data files are accessed in succession.

Using floppy disk drives, at this time, can become torture because you must constantly switch disks to change programs or data disks.

At this time, the small-computer user probably wishes he had a hard disk drive to accommodate at least his highly-used programs and files, especially because of the high-density storage potential and because of the speed of program or data access. Hard-disk drives spin at 3,600 rpm and information on them literally leaps onto the screen.

However, the user also probably can't justify a hard disk on the grounds of expense, so he must remain with a dual-drive system.

Super high-density disks solve this quandary because they offer prodigious amounts of storage and are less expensive than hard disk drives. So, this type of drive is a good way point in the move to the hard drive.

Unless the computer user is willing to invest in a costly streaming tape cartridge drive, then he must back up his hard disk with floppy diskettes. On the IBM *PC*, that will take about 28 standard diskettes and require the better part of an afternoon. With a super high-density disk, however, it takes only four diskettes to back up the hard disk and it's a much speedier proposition. The super high-density disk has a transfer rate of 500 kilobits per second.

So, from many viewpoints the super high-density disk makes sense. It's only a recent development, but it's likely the rest of the industry will soon follow suit.

PRINTER PROBLEMS II

Last month we examined parallel printers. Now serial printers come under the spotlight.

HERB FRIEDMAN

■More often than necessary, the best of intentions lead to even greater problems, frustrations, or outright disasters. The *RS-232C serial printer interface* is a classic example of how to make something that is inherently simple into something so complex that it is often beyond the ability of non-technical users.

How teletypewriters work

The original teletypewriters were mechanical marvels that used the interruptions in a closed circuit—a current loop—to exchange information between several machines or printers. As shown in Figure 1, the teletypewriter consisted of two completely independent devices—a keyboard and a printer—though both units were generally housed in the same cabinet. The complete teletypewriter, consisting of a keyboard and printer was called a KSR—for *K*eyboard *S*end *R*eceive. If the printer was housed in its own cabinet, it was called an RO—for *R*eceive *O*nly.

The loop current—called the *mark* (standby) current—was provided by a power supply or batteries. Depressing any key on the keyboard caused the motorized keyboard machinery to produce an interruption to the current loop—called a *space* which all machines in the loop recognized as the "start" signal for the next character. The time period used for the space interruption to the current was called a "bit." (It had nothing to do with the binary code.) Following the space, the machinery produced a series of five bits consisting of marks and spaces which represented characters. Each character was represented by its own specific pattern of marks and spaces, which the printers recognized as the character to be printed.

The bit timing is extremely critical. If the space and character bits weren't transmitted within a specific time period, the printing mechanisms got out of synchronization and produced random characters—"garbage." To insure that all machines started and ended together, after the five *character bits* were transmitted, the keyboard returned the current loop to the marking state (current flow), which the printers recognized as the "end of character" and "standby" for the next character. Because of "slop" (tolerances) in the mechanical system, the minimum length of time for marking current before the next character was started was standardized at the equivalent of 1.5 or 2.0 times the bit length. This was enough time for the machine to get ready to receive the next character. The time required for all the bits necessary to transmit one character—the start, character and stop bits—is called the *frame*.

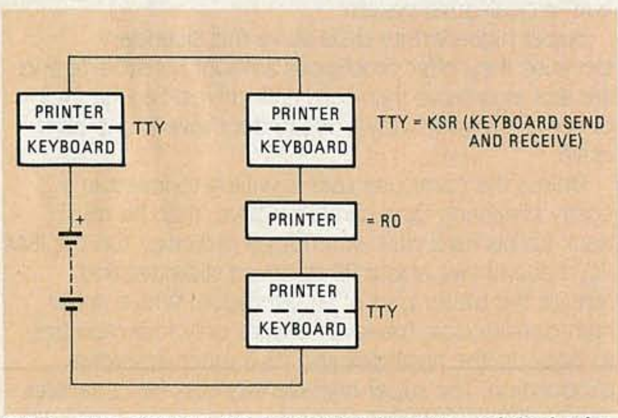


FIG.1—THE SERIAL I/O is derived from the original teletypewriter system, in which all elements were connected in series and responded to serial loop current interruptions that represented characters and control functions.

Reliability

In order to transmit both upper and lower case characters and to provide for a quick-and-dirty way to test the reliability of the transmission, the number of character bits were eventually increased to eight: seven bits to produce the ASCII character set and control codes, and one bit—called the *parity bit* —for testing the reliability of the communications path. (Later, instead of the eighth bit being used to indicate parity, it became part of the character code for transmitting or printing graphic symbols.)

The mainframe computer and teletypewriter terminals that connected to a computer via modems were essentially a *communications system*. The same is true for the printers driven by modems which could print information originating at a mainframe computer or a KSR TTY terminal. (For example, many doctors had RO units (printers) that connected through a modem and a dedicated telephone line to a medical laboratory. Test results from a patient's blood samples—which had been sent to the laboratory—were instantly transmitted to the printer in the doctor's office.)

Notice that in every instance, except when the terminal is connected directly to the computer, there is a modem before or after the TTY device—the whole system is meant for communications.

The RS-232C I/O is born.

While effective, the current loop was unweildy and lacked hardware handshaking, and so an "industry group" came up with the RS-232C I/O, an electronic replacement for the current loop. RS-232C substituted variations in a DC voltage level for the current loop and also provided special DC voltages for hardware handshaking, a means whereby one item of equiupment knows if another is turned on or ready to accept data, or capable of transmitting.

But the RS-232C standardization was meant for the mainframe—or dinosaur—age of computing, and so RS-232 was designed for communications. Its connections—shown in Table 1—are entirely communications-oriented.

TABLE 1

TERMINAL	NAME	FUNCTION
1	HGND1	Hardware Ground (often not used)
2	TX	Transmit. Data fed into modem or DCE device from computer or terminal.
3	RX	Receive. Data received by modem from the telephone line (to printer or terminal).
4	RTS	Request to Send (from DTE)
5	CTS	Clear to Send (DCE device ready)
6	DSR	Data Set Ready (DCE device ready)
7	GND	Common signal ground
8	CD	Carrier detect (Modem received carrier)
20	DTR	Data terminal or DTE ready
22	RD	Ring detector. (For auto-modems)

Even for communications, there is a serious problem. When using a current loop, anything connected into the loop will work as long as the *framing* is correct. Every printer in the loop will simultaneously print whatever is entered in a keyboard, and any keyboard can enter a character into the loop. But an electronic circuit using variations in DC voltage level must have seperate send and receive circuits. For example, if RS-232C terminal #2 is input, it's input for every piece of equipment, while terminal #3 is output for every piece of equipment. If terminal #2 of the keyboard is connected to terminal #2 of the printer, absolutely nothing will happen. In order to print, terminal #2 of the keyboard or modem (the output) must connect to terminal #3 (the input) of the printer.

Standards again.

This was understandable by everybody, but there are always people who believe "standards" should be standard even if they don't work. Since it was impossible to have a single set of connections serve as a "standard," the group created two sets of RS-232C connections: One called DCE for *D*ata *C*communications *E*quipment, the other DTE for *D*ata *T*erminal *E*quipment. And the DTE connections mated with the DCE. Anything remotely resembling terminal equipment was considered DTE; anything that originated or passed data into or from a telephone line was considered DCE. A modem, being DCE, could be connected directly to a printer, which was DTE. Unfortunately, none of the connections allowed for the personal computer, and it is this lack of foresight that creates some of the worst interfacing problems with personal computers.

Consider this situation: Your computer has one serial I/O which is used for both the printer and the modem. Since the modem is DCE, the computer's serial must be DTE. Then what is the printer? DTE or DCE? By convention, a printer is DTE because it is meant to be fed by the modem. But we feed printers from personal computers. If the computer's output is DTE in order to drive the modem, it can't drive the printer, which is also DTE.

The hardware handshaking of the DTE computer is also intended for the modem; it expects to see a positive handshake voltage on terminals #4, #5, #6 or #8, or a combination of terminals, when the modem is ready to accept data. This is the exact opposite of what the printer needs because the printer was originally intended to work with the modem in place of the computer. The printer does not need a hardware handshake because it originates the handshake for the modem, or the printer provides a software handshake through pin #2. But if both the computer and printer are providing a handshake on the same terminals neither will know what's going on.

All this—the result of poor compromises and some manufacturers who seemingly go out of their way to make serial connections as difficult as possible—is the reason why what should be a simple printer-to-computer connection becomes a week-long nightmare.

Get the handshake right.

On the other hand, there are a few manufacturers, such as Smith-Corona (printers) and Kaypro and Radio Shack (computers) who go out of their way to make serial interfacing as uncomplicated as possible. For example, Smith-Corona's serial connections use the #20/#4 hardware handshake, meaning, that if you connect the printer's #20 or #4 terminal to the #20 or #4 terminal of any computer's serial I/O *intended for printers* it's all going to work. The serial printer I/O of Radio Shack's *Color Computer* is even easier. There is one single terminal that will work if connected to any printer handshake. Then there is IBM *PC* and its clones, which expect to see a modem connected to the serial I/O. If you use a printer, you must prewire the connections so the computer thinks it's connected to a modem. (Regardless what kind of connections are made between the computer and the printer, keep in mind that handshake polarity must be observed. Some printers provide for either a positive or negative handshake. Know what your computer needs and what the printer delivers before you buy.)

Table 2 shows some of the unusual wiring problems you may run across. All three computers, the IBM *PC*, the Kaypro *II* and the Texas Instruments *Professional* have RS-232C I/O intended for a modem, yet note how all three connect differently to a standard printer's

TABLE 2

IBM PC TERMINAL NO.	SERIAL PRINTER TERMINAL NO.
2	3
3	2
7	7
5	20
6, 8, 20	6
KAYPRO II TERMINAL NO.	**SERIAL PRINTER TERMINAL NO.**
2	3
3	2
5	20
6	4
7	7
20	6
T.I. PROFESSIONAL TERMINAL NO.	**SERIAL PRINTER TERMINAL NO.**
2	3
3	2
4-5 (short)	NC (No Connection)
6	20
7	7
8	4
20	6

RS-232C input (Diablo *620*). Essentially, the connections trick the computer into thinking it's connected to a modem rather than a printer.

Getting it all together.

Any one mistake in serial interfacing, from the number of characters, stop or total bits, to the signal or handshake connections, can stop your printer cold—or cause it to print "garbage." But if you initially set up the printer in a specific order, giving attention to what appears to be the most insignificant details, you should be able to have it running at the first try. Just keep this one fact in mind at all times—regardless of the variations in connections, labelling or whatever, if *the printer* employs a DB-25 connector terminal #3 is always the data input. Do not get confused by DCE, DTE or any other nomenclature. If the printer was intended to work with a personal computer, it's looking for data on terminal #3. If it has a hardware handshake it's either #4, #20 or both, with the user selecting the one to use. If it has a software handshake (ETX/ACK or X-on/Xoff) the handshake comes from terminal #2. (There might or might not be other connections.) Inexpensive serial printers can generally work with only a three-wire connection; signal, ground and handshake.

First things first.

Serial printers have switches or a patch panel (small jumpers) that set the various parameters and functions. You must set them for the printer's baud rate and character bits. Baud rate is no problem: the computer's manual specifies the output baud rate or tells you how to program the computer for the desired baud rate. The number of character bits is something else. If the computer's serial output is programmed for eight bits, even if it is only using seven bits per character the printer must account for all eight bits. In some printers, if seven character bits are programmed, the eighth bit is always a parity bit: either on or off, but there is either a mark or space bit to fill the void. on the other hand, some printers don't recognize the eighth bit if the parity isn't specified as *even* or *odd*: if not specifically programmed for the eighth bit, the printer looks only for the seven bits between the start and stop bits. This throws the framing off and after the first or second character the printing is "garbage." You can never go wrong if you account for the parity bit. If the computer is specified as "seven bits no-parity" you must set the printer for 7 bits +parity off (8 bits total). You cannot add 7+"no parity" and assume it equals 8 bits. Parity off on a 7 bit printer is a forced space or mark, the printer doesn't care which as long as the stop bit(s) follow at the correct time.

If you think this is confusing, some of the serial interfacing for a very popular computer as given in the set-up manual of a famous, highly-rated printer has been wrong in every printing. What generally happens is that after many futile hours of effort, the user telephones that printer manufacturer's service department and finally gets the correct switch settings over the phone. (No, I will not embarass them by mentioning names. The parity bit problem has happened to the best and worst of printer manufacturers.)

Part of the framing includes the stop bit(s). Normally, above 110 baud only one stop bit is used. However, there are computers that use two stop bits (the Radio Shack *Color Computer* is one of the more popular). Normally, the modern printer will function with only one stop bit because it frames only the first stop bit and accepts the voltage transition that takes place with the following start bit (the space) as the beginning of the next character. On the other hand, a few printers frame to the second stop bit, and you *must* set the computer to provide two stop bits.

The hardware handshake.

Except for an unbelievable blunder by one of the major foreign manufacturers, the serial hardware handshake for a printer with a DB-25 connector is always printer terminal #20 and/or #4: Usually, it's only #20. Software handshaking—the ETX/ACK or DC1/DC2 (which is also called X-on/X-off)—is always through printer terminal #2.

If your computer's RS-232C is specifically wired as a printer port (DCE) you simply bring the signal and handshake wires straight across, #2 to #2, #7 to #7, #20 to #20, etc. If the computer has an RS-232C I/O which is wired for DTE for connection to a modem, but which is software programmed for a printer, you have big trouble because the wiring at the computer's connector can vary from model to model.

Depending on the particular printer and computer being used, some of the connections might not be required or even exist. That's when the going gets sticky. Unless you have the detailed connections for a particular combination of printer and computer, you might never get the printer working if the computer does not have a true RS-232C printer I/O. Contact the manufacturer of the printer if you have any doubts. They usually can give you the connections over the phone.

COMPUTER-DESIGNED AUDIO NETWORKS

This program eliminates the hard work in designing impedance-matching networks and attenuators for audio systems.

FRANK GALDES

■Ever since the early days of the telephone, attenuator networks have been used to control sound levels and to match impedances. Technicians, hobbyists, and experimenters who work with audio equipment and circuitry often find that a particular piece of equipment has an input (or output) impedance or line level that does not meet their requirements. In many of those instances, a commercially manufactured attenuator network is not readily available to solve the problem. Of course, you don't need a commercial network—you can put one together yourself.

Only four networks—the T, H, L, and U—will be considered. The T network consists of three resistors connected in the form of a "T," as shown in Fig. 1-a. It is an unbalanced attenuator. When used between circuits of unequal impedance, it is often called a taper pad. The H-type attenuator is a balanced T pad. It consists of 5 resistors connected in the form of an "H," as shown in Fig. 1-b.

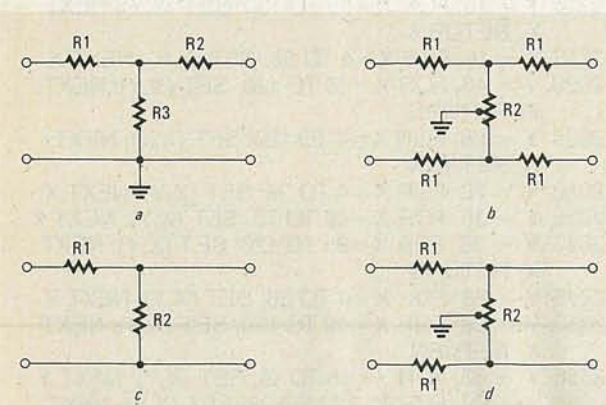


FIG. 1—THE FOUR ATTENUATOR TYPES that the program will help you design. Shown in *a* is a T attenuator, in *b* is an H-type, in *c* is an L-type, and in *d* is a U-type attenuator. Note that the tap on R2 (in *b* and *d*) is at the exact center of resistance.

An L-type attenuator, shown in Fig. 1-c, is perhaps the simplest form of attenuator, consisting of two resistive elements configured in the form of an "L." The L pad does not reflect the same impedance in both directions.

A U-type attenuator, shown in Fig. 1-d, is most often used matching a high impedance to a low impedance.

Before the era of personal computers or hand-held calculators, much time was spent using network formulas, dB charts, and possibly a slide rule to calculate the resistor values for one of those networks. Those calculations were time-consuming and tedious, especially for those not mathematically inclined.

The computer program shown in Table 1 will do all the lengthy calculations in seconds, after you choose one of the 4 networks, enter the line impedance, and the loss (in dB) desired (if applicable). It will then draw the circuit diagram showing the resistor values, the input and output impedances, and where the circuit may be grounded if necessary.

The program is written for the *TRS-80 Model III* with 16K, but it should be adaptable to other computers as well. Note that in the following program a bracket ([) indicates an exponent.

TABLE 1—AUDIO-NETWORK DESIGN

```
 5 CLS; PRINT
10 PRINT "DESIGN AN AUDIO LINE IMPEDANCE
   MATCHING NETWORK OR ATTENUATOR":
   PRINT: PRINT
15 PRINT " KIND", "Z IN/OUT",
   "CONFIGURATION", "SELECT ONE:":PRINT
20 PRINT " T", "EQUAL/TAPER",
   "UNBALANCED","1"
25 PRINT " H", "EQUAL/TAPER",
   "BALANCED","2"
```

```
30 PRINT " L", "TAPER", "UNBALANCED", "3"
35 PRINT " U", "TAPER", "BALANCED","4"
40 PRINT
45 INPUT"ENTER NUMBER FOR CIRCUIT
   DESIRED";S
50 ON S GOTO 1ØØ, 2ØØ, 3ØØ, 4ØØ
7Ø PRINT "ERROR -- DO OVER": GOTO 45
1ØØ CLS: PRINT: PRINT: PRINT " INPUT AND
   OUTPUT IMPEDANCES ARE EQUAL,
   SYMMETRICAL:....1"
1Ø5 PRINT: PRINT " INPUT AND OUTPUT
   IMPEDANCES ARE NOT EQUAL, TAPER:....2"
11Ø PRINT: PRINT: INPUT "ENTER NUMBER FOR
   CIRCUIT DESIRED" ;N
115 ON N GOTO 12Ø, 15Ø: PRINT "ERROR = DO
   OVER": GOTO 11Ø
12Ø CLS: GOSUB 51Ø: CLS
125 RA=INT (Z*( (K-1)/K+1))):
   RC=INT(Z+K)/(K[2-1))):A=Z: B=Z
13Ø RA=RA+1: IF S = 2 THEN 2Ø5:CLS
135 T$="T": B$="UNBALANCED":
   I$="SYMMETRICAL": U$="MATCH
   IMPEDANCE AND REDUCE POWER LEVEL.
14Ø GOSUB 1ØØØ: GOSUB 1Ø2Ø: GOSUB: 1Ø55
145 GOSUB 2ØØØ: GOSUB 2Ø25: GOSUB 2Ø25:
   GOTO 3ØØØ
15Ø CLS:GOSUB 5ØØ:GOSUB 53Ø:GOSUB
   525:CLS
155 KA=(K-1)/(K+1):KB=(K[2-1)/(2*K):
   RC=INT((A+B)/(2*KB))
16Ø RA=INT(((((A+B)*KA)+(A-B))/2)
165 RB=INT((((A+B)*KA)-(A-B))/2)
17Ø RC=RC+1:IF S = 2 THEN 25Ø
175 T$="T": B$="UNBALANCED";I$="TAPER":
   U$=MATCH IMPEDANCE AND REDUCE
   POWER LEVEL"
18Ø GOSUB 1ØØØ:GOSUB 1Ø25:GOSUB 1Ø55
185 GOSUB 2ØØØ:GOSUB 2Ø25:GOSUB 2Ø55:
   GOTO 3ØØØ
2ØØ GOTO 1ØØ
2Ø5 RA=INT (RA/2):RB=INT(RB/2)
218 CLS
215 T$="H": B$="BALANCED":
   I$="SYMMETRICAL":U$="MATCH
   IMPEDANCE AND REDUCE POWER LEVEL"
22Ø GOSUB 1ØØØ: GOSUB 1Ø5Ø
225 GOSUB 2ØØØ: GOSUB 2Ø3Ø: GOSUB 2Ø55:
   GOTO 3ØØØ
25Ø RA=INT (RA/2): RB=INT(RB/2)
255 T$="H": B$="BALANCED":
   I$="TAPER":U$="MATCH UNEQUAL
   IMPEDANCES"
26Ø GOSUB 1ØØØ:GOSUB 1Ø35:GOSUB1Ø5Ø
265 GOSUB 2ØØØ:GOSUB 2Ø3Ø:
   GOSUB 2Ø55:GOTO 3ØØØ
3ØØ CLS
3Ø5 GOSUB 5ØØ:GOSUB 53Ø: DB=DB+1:
   GOSUB 525
31Ø RA=INT((A/SQR(A/B))*(((K*SQR(A/B))-1/K))
315 RC=INT((A/SQR(A/B))*(1/(K-SQR(A/B))))
32Ø T$="L":B$="UNBALANCED"; I$="TAPER":
   U$="MATCH UNEQUAL IMPEDANCE"
325 GOSUB 1ØØØ:GOSUB 1Ø4Ø:GOSUB 1Ø55
33Ø GOSUB 2Ø15:GOSUB 2Ø25:GOSUB 2Ø55:
   GOTO 3ØØØ
4ØØ CLS
4Ø5 GOSUB 5ØØ: GOSUB 53Ø: CLS:RO=B/A
41Ø RA=INT(A*((SQR(1-RO))/2))
415 RC=INT(A*(RO/SQR(1-RO))):RC=RC+1
42Ø T$="U": B$="BALANCED": I$= TAPER":
   U$="MATCH UNEQUAL IMPEDANCES"
425 GOSUB 1ØØØ:GOSUB 1Ø45
43Ø GOSUB 2Ø15:GOSUB 2Ø45:GOSUB 2Ø55:
   GOTO 3ØØØ
5ØØ PRINT:PRINT:INPUT "ENTER LARGER OF
   TWO IMPEDANCES" ;A
5Ø5 INPUT "ENTER SMALLER OF TWO
   IMPEDANCES";B:RETURN
51Ø PRINT:PRINT INPUT"ENTER THE
   ATTENUATOR IMPEDANCE";Z
515 PRINT "ENTER THE REQUIRED LOSS IN DB"
52Ø INPUT"DB LOSS CAN BE Ø.5 TO 3Ø+ IN
   SOME CASES";DB
525 K=EXP((DB/2Ø)/(LOG(2.71828)/LOG(1Ø)))
   :RETURN
53Ø DB=CINT(ABS(2Ø*(LOG(SQR(1/(A/B
   (((/(1+SQR(1-(1/(A/B)))))/LOG(1Ø)))+1)
535 RETURN
1ØØØ PRINT @ 83, "TYPE: "T$: PRINT @ 1ØØ,B$
1ØØ5 PRINT @ 164, "LOSS IN DB: "DB
1Ø1Ø PRINT @ 147,I$
1Ø15 PRINT @ 211, "USE: "U$:RETURN
1Ø2Ø PRINT @ 338, RA: PRINT @ 355,RA: PRINT
   @ 45Ø,A: PRINT @ 476,RC: PRINT
   @ 5Ø5,A:RETURN
1Ø25 PRINT @ 338, RA: PRINT @ 355, RB: PRINT
   @ 45Ø, A: PRINT @ 476, RC: PRINT @ 5Ø5,B:
   RETURN
1Ø3Ø PRINT @ 338, RA: PRINT @ 355, RA: PRINT
   @ 45Ø, A: PRINT @ 476, RC: PRINT @ 5Ø5, A;
   PRINT @ 594, RA: PRINT @ 611, RA:
   RETURN
1Ø35 PRINT @ 338, RA: PRINT @ 355, RB: PRINT
   @ 45Ø, A: PRINT @ 476, RC: PRINT @ 5Ø5, B:
   PRINT @ 594, RA: PRINT @ 611, RB:
   RETURN
1Ø4Ø PRINT @ 338, RA: PRINT @ 45Ø, A:PRINT @
   476, RC: PRINT @ 5Ø5, B: RETURN
1Ø45 PRINT @ 338, RA: PRINT @ 45Ø, A: PRINT @
   476, RC: PRINT @ 5Ø5, B: PRINT @ 594, RA:
   RETURN
1Ø5Ø PRINT @ 77Ø, "IF NECESSARY GROUND AT
   CENTER OF "RC" OHMS RESISTOR.":
   RETURN
1Ø55 PRINT @ 77Ø, IF NECESSARY LOWER LINE
   MAY BE GROUNDED": RETURN
2ØØØ Y = 16: FOR X=4 TO 36: SET (X,Y): NEXT X
2ØØ5 Y = 16: FOR X=49 TO 7Ø: SET (X,Y): NEXT X
2Ø1Ø Y = 16: FOR X=85 TO 12Ø: SET (X,Y): NEXT
   X: RETURN
2Ø15 Y = 16: FOR X=4 TO 36: SET (X,Y): NEXT X
2Ø2Ø Y = 16: FOR X=49 TO 12Ø: SET (X,Y): NEXT
   X, RETURN
2Ø25 Y = 28: FOR X=4 TO 12Ø: SET (X,Y): NEXT
   X: RETURN
2Ø3Ø Y = 28: FOR X=4 TO 36: SET (X,Y): NEXT X
2Ø35 Y = 28: FOR X=49 TO 7Ø: SET (X,Y): NEXT X
2Ø4Ø Y = 28: FOR X=85 TO 12Ø: SET (X,Y): NEXT
   X: RETURN
2Ø45 Y = 28: FOR X=4 TO 36: SET (X,Y): NEXT X
2Ø5Ø Y = 28: FOR X=49 TO 12Ø: SET (X,Y): NEXT
   X: RETURN
2Ø55 Y = 6Ø: FOR Y=16 TO 19: SET (X,Y): NEXT Y
2Ø6Ø Y = 6Ø: FOR Y =24 TO 28: SET (X,Y): NEXT
   Y: RETURN
3ØØØ PRINT: PRINT: INPUT "PRESS <ENTER> TO
   START NEW CALCULATION.";:GOTO 5
3Ø1Ø END
```

TELE-TOLL TIMER

continued from page 64

edges so that the filter stays in place.) Now feed the telephone and supply cords through the hole in the panel and strip away some insulation. The telephone cord will have four color-coded leads; clip off the yellow and black leads (they are not needed), and solder the red and green leads to the points indicated in the parts-placement diagram of Fig. 8.

Using a piece of hook-up wire, solder one end to the fuse holder and the other to the main board as shown in the parts-placement diagram. Solder one side of the line cord to the free end of the fuse holder and the other to the board. Then mount the holder.

Install the boards in the cabinet. Figure 9 shows the installed unit as viewed from the top: Note that the regulator (IC8) is secured to the rear panel. That grounds the cabinet and also allows the cabinet to be used as a heat sink. Press-on letters can be used to label the project to improve it's appearance. Now, it's finally time to test the unit.

Testing and use

Verifying the operation of the unit is easy. Simply plug T1 into any nearby AC outlet. The display should light showing "000," and then start counting. If it doesn't, first check the power supply and the wiring of IC1. Once you get the correct readout, insert the modular plug into your telephone jack. The elapsed time shown on the display should then freeze and, after about 20 seconds, go out. If it doesn't, again check the IC1 wiring. If everything is OK, your telephone timer is ready for use.

Now, anytime the phone is picked up, the display will light and the unit will begin counting. By periodically checking the display (during your conversation), it's easy to hold down the time you spend on the phone—just think about how much each minute costs as you are reminded by bright LED's about just how much time you're spending talking (or listening)!

We should note that, in addition to timing phone calls, the unit is great for other timing tasks around the house as well. To use the unit as a simple timer, just disconnect the telephone plug and it starts counting. To reset the timer, unplug T1 and plug it in again when you are ready to start timing. Of course, it's also easy enough to add a manual reset switch for that purpose.

As a side note, try timing the next sales call you get. You'll be amazed at how long some of them last—five minutes or more. Surely there are better things to do with your time than listen to sales pitches over the phone! **R-E**

DESIGNER'S NOTEBOOK

Motor speed control

ROBERT GROSSBLATT

SMALL DC MOTORS, LIKE THOSE USUally found in toys, can be really handy things to keep around. They can be used in a variety of applications where the circuit you're designing has to move something other than just electrons. Those motors are great for control applications or just about anything else you can think of that doesn't require a great deal of precision.

However, those small DC motors have their own set of problems. For one, the motor's speed is notoriously dependent on the applied voltage. But that drawback can be turned into a benefit with the simple addition of a rheostat or potentiometer to make the motor speed variable. However, anyone who's ever tried making a motor-speed control using that principle, soon discovers that it's terribly unreliable, and it's an inefficient way to go about things.

No matter how small the motor, you still have to deal with the fact that they all have a certain amount of inertia, however small. That means that regulating really slow speeds with just a potentiometer is almost impossible. It usually requires that you get the motor going first and then back the potentiometer off until you achieve the desired speed.

Not only that, but if the motor draws a substantial amount of current, you're going to find that standard potentiometers won't be able to handle the power requirements: They'll start smoking and that will be the end of that. More expensive potentiometers can be used, but you'll still have the same low-speed problems. Obviously, there has to be a better way—and there is!

Controlling DC motors

Another way of controlling the speed of a DC motor is shown in Fig. 1. Here instead of controlling the motor by varying the voltage, we simply apply a constant voltage and vary the duty cycle. All that means is that we'll control the amount of time the motor is on and allow the applied voltage to remain constant. By doing things that way, the inertia of the motor can be made to work on our behalf because it will keep the motor turning until the next pulse is applied to "kick" it along. Therefore, how fast the motor turns depends on the controlling oscillator.

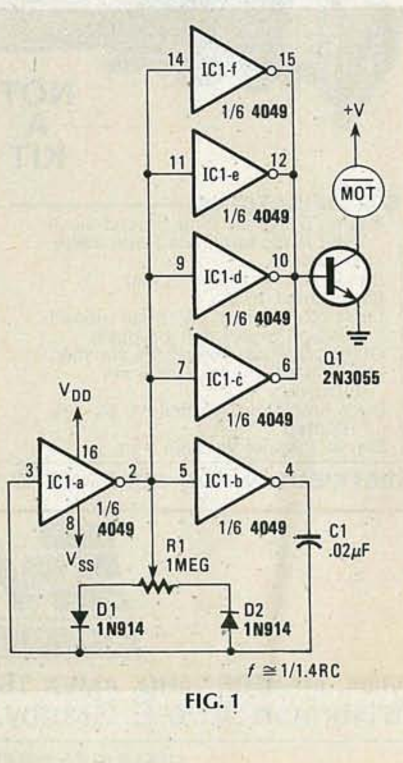


FIG. 1

Now, there are many ways to build an oscillator that can be used to control a motor. We've already seen that oscillator design is a wide open field and just about any combination of circuit building blocks can be used. Transistors, logic gates, 555 timers, and so on can be used to form the basis of a perfectly workable circuit. Each has it's own advantages and disadvantages.

Figure 1 shows an oscillator circuit that may be used in motor-speed control applications: It is by no means the absolute last word in—or the best approach to—solving the problem. It is, however, one way to go about it and is perfectly workable in a wide variety of applications. In any event, that circuit will show you the basic method to follow in designing a circuit that is capable of handling your particular requirements.

Higher precision means using a more precise oscillator and adding a crystal to the circuit to lock-in the frequency. Heavier motors will need a "beefier" output stage than the single transistor shown in Fig. 1. However, that circuit shows the basic approach to follow (you may not find it necessary to go any further).

As shown, two inverters—IC1-a and IC1-b (each ⅙ of a 4049 hex inverter)—are used to make a simple oscillator whose frequency is approximately given by:

$$f = 1/1.4RC$$

Where R is the value of the potentiometer.

The basic circuit shown is one that you've seen a million times and have probably used just as often as a convenient clocking circuit. By adding the two diodes (D1 and D2), we can split the charging of the capacitor and thereby control the positive and negative parts of the cycle—D1 controls the positive and D2 controls the negative.

The time the circuit puts out a high and turns on the motor is controlled by the value of the left part of potentiometer R1 and the low-time is controlled by the right part of potentiometer. Regardless of how the potentiometer is set, the motor will always "see" the maximum voltage and as a result, the motor is less likely to stall at low speeds. You'll also find that the motor will start turning at a much slower speed than it would if the control was achieved by varying the voltage applied to it.

Although the transistor in our example is a 2N3055, any transistor that can handle the power requirements of the motor will do. If the motor is really "chunky," you might have to make a Darlington or add another stage to the output. Ganging the four remaining gates in the IC provides enough power to drive even a 2N3055, however, other applications may require other components. Although you can use any CMOS gate that can be made to oscillate, the 4049 is heftier than most of the others. But then, the final decision of circuit elements is yours, since only you know what your needs are.

There are several improvements on the basic circuit that come to mind almost immediately: They include using a crystal oscillator, adding a keyboard for speed-selection, or adding a digital display (which offers some interesting possibilities since all you have to do is count pulses and do a bit of arithmetic). Just as with all the circuits discussed in this column, remember that what we have described here is only a starting point.

You can elaborate on the circuit as much as you want to make it as versatile as you need. The only thing I ask is that you let me know what you've done—there's a lot of people out there who are interested. **R-E**

DRAWING BOARD

ROBERT GROSSBLATT

Making the 4089 do useful things

ONE OF THE NICEST THINGS ABOUT DEsigning logic circuits is that they're, well, so logical. All you need do is figure out what you want the circuit to do, work out a flow chart or block diagram of the unit, find the parts, and that's that.

Well, to be truthful about it, there's a bit more to it than that (as we all know), but the creative work can all be done on paper. Once the circuit has been breadboarded, there are always certain minor technical problems to be taken care of—like the unit doesn't work. But that's circuit *hacking,* not circuit *design*.

Anybody who's been following our discussion on rate multipliers and has breadboarded the circuit we worked out last time, should've found the 4089 to be really simple to use.

In our last discussion of rate multipliers, we left out part of the circuit—the display—because, as previously stated, you can use any counter arrangement that you're familiar with. All you need is a circuit that's able to count and display the number of digits you expect to see in your answer.

This month we'll add the display circuitry and also take a look at what must be done to make our circuit do useful things. We'll begin our discussion with the display circuit.

The display

Before we get into our discussion, here's a little advice that can save you plenty of trouble in the long run. One of the best habits to get into when designing is to keep a notebook containing schematics of often-used circuits. (The "Designer's Notebook" is a good example of the type of circuits you should keep handy.) Remember Grossblatt's 15th law: *Never trust your memory!*

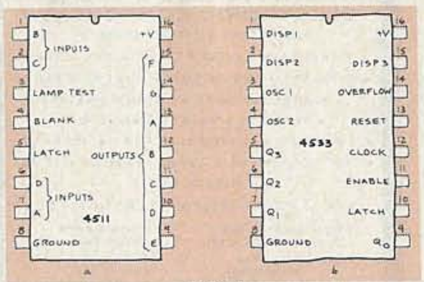


FIG. 1

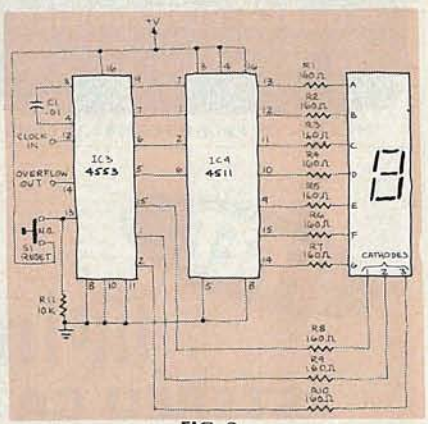


FIG. 2

A counter-display combination is used almost as often as a clock circuit and, therefore, is a natural addition to your files. With that out of the way, let's get to it!

In the example we used for the circuit last time around, we were multiplying 14 times 67. That means we'll need 3 digits (to display 938). Since we'll be counting three digits and using CMOS logic, the 4553 decade counter/multiplexer is a good choice. We will couple it to a standard 4511 decoder driver.

Figure 1 shows the pinouts for both those IC's. You should be familiar with the 4511 (Fig.1-a) since we used it to drive the displays in the keyboard encoder we designed about a year or so ago (February, March, and April, 1983). It's a "plain vanilla" decoder/driver for common-cathode displays.

The 4553 (Fig. 1-b) is a mainstream device that has all the circuitry needed to count up to 999 on board, as well as the multiplexing logic to directly handle three digits. The IC also contains three cascaded synchronous-counters whose outputs time-share pins 5, 6, 7, and 9.

The individual digits are turned on by using the three DISPLAY-ENABLE pins (1, 2, and 15). The RESET, LATCH-ENABLE, and CHIP-ENABLE pins are self explanatory (they're the same as similar controls found on other IC's). Pins 3 and 4 are the external-world connections for the timing capacitor used by the on-board, low-frequency multiplexing oscillator.

Although you may find the 4553 a bit on the expensive side—usually about three or four dollars by mail order—it's a good choice because takes the place of a whole handful of IC's. The savings in board complexity, power consumption, and bench time make it more than worth the extra cost.

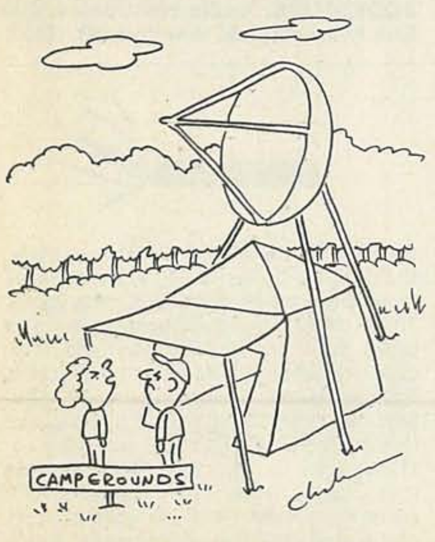
Figure 2 is the schematic for the display portion of the rate-multiplier demonstration circuit we started last month. Because the parts count is low, designing a printed circuit board for it is a snap. (You should be able to fit everything on a small, single-sided board.)

By coupling the circuit in Fig. 2 to the one we worked out last month, you'll have yourself a complete demonstrator for a rate multiplier. Admittedly, last month's circuit isn't the most useful circuit in the world, since it's hard-wired to multiply two particular numbers together. But we'll talk about how to make it a little more versatile in a little bit.

We've already seen how easy it is to do multiplication, but what about division? Well, believe it or not, adapting our circuit to do division is simple. But first, let's go through a quick run down on the theory behind doing multiplication. The rate multiplier takes an input clock and gives us two different kinds of outputs—the base rate and the multiplied rate.

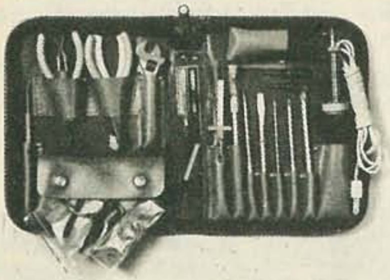
The relation between the two is controlled by a 4-bit word (number) presented to the IC's data or weighted inputs. The multiplied rate will be equal to the product of the base rate and the binary word. As mentioned in previous discussions, doing multiplication is really just successive addition. We keep track of the base-rate pulses and count the multiplied-rate pulses.

When we continue, we will take a look at what steps we have to follow to get the device to perform division. **R-E**



"People will think we came here to watch television."

Radio-Electronics mini-ADS



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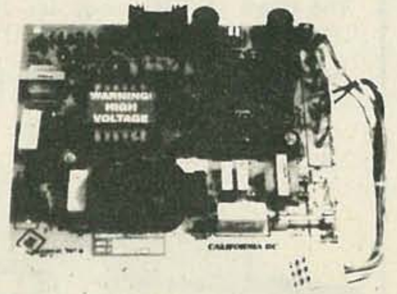

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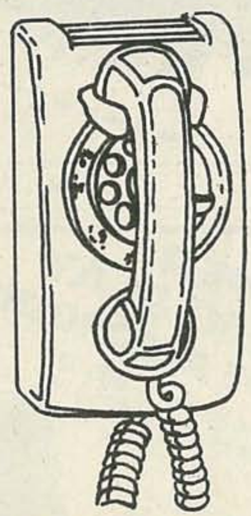

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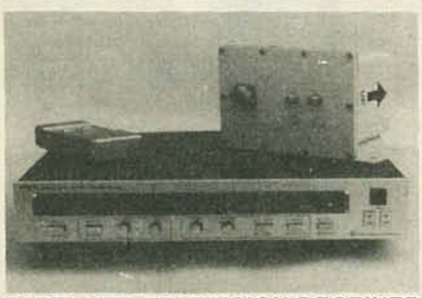

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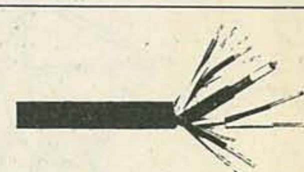

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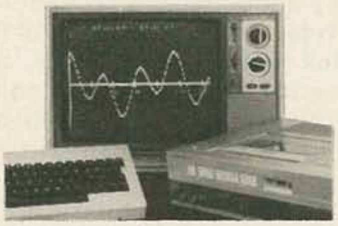

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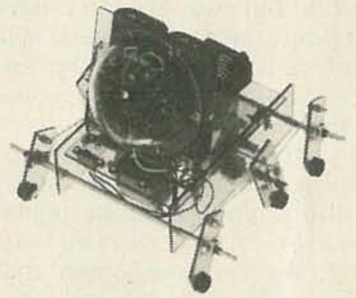

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COMMUNICATIONS CORNER

Mobile digital-communications systems

HERB FRIEDMAN
COMMUNICATIONS EDITOR

AS DIGITAL DEVICES WORK THEIR WAY into more and more communications systems, they are usually applied within the context of a complete operating package. That is, if they provide data or communications exchange, they do 100% of the work. But you shouldn't think that computerization *necessarily* excludes voice—it can serve to enhance what is essentially voice communication.

An example of that is the application of computers to radio-taxi dispatching, whereby digital information is transmitted through the same equipment that carries voice communications. The digital data, in such an instance, is the trip charges determined by a computer that has been programmed according to the voice information that the dispatcher receives from the driver.

How it works

Figure 1 shows the communications system. It's really a UHF radio with a computerized taximeter in the vehicle and a computer at the central station. The computerized meter has a digital display and a microprocessor that monitors waiting time and *trunks.* (Trunks being the number of suitcases or parcels handled by the driver or loaded by the passenger.) The waiting time at each stop is determined by a clock within the meter; when the wheels stop turning, the clock starts running. The total number of trunks for which there is a charge is entered by the driver, if possible. If the meter does not have provisions for entering trunk data, it could be supplied to the dispatcher by the driver through the voice channel; the dispatcher would then enter that information into the central computer.

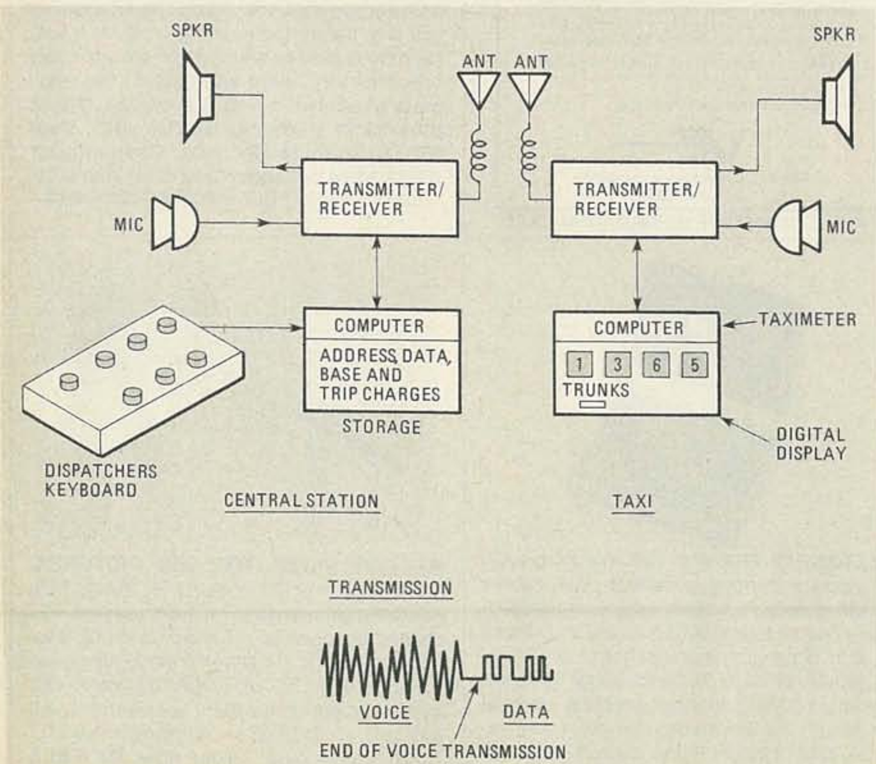

FIG. 1

When the driver picks up a passenger, he radios his starting location and the passenger's end the destination to the dispatcher. The dispatcher then enters the driver's location and destination into his terminal, which is connected to a computer that's been pre-programmed with every street address in town and the surrounding area.

The computer calculates the basic mileage charge and also automatically transmits that information (in digital form) to the taxi, where it is passed on to the meter. The mileage charge serves as a base rate to which waiting and trunk charges are added. At the end of the trip, the computer in the meter calculates the waiting-time and trunk charges, and adds them to the trip charge. The total cost of the trip would then be displayed on the meter's digital readout. Depending on the sophistication of the system, the taximeter might automatically transmit the total charges back to the central computer.

Obviously, the computerized part of the system is no problem. It doesn't take advanced technology to transmit information from the taxi or the central computer and then manipulate the data in any way necessary. Here the problem is really in integrating the computer and voice channels. Noise, fading, and other characteristics of mobile radio usually do not interfere with voice communications because the operator can ask for a repeat of the transmission (or simply fill in the holes with his own judgment, based on knowledge and experience). Voice systems are only designed to transmit about 80% of the intelligence with the brain filling in the remainder.

Computers, unfortunately, cannot fill in the blanks from experience. If the central station transmits the data for a $12.50 trip-charge and the data doesn't get into the taximeter, nothing is going to work correctly. Then there's the problem of shared channels. If the computer transmission is automatic, it must be certain the channel is clear.

Because we are dealing with less than a byte of data, (8 bits can represent a charge of $255—and that's a pretty large taxi fare) OK, so now we're dealing with an extremely short data-transmission (on the order of 7 to 30 milliseconds), even if the sequence is repeated several times because of a checksum error. Thus, it's possible to easily squeeze the data between the time the operator stops talking and the carrier drops out; all that's needed is the length of time it takes to take a breath to piggyback the data on the voice channel. Therefore, we do not need a clear channel specifically for data transmission; if it was clear for voice it will be clear for data. The only problem we would have appending the data to the end of the voice transmission is knowing when the chit-chat was over.

In the interval between the voice and carrier drop-out, we could easily add digital data to just about any voice system. What we need is a gizmo that knows when the voice transmission is over and will then signal a computer to "go." That can easily be done by something as simple as monitoring the push-to-talk switch on the transmitter. **R-E**

SERVICE CLINIC

Why do things the hard way?

JACK DARR,
SERVICE EDITOR

THERE'S AN OLD LATIN SAYING THAT goes, "Essentia non sunt praeter necessitatem." All it means is *don't make things harder on yourself than you have to.* (In other words, do everything the easiest way!) In my own shop and several others, I've noticed that many technicians have a tendency to do things the hard way. They (and that includes myself) take a simple task and make it harder than it should be. However, that can be remedied by taking a little time (at the beginning of each job) to look for an easy way.

Troubleshooting shortcuts

Finding the easy way to solve a problem isn't always a simple proposition. It requires that you first do a little brain work and then pay strict attention to detail. (Translation: Look before you leap!)

For example, let's suppose you have a dead stereo. The hard way to fix it is to jump right in and take detailed voltage readings of every stage. But the easy way is to feed an audio signal to the input of the unit and use a scope to trace the signal through the many stages to find out where it stops.

Once you have found the malfunctioning stage, it is a simple matter to locate the cause by taking voltage measurements. A quick check of the emitter voltage of all transistors in a particular stage should point you in the right direction.

Figure 1 shows a schematic of a TV audio stage, which we'll use for our discussion. (Although that schematic is taken from a TV set, the principle that we'll discuss applies to stereo's as well.)

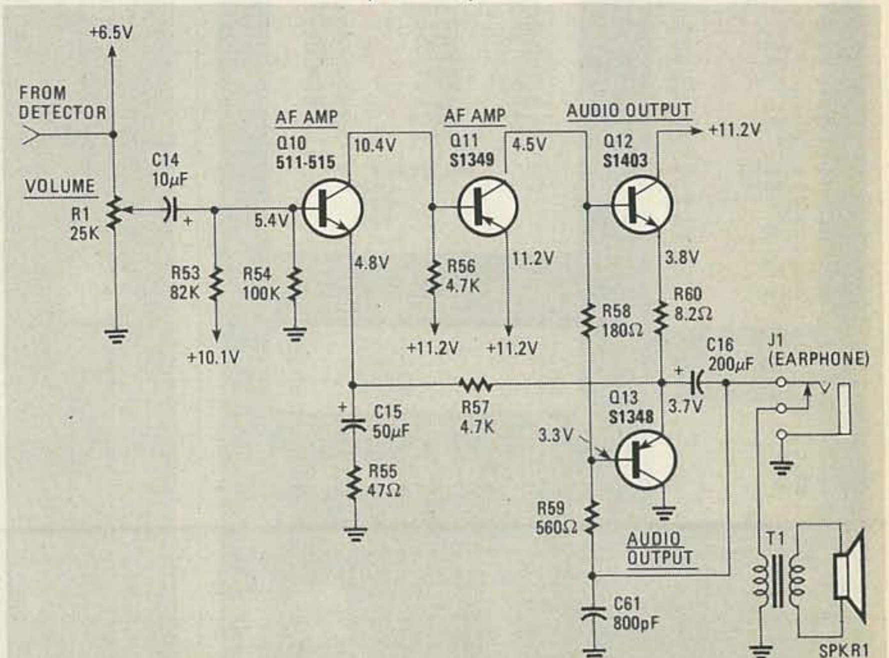

FIG. 1

Let's say, for instance, that you measure the voltage across the emitter resistor of transistor Q12 (see Fig. 1) and find it to be zero when it should be 3.8 volts. You already know that a signal is being applied to the base of the transistor. That simple voltage measurement should have told you that the transistor is not drawing any current because the emitter voltage is usually the drop across the emitter resistor.

Looking at the other side of the coin, what if there is no emitter resistor (as is the case with Q11)? A little thought should tell you to read the voltage drop across the load resistor (or any resistor that carries the collector current). If you find that there is no voltage drop, but the voltage is present, suspect an open transistor.

A mind-boggling problem

Here's another one for you: I didn't see this one myself, but I heard about it from a usually reliable source. The complaint was that there were several "jailbars" on a TV screen (20 of them, to be exact). The actual cause of the symptom was a broken ground on the coax that carries the signal from the tuner to the input of the IF. The cure is simple enough: Fix the ground and the symptom disappears. But, the thing that puzzled me was the number of bars!

The standard jailbar symptom, of course, comes from the 4–5 "rings" on the baseline of the horizontal pulse. They are at the flyback frequency, maybe 45–60 kHz. But why 20 bars? Twenty bars would mean that the frequency was up somewhere around 3 kHz, but where would we get that?

Taking a guess at it, I suspect that the waveform of the solid-state horizontal stage may have generated it somehow by developing some sort of ringing on each transition of the signal (or something like that). But I never did find out. If any of you have run across that symptom and have managed to pinpoint the cause, I will be only too happy to print it and give you full credit for it. R-E

MARKET CENTER

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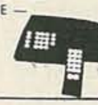

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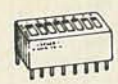

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7412	.24	7493	.35	74176	.69
7413	.29	7494	.69	74177	.69
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7421	.35	74107	.24	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	1.19	74116	1.25		
7425	.29	74121	.29		
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.45	74191	1.15
7429	.45	74125	.39	74192	.75
7430	.18	74126	.44	74193	.75
7432	.29	74128	.59	74194	.75
7437	.25	74132	.45	74195	.68
7438	.29	74136	.75	74196	.75
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4023	.25	4070	.35	4512	.79
4024	.59	4071	.28	4514	1.18
4025	.25	4072	.28	4515	1.79
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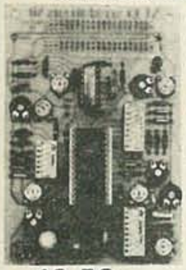

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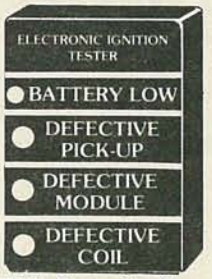

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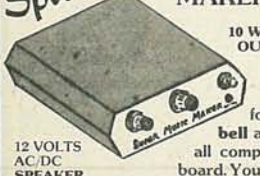

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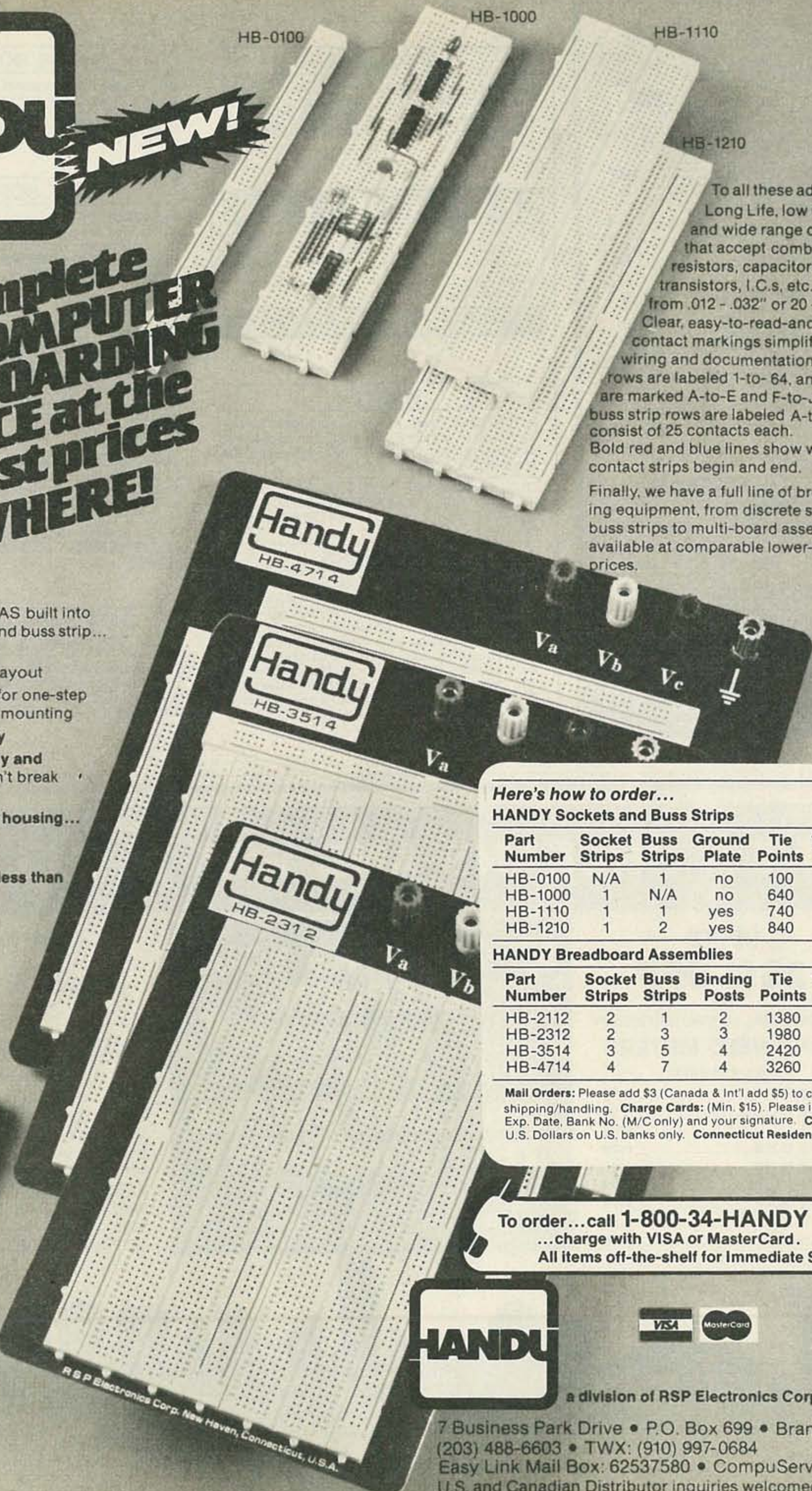

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6 VOLTS @ 150 MA	$1.25
12 VCT @ 200 MA	$2.00
18 V. @ 650 MA	$3.50
18 VOLTS @ 1 AMP	$4.50
24 VOLTS @ 250 MA	$2.50
24 VCT @ 1 AMP	$4.50
42 VCT @ 1.2 AMP	$4.50

RS-232 EXTENTION
9 LINE CONNECTED. LINES 1 THROUGH 8 & 20. DB25 MALE TO FEMALE. 10 FEET SHIELDED.
$11.00 EACH

MIKE CONNECTOR
5 CONDUCTOR IN-LINE PLUG AND CHASSIS MOUNT JACK. TWIST LOCK STYLE, SAME AS SWITCHCRAFT 12CL5M.
$2.50 PER SET

7 CONDUCTOR RIBBON CABLE
SPECTRA-STRIP RED MARKER STRIP. 28 GA STRANDED WIRE.
$5.00 PER ROLL (100 FT.)

8 TRACK RECORD/PLAY TAPE DECK
MORSE MODEL 94-A

8 TRACK RECORD WITH AUTO STOP. NOT FULLY FUNCTIONAL. REMOVED FROM ASSEMBLY LINE FOR MINOR PROBLEMS. IDEAL FOR PARTS. EACH UNIT CONTAINS SWITCHES, LIGHTS, TAPE MOTOR, BELT, WHEELS, PULLEYS, PRE AMPS, TAPE HEADS, ETC.
SPECIAL PRICE $4.00 EACH
10 for $35.00

MULTI-SWITCHES

3 STATION NON-INTERLOCKING
3 - 2PDT SWITCHES. EACH OPERATES INDEPENDENTLY.
1¾" BETWEEN MOUNTING CENTERS.
$1.75 EACH

5 STATION INTERLOCKING
MADE BY ALPS. 3 - 2PDT AND 2 - 6PDT SWITCHES ON FULLY INTERLOCKING ASSEMBLY. 3¼" BETWEEN MOUNTING CENTERS.
$2.50 EACH

5 STATION NON-INTERLOCKING
SAME AS ABOVE, EXCEPT EACH SWITCH OPERATES INDEPENDENTLY.
$2.50 EACH

METER 0 - 15 V.D.C.
THIS 2-1/4" SQUARE METER MEASURES 0-15 VDC.
$4.50 EACH

WALL TRANSFORMER
ALL ARE 115 VAC PLUG IN

4 VDC @ 70 MA	$2.00
6 VDC @ 100 MA	$2.50
6 VDC @ 500 MA	$5.00
15 VAC @ 300 MA	$3.00
16.5 VAC @ 10 VA	$3.50
17 VAC @ 500 MA	$4.00

COMMUNICATION MICROPHONE
NEW C.B. STYLE MIKE WITH PUSH S.P.D.T. SWITCH.
$5.00 EACH

SUB-MINIATURE D TYPE CONNECTOR
SOLDER TYPE SUB-MINIATURE CONNECTORS USED FOR COMPUTER HOOK UPS.

DB-15 PLUG	$2.75
DB-15 SOCKET	$4.00
DB-15 HOOD	$1.50
DB-25 PLUG	$2.75
DB-25 SOCKET	$3.50
DB-25 HOOD	$1.25

2K 10 TURN
MULTI-TURN POT
SPECTROL #MOD 534-7161
$5.00 EACH

SWITCHES
MINI-PUSH BUTTON
S.P.S.T. MOMENTARY NORMALLY OPEN 1/4" BUSHING
35¢ EACH
10 FOR $3.25
100 FOR $30.00
SPECIFY COLOR: RED, BLACK, WHITE, GREEN, YELLOW.

SPRING LEVER TERMINALS
TWO COLOR CODED TERMINALS ON A STURDY 2 3/4" × 3 3/4" BAKELITE PLATE. GREAT FOR SPEAKER ENCLOSURES OR POWER SUPPLIES.
$1.00 EACH 10 FOR $9.00

PUSHBUTTON POWER SWITCH
DOUBLE POLE POWER SWITCH PUSH-ON, PUSH-OFF.
$1.00 EACH

EDGE CONNECTORS
ALL ARE .156" SPACING

10 PIN EDGE CONNECTOR
TRW #50-10-A-20 **$2.00 EACH**

18/36 GOLD
SOLDER EYELET **$2.00 EACH**

22/44 TIN
P.C. STYLE; NO MOUNTING EARS.
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22/44 GOLD
P.C. STYLE **$2.00 EACH**
10 FOR $18.00

28/56 GOLD
28/56 GOLD PLATED CONTACTS .156 CONTACT SPACING.
$2.50 EACH 10 FOR $22.00

"PARALLEL" PRINTER CONNECTOR
SOLDER STYLE 36 PIN MALE USED ON "PARALLEL" DATA CABLES.
$5.50 EACH

SOLID STATE BUZZER
STAR #SMB-06L. 6 VDC. TTL COMPATIBLE
$1.00 EACH
10 FOR $9.00

NEON W/ RESISTOR
DIRECT OPERATION FROM 120 VOLT
7 for $1.00

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EASILY HOOKS INTO STEREO SPEAKERS AND ALLOWS 110 VAC LIGHTS TO DANCE WITH MUSIC. TWO SEPARATE 110 VAC OUTPUTS FOR HIGH AND LOW FREQUENCY AUDIO SIGNALS. USE TWO ORGANS FOR STEREO...
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WILL PRESS FIT ON STANDARD RIBBON CABLE.
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NEON INDICATOR RATED 120 V 1/3 W. MOUNTS IN 5/16" HOLE ... RED LENS.
75¢ EACH
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HEINEMANN ELECTRIC #101-5A-140 - 5 AMP CONTROL: 3-32VDC. LOAD: 140VAC 5 AMPS SIZE: 2" X 1" X ¾" HIGH
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6' 18ga TWO WIRE
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THREE WIRE
18 INCH 18ga THREE WIRE
2 for $1.00
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$1.00 EACH
CONTAINS 5 SINGLE-POLE NORMALLY OPEN SWITCHES. MEASURES 3 3/4" LONG.

6 KEY
$1.25 EACH
CONTAINS 6 SINGLE-POLE NORMALLY OPEN SWITCHES. MEASURES 4 1/4" LONG.

ROTARY SWITCH
1 POLE 6 POSITION
1¼" DIA x 1½" HIGH
75¢ EACH 10 for $6.00

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2,000 mfd. 200 VDC	1 3/4" DIA. × 5" HIGH	$2.00
3,600 mfd. 40 VDC	1 3/8" DIA. × 3 3/4" HIGH	$1.00
6,400 mfd. 60 VDC	1 3/8" DIA. × 4 1/4" HIGH	$2.50
22,000 mfd. 40 VDC	2" DIA. × 6" HIGH	$3.00
31,000 mfd. 15 VDC	1 3/4" DIA. × 4" HIGH	$2.50
72,000 mfd. 15 VDC	2" DIA. × 4 3/8" HIGH	$3.50
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CLAMPS TO FIT CAPACITORS 50¢ ea.

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100K linear tape
2" LONG
1 5/8" TRAVEL **75¢ EACH**
500K linear taper
2 7/8" LONG
1 3/4" TRAVEL **75¢ EACH**
DUAL 100K audio taper
3 1/2" LONG
2 1/2" TRAVEL. **$1.50 EACH**

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STANDARD JUMBO DIFFUSED
RED 10 FOR $1.50
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FLASHER LED
5 VOLT OPERATION RED JUMBO SIZE
$1.00 EACH

BI POLAR LED
2 FOR $1.70

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.079" × .098"
RED 10 FOR $1.00
200 FOR $18.00
GREEN 10 FOR $1.50

LED HOLDERS
TWO PIECE HOLDER FOR JUMBO LED
10 FOR 65¢ 200 FOR $10.00

RELAYS
MINIATURE 6 VDC RELAY
SUPER SMALL SPDT RELAY; GOLD COBALT CONTACTS. RATED 1 AMP AT 30 VDC. HIGHLY SENSITIVE, TTL DIRECT DRIVE POSSIBLE. OPERATES FROM 4.3 TO 6 V. COIL RES. 220 OHM.
1 3/16" × 13/32" × 7/16"
AROMAT # RSD-6V
$1.50 EACH 10 FOR $13.50

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SPRING STEEL IRON HOLDER ON WEIGHTED BASE.
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CASE STYLE HC33/U

2 MHZ	COLORBURST 3579.545 KC
$3.50 EACH	**$1.00 EACH**

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BRK MODEL #79R
UL APPROVED.
9 VOLT BATTERY OPERATION FOR CEILING OR WALL MOUNT.
$8.00 EACH 2 FOR $15.00

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G.E. # V82ZA12
50 VOLTS, NOMINAL D.C. VOLTAGE. 5/8" DIAMETER.
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13 VDC RELAY
CONTACT: S.P.N.C. 10 AMP @ 120 VAC. ENERGIZE COIL TO OPEN CONTACT. COIL: 13 VDC 650 OHMS
SPECIAL PRICE **$1.00 EACH**

MINIATURE TOGGLE SWITCHES
ALL ARE RATED 5 AMPS @ 125 VAC

S.P.D.T. (on-on)
P.C. STYLE. NON-THREADED BUSHING.
75¢ EACH
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$1.00 EACH
10 FOR $9.00
100 FOR $80.00

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NON-THREADED BUSHING. P.C. STYLE.
75¢ EACH
10 FOR $7.00

S.P.D.T. (on-on)
P.C. LUGS. THREADED BUSHING.
$1.00 EACH
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SOLDER LUG TERMINALS.
$2.00 EACH
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MAKE LED A FANCY INDICATOR. CLEAR.
4 FOR $1.00

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THIS SUPPLY WAS USED TO POWER AN 8 TRACK/CASSETTE UNIT. IT WILL SUPPLY APPROX. 18 VDC AND INCLUDES A SMALL PRE-AMP TO BOOST SIGNAL LEVEL. RCA PLUGS FOR LINE IN/OUT.
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- 14 pin style
- 3 amp contacts
- 24 volt d.c. or 120 volt a.c. coil
- Used but fully tested

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specify coil voltage
LARGE QUANTITIES AVAILABLE
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170 MFD 330 VOLT
1 1/8" × 7/8"
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SN7403N	14	.29	SN7475N	16	.45	SN74161N	16	.59
SN7404N	14	.35	SN7476N	16	.39	SN74162N	16	.59
SN7405N	14	.49	SN7479N	14	4.95	SN74163N	16	.59
SN7406N	14	.59	SN7480N	14	.89	SN74164N	14	.69
SN7407N	14	.59	SN7482N	14	1.49	SN74165N	16	.69
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SN7411N	14	.29	SN7489N	16	2.25	SN74172N	24	4.95
SN7412N	14	.49	SN7490N	14	.49	SN74173N	16	.85
SN7413N	14	.39	SN7491N	14	.79	SN74174N	16	.59
SN7414N	14	.49	SN7492N	14	.45	SN74175N	16	.59
SN7416N	14	.49	SN7493N	14	.45	SN74176N	14	.79
SN7417N	14	.59	SN7494N	14	.89	SN74177N	14	.79
SN7420N	14	.19	SN7495N	14	.49	SN74179N	16	1.49
SN7421N	14	.59	SN7496N	16	.49	SN74180N	14	.69
SN7422N	14	.59	SN7497N	16	3.25	SN74181N	24	1.95
SN7423N	16	.69	SN74100N	24	1.95	SN74182N	16	1.05
SN7425N	14	.39	SN74104N	14	1.19	SN74184N	16	2.29
SN7426N	14	.39	SN74105N	14	1.19	SN74185N	16	2.29
SN7427N	14	.25	SN74107N	14	.29	SN74190N	16	.69
SN7428N	14	.59	SN74109N	16	.39	SN74191N	16	.69
SN7430N	14	.35	SN74116N	24	1.49	SN74192N	16	.69
SN7432N	14	.39	SN74121N	14	.45	SN74193N	16	.69
SN7437N	14	.25	SN74122N	14	.69	SN74194N	16	.69
SN7438N	14	.49	SN74123N	16	.55	SN74195N	16	.49
SN7439N	14	.79	SN74125N	14	.49	SN74196N	14	.75
SN7440N	14	.19	SN74126N	14	.49	SN74197N	14	.75
SN7441N	16	.89	SN74132N	14	.59	SN74198N	24	1.19
SN7442N	16	.45	SN74136N	14	.69	SN74199N	24	1.19
SN7443N	16	1.25	SN74141N	16	.69	SN74221N	16	1.19
SN7444N	16	1.25	SN74142N	16	3.95	SN74251N	16	.79
SN7445N	16	.69	SN74143N	24	3.95	SN74276N	20	2.49
SN7446N	16	.75	SN74144N	24	3.95	SN74279N	16	.79
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SN7448N	16	.75	SN74147N	16	1.29	SN74284N	16	2.95
SN7450N	14	.19	SN74148N	16	.89	SN74285N	16	2.95
SN7451N	14	.19	SN74150N	24	1.49	SN74365N	16	.55
SN7453N	14	.19	SN74151N	16	.49	SN74366N	16	.55
SN7454N	14	.19	SN74152N	14	.49	SN74367N	16	.55
SN7459N	14	.35	SN74153N	16	.99	SN74368N	16	.55
SN7460N	14	.39	SN74154N	24	1.49	SN74390N	16	1.49
SN7470N	14	.39	SN74155N	16	.49	SN74393N	14	1.49

74LS

74LS00	14	.29	74LS92	14	.55	74LS192	16	.79
74LS01	14	.29	74LS93	14	.50	74LS193	16	.89
74LS02	14	.35	74LS95	14	.79	74LS194	16	.69
74LS03	14	.29	74LS96	16	.89	74LS195	16	.59
74LS04	14	.39	74LS107	14	.39	74LS197	14	.89
74LS05	14	.35	74LS109	16	.39	74LS221	16	1.09
74LS08	14	.35	74LS112	16	.45	74LS240	20	1.09
74LS09	14	.35	74LS113	14	.39	74LS241	20	.99
74LS10	14	.35	74LS114	14	.39	74LS242	14	1.09
74LS11	14	.35	74LS122	14	.49	74LS243	14	1.09
74LS12	14	.35	74LS123	16	.79	74LS244	20	1.29
74LS13	14	.39	74LS125	14	.59	74LS245	20	1.49
74LS14	14	.59	74LS126	14	.59	74LS247	16	.89
74LS15	14	.35	74LS132	14	.65	74LS248	16	.89
74LS20	14	.29	74LS133	16	.59	74LS249	16	.89
74LS21	14	.35	74LS136	14	.39	74LS251	16	.59
74LS22	14	.19	74LS138	16	.59	74LS253	16	.59
74LS26	14	.29	74LS139	16	.59	74LS257	16	.59
74LS27	14	.35	74LS151	16	.59	74LS258	16	.59
74LS28	14	.39	74LS153	16	.59	74LS260	14	.59
74LS30	14	.39	74LS154	24	1.49	74LS266	14	.49
74LS32	14	.39	74LS155	16	.69	74LS273	20	1.49
74LS33	14	.49	74LS156	16	.69	74LS279	16	.49
74LS37	14	.35	74LS157	16	.69	74LS283	16	.69
74LS38	14	.39	74LS158	16	.59	74LS290	14	.89
74LS40	14	.29	74LS160	16	.69	74LS293	14	.69
74LS42	16	.49	74LS161	16	.69	74LS298	16	.89
74LS47	16	.89	74LS162	16	.69	74LS352	16	1.09
74LS48	16	.75	74LS163	16	.69	74LS353	16	1.09
74LS49	14	.75	74LS164	14	.89	74LS365	16	.49
74LS51	14	.29	74LS165	16	.89	74LS366	16	.49
74LS54	14	.29	74LS168	16	1.19	74LS367	16	.49
74LS55	14	.29	74LS169	16	1.49	74LS368	16	.49
74LS73	14	.39	74LS170	16	1.49	74LS373	20	1.49
74LS74	14	.49	74LS173	16	.69	74LS374	20	1.49
74LS75	16	.45	74LS174	16	.69	74LS375	16	.69
74LS76	16	.39	74LS175	16	.69	74LS386	14	.39
74LS78	14	.45	74LS181	24	2.49	74LS393	14	1.19
74LS83	16	.59	74LS190	16	.79	74LS399	16	1.49
74LS85	16	.69	74LS191	16	.89	74LS670	16	1.49
74LS86	14	.39				81LS95	20	1.49
74LS90	14	.55				81LS97	20	1.49

74S/PROMS*

74S00	14	.35	74S114	14	.55	74S243	14	2.19
74S02	14	.35	74S133	16	.45	74S244	20	2.19
74S03	14	.35	74S134	16	.39	74S251	16	.99
74S04	14	.45	74S135	16	.89	74S253	16	.99
74S05	14	.45	74S136	14	1.39	74S257	16	.99
74S08	14	.45	74S138	16	.89	74S258	16	.99
74S09	14	.39	74S139	16	.89	74S260	14	.79
74S10	14	.35	74S140	14	.69	74S280	14	1.89
74S11	14	.35	74S151	16	.99	74S287*	16	1.79
74S15	14	.35	74S153	16	.99	74S288*	16	1.79
74S20	14	.35	74S157	16	.99	74S373	20	2.49
74S22	14	.35	74S158	16	.99	74S374	20	2.49
74S30	14	.35	74S160	16	2.29	74S387*	16	1.95
74S32	14	.45	74S174	16	1.09	74S471*	20	4.95
74S38	14	.89	74S175	16	1.09	74S472*	20	4.95
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74S64	14	.39	74S195	16	1.49	74S475*	24	4.95
74S65	14	.39	74S196	14	1.49	74S570*	16	2.95
74S74	14	.55	74S240	20	1.95	74S571*	16	2.95
74S85	16	1.99	74S241	20	1.95	74S572*	18	4.95
74S86	14	.55	74S242	14	2.19	74S573*	18	4.95
74S112	16	.55				74S940	20	2.49
74S113	14	.55				74S941	20	2.49

CA—LINEAR

CA3010H		1.09	CA3081N	16	1.15	CA3130E	8	1.19
CA3039H		1.25	CA3082N	16	1.15	CA3140E	8	.85
CA3046N	14	.99	CA3083N	16	1.15	CA3160H		1.79
CA3059N	14	2.95	CA3086N	14	.85	CA3161E	16	1.79
CA3060N	16	2.95	CA3089N	16	1.95	CA3162E	16	6.95
CA3065E	14	1.49	CA3096N	16	1.75	CA3189E	16	2.79
CA3080E	8	.99				CA3401N	14	.59

CD—CMOS

CD4000	14	.29	CD4040	16	.75	CD4098	16	1.95
CD4001	14	.29	CD4041	14	.69	CD4506	16	1.29
CD4002	14	.29	CD4042	16	.69	CD4507	14	1.19
CD4006	14	.89	CD4043	16	.79	CD4508	24	1.95
CD4007	14	.29	CD4044	16	.79	CD4510	16	.85
CD4009	16	.59	CD4046	16	.89	CD4511	16	.85
CD4010	16	.49	CD4047	14	.89	CD4512	16	.85
CD4011	14	.29	CD4048	16	.59	CD4514	24	1.49
CD4012	14	.29	CD4049	16	.39	CD4515	24	1.49
CD4013	14	.39	CD4050	16	.39	CD4516	16	.89
CD4014	16	.89	CD4051	16	.79	CD4518	16	.89
CD4015	16	.39	CD4052	16	.89	CD4519	16	.59
CD4016	14	.49	CD4053	16	.79	CD4520	16	.89
CD4017	16	.79	CD4056	16	2.95	CD4526	16	1.19
CD4018	16	.79	CD4059	24	3.95	CD4528	16	1.19
CD4019	16	.49	CD4060	16	.89	CD4529	16	1.69
CD4020	16	.75	CD4066	14	.45	CD4543	16	1.19
CD4021	16	.75	CD4068	14	.39	CD4562	14	6.95
CD4022	16	.75	CD4069	14	.35	CD4566	16	2.95
CD4023	14	.29	CD4070	14	.29	CD4583	16	2.49
CD4024	14	.69	CD4071	14	.29	CD4584	14	.59
CD4025	14	.29	CD4072	14	.29	CD4723	16	1.19
CD4026	16	1.59	CD4073	14	.29	CD4724	16	1.19
CD4027	16	.45	CD4075	14	.29	MC14409	16	16.95
CD4028	16	.69	CD4076	16	.89	MC14410	16	8.95
CD4029	16	.79	CD4078	14	.49	MC14411	24	11.95
CD4030	14	.39	CD4081	14	.29	MC14412	16	7.95
CD4034	24	1.79	CD4082	14	.29	MC14419	16	12.95
CD4035	16	.79	CD4093	14	.49	MC14433	24	17.95
(More in Catalog)						MC14538	16	1.49
						MC14541	14	1.49

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
D765AC	40	Floppy Disk Controller	19.95
2650	40	MPU (2MHz)	9.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
MC56502	40	MPU w/Clock (1 MHz)	4.95
MC56502A	40	MPU with Clock and RAM (2Mhz)	6.49
MC56502B	40	MPU w/Clock at 3MHz	8.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	8.95
6809E	40	CPU—8-bit (External Clock) 1MHz	9.95
8031	40	Control Oriented CPU w/RAM & I/O	14.95
INS8035N	40	MPU—8-bit	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	19.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	19.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8237	40	High Performance Prog. DMA Cont.	15.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	19.95
8748	40	HMOS EPROM MPU	39.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(Z80C) 2MHz	2.95
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-PIO	40	Parallel I/O Interface Controller	3.49
Z80-SIO/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-SIO/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-SIO/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-SIO/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4)(Z80C-1) 4MHz	3.49
Z80A-CTC	28	Counter Timer Circuit	4.49
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-PIO	40	Parallel I/O Interface Controller	3.95
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	11.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-SIO/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-PIO	40	Parallel I/O Interface Controller	10.95
Z8001	48	CPU Segmented	44.95

6500/6800/68000 SERIES

Part No.	**Pins	Function	Price
MC6502A	40	MPU with clock and RAM (2MHz)	4.95
MC6520	40	Peripheral Inter. Adapter	3.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	9.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	39.95
MC68488P	40	General Purpose Int. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	14.95
MC68661PB	28	Enhanced Prog. Comm. Int.	8.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	5.49

8000 SERIES

Part No.	**Pins	Function	Price
INS8080A	40	CPU	3.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	8.95
DP8212	24	8-bit Input/Output (74S412)	2.95
DP8214	24	Priority Interrupt Control	3.79
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.95
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	4.95
DP8238	28	System Controller (74S438)	4.95
INS8243	24	I/O Expander for 48 Series	4.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.95
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.95
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	5.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	6.95
8284	18	Clock Generator/Driver	6.95
8288	20	Bus Controller	19.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.49
DP8304	20	8-bit Bi-Directional Receiver	3.49
DP8307	20	8-bit Bi-Directional Receiver	3.49
DP8308	20	8-bit Bi-Directional Receiver	3.49
DP8310	20	Octal Latched Peripheral Driver	3.95
8741	40	8-bit Univ. Peripheral Interface	29.95

DISK CONTROLLERS

Part No.	**Pins	Function	Price
INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	24.95
FD1793	40	Single/Double Density (True)	26.95
FD1795	40	Dual Density/Side Select (Inv.)	26.95
FD1797	40	Dual Density/Side Select True	29.95

SPECIAL FUNCTION

Part No.	**Pins	Function	Price
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	7.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM54240N	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.79
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	**4096x1**	**(250ns)**	1.49
4116N-2	16	16,384x1	(150ns)	1.39 - 8/10.95
4116N-3	16	16,384x1	(200ns)	1.15 - 8/8.95
4116N-4	16	16,384x1	(250ns)	.89 - 8/6.95
4164N-150	16	65,536x1	(150ns)	5.19 - 8/40.95
4164N-200	16	65,536x1	(200ns)	4.95 - 8/38.95
MM5261	18	1024x1	(300ns)	.35 - 8/1.95
MM5262	22	**2048x1**	**(365ns)**	.10
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95

NEW 256K DYNAMIC RAM
41256 16 262,144x1 (200ns)...31.95

Part No.	**Pins	Function		Price
MM5298-3	16	8192x1	(200ns)	.59

STATIC RAMS

Part No.	**Pins	Function		Price
1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114	18	1024x4	(450ns)	1.29 - 8/9.95
2114L	18	1024x4	(450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4	(200ns)	1.39 - 8/10.95
2114L-2	18	1024x4	(200ns) L.P.	1.69 - 8/13.49
2147	18	4096x1	(70ns)	4.49
2148	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	3.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-3	24	2048x8	(150ns) CMOS	4.95
HM6116P-4	24	2048x8	(200ns) CMOS	4.75
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8	(150ns) CMOS	34.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	37.95
27LS00	16	256x1	(80ns) L.P.	3.95
7489	16	16x4	(50ns) 3101	2.25
74C920	22	256x4	(250ns)	5.95
74C921	18	256x4	(250ns) CMOS	5.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

Part No.	**Pins	Function		Price
1702A	24	256x8	(1us)	3.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	3.49
TMS2516	24	2048x8	(450ns) 2716	4.95
TMS2532	24	4096x8	(450ns) NMC2532	5.49
TMS2564	28	8192x8	(450ns)	10.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	14.95
2716-1	24	2048x8	(350ns)	5.49
27160-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.95
2732A-3	24	4096x8	(300ns)	7.95
2732A-4	24	4096x8	(450ns) 21V	6.49
27320-4	24	4096x8	(550ns) 21V	5.95
27580-A	24	1024x8	(450ns)	2.95
2764-4	28	8192x8	(450ns)	6.49
2764-3	28	8192x8	(300ns)	7.19
27C64	28	8192x8	CMOS	22.95
MCM68764	24	8192x8	(450ns)	24.95
27128	28	16,384x8	(450ns) 128K EPROM	21.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.49
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.29
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.95
AY-5-1013A	**40**	**30K Baud Uart (TR1602)**	**3.95**

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.28	.27
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.45	.42	.39
40 pin LP	.49	.46	.43

LP

SG

ST

WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
24 pin SG	.79	.69	.65
28 pin SG	.99	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.30	1.25	1.15

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.59	.49	.45
10 pin WW	.69	.65	.58
14 pin WW	.69	.65	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.85
22 pin WW	1.29	1.19	.85
24 pin WW	1.35	1.19	.89
28 pin WW	1.59	1.39	.99
36 pin WW	1.89	1.79	.99
40 pin WW	2.29	1.85	.79

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Digitalker™

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

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

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

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INTERSIL

*Evaluation Kits

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
FE0203D		3½ Digit LCD Display for 7106 & 7116	14.95
7106EV/Kit*	40	IC, Circuit Board, Display	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit*	40	IC, Circuit Board, Display	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit*	24	Stopwatch Chip, XTL	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	8.49
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	99.95

30009 1983 INTERSIL Data Book (1356p.) **$9.95**

NEW PRODUCT! 74HC High Speed CMOS

74HC00	14	.59	74HC139	16	1.05	74HC253	16	1.09
74HC02	14	.59	74HC147	16	1.29	74HC257	16	.99
74HC03	14	.89	74HC151	16	.99	74HC259	16	1.69
74HC04	14	.59	74HC153	16	1.09	74HC266	14	.89
74HCU04	14	.69	74HC154	24	2.65	74HC273	20	2.79
74HC08	14	.59	74HC157	16	.99	74HC280	14	4.59
74HC10	14	.59	74HC158	16	.99	74HC299	20	5.59
74HC11	14	.69	74HC160	16	1.39	74HC366	16	2.59
74HC14	14	.89	74HC161	16	1.39	74HC367	16	2.59
74HC20	14	.59	74HC162	16	1.39	74HC373	20	2.69
74HC27	14	.59	74HC163	16	1.39	74HC374	20	2.69
74HC30	14	.69	74HC164	14	1.35	74HC390	16	1.59
74HC32	14	.79	74HC165	16	2.15	74HC393	14	1.59
74HC42	16	1.09	74HC166	16	2.49	74HC533	20	2.69
74HC51	14	.89	74HC173	16	1.29	74HC534	20	2.69
74HC58	14	.89	74HC174	16	1.09	74HC595	16	3.19
74HC73	14	.79	74HC175	16	1.09	74HC688	20	3.59
74HC74	14	.79	74HC192	16	1.49	74HC4002	14	.59
74HC75	16	.99	74HC193	16	1.49	74HC4017	16	1.49
74HC76	16	.79	74HC194	16	1.19	74HC4020	16	1.49
74HC85	16	1.69	74HC195	16	1.19	74HC4024	14	1.75
74HC86	14	.75	74HC237	16	1.49	74HC4040	16	1.49
74HC107	14	.79	74HC240	20	2.29	74HC4060	16	1.49
74HC109	16	.79	74HC241	20	2.29	74HC4075	14	.59
74HC112	16	.79	74HC242	14	2.15	74HC4078	14	.59
74HC113	14	.79	74HC243	14	2.15	74HC4511	16	1.95
74HC125	14	1.75	74HC244	20	2.29	74HC4514	24	4.19
74HC132	14	1.29	74HC245	20	2.59	74HC4538	16	2.59
74HC137	16	1.59	74HC251	16	.99	74HC4543	16	3.75
74HC138	16	1.19						

74HCU04 is unbuffered. All others are buffered

74C—C/MOS

74C00	14	.29	74C95	14	1.19	74C221	16	1.75
74C02	14	.35	74C107	14	.79	74C240	20	1.95
74C04	14	.35	74C151	16	2.19	74C244	20	1.95
74C08	14	.35	74C154	24	3.25	74C373	20	2.29
74C10	14	.35	74C157	16	1.75	74C374	20	2.29
74C14	14	.59	74C160	16	1.19	74C901	14	.59
74C20	14	.35	74C161	16	1.19	74C903	14	.59
74C30	14	.35	74C162	16	1.19	74C906	14	.59
74C32	14	.39	74C163	16	1.19	74C911	28	8.95
74C42	16	1.19	74C164	14	1.29	74C912	28	8.95
74C48	16	1.79	74C173	16	.89	74C915	18	1.19
74C73	14	.69	74C174	16	1.19	74C917	28	8.95
74C74	14	.59	74C175	16	1.19	74C922	18	4.49
74C85	16	1.39	74C192	16	1.39	74C923	20	4.95
74C86	14	.29	74C193	16	1.39	74C925	16	5.95
74C89	16	5.95	74C195	16	1.29	74C926	18	5.95
74C90	14	1.09				80C95	16	.69
74C93	14	1.09				80C97	16	.59

LINEAR

TL071CP	8	.79	LM342P-5		.65	LM741CN	8	.39
TL072CP	8	1.09	LM342P-12		.65	LM747N	14	.69
TL074CN	14	1.95	LM342P-15		.65	LM748N	8	.59
TL081CP	8	.59	LF347N	14	1.49	LM1310N	14	1.49
TL082CP	8	1.19	LM348N	14	.89	MC1330AI	8	1.69
TL084CN	14	1.95	LM350K		4.79	MC1349	8	1.69
LM301CN	8	.39	LF351N	8	.59	MC1350	8	1.19
LM302H		2.49	LF353N	8	.89	MC1358	14	1.49
LM304H		1.95	LF355N	8	1.09	LM1456V	8	1.95
LM305H		.99	LF356N	8	1.09	LM1458CN	8	.59
LM307CN	8	.49	LM358N	8	.59	LM1488N	14	.69
LM308CN	8	.69	LM359N	14	1.79	LM1489N	14	.69
LM309K		1.25	LM370N	14	4.95	LM1496N	14	.99
LM310CN	8	1.95	LM373N	14	4.95	LH1605CK		9.95
LM311CN	8	.59	LM377N	14	1.95	LM1800N	16	2.49
LM312H		2.79	LM380CN	8	1.09	LM1871N	18	2.95
LM317T		1.19	LM380N	14	.89	LM1872N	18	3.25
LM317K		3.49	LM381N	14	1.79	LM1877N-9	14	2.95
LM318CN	8	1.59	LM382N	14	1.49	LM1889N	18	1.95
LM319N	14	1.49	LM384N	14	1.95	LM1896N	14	1.59
LM320K-5		1.35	LM386N-3	8	.89	LM2002T		1.95
LM320K-12		1.35	LM387N	8	1.39	ULN2003A	16	1.49
LM320K-15		1.35	LM389N	18	1.19	XR2206	16	3.95
LM320K-24		1.35	LM391N-80	16	1.19	XR2207	14	2.49
LM320T-5		.85	LM392N	8	.59	XR2208	16	1.79
LM320T-12		.85	LM398N	8	3.95	XR2211	14	2.95
LM320T-15		.85	LM399H		5.95	LM2877P		1.95
LM320T-24		.85	TL494CN	16	2.79	LM2878P		2.95
LM322N	14	1.49	TL496CP	8	1.59	LM2901N	14	.79
LM323K		4.95	NE531V	8	1.79	LM2902N	14	.69
LM324N	14	.59	NE544N	14	1.95	LM2907N	14	2.49
LM329DZ		.65	NE550A	14	1.95	LM3900N	14	.59
LM331N	8	3.95	NE555V	8	.35	LM3905CN	8	1.19
LM334Z		1.19	XR-L555	8	.69	LM3909N	8	.89
LM335Z		1.29	LM556N	14	.79	LM3914N	18	2.39
LM336Z		1.09	NE564N	16	1.95	LM3915N	18	2.39
LM337MP		1.15	LM565N	14	.99	LM3916N	18	2.39
LM337T		1.89	LM566CN	8	1.49	RC4136N	14	1.25
LM338K		6.95	LM567V	8	.99	RC4151NB	8	1.95
LM339N	14	.69	NE570N	16	2.95	RC4194TK		4.49
LM340K-5		1.35	NE571N	16	2.49	RC4195TK		5.95
LM340K-12		1.35	LM703CN	8	1.49	LM4250CN	8	1.49
LM340K-15		1.35	LM709N	14	.59	LM4500A	16	2.95
LM340K-24		1.35	LM710N	14	.69	NE5532	8	1.69
LM340T-5		.75	LM711N	14	.79	NE5534	8	1.39
LM340T-12		.75	LM723N	14	.49	79M05AH		1.29
LM340T-15		.75	LM733N	14	.89	ICL8038B	14	3.95
LM340T-24		.75	LM739N	14	1.95	LM13080N	8	1.19
LM341P-5		.69				LM13600N	16	1.19
LM341P-12		.69				76477	28	3.95
LM341P-15		.69				MORE AVAILABLE		

30003 1982 Nat. Linear Data Book (1952 pgs.) . **$11.95**

CIRCLE 41 ON FREE INFORMATION CARD

Commodore

RS232 ADAPTER FOR VIC-20 AND COMMODORE 64

The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.

· Plugs into User Port · Provides Standard RS232 signal levels · Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready).

JE232CM $39.95

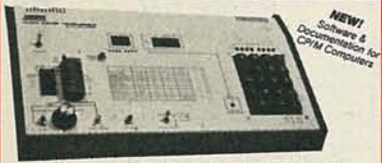
VOICE SYNTHESIZER FOR APPLE AND COMMODORE

• Over 250 word vocabulary - affixes allow the formation of more than 500 words • Built-in amplifier, speaker, volume control, and audio jack • Recreates a clear, natural male voice • Plug-in user ready with documentation and sample software • Case size: 7¼"L × 3¼"W × 1-3/8"H

APPLICATIONS: • Security Warning • Teaching • Instrumentation • Telecommunication • Handicap Aid • Games

The JE520 VOICE SYNTHESIZER will plug right into your computer and allow you to enhance almost any application. Utilizing National Semiconductor's DIGITALKER™ Speech Processor IC (with four custom memory chips), the JE520 compresses natural speech into digital memory, including the original inflections and emphases. The result is an extremely clear, natural vocalization.

Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	$114.95
JE520AP	For Apple II, II+, and IIe	$149.95



JE664 EPROM PROGRAMMER

8K to 64K EPROMS — 24 & 28 Pin Packages

Completely Self-Contained — Requires No Additional Systems for Operation

· Programs and validates EPROMs · Checks for properly erased EPROMs · Emulates PROMs or EPROMs · RS232C Computer Interface for editing and program loading · Loads data into RAM by keyboard · Changes data in RAM by keyboard · Loads RAM from an EPROM · Compares EPROMs for content differences · Copies EPROMs · Power Input: 115VAC, 60Hz, less than 10W power consumption · Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown · Size: 15⅝"L x 8¾"D x 3½"H · Weight: 5¾ lbs.

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM; (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of pr_ am content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity and 2 stop bits.

FOR A LIMITED TIME A SAMPLE OF SOFTWARE WRITTEN IN BASIC FOR THE TRS-80* MODEL I, LEVEL II COMPUTER WILL ALSO BE PROVIDED.

JE664-ARS EPROM Prog. w/JE665 Option. $1195.00
Assembled & Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, Nat., Intel, TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Nat., NEC, TI, AMD, Hitachi, Mostek.	$14.95
JM16B	TMS2716 (3-V's)	-5V, +5V, +12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68.764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95

ProModem 1200

Intelligent 300/1200 Baud Telephone Modem with Real Time Clock/Calendar

The ProModem™ is a Bell 212A (300/1200 baud) intelligent stand-alone modem · Full featured expandable modem · Standard features include Auto Answer and Auto Dial, Help Commands, Programmable Intelligent Dialing, Touch Tone™ and Pulse Dialing & More · Hayes command set compatible plus an additional extended command set · Shown w/alphanumeric display option.

PM1200. . . . . . . $374.95

KEYBOARDS

13⅛"L x 4¼"W x ¾"H

Mitsumi 54-Key Unencoded All-Purpose Keyboard

· SPST keyswitches · 20 pin ribbon cable connection · Low profile keys · Features: cursor controls, control, caps (lock), function, enter and shift keys · Color (keycaps): grey · Wt.: 1 lb. · Pinout included

KB54. . . . . $14.95

New!

16-9/16"L x 6⅜"W x 1⅝"H

76-Key Serial ASCII Keyboard

· Simple serial interface · SPST mechanical switching · Operates in upper and lower case · Five user function keys: F1-F5 · Six finger edge card connection · Color (keys): tan · Weight: 2 lbs. · Data incl.

KB76. . . . . $29.95

Nationally Known Manufacturer!

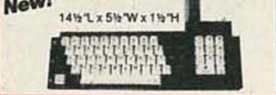
21⅞" L x 9.8" W x 3⅛" H

106-Key Serial ASCII Keyboard

· 8-bit serial ASCII (12-bit data structure – requires 3 instruction bits and 1 sync bit) · The terminals were designed to be daisy chained around a central host computer and used as individual work stations · Hall effect switching · Numeric and cursor keypad · 10 user definable keys · 50" interface cable with 9-pin sub-miniature connector · 7 LED function displays · Security lock · N-key rollover · Automatic key repeat function · Color (case): white with black panel – (key caps): grey and blue Weight: 6½ lbs. · Data included

KB139. . . . . $49.95

New!



14½"L x 5½"W x 1½"H

68-Key Keyboard with Numeric Keypad for Apple II and II+

· Plugs directly into Apple II or II+ motherboard with 16-pin ribbon cable connect. · 26 spec. func. · Color (keys): white/grey · Wt. 2 lbs. · Enclosures available

KB-A68. . . . . $79.95

POWER SUPPLIES

TRANSACTION TECHNOLOGY, INC. 5VDC @ 1 AMP Regulated Power Supply

· Output: +5VDC @ 1.0 amp (also +30VDC regulated) · Input: 115VAC, 60 Hz · Two-tone (black/beige) self-enclosed case · 6 foot, 3-conductor black power cord · Size: 6½" L x 7" W x 2¼" H · Weight: 3 lbs.

PS51194. . . . . $14.95

Power/Mate Corp. REGULATED POWER SUPPLY

· Input: 105-125/210-250 VAC at 47-63 Hz · Line regulation: ±0.05% · Three mounting surfaces · Overvoltage protection · UL recognized · CSA certified

Part No.	Output	Size	Weight	Price
EMA5/6B	5V@3A/6V@2.5A	4⅞"L x 4"W x 2⅛"H	2 lbs.	$29.95
EMA5/6C	5V@6A/6V@5A	5⅝"L x 4⅞"W x 2⅞"H	4 lbs.	$39.95

POWER SUPPLY +5VDC @ 7.6 AMP, 12VDC @ 1.5 AMP SWITCHING

· Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp · Fan volt/power supply select switches (115/230VAC) · Output: 5VDC @ 7.6 amp, 12VDC @ 1.5 amp · 8 foot black power cord · Size: 11½"L x 13¼"W x 3¾"H · Weight: 6 lbs.

PS94VOS. $34.95

KEPCO/TDK 4-OUTPUT SWITCHING POWER SUPPLY

· **Ideal for disk drive needs of CRT terminals, microcomputers and video games** · Input: 115/230VAC, 50/60Hz · Output: +5V @ 5 Amp, +12V @ 1.8 Amp, +12V @ 2 Amp, -12V @ 0.5 Amp · UL recognized · CSA certified · Size: 7⅞"L x 6-3/16"W x 1⅝"H · Weight: 2 lbs.

MRM 174KF. $59.95

New!

POWER PAC INC. REGULATED POWER SUPPLY

· Perfect for computer systems · Output: +5VDC @ 11 Amps, −5VDC @ 1 Amp, +12VDC @ 2 Amps, −12VDC @ 0.5 Amp and +24VDC @ 3 Amps · Overvoltage protection · Size: 12⅝"L x 6⅝"W x 4⅝"H · Weight: 17 lbs. · Spec incl.

PS2922. . . . . $69.95

4-CHANNEL SWITCHING POWER SUPPLY

· Microprocessor, mini-computer, terminal, medical equipment and process control applications · Input: 90-130VAC, 47-440Hz · Output: +5VDC @ 5A, -5VDC @ 1 A; +12VDC @ 1A, -12VDC @ 1A · Line regulations: ±0.2% · Ripple: 30mV p-p · Load regulation: ±1% · Overcurrent protection · Adj: 5V main output ±10% · Size: 6⅝"L x 1⅞"W x 4-15/16"H · Weight: 1½ lbs.

FCS-604A. . . . . $69.95 each

Switching Power Supply for APPLE II, II+ & IIe™

· Can drive four floppy disk drives and up to eight expansion cards
· Short circuit and overload protection · Fits inside Apple computer
· Fully regulated +5V @ 5A, +12V @ 1.5A, -5V @ .5A, -12V @ .5A
· Direct plug-in power cord included · Size: 9⅞"L x 3½"W x 2¼"H
· Weight: 2 lbs.

KHP4007. . . . . $59.95

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
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Send S.A.S.E. for Monthly Sales Flyer!

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Fiberoptics

NEW! The EDU-LINK Learning Kit

The EDU-LINK fiber optic system is a low-cost, TTL compatible data transmission system designed specifically as an educational tool for students and engineers working in many different industries. Includes: transmitter PCB, a receiver PCB, one meter of plastic optic fiber, and all the necessary electrical hardware · Complete step-by-step instructions, theory of operation, and tutorial information are included.

ELK-1. . . . . *ONLY* $19.95

APPLE ACCESSORIES

5¼" APPLE™ Direct Plug-In Compatible Disk Drive and Controller Card

The ADD-514 Disk Drive uses Shugart SA390 mechanics–143K formatted storage · 35 tracks · Compatible with Apple Controller & ACC-1 Controller · The drive comes complete with connector and cable – just plug into your disk controller card · Size: 6"L x 3½"W x 8-9/16"D · Weight: 4½ lbs.

ADD-514 (Disk Drive). $179.95
ACC-1 (Controller Card). . . . . $ 49.95

Also Available...
JE864 (80 Col. + 64K RAM for IIe). . . . . . **$ 99.95**
JE614 (Numeric/Aux. Keypad for IIe). . . . . **$ 59.95**
F051APC (Apple Compat. ½-Ht. Drive). . . . **$189.95**

INDUSTRIES *Protect Yourself...*

DATASHIELD® Surge Protector

· Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss · 6 month warranty · Power dissipation (100 microseconds): 1,000,000 watts · 6 sockets · 6 foot power cord · Normal line voltage indicator light · Brown out/black out reset switch · Weight: 2 lbs.

Model 100. . . . . $69.95

Protect Yourself...

DATASHIELD® Back-Up Power Source

Provides up to 30 minutes of continuous 120 VAC 60Hz power to your computer system (load dependent) when you have a black out or voltage sag · Output rating: 200 watts · Six month warranty · Weight: 24 lbs.

PC200 (Model 200). $299.95

For more demanding systems (e.g. with hard disks)
· Output rating: 300 watts

XT300. . . . . $399.95

IBM MEMORY EXPANSION KIT COMPAQ COMPATIBILITY

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs). . . . $43.95

TRS-80 MEMORY EXPANSION KIT

TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III **$8.95**
TRS-16K4 *250ns for Model I. **$6.95**

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kits comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 color computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K2. . . . . $38.95

UV-EPROM Eraser

8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser . . . **$79.95**
UVS-11EL Replacement Bulb . . $16.95

CIRCLE 41 ON FREE INFORMATION CARD

PARTIAL LISTING ONLY- PLEASE CALL OR WRITE FOR FREE CATALOG.

CAPACITORS

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50v	.14	10	50v	.16
10	50v	.15	22	16v	.14
47	35v	.18	47	50v	.20
100	16v	.18	100	15v	.20
220	35v	.20	150	25v	.25

50v MONOLITHIC

.01uf	.14	.1	.05
.047	.15	.47	.25

50v DISC

10pf	.05	470	.05
22	.05	560	.05
25	.05	680	.05
27	.05	820	.05
33	.05	.001uf	.05
47	.05	.0015	.05
56	.05	.0022	.05
68	.05	.005	.05
82	.05	.01	.07
100	.05	.02	.07
220	.05	.05	.07
330	.05	.1	.12

SPECIALS ON BYPASS CAPS

.01uf disc	50v	100/6.00
.1uf disc	12v	100/8.00
.01uf mono	50v	100/12.00
.1uf mono	50v	100/15.00

ACCESORIES & PERIPHERALS

FOR IBM

MAXIMIZER Memory Multifunction	259.95
HAYES SMARTMODEM 1200B	419.95
PC PEACOCK Color Display Adaptor	239.95
130W POWER SUPPLY	175.00
PROTOTYPE CARD	27.95
PROTOTYPE CARD With Decoding	29.95

FOR APPLE

JDR 16K RAM CARD	39.95
BAL-500 ½ Ht. Disk Drive, Teac Mechanism	169.95
MITAC AD-1 Full Height, Shugart Mechanism	179.95
DISK CONTROLLER CARD	49.95
OMNIGRAPH Parallel Graphics Card	79.95
VIEWMAX-80 80 Column For Apple II+	159.95
VIEWMAX-80e 80 Column For Apple IIe	129.95
THUNDERCLOCK Official PRODOS Clock	129.95
KRAFT JOYSTICK	39.95
60W POWER SUPPLY	49.95

MISCELLANEOUS

ZENITH ZVM-123 15 MHz Green Monitor	105.00
NEC JB1201M 20 MHz Green Monitor	169.00
BMC BM-AU9191U Comp. 13" Color Monitor	279.00
BMC BX-80 PRINTER	249.00
NASHUA DISKETTES SS/SD Box of 10	19.95
VERBATIM DATALIFE DISKETTES DS/DD	34.95
DISKETTE FILE Holds 70 Diskettes	16.99

BARGAIN HUNTERS CORNER

FLOPPY SALE

FD200-8 For S-100 **$195.00**
- ★ Manufactured by Siemens w/ 90 day warranty
- ★ 8" Double sided, double density
- ★ Manual included
- ★ NEW (not surplus as sold by others)

MPI-B52 FOR IBM PC **$139.95**
- ★ Manufactured by MPI w/ 90 day warranty
- ★ 5¼" DS/DD, better than Tendon
- ★ NEW (not surplus as sold by others)

BAL-525 FOR APPLE USERS **$139.95**
- ★ ½ Height — ALPS mechanism
- ★ 100% Apple compatible
- ★ Full 1 YEAR WARRANTY

NEW

DISKETTES

NASHUA SS/DD WITH HUB RING	$15.95
VERBATIM DATALIFE DS/DD	$29.95

SPECIALS END 11/30/84

5¼" DISK DRIVES

TANDON TM100-2	DS/DD	199.00
SHUGART SA400L	SS/DD	199.95
MPI B52	DS/DD	139.95
TEAC FD55B ½ Ht.	DS/DD	159.00
TEAC FD55F ½ Ht.	DS/Quad	200.00

8" DISK DRIVES

SIEMENS FD200-8	DS/DD	195.00
SIEMENS FD100-8	SS/DD	149.95

IC SOCKETS/DIP CONNECTORS

LEADS	LOW PROFILE SOLDERTAIL 1-99pcs.	LOW PROFILE SOLDERTAIL 100&up	3 LEVEL WIREWRAP 1-99pcs.	3 LEVEL WIREWRAP 100&up	TEXTOOL ZERO INSERTION ZIFxx	COMPONENT CARRIES ICCxx	IDC PLUG RIBBON CABLE IDPxx
8	.13	.11	.59	.49	---	.65	---
14	.15	.12	.69	.52	5.95	.75	1.45
16	.17	.13	.69	.58	5.95	.85	1.65
18	.20	.18	.99	.90	---	1.00	---
20	.29	.27	1.09	.98	---	1.25	---
22	.30	.27	1.39	1.28	---	1.25	---
24	.30	.27	1.49	1.35	7.95	1.35	2.50
28	.40	.32	1.69	1.49	8.95	1.50	---
40	.49	.39	1.99	1.80	10.95	2.10	4.15
64	4.25	---	---	---	---	---	---

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 20	26	34	40	50
RIBBON HEADER SOCKET	IDSxx	1.86	2.43	3.15	3.73	4.65
RIBBON EDGE CARD	IDExx	2.36	2.65	3.25	3.80	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. EXMAMPLE: A 20 pin ribbon edge card would be IDE 20.

SWITCHING POWER SUPPLIES

KEPCO/TDK MODEL MRM174KF	ASTEC MODEL AA11190
+5V @ 5A	+5V @ 4A
+12V @ 2A	+12V @ 2.5A
+12V @ 2.8A	-5V @ .25A
-12V @ .5A	-12V @ .30A
49.95	39.95

LIGHT EMITTING DIODES

JUMBO	1-99	100-up	DISPLAYS		
RED	.10	.09	MAN-72	CA .3"	.99
GREEN	.18	.15	MAN-74	CC .3"	.99
YELLOW	.18	.15	FND-500	CC .5"	1.49
			FND-507	CA .5"	1.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	25	37
SOLDER CUPS	MALE	DBxxP	2.08	2.69	2.50	4.80
	FEMALE	DBxxS	2.66	3.63	3.25	7.11
RT. ANGLE PC SOLDER	MALE	DBxxPR	1.65	2.20	3.00	4.83
	FEMALE	DBxxSR	2.18	3.03	4.42	6.19
IDC RIBBON CABLE	MALE	IDBxxP	3.37	4.70	6.23	9.22
	FEMALE	IDBxxS	3.69	5.13	6.84	10.08
HOODS	BLACK	HOOD-B	---	---	1.25	---
	GREY	HOOD	1.60	1.60	1.25	2.95

MOUNTING HARDWARE-$1.00
FOR ORDERING INSTRUCTIONS, SEE IDC CONN. ABOVE.

9000

9334	2.50
9368	3.95
9602	1.50

INTERSIL

ICL7107	12.95
ICL7660	2.95
ICL8038	3.95

DIP SWITCHES

4 position	.85
6 position	.90
7 position	.95
8 position	.95

TRANSISTORS

2N2222	.25	PN2907	.25
PN2222	.10	2N3055	.79
2N2905	.50	2N3904	.10
2N2907	.25	2N3906	.10

DISCRETE

1N751	5.1v zener	.25
1N759	12.0v zener	.25
1N4148	(1N914) switching	25/1.00
1N4004	400PIV rectifier	10/1.00
KBP02	200PIV 1.5a bridge	.45
4N33	OPTO-ISOLATOR	1.75

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
25	.75	6.60	1.32	11.80
34	.98	8.80	1.65	14.50
50	1.38	12.10	2.50	22.00

36 PIN CENTRONICS

CEN36 MALE SOLDER CUP	7.95
IDCEN36 MALE RIBBON CABLE	8.95
IDCEN36F FEMALE RIBBON CABLE	8.95

VOLTAGE REGULATORS

7805T	.75	7915T	.85
78M05C	.35	7805K	1.39
7808T	.75	78H05K	9.95
7812T	.75	7812K	1.39
7815T	.75	7912K	1.49
7824T	.85	78L05	.69
7905T	.85	79L05	.79
7912T	.85	79L12	.79

C,T TO-220, K TO-3, L TO-92

CMOS

4001	.25	4027	.45	4066	.39	4538	1.95		
4002	.29	4028	.69	4069	.29	4543	1.19		
4011	.25	4029	.79	4070	.35	4553	5.79		
4012	.25	4040	.75	4071	.29	4584	.75		
4013	.38	4042	.69	4081	.29	74C00	.35		
4015	.39	4046	.85	4082	.29	74C04	.35		
4016	.39	4047	.95	4093	.49	74C14	.59		
4017	.69	4049	.35	4503	.65	74C74	.65		
4018	.79	4050	.35	4511	.85	74C906	.95		
4020	.75	4051	.79	4518	.89	74C922	4.49		
4023	.29	4053	.79	4520	.79	74C923	4.95		
4024	.65	4060	.89	4528	1.19	74C926	7.95		

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4013	276-2413	1.19
4017	276-2417	1.49
4049	276-2449	1.19
4066	276-2466	1.19

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With Pin-Out and Specs

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7404	276-1802	.99
7408	276-1822	1.29
7447	276-1805	1.59
7490	276-1808	1.09

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Type		Cat. No.	Each
741	(Single)	276-007	.89
MC1458	(Dual)	276-038	.99
LM324	(Quad)	276-1711	1.29
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TL084	(Quad)	276-1714	2.99
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LM339	(Quad)	276-1712	1.49
TLC271	(Single)	276-1748	1.59
TLC272	(Dual)	276-1749	2.19
TLC274	(Quad)	276-1750	2.99

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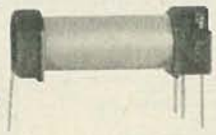
Type	Adjustable	Cat. No.	Each
LM723	0 to 40 VDC	276-1740	.99
LM317T	1.2 to 37 VDC	276-1778	2.79

Type	Fixed Output	Cat. No.	Each
7805	+5 VDC	276-1770	1.59
7812	+12 VDC	276-1771	1.59
7815	+15 VDC	276-1772	1.59
7905	−5 VDC	276-1773	1.59
7912	−12 VDC	276-1774	1.59

Compact SPST Reed Relays



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12 VDC Coil. 275-233 . . . . **1.49**

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Pins	Cat. No.	Pkg. of 2
8	276-1988	1.19
14	276-1993	1.29
16	276-1994	1.39

Solder-Tail DIP Sockets

Pins	Cat. No.	Price
8	276-1995	2/59¢
14	276-1999	2/89¢
16	276-1998	2/89¢
18	276-1992	49¢ Ea.
20	276-1991	59¢ Ea.
24	276-1989	79¢ Ea.
28	276-1997	89¢ Ea.
40	276-1996	99¢ Ea.

Communications ICs

Type	Cat. No.	Each
XR 2206 AFSK Generator	276-2336	5.95
XR 2211 AFSK Decoder	276-2337	5.95
ICL8038 Function Gen.	276-2334	5.95
LM565 PLL	276-1720	1.99

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Type	Cat. No.	Each
MC1488 Driver	276-2520	1.79
MC1489 Receiver	276-2521	1.79

Replacement Transistors

Type		Cat. No.	Each
2N1305	PNP	276-2007	1.19
MPS2222A	NPN	276-2009	.79
PN2484	NPN	276-2010	.89
MPS3904	NPN	276-2016	.69
TIP31	NPN	276-2017	.99
TIP3055	NPN	276-2020	1.59
MPS2907	PNP	276-2023	.79
MJE34	PNP	276-2027	1.49
2N3053	NPN	276-2030	.99
MPS3638	PNP	276-2032	.79
TIP120	NPN	276-2068	1.29
2N3055	NPN	276-2041	1.99
MJ2955	NPN	276-2043	2.19
2N4401	NPN	276-2058	.59
MPSA06	NPN	276-2059	.59
MPSA13	NPN	276-2060	.59
MPSA42	NPN	276-2061	.69
2SC945	NPN	276-2051	.79
2N3819	N-FET	276-2035	.99
MPF102	N-FET	276-2062	.99
IRF511	V-FET	276-2072	2.59
IRFD1Z3	V-FET	276-2073	1.49
2SC1308	NPN	276-2055	7.95

Computer/Game Connectors

Type	Positions	Cat. No.	Each
Solder Sub-D Male	9	276-1537	1.99
Solder Sub-D Female	9	276-1538	2.49
Hood for Above	9	276-1539	1.99
Solder Sub-D Male	15	276-1527	2.49
Solder Sub-D Female	15	276-1528	3.49
Hood for Above	15	276-1529	1.99
Solder Sub-D Male	25	276-1547	2.99
Solder Sub-D Female	25	276-1548	3.99
Hood for Above	25	276-1549	1.99
Solderless Sub-D Male	25	276-1559	4.99
Solderless Sub-D Fem.	25	276-1565	4.99
Printer Connector	36	276-1534	6.99
Cable Socket	34	276-1525	3.19

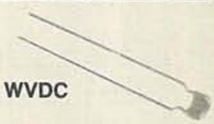
¼-Watt, 5% Resistors

Pkg. of 5 **39¢**

Ohms	Cat. No.
10	271-1301
100	271-1311
150	271-1312
220	271-1313
270	271-1314
330	271-1315
470	271-1317
1k	271-1321
1.8k	271-1324
2.2k	271-1325
3.3k	271-1328
4.7k	271-1330
6.8k	271-1333

Ohms	Cat. No.
10k	271-1335
15k	271-1337
22k	271-1339
27k	271-1340
33k	271-1341
47k	271-1342
68k	271-1345
100k	271-1347
220k	271-1350
470k	271-1354
1 meg	271-1356
10 meg	271-1365

Monolithic Ceramic Caps



Epoxy Dipped ■ 50 WVDC

Value	Temperature Coefficient	Cat. No.	Each
10 pF	NPO	272-151	.69
100 pF	NPO	272-152	.69
470 pF	NPO	272-153	.69
1000 pF	Z5U	272-154	.69
4700 pF	Z5U	272-155	.69
.01 µF	Z5U	272-156	.69
.047 µF	Z5U	272-157	.69
.1 µF	Z5U	272-158	.79

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Pin

Socket

Part No.	Description	Finish	1	10
A1320	Pin, 18-14 AWG	Tin	.18	1.60
A1321	Socket, 18-14 AWG	Tin	.21	1.93
A1322	Pin, 24-20 AWG	Tin	.18	1.60
A1323	Socket, 24-20 AWG	Tin	.21	1.93
A1324	Pin, 28-24 AWG	Tin	.18	1.60
A1325	Socket, 28-24 AWG	Tin	.21	1.93
A1329	Contact Extraction Tool		8.95	
A8000	Contact Crimp Tool		40.95	

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.100 TYP

PCB CONNECTOR

CARD EDGE CONNECTOR

.100 TYP

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DIP Jumper Cable Assembly

Standard Assembly Styles

Style 2

Style 4

Style 6

Style 8

Style 0

Dot Indicates Pin 1

Number After Dash Is Cable Length In Inches

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UL, Style 1015, 600V, -55°C to 105°C, VW-1

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AWM 2464, E-2614, 150V, -20° to 80°C

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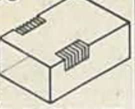

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C-0405
WT 1.5 LB

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QUALITY ALUMINUM CABINETS ARE FINISHED IN "APPLE" BEIGE, ACCEPT EITHER ONE FULL HEIGHT OR TWO HALF-HEIGHT DRIVES. 6 X 3-1/2 X 8-5/8" OVERALL. MFR'S SURPLUS, THEIR LOSS IS YOUR GAIN!

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PRICE PER FOOT		
1 FT	10 FT	100 FT
.79	.72	.62
WT 0.2 LB	WT 0.5 LB	WT 6.0 LB

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PLUG-IN STYLE WITH LONG CORDS. GREAT DEALS TO POWER YOUR PROJECTS.

STOCK#	OUTPUT	CURRENT
T-6192	12 VAC	100 MA
T-6194	18 VAC	250 MA
T-0120	24 VAC	460 MA

WT 1.0 LB

$3 EA. YOUR CHOICE

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$4.95

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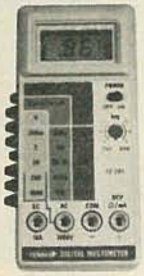

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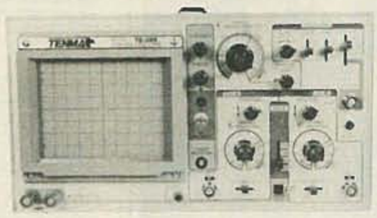

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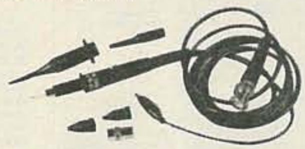

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