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August 1993 Electronics NOW®

Vol. 64 No. 8

ON THE COVER

With today's sophisticated video systems, just having a television set in every room doesn't mean that you can watch what you want, where and when you want. To do so, you'd need a VCR, cable box, and maybe even a laserdisc player and satellite receiver in each room. Or, you could build our Video Master video-distribution system and create your own video network. All your video sources are first placed on unused UHF channels and then combined with normal TV channels into one cable that can feed several TV's. Each set's remote control still works, and you can select the video source by simply changing the channel. To learn how to build the Video Master—so you can, for instance, play a tape in the family room, and watch it in the bedroom—turn to page 39.

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A review of the latest happenings in electronics.

In-Charge Cards

A credit card system based on a radio-frequency communication/transaction system and an "active" credit card has been developed for such applications as payment of transportation fares and hotel bills, or even personal identification.

The "In-Charge" card looks like a conventional credit card with a magnetic read-only strip, but it contains a single-chip RF transponder with 256 bits of memory.

Racom Systems, Inc. (Boulder, CO) and Ramtrom International Corporation (Colorado Springs, CO) developed the system as a joint venture. The "In-Charge" card contains a Ramtron ferroelectric random-access memory (FRAM), which can retain data in the absence of power. The card interacts with Racom's RF communications controller that is connected through an RS-232C interface to an IBM-compatible PC host.

The card user positions the card within six inches of a controller that generates a 125-kHz signal which powers the on-card transponder. The transponder and the controller create an RF interface for reading and writing to the card's internal memory.

Americans have become used to paying for goods and services with passive credit cards and Europeans and Japanese are now using "smart cards" with built-in semiconductor devices that record transactions such as paying for phone calls. However, both of those systems have drawbacks. Magnetic strip cards require time-consuming manual insertion in an imprinter or scanner, and even the "smart" cards must be placed in a machine that accounts for the transaction and updates the card.

Conventional credit card imprints or readouts generate paper receipts that are sent back to the credit organization for billing purposes. However, if those receipts are misplaced or stolen, thieves can gain access to a customer's identification number and charge goods and services against that number.

Because the In-Charge card does not need to make contact with the communications controller for reading and writing in the card's internal memory, the card need never leave the user's hand. Moreover there is no "paper trail" created. Transaction time is cut to a fraction of a second, making it possible to use the card while boarding a bus or train, or passing through a subway turnstile without slowing down.

Pre-programmed applications test kits are available from Racom (303-447-2474) for $1800.

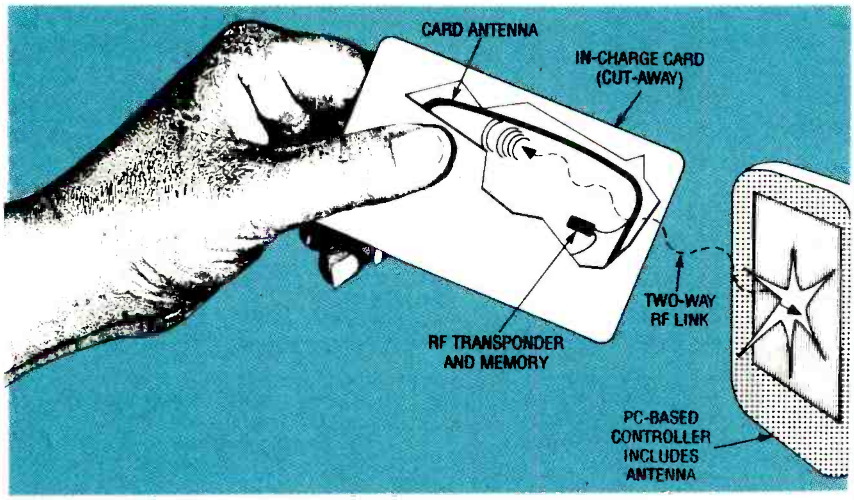

FIG. 1. THE "IN-CHARGE" ELECTRONIC CARD has an on-card radio-frequency transponder and memory. The card's antenna receives radio signals from the communications controller that activates its circuitry. The card than communicates with the controller and records the transaction.

Safer etching technique

An electron-assisted etching technique that promises routine fabrication of nanometer-scale semiconductor chips without the surface damage caused by conventional ion-beam etching has been developed at the Georgia Institute of Technology (Atlanta, GA).

Quantum-scale devices, which could have features that are one-thousandth the size of those on today's advanced VLSI circuits are forseen by Georgia Tech researchers. They see them spurring the next wave of development in microwave technology. The devices are also expected to have a major impact on developments in electro-optic devices, optical processing, and radiation detectors.

Conventional ion-beam etching can damage the surfaces of the devices being fabricated in the same way that dull or crude cutting tools can damage the material of a part being machined.

Ions have enough mass and can gain such high levels of kinetic energy that they can disrupt the delicate crystalline structure of the semiconductor surface on impact. Moreover, unwanted materials can be introduced into the crystal structure by this "brute force" etching.

In the process developed at Georgia Tech, low-energy electrons (10 to 500 electron volts) in combination with reactive hydrogen gas (H^2)

Continued on page 86

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• "CaptionVision" is here. Most TV sets on sale today—and all 13-inch-and larger sets in the near future—will be able to display closed captions. Designed originally as an aid for the hearing impaired, captions are expected to have increasing applications in the future.

By act of Congress, all TV sets 13-inches and larger, made or imported after June 30 of this year must be able to receive and display captions generated by TV stations, cable systems, videotapes, and laserdiscs.

The new caption law has resulted in the most extensive changes to TV sets in their history. In most cases, the TV set chassis had to be redesigned to accommodate the caption circuit chips. Many manufacturers took the opportunity to change the external appearance of their sets as well. They made an effort to recoup some of the costs of the changeover by adding features or making their TV sets more attractive.

Because most people hear fairly well, asking buyers to shell out $20 more for a captioned set is a tough sell. So the EIA has decided to put its best foot forward, and has launched a campaign to sell "CaptionVision," as it has dubbed the new service. In addition to providing assistance to the hearing impaired, the EIA campaign says, CaptionVision has other excellent practical applications.

For example, captions could help school children learn to spell and read. They could help those who are learning English as a second language, and they could be a boon for folks who want to watch TV in bed without disturbing sleeping spouses. Another use is envisioned in bars, where TV sound is drowned out by the conversation of convivial customers and other background noise.

Moreover, a new service is expected to grow out of CaptionVision. At present, captions are transmitted on field one of line 21 of TV's vertical blanking interval. The FCC is expected to approve the use of the second field of the same line for expanded service. It could result in teletext service, providing many different kinds of graphic material to the family TV set, even automatic programming systems for VCR's for the 500-channel age. That video data service could start in the latter part of this year if everything stays on schedule.

• Digital video in 1994. Full-motion, digital, high-resolution—and even high-definition—video should be available for consumer use next year, in a standardized form. It will be the result of an international agreement by the Motion Picture Experts Group on "MPEG-2" standards.

This follows the agreement on MPEG-1 for VHS-quality motion on digital media. MPEG-1 covers digital coding of video at rates below 1.5 Mbps, low enough to provide 74 minutes of full-motion video on a CD. MPEG-1 will be used in full-motion video cartridge adaptors for Philips' CD-I players.

The MPEG-2 standard extends to the higher data rates required for signals delivered from remote sources, and is designed to support a variety of picture-aspect ratios, including both 4:3 and 16:9. Eventually it will support HDTV. The first applications are expected to be for digital high-powered satellite broadcasts, such as the Hughes DirecTV system, scheduled for launch next year.

MPEG-2's audio standard provides for up to five full bandwidth channels, an additional subwoofer enhancement channel, and as many as seven commentary or multilingual channels.

• Sega channel. Videogames will be distributed by cable this fall in a pilot venture to determine whether a national videogame network is warranted. The participants represent the top of the field—Sega, the Number 2 game company, and Time Warner and Telecommunications Inc., the two top cable-TV operators in the U.S. They plan to air The Sega Channel on some of their systems this fall as an experimental subscription service, which could be rolled out nationwide early in 1994, if it succeeds in the test.

For a monthly subscription fee of about $10, subscribers will receive a cartridge that connects to the cable and plugs into the standard cartridge slot on the Sega Genesis console. The subscriber will review an on-screen menu that will offer games, information, playing tips, and previews. Subscribers will be able to download any of about 100 games. Games will be downloaded in a short burst into the subscriber's DRAM, permitting unlimited play.

• "Ghostbusters" coming. Ghost-cancellation circuitry—"the last major improvement in NTSC"—will be available as an add-on for some high-end TV sets next year, according to Philips, which developed the system. Philips says that more than 100 stations already are transmitting the ghost-canceling reference signal.

The first use of ghost cancellation is expected to be in assuring delivery of quality signals to cable systems. However, some high-end Philips and Magnavox sets are expected to include jacks that will accommodate ghost-killing adapters next year.

Philips' current ghost-canceling circuit board is based on an integrated circuit that replaces 450,000 transistors. Its goal is to reduce cost to the consumer to somewhere around $50. Ω

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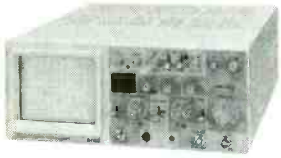

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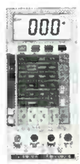

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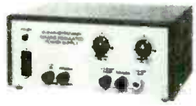

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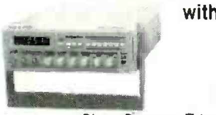

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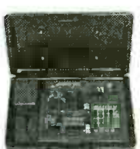

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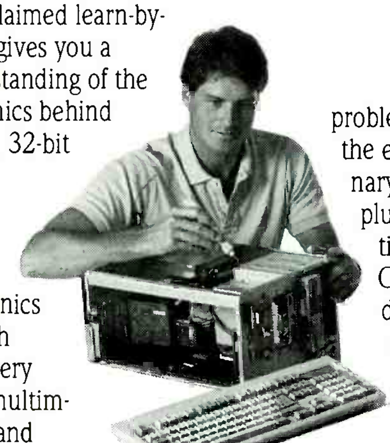

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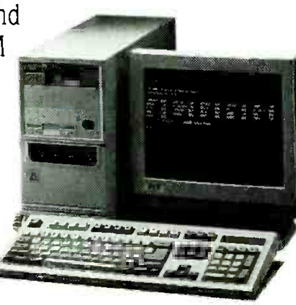

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Q & A

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LIGHTING CONTROL

I have built a lighting control system for my home using momentary switches. I have it set up so that the first press turns on the light and the next press turns it off. However, frequently a single press will cause the light to turn on and then turn immediately off. I think the problem is with the switches themselves. Can you suggest a way around this problem?—Y. Geben, Tetour, CO

You haven't given me much detail about your circuit but, from what you've described, the problem seems to be that the switches are "noisy." In other words, the switch contacts are "bouncing," or opening and closing several times very rapidly when you push and release the switch. This is a common problem with run-of-the-mill pushbutton switches, and there are several things you can try to get rid of the problem.

The first solution, which you probably don't want to hear, is to modify the circuit that the switches are controlling so that it won't respond to what I believe are the extra pulses from the switches. This can be done with a 555 timer IC set up as a one-shot multivibrator. But it does mean adding some new circuitry, which might not be easy to add to what you've already done.

A second idea is to get rid of the switches you're now using and replace them with high-quality units that won't bounce as much—but they are significantly more expensive than the ones you now have. Unfortunately, in spite of their price, even the world's best switches will bounce occasionally.

A much better fix is to debounce the switches you're currently using. This will take some additional hardware, but much less than would be needed for my first suggestion. You didn't include a schematic of your circuit, but the switch debouncers

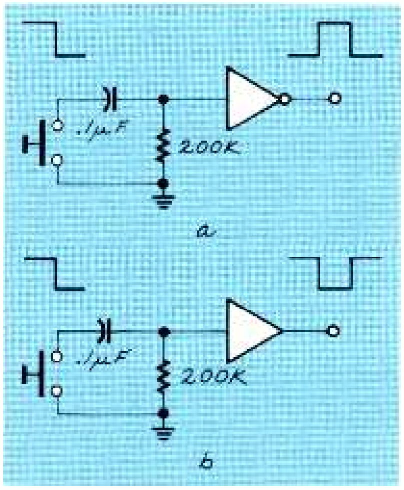

FIG. 1—SWITCH DEBOUNCERS. These circuits will cure problems caused by switch-contact bounce. The one shown in *a* will give you a positive output pulse, and the one shown in *b* will give you a negative output pulse.

that I've drawn in Fig. 1 should do the trick.

By the way, it's always a good idea to debounce mechanical switches, regardless of the application. In your case, the effect of switch bouncing seems to be fairly obvious, but in other circuits, it might be hard to track down the problem.

TIME DELAY CIRCUIT

I use an electronic timer in my darkroom, and because of the kind of work I do the exposure times for my prints are extremely long. In order to extend bulb life I've put a fan on the enlarger head to cool the bulb. I can't have it running during the exposure because of the vibrations, but I've rigged up a circuit that will turn it on when the bulb is switched off. What I need is a control circuit that will keep the fan running for a certain period of time and then shut it off automatically. The fan control circuit is now driven by logic signals. Any ideas?—J. Metzler, Portland, OR

Regardless of what you're controlling, it sounds to me as if you're looking for a simple time-delay circuit. And whenever you need a simple time-delay circuit, your first thought should be the 555 timer IC, the king of time-delay circuits.

Because you already control the fan with logic level signals, the output of a 555 should be perfect for the job. You neglected to say whether you need a high or low signal to activate the fan, but it's a simple matter to run the output of the 555 through a transistor set up as a simple inverter.

The circuit shown in Fig. 2 should work for you. Rotating the potentiometer wiper will change the time delay from the 555. If you use this circuit, it's a good idea to get a data sheet on the 555 in case you want to make a change in the time delay or alter the circuit to do something else.

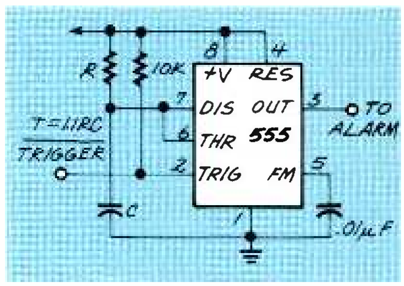

FIG. 2—SIMPLE TIME-DELAY CIRCUIT. Rotating the potentiometer wiper will change the time delay from the 555 IC.

TRIANGLE GENERATOR

I need a source of triangle waves to test a piece of equipment I have. I don't want to spend a lot of money on it because I'll probably use it once and never need it again. Is there some simple circuit I can build to generate triangle waves that also gives me control of the frequency?—T. Barabbas, Enid, OK

The schematic in Fig. 3 is the simplest triangle-wave generator I can come up with. All you need is three

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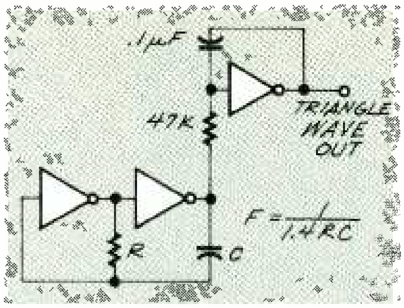

FIG. 3—TRIANGLE-WAVE GENERATOR. The first two gates are set up as a square-wave oscillator, and the last one makes the conversion to triangle waves.

inverters and a handful of passive components to put it together. Because it's built with CMOS parts, the output waveform will swing pretty close to the supply rails, and the operation of the circuit will be noise-free.

The first two gates are set up as a square-wave oscillator, and the last one makes the conversion to triangle waves. I'm pointing this out because if you already have a good square-wave generator, you can feed its output through the last part of the Fig. 3 circuit and convert the square waves to triangle waves.

FOREIGN CHARACTERS

The word processor I use allows me to type in the foreign characters that are part of the IBM character set, but it doesn't show me what they are. Because I write a lot of French text, it would be a great help if I could call up an ASCII table and see what codes I have to use to get the accented letters and other foreign-language characters. Do you have anything that would help?—P. Durand, Trinity, MA

This kind of request is one of the best arguments I know for using bulletin boards. The freeware and shareware files you can find there are usually written because someone has had a similar problem and decided to write a small piece of utility software to do the job.

The answer to your problem is a program called ASC.COM. It's a small TSR (terminate and stay ready) program that takes up about 1 kilobyte of memory and provides you with a complete ASCII table. All you have to do is run the program—and it's small enough to be considered as a permanent load via your AUTOEXEC.BAT file. Once the program is installed, it can be called up by pressing ALT-A. A window with an ASCII table will appear on the screen, and you can move around it with the cursor keys. When you get the code you need, the program is exited by pressing the escape key.

There are just a couple of things to watch out for. Because there's no source code with the program, there's no way to change the hot-key assignment. Also, if you use a spell checker, it might choke on the foreign characters.

DENSITY PROBLEMS

I recently bought a home computer so I could take work home from the office but I'm having trouble reading the office disks at home. The computer in my office is an IBM PS-2 model 50 with a 3½-inch high-density disk drive. My computer at home is a PC compatible with the same kind of floppy drive. Disks that are written in the office usually produce an "Undetermined

Continued on page 85

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LETTERS

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POWER CONTROLLER UPDATE

I'd like to thank William E. Baker who wrote a letter about my "Power Controller" article (**Electronics Now**, November 1992) that appeared in the June "Letters" column. I always enjoy getting feedback on projects.

As Mr. Baker suggested, the Power Controller contains more components than are needed for a load, such as extra lights. The purpose of the controller, however, is to provide more versatility than can be realized from a simple relay circuit. The power controller provides: 1) pulse sensing for wireless, wired, or remote oscillator control; and 2) automatic reset when the vehicle is shut down. The automatic reset works well with the other devices in a computer-controlled car and provides a nice "feel" to the dashboard controls.

Furthermore, the addition of the electronics for pulse control represents a small percentage of the effort needed to assemble the hardware and build a suitable unit.

The circuit suggested in Mr. Baker's letter would certainly work. As a matter of fact, it is similar to the one I initially built to control the lights in my old Chevy van. However, I would connect the indicator lamp with resistor across the load. That way, the lamp will positively indicate that power is applied to the load, not simply that power is applied to the relay.

DAVE SWEENEY

CALL FOR CLEAN AIR

Tch, tch, tch. Forty lashes with a wet environmental noodle to Martin Fournier for suggesting in his article "Remote Car Starter" (**Electronics Now**, April 1993) that you should warm up a car for as long as 15 minutes.

Any environmentally conscious 10-year old can tell you that you should idle a cold engine for no longer than one minute, and then drive and accelerate gingerly while the car warms up. Do not idle for excessive periods. Like the echo of a faraway gunshot, we Canadians hear (and breathe) the report a few days later.

Remember to reduce, reuse, recycle, and rethink. Every little bit helps.

GAVIN EARLE
St. John's, Newfoundland, Canada

PREDICTING THE FUTURE OF HDTV

The article "The New World of HDTV" (**Electronics Now**, May, 1993) was quite a thorough report on the four finalists in the HDTV derby.

However, it may well be that the right answer for the long term is: E. "None of the above." They're really not ready for prime time.

Look at it from the broadcaster's point of view—from the Big Three (and a half) networks on down to the individual, independent, peanut-whistle TV station. Here, Mr. Broadcaster, is what each of the systems offers you:

1 You'll be required to duplicate all of your existing NTSC equipment with brand new (and far more costly) equipment, and you'll even have to buy a whole new transmitter tower!

2. You'll have to staff and maintain both facilities until the year 2008.

3. You might get Joe Sixpack to watch a few more minutes of your broadcasts than he does now—or maybe not. Ol' Joe's about maxed out on his couch-potato viewing time already.

4. You might get General Motors to pay more to run a Chevy commercial than it does now—but probably not twice as much. After all, they're trying to appeal to the same simulcast audience.

The bottom line is that a mere "NTSC with more lines on your TV screen" makes no economic sense. It means substantial amount of extra expense, and minuscule extra income.

The big push for high-definition TV exists only because the NTSC standard forces us to live with the 525-line picture that was the best that vacuum tubes could do in 1942. All of the proponent systems make the same mistake of carving in stone the limits of today's technology for yet another 50 years or so. Then we repeat this process of junking everything and starting over.

The good news is that there are other concepts that do make sense.

Work is now going on within SMPTE on a hierarchy or architecture of interrelated digital image standards. The different levels within this system would identify themselves to broadcast equipment with digital headers. (See the December 1992 *SMPTE Journal* for details.)

That would allow us to incorporate advances in technology naturally and painlessly, at least compared with the present debacle. The situation would be more like the sequence of compatible upgrades that we've seen in computing.

It's the distribution, not the definition, that will make digital television economically viable. With compression and a choice of resolution levels, broadcasters will have the opportunity to provide many simultaneous services, rather than competing for maximum Nielsen ratings from a single channel. They'll be able to tap niche markets and really function as a kind of "common carrier of digits." The header/descriptor is the key to that diversification.

JOHN SPRUNG
San Pedro, CA

OPEN SPEAKER CONNECTIONS

In response to Mr. Ott's request for information about oscillating open-load amplifiers, I think that this is a carryover from the tube-amplifier era. I have had experience with marginally stable tube amplifiers self-oscillating to destruction when they were not loaded by speakers or resistors. That is caused by reactive parameter changes in marginally designed output transformers permitting positive feedback when not stabilized by the load.

The old Knight KG-250 Stereo Hi-Fi amplifier (does anyone remember Knight-Kit, or am I showing my age?) actually had a warning in its manual against no-load operation. The amplifier was inexpensive and served me for many years, even with that obvious trade-off. I fully agree with Mr. Ott that there should be no adverse effects from operating a reasonably well-designed solid-state power amplifier without load. Moreover, I also agree that most tube amplifiers are stable without a load (e.g., MacIntosh, Dynaco, Marantz, Harmon-Kardon), but caution should be exercised.

As a side note, I own a Teknika solid-state integrated stereo amplifier that places A and B speaker systems *in series*, not parallel, across the power amplifier output to reduce the load when both pairs are operating. That results in a definite change of sound in both systems because the reactive parameters of one system affect the other.

That is not desirable for critical listening, and it has proven downright irritating at times. Nevertheless, it reduces heating in the output stage, even with the volume control turned up to compensate for volume loss when driving that way. I use the amplifier only as a background sound source. I have seen that method of multiple-speaker drive in several (15 to 20%) of the low-end amplifiers that I have worked on over the years.

Thanks for the *Q&A* column.

GEOFF POMEROY
Westerville, OH

Carl Ott questioned the suggestion that "leaving stereo outputs open (i.e., *infinitely* loaded) causes strain on output transistors." He stated that he had been trying to track down the source of that "rumor" since his high-school days.

Mr. Ott is correct in saying that open speaker connections do not damage the output transistors of stereo systems. As an electrical engineer who completed college a couple of years before transistors were invented, I think I know how the belief that open speaker connections cause damage originated.

In my view, the practice of avoiding open-circuited speaker outputs is a carry-over from the possible damage that could occur in vacuum-tube audio-output amplifiers. Vacuum tubes are inherently high-impedance devices, whereas transistors are inherently low-impedance devices. It is necessary to use a matching transformer in a tube amplifier to match the high-output impedance of the receiving tubes to the very low-output impedance of the loudspeakers.

The low impedance of the loudspeaker is transformed from the secondary winding of the transformer to the primary winding (tube-to-plate circuit) by the square of the turns ratio. The primary impedance, as reflected from the secondary winding, of a tube amplifier might be between 2000 and 5000 ohms. If the secondary winding is open-circuited, the primary impedance becomes extremely high.

Considering the relatively high grid-to-plate capacitance of audio output tubes, such conditions can easily cause runaway oscillation and the destruction of the output tubes. In a pentode output tube, for example, much of the current (electron flow) that would normally go to the plate would be intercepted by the screen grid. That could cause overheating and destruction of the screen grid.

With relatively high inverse feedback, most of that damage could be prevented in a well-designed tube amplifier. However, as a precaution, those who worked with vacuum tubes always made sure that the secondary winding of the speaker output transformer was loaded.

Because transistors are inherently low-impedance devices, they are relatively immune to damage when speaker outputs are open-circuited. The current requirements for an open-circuited loudspeaker are essentially zero, so the output transistors are not damaged.

W.E. BABCOCK
Warren, NJ Ω

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The *Model 2910A* digital synthesizer is priced at $1499.—**Novatech Instruments, Inc.**, 1530 Eastlake Avenue E., Suite 303, Seattle, WA 98102; Phone: 206-328-6902; Fax: 206-328-6904.

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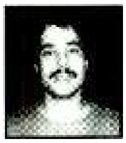

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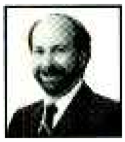

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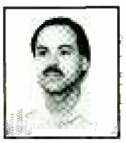

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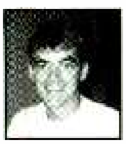

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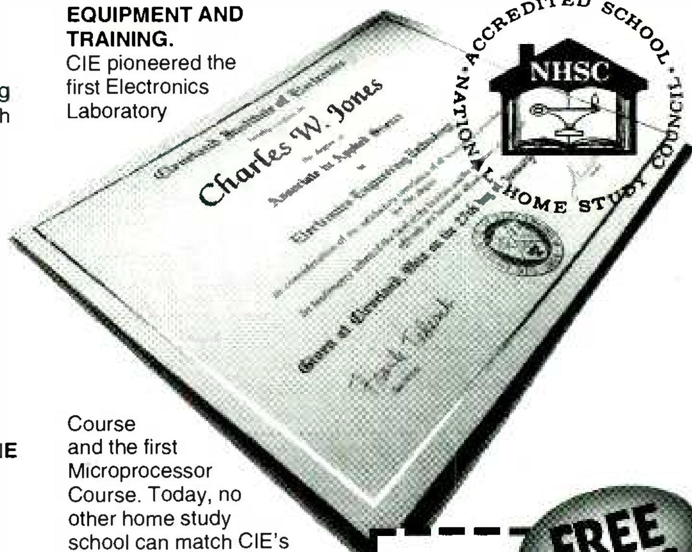

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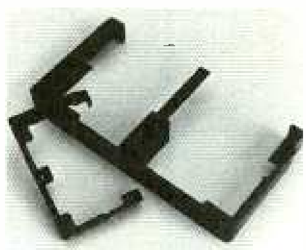
VCR SERVICE CASSETTES. Service cassettes are now available to help in the servicing of VCR's. *Tenma 8 mm (No. 32-4605)* and *VHS (No. 32-3840)* service cassettes from *MCM Electronics* provide useful input for the troubleshooting and repair of 8mm and VHS camcorders and VCR's.



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The service cassette is inserted in the VCR or camcorder, and the unit under test runs as if a standard cassette were loaded. The service cassettes include tape-detect functions, latch releases, sensor switches, and cassette alignment guides to help pinpoint problems.

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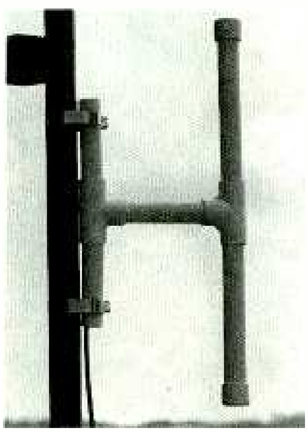
to emulate the front panel of a consolidated meterological instrumentation console displays all the measured phenomena.

Prices for the *ENV-100* start at $449.—**SensoMetrics, Inc.**, P.O. Box 1049, Lakeville, MA 02347; Phone: 508-946-4904.

SCANNER ANTENNAS. The *H-TENNA-SCN* receive-only scanner antenna from *Electron Processing* receives all frequencies from 25 to 1200 MHz. If your antenna tower is getting a bit crowded these days, an antenna that can be conveniently mounted on the side of that tower should be a welcome addition to your setup.

The antenna is only 44 inches long, and it can be mounted for either vertical or horizontal polarization. When mounted singly aside most towers, the antenna is said to provide near omnidirectional coverage. More than one antenna can be stacked to optimize performance on a specific band or for customized antenna reception patterns.

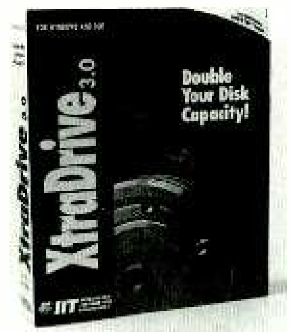


CIRCLE 21 ON FREE INFORMATION CARD

A two-foot "pigtail" is included for connection to your feedline. For UHF reception or setups including long runs of coaxial cable, the *Super-H-TENNA-SCN* includes a 16-dB gain low-noise preamplifier to boost reception of weak signals. The *Super* model is sold with 25 feet of coaxial cable, a 120-volt VAC power supply, and jumper for your scanner. Both models are protected in PVC radomes, and can be connected with your choice of BNC, N, or PL259 connectors.

The *H-TENNA-SCN* is priced at $55 and the *SUPER-H-TENNA-SCN* is priced at $90. Add a $5 shipping and handling charge for each.—**Electron Processing, Inc.**, P.O. Box 68, Cedar, MI 49621; Phone: 616-228-7020.

DATA-COMPRESSION SOFTWARE. *Integrated Information Technology's latest XtraDrive* software compresses data on disk drives, effectively doubling the drives' capacity. It requires no hardware upgrades, and it allows the user to read and write to compressed floppy disks on computers that do not have *XtraDrive* installed.



CIRCLE 22 ON FREE INFORMATION CARD

It provides full support for removable memory data including that from Bernoulli and Syquest drives, optical disks, and floppy disks. The software is said to make data compression easy and transparent. It features improved directory listings, media interchangeability, and data-compression safety.

If a disk crashes during the compression process, no data will be lost because of *XtraDrive*. The program completes and verifies a successful compression before erasing the original file. Each compressed file is stored individually to minimize the danger of large-scale data loss. Operating on the BIOS level, *XtraDrive* is fully compatible with most defragmentation utilities such as Norton and PC Tools. Moreover, the compression works invisibly with Windows swap files.

The price of *XtraDrive Version 3.0* is $98.—**Integrated Information Technology, Inc. (IIT)**, 2445 Mission College Blvd., Santa Clara, CA 95054; Phone: 408-727-1885; Fax: 408-980-0432.

BUTANE SOLDERING IRON. The *Antex GasCat* butane soldering iron from *M.M. Newman Corporation* will come in handy if you want to solder a connection in the field and you are not near a convenient electric outlet.

The soldering tool has a transparent fuel reservoir and its own flint-wheel starter. It can heat up to 750°F and operate continuously for up to one hour. An assortment of replacement tips is available. The threaded tips can easily be removed and replaced.

CIRCLE 23 ON FREE INFORMATION CARD

The *Antex GasCat* burns commercially available butane lighter fluid. The multipurpose tool can also be used for brazing, heating the air to shrink-fit plastic wrap and cable jackets, and as a hot knife for various applications.

The *Antex GasCat* soldering iron is priced at $37.49.—**M.M. Newman Corporation**, 24 Tioga Way, Box 615, Marblehead, MA 01945; Phone: 617-631-7100; Fax: 617-631-8887.

DUAL-SLOT MEMORY-CARD CONNECTORS. *Hirose Electric's IC6 Series* of dual-slot memory-card header connectors hold two memory cards per connector. They are intended for mobile computers that must meet PCMCIA 2.0 and JEIDA Version 4.1 requirements.

CIRCLE 24 ON FREE INFORMATION CARD

The *IC6* is made of SMT-compatible material and accepts Type I or Type II cards for insertion in either slot. Thicker Type III cards can be inserted in the upper slot. Ejectors are provided for each slot, and users can choose between 2.2 mm, 5.0 mm, or no standoffs.

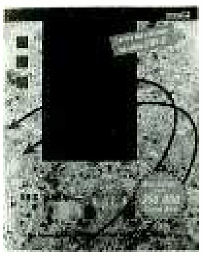
The *IC6* dual-slot memory-card connector is priced at $12.50 each 1000 quantity.—**Hirose Electric (U.S.A.), Inc.**, 2688 Westhills Court, Simi Valley, CA 93065-6235; Phone: 805-522-7958; Fax: 805-522-3217 or 800-879-8071 (ask for No. 8005). Ω

NEW LIT

Use The Free Information Card for fast response.

DOS: The Complete Reference, Fourth Edition; by Kris Jamsa. Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710; $29.95.

This is a one-volume DOS reference library that answers just about any question you could have on the DOS operating system. It has been newly updated to cover Version 6.0. Written for the beginner as well as the experienced user, Jamsa's book starts with an easy-to-follow, step-by-step introduction to DOS, and takes the reader into advanced concepts. It also reveals tips that users at all levels of experience will appreciate.



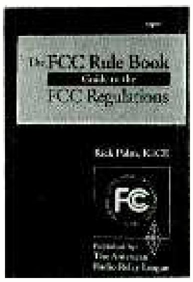
CIRCLE 25 ON FREE INFORMATION CARD

Introductory chapters are organized for do-it-yourself sessions to familiarize you with your computer, its peripherals, and the basics of DOS. Later chapters tell you how to get the most from DOS directories, how to protect your files, and how to avoid disk crashes. You'll also learn how to debug and recover disk errors, and protect against viruses. Advanced topics include DOS memory management.

The book includes a Command Reference Guide to give you answers to specific questions. There's no need to wade through the entire 1100 pages to find the information you need.

The FCC Rule Book: Guide to the FCC Regulations; by Rick Palm; K1CE. The American Radio Relay League, 225 Main Street, Newington, CT 06111. $9.00.

A understanding of FCC regulations and how they apply is helpful for any radio amateur trying to develop his or her operating skills and technical knowledge. The ninth edition of this popular guide contains clear explanations of how FCC rules apply in day-to-day amateur radio operation, how FCC rules are enacted, and how citizens can participate in the rule-making process.



CIRCLE 26 ON FREE INFORMATION CARD

Each chapter includes answers to commonly asked questions about specific FCC rules: "Whose call sign should be used if a friend operates my station?" "Because I live near an airport, What FCC regulation, if any, applies when I put up my tower?"

This guide provides reference information on international regulations, operating an amateur radio in other countries, call-sign assignment, and testing procedures. You'll also find a listing of countries that allow third-party traffic handling by U.S. amateurs. Sample application forms for such activities as license renewal and antenna approval are included along with full instructions on how to fill them out properly and completely.

Test Measurement Instruments Catalog. Bel Merit Corporation, 17 Hammond, Suite No. 403; Irvine, CA 92718-1635; Phone: 714-586-7300; Fax: 714-586-3399; $2.

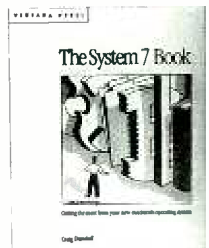
This is the latest test and measurement instrument catalog from Bel Merit. The 12-page catalog includes detailed specifications and descriptions of portable and benchtop test and measurement instruments for engineers, students, and technicians who test, repair, or assemble electronic equipment.

CIRCLE 27 ON FREE INFORMATION CARD

Highlighted in the catalog are multifunction digital multimeters, clamp-on current meters, frequency counters, sweep/function generators, DC power supplies, audio and RF signal generators, voltage testers, continuity checkers, and circuit analyzers.

The System 7 Book, Second Edition; by Craig Danuloff. Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $24.95.

Here is a new book on version 7.1 of Apple's Macintosh operating system. This second edition of the reference work has been updated to include new information on major extensions and utilities. New chapters describe QuickTime and offer insiders' tips on dozens of attractive useful utilities.



CIRCLE 28 ON FREE INFORMATION CARD

Danuloff's book explains all System 7 and 7.1 commands and features. It also includes a complete overview of the benefits and problems of working with fonts on the Mac, covering such subjects as the new Fonts Folder, TrueType, bitmapped, and PostScript fonts. Other topics covered are upgrades of system software elements, including Publish and Subscribe, and how to take advantage of Finder enhancements.

You'll find out how to use the Label menu and Make Alias and Find commands to improve your Mac's

Hints and tips on buying a speaker system—Part I

LARRY KLEIN

If you've been shopping for speaker systems, or reading the hi-fi directories and magazines in preparation for doing so, you should by now be fairly confused. Welcome to the club! Since even professional speaker designers can't agree as to what makes speakers sound good, it is not surprising that speaker shoppers faced with hundreds of brands and models find it difficult to make their buying decisions.

The advice that follows was culled from some 25 years of readers' questions and answers. You won't find it a totally definitive guide to choosing a speaker—it would take a book and a half to do that job—but you should find it helpful in avoiding the worst pitfalls that beset the shopper. Let's start where the action is.

Showroom strategies

Be aware that some brands, because of a higher markup or bonus money ("spiffs") paid to the salesman, are more profitable for the dealer than other speakers of equal or superior performance. Also, be cautious about the private label "house brands" sold by some large dealers. House brands prevent you from making price comparisons because the brand name is not available from competing dealers. That's not to say that spiffed speakers or house brands are necessarily bad buys, just that caution is in order when a particular brand is being pushed particularly hard and doesn't seem to be available elsewhere.

Beware of rigged demonstrations. At one time they were an unhappy fact of hi-fi life. They seem to have diminished considerably over the years, but if you have any reason to suspect hanky-panky, make sure that all amplifier tone and loudness controls are switched out and check, if you can, how the midrange and treble balance controls (if any) on the speakers are set. Also, don't let a salesman demonstrate speakers with his own specially taped material; ask to hear a good CD or audiophile disc.

It has been suggested that you bring along a familiar disc to serve as a "standard of comparison" when auditioning speakers. That can be helpful, but only if you already know how the reference material should sound on a good system. If you've become used to the sound of your disc on second-rate equipment, you might not like the way it sounds on a system with a flatter, wider-range response.

Because speaker efficiency varies from brand to brand and model to model, make sure that the dealer's speaker switching panel is set to equalize the levels of the systems being compared. Otherwise, psychoacoustic effects will make the loudest speakers sound best. In fact, a barely perceptible level boost can make the loudest pair of systems seem subjectively more "open" and "live," regardless of whether your perception can be objectively justified.

Listening tests

Don't assume that you are a good judge of sound quality just because you came factory-equipped with two working ears. A sonically trained ear is needed to appreciate nuances of audio reproduction for the same reason that a musically trained ear is needed to analyze subtleties of interpretation or performance. When a listener is insensitive to sonic (or musical) nuances, speaker sound is perceived as a more or less homogenized auditory event. Typical speaker shortcomings such as overemphasis of the upper bass frequencies, a peaky midrange, or a loss of the very high frequencies might go by unnoticed—or worse yet, be preferred.

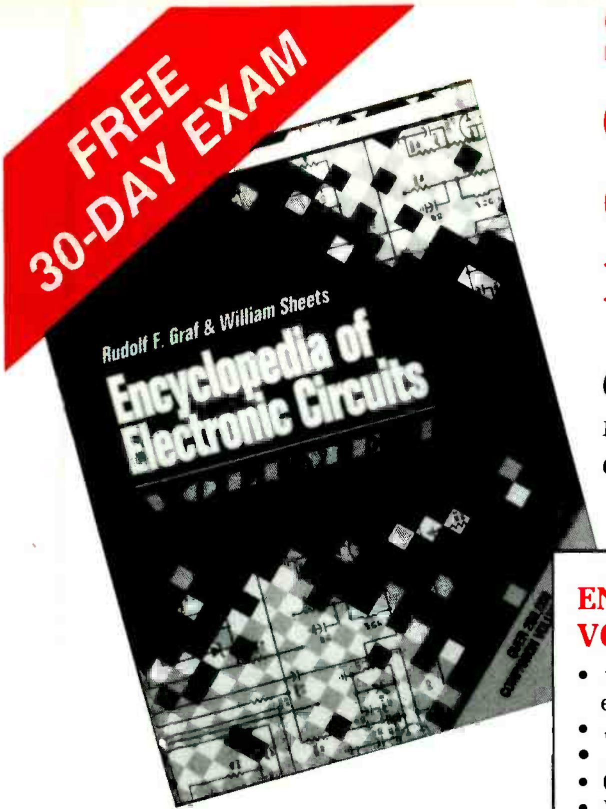
Here are some suggestions about to what to listen for, starting at the lowest frequencies:

- Bass—This end of the audio spectrum is very much affected by the room's dimensions and configuration, as well as speaker placement. A further complication is that most people confuse a typical 70-Hz "bump" in a speaker's response with true low-bass performance. Real bass has a "thud" and impact that will be appreciated once it is heard.

It is a lot easier to find well-defined low-bass performance on discs today, because CD recordings do not suffer from the inherent bass limitations of LP's. Have your dealer play some CD's with good low bass, and use them to compare speakers. Some systems will audibly "break up" when called upon to reproduce low bass at high volumes; others, instead of breaking up, will deliver only the higher harmonics of the bass tone, omitting the fundamental frequencies that give low bass its "thud" quality. I prefer the second response, because such behavior sometimes means that a little bass boost (from an equalizer or tone controls) will work wonders.

- Midrange—Performance in the middle frequencies depends on how efficient a speaker is, and how loudly it plays. If the mid frequencies (roughly defined as 400 to 3000 Hz) are disproportionately emphasized, vocalists and instruments take on a forward, projected quality, which some listeners like. Unfortunately, this is usually accompanied by a nasal coloration on female voices, brass instruments, and woodwinds. The sound also takes on a hollowness, such as you would hear if you talked into your cupped hands.
- Treble—High-frequency performance is also best judged with a good CD or audiophile disc. When the higher frequencies are present in full measure, they provide spar-

Continued on page 87



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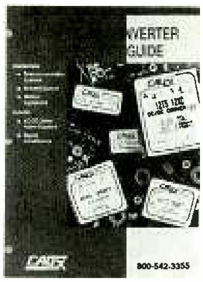
hard-disk efficiency. You'll also get advice on optimizing your Mac's memory, and how to use ColorSync Extension for desktop color calibration and related synchronization.

Tips and shortcuts are included for memory management, file-sharing, networking, and multitasking. The book is organized to help readers master the Mac. An appendix describes the installation process step by step. The book's purchase price includes two free issues of *The Ventana Mac Update* newsletter.

DC/DC Converter Product Guide; Calex Mfg. Co., Inc., 2401 Stanwell Drive, Concord, CA 94520-4841; Phone: 510-687-4411 or 800-542-3355; Fax: 510-687-3333; free.

With this catalog Calex has announced nearly 100 new additions to its DC-to-DC converter product line. The free catalog includes product descriptions and



CIRCLE 29 ON FREE INFORMATION CARD

specifications of Calex AC/DC linear power supplies and signal-conditioning modules. To simplify product selection, the catalog includes Quick Locator charts. Other pertinent facts such as case dimensions, UL-approval announcements, and quantity pricing are included

1993 Comprehensive Belt & VCR Parts Cross Reference Guide; Projector-Recorder Belt (PRB) Corp., P.O. Box 176, Whitewater, WI, 53190; Phone: 414-473-2151.

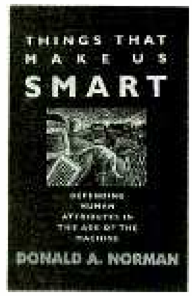
If you repair VCR's and related equipment as a hobby or professionally, you should have this handy cross-reference guide on replacement parts. It's available as a catalog or on 5¼- or 3½-inch IBM-compatible diskettes. The software version includes a menu for the quick location and identification of replacement parts or belts.

CIRCLE 30 ON FREE INFORMATION CARD

Both the catalog and the disk versions have been updated to include the latest data on replacement parts and belts for VCR's, camcorders, answering machines, CD players, cassette decks, car stereos, and other electronic equipment. Mechanical parts are listed by manufacturer, make, and model. They are also cross referenced to PRB's recommended replacement.

Things That Make Us Smart: Defending Human Attributes in the Age of the Machine; by Donald A. Norman. Addison-Wesley, Jacob Way, Reading, MA 01867; Phone: 617-944-3700; $22.95.

Here is a book that looks at the man-machine interface, and warns us about the consequences of over-dependence and reliance on the many new-fangled entertainment, work-saving and communications devices that have invaded modern society.



CIRCLE 31 ON FREE INFORMATION CARD

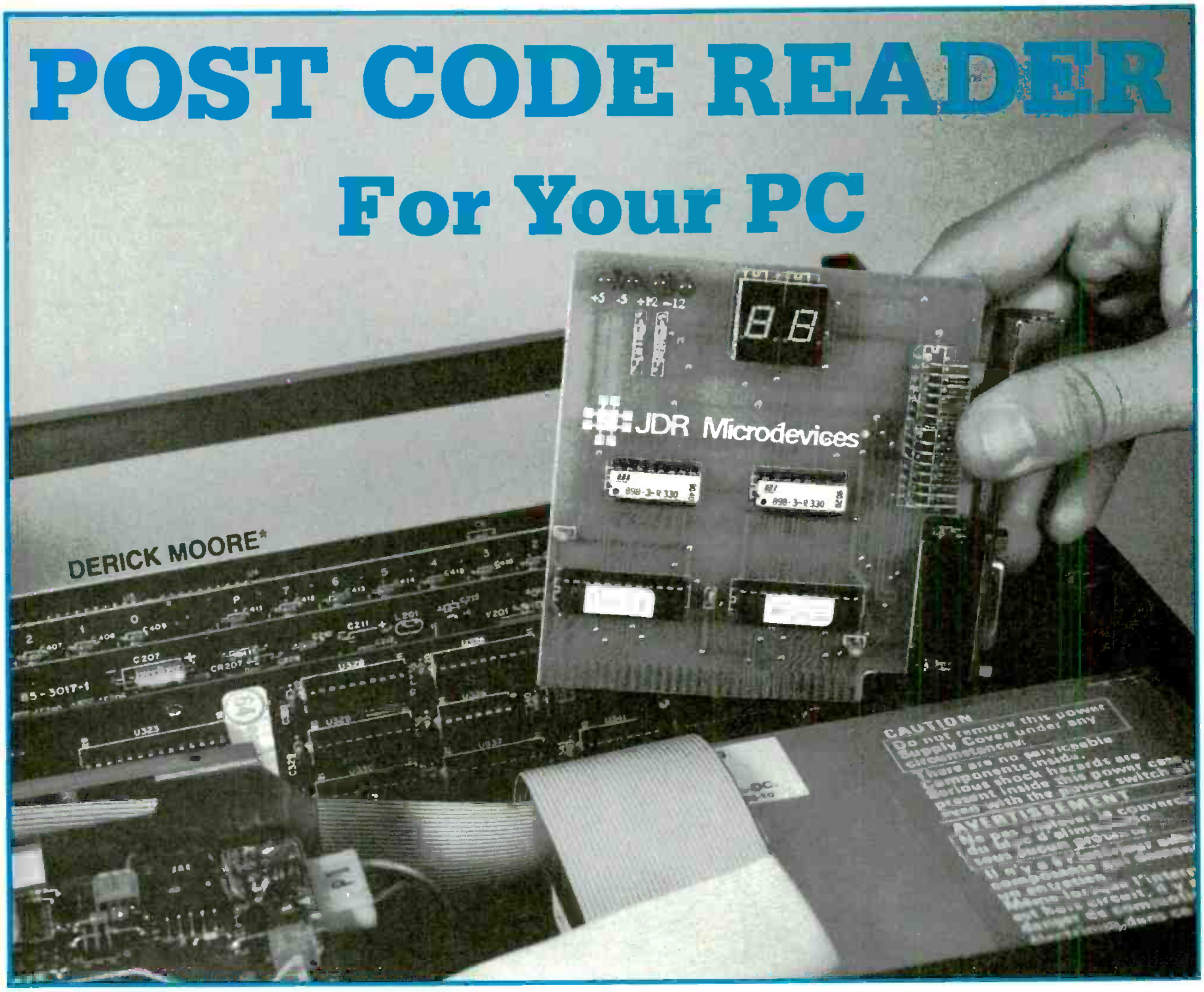
Mr. Norman believes that we have lost control of our TV's, telephone answering machines, and computers. Far from helping us to work more efficiently, learn faster, communicate better, and control our environment, he believes that they have taken control of our lives. In fact, he thinks they have made us slower, dumber, more isolated, and, in some cases, helpless.

This is not a reactionary book; it does not advocate a return to Luddite behavior of the 19th century in which workers smashed new machinery in hopes of restoring an agrarian society. But it does urge that we evaluate the effects of this technological tidal wave on human beings and their lives.

The author, a cognitive psychologist, provides a fresh perspective on how we experience and reflect upon the world, and the changes in the way we live that have been forced on us by the introduction of new technology. Hanson is pleased by the latest technological achievements, but suggests that there should be more concern about enhancing those basic human attributes of imagination, humor, and creativity. This is bad news for the TV "couch potato" who has isolated himself with an answering machine and whose idea of society is best expressed with a computer network..

POST CODE READER For Your PC

DERICK MOORE*



Your PC is trying to tell you something—and a couple of GAL's can tell you what!

LIKE THE VICTIM IN SOME CHEESY murder mystery who scrawls his dying message in the sand, your IBM-PC compatible computer might be trying to communicate with you.

Every time your PC boots, it performs a power-on self test or POST. The POST verifies all the major subsystems of your PC. If they appear live and well, the BIOS (basic input/output system) continues with the boot sequence. If any test fails, testing halts, and the value latched in I/O port 080x indicates what went wrong. (Throughout this article, an *x* appended to a number indicates that it's a hexadecimal value; decimal values have no special markings.)

The problem is that few motherboards have any way of displaying POST code values—and that's where we can help. This article describes a low-cost POST-code display board (we call it PCODE) that you can build in an hour or two. Complete kits are available, as are bare boards. (See Parts List.)

The heart of this project consists of two custom-programmed Generic Array Logic IC's (also available separately), commonly known as GAL's. Before delving in to the construction details, we'll provide some background on GAL technology and how to design with GAL's.

PC boot sequence

When a PC boots, the CPU begins executing the code at a special location in the BIOS ROM. One of the first things the BIOS does is test and initialize circuitry on the motherboard and expansion cards. Both what it does and the order it does it depend on the BIOS vendor and the version of the BIOS. However, the general sequence is:

- Check the CPU registers.
- Set up the 8253/54 timer for RAM refresh.
- Set up the DMA IC for RAM

*Director of Engineering, JDR MicroDevices

refresh.
- Verify that the RAM refresh is working.
- Test the first 64K of RAM.
- Load the interrupt vectors and assign stack space.
- Initialize the keyboard and video board.
- Size and test the remaining RAM.
- Initialize the COM, LPT, and game ports.
- Initialize the floppy disk drive(s).
- Initialize the hard disk drive(s).
- Scan and link the user ROM's, if any.
- Boot the PC.

As the computer performs each test, it updates the value in I/O port 080x. If a test fails, the CPU typically emits several beeps and then halts. The beep codes can be of some value in diagnosing problems, but typically they're neither specific nor comprehensive. So a simple device that can decode and display the value in I/O port 080x will be a very effective diagnostic tool. Ergo PCODE.

Note that different BIOS manufacturers use different code values, so you must be careful about how you interpret the values displayed by PCODE. Several values for common BIOS's appear in Table 1, but you should check with your BIOS vendor for accurate, up-to-date values.

Circuit overview

The procedure is really quite simple. We need to latch the value on the lower eight bits of the data bus whenever the CPU performs a write to I/O port 080x. Figure 1 shows a functional diagram of what we want to happen. Our goal is to achieve the $\overline{\text{SELECT}}$ signal shown in the figure.

Port 080x may be represented in binary as 00 1000 0000. In other words, the circuit needs to capture the condition when address lines A0–A6, A8, and A9 are all low, and only A7 is high. Address lines A8 and A9 must also be low, otherwise the circuit would trigger on multiples of 080x, (i.e., 0180x, 0280x, and 0380x). So note that, except

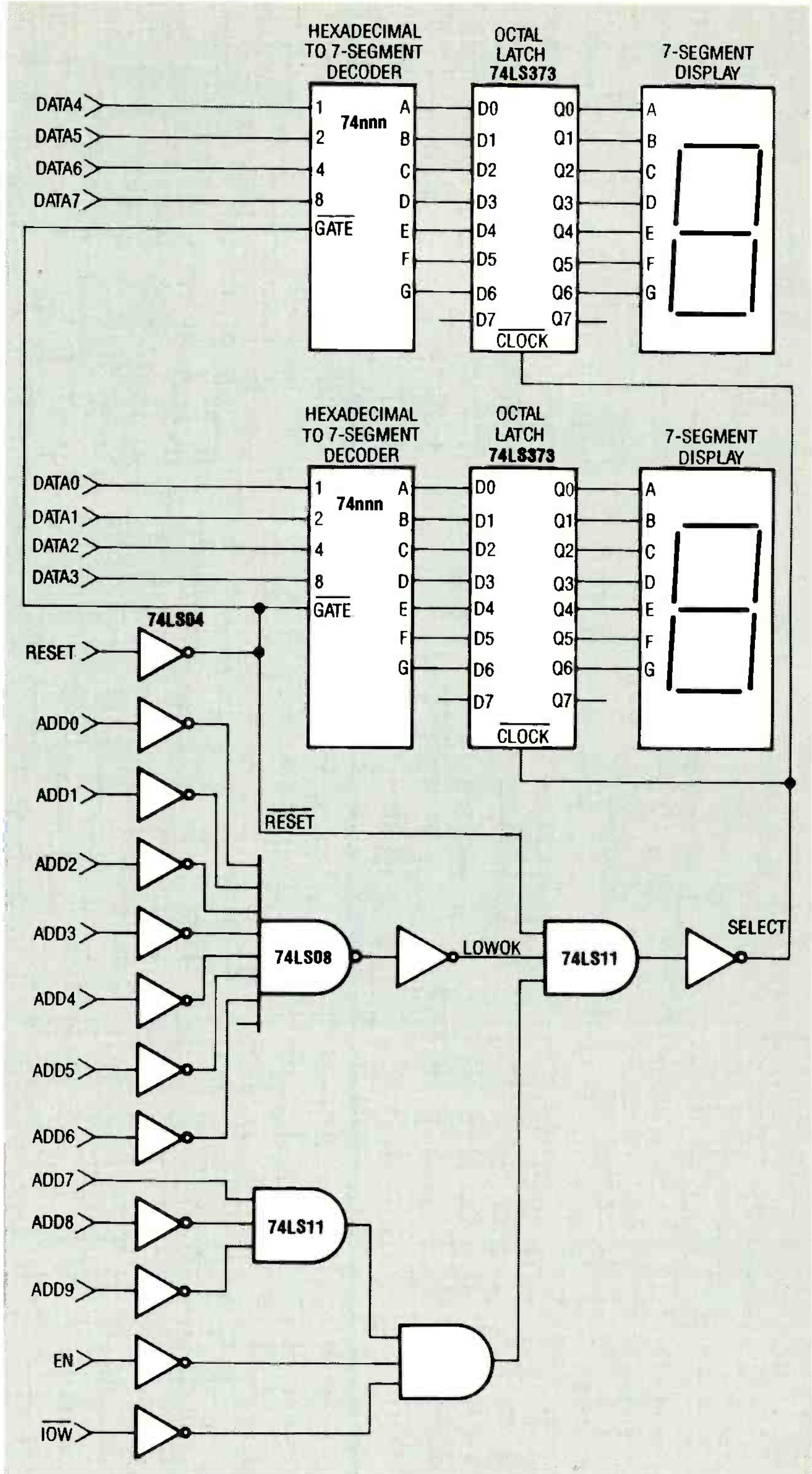


FIG. 1—FUNCTIONAL DIAGRAM provides high-level view of desired decoding. The goal is to get a Select signal that will latch data whenever the CPU writes to I/O port 080x.

for A7, we take the inverted states of A0–A9. That gives the raw port address; we also must combine the states of three control signals to achieve $\overline{\text{SELECT}}$.

Working down from the top, we combine the low states of the RESET, I/O write ($\overline{\text{I/OW}}$), and memory access enable (AEN) signals. RESET is normally low; it goes high only during power-up, or when the user presses the reset switch (on a non-IBM computer). $\overline{\text{I/OW}}$ is normally high; it goes low each time the CPU writes to an I/O port. AEN is normally high; it goes low when a DMA device (e.g., a disk controller) seizes the bus.

Note in Fig. 1 that RESET also drives the $\overline{\text{GATE}}$ inputs of the two display decoders. In other words, as long as the machine is not being reset, the "gates" are open and the decoders can do their jobs. Those decoders sit on the data bus constantly decoding signals and feeding them to the display latches. The latches only *accept* new values, however, when $\overline{\text{SELECT}}$ goes low.

Although it's possible to buy IC's for some of the functions shown in Fig. 1, it's not possible for them all. The most difficult IC's to find is the pair of decoders, which have to accept hexadecimal input and deliver outputs suitable for driving a pair of dumb seven-segment LED's. In addition, combining all the inverted and true address and control signals would require numerous inverters and gates, all of which increase circuit complexity and cost, and reduce reliability.

Wouldn't it be nice if you could combine all the address-decoding logic, all the display-decoding logic, as well as the display latches and drivers, in just a few IC's? Well you can; a couple of GAL's make it easy.

PLD overview

Before we discuss the specifics of the devices used here, let's back up and look at GAL's from a more general perspective. The GAL is a member of the family of programmable logic devices (PLD's). A single PLD can replace several standard TTL devices. All PLD's share one common characteristic: they are programmable. The GAL exhibits one other characteristic that makes it extremely versatile in the design lab: Like an Electrically Erasable Programmable Read Only Memory (EEPROM), a GAL is erasable.

Figure 2 shows a simplified diagram of a portion of the 20V8 GAL used in this project. The 20V8 has a total of 24 pins. Two are used for power and ground, two for control purposes, and

TABLE 1—COMMON BEEP AND BIOS CODES

Description	IBM Beep Code	IBM AT BIOS	Phoenix 286 BIOS	AMI BIOS 2.2x	Award BIOS
CPU Register		01	01	03	07
CMOS	1 - 1 - 3	03	02	2D	0F, 1C, 1D
BIOS Checksum	1 - 1 - 4	02	03	09	
8253/4 Timer	1 - 2 - 1	04, 05	04	0F, 7E	08–0E
DMA Setup	1 - 2 - 2	06, 07	05	15, 18	08–0E
DMA Page Register	1 - 2 - 3	08	06		
RAM Refresh	1 - 3 - 1	09	08	12	
First 64K RAM		0D, 0E	09—0D, 10—1F	21, 24, 7	15
8259 #1	3 - 1 - 3	13		1B, 1E	08–0E
8259 #2	3 - 1 - 4	24, 25, 26			
0842 Keyboard Controller and Keyboard	3 - 2 - 4	0D, 2D, 35, 36, 38, 39, 3A			01–05, 2A
Address Lines 19–23 Problem		1F		60	
Video Initialization	3 - 3 - 4	22, 23		48	17, 18
Video ROM Scan in Progress	3 - 4 - 2		2D		
Video ROM Svan	3 - 4 - 3				
Real-time Clock			3B		
Serial Port			3C	93	2C
Parallel Port			3D	96	2D
Math Coprocessor			3E	90	2F
Hard Disk, Floppy Disk		3E		9C, 9F, A2	2B, 2E
Initialize Printer		3F			

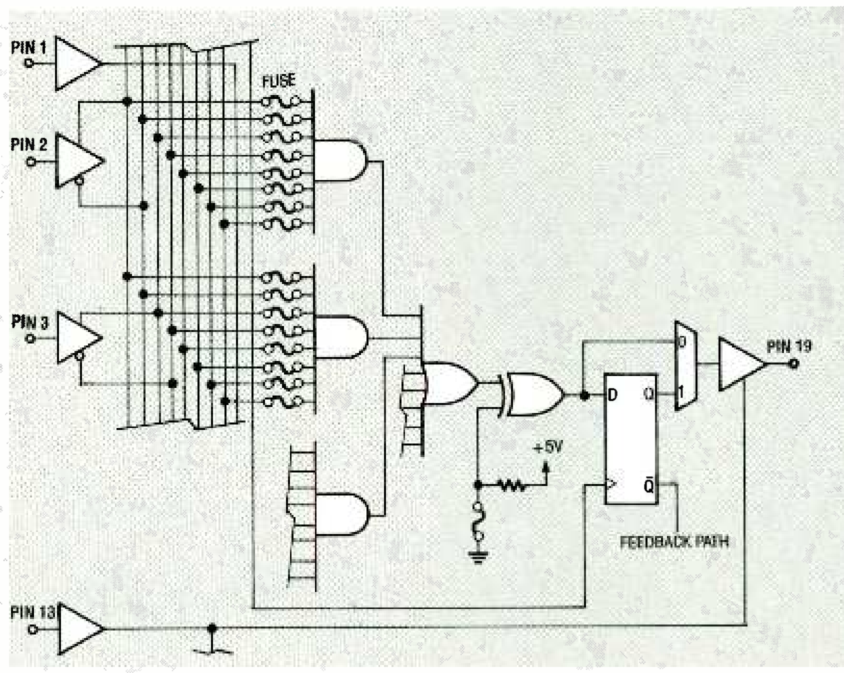
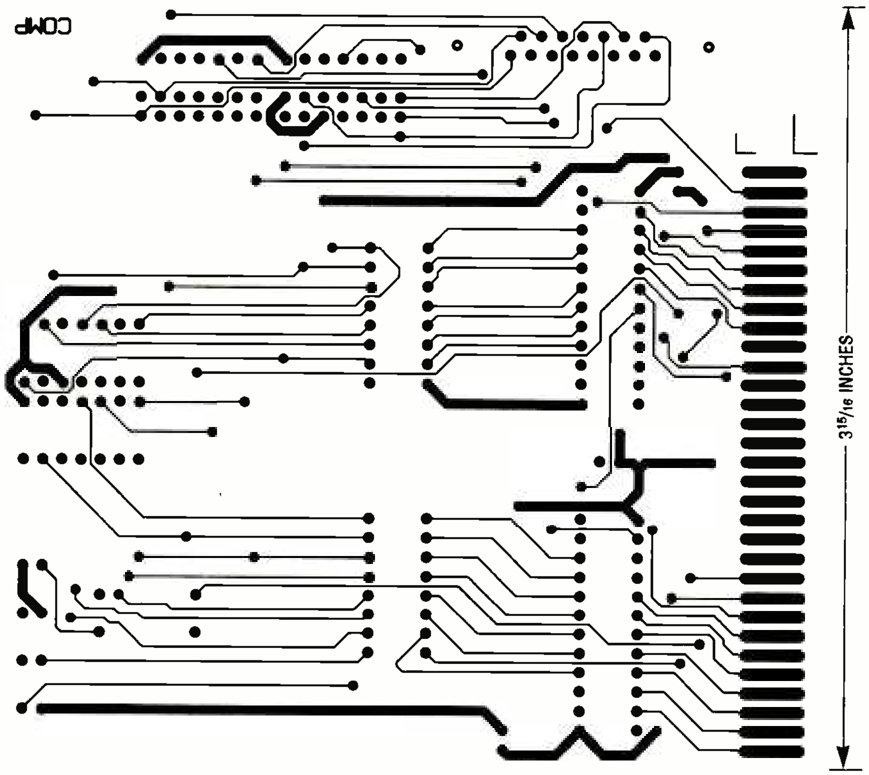
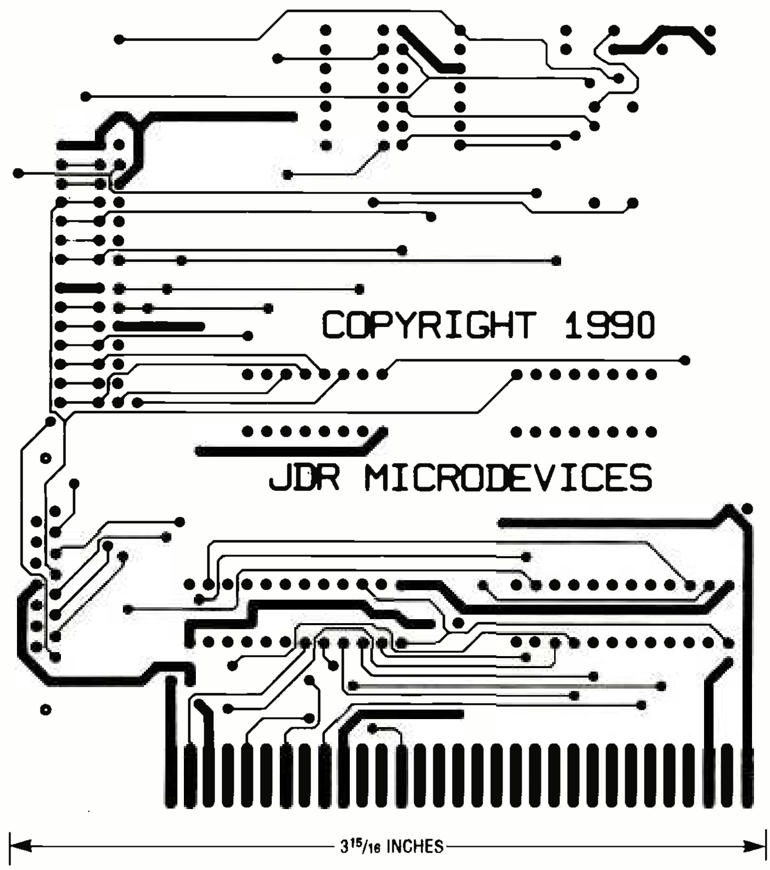


FIG. 2—SIMPLIFIED GAL VIEW indicates the logical complexity that can be hidden in a 24-pin 0.3" DIP.



PCODE COMPONENT SIDE.



PCODE SOLDER SIDE.

PARTS LIST

- R1, R2—820 ohms
- R3, R4—330 ohms, 8-position DIP package
- C1, C2—10 µF, 16 volts, tantalum
- C3—0.1 µF, 16 volts, tantalum
- IC1, IC2—G20V8 GAL
- DISP1, DISP2—MAN72 7-segment LED display (or equivalent)
- J1—15-pin D connector, female, PC-board mount
- LED1, LED4—T1-¾ green LED
- LED2, LED3—T1-¾ red LED
- IC Sockets, circuit board, mounting bracket and screws, etc.

Note: The following parts are available from JDR Micro-Devices, 2233 Samaritan Drive, San Jose, CA 95124, (800) 538-5000, (408) 559-1200:

- **Complete PostCode kit (including PC board, mounting bracket, all IC's, and LED's)—$39.95**
- **PC Board only—$14.95**
- **Programmed IC1 and IC2—$14.95**

CA residents add applicable sales tax.

the remaining 20 are used as general-purpose I/O. Of the 20, 12 are dedicated as inputs, and eight can be programmed as either inputs or outputs. Programming and erasing a GAL involves applying specific voltages in specific sequences. For detailed information on designing with GAL's, request data from a GAL vendor (e.g., AMD, Gould, Harris, Intel, Lattice, Motorola, National Semiconductor, Rockwell, SEEQ, Signetics, TI, Xicor, or Zilog).

Designing with GAL's

If you just want to use a GAL, you don't need to worry about the bit-banging that goes on in programming and erasing. In fact, that's the whole purpose of PLD's in general and GAL's in particular. Instead, you concentrate on the logic of what you're trying to do. Doing so allows you to be productive almost immediately.

Let's take an example. Suppose you have a conventional TTL design that you want to convert to PLD's. You might do the following:

1. Eliminate discrete inverters

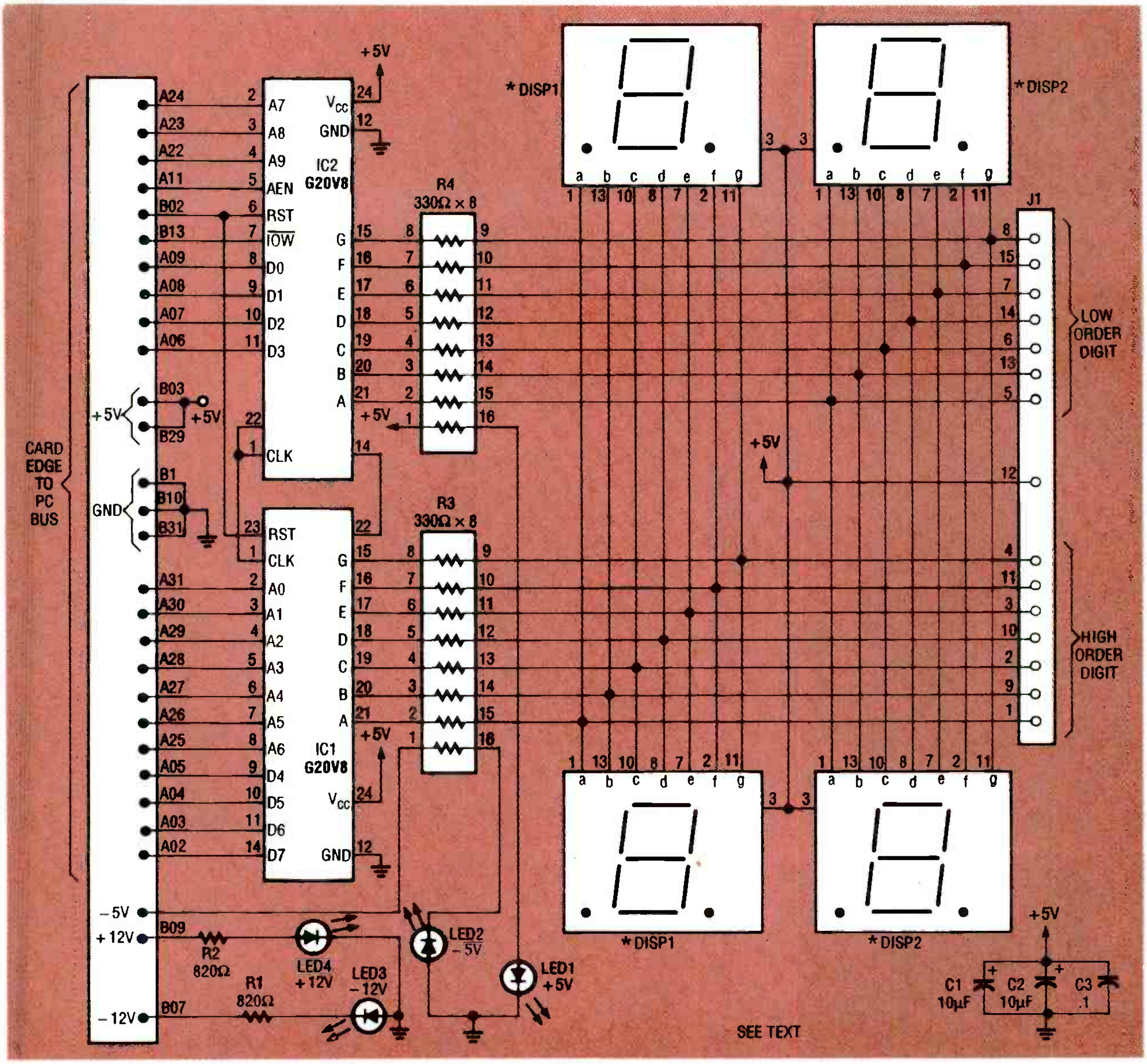


FIG. 3—COMPLETE SCHEMATIC of the POST Code display board appears here. Note that IC1 and IC2 perform all of the decoding, latching, and display driving shown in the functional diagram (Fig. 1) thereby replacing about 40 IC's.

by moving inversions to source or destination logic connections.

2. Name the signals in your TTL circuit.
3. Count the number of input and output signals.
4. If the number of inputs and outputs exceeds the capacity of the intended device, break the logic into sections for partitioning into several devices.
5. Write equations that describe the logic of your TTL design and that can be processed by a logic compiler.
6. Run the compiler and generate an object file.
7. Use the object file, a PLD programmer, and special software to "burn" the code into the device.
8. Test the device; if necessary, modify your equations, and go back to Step 6.

How would you apply that sequence to a practical problem? Take a look at Listing 1 and Listing 2, the source files for the GAL's used in PCODE. Note that the two listings share a structural similarity. Both begin with a header that specifies part name and number, date, revision number, etc. Then comes a section of comments, followed by specifications of inputs, outputs, intermediate variables, and last, the logic equations. To understand the latter, take an example logic equation from Listing 2.

```
SELECT = POST & !IOW & !AEN &
         LOWOK & !RESET
```

That statement says that SELECT is true when POST, IOW, and LOWOK are all true; in addition, AEN and RESET must both be false. You can see that the equation is a very compact way of notating circuit logic.

After creating the source file, run the PLD compiler. There are several commercial options including CUPL from Logical Devices. CUPL will compile the

LISTING 1—PLD SOURCE FOR IC1

```
Name        POST1;
Partno      POST1;
Date        04/07/90;
Revision    01;
Designer    DERICK;
Company     JDR Microdevices;
Assembly    00001;
Location    U1;
Device      G20V8;

/****************************************************************/
/*                                                              */
/*   TURNS HEX INTO 7 SEGMENT HEX DISPLAY INFO                  */
/*                                                              */
/****************************************************************/
/*  Allowable Target Device Types: G20V8                        */
/****************************************************************/

/**  Inputs  **/

Pin    1   = CLOCK    ;    /* FROM SELECT ON OTHER GAL          */
Pin    2   = A0       ;    /*                 +-----------+     */
Pin    3   = A1       ;    /*                 |A      VCC|      */
Pin    4   = A2       ;    /*                 |F        B|      */
Pin    5   = A3       ;    /*                 |VCC       |      */
Pin    6   = A4       ;    /*                 |          |      */
Pin    7   = A5       ;    /*                 |         G|      */
Pin    8   = A6       ;    /*                 |         C|      */
Pin    9   = D0       ;    /*  D4             |DB        |      */
Pin   10   = D1       ;    /*  D5             |E        D|      */
Pin   11   = D2       ;    /*  D6             +-----------+     */
Pin   14   = D3       ;    /*  D7                               */
Pin   23   = RESET    ;    /*                                   */

/**  Outputs  **/

Pin   15   = !SEGG    ;    /*              ---A---              */
Pin   16   = !SEGF    ;    /*             |       |             */
Pin   17   = !SEGE    ;    /*             F       B             */
Pin   18   = !SEGD    ;    /*             |---G---|             */
Pin   19   = !SEGC    ;    /*             E       C             */
Pin   20   = !SEGB    ;    /*             |       |             */
Pin   21   = !SEGA    ;    /*              ---D---              */
Pin   22   = LOWOK    ;    /*                                   */

/** Declarations and Intermediate Variable Definitions **/
FIELD ADDRESS = [A6..0];
FIELD DATA = [D3..0];
POST = ADDRESS:[080];

/**  Logic Equations  **/
LOWOK = POST;

SEGA.D = DATA:[0,2,3,5,6,7,8,9,A,C,E,F] & !RESET;
SEGB.D = DATA:[0,1,2,3,4,7,8,9,A,D] & !RESET;
SEGC.D = DATA:[0,1,3,4,5,6,7,8,9,A,B,D] & !RESET;
SEGD.D = DATA:[0,2,3,5,6,8,B,C,D,E] & !RESET;
SEGE.D = DATA:[0,2,6,8,A,B,C,D,E,F] & !RESET;
SEGF.D = DATA:[0,4,5,6,8,9,A,B,C,E,F] & !RESET;
SEGG.D = DATA:[2,3,4,5,6,8,9,A,B,D,E,F] & !RESET;
```

LISTING 2—PLD SOURCE FOR IC2

```
Name        POST2;
Partno      POST2;
Date        04/07/90;
Revision    01;
Designer    DERICK;
Company     JDR Microdevices;
Assembly    00002;
Location    U2;
Device      G20V8;

/****************************************************************/
/*                                                              */
/*   TURNS HEX INTO 7 SEGMENT HEX DISPLAY INFO                  */
/*                                                              */
/****************************************************************/
/*  Allowable Target Device Types: G20V8                        */
/****************************************************************/

/**  Inputs  **/

Pin    1   = CLOCK    ;    /* WRAPPED FROM SELECT OUT PIN       */
Pin    2   = A7       ;    /*                 +-----------+     */
Pin    3   = A8       ;    /*                 |A      VCC|      */
Pin    4   = A9       ;    /*                 |F        B|      */
Pin    5   = DMAAEN   ;    /*                 |VCC       |      */
Pin    6   = RESET    ;    /*                 |          |      */
Pin    7   = !IOW     ;    /*                 |         G|      */
Pin    8   = D0       ;    /*  DO             |         C|      */
Pin    9   = D1       ;    /*  D1             |DB        |      */
Pin   10   = D2       ;    /*  D2             |E        D|      */
Pin   11   = D3       ;    /*  D3             +-----------+     */
Pin   14   = LOWOK    ;    /*                                   */

/**  Outputs  **/

Pin   15   = !SEGG    ;    /*              ---A---              */
Pin   16   = !SEGF    ;    /*             |       |             */
Pin   17   = !SEGE    ;    /*             F       B             */
Pin   18   = !SEGD    ;    /*             |---G---|             */
Pin   19   = !SEGC    ;    /*             E       C             */
Pin   20   = !SEGB    ;    /*             |       |             */
Pin   21   = !SEGA    ;    /*              ---D---              */
Pin   22   = !SELECT  ;    /* WRAPS TO CLOCK ON BOTH GALS       */

/** Declarations and Intermediate Variable Definitions **/
FIELD ADDRESS = [A9..7];
FIELD DATA = [D3..0];
POST = ADDRESS:[080];

/**  Logic Equations  **/
SELECT = POST & IOW & !DMAAEN & LOWOK & !RESET;

SEGA.D = DATA:[0,2,3,5,6,7,8,9,A,C,E,F] & !RESET;
SEGB.D = DATA:[0,1,2,3,4,7,8,9,A,D] & !RESET;
SEGC.D = DATA:[0,1,3,4,5,6,7,8,9,A,B,D] & !RESET;
SEGD.D = DATA:[0,2,3,5,6,8,B,C,D,E] & !RESET;
SEGE.D = DATA:[0,2,6,8,A,B,C,D,E,F] & !RESET;
SEGF.D = DATA:[0,4,5,6,8,9,A,B,C,E,F] & !RESET;
SEGG.D = DATA:[2,3,4,5,6,8,9,A,B,D,E,F] & !RESET;
```

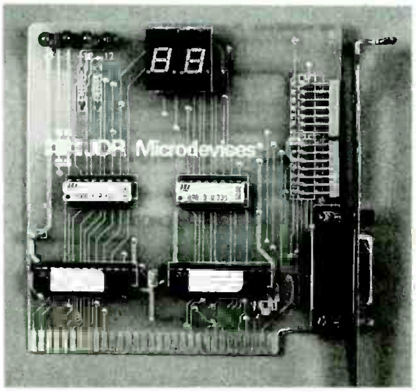


FIG. 5—NOTE THE DISPLAY SOCKETS mounted at right angles to the PC board.

source file and output an object file in several formats. For example, to create a JEDEC-compatible file for the programmer, you might enter the following DOS command line.

C:>CUPL -J PCODE

Next you would use a programmer to burn the logic specified by PCODE.JED into the selected device. PLD programming software normally reads object files in several formats, and can program and erase several types of devices.

Circuit description

With that under our belts, the rest is easy, as shown in Fig. 3. Note that IC1, DIP resistor R3, and DISP1 form a group that decodes, drives, and displays the most-significant digit; similarly, IC2, R4, and DISP2 do the least-significant digit.

Our design provides three possibilities for mounting the displays: 1) A pair of sockets mounted flat against the board. 2) Another pair mounted at a right angle so they can be seen through a hole in the mounting bracket. 3) Connections necessary for remote viewing via a 15-pin female D connector.

The first option is for "case-open" troubleshooting of a motherboard. The second is for "case-closed" motherboard monitoring. The third might be used in a situation where it's necessary to verify correct operation remotely. Regardless which display option you choose, *only use one pair of displays at a time*, because of current-sinking limitations of the GAL's.

One note about the card-edge connector pin numbers: We show the official IBM pin names and numbers: if you purchase the kit mentioned in the Parts List, the names and numbers may vary.

Construction and testing

This circuit is simple, but there are lots of interconnections, hence we recommend use of a PC board. Patterns are shown here; etched and drilled boards are also available.

Using the parts-placement diagram shown in Fig. 4, mount the two discrete resistors followed by the sockets for the IC's, resistor networks, and seven-segment LED displays. The sockets for the displays that can be seen through the mounting bracket must be mounted at a right angle, as shown in the photograph of PCODE in Fig. 5.

Mount the capacitors and dis-

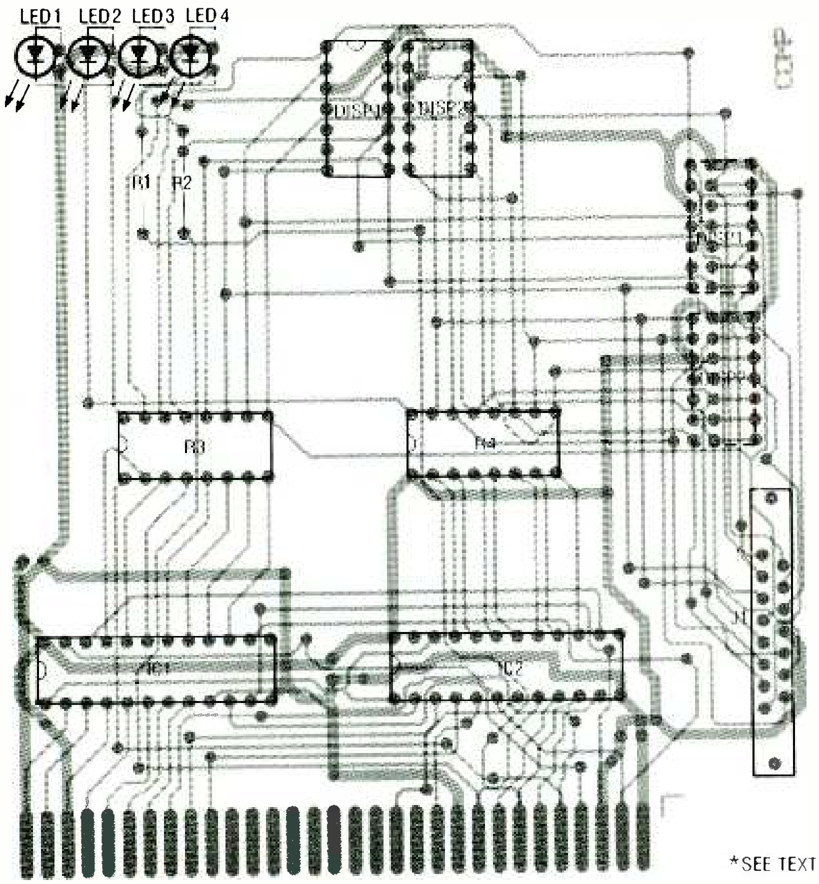


FIG. 4—MOUNT ALL COMPONENTS as shown here.

crete LED's. Last, mount J1 and attach a PC expansion-bus mounting bracket to it. Check your work carefully for shorts between traces and for bad solder joints; make any required corrections.

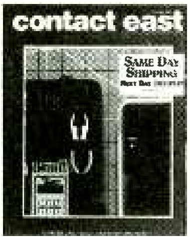
If you're not purchasing preprogrammed GAL's, you can burn your own using JEDEC format files available on JDR's BBS (408-559-0253). They are also available on the *Electronics Now BBS* (516-293-2283). Otherwise, you'll have to enter the logic equations (Listing 1 and Listing 2), compile them, create object files, download them to your device burner, and then burn the GAL's. We can't provide specific directions on those operations, as they depend on the software and hardware you use.

Insert the GAL's and the remaining components in the appropriate sockets on the PC board and make a final visual check. If all seems well, turn off the power and remove the case from a working PC; then insert the board in any vacant 8- or 16-bit slot. When you reapply power, the PC should boot as normal, but PCODE should display a sequence of codes as each POST test occurs. If the board seems to function properly, you can now use it to help diagnose nonfunctional units.

Other applications

PCODE was designed to test new motherboards, diagnose problems with existing boards, and provide more detailed information than the "beep" codes emitted by most BIOS's.

However, the ideas presented here have applications that extend way beyond a simple display unit. Designing with GAL's will allow you to create your own simple PC-bus interface circuits. Using a GAL to simplify the decoding, buffering, and latching of I/O ports will allow you to add your own analog and digital inputs and outputs. Now you can monitor and control anything that can be represented by a voltage or current. First POST codes, then the world! Ω



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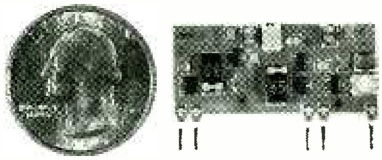

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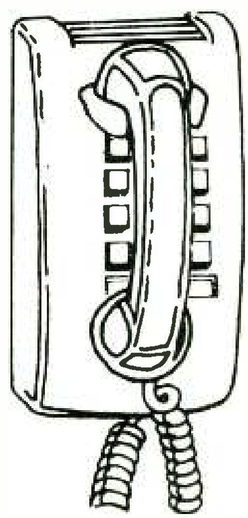

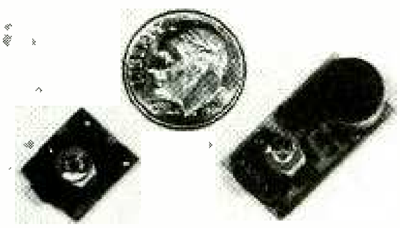

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The Video Master, described in this article, consists of a series of converters that place all your video sources on unused UHF channels and then combines them with normal TV channels (terrestrial or cable) into one cable. That one cable can then feed several TV sets for whole-house coverage. The desired video source is selected with the TV set's tuner. All of the TV's remote-control features are retained, and you'll be able to switch between any of the sources simply by changing the channel!

Keep in mind that it's illegal to insert unauthorized signals into any public cable system. An isolation amplifier, incorporated in the Video Master's design, prevents signals from feeding back into the cable system. *Do not omit the amplifier portion of the system for any reason.*

Figure 1 shows a block diagram of a typical system setup with the Video Master. It shows a TV antenna (or cable system), satellite TV receiver, VCR, security camera, video game, and laserdisc player, all feeding the Video Master. Notice that all inputs (except cable or antenna) are on Channel 3. There are five upconverters (1 through 5) and a buffer amplifier/power supply module, which supplies +12-volts DC to the upconverters.

The six outputs are combined with a splitter in reverse so that it acts as a signal combiner. The splitter feeds the combined output to all the TV sets in the system. The combined output contains all terrestrial or cable channels (VHF 2–13, MID-BAND, UHF, etc.) in the original locations, plus five new channels—36, 39, 42, 59, and 61. Those five new channels carry the signals from the satellite TV, VCR, security camera, video game, and laserdisc player. Any TV on the system can select any signal source by tuning to its new channel.

A buffer amplifier and power supply module inputs the broadcast or cable channels into the system and prevents signals from being fed back to the antenna or cable system. The amplifier also provides about a 7-dB gain to overcome unavoidable losses in the combiner network at the output of the system. The power supply is fed by either 12–14 volts AC or 15–20 volts DC; it supplies +12 volts DC at up to 180 milliamperes to power as many as five upconverters. (The amplifier/power supply module requires about 30 milliamperes, and each upconverter module requires about 35 milliamperes.)

Block diagrams of the upconverter and amplifier modules are shown in Fig. 2. The upconverters consist of a preamplifier operating at 60–66 MHz, with 23-dB gain, and a two-pole bandpass filter between the amplifier and mixer. A double-balanced mixer combines the 60–66 MHz (Channel 3) TV signal with a local oscillator (LO). The LO is set to operate at a frequency 60 MHz below the low end of the desired output signal. For example, to obtain an output on Channel 39 (620–626 MHz), the LO must be at 560 MHz.

Several outputs appear at the mixer output: the original Channel 3 signal, the LO signal, and their sum and difference frequencies. A three-pole bandpass filter selects the desired output (the sum of LO + Channel 3) and rejects the difference frequency. (Theoretically, a double-balanced mixer produces no LO or Channel 3 output, but the mixer used here is not a perfect device, and those frequencies still appear.) The Channel 3 signal is severely attenuated, but the LO signal is suppressed by only 25 dB. Because the LO level must be about +7 dBm (decibels above one milliwatt) or about 0.3 to 0.5 volts rms at the mixer input, the LO appearing at the mixer output is still −18 dBm (about 30 millivolts rms). The desired Channel 39 signal is at about −34 dBm (approximately 4 millivolts rms). Therefore, the LO signal is about 16dB stronger than the desired Channel 39 signal, even using a balanced mixer and keeping the input signal level as high as possible (10 millivolts) to avoid generating excessive spurious signals. The LO signal can interfere with another channel 60 to 66 MHz lower (in this case, Channel 28).

If the LO signal is suppressed to less than half a millivolt, it causes no problems as long as it is placed outside an existing UHF channel. Because typically ten or fewer UHF channels can be received in any given area, ten or fewer new channels—or upconverters—will be needed. The upconverter channel outputs must be selected so as to

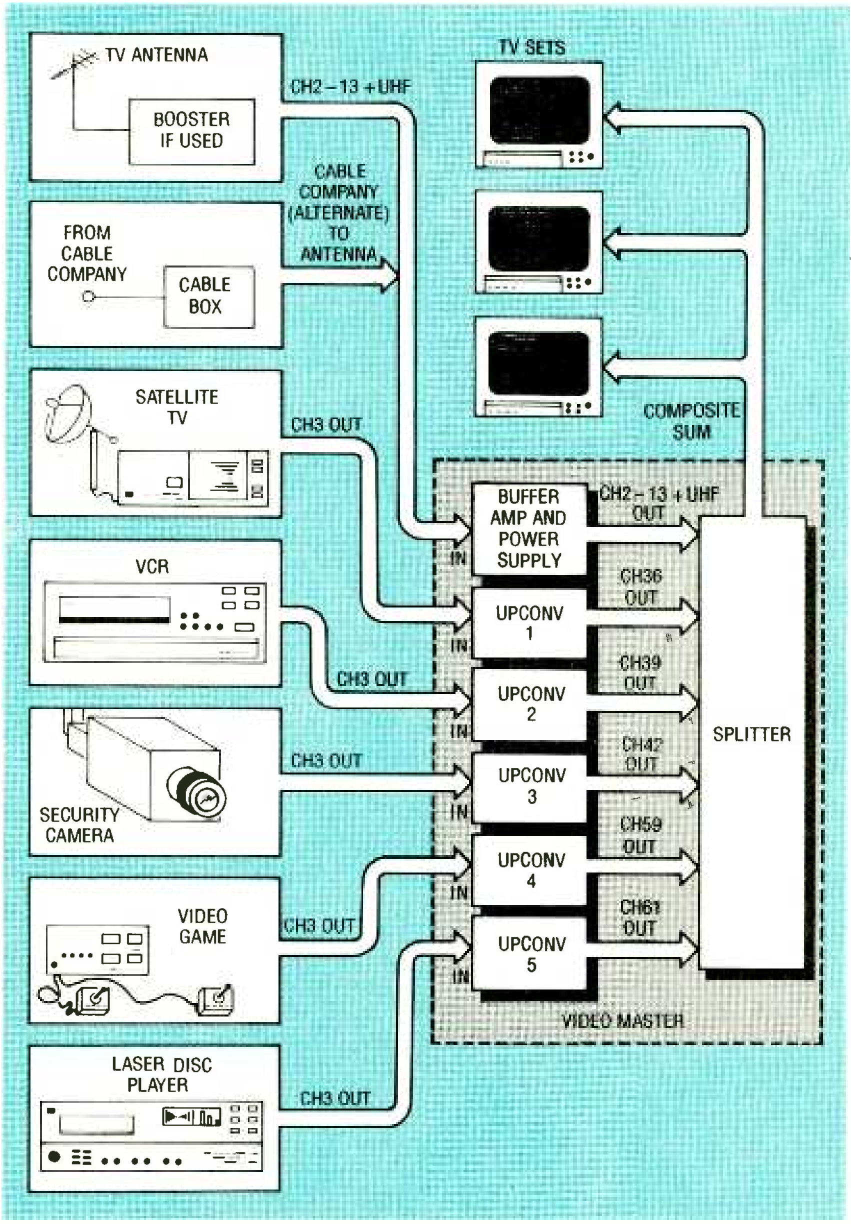


FIG. 1—THE VIDEO MASTER lets you convert Channel-3 outputs from many video devices to unused cable channels, combine them with your normal channels, and view them from any cable-ready set in your house, simply by tuning to the proper channel.

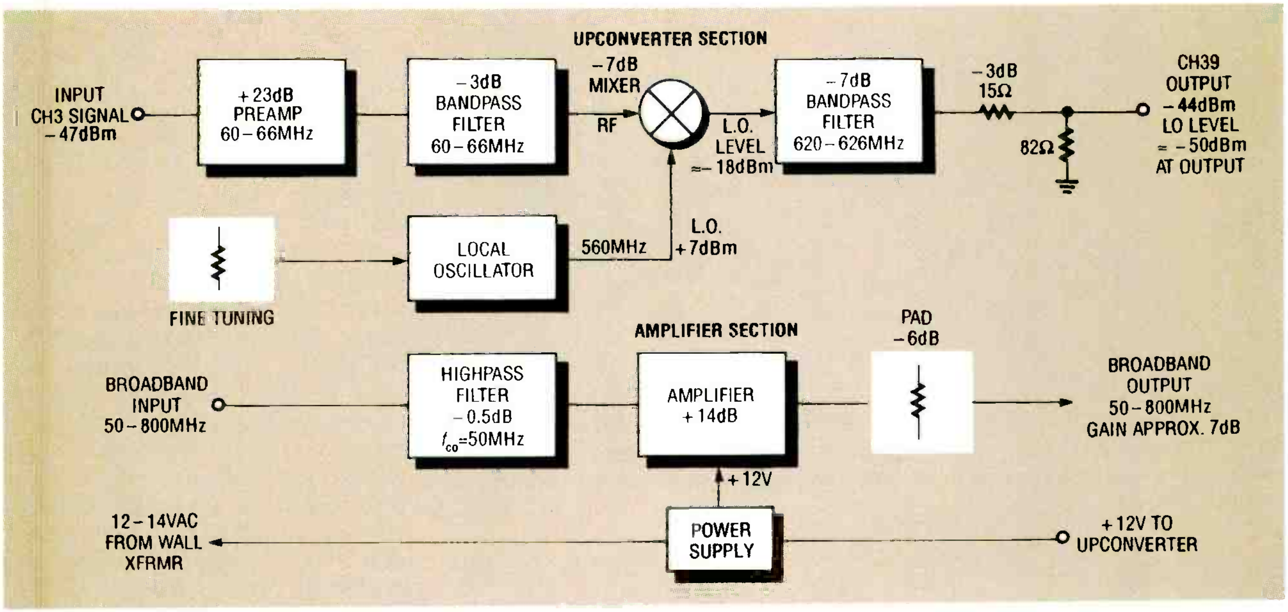


FIG. 2—BLOCK DIAGRAMS of an upconverter module and an amplifier/power supply module.

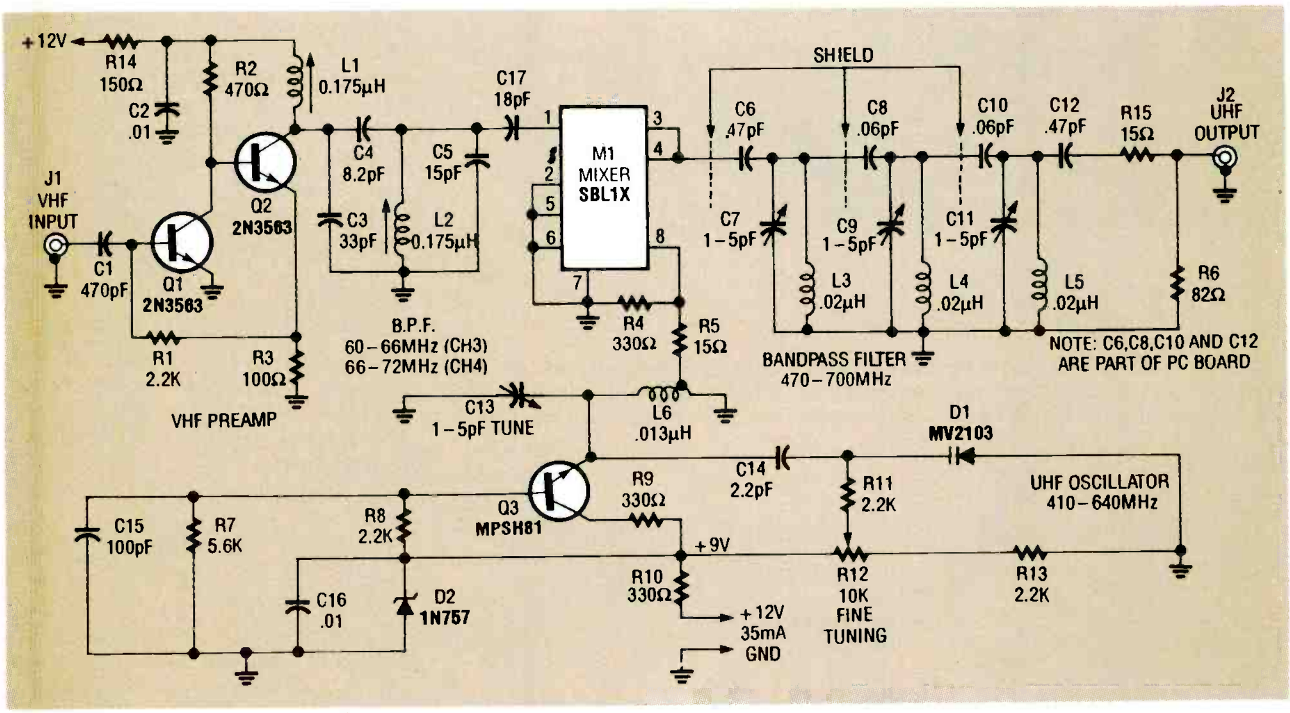


FIG. 3—VIDEO MASTER SCHEMATIC. This circuit inputs a VHF signal at J1 and converts and outputs it as a UHF signal at J2.

avoid placing the LO signal on top of an existing UHF channel. In our example, a Channel 39 upconverter output would have its LO at 560 MHz, and therefore it could interfere with Channel 28 and Channel 29. In an area where a UHF station exists on those channels, the upconverter should be moved up to Channel 41 or down to Channel 37 to avoid interference with Channel 28 or Channel 29. In general, do not select an output frequency 10 or 11 channels higher than our existing UHF channel or any UHF channel to be used by another upconverter in the system.

To reduce stray signal pickup and interference problems in general, individual upconverter and amplifier/power supply modules are used. That eliminates crosstalk problems, and simplifies shielding and circuit layout. The modular approach also lets you build only what you need, yet still allows future upgrades and expansion.

Circuitry

A schematic diagram of the upconverter is shown in Fig. 3, and its companion amplifier and power supply is shown in

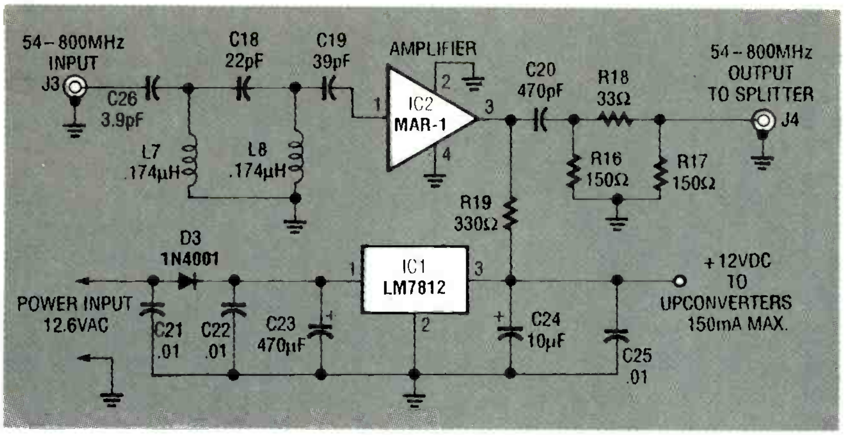
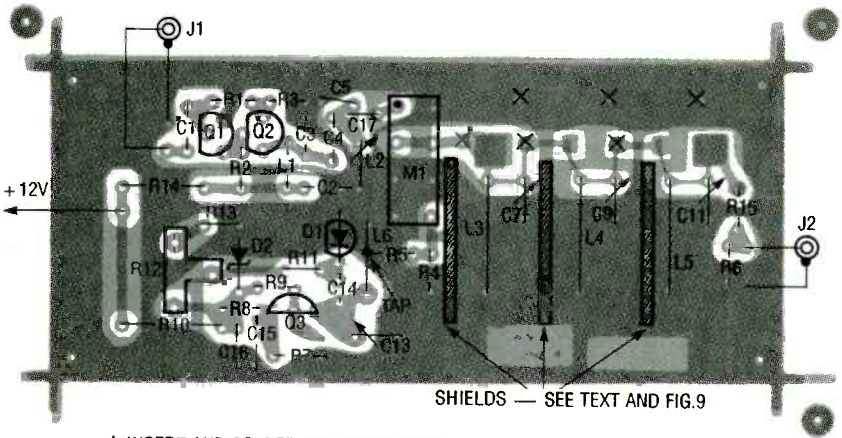


FIG. 4—AMPLIFIER/POWER SUPPLY MODULE. This circuit buffers and conditions your existing cable or antenna input and also supplies power to the upconverter modules.



* INSERT AND SOLDER JUMPER ON BOTH SIDES OF BOARD AT LOCATIONS MARKED "X"

FIG. 5—UPCONVERTER PARTS PLACEMENT. Be sure to solder leads on both sides of the board, and insert jumper wires through unused holes and solder them on both sides. Don't forget to install the shields between M1, L3, L4, and L5 (see Fig. 9).

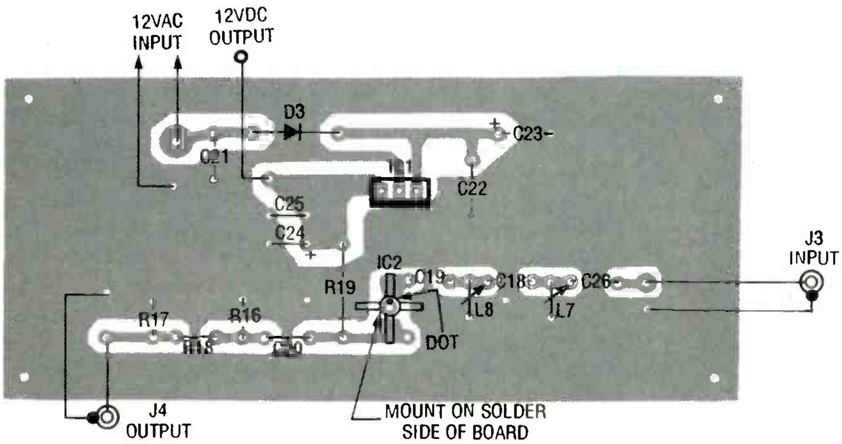


FIG. 6—PARTS-PLACEMENT DIAGRAM for the amplifier/power supply board.

Fig. 4. Channel 3 (VHF) input from a video device such as a VCR is supplied to J1. The signal level is assumed to be −47 dBm (about 1 to 2 millivolts). Capacitor C1 couples the input to an amplifier consisting of Q1 and Q2. The collector of Q2 feeds a filter with a 60–66 MHz passband. The filter components are L1, C3, coupling capacitor C4, L2, C5, and matching capacitor C6. The total gain at the mixer input (pin 1 of M1) is about 20dB referenced to J1.

Mixer M1 is driven by a UHF LO signal that is 60 MHz lower than the desired channel. Transistor Q3 is in the oscillator; R7, R8, and R9 are bias resistors, and C15 grounds the base of Q3 for UHF signals. Variable capacitor C13, coil L6, and the capacitance of the series combination of C14 and varactor diode D1 determine the frequency. Potentiometer R12, R13, and R11 supply DC bias to varactor D1, which allows fine tuning of Q1's frequency by ±3 MHz. The oscillator signal (about 0.3 to 0.5 volts) is supplied through R5 and R4 to pin 8 of M1. The mixer output appears at pins 3 and 4 of M1, where about 4 millivolts of desired signal (the output) is present, along with 25–30 millivolts of residual LO signal. The output is fed to tunable bandpass filter made up of C6, C7, L3, C8, C9, L4 and C10, C11, C12 and L5. (Due to the very low values of capacitors C6, C8, C10, and C12, they are not discrete components, but are formed by traces on the PC board.)

Filter loss is about 7dB, and the bandwidth is about 10 MHz, depending on the center frequency. A simple attenuator pad formed by R15 and R6 reduces the detuning effect of varying loads connected to J2. The filter is a three-pole zero-ripple (Butterworth) type that allows easy alignment. In practice, the filter can be tuned simply by watching the output signal on a UHF TV receiver. It provides up to 50dB LO suppression with respect to the center frequency. Overall gain from J1 to J2 is about +3 to +6dB. That allows for loss in combining the output of J2 with the outputs of additional converters.

Figure 4, the amplifier-section schematic, shows that the antenna or CATV input is applied to J3. A high-pass filter formed by C26, C18, C19, L7, and L8 attenuates unwanted signals (such as shortwave, CB, amateur, and AM) below 50 MHz. A monolithic microwave integrated circuit (MMIC) amplifier, IC2, has a broadband gain of about 14dB. Resistor R19 provides DC bias to IC2, and C20 couples the amplified output to resistors R16, R17, and R18 (which sets the total gain to about +7 to 8dB) and to J4. The amplifier compensates for the inevitable loss in the signal-combining network connected to J4.

A 12.6-volt AC wall-mounted transformer feeds components C21, D3, C22, and C23. Those components supply approximately 16-volts DC to the input of an LM7812 regulator (IC1), which supplies 12-volts DC to the rest of the circuit. (If desired, +15 to +20 volts DC can also be introduced to the supply. In that case, D3 would guard against reversed DC power-input polarity.)

Construction

The PC board for the upconverter is double-sided, and the board for the amplifier and power supply is single-sided; foil patterns are provided for both. Parts-placement diagrams for the two boards are shown in Figs. 5 and 6, respectively. Do not change the PC layout, because filter characteristics are dependent on it. PC boards and complete parts kits are available from the source given in the Parts List.

Although the upconverter boards are double-sided, they are not through-hole plated. Therefore, solder all component leads on both sides of the board wherever there is copper foil on both sides. In addition, you must place grounding jumpers in all holes marked with an "X," and solder them on both sides of the board to connect the top and bottom foils. Short lead lengths are important in RF projects because long leads can act as antennas. Also, mount all components snugly against the circuit board and clip their leads close to the board.

Although it would be possible to integrate inductors L3, L4, L5, and L6 into the PC board, the resulting printed inductors would have Q values that are too low, and there could be stray coupling and shielding difficulties. A high value of Q is necessary for L3, L4, and L5 to achieve narrow filter bandwidth, and for L6 to stabilize the oscillator. Those coils are made from lengths of No. 18 AWG wire as shown in Fig. 7.

Note that shields—small scraps of G-10 double-sided PC-board material from 0.020- to 0.062-inch thick—must be soldered after standing them on

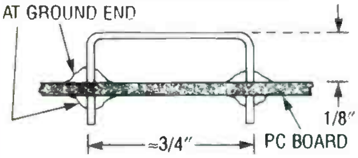
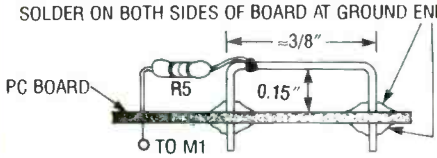
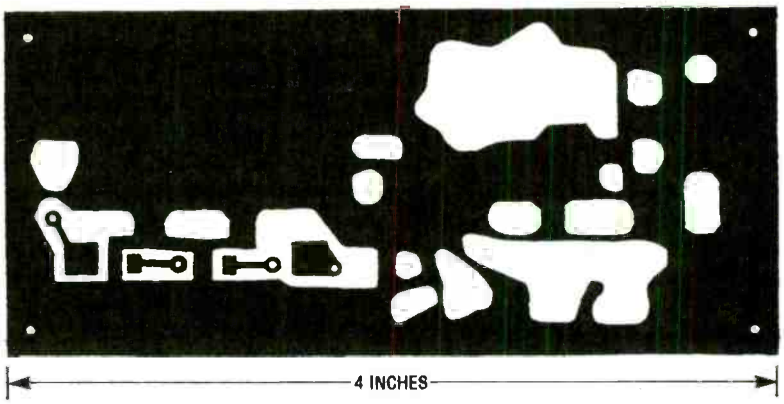
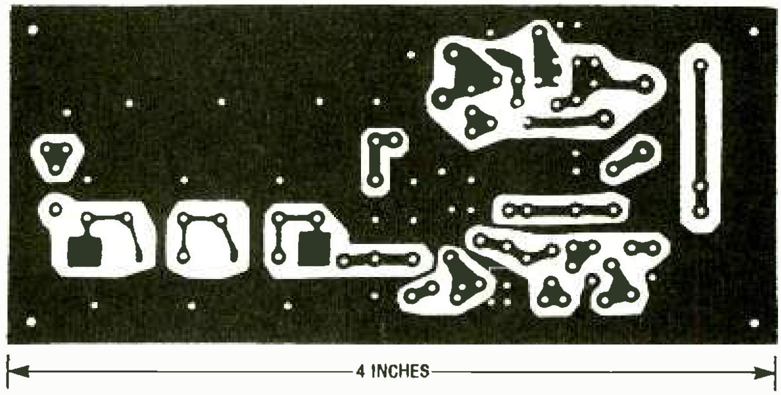
PART #	INDUCTANCE	CONSTRUCTION
L1,L2 65MHz FILTER COILS	.105–.230µH	 6½ TURNS OF 22-GAUGE ENAMELED WIRE WIND WIRE IN THREADS OF 8–32 SCREW, FORM LEADS TO FIT PC BOARD, TIN LEADS, REMOVE SCREW, AND INSTALL SLUG
L3,L4,L5 UHF FILTER RESONATORS	0.02µH	18-GAUGE WIRE BENT TO FIT PC BOARD 
L6 OSCILLATOR INDUCTANCE	0.013µH	18-GAUGE WIRE BENT TO FIT PC BOARD MAKE TAP FOR R5 CLOSEST TO GROUND END OF L6. POSITION CAN BE ADJUSTED TO VARY L.O. DRIVE 
L7,L8 HIGH-PASS FILTER COILS AMP/POWER SUPPLY	0.174µH	 9-½ TURNS OF 22-GAUGE ENAMELED WIRE WIND WIRE IN THREADS OF 8–32 SCREW, FORM LEADS TO FIT PC BOARD, TIN LEADS, AND REMOVE SCREW (NO SLUG USED)

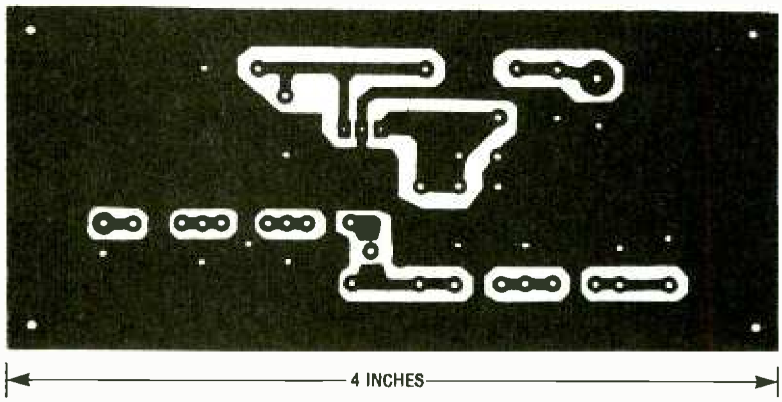
FIG. 7—COILS L1–L7 are made according to these instructions.



COMPONENT SIDE of the upconverter board.



SOLDER SIDE of the upconverter board.



SOLDER SIDE of the amplifier/power supply board.

edge on the top ground plane of the upconverter PC board between M1, L3, L4, and L5 in the locations shown in Fig. 5. The shields are necessary for proper filter performance because they keep down spurious outputs—especially the LO residual leakage. The shields must be well soldered to the top of the PC board.

Mount each converter in its own enclosure. A suitable case is included with the previously mentioned upconverter kits. Suitable connectors are F, BNC, TNC, or SMA—do not use UHF or RCA connectors. Figure 8 shows a suitable packaging scheme for the upconverter board and the amplifier board. Do not omit the three shields in the upconverter filter section, as shown in the photo of the board in Fig. 9. Figure 10 is a photograph of the amplifier/power supply board.

Figure 11 shows one way to mount several modules together to make up a system. The module outputs all connect to the "outputs" of a passive split-

PARTS LIST

All resistors are ⅛ watt, 5%, unless otherwise noted.

R1, R8, R11, R13—2200 ohms
R2—470 ohms
R3—100 ohms
R4, R9—330 ohms
R5, R15—15 ohms
R6—82 ohms
R7—5600 ohms
R10, R19—330 ohms, ¼-watt
R12—10,000 ohms, potentiometer
R14—150 ohms, ¼-watt
R16, R17—150 ohms
R18—33 ohms

Capacitors

C1, C20—470 pF, ceramic disc
C2, C16, C21, C22, C25—0.01 µF, ceramic disc
C3—33 pF, 5%, NPO
C4—8.2 pF, 5%, NPO
C5—15 pF, 5%, NPO
C6, C8, C10, C12—Part of PC board
C7, C9, C11, C13—1–5 pF trimmer
C14—2.2 pF ±0.5 pF, NPO
C15—100 pF, 10%, NPO
C17—18 pF, 5%, NPO
C18—22 pF, 5%, NPO
C19, C26—39 pF, 5%, NPO
C23—470 µF, 25 volts, electrolytic
C24—10 µF, 16 volts, electrolytic

Semiconductors

IC1—LM7812 12-volt regulator
IC2—MAR1 MMIC
D1—MV2103 varactor diode
D2—1N757 9-volt Zener diode
D3—1N4001 diode
Q1, Q2—2N3563 NPN transistor
Q3—MPS H81 NPN transistor

Other components

L1, L2—6½ turns No. 22 AWG enameled wire wound on 8-32 screw with 8-32 ferrite slug (see Fig. 7)
L3–L5—0.02 µH (¾-inch No. 18 AWG wire, see Fig. 7)
L6—0.013 µH (½-inch No. 18 AWG wire, see Fig. 7)
L7, L8—0.174 µH (9½ turns No. 22 AWG enameled wire wound on 8-32 screw)
M1—SBL1X mixer
J1–J4—chassis-mount F-connector

Miscellaneous: PC boards, one shielded enclosure per module, hardware, feedthroughs or bushings for power inputs and outputs, 12.6-volt AC wall transformer, two feet of 22-gauge enameled copper wire, two feet of 18-gauge tinned copper wire, 2- or 4-way splitter, 75-ohm cable, solder

Note: The following items are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804:

- **Amplifier/power supply kit (includes case, hardware, connectors, PC board, and all parts)—$29.50**
- **Upconverter kit (includes case, hardware, connectors, PC board, and all parts)—$34.50**
- **Four-way splitter—$5.50**
- **12.6-volt AC wall transformer—$ 9.50**

Please add $3.50 S&H (foreign orders $5.00) to any order. NY residents must add sales tax. For a catalog of other kits, please send $1 (refundable on next order) or SASE (52 cents postage) to North Country Radio at the above address.

ter. A passive splitter can be used as a combiner simply by running it backwards. That won't work for an active, amplified splitter.

The upconverter modules have a 3-dB gain, which is adequate for compensating for splitter loss. Because most video devices have an RF output of about 3dB above 1 millivolt, approximately 1 millivolt of UHF signal will appear at the system output for each channel, assuming the use of a four-way splitter and three upconverters. The cable level should be around 1 millivolt per channel, which will give about 50dB or better signal-to-noise ratio for the average TV receiver. Levels lower than 200 microvolts might yield a snowy picture. If necessary, the system output can be run through a distribution amplifier. Remember to terminate all unused splitter ports with 75-ohm terminating resistors.

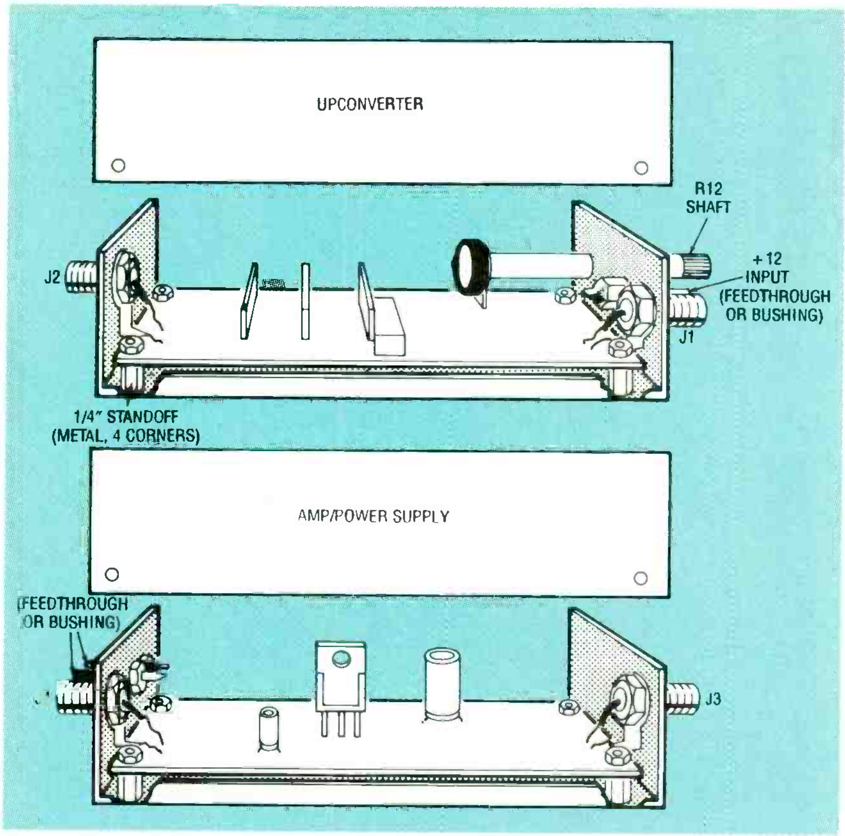


FIG. 8—SUGGESTED PACKAGING SCHEMES for the upconverter and amplifier/power supply boards.

Test and alignment

Alignment of the completed unit requires a video source on Channel 3 (your VCR will do) and a digitally tuned TV set. A frequency counter will also be helpful in this procedure.

First check out the amplifier/power supply. Connect a source of 12 to 14 volts AC, of at least 250 milliamperes to the junction of C21 and D3, and connect the remaining lead to ground—a plug-in wall transformer is recommended. Alternatively, a DC source of 15 to 20 volts can be used, with the positive lead to the C21-D3 junction, and negative lead to ground. Regardless of the supply you use, verify that there is 15 to 20 volts DC across C23.

Next check for +12 volts at the junction of IC1, C24, C25, and R15. If there is less than 11.5 volts or more than 12.6 volts, check to see if IC1 is defective or improperly inserted in the PC board. Check to be sure that IC1 does not get hot. If all tests are passed so far, check for +4 to +7 volts at pin 3 of IC2. Next check for infinite resistance from the center pin of J3 to ground. Next, check the resistance from J4's center conductor to ground; it should be about 80 ohms. Mount the board in a case, apply power, and connect a TV receiver to J4, and the antenna to J3. Normal

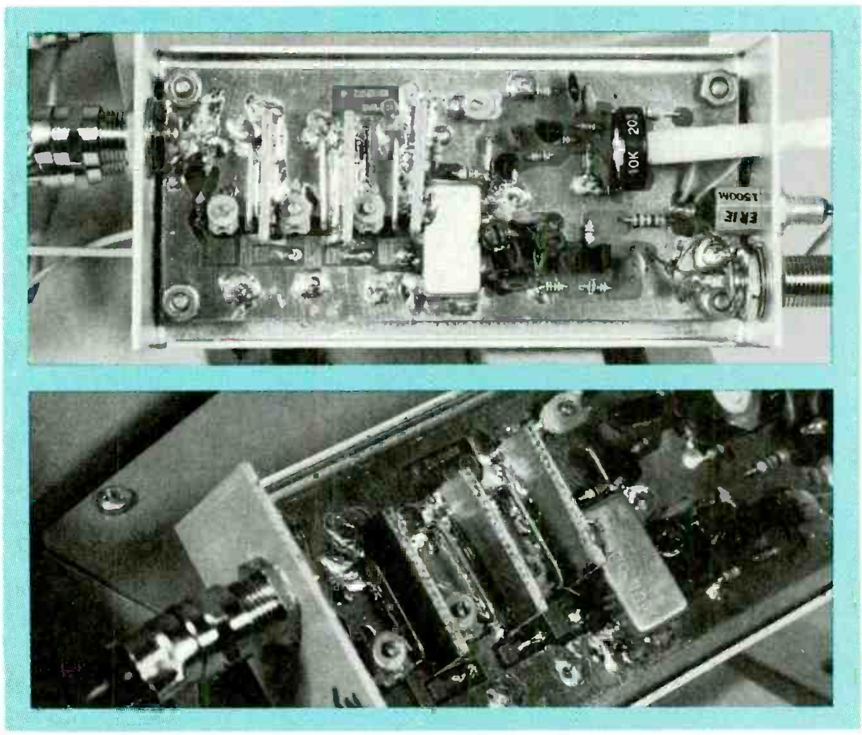


FIG. 9—UPCONVERTER BOARD. Note the shields, made from scraps of double-sided PC board material, that are placed between M1, L3, L4, and L5.

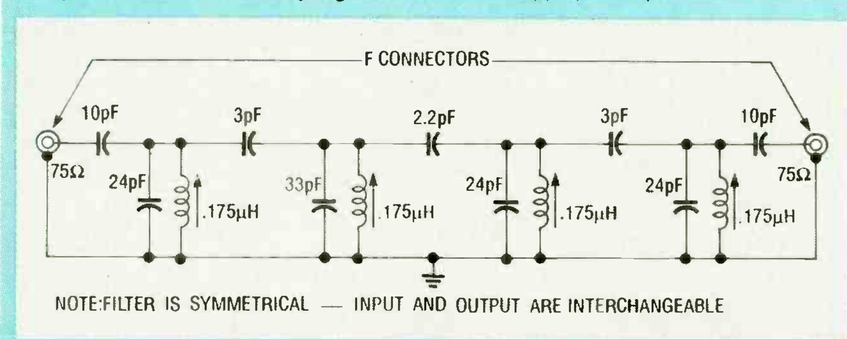
CABLE BOXES

There are many different types of cable boxes, but as far as the Video Master is concerned, there are only two types. One type contains a built-in video modulator and its output is spectrally clean enough for the Video Master.

However, many cable boxes are simply RF converters, and there are other frequencies mixed in with the Channel-3 or -4 output. You can easily test this by changing channels on the TV's tuner. If the TV can receive any channels other than Channel 3 (or 4), you could have problems with the upconverter modules that will show up as lines, ripples, noise, and beats in the picture.

If you have any of those problems and you're sure that no stray signals are leaking into your system, build the filter shown here. It's designed to pass only Channel 3, but it can be retuned for Channel 4. Its capacitors are all silver mica or NPO ceramic. The coils are 0.175 μH, and can be made in the same way as L1 and L2 in the upconverter modules.

The filter can be built on a scrap piece of G-10 copper-clad PC board material. It should be mounted in a shielded box and provided with F connectors for best results. It is aligned by peaking the coils for maximum signal on Channel 3. A VCR can be used as a signal source. The filter should be inserted between the cable box and the input connector on the appropriate upconverter. Ω



This filter will remove all signals except Channel 3 (or 4) from the output of your cable box.

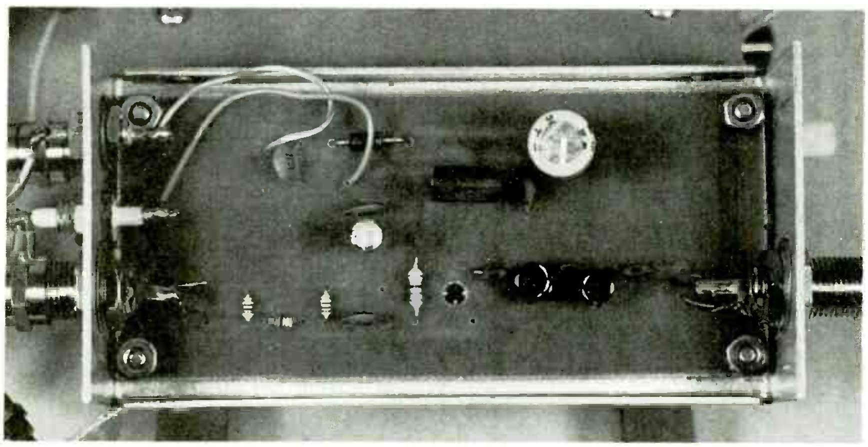


FIG. 10—AMPLIFIER/POWER SUPPLY. This board is mounted in the same type of case as the upconverter modules.

TV reception should result, with no loss of picture quality. If RF test equipment is available, measure the gain from J3 to J4. About 7 to 8dB should be obtained at 450 MHz (UHF), and slightly more on VHF (100 MHz). That completes the amplifier/power supply tests.

The upconverter board is tested as follows: After the board has been visually checked for shorts, solder bridges, and correct component placement, install the board in its case. Connect a Channel-3 source to J1 and connect a TV receiver to J2. Use 75-ohm cable. Apply power to the 12-volt input (the junction of R10 and R14), and check for the following voltages:

- Junction of D2 and R10—+8.4 to 9.5 volts
- Wiper of R12—+3 to 9 volts depending on setting of R12
- Junction of R11 and D1—+3 to 9 volts depending on setting of R12
- Emitter of Q3—+6 to 7.5 volts (adjusting C13 should vary the voltage by ±0.1 volt—this verifies that Q3 is oscillating)
- Base of Q3—+6 to 7.5 volts (adjusting C13 should vary the voltage by ±0.1 volt—this verifies that Q3 is oscillating)
- Emitter of Q2—+1 to 1.2 volts
- Base of Q2—+1.8 to 2.1 volts
- Collector of Q2—+8.5 volts (typical)
- Pin 8 of M1—0.3 to 0.5 volts RMS (this test is optional, and can only be done with an RF voltmeter)

Tune the TV receiver to the UHF channel on which you would like the upconverter to produce a signal. Set the slugs in L1 and L2 halfway in the coil winding. Set C7, C9, and C11 so that their plates are halfway engaged, and C13 fully engaged. Set R12 to mid-position. Turn on the source connected to J1. Slowly rotate C13 with a plastic alignment tool; at several points the TV set should exhibit a response of some kind. (If you have a frequency counter, connect it to pin 8 of M1 and set C13 for the correct oscillator frequency.) When you get a response, you might see a very weak picture, but at first you will probably only hear audio. Note the position of C13. Now look for other responses; the correct one will be where C13 is set at greater capacitance (more of the plates engaged).

The oscillator can produce an output either on the high or low side of the desired channel—you want the low side, otherwise the converter output will have picture and sound frequencies inverted from the usual positions. Next, slowly adjust C7, C9, and C11 for best picture and sound. Now go back to L1 and L2 and adjust for best picture quality as well as sound quality. Readjust C7, C9, and C11 for the best picture and sound. Repeat any alignment as needed.

The adjustment of trimmer

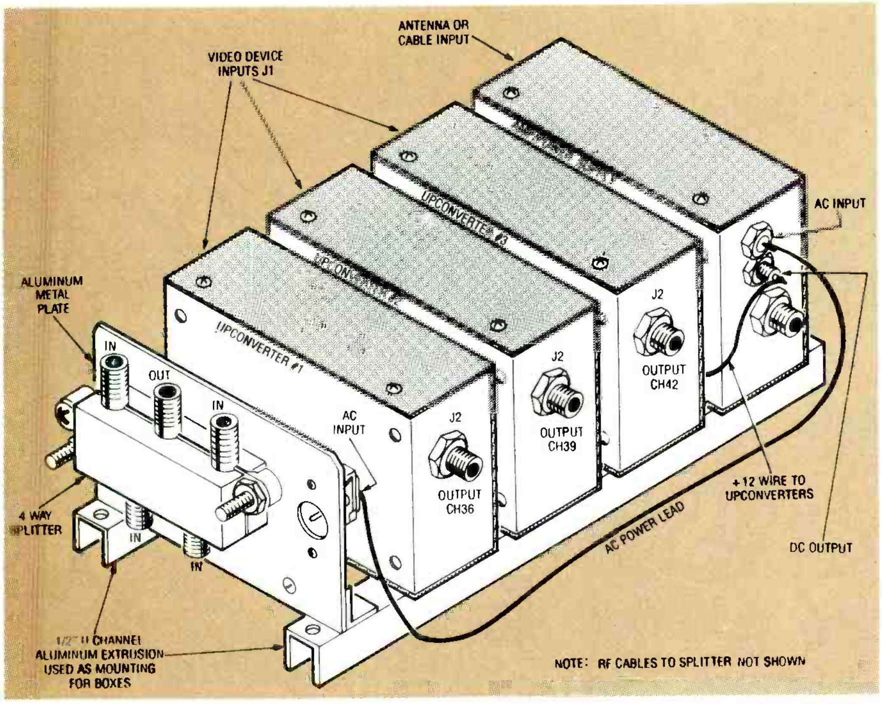


FIG. 11—ALL OF THE MODULES for the prototype Video Master are mounted together on a pair of aluminum rails, with everything feeding into a 4-way splitter mounted on one end of the assembly.

capacitors C7, C9, and C11 is very critical. Some difficulty might be experienced at first, "getting in the ballpark," since the bandpass filter is quite sharp (10 MHz), and it will have high attenuation when misaligned. Once you get a picture of any kind, the rest is easy. If the unit appears to work but the TV set tuning is critical, the picture "grainy," or the color poor, make sure that C13 is set on the proper side. (As mentioned before, there will be two settings, and the lower frequency is correct.) When aligned, the picture on the selected UHF channel should be of excellent cable quality.

After alignment is complete, verify the fine-tuning adjustment R12. Normally R12 is left in the halfway position, and adjusted only to touch up the frequency setting.

The upconverter can now be installed in your TV system, and should operate reliably with no attention from you. For overall system stability, we recommend leaving the upconverter system on all the time, hence no switch is installed in the system. Ω

CHRISTOPHER ZGURIS

Automatic FOUR-LINE TELEPHONE SELECTOR

Build this telephone ring selector circuit that will pick up on the first call received on multiple-line telephone installations.

A "BLACK BOX" THAT ALlows any standard single-line answering machine or telephone to answer up to four lines will make it easier to handle up to four phone lines in your home or office. Ring selector, the subject of this article, provides that service—without the need to modify any of your telephone lines.

As a bonus, the ring selector also works as a ringing-line router to allow a standard single-line telephone located in a remote location (such as a garage, basement, or workshop) to answer multiple lines. It can also route multiple lines to a cordless telephone so that no matter where you are, you can answer any line.

Figure 1 is the schematic for the ring selector. Its operation depends on board-mounted multipole and reed relays for switching the telephone line. The circuit consists of four identical switching circuits partitioned so that two switching circuits are on each of two separate boards for convenience in packaging. There is, however, only one line- sense relay and two 556 timer ICs that function as pulse stretchers for four circuits. The 556 is a dual 555, providing a 555 for each line.

How it works

Terminal strip TS1 mounted on the upper board accepts the wires from RJ-11 telephone jack J1 and RJ-45 telephone jack J2, as well as the positive and negative wires from the AC-to DC adapter. Assume that telephone line 1 rings. When the ringing pulse arrives, the ringing voltage and current are limited by diode D17 and resistor R29. The voltage at the anode of D17 falls to a level that energizes 5-volt reed relay RY13.

Because the ringing voltage is an an AC signal, the relay is energized and deenergizes very rapidly. While RY13 is energized, positive voltage is fed through it to transistor Q14, which turns on and momentarily grounds pin 6 of IC1. That triggers IC1's timing cycle. Output pin 5 goes high and remains high until the timing cycle ends. Positive voltage is then sent to Q9, which energizes SPST reed relay RY9. Transistor Q1 is also activated when RY13 is energized, and it sends a positive voltage to SCR1. With disable relay RY9, energized, SCR1 conducts and relay RY1 is energized.

Dual timer IC1 keeps the ringing line connected to telephone jack J1 by keeping RY9 energized, thus keeping the switching circuit based on SCR1 powered. The switching circuit is activated by SCR1 within the first half second of the ringing pulse.

With the switching circuit powered and the ringing line connected to J1, most of the ringing pulse is passed on to any equipment plugged into J1. As the pulse stretching function of IC1 ends and pin 5 goes low, the ringing pulse retriggers IC1, RY9 remains energized, and the switching circuit stays powered.

If the equipment connected to J1 goes off-hook, positive voltage flows from line-sense relay RY17 to transistor Q13, which also triggers IC1. Timer IC1 does not begin its timing cycle until after its INPUT pin 6 goes high again.

As long as power is applied to Q13, the output at pin 5 of IC1 will remain high, and the switching circuit will remain powered. Relay RY17 will remain energized as long as any equipment connected to J1 remains off-hook.

When that equipment goes on-hook, RY17 is deenergized and power no longer flows to Q13. When IC1 completes its timing cycle, RY9 will no longer conduct, and the switching circuit will be de-activated, line 1 will be disconnected from J1, and the ring selector will reset for the next telephone call. If the equipment on J1 does not go off-hook, the switching circuit will automatically shut down and reset after line ringing stops.

With the switching circuit powered, RY1 energizes. Relay RY1 has two main functions: to connect telephone line 1 to J1 (to which equipment is connected), and to disable the other switching circuits. Its ability to disable the other switching circuits is an important feature of the ring selector.

The disabling of the other switching circuits prevents other ringing from being connected to J1 at the same time. To disable the other switching circuits, one of the switching elements of RY1 sends a positive voltage to the disable relay of the other switching circuit on the board (but *not* to the disable relay of the same switching circuit). During a call on line 1, normally closed relay RY6 is energized, while the contacts of RY5 remain closed.

In effect, if the switching circuit for line 1 is powered, the switching circuit for line 2 is disabled. Similarly, if line 2 is powered, line 1 is disabled. The lines disable each other, but only one at a time because only one switching circuit at a time can be powered.

Another of the elements of relay RY1 switches off the power to two switching circuits on the board. With this arrangement, all other switching circuits are disabled while one is powered.

TABLE 1
ELECTRICAL CHARACTERISTICS OF STOCK RELAYS*

Relay Number	Manuf. Number	Coil Voltage (VDC)	Coil Resistance (ohms)	Contacts Type	Contacts Rating (amps)	Contacts Resistance (milliohms)
RY1-4	W78PCX-1	5.0	13K	4PDT	3.0	50
RY-5	W178REI-5DC	5.0	63	SPDT	5.0	100
RY9-13	W117SIP-1	5.0	500	1Form A SPDT N.O.	0.5	—

*Circuit board mounting, DC operation

This explains the presence of two switching circuits per board and two boards per ring selector.

Building the ring selector

The prototype ring selector was built on two stock 6¼ × 4½-inch perforated phenolic circuit boards with copper pads deposited around the 0.1-inch-spaced holes on one side for easier solder bonding. All wiring was point-to-point method. Twelve-position terminal strip TS1 with screw terminations accepts all 10 wires from the telephone jacks and the plus and minus 6-volt DC wires from the wall-outlet mounted AC-to-DC adapter.

All components but line-sense relay RY17 are standard items available from most mail-order distributors and electronics stores. Line-sense relay RY17 (see Fig. 2) is a small circuit-board mount loop-current detector with the safety and reliability features required for FCC Part 68 regulated telephone applications. When connected to the voice pair (tip and ring) of the telephone line, a 1 Form A relay closes in response to current above 20 milliamperes flowing through the wires.

This relay controls the ring selector circuitry for on-hook/off-hook operation. It is installed between telephone-related equipment and the telephone line. When plugged-in telephone equipment is off-hook, current flows through the two coils inside the relay and a contact closes.

Current must flow from the telephone line through the relay to the telephone equipment to energize the relay. Thus the relay is energized only when the connected telephone equipment is off-hook. When the relay is installed between a telephone and the telephone line, the relay will be energized only if that telephone is taken off hook; it will not be energized if other telephone units on the line are taken off-hook.

Caution: Take care when installing RY17. If it is connected incorrectly, current will not flow, and the relay will not be energized. Check and double-check the installation of this relay.

Relay RY17 is manufactured by Teltone Corp. 22121-20th Ave., SE, Bothell WA 98021, (800) 426-3926 as Part No. M-949-01.

Relays RY1 to RY4 are 4PDT 5-volt reed relays, relays RY5 to RY8 are SPDT 5-volt relays, and relays RY9 to RY16 are 1 Form A SPDT—N.O. reed relays that interface with logic-level signals. Table 1 lists the principal electrical characteristics of these standard relays.

Electronic assembly

There are no critical requirements for the placement of components on the circuit boards of the ring selector. However, parts placement diagram Fig. 3 is included to show how the components were placed on the two perforated boards of the prototype. With the components inserted as shown, there will be adequate spacing for the interconnecting wires.

There was adequate space in the enclosure selected to permit some of the resistors to be mounted vertically on the circuit boards. In the prototype, common ground buses were made by soldering lengths of solid No. 18 AWG wire along

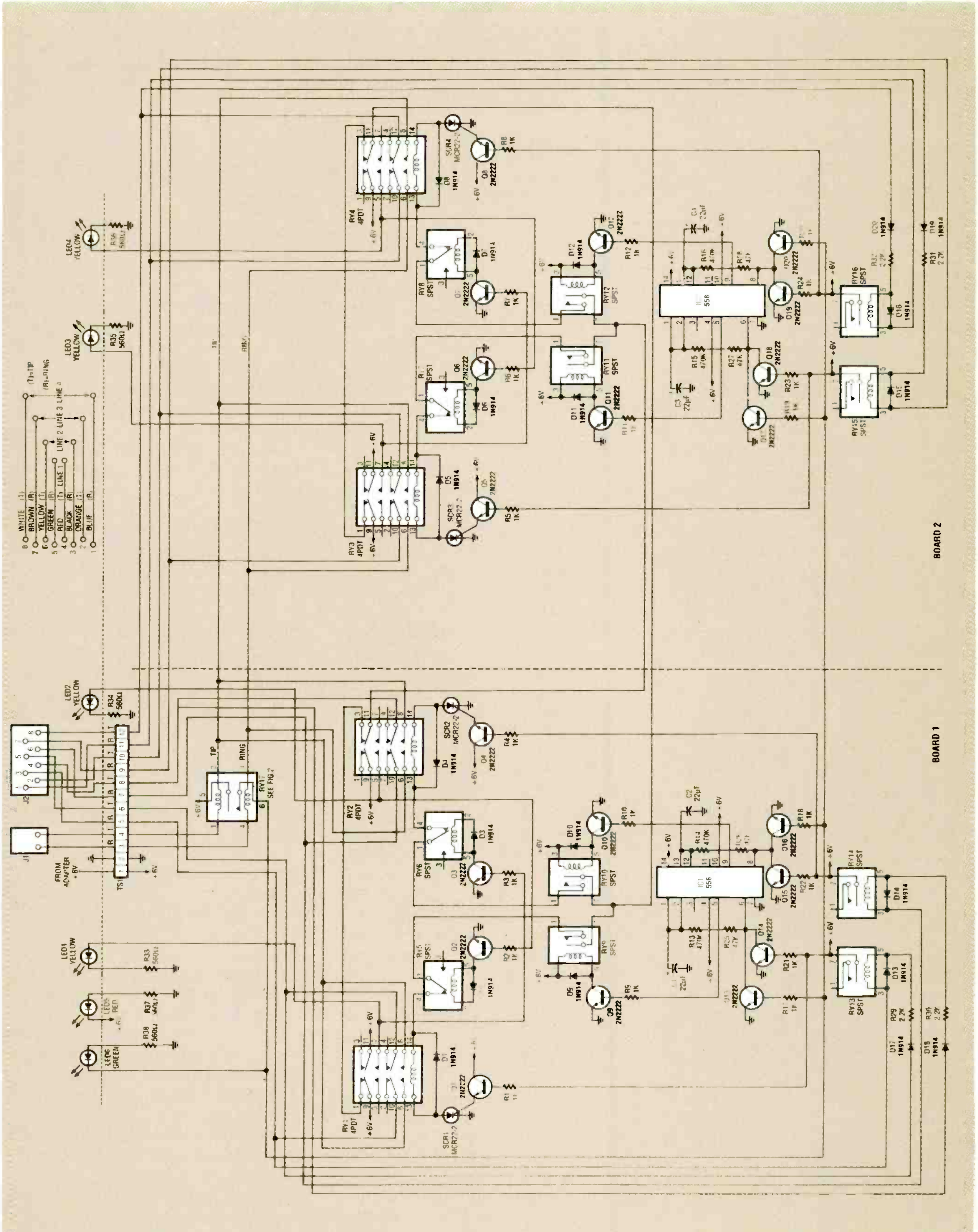


FIG. 1—SCHEMATIC FOR TELEPHONE RING SELECTOR: The complete circuit is partitioned into two switching circuits on each of two circuit boards.

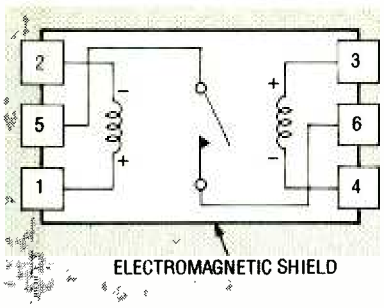


FIG. 2—ELECTRICAL SCHEMATIC for line sense relay M-949-01 made by Teltone.

both long sides of the boards near the edges on the copper-pad side of the boards. The two 556 IC's, IC1 and IC2, were mounted in sockets.

After all wiring was complete on both boards, the wires between the two boards were bundled with plastic cable clamps attached to the boards with screws to form a loose cable between boards. Be sure that this interboard wiring is long enough to permit the removal of the upper board from the lower board for ease in testing and maintenance.

Mechanical assembly

A stock two-part aluminum case was selected for packaging the prototype ring selector. The case measures 8×6×3 inches, and the lower section was equipped with four rubber foot pads.

Drill four holes in the base section for the four mounting screws that support the stacked boards, as shown in Fig. 4. Determine the spacing from the holes in the circuit boards. Displace the position of these holes toward one corner of the base in order to provide enough room for wiring 12-position terminal strip TS1.

Drill six holes in a horizontal row in the vertical wall of the case as shown in Fig. 4 with diameters that will accept snap-in sockets for T-1¾ LED's LED1 to LED6. Snap the six sockets into the drilled holes.

Form a rectangular hole in the vertical wall of the case, as shown in Fig. 4, just large enough to permit mating plugs to access jacks J1 and J2. Cement the standard four-conductor RJ-11 jack J1 and the standard eight-conductor RJ-45 jack J2 together with epoxy or other suitable adhesive. Then cement both jacks to the inside vertical wall of the case behind the cutout. Jack J2 can accept four telephone lines so it takes up less space than four RJ-11 jacks.

The power supply is a wall-outlet mounted AC-to-DC adapter rated for 6-volts, 200 milliampere DC output. *Caution:* input voltage greater than 6 volts could damage some of the relays. Remove the plug from the DC line cord of the adapter and strip the insulation back from the ends of the wires. Drill a hole for the cord and grommet in the case large enough to admit a grommet as shown in Fig. 4; install the grommet and insert the cord ends. Tie a knot in the cord about 3 inches back from the ends.

Assemble the wired boards to the four vertical screws mounted on the bottom plate of the case with nuts and spacers as shown in Fig. 4. With the boards mounted securely in position, connect the positive and negative wires from the adapter to terminal strip TS1 as shown in Figs. 1 and 4.

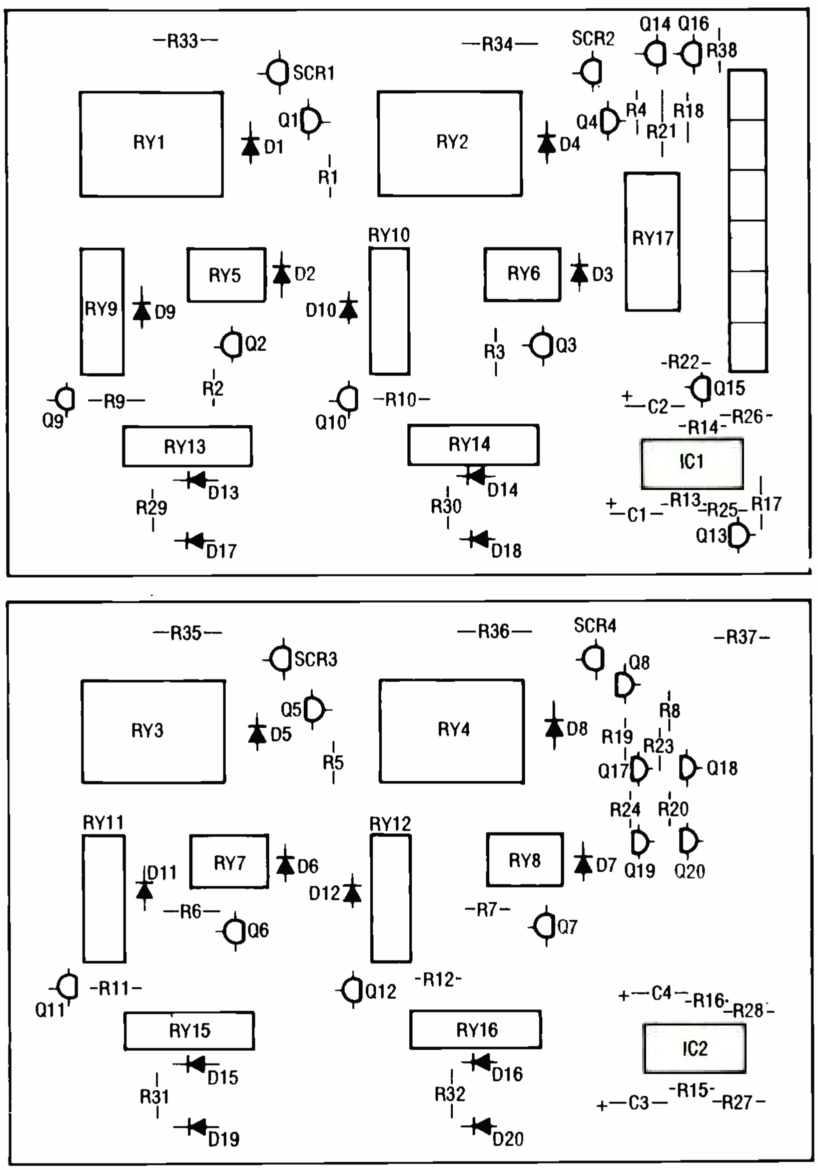


FIG. 3—PARTS LAYOUT FOR TELEPHONE RING SELECTOR showing the recommended arrangement of components on the two perforated circuit boards. The six LED's and two telephone jacks are off-board.

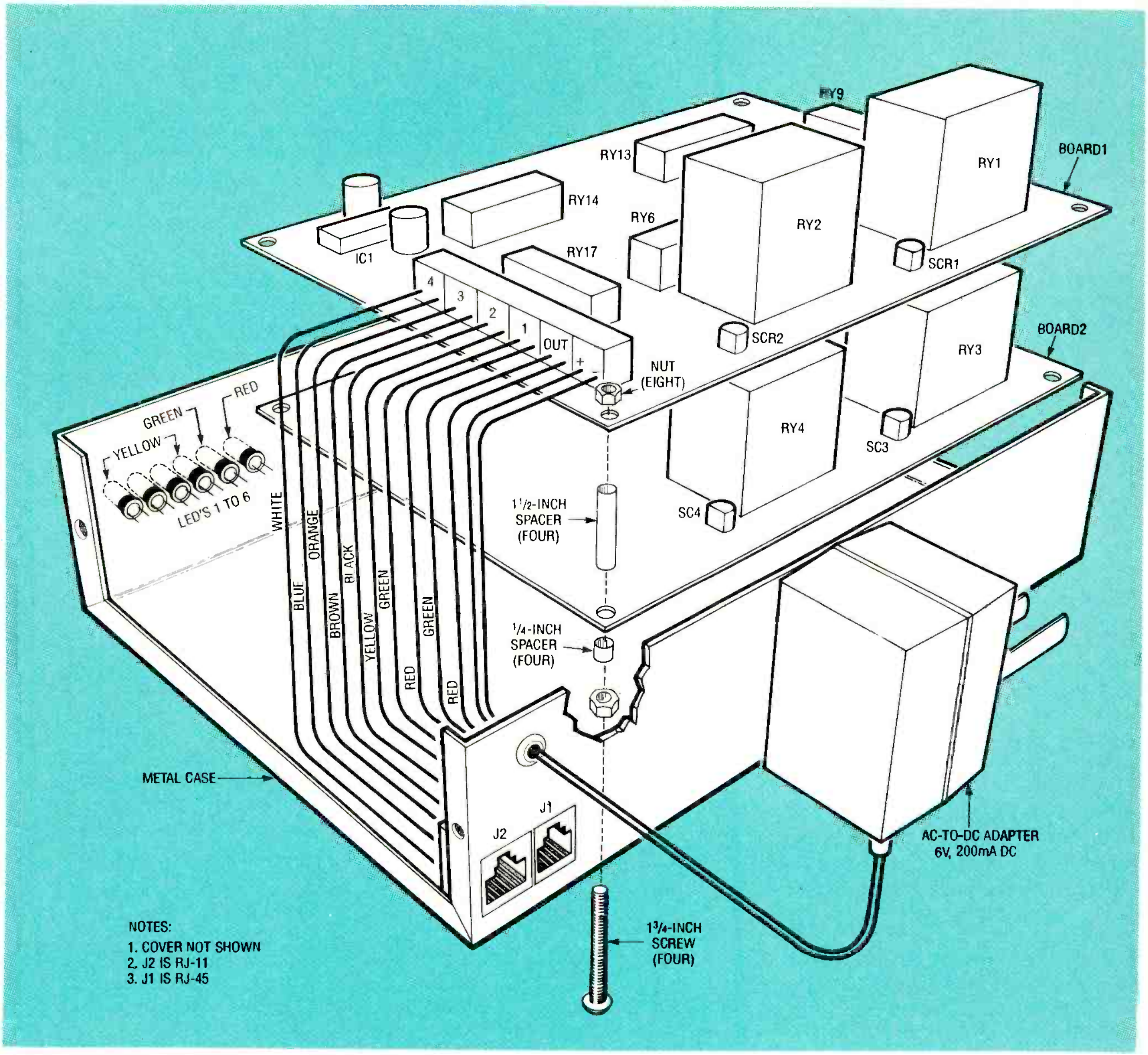


FIG. 4—EXPLODED VIEW OF TELEPHONE RING SELECTOR showing arrangement of circuit boards and off-board components. Note the order of color coding at the terminal strip.

Test and installation

Caution: the telephone line has an approximate 50-volt ringing circuit. If you are working on any exposed contacts that are connected to the telephone line, take the telephone handset off-hook until you have completed the work. The off-hook voltage is only about 6 volts, so the shock hazard is reduced. However, you must still avoid shorting the phone line because this can damage the phone line and disable your phone service.

Before connecting ring selector to a telephone line or any telephone-related equipment, perform the following tests to verify proper circuit operation:

1. Plug the AC-to-DC adapter into an outlet and, with a voltmeter, verify that the polarity of the 6-volt DC available on the board is correct. Light-emitting diode LED5 should light. If it does not, the DC polarity is incorrect. Unplug the adapter and check for the source of the problem. The power supply might have been inadvertently connected backwards.

2. Short pins 1 and 7 of relay RY13 together to bypass the relay's coil and simulate an incoming ring. If all wiring is correct, the switching circuit for that line should be powered and LED1 should be illuminated. However, after a few seconds the circuit should automatically shut itself off. Then perform this test in sequence on relays RY14, RY15 and RY16.

3. Repeat test 2 again after you have actuated relays RY13, RY14, RY15, and RY16, and shorted pins 5 and 6 of relay RY17. Shorting relay RY17 simulates an answering machine. If the switching circuit under test is working properly, one of the corresponding line indicator

LED's (for example, LED1 will light for Line 1, LED2 for line 2, etc.) will stay illuminated until the jumper on relay RY17 is removed.

After removing the jumper from RY17, ring selector should reset and LED1 (or LED2, LED3, LED4, depending on which relay is under test) will extinguish. If the switching circuit being tested shuts off while this test is being performed, it indicates a fault, probably with the connections from RY17. Recheck the wiring, and make any necessary changes before proceeding with further testing of the unit.

4. Repeat test 2 to verify the proper operation of the disable relay functions. Immediately after shorting relay RY13, momentarily ground pin 5 of RY5. When pin 5 of these relays is grounded, the switching circuit should shut off immediately. Then test relay RY14 with RY6 grounded, RY15 with RY7 grounded, and RY16 with RY8 grounded.

5. Connect the leads of a continuity checker to positions 3 and 4 on terminal strip TS1 that terminate the red (ring) wire and the green (tip) wire, respectively. There should be no continuity. If there is, recheck the wiring and correct the fault before proceeding with any further testing.

6. With the continuity checker still attached to the terminal strip as in step 5, trigger relays RY13, RY14, RY15 and RY16 (as described in step 2). As relays RY13 to RY16 are actuated, observe or listen to the continuity checker to be sure there are no shorts. If there is a short, recheck the wiring, looking for an error, and correct that error before proceeding.

7. With the continuity checker still attached as in step 6, connect a jumper across the terminals for line 1 (positions 5 and 6) on terminal strip TS1 to short them together. Actuate RY13 and observe or listen to the continuity checker. There should be an indication of a short to indicate that line 1 is wired properly. Repeat this test on the other lines, being sure to move the shorting wire to each line you are testing. After completing this test, remove the jumper.

8. After completing the tests, remove the continuity checker and wire both telephone jacks J1 and J2 to the terminal strip. After this is completed, plug a telephone into J1, then connect connect a telephone line to line 1 on the terminal strip (positions 5 and 6).

If the switching circuit for line 1 engages, disconnect the telephone line and reverse the wires to the terminal strip (positions 5 and 6) to correct the polarity. Repeat the test for line 1. The switching circuit should not engage.

With the telephone line attached, ask another person to dial the telephone number for the line attached to Ring Selector. When the phone rings, the switching circuit should engage immediately. Take the handset off the cradle of the telephone plugged into J1; LED6 should light and the circuit should remain functional. Speak into the handset to be sure that the circuit is working properly. Hang up the telephone plugged into J1, and the switching circuit should disconnect after a few seconds. Repeat this test for all of the other telephone lines.

9. The ring selector should now be completely tested and fully operational.

Reassemble the circuit boards on the four screws. Then close the cover and fasten it. If the "immediate engage" problem discussed in step 8 should recur, it is possible that the telephone cord has reversed wires that cause the problem. If this happens, all you have to do is reverse the connection as discussed in step 8. Ω

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise specified.

R1–R12, R17—R24—1000 ohms
R13–R16—470,000 ohms
R25–R28—47,000 ohms
R29–R32—2,200 ohms
R33–R36—560 ohms

Capacitors

C1-C4—22µF, 16 volts, aluminum electrolytic

Semiconductors

Q1–Q20—2N2222 NPN switching transistor
SCR1–SCR4—silicon-controlled rectifier, 1.5 ampere, Motorola MCR22-2 or equivalent
IC1, IC2—556 dual timer, Motorola MC3456 or equivalent
D1–D20—1N914 silicon switching diode
LED1–LED4—yellow light-emitting diode, T-1 3/4 package
LED5—red light-emitting diode, T-1 3/4 package
LED6—green light-emitting diode, T-1 3/4 package

Relays

RY1, RY2, RY3, RY4—4PDT Relay, 5-volt DC coil, Magnecraft W78PCX—1 or equivalent.
RY5, RY6, RY7, RY8—SPDT Relay, 5-volt DC coil, Magnecraft W178RE1-5DC or equivalent
RY9, RY10, RY11, RY12, RY13, RY14, RY15, RY16—SPST Reed Relay, 5-volt DC coil Magnecraft W117SIP-1 or equivalent.
RY17—Line-sense relay, Teltone Corp., No. M-949-01. (see text)

Other components

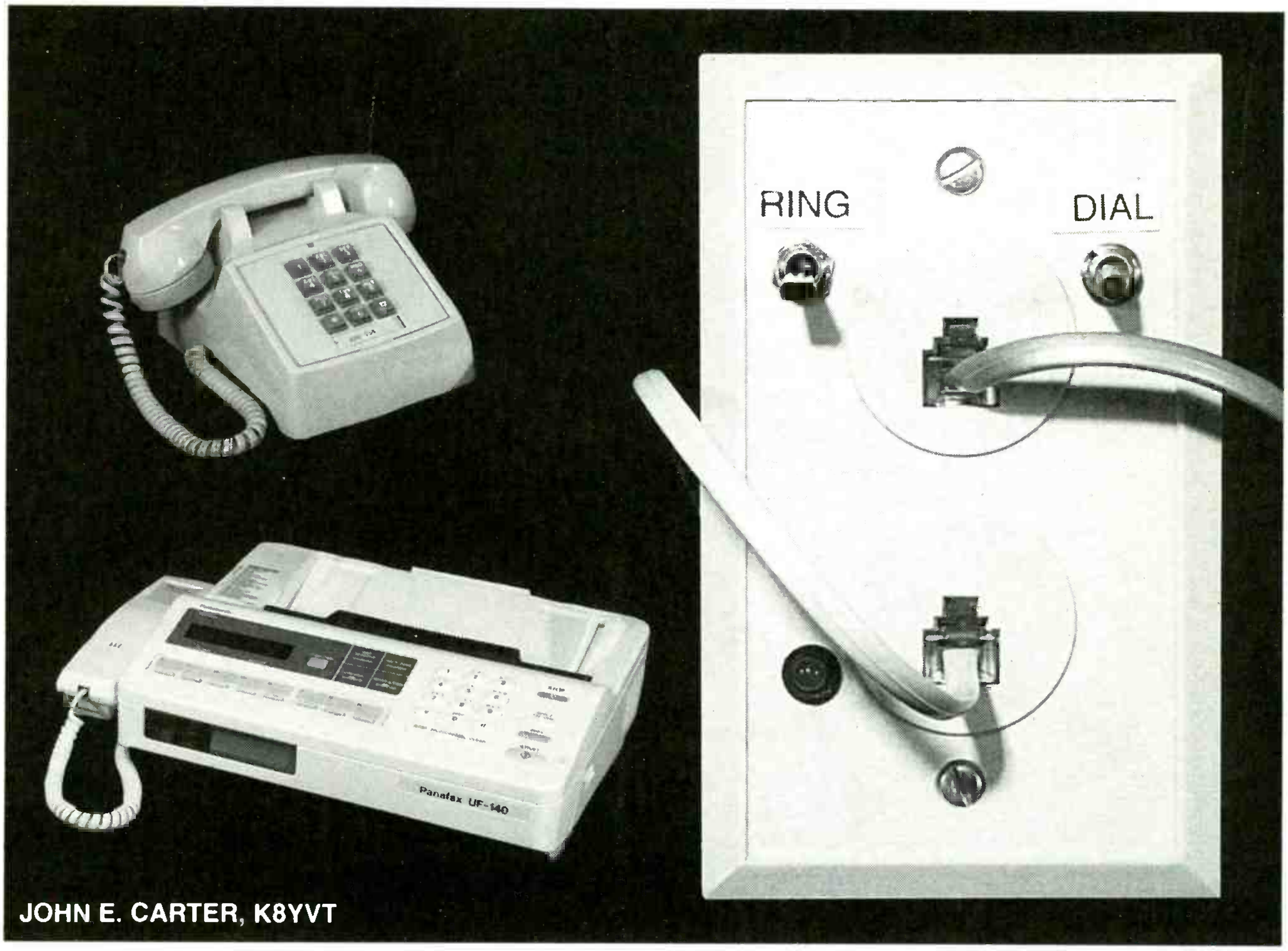
J1—RJ-11 telephone jack
J2—RJ-45 telephone jack
TS1—12-position, PCB terminal strip with screw connections

Miscellaneous: Two 0.10-inch perforated phenolic circuit boards with copper pads (see text), two 14-pin IC sockets, aluminum two-part case (see text), AC-to-DC adapter with 6-volt, 200 mA DC output, six snap-in sockets for T-1¾ LED's, two plastic cable clamps, No. 18 AWG insulated hookup wire, screws, nuts, spacers, solder, plastic adhesive.

Note: The following parts are available from Christopher Zguris, 521 West 26th Street, New York, NY 10001

- **Complete kit of components including perforated boards, relays, IC's, transistors, resistors, diodes, LED's, phone jacks and terminal strip.—$58.00**
- **Line sense relay—$5.00**

Add $4.00 for shipping and handling. New York State residents add appropriate sales tax for county of residence.



JOHN E. CARTER, K8YVT

PHONE-LINE SIMULATOR

Build this low-cost telephone-line simulator that tests phone-based equipment without tying up two phone lines and perhaps an assistant's time.

A LOW-COST, EASY-TO-BUILD TELEphone-loop simulator will permit you to test telephone answering machines, fax machines, modems, electronic telephones, automatic dialers, and other telephone-related equipment. It includes a talk battery, ringing voltage, and simulated dial tone that are necessary for this testing.

Phone Helper, the telephone-loop simulator described here, makes the testing of telephone equipment as simple as plugging in RJ-11 plugs. It simulates a common-carrier telephone line, and permits you to test equipment without tying up several working telephone lines—and possibly damaging one of them if there is a fault in the equipment-under-test. It also permits you to perform tests without an assistant.

Figure 1 is the schematic, and Table 1 gives the unit's specifications. One switch is toggled on and off to obtain a simulated dial tone, and the other can be jogged to provide a simulated ring signal.

Commercial telephone-loop simulators capable of performing the same tests as Phone Helper are priced at a several hundred dollars or more. Phone Helper costs a lot less; just the parts cost less than $50, and you can purchase a completely assembled and tested unit with an AC-line adapter from the source given in the Parts List for less than $70.

FCC Requirements

Before discussing the loop simulator further, it will be useful to review the related telephone-ringing variables. The Federal Communications Commission's (FCC) Rule Section 68.312 defines the permissable AC voltages, frequencies, and impedances for ringing circuits. These are required guidelines for both domestic and foreign telephone equipment manufacturers.

The FCC requires that manufacturers submit prototype equipment for testing by an approved laboratory, which runs many different tests on it. The test lab assigns a unitless ringer equivalency number (REN) that states the power required to actuate the ringing circuitry of the equipment. The manufacturer must stamp or print that number on all approved interconnect products sold.

The telephone operating companies require that no interconnect device shall have a REN greater than 5. In addition, the sum of all REN's on a particular loop must not exceed 5. A standard mechanical bell-type telephone typically has a REN of 1.0A. The "A" indicates that the device will respond to a ringing frequency between 17 and 33 Hz). Similarly a "B" indicates that the unit will respond to a ringing frequency between 15.3 Hz and 68 Hz.

A long list of REN suffixes from A to Z has been prepared to cover all combinations and permutations of ringing arrangements. Nevertheless, A and B type devices predominate, but today most answering machines, modems, fax machines, and electronic telephones are type B.

That equipment typically includes a bridge rectifier installed across the telephone line for receiving a large AC voltage which is rectified to obtain the signal for tripping the ring-detect circuitry. As a result, most of this equipment can be tested with a simulator that is based on a 60-Hz ringing-voltage source capable of operating only Class B ringers.

Versatile 20-Hz generator

The test unit in this article includes a true 20-Hz ringing generator rather than a 60-Hz ringing voltage source, so it can actuate both class B and class A ringers. (See the box in this article for a 60-Hz alternative tester.) The 20-Hz ringing generator provides about 85 volts at 20 Hz with enough power to drive up to five 1.0A or 1.0B REN numbered devices simultaneously. It is packaged as a potted module that can be directly mounted on a circuit board.

The module contains a 20-Hz multivibrator and amplifiers to obtain the power needed to actuate the ringers. It is available from the source given in the Parts List.

Telephone dial tone

Now it will be useful to review the basics of telephone dial tones. The telephone equipment industry has specified that the dial tone be composed of an equal mixture of 350-Hz and 440-Hz frequencies that leave the central office at a level of -13 dBm0 (measured at the zero transmission level point).

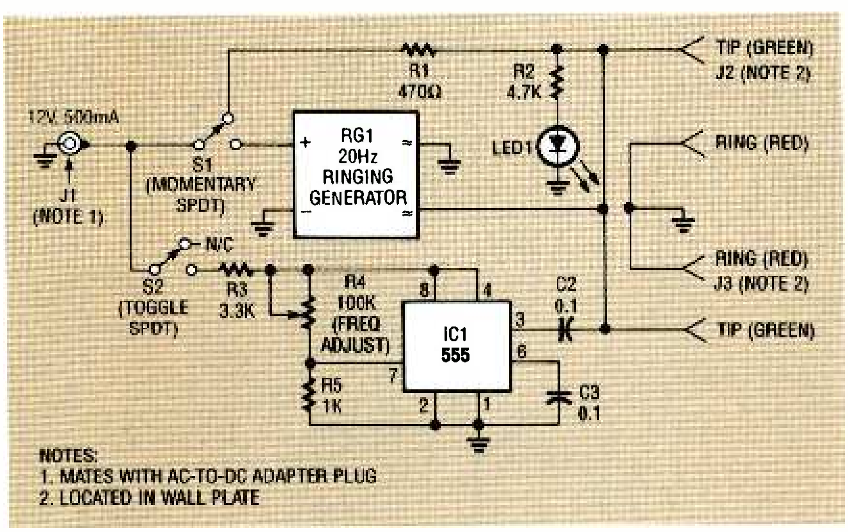


FIG. 1—SCHEMATIC FOR PHONE HELPER 1. The ringing generator is a proprietary device available from the source in the Parts List.

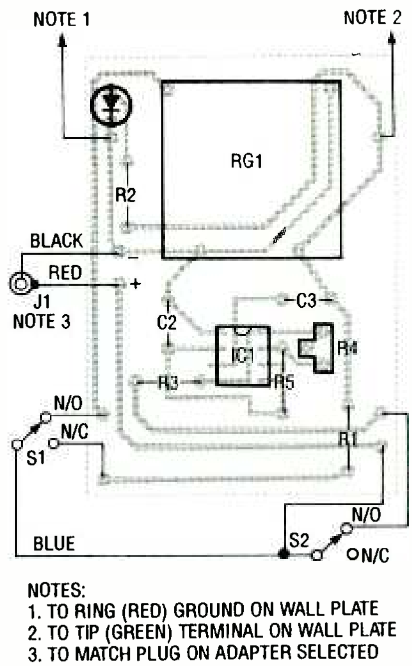


FIG. 2—PARTS PLACEMENT DIAGRAM for Phone Helper 1 circuit board.

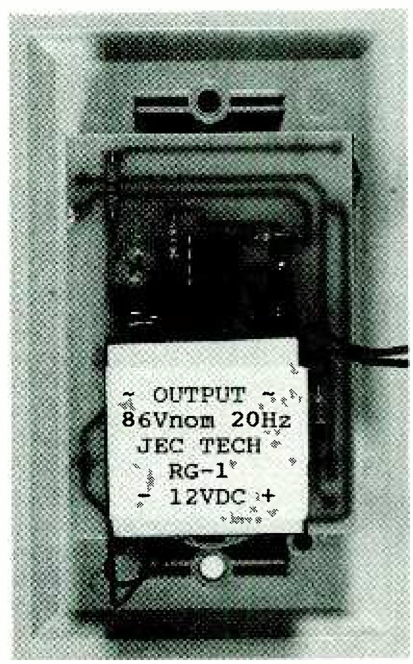


FIG. 3—PHOTOGRAPH OF PHONE Helper circuit board showing external connections.

The signal could have dropped as much as 10 dBm0 lower (-23 dBm0) when it reaches the subscriber. However, tests have shown that most telephone interconnect devices will respond if they receive a steady tone that is close to either 350 Hz or 440 Hz.

For example, if a single-frequency tone of about 500 Hz is presented to them, most telephone-related devices will respond as if they received a true dial-tone signal. This fact permits the design and construction of lower cost, less complicated telephone-loop simulators.

A note of caution here: some telephone-related products are designed to respond only to a "precision" dial tone; they won't be fooled by a single tone. They require both 350-Hz and 440-Hz signals to respond—and then only if the tones don't deviate too far from their true frequencies. Fortunately, these products are in the minority.

The single-tone generator in the simulator is included because some equipment, such as modems and fax machines, are designed to respond to a dial tone before they will dial out.

If a product does not "hear" a dial tone (when directed to dial out), it triggers the dreaded NO DIAL TONE message that can show up on your personal computer's display or your fax machine. In that case, a brief tone burst from a single-tone oscillator triggers the unit, causing it to dial the number.

Building Phone Helper

The construction of Phone Helper is simple because it obtains its power from a wall-mounted AC-to-DC adapter rather than directly from the 120-volt line. A circuit board foil pattern has been included here for those who want to make the circuit board. Alternatively, you can purchase a completed board from the source given in the Parts List, or use a perforated phenolic board cut to the same size and wire the circuit components point-to-point.

A design objective for Phone Helper was to package it in the smallest possible case without making it difficult to build. A basic requirement for the project was the availability of two RJ11/14 phone jacks, and this was met by a standard dual-jack wall plate, which also serves as the case cover. The nominal 2¾ × 4½-inch plate permits the use of a standard 3½ × 2⅛-inch × 2⅛-inch deep (inside di-

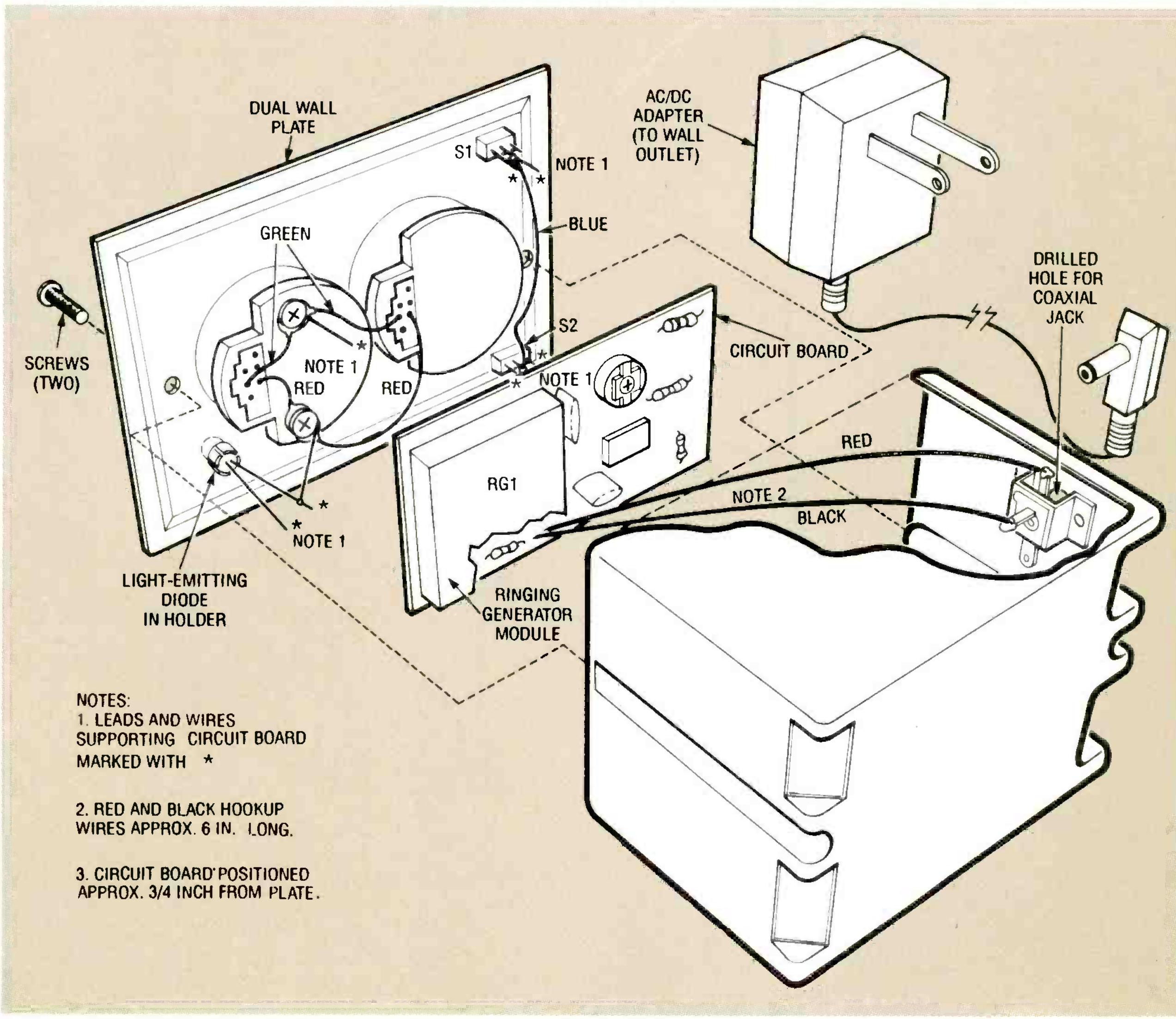


FIG. 4—EXPLODED VIEW OF PHONE HELPER 1 showing showing method of assembly and off-board wiring.

How about an economy model?

If you do not require the performance offered by DC-powered Phone Helper with its 20-Hz ringing generator, you can build a lower-cost version. Phone Helper 2 can test only Class B ringers (Phone Helper 1 will test both Class A and B). It is powered directly from the 120-volt AC line, and a transformer replaces the ring generator.

Figure 6 is the schematic for the Phone Helper 2. Notice that the output side is identical to that of Phone Helper 1 (see Fig. 1), but the input includes a transformer, and a packaged full bridge rectifier. There is also a zener diode, and there are some differences in the values of the resistors and capacitors. However, Phone Helper 2 will fit in the same plastic case that was specified for the DC-powered unit, and the cover is the same dual RJ-11 wall plate. Table 2 summarizes the specifications for Phone Helper 2.

Building Phone Helper 2

The principal circuitry of Phone Helper 2 can be built on a 3 × 2-inch piece of 0.10-inch pitch perforated phenolic circuit board, or it can be be built on a circuit board. In both alternatives, notches or holes must be formed at the ends of the board to permit the passage of the screws from the wall plate to the case. The foil pattern of the circuit board is provided here for those who want to make their own, but a complete circuit board is available from the source given in the Parts List.

Transformer T1 has a dual 120-volt AC primary and a dual secondary. The transformer in the prototype was made by Microtran, Valley Stream, NY. It has a 12 VA rating with dual 17-volt outputs. (Digi-Key offers the MT1127-ND that meets this requirement.) However, any transformer that provides up to 20 volts DC after rectification and filtering will work here.

One of the primaries is powered by 120 volts AC and the second primary provides the ringing voltage. The dual secondaries are wired in parallel to increase current, and the output is rectified and filtered to produce the talk voltage and a power source for the dial-tone simulator circuit.

Figure 7 is the parts placement diagam for the AC-powered simulator. Figure 7-*a* shows the components on the "component" side and Fig. 7-*b* shows the components mounted on the foil side. There are three jumpers on the foil side. The longest is made from insulated No. 18 AWG hookup wire and the other two are made from scraps of bare wire.

The location of the components on the circuit board was dictated by the size of the case and not by any critical placement considerations. It is recommended that all of the small components be inserted and soldered before mounting the transformer.

The transformer was clamped to the PC board by bending the end tabs of the frame around the edges of the board and compressing them with pliers. A thin strip of plastic was placed between the transformer and the board as insulation.

After completing the component assembly and wiring on both sides of the board, refer again to Fig. 7-*b* and complete the off-board wiring. Install the switches in the drilled holes in the wall plate and install the socket for LED1. Then install LED1. Solder bare copper wires to the two terminals on switch S1 and one on switch S2. Solder a third 1¼-inch bare wire to the lug on the ring (red) terminal.

Solder a bare jumper to the center terminals of both switches. Solder resistor R2 to the tip (green) lug; solder its other end to the anode of LED1, and its cathode to ground. Drill a hole in the case large enough to admit a line-cord locking grommet and line cord. Strip the ends of the line cord ¼ inch, and solder the wires to the board.

Using Fig. 4 as a guide, mount the loaded board on the wall plate with the foil side toward the plate. Position the three bare wires in the appropriate board holes and solder them in position. (Note that the positions of the momentary and toggle switches have been reversed.)

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mensions) plastic outlet box as the case.

While referring to schematic Fig. 1 and parts placement diagram Fig. 2, begin construction by mounting all of the electronics components on the circuit board (or perforated board). There is nothing critical about the placement of components on the circuit board and the parts layout diagram shows a simple layout. Insert and solder all of the resistors, capacitors, trimmer potentiometer and timer IC1 before mounting the 20-Hz ringing generator module RG1.

Regardless of the construction option you select, follow accepted workmanship practice in soldering all component leads. Check carefully to be sure that all solder joints are shiny and clean, and that there are no unwanted solder "bridges" or cold-soldered joints, which are dull gray and lumpy. Figure 3 is a photograph of the completed circuit board showing some of its off-board wiring.

After completing the circuit board assembly, proceed with the mechanical construction. Prepare the wall outlet case by removing any small plastic tabs. Drill the ¼-inch hole in the case to admit the DC power jack in the location shown in exploded view Fig. 4. Then drill either one or two smaller holes adjacent to that hole for fastening the jack to the case with rivets or screws.

Prepare the wall plate by removing all but two of the screws that secure the associated wiring and clipping off the black and yellow wires. The red and green wires are for *line 1*, the pair found on all standard telephone-connected devices. Drill the three holes in the wall plate with the diameters necessary for mounting switches S1 and S2, and the panel-mounting clip for LED1 using the drilling template provided here as a guide.

Mount switches S1 and S2 on the back of the wall plate with their washers and locknuts. Then insert the snap-in-holder for the T-1¾ LED in the wall plate and insert LED1 in the holder. Solder two bare, solid hookup wires approximately one inch long to two of the terminals on switches S1 and S2 as shown in Fig. 4. Solder another short length of wire to the lug at the end of the red ring wire on the back of the wall plate. Then solder a short length of insulated hookup wire between the center terminals of switches S1 and S2. (It is shown as a blue wire in Fig. 4).

Cut two six-inch lengths of red and black insulated hookup wire, trim their ends, and solder them to coaxial jack J1 as shown in Fig. 4. Insert the other two ends in the circuit board from the component side as shown in Figs. 2 and 4, and solder them in position.

The circuit board assembly is light enough to permit it to be supported by the seven leads

Testing the simulator

Before plugging the completed unit into the 120-volt, 60 Hz outlet, be sure the line is properly protected with a fuse or circuit breaker. The LED should light up as soon as the cord is plugged in. *Caution:* Do not plug any equipment into the RJ-11 jacks J1 and J2. With a suitable voltmeter, measure the voltage across the tip (green) and ring (red) connections on the back of the wall plate.

If transformer T1 has dual 10- to 20-volt secondaries, the voltage should read between 15 and 45 volts AC rms. If the voltage is near zero, the secondaries were probably wired out-of-phase. Correct any errors before proceeding. If the voltage is significantly more than 50 volts DC, replace the transformer with one that meets the stated requirements.

Telephone operating companies can place from 40 to 130 volts DC across their lines when all phone are on-hook. Typically the on-hook voltage for telephone operating companies in the U.S. is about 48 volts DC.

Plug a telephone into one of the two RJ-11 jacks (J1 or J2) and remove the handset. The brightness of LED1 should decrease, indicating that the voltage has dropped. Measure across the tip and ring again. The reading should now be between 4 and 12 volts DC. If it is outside those limits, check the wiring again and make any corrections before proceeding. If the off-hook voltage is too low, reduce the value of resistor R1 to put the output within the acceptable range.

Toggle DIAL switch S2 and listen for the single dial-tone simulation. Trimmer potentiometer R4 might have to be adjusted to obtain an audible tone. If you have access to a telephone system transmission test set, set it for an output frequency of 500 Hz.

However, if that equipment is not available, you can approximate a 500-Hz note by striking the middle C key on a piano, which provides a 440-Hz tone. Hold the sustain pedal in to prolong the note, and adjust trimmer potentiometer R4 so that the tone you hear is slightly higher than the piano's middle C.

Now hang up the handset and jog the RING toggle switch S1. The brightness of LED1 should increase, indicating that the simulator is working correctly.

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise specified.

R1—1000 ohms, 1 watt (see text)
R2—10,000 ohms
R3—2.200 ohms
R4—100,000 ohms, trimmer potentiometer
R5—1000 ohms

Capacitors

C1—1000 µF, 50 volt, aluminum electrolytic
C1, C2—0.1µF

Semiconductors

IC1—555 Timer IC
BR1—Bridge rectifier, 1.5 ampere
D1—IN4742A, 12-volt, 1 watt Zener
LED1—red light-emitting diode, T-1¾ package

Other components

S1—SPDT momentary toggle switch, panel mount, miniature
S2—SPDT toggle switch, panel mount, miniature
T1—two 120- volt input and two 17-volt output (see text)

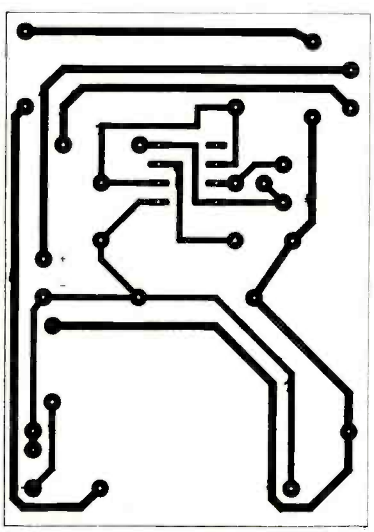
Miscellaneous: circuit board, PC or perforated board (see text), dual RJ-11 wall plate, plastic outlet box (see text), snap-in holder for a T-1¾ LED, insulated No. 18 AWG stranded hookup wire, solid bare hookup wire, six foot length of AC line cord terminated by a polarized plug, solder.

from switches S1 and S2, the green tip wire lug, and the leads of LED1. Insert those leads in the foil side of the circuit board assembly as shown in Figs. 2 and 4, and adjust the spacing of the loaded board so that it is parallel with the back of the wall plate and spaced about ⅞-inch away from it. Then solder the seven wires on the foil side of the board, and solder the jumper and the red ring terminal lug to the cathode of LED1.

Testing Phone Helper

When Phone Helper construction is complete, and before fastening the cover in position with two screws, verify that the DC power supply section is working properly. Plug the AC-to-DC adapter into a 120-volt AC outlet, and plug its power cord into the coaxial jack in the case. The LED should light normally during this test.

Plug a telephone known to be in proper working condition into RJ-11 jack J2 or J3 and make voltage measurement with a suitable voltmeter. Place the negative probe on the ring (red) terminal and the positive



1 13/16 INCHES

FOIL PATTERN FOR PHONE HELPER 1 circuit board.

TABLE 1
SPECIFICATIONS FOR PHONE HELPER

Ring Signal (1)	85 V, 20 Hz, 5 REN
Dialtone (2)	−20 dBm0 (min), 500Hz + 20%
Power Requirements	12 V DC, 500 mA.

Notes: 1. Momentary switch S1 jogged on and off
2. Switch S2 on or off

TABLE 2
SPECIFICATIONS PHONE HELPER 2

Ring Signal (1)	90 Vrms, 60 Hz, 4 REN
Dialtone (2)	−20 dBm0 (min), 500 Hz + 20%
Power Requirements	12 V DC, 500 mA.

Notes: 1. Momentary switch S1 jogged on and off
2. Switch S2 on or off

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise specified.
R1—470 ohms, ½ watt
R2—4,700 ohms
R3—3,300 ohms
R4—100,000 ohms trimmer potentiometer
R5—1000 ohms
Capacitors
C1, C2—0.1µF
Semiconductors
IC1—555 Timer IC
LED1—red light-emitting diode, T-1¾ package
Other components
S1—SPDT momentary toggle switch, panel mount, miniature
S2—SPDT toggle switch, panel mount, miniature
RG1—20-Hz ringing generator, (see text)
Miscellaneous: dual RJ-11 wall plate, plastic outlet box (see text), AC-to-DC adapter with 12-V, 500-mA output, coaxial power connector to mate with plug of 12-volt adapter, snap-in holder for a T-1¾ LED, insulated No. 18 AWG stranded hookup wire—(red, black, and blue), solid bare hookup wire, solder.

Note: Parts as well as an assembled and tested Phone Helper are available from JEC TECH, 13962 Olde Post Road, Pickerington, OH 43147.

- **Assembled and tested Phone Helper 1 with a 12-volt AC-to-DC adapter—$69.50**
- **Complete Phone Helper 1 kit with a 12-volt AC-to-DC adapter—$59.50**
- **Ringing generator module (RG1) and a complete circuit board— $44.00**
- **Assembled and tested Phone Helper 2—$44.50**
- **Partial Phone Helper 2 kit with transformer and a complete circuit board—$34.50**

Add $4.00 shipping and handling. Ohio residents add appropriate sales tax.

probe on the tip (green) terminal. With the attached telephone's handset on-hook, the reading should be 15 ±2 volts DC; with it off-hook the reading should be 4 to 12 volts DC.

Testing with Phone Helper

To test a telephone-answering machine with Phone Helper, plug it into one of the RJ-11 jacks

FIG. 5—SETUP FOR TESTING AN ANSWERING MACHINE with phone helper.

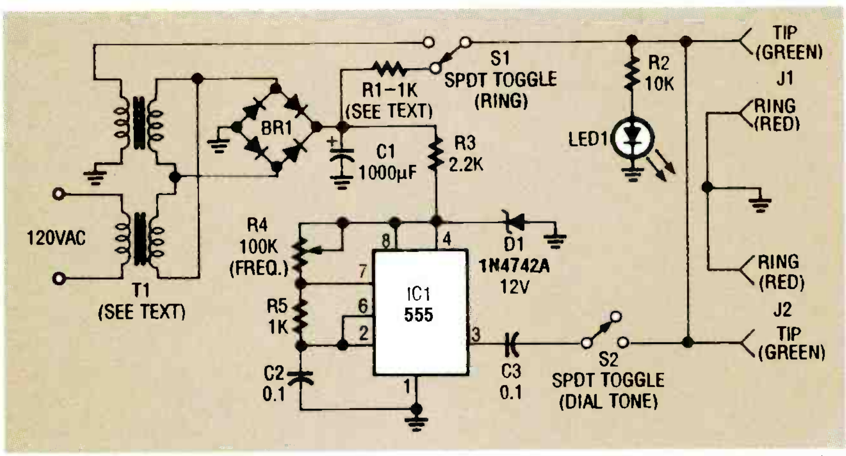
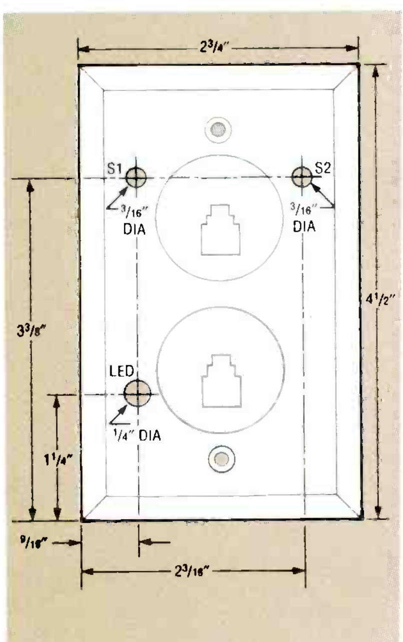


FIG. 6—SCHEMATIC FOR PHONE HELPER 2. A transformer replaces the 20Hz ringing generator of Phone Helper 1.



TEMPLATE FOR DRILLING HOLES.

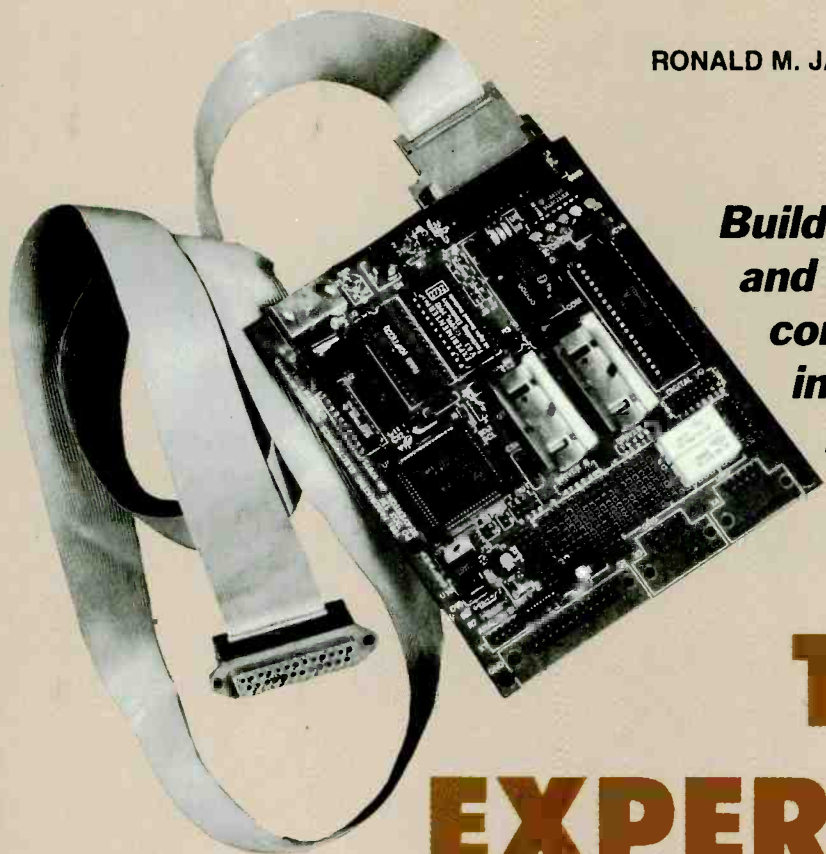
on Phone Helper and plug a telephone into the other jack, as shown in Fig. 5. Set the answering machine to receive calls, and jog the RING toggle switch S1 often enough to simulate a ring that makes the answering machine answer. When the answering machine answers, pick up the telephone handset and you will hear the outgoing message.

A plugged-in telephone, whose handset can be taken off-hook is necessary to make this test because most answering machines will reset if the telephone is on-hook—indicating that the calling party has hung up. You can then leave a message or retrieve stored messages, just as you would if you were calling in from the outside.

To test a facsimile machine,

Continued on page 84

RONALD M. JACKSON



Build the Experimenter, and put your personal computer to work doing interesting and useful real-time tasks.

THE EXPERIMENTER

LAST MONTH WE WENT OVER THE OPerating theory of the Experimenter, and discussed the various commands that control it. Now it's time to build it.

Assembly

Experimenter is constructed on a double-sided PC board with fine conductive traces and through-hole plating. It is, admittedly, a difficult board for the hobbyist to make in his home workshop. Nevertheless, circuit foil patterns have been provided for those who choose to try it. Fortunately, a high-quality PC board, screened on both sides, is available from the source given in the Parts List. The component locations printed on the board make it easier to troubleshoot the board and add circuitry at a later date.

Figure 2 is the parts-placement diagram. Start component assembly work by installing power connector J2 first, and then inserting the power supply components. Figure 3 shows how to set the J1 jumpers to obtain the proper power-supply polarity. However, the voltage regulators are designed to withstand an accidental reversal in power-supply polarity.

Test the power supplies before installing any other components. A measurement of about 5 volts should be obtained at the logic-supply output. If you build the analog supply, adjust R6 so that the +5.12-volt test point measurement is as close to that voltage as possible. Jumper J10 makes the selection between the logic supply and the analog supply. Install J10 between positions 1 and 2 if you built the analog supply, or between positions 2 and 3 if you did not.

Install all of the jumpers before adding the remaining components. At this stage of the construction process you will have better access to the board than when all the larger components are in place. Set J4 through J7 for the specific EPROM that you intend to use (either the one that came with the kit of parts offered or one of your own choice). Figure 4 shows the jumper connections for the different kinds of EPROM's that can be used.

The Experimenter kit includes six rubber feet to hold the loaded PC board off the bench top. They mount in the formed holes along the sides of the circuit board. The feet can be difficult to install, so be patient. Push the tapered end of the foot through its mounting hole, and grasp the end with your fingers. With a blunt tool, push the base of the tapered piece through the hole while pulling on the tapered end. The foot will then pop into position.

Install the special heatsinks on driver IC's IC7 and IC8 before soldering them to the circuit board. The small hole in each heatsink must line up with the notch on the pin-1 end of the drivers. You won't be able to see the top of the driver when the heatsink is installed, so you must rely on the small hole for the correct orientation of the driver in the circuit board.

Solder the four center pins of the drivers to their heatsinks. A high-wattage, temperature-controlled soldering iron will make this task easier Exercise care and patience in making all solder joints. Be sure they are smooth and shiny. A cold solder joint (indicated by its dull sur-

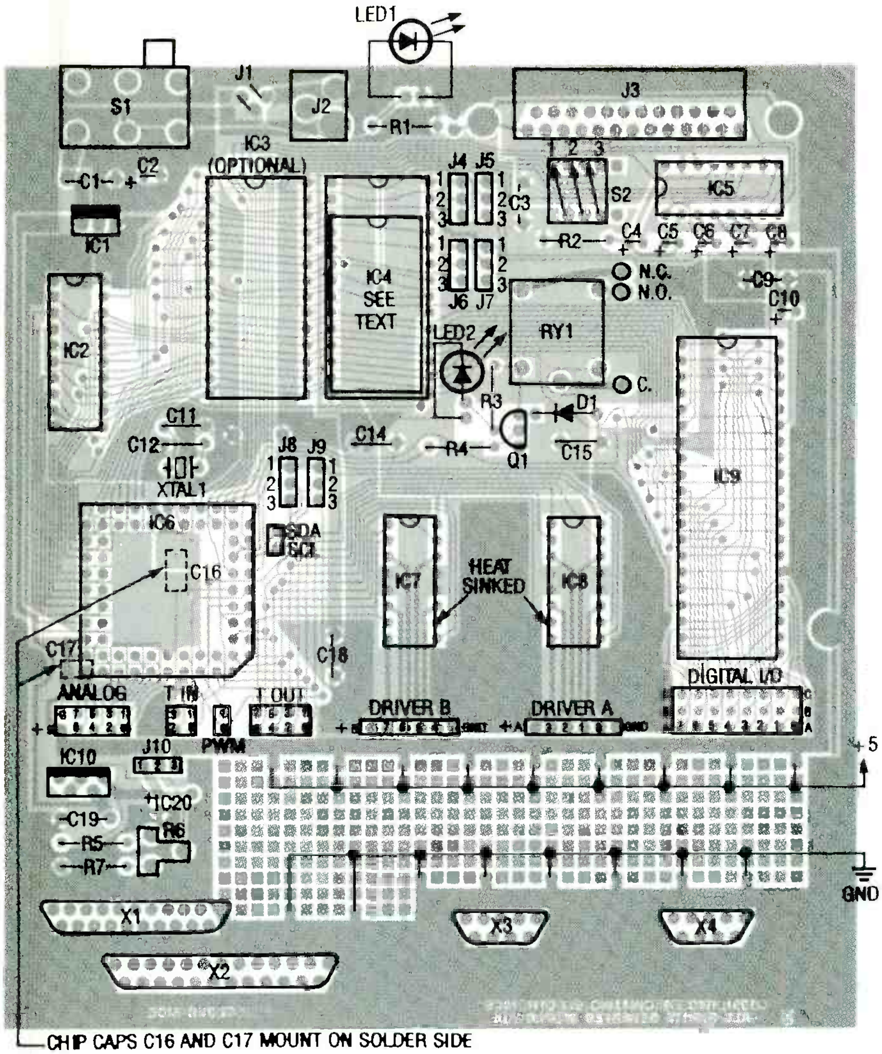


FIG. 2—PARTS-PLACEMENT DIAGRAM. Note that two chip capacitors, C16 and C17, mount on the solder side of the board.

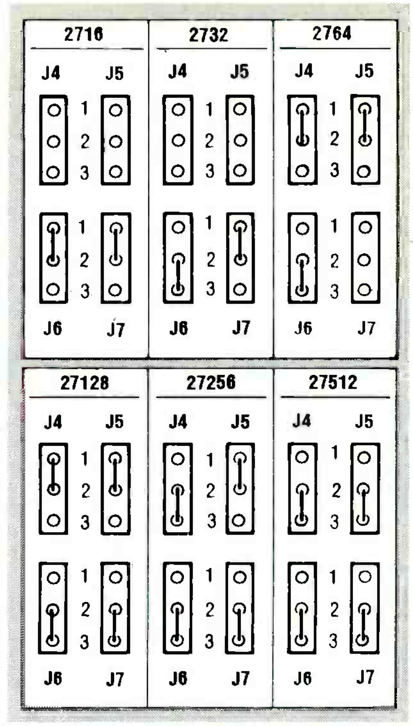


FIG. 4—EPROM JUMPER SETTINGS. Six different types of EPROM's can be used, ranging in size from 2 Kbytes to 64 Kbytes. Some EPROM types do not use all four jumpers. Also note that types 2716 and 2732 are 24-pin devices, and must be installed in the lower part of the socket, leaving the top connections open.

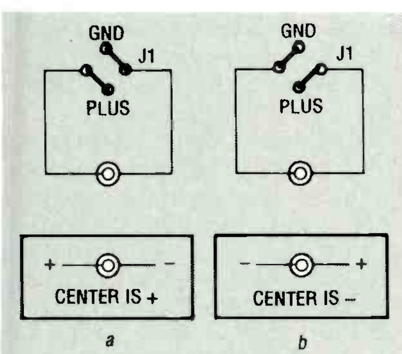


FIG. 3—POWER SUPPLY JUMPERS. Be careful that the jumpers do not touch!

face appearance) might not be strong enough to hold the heat-sinks securely in place.

When installing circuit board components, start by installing the smallest components first. Note that two ceramic chip capacitors, C16 and C17, are mounted on the solder side of the PC board.

Use sockets to install microcontroller IC6, EPROM IC4, the RS-232C interface chip (IC5), and the parallel interface chip (IC9). Note that the microcontroller socket has one flattened corner that must be oriented as shown in Fig. 2. The microcontroller also has a notched corner that must be positioned to match the notch on the socket.

If you install drivers IC7 and IC8 with sockets, they will be easier to replace if they fail due to overcurrent. However, their maximum power-handling capability will be limited to about 700 milliamps for each output. If you want to obtain 1 ampere from each output, you must solder the driver chips directly to the circuit board for optimum heat transfer. The completed circuit board is shown in Fig. 5.

Test procedures

Connect the Experimenter to your computer with a standard serial interface cable (the same type that is used to connect to an external modem). Then run a communications program on your computer. Use ECHO-EXP.BAS or any communications program of your choice.

If you use a program other than the one given in this article, set it to use the correct serial port and the baud rate you wish to run, 8 data bits, no parity, and 1 stop bit. Before powering up the Experimenter, set baud-rate switch S2 for the baud rate you selected (see Table 8). If you use ECHO-EXP.BAS, the Experimenter must be set for 9600 baud. Flip all of the switches on S2 at least once to assure that solid electrical contacts are being made.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R3—220 ohms
R2—4.7 ohms
R4—1000 ohms
R5—750 ohms
R6—200 ohms, trimmer
R7—2700 ohms

Capacitors
C1, C19—0.47 µF, 50 volts, Mylar
C2—330 µF, 6 volts, electrolytic
C3, C9, C13–C15, C18—0.1 µF, ceramic
C4–C8—4.7 µF, 35 volts, electrolytic
C10—1 µF, 50 volts, electrolytic
C11, C12—33 pF, ceramic
C16, C17—0.1 µF, 50 volts, surface-mount chip capacitor
C20—330 µF, 6 volts, electrolytic

Semiconductors
IC1—LM2940CT-5.0 voltage regulator, National Semiconductor or equivalent
IC2—74LS373 octal latch, Texas Instruments or equivalent
IC3—5164 8K byte static RAM or equivalent (optional, see text)
IC4—27xxx family EPROM, or equivalent (see text and Fig. 4)
IC5—DS14C232CN RS-232 driver
IC6—S80C552-1A68 CMOS microcontroller, Intel or equivalent
IC7, IC8—SN754410NE high-current driver IC, Texas Instruments or equivalent
IC9—82C55A parallel interface, Toshiba or equivalent
IC10—LM2931CT voltage regulator, National Semiconductor or equivalent (optional, see text)
LED1, LED2—Red light-emitting diode, T1 package
D1—1N4001 silicon diode
Q1—2N3906 PNP transistor

Other components
RY1—SPDT relay, 5-volt coil (Omron G5LE-114P-PS)
S1—DPDT switch
S2—3-position DIP switch
XTAL1—7.3728 MHz crystal
J1, J4–J10—wire jumper
J2—5.5/2.0mm coaxial power jack
J3—PC-mount female DB-25 connector

Miscellaneous: PC board, six plug bumpers (rubber feet), 6–15 volt DC power supply with 5.5mm/2.1mm coaxial plug, TO-220 heatsink for IC1, two 16-pin DIP heatsinks for IC7 and IC8, 28-pin DIP socket for IC4, 16-pin DIP socket for IC5, 68-pin PLCC socket for IC6, 40-pin DIP socket for IC9, wire, solder.

Note: The following items are available from Fascinating Electronics, PO Box 126, Beaverton, OR 97075:
- **PC board silkscreened on both sides—$59.90**
- **Programmed EPROM (contains Experimenter operating software)—$49.90**
- **Kit including PC board, programmed EPROM, all components, assembly instructions, and a reference and applications manual (does not include user connectors X1–X4, analog supply, and wall-mount supply)—$149.90**
- **Assembled and tested Experimenter (includes reference and applications manual and analog supply)—$199.90**
- **9-volt, 500 mA wall-mount DC power supply—$11.90**
- **Analog power supply components—$4.90**

Please include $3.40 for shipping and packaging. Foreign orders must inquire for pricing and availability. You can order by telephone using VISA or Mastercard weekdays from 10:00 AM to 5:00 PM, Pacific time at (800) 683-KITS.

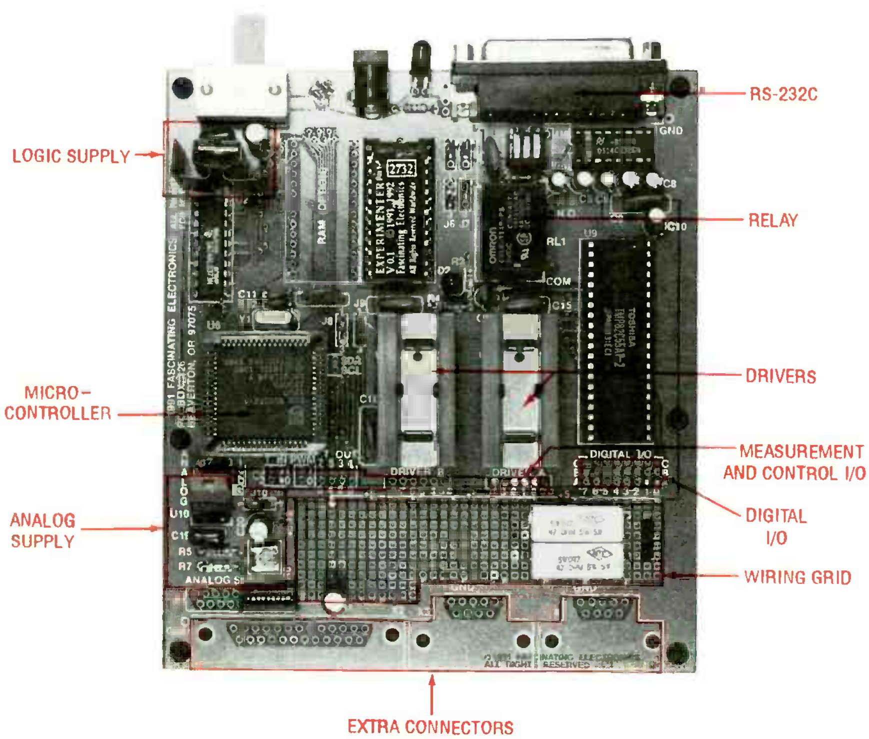
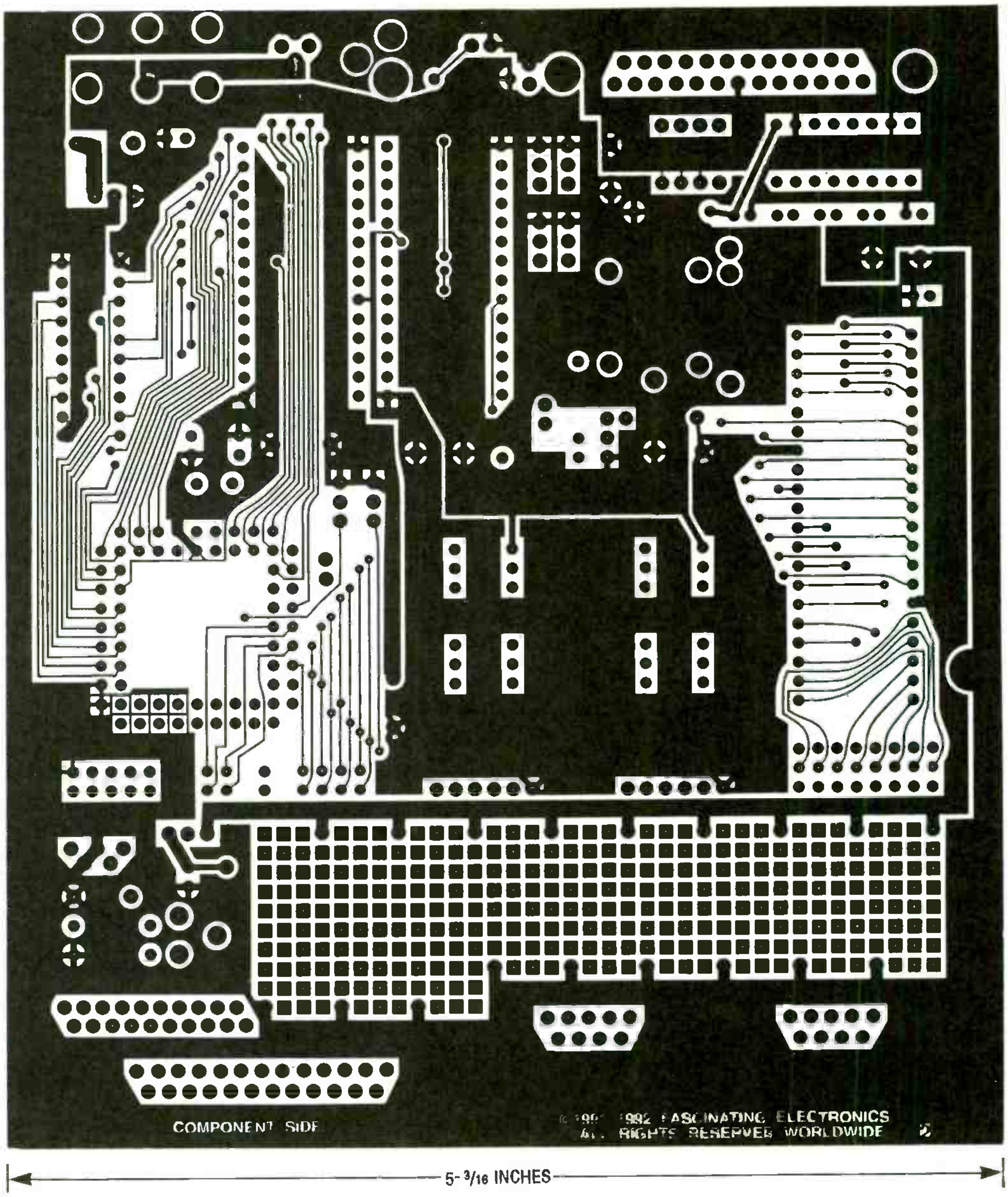


FIG. 5—CLOSEUP OF THE EXPERIMENTER. The Experimenter is a powerful measurement and control board that links your computer to the physical world with a variety of functions.

After turning on Experimenter's power, it should transmit a message listing its software version. It also runs a diagnostic check that will tell you if it has found an error.

Begin by testing the Experimenter's measurement and control capabilities, starting with the block of connections at the far left (the analog measurement inputs). Connect a hookup wire from the analog ground (AG) connection to the Channel 0 input. Send the Experimenter the command "A 0," and it should respond with a "0". Now jumper from the Analog +5 connection (A+5) to channel 0. This time when the A 0 command is given, Experimenter should respond with "5115," its full-scale reading. Repeat this procedure for channels 1 to 7.

Now check the time-measurement capabilities and the pulse-width modulators. Connect a hookup wire from PWM 0 to



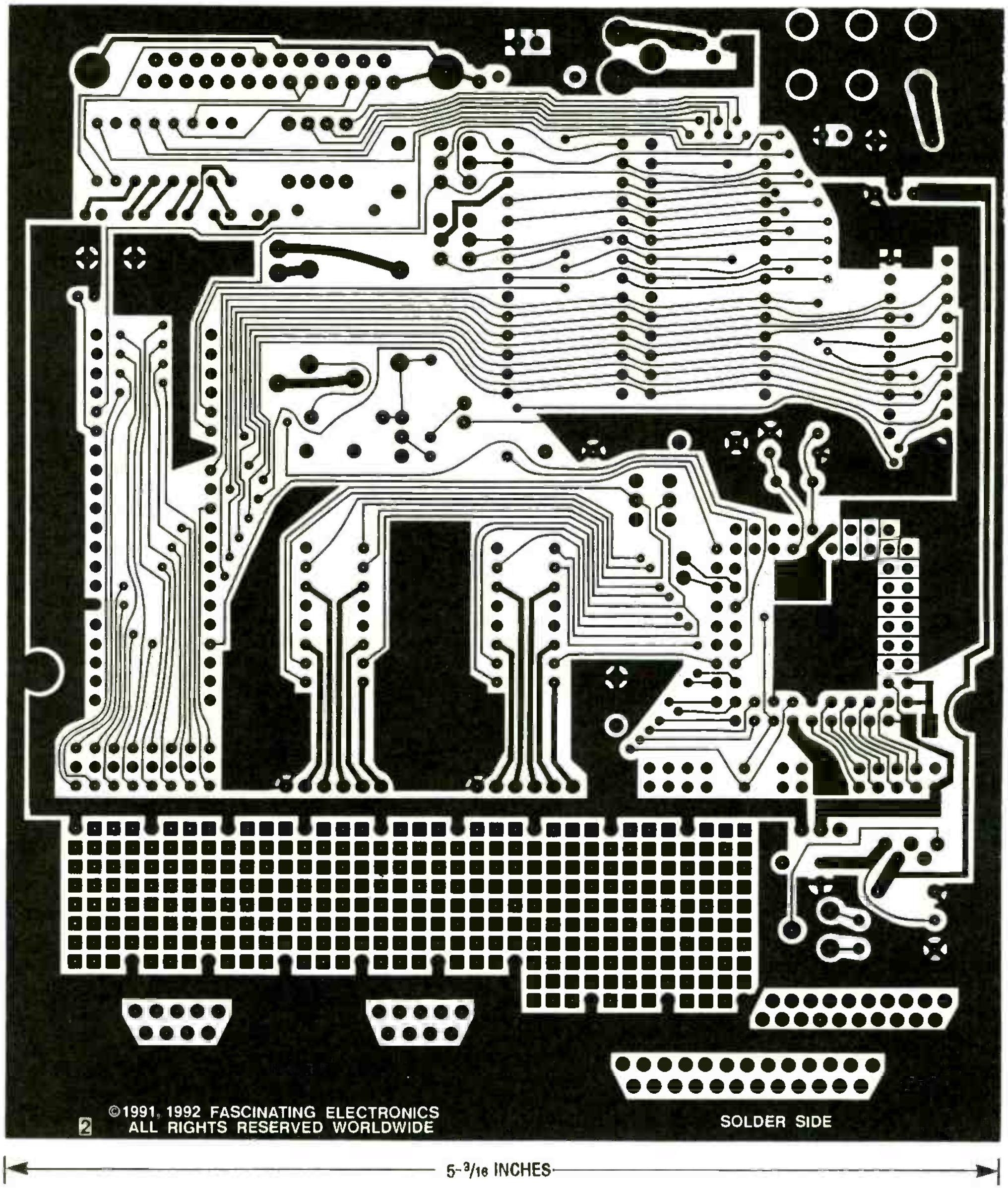
COMPONENT SIDE of the Experimenter board.

$T_{IN}0$. Give the command "E 0 204 144." That sets PWM 0 to an 80% duty cycle pulse at a rate of about 100 Hz. The command "C 0 7" will read the period, and respond "10030," meaning 10,030 microseconds. The command C 0 5 will read the positive pulse width, a value of 8020 microseconds. The command C 0 6 will read the negative pulse width, a value of 2010 microseconds. You can repeat this procedure for PWM 1, and the other timer inputs (T_{IN} 1–3).

The timed outputs (T_{OUT} 0–7) can also be tested with the time-measurement functions. Connect a wire from $T_{OUT}0$ to $T_{IN}0$. The command "I 0 1 10 1" will produce a train of pulses on $T_{OUT}0$ that remain high for about 10 milliseconds and low for 1 millisecond. The command C 0 5 will measure the positive pulse width, and respond with 9990 microseconds. The command C 0 6 will measure the negative pulse width, 1000 microseconds. Repeat this procedure for the other timed outputs.

To test the driver outputs (DRIVER A 0–3 and DRIVER B 4–7), connect a power source to the +A and +B inputs. For this test, wire those supply inputs to the +5-volt logic supply. Caution: Do not try to run any large motors from this supply! Not much current is available, and motors introduce electrical noise into their power sources. The noise could interfere with your Experimenter's proper operation. The connections to the +5-volt logic supply are marked among the top row of holes in the user-available wiring grid.

Now test the driver outputs the same way you tested the timer outputs. Recall that the only difference between the timer outputs and the driver outputs is that the driver outputs are buffered. Connect a wire from DRIVER A 0 to $T_{IN}0$. Give the commands E 0 255 and E 1 255 to assure that the PWM's are fully enabling the drivers.

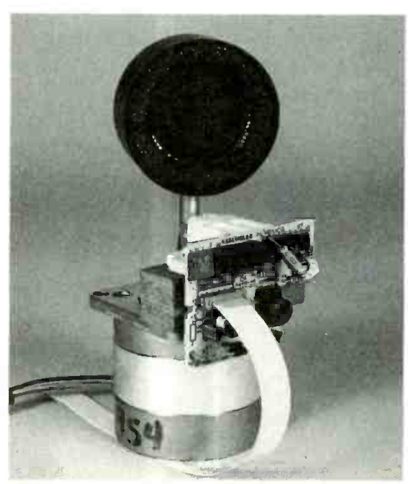


SOLDER SIDE of the Experimenter board.

Use the command I 0 1 10 1 to send a pulse train to DRIVER A 0. Use the command C 0 5 to measure the positive pulse duration. It should read about 9990 microseconds, as in the timed output tests. Repeat the test for the other driver outputs.

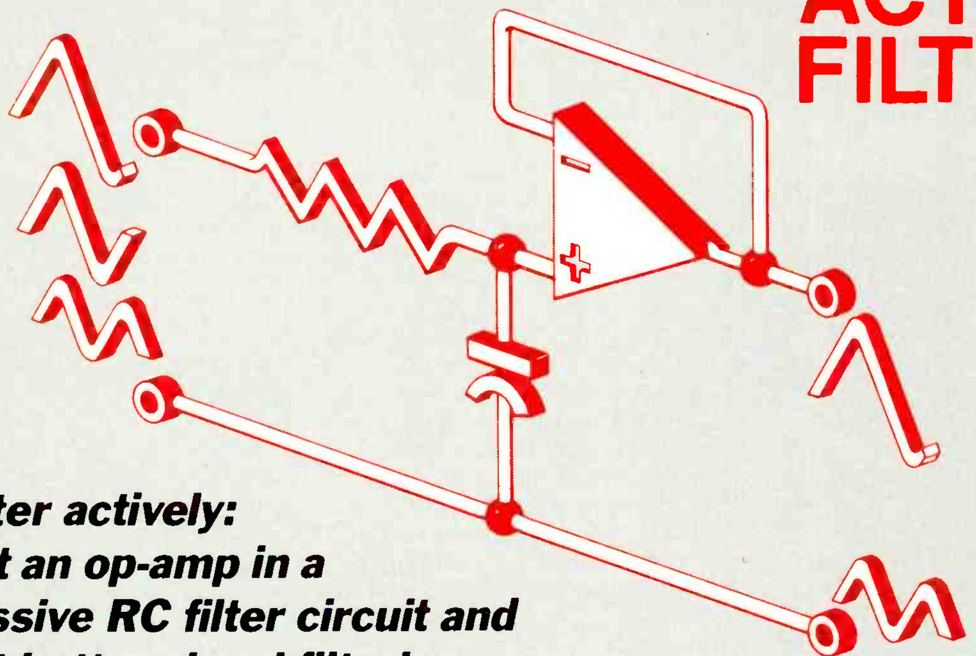
Finally, test the digital input/output with a logic probe, a digital multimeter, or with a wire jumper to an analog signal generator input. The command D 3 128 programs ports A, B, and C to be outputs. Because the microcontroller resets at power-on to all zeros, probing each output should show that each has a logic low state. The command D 0 255 sets all outputs on digital I/O port A high. Verify those outputs, and then test ports B and C with the commands D 1 255 and D 2 255.

Congratulations! You have now built and tested a versatile computer peripheral tool that vastly expands the capabilities of your computer. Next month we will describe a project based on Experimenter's digital output, time measurement, and stepper-motor control capabilities. That project will be the ultrasonic "radar" that actually makes very accurate distance measurements to nearby objects. Ω



HERE'S THE RADAR PROJECT that we'll be working on next month.

ACTIVE FILTERS



Filter actively: Put an op-amp in a passive RC filter circuit and get better signal filtering.

RAY MARSTON

YOU CAN BOOST THE PERFORMANCE of any resistive-capacitive filter by combining it with one or more operational amplifiers. The result is an active filter that can do things passive filters can't do.

An active filter is a filter that contains a device which supplies signal gain; the op-amp performs that function in all of the circuits presented here. The schematics in this article will permit you to carry out many interesting experiments. Moreover, the circuits can also be put to work in original projects that you design.

All of the active filters discussed in this article include the industry-standard μA741 operational amplifier. It operates from a dual power supply that can provide both the +9- and −9-volt DC needed to power it.

The μA741 was first introduced many years ago by National Semiconductor. Now a true commodity or "jellybean" IC, it is widely second-sourced and readily available throughout the world under such labels as the AD741, CD741, LM741, RM741, and SG741, as well as the μA741. There are also many modifications of the 741 indicated by suffixes to these standard designations.

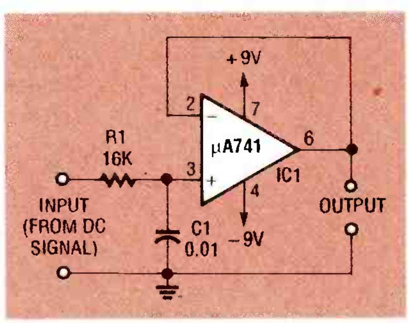


FIG. 1—AN ACTIVE FIRST-ORDER, LOW-pass filter for 1-kHz signals.

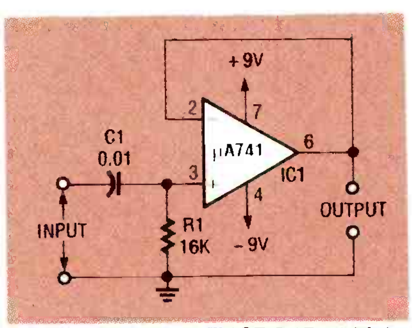


FIG. 2—AN ACTIVE FIRST-ORDER high-pass filter for 1-KHz signals.

Dual versions of the 741, such as the 1458, will also work in the circuits described here. Another widely second-sourced device, it is available under such labels as CA1458, LM1458, and MC1458. However, the circuits presented here will also work with most commodity op-amps, provided that they are supplied with their required voltages. If you want active filters for frequencies above a few tens of kilohertz, select a wide-bandwidth op-amp such as the high-speed, dual JFET-input LF353, also widely second-sourced.

The two most basic active-filters, low-pass and high-pass, shown in Figs. 1 and 2, are known as *first-order* filters because each has a single resistive-capacitive stage. These filters are simple modifications of the passive filters described in the article on RC filters in the June Issue of *Electronics Now* starting on page 57.

However, each of these active filters is buffered by a unity-gain, non-inverting op-amp to give a low-impedance output with a −3 dB crossover frequency (f_c) of $1/(2\pi RC)$, and an output slope of 6 dB/octave or 20 dB/decade.

With the component values shown with Figs. 1 and 2, both filters will have a center frequency (f_c) of 1 kHz. Notice that the input signal to the low-pass filter shown in Fig. 1 must provide an effective DC path to ground.

Figure 3 is a schematic for an active filter that will provide a very flat, unity-gain, second-order, low-pass output with a 10-kHz center frequency. It is known as a second-order filter because of its two RC stages, and as a *Butterworth* filter because it exhibits a virtually rectangular attenuation curve. These filters have flat response characteristics in their band-pass regions and steep, uniform rolloffs. Butterworth filters can be designed and built for low-pass, high-pass, or band-rejection response.

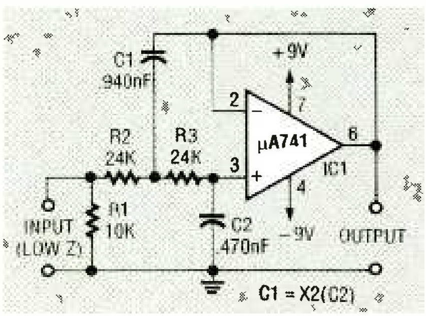


FIG. 3—AN ACTIVE UNITY-GAIN, second-order low-pass (Butterworth) filter for 10-kHz signals.

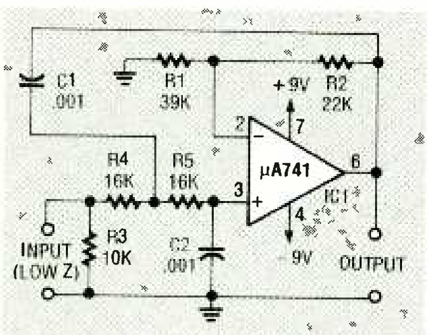


FIG. 4—AN EQUAL COMPONENTS second-order low-pass filter for 10-kHz signals.

In the Fig. 3 circuit, capacitor C1 (with twice the value of capacitor C2) provides unity-gain bootstrapping from the op-amp's output. This circuit's output rolls off at a rate of 12 dB/octave beyond 10 kilohertz. (This turns out to be about 40 dB down at 100 kilohertz.) To alter the center frequency, the value of either resistor R1 or capacitor C1 must be changed.

The rule of thumb here is: reduce the values by this ratio to increase the frequency, or increase the values to reduce the frequency. For example, to obtain a 4-kHz center frequency, increase the values of the resistors by the ratio of 10 kHz/4 kHz, or by a multipler of 2½. The formula for determining center frequency (f_c) for the circuit in Fig. 3 is:

$f_c = 1/2.83\pi RC$

A minor drawback in the Fig. 3 filter design is that capacitor C1 must be precisely twice the value of C2. That requirement makes it necessary to find non-standard capacitor values or make them up from standard values. Figure 4 shows an alternative second-order, 10-kHz low-pass filter circuit that overcome, that handicap because it works with capacitors of equal value. The μA741 op-amp offers a voltage gain of 4.1 dB through resistors R1 and R2. This yields greater than unity bootstrapping for one of the filter's two input capacitors.

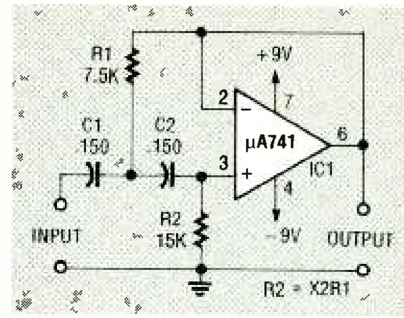


FIG. 6—A UNITY-GAIN, SECOND-order, 100-Hz high-pass filter.

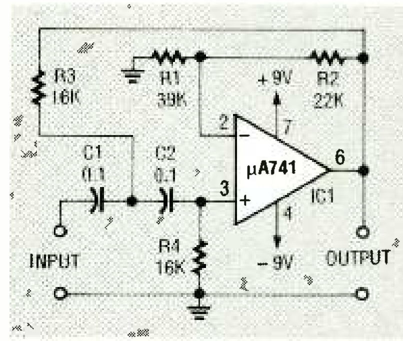


FIG. 7—AN EQUAL COMPONENTS second-order 100-Hz high-pass filter.

Figure 5 shows how two filter circuits with equal-component values can be cascaded to make a fourth-order, low-pass filter with a rolloff of 24 dB/octave. In this example, if the 39 K value of gain-determining resistor R1 is divided by the 5.87 K value of resistor of R2, a ratio of 6.644 is obtained. Also, if the value of 39 K resistor R3 is divided by the 58.5 K value of resistor R4, a ratio of 0.805 is obtained. The center frequency of this circuit is determined by the standard formula.

The cascaded combination in Fig. 5 provides an overall voltage gain of 8.3 dB. The non-standard resistor values of R2 and R4 can be obtained by connecting two standard 5% resistors in series to equal the desired value. The center frequencies of the filters shown in Figs. 4 and 5 can be altered in the same way that was discussed for Fig. 3.

Figure 6 is the schematic for a unity-gain, second-order, 100-kHz filter. Its center frequency is determined by the formula:

$f_c = 1/(2.83\pi RC)$

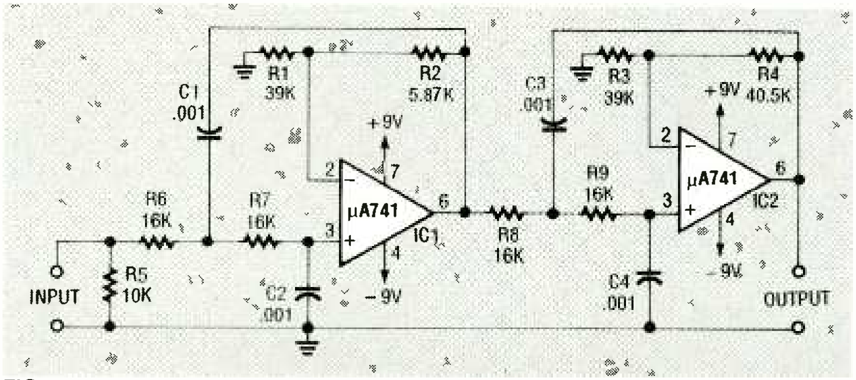


FIG. 5— A FOURTH-ORDER LOW-PASS FILTER for 10-kHz signals.

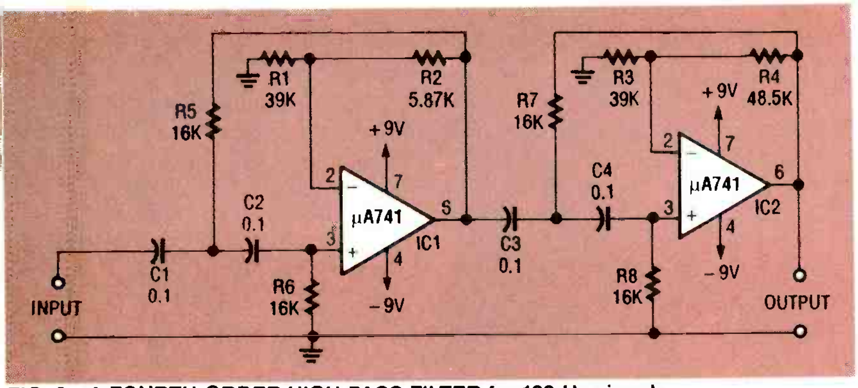


FIG. 8—A FOURTH-ORDER HIGH-PASS FILTER for 100-Hz signals.

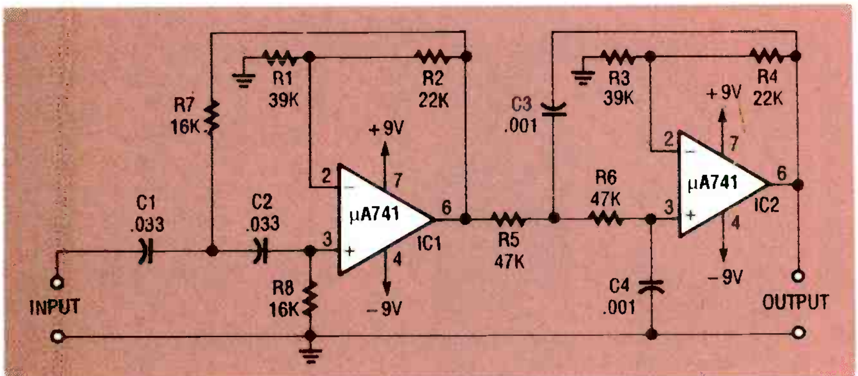


FIG. 9—A SECOND-ORDER BANDPASS FILTER with a range of 300 Hz to 3.4 kHz.

Figure 7 is the schematic for an equal-value components version of the Fig. 6 second-order 100-kHz filter. However, its center frequency is determined by the standard formula. The operating frequencies of both of these filters can also be changed in the way that was discussed for Fig. 3.

Figure 8 shows a fourth-order, 100-Hz highpass filter. Finally, Fig. 9 illustrates how the high-pass filter of Fig. 7 and low-pass filter of Fig. 4 are connected in series to form a 300-Hz to 3.4 kHz, audio-range bandpass filter. It offers 12dB/octave rejection to all signals outside of that passband. Notice, however, that certain changes must be made in component values for this circuit to work. In the front end high-pass filter based on Fig. 7, the values of C1 and C2 were reduced by ⅓ to 0.33µF to raise the center frequency to 300 Hz from 100 Hz. In the back end low-pass filter based on Fig. 4, resistor R3 was deleted and the values of resistors R4 and R5 were increased by a factor of 2.94 from 16 K to 47 K. That

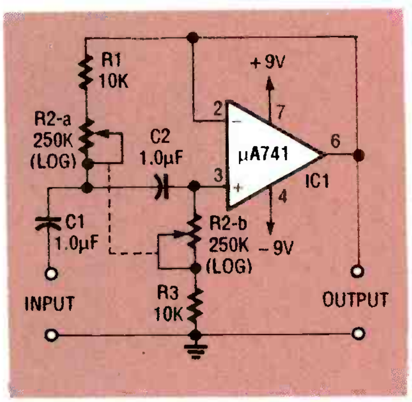


FIG. 10—A VARIABLE HIGH-PASS filter that covers the 23.5- to 700-Hz. band.

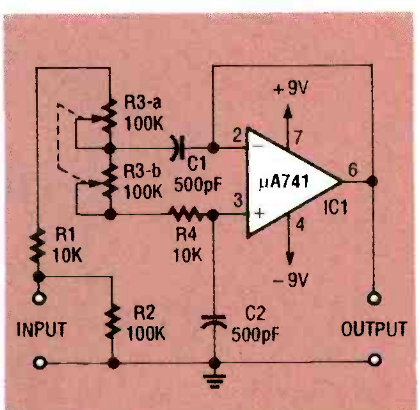


FIG. 11—A VARIABLE LOW-PASS filter that covers a 2.2- to 24-kHz band.

change reduces the center frequency from 10 kHz to 3.4 kHz.

Variable active filters

The most useful active filter is one that offers a wide frequency range with an easy-to-change crossover frequency. Figures 10 to 12 are schematics for three useful second-order filters that meet that criteria.

The circuit in Fig. 10 is a simple modification of the high-pass filter in Fig. 6. However, by varying dual trimmer potentiometer R2, a crossover frequency with a range of 23.5 Hz to 700 Hz can be obtained. Notice that, unlike the situation in Fig. 6, the resistive value of the upper arm of the filter (R1 + R2-a) equals the resistive value of the lower arm (R2-b + R3).

Unfortunately, this modification detracts from the virtually flat Butterworth characteristic curve, although it still provides very good filter performance. This circuit will work as a high quality filter for removing turntable motor "rumble" in LP disc players. Moreover, fixed versions of this filter can be expected to exhibit a 50-Hz crossover frequency.

The schematic in Fig. 11 is a modification of the high-pass filter in Fig. 3. However, trimmer potentiometer R3 permits its crossover frequency to be fully variable from 2.2 kHz to 24 kHz. Although this modification detracts from a truly flat Butterworth characteristic, this filter can, nevertheless, function as a high quality filter for the removal of scratch noises in LP disc players. Fixed versions of this filter typically have a 10-kHz crossover frequency.

Figure 12 illustrates how the filter circuits of Figs. 10 and 11 can be combined to make a truly versatile, variable high-pass/low-pass or rumble/scratch/audio filter. Trimmer potentiometer R2 varies the high-pass crossover frequency from 23.5 to 700 Hz, while trimmer capacitor R7 varies the low-pass value from 2.2 to 24 kHz.

Tone and notch filters.

High-performance active RC tone filters with high effective Q

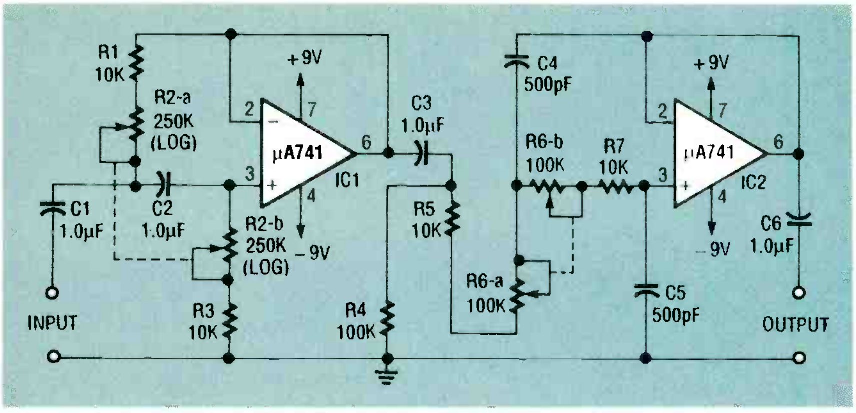


FIG. 12—A VARIABLE HIGH-PASS/LOW-PASS OR RUMBLE/SCRATCH audio filter.

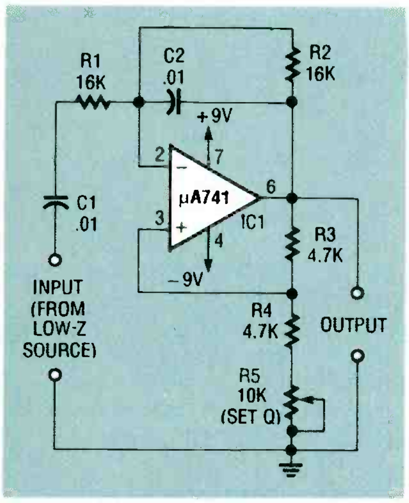


FIG. 13—A HIGH-Q TONE FILTER based on the Wien bridge for 1-kHz tones.

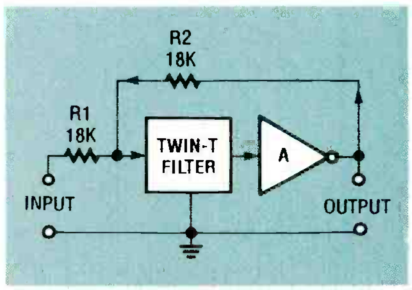


FIG. 14—A DIAGRAM FOR A BASIC twin-t notch filter with shunt feedback.

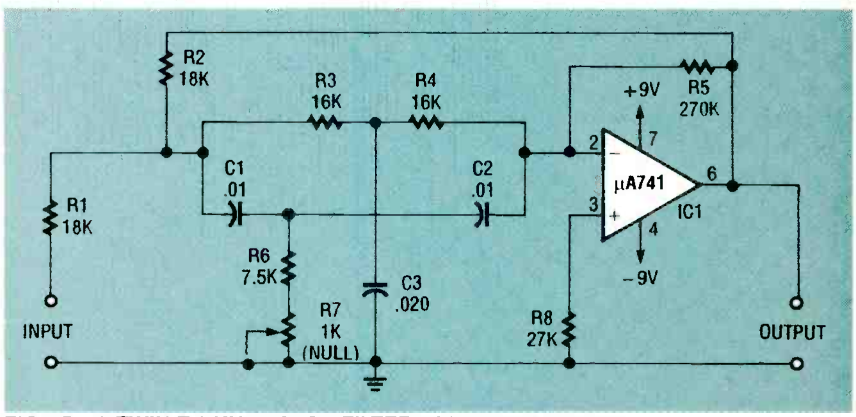


FIG. 15—A TWIN-T 1-KHz NOTCH FILTER with shunt feedback.

values can be made with twin-T or Wien networks in the feedback loops of op-amps. Figure 13 shows a useful 1-kHz tone or acceptor filter based on the Wien-bridge circuit. The Q of this filter can be varied by fixed resistor R4 in series with 10K SET Q trimmer potentiometer R4. Caution: this circuit will oscillate if the wiper on R4 is positioned so that the value of R4 is less than twice the value of R3.

The basic twin-T notch filter has a very low Q. The filter's Q and the sharpness of its notch characteristic can be increased by including the twin-T in the feedback network of an active filter. There are two conventional ways to do this.

The first is to organize the circuit in a general shunt feedback arrangement as shown in Fig. 14. The input signal is fed to the twin-T filter through resistor R1 before it is amplified by amplifier A. The amplified and inverted version of the twin-T filter's output is fed back to the circuit's input through resistor R2, which has the same resistance value as R1.

Figure 15 is the schematic for 1-kHz practical example of this class of active filter. The network's null point can be adjusted with 1 K NULL trimmer potentiometer R7.

The second (and more modern) method for improving Q is with a bootstrapping technique. Figure 16 is a practical schematic for a 1-kHz variable-Q version of that circuit concept. The twin-T filter's output is buffered by operational amplifier IC1 (organized as a unity-gain voltage follower). Part of its buffered output is taken by pin 3 of op-amp IC2 (another unity-gain voltage follower), from SET Q trimmer potentiometer R7. The output of IC2 is then fed to the bottom of the twin-T filter as a bootstrap signal.

When the wiper of R7 is set to its lowest (ground) point, the network exhibits zero bootstrapping, and the circuit acts like a standard twin-T filter with a Q of 0.24. However, when the wiper of R7 is set to its highest value of resistance, the network exhibits heavy bootstrapping. This results in a filter with an effective Q of about 8 with a sharp notch characteristic.

The filter's center-frequency can be adjusted slightly with TRIM F trimmer pottentiometer R3, and the null point can be adjusted with NULL trimmer potentiometer R6. For best results, trimmer R6 should be a multiturn unit.

Building a THD meter

The bootstrapped twin-T notch filter can function as a total harmonic distortion or THD meter. With the filter's notch tuned to the basic frequency of the input test signal, the filter totally rejects the fundamental frequency of the signal, and applies zero attenuation to the signal's unwanted harmonics. The output signals must be measured on a true RMS voltmeter.

If the original input signal

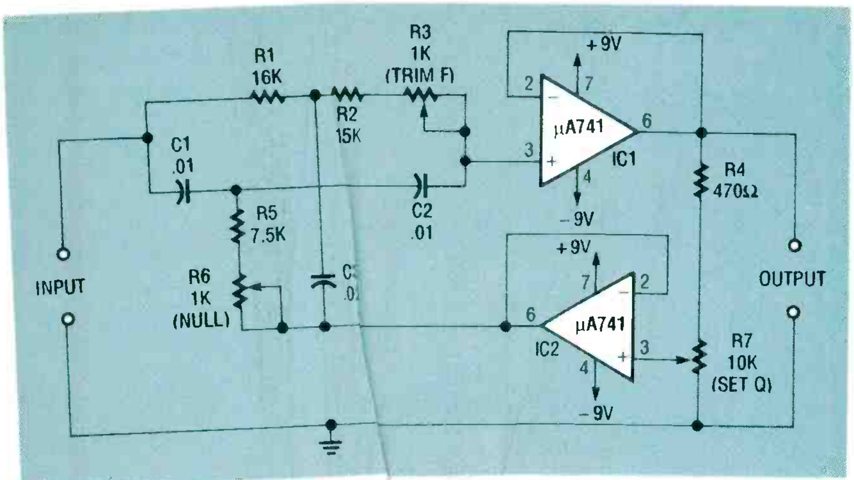


FIG. 16—A VARIABLE-Q, BOOTSTRAPED TWIN-T NOTCH filter for 1 kHz.

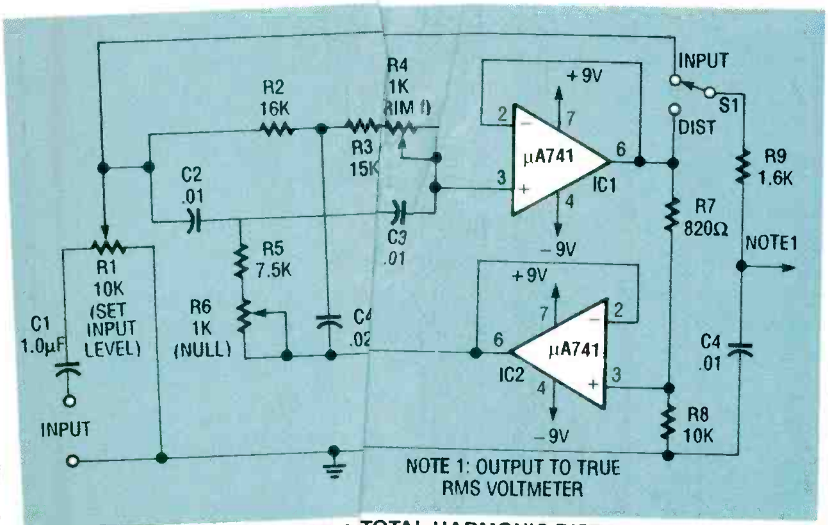


FIG. 17—THE SCHEMATIC FOR A TOTAL HARMONIC DISTORTION (THD) meter circuit.

has an RMS amplitude of millivolts, and the nullec put has an amplitude of 1- livolts, the ratio of output to input signal multipl 100 gives a THD of 1.5 %

Figure 17 is a schemat high-performance, 1-kH meter. In this circuit, th Q is set at a value of 5 voltage divider formed ohm resistor R7 in ser the 10 K resistor R8.

The input signal to can be varied with 10 PUT LEVEL trimmer capa and the filter's tuning ing can be varied trimmer potentiom Switch S1 permits the be switched to either INPUT or distorted (DIS Either output can b external true RMS vc

To make a measurement with the THD meter shown in Fig. 17, set switch S1 to its INPUT position, connect the 1-kHz input test signal, and adjust R1 to set a convenient (1- or 2-volt) reference level with the true RMS voltmeter switch.

Then set S1 in the DIST position, adjust the input frequency for an approximate null, and adjust trimmer potentiometers R4 and R6 alternately until you obtain the best possible null. Read the nulled voltage and calculate the distortion factor from the formula:

$$THD\,(\%) = (V_{DIST} \times 100)/V_{IN}$$

Studying and building filter circuits should give you some new insights into the way operational amplifiers can enhance the effectiveness of passive filter circuits. Ω

HARDWARE HACKER

A flying-car newsletter, photopolymer resources, amateur television books, royalty-free real Postscript, and a BASIC Stamp controller.

DON LANCASTER

A reminder once again that sources for most of the items mentioned in this column are listed in a pair of sidebars. You will usually find one for all the regular *Names & Numbers*, and a second one that targets a special resource category. We try to triple check all entries so that they are up to date.

However, to date, I have received over *two hundred* helpline calls asking me for the *Integrated Circuit Systems* source from two columns back. Well, it was right where it belonged. Smack dab in the middle of that *Names & Numbers* sidebar. Complete with a reader service number.

Before calling my no-charge tech helpline, please read the *entire* story, double check both sidebars, and have a pencil or pen ready.

A new microcontroller

As Fig. 1 shows, the *BASIC Stamp* from *Parallax* is a brand new $39.00 hacker computer the size of a commemorative postage stamp. It is basically a PIC16C56 microcontroller, a 256-byte EEPROM, a resonator, and a voltage regulator. Eight I/O lines, provided in a breadboard area, form a real-world interface. *Microchip Technology* is the supplier of the CPU.

This one is cute as a bug.

An approximate schematic of the BASIC Stamp appears in Fig. 2. Programmed into the custom CPU is a BASIC interpreter. The fully tokenized instructions are stored in the companion serial EEPROM and then automatically interpreted on each power up.

The *total* program and data storage area is only 256 bytes in the EEPROM plus an additional 16 internal working registers.

No, you can not run multi-tasking Unix on this machine. But since each tokenized BASIC command requires only a few bytes, and since some powerful macros are available, you can create surprisingly sophisticated programs.

Programs are normally developed on a PC host, using the fancy editor and interpreter provided with the Stamp. You can work directly in BASIC on the host, and you have all the PC's normal resources available. The interpreter then tokenizes the final program and uploads it to the BASIC Stamp via a three-wire cable that connects to your host's parallel port. Once the program is uploaded, the BASIC Stamp becomes a dedicated computer that can be used just about anywhere.

Power is provided by a snap-on 9-volt battery. Power consumption is an impressive 2 milliamps when running, and a mere 20 microamps when asleep.

Figure 3 shows the instruction set. Besides all the usual tiny BASIC commands, there are some powerful macros offered. BUTTON debounces input contacts—with a lot of options.

DEBUG returns variables to your host for debugging and analysis. A BRANCH macro offers a direct option picking. As in the CASE command in fancier languages.

PAUSE provides selectable time delays. POT is an 8-bit A/D converter that reads a potentiometer input. It ca also read a photocell or thermisor. PULSIN can measure the durtion of any input pulse with a 10-miosecond resolution. The similar PLSOUT command delivers a tied output signal.

WM directly outputs pulse-width modulation. Adding a resistor and capacitor can change that to an 8-precision analog voltage.

Now for the neat stuff. The SERIN mro is a full serial data receiver wselectable baud rates from 300 t200. This can become *self-qfying* in which the processor w for a specified character seqe. SEROUT directly generat erial output data for RS-623 usS-232 is available with an exte driver.

OUND command can produ28 tones and 128 noise eff

NDOM number generator is alsuded for white-noise audio sou or to randomize video gamcts. Naturally, you can select ead, toggle, or write any indiv/O line. You can also tempora permanently put the processo its sleep mode. You "wak" by cycling the power off an back on. Sixteen subroutie allowed, nested two deep.

PIC based on RISC rather than \umann computer architecture 12-bit instruction words ed in conjunction with 8-bit ords. The chips themselves ustom operating system cc be purchased for as little 0 each. See the *MicroC Book* and its companion *ded Control Handbook* fo nal details.

Spee PIC series blows away m competition in execution code length. On the othe serial EPROM ac-

> **NEED HELP?**
>
> **Phone or write your Hardware Hacker questions to:**
>
> Don Lancaster
> **Synergetics**
> Box 809-EN
> Thatcher, AZ, 85552
>
> (602) 428-4073
>
> For fast **PSRT** access, modem (800) 638-8369, then an HHH. Then XTX99005,SCRIPT.

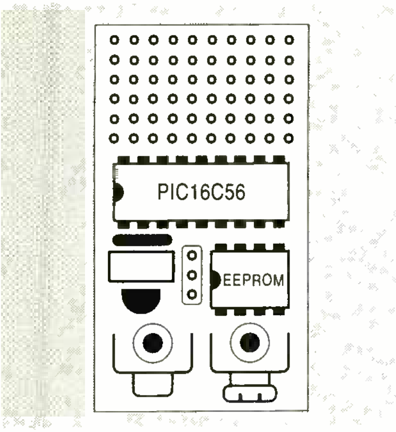


FIG. 1—THE BASIC STAMP is a $39.00 hacker microcontroller. The Microchip Technology PIC16C56 is used.

cess for the tokens does slow things down considerably. But hundreds of internal machine language commands can be executed at full speed for any one token fetch. Clock frequencies as high as 20 megahertz can be obtained, so long as low power is not critical.

One possible trick: Use the BASIC Stamp to develop your application. Then you switch to plain old machine language to obtain full speed and ultra low cost for your production units.

Much more information on the fundamentals of working with microcontrollers can be found in my *Micro Cookbooks*, volumes I and II.

Homebrew PostScript

One potential use for the BASIC Stamp is shown in Fig. 4. I've been doing a lot of work with the great PostScript general-purpose computer language. In fact, this is the *only* language I use for *all* of my electronic design, printed circuit layouts, stock market analysis, schematics, and book-on-demand publishing.

All the camera-ready figures you have seen here in *Hardware Hacker* for years have been produced with nothing but my word processor and PostScript. Device independently.

The only little problem has been that PostScript I/O tends to be a tad on the skimpy side. Usually you have only three choices: dirtying up otherwise clean sheets of paper or plastic, writing files to a hard disk, or returning data back to a host for recording or other reuse.

The BASIC Stamp will let you extend the genuine Adobe Level II PostScript to any personal project or machine of your choice!

Assume you have a homebrew machine that has an X-axis and Y-axis stepper, an up/down mechanism, and a *both steppers home* sensor. This can be a vinyl signcutter, engraving, or embroidery setup. Or it can be an automated printed circuit drill, a wooden sign router, or a Santa Claus machine.

You could use two of the BASIC Stamp lines for RS-423 serial communication with your PostScript printer. Use two lines for both X-axis stepper phases and two lines for Y-axis stepper phases, one line for pen or drill up/down, and a final line that zeros only when both steppers are in their home position.

The hidden beauty here is that all of those fancier PostScript fonts and the level two tools immediately become available for use on your own custom homebrew rig—at unbelievably low cost and with *zero* royalties!

Do let me know if you want more details. Meanwhile, I've posted lots more on PostScript to *GEnie* PSRT.

In particular, be sure to check out, STARTUP.PS for an introductory PostScript tutorial, and POSTVECT.PS for lots of details on vector output. I've also got a free PostScript secrets brochure to get you started.

Thoughts on a PC drill

One really big hacker breakthrough that everyone is waiting for is a $199 automated printed circuit drill. The new BASIC Stamp along with a PostScript printer gives us a brand new handle on this project.

I recently noticed that dentist's air turbines cost only $30. Junkers might end up free from a reasonably curious dentist. The handle on most drills is usually empty, so the turbines can be cut down to the size and roughly the mass of a plotter pen. It sure would be interesting to see if they have enough power for board drilling!

Let's restrict our goals initially to a 4 × 6-inch board. An X-Y system might introduce all sorts of mechanical problems. Instead, the board could be moved along a single axis. The drill could be moved along a second axis, and it might be easier to *lift* your board, rather than drop the drill. Or maybe you could use a raising cam and gravity feed on the turbine.

My current choice for a stepper would be the linear *Hurst* SLS. While it's kind of pricey, it offers twenty pounds of force in 2-mil steps. And *Texas Instruments* offers some dandy new peripheral driver chips.

Fun with photopolymers

I have long been fascinated by *photopolymers*. These are just plastic compounds of one breed or another which are only partially cross-linked during manufacture. A later exposure to light and a development process will selectively harden portions of the material. That can result in a state change from liquid to solid, or a shift in dissolvability.

The materials could be used for etch resists, a 3-D model, a Braille sign, a rubber stamp, a printing plate, an integrated circuit mask, a silk screen master, or a vinyl stick-on letter. Or for zillions of other new applications.

Because of fundamental chemistry, most photopolymers demand strong ultraviolet light for exposure. Three minutes under a contact printer in direct sunlight often will work well. Photopolymers are typically *negative acting*, hardening in the presence of light.

This month I thought the resource sidebar should provide a rundown of the more hackable photopolymers.

The classic material you might be familiar with is spray-on etch resist, often in the form of KPR by *Eastman Kodak* and stocked by *Radio Shack*. More modern substitutes are the *dry film photoresists* such as those now offered by *Dynachem*. These are both uniform and pinhole free. They also develop with sodium triphosphate, a low-cost garage-floor cleaner.

Kepro is one fine supplier of printed circuit supplies. A good magazine on the subject is *Circuits Assembly*.

Photopolymer solder-mask resists are also readily available. Photopolymers offer lots of options for silk-screen printing. The leading film supplier is *Ulano*, while *Advance Process Supply*, *Southern Sign*, and *Dick Blick* offer them in smaller quantities.

3-M, the *Scotch Tape* folks, have many interesting photopolymer products. One is known as *Color Key*. With Color Key, you end up with a clear polyester sheet that has translucent or opaque color areas selectively applied to it. Color Key provides dozens of color options. I can see lots of graphic arts uses for it.

3-M's *Dynamark* imaging products seem great for labels and prototype dialplates. Typically, you will have a white self-stick vinyl with a color overlay. You can selectively remove the color by exposing it to ultraviolet light. Aluminum-backed versions are also offered, priced about $8 per square foot.

The photopolymers have long been essential for *flexographic* printing, as is used on cardboard containers. One leading supplier for larger quantities is *Merigraph*, while *R. A. Stewart* is a wholesale source for more modest amounts.

The same material can make great "rubber" stamps. Any "real" rubber stamp will be pink or black, while a photopolymer stamp will be clear to translucent. The photopolymer stamps often last longer and provide sharper images. Of the many rubber-stamp photopolymer suppliers, *Grantham Polly-Stamp* and the *M&R Marking Systems* are my favorites.

We've seen in previous issues how Santa Claus machines are starting to revolutionize prototyping. A leading firm that uses ultraviolet curing photopolymers is *3-D Systems*. More on Santa Claus stuff in future issues and the *Hardware Hacker* reprints.

The photopolymer that I am really waiting for is a vinyl one which has been only partially cross-linked. An artwork master can be created on your laser printer and then contact printed. After development, you end up with a repositionable cut vinyl letter or a logo—all without needing a costly sign cutter. I keep hearing persistent rumors of such photopolymers, but I have seen no products yet.

Meanwhile, there are now two new products that come close. One is the *Etch-n-Peel* system by *Kimoto*, which is basically a self-stripping lithographic film. While great for its intended graphics art stripping purposes, you are stuck with red, and the results are not repositionable.

The other one is known as *Cooley Brite Eradicable Sign Material*, which is an opaque white and fully

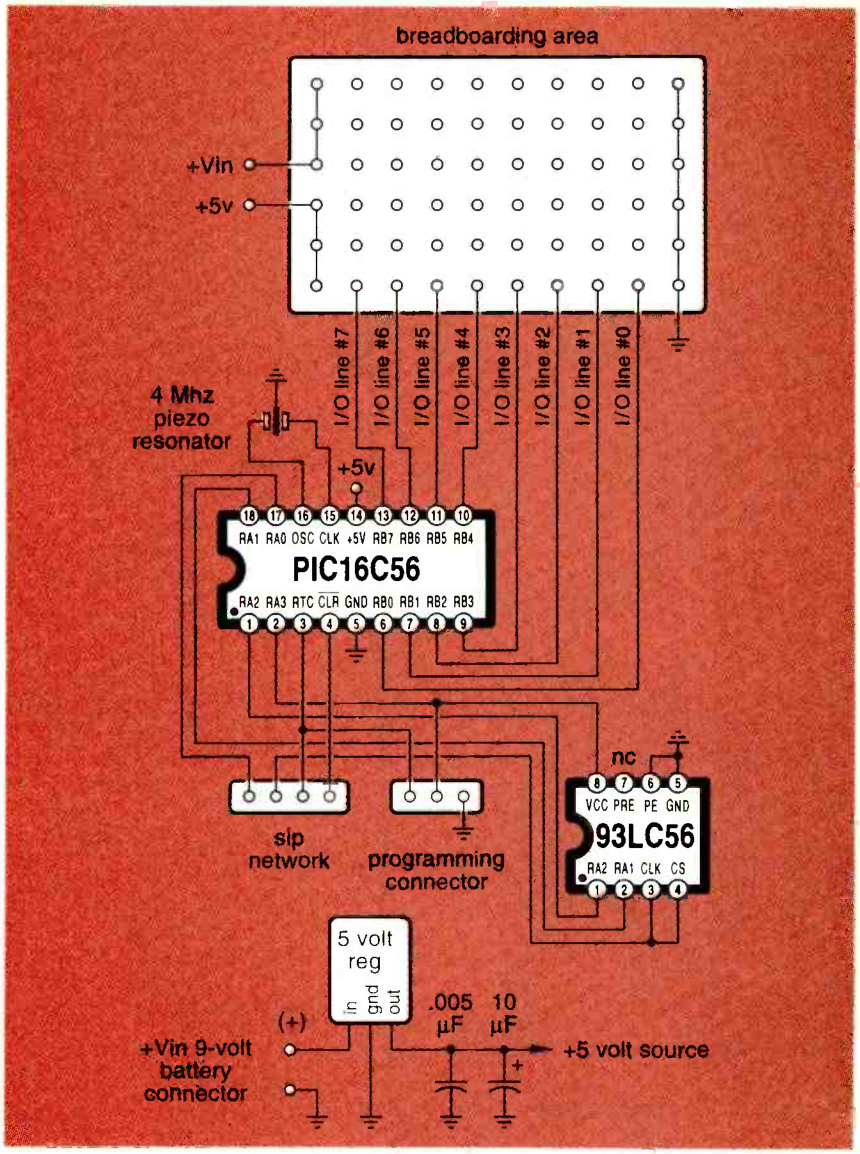


FIG. 2—SCHEMATIC DIAGRAM of the BASIC Stamp.

NAMES AND NUMBERS

Amateur Television Quarterly
1545 Lee Street
Des Plaines, IL 60018
(708) 298-2269
CIRCLE 316 ON FREE INFORMATION CARD

Colorado School of Mines
SPACE
Golden, CO 80401
(303) 273-3321
CIRCLE 317 ON FREE INFORMATION CARD

EAA Aviation Center
3000 Poberezny Drive
Oshkosh, WI 54903
(414) 426-4800
CIRCLE 318 ON FREE INFORMATION CARD

GEnie
401 N Washington Street
Rockville, MD 20850
(800) 638-9636
CIRCLE 319 ON FREE INFORMATION CARD

Hurst Manufacturing
Box 326
Princeton, IN 47670
(812) 385-2564
CIRCLE 320 ON FREE INFORMATION CARD

Integrated Circuits Systems
PO Box 968
Valley Forge, PA 19482
(215) 666-1900
CIRCLE 321 ON FREE INFORMATION CARD

Dan Levels
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Tellevast, FL 34270
(813) 356-2788
CIRCLE 322 ON FREE INFORMATION CARD

McMaster-Carr
Box 54960
Los Angeles, CA 90054
(310) 692-5911
CIRCLE 323 ON FREE INFORMATION CARD

Microchip Technology
2355 W Chandler Blvd
Chandler, AZ 85224
(602) 963-7373
CIRCLE 324 ON FREE INFORMATION CARD

MSC
6700 Discovery Blvd
Mableton, GA 30059
(800) 645-7270
CIRCLE 325 ON FREE INFORMATION CARD

Parallax
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Citrus Heights, CA 95621
(916) 721-8217
CIRCLE 326 ON FREE INFORMATION CARD

Resonance Research
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Baraboo, WI 53913
(608) 356-3647
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Edmonds, WA 98020
(206) 778-0423
CIRCLE 328 ON FREE INFORMATION CARD

Rotary Flight International
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Albuquerque, NM 87108
(505) 298-9362
CIRCLE 329 ON FREE INFORMATION CARD

Small Parts
13980 NW 58th Court
Miami Lakes, FL 33014
(305) 557-8222
CIRCLE 330 ON FREE INFORMATION CARD

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
CIRCLE 331 ON FREE INFORMATION CARD

Texas Instruments
PO Box 809066
Dallas, TX 75380
(800) 336-5236
CIRCLE 332 ON FREE INFORMATION CARD

Don Thompson
23072 Lake Center Dr. No. 100
El Toro, CA 92630
(714) 855-3838
CIRCLE 333 ON FREE INFORMATION CARD

outdoor-rated reinforced vinyl. Color fluid is preapplied to its surface in a selection of 17 different shades.

A magic developer will dissolve *only the color*. To do that, put a vinyl cover (or any suitable mask) onto the material and then simply scrub the color away in selected locations. In the daylight, you have a color over white. At night and backlit, you get white light or translucent colors per your selection. Neat stuff. Sanely priced. And eminently hackable.

Finally, there is an interesting new variation on photopolymer printing plates that should open up all sorts of new hacker ideas. The *Jet USA* folks are using photopolymers for Braille and other low-cost, raised-letter applications. What you really have here is a metal plate with some raised plastic selectively applied exactly where you want it. Unique

BRANCH	Option picker similar to a CASE command.*
BUTTON	Read and debounce mechanical input.*
DEBUG	Send register contents to host.*
EEPROM	Store data in memory.
END	Go into sleep mode until power cycles.
FOR...NEXT	A looping construct.
GOSUB	Execute subroutine.
GOTO	Jump to another location in program.
HIGH	Make the chosen I/O pin high.
IF...THEN	Conditionally execute instructions
INPUT	Make selected pin an input.
LET	Optional definition. Includes add, subtract, multiply hi/lo, idivide, modulo, min, max, AND, NAND, OR, NOR, XOR, and NXOR.*
LOOKDOWN	Search table for match.*
LOOKUP	Read values from table.*
LOW	Make the chosen I/O pin low.
NAP	Enter sleep mode for a selected time.*
OUTPUT	Make the chosen I/O pin an output.
PAUSE	Short selected time delay.
POT	Read a potentiometer (8-bit A/D convert).*
PULSIN	Measure input pulse width.*
PULSOUT	Output pulse of selected width.*
PWM	Output pulse width modulation (D/A convert
RANDOM	Generate pseudorandom number.*
READ	Read variable from memory.
RETURN	Return from subroutine.
REVERSE	Change direction of selected I/O pin.
SERIN	Read serial input and interpret format.*
SEROUT	Format and output serial data.*
SLEEP	Long selected time delay.
SOUND	Output musical notes or white noises.*
TOGGLE	Change state of selected I/O pin.
WRITE	Store data to memory.

FIG. 3—INSTRUCTION SET FOR THE BASIC STAMP. The macros marked with an asterisk (*) make the stamp surprisingly powerful.

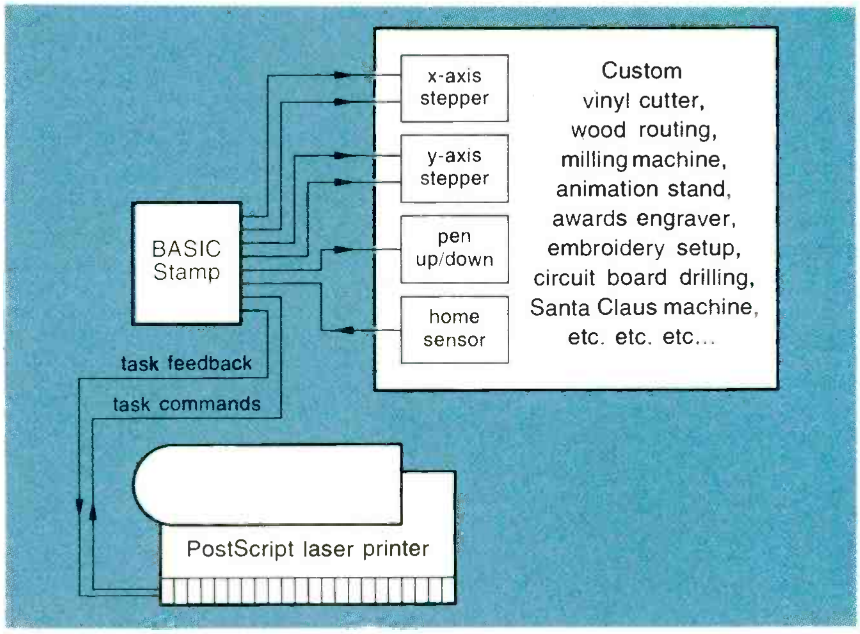

FIG. 4—THE BASIC STAMP can be used as a low cost and royalty-free interface to let you apply real Adobe PostScript level 2 to any old homebrew project!

business cards are one possibility.

There is a slight chamfer to their resin, improving the appearance. Cost is in the twenty cents per square inch range. Jet's processing equipment is ridiculously expensive, but it should be easy enough to fake. They have some free samples available.

Needless to say, *any* hacker work involving photopolymers can be very much improved by using PostScript. Full details on *GEnie* PSRT. One little known capability of PostScript is its *microsizing* ability. This lets you get the final size of your printed circuit layout exactly right, even on a printer with sloppy tolerances and paper that swells or shrinks.

In flexographic printing and other places where images stretch as they are bent around a drum, anamorphic scaling with PostScript gives you a fast, simple, and accurate fix.

Two contests

Let's have two contests this month. Either (A) dream up a new application for the BASIC Stamp, or (B) see if you can come up with some hacker use for photopolymers that is not obvious.

As usual, there will be a dozen or so of my recently updated *Incredible Secret Money Machine* book prizes, along with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

Be sure to send your *written* entries directly to me here at my *Synergetics*, and not to the **Electronics Now** editorial offices.

New tech lit

We have a super selection of new goodies this month. For great books and magazines on ATV, try the *Amateur Television Quarterly* folks.

Gyro Gearloose is alive and well! *Roadable Aircraft* is a unique labor-of-love newsletter from Ron Borovec for flying car enthusiasts. Similar publications include *Experimental Aircraft* from the *EAA Aviation Center* and the *Experimental Rotorcraft* from *Rotary Flight International*.

All the fundamentals of telephone

PHOTOPOLYMER RESOURCES

Advance Process Supply
400 N Noble Street
Chicago, IL 60622
(312) 829-1400
CIRCLE 334 ON FREE INFORMATION CARD

Dick Blick
Box 1267
Galesburg, IL 61401
(800) 447-8192
CIRCLE 335 ON FREE INFORMATION CARD

Cooley Sign Systems
50 Esten Avenue
Pawtucket, RI 02860
(800) 992-0072
CIRCLE 336 ON FREE INFORMATION CARD

Dynachem/Thiokol
2631 Michelle Drive
Tustin, CA 92680
(714) 730-4200
CIRCLE 337 ON FREE INFORMATION CARD

Dynamark
3M Center Bldg 220-7W-03
Saint Paul, MN 55144
(800) 241-4819
CIRCLE 338 ON FREE INFORMATION CARD

Eastman Kodak
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operation are well covered in a new self-published *Tech Notes from a Telephone Engineer* by Dan Levels.

Science Under Siege is a new book by Michael Fumento. It explores the nature of evidence and statistics in a scientific controversy, and covers everything from the Alar

Continued on page 83

COMPUTER CONNECTIONS

Operating system wars.

JEFF HOLTZMAN

Operating systems have been controversial as long as there have been computers. The reason is simple: The operating system is a critical link in the chain joining the economically significant computer hardware and application software. Recall that an operating system is an integrated collection of supervisory programs and subroutines that controls the execution of computer programs and performs special system functions. It organizes a central processor and peripheral devices into an active unit for the development and execution of programs.

Without an operating system, applications software would have to be rewritten every time a change occurred in the hardware. But with an operating system, hardware evolution can at least be partially masked, so applications vendors can focus on innovating end-user solutions. Of course, an operating system such as Microsoft's Disk Operating System (MS-DOS) that runs on so many IBM PC's and compatibles has been an outstanding market success and is a formidable competitor with tremendous staying power.

Microsoft's increasingly aggressive domination of the PC sector portion of the computer industry has angered—and frightened—many established equipment manufacturers of minicomputers and mainframes. This has led to the latest in a long line of "open system" joint ventures—this time with a twist. The Common Open Software Environment (COSE) unites computer manufacturers and other organizations with an interest in replacing MS-DOS with the UNIX operating system or its modifications—Hewlett Packard, IBM, Sun Microsystems, Univel, and UNIX Systems Laboratories.

COSE, as well as recent moves by Microsoft to keep MS-DOS competitive, added to the responses from IBM and Novell keep the operating system controversy at a boiling point.

It will be useful to sort through these events and try to make sense of them. First let's review some of the major events that took place early in 1993. Figure 1 is a diagram that summarizes how operating systems and their advocates interact.

IBM, Microsoft, and Novell

IBM has successfully improved its proprietary Operating System OS/2 2.x to the point where it's now more effective than DOS, and it has improved running Windows so that it is reasonably effective. However, to cover its bets, IBM is active in COSE. Third, the IBM/Apple/Motorola partnership that plans to produce inexpensive RS6000 microprocessors (the Power PC) is nearing completion. Reports from insiders suggest that these devices have demonstrated price-performance improvements.

These MPU's can run both Aix, a variant of IBM's UNIX, and Macintosh 680x0 applications directly. It can also run DOS/Windows code through emulation. From a marketing point of view, it seems unfortunate that IBM didn't put an X86 CPU in the Power PC as well.

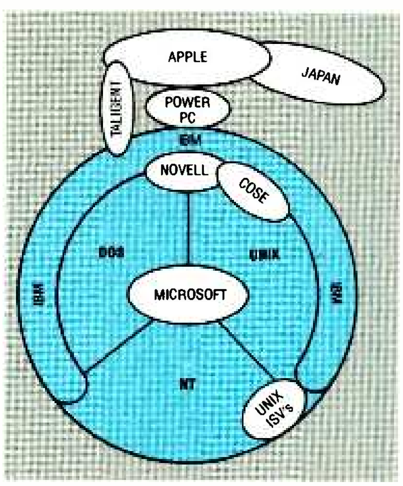

FIG. 1—THE WORLD OF computer operating systems is becoming more complex because of major software and hardware vendor alliances. IBM has covered the largest number of bases, but Microsoft leads its competitors by ten to one.

Novell released version 4.0 of NetWare last spring, a product that has received generally positive reception in the marketplace. Novell has also purchased UNIX Systems Laboratories (USL) from AT&T. That purchase might do more to revitalize and focus the UNIX community than the competition with MS-DOS over the last decade. The USL purchase makes Novell a key player in COSE.

Of course, Microsoft has not been resting on its laurels either. Its release of Windows NT should have taken place by the time you read this. Microsoft hopes that its Windows NT will fare better in the marketplace than Windows for Workgroups, the company's peer-to-peer networking software whose sales have been disappointing. Information about Chicago and Cairo, supposedly the wave of the future, is beginning to trickle out of industry closed doors.

Unfortunately, all of Microsoft's operating system-related activity has sown confusion and uncertainty among present and potential customers. The profusion of products has raised questions about existing software obsolescence and its compatibility with future products. This applies to Microsoft's networking software, Lan Manager, as well.

Cairo: king of the MS hill?

Industry insiders have widely assumed that Windows NT was the designated heir to the Windows 3.1 throne. Recently, however, that view has faded; it now appears that NT is an interim operating system intended as a bridge to the UNIX community. Almost incidentally, it will support DOS and Windows. In an ironic twist, it now seems that OS/2 might provide better support for DOS and Windows than NT!

In recent months NT has attracted a lot of attention from the UNIX Independent Software Vendors (ISV). The UNIX OS vendors such as the COSE group were justifiably shaken by ISV's interest in NT. The UNIX community is fully aware of Microsoft's ongoing power. However, that same UNIX community has a habit of creating "open systems" groups that do little more than carry out public relations promo and hype exercises. It remains to be seen if an open-systems specification will ever gain significant industry support.

Meanwhile, NT does not seem to be the end of Microsoft's reign. It appears to be an interim step toward Cairo, the object-oriented (OO) OS that Microsoft is keeping close to its vest—Sphinxlike—(see Fig. 2). Cairo will encompass both NT and Chicago, an interim 32-bit version of DOS Windows. Chicago (a.k.a. DOS 7 and Windows 4) is expected to be released by mid 1994.

Chicago will contain a partial 00 application-program interface (API), and Cairo, a full API. Cairo will probably contain backward-compatible API's (for DOS/Windows and NT, and possibly for OS/2, COSE, and POSIX). Microsoft's goal appears to be to make Cairo an all-encompassing, fully object-oriented distributed operating system.

It should be capable of running DOS, Windows, and UNIX software and perhaps it could be adapted to run OS/2 applications, if a significant number of users adopt it. Until Cairo is released, however, it appears that there will be heavy competition between NT and Chicago development groups within Microsoft and the industry at large. However, NT vs. Chicago appears to be a moot question—all roads lead to Cairo.

Preoccupied with all of its operating system activity, Microsoft has neglected to clarify what will happen to its Lan Manager. It is the chief competitor—and a weak one at that—to Novell's NetWare. Will LanMan merge with NT? With Chicago? Will it remain a separate product? And what about Windows for Workgroups?

When Microsoft released Windows for Workgroups (WFW) in the fall of 1992, the company claimed that it would be the largest selling version of Windows by the fall of 1993. To date, however, sales have been disappointing. It appears that Microsoft tried to turn WFW into a Trojan horse to get its networking technology into large corporate accounts with the intent of converting those customers from NetWare to LanMan.

If that was their strategy, it seems to have failed. It put the burden back to Microsoft to come up with PC-based networking software that will overtake Novell's reported 60% to 70% of market share. (That compares with LanMan's small market share of 2% to 3%.)

Meanwhile IBM has been churning out revision after revision of its OS/2, and it has been attracting significant ISV support. For example, important Lotus, Borland, and WordPerfect products are now available in OS/2 versions. Nevertheless, IBM continues to lag Windows releases by 6 to 12 months, and IBM's access to Microsoft code will end this fall. That might not be the disadvantage it appears to be; both Windows 3.1 and OS/2 seem to be headed for the scrap heap, to be replaced by distributed object-oriented operating systems such as Chicago and a rumored OS/2 version 3.0.

PRODUCT WATCH

Where was I when the lights went out? Because I don't have a good uninterruptible power supply (UPS) I was in the dark in more ways than one. For years, every spring when the thunderstorms start to rumble in, I promise myself that I will add a UPS to my computer system. Finally, this year, I could no longer procrastinate. For the last couple of months I've had the services of a Fortress, a UPS made by Best Power Technology. It's a monster, about the size of two stacked shoe boxes, and it provides 1.3 kVA of power. That's enough to keep my big 486 system and a 19-inch monitor running for at least 40 minutes after a power outage. The unit includes extensive surge protection because it conforms to the Category A and B specifications of ANSI/IEEE C62.41.

In addition to is power capabilities, the Fortress also provides automatic shutdown for many computers and operating systems, including Netware, Lan Manager, Lantastic, OS/2, and Windows 3.X. It has a useful front-panel display of available runtime, line and battery voltage, and other variables. My only caveat is its noisy cooling fan that runs constantly. But I think that this is a small annoyance when I consider the security the unit provides. Best Power Technology offers a range of Fortress systems with power output from 360 VA to 2000 VA. Ω

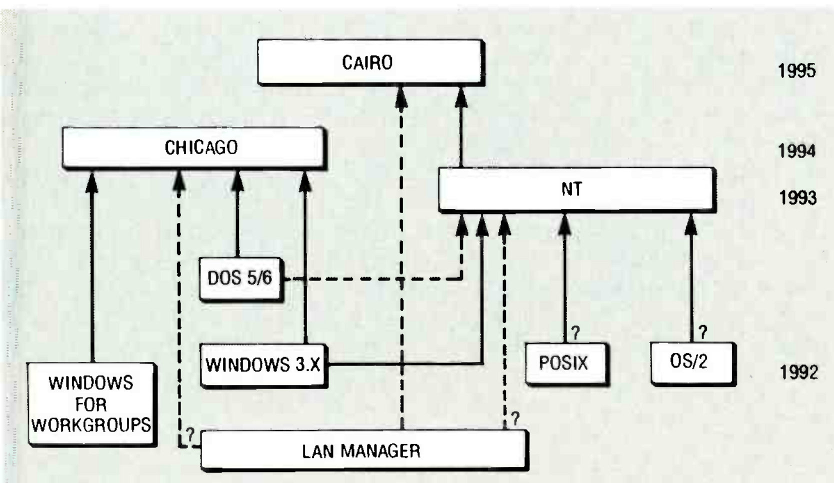

FIG. 2—MICROSOFT'S EVOLUTIONARY OPERATING SYSTEM STRATEGY now appears to be herding technology toward its top-secret Cairo project, scheduled for release in about two years.

CSC vs. OODC

In the years before networking became accepted, there was a lot of talk about *client-server computing* (CSC), and how it would revolutionize computing by uniting disparate databases. Under this scenario, a server serves, maintains, and distributes information to one or more clients on request.

CSC's handicap was its inability to handle the complexities of the real world. In larger organizations, those that are geographically dispersed, as well as so-called "virtual," organizations which might have several servers linked hierarchically, CSC proved inadequate. Users in those organizations want to link parts of text files, spreadsheets, graphics and databases that are stored in different locations and are subject to change over time, and CSC just couldn't do that.

Microsoft signaled its awareness of the issue with its release of version 2.0 of the Object Linking and Embedding (OLE) specification. However, critics have found OLE 2.0 difficult to use in programming. While it is a good start, it is still unable to keep track of objects across any kind of network, local or otherwise.

The characteristic that is really needed is the ability to track storage and linkage information at a lower level, in an object-oriented database maintained by the OS itself. That was the approach taken by the Object Management Group (OMG) in its Common Object Request Broker Architecture (CORBA).

CORBA has an impressive list of supporters—nearly every influential hardware and software supplier, including Microsoft. But it is an open system specification that grew out of the efforts of the UNIX community, so it is not directly applicable to the DOS/Windows API.

However, as Microsoft urges software developers toward Chicago and Cairo, CORBA compatibility might be a superfluous issue. Microsoft is a member of OMG; surely it must recognize the strategic value of CORBA. The drawback to open systems in the past has been that they seldom lived up to expectations. Nevertheless, computer visionaries seem to agree that object-oriented distributed computing (OODC) represents the next major step.

The OODC concept is demonstrated with OLE 1.0 and network Dynamic Data Exchange (NetDDE) under Windows for Workgroups, but a more robust implementation is needed. Perhaps this will be achieved with Chicago.

The long haul

Don't get too comfortable with DOS, Windows, Mac OS, AmigaDOS, UNIX, VMS, MVS, or whatever. And don't think that shiny new Ultra Hype 5000 is the end of the road. They are really more like the beginning. For years people have dreamt of owning computers with "3M" capabilities: memory, speed, and display resolution, all measured in mega units. That day is at hand, but now it looks like what we really need is a "3G" machine: permanent storage, semiconductor memory, and available network bandwidth, all measured in giga units. By the way, CPU speed and display resolution should still be kept at a significant fraction of G.

In the old days, basic computer resources—hardware and software—cost more than the labor to run them, while the opposite is true today. Twenty years ago, for example, efficient utilization of computer resources mattered more than efficient utilization of the time people spent interacting with computers. Again, the opposite is true today. Now user interface time really counts.

Industrial software designers are

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HARDWARE HACKER

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worries to ELF (extremely low frequency) radiation. This is a book that should be read by anyone with an interest in science and concern for the possible effect on people of science that has gotten out of hand. must read.

The *Colorado School of Mines* just completed its fourth *Subsurface Exploration Technology* symposium, mostly on underground radar for mining, caving, and archaeological uses. Proceedings are available by writing to CSM and requesting it.

A video on *Designing and Building High Performance Tesla Coils* is now available from *Resonance Research.*

New videos, parts kits, and training seminars on laser printer repairs are available through *Don Thompson* who is located in El Toro, California.

Small Parts now ships a new and free *Catalog No. 14*. The company is probably the greatest robotic resource in the world. It has everything your hardware store never heard of—and then some. Just peruse the catalog and you'll see.

MSC is a *McMaster-Carr* alternate that carries extensive local stocks of machine-shop supplies and hardware. It is also a no-hassle source of the EDM (electrostatic discharge machining) wires and dielectric oils. A 2000-page catalog is offered by the Mableton, Georgia, distributor.

Turning to my own products, my new *Book-on-demand Resource Kit* contains lots of self-publishing information; and my new *Resource Bin I* gives you insider access to scads of my secret supply sources. Or if you really want to get involved with PostScript in a big way, try my *Whole Works* package. See my nearby *Synergetics* ad for more information.

Over on *GEnie* PSRT, I have just added NONLINGR.PS, a nonlinear graphics tutorial (for mapping stuff onto oddball surfaces). Also a reminder that I have arranged for a new and faster *GEnie* signup. See the *Need Help?* box for details. Ω

PHONE HELPER

continued from page 63

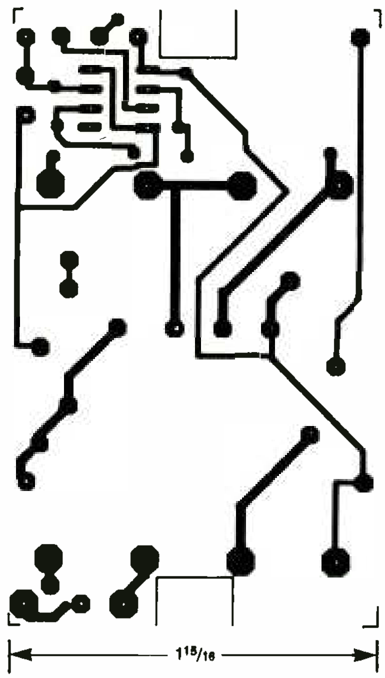
plug the unit-under-test into one of the jacks of Phone helper, and then plug a jack from a known good fax machine (or fax card) into the other jack. The receive capabilities of the fax machine under test can be determined by placing a call on the known good unit with the simulated dial-tone function if needed.

Once the fax machine known to be in good working condition has dialed out, jog the momentary RING toggle switch S1 often enough to signal the unit-under-test. It should answer, establishing a connection with the known good unit, which will then send your test fax.

If you have a fax card in your computer and a stand-alone fax machine, Phone Helper will permit you to convert your fax machine into a full-page scanner. Insert a page of images and text that you want to enter into your computer into your stand-alone fax machine. Then "call" your fax card (any number will do) and send it the text or images. You can now modify your computer files with a graphics editor or run the text through an optical character recognition program to convert the scanned-in text into an ASCII file.

Modems can be tested in exactly the same way. The only difference will be in the frequencies of the tones that are used to communicate between them.

Several accessories will come in handy for making equipment tests with Phone Helper. An inexpensive electronic telephone and a duplex adapter will permit you to monitor while testing. Ω



FOIL PATTERN FOR PHONE HELPER 2.

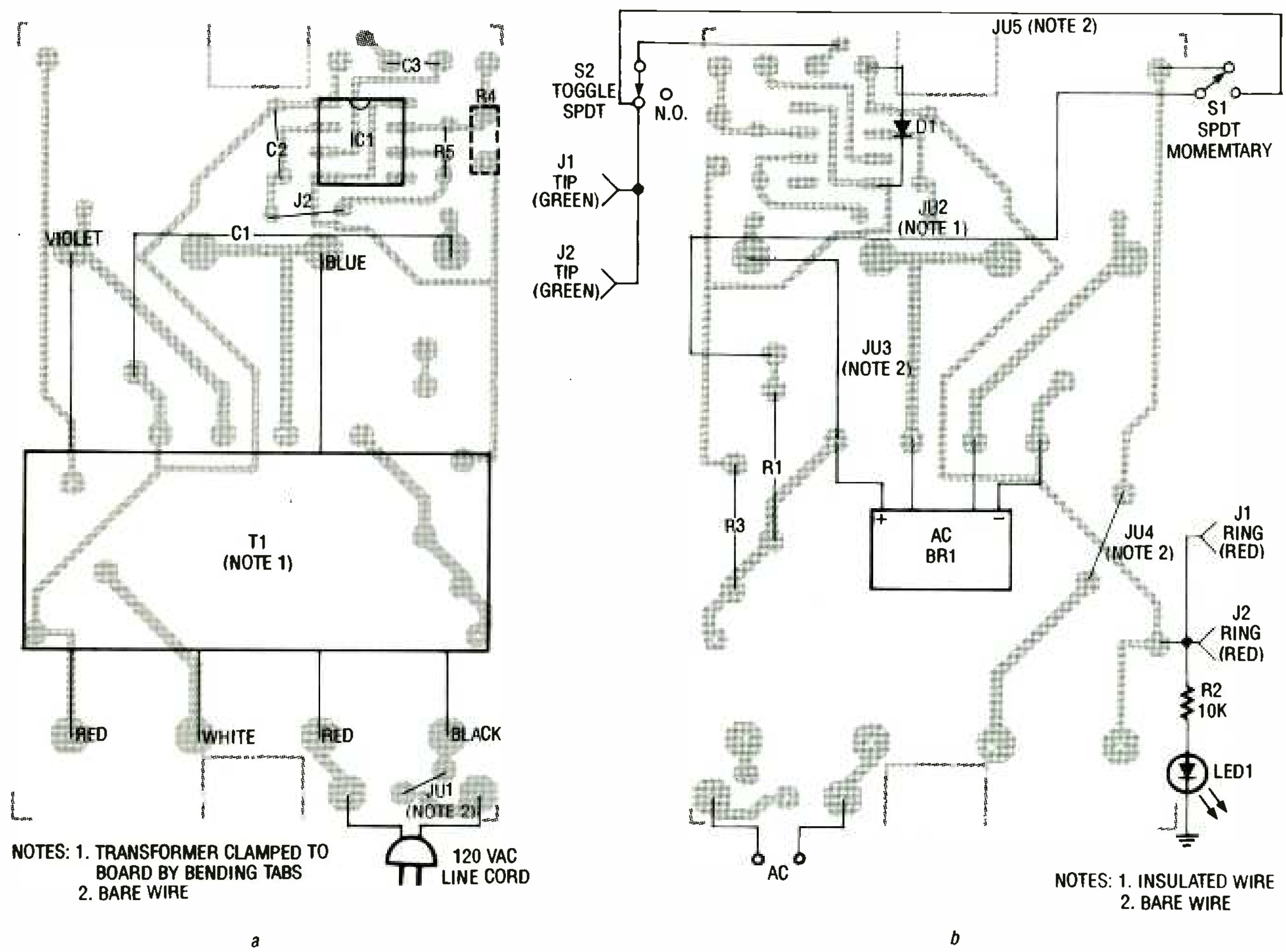


FIG. 7—PARTS PLACEMENT DIAGRAM for Phone Helper 2. Timer IC1, transformer T1, and all capacitors are placed on the "component" side of the board (*a*), and the low-profile components are on the "foil" side (*b*).

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Error" or "General Failure" error at home. Do you know what's going on?—J. Hilton, New York, NY

The first time I ran across this problem it drove me crazy because I knew that there wasn't anything wrong with my hardware. It took a bit of detective work to come up with the answer, and since then I've seen this problem several times.

The cause of the problem is the IBM machine you use at work. If you look at the back of a 3½-inch high-density disk (1.44MB), you'll see that there are two holes in the plastic case. The hole with the movable tab is for write-protecting the disk and the second hole is there to indicate that the disk is high density. Modern disk drives have an LED that shines through that second hole and a detector for the LED that sits on the other side of the disk. If the detector sees the light from the LED, it tells the computer that the disk is high-density. If no light is seen, the computer assumes that the disk is only double density (720K)—double-density disks don't have a second hole.

The disk drive in the IBM doesn't have an LED emitter-detector pair to detect the presence of high-density disks—it simply believes what you tell it from the keyboard. This means that double-density disks (without the second hole) are treated as high-density by the PS-2 unless you tell it otherwise—which must be what happened with your office disks. Your computer at home, however, will see the disk as double-density, even though you formatted it as high-density at the office.

Since the track and sector formatting is quite different between double- and high-density disks, your home computer won't recognize any of the data on the disk. You can correct the problem by using real high-density disks in the office or by drilling a second hole in the disks you're having problems with at home.

The second hole will satisfy the drive in your home computer and will be ignored by your office computer. Although floppy-disk manufacturers insist that punched disks will be unreliable because of differences in the magnetic media, many people punch them all the time and have no problems. However, it's a fact that plastic shavings that are left inside the disk after drilling the hole can permanently damage the disk as well as the drive. To avoid that problem, you can buy punches that are specifically designed to add the second hole to double-density disks. Ω

COMPUTER CONNECTIONS

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just now becoming aware of ideas that are thirty or more years old. Bear in mind that neither the mouse nor the graphical user interface (GUI) were invented by Microsoft, Apple, Commodore or even Xerox. The concepts have been around since the early 1960's but only now, in the early 1990's, do we have the economical computer power capable of exploiting them to their fullest extent.

Ironically, now that we can make economical use of those products, it turns out that the WIMPy (windows, icons, menus, and pointing devices) approach is *not* enough. At the present rate that innovations are being introduced, it won't be long before the Windows/Macintosh interface looks as outdated as the familiar UNIX/DOS command-line interface.

Don't let anybody surprise you. Be prepared. Computer evolution is still in its embryonic stages. The end is not in sight. Ω

WHAT'S NEWS

continued from page 4

cut the required electronic features in a patterning process. Electrons are lighter and less energetic than ions, so they do not produce the same kinds of damage to the semiconductor surface.

As the beam of low-energy electrons and the beam of reactive hydrogen molecules strike the semiconductor surface simultaneously, the electrons stimulate the etching action between the hydrogen and the semiconductor surface.

Because the reaction occurs only where both beams coincide, the careful guidance of the beams through a rudimentary mask makes it possible to transfer patterns to a semiconductor substrate.

The Georgia Tech scientists have yet to determine if hydrogen causes any undesirable long-term effects in the process. However, observation of samples before and after etching has revealed little damage.

According to Dr. H. P. Gillis, associate professor of chemistry at Georgia Tech, at least two more years of work will be required to convert the laboratory process to a practical and cost-effective commercial process. Dr. Gillis does not expect that the electron-assisted etching technique will replace conventional etching in the near future, but he says it does offer an alternative for the fabrication of future generations of nanometer-scale integrated circuit.

Corporate acquisition

LKG Industries has announced its acquisition of Datek Corporation, a manufacturer of printed-circuit drafting aids, dry transfers, wire markers, and many PCB prototyping systems.

Datak's Sparks, NV, manufacturing facilities will be moved to LKG's Rockford, IL, headquarters by mid 1993. The Datak trade name will be maintained, and LKG has announced plans for additional, related product groups. LKG, a five-year-old company, makes consumer and commercial products for both the electronics and electrical OEM markets. Ω

AUDIO UPDATE

continued from page 26

kle, shimmer, definition, and "air" for music from instruments that include tambourines, cymbals, castanets, and wire brushes.

And finally, don't be upset because you find it difficult to decide which of several sets of good-sounding speakers sounds best. Experts also sometimes find it impossible to make definitive judgments, even when listening comparisons are conducted with scrupulous care.

Design theory and sound quality

Don't get hung up on design theory or special driver configurations as a guide to sonic performance. Speaker designers, like other hardware designers, usually have a choice of available paths to reach their goals. The chosen approach might be based on new materials, new technology, personal prejudice, or whatever. Technical considerations include cost effectiveness, absence of resonance, extended low-bass performance, high efficiency, large power-handling capability, or recently, the ability to be placed next to a TV monitor without affecting its picture.

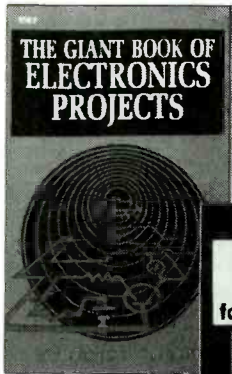
Granting that you might not share a specific designer's concerns, and because widely different design approaches can produce equivalent audible results, put aside considerations of design theory while you are auditioning speakers. Only after you've decided that you like the sound coming out of a system does it make sense to investigate what's inside it.

Go for neutral sound. Most designers would agree that a speaker system should have an acoustic analog of the electrical audio signal supplied to it by the amplifier. A speaker system should have no tonal character or sound quality of its own. Otherwise, it will overlay its built-in tonal qualities on whatever program material it is reproducing. Sometimes the special colorations of a speaker may seem to enhance its performance, but on most recordings a speaker with coloration will degrade the fidelity.

Coloration is not mysterious. It almost never comes about because of esoteric crossover phase problems, distortions in the performance of individual drivers, or other hard-to-pinpoint reasons. Gross audible differences between different brands of speaker systems are due almost entirely to differences in their octave-to-octave frequency response. Effects such as shrillness, honkiness, boominess, or, more positively, openness, clarity, inner detail, and transient performance, are almost always the result of a system's measurable frequency balance.

Next month we'll look at the meaning, if any, of some standard specifications. Ω

I got the woofer and tweeter you asked for.



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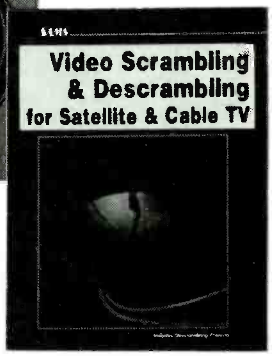

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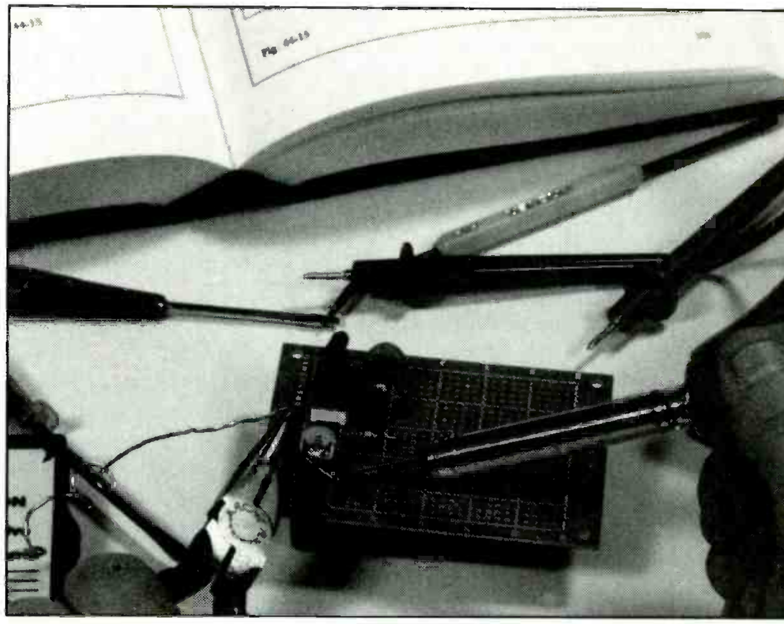

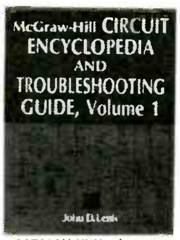

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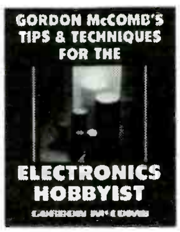

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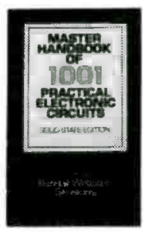

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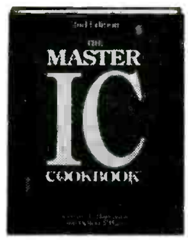

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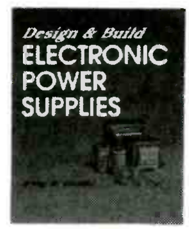

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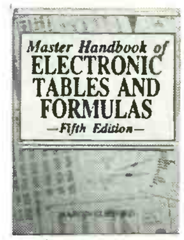

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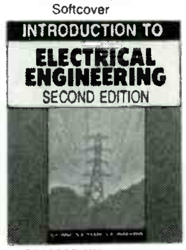

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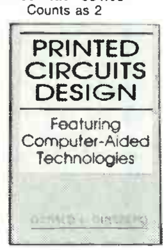

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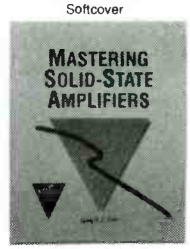

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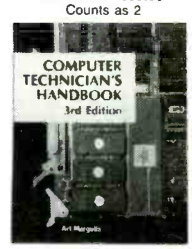

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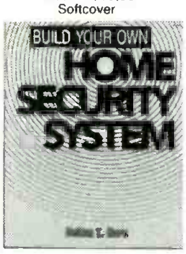

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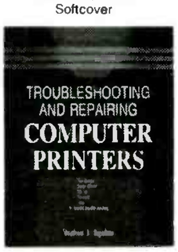

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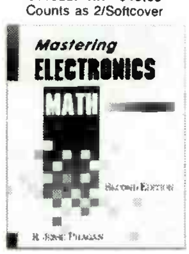

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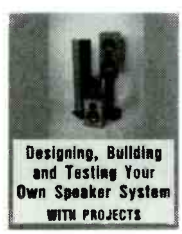

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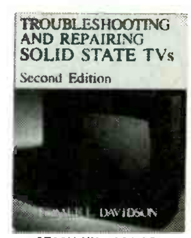

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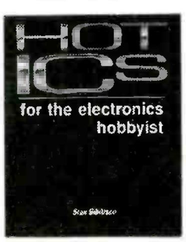

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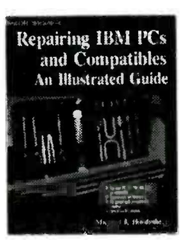

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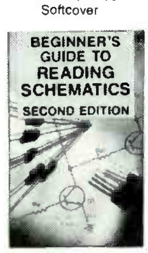

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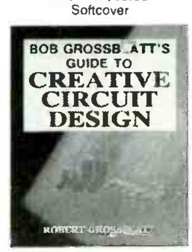

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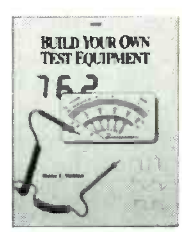

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A magic developer will dissolve *only the color*. To do that, put a vinyl cover (or any suitable mask) onto the material and then simply scrub the color away in selected locations. In the daylight, you have a color over white. At night and backlit, you get white light or translucent colors per your selection. Neat stuff. Sanely priced. And eminently hackable.

Finally, there is an interesting new variation on photopolymer printing plates that should open up all sorts of new hacker ideas. The *Jet USA* folks are using photopolymers for Braille and other low-cost, raised-letter applications. What you really have here is a metal plate with some raised plastic selectively applied exactly where you want it. Unique

BRANCH	Option picker similar to a CASE command.*
BUTTON	Read and debounce mechanical input.*
DEBUG	Send register contents to host.*
EEPROM	Store data in memory.
END	Go into sleep mode until power cycles.
FOR...NEXT	A looping construct.
GOSUB	Execute subroutine.
GOTO	Jump to another location in program.
HIGH	Make the chosen I/O pin high.
IF...THEN	Conditionally execute instructions
INPUT	Make selected pin an input.
LET	Optional definition. Includes add, subtract, multiply hi/lo, idivide, modulo, min, max, AND, NAND, OR, NOR, XOR, and NXOR.*
LOOKDOWN	Search table for match.*
LOOKUP	Read values from table.*
LOW	Make the chosen I/O pin low.
NAP	Enter sleep mode for a selected time.*
OUTPUT	Make the chosen I/O pin an output.
PAUSE	Short selected time delay.
POT	Read a potentiometer (8-bit A/D convert).*
PULSIN	Measure input pulse width.*
PULSOUT	Output pulse of selected width.*
PWM	Output pulse width modulation (D/A convert
RANDOM	Generate pseudorandom number.*
READ	Read variable from memory.
RETURN	Return from subroutine.
REVERSE	Change direction of selected I/O pin.
SERIN	Read serial input and interpret format.*
SEROUT	Format and output serial data.*
SLEEP	Long selected time delay.
SOUND	Output musical notes or white noises.*
TOGGLE	Change state of selected I/O pin.
WRITE	Store data to memory.

FIG. 3—INSTRUCTION SET FOR THE BASIC STAMP. The macros marked with an asterisk (*) make the stamp surprisingly powerful.

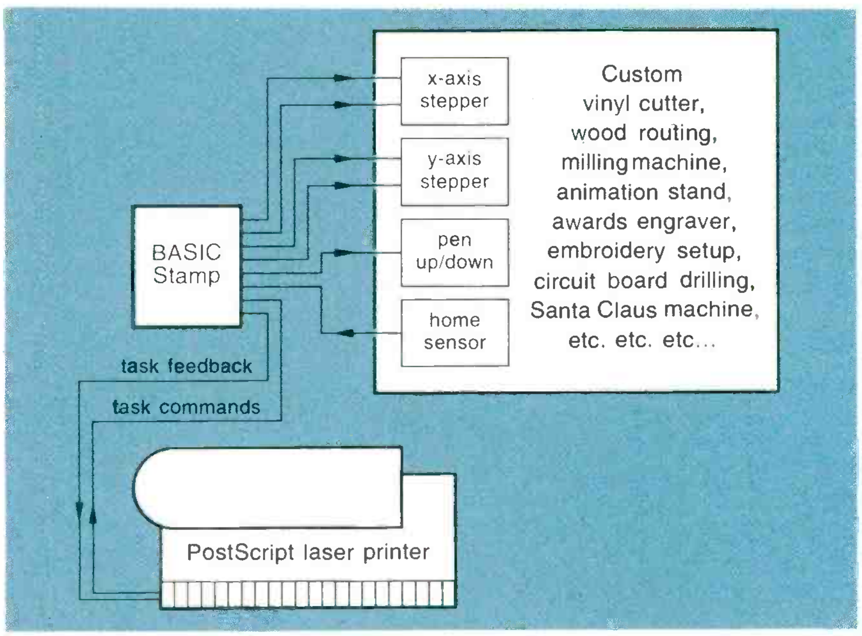

FIG. 4—THE BASIC STAMP can be used as a low cost and royalty-free interface to let you apply real Adobe PostScript level 2 to any old homebrew project!

business cards are one possibility.

There is a slight chamfer to their resin, improving the appearance. Cost is in the twenty cents per square inch range. Jet's processing equipment is ridiculously expensive, but it should be easy enough to fake. They have some free samples available.

Needless to say, *any* hacker work involving photopolymers can be very much improved by using PostScript. Full details on *GEnie* PSRT. One little known capability of PostScript is its *microsizing* ability. This lets you get the final size of your printed circuit layout exactly right, even on a printer with sloppy tolerances and paper that swells or shrinks.

In flexographic printing and other places where images stretch as they are bent around a drum, anamorphic scaling with PostScript gives you a fast, simple, and accurate fix.

Two contests

Let's have two contests this month. Either (A) dream up a new application for the BASIC Stamp, or (B) see if you can come up with some hacker use for photopolymers that is not obvious.

As usual, there will be a dozen or so of my recently updated *Incredible Secret Money Machine* book prizes, along with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

Be sure to send your *written* entries directly to me here at my *Synergetics*, and not to the **Electronics Now** editorial offices.

New tech lit

We have a super selection of new goodies this month. For great books and magazines on ATV, try the *Amateur Television Quarterly* folks.

Gyro Gearloose is alive and well! *Roadable Aircraft* is a unique labor-of-love newsletter from Ron Borovec for flying car enthusiasts. Similar publications include *Experimental Aircraft* from the *EAA Aviation Center* and the *Experimental Rotorcraft* from *Rotary Flight International*

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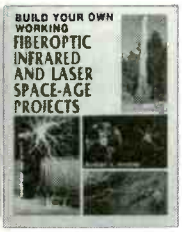

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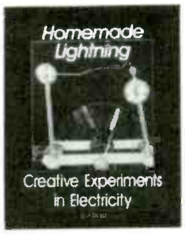

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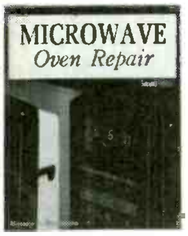

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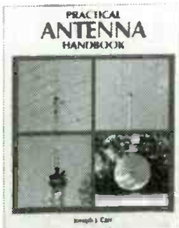

3270H-XX $32.95
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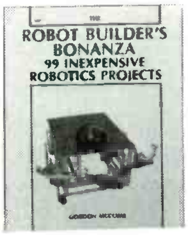

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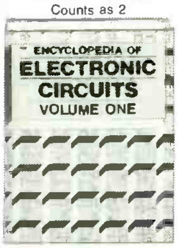

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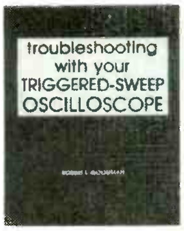

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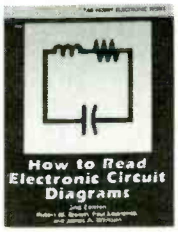

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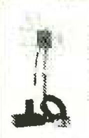

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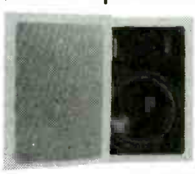
#296-070 .... $49.90 (1-3) **................ $46.50** (4-UP)

8" Two-Way Ported In-Wall Speaker System



8" paper cone woofer with polymer resin coating and a 1" textile dome tweeter. Ported plate speaker system for better bass response. Integral crossover with a tweeter protector and pushbutton terminals. 8 ohm impedance. Frequency response: 30-25,000 Hz. 50 watts RMS, 100 watts maximum power handling capability. Sensitivity: 92 dB 1W/1m. Dimensions: 10-5/8" (W) x 13" (L). Net weight: 17 lbs. per pair. $274.95 list price.

#300-425 .... $169.90 (1-3 PRS) **... $159.90** (4 PRS-UP)

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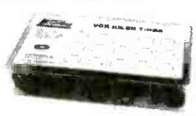

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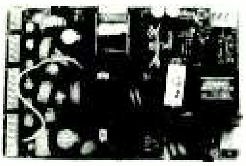

40 Watt Switching Power Supply

+5V @ 1.5A	-5V @ .32A
+5V @ .4A	-12V @ .075A
+12V @ .5A	+22V @ 1A

Input: 115VAC @ 60Hz

2-pin Molex input connector and 4 output connectors

Size: 5.375"L x 3.5"W x 1.25"H

Weight: .5 lb.

art No.	Product No.	Price
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- Weight: .5 lb.

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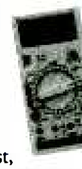

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- One-year warranty

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8R20757

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8R20722	1	2	830	6.95
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8R20773	2	4	1,660	17.95
8R20790	3	5	2,390	24.95
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Linear Integrated Circuits

art No.	Product No	Price 1-9
R33241	TL082CP	$.59
R23579	LM317T	.65
R23683	LM324N	.35
R23771	LM336Z	1.09
R23851	LM339N	.45
R27422	NE555V	.35
R24328	LM556N	.49
R24467	LM723CN	.49
R24539	LM741CN	.29
R23131	LM1458N	.39
R23157	LM1488N	.45
R23181	LM1489N	.45
R34278	ULN2003A	.69
R24230	LM3914N	2.49
R27385	NE5532	1.19
R51262	7805T	.45
R51334	7812T	.45

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Part No.	Product No	Price 1-9
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8R46287	74LS02	.25
8R46316	74LS04	.25
8R46375	74LS08	.29
R46640	74LS14	.39
R47458	74LS30	.25
R47466	74LS32	.25
R48004	74LS74	.29
R48039	74LS76	.49
R48098	74LS86	.25
R46447	74LS112	.25
R46480	74LS123	.39
8R46607	74LS138	.39
8R46957	74LS175	.35
8R47036	74LS193	.59
8R47183	74LS244	.69
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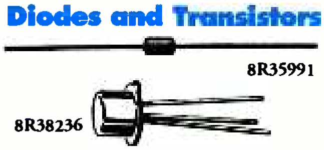

8R35991

8R38236

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8R36097	1N4733	Zener diode	.25
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8R38279	2N2907A	Gen. pur. transistor	.25
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TA-90 Antenna

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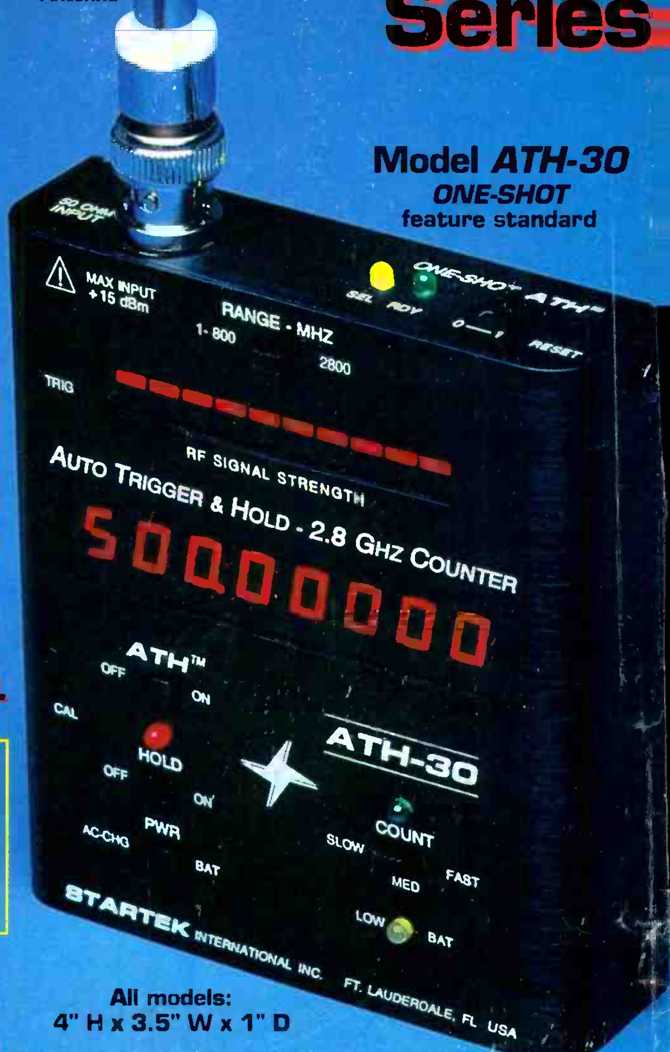

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E	***RD-2750***	27-50 MHZ rubber duck	28.
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