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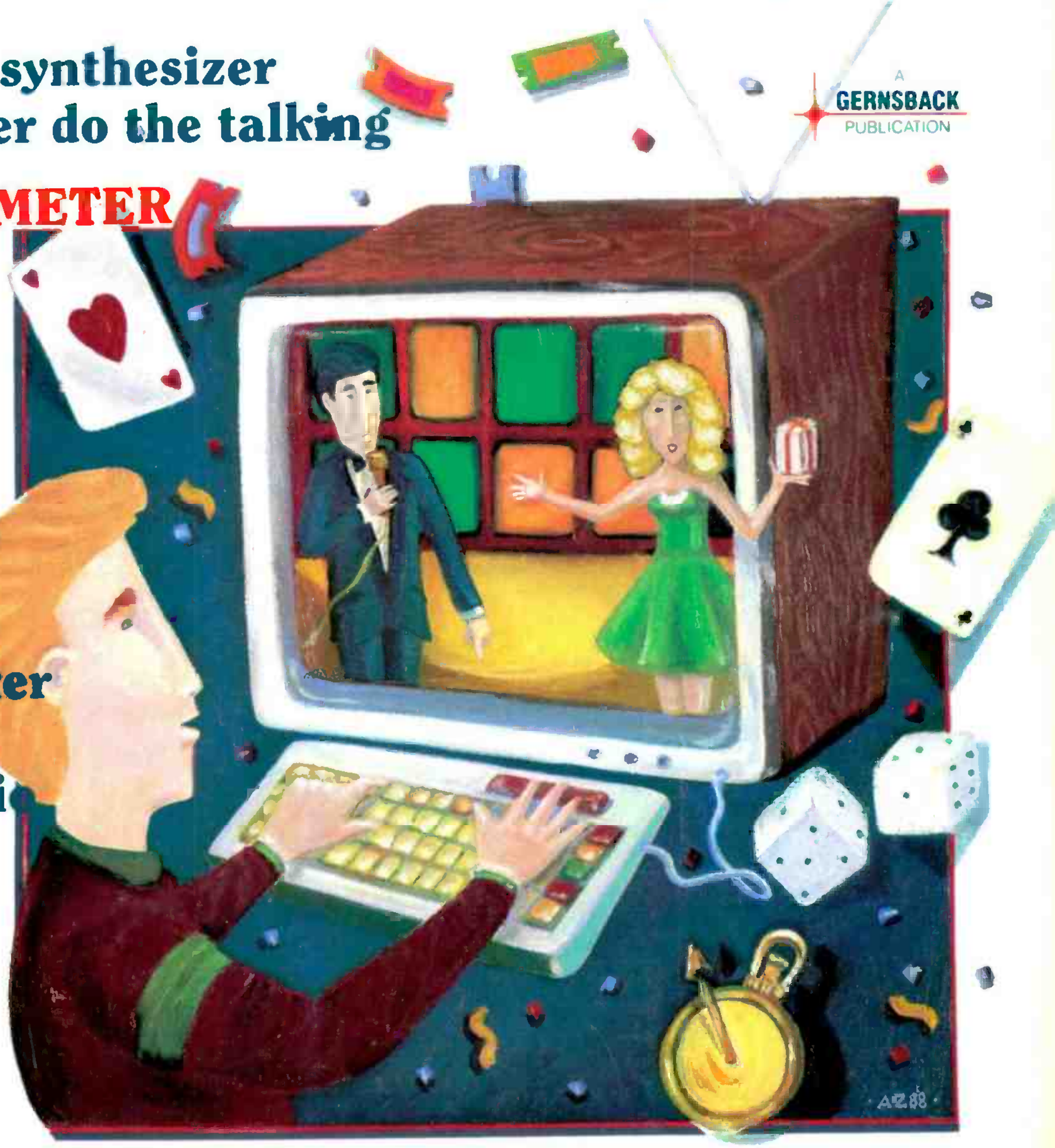

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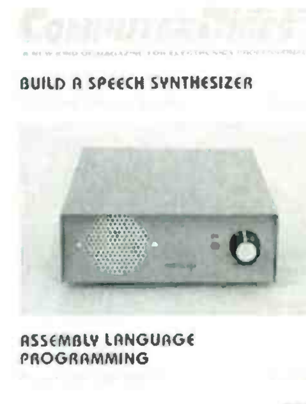

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SEASON'S GREETINGS

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ON THE COVER

If you've ever watched a TV game show, you know how difficult it is not to play along—especially when *you* know the answer that is stumping all the contestants! By this time next year, you may be able to do something other than pounding the coffee table. A proposal by the Interactive Game Network would let you play along with your favorite show, and even win prizes.

The interactive home terminals could also be used for public-opinion polling on a scale that simply cannot be done today. For a complete overview of interactive TV technology, turn to page 45.

COMING NEXT MONTH

THE JANUARY ISSUE IS ON SALE DECEMBER 1

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Use your home's power lines to transmit audio.

PROBES
All about oscilloscope probes, how they can affect your measurements, and how to build a low-capacitance scope probe.

Radio Electronics ADVANCED CONTROL SYSTEM
REACTS returns with a backup power supply.

ComputerDigest
Inside Intel's 80386.

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WHAT'S NEWS

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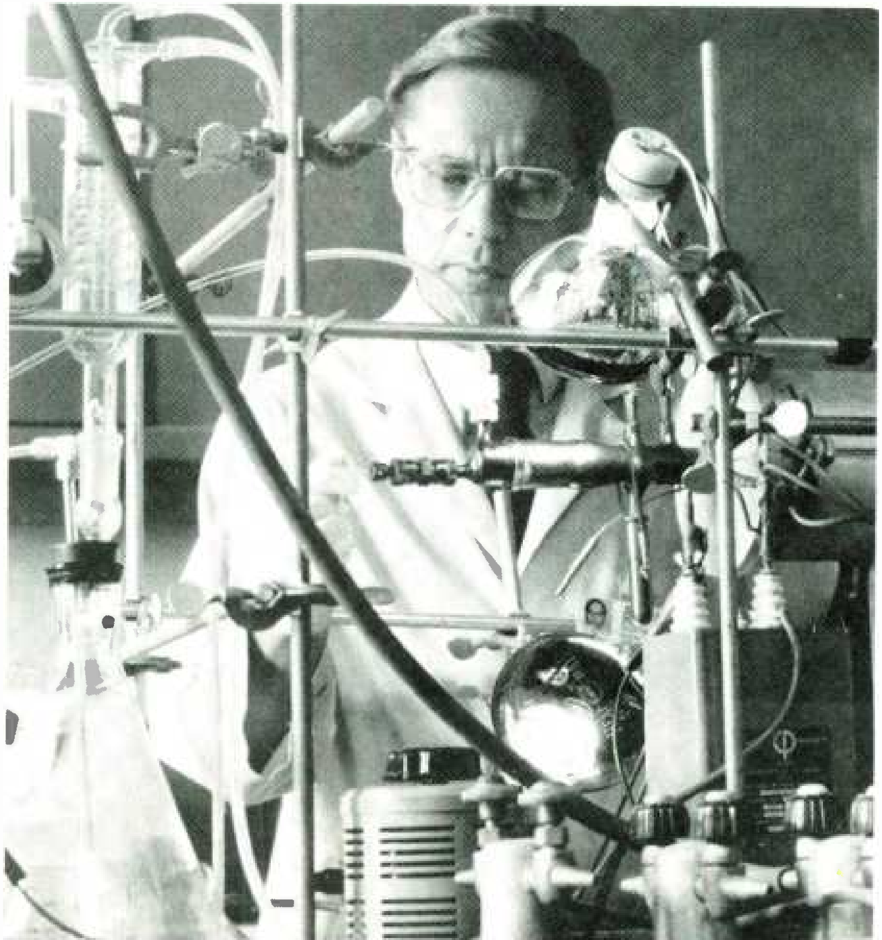

WESTINGHOUSE SCIENTIST DR. ALFRED PEBLER with the equipment used to produce super-high quality yttrium, barium, or copper powders.

Westinghouse scientists have developed a new technology for producing raw materials for the new high-temperature superconductors. The materials are produced in a highly pure powder form that can make superconductor manufacture cheaper while improving the product. "Our particles are so pure and fine that the samples we make from them give us the sharpest transistion to the superconductor state that we have seen," states Dr. Alfred Pebler, head of the team working on the new technology. "It occurs at 94° Kelvin, over a temperature range of at most 3 degrees."

The process starts by dissolving the powders in nitric acid to form a homogeneous solution. Aerosol droplets are then formed from a water solution of the dissolved nitrates and passed through a tubular furnace at temperatures of up to 1,000°C. In the short time while the solution is at that extremely high temperature, the water evaporates, leaving only a metal-oxide compound in the form of a very fine, pure crystalline powder.

News from NPEC '88

At the 1988 National Professional Electronics Convention (NPEC), Larry Steckler CET/EHF was presented with the National Electronics Sales & Service Dealers Association's (NESDA) prestigious "Friend of Service Award," honoring the most significant contribution by a person or company to the advancement of the independent sales and service industry in 1988.

Mr. Steckler, a heavy promoter of the industry's trade associations' causes, owns Gernsback Publications and is the publisher and editor-in-chief of **Radio-Electronics**, **Popular Electronics**, and **Electronics Experimenters' Handbook**. He is a member and chairman of the board of the Electronics Industry Hall of Fame, and also happens to be a participating member of both NESDA and ISCET (International Society of Certified Electronics Technicians).

A recurrent theme at NPEC '88—which was held in St. Charles, IL from August 1-6, and included a wide array of management and technical seminars along with a 2-day trade show—was the need to improve service profitability. Discussions focused on how improved communications between servicers and manufacturers can increase profitability for manufacturers, servicers, and dealers. Also emphasized was the need for dealers to become more familiar with each manufacturer's warranty policies, and for a hard line in negotiating rates with manufacturers annually.

Management seminars covered negotiation techniques and liability traps as well as basic management skills. A variety of technical seminars provided professional instruction in the intricate workings of CD players, digital VCR's, super-VHS VCR's, and camcorders. **R-E**

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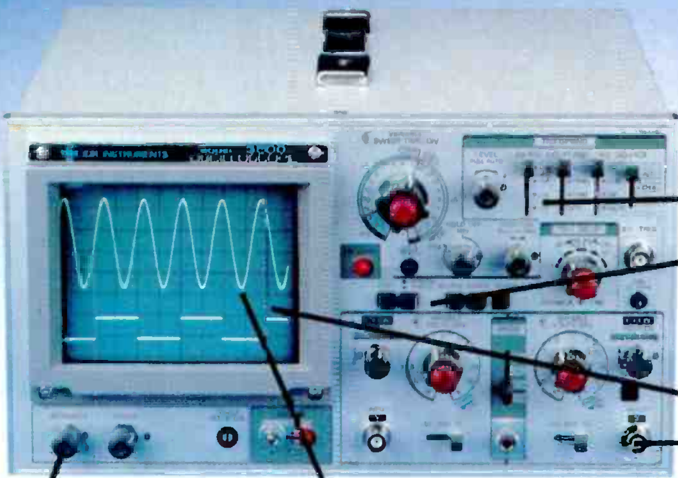

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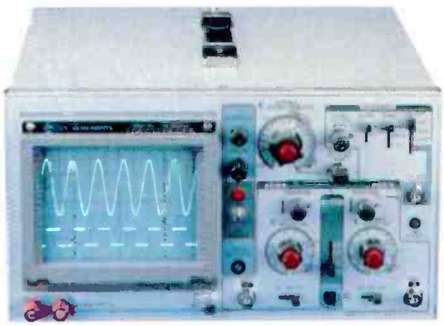
- Transistor Tester: 0°–2000°F
- Conductance: 200ns
- Fully overload protected
- Input impedance: 10M ohm.



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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Battle of the Midgets.** The fight between the 8mm-video and VHS-C formats is heating up. Last month I reported that Sony has further miniaturized the 8mm recorder's mechanical transport. While there has been no reported move to further miniaturize VHS-C, Matsushita is working to increase the recording and playing time of that format. One report indicates that there may soon be 30- and 40-minute VHS-C tapes, in addition to the current 20-minute types—presumably through the use of a thinner film base. Since most recent VHS-C camcorders also offer a one-third speed switch, the extended play mode will provide 90- and 120-minutes recording time. The 8mm format provides up to two hours recording time on a cassette in the standard play mode and four hours at half speed.

Japanese manufacturers are beginning to introduce Super VHS-C format camcorders with high-fidelity stereo sound. While the 8mm sound is hi-fi, the camcorder models don't provide stereo. Sony is expected to offer a model with digital stereo sound, and some other 8mm adherents are planning analog stereo. To compete with Super VHS, you can expect to see the first models in the new 8mm Hi-Band subformat early in 1989. Hi-Band provides a picture with resolution comparable to S-VHS (**Radio-Electronics**, June 1988).

Sony has already introduced its Video Walkman ("New Products," September 1988), combining a 3-inch LCD color TV set and an 8mm VCR in a 2½ -pound package—ideal for watching movies while riding the bus or waiting for the dentist. Not to be outdone, Matsushita has introduced a similar, slightly heavier package using the S-VHS-C format. It's on sale in Japan; there's no word yet on American marketing plans from Panasonic, a subsidiary of Matsushita. Sony's Video Walkman is due on the American market by the time you read this, for approximately $1,300.

• **Stereo TV All Over.** There are now more than 500 TV stations in North America broadcasting in stereo *M*ultichannel-*TV* *S*ound (MTS), according to a survey by *Television Digest*, that turned up 514 MTS-equipped stations. Those stations are in all of the top market areas, and bring a stereo signal within the tuning range of more than 99% of American TV homes. While the total is still only about 35% of the 1,392 TV stations on the air in the U.S., it contains many of the major outlets. In addition, some 7,362 cable-TV channels carry MTS, according to a survey by the Recoton Corp. Those are all special satellite-delivered channels, and are in addition to those broadcast channels with MTS that the cable systems may be relaying. The 7,362 cable-TV channels constitute only 7.5% of the 97,600 satellite-program channels on the nation's 8,800 cable systems, but most of the stereo-sound channels are believed to be on the larger cable systems. In addition to MTS stereo, many cable systems also use FM signals to relay stereo sound for satellite-TV programs to subscribers. Some systems use both stereo-sound systems on the same channels to cover subscribers who have MTS-stereo TV sets as well as those who don't.

• **Airvision.** You take your seat in the airliner and instead of listening to music or reading a magazine, you flip the switch in the armrest to the TV news, a choice of several movies, language instruction, or a live picture of the plane's takeoff—and watch the small bright color screen embedded in the back of the seat in front of you (or in the between-seats console if you're traveling first class). You might even choose to play an exciting video game or two to while away your travel time.

How far in the future is all of that? Would you believe this year? Philips of the Netherlands and Warner Brothers pictures say the first aircraft equipped with Airvision will have taken off by the time you read this. The viewing screens initially will be three-inch active-matrix back-lighted LCD's; at least five VHS videocassette players in the aircraft will be used as signal sources, with other sources possible. They're proposing the system for buses, taxicabs, trains, and ships, too. And a competing system, ACES (*A*irborne *C*abin services and *E*ntertainment *S*ystem), with four-inch flat color CRT's has been developed by Sony and Sundstrand Data Control.

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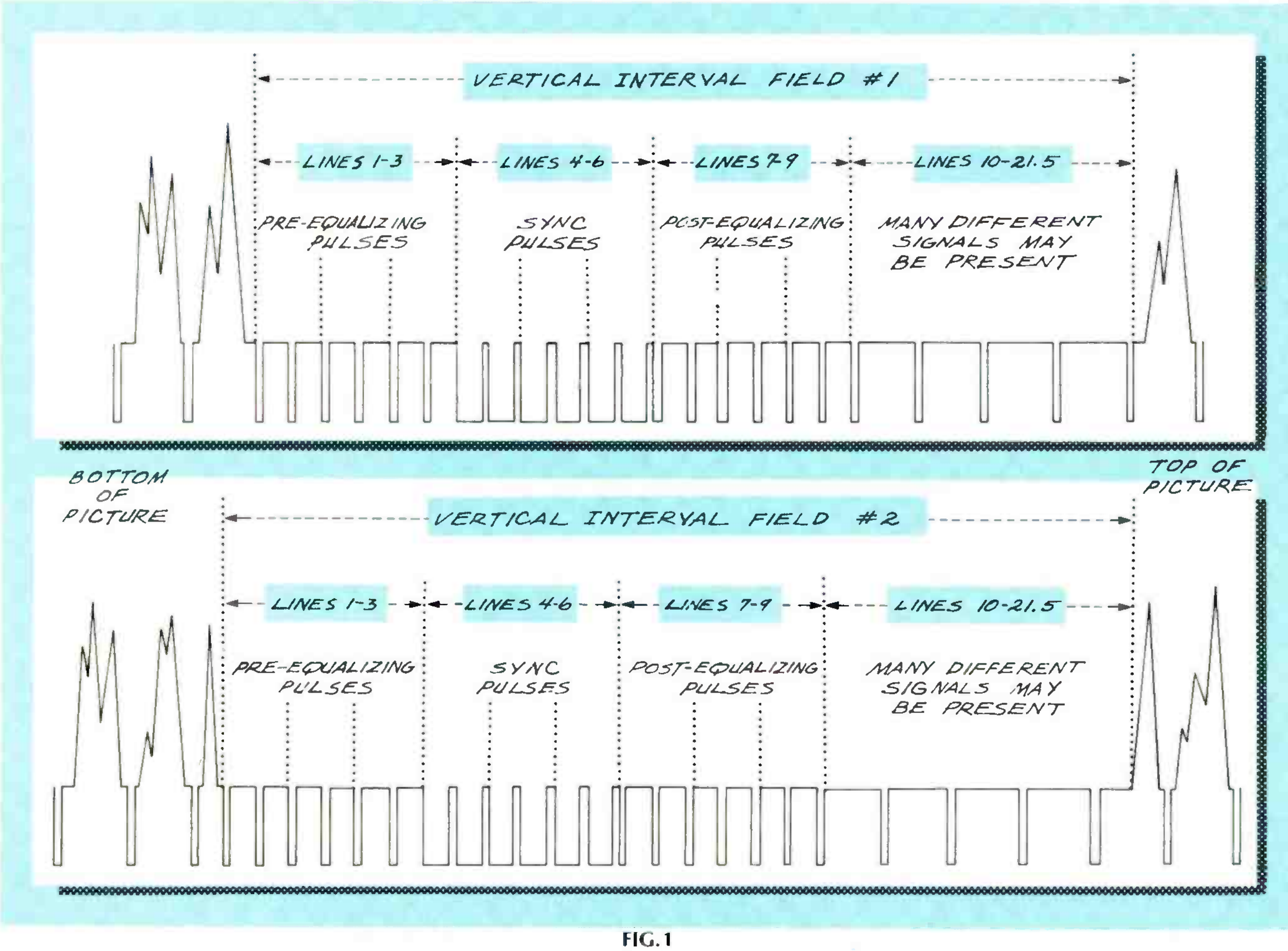


FIG. 1

Automatic editing

I've heard that commercial television sends "station break" signals and other information during the vertical interval. Is there some way that I could take advantage of that to automatically edit commercials when I'm recording off the air?—H. W., Santa Maria, CA

It is with the greatest sorrow and deepest sympathy that I tell you there is absolutely nothing you can be sure of finding in the vertical interval other than equalizing pulses and the vertical-sync pulse. And however bad that sounds, that's only part of it. The complete story is even worse.

Here's the deal: There are actually two vertical intervals, one for each of the two fields of video that make up a full video frame. There are broadcast conventions defining what's on a particular line in each of the fields but they're only conventions—not law.

Figure 1 is the ideal vertical blanking interval as defined by the NTSC. Both fields are very similar in appearance and content but the timing difference between them lets television equipment know which field they're associated with. That information is important because it's used in maintaining sync for interlacing the two fields of standard video.

The vertical interval is defined to be 20-½ horizontal lines of video.

The first three lines contain six *pre-equalizing pulses* and their job is to maintain interlace. The next three lines are the actual vertical-sync signal. There are six vertical-sync pulses that most television equipment combines into one long negative pulse. The last three lines have six *post-equalization pulses*, identical to the pre-equalization pulses on the first three lines.

Some of the remaining 11-½ lines in the vertical interval are used by broadcasters for other purposes. For example, lines 17 and 18 are where you'll find the VITS (*V*ertical *I*nterval *T*est *S*ignal), line 19 is the location for the VIRS, (*V*ertical *I*nterval *R*eference *S*ignal), and line 21 is for Closed Caption data. But, sometimes those signals don't exist, so don't count on finding them there. The important thing to remember is that none of those signals will help you eliminate commercials.

But wait. There's even less.

Once upon a time you could build hardware that would automatically edit commercials from black and white broadcasts. The basic idea was that commercials were in color so you could detect the colorburst and use it to put your VCR in pause. After all, the broadcaster would turn off the colorburst during black and white video to keep things like false color and fringing from messing up the picture—but that is not true any more.

WHAT'S A LOCAL-DISTANCE SWITCH?

While watching a "Shoppers Channel" on TV, a radio was mentioned that had a local/distance switch to help pull in distant stations. How does that work? Is it an added amplifier or a stronger antenna?—L.R.G., Franklinville, NC

When designing a high-performance receiver, engineers often have to compromise between high sensitivity, high selectivity, or signal-handling capability. A set designed for high sensitivity may be easily overloaded by strong signals. Radio-frequency amplifiers designed to handle a wide range of signals can greatly increase the cost of the set. So, some designers include a way to provide high sensitivity when needed, and a way to reduce the sensitivity to prevent circuit overload in the presence of stronger-than-average signals.

Radios that have local/distance switches are especially sensitive, and are easily overloaded by strong signals. When the switch is in the local position, it desensitizes the set by increasing the AGC (*A*utomatic *G*ain *C*ontrol) voltage to the RF amplifier or any stage that is ahead of the stage likely to be overloaded. To receive distant stations, the listener puts the switch in the distance position. That reduces the AGC voltage so that the RF and IF amplifiers will run with maximum gain. Also, in electronically tuned radios, the local/distance switch determines what stations scanning will stop at. For instance, if you were to press the scan button while the radio is set in the local mode, the radio would stop at only the strongest of the received stations. **R-E**

LETTERS

FROM RUSSIA...

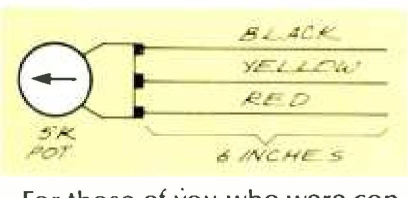
I read G.O.P.'s letter regarding vacuum tubes that appear to be manufactured in the USSR ("Ask R-E," **Radio-Electronics**, October 1988), and your reply. It is quite possible that those tubes are, in fact, made in the USSR; U.S. Customs regulations require the country of origin to be marked on any imported item.

I, too, have been an electronics technician for over ten years; for most of that time, I was with a government agency. I regularly see tubes that are *definitely* manufactured in the USSR and Hungary—I get them through the Federal supply system! I haven't seen any quality problems with those tubes; the ones that I have tested are right in line with the specifications in my old *RCA Receiving Tube Manual*. Those of us who still work with vacuum-tube equipment are going to see more imported ones in the future, for one simple reason: There are many types of tubes that are no longer manufactured in the U.S. Once existing stocks are depleted, they will all be imported from somewhere—including the Soviet Union.

In my opinion, G.O.P. should have nothing to worry about from "the authorities" by using those tubes. If they are good enough for Uncle Sam, they should be OK for everyone else. Electrons, fortunately, are not political—they don't care who pushes them. Think of it as doing your bit to bring capitalism to the Soviet empire, and to give *perestroika* and *glasnost* a little help.

GRAEME C. PAYNE
Summerville, SC

CALIBRATE



For those of you who were confused on how to calibrate the Breath Alert blood-alcohol monitor (**Radio-Electronics**, October 1988), here's the missing Fig. 9 so you can obtain the correct calibration voltages. We're sorry about the inconveniences.

—*Editor*

...WITH...

I hate to burst your bubble, but you didn't do your homework before you answered the inquiry on "Red Star" 6L6's. Without a doubt, the tubes in question were made in Russia.

Because the U.S. and most, if not all, other foreign sources decided to abandon that section of the electronics market, the "Evil Empire" has moved in to fill the void.

Get used to it—in the future, when you need a 6L6, KT66, 6CA7, or whatever to keep your treasured Ultra-Linear Williamson alive, that's where it's likely to come from. And hold your breath when you ask the price!

AL YEAGER
Portsmouth, NH

...TUBES

I'm afraid you really missed the mark with your answer to G.O.P. regarding his question about Russian tubes: The part in question was almost certainly a Commie!

The giveaway on that 6L6 is the overly large plastic base, coupled with a large glass projection (about 1-inch tall) at the bottom of the envelope. That device is *notorious* in the musical-instrument tech industry—for poor quality. Another problem one can encounter when installing those Russian 6L6's in guitar amps is that most musical-instrument amps operate the tubes in an upside-down position, using a spring-steel clamp to keep the tube in the socket. The Russian tube's base is too large to fit through the tube clamp, so the tech has to squash the clamp down against the chassis, or remove it. Either way, if the tube doesn't fry itself first, it will certainly commit suicide by jumping out of the hole when the amp is transported to jobs. Believe me; I learned that the hard way!

High-power audio-output tubes are getting hard to come by these days, and the importers are turning in droves to the few remaining tube producers. Most of the manufacturers currently producing the 6L6 are in the communist bloc. I've seen that particular tube marked with such brands as RCA, GE, United, Radio Shack, Mullard, and Penta Labs, and it stamped with such countries of origin as USSR, Poland, East Germany, West Germany, Hungary, Yugoslavia, England, France, and even U.S.A.! My contacts in the tube industry tell me that *all* of them, regardless of what's marked on the box or the glass, come out of a shoddy little factory in Yugoslavia.

There are some good tubes to be had from Russia. There is an outfit that imports certain types, screens them extensively, and markets them under the brand name "Virgin Commies" (no kidding). You can find their ads in

high-end audio-specialty magazines. Word has it that they reject about 90% of everything they get, though; that might explain their outrageous prices.

W.A. "FAT WILLIE" WHITTAKER, JR.
Denver, CO

PATENTLY MISLEADING

I was dismayed to see Don Lancaster's extremely negative statements about patents ("Hardware Hacker", **Radio-Electronics** October 1988), especially since most of them are untrue. Perhaps he is making a gross overgeneralization because of one unprofitable experience he's had with patents.

His admonition not to even think about patenting is absurd. As a patent attorney, I have several independent-inventor clients who have made handsome profits—over $1,000,000 in one case—from patents. Consider Polaroid's recent award of over $10,000,000 from Kodak, for infringement of Polaroid's instant-camera patents. And don't forget the major drug companies: As soon as a patent on a drug expires, the clones come in and sell what was formerly a 75-cent pill for 20 cents. Does Mr. Lancaster think that any of those patent holders would agree with him?

His statement that three help-line callers are trying to get patents on old ideas may be true. But is it fair to blame the patent system for the patent applicants' failure to make adequate searches before filing?

The Patent and Trademark Office (PTO) does not offer poorer odds than a state lottery—the PTO doesn't offer any odds at all. It simply grants a 17-year monopoly on any invention presented to it (no matter how harebrained) that it finds to be substantially different from the prior art. It has no responsibility for, authority over, or interest in the commercial success of the inventions that it patents. That is totally the responsibility of the inventor. A patent should never be construed as any indication of commercial value—only that the invention is "unobvious" over the "prior art."

Mr. Lancaster's statement that "Not one single patent in one hundred will ever show any positive cash flow" is a gross exaggeration, but has some truth. Probably only one in twenty patents is profitable or covers a commercial product. The low success rate of patented inventions is, again, not due to the patent system, but to the failure of most inventors to adequately investigate their brainchild's commercial prospects before filing, and inadequate promotion thereafter. I have devoted a whole chapter in my book (*Patent It Yourself*, Nolo Press) to the need for stringent commercial evaluation before filing and another chapter to urge vigorous exploitation after filing. However, I admit that many inventors still don't get that important message.

Mr. Lancaster's statement that not one patent in a thousand will stand up if challenged is another wild exaggeration. At present over 60% of all litigated patents are upheld. That doesn't count those that never make it to court because the infringer saw the handwriting on the wall and agreed to pay the patent owner royalties.

His claim that the side with the most resources wins in patent litigation has been changed by the reexamination procedure, where the validity of most challenged patents can be decided—economically—by the PTO instead of in an expensive court proceeding. In litigation, the individual inventor has a tremendous advantage: In cases where an individual inventor sues a big company, juries love to find in favor of you-know-who.

It is true that many valuable and successful products, like the Apple and IBM computers, weren't covered by any major patents. But thousands of great products—Dolby noise reduction, floppy disks, and videocassette tapes, to name a few electronic ones—are patented and earn handsome royalties.

It is not true that many large companies won't look at outside ideas for fear of getting sued. Almost every company in the U.S. will be glad to look at an outsider's ideas. They will protect themselves by first having the inventor sign their "waiver" form, that requires the inventor to rely only on his or her patent rights. But they will look. Big companies have one major drawback: the Not-Invented-Here syndrome. That's why I recommend in my book that inventors try only smaller companies, which are more receptive to outside ideas.

Finally, it might surprise Mr. Lancaster to learn that each year the PTO issues about 75,000 patents, and that tens of billions of dollars change hands in the U.S. for the licensing and sale of patent rights—hardly something a hacker can ignore!

DAVID PRESSMAN,
San Francisco, CA

BIOFEEDBACK FEEDBACK

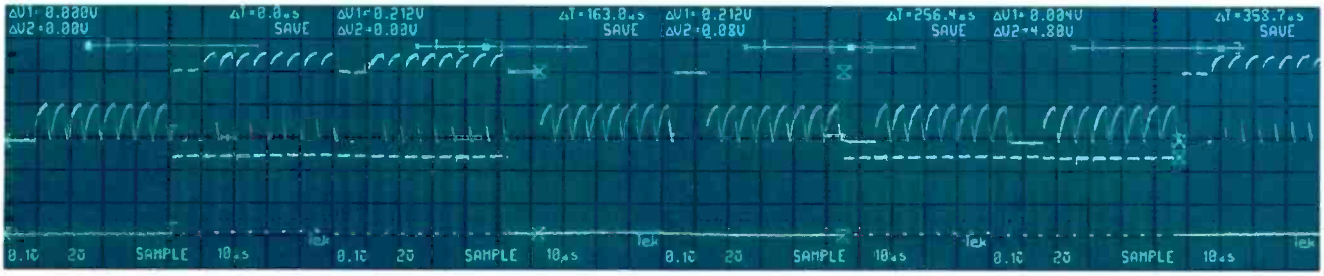
As a subscriber to **Radio-Electronics** for about five years, I've enjoyed each and every issue, and I've even built a few of the projects detailed. The "Biofeedback Monitor" (**ComputerDigest**, October 1988) sounded simple and interesting—like something I'd want to tackle.

Most of the parts needed could easily be scrounged from my junkboxes; the rest were readily available locally. It went together very easily in one evening—after which, unfortunately, I spent a good deal of time troubleshooting its improper operation.

I set out to use a CMOS NE555C to minimize the draw on my batteries, as I intended to use Ni-Cad rechargeables and wanted them to last as long as possible between charges. Building it with that in mind, I fell victim to a minor point—missed in the article—that can probably be safely ignored if using a non-CMOS 555. But it really caused me a headache.

The functional block diagram for a 555 shows that pin 4 is called $\overline{RESET}$, an active low-input signal. Typically, in non-CMOS applications that input probably floats high. With the indeterminate nature of CMOS inputs, I was getting erratic operation; $\overline{RESET}$ was preventing the circuit from functioning as intended. That was re-

Digital scopes with a



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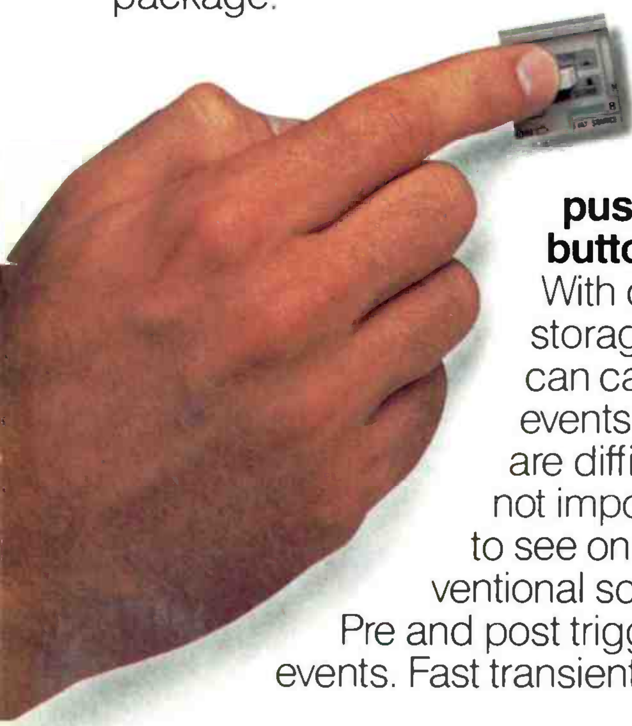

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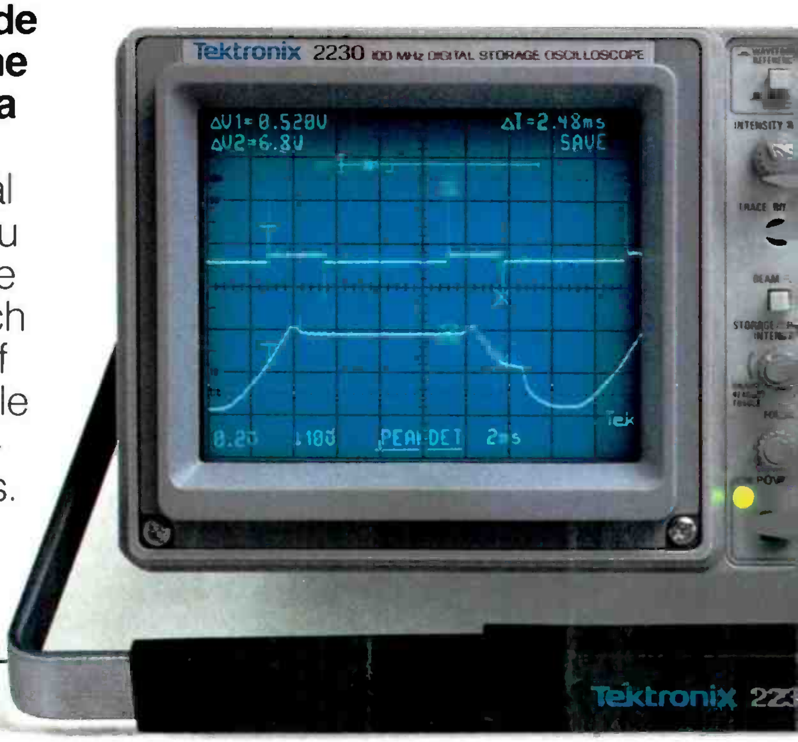

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Vertical Resolution	8-12 bits	8-10 bits	8 bits	8 bits	8 bits
Record Length	1K/4K Selectable	4K	4K	4K	2K
Glitch Capture	100 ns	100 ns	100 ns	No	No
CRT Readout/ Cursors	Yes	Yes	No	No	No
GPIB/RS-232-C Options	Yes	Yes	Yes	No	RS-232-C Hardcopy
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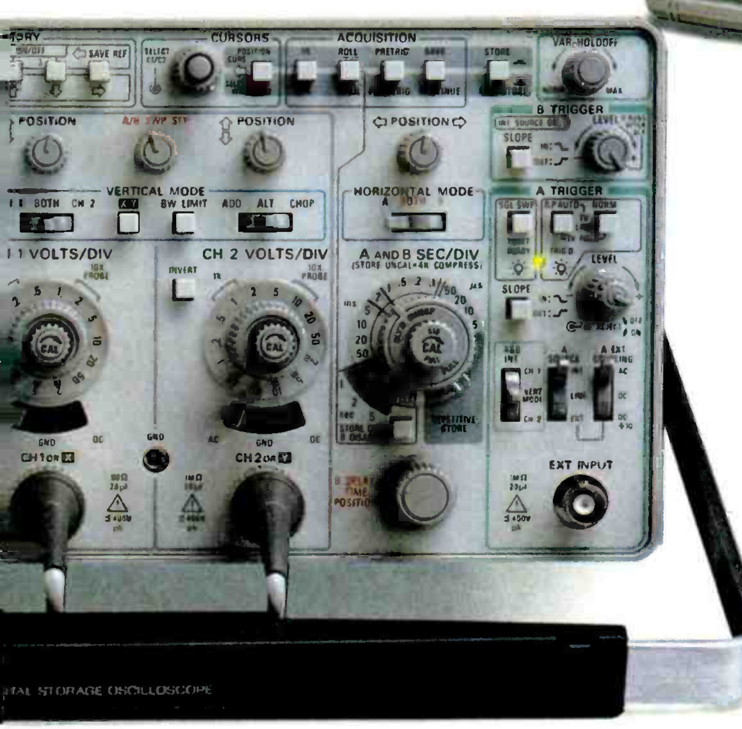

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medied by adding a pullup here to the supply.

After that small addition, all worked as advertised. My box is a resounding success at the office, where the challenge is to see who can relax the quickest.

MARK J. CULROSS
Fort Worth, TX

ANTIQUE CAR-RADIO REPAIR

"Antique Radios" (**Radio-Electronics**, July 1988) referred to electronic replacements available for vibrators, but gave the impression that they all required external mounting, gave interior performance, and would detract from the value of the radio.

We have been manufacturing a direct, electronic plug-in replacement for 6- and 12-volt units for two years. They perform very well and do not require any mounting. They are also economically priced. We repair original vibrators, too.

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EQUIPMENT REPORTS

IF THE IDEA OF HAVING 550 MEGABYTES of optical storage at your fingertips intrigues you, but the thought of having to buy a high-priced external CD-ROM drive for that privilege turns you off, then you haven't heard about Amdek's half-height CD-ROM for the IBM PC and its clones.

Called the Laserdek 1000, this $895 CD-ROM drive fits into a single floppy-disk-drive bay. A half-length adapter board controls all CD-ROM functions and an assortment of software utilities put the drive through its paces—including a program that lets you use your CD-ROM drive as if it were an audio CD player.

An obvious advantage of an optical disk is the amount of data that it can store. Because the holes are microscopic in size, much more data can be placed on an optical disk than can be put on a floppy disk. In fact, it takes over 1500 floppy disks to equal the 550-MB capacity of a single CD.

A compact compact

The Laserdek 1000 is the first CD drive to install inside a PC. Previous CD-ROM's, like Amdek's Laserdek 2000, have been full-height external units that must compete with the PC and other peripherals for desk space.

The Laserdek 1000 can be installed in any IBM PC, XT, AT, or compatible. Installation is equivalent to installing an internal hard disk. The half-length card is inserted into any empty 8-bit expansion slot and the drive is fitted into one of the drive bays; slide rails are available for AT installation. Power is obtained from the PC's power supply via a standard power connector. The drive contains four DIP switches that you don't have to adjust unless you are installing more than one CD-ROM in the system.

The software drivers automatically install themselves onto your hard disk using an installation utility. During the software-installation process, your CONFIG.SYS and AUTOEXEC.BAT files are modified to recognize the presence of the CD-ROM. When the system is rebooted, the Laserdek 1000 appears as a D: drive (or E: drive, if you have two hard disks). You can then access the CD-ROM as you would any other disk drive, which means that you can display a directory of the disk's contents.

Software availability

Within the last year, there has been a generous offering of general-purpose CD's—including the very popular Microsoft Bookshelf (see the January 1988 issue of "Computer Digest" for a review). There is always the venerable Grolier Electronic Encyclopedia, and Lotus has announced that it will publish a trillion and a half pages of financial data that interfaces with 1-2-3.

The sounds of music

When you're not running Microsoft Bookshelf or some other CD application, you can use your Laserdek 1000 to play Tchaikovsky or Hank Williams. To use the Laserdek 1000 as an audio CD player, simply plug a set of headphones into the front of the drive and run the audio software that comes with the drive. Headphone volume is adjusted by a control that is also located on the front of the drive.

The audio software requires 10K and becomes RAM resident when installed, which means that you can go about your normal PC business while the music plays in the background. An Amdek utility allows you to select specific tunes from the disk, skip around tracks, or program the drive to play a sequence of songs.

If the rather thin sound of the earphones is objectionable, you can run the music through your stereo system by plugging into the jacks provided at the back of the drive. In its current configuration you will need a special connector (available from Amdek) to plug into the drive, but Amdek claims it will soon have standard RCA jacks on the Laserdek 1000 for the audio interface.

Conclusion

While the Laserdek 1000 isn't going to set the world afire at $895, it

continued on page 105

NEW PRODUCTS

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HOME-THEATER SOUND. Pre-recorded video tapes are hot items: American households devote an average of 7.1 hours to watching them every week—spending almost twice as much money on tapes than on going out to the movies. And an increasing percentage of those tapes are encoded for surround sound, as are some current made-for-TV movies.

Shure Brother's HTS Theater Reference System, aimed at the top end of that viewing market, is the first complete audio system for home theater.

The system centers around an exceptionally accurate surround-sound decoder, the *HTS5300 Acra Vector Decoder*, with wireless remote.

Three *HTS50SPA Signal Processing Amplifiers*—the direct links between decoder and speakers—balance the entire system. With switchable outputs, the appropriate amount of compensation can be added to each speaker, greatly reducing distortion.

The system's array of six loudspeakers was designed to provide the best possible sound from the smallest possible speakers. It includes one model *HTS50CF* center-front speaker, four model *HTS50LRS* left-right-surround speakers, and the model *HTS50SW* subwoofer speaker.

The multiple sound sources permit flexible seating arrangements anywhere within the perimeter of the speakers; a large room isn't required for good performance.

The *HTS Theater Reference System*—one decoder, three amplifiers, one center-front speaker system, four left-right-surround speaker systems, and one subwoofer-speaker system—has a suggested retail price of $9600.00.—**Shure Brothers, Inc.**, Home Theater Sound Division, 222 Hartrey Avenue, Evanston, IL 60202-3696.

SCANNING CABLE TESTER. This microprocessor-based tester automatically tests from one point to all other points of a data-interface cable. It can program itself from a good sample, making it easy to test RS-232 cable prior to installation.

The unit features two rows of 26 LED's and twin 2-digit displays; the scanning sequence for shorts, opens, continuity, and miswiring is quickly identified. The user can choose the SCAN mode to test each cable lead automatically, or the STEP mode for one-step-at-a-time testing.

A loop-back receiver module is included for remote testing of installed cables. The tester "learns" from a good reference cable by storing the complete wiring configuration in memory. Then it sequences a "comparison test" between the cable being tested and the stored memory. A PASS or FAIL determination appears in less than one second, and then the final wiring information appears as LED indications for the user's reference.

The unit comes equipped to test any RS-232 cable using male or female DB-25 connectors; optional adaptor cables for testing DB-9 cables and DB-25 varieties are available. The tester operates from a 115-volt AC source. With the optional purchase of six rechargeable pen cells and battery holder, portable use is possible.

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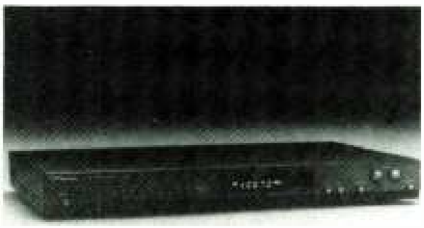
The cable tester, with padded-vinyl carrying case, is priced at $359.00.—**L-COM Data Products**, 1755 Osgood Street, North Andover, MA 01845.

AM/FM STEREO TUNER. *Audio Dynamics' T-2000E* programmable, remote-controllable AM/FM tuner combines Schotz noise reduction, efficient interference rejection, and wide separation with attractive, low-profile styling. It allows up to 10 AM and 10 FM stations to be programmed for instant access.

Audiophile-quality features include a 1.5-dB capture ratio over the entire signal-strength range of 25 to 65 dB, providing effective interference control even for weak stations. Separation is well over 30 dB across the entire radio band, and Schotz noise reduction affords quieter stereo reception.

The tuner's high performance and clean Euro-style design match Audio Dynamics' *CD-2000e* CD



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player and *CA-2000E* integrated amplifier. Armchair operation of the tuner is possible with the wireless remote control that is supplied with that amplifier.

The *T-2000E* has a suggested list price of $349.00.—**Audio Dynamics Corporation**, 851 Traeger Avenue, San Bruno, CA 94066.

SOLDER DISPENSER. A product that simplifies a frequently performed task is always welcome. The *SOLDERSTAT* wrist-strap dispenser falls into that category, by slashing soldering time by as much as 40%.

The spool dispenser is attached to an elastic or Velcro static-control strap, so that up to ¼-pound of solder can be fed out directly from the wrist. The unit unsnaps for easy reloading.

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The *SOLDERSTAT*, with an elastic strap for one-time adjustment, costs $8.00. With a Velcro strap, it costs $9.50. Options include an adjustable static-control elastic strap for $7.00, and a six-foot coiled grounding cord for $9.50. (Please add $2.00 for postage and handling to each order.)—**SGW Co.**, 6414 Hallee Road, Joshua Tree, CA 92252; phone 1-800-537-1535.

SCANNER-RECORDING. *Electron Processing's TAPE-SAVER TS-1* provides a way for scanner owners to

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avoid wasting recording tape during periods of scanner inactivity. The unit connects the tape recorder to the scanner and automatically switches the tape recorder on and off via its remote-control jack. With the "dead time" removed by the *TS-1*, an entire evening's monitoring can be listened to in less than an hour.

Standard mini-plugs are used to connect the scanner and the recorder. A sub-mini plug connects to the recorder for on/off control. The recorder is controlled by a high-quality isolated-reed relay that will accommodate control currents up to 1 amp. An internal speaker is provided so that the unit can be left plugged in during normal use, yet switched off when silent recording is desired. Speaker-mode is controlled from the front panel, which also provides indicators for power and recording. The unit requires 115-volts AC at 4 watts maximum.

The *TAPE-SAVER TS-1* interface costs $49.95.—**Electron Processing, Inc.**, Sales Dept., P.O. Box 708, Medford, NY 11763.

POWER-LINE MONITORS. *HMC's Model WD121 and WV120C* power-line monitors can save their users' time and money by revealing fluctuations in the line voltage that is

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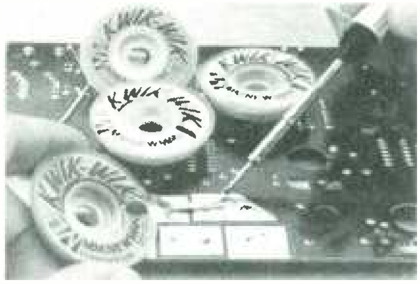
Digital *Model WD121* features a high-accuracy, 3-digit, .8-inch LCD display. Analog *Model WV120C* features easy-to-read scales. The monitors can be used to monitor the power line only, or they can be installed between the AC line and equipment. Both models measure true-RMS AC voltage. The compact units weigh only 1.5 pounds, with its outside dimensions of 4 × 5 × 3 inches.

The digital unit, *Model WD121*, costs $138.21; the analog *Model WV120C* costs $95.36.—**HMC**, P.O. Box 526, Canton, MA 02021.

DESOLDERING BRAID. *Kwik-Wik* is a line of flux-impregnated copper braid for rapidly desoldering plated-through holes and DIP's. It quickly absorbs solder by capillary action, and eliminates the need for any kind of desoldering tools in many assembly and field-service applications.

The copper braid is easy to use, by simply placing it on the joint being desoldered and holding the tip of a soldering iron against it. When the braid absorbs the solder



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and turns silver it is then snipped off and thrown away.

Kwik-Wik is available in four sizes: Thin (.03 inch), small (.06 inch), medium (.08 inch), and wide (.10 inch), all on 5-foot spools. It is list priced from $1.35 per spool in quantities of 11 to 99.—**M.M. Newman Corporation**, 24 Tioga Way, P.O. Box 615, Marblehead, MA 01945.

HARDWARE HACKER

Digital compass circuits
The Earth's magnetic field
Measuring magnetic fields
A low-end PostScript driver
Computer model prototypes

A solid-state digital compass

DON LANCASTER

DO YOU REMEMBER THE SANTA CLAUS machine that we looked at a few columns back? Well, it turns out that you can now buy them off the shelf from the *3-D Systems* folks.

The price (a house and two cars) may seem a tad on the steep side at first glance, until you allow for the obvious "Uh – compared to what?" factor. And then you see that it becomes a rather astounding bargain.

What it does is create a plastic prototype from a software data base by the selective laser hardening of a liquid plastic photopolymer. It is particularly good at machining the unmachinable, and can often do so in minutes rather than months.

There are quite a few new hacker opportunities here. One is to start up a prototype "service bureau," similar to the laser-printer rentals at quick-copy centers. Another is to come up with a super-cheap low-end Santa-Claus system that can, in fact, be built on a hacker budget.

Meanwhile, bunches of your helpline callers have been asking for "low-end" PostScript graphics and typesetting routines that will work on dot-matrix printers. Well, to do that would be the equivalent of trying to install a *Porsche* engine on a skateboard.

Nonetheless, *Lasergo* has freshly announced its brand new *Geoscript* software that does give you some PostScript abilities for the cheaper and older printers. Cost is in the $200 range, and the software is primarily intended for IBM and its many clones.

Our feature distraction this month involves a new solid-state digital compass. But first, let's take a quick look at . . .

Computer modeling

I must get a dozen calls a week from people that want to build some "simple" custom circuit that usually will involve a keyboard, a display, some I/O, and perhaps some storage. What I will usually do is tell them that the product already exists, that it costs around $30, and that it is scunging away in their neighbor's driveway.

If you haven't guessed, it is called a *Commodore 64*, and thirty bucks is the typical yard-sale price.

In this day and age, if you are designing *any* circuit that involves more than four chips total, you will save an incredible amount of time, money, and frustration by modeling what it is that you think you want on a personal computer, doing as much as possible with the computer, and as little as possible with external custom hardware.

Even if your ultimate goal is to build and sell a brand new product, starting the project off with a computer model will nearly always get you a better product out the door much faster.

Why bother with a model? First and foremost, software is far easier to change than hardware. Once you have something doing what you thought you wanted it to, there will be many obvious improvements and changes that will just be crying to be made.

And the chances these days are overwhelming that a RAM-ROM-CPU circuit will be cheaper, have fewer chips, and will end up far more buildable than would a traditional circuit built up out of a handful of CMOS or TTL chips.

NEED HELP?

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

Earth's magnetic field

There's an obscure electronics study area that is known as *magnetohydrodynamics*. Basically, if you have a moving and highly conductive pressurized gas or liquid, you can either generate an electrical current by applying a magnetic field, or else you can apply an electrical current and generate a magnetic field.

The liquid iron-nickel core of Earth does indeed qualify as a humongous magnetohydrodynamic generator.

As such, it generates a very large, but rather weak, magnetic field. And that is why compasses point to the north.

Well, sort of.

Actually, that north pole of Earth's electromagnetic field is only roughly at the real north pole, and it wanders around from time to time. It even flops over and reverses itself completely every few tens of thousands of years.

The deviation from true north is called the *magnetic declination*.

Here in Arizona, the magnetic declination is around 14 degrees easterly. In Kansas, the declination is nearly zero, while on the East Coast, the declination is a few degrees westerly.

You can find the declination for your region from any USGS topographic map. To do that, you take the declination at the time the map was published and add the yearly drift rate to it, and multiply by the map's age. The drift rate is usually negligible, except possibly for the oldest of maps.

It is obviously very important to know whether you are using "true" or "magnetic" north, or very serious errors will result. Many better-grade compasses and survey instruments have adjustment screws that let you preset your declination.

It is also very important to keep your compass or whatever completely and totally level at all times. The magnetic field is also three dimensional. It points "straight up" at the far north, "horizontal" near the equator, and "straight down" near the south pole.

The vertical component of Earth's field is called the *magnetic inclination*. One instrument to measure that is called a *dipping needle*.

If your compass or whatever is not completely level, then your reading will end up as mix of the horizontal and vertical field components, and will lie like a rug.

It gets nasty fast on an airplane that is not flying level. On a bank, you can get a severe *northerly turning error*. One cure is to use a "floating" compass on gyro that stays level when the plane banks.

Why would you want to hack Earth's magnetic field? Navigating, orienteering, and surveying are the three biggest reasons.

Not getting lost is another.

By carefully measuring the tiny variations over a very accurately gridded area, it is sometimes possible to map buried features such as archaeological sites, lava tubes, ore bodies, or even larger caves.

Further, there are two obscure but highly fascinating scientific fields that are known as *archaeomagnetism* and *paleomagnetism*. They study the history of the magnetic field's wandering, the first over thousands of years, and the second over hundreds of thousands. Accurate absolute dating is one application.

For instance, when a prehistoric fireplace is used, its temperature exceeds the *Curie* point of the magnetic materials in its rocks, and all of the old fields are erased, just like erasing a cassette tape.

As the fireplace cools, it takes an automatic snapshot of the inclination and declination of the field at that instant and preserves it.

By carefully measuring that magnetic snapshot, the last-use time of the fireplace can be accurately and absolutely dated. Even pots can be dated if you assume they were fired right-side up. And anything nearby can be relatively dated through guilt by association.

Simarily, the lava vents that cause sea floor spreading have a neat locked-in history of all the magnetic reversals that took place over time. That lets you accurately date all the extruded lava; and then you can measure the actual spread rate.

But, to hack any of that, we need some way of . . .

Measuring magnetic fields

The strength of Earth's field is roughly one *Gauss*. That is a rather weak field, and special tricks are required if you want to accurately measure it.

Obviously, a compass works like a champ. My favorite here is the good old *Brunton*, which is a cross between a high-end compass and a low-end survey instrument.

You can build your own compass by magnetizing a needle, sticking it through a cork and floating it in a cup of water. Ultra-cheap compasses are available by the bagful through *Edmund Scientific*.

Only there are problems. A compass will give you direction

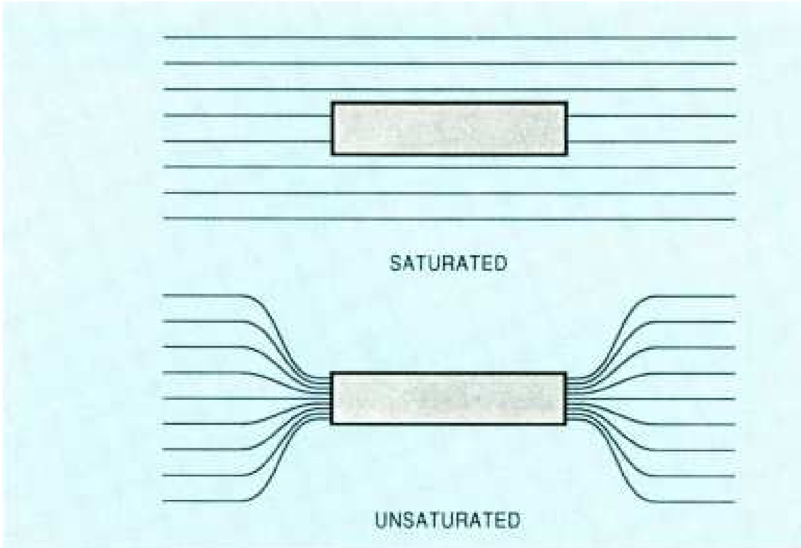

FIG. 1—AN UNSATURATED MAGNETIC MATERIAL will "pull in" the lines of force from Earth's or any other magnetic field. A saturated material will not.

but it will not give you an amplitude. It is also a mechanical device subject to both settling and vibration. Worst of all, it has *damping* problems, as does any other moving mechanism.

The *Hall Effect* is one solid-state way of measuring magnetic fields. That effect will cause a transverse voltage output to be generated in response to an input current in certain solid-state materials. While Hall-Effect devices are low in cost and readily available, most of them are not nearly sensitive enough to use as a solid-state compass.

The *F.W. Bell* people do have some very large and very expensive Hall-Effect devices that do seem to have enough sensitivity, but something better is clearly needed.

Another candidate is known as a *proton precession magnetometer*.

What you do is take a baby bottle full of water and then wind a zillion turns of wire around it. You apply a strong current for a fraction of a second. The current aligns all of the deuterium atoms present in ordinary water into a fixed orientation.

When the current is released, Earth's weaker magnetic field will cause the deuterium atoms to *precess* like miniature gyroscopes.

The precession in turn induces an audio signal of a microvolt or so into the winding. The frequency of that fairly brief resultant signal is proportional to the strength of Earth's field.

One very big limitation to proton-precession magnetometers is that they only measure the total strength of the field, and not its direction. Another drawback is that you are working with extremely small, quite noisy, and rather brief signals.

It sure would be interesting to combine a modern digital signal-processing chip with some better-grade analog integrated circuits and see what could result.

The most practical way of solid-state sensing Earth's magnetic field is with a beastie called a *flux-gate magnetometer*.

Most magnetic materials have what is called a B-H magnetization curve. Up to a certain level, they behave linearly. Above a certain point, they will *saturate* and lose all of their magnetic properties. What you have done is "filled" them with all the magnetic energy that they can possibly hold.

As Fig. 1 shows us, an ordinary magnetic material in its linear region will "pull in' magnetic lines of force, since the *permeability* of the material is greater than air.

Thus, a local distortion in Earth's magnetic field is created as the lines of force get "sucked in."

On the other hand, if you cause the magnetic material to saturate, there is no attraction or concentration of additional field lines, and Earth's field will ignore the material completely.

So, if you do switch, or *gate* a magnetic material into and out of saturation, you will also alternately concentrate and later ignore Earth's field. Should you now add a new *sense winding*, current pulses will be induced into that winding every time Earth's field enters or leaves the material.

The strength of the pulses will be proportional to Earth's magnetic-field strength along the sensing axis.

The trick is to saturate and then unsaturate the fluxgate core without getting any of the drive current into the sense winding. Figure 2 shows us one possibility. A toroid of special magnetic material with a "square" B-H curve is used, along with a toroidal drive winding.

The sense winding is a linear overwrap of the toroid, going in one direction only.

With proper circuit design and a reasonable amount of luck, most of the drive current and its resultant saturating field will stay inside

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the toroid and thus not be picked up by the sense winding.

Figure 3 shows us how a second *quadrature* sense winding can be added, giving us a sine and cosine output of the horizontal field component. We can now work with the *ratio* of those two signals and can often be more accurate.

Solid-state compasses

A fluxgate magnetometer seems to be the best approach today to building your own solid-state digital compass. Options include working direct or at the second harmonic of the drive frequency,

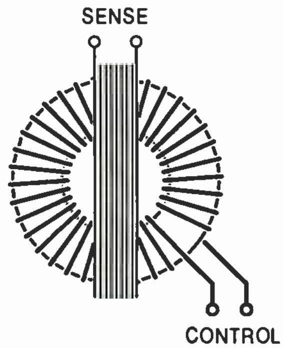

FIG. 2—A FLUXGATE magnetomometer is built by using a control winding to alternately saturate and unsaturate a toroidal core. As Earth's magnetic field gets sucked into and out of the core, it induces pulses in the sense winding. All of the introduced pulses are proportional to the strength and the direction of Earth's magnetic field.

CORE: Magnetics 50086-2F
CONTROL: 143 turns #30
SENSE: 1000 turns #35

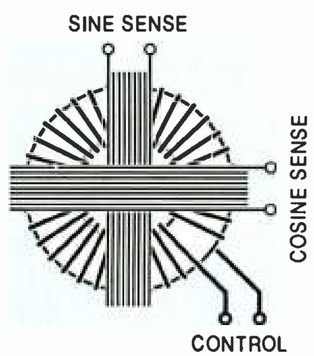

FIG. 3—ADDING A NEW quadrature sense winding will give you both the sine and cosine of the field strength. When one is weak, the other will be strong. The final magnetic bearing is found by dividing the sine output by the cosine output. A list of possible winding details are also shown.

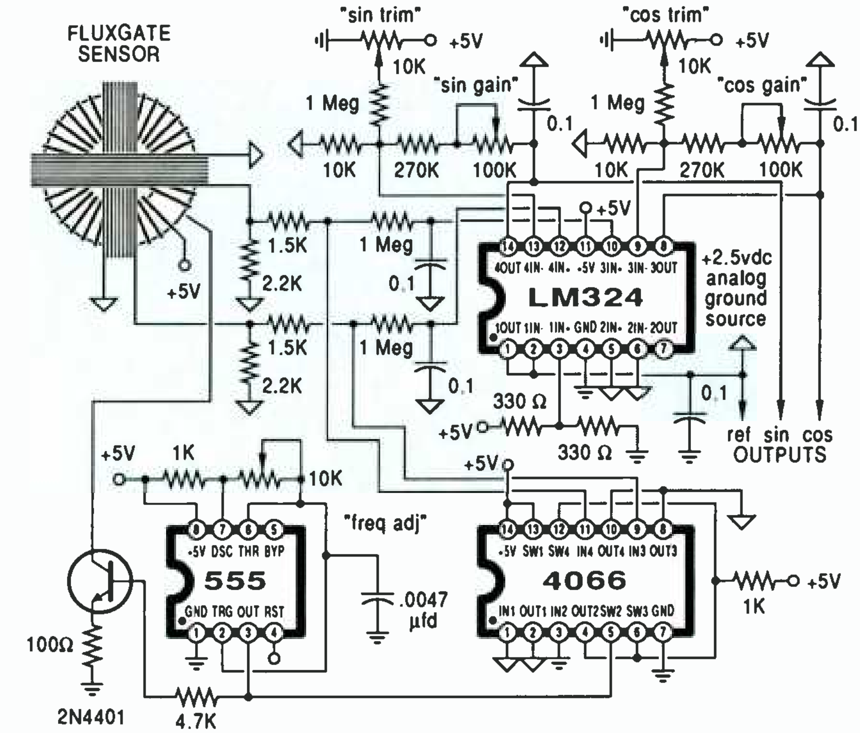

FIG. 4—A SIMPLIFIED SCHEMATIC of a solid-state digital compass. The outputs are A/D-converted and then routed to a microprocessor that handles the bearing calculations and a suitable digital display.

or of using a single or double quadrature sense winding, and of either working with nulls (by rotating the sensor) or by using absolute amplitudes.

In aircraft or radio-control model applications, one single fluxgate magnetometer can replace *both* the traditional compass and its backup gyro. At the same time, a compensation winding can be added so as to minimize any northerly turning-error problems.

That new approach to navigation is ridiculously cheaper and simpler than others. Figure 4 shows you the circuitry that is involved. What you have here on the driver is a 60-kHz square-wave generator that drives both the magnetometer and a pair of output-sensing gated half-wave demodulators and amplifying integrators.

The two quadrature DC-output signals are proportional to the sine and cosine of the amplitude of Earth's magnetic field. They can be routed through an A/D converter and sent to a microprocessor for further processing. Surprisingly, only a few hundred bytes of very simple code are needed to produce a complete digital compass.

One source of prewound and ready-to-use flux gate cores is *Precision Windings*. Circuit boards and complete kits are available from *Electronics Research*. Further info on licensing for resale or commercial use is available through *Doug Garner*.

For more details on building your own digital compass, see the NASA Tech Brief LAR-13560 on *An Improved Flux-Gate Magnetometer*, and *A Magnetic heading Reference for the Electro/Fludic Autopilot* from the December 1981 and January 1982 issues of *Sport Aviation*. Updates to that earlier design are once again available through Doug Garner. Ask for the "Oshkosh 1987" and "Sensors Expo 1987" reprints.

Solid-state compasses are also becoming commercially available from other sources at reasonable prices. Do check out your boating-supply store for more details.

Those that I have looked at so far are British made and cost around $90. Unfortunately, they are not quite accurate enough for cave surveying and they lack a built-in level and inclinometer.

continued on page 96

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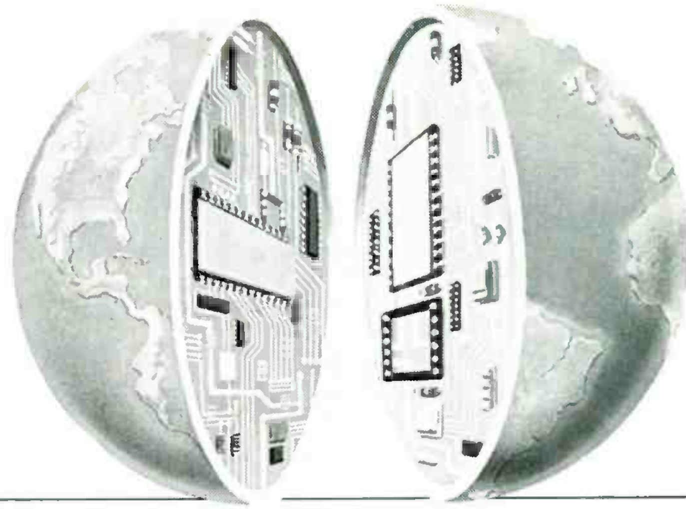

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Radio Station WWV

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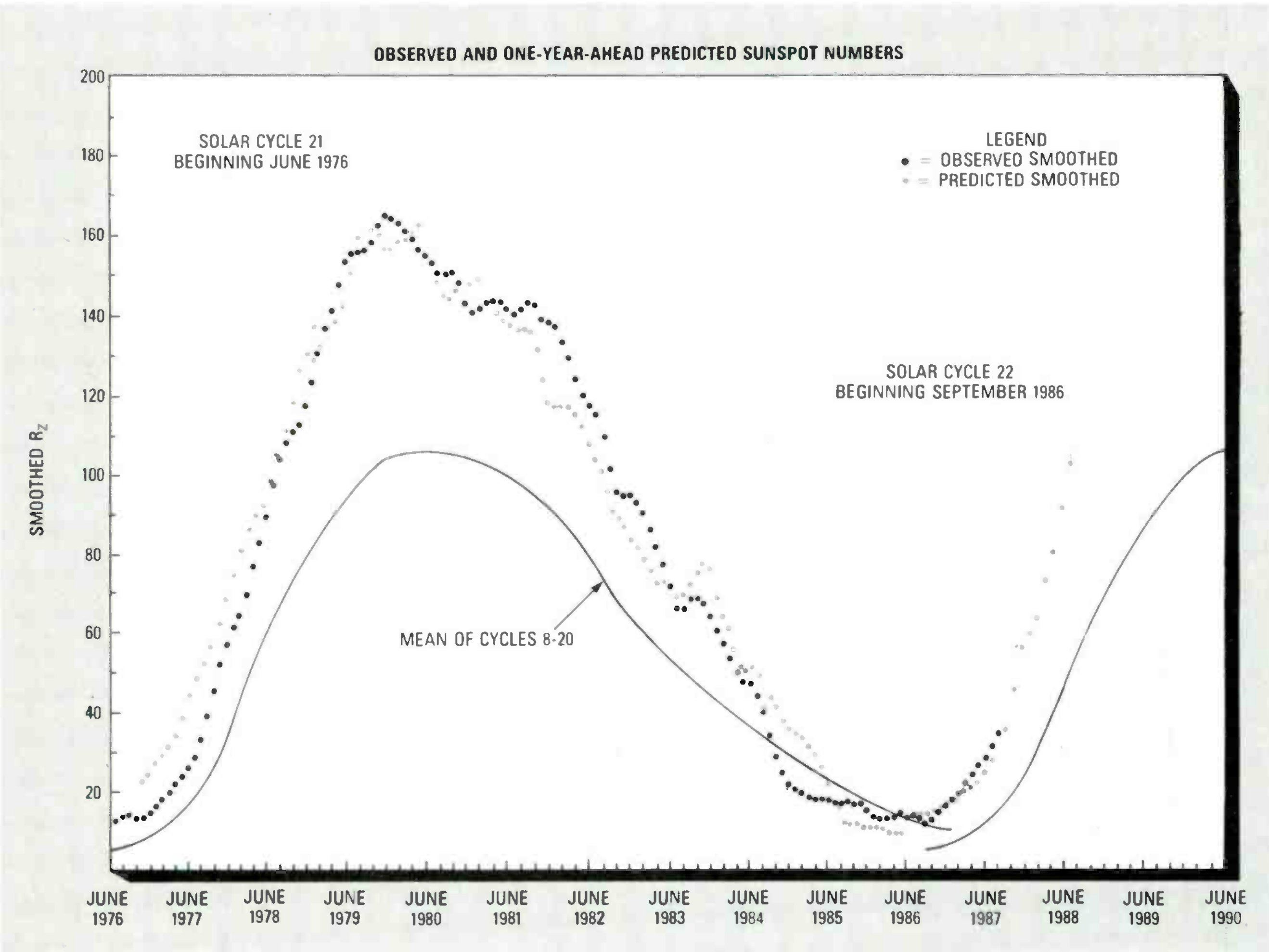

FIG. 1

THE FIRST MAJOR IONOSPHERIC STORM of the current sunspot cycle occurred last May, when a massive flare erupted on the sun, causing a virtual radio blackout throughout the world for several days.

During the early days of radio, before things like solar flares and geomagnetic storms were understood, many radio hobbyists took their receivers apart during such radio storms looking for bugs that didn't exist, because they thought their receivers weren't working properly.

With increasing sunspot activity there will be more blackout-producing storms, caused by a growing number of solar flares. Before you dismantle *your* receiver, we suggest you listen to WWV, the National Bureau of Standards time and frequency station, which broadcasts continuously on 2.5, 5, 10, 15, and 20 MHz. In addition to giving the correct time every minute, WWV also broadcasts hourly geophysical alerts that describe radio conditions during the previous 24 hours and give a forecast

for the following 24 hours. The messages are broadcast at 18-minutes past the hour, every hour, and are updated every three hours.

WWV and its sister stations, WWVB and WWVH, provide numerous other services, including standard time and frequency information, and marine storm warnings. National Bureau of Standards publication 432, entitled *Time and Frequency Dissemination Services*, can be obtained free of charge by writing Diana Gibson, Time and Frequency Division, National Bureau of Standards, Boulder, Colorado 80303.

General Conditions

With sunspot activity relatively high and increasing, daytime DX will be good to excellent, with the 15-, 17-, and 21-MHz bands providing numerous opportunities. The amateur 10-meter band will also open regularly. In addition, DX Citizens Band openings will become more frequent.

At night, conditions will be better than they were last winter, when only the 6-MHz band was reliable for long periods. This year, the 9-MHz band will be useful for DX; even the 11- and 15-MHz bands will open over long circuits from southerly locations, such as Africa and Latin America.

Because noise levels due to thunderstorm activity are at a minimum in the northern hemisphere during the winter, broadcast-band DX will improve significantly during the hours of darkness.

We are currently in the 22nd recorded sunspot cycle. Based on the average of the first twenty-one sunspot cycles, the following is a general summary of sunspot cycle behavior:

- The average period of a sunspot cycle, from minimum to maximum and back to minimum is 10.7 years.
- The average period from the beginning of a cycle (minimum) to the maximum is about 4 years.
- The average period from the maximum to the minimum of a cycle is approximately 6.7 years.

Figure 1 is a composite drawing, courtesy of the Institute for Telecommunications Sciences, that shows the average of cycles 8–20 (the period during which accurate records have been kept). Superimposed on that, is the complete cycle 21, the last complete cycle we have had. It can be seen that cycle 21 was considerably above average. Its maximum, observed in December 1979, was the second highest ever observed, with a smoothed number of 165.

Sunspot numbers are smoothed because month-to-month averages can vary widely, and scientists have found that by smoothing sunspot numbers, a more accurate assessment of trends can be made. A smoothed number for a given month (R7) can be obtained using the following equation:

$R7 = (N1 + N2 \ldots + N7 \ldots + N13) / 13$

where N1–N13 are sunspot numbers for 13 consecutive months and R7 is the smoothed number centered on the seventh month of the sequence. It can be observed that a smoothed sunspot number can't be obtained until monthly numbers for six months afterward are available. Monthly numbers are obtained by averaging daily values during each month.

continued on page 95

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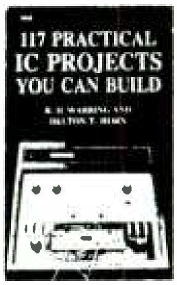

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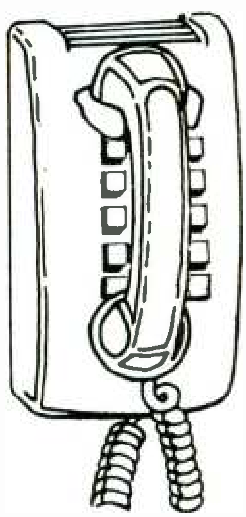

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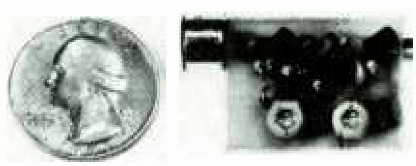

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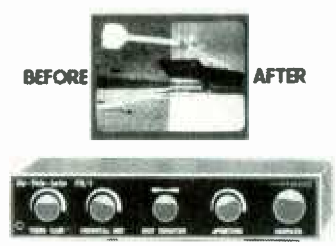

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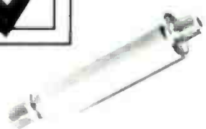

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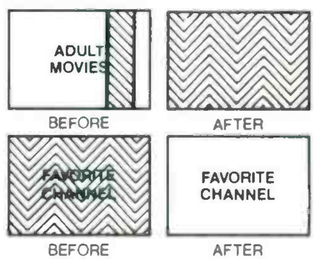

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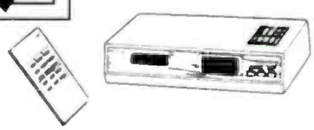

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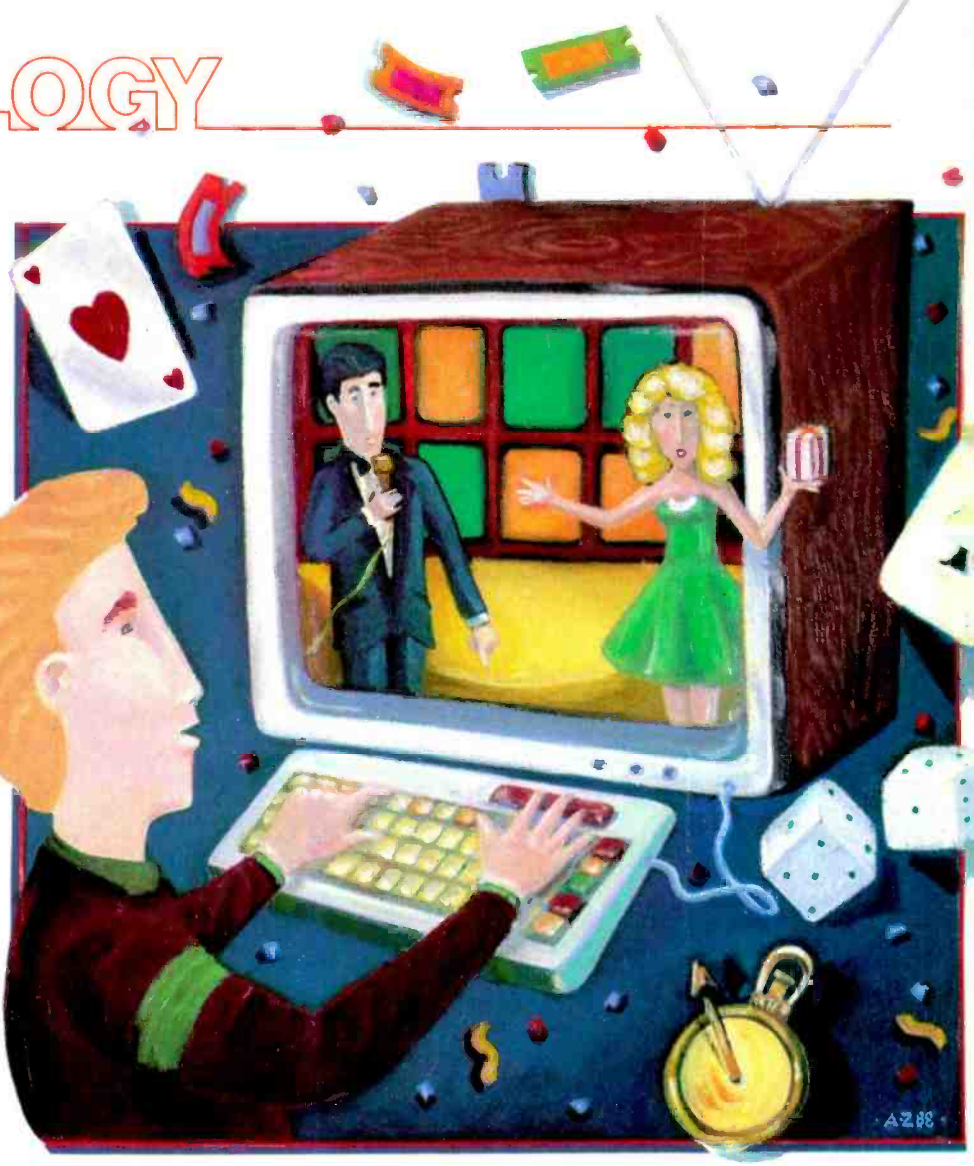
BRIAN C. FENTON, EDITOR



INTERACTIVE TV

Interactive TV turns armchair spectators into active participants.

TELEVISION HAS CHANGED QUITE A BIT since its invention. Compatible color and stereo audio were hailed as major advances that changed the way we look at and listen to TV. Some claim that HDTV will be the next breakthrough. We're looking forward to HDTV, too; but *nothing* promises to be as exciting—and have as much of a sociological impact—as a practical interactive TV system.

We've all had the experience of watching a TV game show and knowing the answer long before any of the contestants—and, we think, before anyone else in the viewing audience. Other than pounding the coffee table, there's not much you can do in such a situation. But next year, if the people at the Interactive Game Network (IGN) have their way, that may change drastically.

Imagine being able to play your favorite game against the contestants, and all other viewers, in real time. The system proposed by IGN would let you prove to the nation that you knew the answer first. And it would open up a whole world of other possibilities, too, including electronic opinion polling, lottery playing, TV auctions, and more.

What is interactive TV?

The idea of interactive TV is not new. Two-way TV that lets the viewer play an active role has been talked about for years, and it's even been tried before. One of the better known two-way systems was QUBE, an interactive cable system developed by Warner-Amex Cable for distribution in Columbus, Ohio. QUBE was successful in securing more than 300,000 subscribers, but in a 1984 cost-cutting move Warner Communications canceled QUBE's operation.

QUBE failed because the revenues generated did not justify its development costs, or the expenses incurred in laying the two-way cable and obtaining the head-end equipment. IGN's proposed system is significantly different from two-way cable systems. It promises to bring interactivity to *everyone* because its required infrastructure is already in place. IGN's system does not involve any new technology nor does it require the development of new equipment. Instead, it is a new combination of the existing technology of computers, FM subcarriers, and TV. It doesn't even require any change in FCC regulations! We're confident that the only things standing in the way of your having interactive TV in your living room are contracts with program suppliers and a massive advertising campaign.

Before we get into the technical details of the system, we should take a realistic look at where the system will go. As of press time (mid September), the system's introduction is *planned* for August 1989.

NBC is participating with IGN in a joint development agreement to devise interactive sports and game shows. Since NBC owns the rights to the daytime version of *Wheel of Fortune*, we would expect an interactive version of that most popular game show to be among the first.

The major sports leagues have also expressed an interest in working with IGN to develop interactive contests around their televised sports. An "armchair quarterback" game, where viewers try to predict the next play would likely be the first game of that genre.

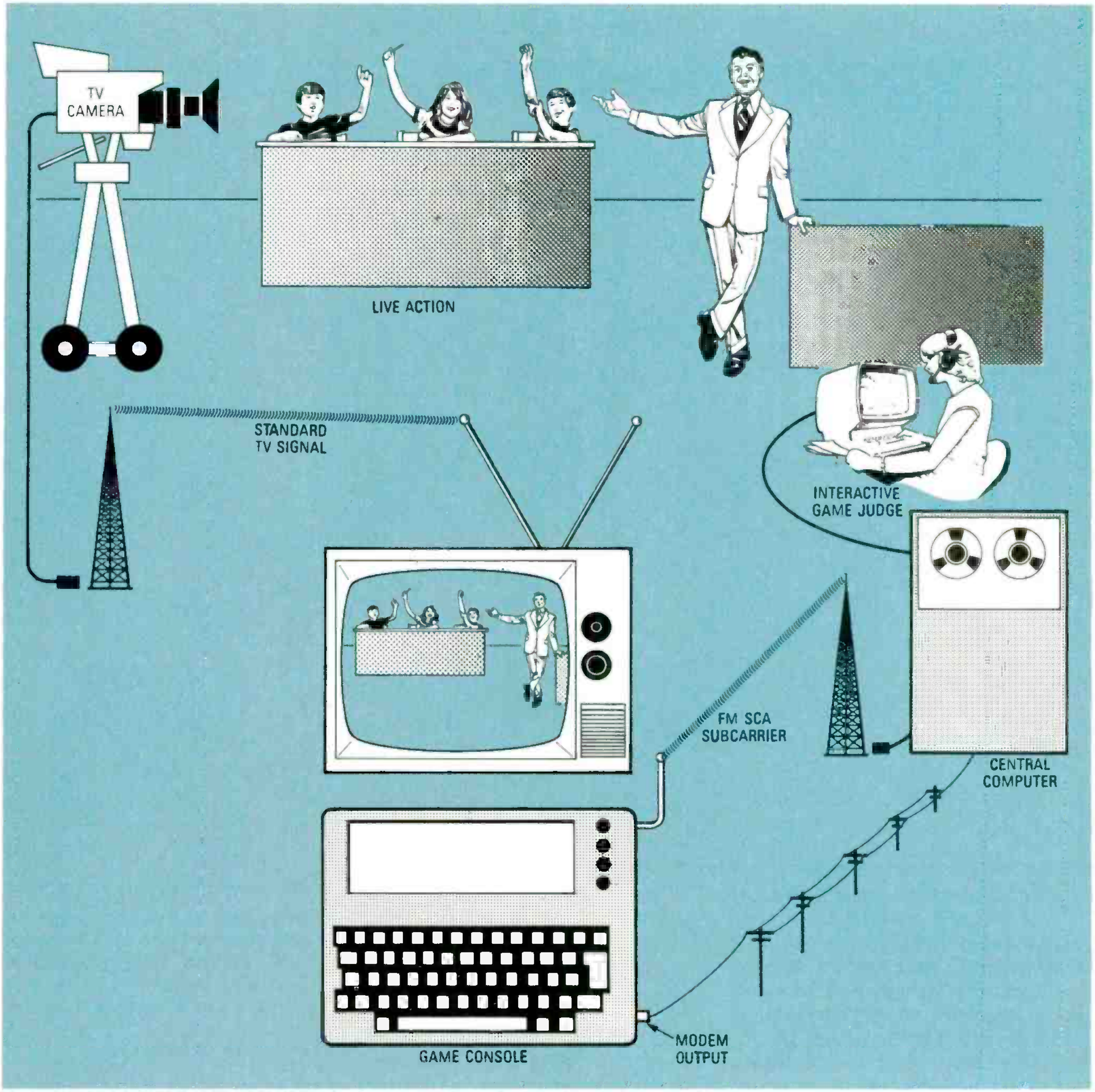


FIG. 1—INTERACTIVE GAME NETWORK'S system consists of a standard TV broadcast coupled with an FM SCA subcarrier transmission. The game consoles receive the questions from the subcarrier, along with the correct answers and a difficulty multiplier. After the game is over, the home player calls the central computer to upload his score. Winners are notified by the subcarrier transmissions.

Figure 1 shows the basic idea of how IGN's interactive TV system works. An event, such as a quiz game, is televised as it is normally. Viewers who are not interactive players enjoy TV normally. However, those who are equipped with an interactive game console receive—via an FM SCA subcarrier—instructions on their displays on how to play the game interactively.

When quiz questions are asked, the home game players have an opportunity to answer the question. In a fast-moving game such as *Jeopardy*, the home game player sees multiple-choice answers on the screen that require only a single keystroke to answer. A slower-moving game, such as *Wheel of Fortune*, requires the player to type in the full answer.

In either case, once the question is answered correctly on TV, a lockout signal is sent via the FM SCA subcarrier to prevent the console from accepting any more answers.

The use of an SCA subcarrier is essential to IGN's system. It's no coincidence that IGN's president, who holds the patent for the interactive system, is David Lockton, the founder of Dataspeed. That company pioneered the use of FM subcarriers to transmit stock quotes around the country.

Of course, not everyone in the U.S. lives within the range of an FM station that will carry IGN's data on a subcarrier. At the outset, FM stations in the top 25 markets will carry IGN's data subcarrier, leaving about 35 percent of the population out of range. Those people have no reason to despair, however. The same information as is transmitted on the subcarrier will be carried on the VBI (*V*ertical *B*lanking *I*nterval) of PBS TV stations. An adapter box, tuned to the local PBS station, will translate the data from the VBI to an FM signal, and send it to the game console using a low-power FCC type-approved transmitter.

The game console

As far as the home game player is concerned, the game console is the most important part of the system. Although the console's exact design hasn't been chosen, it will probably look much like a lap-top computer, with a full-size keyboard and a multi-line LCD display. As we mentioned previously, not all games require a full keyboard. Many games can make use of *soft keys*, which are placed along the display and take on the meaning assigned by the display.

The game console features a built-in SCA receiver and a telephone modem. Its block diagram is shown in Fig. 2. We'll continue with our game-show scenario as we discuss its operation.

The heart of the game console is a microprocessor that accepts data from an FM SCA subcarrier and also from keyboard inputs. It presents appropriate information on its display. Say, for example, a game-show question asks for the proper capital of the United States. Assuming that the game show receives rapid-fire answers from its contestants, the display would show four choices alongside four soft keys.

The interactive game judge assigns a *degree of difficulty* multiplier to the question that allows for more difficult question to be worth more. For example, a question that asks for the capital of the republic of Lithuania might be worth three times as much as the previous one. The game console receives, along with the question, the correct answer on the FM subcarrier. If your answer matches, your score is increased, and added to the score stored in your console's memory.

Along with questions, answers, and lock-out signals, the game judge (or, to be more precise, the central computer) also sends random counter-start signals. When those signals are received by the microprocessor, the current time from the microprocessor's real-time clock is transferred to one of ten counters, and a

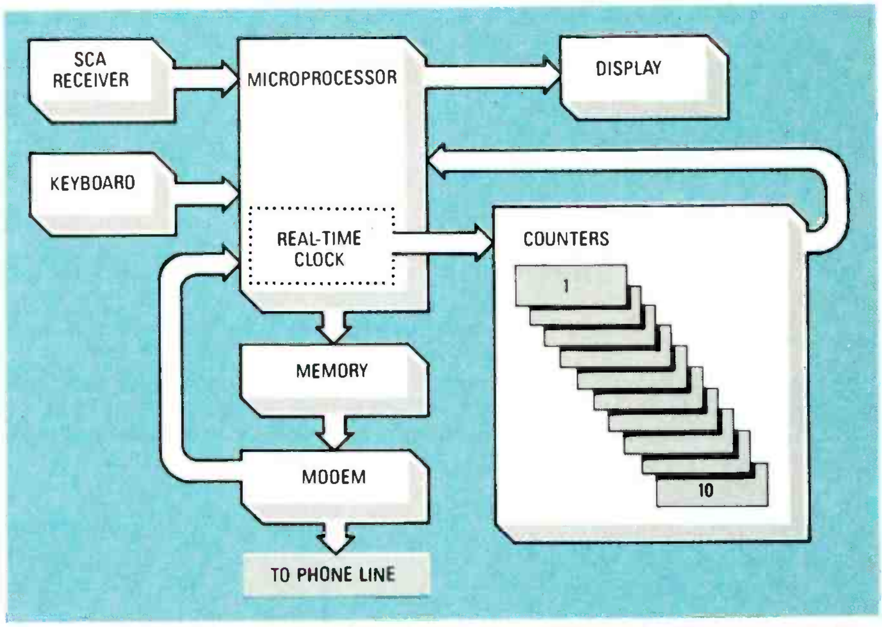


FIG. 2—THE GAME CONSOLE'S HEART is a microprocessor that receives data and time stamps from digital data in an FM subcarrier, and inputs from the keyboard. The time stamps are stored in incrementing counters that are used for verification purposes.

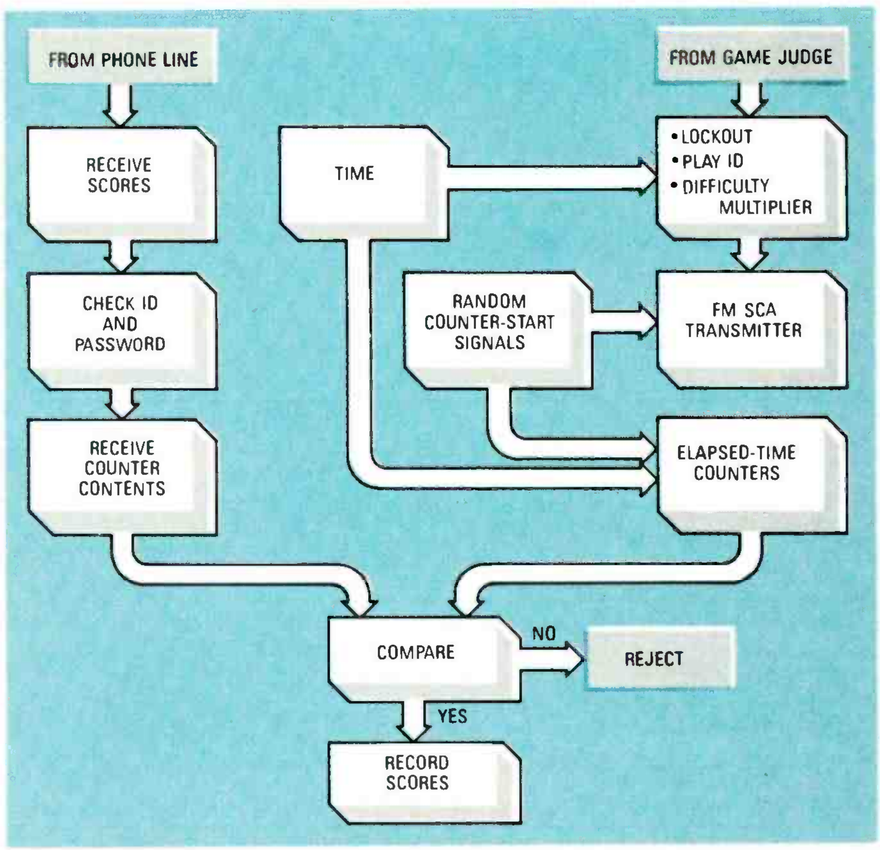


FIG. 3—THE CENTRAL COMPUTER controls the subcarrier transmissions based on inputs received from the game judge. It also generates random time stamps to start the game consoles' counters. Finally, it receives scores from game players, computes their standings, and transmits the results over an FM SCA subcarrier.

count-up operation begins in that counter. That time-stamping operation is very important—it is the main anti-cheating safeguard.

Once the game ends, you can upload your score to the central computer, where it is compared against all other players'. The upload process is nothing like what you may be used

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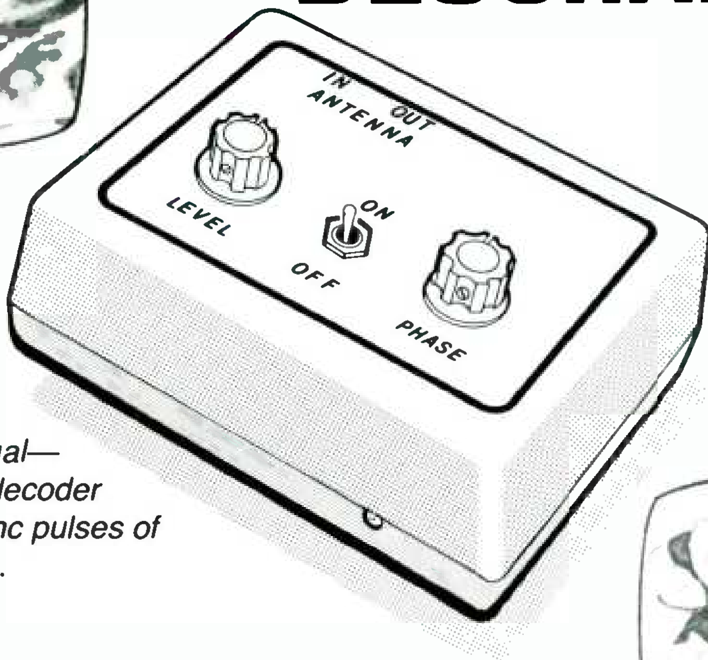
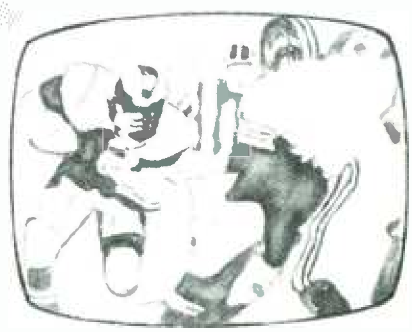
GATED-SYNC DESCRAMBLER



This somewhat unusual—but easily installed—decoder restores the gated sync pulses of scrambled TV signals.



STEVE PENCE

OF THE MANY METHODS USED TO SCRAMble a video signal for secure transmission, one of the more popular ones is called *Gated Pulse* or *Gated Sync*. The scrambling is accomplished by applying 6-dB suppression to the video signal's horizontal sync pulses thereby making it impossible for a television set to maintain a synchronized picture on the screen.

Figure 1 shows how gated sync works. Figure 1-*a* shows a conventional video signal with normal horizontal sync pulses. Notice the colorburst riding on the *back porch* of the horizontal blanking pulse. Figure 1-*b* shows the same signal with the horizontal sync pulse suppressed 6 dB. Notice that in Fig. 1-*b* the horizontal sync pulse and its blanking pulse, and the colorburst are all within the video-signal level.

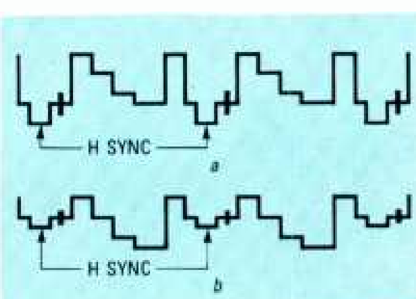


FIG. 1—A CONVENTIONAL TV signal is shown in *a*. With suppressed sync the signal resembles *b*.

YOU MUST PAY

Please note that the gated-pulse decoder is intended only for those who presently subscribe to a scrambled cable service and are dissatisfied with the picture quality attained from the supplied decoder, or who want to experiment with various decoding devices. If you are not presently a subscriber but want to view scrambled programs using our decoder, you must make subscriber arrangements with the originating program service.

The subscriber arrangement is necessary because the unauthorized reception of cable services is illegal under Federal and State laws. Federal law renders illegal both the interception and reception of any communications service offered over a cable system, unless those actions have been specifically authorized by the cable operator or by law. Federal law imposes both civil and criminal penalties for violation of the applicable statutes. In addition, states have enacted "theft of cable services" statutes that impose penalties for violations thereof.

The foregoing is not intended to constitute legal advice. Readers are advised to obtain independent advice based upon their individual circumstances and jurisdictions.

Although the gated-sync scrambling technique is basic and straightforward, its exact implementation can vary greatly from one equipment manufacturer to another; which means that each system needs its own particular kind of decoder to regain the original programming. As a general rule, the variations used to customize gated-sync scrambling usually involve a reference signal of some kind that is either multiplexed onto the audio carrier in some fashion, or onto some kind of outband carrier on an empty channel.

But if we can get around the "misplaced" reference signal, a simple gated-sync decoder is all that's necessary to decode nearly any single-level gated-pulse signal. And that's exactly what our decoder does. It eliminates the need for a reference signal, so it doesn't matter where the scrambling system hides the reference.

As you'll see, our decoder requires no special set-up equipment, although a scope does simplify setting up. Best of all, there's no intricate RF alignment because no RF tuned circuits are used in the decoder.

Pluses and minuses

As with any other decoder, ours has both advantages and disadvantages. Its advantages include: versatility—it will work on nearly any single-level sync-suppression system and does not need a reference signal to operate; no demodulation of any kind; a simplified circuit design that uses low-cost, readily available parts.

The disadvantages are that the device must be used with a television set—a VCR by itself will not do. The television set must be tuned to the channel that is being decoded, and phase-lock is not automatic—it must be done manually each time the decoder is turned on or when the channel is changed. Also, the decoder will not work on tri-mode systems or any other system that uses more than one level of sync suppression, or on any system that suppresses the vertical sync pulse. Also, the decoder will operate only in the low VHF band; hence it must be used with a cable downconverter that outputs on channels 2, 3, or 4.

How it works

As shown in Fig. 2—a functional block diagram of the decoder and some of a TV set's circuits—the basic principle used in the gated-sync decoder is that of a phase-locked loop. The loop, which is indicated by the bold lines, is formed by the TV set's sync separator, horizontal AFC circuit, horizontal oscillator and output, and the high-voltage *flyback* transformer. When all of that circuitry is being fed normal video (containing sync pulses), the loop is closed by taking a pulse from a winding on the flyback transformer and feeding it back to the AFC circuit, where the flyback's pulses and the sync pulses are compared. If they are not in phase, an error voltage is generated that forces the horizontal oscillator to change frequency until the two signals are finally in phase and the picture locks.

If the sync pulses are suppressed, as they are in a gated-sync system, the AFC loop has been opened because the pulses from the flyback transformer have nothing to be compared with; so the horizontal oscillator runs free (unsynchronized).

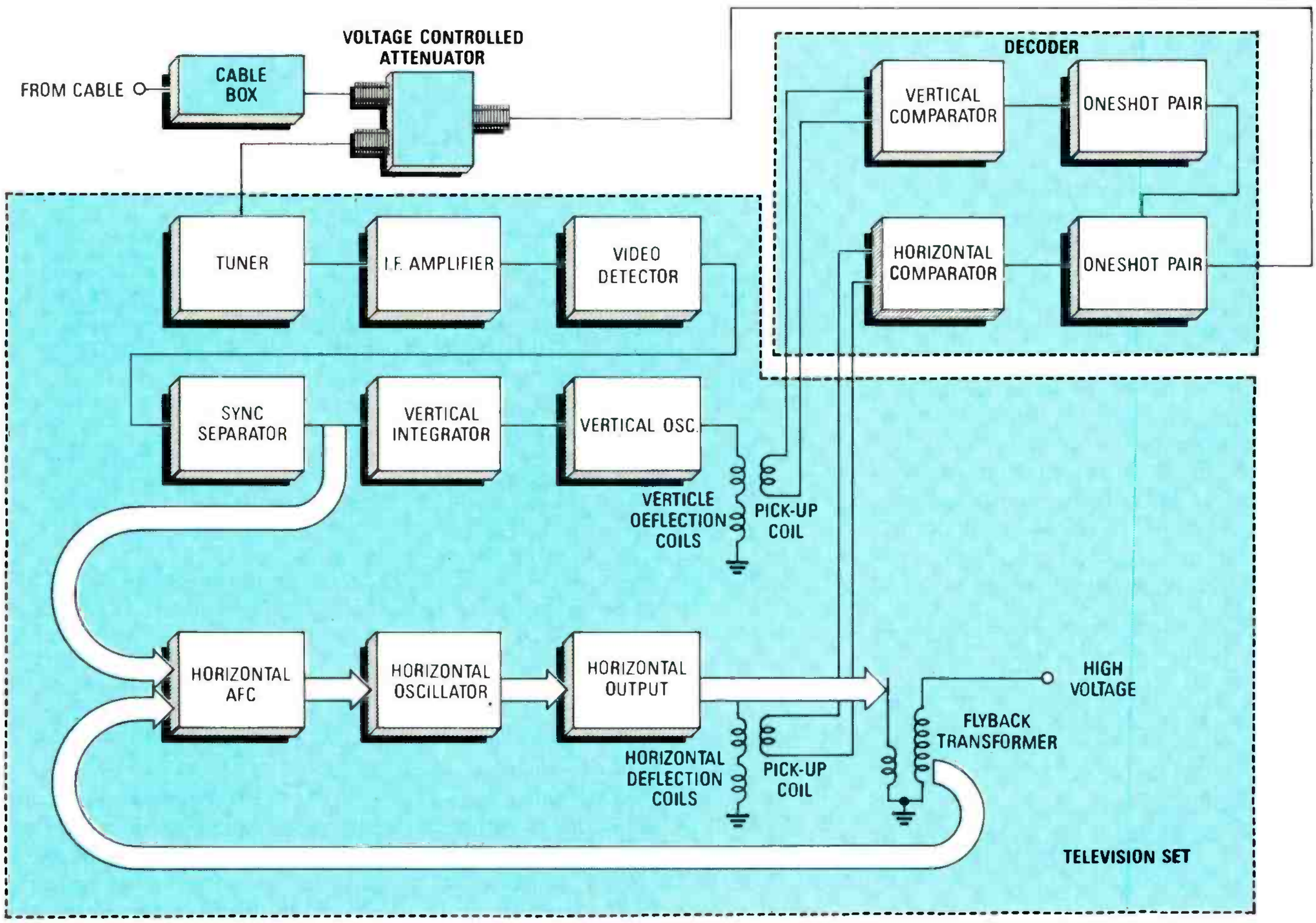


FIG. 2—THE DECODER WORKS by using sync samples from the TV's deflection yoke to control a signal attenuator.

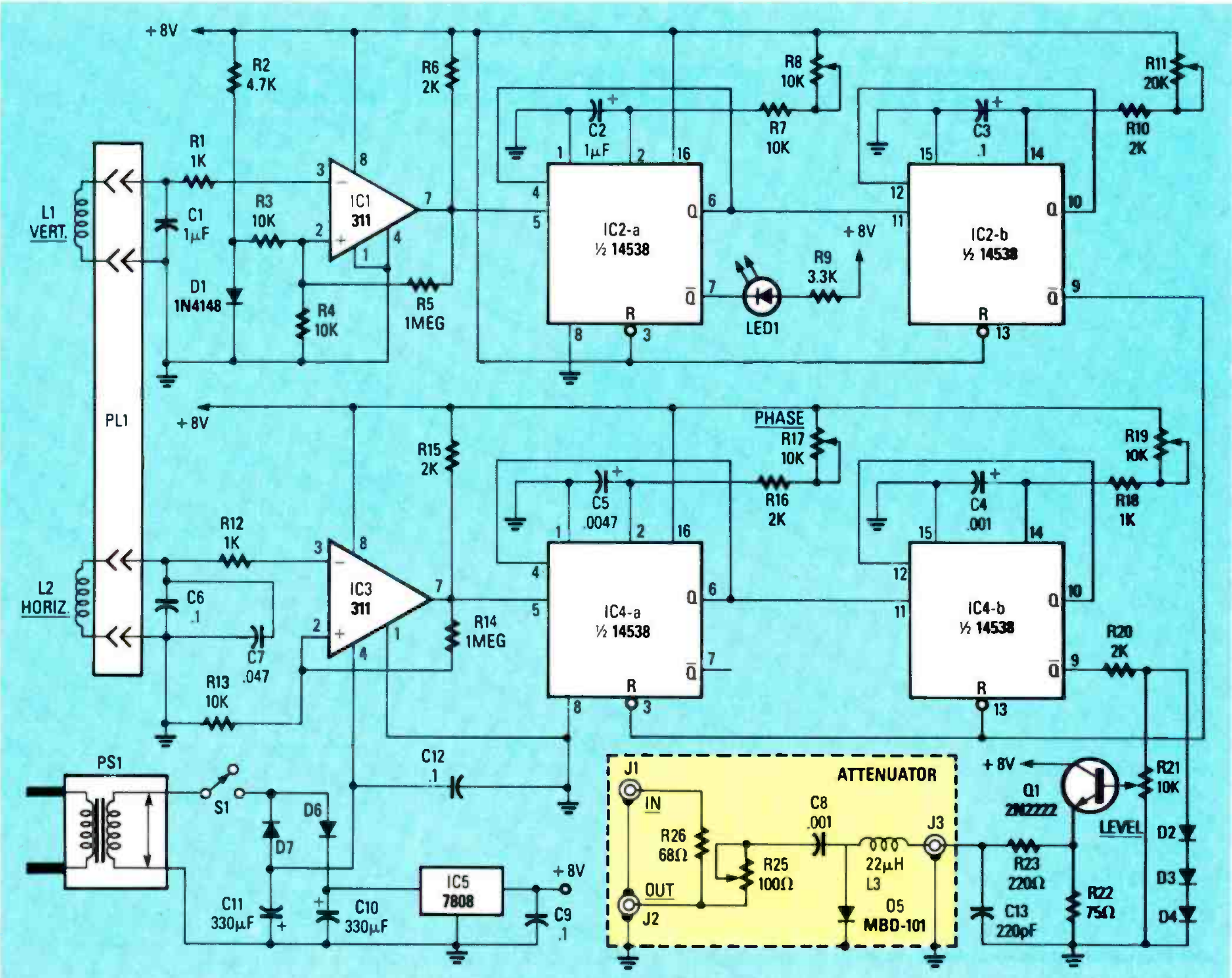


FIG. 3—THE DECODER'S CIRCUIT. The attenuator is built as a separate subassembly.

Closing the loop

Our decoder closes the loop by taking samples of the pulses produced by the horizontal oscillator and feeding them back around to the antenna input to increase the amplitude of the RF envelope during the signal's sync-pulse period. The samples of the TV set's vertical and horizontal sync pulses are obtained by induction from the TV's vertical and horizontal deflection coils.

The sync-pulse reinsertion is accomplished with a voltage-controlled attenuator. The attenuator reduces the amplitude of the RF signal feeding the TV set. Pulses from the decoder cause the attenuator to "unattenuate," thus increasing the signal level during the "unattenuate time"—which is effectively the same thing as re-inserting the sync pulse. Sync pulses are inserted pretty much randomly until the right combination of horizontal oscillator, decoder oneshot phase delay, and re-insertion level occur. When everything is correct, so that a few sync pulses are inserted at the proper time, the whole system locks up and stability is restored to the picture.

The circuit

The decoder, which is shown in Fig. 3, requires that no direct electrical connection, nor any modification, be made to the TV set. The TV signals are obtained by pickup coils L1 and L2 through inductive coupling; hence, there is no shock hazard during set up as long as the television set is unplugged from the powerline and you touch nothing but the deflection yoke during the installation of the coils. The purpose of the coils—which are taped to the deflection yoke—is to pick up the horizontal and vertical scanning pulses.

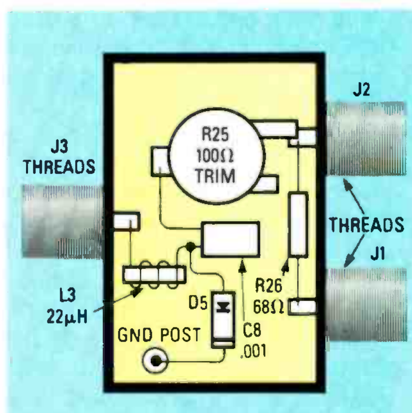


FIG. 4—THE ATTENUATOR is built in a gutted splitter. The assembly will be simplified if you follow this parts layout.

L1 and L2 are identical air-core coils. The vertical coil, L1, is taped to the *side* of the yoke (either right or left, it doesn't matter). Coil L2 is the horizontal coil, and it is taped to the *top* of the yoke.

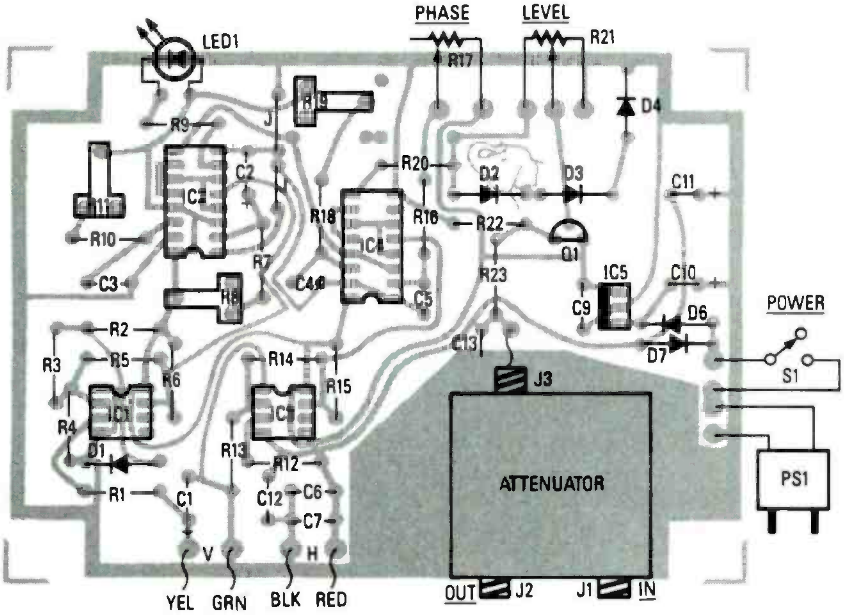


FIG. 5—THE PARTS LAYOUT. The attenuator subassembly is installed directly on the component side of the PC board.

A 15.734-kHz resonant circuit is formed by L2 and C6/C7. The waveform displayed on an oscilloscope that is connected across L2/C6/C7 will be a pure sine wave whose amplitude depends on the size of the picture tube. That's because as the screen gets larger, the yoke scanning current must become larger to deflect the beam.

IC3 is a zero-crossing detector that squares up the sine wave induced in L2 and converts it to single-ended drive for IC4—a CMOS oneshot—that follows. Because the input to IC3 is a sine wave that goes both above and below ground potential, IC3 must have both a positive and negative supply voltage. The positive voltage is supplied by voltage regulator IC5. IC3's negative voltage is provided by D7 and C11.

IC4-a is used as a phase delay and sync pulse restorer pair. *Phase Adjust* control, R17, can vary the period of IC4 over the range of 9–56 µs. R17 is installed on the front panel because it is used to phase-lock the decoder when the unit is first powered up, or when the user selects a different television channel.

IC4-b is used as a sync restorer that provides a pulse of 1–11 µs (set by trimmer-potentiometer R19). The output pulse at pin 9 is normally high; it goes low during the sync pulse. Transistor Q1 is a low-impedance driver for attenuator-diode D5. Diodes D2, D3, and D4 limit the amplitude of the pulse so that D5 (in the attenuator) cannot be overdriven.

A simple shunt attenuator is made up of R25, R26, and D5. The RF signal that is applied to J1 is attenuated at J2 when D5 is forward biased. When the voltage across D5 drops to zero, the RF signal is unattenuated.

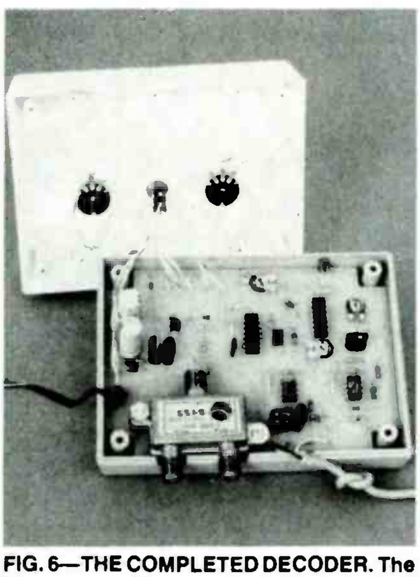


FIG. 6—THE COMPLETED DECODER. The three operating controls are mounted on the cabinet's cover.

Basic circuit

In many instances, only the previously described circuit that is associated with L2 is all that's needed. With some judicious knob twisting, the circuit can be aligned by simply observing the picture to see the effect

PARTS LIST

All resistors ¼ watt, 5%, unless otherwise specified.
R1, R12, R18—1000 ohms
R2—4700 ohms
R3, R4, R7, R13—10,000 ohms
R5, R14—1 megohm
R6, R10, R15, R16, R20—2000 ohms
R8, R19—10,000 ohms, trimmer
R9—3300 ohms
R11—20,000 ohms, trimmer
R17, R21—10,000 ohms, potentiometer
R22—75 ohms
R23—220 ohms
R24—not used
R25—100 ohms, trimmer
R26—68 ohms
All capacitors polystyrene, 25 volts, unless otherwise noted
C1, C2—1 µF, 25 volts, tantalum
C3, C6, C9, C12—0.1 µF
C4, C8—0.001 µF
C5—0.0047 µF
C7—0.047 µF
C10, C11—330 µF, 25 volts, electrolytic
C13—220 pF
Semiconductors
IC1, IC3—LM311 voltage comparator
IC2, IC4—MC14538 dual monostable multivibrator
IC5—7808, 8-volt regulator
D1, D2, D3, D4—1N4148 silicon rectifier
D5—MBD-101 or 1N5817 silicon rectifier
D6, D7—1N4001 silicon rectifier
LED1—red light-emitting diode
Q1—2N2222, NPN transistor
Other components
Attenuator—see text
J1, J2, J3—part of attenuator
PS1—wall transformer, 12 volt, 50mA
S1—SPST switch
PL1—Mating DIN connectors
Miscellaneous: Printed-circuit materials, wires, solder, soldering iron, hardware, tools, etc.
Note: The following items are available from Steve Pence, P.O. Box 41850, Phoenix, AZ 85080. The printed-circuit board: $15.00. A partial kit that includes the PC board, IC's, and coils: $25.00. The PC board for the April '85 Sync Separator project is available for $15.00 (the complete kit has been discontinued). Allow 4 to 6 weeks for delivery. We cannot accept orders from Arizona residents. Canadian orders please use postal money orders in U.S. funds and add $2.00 handling.

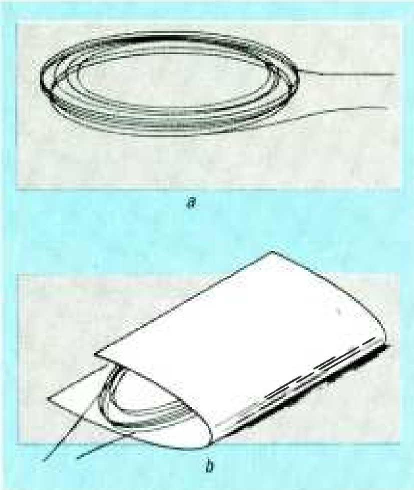


FIG. 7—STRETCH THE COIL into an oval, as shown in *a*. Then cover the coil with tape, as shown in *b*.

of each control. The decoder is connected between the output of a cable box and the antenna input of the television set. If desired, a VCR can be placed between the decoder and the television set, and the effect on the signal can then be observed with a scope by looking at the VCR's video output.

The vertical circuit, composed of L1, IC1, and IC2, locks out IC4 during the vertical interval. The pickup coil, L1, must be taped to the deflection yoke in order to pick up enough of a signal to drive IC1. Capacitor C1, which is connected across L1, serves only as a filter to remove the horizontal hash that is picked up along with the vertical pulse by L1.

The signal across L1 will be polarized, and must be of the correct polarity to drive IC1; hence it may be necessary to reverse the coil's connections. LED1 will light when L1's polarity is correct.

The two sections of IC2 operate the same as they do for IC4, except that they are used for the vertical, rather than the horizontal, sync pulses. IC2 is adjusted by R8 and R11 until the output pulses at pin 9 go low during the time you want the horizontal pulses locked out, which usually occurs during vertical blanking.

Construction

Except for the RF attenuator, construction is non-critical. The author's prototype was first built on a Radio Shack breadboard, and the circuit worked perfectly the first time. For those of you who prefer printed-circuit assembly, we provide a full-scale template in PC Service. Take note that space and a ground plane are provided on the PC board for the RF attenuator, which, as shown in Fig. 3, is a separate unit.

Figure 4 shows the assembly of the attenuator, which is built inside a gutted two-set coupler. Most couplers are made of aluminum and cannot be soldered to; and most, but not all, will have a solderable ground stud inside. If yours does not, you will have to drill a hole for a machine screw with which you can bolt down your own ground lug. Solder a bare bus wire to the ground lug in the attenuator (the cut-off lead of a resistor or capacitor will do). The wire should exit out the bottom of the attenuator and be snaked through a hole in the PC board that you must drill specifically for the ground wire. After the module is mounted to the board, solder the wire to the PC board's ground plane.

The reason for the ground wire is because the attenuator module's mounting screws often do not make a good ground connection to its case and the PC board. The ground wire is simply ensurance against possible grounding problems.

You should also drill a ⅜-inch hole in the top of the attenuator module directly over where trimmer-potentiometer R25 will be mounted. The hole will allow you to adjust the trimmer without dismounting the module.

Figure 5 shows the parts placement on the PC board. Secure the attenuator case to the PC board with two screws. If the case has a separate external grounding tab, simply cut it

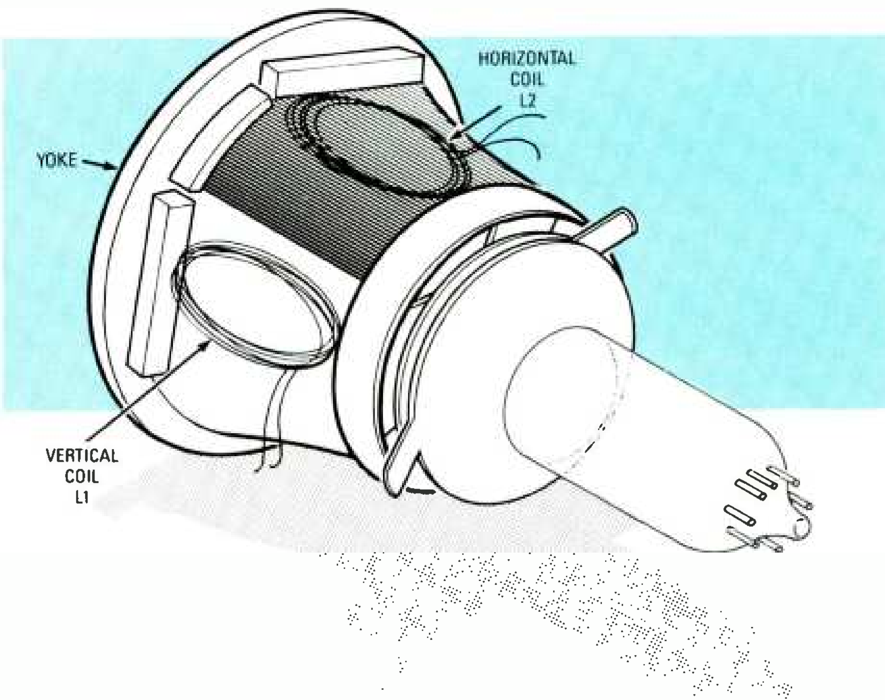


FIG. 8—TAPE THE COILS on the CRT's yoke as shown.

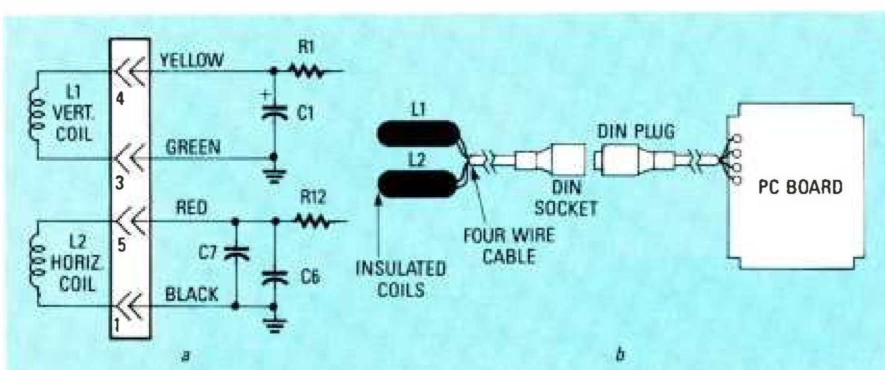


FIG. 9—THE ELECTRICAL COIL connections are shown in *a*. The way they are connected to printed-circuit board is shown in *b*.

off if it gets in the way of anything. Notice that IC1–IC4 are not mounted with the same orientation; that is, all No. 1 pins and/or notches do not face the same direction. Instead, all pin 1's and/or notches face the center of the PC board, as does IC5's metal tab.

Figure 5 also shows color-coding for the wires connected to the vertical and horizontal PC-board connections. The exact colors are unimportant—they will depend on the particular multi-conductor wire that's used. (The colors shown are those of conventional telephone quad.) We only show color-coding to help you integrate the parts placement with the wiring of L1 and L2, which we'll get to in a short while.

At this point the circuit board can be installed in a cabinet, as shown in Fig. 6. The phase (R17) and level (R21) controls, and the power switch (S1), are mounted on the cover.

Making the coils

Coils L1 and L2 are made by scramble-winding 100 turns of No. 28 or No. 30 solid, insulated, magnet wire around a 1¼-inch form. (The author used an empty 35-mm film canister for the form.) As shown in Fig. 7-*a*, after each coil is wound, slide it off the form and elongate the coil to form an oval. To prevent the coils from becoming unwound or deformed, dip them in hot candle wax or paraffin (available in most hardware stores.)

Make two coils, then attach leads to each coil that are long enough to reach from the inside of the TV set to the decoder. You can use either individual wires, pairs for each coil, or quad (four wires: two for each coil). Sandwich the coil assemblies in white adhesive tape for insulation, making certain that the tape covers the coils and the ends of the heavier hook-up wires. (The tape provides stress relief for the thinner coil wires).

Mount the coils to the yoke of the television set as shown in Fig. 8. The easiest way to do it is to simply hold the coils in place with a strip of adhesive or electrical tape. Snake the wires out of the TV set and connect them to a 5-pin DIN connector as shown in Fig 9. Figure 9-*a* shows the actual wiring and the DIN-connector numbers. Figure 9-*b* shows how the coils connect to the PC board.

Tweaking

Due to the differences in inductance that are possible when coils are wound by hand with whatever size wire is readily available, it may be necessary to select the value of C6/C7. The value needed to resonate with L2 will be near 0.15 µF. After the coils are taped to the yoke, turn on the TV set and use a high-impedance voltmeter or scope to measure the induced voltage across C6/C7. Try different values of capacitance until you attain the maximum peak-voltage reading.

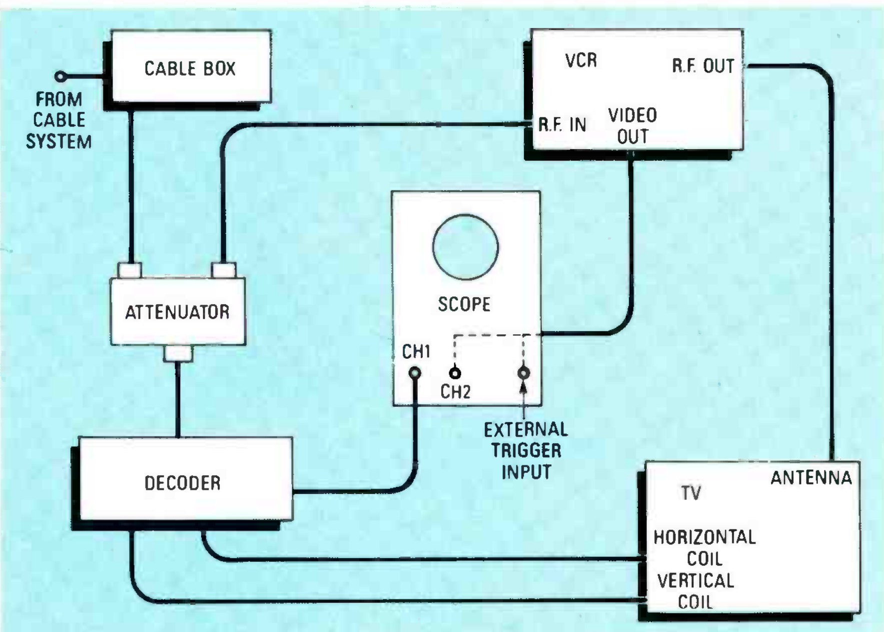


FIG. 10—THIS IS HOW TO CONNECT the equipment when making your checks and adjustments. The VCR is not necessarily required (see text).

USING A SCOPE

Whenever you work with video, and in particular when working with decoders, you must often correlate the video signal with another signal, such as a sync re-insertion pulse. That is impossible to do if the scope you are using is not set-up to be triggered properly.

The secret is in a setup that allows you to look at only one line of video at a time; each time the scope sweeps, it displays the same line. In other words, if you want to look at scanning line number 32 (that is, the 32nd line of video that occurs after the first field begins), you must make the scope sweep only during the time that line 32 is present.

Most scopes do not easily allow you to trigger that way. Those that can be triggered that way have an extra feature called "delayed sweep." Delayed sweep allows you to trigger on a relatively slow repetitive event like vertical sync, delay out to a specific line of video, then begin a very fast sweep that is set by a second time-base. The delayed sweep allows you zero in on any part of a waveform that occurs after the trigger, and then expand that portion.

A project that provides scope delay was described in the April 1985 issue of **Radio-Electronics.**

Alignment

Ideally, alignment should be done with a scope, using the equipment arrangement shown in Fig. 10. The best scope to use is a dual-trace model having delayed sweep. For those of you without access to such a scope, begin by interconnecting the decoder with your television as shown in Fig. 11 (the VCR is optional). Turn on the TV set and tune the cable box to a non-scrambled station. Adjust the set's vertical-hold control until you can see the vertical-blanking bar: Try to get it to sit still long enough so you can measure the vertical height *of the bar* with a ruler or a tape measure. Make a note of the height.

Set R8, R11, R17, R19, and R25 to the center of their rotation, and set R21 fully counterclockwise. When you apply power to the circuit the vertical-polarity LED should come on. If it does not, reverse the leads from L1 or physically flip the coil 180°

Slowly adjust R21 clockwise—the picture becomes lighter as the control

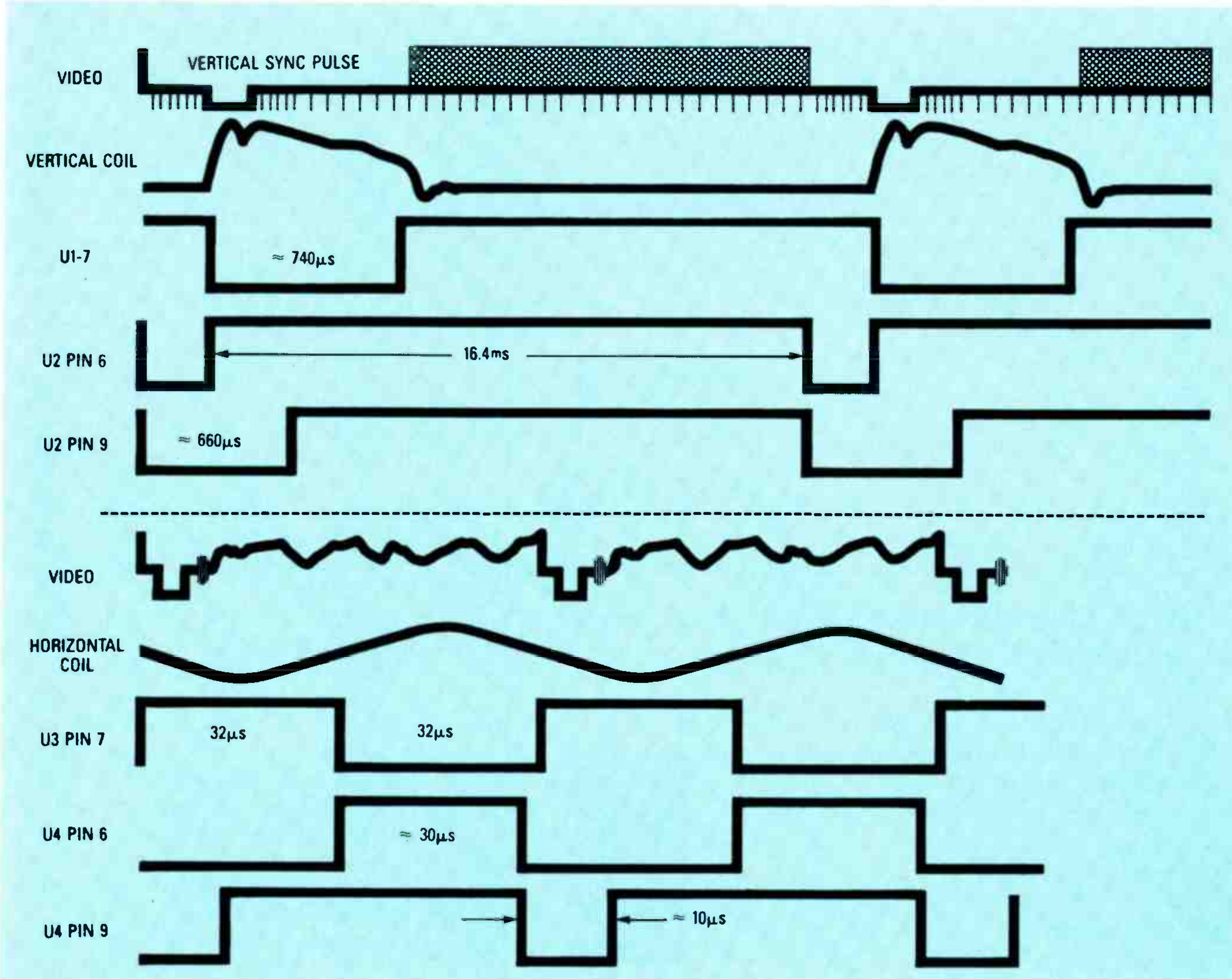


FIG. 11—IF YOU USE A SCOPE for checks and adjustments, this is how the important waveforms will be displayed.

is advanced. You may see a bar near the center of the picture that will be slightly darker than the picture itself. If you do not see the bar, adjust R17 to bring the bar in from either side of the screen. If you cannot make the bar appear from either side, reverse the connections to L2 or flip it over.

Adjust R17 until you can see the full width of the bar; then adjust R8 until you see a clear spot in the vertical bar. Then adjust R11 until the clear spot is just a little wider than the vertical blanking bar was that you measured previously. As R8 is adjusted through its full range, you should be able to make the clear spot appear from either the top or the bottom of the picture. Note where in R8's rotation the spot appears at the top, and where it appears at the bottom of the screen. Set R8 midway between those two points.

Set R17 midway between where the bar disappears on the left and right hand side of the screen. Tune in a scrambled channel and set R21 to about ¾ of its clockwise rotation. (That ensures that the attenuator diode is being driven hard.) Adjust R25 until the picture corrects; which will be easiest to do on a brightly lit picture, and nearly impossible to do on a dark picture. R25 should be set so that the picture is somewhat over-corrected and washed out; then adjust R21 for normal brightness and contrast. The three controls—R21 (phase), R19 (pulse width), and R21 (level)—all interact with one another and may require considerable experimentation and knob twisting to get them all correctly adjusted.

Keep in mind that D5 is being used as a switch and not as a diode. That means that it must be driven hard enough (controlled by R21) to keep it off the sharp knee of its forward-bias curve. If it is allowed to act as a diode, it will also rectify the incoming signals and produce a varying voltage that will also modulate its own forward-bias voltage. That action will produce an interference pattern in the picture.

Once everything is properly optimized, all you should have to do will be to adjust R17 and R21 whenever you turn the decoder on, or after you change channels. In most, but not all, instances, picture-lock will occur automatically when a scrambled channel is selected and a fairly bright scene is available.

If the signal level of your cable system is too low, the 6-dB signal loss caused by the attenuator module will often cause snow in the picture. One solution to the problem is to place a distribution amplifier in the signal chain prior to the decoder.

Scope set up

Begin by interconnecting everything as shown in Fig. 10. Set R8, R11, R17, and R19 to the center of their rotation. Set R21 for zero correction—full counter-clockwise. If the vertical-polarity LED does not come on, reverse the connections to pickup-coil L1 or flip it over and retape it to the yoke. Perform the set-up adjustments with an unscrambled signal.

Adjust R8 and R11 until the vertical-sync waveforms on your scope match those shown in Fig. 11-*a*. Both comparators of IC2 are triggered on the falling edge. The period of IC2-a is approximately 16.4 milliseconds. It should be adjusted to time out just before the beginning of the next vertical interval.

IC2-b is triggered by the falling edge from the first section. For most gated-pulse systems, its period will be approximately 660 μs. Again it should be set by comparing its pulse width to the video waveform. It should fire just before the vertical sync interval and time out just after the last equalizing pulse.

To set up IC4, compare the sine wave across L2 with the video waveform. The leading edge of the horizontal-sync pulses should correspond to the positive to negative transition of the sine wave through zero volts. If it does not, reverse the connections to L2 or flip the coil over.

Both sections of IC4, like IC2, are negative-edge triggered. Adjust R17 and R19 until they match the waveforms shown in Fig. 11. The output at pin 9 should be set for a starting pulse width of 8–10 μs.

Then, use the same alignment procedure as previously described, starting with the adjustment for R21.

Operating tips

If you can't locate an MBD-101 or a 1N5817 you can use a 1N4148; but if you do, another diode must be connected in series with D2, D3, and D4 to make certain that there will be enough drive voltage for D5.

The 14538 used for IC4 must be manufactured by either Motorola or National. The reason for that is because most other manufacturers do not guarantee operation for pulse widths below 20 microseconds, which is not narrow enough. R-E

VIDEO-EDIT CONTROLLER

Here's a low-cost device for professional-quality video editing.

THOMAS A. NERY

EXCITING HOME VIDEOS USUALLY REquire heavy editing—leaving the deadly-dull stuff "on the cutting-room floor." Unfortunately, the commercial video-edit controllers needed for *pro*-quality editing are usually priced beyond the budget of most video hobbyists, which means that most videos usually end up looking like just another home movie—or worse.

But there *is* a low-cost alternative to commercial video editing. It's our video-edit controller; a relatively simple device that requires the use of only two VCR's, or a VCR and camcorder, to edit video tapes electronically like a professional.

Home videos are usually edited by pausing the recording VCR at the point where recording is to begin, and pausing the source (player) VCR at the point where the new video starts. Once satisfied with the edit points, both pause buttons are released simultaneously to allow the playback and recording to start.

Although the procedure for "pause-editing" is theoretically correct, real life proves that theory and practice are not one and the same, because machines—particularly when dealing with precise timing—don't necessarily function the way we would like them to. The variations in the pause-timing characteristics of VCR's and camcorders usually result in several seconds of lost picture at the edit.

Editing controller

But use our video-edit controller and you will eliminate the lost snatches of picture when editing. That's because our controller allows video editing by frames, rather than by time periods.

To understand the operation of the video-edit controller, it's necessary to understand why several seconds of video are lost when using the simultaneous-pause-release method of videotape editing.

When the source (player) VCR's *pause* is released, the machine starts playing slightly after the point where the tape is positioned. The "slightly after" is a function of the tape getting up to speed before the video is output. The recorder, on the other hand, must synchronize itself to the source. To accomplish that, most newer VCR's—as well as camcorders—use a feature known as *preroll*.

Preroll

Preroll means that the recorder is rewound a predetermined number of frames, put into the play mode, and then shifted into *record* at the point where the recording is actually to start. When editing by dual-pause control, the additive "true start" delays of the source and record machines usually result in several seconds of missed video from the source.

There is also a synchronization problem associated with the dual-pause method of editing. Specifically, the recorder is being asked to synchronize itself to two different sources: the video prior to the source-VCR's getting up to speed, and then the video once speed is attained. That complicates the recorder's operation, and can result in video-breakup at the edit point.

Pro-quality editing

On the other hand, our video-edit controller does not depend on pause controls: It edits in a way similar to some professional editors. First, it rewinds the source-VCR for a fixed amount of time and then switches the VCR to the *play* mode. At the appropriate time, while the source-VCR is playing, the controller starts the recording VCR. The recording VCR uses up its preroll, comes up to speed, and then switches to the *record* mode. If all the timings are correct, the source-VCR is feeding the selected edit frame at the precise instant that the-recording VCR switches to the *record* mode.

Overall editing accuracy is dependent on the ability of the source- and recording-VCR's to consistently repeat their operations in exactly the same time periods. Since the recording- VCR's preroll is designed by the manufacturer to always start the recording after a fixed time interval, it is the source-VCR that's the main synchronizing problem.

Review to time

But we can make the source-VCR's rewind timing more or less consistent if we use the machine's *review* function—rather than the *rewind* function—to back up the tape. That is due to the fact that *review* is a *capstan-driven* function that always operates at a predetermined multiple of the nor-

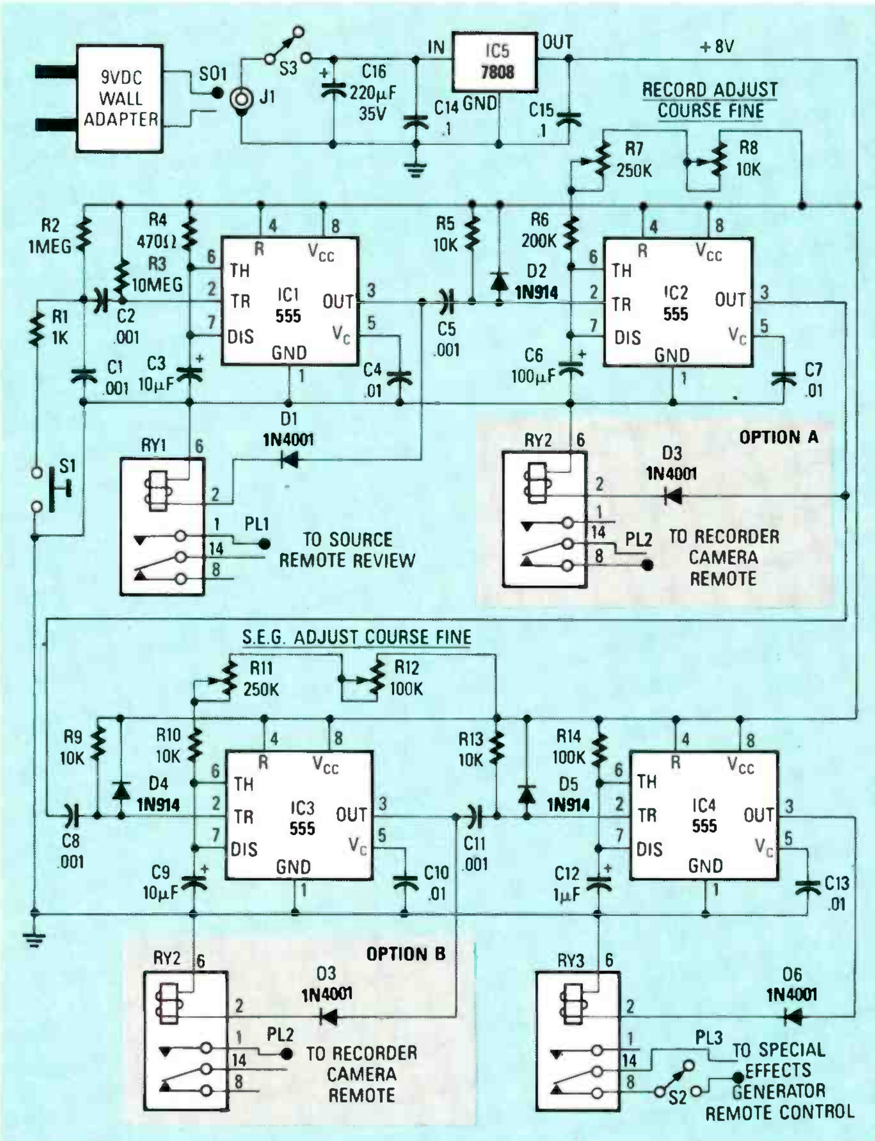


FIG. 1—THE VIDEO-EDIT CONTROLLER basically consists of four similar timer circuits. Both the OPTION A and OPTION B circuits for relay RY2 are built into the PC board. Simply plug the relay into the appropriate socket.

mal play speed. During *review*, the tape is always backed up the same length per period of time; whereas, during *rewind*, the actual amount of tape backed up per unit of time depends on how much tape is left on the supply reel.

In addition to the edit function, the controller also provides a switching circuit for a special-effects generator, such as you might use to cause a fade from, or to, black at the correct time.

How it works

The edit-controller, shown in Fig. 1, consists of four monostable timers. Each timer has the capability to drive a relay, although only three relays are used to interface to the controlled devices. To accommodate different remote-control circuits, relay RY2 can be installed at the locations labeled OPTION A, or OPTION B—more on that later.

The edit operation is started by closing switch S1, which causes a rapid drop to ground of the voltage across capacitor C1. C1's discharge causes a negative-going spike through C2, which triggers timer IC1. The triggering of IC1 causes RY1's contacts to close, and they remain closed during IC1 timing period. The timing period is determined from the equation:

$$\text{time} = 1.1(R4 \times C3)$$

The source-VCR's remote-control *review* jack is connected to RY1's contacts through PL1. The VCR will be held in the *review* mode during IC1's timing period. At the end of the timing period, RY1 is released, its contacts open, and the VCR automatically switches from the *review* to the *play* mode. Also at the end of the timing period, IC1 triggers timer IC2.

Timers IC2–IC4 operate in a similar manner as IC1, the major difference being that IC2 and IC3 have *coarse* and *fine* adjustments for tweaking the time-period. Also, RY2 can be driven either by IC2 or IC3, depending on the requirements of the recording-VCR. If the recorder is started by opening its remote control, RY2 is installed at the OPTION A location. If the recorder is started by closing its remote control, then RY2 is installed at the OPTION B location.

The editor's timing constants are a function of both the type and the speed of the VCR's. While the principles can be applied to any combination of VCR's and speeds, the prototype assumes VHS machines operating at the SP speed. Should a different combination be desired, it will be necessary to adjust the timing components for the selected speed.

Construction

Before building anything, you must make certain that your source-VCR is compatible with the controller. Place a tape in the VCR and start the play. After about 30 seconds, depress the *pause* button. Once the VCR has come to a complete stop—as indicated by a frozen frame on the screen—press and hold the *review* (or dual-function *review/rewind*) button for about five seconds and then release it. The VCR is compatible with the video-edit controller if it rewinds and then automatically enters the *play* state when the *review* button is released. If releasing the button did not cause the VCR to switch automatically into the *play* mode, then it can't be used with the controller.

If the VCR passes the compatibility test, you must make a review-switch modification. Disconnect the VCR from the powerline, open the VCR's case, and locate the *review* switch's contacts. Use a VOM to verify that you have selected the correct contacts. (In some VCR's the *review* switch has DPST contacts that are wired in parallel.) Solder a pair of thin, insulated, stranded wires (i.e. 22 gauge) to the switch's contacts. Then route the wire to an accessible blank portion of the VCR's rear apron. Carefully drill a hole in the apron for a miniature phone jack that will mate with PL1. If the cabinet is metal, use two contacts of a 3-circuit jack and change PL1 to a 3-circuit miniature phone jack. (The plug's *sleeve* connection—which is connected to the VCR's grounded cabinet—should not be used.)

Complete the modification by soldering the wire pair to the phone jack. Then, replace the VCR's cover. At that point, the VCR should be tested for normal operation. Check the modification for a short-circuit if the VCR doesn't operate correctly.

The controller is assembled on a PC board, for which a full-scale template is provided in PC service.

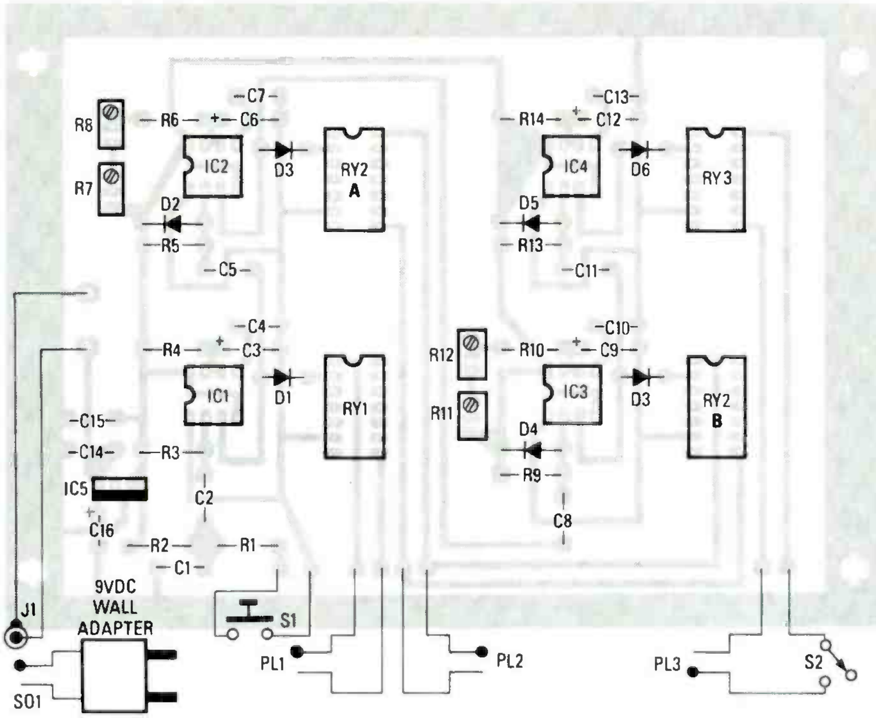


FIG. 2—THE CONTROLLER'S PARTS LAYOUT. Select only one location for RY2; the other remains empty.

FIG. 3—THE PRINTED-CIRCUIT BOARD is mounted in the cabinet using spacers at each mounting screw. Make certain that there is some kind of wire between the PC board's ground trace and the metal cabinet.

PARTS LIST

All resistors 1/4-watt, 10%, unless specified otherwise.
R1—1000 ohms
R2—1 megohm
R3—10 megohms
R4—470,000 ohms
R5, R9, R13—10,000 ohms
R6—200,000 ohms
R7, R11—250,000 ohms, multiturn potentiometer
R8, R12—10,000 ohm, multiturn potentiometer
R10—47,000 ohms
R14—100,000 ohms
All capacitors rated 10 volts, unless specified otherwise.
C1, C2, C5, C8 ,C11—0.001 µF, disc
C3, C9—10 µF, tantalum
C4, C7, C10, C13—0.01 µF, disc
C6—100 µF, tantalum
C12—1µF tantalum
C14, C15—0.1 µF
C16—1000 µF, 35 volts, electolytic
Semiconductors
IC1–IC4—555, timer
IC5—7808, 8-volt regulator
D1, D3, D6—1N4002, silicon rectifier
D2, D4, D5—1N914, rectifier
Other components
J1—male power-supply mini-jack to match SO1
PL1, PL2, PL3—miniature phone plugs to match VCR equipment
RY1, RY2, RY3—SPDT DIP relay, GORDOS 831A-4
S1—N.O. momentary switch
S2, S3—SPST switch
SO1—power socket, part of 9-volt wall adapter
Miscellaneous
Printed-circuit materials, WA1—9-volt DC wall adapter, DIP sockets, cabinet, wire, solder, etc.

The parts layout is shown in Fig. 2. Notice that there are two locations—labeled A and B—for RY2. If you use DIP sockets for mounting the relay, you will then be able to switch RY2's location easily to conform with the remote-control circuit of the associated VCR.

Figure 3 shows how the prototype's fully assembled PC board looks when it's finished, and also how it is installed in its cabinet.

VCR modification

The controller requires a special, though quite simple, modification to the source-VCR's *review* switch. But be aware that opening the case of the VCR and installing the modification will void the warranty (if it is still in effect).

Remote jack

The recording-VCR or camcorder should have a camera-controlled remote jack. Also, for best results the recorder should also perform a preroll operation prior to initiating the recording action. That feature can often be verified by the recorder's user's manual.

The recording-VCR will run-record when the camera-controlled remote jack is switched by RY2's contacts. The location of RY2 is determined by the requirements of the remote jack. If recording is started by opening a contact, RY2 should be installed in the OPTION A location, which is controlled by IC2. If recording is started by closing a contact, RY2 should be installed in the OPTION B location, which is controlled by IC3.

Calibration

The only items required for calibration are two prerecorded tapes. One is a *source* tape, which contains a clean transition of scenes. The tape can easily be made by making an off-the-air recording of about five minute of program up to a commercial, the commercial, and then five minutes of program. The commercial is only needed so that you can easily recognize a scene transition—from program to commercial and vice versa.

The other tape is the recording tape. It should be pre-recorded with about five minutes of programming.

Connect PL1 to the *review jack* that was added to the source-VCR. Connect PL2 to the recording VCR's camera-controlled remote jack.

Roll the source tape, locate the start of the commercial as closely as possible, and place the source recorder into the *pause* mode.

Then play the second tape in the recording VCR. Locate the end of the recording, set the recorder to *pause*, then activate the record function.

Set the *coarse* adjustment associated with RY2 (R7 or R11) to its smallest value and the *fine* adjustment (R8 or R12) to the center of its adjustment. Press S1. Each of the recorders will do its thing—controlled by the video-edit controller.

After the recording VCR runs for about 30 seconds, stop and rewind its tape to the point where the recording was inserted and press the *pause* button. Then release the *pause* button and time the playing time from the source-tape's entry point until the source-tape's commercial appears.

Using the equation given earlier, calculate the combined resistance value of R7 and R8 (or R11 and R12) that is needed to eliminate the pre-commercial timing. Set the *coarse* adjustment to that value.

Repeat the procedure until the editing controller correctly locates the edit point within about one-half second. At that point, the procedure should be repeated once more, using the *fine* adjustment, until the edit point is "on the nose."

That completes the calibration. A similar method is used to calibrate the switch-in of a special-effects generator via PL3.

Now you're ready to edit some video tapes, and it may take a few tries to become familiar with the system. However, in no time at all, you'll be getting rid of unwanted commercials, splicing together your favorite movie scenes, or removing scenes that you don't want your kids to see. **R-E**

CIRCLE 187 ON FREE INFORMATION CARD

BUILD THIS

TRUE RMS CONVERTER FOR YOUR DMM

This simple converter will add true-RMS capability to any VOM or DMM and it will only cost you about twenty dollars!

STEVEN A. BROWN

JUST ABOUT ANY VOM OR DMM CAN ACCURATELY measure the RMS voltage of pure sine-wave AC. But true-RMS capability is a feature that is usually found only on top-of-the-line meters.

In the AC mode, the average multimeter (one that does not have true-RMS capability) simply measures the peak rectified value and scales it by a factor of 0.707. Otherwise, they measure the average rectified value and scale it by the factor 1.11, which is the ratio of RMS-to-average, or 0.707/0.636. Introduce some distortion to the sine wave, however, and the reading's accuracy becomes questionable. Try measuring a non-sinusoidal waveform, such as sawtooth or square wave, and the reading can become utterly meaningless.

For example, when measuring a 10%-duty-cycle square wave, the reading on an average meter can be off by more than 100%! For such waveforms, the only reliable measurement of voltage can be made using a voltmeter or multimeter with true RMS capability. That feature is usually found on only the most expensive digital multimeters—until now. In this article, we'll show you how to build an accurate, low-cost converter that will give true RMS measurement capability to *any* VOM or DMM. Before getting into the details of the circuit though, let's briefly take a look at what RMS means, and why its value is important to know when talking about AC waveforms.

RMS defined

RMS stands for *R*oot *M*ean *S*quare (the square root of the average of the squared values), a mathematically derived quantity that is taken to be the value of an equivalent DC voltage—one that would produce an equal amount of heat in a resistor or light from a light bulb. In an AC waveform, the instantaneous voltage varies as a function of time. Therefore, the equation that defines the RMS voltage must take into account the functional relationship between those two variables, and it can only be applied if an exact mathematical expression for that relationship is known, which can be "plugged into" the equation. An example of such an expression is the one that gives us the instantaneous voltage (v) at any time (t) for a sine wave is:

$$v = V_{MAX} \sin \omega t$$

where V_{MAX} is the peak amplitude, ω is the angular frequency in radians-per-second, and t is the elapsed time from the beginning of the cycle. The equation for the RMS voltage of any periodic waveform, where "V" is a function of t, is given by:

$$V_{RMS} = \sqrt{\frac{1}{T} \int_{t_o}^{t_o + T} v^2(t)\, dt}$$

where T is the total period of time under consideration. For those who are not familiar with calculus, the definite integral under the radical sign, whose symbol resembles a tall thin S, represents the "area under the curve" if v^2 were plotted against t. That quantity, multiplied by 1/T, is equal to the average value of v^2 during the time period T. The square root of the average value is the RMS voltage.

Though it would be possible to construct a circuit to perform the operation of the second equation, a simpler approach—the one that is used by DMM's that can measure true RMS—is to square the instantaneous input voltage, average that square with a

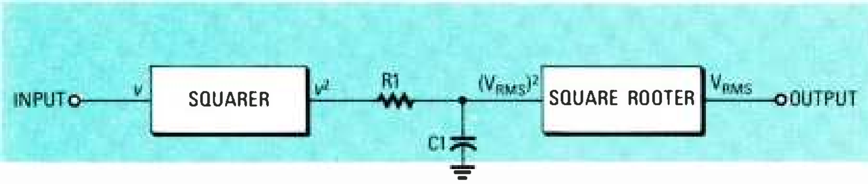


FIG. 1—RMS CONVERTER BLOCK DIAGRAM. This shows how an RMS measurement is obtained.

long time-constant RC network, and take the square root of their average. That sequence of operations is shown in the block diagram of Fig. 1, and can be represented mathematically by the simpler equation:

$$V_{RMS} = \sqrt{Avg.\ (v^2)}$$

where v is the instantaneous voltage. The basic difference between that sequence of operations and that of the previous equation lies in the method—but the result is the same. While the previous equation gives the precise net effect of v over a definite time period, the simpler method makes use of the property of a low-pass RC network (Fig. 1) that causes capacitor C1 to drift slowly to, and finally settle at, the long-term average of the instantaneous voltage applied to resistor R1. The time for the C1 to reach that final value, once a steady-state AC voltage has been applied to the network, is approximately equal to five times the RC time constant. By selecting a suitably long time constant, so C1's voltage does not vary significantly during the period of one cycle, a precise average can be obtained.

Stated simply, the RMS voltage of an AC waveform is equal to the square root of the long-term average of the square of the instantaneous voltage. At this point, the reader might ask why the effective value of an AC voltage is not equal to its average value. The answer to that question becomes apparent if one bears in mind that the power delivered to a load is proportional to the square of the applied voltage, in accordance with the familiar equation:

$$P = \frac{V^2}{R}$$

Therefore, in determining the RMS value of an AC voltage, the square of the instantaneous voltage is proportional to the instantaneous power that would be produced in a load. Since the average of the instantaneous power would be equal to the power produced by an equivalent DC voltage, the RMS voltage is found by averaging the square of the instantaneous voltage over a period of at least one cycle, and taking the square root of that average.

Applications of RMS

Now that we've examined what RMS means, let's take a look at some applications where an accurate RMS measurement becomes an important thing to know.

- To measure the output of motor-speed and light-dimmer controls, where the 60-Hz AC waveform is chopped by SCR or Triac switches.
- To measure pulse-width-modulated waveforms in switching power supplies.
- To measure and adjust the output of a battery charger for optimal rate of charge, where the output is rectified but unfiltered DC.
- To measure the power applied to an audio-speaker system by speech or music. A good approximation of audio power can be found by:

$$P = \frac{V^2}{Z}$$

where V is the RMS voltage measured across the speaker terminals, and Z is the nominal system impedance.

- To measure the effective value of any AC or variable DC waveform.

About the circuit

A complete schematic diagram of the True RMS Converter is shown in Fig. 2, and its specifications can be seen in Table 1. The heart of the circuit is Analog Devices' *AD736* true-RMS-to-DC converter IC. Its low power consumption of 1 mW makes it ideal for portable, battery-powered operation. The device can measure inputs of 1-volt RMS or less, but it is most accurate with a 200-mV RMS input. To measure higher voltages, an input attenuator is required.

The input at pin 2 of the *AD736* is internally connected to the non-inverting input of an FET buffer which has an impedance of 10^{12} ohms. That makes it well-suited for use with the high-resistance input attenuator, R1. Pin 1 is internally connected to the inverting input of the FET buffer which has an impedance of 8,000 ohms, and it is used to reference pin 2 to ground. When switch S2 is closed (DC mode), pin 1 is connected directly to ground. That makes the converter responsive to both DC and AC components of the input signal. When measuring signals having a very small amplitude, S2 can be opened (AC

TABLE 1—SPECIFICATIONS

Transfer Function: RMS-to-DC voltage
Accuracy: ±0.5 mV, ±0.5% (1kHz sinewave, AC-coupled, 0-to-200 mV, 200 mV range)
Input Impedance: 10 megohms
Maximum Input Voltage: 1200 VRMS
Bandwidth: 33 kHz (1% additional error)
190 kHz (±3 db)

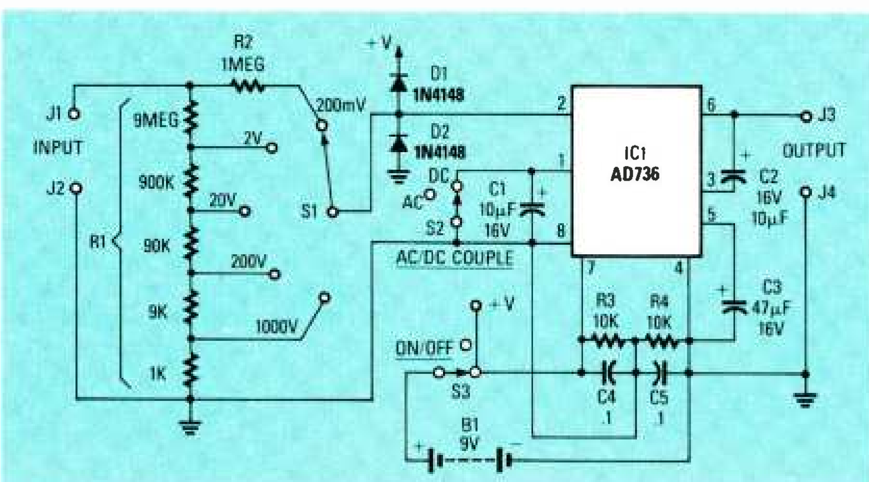


FIG. 2—SCHEMATIC DIAGRAM. The heart of the circuit is the AD736 true-RMS-to-DC converter IC.

PARTS LIST

Resistors
R1—Caddock 1776-C742 5-decade voltage divider
R2—1 megohm, ½-watt, 5%
R3, R4—10,000 ohms, ¼-watt, 5%
Capacitors
C1, C2—10 µF, 16 volts, radial electrolytic
C3—47 µF, 16 volts, radial electrolytic
C4, C5—0.1 µF, 50 volts, 10%, polyester film
Semiconductors
DI, D2—1N4148 diode
IC1—AD736JN RMS-to-DC converter (Analog Devices)
Other components
J1–J4—Insulated binding posts
S1—5-position rotary switch, (Mouser 10YQ025 or equivalent)
S2, S3—SPST subminiature toggle switch
B1—9-volt alkaline battery
Miscellaneous: 9-volt battery connector, 9-volt-battery mounting clip, plastic project case, plastic knob for rotary switch, wire, etc.
Note: A complete kit containing an etched and drilled PC board and all components that mount on it (SPST switches, binding posts, etc., not included) is available for $19.95 plus $2.50 for shipping and handling from Andromeda Electronics, 125 N. Prospect St., Washington, N.J. 07882. New Jersey residents must include 6% sales tax. Allow three weeks for delivery.

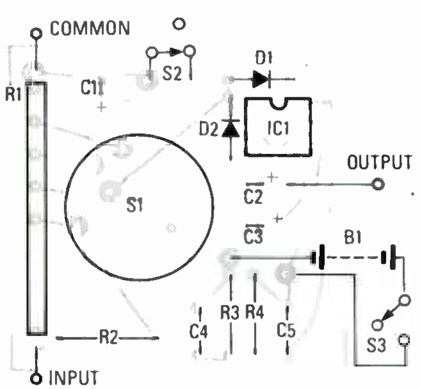


FIG. 3—MOUNT THE COMPONENTS as shown. All other parts mount on the cover of the plastic project case.

mode) and the input thereby becomes AC-coupled. In that mode, signals as small as 100 microvolts RMS can be measured.

Capacitor C3 is the averaging capacitor; C2 removes any residual ripple that might be present at the output. The attenuator is a Caddock *1776-C742* precision 5-decade voltage divider with a ratio tolerance of ±0.25%. Switch S1 is used to select the tap on the voltage divider that corresponds to the range of voltages to be measured.

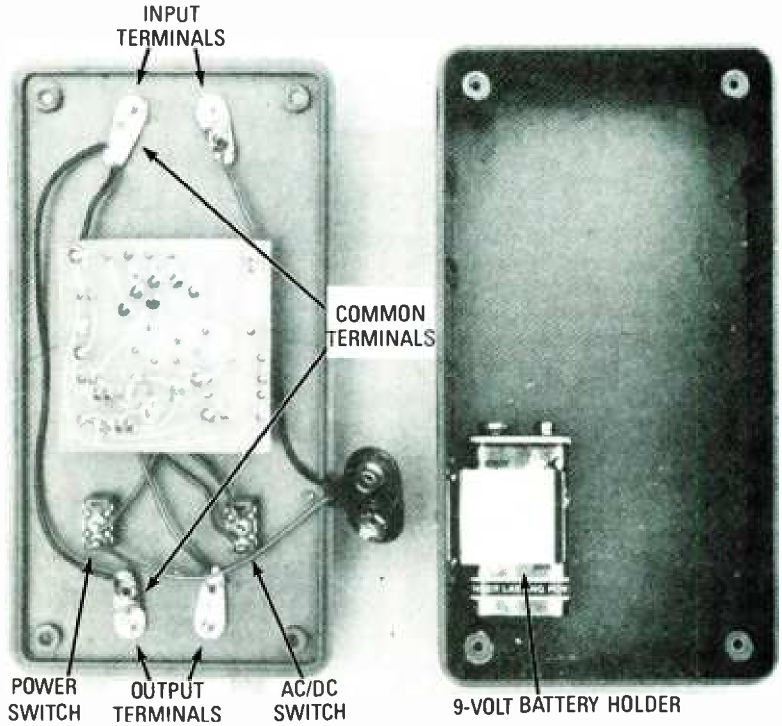


FIG. 4—THIS IS HOW YOUR CONVERTER should look when it's completed. You can see how the common terminal from both the input and the output are wired together.

The network made up of R2, D1, and D2 prevents overvoltage damage to IC1 by limiting the peak input voltage at pin 2. Resistor R2 has a power rating of ½-watt, so the maximum continuous overvoltage that can be sustained by R2 indefinitely without damage is about 700-volts RMS. Overvoltages up to 1200-volts RMS can be withstood for several seconds. No damage at all can occur to R2 from overvoltage in the 2-volt position and higher.

In the 200-mV position, IC1 reads the full voltage across the input terminals. When S1 is placed in the 2-volt position, all input voltages are divided by 10, and the DC voltage across the output terminals, as read by a DC voltmeter, must be multiplied by 10 to obtain a correct RMS reading. With S1 in the 20-volt position, the output reading must be multiplied by 100; in the 200-volt position, by 1000; and in the 1000-volt position, by 10,000 (Table 2 lists the multiplier values). The maximum continuous input voltage in the 1000-volt position should not exceed 1200-volts RMS—the maximum rating of the voltage divider.

TABLE 2—MULTIPLIER VALUES

Range in use	Multiply ouput by
200 mV	1
2 V	10
20 V	100
200 V	1000
1000 V	10,000

An important parameter of AC waveforms is the crest factor, which is defined as the ratio of the peak voltage to the RMS voltage. A sine wave has a crest factor of 1.414, while music with its high transients may have crest factors of 10 or more. The crest factor becomes significant when the peak excursions of the waveform approach the peak transient limits of the input of the measuring device. Peak clipping will occur if either of those limits are exceeded, resulting in a loss of accuracy. For an *AD736* that is powered by a 9-volt battery, the peak transient limits of the input at pin 2 are approximately ±2.5 volts. Therefore, the crest factor of a 200-mV RMS signal, measured on the 200-mV range, would have to exceed 12.5

before peak clipping occurs. If a 1-volt RMS signal were measured on that same range, however, 2.5 would be the maximum crest factor beyond which peak clipping would occur. Switching to the 2-volt range would raise the crest-factor threshold of clipping to 25 for the same 1-volt RMS signal.

Construction

The RMS Converter can be installed in any case (preferably plastic) that is large enough to fit the PC board, the battery, and all other associated wiring, switches, etc.

All components except S2, S3, B1, input jacks J1 and J2, and the output jacks J3 and J4 mount directly on the PC board, as shown in Fig. 3. Rotary switch S1 is soldered directly to the PC board, and its bushing provides a rigid mounting to the case.

To accommodate S1's anti-rotation tab, a ⅛-inch diameter hole should be drilled ½-inch below S1's mounting hole. Both the input and output common terminals should be wired together (see Fig. 4) and to the IC1 pin-8 PC solder pad. The input and output jacks, as well as S2, S3, and the battery-connector leads, should be connected to the appropriate PC pads indicated in Fig. 3, and secured to the face of the case as shown in Fig. 4. If you like, you can install a battery-mounting clip as shown in Fig. 4.

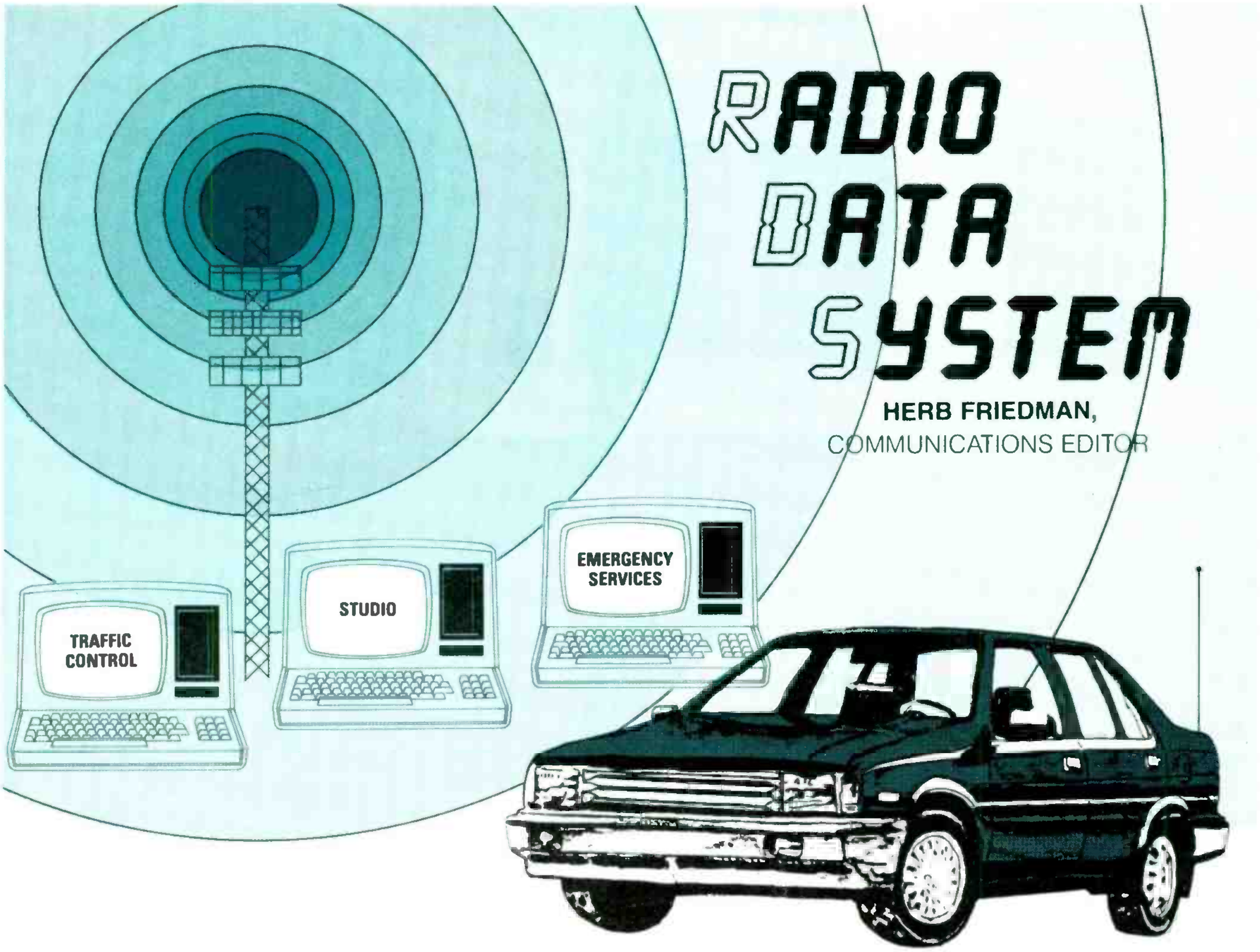
Operation

As can be seen from Fig. 2, there is no isolation between the input and output common terminals. Therefore, ALWAYS CONNECT YOUR VOM OR DMM TO THE OUTPUT TERMINALS BEFORE YOU CONNECT THE INPUT TERMINALS TO AN AC VOLTAGE.

The True RMS Converter is portable and easy to use. Simply connect the test leads of a VOM or a digital multimeter capable of reading zero to 200 millivolts to the output terminals, and connect a pair of insulated test probes to the input terminals. Connect the test probes to the voltage to be measured, and move the selector switch to the appropriate range so that a reading of at least 50 mV but no more than 500 mV is obtained. Then multiply the reading by the scale factor from Table 2 for the range in use. For inputs that are less than 50 mV, the AC-coupled mode will give the most accurate readings. R-E

RADIO DATA SYSTEM

HERB FRIEDMAN,
COMMUNICATIONS EDITOR



A Radio Data System FM car radio can automatically locate the kind of programs you like, control the volume and frequency response, display a paging message, and even keep you informed of traffic conditions.

MOST FM LISTENERS, AND EVEN SOME technicians, do not know that many stations routinely use a subcarrier to carry digital data. The data itself might represent stock-market information, telemetry and remote-control signals for the FM transmitter, radio-paging messages, or even data representing computer programs and messages sent from a school system's headquarters to individual schools.

The fact of the matter is that by using digital data just about anything is possible; and it is extremely fast. At approximately 1200 baud, which is a reliable bit rate for FM broadcasting, a burp of data—sounding like nothing more than a blip of static—can convey enough information to satisfy many personal entertainment and safety needs.

And that's exactly what it's used for in Europe, where digital data broadcast on a conventional FM subcarrier is used to provide a driver with many wide-ranging services through his or her car radio.

Radio Data

The data system that we're talking about is known as RDS—which is derived from *R*adio *D*ata *S*ystem. Basically, RDS is a European-developed system for the co-transmission of digital data and conventional FM programming. It is presently estimated that all of Europe will be integrated into the RDS system in three to five years. Whether the idea travels across the Big Pond to our side of the world probably depends on the results of RDS experiments conducted in Canada, because our FCC is not known as "Mister Speedy" when it comes to legitimizing new communication technologies.

Before we get into the bits, bytes, and code groups of the RDS subcarrier modulation, keep in mind that the system must not interfere with existing subcarrier services used in only a few European countries. Eventually, those services will be integrated into the RDS system; but today, RDS must exist side-by-side with services that preceded RDS.

As shown in Fig. 1, the European stereo-FM RDS signal closely resembles U.S. stereo signal that also has subcarrier modulation. The fact that the RDS subcarrier is at 57 kHz shouldn't disturb you because 57-kHz subcarriers are also used in the U.S.,

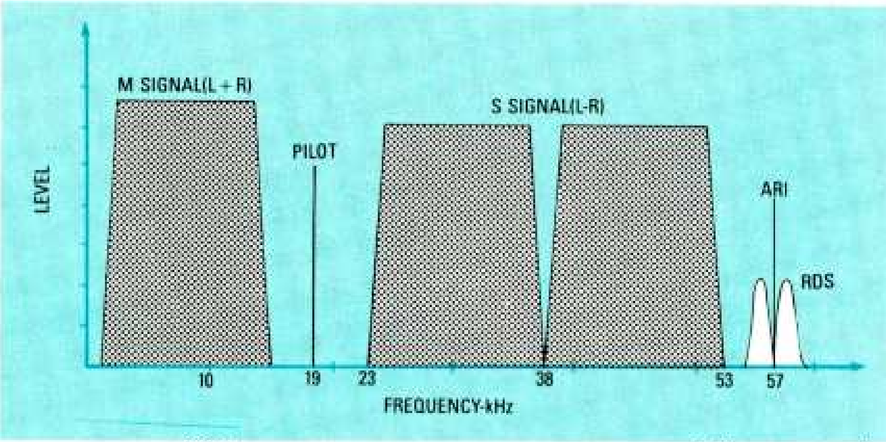


FIG. 1—THE RDS SIGNAL IS PLACED on a 57-kHz subcarrier. If the station also broadcasts an ARI auto-radio information signal on 57 kHz, the RDS signal is applied in quadrature so both can use the subcarrier.

even though a 67-kHz subcarrier is more common here. The Europeans selected 57 kHz because it's a multiple of the 19-kHz stereo pilot, which makes the subcarrier frequency easy to derive and phase-lock.

Note that the RDS 57-kHz subcarrier shows two distinct services: ARI and RDS. That is where "accommodating existing services" comes into play. ARI stands for *A*uto *R*adio *I*nformation; a system used in Germany and other countries to provide up-to-the-minute traffic information. (Actually, ARI stands for the German words that mean "auto radio information." Fortunately, the German and English words have the same initial characters—ARI.)

ARI works this way: The car radio constantly monitors the ARI subcarrier even if the driver is playing a tape. If the station broadcasts a subaudible frequency of approximately 10 Hz to 30 Hz, the tape program is interrupted by the radio so that the driver can hear traffic announcements made over the main channel by the station announcer. If the driver wants peace and quiet but wants to be kept up to date on traffic conditions, he can keep the volume turned down. Reception of an ARI signal automatically raises the volume so that the driver can hear the station's announcements and be aware of any emergency situations.

On the other hand, Sweden uses 57 kHz for its MBS national paging service. You can drive the entire 2000-mile length of Sweden and be paged if your radio is tuned to an FM station. (It is exactly the same as the cue nationwide radio paging system, which we covered in the January '88 issue of **Radio-Electronics**)

Multipath

In order to share the subcarrier with existing ARI 57-kHz subcarrier services in Austria, Germany, and Switzerland, the RDS modulation is applied in quadrature (90° out of phase) with the existing service. An RDS radio can use either quadrature signal. Unfortunately, although the quadrature method works almost exactly the same as our FMX stereo broadcasts, which were discussed in Larry Klein's *Audio Update* column in the June '88 issue of **Radio-Electronics**, quadratured RDS also suffers from the same kind of multipath interference that afflicted early FMX reception. Again, like FMX, multipath interference problems created by quadratured RDS is being reduced. Since, as we'll show, RDS can accommodate both traffic and paging digital data, when RDS is the sole ancillary FM communications system, the multipath problem won't exist because RDS will be the only signal using a 57-kHz subcarrier.

The quadrature modulation is the reason why Fig. 1 shows both the ARI and RDS services sharing the 57-kHz subcarrier. It does not show the Swedish MBS paging signal because that is not compatible with RDS. Sweden is developing an interim system where MBS and RDS will be implemented on individual radio networks. Eventually, MBS will be phased out, and paging will be integrated within RDS.

Digital info

Bear in mind that once we have a digitized source of information, any device associated with the digital data can be made intelligent; which means that the device is capable of making decisions. In the case of RDS, the intelligent device is the car radio. And before we get into the nuts and bolts of RDS, let's take time out for a few whet-the-appetite examples of what's possible with an intelligent RDS car radio.

Intelligent is a broad term that covers anything and everything. The most recent RDS radios can be programmed on-the-fly by the user for certain functions, such as traffic-information reception, specific programming, etc. A super-intelligent radio—which is what is really envisioned, since an RDS radio has an onboard microprocessor—will resemble the functional block diagram shown in Fig. 2. Other than the power switch, and the manual tuning and volume controls, just about every feature and function can be determined, set, or varied by the digital signal received on the RDS subcarrier. For example, an RDS station might send a signal indicating whether they are broadcasting music or voice. The user can program the radio, through a keypad or other pushbuttons, to automatically raise the volume when music is broadcast, even optimize the radio's frequency response for speech or music, or for a particular kind of music.

If the RDS data signal indicates that speech is being broadcast, the data can be used by the radio's microprocessor to reduce the radio's audio-frequency response to the 250–7500 Hz range for maximum clarity. When the RDS data indicates that music is being broadcast, pre-programming by the user can cause the audio bandwidth to increase to 50–15,000 Hz, with or without Dolby decoding. It is even possible to use the RDS signal to indicate rock, wall-to-wall, or classical music, and then to adjust the radio automatically—for example, the volume level for the specific kind of music being broadcast.

On the other hand, the radio can be user-programmed so that if the RDS signal is an emergency announcement, the driver hears the emergency signal itself—a tone burst, or the volume is automatically increased to the threshold of pain.

User memory

As shown in Fig. 2, the receiver's microprocessor control is what makes both user and automatic feature/function control possible. But also note that the receiver has EPROM memory and a voice synthesizer. In later RDS receivers, the user will be able to order a custom EPROM; one that is replaceable from the front panel. The first reason for the replaceable EPROM is obvious: The user can change features on demand. The second reason is not so obvious, but it is sports. Figure 3-*b* shows the display if a message page, coded specifically for that radio, was received. Figure 3-*c* shows how the display might appear if a traffic-information bulletin were being transmitted, or scheduled to be transmitted. It might be accompanied by a warning tone; or the message might override normal tape or radio reception, with the display serving only to tell the user what the message is about.

The user of an RDS car radio could accommodate possible variations in the RDS data, or a language barrier, by simply substituting the appropriate

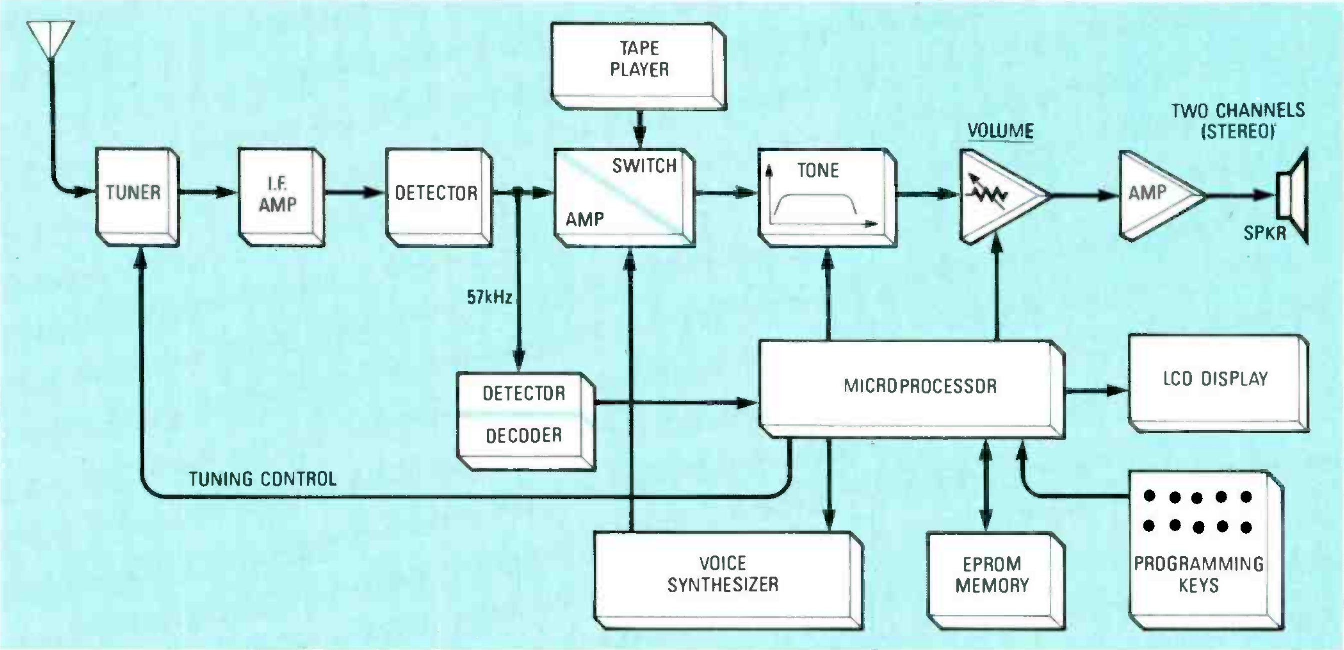


FIG. 2—THE FUNCTIONAL BLOCK DIAGRAM of a super-intelligent RDS receiver. The voice synthesizer allows an emergency or traffic bulletin to be heard in the listener's native language.

probably more important, particularly in Europe where an auto can easily be driven across three or four language borders in a single day.

The EPROM, in conjunction with the voice synthesizer, can be pre-programmed with standardized emergency and road-service phrases in the driver's native language. That means that an RDS signal can force the voice-synthesized announcement to override or replace a received signal, or even a tape playback, with emergency broadcast announcements or a personal-paging message. Either way, regardless of the country of origin of the RDS signal, the driver hears the emergency announcements or the page *in his own language*.

Also, the message or page might be shown on the radio's LCD display. In Fig. 3 we use a conventional RDS receiver to illustrate the kind of display that might be attained on a super-intelligent RDS radio. Figure 3-*a* shows how the display would appear during the microprocessor's programming if the user wanted the radio to tune only stations broadcasting

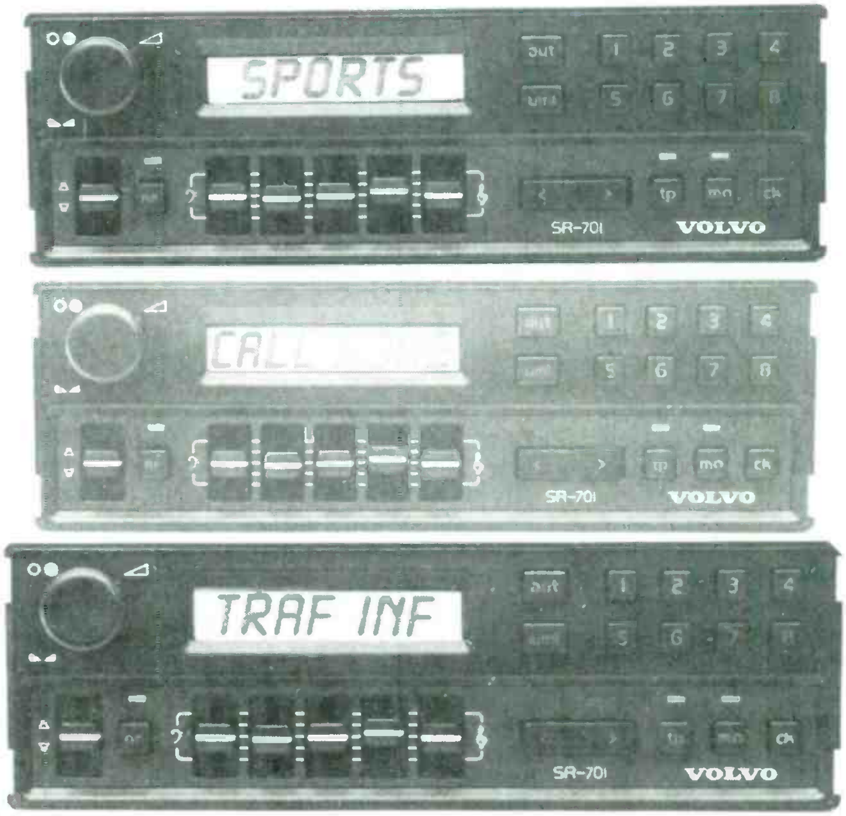


FIG. 3—THE DISPLAYS MIGHT INDICATE: *a*) the kind of station that the listener wants tuned in; *b*) a personal paging message; *c*) traffic information.

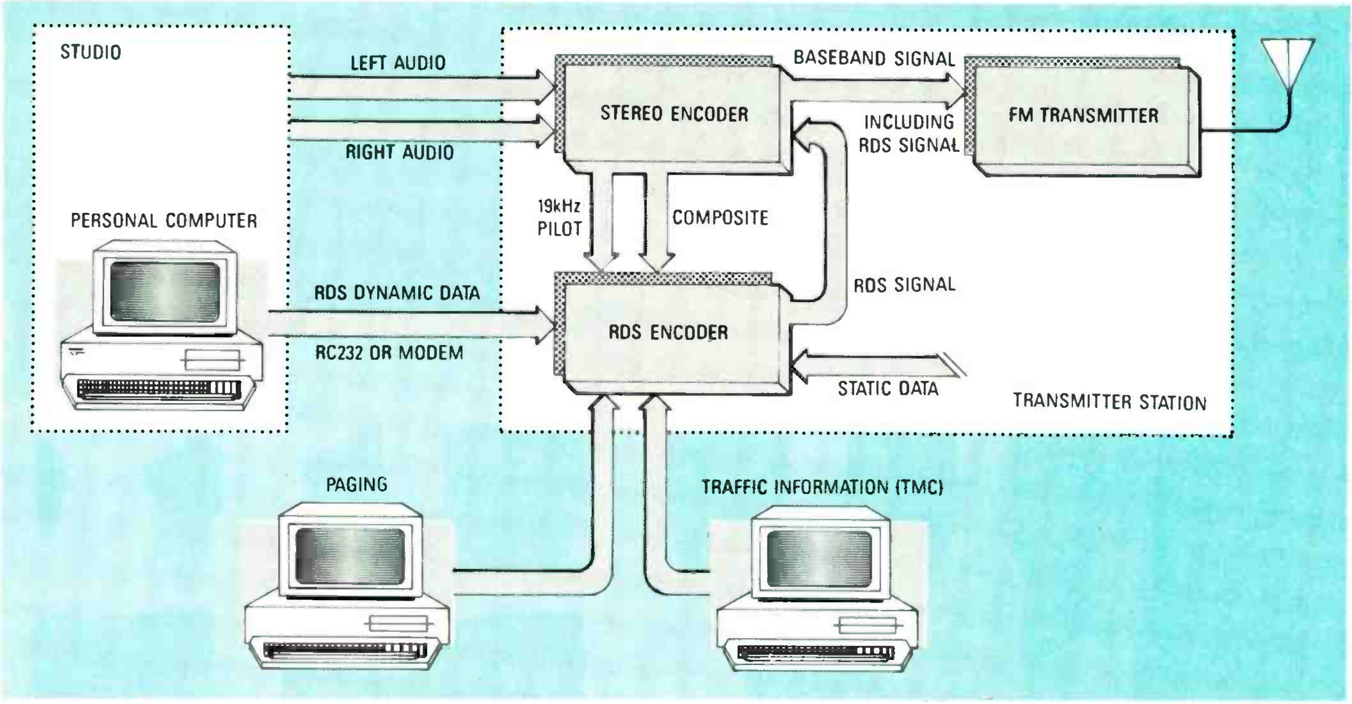


FIG. 4—RDS INFORMATION CAN ORIGINATE from ROM's as static (permanent) data, or from individual computer sources as dynamic data.

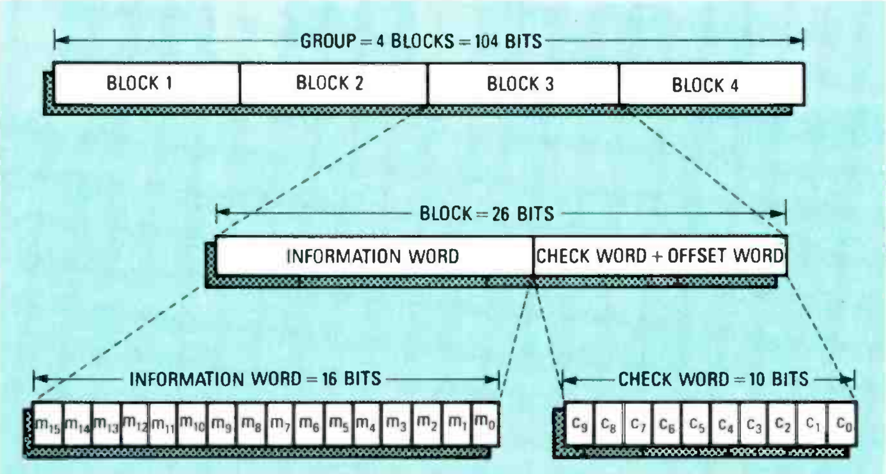


FIG. 5—THE RDS DATA IS TRANSMITTED in groups of 104 bits. Each group consists of four 26 bit blocks. Each block uses 16 bits for information, 10 bits for error-checking. The effective information transmission-rate is 730 bps.

EPROM when the car crossed a country's border. For example, imagine that you're traveling in Italy, the language of which you have little knowledge other than a few words such as pizza and manicotti. You're tooling your Fiat up the Appian Way while listening to your travel-tape of Bruce Springsteen on the car stereo, when suddenly "The Boss" is interrupted by an emergency travel advisory—given in perfect, though computerized English. And while you're hearing the travel bulletin in English, French tourists are hearing the same bulletin in French, and in another car, filled with visitors from Japan, they are hearing the same bulletin, at the same time, in Japanese.

If user-exchange of the EPROM is needed because you intend to drive through many countries, you simply rent a car having an RDS radio that speaks your language. If you own the car, the voice synthesizer will, of course, be in your native language.

An RDS emergency-announcement uses the same digital code regardless of the country of origin, although there might be exceptions to handle unusual conditions. For example, it is more likely that the digitized phrase *M1 motorway* rather than *Appian Way* is pre-programmed for car radios intended for Great Britain; while *autobahn* would be used in German radios. To handle unusual traffic conditions, the voice synthesizer might simply contain the equivalent of "Ho Boy! You drivers in the south of England (or wherever) are in for massive tie-ups, so pay attention to local officials."

Static and dynamic

RDS data can be either static or dynamic. Static data can be the station's I.D., automatic time and clock correction (as you drive through different times zones the radio's clock is automatically corrected), the network affiliation, the kind of program being broadcast, etc. For example, in Sweden you can drive 2000 miles and have an RDS radio track the same program even as you drive out of the range of one station into the reception zone of another. If programmed to a particular service or program, such as *sports*, the radio continually searches out the RDS data representing that service or program—automatically adjusting the radio's tuning to the appropriate local station.

Dynamic data is RDS information

continued on page 76

WORKING WITH A NORTON OP-AMP

This month we explore the mysteries of the LM3900 op-amp, and show the many ways of using this versatile device.

RAY MARSTON

MOST OPERATIONAL AMPLIFIERS ARE *V*oltage-*D*ifferencing *A*mplifiers, or VDA's, which have an output that is proportional to the difference between the voltages applied at the two input terminals. But the LM3900 is a *C*urrent-*D*ifferencing *A*mplifier, or a CDA; it is also known as a *Norton* op-amp. The device has an output that is proportional to the difference between the currents applied at the two input terminals.

The LM3900, first introduced in the early 1970's, was specifically designed as a low-cost, medium-performance, quad op-amp that could operate off a single-ended power supply and provide a large output-voltage swing. It is the most widely known CDA-type op-amp, containing four identical and independently accessible op-amps, as shown in Fig. 1. The device can operate with any DC supply from 4 + −46 volts, and each op-amp has a unity-gain bandwidth of 2.5 MHz and an open-loop gain of 70 dB.

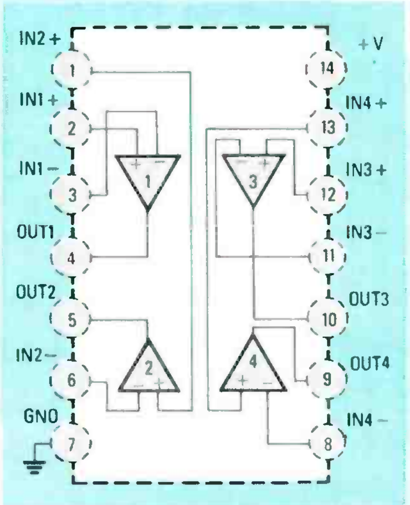


FIG 1—THE LM3900 NORTON OP-AMP contains four identical and independently accessible amplifiers.

Basic principles

The LM3900 incorporates four identical op-amps, each having the circuit shown in Fig. 2. To help you understand how that circuit works, it is broken down into four simple stages in Fig 3.

Figure 3-*a* shows the basic inverting-amplifier circuit. Transistor Q1 is a common-emitter amplifier with a constant-current collector load, providing high-gain inverting action. Transistor Q2 is a non-inverting emitter-follower output buffer with a constant-current emitter load. The upper-frequency response of the resulting high-gain non-inverting amplifier is rolled off by C1 to enhance circuit stability. Note that the output can swing within a few hundred millivolts of ground and the supply voltage.

The overall current gain of the Fig. 3-*a* circuit is limited to the product of the two individual transistor current gains. Fig. 3-*b* shows how the current gain can be further increased, with little reduction in the output-voltage swing, by adding transistor Q3.

The output from the circuit in Fig. 3-*b* can typically source up to 10 mA, but can sink only 1.3 mA (via the constant-current generator of Q2). Figure 3-*c* shows how the sink current can be increased by adding Q4, providing class-B operation during the over-drive condition. Also, transistors Q5 and Q6 are used as constant-current generators, which are biased by an internal network in the LM3900 IC.

The circuit in Fig. 3-*c* is the basis of each of the LM3900 amplifier stages, but it can only provide inverting action. The non-inverting action of the LM3900 is provided by the addition of the current-mirror circuit in Fig. 3-*d*. That circuit is made up of two identically matched transistors and will draw an output current that is almost identical to the input current. The circuit operates as follows:

The input current to the circuit in Fig. 3-*d* is applied to the base of each transistor. Suppose that both transistors have current gains of 100, and that both transistors draw base currents of 5 μA. In that case, the collectors of both transistors will draw 500 μA. Note, however, that the collector current of Q7 is drawn from the circuit's input current, and equals 500 μA plus (2 × 5 μA), or 510 μA, and that the collector current of Q8 is the output or *mirror* current of the circuit. The input and output currents are almost identical, regardless of the input-current magnitude.

Finally, if we connect the current-mirror circuit in Fig. 3-*d* to the circuit in Fig. 3-*c*, we have the circuit in Fig. 2, where the mirror circuit is driven by the non-inverting input terminal, and the mirror current is drawn from the inverting-input terminal, which is also connected directly to the base of the Q1 amplifier stage. Consequently, the base current of Q1 is equal to the input current at the inverting input, minus the input current at the non-inverting input. The complete amplifier (Fig. 2) thus provides CDA action already mentioned. Note that CDA's can operate like conventional VDA's by wiring high-value resistors in series with the input terminals, so that the input currents are directly proportional to the input-voltage/resistor values.

The output of an LM3900 amplifier will start to swing down through the half-supply point (half of the supply voltage) when the input-bias current

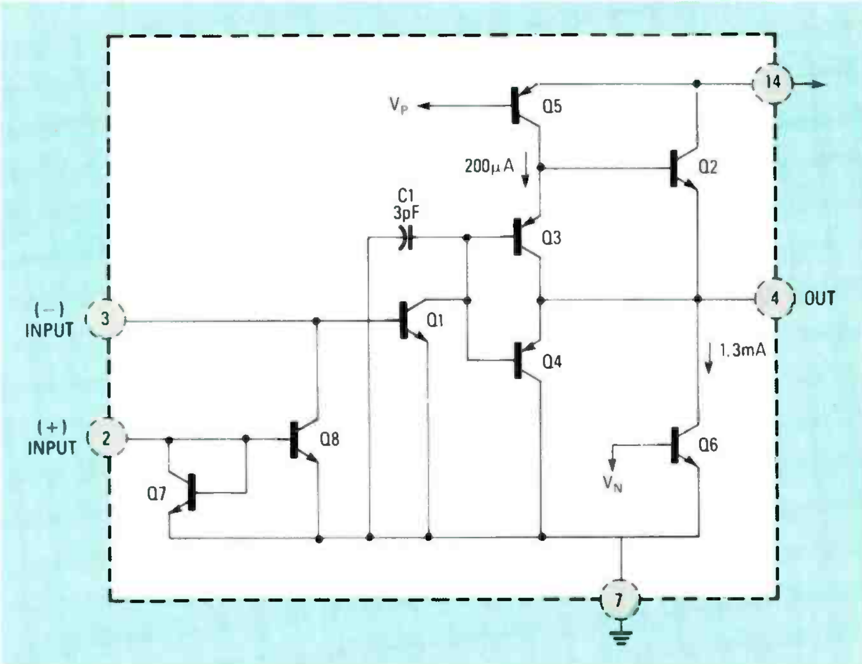


FIG 2—THE CIRCUITRY for each of the four op-amps inside the LM3900 looks like this.

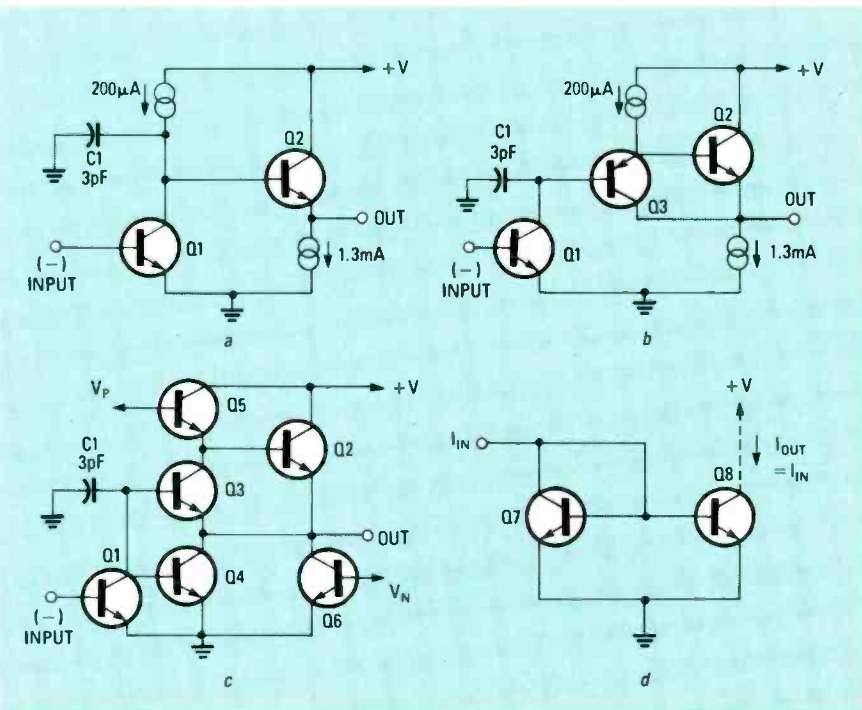


FIG 3—THE BASIC INVERTING AMPLIFIER is shown in *a*, and an improved inverting amplifier is shown in *b*. Constant-current generators have been added in *c*, and the current-mirror circuit is shown in *d*.

of Q1 rises above 30 nA or so. The input-bias current is normally equal to the difference between the two input-terminal currents, and those currents should normally be restricted to the range from 0.5 μA to 500 μA.; an ideal value for the input-bias current of an LM3900 amplifier is usually around 10 μA.

Linear amplifier circuits

In linear applications, an op-amp is normally biased so that its output takes on a quiescent value of half of the supply voltage to accommodate maximum undistorted signal swings. Also, when an op-amp is biased for linear operation, its output is proportional to its input. The feedback current automatically limits the internal Q1 base current, providing a closed-loop gain. In Fig. 4, R1, R2, and C1 generate a decoupled half-supply reference voltage, which applies a reference current to the non-inverting terminal via R3. Also, a negative-feedback current is applied to the inverting terminal via R4, from the op-amp's output.

In Fig. 5, R2 and R3 bias the output to a quiescent half-supply value. The input signal is applied to the inverting

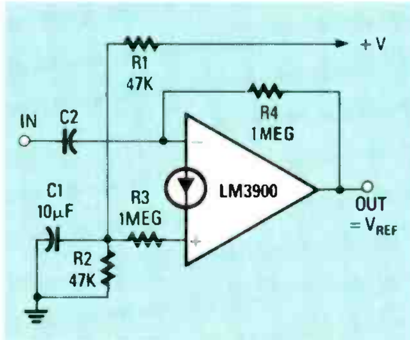


FIG 4—AN OP-AMP CAN BE BIASED so that its output takes on a quiescent value of half of the supply voltage.

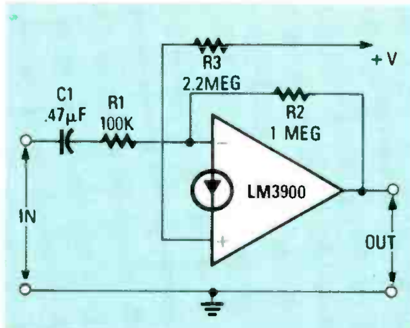


FIG 5—THIS INVERTING AC AMPLIFIER uses supply-line biasing.

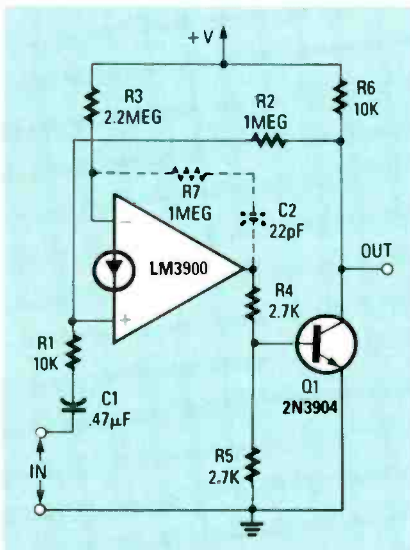


FIG 6—AN IMPROVED BANDWIDTH and high gain are featured in this circuit.

terminal via R1, and the voltage gain is determined by the R2/R1 ratio, so that circuit is set up as a × 10 inverting amplifier.

The op-amps of the LM3900 have slew rates of only 0.5V/µs, so they have very restricted useful bandwidths. Figure 6 shows how the useful bandwidth can be increased by connecting a transistor to the output and rearranging the input connections of the standard amplifier circuit to make a × 100 inverting amplifier with a 200-kHz bandwidth. Because of the high overall gain, that circuit may be somewhat unstable. If so, R7 and C2 can be added to slightly reduce the bandwidth and improve overall circuit stability.

The circuit in Fig. 6 can be modified to have a peak-to-peak output swing of 150 volts. That is done by supplying the output transistor with a separate supply of 150 volts DC. The output will then take on a quiescent value of 75 volts, causing 7.5 µA to be fed to the non-inverting terminal of the op-amp. Therefore, in order to have correct biasing, 7.5 µA would also have to be applied to the inverting input.

The LM3900 op-amp can be used as a unity-gain non-inverting buffer amplifier, or voltage follower. That is done by connecting the output to the inverting input with a 1-megohm resistor, and applying the input signal to the non-inverting terminal via an equal-value resistor; that way the circuit will provide unity gain.

Schmitt triggers

The LM3900 op-amp can be used as a voltage comparator by wiring equal-value current-limiting resistors in series with each input, using one resistor as the input, and the other as the sample input. The circuit in Fig. 7 is an inverting voltage comparator, in which the output switches high when V_{IN} falls below V_{REF}.

The circuit in Fig. 7 could also be used as a non-inverting voltage-comparator. That would be done by applying V_{REF} to the inverting input and V_{IN} to the non-inverting input. The output will then switch high when V_{IN} rises above V_{REF}.

The circuit in Fig. 7 can supply output currents of only a few mA. However, the output current can be boosted to tens or hundreds of mA by connecting a transistor to the circuit's output.

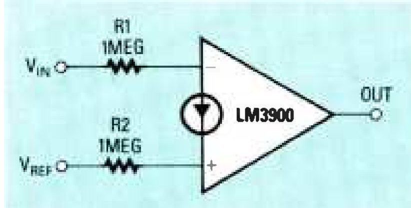


FIG 7—THE CIRCUIT SHOWN HERE is an inverting voltage comparator.

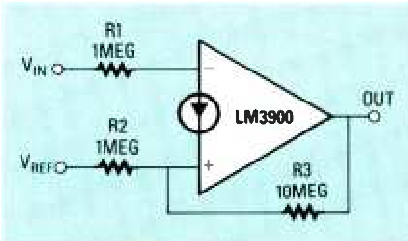


FIG 8—THE CIRCUIT SHOWN HERE is an inverting Schmitt trigger.

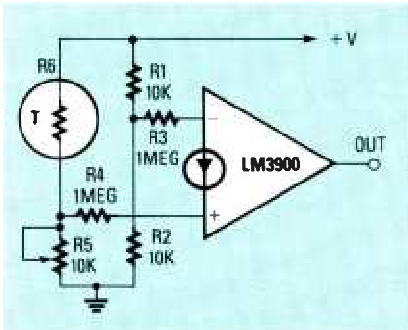


FIG 9—AN OVER-TEMPERATURE SWITCH will trigger its output when a predetermined temperature is exceeded.

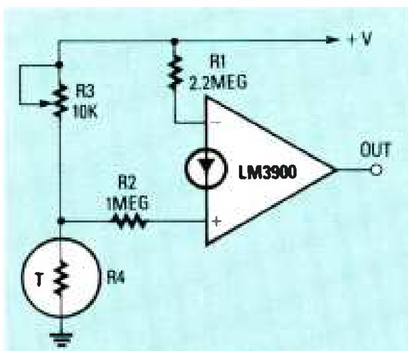


FIG 10—AN UNDER-TEMPERATURE SWITCH will trigger its output when the temperature falls below a predetermined value.

Hysteresis can easily be added to LM3900 voltage-comparator circuits so that they operate as Schmitt triggers. That is done by connecting a high-value resistor between the output and the non-inverting terminal. Figure 8 is an inverting Schmitt trigger, in which the R3/R2 ratio determines the hysteresis magnitude. The circuit becomes a non-inverting Schmitt trigger by transposing the inputs.

Comparator applications

Figures 9–12 show some useful applications for voltage comparators. The circuit in Fig. 9 is an over-temperature switch, where the output goes high when a pre-set temperature is exceeded. A fixed half-supply reference voltage feeds a reference current to the inverting input, and a variable current is fed to the non-inverting input. Resistor R6 is a *N*egative-*T*emperature-*C*oefficient (NTC) thermistor, so the potential at the junction of R5 and R6 rises with temperature. The op-amp will switch high when that voltage exceeds the half-supply value. The trip temperature can be pre-set via R5.

Figure 10 is an under-temperature switch. In that circuit the reference current is fed from the supply voltage via R1, to the inverting terminal, and the variable (non-inverting) current is

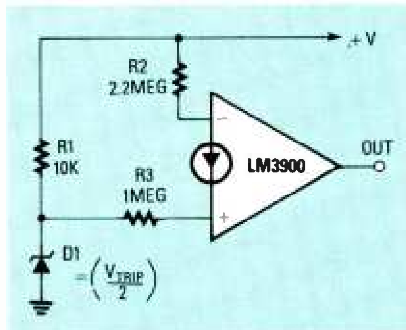


FIG 11—AN UNDER-VOLTAGE DETECTOR can be used to monitor a voltage supply.

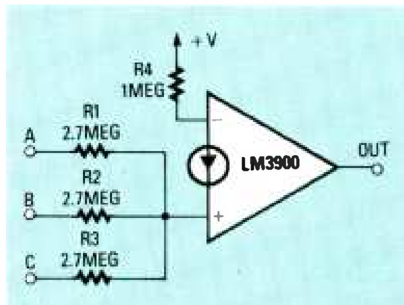


FIG 12—A 3-INPUT AND GATE can be converted to a NAND gate by transposing the two inputs.

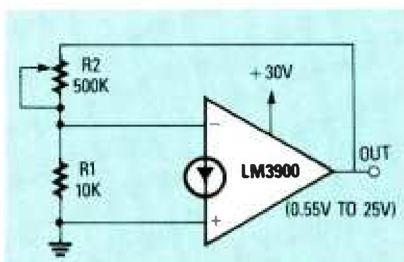


FIG 13—SIMPLE VARIABLE-VOLTAGE reference circuit uses the voltage at its inverting terminal as a reference.

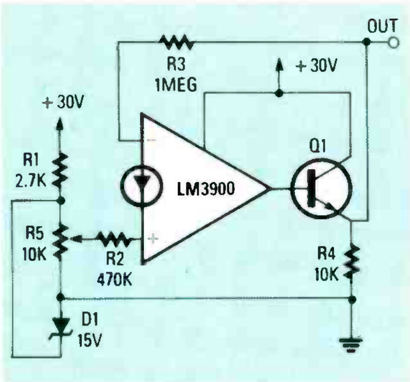


FIG 14—THIS VARIABLE-VOLTAGE REGULATOR has a boosted-current output.

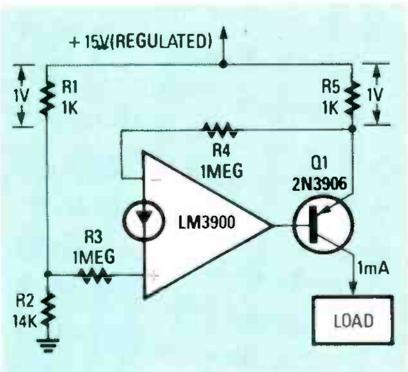


FIG 15—FIXED-CURRENT SOURCE can deliver 1 mA to any load that is from 0 to 14 kilohms.

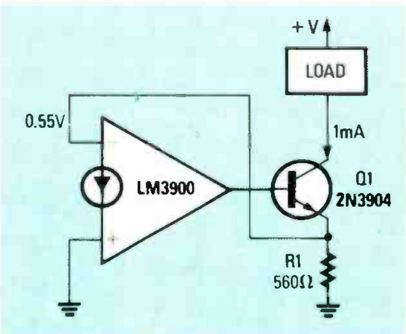


FIG 16—A SIMPLE 1-mA CURRENT SINK will draw 1 mA from any load.

supplied from the junction of R3 and R4. Since the value of R1 is approximately double that of R2, and generates a current that is proportional to the supply voltage, the trip temperature (pre-set via R3) is independent of the supply voltage.

An under-voltage detector is shown in Fig. 11. Its output goes high when the supply falls below a value determined by Zener diode D1. If D1 is a 5.6-volt Zener, the op-amp will switch high when the supply voltage falls below approximately 11 volts. The precise trip point can be varied by replacing R3 with an 820K resistor in series with a 470K potentiometer.

Finally, Fig. 12 shows how a comparator can be used as a 3-input AND gate, having a high output only when all three inputs are high. The non-inverting-input current, when all three inputs are high, must exceed that of the inverting input, as determined by R4. The circuit can be converted to a NAND gate by transposing the two inputs of the op-amp.

Voltage-regulator circuits

There are various applications that can make use of the LM3900 as a voltage regulator or reference. Figure 13 is a variable-voltage reference source. The non-inverting terminal of the op-amp is grounded, and the circuit uses the voltage at the inverting terminal as a reference. Its voltage gain is determined by the R2/R1 ratio. When R2 is set at zero, the circuit has unity gain and a 0.55-volt output. When R2 is set to the maximum value, the circuit has a gain of 50 and an output of about 25 volts. The circuit provides good regulation and can supply output currents of several mA. The output voltage however, is not temperature compensated.

Figure 14 is a variable voltage regulator. The op-amp is wired as a ×2 non-inverting DC amplifier with a gain that is determined by the R3/R2 ratio. The input voltage to the op-amp

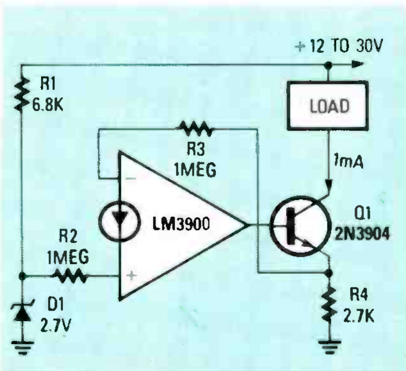


FIG 17—AN IMPROVED CURRENT SINK with a fixed reference of 2.7 volts.

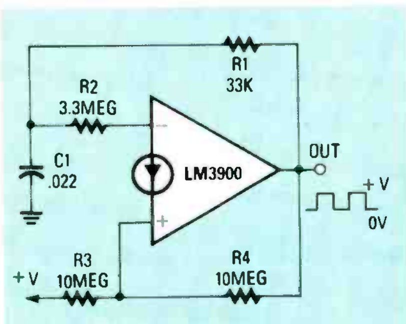


FIG 18—A 1-kHz SQUARE-WAVE generator can be used as a tone generator.

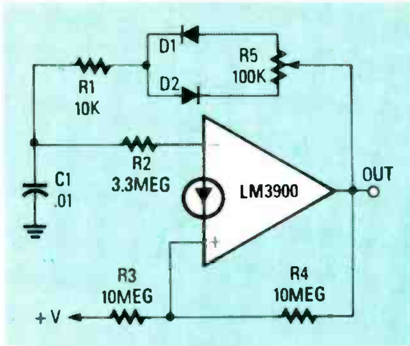


FIG 19—THIS CIRCUIT is a variable duty cycle square-wave generator.

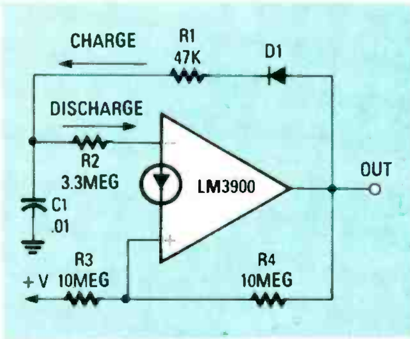


FIG 20—THIS PULSE GENERATOR has a duty cycle of about 1:60.

is variable between 0 and 15 volts via R5. The output voltage is therefore variable over the approximate range from 0.5–30 volts. The available output current has been boosted by adding transistor Q1 to the output.

Current-regulator circuits

The LM3900 can be used as a fixed-current regulator. Figure 15 is a fixed 1-mA current source, which delivers a fixed current to a load connected between Q1's collector and ground; the load can be anywhere in the range from 0 ohms to 14 kilohms. The circuit is powered from a regulated 15-volt supply, and the R1-R2 voltage divider applies a 14-volt reference to R3. The op-amp's output automatically adjusts to provide an identical voltage at the junction of R4 and R5. That produces 1 volt across R5, resulting in an R5 current of 1 mA. Since that current is derived from Q1's emitter, and the emitter and collector currents of a transistor are almost identical, the circuit provides a fixed-current source. The output current can be doubled by halving the value of R5.

Figure 16 shows a simple 1-mA current sink, in which a fixed current flows through any load connected be-

continued on page 76

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RADIO DATA SYSTEM

continued from page 68

that is usually input, when needed, from personal computers located at various locations. Figure 4 shows how both static and dynamic data are integrated. The stereo encoder provides a sample of the 19-kHz pilot signal to the RDS encoder for phase-locked generation of the RDS subcarrier. The static data is input to the encoder, as is dynamic data from three independent sources: (1) local announcements from the radio station's studio; (2) paging data from a paging service; (3) emergency and traffic information from the local safety officials (police, fire, etc.).

Actually, to avoid a clash of data if several dynamic sources decide to operate at the same time, all RDS data sources generally pass through some kind of automatic polling or sequencing master-control facility. Also, the master control does not allow an individual operator to create interference to an RDS data source to which he does not have access. In other words, if the master control allows the public-safety computer to give its data precedence by immediately seizing the RDS system, other operators cannot override, delay, or interfere with the public-safety data; nor can they interfere with the paging data, etc. The protection is attained by tagging incoming data with its source or origin, so that the master control knows what signal is coming from where, and its order of precedence.

Data groups

As shown in Fig. 5, RDS data is transmitted in groups of 104 bits divided into four 26-bit blocks. Of the 26 bits, which are transmitted at 1187.5 bps (bits-per-second), the first 16 bits represent information, the remaining 10 bits are checks for error protection. Therefore, the effective information bit-rate 1187.5 × 16/26, or 730 bps.

RDS provides for individual identified groups, such as 0A, 0B, 7A, and 15B. The system requires that specific data be placed in specific groups and blocks so that no station creates a Tower of Babel by going its own way. For example, Swedish paging, which allows up to 18 characters per pager, must be in group 7A, while decoder information, which provides information on mono/stereo transmission and special noise reduction or encoding is found in groups 0A, 0B, and 15B. A station's program service data, a maximum of 8 ASCII characters (for LCD display) must be transmitted at least once each second on groups 0A and 0B.

Various services and future expansion is built into the group assignments; for example, a 5-bit channel code representing computer-program normal text can be placed in groups 5A and 5B; the music/speech identification bit that enables the radio to switch between two volume levels or tone-control adjustments is transmitted four times per second in groups 0A, 0B, and 15B; the station's automatic telemetering and remote-control signals can be in groups 6A and 6B. It is even possible, within groups 2A and 2B, to display up to 64 characters for say, a program parade (schedule), or program information such as "Verdi – *La Traviata*."

As you can see from the few previous examples, each group can contain the data for several functions because the data can utilize the individual group blocks.

Why not here?

To say that Europe is rushing pell-mell toward total implementation of the system would be an understatement, because almost everything coming from Europe that concerns communications mentions RDS and when it will be totally implemented on a country-by-country basis. The question we should ask is why RDS stops at Land's End in Europe. The U.S. is 3000 miles wide, and while we don't have contiguous government-controlled radio networks that allow the tracking of a single broadcast from coast to coast, and while we also don't have a single paging system, certainly all the other RDS functions would be the ideal thing for the average autosound enthusiast. Its an idea whose time and technology came a long time ago in the U.S. In fact, the equipment is here; the encoding-equipment manufacturer, RE Instruments Corp. (31029 Center Ridge Road, Westlake, OH 44145), has encoding units here that they use for demonstration. It really would be an advantage to the consumer if the FCC allowed FM communications to get ready for the 21st century—it's almost here. **R-E**

NORTON OP-AMP

continued from page 72

tween the positive supply and Q1's collector. The non-inverting terminal of the op-amp is grounded, and negative feedback flows between the output of the circuit (Q1's emitter) and the inverting terminal. The voltage across R1 is thus equal to the voltage at the inverting terminal (approximately 0.55 volt), so a fixed current of about 1 mA flows through the load, Q1's emitter, and R1.

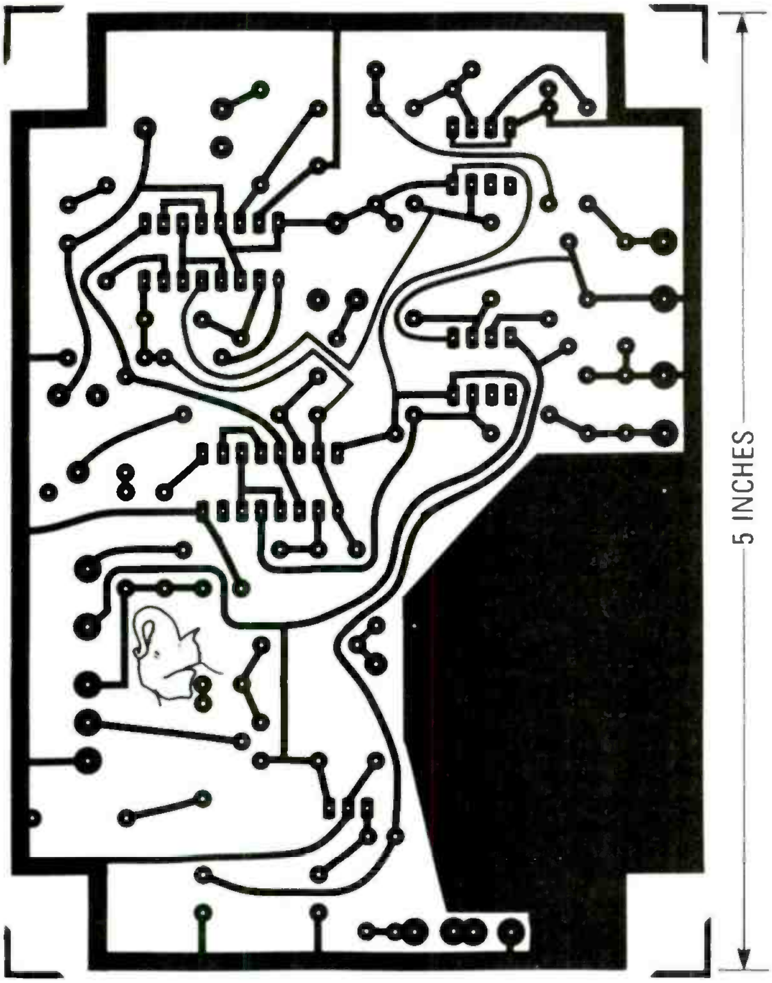
Figure 17 shows another type of current sink, in which the op-amp has a fixed reference of 2.7 volts applied to the non-inverting terminal via R2. Consequently, the circuit automatically adjusts to generate 2.7 volts across R4, which has a value of 2.7K; therefore 1 mA flows through the emitter and collector of Q1

Waveform-generator circuits

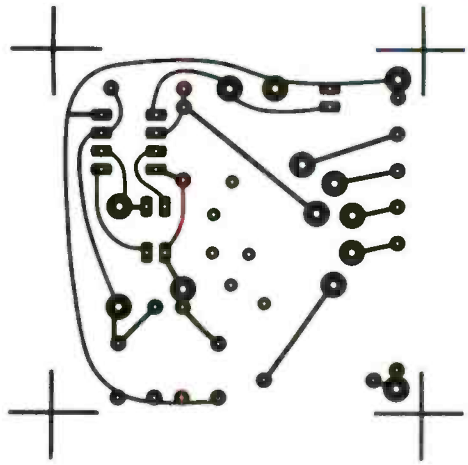
Figure 18 is a 1-kHz square-wave generator. When the output is high, R3 and R4 are in parallel, and C1 charges via R1 until the current in R2 equals that the non-inverting terminal. That occurs when C1's voltage rises to ⅔ of the supply voltage. At that point the circuit switches regeneratively. The output switches low and C1 starts to discharge via R1. Now R4 is effectively disabled and the current to the non-inverting terminal is determined solely by R3, so C1 discharges until the current through R2 falls slightly below that of R3. That happens when the voltage across C1 falls to about ⅓ of the supply voltage. At that point the circuit again switches regeneratively, and the output again goes high.

The circuit in Fig. 18 is useful for generating symmetrical square waves with maximum frequencies of only a few kHz. And, because of the poor slew-rate characteristics of the LM3900 (0.5V/μs), the output waveforms have rather slow rise and fall times. In the circuit in Fig. 19, C1 alternately charges via R1-D1 and the upper half of R5, and discharges via R1-D2 and the lower half of R5. The duty cycle can be varied over the range from 1:10 to 10:1 via R5.

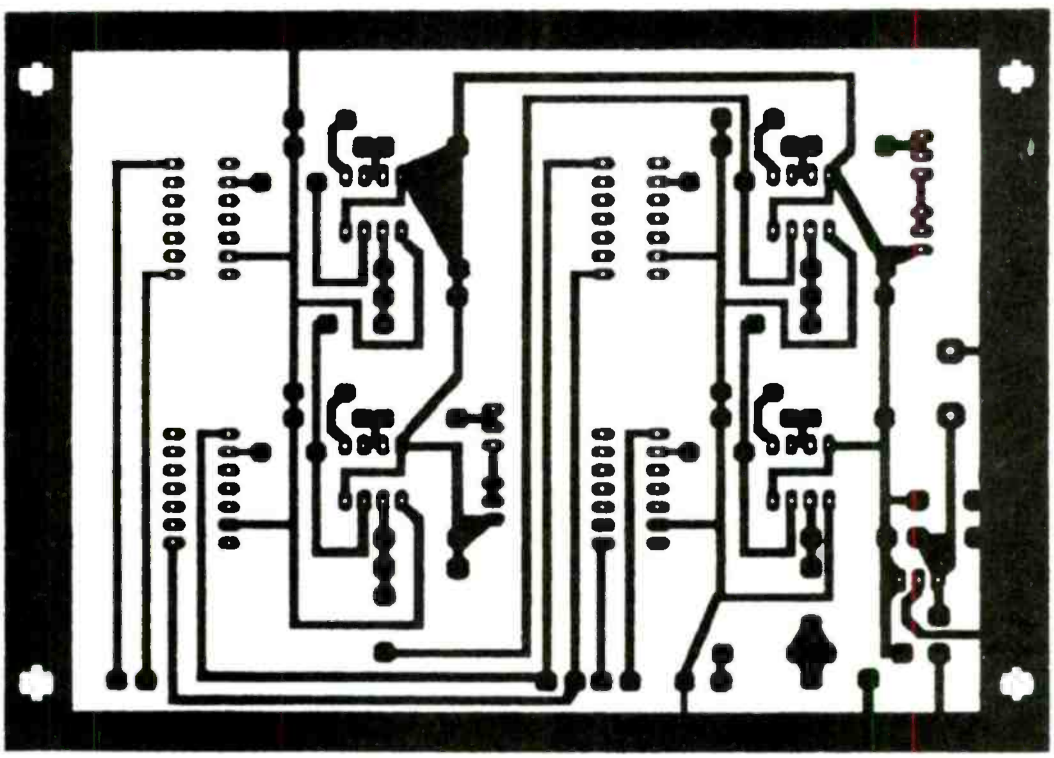
Figure 20 is a free-running pulse generator. In that circuit C1 alternately charges via R1-D1 and discharges via R2, producing a duty cycle of about 1:60. **R-E**



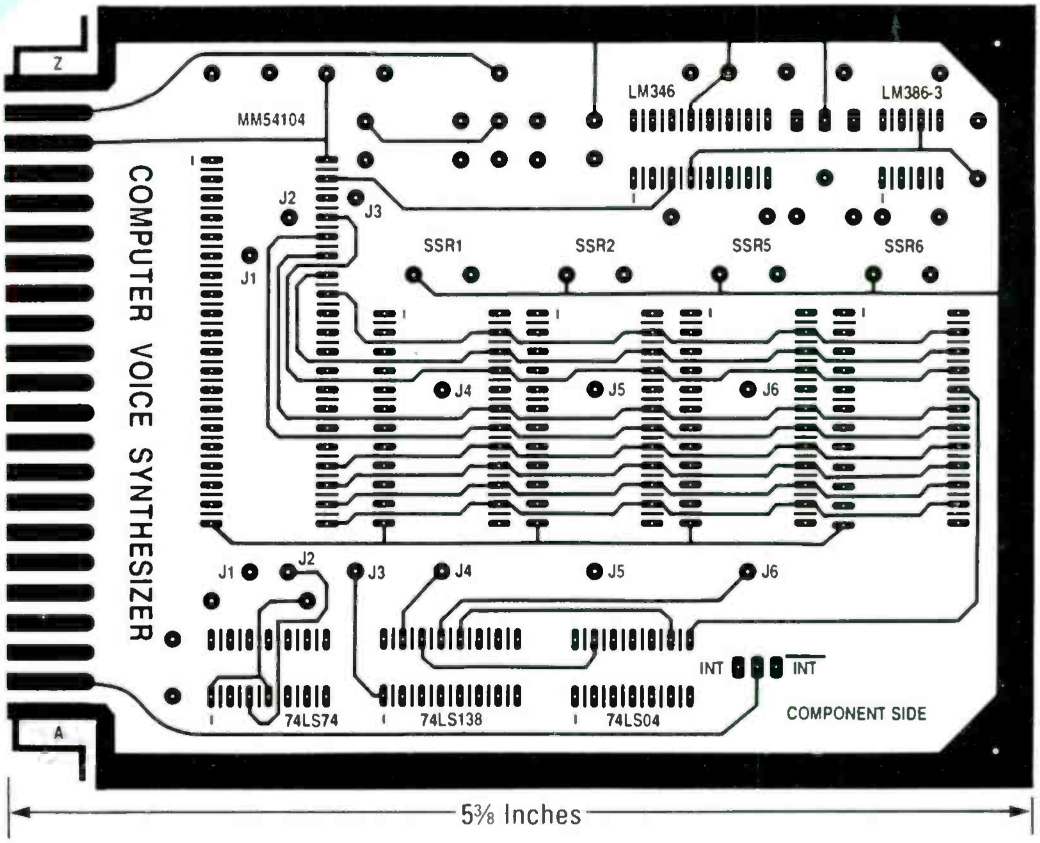
THE GATED SYNC experimenter's descrambler board.



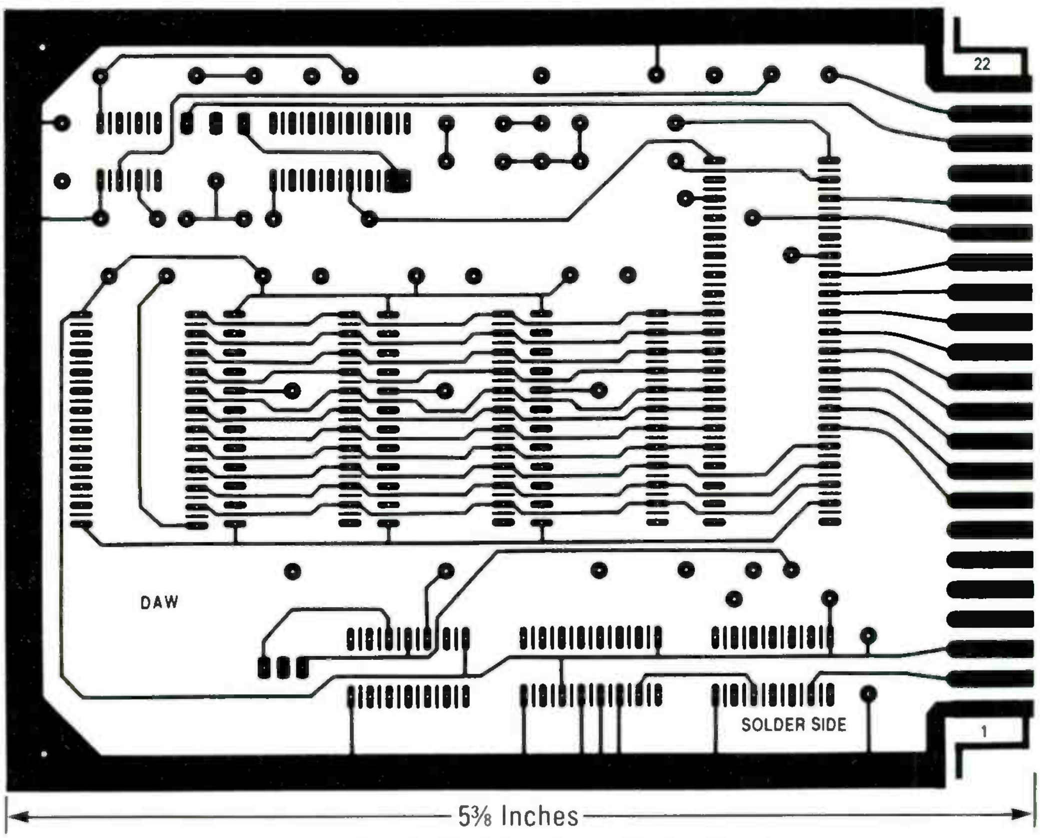
YOU CAN BUILD the RMS adapter using this foil pattern.



FULL SIZE FOIL PATTERN for the video-edit controller.



THE COMPONENT SIDE of the voice-synthesizer board.



THE SOLDER SIDE of the voice-synthesizer board.

VOL. 5 NO. 12 DEC. 1988

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

BUILD A SPEECH SYNTHESIZER

Teach any computer to talk. Page 80

ASSEMBLY LANGUAGE PROGRAMMING

Programming the 68000 Page 86

A GERNSBACK PUBLICATION

BUILD THIS SPEECH SYNTEHSIZER

DAVID A. WARD

Computerized voice synthesizers are turning up everywhere. Perhaps you've heard one at the grocery store check-out stand, in an automobile, or from an educational toy. Other uses include text-to-speech converters for the visually impaired, talking clocks, calculators, radar detectors, chess and other games, blood-sugar and pressure-monitoring devices, and automotive test equipment.

It's a lot of fun experimenting with voice synthesizers; in fact, the author has built and experimented with four different voice synthesizer IC's, and has listened to at least ten different synthesizers in all.

So that you can share in the fun too, we'll present theory and construction details of a stored-word speech system that you can connect to any personal computer having a parallel printer port. A simple BASIC program then uses LPRINT statements to create speech output. A number of terms relevant to electronics are included: ampere, kilo, milli, volt, circuit, connect, farad, hertz, meg, mega, micro, nano, ohms, pico, as well as letters of the alphabet, numbers, and numerous others. The project can be built for about $75.

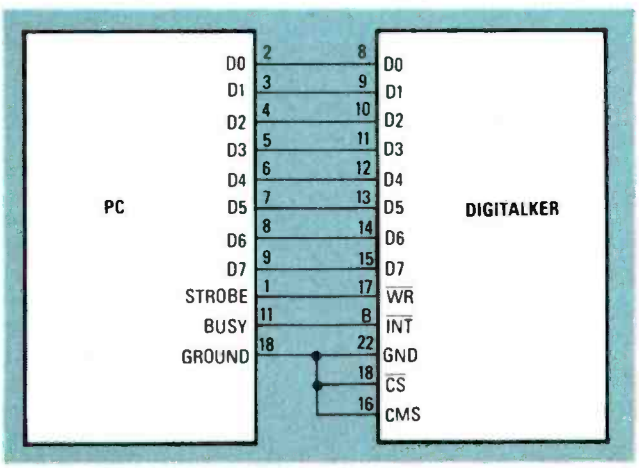


FIG. 1—THE PARALLEL PRINTER PORT of any personal computer can drive the Digitalker.

Speech systems

Most speech synthesis systems operate in one of two ways: the stored-speech method or the allophone method. The allophone method uses *allophones,* little chunks of sound that can be combined to form words. The stored-word system stores entire words and phrases.

Each system has advantages and disadvantages. Allophone synthesis can offer an unlimited vocabulary and yet require very little memory. However, allophone speech synthesis is usually artificial sounding, monotone, and difficult for the untrained ear to understand. Probably the best application for allophone synthesis is in converting text to speech. Text-to-speech conversion can be a great aid for the visually impaired, allowing them to operate word processors and other computer programs.

By contrast, a stored-word synthesizer can offer excellent speech quality with intonation or feeling. However, a stored-word system requires tremendous amounts of memory for just a few minutes of speech. Typically, that limits a stored-word system to a vocabulary of several dozen words. The best application for a stored-word synthesizer is one that requires the clearest possible speech and a limited vocabulary, such as in an automobile, or a supermarket check-out stand. A stored-word

TABLE 1—WORD LIST (SSR1 AND SSR2)

Word	No.	Word	No.	Word	No.
THIS IS		Q	48	IS	96
DIGITALKER	0	R	49	IT	97
ONE	1	S	50	KILO	98
TWO	2	T	51	LEFT	99
THREE	3	U	52	LESS	100
FOUR	4	V	53	LESSER	101
FIVE	5	W	54	LIMIT	102
SIX	6	X	55	LOW	103
SEVEN	7	Y	56	LOWER	104
EIGHT	8	Z	57	MARK	105
NINE	9	AGAIN	58	METER	106
TEN	10	AMPERE	59	MILE	107
ELEVEN	11	AND	60	MILLI	108
TWELVE	12	AT	61	MINUS	109
THIRTEEN	13	CANCEL	62	MINUTE	110
FOURTEEN	14	CASE	63	NEAR	111
FIFTEEN	15	CENT	64	NUMBER	112
SIXTEEN	16	400 HZ TONE	65	OF	113
SEVENTEEN	17	80 HZ TONE	66	OFF	114
EIGHTEEN	18	20 mS SILENCE	67	ON	115
NINETEEN	19	40 mS SILENCE	68	OUT	116
TWENTY	20	80 mS SILENCE	69	OVER	117
THIRTY	21	160 mS SILENCE	70	PARENTHESIS	118
FORTY	22	320 mS SILENCE	71	PERCENT	119
FIFTY	23	CENTI	72	PLEASE	120
SIXTY	24	CHECK	73	PLUS	121
SEVENTY	25	COMMA	74	POINT	122
EIGHTY	26	CONTROL	75	POUND	123
NINETY	27	DANGER	76	PULSES	124
HUNDRED	28	DEGREE	77	RATE	125
THOUSAND	29	DOLLAR	78	RE	126
MILLION	30	DOWN	79	READY	127
ZERO	31	EQUAL	80	RIGHT	128
A	32	ERROR	81	SS (NOTE 1)	129
B	33	FEET	82	SECOND	130
C	34	FLOW	83	SET	131
D	35	FUEL	84	SPACE	132
E	36	GALLON	85	SPEED	133
F	37	GO	86	STAR	134
G	38	GRAM	87	START	135
H	39	GREAT	88	STOP	136
I	40	GREATER	89	THAN	137
J	41	HAVE	90	THE	138
K	42	HIGH	91	TIME	139
L	43	HIGHER	92	TRY	140
M	44	HOUR	93	UP	141
N	45	IN	94	VOLT	142
O	46	INCHES	95	WEIGHT	143
P	47				

NOTE 1: "SS" (#129) can be used to make singular words plural

TABLE 2—WORD LIST SSR5 AND SSR6

Word	No.	Word	No.	Word	No.
ABORT	0	FARAD	44	PER	88
ADD	1	FAST	45	PICO	89
ADJUST	2	FASTER	46	PLACE	90
ALARM	3	FIFTH	47	PRESS	91
ALERT	4	FIRE	48	PRESSURE	92
ALL	5	FIRST	49	QUARTER	93
ASK	6	FLOOR	50	RANGE	94
ASSISTANCE	7	FORWARD	51	REACH	95
ATTENTION	8	FROM	52	RECEIVE	96
BRAKE	9	GAS	53	RECORD	97
BUTTON	10	GET	54	REPLACE	98
BUY	11	GOING	55	REVERSE	99
CALL	12	HALF	56	ROOM	100
CAUTION	13	HELLO	57	SAFE	101
CHANGE	14	HELP	58	SECURE	102
CIRCUIT	15	HERTZ	59	SELECT	103
CLEAR	16	HOLD	60	SEND	104
CLOSE	17	INCORRECT	61	SERVICE	105
COMPLETE	18	INCREASE	62	SIDE	106
CONNECT	19	INTRUDER	63	SLOW	107
CONTINUE	20	JUST	64	SLOWER	108
COPY	21	KEY	65	SMOKE	109
CORRECT	22	LEVEL	66	SOUTH	110
DATE	23	LOAD	67	STATION	111
DAY	24	LOCK	68	SWITCH	112
DECREASE	25	MEG	69	SYSTEM	113
DEPOSIT	26	MEGA	70	TEST	114
DIAL	27	MICRO	71	TH (NOTE 2)	115
DIVIDE	28	MORE	72	THANK	116
DOOR	29	MOVE	73	THIRD	117
EAST	30	NANO	74	THIS	118
ED (NOTE 1)	31	NEED	75	TOTAL	119
ED (NOTE 1)	32	NEXT	76	TURN	120
ED (NOTE 1)	33	NO	77	USE	121
ED (NOTE 1)	34	NORMAL	78	UTH (NOTE 3)	122
EMERGENCY	35	NORTH	79	WAITING	123
END	36	NOT	80	WARNING	124
ENTER	37	NOTICE	81	WATER	125
ENTRY	38	OHMS	82	WEST	126
ER	39	ONWARD	83	SWITCH	127
EVACUATE	40	OPEN	84	WINDOW	128
EXIT	41	OPERATOR	85	YES	129
FAIL	42	OR	86	ZONE	130
FAILURE	43	PASS	87		

NOTE 1: "ED's" 31 and 32 work best with words that end with "T" or "D". "ED" 34 works best with words that end with soft sounds.

NOTE 2: "TH" (#115) can be added to words like; six, seven, and eight to make sixth, seventh, and eighth etc.

NOTE 3: "UTH" (#122) can be added to twenty, thirty, and forty to make twentieth, thirtieth, and fortieth, etc.

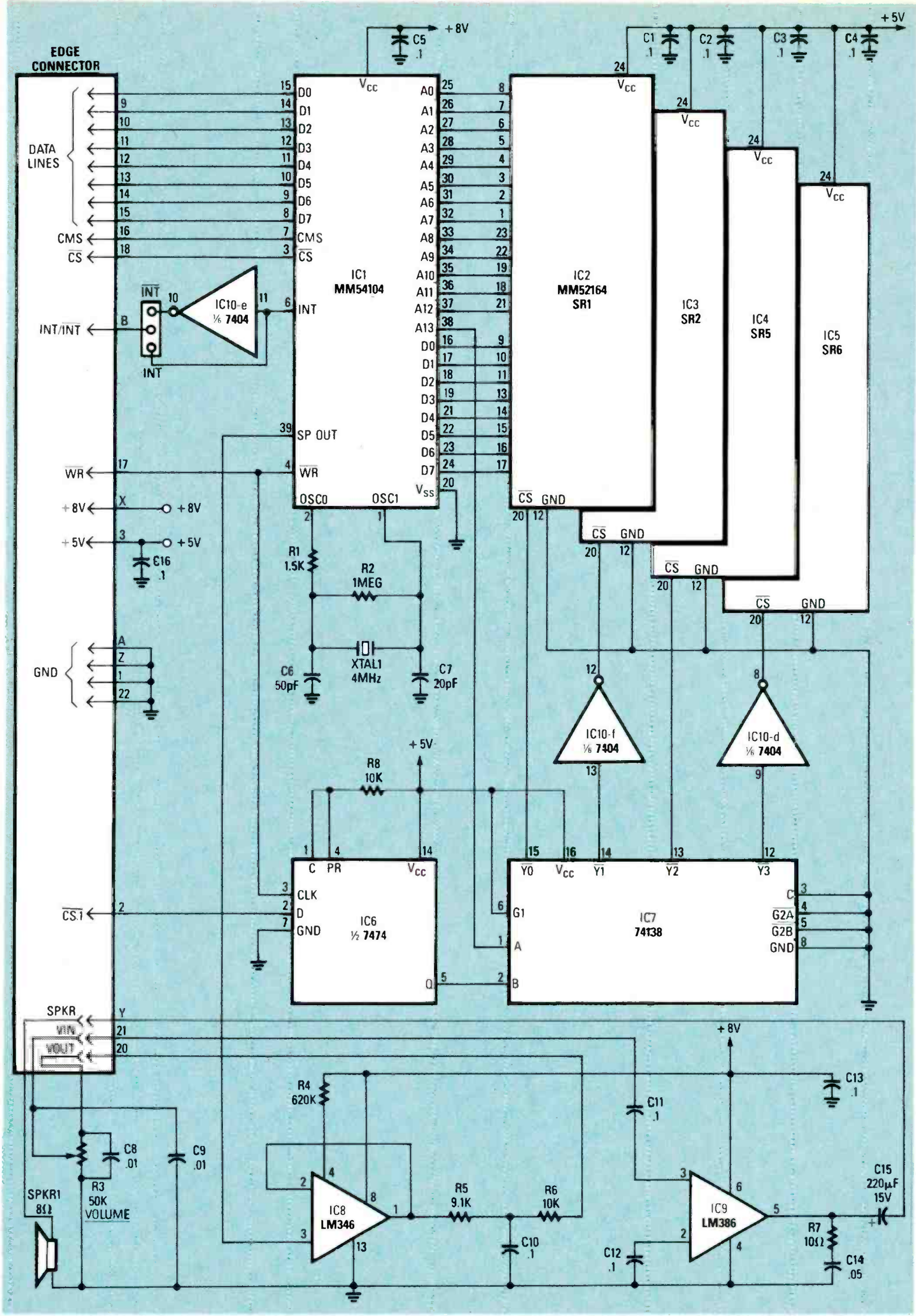


FIG. 2—SCHEMATIC DIAGRAM OF THE DIGITALKER. The speech processor (IC1) reads data from the ROM's (IC2–IC5) and delivers speech output via pin 39.

synthesizer is useless for text-to-speech conversion because of the large amount of memory that would be required.

The Digitalker

National Semiconductor's Digitalker is a stored-word speech synthesis system that produces an exceptionally clear "voice." In fact, the Digitalker's quality exceeds Texas Instrument's *Speak & Spell* speech synthesizer. The Digitalker's voice has intonation or feeling, is not monotone, and even uses a female voice for the phrase "This is Digitalker."

The MM54104 SPC (Speech Processor Chip) is the heart of the Digitalker system. It's a 40-pin IC having 8 data lines (pins 8–15) that can be programmed manually with switches, or by connecting the device to a computer. For best results, a computer should be used to control the SPC so that sentences can be formed by stringing words together rapidly.

The SPC also has 14 ROM address lines (A0–A13, pins 25–38) that are to address ROM's containing speech data. Through those 14 address lines, the SPC can directly access 128K bits of speech data, which is good for about one minute of continuous speech. The SPC receives its data from the ROM's through eight data lines (pins 16–19 and pins 21–24). A number of other lines (pins 3, 4, and 7) are used for handshaking with a host computer, for connecting an external crystal oscillator (pins 1 and 2), and for speech output (pin 39)—which is connected to a filter and an audio amplifier. For more information on the SPC, see National's 1982 Linear Databook.

The right words

One key to a good stored-word speech-synthesis system is to choose the right words to store, convert them from an analog source, and then compress them into digital data suitable for the SPC.

National Semiconductor will convert analog tapes into custom digital data for customers, but that's an expensive proposition for hobbyists. However, the company has developed four general-purpose 64K-bit ROM's that contain data for 273 words, phrases, tones, and pauses. National's Linear databooks list several different ROM sets, but the SSR1, SSR2, SSR5, and SSR6 provide the best selection of words and are easy to obtain. The four ROM's together contain nearly two minutes of continuous speech; the words contained in each ROM set are shown in Tables 1 and 2.

Hooking it up

As shown in Fig. 1, the simplest way to use the Digitalker is to connect it to your computer's printer port. There are several advantages to doing so. First, handshaking between the computer and the Digitalker is automatic, so it isn't necessary to place timing loops in the software.

Second, most printer ports have a $\overline{\text{STROBE}}$ line that goes low when data at the port is valid. The strobe line can be connected to the SPC's $\overline{\text{WR}}$ line. When it is asserted, the SPC reads the ROM data for the selected word over its eight data lines (D0–D8), and then delivers the word to the audio output (pin 39).

The SPC's INTR line (pin 6) goes high after the entire word has been pronounced. By connecting the INTR line (or, if necessary, the inverted $\overline{\text{INTR}}$) to the printer port's BUSY input,

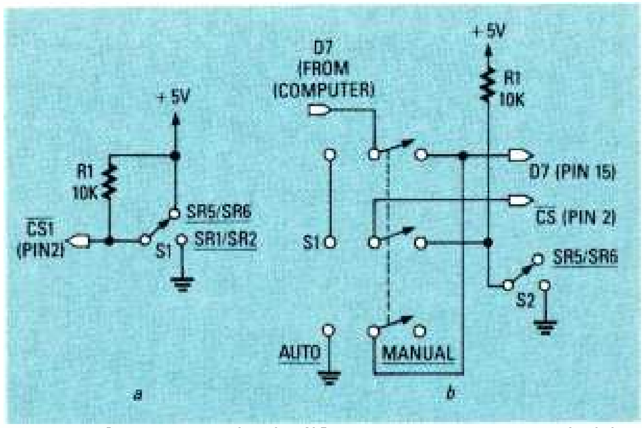


FIG. 3—ROM-SELECT CIRCUITS: Use the circuit shown in (*a*) to select between ROM sets manually. The circuit shown in (*b*) allows manual or automatic computer control, but only the first 128 words and phrases are accessible in the auto mode.

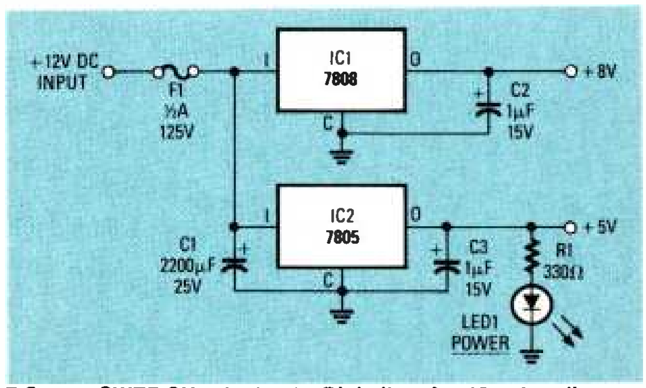


FIG. 4—POWER SUPPLY for the Digitalker. A +12-volt wall transformer provides the raw DC input.

the host computer will wait until each word has been spoken before sending more data to to the SPC.

Two SPC pins provide options. First, $\overline{\text{CS}}$ is the chip-select line;it must be grounded momentarily when the computer addresses the SPC. $\overline{\text{CS}}$ is provided to allow the SPC to share the data bus with other devices.

Second, CMS (command select) resets the interrupt and starts a speech sequence when it is low, and only resets the interrupt when it is high.

The PC board layout brings both $\overline{\text{CS}}$ and CMS out to the edge connector. For normal operation from a parallel-printer port, it's most convenient to ground both pins at the edge-card connector.

Now let's look at the circuit, shown in Fig. 2. The SPC's speech output drives IC8, which buffers the audio signal and drives a volume control. Final audio output is provided by IC9.

Flip-flop IC6 and 3-to-8 line decoder IC7 select the speech ROM's, depending on whether SPC address line AD13 is high or low, and on the state of the $\overline{\text{CS1}}$ signal (edge connector pin 2). AD13 picks the high or low ROM of a pair, and $\overline{\text{CS1}}$ picks one pair or the other.

There are several ways to select which ROM pair you want to use. If you have an extra output bit available on your PC (perhaps a bit from a second parallel port), you can program $\overline{\text{CS1}}$ directly. Otherwise, you can use a manual switch, as shown in Fig. 3-*a*.

A combination approach is shown in Fig. 3-*b*. With switch S1 in the Manual position, you can use S2 to switch between ROM's. But with S1 in the Auto position, you can switch between ROM's using a single eight-bit port. The upper data bit (D7) provides the switching function, so only the first 128 words (0–127) in each ROM set will be accessible using that approach.

The power-supply schematic is shown in Fig. 4. An inexpensive wall transformer provides the raw DC power. Voltage regulators inside the project's cabinet provide the required voltages: +5-volts DC for the digital circuits, and +8-volts DC for the audio circuitry. The entire circuit draws about 300 mA when the volume is turned up, so use a +12-volt DC, 500-mA power supply.

Construction

PC board patterns are shown in PC Service. An etched and drilled PC board is also available from the source given in the Parts List. Figure 5 shows how the parts are mounted on the board. **Note:** six jumper wires must be soldered to the circuit board before the IC sockets are installed. An additional jumper must be soldered from the center INT terminal to either INT or $\overline{\text{INT}}$, depending on the handshaking requirements of your computer's parallel port. Most computers use an active-high BUSY signal, so try the INT setting first if you're not sure which one to use.

Observe normal precautions when handling the SPC and ROM IC's.Leave the chips in their protective "rugs" until they are ready for use. To protect the components against damage caused by static electricity, make sure to ground yourself before removing the IC's from from their rugs, or when handling or moving the PC board.

After mounting all components, check your work carefully for solder bridges and cold joints. Fix any problems before applying power to the board.

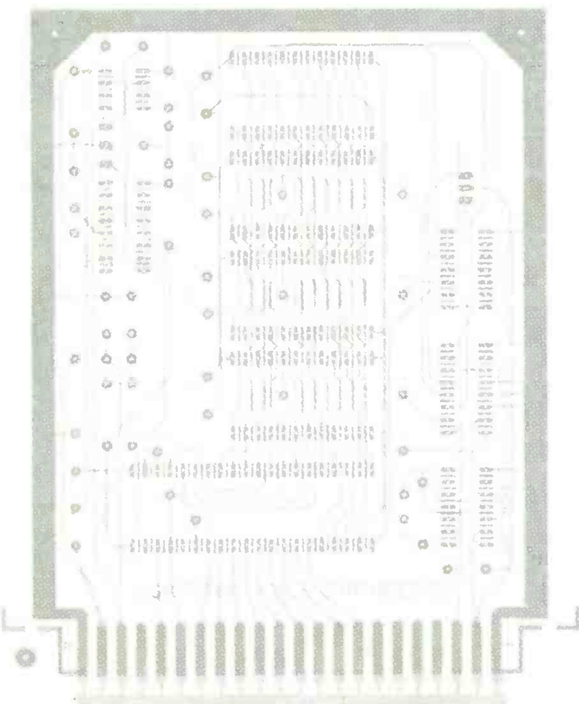


FIG. 5—PARTS LAYOUT: Note that six jumpers must be installed on the component side of the board before installing the IC sockets. (Sockets mount over five of the six jumpers.)

DIGITALKER PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—1500 ohms
R2—1 megohm
R3—50,000 ohms, potentiometer
R4—620,000 ohms
R5—9100 ohms
R6, R8—10,000 ohms
R7—10 ohms
All capacitors are rated 15 volts or higher
C1–C5, C10–C13, C16—0.1 µF, ceramic disc
C6—50 pF, ceramic disc
C7—20 pF, ceramic disc
C8, C9—0.01 µF, ceramic disc
C14—0.05 µF, ceramic disc
C15—220 µF, 15 volts, electrolytic
Semiconductors
IC1—MM54104, speech processor
IC2—MM52164-SSR1, speech ROM
IC3—MM52164-SSR2, speech ROM
IC4—MM52164-SSR5, speech ROM
IC5—MM52164-SSR6, speech ROM
IC6—7474, dual D flip-flop
IC7—74138, 3-to-8 line decoder
IC8—LM346, programmable op-amp
IC9—LM386, audio power amplifiere
IC10—7404, hex inverter
Other components
XTAL1—4.00 MHz crystal

POWER SUPPLY PARTS LIST

R1—330 ohms
IC1—7808 8-volt regulator
IC2—7805 5-volt regulator
C1—2200 µF, 25 volts, electrolytic
C2, C3—1 µF, 15 volts, tantalum
F1—fuse, 0.5 amp, 125 volts
LED1—light-emitting diode
Note: An etched and drilled PC board is available for $15.95 from David A. Ward, 2261 W. Skyview, Cedar City, UT 84720-2233. All orders add $2.00 shipping and handling; Utah residents add 6% sales tax.

LISTING 1

```
10 REM This program will make the
20 REM Digitalker pronounce all words
30 REM in SSR1 and SSR2 (CS1 is low)
40 FOR X = 0 to 143
50 LPRINT CHR$(X);
60 NEXT X
70 END
```

LISTING 2

```
10 REM This program will make the
20 REM Digitalker pronounce all words
30 REM in SSR5 and SSR6 (CS1 is high)
40 FOR X=0 to 130
50 LPRINT CHR$(X);
60 NEXT X
70 END
```

LISTING 3

```
10 REM REAL TIME CLOCK PROGRAM
20 CLS
30 PRINT"HOW OFTEN DO YOU WANT THE TIME ANNOUNCED?"
40 PRINT:PRINT
50 PRINT"ENTER 1 FOR 1 MINUTE INTERVALS..."
60 PRINT"ENTER 5 FOR 5 MINUTE INTERVALS..."
70 PRINT"ENTER 30 FOR 30 MINUTE INTERVALS..."
80 INPUT"",I
90 TIME$=TIME$
100 T$=LEFT$(TIME$,2)
110 T1$=MID$(TIME$,4,2)
120 H$=LEFT$(T$,1)
130 H1$=RIGHT$(T$,1)
140 H=ASC(H$)
150 H1=ASC(H1$)
160 H=H-48
170 H1=H1-48
180 H=H*10
190 HT=H+H1
200 IF HT>12 THEN HT=HT-12:P=47:GOTO 220
210 P=32
220 IF HT=12 THEN P=47
230 IF HT=0 THEN HT=12:P=32
240 M$=LEFT$(T1$,1)
250 M1$=RIGHT$(T1$,1)
260 M=ASC(M$)
270 M1=ASC(M1$)
280 M=M-48
290 M1=M1-48
300 IF M=0 AND M1=0 THEN M=68:M1=68
310 IF M=0 AND M1>0 THEN M=46
320 IF M=1 AND M1=0 THEN M=10:M1=68
330 IF M=1 AND M1=1 THEN M=11:M1=68
340 IF M=1 AND M1=2 THEN M=12:M1=68
350 IF M=1 AND M1=3 THEN M=13:M1=68
360 IF M=1 AND M1=4 THEN M=14:M1=68
370 IF M=1 AND M1=5 THEN M=15:M1=68
380 IF M=1 AND M1=6 THEN M=16:M1=68
390 IF M=1 AND M1=7 THEN M=17:M1=68
400 IF M=1 AND M1=8 THEN M=18:M1=68
410 IF M=1 AND M1=9 THEN M=19:M1=68
420 IF M=2 THEN M=20
430 IF M=3 THEN M=21
440 IF M=4 THEN M=22
450 IF M=5 THEN M=23
460 IF M1=0 THEN M1=68
470LPRINT CHR$(0);CHR$(138);CHR$(67);CHR$(139);CHR$(67);
CHR$(96);CHR$(71);CHR$(HT);CHR$(69);CHR$(M);CHR$(M1);
CHR$(71);CHR$(P);CHR$(44);CHR$(71);CHR$(71);
480 PRINT TIME$
490 GOSUB 510
500 GOTO 90
510 IF I=1 THEN I=60
520 IF I=5 THEN I=300
530 IF I=10 THEN I=600
540 IF I=30 THEN I=1800
550 Z=TIMER
560 Y=TIMER
570 IF Y-Z<I THEN 560
580 RETURN
```

Making the connection

Connecting the Digitalker to your computer is as simple as plugging it into your computer's parallel printer port. For testing purposes, wire a ROM-select switch as shown in Fig. 3-*a*.

It's easy to program the Digitalker. For example, simply by typing

LPRINT CHR$(0);

the Digitalker will say the phrase "This is Digitalker" if $\overline{CS1}$ is low, or "abort" if $\overline{CS1}$ is high.

Listing 1 and Listing 2 are test programs that sequentially pronounces all words contained in the selected ROM set. Both programs were written in GW-BASIC; they were tested on a Kaypro PC.

More sophisticated applications are not difficult. For example, the author has written BASIC programs that do the following; announce the time from the computer's real-time clock, pronounce the corresponding letter of the alphabet as a key is typed (great for a small child learning his ABC's), pronounce phone numbers as names are typed in, and prompt the user for input in various programs. The talking clock program is shown in Listing 3.

There are a couple of things to be aware of when programming the Digitalker. First, addressing a word with a number higher than that listed in the word lists will produce unintelligible speech, but will not damage the SPC or ROM chips. Second, the semicolons following the LPRINT statements are essential. If they are not present the Digitalker will pronounce *thirteen* and then *ten* after each word is spoken. That occurs because an ASCII 13 is a carriage return, and an ASCII 10 is a linefeed. The semicolon (;) eliminates the carriage return and linefeed.

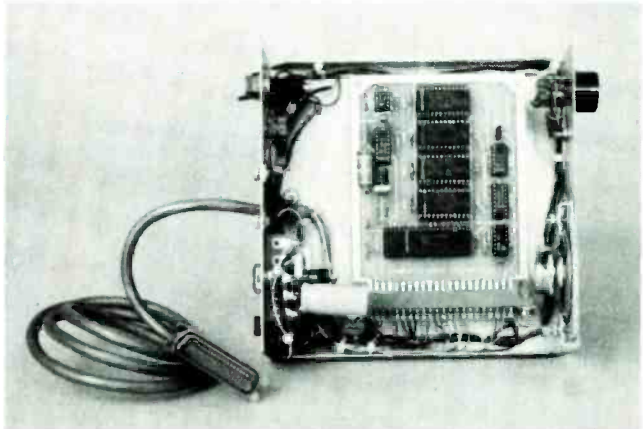


FIG. 6—THE ASSEMBLED SYNTHESIZER with its cover removed.

Applications ideas

Computer voice synthesis can be a very natural way for computers to communicate with people. For example, a synthesizer could be used to warn a pilot that the plane's altitude is critically low, or that the fuel level is low. A visually impaired person could compose documents with a word processor, or compute math problems with a calculator.

Undoubtedly, there are many other uses for computerized voice synthesis in cash registers, automatic teller machines, emergency warning systems, automobiles, telephone systems, etc. Have fun finding them! R-E

"The man at the pet shop said he can store up to 20 separate commands."

68000 ASSEMBLY LANGUAGE

An introduction to 68000 assembly-language programming.

PETER A. STARK,
STARK SOFTWARE SYSTEMS CORPORATION

Programming the 68000 in a high-level language (BASIC, C, etc.) is not much different from programming in a high-level language on any other microprocessor. But if you're building the PT-68K computer, we assume that you want to go beneath the surface and learn a bit about the internal structure of the microprocessor, and how to program it in its native language. What follows will serve as a necessarily brief introduction; we'll also provide references for further information.

Even though the 68000 is an extremely versatile and powerful microprocessor, it is still fairly easy to program it in assembly language, especially compared with the difficulty of programming other microprocessors (the Intel family in particular). With some effort, it is even possible to program it in machine language, though one has to be pretty desperate to want to attempt it.

As shown in Fig. 1, Internally, the 68000 has nineteen user-accessible registers; each register is a memory location within the microprocessor that can store a number while it is being used. All registers but one are 32 bits long.

For purposes of experimentation, we'll use HUMBUG, the PT-68K's built-in ROM monitor that allows you to examine and change memory, execute programs at full speed and a step at a time, etc. Start your computer, and when you get the prompt, you can press the letters HE to display a help screen. Each command is a two-character abbreviation for the command.

One useful command is RE (Register Examine). At the prompt, press RE to get a display similar to that shown in Table 1. The line starting D: shows eight 8-digit numbers corresponding to the eight *data registers* (D0–D7); the line starting with A: shows eight 8-digit numbers corresponding to the eight *address registers* (A0–A7). For example, data register D3 is shown on the D: line, under the 3; address register A0 is on the A: line, under the 0.

The last line of Fig. 1 shows four additional registers: the *program counter* (PC), the *status register* (SR), the *user stack register* (US), and the *supervisor stack register* (SS, also called the *system stack register*). Actually, only nineteen registers are shown, because one of the registers is shown twice. Register A7 is normally used as the user stack pointer, so the register dump shows that the two registers have identical contents.

Except for SR (the status register), each register contains an eight-digit hexadecimal number. For example, Table 1 shows that D0 contains the number 12121212 (your display will contain different numbers). Each hex digit represents four bits, so each register (other than SR) can contain a 32-bit number.

The SR (status) register differs in that it contains only 16 bits, or four hex digits. In the example, those hex digits are 0000; the periods to the right of the number indicate the status of each bit.

The 68000 can work with an entire register (32 bits), half a register (16 bits), or even a quarter of a register (8 bits) at a time. A two-digit hex number is called a *byte;* a four-digit hex number is called a *word;* an eight-digit number is called a *long word.*

Although instructions in a high-level language may consist of complex mathematical calculations, at the lowest level all microprocessors work with *machine language,* which are usually represented with hex numbers and binary digits. Somewhat more readable (to humans, that is) is *assembly language,* which represents those instructions with words, not just numbers.

Machine- and assembly-language instructions are concerned with relatively small tasks. The most common such task is one that simply moves a number from one place to another. For example, the assembly-language instruction that moves a long word from the D5 register to the A2 register would be written:

MOVE.L D5,A2

Note that the instruction consists of four parts: MOVE tells

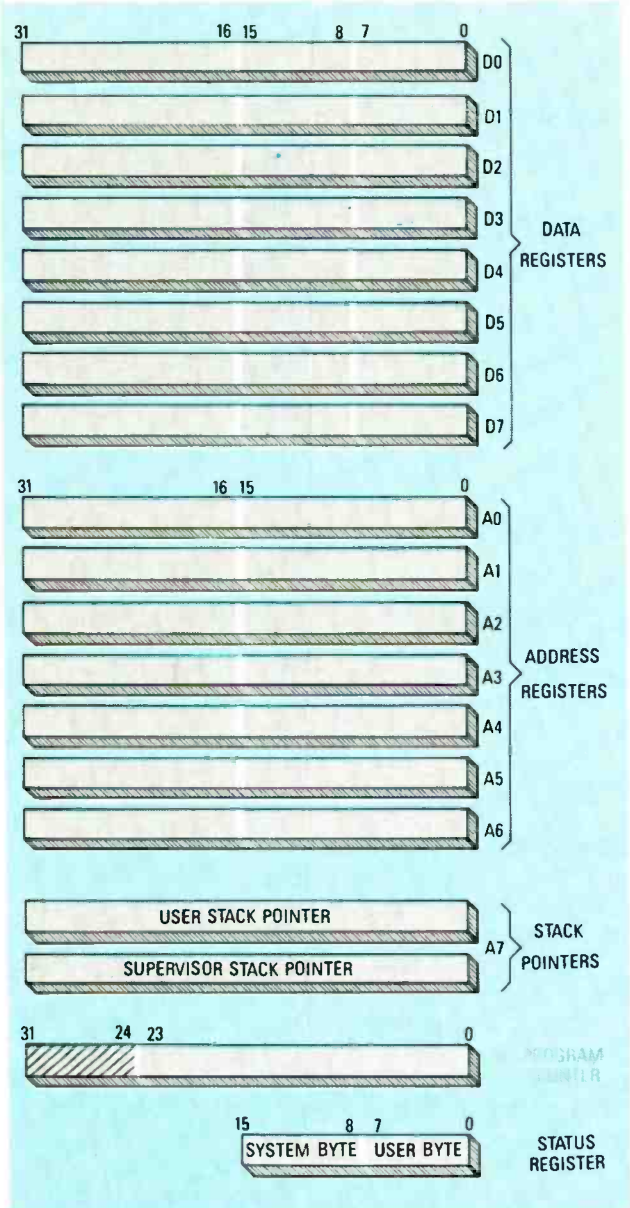


FIG. 1—THE MC68000'S REGISTER MODEL. All registers except the status register (also called the condition code register or CCR) are 32 bits long. A7 is used as the user stack pointer.

what we want to do, .L specifies that a long word (32 bits) is to be moved, D5 (the *source*) tells where the number is to be moved from, and A2 (the *destination*) tells where to move it to. In 68000 programming, the source always comes first, so you may think of the format as *from, to*; that differs from some microprocessor families (notably the Intel family) where the format is *to, from*.

Normally data registers contain numbers used in calculations of some kind, and address registers contain addresses that indicate the location of that data. There are exceptions to that rule, so moving a long word from D5 to A2 is perfectly valid—the 68000 doesn't care whether the number being moved is an address or data. That is why Motorola states that the 68000 has sixteen "general purpose" registers.

The 68000 can directly address as many as 16 million locations; those addresses are numbered consecutively from $000000 to $FFFFFF, for a total of just six hex digits. But the registers can hold eight hex digits, not just six. Therefore, in most cases the two left digits of an address will both be 00 (like the A7 and PC registers in Table 1).

Even though the two left digits are not used by the 68000 for addressing, the scheme maintains compatibility with the microprocessor's more powerful siblings, the 68020 and the 68030, both of which allow full eight-digit addresses, thereby allowing as many as four *billion* locations to be accessed directly.

Here are two other common 68000 assembly-language instructions intended to exemplify the *from, to* structure:

MOVE.B D7,$00FF0200

moves a byte from register D7 to memory location $FF0200, and

ADD.W $00FF0100,D6

adds the number that is stored in memory location $FF0100 to the contents of data register D6, and leaves the result in that register.

Machine and assembly language

Those instructions are simple examples of assembly language. Unfortunately, microprocessors don't understand assembly language—instead, they require an even more down-to-earth language called machine language, in which the four parts of the above instructions are coded as binary bits. For example, our first example instruction (MOVE.L D5,A2) is actually coded as the 4-digit hex number 2445, which translates to a binary 0010010001000101. Each of the parts of the original assembly-language instruction is carefully preserved in the machine code as well: the first 0010 means "MOVE.L," the next 010001 means "to A2," and the final 000101 means "from D5."

Although the original MOVE.L D5,A2 is understandable to humans, a number like 2445 (or, worse yet, 0010010001000101) doesn't make much sense. If we had to write all our programs in machine language—as either hex numbers or even strings of ones and zeroes—programming would be very difficult indeed. Fortunately, a program called an *assembler* translates from assembly language to machine language for us. SK*DOS includes a 68000 assembler, but you need a built-up PT-68K (one with disk drives and some DRAM) to run it. If you've got only a bare-bones system (one with 2K or 4K of RAM), to assemble programs what you are going to have to do is to try one of the ideas outlined below.

TABLE 1—HUMBUG'S REGISTER DISPLAY

	0	1	2	3	4	5	6	7
D:	12121212	00000012	00000013	00000014	00000015	00000016	00000017	00000018
A:	98765432	00000099	00000088	00000077	00000066	00000055	00000044	00FF0EFC

PC=00F00206   SR=0000 =.....0........   US=00FF0EFC   SS=00FF0DFC

LISTING 1

```
FF0000                                  ORG       $FF0000

FF0000 2002                  START      MOVE.L    D2,D0        Move D2 to D0
FF0002 2401                             MOVE.L    D1,D2        Move D1 to D2
FF0004 2200                             MOVE.L    D0,D1        Move D0 to D1
FF0006 4EF9 00FF 0000                   JMP       START        And repeat

                                        END
0 ERROR(S) DETECTED
```

You can, of course, wait until you have installed more memory and a disk interface, at which time you can run the SK*DOS assembler. Alternatively, you could use an assembler that runs on another computer, such as a Macintosh, an Atari ST, or even a PC compatible. (An assembler which runs on a totally different computer is often called a *cross-assembler.*) With the latter approach, you'll have to enter the hex bytes generated by the assembler into your PT-68K by hand.

If you are really persistent, it is possible (though not easy, and definitely not enjoyable) to "hand-assemble" a program—i.e., translate it manually from assembly language to machine language—with the aid of a few good books on 68000 assembly-language programming. Two such books are *The 68000: Principles and Programming,* written by Leo J. Scanlon, and published by Howard W. Sams & Co., and *M68000 16/32-bit Microprocessor Programmer's Reference Manual,* by the Motorola Staff, published by Prentice-Hall Inc. Both books are also available from local Motorola sales offices; the latter book is a "must have" if you intend to do really serious assembly-language programming.

Last, you could send your assembly language program to the PT-68K BBS (at 914-241-3307) by phone; the Sysop will assemble it for you free of charge. Again, you'll have to enter hex bytes by hand.

To get started, let's write a simple program and show you how you could enter it and test it on your computer. Let's start with a simple BASIC program; it's not really useful, but it does make a good introduction to assembly language:

TABLE—ENTERING A SIMPLE PROGRAM

```
*ME   ADDRESS: FF0000
00FF0000 00   20
00FF0001 00   02
00FF0002 00   24
00FF0003 00   01
00FF0004 00   22
00FF0005 00   00
00FF0006 00   4E
00FF0007 00   F9
00FF0008 00   00
00FF0009 00   FF
00FF000A 00   00
00FF000B 00   00
00FF000C 00
*HD   FROM FF0000   TO FF000B
00FF0000    20 02 24 01 22 00 4E F9    00 FF 00 00
*
```

```
ab 10 D0 = D2 ' MOVE D2 TO D0

ab 20 D2 = D1 ' MOVE D1 TO D2

ab 30 D1 = D0 ' MOVE D0 TO D1

ab 40 GOTO 10 ' AND REPEAT
```

The equivalent assembly language program is shown in Listing 1.

The two programs are similar, but there are differences. In BASIC, for example, D0 is a variable (possibly with a decimal point or exponent), whereas in assembly language it represents a binary integer that, in this case, happens to be contained in a specific register.

Assembly-language syntax

In assembly language, any line may consist of four parts: a *label*, an *operation code,* an *operand,* and a *comment.* Not every line will have all four parts; some will have all four, and others will have only one or two. Let's discuss each in turn, using analogies in BASIC where possible.

In most versions of BASIC, every line has a line number, although only line 10 in this example really needs one (because it is referred to in line 40). In assembly language, lines have (optional) labels, rather than numbers. The first line is labeled START, because it is where code begins, and so that the last program line can refer to it.

The operation code (MOVE.L or JMP, for example) tells the microprocessor what to do, and the operand tells the microprocessor what to do it to, or where to do it, or even how to do it. For example, a MOVE instruction must have source and destination registers or memory locations.

As in BASIC, an assembly-language statement can have explanatory comments appended to the end of the line, but in 68000 assembly language, a comment needs no quote (or, as in some versions of BASIC, a :REM).

For an assembler to translate the program into machine language, we must add two more lines. At the top, we add the *assembler directive*

ORG $FF0000

which tells the assembler where in memory to place the program. It is called an assembler directive because it is an instruction to the assembler, rather than an instruction within the program. We use address $FF0000 for the beginning of the program, because that is the only place where RAM is installed in a minimal system.

At the end of the program, we place the directive

END

which tells the assembler to stop translating. The resulting six lines are called the *source program.*

TABLE 3—SINGLE STEPPING WITH HUMBUG

```
*ST   FROM FF0000
00FF0000: 2002
       0        1        2        3        4        5        6        7
D: 22222222 11111111 22222222 33333333 44444444 55555555 66666666 77777777
A: 88888888 99999999 AAAAAAAA BBBBBBBB CCCCCCCC DDDDDDDD EEEEEEEE 00FF0EFC
PC=00FF0002     SR=0000 =.....0........    US=00FF0EFC     SS=00FF0DFC

*SS
00FF0002: 2401
       0        1        2        3        4        5        6        7
D: 22222222 11111111 11111111 33333333 44444444 55555555 66666666 77777777
A: 88888888 99999999 AAAAAAAA BBBBBBBB CCCCCCCC DDDDDDDD EEEEEEEE 00FF0EFC
PC=00FF0004     SR=0000 =.....0........    US=00FF0EFC     SS=00FF0DFC

*SS
00FF0004: 2200
       0        1        2        3        4        5        6        7
D: 22222222 22222222 11111111 33333333 44444444 55555555 66666666 77777777
A: 88888888 99999999 AAAAAAAA BBBBBBBB CCCCCCCC DDDDDDDD EEEEEEEE 00FF0EFC
PC=00FF0006     SR=0000 =.....0........    US=00FF0EFC     SS=00FF0DFC

*SS
00FF0006: 4EF9
       0        1        2        3        4        5        6        7
D: 22222222 22222222 11111111 33333333 44444444 55555555 66666666 77777777
A: 88888888 99999999 AAAAAAAA BBBBBBBB CCCCCCCC DDDDDDDD EEEEEEEE 00FF0EFC
PC=00FF0000     SR=0000 =.....0........    US=00FF0EFC     SS=00FF0DFC

*SS
00FF0000: 2002
       0        1        2        3        4        5        6        7
D: 11111111 22222222 11111111 33333333 44444444 55555555 66666666 77777777
A: 88888888 99999999 AAAAAAAA BBBBBBBB CCCCCCCC DDDDDDDD EEEEEEEE 00FF0EFC
PC=00FF0002     SR=0000 =.....0........    US=00FF0EFC     SS=00FF0DFC
```

LISTING 2

```
                                  ORG       $FF0000
FF0000 287C 00FF 0012   START     MOVE.L    #STRING,A4      Address of string
FF0006 4EB9 00F8 0102             JSR       $F80102         Print it
FF000C 4EF9 00FF 0000             JMP       START           And repeat

FF0012 48454C4C4F2104   STRING    DC.B      'HELLO!',4

                                  END
0 ERROR(S) DETECTED
```

We then call the assembler to do the translation; it prints out a listing of both the source program and the translated machine code, which is called the *object program* or *object code*. As shown in Listing 1, the object code is at the left, and the source code is at the right.

At the left side of the listing, the first column of numbers (beginning with FF0000) are the addresses where the program instructions will be stored. (The beginning address was specified in the ORG directive at the beginning of the program. The first instruction (MOVE.L D2,D0), translates into a 2002 machine-language instruction, which is stored in location FF0000. That instruction occupies two locations in memory, namely FF0000 and FF0001; therefore the second instruction begins at location FF0002. The second instruction also occupies two bytes, so the third instruction begins at FF0004, and so on.

Note that each of the three MOVE instructions take only two bytes, but the JMP instruction (equivalent to BASIC's GOTO) at the end of the program takes six bytes. In general, instructions that involve only internal registers tend to be short (and fast), whereas instructions that involve memory tend to be long (and slow), because they often require a complete four-byte memory address. Thus JMP translates into 4EF9, followed by 00FF0000, which is the address of the START label.

Without an assembler, you'll have to type the machine-language code in by hand to test and run it. As shown in Table 2, first type in the command ME (which stands for Memory Examine), and then respond with FF0000 (and a space) when HUMBUG asks for an address.

On the second line, HUMBUG prints out the address 00FF0000, followed by the present contents of that address. Although it is shown as 00 in the example, your computer will most likely have some other data there when you begin. You should then type in the number 20, which is the first byte of the first instruction (2002). HUMBUG will then go to the next line and display the contents of the next location; now you should type in the 02. After typing in twelve bytes, just press the Enter key when the program asks for data to place in location 00FF000C.

The last two lines in Table 2 show how to use the HD (Hex Dump) command in order to ensure that the data was entered correctly. The twelve bytes of our program are now neatly displayed, one after another, in consecutive locations.

Now let's test the program. If you look at the original BASIC program, you see that if we typed it in and typed RUN, the program would simply get tied up in a loop and never output a single number. The same would happen with the machine-language program. To avoid that, and to see what is happening, we will *trace* the program one instruction at a time, rather than run it at normal speed.

As shown in Table 3, start by issuing the ST (STart STepping) command, and reply FF0000 when HUMBUG asks where to start.

On the next line, HUMBUG prints out the address and operation code of the instruction it is about to perform (in this case, 00FF0000: 2002). Then the instruction is executed, and next the 68000's registers are dumped. (For purposes of illustration, all registers had been preloaded with distinctive data, thereby making it easy to see that the contents of D2 has been copied into D0.)

In the first register dump, note the item that reads PC = 00FF0002. The PC is the Program Counter, a register in the 68000 that holds the address of the *next* instruction to be performed. In this case, the next instruction is at location 00FF0002.

Next the SS command was typed in, HUMBUG performed the next instruction, and the registers were dumped again. Now both D1 and D2 contain the number 11111111.

Note what happens after the computer performs the JMP (4EF9) instruction at 00FF0006. This time the data registers do not change; what happens is that the program counter changes to 00FF0000, indicating that the computer will do the instruction at FF0000 next. In that way we see how the JMP instruction causes the program to repeat from the beginning.

For more practice, you can play with the program shown in Listing 2. Here, the second instruction (JSR $F80102) causes HUMBUG to display the string pointed to by A4, in this case the message "HELLO!" Enter the machine code as before, but don't try to trace through HUMBUG. Just execute the program at high speed (using the command JS FF0000) to see what happens. Then try to figure out how to vary the message.

Conclusions

Assembly-language programming is a complex topic, so we cannot possibly do it justice here. However, we hope that we've given you an idea of what it's like to program in assembly language. If you want to learn more about it, consult your local engineering bookstore, one of the books mentioned above, local computer clubs, and your local college or university. Most important try to get some experience. Good luck. R-E

AUDIO UPDATE

The Audio Engineering Society—Pt. II

LARRY KLEIN,
AUDIO EDITOR

IN LAST MONTH'S COLUMN I WROTE about the Audio Engineering Society and the services it provides to those interested in the technical side of audio. I had mentioned that I've been a member of the AES for some 30 years, and I credit it—through its monthly Journal and meetings—for much of my audio education. Present AES membership includes more than 10,000 engineers, researchers, educators, manufacturers, audio retailers, and students.

Aside from the talks, lectures, and debates scheduled during the regular local section meetings held in many major cities, scores of papers detailing the latest audio research and developments are presented during the annual conventions. For information on becoming a member of the AES and/or a catalog of available papers and special publications, simply write to: Audio Engineering Society, 60 East 42nd Street, New York, NY 10165. Anyway, here's a couple of presentations from the October 1987 meeting that I found particularly interesting.

DYNAMIC ENVELOPES OF VARIOUS MUSICAL SIGNALS.

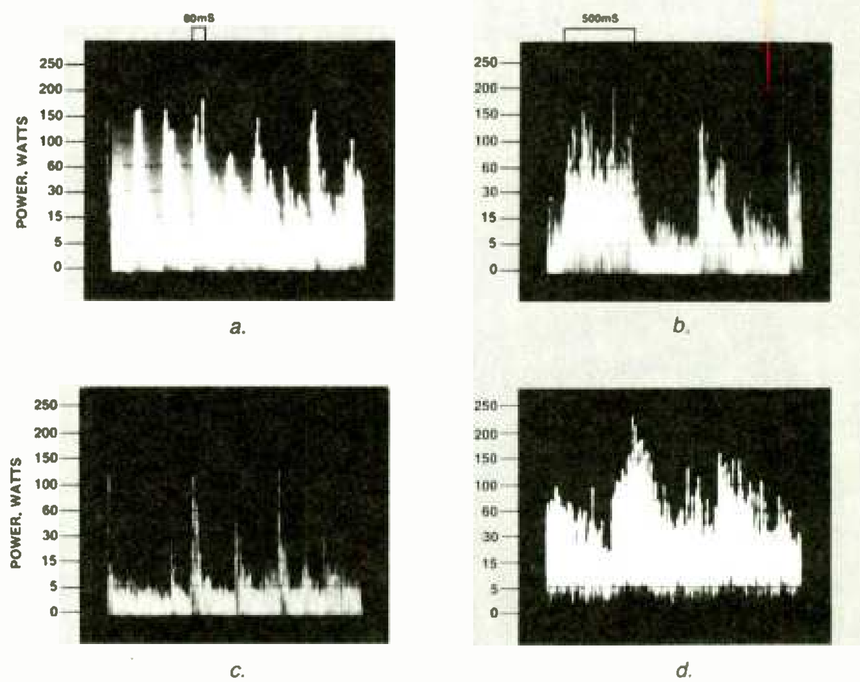


FIG. 1

2504, 0-7

A Musically Appropriate Dynamic Headroom Test for Power Amplifiers, Mitchell.

This paper discusses in depth a matter that I have written about extensively in a variety of publications. It questions the validity of the EIA dynamic headroom test found in the current amplifier standard, which measures an amplifier's ability to provide more power for brief peaks than it can on a continuous or sustained basis. The author does not find the *concept* of dynamic headroom at fault; the problem lies in the specific characteristics of the standard test signal that is used to determine dynamic power, which, in his view (and mine), are inadequately representative of typical music waveforms.

The present amplifier test standard (EIA RS-490) calls for a 1,000-Hz tone burst of 20-milliseconds duration, recurring at half-second intervals. The amplitude of the tone-burst test signal is gradually increased until the output waveform begins to clip. The difference, expressed in dB, between an amplifier's maximum rated output with a continuous signal versus its output with a tone-burst signal is its *dynamic headroom* rating. The dynamic headrooms of today's amplifiers have been measured as low as 0.25 dB, and as high as 6 dB—or four times the continuous-power rating.

Mitchell's paper includes nine oscilloscope photos (some of them are displayed in Fig. 1) showing the dynamic envelopes for a 2-second period of recorded selections ranging from Genesis and the Bee Gees to Bruckner, Mahler, and Strauss. The scope photos adequately establish that there are substantial musical peaks on compact discs that extend in time far beyond the 20 milliseconds of the EIA standard. Equally interesting are two graphs that illustrate the differences between conventional amplifiers and "commutating" amplifiers that adjust their power-supply voltages to the demands of the output signal. In the latter case, the power supply is operating at a low level most of the time—which minimizes heating and the need for a heavy-duty power supply. When musical tone bursts demand more power, the power supply switches to a higher voltage level.

Mitchell states that the original choice of 20 milliseconds for the tone-burst length was done "somewhat arbitrarily." Not so. As I recall, Edward Foster, who as chairman of the committee had undertaken the task of framing the standard, volunteered to research the question of an appropriate test signal. Only one technical paper bearing on the duration of musical peaks turned up, and our test-signal parameters were based on it.

Mitchell's paper concludes with a suggestion that the audio industry adopt a revised dynamic-headroom rating as its primary standard, because it most closely relates to an amplifier's ability to reproduce music without distortion. That is an interesting suggestion; but my experience as a member of the original IHF committee—which took two years to frame the current dynamic-headroom standards—leads me to believe that changes are unlikely to be agreed upon and adopted, given the nature of today's industry.

2518 C-1

Results of the 1986 AES Audiometric Survey, Martinez, Gilman.

About 25 years ago I visited the sound-mixing department of a major Hollywood motion-picture studio. As I recall, what impressed me most about the facility were the ear-blasting sound-pressure levels that were used for monitoring the mixes.

The sound was so loud that I couldn't see how it was possible to judge the finer points of audio quality while being buffeted by such sonic storms. I was later told that the high volume levels were used to listen for artifacts such as audible tape splices, rather than for nuances of quality. But there's another reasonable—and rather unfortunate—explanation for the high levels used by many audio professionals and musicians: hearing loss.

We'll look at that problem next month before we move on to the topic of amplifier damping factors. **R-E**

DRAWING BOARD

Seven-segment displays

ROBERT GROSSBLATT,
CIRCUITS EDITOR

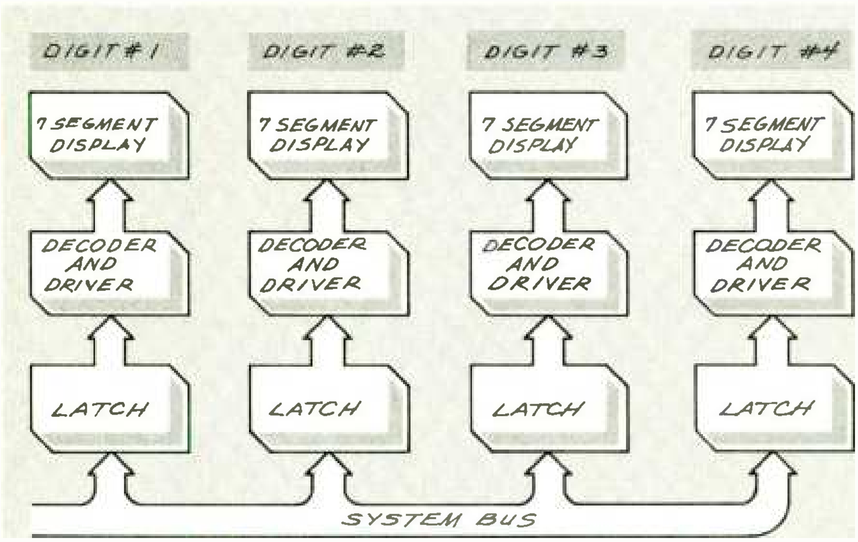


FIG. 1

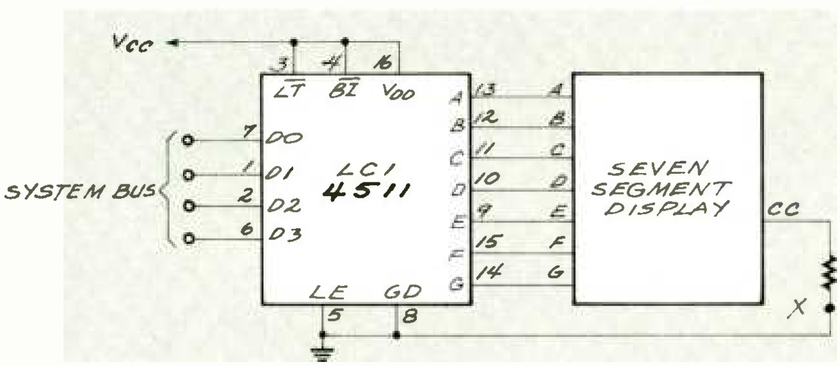


FIG. 2

WE'VE COVERED SOME OF THE BASICS of display multiplexing, but everything we've talked about so far involved single LED's. Not only that, but we've also looked at circuitry that only demonstrated the idea of multiplexing. As everyone knows, there's usually quite a difference between demonstration stuff and reality.

All LED-display multiplexing uses the same basic principle we've been talking about—strobing the LED's fast enough so that it seems as if they're constantly on. But, different circuits may have to be handled in different ways. Now let's try multiplexing a seven-segment display.

The block diagram in Fig. 1 is a typical setup for a seven-segment display. Each display has a latch-and-decoder combination in front of it, and most circuits will use chips that combine the latch and driver in one package but the operation of the circuit is the same.

A practical implementation of that block diagram is shown in Fig. 2. The only thing that's missing from the display is multiplexing—and that's exactly what we're going to add to it. Although the design considerations are specifically aimed at the circuit that you see in Fig. 2, they're the same for any other circuit.

The first thing we need is a scan oscillator. You can use the one that we put together in the October issue, or any other one that you happen to have around. That isn't as silly as it sounds, because if you're adding display multiplexing to a circuit, the chances are that there already is a clock in that circuit. It's always a good idea to keep the amount of silicon on a board to a minimum, so it makes perfect sense to steal a clock signal from something in the circuit if you can.

The requirements for an oscillator are really minimal. As a matter of fact, there are only two requirements that are absolutely essential: The first is that the frequency be high enough to keep the display from flickering noticeably and the second is that the duty cycle will make the display bright enough.

The minimum frequency needed to avoid flicker depends on several different things—how many display elements are being

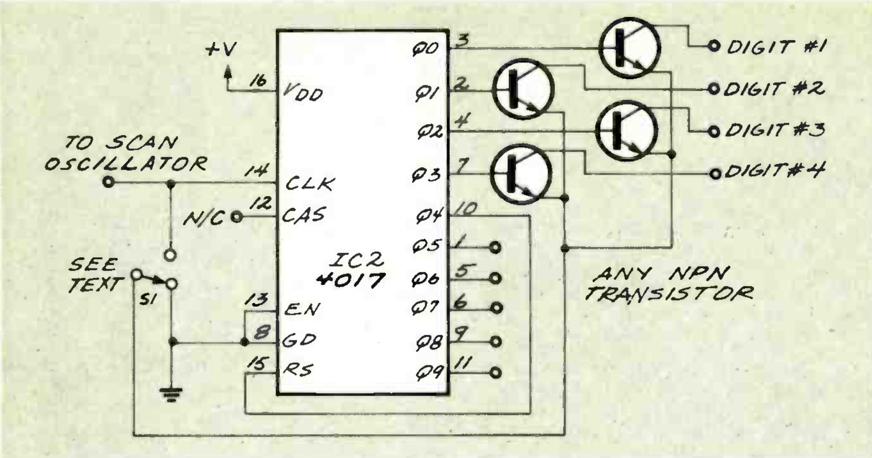


FIG. 3

multiplexed, the characteristics of the particular displays being used, and so on. But as long as you turn on each display at least once every hundredth of a second or so you don't have anything to worry about. You can do it less often but the demonstration circuit we've already discussed should have shown you that the minimum frequency varies from person to person. Most circuit designs that use multiplexing techniques have scan frequencies of well over 1 kHz to keep the problem from even being considered.

The clock's duty cycle can determine how bright the display is going to be, depending on the particular circuit. The one we're looking at, for example, uses common-cathode displays; the more time the common-cathode terminal spends low, the brighter the display is going to be. If you're stealing a clock signal from an already-existing circuit, you'll probably be stuck with a given duty cycle. But, if you're generating your own, you have control over everything. Let's do it both ways.

The circuit in Fig. 3 is the same basic one that we used before. A few additions are needed, because the 4017 puts a high on the selected pin and we need a low to light the digit. The transistors are set up as simple switches to invert the 4017 outputs. It may seem as if the circuitry we're adding is unnecessarily cumbersome, but there are reasons for it.

It's true that we could replace the 4017 with a multiplexer that puts a low on the selected output rather than a high. Then we wouldn't need the transistors and we could have the display driven directly by the multiplexer's outputs. On the face of it, that seems like a good idea—fewer parts is a good thing...sometimes.

Using the circuit in Fig. 3 adds complexity but it also gives us two advantages that we'll discuss next month. R-E

SHORTWAVE RADIO

continued from page 42

The highest maximum ever observed was during cycle 19, which started in April of 1954 with a smoothed number of 3.3. Within 2-½ years it exceeded 159, which had been the previous record of cycle 3. By March 1958 the smoothed number was 201.3.

Conditions during the maximum year of cycle 19 have already become legendary. Worldwide ionospheric propagation in the amateur 6-meter band (50 MHz) was observed; the 16-meter (17 MHz) broadcast band was open around the clock on a worldwide basis. From 1957–1959, transatlantic and transcontinental TV DX was commonplace via the ionosphere on channels 2–5.

Cycle 20 was more "normal," reaching a maximum of 111 in November 1968. However, once the cycle began to decline it displayed some unusual characteristics in that it remained confined to the range between 100 and 110 for 21 months, from November 1967, to August 1970. To cycle 20 belongs the distinction of the longest plateau at maximum ever observed. Cycle 20 was also longer (11.5 years) than the average cycle, and took longer (7.4 years) to go from maximum to minimum.

Cycle 21

Cycle 21 began in June 1976 with a smoothed sunspot number of 12.2; many scientists and astronomers were fooled by that cycle, having expected it to be similar in intensity to cycle 20. Some forecasters had predicted that we'd see a maximum smoothed number under 100. However, within 27 months of its start, the smoothed number had already risen above 100, and by November of 1979 had become the second highest cycle ever recorded.

A Look at the Future

If we consider that the sun is about four billion years old, and that we have been keeping records for about 250 of those four billion years, it becomes apparent that we really don't know very much about sunspot cycles. We can, at best, offer only educated guesses:

- Cycle 22 will reach its maximum in the summer of 1990.
- There is a strong possibility that cycle 22 will peak at 200 or above, and that it will be the highest ever observed.
- That would result in unprecedented radio conditions, including around-the-clock amateur 10-meter and Citizen's Band DX a reality. DX television will be commonplace, and TV interference levels will be significant. 17-MHz short-wave DX is likely to be possible around the clock during the summer months, and 21 MHz will be open for longer periods than ever before.
- During the next three years, short-wave DX will be better than ever before!

We'll have to wait and see, of course, how those predictions turn out. When will it reach its peak, will it be the highest cycle ever to be recorded, and will it reach 200? Those are questions that only time can answer.

Don't forget—you heard it here first!

HARDWARE HACKER

continued from page 36

Two ready-to-use solid-state digital compasses are now available from *AutoHelm* and *KVH Industries*. Further info on those appears in issue ten of *Speleonics*.

For this month's contest, just tell me something new and unusual that you would do with a solid-state compass, particularly if the compass measured amplitude as well as direction.

There will be the usual *Incredible Secret Money Machine* book prizes, along with an all expense paid (FOB Thatcher, AZ) *tinaja* quest for two for the very best entry of all.

New tech lit

Siliconix has some free samples available on their new ultra-fast DMOS transistors and analog gates. Those dudes switch in less than a nanosecond and can have their on-resistance value as small as 19 ohms. Obvious uses are in video switching and for various special-effect generators.

Crystal Semiconductor has an amazing new 16-bit A/D converter available with pricing in the $20 range. The part number is CS-5501. It is very easy to interface with most any personal computer.

The *Silicon Systems* people have a pair of new data books out, one on *Microperipheral Products*, and a second on *Telecommunications*. Products described include modems, call-progress detectors, disk-drive chips, and precision motor controllers.

For information on alternates to traditional power generation that include cogeneration, solar energy, management, conservation, and superconductivity, you might want to check into the *Association of Energy Engineers*.

Turning to my own products, for lots more information on computer-circuit modeling, you might like to try out my *Micro Cookbooks*, volumes I and II. And, yes, we finally have complete sets of edited and up-graded *Hardware Hacker* reprints available, as well as plenty of other great stuff on the *PostScript* language.

Let's hear from you. **R-E**

"Help! The laser printer is malfunctioning again!"

1988 ANNUAL INDEX

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and

ComputerDigest Volume 5

Abbreviations: (AR)Antique Radio; (ARE) Ask Radio-Electronics' (AUD)Audio Update; (C)Construction; (CC)Communications Corner; (D)Department; (DB)Drawing Board; (DN)Designers Notebook; (ED)Editorial; (ER)Equipment Reports; (HH)Hardware Hacker; (LTR)Letter; (NI)New Ideas; (PCS)PC Service; (SC)Service Clinic; (SR)Shorwave Radio; (SOSS)State of Solid State

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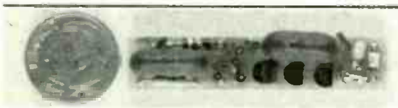

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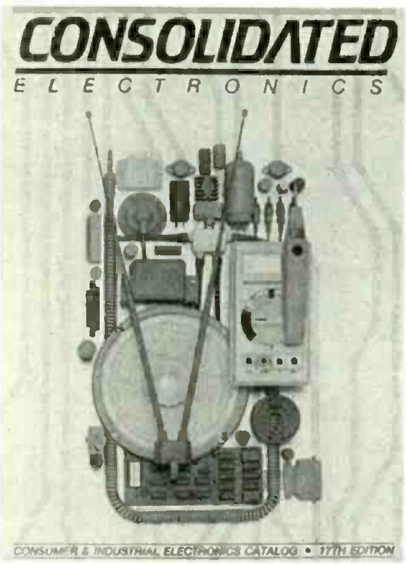

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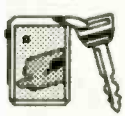

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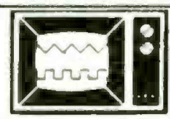

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EQUIPMENT REPORTS

continued from page 24

does represent a major step forward in CD-ROM technology. For the first time you can have a CD in your PC that behaves like and offers the same conveniences of a hard disk. The software drivers are considerably easier to use than in competitive units like the Sony CDU-100, and software installation is a snap. That along with audio-CD capability and Amdek's commitment to CD-software distribution make the Laserdek 1000 one attractive deal. **R-E**

INTERACTIVE TV

continued from page 47

to—most of the operation is automatic, and the entire upload takes about five seconds. Once your game console uploads your name, password and score (which are stored in the console's memory), a signal from the control computer instructs the microprocessor to also upload the counter contents.

The central computer

The return link of the interactive system ends at the central computer. Its block diagram is shown in Fig. 3. As we mentioned earlier, the central computer controls the SCA subcarrier transmitter. It receives the questions, the correct answers, and a difficultly multiplier for each question from the interactive game judge. It transmits all the information, via an FM SCA subcarrier to the game console, which keeps its own score.

The SCA transmitter also sends out random counter-start signals, which are sent to the game consoles to start one of the ten counters. An equivalent set of counters in the central computer also receive the start signals.

When the player calls to upload his results, his score is transmitted first, followed by his ID and password, which are checked and, we hope, approved. Then the contents of the consoles's ten counters are uploaded, and are compared with the counters of the central computer. If everything matches, the score is recorded. After the upload time period is over, (say 1/2 hour after the end of the game) the winners will be notified, via the FM subcarrier.

Security

The interactive TV system can be used for a lot more than playing games. Using the game console for placing orders to a home-shopping channel or to order pay-per-view programming are only a couple of the many potential uses. State-lottery registration might be in the works, also. If IGN's system is going to be used for something as potentially lucrative as winning the state lottery, it had better be secure. There are sure to be more than just high-school kids trying to get through the security measures. All data that is uploaded and downloaded by the game console is encrypted using DES (the *D*ata *E*ncryption *S*tandard). To make it even more of a challenge to would-be hackers, the required software can be changed every day, so that a potential hacker has, at most, 24 hours to crack the security code!

Each console has its own software-encryption key, and thus its own way of sending encrypted data. Since all game players must be subscribers with registered ID's and passwords, it will quickly be obvious who is trying to play around.

Speaking of playing around, the next time you find yourself watching a game show, remember: Now's the time to start getting in shape to win the game of the 1990's. **R-E**

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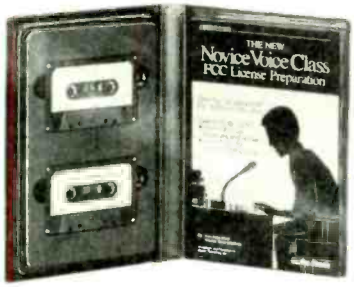

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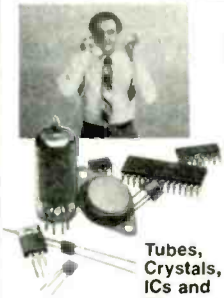

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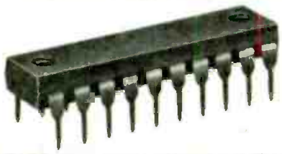

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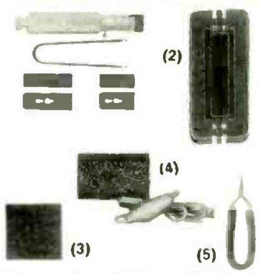

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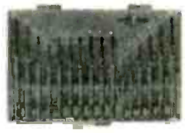

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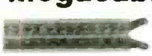

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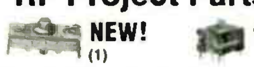

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6803	3.95
6809	2.95
68B09	5.99
6809E	2.95
68B09E	5.49
6810	1.95
6820	2.95
6821	1.25
68B21	1.85
6840	3.95
6845	2.75
68B45	4.95
6847	4.75
6850	1.95
68B50	1.75
6883	22.95
68000	9.95

8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8228	2.25
8237	3.95
8237-5	4.75
8238	4.49
8243	1.95
8250	6.95
8251	1.29
8251A	1.69
8253	1.59

Z-80

Z80-CPU	1.25
Z80A-CPU	1.29
Z80B-CPU	2.75
Z80A-CTC	1.69
Z80B-CTC	4.25
Z80A-DART	5.95
Z80B-DART	6.95
Z80A-DMA	5.95
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Z80B-PIO	4.25
Z80A-SIO/0	5.95
Z80B-SIO/0	12.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
Z80B-SIO/2	12.95
Z8671BASIC	9.95

V-20 SERIES

SPEED UP YOUR PC BY 10 TO 40%!

- HIGH SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8088 INSTRUCTION SET
- LOW POWER CMOS

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

VOLTAGE REGULATORS

7805T	.49	7812K	1.39
7808T	.49	7905K	1.69
7812T	.49	7912K	1.49
7815T	.49	78L05	.49
7905T	.59	78L12	.49
7908T	.59	79L05	.69
7912T	.59	79L12	1.49
7915T	.59	LM323K	3.49
7805K	1.59	LM338K	4.49

PALS

16L8	2.95
16R8	2.95
16R6	2.95
16R4	2.95

UARTS

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

MISCELLANEOUS

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

INTERSIL

ICL7107	10.95
ICL7660	1.99
ICL8038	3.85
ICM7207A	5.95
ICM7208	15.95

74LS00 TTL LOGIC

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

LINEAR COMPONENTS

TL071	.69	LM380	.89	XR2206	3.95
TL072	1.09	LM383	1.95	XR2211	2.95
TL074	1.95	LM386	.89	LM2917	1.95
TL081	.59	LM393	.45	CA3046	.89
TL082	.99	LM394H	5.95	CA3146	1.29
TL084	1.49	LM399H	5.95	MC3373	1.29
LM301	.34	TL494	4.20	MC3470	1.95
LM309K	1.25	TL497	3.25	MC3480	8.95
LM310	1.75	NE555	.29	MC3487	2.95
LM311	.59	NE556	.49	LM3900	.49
LM311H	.89	NE558	.79	LM3909	.98
LM311K	3.49	NE564	1.95	LM3911	2.25
LM312H	1.75	LM565	.95	LM3914	1.89
LM317T	.69	LM566	1.49	LM3915	1.89
LM318	1.49	LM567	.79	MC4024	3.49
LM319	1.25	NE570	2.95	MC4044	3.99
LM323K	3.49	NE590	2.50	RC4136	1.25
LM324	.34	NE592	.98	RC4558	.69
LM331	3.95	LM723	.49	LM13600	1.49
LM334	1.19	LM733	.98	75107	1.49
LM335	1.79	LM741	.29	75108	1.49
LM336	1.75	LM747	.69	75110	1.95
LM338K	4.49	MC1330	1.69	75150	1.95
LM339	.59	MC1350	1.19	75154	1.95
LF347	2.19	LM1458	.35	75188	1.25
LF353	.59	LM1488	.49	75189	1.25
LF356	.99	LM1489	.49	75451	.39
LF357	.99	LM1496	.85	75452	.39
LM358	.59	ULN2003	.79	75477	1.29

HIGH SPEED CMOS LOGIC

74HC00	.21	74HC244	.85	74HCT138	.35
74HC04	.25	74HC245	.85	74HCT139	.55
74HC08	.25	74HC273	.69	74HCT157	.59
74HC14	.35	74HC367	.69	74HCT161	.79
74HC32	.35	74HC373	.69	74HCT240	.89
74HC74	.35	74HC390	.79	74HCT244	.89
74HC138	.45	74HC374	.69	74HCT245	.99
74HC139	.45	74HC4040	.89	74HCT273	.99
74HC154	1.09	74HCT00	.25	74HCT373	.99
74HC157	.55	74HCT04	.27	74HCT374	.99
74HC161	.65	74HCT08	.25	74HCT393	.99
74HC164	.65	74HCT32	.27	74HCT4040	.99
74HC175	.59	74HCT74	.45	74HCT4060	1.49

STANDARD CMOS LOGIC

4001	.19	4028	.65	4069	.19
4011	.19	4040	.69	4070	.29
4013	.35	4042	.59	4081	.22
4015	.29	4044	.69	4093	.49
4016	.29	4046	.69	14411	9.95
4017	.49	4047	.69	14433	14.95
4018	.69	4049	.29	14497	6.95
4020	.59	4050	.29	4503	.49
4021	.69	4051	.69	4511	.69
4023	.25	4052	.69	4518	.85
4024	.49	4053	.69	4528	.79
4025	.25	4060	.69	4538	.95
4027	.39	4066	.29	4702	9.95

7400 SERIES LOGIC

7400					
7400	.19	74121	.29	74F240	1.29
7402	.19	74123	.49	74S00	.29
7404	.19	74125	.45	74S02	.29
7406	.29	74150	1.35	74S04	.29
7407	.29	74151	.55	74S08	.35
7408	.24	74153	.55	74S10	.29
7410	.19	74154	1.49	74S32	.35
7411	.25	74157	.55	74S74	.49
7414	.49	74159	1.65	74S86	.35
7416	.25	74161	.69	74S112	.50
7417	.25	74164	.85	74S124	2.75
7420	.19	74166	1.00	74S138	.79
7430	.19	74175	.89	74S153	.79
7432	.29	74367	.65	74S157	.79
7438	.29			74S158	.95
7442	.49	74F/74S		74S163	1.29
7445	.69	74F00	.35	74S175	.79
7447	.89	74F02	.35	74S195	1.49
7473	.34	74F04	.35	74S240	1.49
7474	.33	74F08	.35	74S241	1.49
7475	.45	74F10	.35	74S244	1.49
7476	.35	74F32	.35	74S280	1.95
7483	.50	74F64	.55	74S287	1.69
7485	.59	74F74	.39	74S288	1.69
7586	.35	74F86	.55	74S299	2.95
7489	2.15	74F138	.79	74S373	1.69
7490	.39	74F139	.79	74S374	1.69
7493	.35	74F253	.89	74S471	4.95
		74F157	.89	74S571	2.95

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CIRCLE 113 ON FREE INFORMATION CARD

CRYSTALS

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

OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	5.95
4.0	4.95
5.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
14.31818	1.95
15.0	1.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

DISCRETE

1N751	.49	2N4403	.25
IN5402	.25	2N6045	1.75
IN4004	10/1.00	MPS-A13	.40
IN4148	25/1.00	TIP31	.49
KBP02	.55	4N26	.69
PN2222	.10	4N27	.69
2N2222	.10	4N28	.69
2N2907	.25	4N33	.89
2N3055	.79	4N37	1.19
2N3904	.10	MCT-2	.59
2N3906	.10	MCT-6	1.29
2N4401	.25	TIL-111	.99

CAPACITORS

TANTALUM

1.0µf	15V	.12
6.8	15V	.42
10	15V	.45
22	15V	.99
1.0µf	35V	.45
2.2	35V	.19
4.7	35V	.39
10	35V	.69

DISC

10pf	50V	.05
22	50V	.05
33	50V	.05
47	50V	.05
100	50V	.05
220	50V	.05
.001µf	50V	.05
.005	50V	.05
.01	50V	.07
.05	50V	.07
.1	12V	.10
.1	50V	.12

ELECTROLYTIC

RADIAL

1µf	50V	.14
4.7	50V	.11
10	50V	.11
47	35V	.13
100	16V	.15
100	50V	.23
220	35V	.20
470	25V	.30
2200	16V	.70
4700	25V	1.45

AXIAL

1µf	50V	.14
10	16V	.14
10	50V	.16
22	16V	.14
47	50V	.19
100	35V	.19
470	50V	.29
1000	16V	.29
2200	16V	.70
4700	16V	1.25

SOLDER STATION

UL APPROVED

- ADJUSTABLE HEAT SETTING
- TIP TEMPERATURE READOUT
- REPLACEMENT TIPS AVAILABLE $2.95

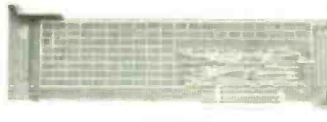
168-2C

$49.95

FULL 1 YEAR WARRANTY ON EVERY PRODUCT!

WIREWRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD PLATED EDGE-CARD FINGERS AND SILK SCREENED LEGENDS.



FOR PS/2		
JDR-PR32	32 BIT PROTOTYPE CARD	69.95
JDR-PR16	16 BIT WITH I/O DECODING LAYOUT	49.95
JDR-PR16PK	PARTS KIT FOR JDR-PR16 ABOVE	15.95
JDR-PR16V	16 BIT FOR VIDEO APPLICATIONS	39.95
FOR AT		
JDR-PR10	16BIT WITH I/O DECODING LAYOUT	34.95
JDR-PR10PK	PARTS KIT FOR JDR-PR10 ABOVE	12.95
FOR XT		
IBM-PR1	WITH +5V AND GROUND PLANE	27.95
IBM-PR2	AS ABOVE WITH I/O DECODING LAYOUT	29.95

POWER SUPPLIES

APPLE TYPE SUPPLY
- APPLE CONNECTOR
- +5V @ 6A, +12V @ 3A, -5V @ 1A, -12V @ 1A

PS-A $49.95

75 WATT SUPPLY
- UL APPROVED
- +5V @ 7A, +12V @ 3A, -5V @ 300MA, -12V @ 250MA

PS-1558 $34.95

FLOPPY DRIVE SUPPLY
- +5V @ 2.5A, +12V @ 2A, -12V @ .1A
- +5V @ 5A, IF +12 NOT USED

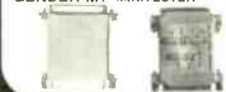
PS-ASTEC $24.95

MICRO SUPPLY
- UL APPROVED, 144 WATTS
- +5V @ 18A, +12V @ 4A, -12V @ 500MA

PS-1554 $29.95

GENDER CHANGERS

GENDER-FF	FEMALE-FEMALE	7.95
GENDER-MM	MALE-MALE	7.95
GENDER-MF	MALE-FEMALE	7.95
GENDER-NM	NULL MODEM	8.95
GENDER-JB	JUMPER BOX	8.95
GENDER-MT	MINITESTER	14.95



BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM5016	16.95
COM8116	8.95
MM5307	4.95

BYPASS CAPACITORS

.01xx	CERAMIC DISC	100/5.00
.01xx	MONOLITHIC	100/10.00
.1xx	CERAMIC DISC	100/6.50
.1xx	MONOLITHIC	100/12.50

CLOCK CIRCUITS

MC146818	5.95	MM58174	9.95
MM58167	9.95	MSM5832	2.95

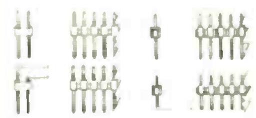
DISK CONTROLLERS

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

"SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE LEAD	.49
2x40	2 STRAIGHT LEADS	2.49
2x40	2 RIGHT ANGLE LEADS	2.99

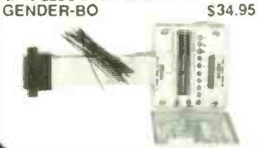


RS-232 BREAKOUT BOX

FOR TROUBLESHOOTING SERIAL COMMUNICATIONS

- OPEN/CLOSE INDIVIDUAL CIRCUITS
- 20 JUMPERS CROSS-CONNECT ANY TWO CIRCUITS
- 10 LEDS SHOW CIRCUIT ACTIVITY

GENDER-BO $34.95



IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	–	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45
10' PLASTIC RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	–	.79	2.27	–
	FEMALE	DBxxSR	.55	.75	–	.85	2.49	–
WIREWRAP	MALE	DBxxPWW	1.69	2.56	–	3.89	5.60	–
	FEMALE	DBxxSWW	2.76	4.27	–	6.84	9.95	–
IDC RIBBON CABLE	MALE	IDBxxP	1.30	1.99	–	2.25	4.25	–
	FEMALE	IDBxxS	1.45	2.05	–	2.35	4.49	–
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	–	–
	PLASTIC	HOODxx	.39	.39	–	.39	.69	.75

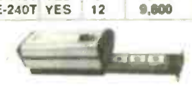
ORDERING INSTRUCTIONS:
INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE 59¢

EPROM ERASERS

SPECTRONICS CORPORATION

Model	Timer	# of Chips	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$ 89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189



DATARASE *$34.95*

- ERASES 2 EPROMS IN 10 MINUTES
- VERY COMPACT, NO DRAWER
- METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

JOYSTICK

- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- COMPATIBLE WITH IBM, APPLE II, IIE, IIC, ATARI & VIC 20/64

GC-10

$19.95

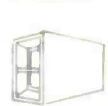
IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	.11	.11	.12	.15	.18	.15	.20	.22	.30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	–	4.95	4.95	–	5.95	–	5.95	6.95	9.95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	–	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

SHORTING BLOCKS

5/$1.00



LITHIUM BATTERIES

- 6.8V FOR 286/386 COMPUTERS
- MOTHERBOARD CONNECTOR
- ADHESIVE VELCRO STRIP FOR EASY MOUNTING

LITHIUM 6.8V $11.95

LITHIUM-3V	3V COIN TYPE LITHIUM BATTERY	$1.95
3V-MHW	BATTERY HOLDER	$1.49

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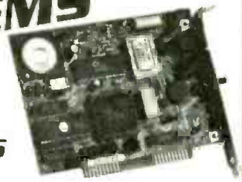

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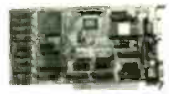

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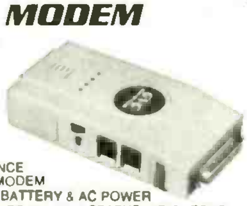

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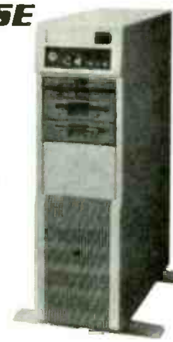

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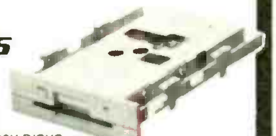

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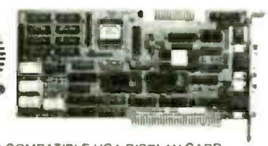

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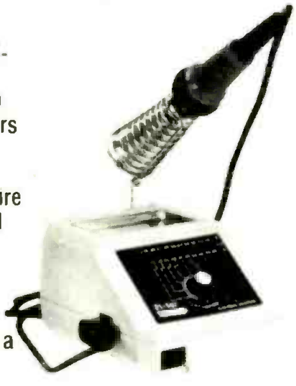

■ Adjustable temperature range of 150°-420°C (300°-790°F) ■ Grounded tip for soldering static sensitive devices ■ LED power, heater and temperature indicators ■ Overheat protection with closed loop temperature control ■ Heat resistant soldering iron cord ■ Grounded three wire power cord ■ Auxiliary ground terminal ■ Built-in tray with cleaning sponge ■ Easily accessible fuse holder ■ Replaceable iron clad tip ■ Improved circuit design for greater temperature stability ■ Adjustable temperature, and a variety of available tips make this unit perfect for most soldering applications including SMD

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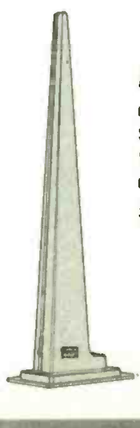

Amplified Indoor FM Antenna

■ Helps your FM receiver deliver clean undistorted sound ■ Adjustable gain ■ Improves reception without installing unsightly outdoor antenna ■ Black color blends well with any decor

#80-335

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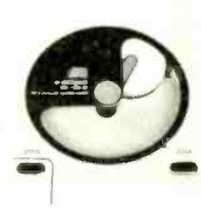
Automatic CD Cleaner



■ Motorized chamois cleaning system provides true radial cleaning ■ Cleaner automatically stops when finished ■ Can be used wet or dry ■ 1 oz. bottle of cleaning fluid included ■ Operates on four "AA" batteries (not included)

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CD 700 Headphones

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#35-320

audio-technica SG750CD Headphones

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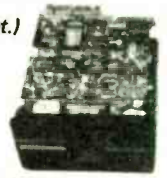
10Mb *(ST412 Compat.)*
Major manufacturers — *Get them while they last!*
Item #17199 **$99.00** ea.

5¼" HALF-HT. 10Mb HARD DISK DRIVES

10Mb *(IBM® Compatible)*
Mfr – NEC #D5124
Item #19704 *New* – **$99.00**

20Mb *(ST225 Compatible)*
Mfr – Olivetti #EM5520/2
Tested—Like New!
Item #20060 *New* – **$159.00**

5¼" FULL-HEIGHT DISK DRIVE *(IBM® Compat.)*



48 TPI, 40 Track, Double Side/Double Density
Tandon #TM100-2 or equiv.
Item #7928 **$79.00** New
2 for **$150.00** New

5¼" 1.2Mb. HALF-HEIGHT FLOPPY DISK DRIVE

IBM® AT Compatible.
48/96 TPI, 1.2 Mb.
Double sided, high density; 160 tracks. Mfr — Panasonic #JU-475
Item #10005 *New* – **$99.95**

COMMODORE COMPUTERS...

PLUS 4 — *(Cust. Returns — Tested Good!)*
Built-in software incl.: a word processor, spread sheet, graphics, & a filing system. Comes complete w/power supply & instruction manual.
Item #19202 **$49.95**

VIC 20 — *(Cust. Returns — As Is!)*
No guarantee. (Power supply not incl.)
Item #18770 **$29.95**

3½" MICROFLOPPY DISK DRIVE

1 Mb (unformatted), 135 TPI, 3 ms. access time. Power requirements: +12, +5 volts. Removed from operational computers — *TESTED — LIKE NEW!*
Mfr — NEC, model FD1036
Item #17171 **$79.00** ea.
2 for **$150.00**

2-WAY, HIGH-TECH, WALL MOUNT SPEAKER SYSTEM (3¼" Thin)

80W. max., 4/8 Ohm, 150–20,000 Hz.

Cabinet.: heavy-duty aluminum, black w/mesh grille cover.
Dim.: 9"H x 13½"W x 3¼" deep
Mfr #SB-5000
Item #19634 **$119.00** /pair

EXTERNAL DISK DRIVE CHASSIS

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

COMMODORE 8050 Dual Disk Drive Unit...

The 8050 uses 2 full-height, 100 TPI single-sided disk drives, ea. w/storage cap. of 533,248 bytes. Ea. 8050 diskette has 77 tracks & is read/write compatible w/the 8250 disk drive. Complete w/built-in power supply. Power req.: 115VAC/60Hz. (manuals incl.)
Dim.: 13¾"W x 13¾"D x 6"H.
Item #19313 *New* – **$89.95**

115 CFM MUFFIN® FANS

115VAC, 60Hz., 21W., 28A.,
3100 RPM, 5-blade model, aluminum housing. Can be mounted for blowing or exhaust.
Dimen: 4¹¹⁄₁₆" sq. x 1½" deep

NEW — Mfr: IMC
Item #1864 **$9.95**

USED — Mfr: Centaur/Howard
Item #5345 **$5.95**

Call or write with any other requirements...

TTL MONITORS...

HI-RES... *(Open Frame)*

12"–Monitor Kit
Green phosphor. Input: 115VAC. Made up of sub assemblies: CRT, board, & transformer. (Hook-up diagram incl.)
Item #6811 *New* – **$19.95**

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

12/24VDC MUFFIN®-TYPE FANS

55/100CFM

8W. Can be mtd. for blowing or exhaust. Alum. housing. Brushless, ball-bearing type.

1" THIN: 5 plastic blades with feathered edges.
Centaur #CUDC24K4-601
Item #8541 *New* – **$19.95**

1" STANDARD: 5 plastic blades.
Centaur #CNDC24K4-601
Item #12848 **$14.95** RFE

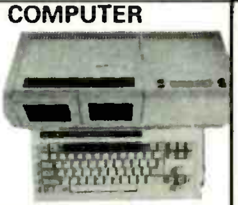
Free Catalog with every order!

COMPUTER/GAME ADAPTERS...

COMMODORE 64
DC Output: 5VDC @ 7.5W *and* 9VAC @ 6.7VA
Input: 117VAC, 50/60Hz.
Commodore #310157-02 (black)
Item #19315 *New* – **$24.95**

COLECOVISION
DC Output: +5VDC @ 9A, -5VDC @ .1A, +12VDC @ .3A
Input: 120VAC/60Hz., .25A
Coleco #55416 (black)
Item #1882 *New* – **$9.95**

ADAM COMPUTER



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

ACCESSORIES...

DATA DRIVE — Item #6641...**$19.95**
PRINTER POWER SUPPLY — Item #6642...**$14.95**
ASCII KEYBOARD — Item #6643...**$19.95**
CONTROLLERS (Set of 4) Item #7013...**$9.95** RFE
ADAM CASSETTES — Incl. Smart Basic, Buck Rogers & blank cassette. Item #7786 *Baker's Dozen* — **$19.95**
DISK DRIVE POWER SUPPLY Item #14603...**$14.95**
ADAM DAISY PRINT WHEEL Item #13305...**$3.95**
COLECOVISION to *ADAM* EXPANSION KIT
Just plugs into your *ColecoVision*. W/printer power supply & data drive (both incl.) you will have a working *Adam* computer. *Adam* keyboard, 1 Smart Basic cassette & hook-up diagram also incl.
Item #9918 **$59.50**

HEAD & SCREEN MAINTENANCE KIT

(5¼" Diskettes)

Maintain your disk heads & CRT screens. Use regularly to help prevent memory loss & downtime. Protecting users from eye strain. One bottle of head-cleaning fluid, 2 head-cleaning diskettes, & 10 wet/10 dry screen cleaning pads.
Mfr – Dialight #611-0001
Item #19228 *New* – **$7.95**

COLECOVISION Accessories...

EXPANSION MODULE #2
Play arcade quality driving & racing games on your *ColecoVision*. Incl. *Turbo* cartridge.
Item #13146 *New* – **$39.95**

ROLLER CONTROLLER
Gives full 360° game control. Hi-speed action of an arcade. Can be used w/the *Adam*. Incl. *Slither* cartridge.
Item #13147 *New* – **$39.95**

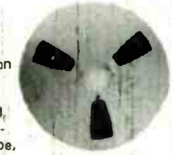
SUPER ACTION CONTROLLER SET
Gives you indiv. control of 4+ on-screen players. Includes *Baseball* cartridge.
Item #13148 *New* – **$39.95**

RECORDING TAPE

7½" Reel, 2400 ft.

1/4 Mil. Bulk erased. Major mfrs.: Ampex, Scotch, etc. Item #6711.
15 reels for **$9.95**

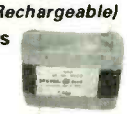
HIGH-RESOLUTION INSTRUMENTATION TAPE



1/2" tape on 14" reels; 9200'/reel. Wide band, highly conductive tape, w/magnetic oxide surface (makes it ultrasmooth for chart-wave recording). Orig. used in gov't & other critical instrument applications. Standard hub size.
Mfr – Scotch/Ampex #890/892
Item #17656 **$8.95** ea.
2 for **$16.00**

NICAD BATTERY PACKS *(Rechargeable)*

"AA" Cells



12V @ 450ma
Contains 10 "AA" cells, connected in series. Recharge rate: 45 ma., 16–18 hrs. Case w/tab output connex.
Dim.: 2¹⁄₁₆" x 2¼" x 2¹⁵⁄₁₆"
Mfr – GE #123233
Item #5443 **$5.95** RFE

"Sub C" Cells

12V @ 1.2Ah.
Consists of 10 "Sub C" cells. Connected in series. Case w/tab output connex. Recharge rate: 100 ma. for 14–16 hrs.
Dim.: 4½" x 1¾" x 1⅞"
Mfr – GE or equiv.
Item #19677 **$9.95** RFE

"C" Cells

7.2V @ 1.25Ah.
Consists of 6 "C" cells. Connected in series. Recharge rate: 80–100 ma. for 16 hrs. Dim.: 6" x 1⅞" x 1". Major Mfrs.
Item #19676 **$9.95**

MECHANICAL KEYBOARDS...

48-KEY – Timex Z81/1000
Item #6712 *New* – **$5.95**

75-KEY – Timex or Adam
For computer upgrade—
Item #7429 *New* – **$5.95**

66-KEY – Commodore C-16
Item #9394 *New* – **$5.95**

NEON TRANSFORMER

(Hi-Voltage)

7300 VAC @ 5 Ma.
May be used for powering neon lights, replacing oil burner ignition transformer, building Jacob's ladder (spark gap). Hi-voltage output: ¼ quick connect terminal & case ground input fully enclosed metal case. Wt. 12 lbs. Base mount: 4½"H x 5¼"W x 6⅞".
Item #151 *New* – **$14.95**

CIRCLE 106 ON FREE INFORMATION CARD

"The First Source"— for electromechanical & electronic equipment and components — AMERICAN DESIGN COMPONENTS!

12" EGA COLOR MONITOR
25 KHz — High Resolution

Perfect for text, CAD, & other graphics. 8-color display. Scanning frequency to 25KHz. Res.: 752 x 410. Input: 110/220V, 50/60Hz., 75W. Mounted in metal chassis. Works ideally w/the EGA "Wonder Card" *(sold below)*. Diagram incl. Hitachi #CD1215-DTL

Item #18059 **$129.00**

★ ***Also available in 14"*** (Same specs as above.) Hitachi #CD1415-DTL

Item #18599 **$149.00**

SWITCHING POWER SUPPLY

DC Output: +5V @ 18A
-5V @ 2.5A
+12V @ 2.5A
Input: 115/230VAC, 50/60Hz.
Dim: 13"L x 4$^1/_2$"W x 1$^1/_2$"H
Mfr — Sola #39–139

Item #17210 *New* – **$29.95**

PC/XT/AT Compatible ENHANCED LAYOUT 101-KEY KEYBOARD

★ Membrane
★ 12 Function Keys
★ Separate Numerical Cursor
★ LED indicators for Scroll, Caps & Number locks
★ 1" inclination Foot Stand
Mfr. #29079

Item #19680 *New* – **$49.95**

EGA WONDER CARD
(EGA/CGA/HGC & MDA Compatible)

Offers wide flexibility: displays all major software standards on any of the major monitor types. Incl.: connectors for EGA & RGB color monitors, TTL & composite monochrome monitors. RF modulator, PC portable, video in/out light pen & IBM feature connector. User-friendly manual; 132 column support for Lotus 1-2-3.

Item #19693 *New* – **$229.00**

ADJUSTABLE POWER SUPPLY
0 – 16VDC

Input: 120VAC/60HZ., .6A. Output: variable, 0-16V, 16VDC max. @ 4.0A. UL approved; thermally protected. Has 'on/off' indicator light & front panel mtd. polarized jack. Perfect for use w/variable speed motors, fans, toys, etc. Dim.: 6$^5/_8$"W x 3$^3/_8$"H x 3$^1/_2$"deep Mfr – Black & Decker #9821

Item #19585 *New* – **$19.95**

VOICE-ACTIVATED SWITCH

"Activate 'on' or 'off' with the sound of your voice, a whistle or clap..."

Ideal for robotics, lights, etc. Turns on w/the first sound & off w/the second. Solid-state units w/adjust. sens. control & pick-up microphone attached to PC board. Dim.: 2$^3/_4$" x 3$^1/_{16}$" x $^7/_8$". VOX input: 6–9VDC; can be used w/any standard battery. Item #16440.

3 switches / **$9.95**

ANTI-GLARE SCREENS...
Glare & reflection filters that improve speed, accuracy, & operator comfort...

IBM PC Monochrome	Item #19215
IBM PC Color	Item #19216
AT&T Monochrome	Item #19223
APPLE Macintosh	Item #19225
COMPAQ Portable	Item #19226

New – **$8.95** ea.; 2 for **$15.00**

SMART WATCH DS1216

DS1216 is a 28-pin, 6"-wide dip socket w/built-in CMOS watch function. Non-volatile RAM controller & lithium energy source. Accepts either 24-pin 2K x 8 or 28-pin 8K x 8 CMOS static RAM. Communication w/Smart Watch function is established by pattern recognition on a serial bit stream of 64 bits on D.O. Mfr — Dallas Semiconductor

Item #15939 *New* – **$29.95**

MAGNIFYING LAMP

Multi-position, 30", completely adjustable swing arm with 3-way metal C-clamp. Has 4" diopter magnifying lens, w/ruler. Porcelain lamp socket & on/off switch; uses up to a 60W bulb. Color: beige. UL listed.

Item #13136 *New* – **$29.95**

INTEGRATED CIRCUITS...

— STATIC RAMS —

TMM2016-100	2,048 x 8	$4.00	6116-3	2,048 x 8	$4.00
2101-45	256 x 4	1.75	6116-4	2,048 x 8	3.50
2102L-2	256 x 4	.99	6116LP-2	2,048 x 8	4.50
2114-150	1,024 x 4	1.25	6116LP-4	2,048 x 8	4.00
2114-200	1,024 x 4	.95	6264LP-12	8,192 x 8	10.50
2114L-2	1,024 x 4	1.00	6264LP-15	8,192 x 8	10.25
2148-55	1,024 x 4	3.49	6264LP-20	8,192 x 8	9.75
2149	1,024 x 4	2.49	62256LP-12	32,768 x 8	20.95
2167S-55	16,384 x 1	2.00	62256LP-15	32,768 x 8	19.95
MK4027N-4	4,096 x 1	2.00	6514	1,024 x 4	3.50
5101	256 x 4	4.95			

— DYNAMIC RAMS —

4116-150	16,384 x 1	$ 1.55	4164-250	65,536 x 1	$ 1.25
4116-200	16,384 x 1	.69	4416-120	16,384 x 4	10.00
4116-250	16,384 x 1	.49	4416-150	16,384 x 4	9.00
41256	262,144 x 1	15.00	4464-15	65,536 x 4	18.95
41464	64,536 x 4	18.95	511000P-10	1,048,576 x 1	39.95
4164-15	65,536 x 1	1.95	514256	262,144 x 4	69.95
4165-200	65,536 x 1	1.50	6665	65,536 x 1	1.50

— EPROMS —

TMS2516	2,048 x 8	$3.75	2764-45	8,192 x 8	$ 2.95
TMS2532	4,096 x 8	5.95	27C64	8,192 x 8	6.49
TMS2564	8,192 x 8	4.25	27128-25	16,384 x 8	5.95
2708	1,024 x 8	4.50	27C128-25	16,384 x 8	6.95
27L08	1,024 x 8	7.50	27128-30	16,384 x 8	5.45
2716	2,048 x 8	3.75	27256-25	32,768 x 8	5.95
27C16	2,048 x 8	5.49	27C256-25	32,768 x 8	7.95
2732	4,096 x 8	3.95	27512-25	65,536 x 8	11.75
27C32	4,096 x 8	5.95	27C512	65,536 x 8	14.95
2732-35	4,096 x 8	4.45	68764	8,192 x 8	15.95
2764-20	8,192 x 8	4.25	68776	8,192 x 8	15.95
2764-25	8,192 x 8	3.75			

— VOLTAGE REGULATORS —

7805T	$ .49	7905T	$ .49	7920T	$ .49
7806T	.49	7906T	.49	7805K	1.59
7808T	.49	7908T	.49	7812K	1.59
7812T	.49	7912T	.49	7905K	1.59
7815T	.49	7915T	.49	7912K	1.59
7818T	.49	7918T	.49	LM323K	4.50
7820T	.49			LM338K	3.95

— INTEGRATED CIRCUITS — SEMICONDUCTORS — CAPACITORS — CONNECTORS — — DISK DRIVES — MONITORS — POWER SUPPLIES — OPTO ELECTRONICS —

DYNAMIC MEMORY BOARD

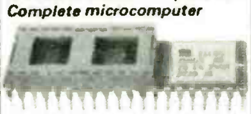
★ 0-256Kb memory in 64Kb increments
★ Software included
★ Fully socketed for easy upgrade (IBM parity checking)
★ Memdisk: simulates high-speed disk in RAM memory
★ Allows you to print while still using the computer

Techmar #MU203010 (w/o RAM)

Item #19977 *New* – **$29.95**

★ 64Kb RAM in sets of 9
Item #19983 *9 chips for* **$17.50**

PROTOTYPING DEVICE w/EPROM INTERFACE — (Z8603)
Complete microcomputer



2Kb ROM; 128 bytes RAM; 32 I/O lines; up to 62Kb addressable extern. space ea.; 144 byte reg. file; 124 G.P. reg.; 4 I/C port reg.; 16 status & contr. reg; Full duplex UART; 2 program. 8-bit counter/timers On-chip oscill. accepts crystal or external clock drive; 1.5V power supply. TTL compat.

Item #18515 **$24.95**

STEPPING MOTORS for ROBOTICS...
Precision steppers with increments from 1 to 7.5∞ Speeds up to 5,000 steps.

Fig. 1 Fig. 2

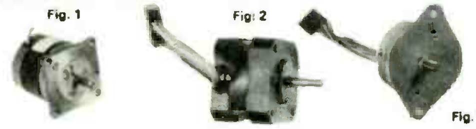


Fig. 3

Item No.	Step Angle	DC Voltage	Torque oz/in.	Type	Mfr. & Part No.	Dimensions	Fig.	Price
5275	1.8∞	1.8	72	PM 2Ø	Superior MO61-FF-6201B	2"L x 2$^1/_4$"dia. x 2$^1/_4$"H	1	$19.95 ea. 2 for $37.50
7630	1.8∞	3.0	200	PM	Superior MO92-FT-402	2"L x 2$^1/_4$"dia. x 2$^1/_4$"H	1	$34.50 ea. 2 for $59.50
16410	1.8∞	12.0	700*	PM	Applied Motion 4017-839	1$^1/_2$"sq. x 1$^1/_4$"D	2	$9.95 ea. 2 for $14.95
16406	3.6∞	12.0	700*	PM	Applied Motion 4017-838	1$^1/_2$"sq. x 1$^1/_4$"D	2	$9.95 ea. 2 for $14.95
7014	7.5∞	12.0	900*	PM	Mitsubishi 55SI-25DAYA	2$^1/_8$"sq. x 1"D	3	$10.95 ea. 2 for $19.95

*Grams per Cm.

THERMAL PRINTER
Dot Matrix—120 CPS

Print speed: 120 CPS; paper width: 8$^1/_2$". 80/132 columns/line. With RS-232 IBM serial interface. Operates on 115/230V, 50/60Hz. Hewlett Packard #HP2671A

Item #19705 **$79.00**
(Removed from working systems!)

AMERICAN DESIGN COMPONENTS, 815 FAIRVIEW AVE., P.O. BOX 220, FAIRVIEW, N.J. 07022

MINIMUM ORDER $15.
RE–1288

YES! Please send me the following items—

Item No.	How Many?	Description	Price	Total

Total ____
Shipping & handling: we ship UPS unless otherwise specified. Add $3 plus 10% of total. Canadian: $3 plus P.O. cost. Charge only. ____
Sales Tax (N.J. residents only, please add 6% of total) ____
ORDER TOTAL ____

FREE! Fall '88 Catalog with every order!

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☐ Visa ☐ Master Card ☐ Amex

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Exp. Date ____
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CIRCLE 106 ON FREE INFORMATION CARD

Active gives you more... ☑SELECTION ☑QUALITY ☑SERVICE ☑VALUE

1660 POINT QUALITY PROJECT BOARD

15.50

- Ideal for full circuit designs
- 2 terminal strips with 1260 tie-points
- 4 distribution strips with 400 tie-points
- 3 binding posts for power connections

ACT NO: 69311

QUALITY 2 TO 1 DB25 SERIAL SWITCH BOX

30.40

- Permits low-cost sharing of peripherals
- Quality rotary switch construction
- Gold plated connector contacts
- No external power required

ACT NO: 69393

QUALITY OSCILLOSCOPE PROBE KIT

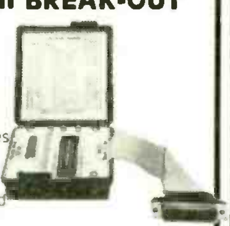
34.99

- Switchable X1, x10 attenuation ranges
- Input impedance (X1) 1Megohm (X10) 10Megohms
- Bandwidth (X1) 10MHz, (X10) 100MHz
- Maximum input voltage 600V
- Compensation range 10-60pf

ACT NO: 70138

QUALITY MINI BREAK-OUT BOX

42.20



- Allows complete testing of RS232 lines
- 24 DIP switches for reconfigurations
- 20 jumpers included
- 12 interface powered LED's for status monitoring

ACT No: 70196

QUALITY ANTI-STATIC FIELD SERVICE KIT

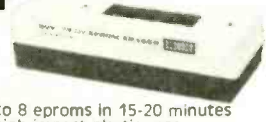
47.50

- For in-the-field static protected conditions
- Tear-resistant, dissipative fabric
- Wrist strap and grounding cords included
- A must for all professional service personnel

ACT NO: 69269

QUALITY EPROM ERASER

64.00



- Erases up to 8 eproms in 15-20 minutes
- Two-part, high impact plastic case
- Recommended for hobbyist/student use
- Erases 24, 28 or 40 pin eproms

ACT NO: 69492

QUALITY EFI SUPPRESSOR STRIP

105.25

- Handles up to 10 amp loads
- Under 1ns response to line problems
- Brownout protection (4.5uF)
- Protects against possible catastrophic failures due to line voltage problems/transients
- UL listed with circuit breaker/high impact plastic housing

ACT NO: 69326

QUALITY, SUPER RUGGED TOOL CASE

120.70

- Size 17 3/4 x 14 1/2 x 9"
- Numerous pockets for secure tool storage
- Quality high density polyethylene construction
- Anodized aluminum valence and draw bolt latches

ACT NO: 86130

Tools not included

Semiconductors and integrated circuits... in stock for immediate delivery.

PART #	ACT #	PRICE
LINEAR		
AM26LS31PC	54012	1.58
AM26LS32PC	54096	1.97
TL062CP	54097	1.05
TL064CN	54041	1.81
TL071CP	54042	2/1.05
TL072CP	54043	2/1.58
TL074CN	54044	1.47
TL081CP	54142	2/1.05
TL082CP	54048	2/1.36
TL170CLP	54050	2/1.05
TL172CLP	54051	2/1.05
TL173CLP	54427	1.14
MAX232CPE	54010	4.00
TLC272CP	54437	1.05
TL274CN	54103	1.36
308TC	06132	2/1.03
311TC	06103	3/1.14
318TC	06014	1.14
319PC	06081	1.29
324PC	06025	3/1.36
339PC	06042	3/1.25
347PC	06225	1.03
348PC	06045	2/1.58
353TC	06136	2/1.58
358TC	06104	3/1.47
393TC	06105	3/1.36
TL494CN	54100	1.58
555TC	06106	3/1.03
TLC555CP	54404	3/1.64
XRL555CP	54148	1.58
556PC	06107	2/1.14
558PC	06226	1.36
567TC	06060	2/1.47
733PC	06064	2/1.64
741HC	06122	2/1.64
741TC	06076	3/1.25
747PC	06049	2/1.14
TDA1170N	54037	1.97
TDA1170S	54040	1.25
MC1330A1P	54082	1.25
MC1350P	54019	1.05
MC1408L8	54009	1.75
1458TC	06082	3/1.14
1488PC	06099	3/1.25
1489APC	06057	3/1.25
ULN2003AN	54401	2/1.97
ULN2004AN	54402	2/1.97
XR2206CP	54072	3.75
2240PC	06061	1.36
ULN2803A	54067	1.68
ULN2804A	54068	1.47
UDN2981A	54439	1.90
MC3340P	54025	1.14
MC3470AP	54029	2.36
MC3486P	54030	1.58
MC3487P	54031	1.58
SG3524BJ	54426	2.58
3900PC	06210	2/1.36
4136PC	06215	2/1.36
4151TC	06072	1.03
4558TC	06220	3/1.25
NE5532AP	54089	1.80
NE5534AP	54034	1.58
MORE IN STOCK-CALL		

PART #	ACT #	PRICE
TRANSISTORS		
2N2222A	02185	3/1.58
2N2646	02188	1.03
2N2904A	02190	3/1.36
2N2905A	02191	2/1.03
2N2907A	02193	3/1.58
2N3053	02194	2/2.08
2N3055	02196	1.58
2N3440	02106	2/2.19
2N3771	02133	2.36
2N3772	02205	2.97
2N3773	02206	3.08
2N3792	02134	2.36
2N3819	02207	2/1.03
2N3905	02211	5/1.03
2N3906	02212	5/1.03
2N4401	02214	4/1.03
2N4920	02239	1.86
2N4923	02240	1.86
2N5064	02217	3/1.25
2N5401	02224	5/1.25
BU406	26102	1.36
IRF530	26028	2.01
IRF630	26032	2.41
IRFZ20	26056	1.04
IRFZ30	26057	2.71
IRFZ40	26058	3.75
MJ802	26072	2.47
MJE172	26083	1.03
MJE800	26096	1.14
MPF102	44001	3/1.58
MPSA06	44003	4/1.05
MPSA06	44005	4/1.05
MPSA13	44070	3/1.05
MPSA42	44013	3/1.05
MPSA43	44039	3/1.05
PN2222A	44077	3/1.05
TIP29C	29002	2/1.36
TIP30C	29004	2/1.36
TIP31C	29076	2/1.36
TIP32C	29077	2/1.75
TIP35C	29016	2.08
TIP41C	29019	2/1.75
TIP42C	29080	1.36
TIP50	29083	1.25
TIP102	29039	2/1.47
TIP107	29001	2/1.47
TIP110	29040	2/2.64
TIP112	29041	1.03
TIP117	29043	1.65
TIP120	29044	1.03
TIP122	29081	1.72
TIP125	29026	2/1.58
TIP127	29082	1.47
TIP147	29046	2.36
MORE IN STOCK-CALL		
TRIACS		
TIC106D	29085	2/2.08
TIC116M	29100	1.47
TIC126D	29087	2.01
TIC206D	29088	1.75
TIC216D	29090	2.08
TIC226D	29095	2.08
MORE IN STOCK-CALL		

PART #	ACT #	PRICE
SN74LS SERIES		
SN74LS02N	05776	4/1.58
SN74LS04N	05780	4/1.58
SN74LS05N	05784	4/1.58
SN74LS08N	05786	4/1.58
SN74LS14N	05802	2/1.25
SN74LS20N	05806	4/1.58
SN74LS30N	05818	4/1.58
SN74LS32N	05820	4/1.49
SN74LS47N	05834	2/1.58
SN74LS73AN	05846	3/1.47
SN74LS74AN	05848	3/1.25
SN74LS75N	05850	3/1.25
SN74LS76AN	05852	3/1.25
SN74LS85N	05858	2/1.75
SN74LS86N	05860	3/1.25
SN74LS90N	05864	3/2.08
SN74LS93N	05868	3/1.58
SN74LS123N	05888	2/1.58
SN74LS125AN	05892	3/1.47
SN74LS138N	05902	2/1.14
SN74LS139N	05904	2/1.14
SN74LS148N	05906	1.64
SN74LS153N	05909	2/1.14
SN74LS157N	05913	3/1.64
SN74LS161AN	05916	2/1.58
SN74LS163AN	05918	2/1.58
SN74LS164N	05919	2/1.58
SN74LS192N	05931	2/1.64
SN74LS193N	05932	2/1.64
SN74LS221N	05936	2/2.08
SN74LS244N	05943	1.03
SN74LS245N	05945	1.03
SN74LS257AN	05952	2/1.14
SN74LS259N	05954	1.03
SN74LS273N	05956	1.03
SN74LS373N	05971	5/3.97
SN74LS374N	05970	1.03
SN74LS390N	05975	1.03
MORE IN STOCK-CALL		
SN7400 SERIES		
SN7400N	05500	3/1.14
SN7402N	05506	3/1.14
SN7404N	05510	3/1.14
SN7406N	05516	2/1.03
SN7407N	05518	2/1.03
SN7408N	05520	3/1.14
SN7414N	05526	2/1.03
SN7416N	05528	2/1.03
SN7417N	05530	2/1.03
SN7430N	05546	2/1.03
SN7432N	05548	3/1.14
SN7438N	05550	2/1.03
SN7442AN	05556	2/1.14
SN7445N	05562	1.03
SN7447AN	05566	1.03
SN7474N	05588	2/1.03
SN7475N	05592	2/1.03
SN7476N	05594	3/1.47
SN7490AN	05610	5/3.08
SN74121N	05640	2/1.03
SN74123N	05644	2/1.14
SN74150N	05670	1.64
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7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.39	.29
7408	.35	.25	74123	.49	.39
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.55	.45
7416	.35	.25	74143	4.95	4.85
7417	.35	.25	74150	1.35	1.25
7420	.29	.19	74154	1.35	1.25
7430	.29	.19	74158	1.49	1.39
7432	.39	.29	74173	.79	.69
7438	.39	.29	74174	.59	.49
7442	.49	.39	74175	.59	.49
7445	.79	.69	74176	.79	.69
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7475	.49	.39	74365	.59	.49
7476	.45	.35	74367	.59	.49

74LS

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74LS05	.28	.18	74LS174	.39	.29
74LS06	.59	.49	74LS175	.39	.29
74LS07	.59	.49	74LS189	3.95	3.85
74LS08	.28	.18	74LS191	.59	.49
74LS10	.26	.16	74LS193	.69	.59
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.59	.49
74LS30	.28	.18	74LS243	.69	.59
74LS32	.28	.18	74LS244	.69	.59
74LS42	.49	.39	74LS245	.79	.69
74LS47	.89	.79	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	3.49	3.39
74LS76	.39	.29	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.29	.19	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.49	.39	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	5.95	5.85
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74S86	.29	74S288*	1.49
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74F

74F00	.25	74F139	.59
74F04	.25	74F157	.59
74F08	.25	74F193	2.95
74F10	.25	74F240	.69
74F32	.25	74F244	.69
74F74	.29	74F253	.59
74F86	.39	74F373	.79
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*6264LP-15	8192 x 8	(150ns) LP CMOS	10.25
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27C16	2048 x 8	(450ns) 25V (CMOS)	4.25
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	4.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.59
2764A-25	8192 x 8	(250ns) 12.5V	3.69
2764-45	8192 x 8	(450ns) 21V	3.39
27C64-15	8192 x 8	(150ns) 12.5V (CMOS)	5.95
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27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.49
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	6.25
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27512-25	65,536 x 8	(250ns) 12.5V	9.95
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*No specs. available
**Note: 82S100PLA = U17 (C-64)

74C/CMOS

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MISC. COMPONENTS

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TM1/35 .1μf @ 35V	.19	TM4.7/35 4.7μf @ 35V	.45
TM1/35 1μf @ 35V	.19	TM6.8/35 6.8μf @ 35V	.49
TM2.2/35 2.2μf @ 35V	.25	TM10/35 10μf @ 35V	.59

POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX ¾ Watt, 15 Turn	.99	63PXX ½ Watt, 1 Turn	.89

TRANSISTORS AND DIODES

PN2222	.13	PN2907	.13	1N4004	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C10681	.49

SWITCHES

JMT123 SPDT, On-On	1.19	206-8 SPDT, 16-pin DIP	1.25
MPC121 SPDT, On-Off-On	1.19	MS102 SPST, Momentary	.39

D-SUB CONNECTORS

DB25P Male, 25-pin	.69	DB25S Female, 25-pin	.75

LEDS

XC556R T1¾, Red	.13	XC556Y T1¾, Yellow	.17
XC556G T1¾, Green	.17	XC556C T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
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74HC04	.19	74HC240	.69
74HC08	.19	74HC244	.79
74HC10	.25	74HC245	.79
74HC14	.29	74HC253	.49
74HC30	.25	74HC259	.49
74HC32	.29	74HC273	.59
74HC74	.29	74HC373	.69
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74HC86	.35	74HC943	8.95
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74HC125	.49	74HC4049	.39
74HC132	.49	74HC4050	.39
74HC138	.45	74HC4060	.99
74HC139	.45	74HC4511	1.19
74HC154	1.49	74HC4514	1.79
74HC163	.49	74HC4538	1.19
74HC174	.59	74HC4543	1.19

74HCT — CMOS TTL

74HCT00	.17	74HCT139	.39
74HCT02	.17	74HCT157	.29
74HCT04	.19	74HCT174	.35
74HCT08	.17	74HCT175	.39
74HCT10	.17	74HCT240	.69
74HCT32	.19	74HCT244	.59
74HCT74	.29	74HCT245	.69
74HCT86	.25	74HCT373	.49
74HCT138	.39	74HCT374	.49

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LF351N	.39	26LS33	1.49
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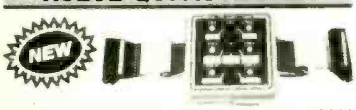

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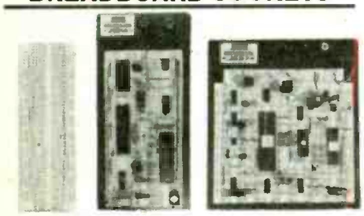

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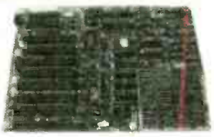

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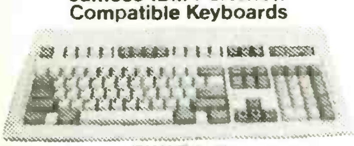

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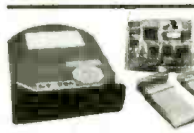

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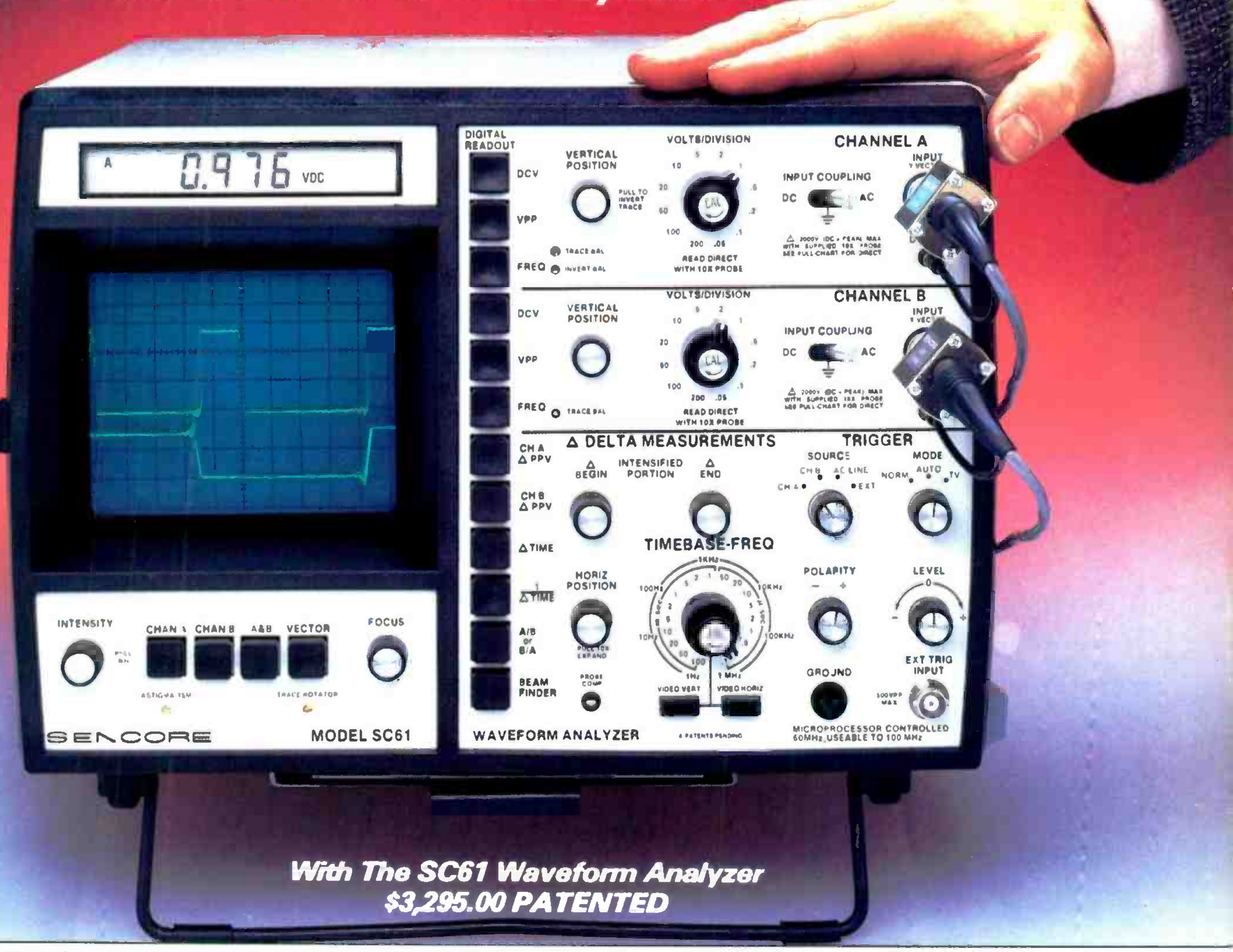

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