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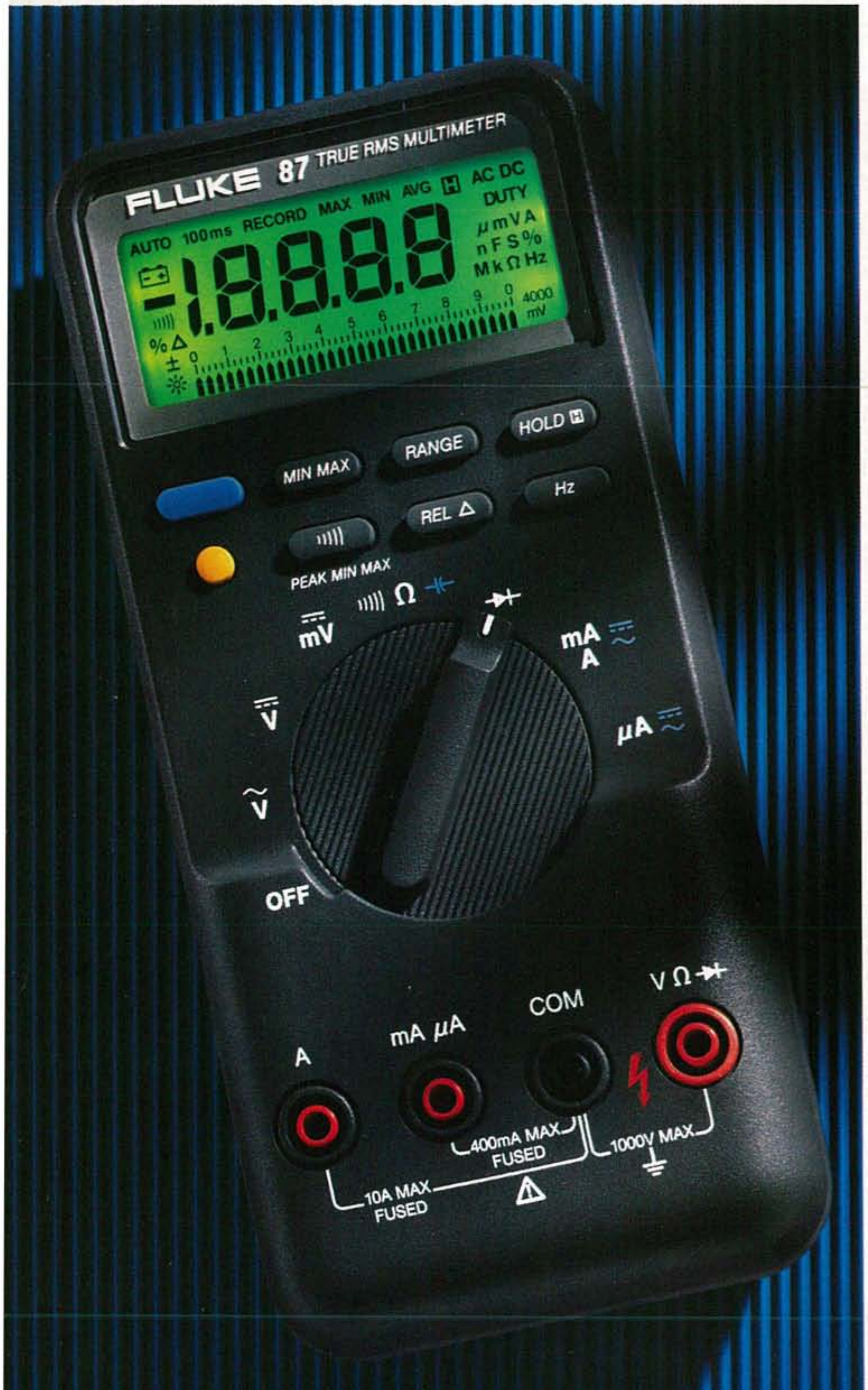

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April 1990

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Vol. 61 No. 4

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DEPARTMENTS

PAGE 69

PAGE 39

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ON THE COVER

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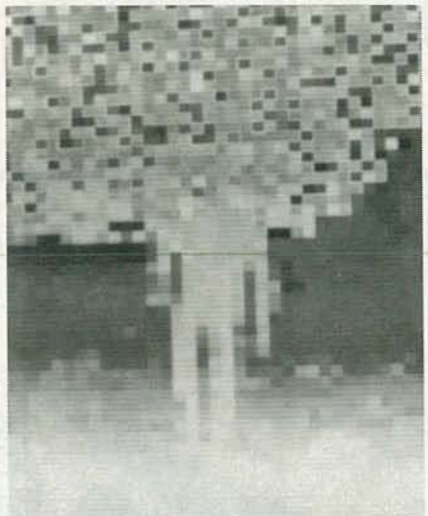
WHAT'S NEWS

Laser radar provides four images per second

MARION SCOTT (LEFT) AND MARK GROHAM INSPECT the optics of the Sandia laser radar.



LASER-RADAR RANGE IMAGE OF A POSSIBLE INTRUDER. Different ranges are represented by varying shades of gray or in pseudocolor. A bush, at longer range, can be seen at right. The sky is shown with random shades because it gives no radar return.

A laser radar that shows not only the distance to a sighted object, but also an image of it—and updates that image four times a second—has been developed and tested at Sandia National Laboratories (Albuquerque, NM). The new laser combines some of the advantages of conventional radar with those of video imaging, and has capabilities about midway between the two. Its frame rate is fast enough for possible short-range military applications.

The Sandia range-imaging laser uses a small gallium-arsenide semiconductor laser diode that emits continuous near-infrared light that is just beyond the range of the human eye. The signal is amplitude modulated at 4 MHz. The phase of the return signal is measured to obtain the range of the viewed object, and its image is displayed on the video screen as a 64 $\times$ 64-pixel pseudocolor map. The present maximum range is about 50 meters.

Future plans include efforts to integrate the electronics, replace the present low-power laser with a higher-powered one, and extend the range to the hundreds of meters necessary for a military version of the system.

Controlled reproduction of superconducting materials.

Researchers at Bellcore (Middletown Township, NJ) have fabricated multi-layered superconducting materials that can be reproduced in a controllable manner, possibly overcoming a critical obstacle to developing high-temperature superconducting devices for commercial use. Bellcore's experimental thin films, when cooled to near liquid-nitrogen temperatures, display the Josephson effects that are necessary for viable superconductive electronics. A Josephson junction is an electrical connection that allows the flow of low-voltage "super currents" between superconductors. Because the connection is weak, the super current can be easily controlled.

Josephson junctions are present in low-temperature superconducting materials, but in high-temperature superconductors they appear only at the natural boundaries between crystal grains or in specially designed structures that are not suitable for device applications. Bellcore's process for fabricating high-temperature superconductor research prototypes offers a means to engineer and control the Josephson properties so that they recur in a highly predictable fashion.

The high-temperature prototype films are composed of three distinct but similar layers, each made of a ceramic material that consists of copper, barium, and oxygen, along with a fourth substance: Yttrium is used in the superconducting first and third layers, while a mix of yttrium and praseodimium results in a non-superconducting middle layer that serves as the critical "weak" electrical link between the others. By substituting some of the yttrium in the layers with praseodimium, the electrical properties of the layers can be significantly varied and controlled. The effect of layering of superconducting and non-superconducting materials was achieved using a process known as pulsed excimer laser deposition.

Because modified semiconductor-processing techniques were employed to make the thin-film prototypes, Bellcore predicts that this approach could be adapted for manufacturing in large quantities with no significant loss in quality. Although this is only the first step toward commercial feasibility, possible applications for the high-temperature superconductors are being considered—including using these materials as extremely sensitive magnetic field detectors for telecommunications systems, and also as integral components in microwave systems. Potential long-range applications include high-speed telecommunications systems and computer logic gates. **R-E**

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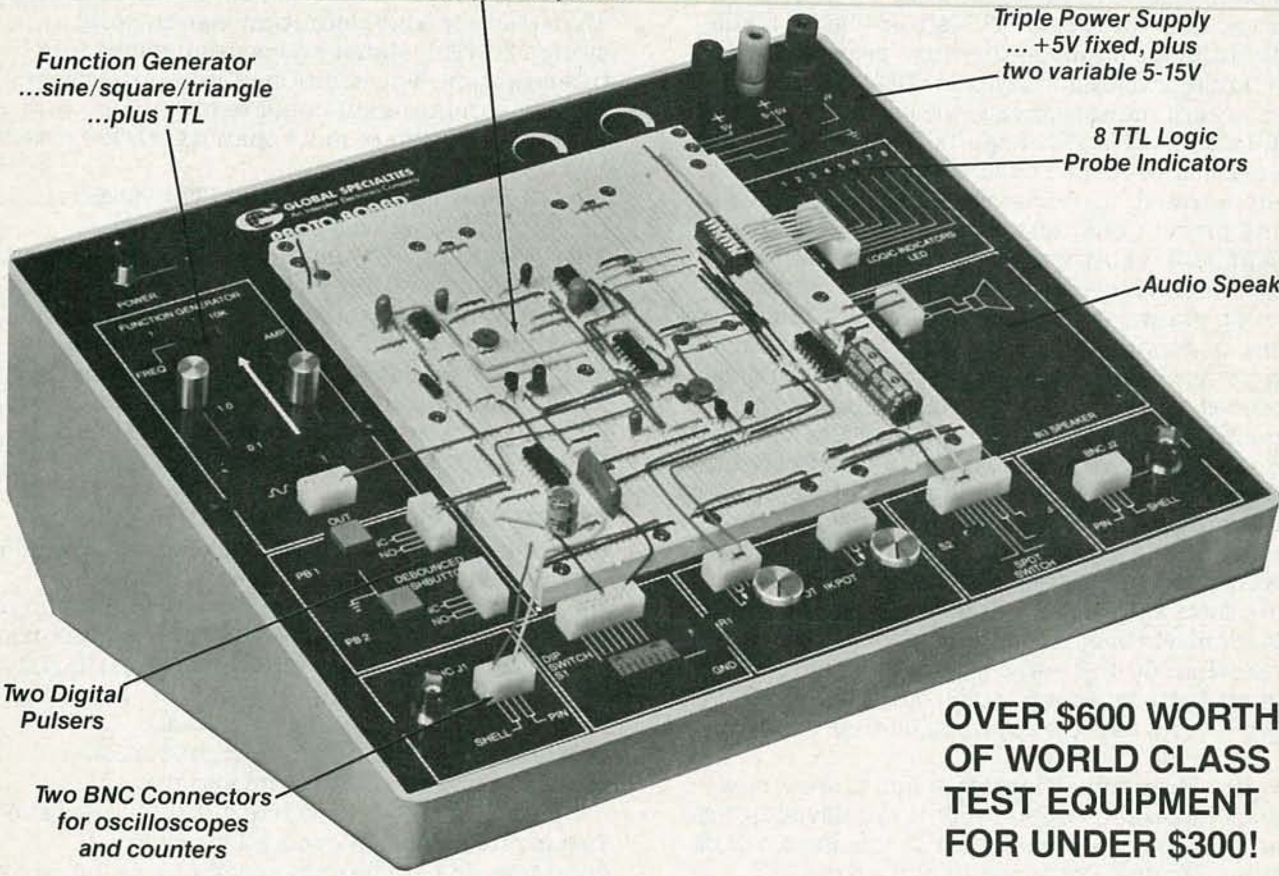

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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Big screens.** The search for a giant, thin replacement for the cathode-ray tube—almost as old as the cathode-ray tube itself—is intensifying. For the first time, color TV sets are being made without picture tubes—the tiny "personal" sets use liquid-crystal displays, or LCD's. That has encouraged manufacturers to search for ways to build giant LCD's. Although LCD color-TV displays as large as 14 inches have been built and demonstrated, their cost would be astronomical using present technology.

Japanese manufacturers, joined by their government, have mounted a crash program to develop giant color LCD's measuring 40 inches or more diagonally. In the United States, several companies have undertaken major projects also intended to lead to giant, thin, wall-mountable color-LCD TV displays. An official of David Sarnoff Research Center in Princeton, NJ (formerly RCA Laboratories) described such a project to a recent conference on flat information displays in Santa Clara, CA. The goal is a wall-hanging HDTV screen measuring 75 inches diagonally and not more than four inches thick, with more than 200 foot-lamberts brightness, and a contrast ratio better than 50-to-1—at a cost of less than $500. Sarnoff Labs expects to reach this goal in 10 years—but it expects Japan to be there in seven.

• **Another new display.** A completely new type of display for high-resolution television has been proposed by Foresight, Inc., a subsidiary of Summa Medical Corporation of Phoenix, AZ. Although details of the product are still obscure because the company's patent applications haven't been granted yet, Japan's giant trading company Mitsui is planning to form a group of Japanese licensees to manufacture the system.

The heart of the Foresight system is a "material"—unrevealed as yet—which "behaves effectively like an optical semiconductor in that its reaction to light can be modified electronically at very high speeds and with great resolution," according to the developer. The material, which is used to coat the face of a direct-view or projection-TV tube, is altered by an electrical signal. One of its properties is the ability to retain its altered state until a new signal changes it. Thus only the changes in a picture need be sent to the tube. Foresight said the result can be an extremely high-definition signal using a standard NTSC signal and computerized line interpolation. The addition of microprocessor picture enhancement could result in a picture with a resolution of more than 4,000,000 pixels.

• **10-Foot rear projection.** The largest rear-projection TV set was demonstrated by Mitsubishi at the Consumer Electronics Show in Las Vegas in a rather large living-room setting. It has a 120-inch diagonal picture and is designed for "home theaters" built into large homes. As displayed in subdued light, the entire wall became an almost theater-sized screen. The cost of this latest step in home-theater television is about $20,000, not counting installation.

• **TV-VCR combos.** VCR's with built-in TV's and TV's with built-in VCR's are the latest trend, on the basis of exhibits at the Consumer Electronics Show. Ever since the introduction of the VCR there have been combinations (the first Betamax was built into a television set), but that approach has more adherents than ever today—from tiny 3-inch LCD personal-video combinations with VCR's to giant-screen televisions with slots for videocassettes.

One of the major exponents of that approach is Panasonic, which introduced six new combinations at the show, each one designed for a different purpose. The smallest is a personal-video combination of VHS recorder and 4-inch LCD monitor. Next is a portable VHS with a 7-inch color TV set, operable on AC or DC. A 20-inch combination is designed to play back videocassettes recorded in European PAL and SECAM color systems as well as NTSC. It can record in NTSC only, however. A second 20-inch combo has two tuners, so it can record one program while displaying another. Panasonic also introduced two 27-inch combinations, one that plays standard VHS cassettes and the other with a built-in Super-VHS recorder and a high-resolution TV set. **R-E**

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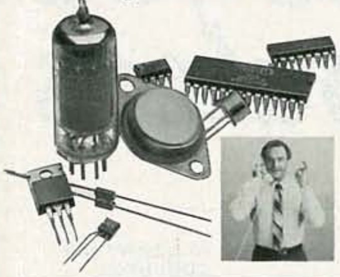

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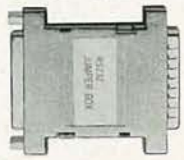

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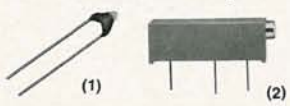

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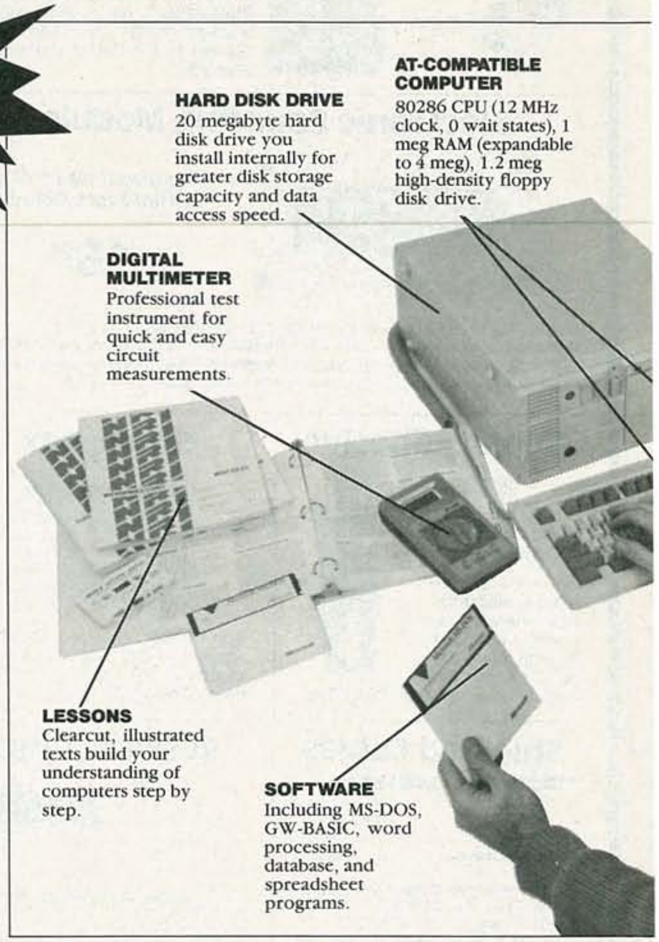

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INFO ON LEADING-EDGE PC COMPATIBLE

I have a PC-compatible computer, a Leading Edge model #MP-1676L. I bought it used and, unfortunately, didn't get any manuals with it. It has a hard disk and a memory expansion card that has 384K in 64K RAM chips. The problem is that the switches on the motherboard and the ones on the memory-expansion card got scrambled, and I don't have any idea how to set them. I've written to Leading Edge but haven't gotten any answer from them.—W.D., Brooklyn, NY.

I'm surprised you didn't get any response from Leading Edge since I've never had any trouble with them. Maybe your letter got lost. You can write again but calling would be faster, at (800) 343-6833. You might have trouble getting information since you bought your computer used, and Leading Edge hasn't made them in over six years. Also, Leading Edge made them on an OEM basis for Mitsubishi, and never really sold them under their own name. The "MP" in the serial number stands for "Mitsubishi Product."

If you can't get any help from Leading Edge, try Mitsubishi at (800) 227-3378. Whoever you speak to, try to get an owner's manual. If you don't have any luck, there are two authorized NY area service centers that can help you, Computer Repair Center at (212) 696-1296, and Autotech Computer Systems at (212) 247-2099. Good luck.

POWER SUPPLY IMPROVEMENTS

I have had a 12-volt DC bench-type power supply for several years. I've never had any trouble with it, but since I'm starting to experiment with digital electronics, I need a 5-volt supply also. I hate to buy another supply because this one works well, and I don't have much bench space. Is there any way to get 5 volts from my present supply? Or, better still, can I make it into a variable supply?—D.P., Los Angeles, CA.

There's good news and bad news. The bad news is that there's no easy way to convert your current supply. You didn't mention this in your letter, but I'll bet the case uses pop rivets or some other method that's difficult to open. And, since you didn't send the schematic, I'm assuming you've never opened it. The good news is that you can build a separate circuit to give you both fixed and variable outputs, and power it with your 12-volt supply.

Since you already have a regulated DC source, you only have to add the circuit shown in Fig. 1 to generate two separate outputs. It's very simple and, if you build it carefully, should be just as reliable as your present supply. Use a plastic case to avoid shorts, and heatsink both regulators, since you can't tell how much current you'll need, or for how long. In general, bench supplies have to work harder than those built for specific circuits. Both regulators are readily available, and have all the neat features you need, like stable outputs and thermal shutdown.

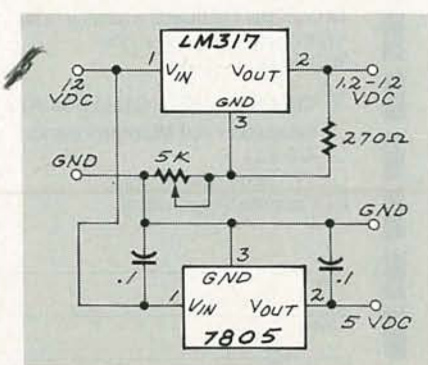

FIG. 1

HARD DISK WOES

I recently bought an ST-238 hard disk for my computer but can't make it work; the controller card is a Western Digital 27X. My computer is a 10-MHz AT clone and works perfectly. I've followed all the steps in the computer manual, but I keep on getting an error every time I try to access the hard disk. Any ideas?—M.M., Chicago, IL.

Several ideas and one really good suspicion. Your letter was rather skimpy on details as to what you've tried, but since you have an AT and a manual (lucky you), I think I know what your problem is.

Although an ST-238 can be used with any IBM clone, the controller you have is an 8-bit device intended for an XT-class machine. If you've followed all the instructions in the manual, you've undoubtedly been told to run the AT setup program, and tell the machine that you have a hard disk as drive one. That is normal procedure for a 16-bit AT controller card. Since you're using an 8-bit controller, you have to tell the computer during setup that you're *not* using a hard disk. That may seem strange, but if you didn't do it, it's the most likely cause of your problem.

The reason has to do with deciding who controls the hard

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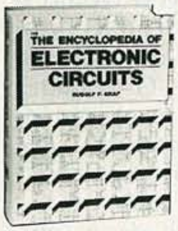

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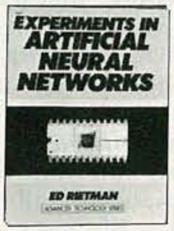

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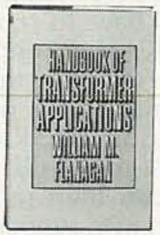

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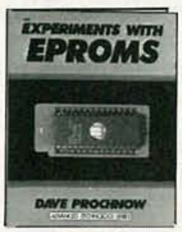

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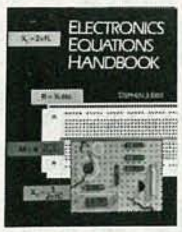

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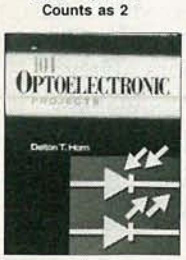

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disk, the computer or the controller. Without getting into nitty-gritty detail, there are two basic steps your computer has to do to talk to the hard disk. It has to know the disk's logical structure (the number of heads and tracks), and second, and how to control the mechanics to move the heads to a specific track and read a sector.

In an XT-class machine, all the hard-disk operations are left to the controller. You tell it what you want, and it translates your request to tracks (cylinders, to be precise), gives the disk the necessary commands to move the heads, and either writes data to the disk or gets the data you're asking for.

By contrast, AT-class machines have the hard-disk translation tables in ROM, and rely on the controller only to operate the drive mechanics—not to do any translations. If you used the setup program and told the computer it had a hard disk connected to it, you'll get an error because the controller is sitting between the ROM-based translation tables and the hard disk itself.

Rerun the setup program, and tell the machine you *don't* have a hard disk attached. Then, format the drive using the controller firmware, just like you would if you were working on an XT. Run DEBUG, and once you're at the dash prompt, type G=C800:5 (no spaces). Follow the screen instructions and, until you get more familiar with the questions, accept all defaults.

The firmware will do a low-level drive formatting, and then you'll have to reboot. Next, run FDISK, and keep pressing RETURN to accept the defaults; that will put a DOS partition on the disk. Both FDISK and DEBUG are on the DOS distribution disks. You can then use the FORMAT program to prepare the hard disk (think of it as a big floppy). If you're not sure about any of this and worried about doing it wrong, get help from someone local who is more familiar with IBM clones. **R-E**

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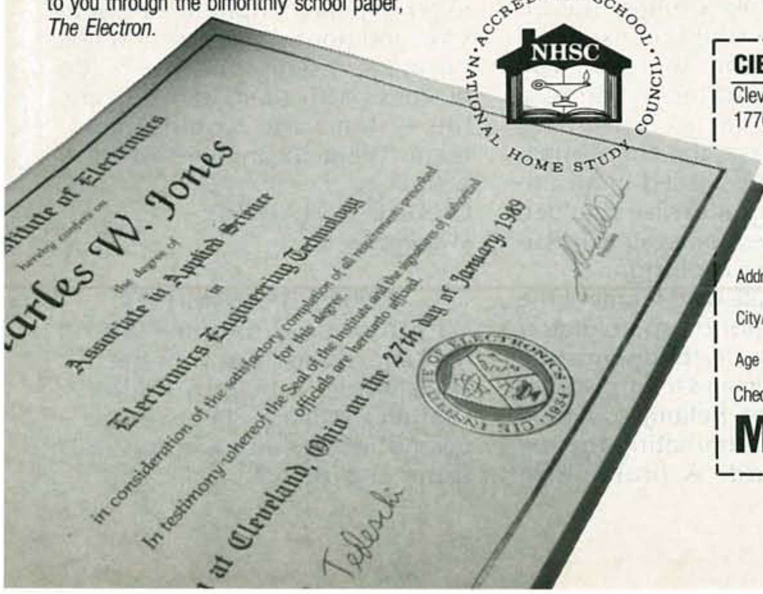

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LETTERS

SUPER SURROUND SOUND

I must tell you that I've been a subscriber for quite a few years and I will never stop the subscription. I wanted to let you know that I've build the surround-sound decoder from the April 1988 issue of **Radio-Electronics**, and the subwoofer simulator from the May 1988 issue. I also built the width circuit and the center-channel section of the acoustic field generator from the January 1990 issue.

I am so impressed with those designs that I can't stop bragging about my system. It sounds exactly like a theater—or maybe even better. Now I automatically look for a rental tape with the Dolby logo on it, particularly Dolby-Surround. We get popcorn, turn off the lights, and the whole family flips out. It's fantastic!

Thanks for sharing your expertise. You're doing a beautiful job!
RICH CIAFARDINI
Queensbury, NY

NOT-SO-COLD FUSION

Don Lancaster's columns on cold fusion (**Radio-Electronics, August and September 1989**) were most welcome—I've been somewhat out of touch and I'm still trying to come up to date on the subject.

In the early 1950's I met a Dr. Johnson from MIT who claimed to have melted the cathode in a Crookes-tube-type apparatus with very low input energy. He attributed that to fusion of the hydrogen or deuterium in the platinum or palladium cathode (I can't remember precisely which materials he used).

Although I've never been in a position to test Dr. Johnson's claims, it occurs to me that many a hacker might be, and that the idea should be spread. It would be far better for that principle to be made available in the public domain than to be patented, because the world so urgently needs a good power source.

The prevalent idea now seems to be that Pons made some mistake in his heat measurements, but how about the reported meltings and explosions? Such phenomena would be hard to think of as mere imaginings, and if there is anything a good chemist knows, it is how to make measurements of such phenomena as heat generation.

If there is any question as to why cathodes should explode, I would like to advance the thought that helium formed within the metal would almost surely be slow to escape as compared to the rate at which hydrogen could be absorbed. The resultant pressure could be immense.

For a possible future power application, I would suggest a tube of suitable metal (PD or PT) with a wire anode with ends made of insulating material drawn through its axis. D_2 or H_2, the gases, would be present at low pressure, characteristic of Crooke's tubes. The tubular cathode could be expected to become very hot, and should be immersed in water, forming a structure similar to a fire-tube boiler. Of course, the entire apparatus should be placed in an underground, or otherwise shielded vault, for protection against possible radiation or explosion.

In the ultimate development the fusion might not be so cold after all. Perhaps the cathode must be allowed to melt, and to form a pool from which the helium could escape readily, eliminating the explosion hazard. A problem of containment for the high-melting noble metals would then arise; that is the sort of problem any hacker would love.

I have tried to make my own little wet setup, using titanium for the cathode, but have had trouble finding a proper cheap anode. No common metal works, because of oxidation. Silicon should work better, but is not readily available to me.
THOMAS ROSS
Freeland, WA

CUSTOMER SATISFACTION

When I decided to build the 386SX PC from the articles that appeared in the June, July, and August 1989 issues of **Radio-Electronics**, the first thing I did was to contact Peripheral Techology for the parts. The people there are first rate: Whenever I had a question they were helpful and courteous in their responses. I had a few problems along the way (a defective power supply zapped the chips), and the people at Peripheral Technology replaced or repaired the parts and shipped the system back to me at no charge. It works just fine now, and I'm writing commend Peripheral's responsible and honest manner of doing business. I will continue to do business with them as I upgrade the system, and would recommend them to anyone involved with PC's.
CHARLES F. FLAHERTY
Waukegan, IL

TERRIFIC TRANSMITTER

I just wanted to comment on how impressed I was with the "TV Transmitter" article by Rudolf F. Graf and William Sheets that appeared in the June and July 1989 issues. I ordered the kit and received it promptly. When I hit a few snags, I called the suppliers and received clear and accurate advise. After the kit was completed, I followed the tuning instructions, and *Voila!* it worked!

The transmitter's design is quite remarkable, using some pretty ordinary electronic components.

Hats off to the authors for providing a reliable, "do-able," mail-order kit, and to **Radio-Electronics** for making it available to folks like me.

LES MALZMAN
Portland, OR

ETCHANT TANK DESIGN

I am writing about a very small, but potentially disastrous, design oversight in the "Etchant Tank" described in the December 1989 issue of **Radio-Electronics.**

As a tropical-fish owner, I can assure you that if you locate the air pump below the level of the etchant or water in any tank you are inviting trouble. There is a very good chance that if the power fails, or one of the reed or flap valves fails, you will get a siphon effect—causing a great big mess.

As for the letter from Michael Catudal, which appeared in the same issue, I suggest that he visit a hamfest to get an idea about the real hobbyist world. The 2716 EPROM is far from obsolete. I suppose he has an 80486-based computer that runs at breakneck speed. C'mon, Michael, join the real world!

PHIL CLINE
Indianapolis, IN

CORRECTION

In our "Universal Laboratory Power Supply" construction article (**Radio-Electronics**, March 1990) a couple of errors need correcting:

- In the schematic (Fig. 1), pin 7 of IC2 is shown connected to R14. It should be connected to the output of IC1. The bottom of R14 should instead be connected to pin 2 of IC2.
- The Parts Placement diagram (Fig. 3) shows the incorrect connection for meter M2. Follow the schematic for the proper way to hook up M2 and it's corresponding current switch, S2.
- The parts list and ordering information incorrectly identify Q1 and Q2, which are MJ15023 transistors.

EQUIPMENT REPORTS

Fluke 85 Digital Multimeter

High accuracy with a human touch.

CIRCLE 25 ON FREE INFORMATION CARD

WHEN ENGINEERS AND TECHNICIANS think about high-tech test equipment, multimeters don't usually come to mind. But many of today's digital multimeters are chock-full of high-tech features. A case in point is the *Fluke 85* DMM from the John Fluke Mfg. Co., Inc. (P.O. Box C9090, Everett, WA 98206).

As is becoming common, the meter can measure more than voltage, current, and resistance: Frequency, capacitance, and conductance-measurement capabilities are included in the *Fluke 85's* features. A host of alternate modes that add "smarts" to the meter, along with numerous human-engineering features, make the *Fluke 85* stand out from a crowded field. Before we get into some of the special features, let's look at the basic specifications.

The *Fluke 85* measures about 7⅜ × 1¼-3⅜ inches and weighs 12½ ounces. Functions are selected using a single rotary switch in the center of the meter's front panel. A 3¾ (4000-count) digit LCD, four test-lead input jacks, and 7 push-buttons for feature selection complete the front panel.

Five AC voltage ranges, from 400 millivolts through 1000 volts, offer a worst-case accuracy of ±0.5% ±4 counts for 60-Hz sine waves. Accuracy decreases for higher-frequency sinewaves; but even at 20 kHz, the specified accuracy is ±4% ±4 counts for the highest specified range of 400 volts.

The *Fluke 85* also offers five DC voltage ranges, from 400 millivolts through 1000 volts. The specified accuracy is similarly impressive: ±0.1% ±1 digit. Six resistance ranges, from 400 ohms through 40 megohms full scale, boast accuracy better than ±0.2% ±1 count on all but the highest range. A 40-nanosiemen conductance range effectively extends the resistance measurement capability to 100,000 megohms for testing leakage in insulators, diodes, circuit boards, and the like. An impressive accuracy within ± 1% ± 10 counts is offered for conductance measurements.

For measuring current, 6 AC and 6 DC ranges, from 400 microamps to 10 amps, provide a worst-case accuracy of ± 0.6% ±2 counts. Capacitance measurements, in four ranges from 5 nanofarads to 5 microfarads, provide an accuracy of ±1% ±2 counts. Frequency measurements in four ranges from 200 to 200 kHz provide an accuracy of .005% ± 1 digit.

(Continued on page 20)

Portasol Butane Gas-Powered Soldering Tool Kit

A field-service tech's dream come true!

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PORTABLE SOLDERING IRONS ARE MERELY a convenience for most of us. But they're a must for field-service technicians, who can't count on having a source of power available where they need it. A rechargeable battery-operated iron can fill the need nicely—but only if you can get it back to its charging holster between jobs.

If you need a portable soldering iron that you can leave in your tool box indefinitely without it losing its charge, then a butane-gas powered tool is your only sensible choice. While they've been around for a few years, we were reminded of their convenience and versatility when we recently examined the Model *P-1K* butane gas-powered soldering tool kit from Portasol, Inc. (7422 Carmel Executive Park, Charlotte, NC 28226).

The kit, which comes packaged in a rugged plastic storage case, includes the soldering tool, a 2.4 mm (3/32 inch) soldering tip, and three other tips that convert the tool into a blow torch, a hot-air blower, and a hot knife. A tip-cleaning sponge, a safety stand, and a cap (that doubles as a flint lighter) complete the kit.

The soldering tool measures about 6½ inches with a tip in place, and less than 7 inches with the cap on. Full of fuel and with a tip in place, the soldering iron weighs just over 2 ounces. It's certainly light enough to feel at home in a shirt pocket—which is probably why a shirt-pocket clip is included on the cap.

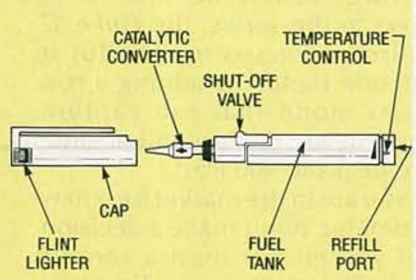

FIG. 1

In continuous use, a single filling of butane provides about 90 minutes of use. When that runs out, standard butane cigarette-lighter fuel can be used to refill the Portasol. A catalytic converter in the soldering tip provides heat from a flameless combustion (except, of course, when the blowtorch tip is in place). An adjustable temperature control on the bottom of the tool provides the equivalent of a 10–60-watt soldering iron.

The cap contains a flint lighter which uses standard, replaceable flints. After lighting, it takes the Portasol soldering tool slightly over one half minute to come up to operating temperature. When you're finished, the cap can be replaced immediately. As a safety feature, replacing the cap automatically shuts off the gas on/off control.

While convenience and portability are certainly good reasons to choose the Portasol butane gas-powered soldering tool, there's yet another good reason: There is virtually no risk of leakage current that could damage sensitive circuits.

The Portasol *P-1K* took kit sells for $54.95. The soldering iron itself (the model *P-1*) is available for $29.99, including a 3/32-inch tip. It's a bargain for anyone who is looking for cordless convenience. If you find yourself in remote or limited-space situations, then you know that this portable soldering tool will pay for itself virtually the first time you need it. **R-E**

EQUIPMENT REPORT

continued from page 18

Features

Although the basic specifications of the *Fluke 85* are, indeed, impressive, they tell only half the story. For example, one of our favorite features is a MIN/MAX recording mode in which the meter stores the lowest and highest readings while also calculating the true average of all the readings taken over a period as long as 24 hours. It's ideal for catching intermittents, or jut to take readings while you are operating the equipment under test and can't watch the meter. We used the meter to measure the AC line voltage over a 12-hour period, and found that it ranged from 104.0 volts to 124.4 volts, with an average of 120.6 volts.

Two recording modes, one with a 100-ms response time, the other, a "high-accuracy" mode with a 1-second response time are offered. Every time a new minimum or maximum reading registers, the meter's beeper will sound. MIN/MAX readings are available for voltage, current, resistance, and frequency measurements.

A relative-measurement mode is also available. For relative measurements, a reading is stored in memory. The display shows the difference between the stored value and subsequent readings.

In the relative-measurement mode, the analog bargraph—which acts just like an analog meter needle in most modes—becomes a zero-center meter. In the other modes, the bargraph can make certain measurements much easier than is normally possible with digital meters. Peaking or nulling a signal, for example, can be seen easily with the bargraph, while changing digital displays usually cause confusion.

An alternate frequency-counter mode makes it possible to measure the duty cycle of input signals. Positive- or negative-edge triggering is selectable.

The little things count

The technical specifications and the measurement features of the *Fluke 85* are enough to recommend the meter to anyone who needs to make a wide range of accurate measurements. But it's the "little things" that the meter offers that really show off Fluke's test-equipment experience.

The front-panel knob and push-buttons are clearly marked and easy to use. However, as with just about every other DMM, it's necessary to switch the test leads if you switch from voltage to current measurements. We all know how easy it is to forget to switch the leads. That's why Fluke incorporates a beeper that lets you know that the leads are not inserted correctly for the measurement you want to make. It's sure to greatly reduce the number of blown safety fuses caused by neglecting to switch leads.

A touch-hold feature, which freezes the display, also makes the *Fluke 85* easier to use.

A holster with Fluke's *Flex-Stand* is included with the meter. The bright yellow holster not only makes the meter easy to find, it offers an added degree of protection. The Flex-Stand tilt bale can be used to stand the meter up. But because the bale is flexible, it can be used to hang the meter over a convenient protuberance, including your belt. Two test-probe clips hold the probes for storage. The probes can be clipped in the holster in operating position, which allows you to use the meter much as you would a logic probe.

The *Fluke 85* sells for $239. Two other meters round out Fluke's *80 Series*. The $199 *Fluke 83* offers the same features of the *Fluke 85*, but with lower accuracy and frequency response. The $289 *Fluke 87* offers not only greater accuracy, but extra features as well. For example, the *Fluke 87* offers a 4½-digit (20,000 count) display, and backlighting, too. Like the other meters in the series, the *Fluke 87* features a MIN/MAX mode. But it goes one better by adding a PEAK MIN/MAX mode that can capture transients to 1 millisecond or sine-wave peaks to 400 Hz.

If you are in the market for a new multimeter, don't make a decision until you give at least a serious look to Fluke's *80 Series*. They represent the state of the art of digital multimeters. **R-E**

READER HELP READER

• PAUL WHITEMAN has turned to us in desperation. He needs a copy of the schematic or, better yet, the service manual for an AB Systems' power amplifier, model *1201a*. He'd gladly pay fair costs and the postage to send it to *404 Dawes Road, Toronto, Ontario, M4B 2E4, Canada.*

• When G.H.M. requested the service manual for a *Fisher 400* in a previous issue of **Radio-Electronics**, a few readers were kind enough to respond—and one of them now has a request of his own. MICHAEL WOLIN needs factory-service information on a KLH model *40* tape recorder (the latest, "improved" model). His address is *440 Pratt Street, Longmont, CO 80501.*

• A long-time **Radio-Electronics** reader from across the Atlantic, SAM HOSENBOCUS, would like to correspond with American electronics hobbyists. He is particularly interested in the surveillance field, and would like to exchange information and diagrams. Write to him at *13 Victoria Terrace, Leeds LS3 1BX, W. Yorkshire, England.*

• DENNIS BETZ is in the dark without the parts list for his *Tigersuarus 210/A* power amp, made by Southwest Technical Products of Texas, in the mid-1970's. If you have a copy of the parts list, or can point him in the right direction, write to *125 N. Railroad St., Annville, PA 17003.*

• WALDO ARNHOLZ never expected to be writing to **Radio-Electronics** for help. However, all his efforts to find a complete schematic of the chassis of his Audiophonic stereo receiver, model *SR-2150*, have left him empty-handed. He'd like to hear from anyone with either the manufacturer's address or the schematic, and he's willing to pay for the schematic copy. Send the information to *1925 Hollow View Drive, Bettendorf, IA 52722.*

Radio-Electronics mini-ADS

NEW PRODUCTS

IEEE-488 BUS ANALYZER. For detecting and analyzing bus difficulties such as program errors, incomplete device responses, timing errors, incompatible instruments or software, and cable problems, *ICS Electronics* has introduced the *ICS 4811 Analyzer*. The small, self-contained analyzer can be used to monitor bus traffic or as a dedicated data-acquisition system. When set to the HANDSHAKE mode, the *4811* can act like any other IEEE-488 device. With the HANDSHAKE disabled, it can be transparent to the controller and other instruments on the bus. It can be programmed to emulate a device responding to addressed requests for system debugging and, when configured as a pattern generator, the *4811* can provide high-speed data and command output. The versatile device can function as the system controller or as a controller emulator for full-system tests.

Weighing less than eight pounds and requiring no external power supply or computer, the bus analyzer can be carried to any testing site. Its nonvolatile 128K memory lets the unit store data and analyze it at another location, or send it to a computer. For uploading and downloading to a PC, the *4811* also comes with a standard RS-232 port.

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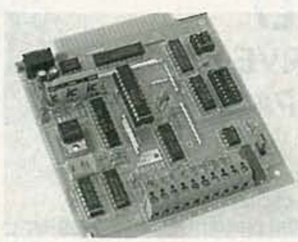
The included software allows optional interactive control and data display of all analyzer functions from any DOS-based instrument, without impacting system operation. The CONFIG function, located on the front-panel membrane keypad, is used to select the function, number base, serial parameters, and other functional parameters. Those setup parameters can be stored and recalled for subsequent use. The analyzer's 8-line × 40-character LCD shows bus data in either ASCII, octal, hex, binary, decimal, or in disassembled bus mnemonics.

The *ICS 4811 Analyzer* costs $1995.00; an optional MS-DOS software package, which provides extensive post-processing and analysis of bus data, costs $500.00.—**ICS Electronics Corporation**, 2185 Old Oakland Road, San Jose, CA 95131.

12-BIT A/D CONVERTER. *Alpha Products' FA-154* is a high-speed, 12-bit analog-to-digital converter designed for high-speed data acquisition and signal processing. Its conversion speed is only 10μs, and each of its eight input channels will accept 0–5-volt signals. A variable-gain amplifier permits the reading of signals less than 1 LSB (1.2 mV). The *FA-154* runs on all IBM-PC bus machines, Apple II's, Commodores, Tandy, and other computers.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The *FA-154* analog-to-digital converter costs $179.00.—**Alpha Products**, 242 West Avenue, Darien, CT 96820.

DUAL DATA ANALYZER. Containing two BERT's, two data-line monitors, and two terminal emulators in one compact package, the *Gemini 1022* from *Telecom Analysis Systems (TAS)* simplifies bench-top testing of data-communications equipment such as modems, ISDN terminal adapters, and DDS sets. It performs bit error-rate, throughput, and polling-performance tests at rates up to 72 kilobytes per second. The tests can be run simultaneously at both ends of the communications path, cutting in half the amount of equipment needed for an end-to-end test.

A built-in call-setup feature eliminates the need for separate data terminals, line monitors, and A/B switches when testing auto-dial modems, which reduces the cost and complexity of modem-testing arrangements. *Gemini* uses a variety of protocols to communicate with modems, and also monitors and displays modem call-setup commands, as well as command responses.


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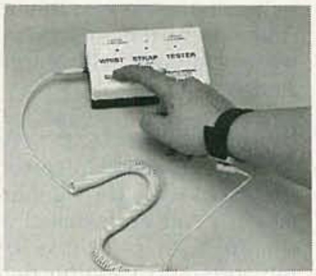
The analyzer can be controlled either through its front-panel keypad and display or through its built-in RS-232 and GPIB interfaces. The simple control-interface commands make it easy to incorporate the unit into automatic modem-test systems. A built-in RS-232-to-GPIB protocol converter allows control of several pieces of GPIB equipment from a single RS-232 port. Its plug-in software cartridge makes it easy to add more features later, and *Gemini* can be combined with other products from *TAS* to make a compact, completely automatic, modem-test system.

The *Gemini 1022* dual data analyzer costs $5950.00.—**Telecom Analysis Systems, Inc.**, 34 Industrial Way East, Eatontown, NJ 07724.

WRIST-STRAP TESTER. Designed to detect malfunctions or breakage in wrist-strap assemblies, *Plastic Systems' WT-6600* also enhances ESD protection. The device also detects inadequate contact between band and operator.



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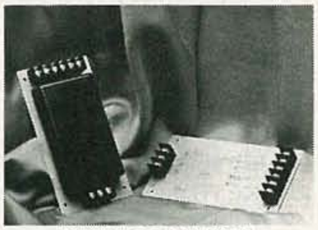
The tester is accurate, portable, and easy to use in electronics and other fields where ESD is a concern. The tester indicates HAZARD at readings of less than 470 kilohms, OK at less than 10 megohms and higher than 470 kilohms, and CAUTION at readings higher than 10 megohms.

The *WT-6600* wrist-strap tester costs $100.00.—**Plastic Systems, Inc.**, 261 Cedar Hill Street, Marlboro, MA 01752.

MOUNTING KIT. The *MS10* mounting kit is designed to make the *CALEX XW*-series "U"-case-size DC-to-DC converters ready to use. The *CALEX XW* DC-to-DC converter series includes six single- and six dual-output units with up to 30 watts of isolated and highly regulated low-noise output power. Single-output units have input-voltage ranges of 9–36 or 20–72 volts; the dual-output units have 9–18-, 18–36-, or 36–72-volt input ranges.



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The *MS-10* converter consists of a PC board, eight single-pin gold-plated sockets, and input/output barrier strips for easy screwdriver connections. The kit is constructed of 1/16-inch glass epoxy and measures 3.25 by 6.3 inches. There are four holes in the board, on 2.75 × 5.5-inch centers, for chassis mounting.

The *MS-10* DC-to-DC converter kit costs $36.00; the XW converters range in price form $160.00 to $165.00.—**CALEX Mfg. Co., Inc.**, 3355 Vincent Road, Pleasant Hill, CA 94523.

DIGITAL PANEL METERS. Measuring less than 1 × 2 inches, the *ACCULEX DP-352J* and *DP-352K* thermocouple-input Digital Panel Meters (DPM's) have large 3.5-digit LED displays that can be read in direct sunlight as well as in low-light situations. The high-performance *DP-352J* and *DP-352K* support J- and K-type thermocouples, respectively. They provide

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cold junction compensation and display directly in degrees Centigrade. A full-scale display range of 0–200°C is standard. Screw-terminal connectors for both primary operating power and direct signal input allow quick and easy field installation.

The *DP-352J/K's* full differential input and dual-slope integrating A/D converters, combined with common-mode rejection capability of greater than 86 dns, allow precise temperature measurements even under poor environmental and electrical conditions. Their accuracy is rated to 1% full scale (±1 digit) with an operating temperature range of 0–50°C.

With a low +5 volts DC at 250 mA primary operating power, the DPM's can be used for field/mobile use or as standard temperature monitors for automotive/marine/avionics applications. Other applications include energy management; electronic test and burn-in chambers; marine, automotive, and medical instrumentation; petrochemical processing; and biochemical and biomedical R&D.

The *DP-352J* and *DP-352K* thermocouple-input digital panel meters each cost $119.00.—**ACCULEX**, A MetraByte Company, 440 Myles Standish Blvd., Taunton, MA 02780.

PIN-FIN HEAT SINK. A cast-aluminum, pin-fin heat sink for cooling 14×14- and 15×15-pin array (PGA) packages is now commercially available from *Aavid Engineering*. Model *567900* is made in a high-conductivity aluminum alloy cast in a staggered-pin configuration, providing highly efficient cooling for those popular PGA packages.

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The advanced aluminum-casting technology used in their manufacture produces a denser, more thermally efficient heat sink than is possible to attain using conventional die casting. Enhanced conductivity, combined with the efficient pin-fin cooling surface, ensures low semiconductor temperatures at high power-output levels.

The heat sink provides rapid heat dissipation for any high-speed, high-power (greater than 3 watts) PGA package—including bipolar, BICOS, and high-density CMOS. Model *567900* has a thermal resistance of 8°C/W with a load of 5-watts under natural convection. The mounting surface is smooth and flat, with an edge stop for simplified self-fixing and adhesive bonding. The heat sink is available in black-anodized and gold-chromate finishes.

The model *567900* pin-fin heat sink costs $1.63 in lots of 1000.—**Aavid Engineering, Inc.**, One Kool Path, P.O. Box 400, Laconia, NH 03247.

S-VHS TESTING OPTION. An optional add-on for several color-TV pattern generators from *John Fluke Mfg. Co.* provides the capability to test Super-VHS VCR's. The *PM 9553 Y/C* option provides the separate luminance (Y) and chrominance (C) signals used in S-VHS recording and playback to reduce cross-contamination between the signals. Its versatility is further enhanced by its standard RGB-output signals.

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The *PM 9553 Y/C* option fits in the *PM 5514V, PM 5515*, and *PM 5518* (pictured here) color pattern generators. It can be installed at the time of purchase or retrofitted to existing pattern generators.

Factory installed, the *PM 9553 Y/C* option carries a list price of $600.00.—**John Fluke Mfg. Co., Inc.**, P.O. Box 9090, Everett, WA 98206; Tel. 800-443-5853.

SOLDERING SYSTEM. With its patented "thermal thrust" tip design, the *Ungar 9910HC* delivers 40% higher thermal capacity than micro irons that use

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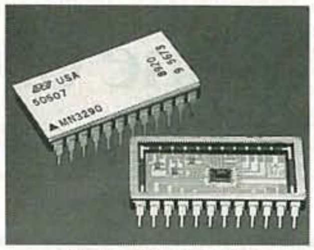
standard tips. Thermal capacity—the iron's ability to minimize and quickly recover from heat loss—determines the system's ability to make repetitive and reliable solder joints. A higher capacity is generally required for soldering larger parts. The *Ungar* system combines the comfort and simplicity of a small iron with the high capacity of a much larger one, so it can be used for high-mass, heavy heat-sink applications as well as for lighter work.

The ESD-protected *9910HC* has a closed-loop circuit for temperature stability at idle. It also features zero switching, reliable grounding form tip to plug, a durable ceramic heater, and a cool grip. The 24-volt micro iron can be customized with a choice of three additional, easy-to-connect irons with a variety of tips. The system meets or exceeds government soldering specifications DOD-STD-2000-1B, WS-6536E, MIL-S-47543E, and MIL-STD-2000. If you are looking for an ESD-protected soldering system that's versatile enough to cover all of your soldering needs, than the *9910HC* may be exactly what you need.

The *9910HC* soldering system has a suggested retail price of $236.00.—**Ungar**, Division of Eldon Industries, Inc., 5620 Knott Avenue, Buena Park, CA 90621.

16-BIT D/A CONVERTER. A new family of extended temperature-range, 16-bit digital-to-analog converters



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(DAC's) is targeted for demanding military, aerospace, and industrial applications. *Micro Networks' MN3290* series is exactly pin- and function-compatible with older, industry-standard DAC71/72 devices, and is expected to replace many of those older devices in new and existing military programs.

There are 37 different models in the series, including six different voltage- and current-output devices that each offer four different electrical grades to address both commercial (0°C to 70°C) and military (−55°C to +125°C) applications. The extended temperature-range devices are available screened in accordance with military specifications.

The *MN3290* series DAC's are made using a bipolar process. They are TTL compatible and contain an on-chip, low-noise, buried-Zener reference. The devices are packaged in standard, 24-pin, ceramic DIP's. All of them guarantee 14-bit monotonicity at room temperature; the higher grade devices guarantee 14-bit monotonicity and ±0.006%FSR integral linearity over the entire extended temperature range.

The *MN3290* commercial and military-standard current-output devices are priced from $31.00 and from $75.00, respectively, in quantities of 100. The commercial and military-standard voltage-output devices are priced from $33.00 and from $75.00, respectively, also in quantities of 100.—**Micro Networks/Unitrode Corporation**, 324 Clark Street, Worcester, MA 01606. **R-E**

NEW LIT

INSTRUMENT CATALOG. Wide selections of instruments for test and measurement, plant maintenance, water-quality checks, and monitor/control applications are featured in this 44-page brochure from *Extech.*

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Photographs accompany every item listed, and the text includes helpful information on how to choose the right instrument for specific applications, as well as explanations of the instruments' features. There is no charge for the catalog.—**Extech Instruments**, 150 Bear Hill Road, Waltham, MA 02154; Tel. 617-890-7440.

INTERCONNECTION PARTS. The 1990 edition of *L-com's* catalog includes more than 3,500 items. A full line of components and accessories for the electronic, computer, and communications markets is featured—including an extensive line of more than 1,200 ready-made coaxial and data cables, baluns, IEEE-488 cables and accessories, patch panels, and line testers. To help the user evaluate the products listed, the catalog has full product descriptions,

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usage information, and pricing up to moderate quantities. Some of the new products in this edition are modular and IBM tokenring wiring aids, an automatic and manual matrix switch, Wang-type surge protectors, Macintosh networking kits, and a new series of coaxial switches that are specifically made for panel mounting. The catalog is free upon request.—**L-com, Inc.**, 1755 Osgood Street, North Andover, MA 01845; Tel. 508-682-6936.

VCR-PARTS CROSS-REFERENCE. Providing the servicer with a quick reference source of key wear items—belts, motors, pressure rollers, and headwheels—*Thomson Consumer Elec-*

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tronics' *VCR Key Items Cross Reference* lists more than 900 models. The guide contains references to 90% of a servicer's parts needs for nine popular brands: RCA, GE, Hitachi, Magnovox, Panasonic, Philco, Philips, Quasar, and Sylvania. The Thomson stock number, as well as a reference number that corresponds to the number shown on the service-data parts list and on the exploded view diagram of the VCR model listed, is included. When combined with the Thomson cross-reference microfiche, the quick-reference guide provides access the entire VCR replacement parts line.—**Thomson Consumer Electronics**, Service Dealer Parts and Components Merchandising, 2000 Clements Bridge Road, Deptford, NJ 08096-2088.

APPLICATION NOTE. *Motorola's Spice Model for TMOS Power MOSFETs (AN1043/D)* includes a library of parameters on selected devices that can be used in conjunction with existing simulation programs. The library is available free of charge on 3½- or 5¼-inch disks for IBM-compatible computers (*DK301/D* and *DK103/D, respectively), or on a 3½-inch disk for use with Macintosh PC's (DK202/D*). The note also

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discusses the physics of power MOSFETs, implementation of a model for simulation programs, parameter extraction methods, and a comparison of a simulation with measured results. The application note and the TMOS Library disk are free.—**Motorola Literature Distribution**, P.O. Box 20912, Phoenix, AZ 85036; Tel. 1-800-521-6274.

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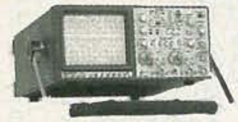

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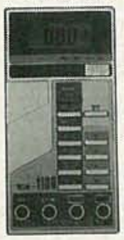

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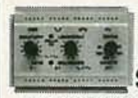

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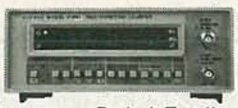

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BUILD THIS

MORSE/RTTY DETECTOR

Let your computer decypher Morse code and radioteletype signals even if you don't know a dit from a dah!

LARRY ASHWORTH, KA7AFR

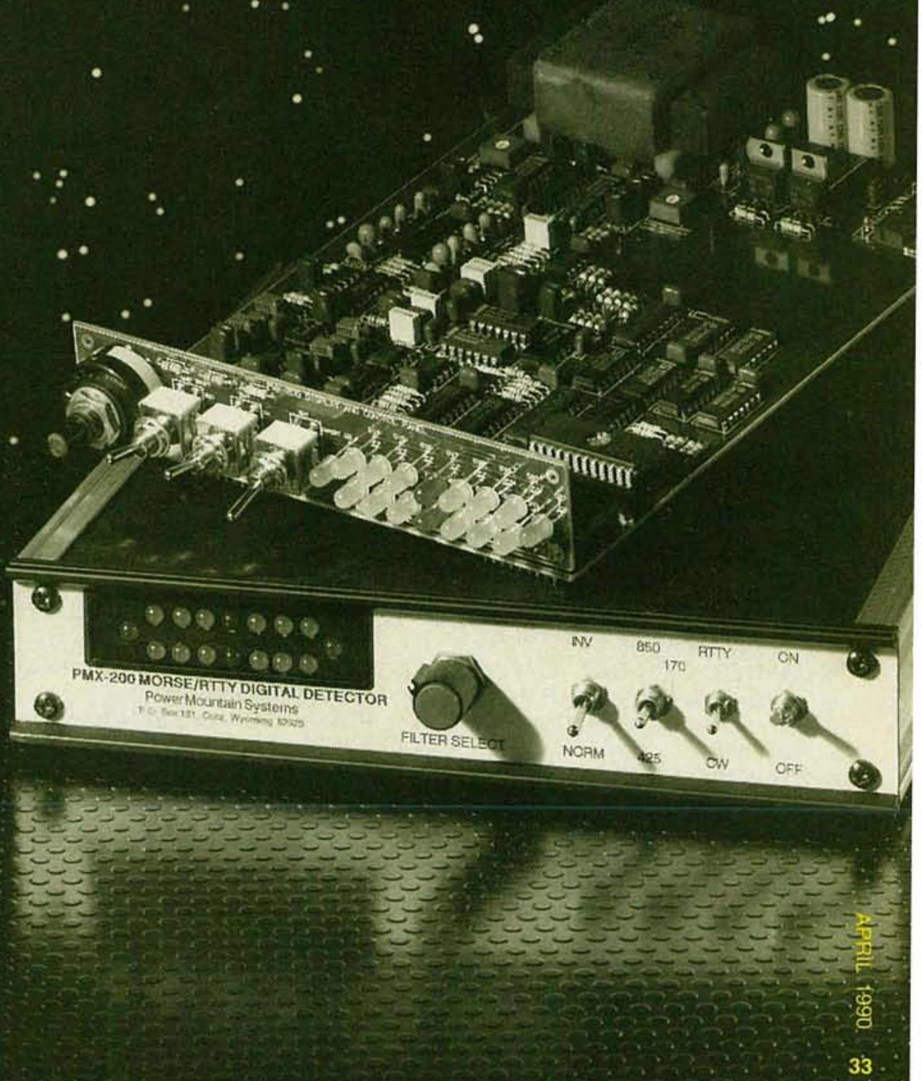
IF YOU ARE EVEN A CASUAL LISTENER OF shortwave radio, you've undoubtedly heard lots of Morse code (CW) and radioteletype (RTTY) communications. Unless you're a radio amateur, you've probably been frustrated because you can't decipher those signals—that is, until now. Now you can build our PMX-200 CW/RTTY detector, connect it to your computer's serial port, and display all of those messages that have previously been hidden from you.

The impetus for the project's design was the author's frustration with the performance of other Morse and RTTY detectors on the market, specifically their inability to copy weak and noisy signals. Despite the fact that there has been a great deal of effort to improve the software side of communications (like packet), the actual detection schemes have changed little if at all.

The detector's performance plays a critical role in a truly high-quality CW or RTTY system, since any information lost cannot be recovered. The detector presented here circumvents many of the traditional difficulties. Its digital detection scheme takes CW and RTTY performance very nearly to the theoretical limit.

Display system

While most RTTY systems are difficult to tune, the PMX-200 uses a digital detector that makes the proper tuning procedure intuitive even to the inexperienced user. Two rows of LED's allow you to see which way you need to tune even before mistuning causes misprint. In CW mode, only one row is lit, which helps to reduce distraction. In RTTY mode, both rows are used. As a tuning aid, the front-panel shift-select switches are decoded. The display will be properly lighted only when the proper RTTY shift has been selected for the incoming signal. Even inexperienced users should have no problem with proper tuning.



CW modulation

Whenever intelligence is added to a carrier, whether by FM, AM, FSK, SSB, or any other method, there are limitations imposed. The limitations are weighed against their strengths to determine the suitability of a given system for communications. ASCII, as opposed to Baudot, in RTTY is a good example of tradeoffs like that.

ASCII has a larger character set available but, since each character takes nearly twice as long to transmit, it is nearly twice as error prone. For transferring computer programs and lower-case text ASCII is the best, but for communicating messages and news, Baudot is better. That's why some commercial carriers still use Baudot.

CW takes less bandwidth than any other modulation system but, when conditions are poor, it's less capable than FSK for a given data rate. Some of the advantages of CW are that it is narrow, slow, and has a limited character set. That might not sound like anything positive, but for getting a message through in the worst of conditions, there is nothing better.

Morse code is a series of tone bursts whose relative duration, and relative absence, carries meaning. That puts a great burden on our receiving system to extract all the information available. Noise immunity is extremely important, and the only thing we know for sure about the tone we are demodulating is the frequency.

Noise by its very nature can appear for an instant to be the frequency we are trying to detect, but will not have a duration long enough to be valid. The faster the detector can detect the correct frequency of the incoming tone, the higher the resolution. That means we can extract greater detail about the signal we are listening to. If we can

PARTS LIST

All resistors are ¼-watt film except where otherwise indicated.

R1, R3, R6, R12, R43, R45, R49, R55, R81, R82, R89—39,000 ohms
R2, R9, R52, R53—27,000 ohms
R4, R7, R8, R19, R22, R24, R59–R62, R85—47,000 ohms
R5, R13, R86, R87—68,000 ohms
R10, R11, R14, R28—15,000 ohms
R15–R18, R69, R70—33,000 ohms
R21, R51, R76—220,000 ohms
R23, R90—20,000 ohms, ⅜-inch single-turn potentiometer
R25, R26, R34, R74, R77—330 ohms
R27, R30, R31, R78, R79—2200 ohms
R20—270 ohms
R29, R32, R33, R35–R39, R41, R50, R56–R58, R63–R65, R71–R73, R75—1000 ohms
R40—470 ohms
R42, R44, R48—48,000 ohms
R46, R47, R92—10,000 ohms
R54, R88—30,000 ohms
R66, R91, R93, R94—20,000 ohms
R67, R68, R95, R96—20,000 ohms, 10-turn potentiometer
R80—4700 ohms
R83, R84—22,000 ohms
R100–R105—2000 ohms

Capacitors

C1, C2—1000 µF, electrolytic
C3, C29, C30, C40, C46, C63—10 µF, electrolytic
C4–C28, C41, C47, C77, C78, C80–C82, C85—0.1 µF, mylar
C31, C34–C36, C49, C51—0.0047 µF, mylar
C32, C33—0.0027 µF, mylar
C37, C38, C43, C44, C59—1 µF, tantalum
C39, C45—2 µF, tantalum
C42, C60—30 pF, ceramic
C48, C76, C79—0.22 µF, mylar
C50, C52—0.002 µF, mylar
C53, C55—0.003 µF, mylar
C54, C56—0.0005 µF, mylar
C57, C58—0.0068 µF, mylar
C61, C62, C64, C65—0.047 µF, mylar
C66–C69, C86–C89—0.01 µF, mylar
C70, C71—0.15 µF, mylar
C72, C73—0.068 µF, mylar
C74, C75—0.03 µF, mylar
C83, C84—0.001 µF, mylar

Semiconductors

IC1, IC2—LM7805 5-volt regulator
IC3—LM7912 −12-volt regulator
IC4—NE570 compander
IC5, IC26, IC36—LM311 voltage comparator
IC6, IC25—LM324 low-power quad op-amp
IC7, IC8, IC27, IC28—4066 quad bilateral switch
IC9—74LS14 hex low-power Schottky Schmitt-trigger inverter
IC10, IC11, IC14, IC15—74LS161 synchronous binary counter
IC12, IC16—74LS30 8-input NAND gate
IC13, IC17—74LS244 octal tri-state buffer
IC18—74LS10 triple 3-input NAND gate
IC19—2.4576-MHz crystal oscillator
IC20—74LS90 decade counter
IC21, IC24—not used
IC22—2732 EPROM
IC23—74154 4-to-16 line decoder
IC29—7416 hex inverter buffer with high-voltage open-collector outputs
IC30—74LS147 10-line decimal to 4-line BCD encoder
IC31, IC32—LM358N low-power dual op-amp
IC33—1488 quad MDTL line driver
IC34—1489 quad MDTL line receiver
IC35—7414 hex Schmitt-trigger inverter
IC37, IC42—74LS00 quad 2-input NAND gate
IC38, IC39—LM555 timer
IC40—74LS05 open collector hex inverter
IC41—4018 presettable divide-by-N counter
D1–D6—1N4003 rectifier diode
D7—4.3-volt Zener diode
D8—4.7-volt Zener diode
Q1, Q2—TIP42C PNP transistor
LED1, LED16—green light emitting diode
LED5, LED12—red light emitting diode
LED2–LED4, LED6–LED11, LED13–LED16

Other components

T1—FP24-500................
HDR1, HDR2—18-pin right angle header
HDR3—2-pin jumper header
S1, S4—DPDT PC-mount switch
S2—DPDT PC-mount switch with center off
S3—12-position rotary PC-mount switch
J1–J4—RCA-type jack, chassis mount
J5—DB25 connector
RY1, RY2—16-pin PC-mount relay
PL1—grounded AC line cord
Miscellaneous: case, hardware, wire, solder, etc.

Note: The following items for the PMX-200 Morse Detector are available from Power Mountain Systems, P.O. Box 161, Cora, Wyoming 82925. Double-sided silk-screened PC boards, $79.95; discrete parts kit (no boards or case), $159.95; pre-programmed EPROM, $15.95; detector software package for IBM/compatible, $19.95; black brushed-aluminum case ready for you to drill, $79.95; complete kit (contains everything), $269.95; an assembled, aligned, and tested unit, $389.95. All prices include UPS Ground, or mailing charges in the USA.

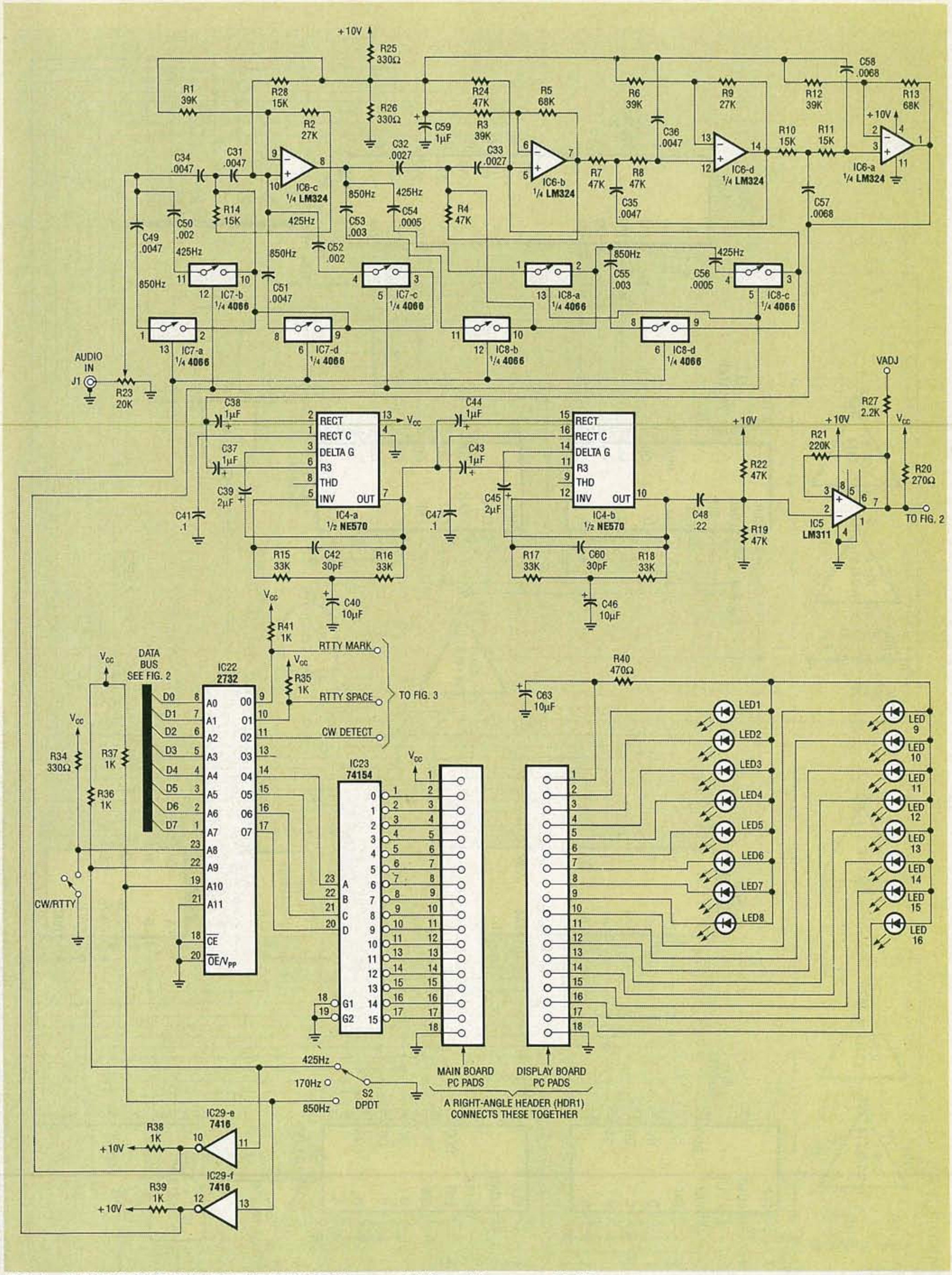


FIG. 1—IN THE FRONT END OF THE PMX-200 there are high- and low-pass, 24-dB-per-octave filters. The low-pass filter is fixed at 1650 Hz, and the high-pass filter is switch selectable (170 Hz, 425 Hz, and 850 Hz) for proper CW and RTTY operation.

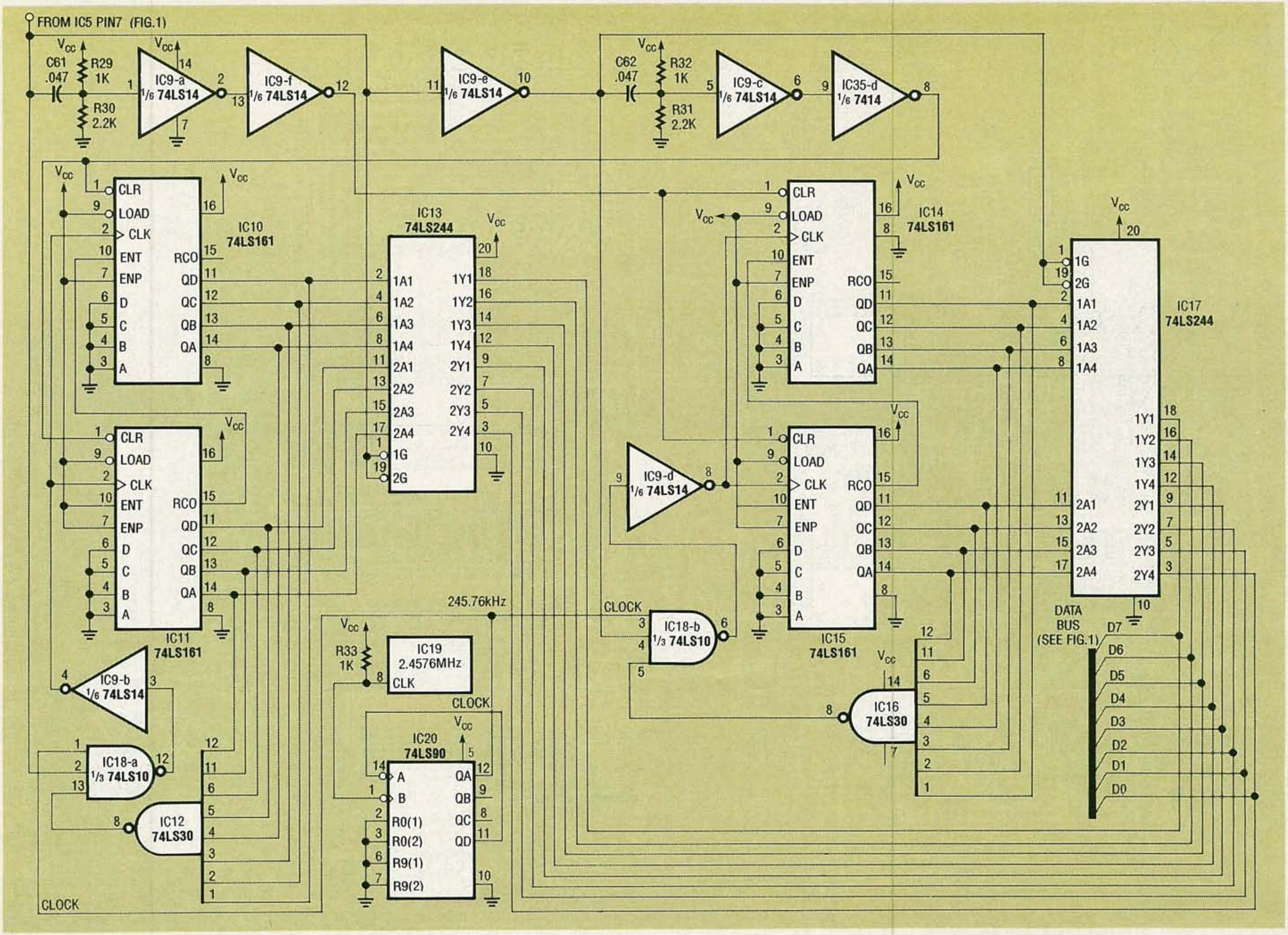


FIG. 2—TWO SEPARATE DETECTORS make up the PMX-200. They each independently measure opposite half cycles.

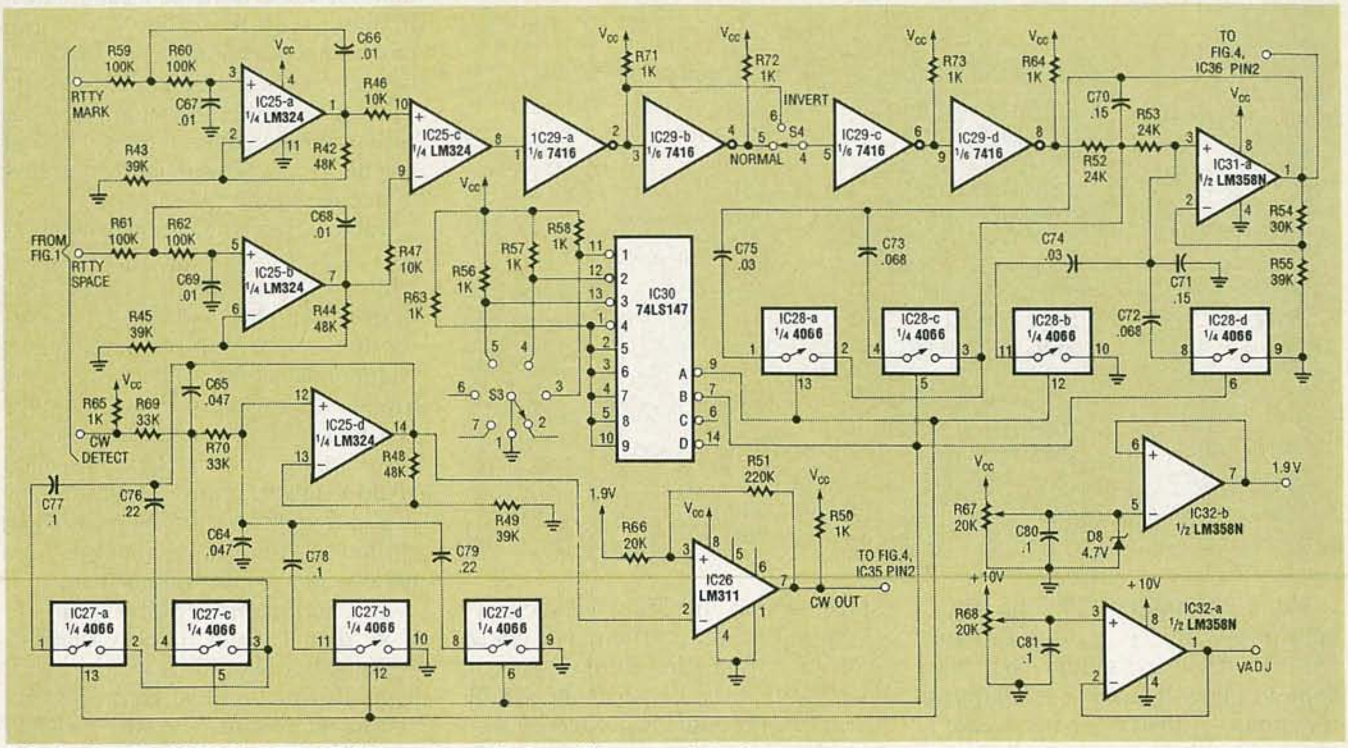


FIG. 3—AFTER ACTUAL DETECTION, analog switches allow us to have four separate low-pass frequencies for CW and four for RTTY to further enhance performance.

detect the proper frequency fast enough, and reject noise fast enough, the detector stops contributing its limitations to the task of detecting the tone and we're left with the constrictions of the modulation system itself.

Devices like the venerable 567 tone decoder have severe limitations for Morse. They can lock to an incoming tone in 10 cycles only 90% of the time. That means that 10% of the time it takes longer. The variation in lock-up time is completely random. If lock is lost for even a half cycle the problem starts all over again. A 567 in this application adds random inconsistency to the problem of decoding Morse code, and that we can do without!

The 567 was never designed for many of the applications for which it is being used—some talented people have managed to do amazing things with it. Unfortunately, it's just not the best way to go.

Phase-lock detectors work well for FSK since they're always locked to a constant carrier, as long as the carrier isn't lost due to noise. They don't do all that well for Morse because the carrier is missing half the time.

Using digital filter techniques, it's possible to measure each half cycle of incoming tone to determine its frequency. That is the reason why the PMX-200 has such high resolution. In 60 milliseconds we can verify 255 times that the frequency is still present. If there's a signal in there, the detector can see it, *rapidly* and *consistently*.

RTTY data is transmitted at a 22-ms bit rate (45.45 baud or 60 wpm), so there's very little time to detect the proper frequency. At 110 baud, the timing is 9 ms per bit, which makes the problem even more difficult. If the frequency we are detecting is 1500 Hz, there is only an average of 13.5 cycles of tone per bit of information at 110 baud. There are, on average, 33 cycles of tone at 45.45 baud. As the baud rate increases there is less time to make an accurate decision, and fewer cycles to work with. Since we are detecting each half cycle, we can detect the signal 27 times per bit at 110 baud, and 66 times per bit at 45.45 baud.

Morse detector

In the front end of the PMX-200 we are using high- and low-pass, 24-dB-per-octave filters (see Fig. 1). The low-pass filter is fixed at 1650 Hz, and the high-pass filter is switch-selectable (170 Hz, 425 Hz, and 850 Hz) for proper CW and RTTY operation. Switching is greatly simplified through the use of 4066 digitally controlled analog switches.

The filter frequencies were selected so as to be in the upper middle of the audio passband of a typical amateur radio transceiver. High frequencies roll off quickly in this type of equipment above 2200 Hz or so. While it is true that higher frequencies give us more half cycles to detect, that has to be weighed against noise, audio passband, and other considerations.

The input-filter section consists of two separate filter systems. A low-pass filter section with a frequency cutoff set for 1650 Hz sets the upper bandpass frequency limit. The high-pass filters, which set the low-frequency limit, have three different cutoffs depending on the setting of the shift-select switch. The cutoffs are 1200 Hz, 925 Hz, and 500 Hz for 170, 425, and 850 shifts respectively.

The higher the Q of a bandpass filter—Q is equal to the operating frequency divided by the bandwidth—the narrower is its response. As with nearly everything else, you can go too far trying to get a little better signal-to-noise ratio by using a very high-Q filter. The difficulty of narrow bandwidth is that the pulse response of a bandpass filter is equal to 1/(bandwidth in Hz). That means a 1-Hz wide filter would take 1 second to reach 90% of maximum amplitude. A 10-ms response requires at least 100-Hz bandwidth.

	Freq. & Count (10)	Count (Hex)	
	2276 Hz = 108	6C	
	2255 Hz = 109	6D	
	2234 Hz = 110	6E	
	2214 Hz = 111	6F	
	2194 Hz = 112	70	
	2175 Hz = 113	71	
	2156 Hz = 114	72	
Center	2137 Hz = 115	73	detection
Freq.	2125 Hz		width
	2119 Hz = 116	74	92 Hz
	2101 Hz = 117	75	
	2083 Hz = 118	76	
	2065 Hz = 119	77	
	2048 Hz = 120	78	
	2031 Hz = 121	79	
	2014 Hz = 122	80	
	1998 Hz = 123	81	

In the case of PMX-200, the initial bandpass filter is calculated for 250–300 Hz bandwidth. That was done to allow for minor component variations so that 1% parts weren't required, and also to take advantage of the quick response of the digital detector. As a general rule, it's better to use more filter sections set for a lower Q, than to try using a single filter section at high Q.

After filtering the incoming audio, an NE570 compandor (IC4) is used as a very fast AGC circuit. Both halves of the NE570 are used, and the dynamic range is very large. That means that audio input levels can vary by a wide margin without affecting performance.

An LM311 (IC5) is used as a hysteresis limiter, and converts the incoming sine wave to a square wave that can be used by the TTL-detector system. Hysteresis adds noise immunity to the detector. The voltage adjust (VADJ) provides a voltage to use as a precision crossover point, to guarantee that both halves of the square wave produced are equal.

There are two separate detectors that make up the PMX-200, and they each independently measure opposite half cycles. The TTL-level output from IC5, a LM311 (Fig. 1) is used to gate an internal oscillator to a pair of counters, each counter being made from a pair of 74LS161's. (One counter is formed by IC10 and IC11, and a second is formed by IC14 and IC15—see Fig. 2.) Each pair is wired to act as one 8-bit counter.

The clock input to the counters is disabled—and thus the counting stops—when the TTL level corresponding to the current half-cycle ends, or when the counter output reaches FF. (The counter output will reach FF only with low-frequency signals that are strong enough to override the high-pass filtering). Since we know the clock frequency, we can determine the frequency of the tone by reading the 8-bit value latched by the counters and the 74LS244 buffers. That 8-bit value is then compared to the values stored in the EPROM, IC22, to determine what tuning LED's should be lit.

The tuning indicator, which is part of Fig. 1, consists of a 4–16 line decoder, IC23, that is under the control of the 2732 EPROM (IC22). There are 16 LED's on the front panel that can be selectively programmed to light, depending on the frequency detected and the switch settings. Three of the four lower output data lines are programmed to provide output for mark, space, and CW.

Here are the formulas for determining the frequency for a given 8-bit detected value, and you can also see how the clock frequency was chosen, where:

256 = maximum count

Count = decimal equivalent of the desired frequency

At maximum count, frequency is minimum

$K = (1/(\text{min. freq.}) \times 2)$

$\text{Clock frequency} = 1/(K/256)$

$\text{Freq. cutoff} = 1/(2 \times (1/\text{clock}) \times \text{count})$

As an example, let's use a clock frequency of 491.52 kHz, and a target frequency of 2125 Hz. The calculations therefore yield the results shown in Table 1. In the EPROM we have programmed a complex lookup table that compares the latched 8-bit value and switch settings to determine what LED should be lit on the display, and whether the corresponding detected frequency is valid.

Table 1 gives a detection bandwidth of 92 Hz, and the center frequency is within 4 Hz of being in the center of the passband. Since the detectors' performance is virtually unrelated to width of detection, you can go as narrow as 18 Hz. Get too narrow though, and you might be retuning your receiver more often and performance could decrease. Noise causes an apparent frequency shift due to slightly shifted zero crossing, making very narrow filter widths impractical.

The minimum width should be more than 1 count, due to aliasing. Aliasing is a counting error at the very edge of detection that causes a miscount. The error is easily worked around by adding one count of extra width to the desired detection bandwidth. You shouldn't try to get super-narrow-width detection, since noise presents a real problem. In fact, you should program for as much width as you can reasonably accept.

Due to the design of the system we can use a push-pull detector system for RTTY. That way we can actually measure the frequency rather than just saying that it is higher or lower than a specific threshold as in a typical discriminator-type detector. That enhances the noise immunity of the system, improving performance. Every little bit can make a difference (no pun intended).

After actual detection we use analog switches to allow us to have four separate low-pass frequencies for CW and four for RTTY to further enhance performance (see Fig. 3). The analog switches also allow us to use a less-expensive single-pole rotary switch, S3, which saves money and eases assembly.

When we continue next month, we'll discuss the circuitry that allows you to interface the detector to your computer. We'll also look at the AFSK generator that allows you to use the detector to transmit RTTY signals. And, of course, we'll show you how to build the detector (will include PC Foil Patterns) and how to tune it so you can put it to work in your radio shack. **R-E**

GLITCHES IN THE POWER LINE

Power quality is becoming an issue for just about everyone!

VINCE T. MIGLIORE

THERE'S A GLITCH IN YOUR POWER LINE and it's going to find you. Imagine that you're right in the middle of saving a file on your PC, or recording a program on your microprocessor-controlled stereo or VCR, and a power-line glitch causes the system to reset. Why? You may never even attempt to find out if it happens only once every month or two, but you should.

In business and industry, the problem becomes more than an inconvenience. Computers, communication devices, sensitive medical instruments, chemical processes, and the like, can succumb to power-line disturbances. A power problem can spell disaster for a small business who can't find a solution.

Power problems can be especially frustrating for the electronics hobbyist. Even you, the solitary electronics buff, can be glitched at home. Your PC boards may burn out for no obvious reason, your PC data may be scrambled, your 10-meter transceiver may run hot, your VCR or stereo may drop dead, and the lights may dim when your refrigerator's compressor turns on. Knowing the causes and cures of power-line disturbances is valuable, technically and financially. You don't have to be a research scientist or utility engineer to discover glitches and take action against them.

The most common way to clean up the power lines is to rely on surge suppressors. But clean power means more than no impulses. It also means eliminating any voltage sags, outages, impulses, surges, frequency errors, harmonics, grounding problems, high-frequency noise, waveshape faults, or RF interference.

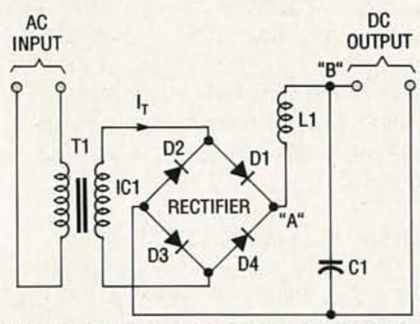


FIG. 1—TYPICAL BRIDGE RECTIFIER, with voltage waveform shaped by an LC filter network. If only a pure resistive network were connected across points *A*, the waveform shown in Fig. 2-*a* would be seen with the aid of an oscilloscope.

Causes

Contrary to popular opinion, the vast majority of power problems aren't caused by power utilities, but by their customers. Occasionally, albeit rarely, utilities are at fault, like when distribution loads are switched, or when large power-factor-correction capacitors kick in. Sometimes lightning or a car can hit a power pole, wreaking havoc with power lines. Such an interruption, if miles away, may not make your lights blink, but the resulting power line hash can blow your PC. Most often, however, transients can travel along a power line from other customers, especially if you're near an industrial area. Major offenders are arc welders or electric-train yards.

However, the above are exceptions, and maybe 95% of disturbances are caused by either home equipment, or faulty or inadequate home wiring. Most utilities bend over backwards to locate problems on their end like low voltages, distribution or switching faults, or line harmonics. Sometimes they'll even attach a monitor or strip-chart recorder to your meter to help find a problem.

Harmonics

One of the most common AC power problems is harmonic distortion, or the unwanted generation of power-line voltage components at frequencies that are multiples of 60 Hz. Linear loads that draw power in proportion to the square of voltage exhibit far fewer problems. With rectifiers, however, strange things start happening to current waveforms. Figure 1 shows a full-wave bridge rectifier, while Fig. 2 shows the relevant voltages and currents.

The voltage across points A and C in Fig. 2-*a* is a full-wave, rectified sinusoid provided that only a purely resistive load were connected. Across points B and C, the LC filter produces the waveform shown in Fig. 2-*b*. The current from the bridge rectifier charges capacitor C1 for a small portion of each half cycle as shown in Fig. 2-*c*, and it supplies power to the load during that brief period. Capacitor C1 provides the power that drives the DC load for the remainder of the half cycle. Inductor L1 smooths the sharp points in the rectified voltage curve at *b*, but its effect on the following discussion is nil.

As the rectifier voltage drops to zero, the charge in C1 drives the DC load. Thus, current flows through transformer T1 for only a small portion of the sinusoid, as shown in Fig. 2-*c*, driving the DC load and recharging C1, so the energy is concentrated in short pulses. This pulsed current generates harmonics, making a transformer run hotter than it would for a pure 60-Hz sinusoid with RMS power identical to that of the corrupt

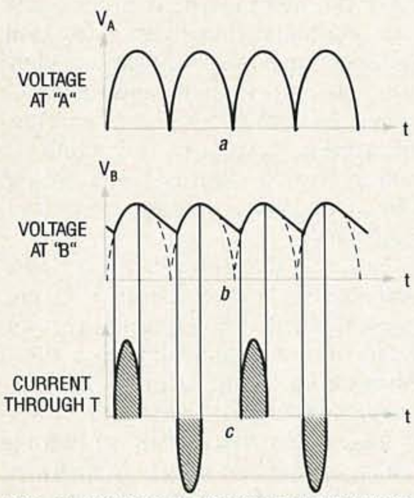


FIG. 2—VOLTAGE AND CURRENT WAVEFORMS at different points in the power supply. At (*a*) is the voltage *exiting* the bridge rectifier, presuming either a resistive load or no load at all, instead of the LC filter; at (*b*) is the voltage exiting the LC filter, and at (*c*) is the current drawn through the transformer.

FIG. 3—THE BMI *2400 POWERSCOPE* power-transient measurement and recording system for single-phase DC, or single- or 3-phase AC. The instrument monitors sags, surges, impulses, waveshape faults, line-frequency variations, and high-frequency noise for single-phase AC or DC, has a built-in RS-232 bus to be used with an external processor to analyze total harmonic distortion and frequency spectral content, and has a full range of available accessories, including temperature and humidity sensors.

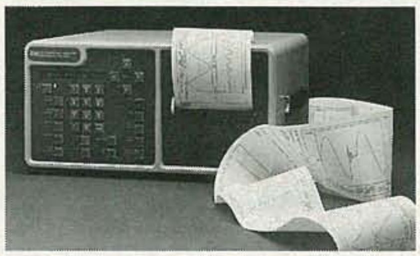


FIG. 4—THE BMI *4800 POWERSCOPE*. While similar to the BMI *2400* in physical appearance, it has considerably more processing power, with up to four main and eight probe channels.

sinusoid *with* its harmonics. This is because the magnetic domains reverse polarity more rapidly than for the pure sinusoid, owing to the harmonics, heating the transformer core.

The bridge rectifier shown in Fig. 1 is waning in popularity, although harmonic generation is identical for more recent versions. Most computers and hi-tech gear now use switched-mode power supplies; those varieties are highly nonlinear and a major source of harmonics. If several loads are on one circuit, expect hot motors and transformers. In short, if you're serving up hash, everyone at the table tastes it!

Latest instrumentation

Power-line monitors range from simple beepers or lights that tell you when line voltages and/or currents are out of range, to printing versions that record values numerically and graphically. Two major manufacturers of such gear are *B*asic *M*easuring *I*nstruments or BMI (335 Lakeside Drive, Foster City, CA 94404, 415-570-5355), and Dranetz Technologies (1000 New Durham Road, Edison, NJ 08818, 201-287-3680 or 800-DRAN-TEC).

BMI has three major instruments, the *2400* and *4800 PowerScopes*, shown in Figs. 3 and 4, respectively, and the *3030 Power Demand Analyzer* (not covered here). They combine oscilloscopes, strip-chart recorders, and RF interference meters in a single portable cabinet to capture transients varying from a few milliseconds to several hours in duration. Note the calculator keyboard, single-line display, and thermal strip-chart graphic printers on each.

Both versions of the *PowerScope* monitor sags, surges, impulses, waveshape faults, line-frequency variations, and high-frequency noise for single-phase or 3-phase AC or DC power lines, and have a built-in RS-232 bus. They can be combined

FIG. 5—THE DRANETZ *SERIES 901 POWER HARMONIC ANALYZER*, similar to a BMI *2400*. In one printout for a instant in time, the device records line voltage, the current used, total power, power factor, harmonic power, fundamental power, and a breakdown of the power in the individual harmonic frequencies above the fundamental (in other words, its spectral content).

FIG. 6—THE DRANETZ *SERIES 626G* Universal Disturbance Analyzer, similar to a BMI *4800*. This device has several add-on modules that increased the scope of the unit with event monitors.

FIG. 7—THE DRANETZ *SERIES 656* Disturbance Waveform Analyzer. Note the built-in CRT, full keyboard, dual floppies, and thermal printer.

with the *A-600 Parallel Processor* to analyze total harmonic distortion and frequency spectral content (such as in the BMI *2460*), and have a full range of accessories, including temperature and humidity sensors.

The BMI *4800* does everything the BMI *2400* does, but has more processing power. Whereas the BMI *2400* has two main and four environmental or probe channels, the BMI *4800* has up to four main channels and eight probe channels. Both models can be configured to take measurements every 1, 3, 6, 12, or 24 hours, and can do both high-resolution graphics, strip-charts, and text summaries, the sole exception being that the BMI *2400* can't do high-resolution graphics using the probe channels—only the main ones.

The Dranetz Technologies gear is comparable in scope and complexity to that from BMI. Their *Series 901 Power Harmonic Analyzer*, shown in Fig. 5, is comparable to the BMI *2400*, and the *Series 626 Universal Disturbance Analyzer* shown in Fig. 6 and *DRAN-SCAN Multipoint Power Monitoring and Analysis System* (not shown) are comparable to the BMI *4800*.

The Dranetz *Series 656 Disturbance Waveform Analyzer* shown in Fig. 7 has a built-in CRT and full keyboard, two floppy disk drives, and internal thermal printer. Their *Series 800 Electric Power/Demand Analyzers* (not shown) are also available, and are similar to the BMI *3030*. Both BMI and Dranetz also have *extensive* power analysis software for any external controllers used with their monitoring instruments.

Typical power-line disturbances

The graphs shown in Figs. 8–12 were made using BMI gear, and those shown in Figs. 13-16 were made using Dranetz gear; they're of similar format. The user selects thresholds and monitors power. Whenever an impulse, voltage sag, or other disturbance occurs, it's graphed as shown in Figs. 8 and 9. Note that the sinusoidal peaks are somewhat flattened where current or voltage reaches a local maximum. If switching loads change a waveshape, that too is recorded. Fortunately, most disturbances have characteristic "signatures." Figure 10 shows a typical motor starting-voltage sag; the in-rush current drops the voltage to 84.5 volts RMS.

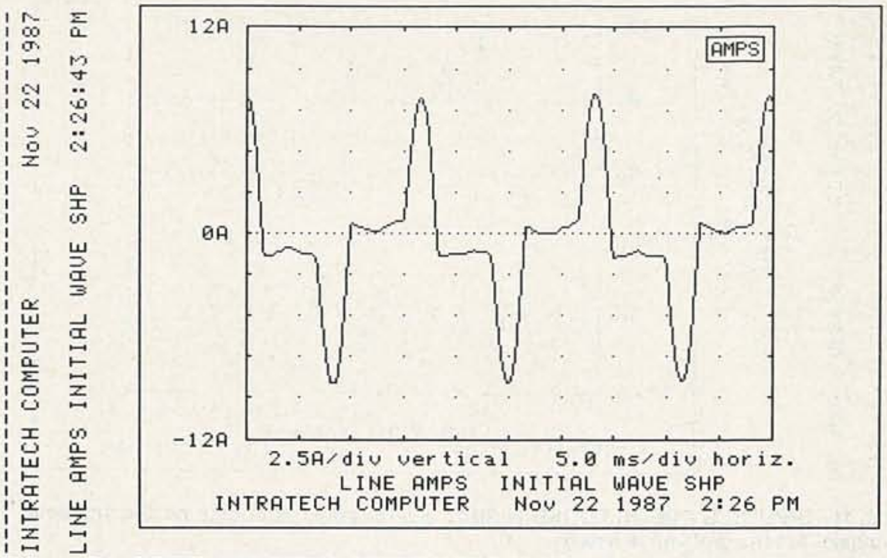


FIG. 8—BMI-GENERATED INITIAL WAVESHAPE REPORT for current for a circuit. Note that the current is drawn in pulses that could seriously compromise the operation of delicate instruments operating on the same or a nearby power line.

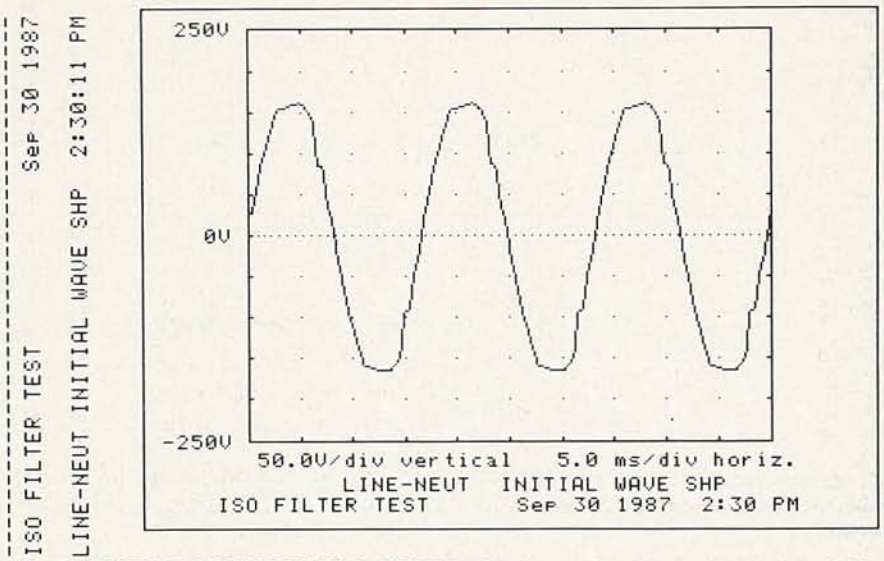


FIG. 9—VOLTAGE WAVEFORM IN A CIRCUIT with harmonics. The voltage sinusoid is distorted at positive and negative peaks, where current flow is maximum.

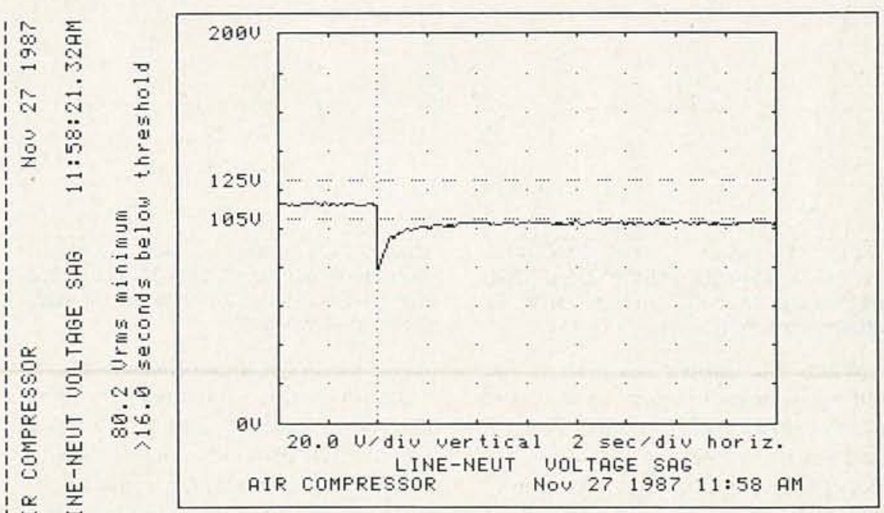


FIG. 10—TYPICAL MOTOR-START SIGNATURE. As the motor stabilizes, voltage returns to normal.

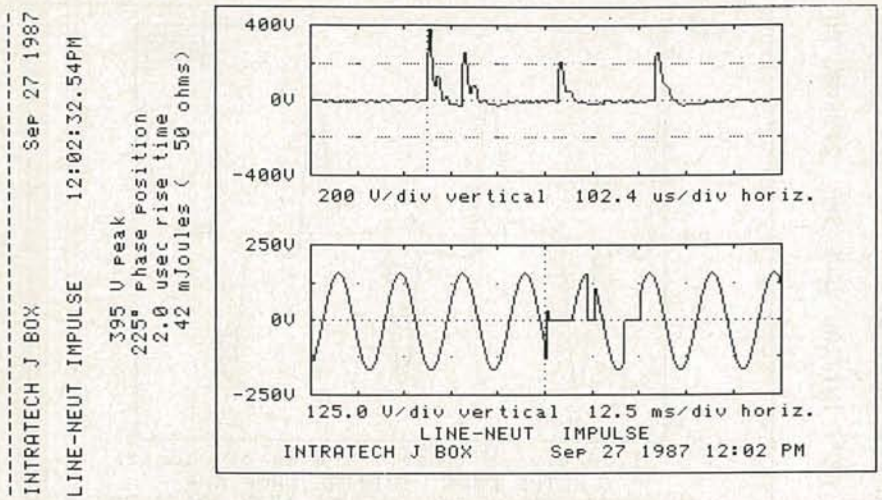


FIG. 11—IMPULSES DUE TO LOOSE WIRING. Sharp- edged dropouts on the sinusoid indicate that the problem is nearby.

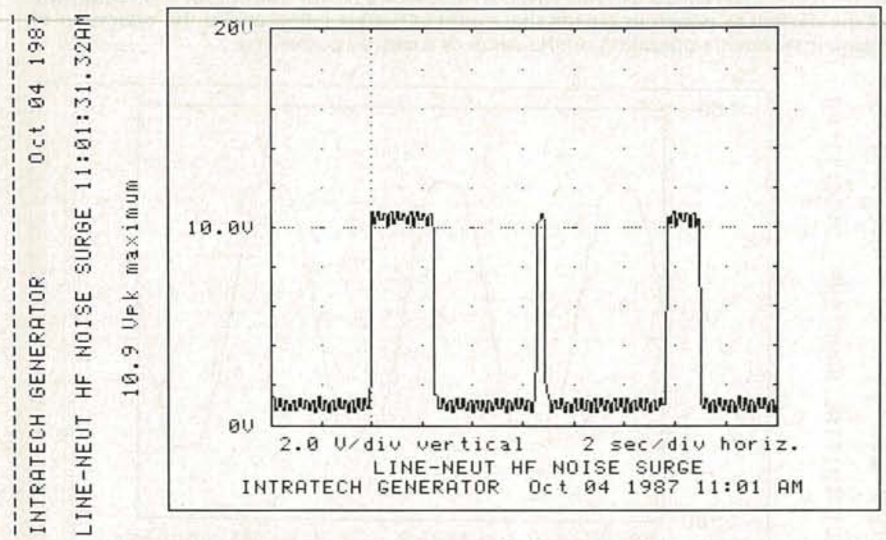


FIG. 12—VOLTAGE SURGES CAUSED BY HIGH-FREQUENCY NOISE. Note the 10-volt peaks that may ride through a power supply to damage memory and program chips in a computer.

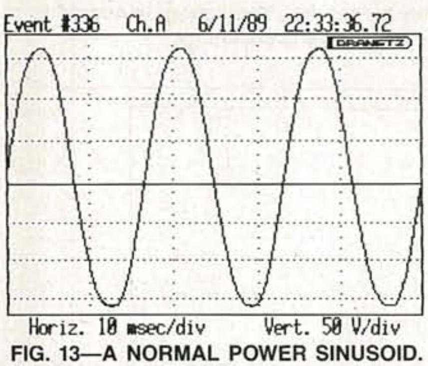


FIG. 13—A NORMAL POWER SINUSOID. The time was 11:33 P.M., when most heavy industrial machinery isn't powered.

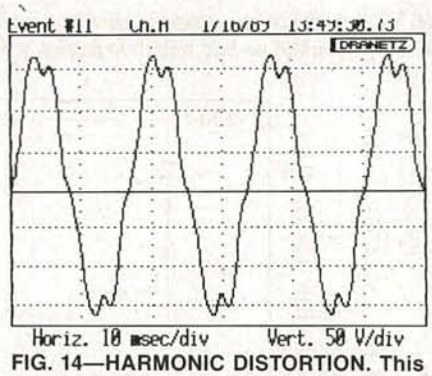


FIG. 14—HARMONIC DISTORTION. This graph was taken at 1:49 P.M. at the same site as that in Fig. 13.

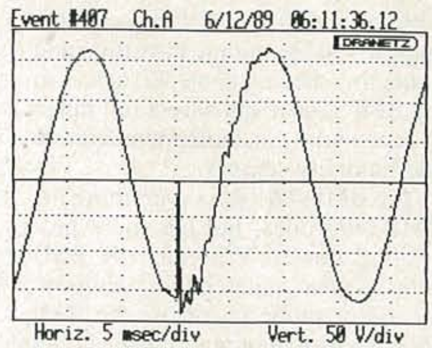


FIG. 15—A POWER GLITCH. Just imagine what the added pulse would due to a counter circuit.

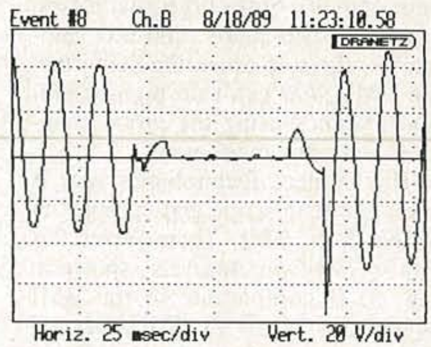


FIG. 16—A BRIEF POWER OUTAGE. Just imagine what this would do to your PC's memory!

When the motor stabilizes, the voltage returns to near-normal; the low threshold was 105 volts. The potential was below 105 volts for 1.2 seconds, enough to make a computer lose data, shut down, and reboot. If you found that disturbance on a line with sensitive equipment, you'd move the motor to another circuit. A common problem in amateur radio shacks and utility communication gear are impulses due to loose wiring; a typical signature is shown in Fig. 11. The top part shows four impulses. The lower part shows how the voltage dropped out and returned a few times over a couple of cycles.

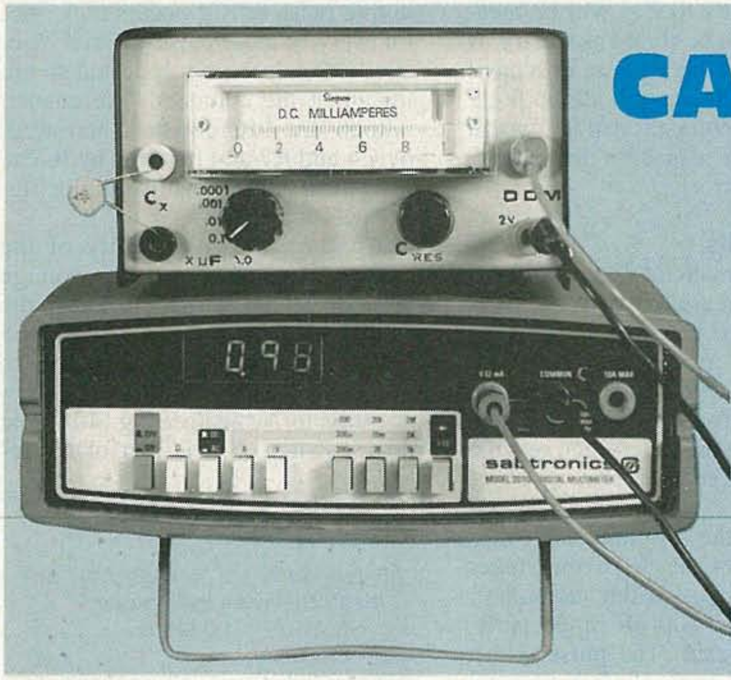
Note the sharp transitions, indicating loose wiring nearby. Had the disturbance occurred farther away, the transitions would've been slower, smoother, and less well-defined, as a result of impedance encountered as the impulse propagated. Power-monitor graphs sometimes need interpretation, but are fairly interesting, and expand your knowledge of power-line problems.

Figure 12 shows bursts of line-to-neutral high-frequency noise, in this case RF interference, while transmitting the letter "K" in Morse code (dah-di-dah) from an amateur radio shack. High-frequency noise is common in such settings, but can also be caused by a CB radio, walkie-talkie, or taxi transmitter. You should check your own transmitter, if you have one, for both neutralization and shielding. The disturbance shown here is only 10 volts, but digital logic circuits work on 5 volts DC. If RF interference can induce 10 volts on a power line, such a level can wreak havoc with even otherwise well-shielded computers or instruments.

Some other waveforms, acquired from Dranetz gear, are shown in Figs.

Continued on page 52

BUILD THIS



CAPACITANCE ADAPTER

Use your digital voltmeter to measure capacitance with this handy adapter.

DOUGLAS A. KOHL

MULTIMETERS OF TODAY CONTAIN A LOT more features than they used to, and perhaps the most useful feature is capacitor checking. It's true that less expensive meters will have only the usual voltage, resistance, and current capabilities but, for a little extra money, you can buy a meter that has capacitance-, frequency-, logic-, and transistor-checking functions. Of course, if you need to measure capacitance, the solution isn't to buy a new multimeter—especially if you already have a meter that you're particularly fond of. But converting your meter with our capacitance adapter may be just what you need.

The adapter converts the value of a capacitor to be tested into a precision analog voltage applied to the input terminals of the digital voltmeter. The adapter covers 5 decades ranging from 100 pF to 1 μF, full scale.

The accuracy and stability of a typical 3-1/2 digit voltmeter is commonly ± 0.25% + 1 digit over a one year period. The accuracy of the adapter in combination with a digital voltmeter has been tested to be ±0.4% over a 1400-hour period. Warm-up is 1 digit (0.1%) or less within 30 seconds of turn-on. The thermal stability was found to be −0.04%/°F.

Including a meter movement in the adapter case permits the device to be used as a stand-alone capacitance meter, but with reduced precision. Power for the adapter may be either from the line or two 9-volt batteries, which will provide about 50 hours of use.

Operation

The outstanding accuracy and stability of the circuit is due to the use of a CMOS version of the 555 timer IC. One is used as an astable pulse generator, that triggers another that is used as a pulse-width modulator. That initiates an R-C exponential rising voltage at J1 and J2 across the capacitor under test, C_X, as shown in the block diagram of Fig. 1. The modulator output switches high upon receipt of the trigger pulse and switches low when the voltage on C_X reaches an internal reference voltage. See the timing diagrams in Fig. 2.

The average value of the pulse waveform in Fig. 2-*a* is a DC value such that the area A_1 exactly equals the area A_2. The duty cycle of the output pulse from the pulse-width modulator is the ratio of the time it is positive to the period, T, or the total time between trigger pulses (P_W/T).

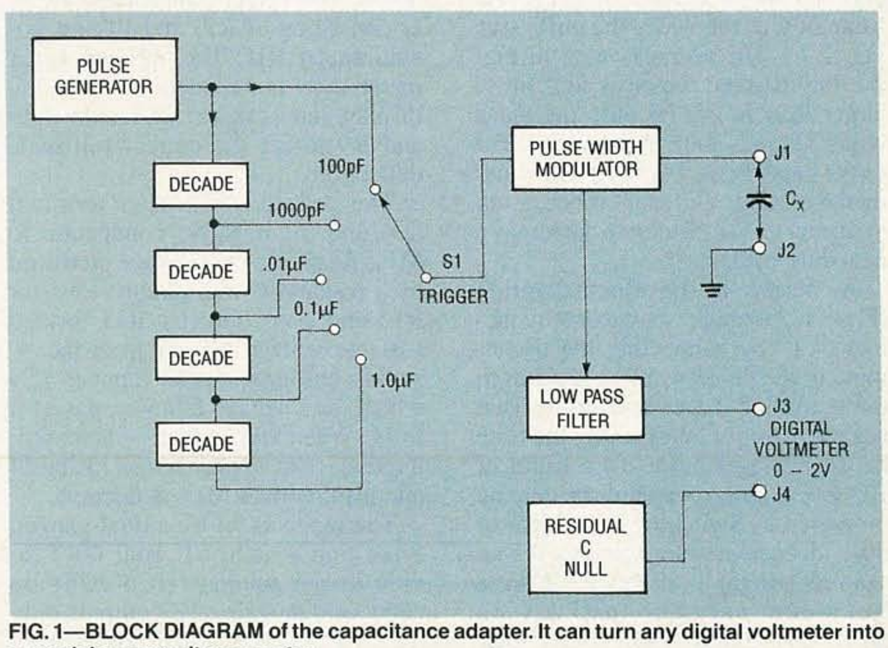


FIG. 1—BLOCK DIAGRAM of the capacitance adapter. It can turn any digital voltmeter into a precision capacitance meter.

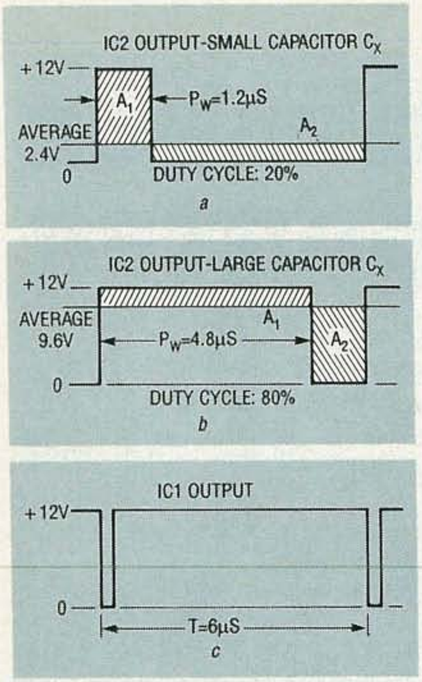


FIG. 2—THE AVERAGE DC VALUE of the pulse waveform in *a* is such that the area A_1 exactly equals the area A_2, or 2.4 volts. The average voltage equals the duty cycle times the maximum pulse voltage. The average value in *b* is 9.6 volts, which is four times larger than *a* because P_W is four times wider. For larger capacitors, P_W becomes wider than 6 μs (*c*), so it is necessary to increase T in order to generate a new duty cycle.

In the example shown in Fig. 2-*a*, the duty cycle is 1.2μs/6μs = 0.2 or 20%. The average voltage equals the duty cycle times the maximum pulse voltage (0.2 × 12V = 2.4 VDC). The average value is extracted in the circuit by a low-pass filter. The larger the value of C_X, the wider the pulse (see Fig. 2-*b*). The average value in Fig. 2-*b* is 9.6 volts, which is four times larger than in 2-*a* because the pulse width (P_W) is four times wider. For larger capacitors, P_W becomes wider than 6 μs (Fig. 2-*c*), so it is necessary to increase T in order to generate a new duty cycle.

As shown in the block diagram (Fig. 1), the range is switched by factors of 10 by connecting the trigger input of the pulse-width modulator to the output of a decade counter. That has the effect of lengthening the time between trigger pulses by a factor of 10. Even larger capacitors can be measured by switching the trigger to other decade-counter outputs. As an example, on the 1-μF range, the time between trigger pulses is 6μs × (10 × 10 × 10 × 10) = 60,000μs or 60ms.

On a low range like 100 pF, the capacitance of the wires used to connect the adapter to C_X, will be measured and must be compensated for. A pair of 6-inch long leads an inch apart have a capacitance of about 6 pF which, if not compensated for, would cause a 10-pF capacitor to read 16 pF—a 60% error!

Circuit details

In the schematic of Fig. 3, all integrated circuits are low-power CMOS types. The TLC555 timer, IC1, is connected as an astable that generates narrow negative-going pulses. That's because C1's discharge resistor, R2, is much smaller than R1, which sets the period (T) of the waveform.

The output pulse of IC1 is further narrowed by the differentiator coupling, C3 and R4. It is fed to the trigger input of the pulse-width modulator, IC2, when the 100-pF range (full-scale) is selected. The pulse-width output of IC2 varies with the actual capacitance of the unknown capacitor, C_X.

A low-pass filter for the pulse output of IC2 is formed by R6 and C6. That extracts the average of the pulse waveform which is a DC level that's proportional to the duty cycle of the waveform. Op-amp IC8 is connected as a voltage follower which gives no gain but transforms the high input resistance of the filter to a low value needed to drive the output circuits.

The DC output from IC8 is reduced and fed to the voltmeter terminals, J3 and J4, by a calibration voltage divider consisting of R10 and 10-turn potentiometer R11. The optional 1-mA meter (M1) is included as an analog display, and it can be calibrated via R8 and R9 to set the correct full-scale deflection.

The negative voltmeter terminal (J4) and the negative connection to M1 is floating with a voltage produced by a residual-C-null circuit. Resistor R12 and potentiometer R13 form a variable voltage divider from the + supply and provides an input to IC9 which, as a voltage follower, passes it to J4. When that voltage is increased, it reduces the voltage across J3 and J4 and also reduces M1's deflection.

The range is set by a dual-ganged 5-position switch, S1. Four 4017 divide-by-ten counters (IC3–IC6) are connected in series; IC3 outputs only once for every 10 input pulses from IC1. That lengthens the period between trigger pulses for IC2 when the S1 is in the 1000-pF position. The output pulse of IC4 occurs only once for every 10 input pulses from IC3, or after 100 pulses from IC1, and so on, for all of the counters. The counter outputs are differentiated (narrowed) by C4 and R7 and inverted by IC7 to form the required negative-going trigger pulses for IC2.

Another key to stability of the adapter's calibration is the voltage regulator, IC10, which must keep the supply voltage constant. Two 9-volt batteries in series can be used to power the circuit until their voltages decrease to 7 volts (see Fig. 4-*a*). The power switch, S2, is part of the re-

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1, R8, R10—4700 ohms
R2—220 ohms
R3—10,000 ohms, 10-turn potentiometer
R4, R7—3300 ohms
R5—33,000 ohms
R6—10 megohms
R9—10,000 ohms, potentiometer
R11—1000 ohms, 10-turn potentiometer
R12—39,000 ohms
R13—10,000 ohms, potentiometer with on/off switch (S2)

Capacitors
C1—470 pF, ceramic
C2—0.001 μF, ceramic
C3—220 pF, ceramic
C4—100 pF, ceramic
C5, C7—0.1 μF, ceramic
C6—0.05 μF, ceramic
C8, C9—100 μF, 12 volts, electrolytic

Semiconductors
IC1, IC2—TLC555 timer
IC3–IC6—4017 divide-by-ten counter
IC7—4011 quad 2-input NAND gate
IC8, IC9—3140 op-amp
IC10—LM7812 12-volt regulator
D1, D2—1N4148 diode
BR1—bridge rectifier, 50 mA or higher

Other components
M1—1-mA meter, optional
S1—double pole, 5-position switch
S2—SPST switch (part of R13)
J1–J4—banana jack
B1, B2—9-volt battery, optional
PL1—AC plug and linecord
T1—12-volt, 50 mA (or higher) transformer
F1—¼-amp fuse
Miscellaneous: two 9-volt-battery clips (optional), hardware, case, solder, etc.

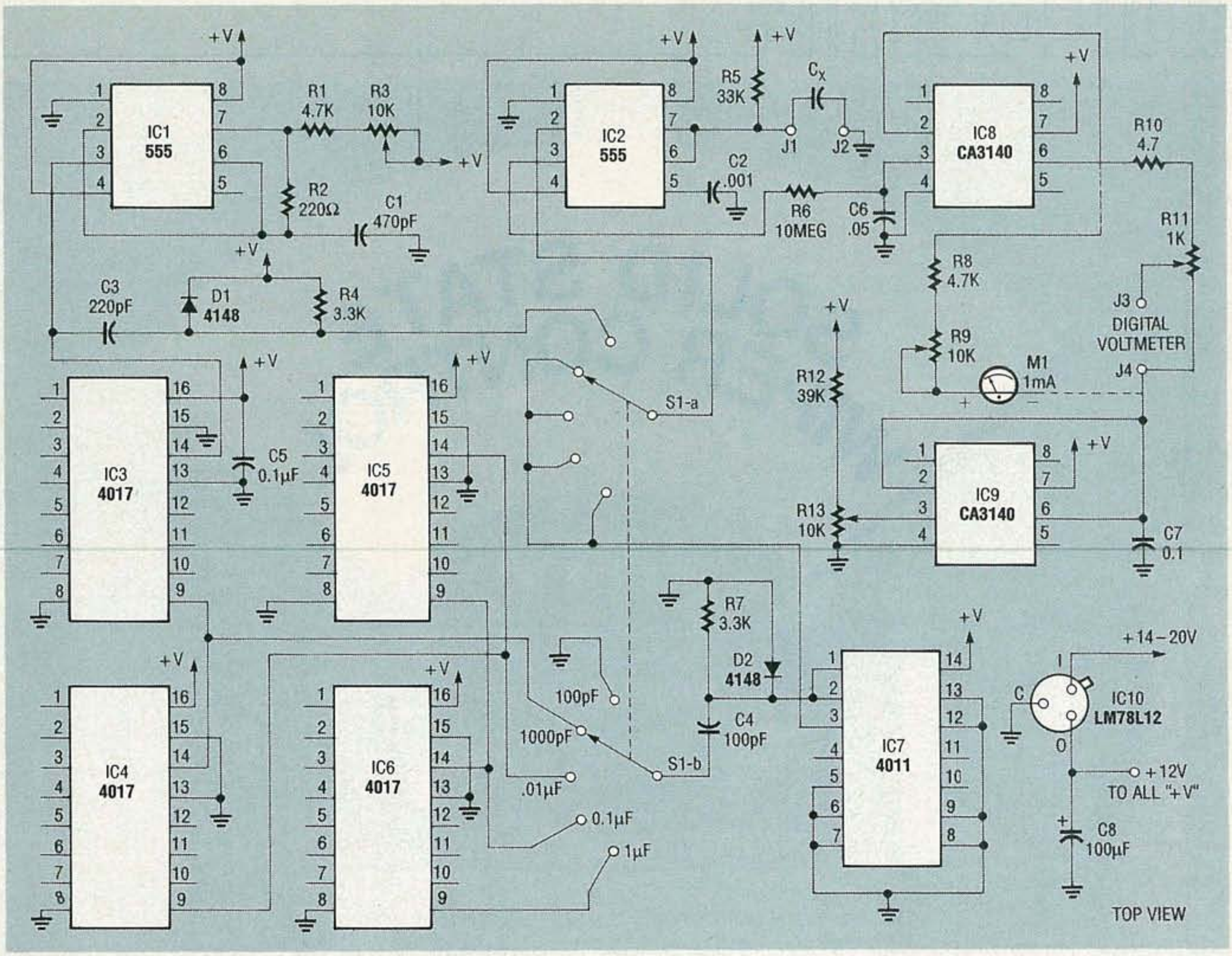


FIG. 3—SCHEMATIC of the capacitance adapter. All IC's are of the CMOS type.

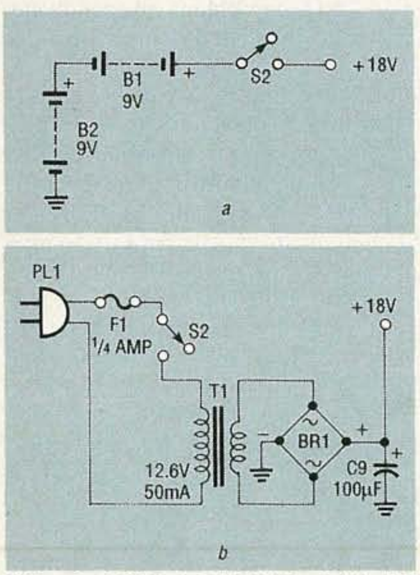


FIG. 4—THE ADAPTER CAN BE POWERED from two 9-volt batteries (*a*) or an AC supply (*b*).

sidual-C-null potentiometer, R13. If the AC power supply is used in the design (Fig. 4-*b*), the transformer can be a small one since the circuit requires only 20 mA—therefore, practically any bridge rectifier can be used for BR1.

Construction

It is recommended that you assemble the circuit on an etched experimenter's board designed for mounting IC's. Component placement is not critical with the exception of IC2; it should be located at the edge of the board and close to the front-panel terminals for C_X. Group the decade counters (IC3–IC6) in a line or cluster and locate the bypass capacitor, C5, in their midst.

Calibration

Before the adapter can make useful measurements, it must first be calibrated. All you have to do is calibrate the unit with one known-value or "standard" capacitor, and all other ranges will automatically be correctly adjusted. Of course, the calibration will be only as accurate as the capacitor you use. If you must use a low-tolerance capacitor, measure it on a meter that you know to be accurate.

Potentiometer R3 should be adjusted so that a scope connected to pin 3 of IC1 shows 6µs between pulses. The goal is to set T so that if a capacitor marked with a full-scale value for any range (100 pF, for example) is connected as C_X, the duty cycle observed at pin 3 of IC2 will be about 80%.

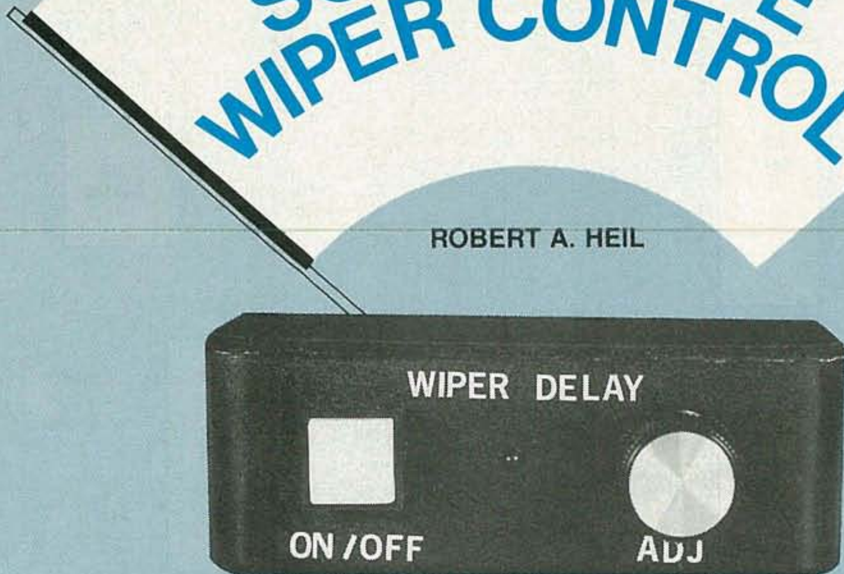
Assuming that you have an accurately known capacitor to use for calibration (0.982 µF, for example), connect it to J1 and J2 and, with a digital voltmeter set on the 2-volt scale connected to J3 and J4, adjust R11 until the voltmeter reads 0.982 volts. If an analog meter is used, adjust R9 to give as close to 0.98 as possible. If you use smaller-value capacitors as your "standard," be sure to set the meters to zero with the re-

continued on page 48

BUILD THIS

SOLID STATE WIPER CONTROL

ROBERT A. HEIL



Build this solid state windshield wiper delay and minimize potentially dangerous driving conditions.

HAVE YOU EVER DRIVEN THROUGH FOG, mist, or light rain and been tempted to turn on your wipers—but didn't because of all the screeching and streaking they make when there's not enough water? One of the more useful features available on today's cars is delayed action and/or manual windshield wiper control. The delay is normally set using either a slide or rotary potentiometer, while the manual control is generally a momentary switch attached to one of the column levers, and flicked with the left hand while holding the steering wheel.

Many drivers with two-speed wiper motors—which are designed for heavy rain—simply don't use their wipers in a light drizzle to avoid the aforementioned screeching and streaking. If you are one of those drivers, you'll surely benefit from the wiper-delay described here. It mounts under the dash, doesn't hinder normal wiper operation, and features a variable 2–18 second delay.

Circuit description

The wiper-delay schematic is shown in Fig. 1. With the ignition on, D1 maintains regulated +12 volts DC. When S1 closes, C1 bypasses transients and passes this +12 volts DC to divider R2-R3, producing a TTL high at pin 3 of IC1, a 4013 CMOS dual leading-edge triggered D-type flip-flop. Filter R4-C3 keeps IC1 from triggering erroneously when the ignition is on. When S1 is pressed, output Q1 (pin 1) of IC1 latches high, turning on Q1, which conducts via R5, turning on IC2; LED1 indicates power, and R6 sets the current. Since IC2 depends on Q1 for power, IC2 stays off until Q1 turns on.

The left half of IC2 is an astable, with its delay set by R7, R8, R11, and C4. The right half of IC2 is a monostable, with its pulse duration set by R9 and C5. With the values used, you might expect R11 to vary the delay from about 15–84 seconds, with a 2.42-second monostable pulse operating the wiper blades on each cycle. However, the actual delay will range between 2–18 seconds, with a 1-second monostable pulse on each cycle. That discrepancy stems from the fact that IC2 is being fed from the emitter of Q1, rather than directly from the regulated +12-volt supply. Transistor Q1 acts as an active current source, making C4 charge and discharge faster than it ordinarily would.

The astable output (OUT1, or pin 5) is tied to TRIG2 (pin 8). When OUT2 (pin 9) goes high, Q2 is biased via R10 and current flows through RY1, with D2 dissipating back-EMF when RY1 shuts off. If RY1 is an SPDT, then it's connected as in Fig. 1, whereas a DPDT relay is connected as in Fig. 2.

Construction

The foil pattern for the wiper-delay is shown in PC Service, and a source for the PC board is given in the Parts List. Whether you hardwire the wiper-delay or use the PC board, use a

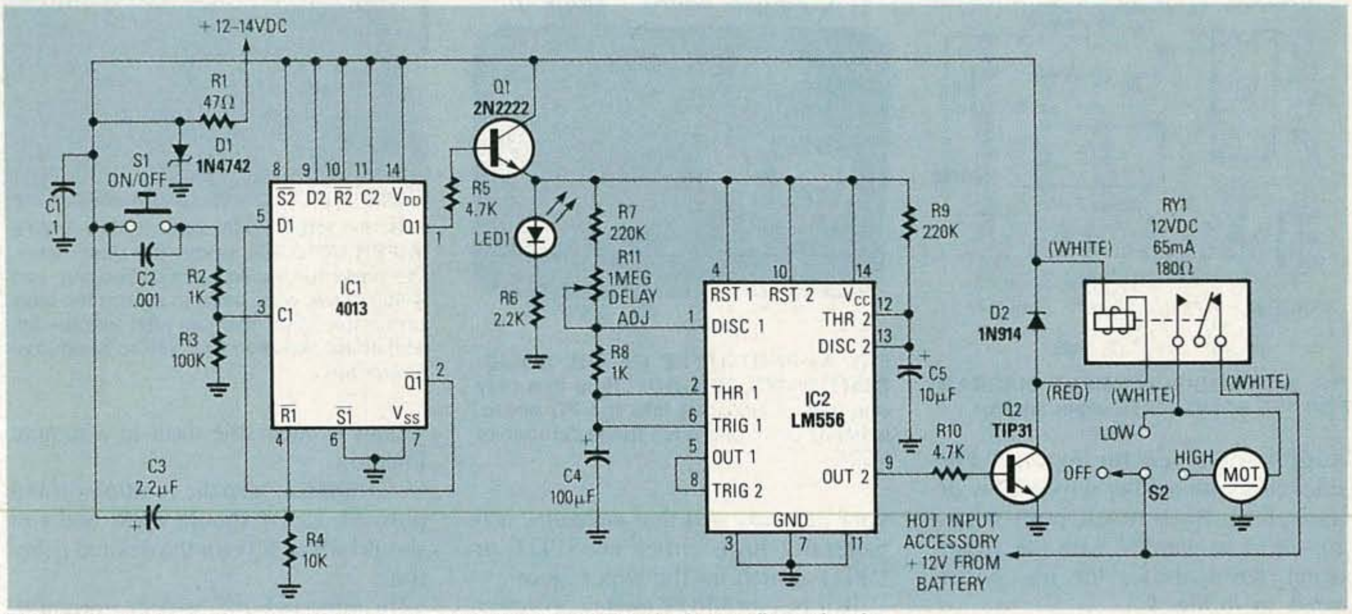


FIG. 1—SCHEMATIC OF THE SOLID-STATE WIPER-DELAY. This is the configuration for older cars without manual pulse delay, using an SPDT wiper switch, where both wires from RY1 are in parallel with the wiper-switch terminals for the low wiper speed.

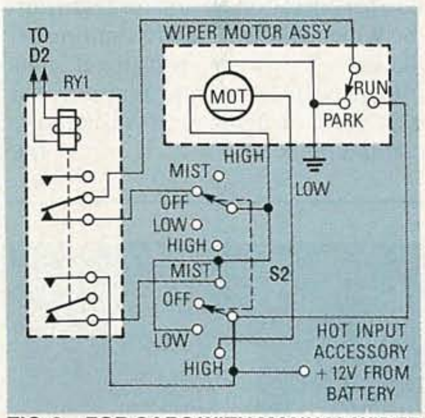


FIG. 2—FOR CARS WITH MANUAL WIPER CONTROL, use either an SPDT or DPDT switch for the wiper motor. For the SPDT switch, connect RY1 in parallel with the manual wiper control switch. For the DPDT switch, a DPDT relay is needed to operate the wiper-delay properly. Pole 1 goes between pole 1 of the switch and the pulse position.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1—47 ohms, ½-watt
R2, R8—1000 ohms
R3—100,000 ohms
R4—10,000 ohms
R5, R10—4700 ohms
R6—2200 ohms
R7, R9—220,000 ohms
R11—1 megohm, 1-turn, chassis mount potentiometer

Capacitors
C1—0.1 µF, ceramic disc
C2—0.001 µF, ceramic discµF
C3—2.2 µF, 25 volts, electrolytic
C4—100 µF, 25 volts, electrolytic
C5—10 µF, 35 volts, electrolytic

Semiconductors
D1—1N4742 12-volt Zener diode
D2—1N914 germanium diode
LED1—green light-emitting diode
Q1—2N2222 NPN transistor
Q2—TIP31 NPN transistor
IC1—4013 dual D-type flip-flop
IC2—LM556 dual timer

Other components
S1—SPST N.O. momentary push-button switch
RY1—SPDT relay, 12 volts DC, 180 ohm, 65 mA (see text)

Miscellaneous: 3.25- × 2.125- × 1.125-inch plastic case, 1.25- × 1.5-inch 4-40 hardware (see text), wire (red, white, and black), plastic wire tie, solder, etc.

NOTE: An etched and drilled PC board is available for $7.50 and any return postage from R.A.H. Projects, P.O. Box 4715, Irvine, CA 92716-4715. California residents must add sales tax.

suitable case that fits under the dash. The parts-placement diagram is shown in Fig. 3; S1 is a PC-board mounted, low-profile, SPST push-button ON/OFF keypad switch. The prototype is shown in Fig. 4. With the top of the case facing upwards, drill a hole on the left for S1, on the right for R11, and in the center for LED1. Use super glue to attach LED1 to a washer, then anchor the washer to the case.

After finishing the PC board, use double-sided tape to attach it and RY1 (upside down) behind R11. Drill a hole in the back panel for the four connecting wires, two for RY1 and two for power. To install the case under the dash as in Fig. 5, use Velcro or double-sided tape. You can also drill completely through all four holes and mount it with four 1.5-inch 4-40 screws. If you use either Velcro or tape, use the lid for the case, whereas for screws, you can discard the lid. Most newer cars have a nonconductive dash, preventing a short.

The prototype in Fig. 4 differs in one minor regard from the parts placement diagram shown in Fig. 3. Figure 3 shows R6 connected to the PC board at both ends between LED1 and Q1 at upper right, while Fig. 4 shows R6 just to the right of C7 in the upper middle, with one end going to the PC board and the other end to the cathode of LED1. The PC board corresponding to Fig. 3, and which appears in PC Service, is correct.

Installation

Before installing the wiper-delay, get a schematic of your car's wiring harness from a service manual. Besides having wiring schematics, it's a

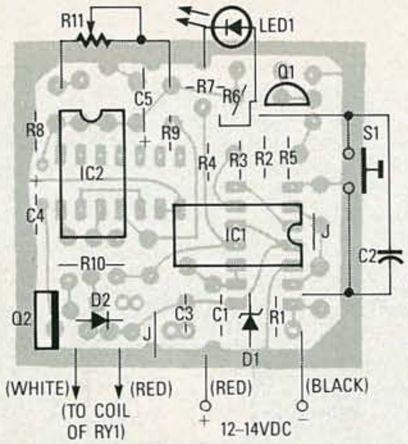


FIG. 3—PARTS-PLACEMENT DIAGRAM FOR THE SOLID-STATE wiper control.

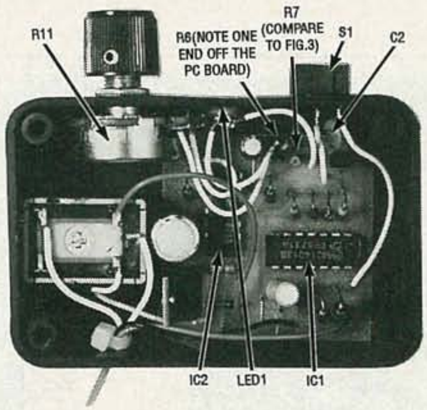


FIG. 4—PROTOTYPE OF THE SOLID-STATE WIPER CONTROL. Note that only one end of R6 goes into the PC board, while its other end goes to the cathode of LED1.

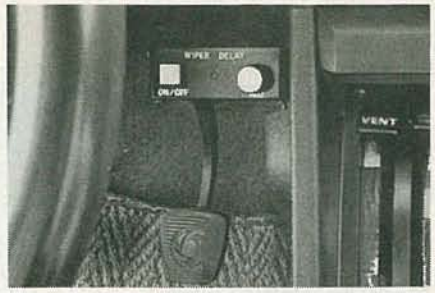


FIG. 5—THE INSTALLED SOLID-STATE WIPER CONTROL under the dash. Here, the holes for the lid were drilled out, and 4-40 screws were used to mount the case under the dash. You can also use the lid, and attach the case with Velcro or double-sided tape.

helpful reference for repairs. For older cars with neither wiper delay or manual control, attach both wires from RY1 in parallel with the wiper switch terminals for the low wiper speed, as in Fig. 1.

If your car has both manual and delayed-action wiper control, then you obviously don't need to install the project described here, except either as a spare, or to experiment with how it works. Most cars that have manual wiper control will also have delay capability, but not necessarily all. If your car falls into that category, it'll generally have either an SPDT or DPDT switch for the wiper motor.

If it has an SPDT switch, connect RY1 in parallel with the manual pulse control switch. For the DPDT switch, a DPDT relay is needed to operate the wiper-delay properly, as in Fig. 2. Pole 1 goes between pole 1 of the switch and the pulse position. If the DPDT relay doesn't fit in the case you're using for your wiper-delay, mount it under the dash in a remote location.

To operate, turn the ignition on and push S1; LED1 should light, and you should adjust R11 for the desired delay time.

In rain, use the wipers normally. Since most wipers operate at 2 Hz or faster, the pulse delay shouldn't affect normal operation. If you forget to turn the wiper delay off before shutting off the car, don't worry because it shuts off when you turn off the ignition, and won't turn on again until you start the car and press S1. **R-E**

CAPACITANCE ADAPTER

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sidual-C-null control before connecting the capacitor. That completes the calibration.

There are several ways to obtain a "standard" capacitor for calibration. One way is to have a paper, polyester film, or dipped mica capacitor measured on some other accurate capacitance-meter and use that value for the calibration. It is possible to buy polystyrene capacitors with ±2% accuracy. Purchase at least 10 of the same kind and measure each one on the adapter, even though it hasn't been calibrated. Take a numerical average of all the readings and pick the capacitor which comes closest to the average and assume that it has the value marked on the body. Calibrate to that value. The more capacitors used, the more accurate the result will be.

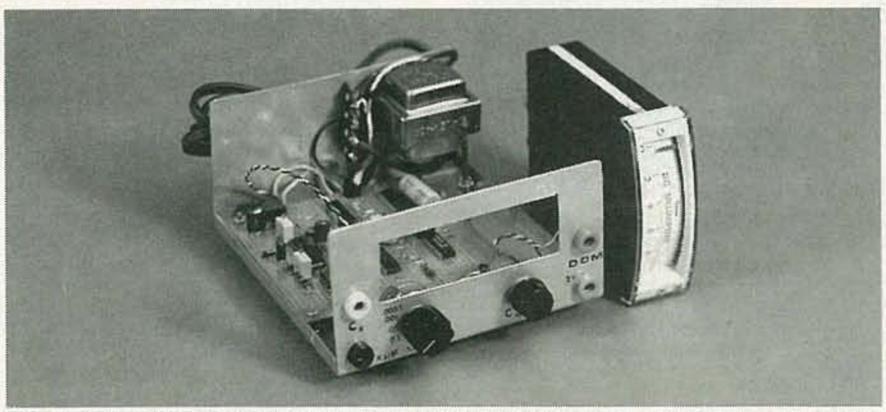


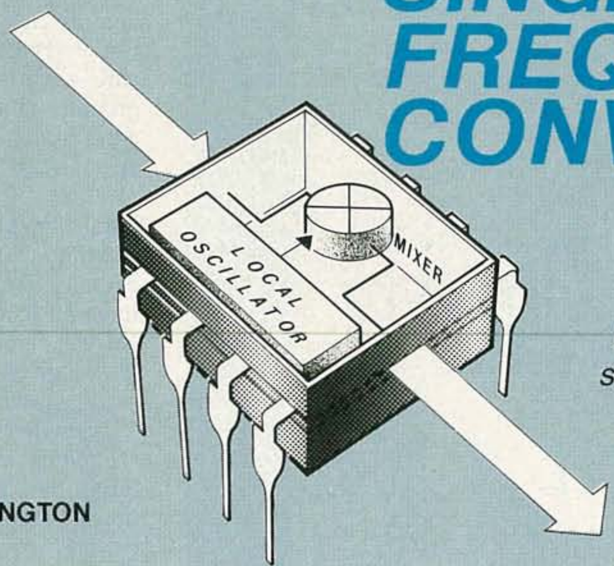
FIG. 5—THE UNIT IS ASSEMBLED on an etched experimenter's board designed for mounting IC's. IC2 should be located at the edge of the board and close to the front-panel terminals for C_X.

Operation

Using the adapter requires choosing the correct range. A range too low for the value of C_X will result in a reading greater than 1 volt, or 1.000 on the voltmeter. A range too high will give readings less than 0.1 volt, or 100, which reduces the accuracy of the readout. For values of C_X less than .01 µF, first adjust the meter to zero with the residual-C-null control with the connecting wires in place but not attached to C_X—then connect C_X. Use the digital voltmeter's digits, not as volts, but as a multiplier times the range-switch full-scale capacitance to arrive at the value of C_X.

A leaky capacitor will give an erroneous high reading. The effect of leakage produces greater errors in the measurement of small capacitors than for larger values. A 470 kilohm leakage in a 0.047-µF capacitor produces a 6% error and a 12% error in a 220-pF size. It is therefore good practice to use an ohmmeter to test C_X before measuring its capacitance. **R-E**

SINGLE-CHIP FREQUENCY CONVERTER



Introducing a general-purpose single-chip frequency converter which should greatly simplify your RF designs.

MICHAEL A. COVINGTON

FREQUENCY CONVERTERS ARE BASIC building blocks of RF equipment. You'll find them wherever there's a need to shift the RF carrier of a signal from one frequency to another, such as in any modern radio receiver.

Frequency conversion, or heterodyning, is the process of mixing an incoming signal with that of a *L*ocal *O*scillator (LO), as shown in Fig. 1. Two signals result from mixing, their frequencies being the sum and difference of those of the originals. Thus, a 9-MHz input and a 2-MHz LO yield outputs of 7 and 11 MHz.

Building a frequency converter is easier now than it's ever been because of a new IC, the Signetics NE602. The NE602 contains an LO and double-balanced mixer in an 8-pin DIP, as shown in Fig. 2, a block diagram of the IC. The NE602 was originally designed for VHF receiver front ends, since the LO works up to 200 MHz, and the mixer to 500 MHz. However, it has plenty of uses at lower frequencies as well, and this article will explore them.

Circuit description

The NE602 uses a double-balanced mixer, producing only the sum and difference frequencies, not that of the RF input or LO. You can thus connect the output of an NE602 directly to a receiver without overloading it. With a conventional mixer, you'd have to add a tuned LC circuit to eliminate the LO output. The NE602 LO is also well isolated from its RF input; you can thus connect a receiving antenna directly to the RF input terminals of the IC without worrying about radiating the LO signal back out through the antenna. This is important in direct-conversion receivers, where the LO frequency is so close to that of the input, that the two can't be isolated by a tuned LC circuit.

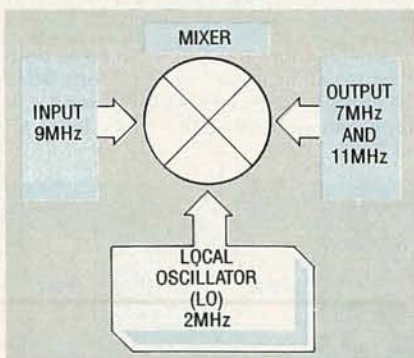


FIG. 1.—FREQUENCY CONVERSION PRODUCES outputs at the sum and difference of input and LO frequencies. In the case of the NE602, since it's double-balanced, both the input and LO signals are absent from the output.

The combination of the differential amplifier and mixer in the NE602 is known as a Gilbert cell. The mixer has on-board voltage regulation, and draws 2.5–3 mA at 4.5–8 volts. For best performance, bypass the power supply with a 0.04-μF capacitor as close to the IC as possible. The absolute maximum supply voltage is 9.0 volts, but a 9-volt battery often exceeds that, and 9-volt wall transformers often deliver as much as 11 volts. For safety, use 1000-ohm dropping resistor R1 as shown in Fig. 3; using a Zener diode, you can use automotive power supplies up to 18 volts.

The RF input and mixer output can be either single-ended or balanced as shown in Figs. 4 and 5. Using a balanced input reduces harmonics, while a balanced output gives better suppression of the input RF and LO signals. However, even in the simplest single-ended configuration, the NE602 gives much better performance than the one-transistor mixer commonly found in receivers.

The input and output impedances of the NE602 are about 1.5K at low frequencies, and decrease with increasing frequency. The input signal should be weak to prevent harmonics; the third-order intercept point is for a -15 dBm input, but the recommended level is -25 dBm or below. That corresponds to 68.87 millivolts into 1.5K if you use direct coupling, or 12.82 millivolts into 52 ohms if you use impedance matching. The NE602 works well with microvolt-level signals from antennas.

The input signal is amplified prior to mixing; the voltage gain is about 10. Thus, a receiving converter built with the NE602 can increase a receiver's sensitivity. The NE602 LO is a transistor with connections to its base and emitter, with biasing handled on the chip. That makes it easy to build many different oscillator types with few external components.

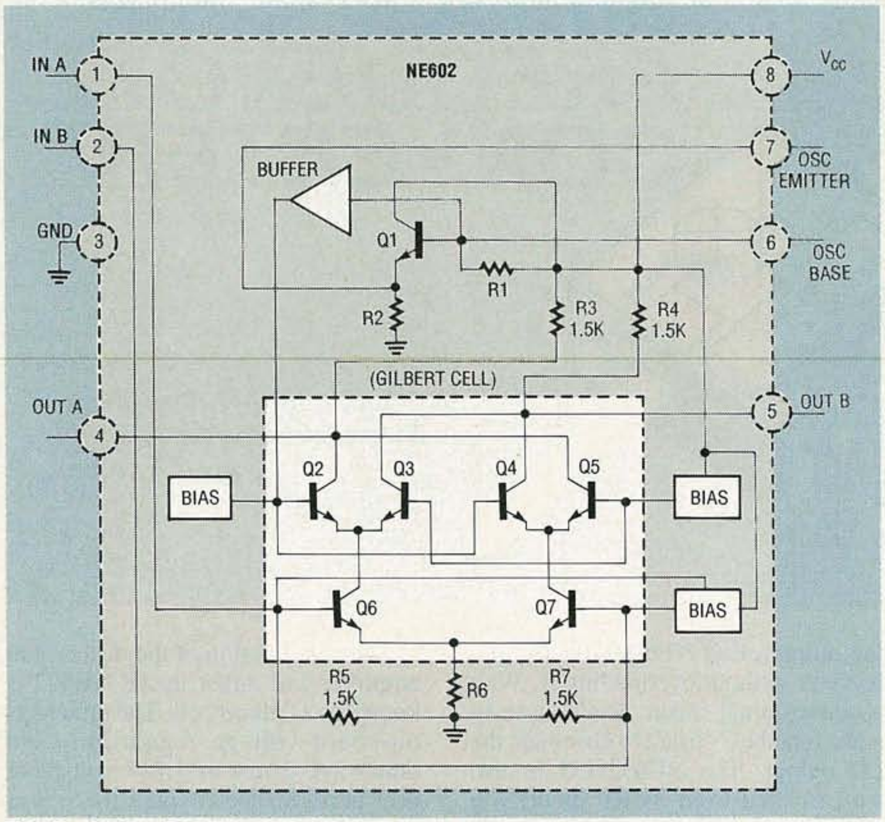


FIG. 2.—NE602 EQUIVALENT CIRCUIT WITH PINOUTS. The combination of differential amplifier Q6-Q7 and mixers Q2-Q3 and Q4-Q5 is called a Gilbert cell.

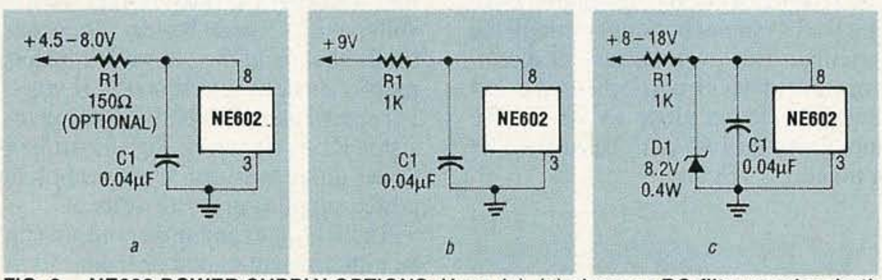


FIG. 3.—NE602 POWER SUPPLY OPTIONS. Here, (*a*)–(*c*) show an RC-filter used as both current limiter (R1) and integrator (C1), as well as for isolation. In (*a*), +4.5–8.0 volts DC is the normal operating range of the NE602. In (*b*), R1 drops voltage, and is used since a +9-volt battery can go higher, and a +9-volt wall supply can produce up to 11 volts. In (*c*), an +8–18-volt DC supply is regulated using 8.2-volt Zener D1.

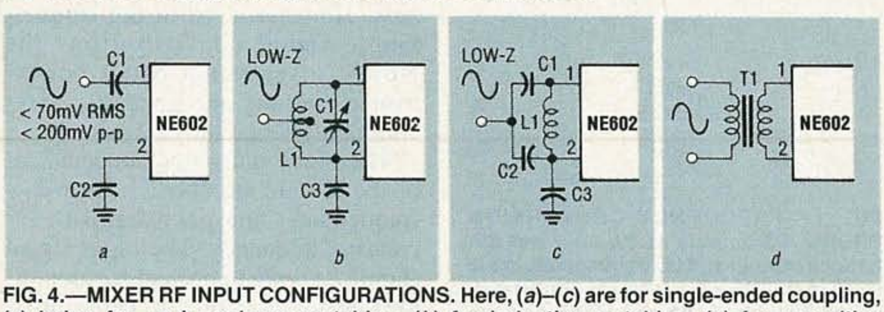


FIG. 4.—MIXER RF INPUT CONFIGURATIONS. Here, (*a*)–(*c*) are for single-ended coupling, (*a*) being for no impedance matching, (*b*) for inductive matching, (*c*) for capacitive matching. By contrast, (*d*) is for a balanced input with reduced second harmonic.

Figure 6 shows some of the main versions; there are many others. The NE602 can be used as an oscillator without the mixer. One way is to sample the LO output at pin 7; a better way is to unbalance the mixer and use it to amplify the LO signal, as shown in Fig. 7. The unbalance is created by a 10K resistor from one input pin to ground, which changes the bias voltage slightly. The output level of such an oscillator is about 0.5 VAC P-P.

Basic crystal oscillator

Many frequency converters are crystal-controlled; Fig. 8 shows the most basic version. The low side of XTAL1 and C2 can be returned either to ground or to V_{CC}; the latter is more compact, because pins 6 and 7 are adjacent to V_{CC} (pin 8). The values of C1 and C2 are important. If C1 is too large, or C2 is too small, there's too much feedback and the oscillator waveform is distorted, with a strong third harmonic. If C1 is too small or C2 is too large, oscillation doesn't occur.

Some suggested values for C1 and C2 are shown in Fig. 6 along with formulae for calculating them. At high frequencies, C1 can be somewhat than the value shown because stray capacitance does some of the work. The values shown are for the best sinusoid. If you want to be sure that a relatively inactive crystal will oscillate and don't mind harmonics, make C1 three times larger. The third harmonic from such a circuit could be used for VHF. There's also a lower frequency limit; the unmodified circuit will oscillate with a 455-kHz ceramic resonator, but not a 100-kHz crystal. Adding 22K from pin 7 to ground will increase the oscillator gain, and improve your chances with low-frequency crystals.

Precise frequency control

A crystal won't necessarily oscillate at its exact rated frequency. There are two kinds, series- and parallel-resonant. They're electrically identical, the only difference being that series-resonant crystals are cut to an exact frequency, whereas parallel-resonant crystals are cut slightly longer, so as to resonate independently slightly below their rated frequency. For that reason, parallel-resonant

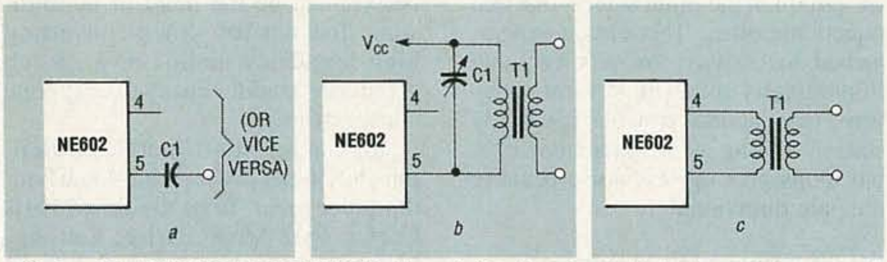


FIG. 5.—OUTPUT CONFIGURATIONS. Here, (*a*) is the simplest single-ended approach without impedance matching, (*b*) is a single-ended approach for a tuned LC circuit load, and (*c*) is for a balanced approach for better suppression of input and LO signals.

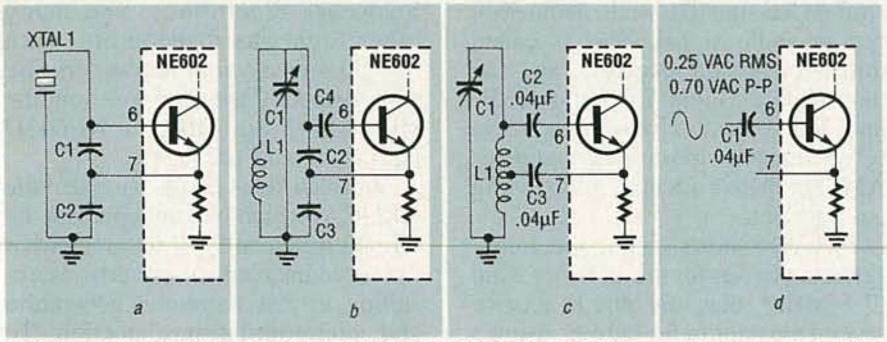


FIG. 6.—BASIC NE602 OSCILLATOR CIRCUITS; (*a*) is Colpitts crystal-controlled, (*b*) is Colpitts LC-tank-controlled, (*c*) is Hartley LC-tank-controlled, and (*d*) is controlled by an external oscillator. Many other configurations are possible.

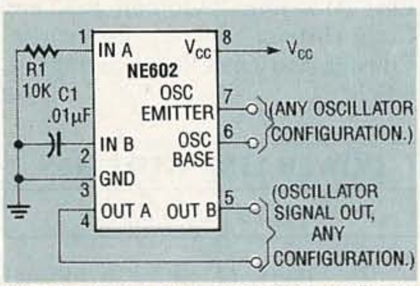
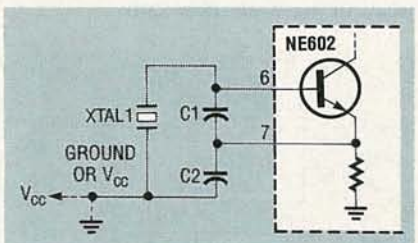


FIG. 7.—THIS IS A GENERAL CONFIGURATION for an NE602. To make an LO signal appear at OUT A (pin 4) and OUT B (pin 5), IN A (pin 1) is grounded through R1.



f MHz	$C1=100pF/\sqrt{f}$	C2=1000pF/f
1	100	1000
2	70	500
4	50	250
10	32	100
20	22	50

FIG. 8.—FUNDAMENTAL COLPITTS CRYSTAL OSCILLATOR. Note that the juncture of XTAL1 and C2 can go to either ground or V_{CC}.

crystals need external capacitors (usually 32 pF) to increase their actual frequency of oscillation to their rated value. In Fig. 8, C1 is this capacitor, but it's usually larger than 32 pF and has less effect than the one depicted here.

Thus, at 10 MHz, parallel-resonant crystals oscillate about 100 *p*arts *p*er *m*illion (ppm) below their rated frequency, while series crystals resonate about 300 ppm above. A parallel-resonant crystal can be pulled up to its rated frequency using a small variable capacitor in series with it, as in Fig. 9, letting you adjust the oscillator as desired. However, even without this capacitor, the frequency error won't be more than 300 ppm (0.03%).

Overtone crystal oscillator

Above 20 MHz, crystals oscillate in overtone mode, and the oscillator needs a tuned LC circuit to select the desired harmonic. For example, a 27-MHz third-harmonic crystal can resonate at 9 MHz (fundamental) or 45 MHz (fifth harmonic). The NE602 data sheet recommends a modified Colpitts oscillator for overtone crystals, but the Butler oscillator in Fig. 10 gives much better results. Its crystal is series-resonant, and L_t and C1 are tuned to the crystal frequency.

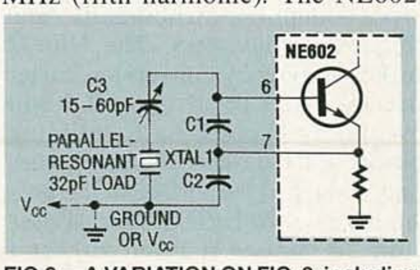


FIG.9.—A VARIATION ON FIG. 8, including C3 to adjust the frequency of XTAL1 (parallel-resonant), bringing it up to its rated value.

This circuit is reliable to at least 60 MHz. Just adjust L_t and C1 until oscillation occurs. By adjusting this tuned LC circuit, you can trim the frequency by about 50 ppm; for greater variation, use a parallel-resonant crystal in series with a variable capacitor for adjustments.

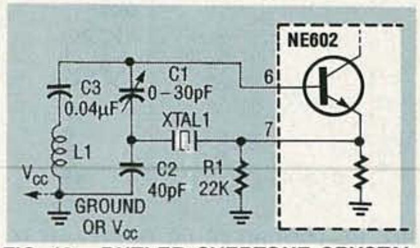


FIG. 10.—BUTLER OVERTONE CRYSTAL OSCILLATOR, with C1 as trimmer. Here: L1≈1300 µH, and both L1 and C1 have to be tuned to the frequency of XTAL1.

Frequency doubler

Figure 11 shows a crystal-controlled frequency doubler with no tuned LC circuits. That circuit is useful in the 20–40 MHz range, but the same method could be used with overtone crystal oscillators for even higher output frequencies.

The doubling is achieved by feeding the LO from pin 7 into the mixer. The output is 2×f (where f is the oscillator fundamental frequency), while the difference frequency is zero (or DC), disappearing due to capacitive coupling.

The output still contains some energy at the LO frequency and isn't pure, but is good enough for hobbyist purposes. A tuned LC circuit can easily provide pure output. Of the oscillators shown here, this is the only one that can't be used with the mixer, because one mixer input is occupied (although you could feed a signal to the other mixer input).

Figure 12 shows a Colpitts LC oscillator using coils and capacitors. Here, L_t forms a resonant circuit with C1 and C2 in series, plus C4 in parallel. Also, C3 blocks DC from pin 6 to V_{CC} or ground; it has little effect on the resonant frequency. Figure 12 also gives formulas for component values. At very high frequencies, a 22K resistor from pin 7 to ground (not V_{CC}) will change the bias point and increase gain.

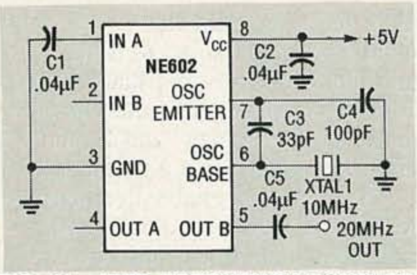


FIG. 11.—THIS FREQUENCY DOUBLER PRODUCES a sine wave at twice the frequency OF XTAL1. Note that output is taken only from OUT B (pin 5), while OUT A (pin 4) is left open.

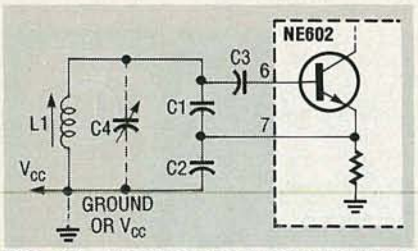


FIG. 12.—COLPITTS LC OSCILLATOR. Here: L1≈7 µH/f, C1≈C2≈C3≈2400 pF/f, where f is in MHz.

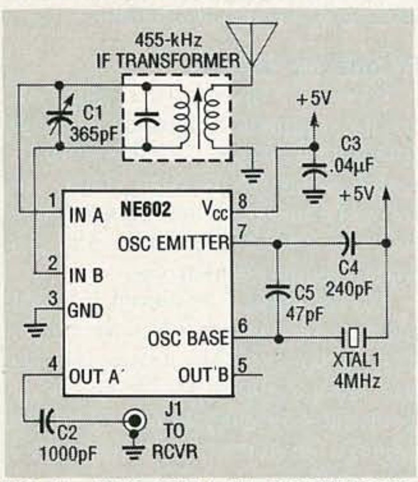


FIG. 13.—THIS CONVERTER DOWN-CONVERTS LONGWAVE signals from 350–500 kHz up to 4.35–4.5 MHz, enabling them to be received via a shortwave receiver plugged into J1.

Longwave receiver converter

Figure 13 shows a frequency converter front end for a shortwave receiver to receive longwave signals (350–500 kHz). It mixes the incoming signal with the 4-MHz signal from the LO. For example, 400 kHz incoming produces 4.4 and 3.6 MHz. The shortwave receiver will receive the signal if tuned to either frequency. The input has a tuned LC circuit to prevent spurious response.

If the receiver is set to 4.4 MHz, then without the tuned LC circuit you'd listen to 400 kHz and 8.4 MHz, because each gives a 4.4-MHz output when mixed with the LO. The tuned LC circuit at the input selects one and rejects the other. This circuit was attached to a shortwave receiver, and immediately received several longwave navigational beacons in nearby states. A long wire antenna works, but loops pick up less noise because they are directional.

Direct-conversion receiver

A frequency converter can shift frequencies up or down. However, if you shift an RF signal down to audio, you get an audio signal. This is called direct-conversion reception, and can demodulate *S*ingle-*S*ide*b*and (SSB) and Morse code *C*ontinuous-*W*ave (CW) transmissions. It demodulates AM, but there's a whine if the tuning isn't perfect.

Figure 14 shows such a direct-conversion receiver for the 40 meter band (7.5 MHz), that was able to receive several amateur radio stations using a 3-foot whip antenna. The design could be refined; tuning would be easier with a variable capacitor instead of an adjustable coil.

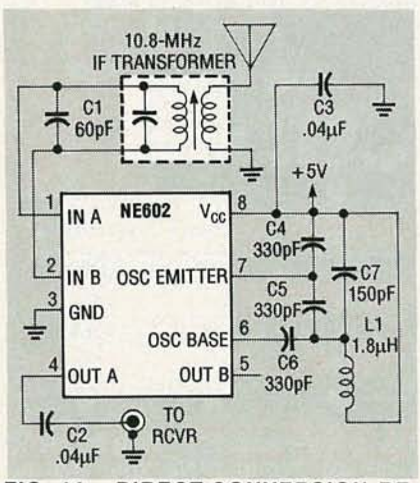


FIG. 14.—DIRECT-CONVERSION RECEIVER for the 40-meter (7-MHz) amateur radio band, where CW is directly down-converted to audio.

Conclusion

There are basically three RF circuit types—amplifiers, oscillators, and frequency converters. The NE602 makes frequency conversion easier than ever. Both it and related IC's will eventually become basic building blocks of RF design. This article has only scratched the surface of the possibilities for the NE602. In an IF section, it makes a good product detector. By mixing audio with RF, it can act as an AM or DSB modulator. By mixing audio with audio, the NE602 can be the heart of an ultrasonic listener (by down-converting high-frequency audio) or a speech scrambler to add security to telephone conversatins.

You can get NE602's at $2.00 each, plus $2.50 per order postage and handling per order, from the Small Parts Center, 6818 Meese Drive, Lansing, MI 48911, (517) 882-6447; there's no minimum order. They're are also available from Arrow Electronics, Schweber Electronics, and many other Signetics distributors, with $25.00 typical minimum orders. Be sure to specify whether you want the NE602N (8-pin DIP) or NE602D (surface mount package).

You also may prefer to order the NE602A, which will be replacing the NE602 imminently; it has somewhat improved intercept characteristics, resulting in less harmonic generation and intermodulation distortion. To specify the desired package type, you'd refer to the NE602AN or NE602AD. We would like to thank Phil Anzalone, Ali Fotowat, and Craig Hirtz of Signetics for their invaluable assistance in preparing this article. **R-E**

POWER LINE GLITCHES

continued from page 42

13–16. Figure 13 shows a normal power sinusoid, Fig. 14 shows harmonic distortion, Fig. 15 shows a brief glitch, and Fig. 16 shows a brief power outage.

Conclusion

Those graphs shown in Figs. 8–16 show only a few of many possible disturbances. Power glitches are common and readily identified. Most are easily fixed, the culprit often being poor wiring, bad grounding, or load switching—all can be corrected cheaply. The most common, practical countermeasure is to install a separate power line from the circuit-breaker box involved to the device being interfered with, like a PC.

Power monitors make identification easy, but they're generally too expensive, and would be needed too infrequently, to warrant purchase by the average hobbyist. They can, however, be rented for short periods, on an as-needed basis, letting you derive the benefits of their technology without making a major investment. **R-E**

AUDIO AMPLIFIERS IC's

A look at practical IC audio-power amplifiers in automotive applications.

RAY MARSTON

LAST MONTH WE DISCUSSED SEVERAL practical audio-power amplifier IC's. This month, we continue with our survey, focusing on automotive audio applications. Among the devices we'll examine are the LM390, LM383, TDA2002, and the LM377/8/9 series.

The LM390 is a 1-watt audio-power amplifier IC that's optimized for a power supply (V_{CC}) of +6–9-volts (+10 volts maximum). Using a +6-volt power supply, the LM390 can deliver 1 watt into a 4-ohm speaker. It's housed in a 14-pin *D*ual-*I*nline *P*ackage (DIP), and features an internal heat sink that's connected on one side to pins 3, 4, and 5, and on the other side to pins 10, 11, and 12.

Figure 1 shows the internal circuit and pinout connections of the LM390. You may notice that it's similar to the LM388 discussed last month, but the output stage has been optimized for maximum output swing. The inputs are ground-referenced, and the output automatically self-biases to a quiescent value of $V_{CC}/2$ when the output stage is DC-biased via external resistors between pins 9 and 14.

The overall voltage gain of the LM390 is internally set at 20, but can be increased to 200 using a shunt capacitor between pins 2 and 6. Figures 2–5 show some applications using the LM390. Figure 2 shows the LM390 as a 1-watt amplifier driving a 4-ohm speaker from a +6-volt power supply. The output stage is DC biased by R1 and R2 in series between V_{CC} and pin 9. The R1-R2 junction is bootstrapped from the output via C2, so that the AC impedance of the R2-C2 combination is far greater than the DC resistance of R2 alone.

Figure 3 shows an alternative configuration for the LM390. Here, DC is fed to pin 9 via the speaker and R1, but here, R1 is bootstrapped via C2, achieving performance similar to that of the version shown in Fig. 2, but with a savings of two parts. Figure 4 shows two LM390's in a bridge amplifier, delivering 2.5 watts into a 4-ohm speaker from a +6-volt power supply. Also, R6 balances the LM390 quiescent outputs, minimizing quiescent current.

Figure 5 shows a single LM390 used in an intercom. Here, R4-C5 provides a gain of: $A_V = 15\ K/51\ ohms \approx 300$. The LM390 has poor ripple-rejection, which can be overcome by adding a 10 µF or larger capacitor from pin 1 to ground. Each of the amplifier configurations shown in Figs. 2–5 have a resistor and capacitor in series from the output of the LM930 to ground, forming a Zobel network which enhances circuit sta-

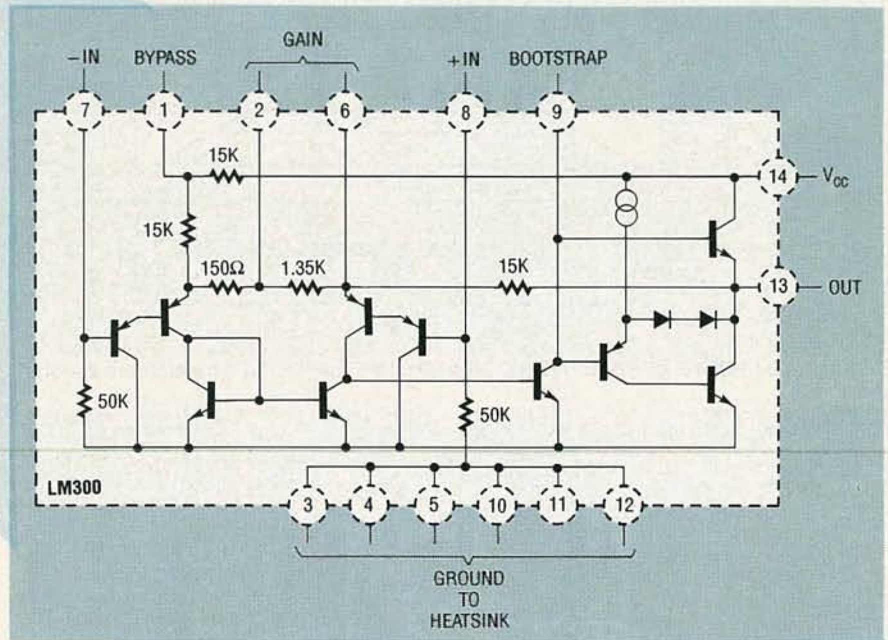


FIG. 1—INTERNAL CIRCUIT AND PIN CONNECTIONS of the LM390 1-watt battery operated audio-power amplifier.

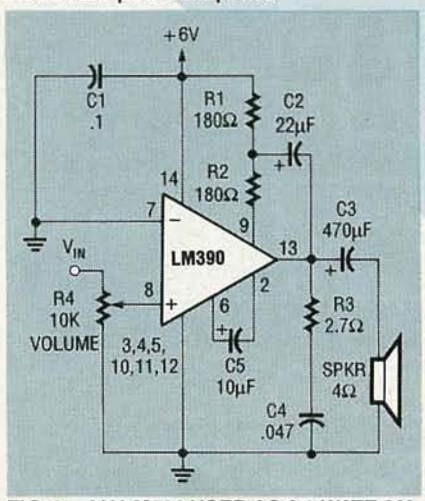


FIG. 2—AN LM390 USED AS A 1-WATT AMPLIFIER. The overall internal voltage gain is 200 with C5, and 20 without.

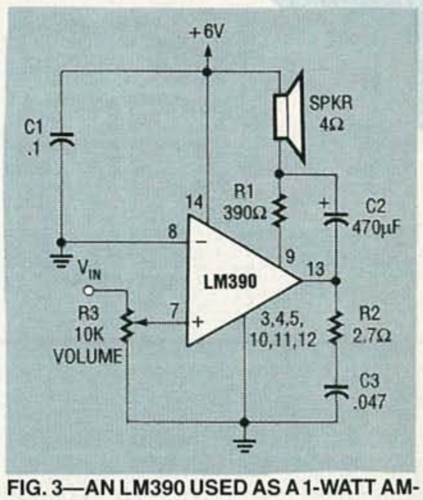


FIG. 3—AN LM390 USED AS A 1-WATT AMPLIFIER with $A_V = 20$ and speaker returned to the +6-volt power supply.

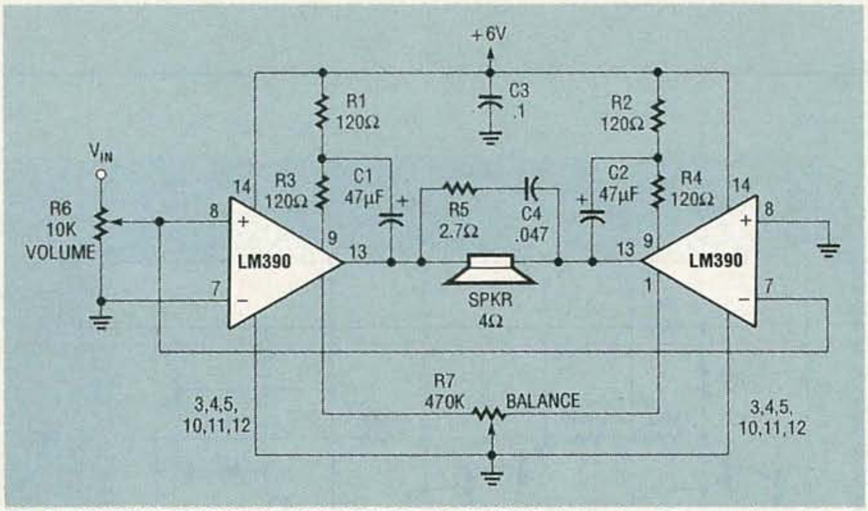


FIG. 4—TWO LM390'S USED AS A BRIDGE AMPLIFIER delivering 2.5 watts into a 4-ohm speaker.

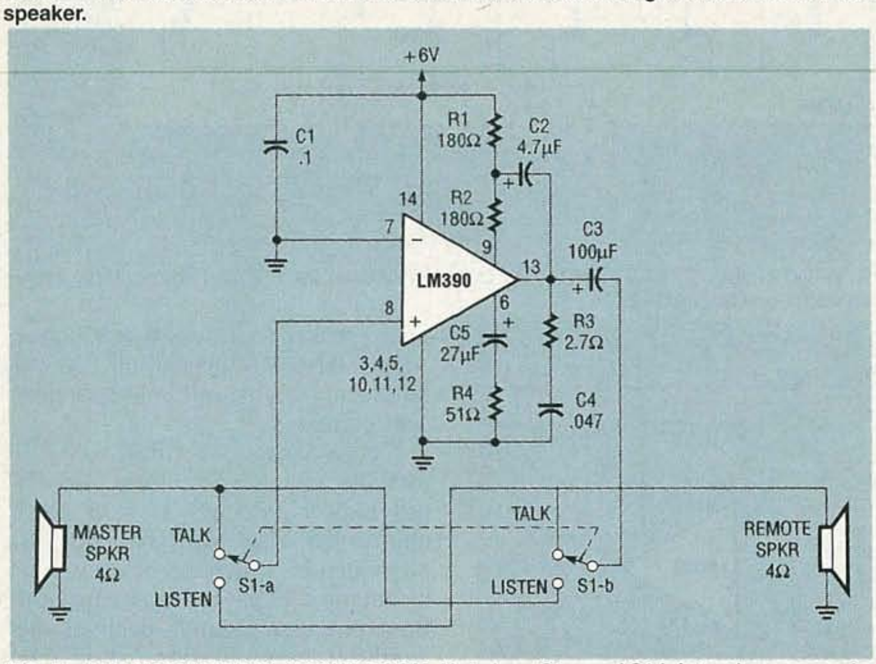


FIG. 5—AN LM390 USED IN AN INTERCOM. Note how S1-a and S1-b interchange speaker and microphone.

TABLE 1—APPROXIMATE PERFORMANCE CHARACTERISTICS OF THE LM377/8/9 AMPLIFIERS

V_{CC} (volts)	Power Limit per Channel (watts)			Maximum Output Power per Channel (watts)	
	LM377	LM378	LM379	8-ohm load	16-ohm load
12	2.5	5.0	6.0	1.6	1.0
16	2.5	5.0	6.0	2.2	1.5
18	2.5	5.0	6.0	3.0	1.8
20	2.5	5.0	6.0	3.8	2.4
22	2.5	5.0	6.0	4.6	2.8
24	—	5.0	6.0	5.4	3.6
26	—	—	6.0	6.0	4.2
28	—	—	6.0	7.0	5.0
30	—	—	6.0	—	5.5

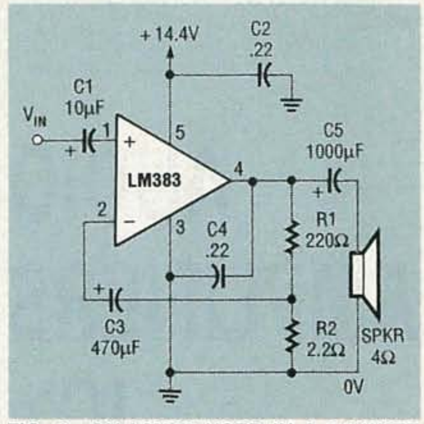


FIG. 6—AN LM383 USED IN A 5.5-WATT AUDIO AMPLIFIER for use in automotive audio applications.

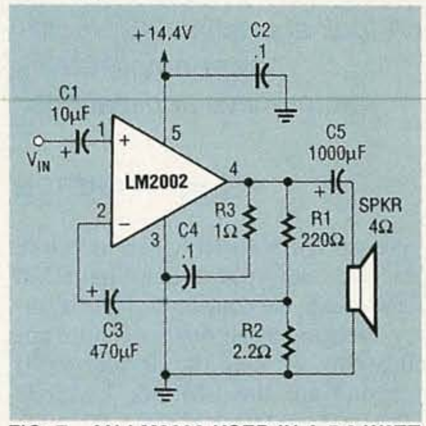


FIG. 7—AN LM2002 USED IN A 5.2-WATT automotive-audio amplifier.

bility; they can be eliminated in some applications.

LM383 circuits

The LM383 is described as an 8-watt audio-power amplifier IC. It's specifically designed for use in automotive audio applications, in which the "running" power supply has a nominal value of 14.4 volts. At that level, the LM383 can typically deliver 5.5 watts into a 4-ohm speaker, or 8.6 watts into a 2-ohm speaker. In reality, the IC can operate using +5–20-volts DC, can deliver peak output currents of 3.5 amps, and has a current-limited and thermally-protected output stage.

The LM383 is housed in a 5-pin TO-220 package, and is very easy to use. Figure 6 shows an application in a 5.5-watt automotive-audio amplifier. Here, the closed-loop gain is 100 via the R1-R2-C3 feedback network, and the LM383 is made non-inverting by feeding the input signal to pin 1 via C1. Also, C2 and C4 ensure high-frequency stability, but C4 *must* be physically close to pins 3 and 4. It is also possible to use LM383's in a bridge configuration for higher power.

LM2002 (TDA2002) circuits

The LM2002 is an 8-watt automotive-audio amplifier IC, equivalent to the TDA2002, and housed in a 5-pin TO-220 package. It can deliver 5.2 watts into a 4-ohm speaker, or 8 watts into a 2-ohm speaker. It uses a +5–20-volt power supply, can deliver peak output currents of 3.5 amps, and has a current-limited and thermally-protected output. It's similar to the LM383, but has a slightly less efficient output, with consequent lower output power into a given load.

Figure 7 shows an application of an LM2002 used in a 5.2-watt automotive-audio amplifier, with a closed-loop gain of 100 set by R1, R2, and C3. Here, R3 and C4 ensure high-frequency stability, and have to be close to pins 3 and 4. Two LM2002's or TDA2002's can be used to form a 16-watt automotive-audio bridge amplifier.

LM377/8/9 circuits

National Semiconductor has a range of dual power-amplifier IC's for mono, stereo, and bridge amplifier applications. The best known are the LM377 2-watt, the LM378 4-watt, and the LM379 6-watt versions. Figure 8 shows the outlines of their DIP's with pinouts, and Table 1 their approximate performance characteristics. They all have high-impedance differential input stages and fully-protected output stages, but differ in voltage, power, and packages. The input stages are DC-biased to $V_{CC}/2$, and a bias generator is built into the IC.

Figure 9 shows a general inverting stereo amplifier using a single-ended power supply. The IC depicted can be any of those in the accompanying table, which lists typical performance. The amplifiers in the IC are biased by connecting each non-inverting input to the bias terminal (pin 1 on the LM377 or LM378, or pin 14 on the LM379), and the closed-loop gain of each is about 50 (R2/R1 or R4/R3). Figure 10 shows how the above circuit can be used in non-inverting mode using a single-ended power supply, with the gain of each half set at 50 (R4/R3 or R6/R5), and the non-inverting input terminals of the amplifiers biased internally.

It is possible to power the circuit of Fig. 10 by using a split power supply. In that case, the internal bias generator is ignored, and the non-inverting input of each amplifier is DC-coupled to the ground half-supply point via R6 and R7.

Figure 11 illustrates how to boost the available power of one half of an LM378 to 15 watts, while generating only 0.05% *T*otal *H*armonic *D*istortion (THD) at 10 watts. At very low power, Q1 and Q2 are inoperative, and power is fed directly to the speaker via R2.

At high power, Q1 and Q2 form a complementary emitter follower, providing most of the power to the speaker. Also, R2 and Q1-Q2 are wired into the negative feedback loop, generating negligible cross-over distortion. Figure 12 shows an application of both halves of an LM377/8/9 in a mono bridge amplifier feeding high power into a DC-coupled speaker.

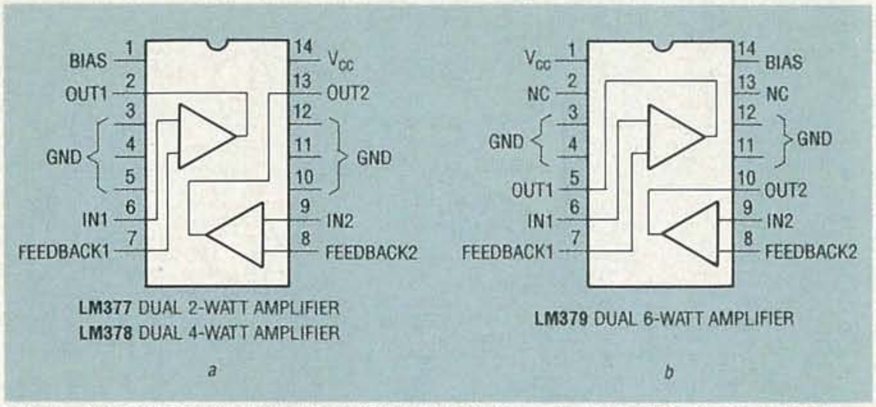
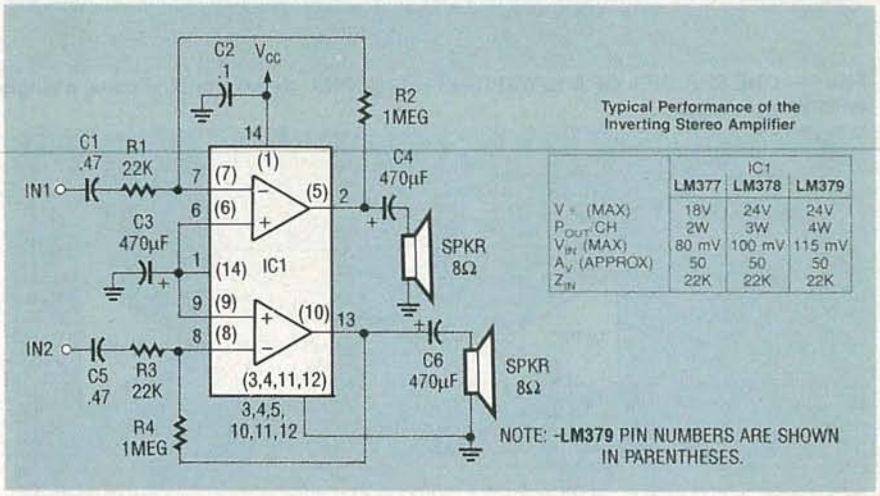


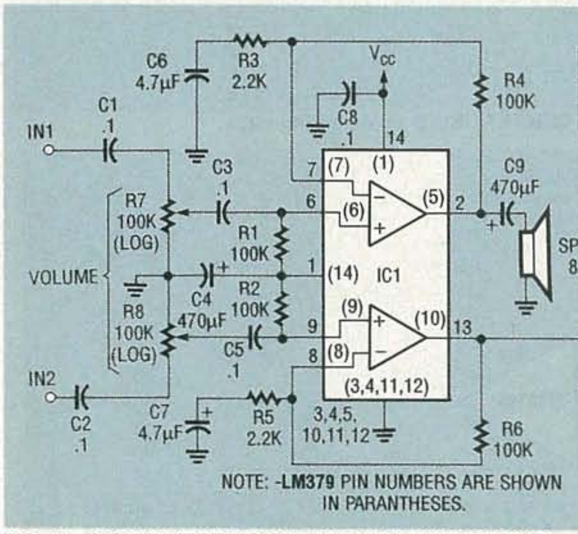
FIG. 8—OUTLINES AND PIN NOTATIONS OF THE popular LM377/8/9 dual amplifiers.



Typical Performance of the Inverting Stereo Amplifier

	IC1 LM377	LM378	LM379
V+ (MAX)	18V	24V	24V
P_{OUT}/CH	2W	3W	4W
V_{IN} (MAX)	80 mV	100 mV	115 mV
A_V (APPROX)	50	50	50
Z_{IN}	22K	22K	22K

FIG. 9—SIMPLE INVERTING STEREO AMPLIFIER using the LM377/8/9 dual amplifiers.



V_{CC}	IC1	P_{OUT}
18V	LM377	2W/CH
24V	LM378	3W/CH
28V	LM379	4W/CH

FIG. 10—NON-INVERTING STEREO AMPLIFIER USING a single-ended power supply.

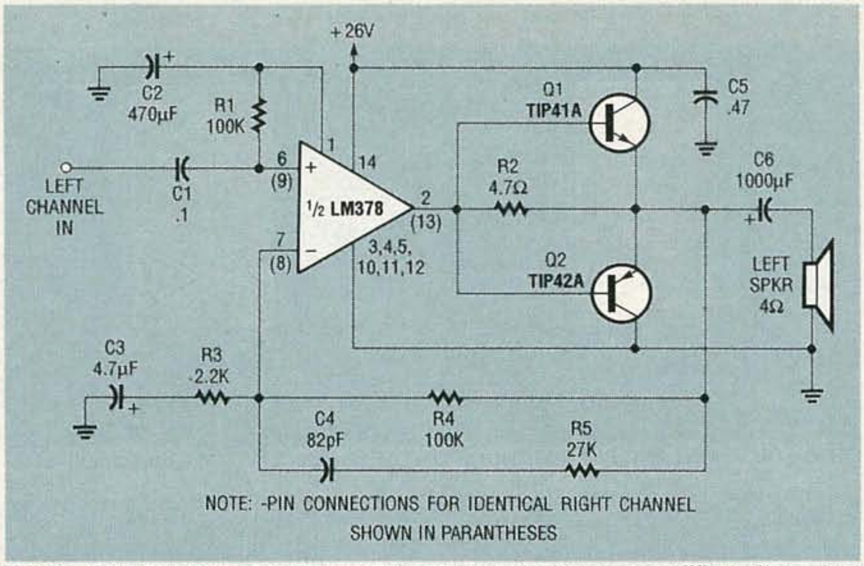
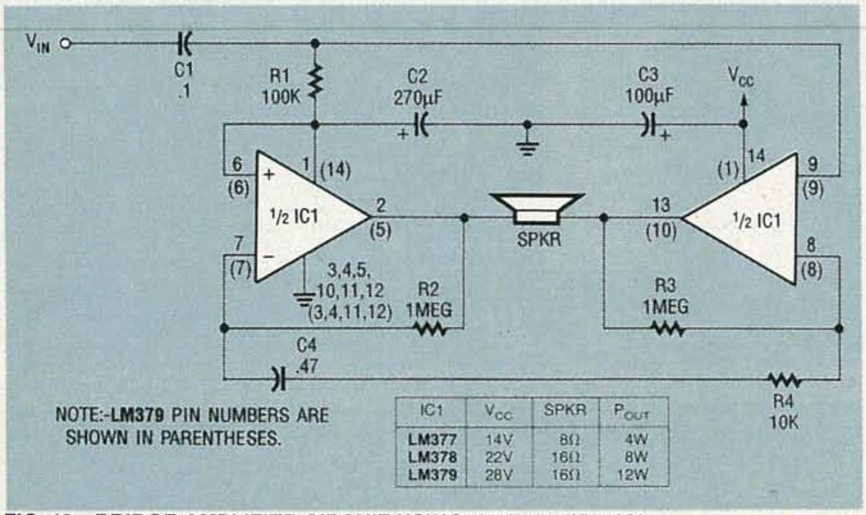


FIG. 11—ONE CHANNEL OF A 15-WATTS-PER-CHANNEL stereo amplifier using a single-ended power supply.



IC1	V_{CC}	SPKR	P_{OUT}
LM377	14V	8Ω	4W
LM378	22V	16Ω	8W
LM379	28V	16Ω	12W

FIG. 12—BRIDGE AMPLIFIER CIRCUIT USING dual-amplifier IC's.

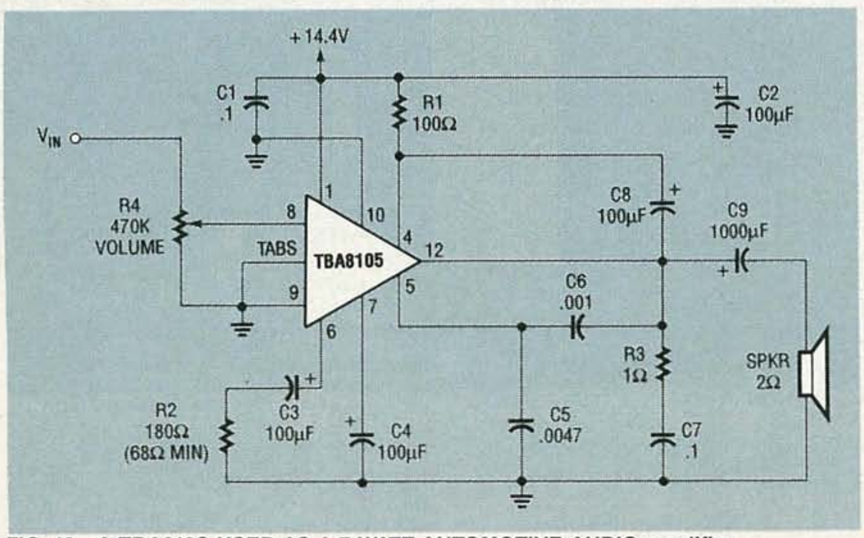


FIG. 13—A TBA810S USED AS A 7-WATT AUTOMOTIVE-AUDIO amplifier.

The LM1877 IC

The LM1877 dual 2-watt power amplifier IC is an improved pin-for-pin replacement for the LM377, to be used in place of the LM1877 whenever possible. It provides improved performance in terms of very low cross-over distortion, very high input impedance, and high slew rate, but has slightly worse ripple rejection and higher quiescent current than the LM377.

Assorted amps

The remainder of this discussion will give brief descriptions of a few popular audio-power amplifier IC's, with applications for each. The TBA810S can deliver several watts for automotive audio applications. It features protection against power supply polarity inversion and high-voltage transients.

Figure 13 shows an application that uses a TBA8105 as a 7-watt automotive-audio amplifier; the gain is determined by R2, while R1 performs output biasing and is bootstrapped via C8, and R3-C7 functions as a Zobel network.

The TBA820M is a low-power amplifier IC capable of delivering a few hundred milliwatts into a 4–16-ohm speaker, and is housed in an 8-pin DIP. It can run on as little as +3 volts, and has low quiescent current, good ripple rejection, and low cross-over distortion.

Figure 14 shows an application of a TBA820M as a low-power audio amplifier, where the gain is determined by R2, and R3-C6 is a Zobel network. It can run on a +16-volt single-ended power supply using a 16-ohm speaker, a +12-volt power supply using an 8-ohm speaker, or a +9-volt power supply using a 4-ohm speaker.

The TDS2005M is a 20-watt automotive audio-power booster IC housed in an 11-pin package, fully output short-protected. It houses two internal bridge-connected power amplifiers, providing high power into a 2-ohm speaker from a +14.4-volt power supply. Figure 15 shows an application as a 20-watt automotive audio-power booster; all electrolytic capacitors should be rated at a minimum of +25 volts.

The TDA2006 and TDA2030 are high-quality amplifiers capable of being used using either split or single-ended power supplies, and generating less than 0.1% distortion when delivering 8 watts into a 4-ohm speaker. They're housed in a 5-pin TO-220 package with an insulated heatsink bolted directly to an external heat sink with no insulating washer.

Figure 16 shows the package and pin connections for both the TDA2006 and TDA2030, and Figure 17 shows an application that uses a TDA2006 in an 8-watt amplifier powered by a split power supply, with the non-inverting input tied to ground via R1. Here, high-frequency roll-off

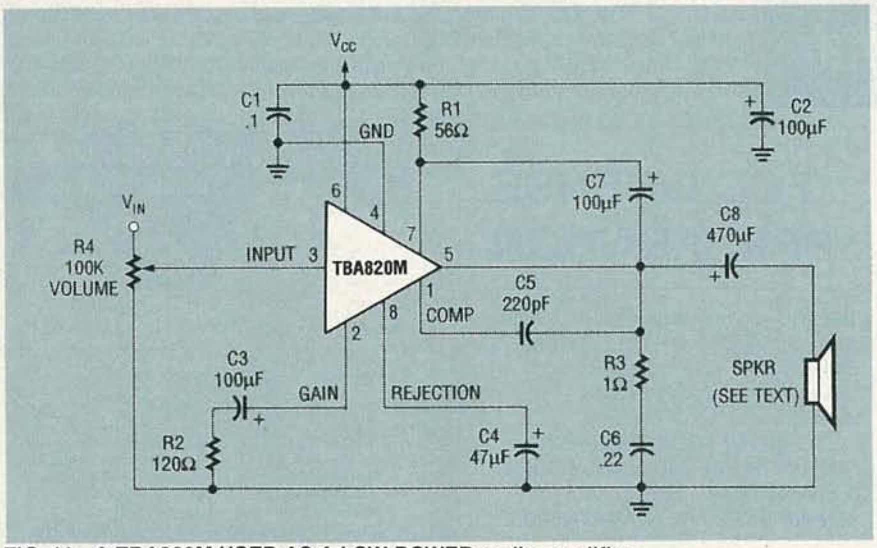


FIG. 14—A TBA820M USED AS A LOW-POWER audio amplifier.

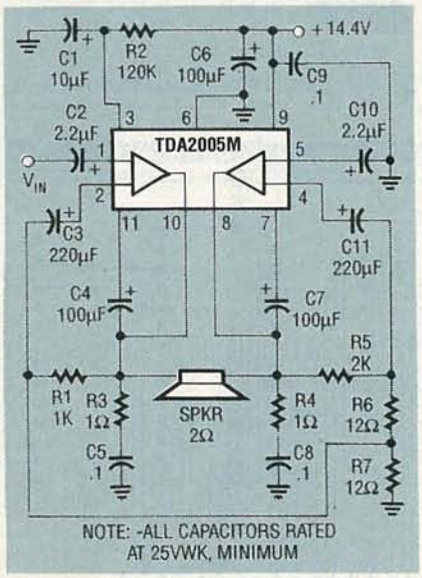


FIG. 15—A TDA2005M USED AS A 20-WATT AUTOMOTIVE audio-power booster.

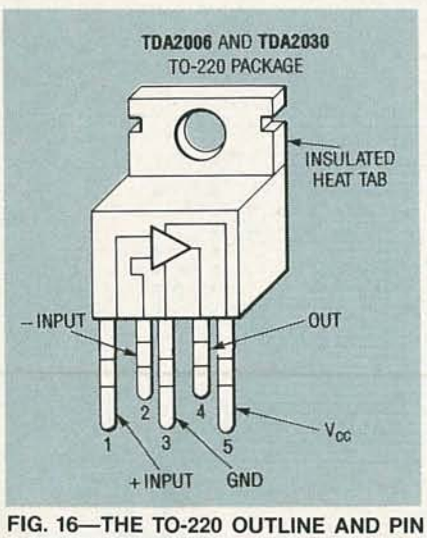


FIG. 16—THE TO-220 OUTLINE AND PIN CONNECTIONS of the TDA2006 and TDA2030.

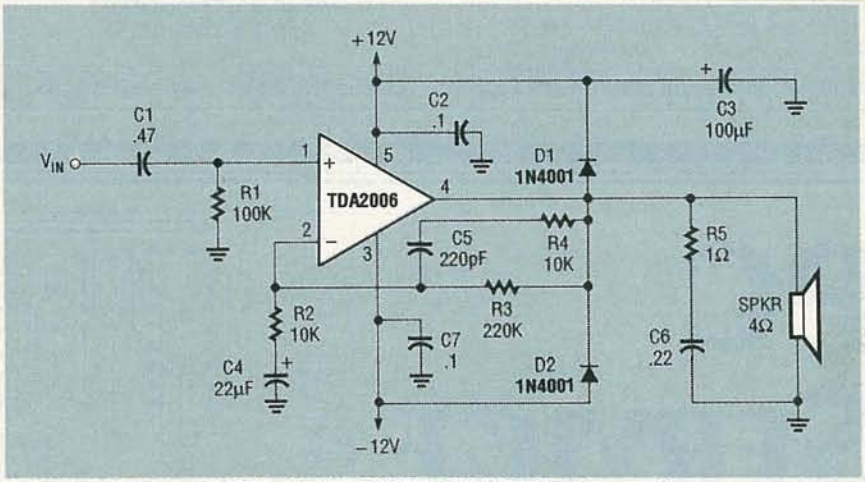


FIG. 17—A TDA2006 USED AS AN 8-WATT AMPLIFIER using a split power supply.

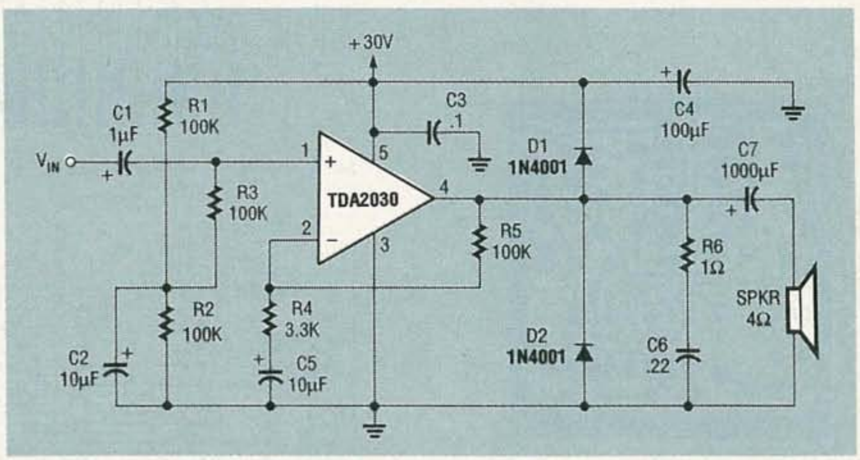


FIG. 18—A TDA2030 USED AS A 15-WATT AMPLIFIER using a single-ended power supply.

is achieved via R4-C5, and the gain is set by R3/R2, or 22. Diode D1 and D2 protect the output against damage from back-EMF from the speaker, and R5 and C6 form a Zobel network.

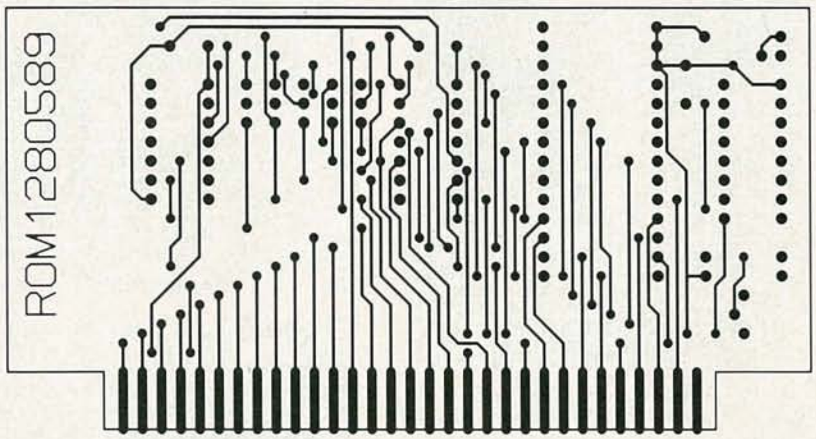
The TDA2030 is an upgraded TDA2006 housed in a 5-pin TO-220 package with insulated heat tab. It can use up to +36 volts in the case of a single-ended power supply, and ±18 volts in the case of a split power supply. Using a +28-volt single-ended power supply, it delivers 12 watts into a 4-ohm speaker or 8 watts into an 8-ohm speaker, with a THD of 0.05% at 1 kHz and 7 watts out.

Figure 18 shows an application of the TDA2030 as a 15-watt amplifier using a +30-volt single-ended power supply and 4-ohm speaker, with 30 dB gain.

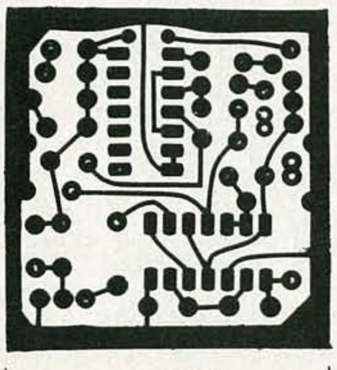
The performance that you can obtain from the circuits presented can be quite impressive. While they form an excellent starting point for an original amplifier design, they can also be used in other projects. For example, with a hand-full of parts and a little bit of work, you can transform the output of your personal portable stereo into car-filling sound.

If you have an older car stereo (and who doesn't?) with blown final output amplifiers, you might find that many of the circuits we presented will fill the bill nicely. **R-E**

PC SERVICE

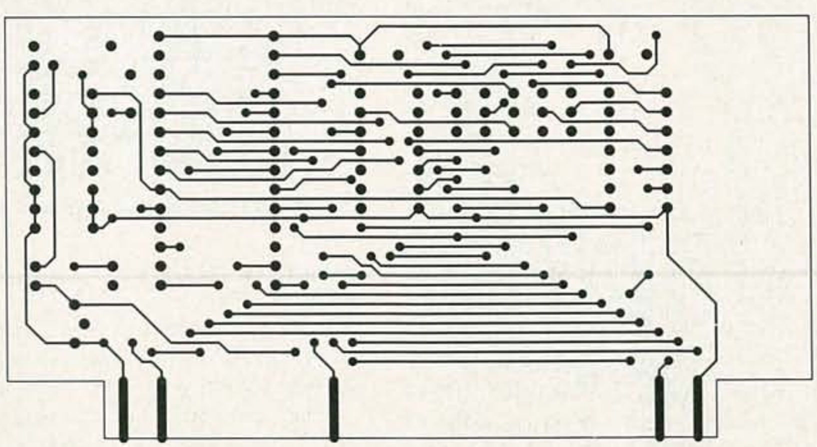


4 ¼ INCHES



1$\frac{11}{16}$ INCHES

FOIL PATTERN for the windshield-wiper delay unit.



4 ¼ INCHES

ABOVE RIGHT is the component side of the PC Access. At right is the solder side.

HARDWARE HACKER

Organic Vapor Detectors
Low Melting Point Alloys
Alternate Energy Resources
Ultraviolet Flame Detector
Five Band Equalizer Circuit

Alternate-energy resources

DON LANCASTER

WE SEEM TO HAVE A REALLY MIXED BAG of outstanding goodies this month, so let's just jump right in. As usual, please note that all of our referenced sources appear in either the alternate-energy resource sidebar or in the names and numbers box.

Harardous materials

I've gotten several calls asking how to dispose of any spent printed-circuit etchant. Since I'm part of the Haz-Mat team at our local fire department, I thought we'd look at the big picture first. Back to square one.

We can define a *hazardous material* as any substance that is out to do you in. It might burn, explode, be chemically reactive, be biologically active, poisonous, radioactive, or might interact violently with water or air.

As a hardware hacker, you probably expose yourself to hundreds of hazardous materials. Knowing ahead of time what these nasties are and what they an do to you is common sense.

Most industrial chemicals and by-products have to provide a *Materials Safety Data Sheet*. Obviously, you'll want to read and collect them. If you have any employees, you are required by law to make any relevant sheets available to them on request.

Unfortunately, most MSDS listings do a total whitewash job and dwell on stupid trivia. For instance, the sheet on Kapton films goes out of its way to tell you that these films are slippery and you can trip on them if you leave them on the floor. But they make no obvious mention that Kapton turns from an insulator into a conductor above a certain temperature, totally thrashing any computer or electronic system it is involved with. Always watch for understatement, weasel words, and any misdirection when you are reading the sheets.

One of the best Haz-Mat references is the "yellow" book from DOT, otherwise known as the *Emergency Response Guidebook*. It lists most industrial chemicals and tells competent professionals how to deal with them under emergency conditions. Single copies are obtainable at no charge on request.

LMA-117
Melts at 117 Degrees F.
Contracts slightly on cooling.
About $7.50 per ounce.

LMA-158
Melts at 158 Degrees F.
Expands slightly on cooling,
About $1.35 per ounce.

LMA-255
Melts at 255 Degrees F.
Expands slightly on cooling.
About $1.00 per ounce.

LMA-281
Melts at 281 Degrees F.
Expands slightly on cooling.
About $2.20 per ounce.

FIG. 1—SOME LOW-TEMPERATURE ALLOYS you can get through Small Parts. Two of these can be melted and cast with boiling water. What hacker uses can you think of?

A second resource is the 24-hour emergency telephone number from *Chemtrec* at (800) 424-9300. It's a free chemical-industry service that can instantly place you in contact with experts on any hazardous material. But note that it's an emergency response number, sort of a nationwide 911. Do not use it for idle chat.

An interesting free trade journal that deals with hazardous materials is *Pollution Equipment News*. That one also exposes you to some real pneumatic and electronic gems that you might not otherwise see.

Naturally, any genuine Haz-Mat incident should be handled by the professionals, usually contacted by your local 911 number. One of the hardest things for the pros to learn is that their preconditioned "Save my Baby!" super-aggressive initial fire-attack strategy is most often dead wrong in a Haz-Mat incident. Doing nothing at all is usually far better then becoming part of the problem.

The quantity of the material and the way you store it will also make a big difference. Common sense is an obvious factor here.

In the case of ammonium-persulfate printed-circuit etchant, storage of the dry etchant in small and sealed plastic containers is recommended. *Tupperware* works quite well. Some ammonium-persulfate etchants also include a highly poisonous mercury activator. So never work in your kitchen, always be in a well-ventilated area, and always wear safety

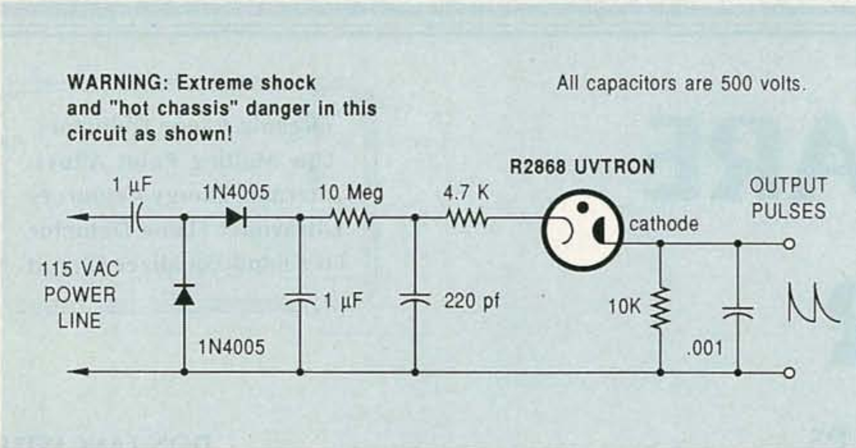


FIG. 2—AN ULTRA-VIOLET FLAME SENSOR. The circuit is basically a neon lamp relaxation oscillator. Its frequency is a few counts per minute in the absence of a flame, and a mid to high audio frequency with a flame present.

glasses and plastic gloves.

Note that ammonium persulfate is an oxidizer. If you use a wooden spoon to stir it, and come back a week or two later, the chances are that you'll have nothing but a burned-off spoon handle left. Do avoid all contacts between ammonium persulfate and organic materials.

To dispose of the etchant, contact your local environmental conservation agency and ask them for the requirements in your area.

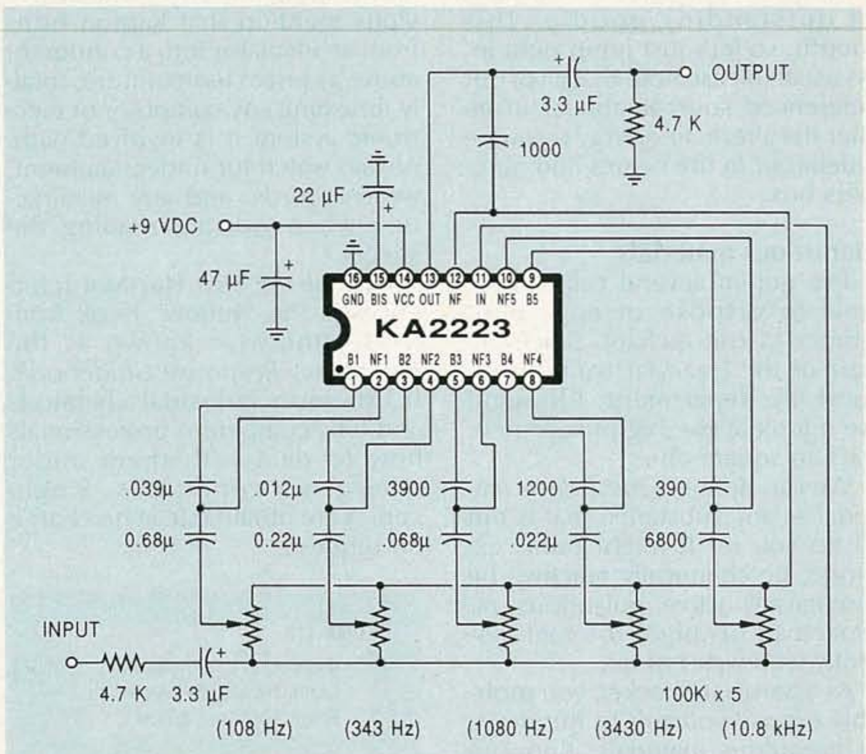


FIG. 3—A 5-BAND GRAPHIC EQUALIZER that uses a single Samsung integrated circuit. A pair of chips can be used for ten bands.

Low-temperature alloys

I just got a new copy of *Catalog #12* from *Small Parts*. As we've seen a time or two in the past, those folks are a great source for everything your hardware store never heard of, besides custom cutting small quantities of metal and plastics for you.

Several of their more interesting products include a series of four low-temperature melting alloys. Figure 1 sums up their properties.

The melting points for those alloys are set to 117 degrees Fahrenheit, 158 degrees, 255 degrees, and 281 degrees. They are available in quarter- and one-pound sizes, and range in price from $28 to $78 per pound. Unfortunately, the 117 degree one is by far the most expensive, since it is around one-fifth irridium, a precious metal.

Those two alloys with the lowest melting point can easily be cast from a "crucible" placed inside boiling water on your stove. Plaster or silicon-rubber molds should work just fine.

While you could, in theory, mix the alloys together to get different melting points, it pays to know what you are doing. Otherwise, instead of a free flowing *eutetic* liquid, you might end up with so much dross. Metallurgy and all.

I can think of all sorts of unusual and off-the-wall uses for them, but why don't you tell me instead? As our contest this month, just dream up a unique application for a low melting point alloy. There'll be all the usual *Incredible Secret Money Machine* book prizes, along with an all-expense paid (FOB Thatcher,

NAMES AND NUMBERS

Chemtrec
Use this number ONLY for a Haz-Mat emergency.
(800) 424-9300

DonJer
Ilene Court Building 8
Belle Mead, NJ 08502
(800) 336-6537
CIRCLE 239 ON FREE INFORMATION CARD

Figaro Engineering
Box 357
Wilmette, IL 60091
(708) 256-3546
CIRCLE 240 ON FREE INFORMATION CARD

Hamamatsu
PO Box 6910
Bridgewater, NJ 08807
(201) 231-0960
CIRCLE 241 ON FREE INFORMATION CARD

Klockit
PO Box 636
Lake Geneva, WI 53147
(800) 556-2548
CIRCLE 242 ON FREE INFORMATION CARD

Logical Devices
6600 NW 12th Ave., Ste 203
Ft. Lauderdale, FL 33309
(800) 331-7766
CIRCLE 204 ON FREE INFORMATION CARD

Midnight Engineering
PO Box 7041
Fort Collins, CO 80525
(303) 491-9092
CIRCLE 205 ON FREE INFORMATION CARD

NEC
401 Ellis Street
Mountain View, CA 94043
(800) 632-3531/(415) 960-6000
CIRCLE 206 ON FREE INFORMATION CARD

Pollution Equipment News
8650 Babcock Blvd
Pittsburgh, PA 15237
(412) 364-5366
CIRCLE 207 ON FREE INFORMATION CARD

Samsung
3725 North First Street
San Jose, CA 95134
(408) 434-5400
CIRCLE 208 ON FREE INFORMATION CARD

SGS-Thomson
1000 East Bell Road
Phoenix, AZ 85022
(602) 867-6259
CIRCLE 209 ON FREE INFORMATION CARD

Silicon Systems
14351 Myford Road
Tustin, CA 92680
(714) 731-7110
CIRCLE 210 ON FREE INFORMATION CARD

Small Parts
PO Box 381966
Miami, FL 33238
(305) 751-0856
CIRCLE 211 ON FREE INFORMATION CARD

Stock Drive Products
2101 Jericho Turnpike
New Hyde Park, NY 11040
(516) 328-0200
CIRCLE 212 ON FREE INFORMATION CARD

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
CIRCLE 213 ON FREE INFORMATION CARD

Tektronix
PO Box 500
Beaverton, OR 97077
(800) 835-9433
CIRCLE 214 ON FREE INFORMATION CARD

Texas Instruments
PO Box 1443
Houston, TX 77001
(800) 232-3200
CIRCLE 215 ON FREE INFORMATION CARD

US DOT; ATTN: DHM-50
400 7th St SW, RM 84-20
Washington, DC 20590
(202) 366-0656
CIRCLE 216 ON FREE INFORMATION CARD

AZ) *tinaja quest* for two for the best entry of all. Please be sure to send your written entries directly to me and not over to **Radio-Electronics** editorial.

A flame detector

At one time way back when, far and away the numero uno hacker component was the NE-2 neon lamp. It was incredible what you could do with them. Panel lamps, night lights, polarity detectors, spike protectors, winking oscillators, tiny disco stars, tone generators for electronic organs, vacuum-tube filament checkers, hot chassis testers, triggers, voltage regulators, and great heaping bunches more.

CMS-302
Oxygen combustion sensor.
Externally heated to 700-900 C.
12 volt supply.

TGS-100
For fumes and odors in air.
1 volt, 440 milliwatt heater.
100 volt supply.

TGS-109
For natural gas and gasoline.
1 volt, 440 milliwatt heater.
100 volt supply.

TGS-203
For carbon monoxide.
0.8 volt, 700 milliwatt heater.
12 volt supply.

TGS-813
For propane and methane.
5 volt, 830 milliwatt heater.
24 volt supply.

TGS-822
For DWI breath alcohol testers.
5 volt, 830 milliwatt heater.
24 volt supply.

TGS-880
For automatic microwave cooking.
5 volt, 830 milliwatt heater.
24 volt supply.

FIG. 4—A FEW VAPOR DETECTORS from Figaro Engineering. Each gets optimized for specific sensing tasks.

Sadly, the good old ten cent neon lamp isn't even on most hacker charts any more, done in by its need for high voltage, and its limited brightness and color range. Sigh.

But the *Hamamatsu* folks have come up with an interesting variation on the traditional neon lamp. It is known as an *UVTRON R2868* flame sensor.

Figure 2 shows you a typical circuit. Any open flame has lots of ultraviolet energy associated with it. The circuit is a simple relaxation oscillator. In the absence of any ultraviolet energy, the oscillator fires only every few seconds or so. When sensing, the oscillator fires as much as 5000 times a second. Thus, you get an audio tone out in the presence of the ultraviolet energy from a flame, and only a few random clicks otherwise.

It's sensitive enough to easily detect a match at 10 feet. While the

ALTERNATE ENERGY RESOURCES

Arco Solar
PO Box 6032
Carmarillo, CA 93010
(805) 482-6800
CIRCLE 217 ON FREE INFORMATION CARD

Assoc of Energy Engineers
4025 Pleasantdale S420
Atlanta, GA 30340
(404) 447-5083
CIRCLE 218 ON FREE INFORMATION CARD

Bergey Windpower
2001 Priestley Avenue
Norman, OK 73069
(405) 364-4212
CIRCLE 219 ON FREE INFORMATION CARD

Energy depot
61 Paul Drive
San Rafael, CA 94903
(415) 499-1333
CIRCLE 220 ON FREE INFORMATION CARD

Home Power
PO Box 130
Hornbrook, CA 96044
(916) 475-3179
CIRCLE 221 ON FREE INFORMATION CARD

HVAC Product News
400 N. Michigan Avenue
Chicago, IL 60611
(312) 222-2000
CIRCLE 222 ON FREE INFORMATION CARD

Mother Earth News
PO Box 70
Hendersonville, NC 28793
(704) 693-0211
CIRCLE 223 ON FREE INFORMATION CARD

Photocomm Inc
930 Idaho Maryland Road
Grass Valley, CA 95945
(800) 544-6466
CIRCLE 224 ON FREE INFORMATION CARD

Popular Science
2 Park Avenue
New York, NY 10016
(212) 779-5000
CIRCLE 225 ON FREE INFORMATION CARD

Real Goods
966 Mazzoni Street, #4B
Ukiah, CA 95482
(800) 762-7325
CIRCLE 226 ON FREE INFORMATION CARD

Sandia National Labs
PO Box 5800
Albuquerque, NM 87185
(505) 844-5678
CIRCLE 227 ON FREE INFORMATION CARD

Snow Belt Solar
286 Wilson Street
Amherst, WI 54406
(715) 824-3982
CIRCLE 228 ON FREE INFORMATION CARD

Solar Energy
Maxwell House, Fairview Park
Elmsford, NY 10523
(914) 592-7700
CIRCLE 229 ON FREE INFORMATION CARD

Solar Energy Research Inst
1617 Cole Blvd
Golden, CO 80401
(303) 231-1000
CIRCLE 230 ON FREE INFORMATION CARD

Solar Jack
325 East Main
Safford, AZ 85546
(602) 428-1092
CIRCLE 231 ON FREE INFORMATION CARD

Solarex
1335 Piccard Drive
Rockville, MD 20850
(301) 948-0202
CIRCLE 232 ON FREE INFORMATION CARD

Solec International
12533 Chadron Avenue
Hawthorne, CA 90250
(213) 970-0065
CIRCLE 233 ON FREE INFORMATION CARD

Solvonics Solar Systems
1100 West Maple Road
Troy, MI 48084
(313) 362-4170
CIRCLE 234 ON FREE INFORMATION CARD

Southwest Windpower
PO Box 22178
Flagstaff, AZ 86002
(602) 526-0997
CIRCLE 235 ON FREE INFORMATION CARD

Whole Earth Review
27 Gate Five Road
Sausalito, CA 94965
(415) 332-1716
CIRCLE 236 ON FREE INFORMATION CARD

Yellow Jacket Solar
Box 253
Yellow Jacket, CO 81335
(303) 562-4884
CIRCLE 237 ON FREE INFORMATION CARD

Zomeworks
PO Box 25805
Albuquerque, NM 87125
(505) 242-5354
CIRCLE 238 ON FREE INFORMATION CARD

recommended supply voltage should be within ten percent of 325 volts, you can usually work with the simple line-operated voltage doubler shown.

Note that it is a "hot chassis" type of circuit with a severe shock hazard potential. You'll probably want to use an optocoupler on the output in your final circuit, and an input isolation transformer would also be a good idea. The output pulses are normally around eight volts high and about five microseconds wide.

Two use tips: Be sure the anode resistor is physically quite close to your flame sensor. And avoid having two sensors near each other, since they produce ultraviolet in use and could badly interact or even latch.

Hamamatsu also makes small and complete flame-sensor circuit cards ready for use that run off the usual 24-volt AC thermostat transformer. While intended for flame detection in gas heaters and air conditioners, there should be lots of other interesting hacker uses. What can you come up with here?

A great new data book

I've seen some exciting data books before, but this one is way off the scale. It reads like a pulp novel that you literally cannot put down. Each and every page is crammed full of outstanding new low-cost hacker integrated circuits that cry to be used.

I am referring to the new *Linear IC Volume I* data book by *Samsung*. That beauty is crammed to the gills with audio, video, and remote-control toy radio chips. All sanely priced, and all with detailed application examples.

As a random example, let's drop in on page 178 where we see a single-chip 5-band graphic equalizer. Full details appear in Fig. 3.

While it is a five-band equalizer, you can easily use a pair of chips for a ten-bander, again per their data book. Only a volume control and a pair of capacitors are needed per band.

Other goodies in the book include audio-power amplifiers and preamps, the complete toy R/C vehicle remote drivers, infra-red encoders and pre-amps and bunches more.

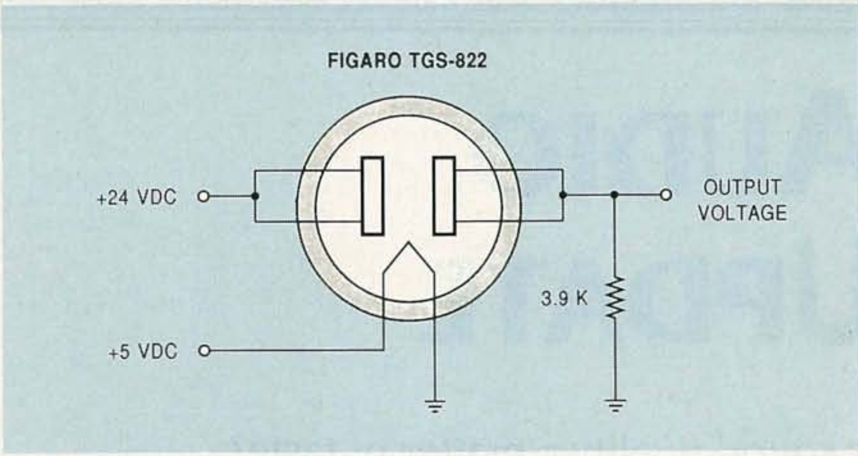


FIG. 5—A DWI BREATH-ALCOHOL TESTER that uses the Figaro TGS-822. The presence of 500 parts per million of grain alcohol lowers the cell resistance by a factor of 10, raising the output voltage.

Fume and vapor detectors

There's lots of reasons why you might like to detect any organic or chemical vapors in the air. In home uses, we have gas-leak detection, fuel vapors, carbon monoxide, "stuffy" air ventilation controls, auto microwave oven "the roast is done" sensing, DWI breath-alcohol testers, the combustion monitoring, odor detection, and oxygen sensing.

Similarly, industrial sensors are sometimes required for ammonia, hydrogen sulfide, organic vapors, for freon, and other organic vapors.

The people at *Figaro Engineering* have dozens of low-cost and easy-to-use sensors, optimized for various substances. Figure 4 summarizes many of their key models. Quantity costs are in the $5 range.

In general, each sensor consists of a sintered block of tin oxide, with variations that will optimize for any particular sensed vapor. An internal heater is used to raise the surface temperature to the 200- to 400-degree Centigrade range.

Through surface absorption, the resistance of the tin oxide will drop in the presence of an organic vapor. The amount that the resistance drops depends on the vapor and its concentration.

For instance, Fig. 5 shows you how the TGS822 gets used as a breath-alcohol detector. You apply a 5-volt AC or DC heater voltage at a current of 120 milliamperes or so. You apply a main supply voltage of 24 volts AC or DC, and sense an output voltage across a 3.9K load resistor.

In the presence of 300 parts per million alcohol, the sensor resistance will drop by 10:1. At 3000 parts per million alcohol, the sensor resistance will drop by 50:1. Thus, both the presence and the strength of the organic vapor can be measured. The response time is typically a few seconds.

These sensors are relatively broad-spectrum devices. They may well respond more strongly to certain other vapors than the one you are really looking for. Thus, they will work best in those situations where one and only one vapor or contaminant is expected.

Ads for similar sensors appear in *Pollution Equipment News*. Let me know if you want more details on sensors of that type.

Alternate-energy resources

Bowseretta and I were recently day hiking over at Antelope Springs, a long-abandoned hippie commune. Besides the obligatory rusting VW microbus shells, the ruins of dozens of alternate-energy experiments seemed strewn about. There were octagon earth-sheltered houses, a sauna and hot-tub combo lovingly crafted from the native stone, the broken *Savonious* windmill rotors, countless cracked batteries, and various solar stills.

At least one of those stills must have been a monumental disaster, since the evaporator and the condenser were both designed to operate at the same temperature and

continued on page 72

AUDIO UPDATE

Is sound quality a matter of taste?

LARRY KLEIN,
AUDIO EDITOR

IN MY LAST COLUMN I DISCUSSED some of the strange beliefs that in the past linked sound preferences to the nationality of the listeners. Philosophically, such a position is part of a larger view that holds that any preference for a particular sound balance is simply a matter of taste. Some home listeners like a "rich, mellow sound" with lots of upper-bass emphasis, others prefer a "clear, distinct sound" with the balance tilted toward the upper frequencies, and still others prefer a sound with lots of "presence"—meaning upper-midrange emphasis. And, of course, there are those strange individuals (such as myself) who tend to prefer the sound of systems that during objective tests show a wide and flat frequency response.

You may have noticed that all my comments have related sound quality to frequency response. I don't mean to imply that frequency response is the only factor that determines a component's sound quality, but when an amplifier or speaker is not being over-driven (or suffering from some internal fault) frequency response differences *are* responsible for perhaps 95% of the "quality" differences heard between audio products.

Don't just take my word for it. If you have a 10-band equalizer as part of your system you can demonstrate for yourself how easy it is to add (or subtract) such subjective audio qualities as openness, air, solidity, detail, warmth, body, and so forth. Depending on the frequency bands involved, a change of only 2 or 3 dB in slider position can have an enormous effect on the "quality" of the sound you're hearing.

Does everyone hear differently?

It's true that no two pairs of ears respond identically. But it's also true that everyone is listening to the same objective sonic reality, and that there is a more-or-less-direct correspondence between the objective world of sound and the impression it makes on our auditory apparatus. For example, if you were to shred this issue's Reader Service card in an operating electric fan it would create a specific sound. If you were able to make a perfect recording of that sound and play it back through a perfect sound system, everyone would agree that the original and recorded sounds were identical. That agreement should hold despite possible differences in sonic taste—or in the acuity of their ears. In other words, whatever aberrations exist in a person's hearing, within his limitation he should be able to tell when the sonic properties of two audio systems are alike. And ultimately—by definition—*reproduced* sound should be referenced to some original.

So why do many speaker systems in the same general price range sound different from each other? (Incidentally, the situation has vastly improved during the 35 years or so that I've been evaluating speakers. The differences in tonal quality heard among today's best speaker systems are quite small; similar in nature and amplitude to what you might hear in different seats in a good concert hall.) As I discussed last month, for many years most of the major Japanese designers appeared convinced that speakers should be designed to taste. I thought a breakthrough had occurred in the early 1970'a when I was invited to Japan to see, among other things, a new computer-assisted speaker-evaluation setup.

Computerized Evaluation

Visualize, if you will, a large, acoustically neutral listening room. On a slightly raised dais at the front is a stage with several speaker systems positioned on the periphery of a large, electrically driven "lazy Susan." One speaker is always at stage-center position. A push of a button rotates the assembly until the next speaker in line is centered. On the arm rest of each of forty audience chairs is a small box with a pilot light and seven pushbuttons labeled, respectively, -3, -2, -1, 0, +1, +2, and +3.

During the evaluations, an acoustically transparent curtain conceals the speakers, and the speaker-positioning button is pressed to bring one of the now-hidden speakers into playing position. After a few moments of light-classical program material, the button is pressed again, a different speaker moves into playing position, and the program material is repeated. The pilot light on our individual response boxes then lights up, and the audience is instructed to push one of the numbered buttons to indicate the degree of our preference between the first and the second speakers. Pushing the zero indicates no preference, pushing a plus number indicates how much more you like the second speaker than the first, and pushing a minus number would show how much less you like it.

I must confess that I didn't care for the sound produced by *any* of the speakers, so I was hard pressed in each case to pick the lesser of the two evils. Where did the computer come in? It simply tabulated the results. The pushbutton data from the audience response boxes was fed to the computer, which provided an instantaneous readout on how many listeners preferred which speakers, to what degree, and—in the full-scale tests—with what kind of music. (Incidentally, my hosts also believed that different speaker sound qualities were desirable depending upon whether one preferred classical, pop, or rock music.)

LARRY KLEIN IN THE SPEAKER ROOM in the Sato Musen showroom in Akihabara, Tokyo.

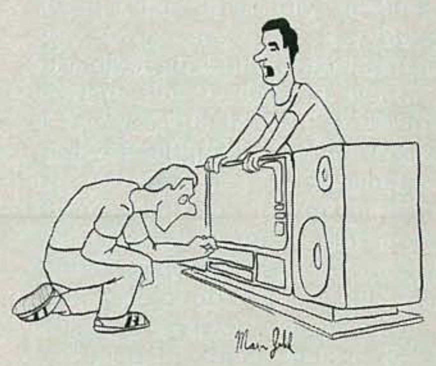
I asked who normally filled the chairs during an evaluation session, and it was carefully explained to me that since the goal was to design speaker systems that would appeal to a large cross-section of the public, the audience was carefully chosen to be representative of that cross-section. Women from the assembly line, maintenance men, clerical workers, and so forth all had their chance to push buttons. During repeated tests the designs were modified until the sound quality satisfied most of the listeners. I found it paradoxical that this *vox populi* approach to speaker design was backed up by a laboratory with more and better instrumentation than I had ever seen in any U.S. lab.

The bottom line

Today, it is evident that most U.S., and some Japanese, audio companies reject the notion that speaker design is a matter of taste. Many years ago I was told by the head of the Swedish Broadcasting System that when they set out to reequip all their studios with new monitors, the Yamaha NS-1000's won out over dozens of European and U.S. competitors during blind listening tests. That didn't particularly surprise me, since at the time I was using a pair of the Yamaha NS-1000's at home. I had chosen them because of their compact size and clean, flat, uncolored response.

Keep in mind that any speaker that has a sonic characteristic of its own will add that quality to whatever material is being reproduced. There are undoubtedly special circumstances when the sonic balance of a given recording might be enhanced by the frequency aberrations of a particular speaker. But most of the time such colorations would serve only to degrade the complex process of high-fidelity reproduction. **R-E**

Ed has yet to find a salesman who knows as much as he does.


Sure it looks great. Now I've got to build the inside.

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Let's plunge deeper into video

VIDEO TIMING RELATIONSHIPS

COLORBURST = MASTER FREQUENCY = 3.579545 MHz

$$\text{HORIZONTAL} = \frac{2 \times (\text{COLORBURST})}{455} = 15{,}734.26\ \text{Hz}$$

$$\text{VERTICAL} = \frac{2 \times (\text{HORIZONTAL})}{525} = 59.94\ \text{Hz}$$

FIG. 1

THE MORE YOU START MESSING around with video, the more jokes you hear about the NTSC standard...Never Twice the Same Color, and so on ad nauseum. Now, I'm the first to admit that it's far from being ideal, but let's also remember that the National Television Systems Committee designed the color standard more than thirty years ago and, when they did it, they had to make sure it was compatible with the black-and-white standard that came before it.

If you're old enough to remember the introduction of color TV, you might also remember some of the schemes that were proposed. If you do, you should also realize that the guys who came up with NTSC did a pretty good job. One alternative I remember had something to do with a wheel of colored gels that revolved in front of the camera. It was a mechanical nightmare and, fortunately, I've forgotten the rest of it. If any of you know more about that, or any of the other early color proposals, drop me a note and I'll pass them on to everyone.

In any event, however crazy the NTSC system seems, it's a lot better than any of the others that were proposed at the time, and no matter what else you have to say about it, it works.

The hallmark of the NTSC standard is that all of the individual signals that make up the complete waveform can be derived from one master clock—everything is locked to everything else. Before we get to the arithmetic, however, let's review some video basics and define some terms.

Fields, frames, and interlace

The NTSC standard picture we all watch and love is produced by having the electron beam paint a series of successive lines of video on the face of the TV tube. The electron beam in the tube has to make two passes in order to paint a complete picture, called a "frame," on the screen. The first pass puts out the odd-numbered lines of video and the second pass puts out the even ones. Each of those half images is called a "field." The reason for the system, called "interlace," is to reduce the amount of flicker on the screen. If all the lines were sequentially painted, the top would begin to fade before the screen was completely "painted."

The vertical scan rate is the amount of time it takes the beam to paint each field (half a frame) of video. In the black-and-white days, the vertical rate was set to match the 60-Hz power-line frequency to minimize interference on the screen. Since each field took 1/60th of a second, a full frame took twice that—or 1/30th of a second. Knowing that, and remembering that each frame of video is made up of 525 horizontal lines, we can begin to understand where the TV-signal frequencies come from.

Since it takes 1/30th of a second to paint 525 lines, the horizontal scanning frequency is 525 + x30Hz = 15.75 kHz and each line is painted in 1/15.75 kHz = 63.5 + mu sec. Those numbers were slightly modified when the NTSC

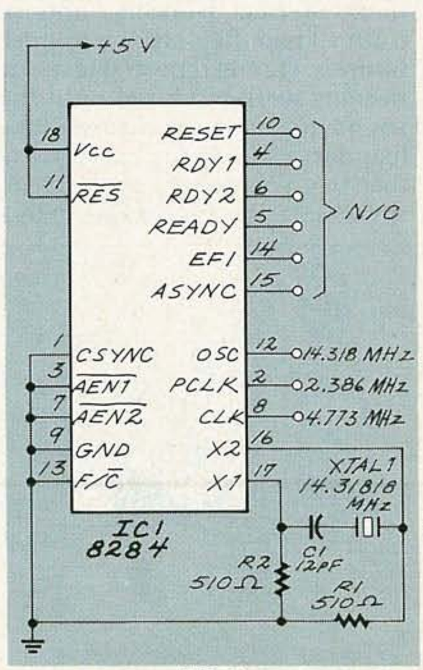


FIG. 2

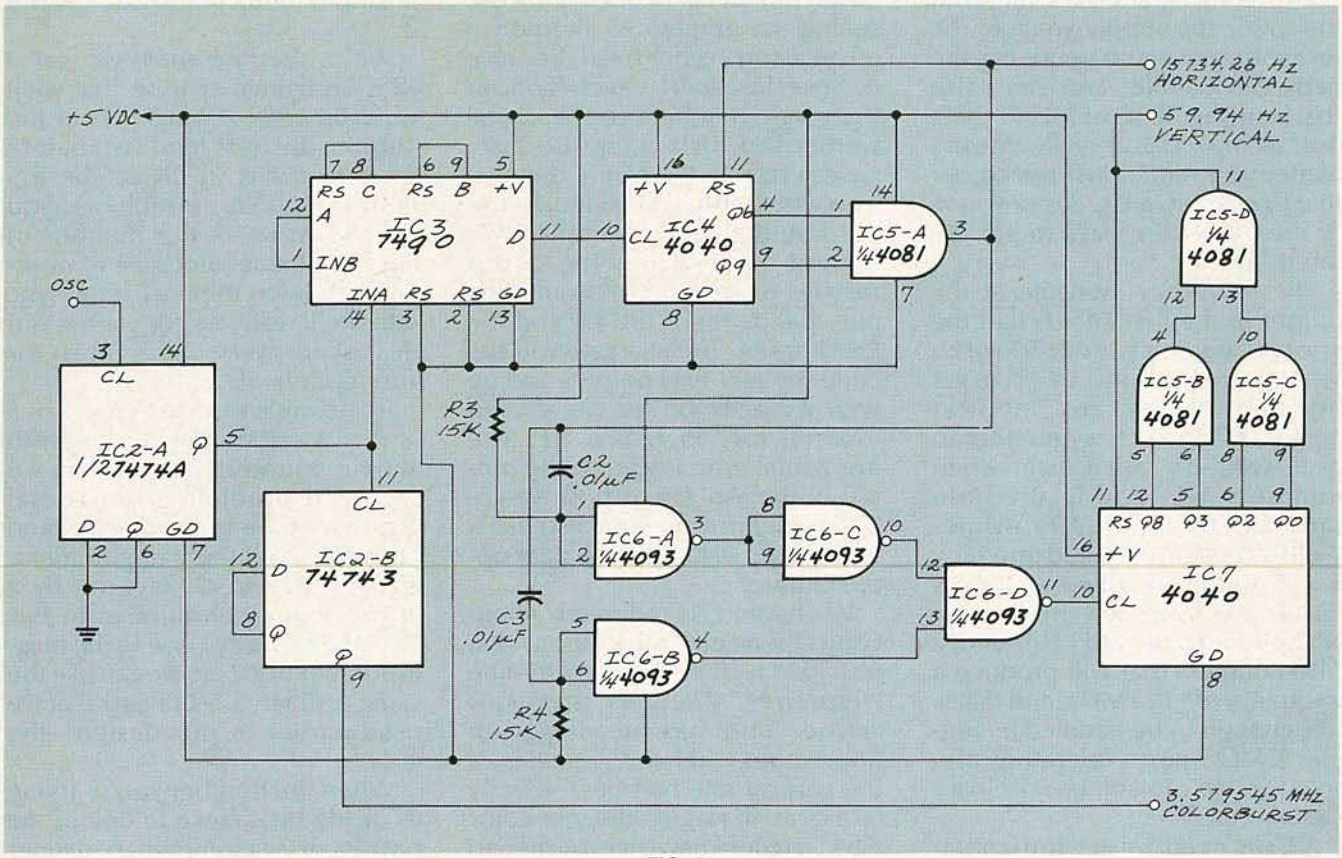


FIG. 3

color standard was developed, but the simple exercise we just went through should help you understand where the numbers came from in the first place.

The master clock for the NTSC color standard was set to be 3.579545 MHz, and all the other signals are derived from it. While the older standard used the power-line frequency and number of scan lines as the basis for the TV picture, the 1953 color standard is built around the burst frequency and a strict arithmatical relationship defined all the other frequencies.

The horizontal scan rate was defined to be the colorburst frequency multiplied by 2/455 (not exactly obvious), and when you do the arithmetic you'll wind up with 15,734.26 Hz—not as neat as the old 15,750-Hz standard, but close enough to lock the horizontal circuitry in old black-and-white TV sets.

The same sort of "close enough" results show up when you calculate the vertical frequency. Given a horizontal scan rate of 15,734.26 Hz, it follows that each line takes 63.56 microseconds, or just slightly longer than the older standard of 63.50 microseconds. Since the new color standard still contained 525 lines in each frame, the vertical frequency works out to 59.94 Hz. That's close enough to the original 60-Hz to avoid interference and still accommodate black-and-white TV sets.

A lot of you might be wondering what I have in mind when I talk about "older black-and-white TV sets." If you pay a visit to your local TV store, you'll find that it's almost impossible to buy a black-and-white TV set anymore, just as, back in 1953, when the NTSC defined the color standard, it was almost impossible to buy a color TV. Since the majority of existing TV sets were black-and-white, compatibility was the overriding issue. It's not such a big deal now but, back then, when the NBC peacock opened its tail, a lot of viewers were happy to hear the magic words "compatible color."

Generating sync triggers

Now that we've put the historical matters behind us (the important numbers and the relationships between them are summarized in Fig. 1), our job is to develop some hardware. The only circuitry we have working so far is the 8284 clock circuit shown in Fig. 2, and I've indicated the frequencies that it produces.

Getting colorburst from the circuit is easy since the OSC output is a buffered version of the crystal. A bit of simple arithmetic tells us that 14.318 MHz divided by four equals the burst frequency of 3.579 MHz. You can see from Fig. 1 that getting horizontal sync from the burst is going to take some multiplication as well as division. Since that's a real pain in the neck, we'll start our search for horizontal sync with one half OSC, rather than the burst. That way we can stick with frequency division and make things somewhat easier.

We all have our own preferences but, if you're a regular reader, you know I like to use CMOS whenever I can. In this case, however, we're going to use some TTL to do the first part of the division since the circuit is operating at 5 volts (because of the 8284). CMOS parts can certainly operate at 5 volts, but the lower the supply voltage, the lower the maximum frequency the parts can handle. You can solve that by using 74HC or 74HCT parts but, in this case, it really doesn't matter very much. Just remember that the circuit in Fig. 3 is only one of the numerous ways to get the job done.

The frequency available at the output of the first 7474 is half the crystal frequency, or 7.159 MHz. We have to divide that by 455 to get horizontal sync and, at first glance, 455 is a screwy number to deal with—it's much nicer when numbers are readily divisible rather than apparently prime. Well, 455 can be factored into 13 × 5 × 7, so the first thing we'll do is divide the frequency by 7 using what should be an old TTL friend, a 7490 counter. That will produce a frequency of 1.022 MHz, and that is low enough to be handled by regular CMOS parts operating at 5 volts. So we can still use ordinary CMOS parts.

All we need to get horizontal sync is a way to divide the resulting frequency by 13 × 5, or 65. Now, seeing the number 65 should set off an alarm in your head, because it's very close to 64, which is one of the magic numbers of the digital world. And, that being the case, we can handle the rest of the division with a 4040 CMOS binary ripple counter, and a simple two-legged gate. When the count reaches 65 in the 4040, only two pins will be high; the Q0 and the Q6 outputs. The AND gate will decode the two 4040 outputs and go high at exactly the rate we've been looking for; 15,734.26 Hz. The horizontal sync trigger at the output of the AND gate is positive-going so therefore we can also use it to reset the 4040 CMOS binary ripple counter.

We haven't talked much about vertical sync other than to say that it's close to the 60-Hz power-line frequency. Well, as they say, "close" only has meaning with horseshoes and hand grenades. If the vertical rate had been exactly 60 Hz as it was in the pre-color days, it would have been a snap to generate. Just feed a 5369AA with the burst frequency and you'll get 60 Hz out at the other end. As we saw earlier in the column, however, things aren't that simple since vertical sync has to be derived from the signals we've generated so far and the number of lines on the screen.

The NTSC standard calls for a 525-line image, but don't forget that each image is made of two interlaced fields. That means that we are going to need a vertical-sync signal after each field of video—or after every 262.5 lines of video. That's the relationship shown in Fig. 1, and that's also the design job that we have laid out in front of us.

We don't have any handy frequency available to avoid multiplication this time, so we'll have come up with a way to do it electronically, and that's exactly what we're doing with the NAND gate in Fig. 3. The first two gates, A and B, are set up as simple edge detectors. Gate A responds to the negative-going edge and gate B to the positive-going edge. If you work out the truth table on a sheet of paper, you'll see that the frequency at the output of Gate D is twice the input frequency at Gates A and B.

We're feeding the NAND gates with horizontal sync so that we'll wind up with 31,468.52 Hz at the output. The next (and last) part of the circuit has to divide the frequency by 525, which, as you should know, is the number of lines in a frame. Since we're working with twice the horizontal sync rate, we'll really be generating vertical sync every 262.5 lines—or after each field.

It's possible to factor 525 as 5 × 5 × 7 × 3 and do the division with simple counters but, just as we saw with producing horizontal sync, you have to keep your mind open when you're trying to figure an easy way to do division by a larger than usual number. In this case, 525 is pretty close to the magic number of 512, so we can use the same ordinary CMOS part that we used earlier in our design—the 4040.

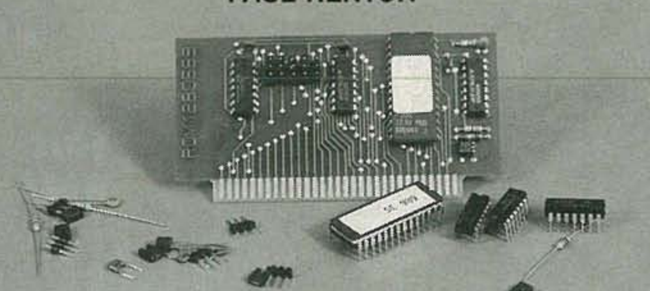
When the number you're trying to divide by is close to one of the powers of 2, a long binary divider becomes a good choice. In our case for example, we're only thirteen away from 512, and that means we only have to decode four of the 4040 outputs (525 decimal is 1 0000 1101 in binary). The job becomes even simpler since we still have three spare AND gates in the circuit. As with horizontal sync, the vertical-sync trigger is positive-going, so we're also using it to reset the 4040 binary ripple counter IC.

When you put the circuit together and power it up, you should see colorburst (3.579545 MHz), a horizontal-sync trigger at 15,734.26 Hz, and a vertical-sync trigger at 59.94 Hz. Keep in mind that the last two aren't the final signals. They're only the frequencies we need to trigger the one shots that will output pulses of the proper width to work as horizontal and vertical sync for the video that we'll be generating very shortly.

When we get together next time, we'll design the one-shots and put together a circuit that will actually produce video images. We won't be seeing an image of the Mona Lisa on the screen, but what we see will be recognizable. I promise. **R-E**

SECURE YOUR HARD DISK WITH PC ACCESS

PAUL RENTON



Computer security may seem like a problem only for large corporations or the government. However, small businesses and home computers often contain sensitive information that should be protected. For example, if you have a small business, your payroll records may not seem to be the most sensitive information in the world, but a competitor would certainly love to see them! And you wouldn't want your babysitter to boot your PC and get into your checking-account data!

There are many approaches to PC security, but the one offered here is a combined hardware/software solution. PC Access provides one master password, which enables access to the password list and to other functions, and fifteen user passwords. An EPROM on a small expansion card contains a BIOS extension that hooks PC Access into your PC's boot procedure. The circuit is simple and inexpensive to build; a kit is available for less than $35.

PC Access provides several extras, including a hold function that allows the user to suspend computer access by pressing a hotkey. The computer then idles until the correct password is entered. The hotkey combination can be configured for compatibility with various memory-resident programs. In addition, you can maintain an audit trail of who logs onto the system. The audit file is encoded, hence meaningless when viewed with a DOS TYPE command. A program provided with the kit decodes the file into ASCII format.

How it works

PC Access works by altering DOS's normal boot procedure in several ways. First, PC Access forces the system to boot from the hard drive by disabling access to floppy drive A during the boot process. Thus, you can't disable PC Access simply by booting from a floppy.

In addition, a software driver must be loaded via CONFIG.SYS and processed by DOS in the usual manner, otherwise the system will not boot. That means that you can't boot the PC by de-

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EDITOR'S WORK-BENCH

Personal Computers and the Future

I tend to spend most of my time here poking around under the hood. For a change, let's take a step back and look at things from a wider perspective. The occasion? The beginning of a new year and of a new decade. For me it's just past the first of the year, and though you won't read this for a good three months, I hope you'll find it interesting.

It's hard to believe sometimes how much this industry has grown the past decade. In the murky beginnings ten or twelve years ago, hobbyists and technically oriented people were the only ones who used personal computers. Now estimates range as high as 40 million PC users in this country alone, and obviously, the vast majority of them don't know a bit from a byte. That makes us members of a pretty elite group.

Personal computers have caught on faster than just about any other modern invention, and they have altered the way we work (and play) so drastically that, short of catastrophe, it's inconceivable that we might ever return to the way things used to be done.

However, industry growth is slowing, partially because of market saturation, and partially because those 40 million people are having trouble adjusting to what's happened so far. Many industry analysts believe that the fastest growth during the next few years is not going to be in new systems or new technologies, but in putting what we've already got to better use. In short, service and support industries are the growing segments of the computer business.

To be sure, top-notch programmers and engineers will still be needed in droves. But the strata beneath those very top levels have to be filled out as well. So if you're trying to plan out your career, think about activities like the following:

- System Integration: With the proliferation of various hardware and software "standards," people who understand the PC architecture and know how to resolve conflicts between competing hardware adapters have been and will continue to be valuable.
- Network Support: Some analysts believe that if the 1980's was the decade in which personal computers brought quality and quantity increases to individual users, the 1990's will be the decade in which those users are linked together. From the support point of view, networks represent an area with much growth potential, both for installation and for maintenance. I've never seen a network with a level of reliability approaching even 1/100th that of the PCs on which it is based. From the development point of view, networks offer virtually unlimited growth opportunities. At this point in time many companies are connecting their PC's together physically. But a lot of work still needs to be done to give some intelligence to the way they interact.
- Applications Support: Becoming an expert in a core group of applications (including just about any major word processor, spreadsheet, and database manger) will just about guarantee you gainful employment as well as a growth path in any decent company. People like to blame software for being hard to use; I believe that in many categories, the software is sufficiently easy to use (or close to it); it's the users who need to be better educated. Modern software has powerful new ways of doing things; along with that power comes the responsibility for learning how to use it. Until the time when children start studying word processing and the like on a wide scale at the grade school level, applications support personnel will continue to be necessary.
- Hardware Service: This is a negative category; jobs here will shrink. Component-level servicing has always been difficult and time consuming; as the semiconductor industry achieves greater and greater component density, and as labor costs continue to skyrocket, upper-level management will dictate that labor-intensive procedures be eliminated. This is not a new trend, but one that will certainly continue. If you want hands-on contact at the component level, figure on working in an engineering lab, either as an engineer or as a research technician. You'll need almost as much education to be the latter as the former; you'll just get paid less. So stay in school as long as you can.
- Education: There is now and will continue to be a crying need for technically competent people to join the ranks of educators. Society as a whole, however, needs to rethink the process of education, take it out of the realm of rote memorization, and bring it into the realm of interactive, self-paced, wide-area-networkable interaction that focuses on mastering processes, not just memorizing facts. Both what we teach and how we teach it are two of society's biggest questions. Education and entertainment must merge to a great extent.
- Entertainment: The rise of the video industry (VCR, cable TV, satellite TV, MTV), various technical advancements in the PC industry (the compact disk, high-resolution video, interactive adventure games, graphical operating environments), and the emerging multimedia industry all lead one to realize that people want control over their entertainment, as well as lots of variety. The television networks will never again enjoy the power they once had. Emerging technologies will allow people to buy off-the-shelf packages combining the forms of entertainment they like. Kind of like buying videotapes, but these new forms will have full motion video, still graphics, high-fidelity sound, and will be fully interactive. The technologies to do this are just now becoming available; there are no standards about how to fit it all together. All the largest computer companies (IBM, Apple, HP, and more) are investing heavily in this area; getting in on the ground floor here is guaranteed to be challenging and exciting.

If you thought the 80's were exciting, just wait. The 90's are going to be even better. CD

MathEdit

Word processing has improved enormously the past decade; it's still the most popular PC application. Users have benefited greatly from the feature wars brought on by vendors competing for the huge word processing market. However, support for editing mathematical equations is lacking from all major word processors. In fact, the only package I know of that does have an equation editor is Lotus Manuscript, which although powerful, is geared toward producing long technical documents, and is unsuited for simpler tasks.

K-Talk Communications has a solution: MathEdit. It is a text-mode program that lets you create equations interactively, and then export them in resolution-independent PostScript format, HP PCL (LaserJet), or one of several bit-mapped formats (PIX, TIFF). You can then import the file thus created into a word processor or desktop publishing program just like any other graphic. PageMaker and Ventura of course can handle that type of file; in addition, modern versions of Word, WordPerfect, and WordStar all have the ability to import such files and display them in a bit-mapped preview mode.

MathEdit comes on four 360K diskettes. You install the program simply by creating a directory on your hard disk and copying all files to it; you'll need about 1.5MB of space. Then you run the program, which takes you to a setup utility in which you specify the output file type and the program into which you'll be importing equations. (Currently, WordPerfect 5.0, Word 5.0, WordStar 5.5, TEX, and Manuscript are supported.) The version of the program that I examined (1.22B) had a lot of confusing information about setting the program up to work with HP LaserJet soft fonts, but if you choose either PostScript or a bit-mapped output format, you can ignore all that. (Also, the company will be dropping support for PCL output in version 2.0, due out about the time you read this.)

As shown in Fig. 1, MathEdit's screen is divided into three windows. System messages are displayed in the bottom window; the cursor and what you type appears in the top window. In the middle window you see a very rough approximation of what

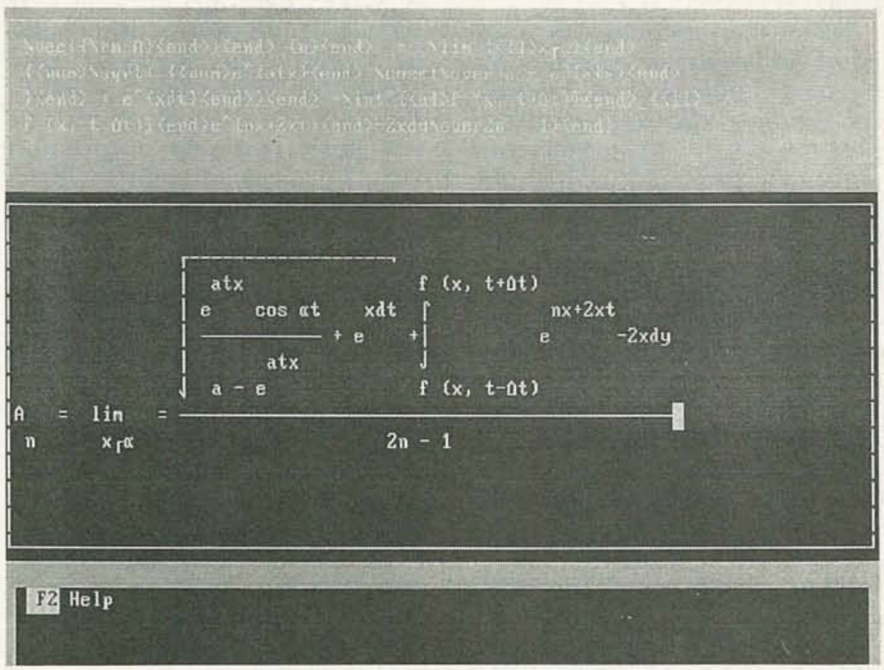

FIG. 1

your equation looks like, or if you press F2 (Help), a list of what the function keys do.

Entering an equation into MathEdit is like typing a formula into a pocket calculator that uses algebraic (not RPN) notation. You type numbers and simple functions (+, −, =, etc.) in directly; you must go through several function-key menus to enter more complicated functions (integrals, summations, roots, fractions, matrix notation, trig and log functions, vectors, "not" bars, braces, brackets, vertical bars, etc.).

You can move around the editing window using the cursor keys, Home, and End; delete characters with Del and BackSpace; and delete to end of line with Ctrl-End. As you type, the middle window provides a rough approximation of your equation. MathEdit also contains a graphic preview mode that provides a more accurate representation of

HARDWARE HACKER

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pressure. Oh well. I guess an awful lot of dreams died here...somewhere along the way.

On the other hand, the solar-pump factory down the street is bursting at the seams with new activity. It seems a dose of reality has at long last caught up with alternate energy. The old order fadeth.

So, where does that leave us? What are the key hardware-hacker alternate-energy resources for the nineties? This month's resource sidebar gives us a clue or two.

The very core of today's alternate energy appears to be a funky little magazine known as *Home Power.* Besides its no-nonsense shirt-sleeves tech articles, that gem is full of ads from all of the leaders in the field. Cost is around $6 per year.

Still at the same old stall is the good old *Whole Earth Review,* the ongoing continuation of the original *Whole Earth Catalog* and its progeny. Of the 497 magazines I personally subscribe to, that one is number two, right up there behind *MAD.* Nothing else even comes remotely close. Today the WER folks are heavy into CD ROM distribution and their major alternate-lifestyle BBS system widely known as *The Well.*

While both *Mother Earth News* and *Popular Science* have lots of useful alternate-energy stuff in them, there is a key difference. PS will admit that they have contacted a terminally incurable case of *Yuppus dementus,* while MEN does not.

I've found that *HVAC News,* a free air-conditioning trade journal, also has a surprising amount of the alternate-energy stuff in it.

Although most of the other solar and wind magazines have folded, *Solar Energy* remains as one useful, but highly technical resource.

The feds have bunches of alternate-energy info available, spread over a dozen agencies. The Department of Energy often sponsors seminars and technical-paper presentations. So does the National Bureau of Standards. Try any large

continued on page 76

$$\vec{A}_n = \lim_{x \to \alpha} = \frac{\sqrt{\frac{e^{atx}\cos\alpha t}{a - e^{atx}} + e^{xdt}} + \int_{f(x,t-\Delta t)}^{f(x,t+\Delta t)} e^{nx+2xt} - 2x\,dy}{2n-1}$$

FIG. 2

the equation. I found that the graphic preview mode didn't always work correctly; the company stated that the bugs won't be fixed in the current version, because 2.0 will operate entirely in a WYSIWYG (what you see is what you get) graphics mode.

After you've got your equation the way you want it, you save it. The program actually saves two versions of the file: one, which contains the master data, has the extension EQU; the other, which contains the desired output format, has the appropriate extension (PIX, TIF, EPS, etc.). If you're set up for PIX output and decide at a later time that you need PostScript (EPS) files—no problem. Just run the setup routine and select the new output format. Then reload and resave the desired equation.

At that point you can fire up your word processor and follow its normal procedure for importing a graphic file. I tested MathEdit with WordStar 5.5, which actually uses Inset for graphics display and printing, and had no problem. If you wanted to get really fancy, you could use Inset to touch up the PIX file created by MathEdit. However, as shown in Fig. 2 (an actual size, unretouched equation printed by WordStar and Inset on an HP LaserJet Series II), you probably won't need to.

To really polish the appearance of your equation, you can enter thin and wide spaces. You can also align a group of equations on a character (the equal sign, for example), and you can number equations. In addition, a number of special characters and symbols are mapped to various Alt- and Ctrl-key combinations. For example, most common Greek characters are mapped to Alt-A–Alt-Z, and many common mathematical symbols are mapped to Ctrl-A–Ctrl-Z. Because of display limitations, you'll need an EGA, VGA, or Hercules Graphics Card Plus (with RAMfont) to view the symbols in the text-mode screen. You can re-map the special characters to different key combinations, but you can't define your own special symbols. However, version 2.0 is supposed to correct that deficiency.

All in all, MathEdit is darned handy for anyone in school or anyone who has to publish documents with equations. The current version is good; I expect version 2.0 to be great! **CD**

ITEMS DISCUSSED

• MathEdit ($199.95), K-Talk Communications, 30 West First Avenue, Suite 100, Columbus OH 43201. (614) 294-3535.

CIRCLE 30 ON FREE INFORMATION CARD

PC ACCESS

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leting the software driver or by changing the contents of CONFIG.SYS. Thus it is impossible to gain access to a secured PC without removing the PC Access card.

Further, PC Access locks out the use of the Ctrl and Alt keys on the PC keyboard, so pressing Ctrl-C or Ctrl-BREAK will not halt the boot process.

Additionally, some computers have monitor or setup functions that can be accessed before DOS has booted. Those setup routines are typically entered by pressing some combination of Ctrl, Alt and some other key. Locking out Ctrl and Alt provides a means to prevent unauthorized access to those functions during boot.

At boot time, PC Access's device driver (SECURITY.BIN) prompts the user for a password and optionally for a user ID as well. The passwords and user ID's are stored in an encoded form inside the device driver. If no valid password is entered in three attempts, access to the computer is denied until it is rebooted. A new password prompt appears each time the computer is rebooted.

After a valid password has been entered, the device driver restores access to drive A, re-enables use of the Ctrl and Alt keys, and returns control to DOS so that it can execute the remaining CONFIG.SYS commands and give user access to the PC.

DOS's boot sequence

When an IBM (or compatible) PC executes its power-up routines, one chore is to search for BIOS extensions. The extensions are located in memory segments C000h through EFFFh. The BIOS searches that area in 2K steps, looking for the two-byte sequence, 55h AAh. If the BIOS finds that "signature," it then assumes that the next byte contains the length (in 512-byte chunks) of the routines contained in the ROM. Next the BIOS computes a checksum on the area described. The checksum must be zero for the extension to be recognized. Once the extension is recognized, the computer executes a far call to the fourth location in the ROM. That call is provided so that the ROM can perform any required initialization. The initialization routine should exit with a far return. The BIOS then continues searching for other extensions. Once all of the legal addresses have been searched, DOS is booted.

Part of DOS's boot procedure is to load the CONFIG.SYS file that is stored in the root directory, and perform any setup and configuration functions specified in the file. One advantage of using a device driver to request user passwords is that the passwords and user ID's can be stored inside the device driver rather than in the EPROM. Circuit cost and complexity would increase if that information were stored in EEPROM.

The software included in the PC Access EPROM sets up a new interrupt handler for floppy- and hard-disk access. The new routine allows DOS to boot from the hard drive, but not from drive A. A second interrupt is established that intercepts scan codes from the keyboard and disables the Ctrl and Alt keys.

Circuit details

The PC Access EPROM is mapped into an 8K slot in the PC's address space somewhere between C000H and EFFFH. As shown in Fig. 1, decoding the desired address is accomplished with a 74LS30 eight-input NAND gate (IC1) and a 74LS04 inverter (IC2). When all eight NAND-gate inputs are high, then the output will be low; otherwise, the output will be high. A low output enables the EPROM's chip select ($\overline{CS}$) input (pin 20).

The address that is actually de-

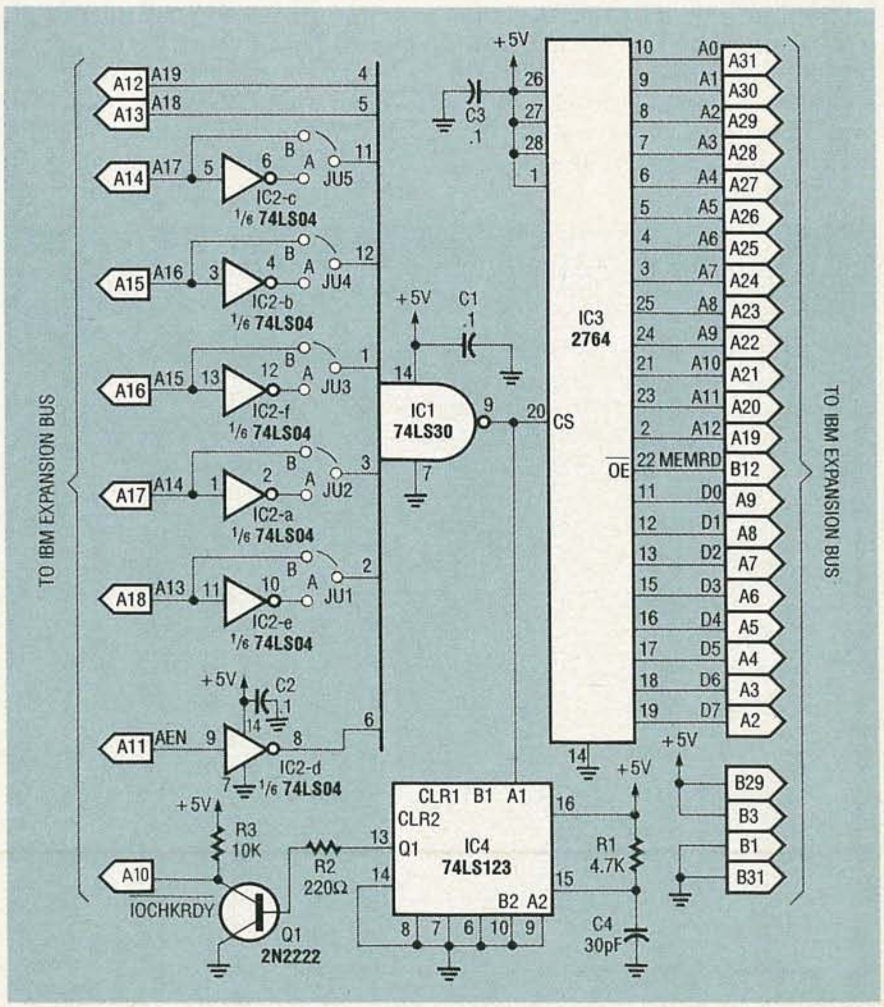

Fig. 1. PC ACCESS SCHEMATIC: IC1 and IC2 decode the 8K block where EPROM IC3 resides. The one-shot (IC4) and associated components extend the memory access cycle, thereby allowing slow EPROM's to be used.

coded is determined by the positions of five address-select jumpers, which are connected to address lines A13–A17. The jumpers determine whether the true or the inverted address lines from the expansion bus are routed to IC1. When a line goes directly to IC1, that line must be a high for the chip-select signal to occur. When the inverted address line is used, it must be a low.

Address lines A18 and A19 drive IC1 directly, because both will be high whenever an address greater than or equal to C0000 is accessed. The A13–A17 lines further decode the address; any available 8K slot from C0000–EE000 may be used. Jumper settings and corresponding addresses are shown in Table 1.

The AEN signal from the expansion bus shows whether the address and data busses are currently being controlled by the microprocessor or by the 8237 direct memory access (DMA) controller. The PC Access EPROM should be enabled only when the microprocessor is controlling the bus, so an inverted version of AEN is routed to IC1.

Data and address lines to the EPROM are connected to the corresponding data and address lines from the expansion bus. The EPROM's output enable ($\overline{OE}$) is provided by the memory read ($\overline{MEMRD}$) signal from the bus.

The 74LS123 is a one-shot that provides a 150-ns pulse at its Q1 output (pin 13) each time the EPROM is selected (i.e., each time $\overline{CS}$ goes low). The output of the one-shot drives Q1, a 2N2222 NPN transistor, which pulls low the expansion-bus signal $\overline{IOCHKRDY}$. That signal is used to insert a wait state into the memory access cycle, and is used to allow slow EPROM's to be used on a fast bus. Slow EPROM's (250 ns) are easier to buy and less expensive than fast (150 ns) ones.

Power for the card is obtained directly from the expansion bus.

Construction

The hardest part of construction is fabricating the PC board. If you want to build your own PC board, foil patterns are shown in PC Service. You can also purchase a prefabricated PC board from the source shown in the Parts List. The commercial PC board has plated-through holes and gold-plated edge connections.

If you make your own board, remember that it's double-sided, so the wires must be soldered on both sides of the board.

After buying or building a board, install the components as shown in Fig. 2. The order of installation is not critical. Just keep polarities straight, and check your work carefully for shorts and opens before installing the board in your PC.

A socket may or may not be necessary for the EPROM. If you

TABLE 1—JUMPER SETTINGS

	JU1	JU2	JU3	JU4	JU5
C000	A	A	A	A	A
C200	B	A	A	A	A
C400	A	B	A	A	A
C600	B	B	A	A	A
C800	A	A	B	A	A
CA00	B	A	B	A	A
CC00	A	B	B	A	A
CE00	B	B	B	A	A
D000	A	A	A	B	A
D200	B	A	A	B	A
D400	A	B	A	B	A
D600	B	B	A	B	A
D800	A	A	B	B	A
DA00	B	A	B	B	A
DC00	A	B	B	B	A
DE00	B	B	B	B	A
E000	A	A	A	A	B
E200	B	A	A	A	B
E400	A	B	A	A	B
E600	B	B	A	A	B
E800	A	A	B	A	B
EA00	B	A	B	A	B
EC00	A	B	B	A	B
EE00	B	B	B	A	B

Note: A refers to an inverted address line and B refers to a non-inverted address line.

Parts List

Resistors

All resistors are ¼-watt, 5%, unless otherwise noted.

R1 .... *4700 ohms*
R2 .... *220 ohms*
R3 .... *10,000 ohms*

Capacitors

C1–C3 .... *0.1 µF disc or monolythic*
C4 .... *30 pF disc*

Semiconductors

IC1 .... *74LS30 8-input NAND gate*
IC2 .... *74LS04 hex inverter*
IC3 .... *2764 EPROM*
IC4 .... *74LS123 dual retriggerable monostable multivibrator*
Q1 .... *2N2222 NPN transistor*

Other components

JU1–JU5 .... *3-pin header with shunt jumper*

Ordering Information

The following are available from
Renton Products
P.O. BOX 16271
Seattle, WA 98116
(206) 682 7341

Etched and drilled PC Board with gold-plated fingers .... $14.

Complete kit of parts (including programmed EPROM and software on 5¼ inch diskette) .... $34.

Assembled and tested units .. $59.

Please add $3 S/H to each order. WA residents add 8.1% sales tax.

just want to use the board for security, you may want to solder the EPROM to the board. But you could use the board to prototype your own ROM BIOS extensions, in which case you'd want to use a socket.

Installation

All of the software for PC Access, including a burned EPROM and a copy of the binary file for burning your own EPROM, comes with the kit of parts. (A hex dump of the EPROM is shown in Listing 1.) The software is also available on the RE-BBS (300/1200 8N1, 516-293-2283) in a self-extracting ZIP file called PCACCESS.EXE. You'll need about 160K of disk space to decompress the file.

The general procedure for installing PC Access is to copy all files to the root directory of the boot drive, add a line to CONFIG.SYS, set the card's address, and then install it.

The easiest way to install the software is to log onto your boot drive (C in most cases), place the distribution diskette in drive A, type *A:INSTALL*, and then press Enter. Doing so runs a batch file that copies all files into the root directory of drive C, and also makes the needed change to CONFIG.SYS. If you wish to install the software yourself manually, copy SECURITY.BIN and the *.COM files into the root directory. Then add the following line to your CONFIG.SYS file:

DEVICE=SECURITY.BIN

That must be the first line in CONFIG.SYS; do not put any spaces in the line. In addition, don't rename SECURITY.BIN.

The card has five jumpers that determine the address at which the EPROM resides. The default (factory) setting is D8000h, which should be fine for most systems. If there is a conflict, the computer system may not boot. If there are any problems, remove the card and select a new address using Table 1.

After configuring the jumpers, park your hard drive and turn the computer off. Then install the card in any empty slot.

With the card and the software installed, turn the computer on.

```
Listing 1--PC ACCESS EPROM CONTENTS

000000  55 AA 03 FA 8C CA 8E DA BA 00 00 8E C2 BF FF 01
000010  B0 EA 26 88 05 BF 4C 00 BE 00 02 26 8B 05 26 89
000020  04 47 47 46 46 26 8B 05 26 89 04 BF 04 02 B0 01
000030  26 88 05 BF 4C 00 B8 08 04 26 89 05 47 47 8C C8
000040  26 89 05 BF 24 00 BE 10 02 26 8B 05 26 89 04 47
000050  47 46 46 26 8B 05 26 89 04 BE 0F 02 B0 EA 26 88
000060  04 BF 24 00 B8 A6 04 26 89 05 47 47 8C C8 26 89
000070  05 FB B8 01 02 BB 00 00 B9 00 30 8E C1 B9 01 00
000080  BA 80 00 CD 13 BA 00 30 8E DA C7 06 27 10 00 00
000090  C7 06 29 10 00 00 C7 06 2B 10 00 00 C7 06 39 10
0000A0  00 00 BF BE 01 8A 05 3C 80 74 09 8B C7 05 10 00
0000B0  8B F8 EB F1 47 8A 05 8A F0 B4 00 A3 00 10 47 8A
0000C0  05 8A C8 B4 00 A3 02 10 47 8A 05 8A E8 B4 00 A3
0000D0  04 10 B8 01 02 BB 00 30 8E C3 BB 00 00 B2 80 CD
0000E0  13 BA 00 30 8E DA BF 0B 00 BE 06 10 B9 13 00 8A
0000F0  05 88 04 47 46 E2 F8 8B 0E 04 10 8B C1 F7 26 15
000100  10 8B D8 8B 0E 00 10 8B C1 F7 26 13 10 03 C3 8B
000110  D8 8B 0E 02 10 8B C1 03 C3 A3 19 10 8A 1E 0B 10
000120  8A C3 B4 00 F7 26 11 10 8B 1E 19 10 03 C3 A3 1B
000130  10 8B 1E 0C 10 8B C3 D1 E8 D1 E8 D1 E8 D1 E8 25
000140  FF 0F 8B 1E 1B 10 03 C3 A3 33 10 48 A3 1D 10 8B
000150  1E 15 10 8B C3 F7 26 13 10 A3 1F 10 8B 1E 1B 10
000160  8B C3 48 A3 31 10 FF 06 31 10 8B 1E 31 10 8B C3
000170  3B 06 1D 10 76 03 E9 BC 00 8B C3 BA 00 00 F7 36
000180  1F 10 A3 21 10 8B C2 BA 00 00 F7 36 13 10 A3 23
000190  10 8B C2 05 01 00 A3 25 10 8B 1E 25 10 8A CB 8B
0001A0  1E 21 10 8A EB 8B C3 D1 E8 D1 E8 24 C0 0A C8 8B
0001B0  1E 23 10 8A F3 B2 80 BB 00 30 8E C3 BB 00 00 B8
0001C0  01 02 CD 13 BE 00 00 8B C6 3D 00 02 75 03 EB 62
0001D0  90 56 BF D5 03 8C CB 8E C3 B9 0B 00 8A 04 26 3A
0001E0  05 75 1B 46 47 E2 F5 C7 06 27 10 FF FF 5E 56 8B
0001F0  C6 05 1A 00 8B F0 8B 04 2D 02 00 A3 2D 10 5E 56
000200  BF E0 03 B9 0B 00 8A 04 26 3A 05 75 1B 46 47 E2
000210  F5 C7 06 29 10 FF FF 5E 56 8B C6 05 1A 00 8B F0
000220  8B 04 2D 02 00 A3 35 10 5E 8B C6 05 20 00 8B F0
000230  EB 95 E9 31 FF 90 8A 1E 08 10 8B C3 B4 00 F7 26
000240  2D 10 8B 1E 33 10 03 C3 A3 2F 10 8B D8 BA 00 00
000250  F7 36 1F 10 A3 21 10 8B C2 BA 00 00 F7 36 13 10
000260  A3 23 10 8B C2 05 01 00 A3 25 10 8B 1E 25 10 8A
000270  CB 8B 1E 21 10 8A EB 8B C3 D1 E8 D1 E8 24 C0 0A
000280  C8 8B 1E 23 10 8A F3 B2 80 BB 00 30 8E C3 BB 00
000290  00 B8 01 02 CD 13 BE 00 00 BF EB 03 8C CB 8E C3
0002A0  BB 00 30 8E DB B9 15 00 8A 04 3C 61 72 06 3C 7A
0002B0  77 02 2C 20 26 3A 05 75 0A 46 47 E2 EB C7 06 2B
0002C0  10 FF FF 8A 1E 08 10 8B C3 B4 00 F7 26 35 10 8B
0002D0  1E 33 10 03 C3 A3 37 10 8B D8 BA 00 00 F7 36 1F
0002E0  10 A3 21 10 8B C2 BA 00 00 F7 36 13 10 A3 23 10
0002F0  8B C2 05 01 00 A3 25 10 8B 1E 25 10 8A CB 8B 1E
000300  21 10 8A EB 8B C3 D1 E8 D1 E8 24 C0 0A C8 8B 1E
000310  23 10 8A F3 B2 80 BB 00 30 8E C3 BB 00 00 B8 01
000320  02 CD 13 B8 00 30 8E D8 8C C8 8E C0 BE 0A 00 BF
000330  00 04 B9 08 00 8A 04 26 3A 05 75 0A 47 46 E2 F5
000340  C7 06 39 10 FF FF 90 8B 1E 27 10 0B DB 75 03 EB
000350  23 90 8B 1E 29 10 0B DB 75 03 EB 18 90 8B 1E 2B
000360  10 0B DB 75 03 EB 0D 90 8B 1E 39 10 0B DB 75 03
000370  EB 02 90 CB B4 0F CD 10 24 7F B4 00 CD 10 B4 02
000380  B7 00 BA 00 02 CD 10 8C CA 8E DA BF A5 03 8A 05
000390  0A C0 74 0F 57 1E B4 0E B7 00 B3 07 CD 10 1F 5F
0003A0  47 EB EB EB FE 41 43 43 45 53 53 20 44 45 4E 49
0003B0  45 44 20 2D 2D 2D 20 49 4D 50 52 4F 50 45 52 20
0003C0  53 59 53 54 45 4D 20 43 4F 4E 46 49 47 55 52 41
0003D0  54 49 4F 4E 00 43 4F 4E 46 49 47 20 20 53 59 53
0003E0  53 45 43 55 52 49 54 59 42 49 4E 44 45 56 49 43
0003F0  45 3D 53 45 43 55 52 49 54 59 2E 42 49 4E 0D 0A
000400  50 38 32 58 5A 5A 43 56 80 FC 00 75 25 80 FA 00
000410  75 20 50 52 1E 57 BA 00 00 8E DA BF 04 02 8A 05
000420  3C 01 74 03 EB 08 90 5F 1F 5A 58 EB 0A 90 5F 1F
000430  5A 58 EA FF 01 00 00 50 53 51 52 1E 06 57 56 55
000440  FB B4 0F CD 10 24 7F B4 00 CD 10 B4 02 B7 00 BA
000450  00 02 CD 10 BF 8C 04 8C CA 8E DA 8A 05 0A C0 74
000460  0C 57 B4 0E BB 00 01 CD 10 5F 47 EB EA 5D 5E 5F
000470  07 1F 5A 59 5B 58 57 83 C4 06 8B FC 36 8B 05 0D
000480  01 00 36 89 05 83 EC 06 5F B4 80 CF 44 72 69 76
000490  65 20 41 20 41 63 63 65 73 73 20 44 65 6E 69 65
0004A0  64 20 0D 0A 0A 00 1E 52 57 50 BA 00 00 8E DA BF
0004B0  04 02 8A 05 0A C0 74 09 BF 17 04 8A 05 24 F3 88
0004C0  05 58 5F 5A 1F EA 0F 02 00 00 FF FF FF FF FF FF
0004D0  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0004E0  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0004F0  9B FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
000500  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
 . . .
 . . .   The rest of the EPROM consists of FF's
 . . .
001FF0  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
```

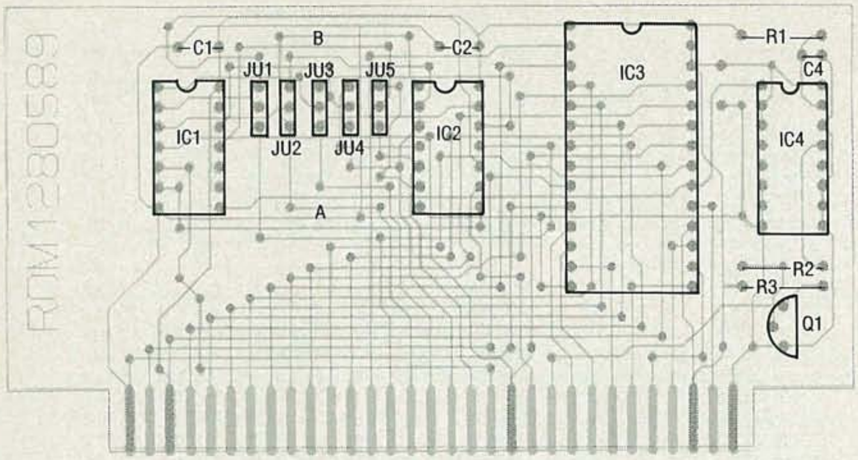

Fig. 2. *PARTS AND JUMPER LOCATIONS. Mount all components as shown here. Table 1 shows how to configure the jumpers for various addresses.*

If all has gone well, any floppy disk in drive A will be ignored and you will be prompted for a password. The default master password is SECURITY. You can change the master password and the user passwords with LOCK.COM, and individual passwords with CHANGE.COM.

To uninstall the security system, delete the DEVICE = SECURITY.BIN line from CONFIG.SYS, park the hard drive, turn the computer off, and remove the card.

Software

What follows are brief descriptions of the PC Access utility programs. LOCK.COM and CHANGE.COM are provided to establish the passwords and user ID's. A user can alter his or her own password using CHANGE; the system administrator can use LOCK to change the master password, any user ID, and any user password. You can optionally require users to type in both the user ID and the password each time the system boots. But even if you don't require the user ID to be typed in, the audit trail will log it.

HOLD.COM allows a user to suspend computer access until the correct password is entered. HOTKEY establishes what key combination triggers the hold function. HOLDOFF.COM removes HOLD.COM from memory.

The FINDROMS program helps locate a free segment in high memory. It searches for the 55AA pattern that signifies a BIOS extension, and reports on any that it finds.

TRAIL.COM can be executed by AUTOEXEC.BAT to record user ID, access date, and access time. TRAIL should be one of the first programs in AUTOEXEC.BAT (after running any programs needed to update time and date from a real-time clock).

The audit file (a hidden system file) can be decoded by use of AUDIT.COM, as follows:

AUDIT Filename

After you hit the RETURN key, AUDIT will prompt the user for the master password. After the password is entered correctly, AUDIT will decode audit trial entries from the encoded file and append them to the specified file. If no file exists with the given filename, a new file will be created. The audit trail will then be cleared of entries. This function works even if user ID's are not required for system access.

Conclusion

PC Access is inexpensive, easy to build and install, yet nonetheless provides a significant deterrent to unauthorized access to your hard drive.

Additionally, the PC Access circuit board can be used to develop other ROM extensions. Not only does the PC Access give you an inexpensive way to protect your computer, it also provides an excellent flat form that allows you to learn more about how your computer works. ◆CD◆

HARDWARE HACKER

continued from page 72

technical library that has a government documents section.

One fed document I've found most useful is the *Stand-Alone Photovoltaic Systems—The Handbook of Recommended Design Practices*. It's available through *Sandia National Laboratories.*

There are lots of distributors of alternate-energy products. One of the largest is *Real Goods,* who also offer a 320-page alternate-energy sourcebook for $6.50. Their competitors include *Photocomm Inc,* the *Energy depot, Yellowjacket Solar,* and *Snow Belt Solar.* Get their catalogs.

Two establishment associations that have useful resource availability include the *Solar Energy Research Institute* and the *Association of Energy Engineers.* Write for their literature and service lists.

The leading manufacturers of solar panels include *Arco Solar, Solarex, Solec,* and *Solvonics.* Two windpower sources include *Bergey Windpower* and *Southwest Windpower.*

Finally, two of the alternate-energy "good guys" definitely include Steve Baer of *Zomeworks,* who is heavy into solar trackers and energy management; plus Jim Allen of *SolarJack,* who specializes in higher efficiency solar pumps and controllers.

New tech literature

Texas Instruments has released their three volumes of Linear Circuits data books.

TI also has free samples of all their new OTP (one time programmable) EPROM's. They work like a "real" EPROM, except that they are in a cheaper plastic case and can only get programmed one time. You use them for repeat copies of known-good code.

From *NEC,* the *Digital Signal Processor and Speech Processor* data book. And from *Silicon Systems,* a *Microperipheral Products Data Book* that covers chips used in floppy disks, hard disks, and cassette tapes.

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continued on page 83

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TUBES: "oldest," "latest." Parts and schematics. **SASE** for lists. **STEINMETZ,** 7519 Maplewood Ave., RE, Hammond, IN 46324.

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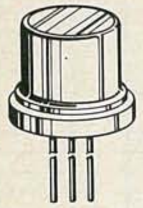

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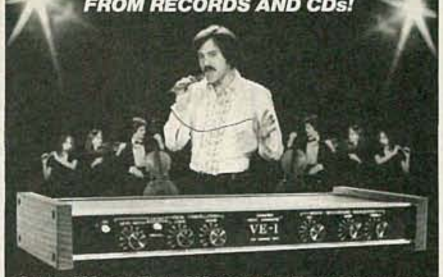

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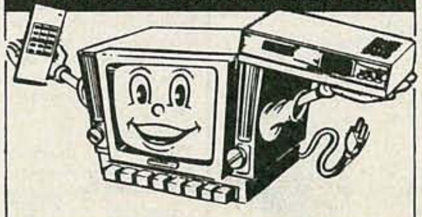

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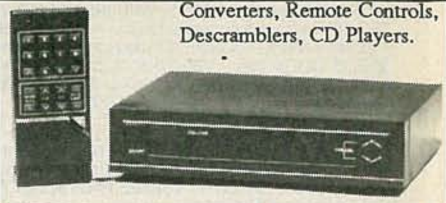

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HARDWARE HACKER

continued from page 76

cludes a *Generic Array Logic Demo* through *SGS-Thomson* and a *CUPL* demo disk from *Logical Devices*. Included here is a *My First PAL Design* booklet.

Tektronix has a new and free *Scope Evaluation Kit* available that includes a test circuit board which purposely generates overshoots and hard-to-see glitches. They also have several free oscilloscope videotapes available. Surprisingly cheap ($3.95) analog hygrometer humidity instruments are available from *Klockit*.

Turning to other mechanical stuff, *Stock Drive Products* has a new data book and master catalog available on such things as gears, belts, couplings, robotics, breadboards, and such.

To improve the appearance of your prototypes, the *DonJer* folks have low-cost "instant suede" applied via liquid glop and a cabbage duster. 28 colors are available, as is a $52 professional starter kit.

Yet another reminder here that the *Midnight Engineering* is a great new hacker magazine aimed at all of your small-scale hardware and software productions. Free samples are available by special arrangement.

Turning to my own stuff, for the fundamentals of microprocessors and microcomputers, check into my *Micro Cookbooks*, volumes I and II. I also have a new and free mailer for you that includes dozens of insider and top hardware-hacking secret sources. Write or call for a copy. **R-E**

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2MEGKIT*	IBM PS/2	100ns 1MEG x 9 SIMM (2 each)	369.95
41256A9A-10	262,144x9	100ns 256K x 9 SIP (Has Leads)	44.95
41256A9B-80	262,144x9	80ns 256K x 9 SIMM	49.95
421000A8B-10	1,048,576x8	100ns 1MEG x 8 SIMM	109.95
421000A9A-80	1,048,576x9	80ns 1MEG x 9 SIP (Has Leads)	124.95
421000A9B-80	1,048,576x9	80ns 1MEG x 9 SIMM	119.95

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7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7474	.39	.29
7402	.29	.19	7475	.49	.39
7404	.29	.19	7476	.45	.35
7405	.35	.25	7483	.59	.49
7406	.39	.29	7485	.65	.55
7407	.39	.29	7486	.45	.35
7408	.35	.25	7489	2.25	2.15
7410	.29	.19	7490	.49	.39
7411	.35	.25	7493	.45	.35
7414	.49	.39	7495	.59	.49
7416	.35	.25	74107	.29	.19
7417	.35	.25	74121	.39	.29
7420	.29	.19	74123	.49	.39
7427	.29	.19	74125	.49	.39
7430	.29	.19	74147	1.99	1.89
7432	.39	.29	74150	1.35	1.25
7438	.39	.29	74151	.39	.29
7442	.49	.39	74154	1.35	1.25
7445	.75	.65	74161	.69	.59
7446	.89	.79	74174	.59	.49
7447	.89	.79	74175	.59	.49
7473	.39	.29	74193	.79	.69

74LS

74LS00	.26	.16	74LS139	.49	.39
74LS02	.28	.18	74LS151	.49	.39
74LS03	.28	.18	74LS153	.49	.39
74LS04	.28	.18	74LS154	1.29	1.19
74LS05	.28	.18	74LS157	.45	.35
74LS06	.59	.49	74LS161	.49	.39
74LS07	.59	.49	74LS163	.49	.39
74LS08	.28	.18	74LS164	.59	.49
74LS09	.28	.18	74LS165	.75	.65
74LS10	.26	.16	74LS166	.89	.79
74LS11	.29	.19	74LS173	.45	.35
74LS14	.49	.39	74LS174	.39	.29
74LS20	.28	.18	74LS175	.39	.29
74LS21	.29	.19	74LS191	.59	.49
74LS27	.35	.25	74LS192	.69	.59
74LS30	.28	.18	74LS193	.69	.59
74LS32	.28	.18	74LS194	.69	.59
74LS38	.35	.25	74LS221	.69	.59
74LS42	.49	.39	74LS240	.69	.59
74LS47	.85	.75	74LS241	.59	.49
74LS73	.39	.29	74LS244	.59	.49
74LS74	.35	.25	74LS245	.79	.69
74LS75	.39	.29	74LS257	.49	.39
74LS76	.39	.29	74LS259	.99	.89
74LS83	.55	.45	74LS273	.89	.79
74LS85	.55	.45	74LS279	.49	.39
74LS86	.29	.19	74LS367	.49	.39
74LS90	.49	.39	74LS373	.79	.69
74LS93	.49	.39	74LS374	.79	.69
74LS123	.49	.39	74LS393	.89	.79
74LS125	.49	.39	74LS541	1.29	1.19
74LS132	.49	.39	74LS590	5.95	5.85
74LS138	.49	.39	74LS688	2.39	2.29

74S/PROMS*

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CD4002	.19	CD4052	.59
CD4007	.19	CD4053	.59
CD4011	.19	CD4060	.65
CD4012	.25	CD4066	.29
CD4013	.29	CD4069	.25
CD4015	.29	CD4070	.29
CD4016	.29	CD4071	.19
CD4017	.49	CD4072	.19
CD4018	.49	CD4073	.19
CD4020	.59	CD4081	.19
CD4021	.49	CD4093	.35
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82C55A-5	4.49
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80387-25 (25MHz)	499.95
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ADC0809CCN	3.75
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AY-3-1015D	4.95
AY-5-1013A	2.95

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2112	256x4	450ns MOS	2.49
2114N	1024x4	450ns	.99
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	1.95
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6116P-3	2048x8	150ns (16K) CMOS	2.79
6116LP-1	2048x8	100ns (16K) LP CMOS	3.59
6116LP-3	2048x8	150ns (16K) LP CMOS	3.09
6264P-10	8192x8	100ns (64K) CMOS	6.75
6264P-15	8192x8	150ns (64K) CMOS	4.95
6264LP-10	8192x8	100ns (64K) LP CMOS	6.95
6264LP-12	8192x8	120ns (64K) LP CMOS	6.49
6264LP-15	8192x8	150ns (64K) LP CMOS	4.95
6514	1024x4	350ns CMOS	3.25
43256-10L	32,768x8	100ns (256K) Low Power	10.95
43256-15L	32,768x8	150ns (256K) Low Power	9.95
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62256LP-12	32,768x8	120ns (256K) LP CMOS	11.25
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41256-120	262,144x1	120ns	2.95
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41264-12	64Kx4	120ns Video RAM	10.95
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511000P-10	1,048,576x1	100ns (1 Meg)	12.95
514256P-10	262,144x4	100ns (1 Meg)	12.95
514258-10	262,144x4	100ns Static Column	26.95

EPROMS

TMS2516	2048x8	450ns (25V)	4.95
TMS2532	4096x8	450ns (25V)	5.95
TMS2532A	4096x8	450ns (12.5V)	5.25
TMS2564	8192x8	450ns (25V)	6.95
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2716	2048x8	450ns (25V)	3.49
2716-1	2048x8	350ns (25V)	3.95
27C16	2048x8	450ns (25V) CMOS	4.25
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	3.95
27C32	4096x8	450ns (25V) CMOS	4.25
2764-25	8192x8	250ns (21V)	3.95
2764A-20	8192x8	200ns (12.5V)	4.19
2764A-25	8192x8	250ns (12.5V)	3.49
27C64-15	8192x8	150ns (12.5V) CMOS	4.95
27128-20	16,384x8	200ns (21V)	5.95
27128-25	16,384x8	250ns (21V)	5.25
27128A-15	16,384x8	150ns (12.5V)	5.95
27128A-20	16,384x8	200ns (12.5V)	4.75
27C128-25	16,384x8	250ns (21V) CMOS	5.95
27256-15	32,768x8	150ns (12.5V)	5.95
27256-20	32,768x8	200ns (12.5V)	5.49
27256-25	32,768x8	250ns (12.5V)	5.49
27C256-15	32,768x8	150ns (12.5V) CMOS	7.25
27C256-25	32,768x8	250ns (12.5V) CMOS	5.49
27512-25	65,536x8	250ns (12.5V)	7.25
27C512-15	65,536x8	150ns (12.5V) CMOS	9.95
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68764	8192x8	64K 450ns (25V) (Chip Enable)	14.95
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EEPROMS

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2817A	2048x8	350ns 5V Read/Write	6.95
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6510	14.95
6526	13.95
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6545-1	3.95
6560	6.95
6567	24.95
6572	6.95
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8566	6.95
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8722	8.95
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901225-01	15.95
901226-01	15.95
901227-02	4.95
901227-03	15.95
901229-05	15.95
901460-03	1.95
901486-06	2.95

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

74C/CMOS

74C00	.25	74C174	.39
74C02	.25	74C175	.39
74C04	.25	74C192	.99
74C08	.25	74C194	.49
74C10	.19	74C221	1.79
74C14	.49	74C240	.99
74C32	.45	74C244	1.49
74C74	.49	74C373	1.49
74C85	1.29	74C374	1.49
74C86	.29	74C911	5.95
74C89	2.95	74C912	7.95
74C90	.99	74C915	1.19
74C151	1.75	74C917	3.95
74C154	2.95	74C920	3.95
74C157	1.49	74C921	3.95
74C160	.49	74C922	3.95
74C161	.49	74C923	3.95
74C162	.49	74C925	4.95
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Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX 3/4 Watt, 15Turn .99 | **63PXX** 1/2 Watt, 1Turn .89

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2N2222A	.29	2N4401	.15	1N4148	.07
2N3055	.69	1N270	.25	1N4735	.25
2N3904	.12	1N751	.15	C106B1	.49

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

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

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XC209R T1, Red	.15	XC556G T1¾, Green	.17
XC556R T1¾, Red	.13	XC556Y T1¾, Yellow	.17

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14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.21	24WW	1.19
28LP	.23	28WW	1.39
40LP	.29	40WW	1.89

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

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.19	74HC175	.59
74HC02	.19	74HC221	.89
74HC04	.19	74HC240	.69
74HC08	.19	74HC244	.79
74HC10	.19	74HC245	.79
74HC14	.29	74HC253	.49
74HC30	.25	74HC259	.49
74HC32	.25	74HC273	.49
74HC74	.29	74HC373	.69
74HC75	.35	74HC374	.69
74HC76	.35	74HC595	1.29
74HC85	.55	74HC688	1.49
74HC86	.29	74HC943	6.95
74HC123	.59	74HC4040	.79
74HC125	.49	74HC4049	.29
74HC132	.49	74HC4050	.29
74HC138	.45	74HC4060	.69
74HC139	.39	74HC4511	.99
74HC154	1.49	74HC4514	1.79
74HC163	.39	74HC4538	1.19
74HC174	.59	74HC4543	1.19

74HCT-CMOS TTL

74HCT00	.17	74HCT139	.39
74HCT02	.17	74HCT157	.29
74HCT04	.19	74HCT174	.29
74HCT08	.17	74HCT175	.29
74HCT14	.29	74HCT240	.69
74HCT32	.19	74HCT244	.49
74HCT74	.29	74HCT245	.49
74HCT86	.25	74HCT373	.49
74HCT138	.39	74HCT374	.39

LINEAR

Part No.	1-9	10+	Part No.	1-9	10+
TL071CP	.69	.59	DS14C88N	1.19	1.09
TL072CP	.79	.69	LM1489N	.49	.45
TL074CN	.99	.89	DS14C89N	1.19	1.09
TL081CP	.59	.49	LM1496N	.69	.59
TL082CP	.59	.49	LM1871N	1.95	1.75
TL084CN	.99	.89	LM1872N	1.95	1.75
LM307N	.45	.39	ULN2003A	.79	.69
LM308N	.65	.59	ULN2004A	.79	.69
LM309K	1.49	1.25	26LS29	2.95	2.75
LM310N	1.49	1.25	26LS31	1.19	.99
LM311N	.49	.39	26LS32	1.19	.99
LM317T	.69	.59	26LS33	1.75	1.49
LM318N	1.09	.99	ULN2803A	1.19	.99
LM319N	1.29	1.19	LM2901N	.39	.29
LM323K	3.49	3.25	LM2907N	1.29	1.19
LM324N	.39	.35	LM2917N (8 pin)	1.75	1.49
LM335Z	1.49	1.25	MC3470P	1.29	1.19
LM336Z	1.09	.99	MC3479P	3.95	3.75
LM337T	1.29	1.09	MC3486P	1.29	1.19
LM338K	4.49	4.25	MC3487P	1.29	1.19
LM339N	.49	.39	LM3900N	.49	.45
LF347N	1.49	1.25	LM3905N	1.29	1.19
LM348N	.69	.59	LM3909N	.89	.79
LF351N	.49	.39	LM3914N	1.95	1.75
LF353N	.59	.49	NE5532	.89	.79
LF356N	.89	.79	NE5534	.89	.79
LF357N	.99	.89	7805K	1.29	1.19
LM358N	.59	.49	7812K	1.29	1.19
LM380N	.89	.79	7815K	1.29	1.19
LM385Z1.2	1.75	1.49	7805T	.49	.45
LM386N-3	.89	.79	7812T	.49	.45
LM393N	.45	.39	7815T	.49	.45
LF398N	1.95	1.75	78L08	.35	.29
LF411CN	.79	.69	7905K	1.49	1.25
LF412CN	1.29	1.19	7905T	.55	.49
NE555V	.35	.29	75113	1.39	1.19
XRL555	.75	.65	75150	1.29	1.19
LM556N	.49	.39	75154	1.29	1.19
LM565N	.99	.89	75174	2.95	2.75
LM566CN	1.29	1.19	75175	2.95	2.75
LM567V	.75	.65	75176	2.25	1.95
LM723CN	.49	.39	75451	.45	.39
LM741CN	.35	.29	75452	.45	.39
LM747CN	.59	.49	75492	.89	.79
LM1458N	.39	.35	MC145406P	2.95	2.75
LM1488N	.49	.45			

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650 only: • Data Hold Switch • 4.5 Digit

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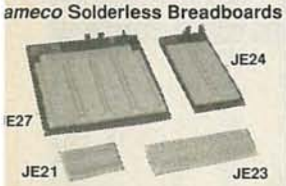
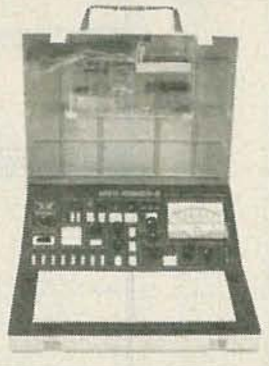


rt o.	Dim. L" x W"	Contact Points	Binding Posts	Price
21	3.25 x 2.125	400	0	$4.95
23	6.5 x 2.125	830	0	$6.95
24	6.5 x 3.125	1,360	2	$12.95
25	6.5 x 4.25	1,660	3	$17.95
26	6.875 x 5.75	2,390	4	$22.95
27	7.25 x 7.5	3,220	4	$32.95

Prototype Design Stations

WM2



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WM1 Analog Prototype Station **$199.95**
WM2 Digital Prototype Station **$249.95**

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JE3520 Pictured

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JE3533	Jameco Baby 33MHz 80386	$1699.95

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JE1010	Flip-Top Standard PC/XT Case	$39.95
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JE1030	150 watt PC/XT Power Supply	$59.95
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JE2012	Mini-Vertical Case w/200W Pwr. Supply	$149.95
JE2014	Flip-Top Baby XT Turbo Case	$69.95
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JE1059 EGA Monitor & EGA Card.............. **$459.95**

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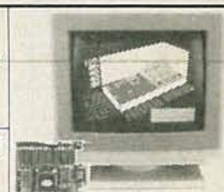

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JE2016	111-Key Enhanced with Solar Powered Calculator	$79.95
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MPF11 Pictured

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MPF11	3.5" 720Kb Internal Drive	$49.95
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MF355B	3.5" 1.44Mb Half Height	$119.95

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XY2660 .... $89.95

60 Watt Digital Display Soldering Station • Electronic temperature control from 200° to 878°F • Temperature displayed on easy to read .560"H 3-digit LED readout • Nichrome heating element

XY960 .... $99.95

30 Watt Electronic Temperature Controlled Desoldering Station • Electronic temperature control from 212° to 842°F • Self-contained high rotary vacuum pump

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SILICON TRANSISTORS

[illegible]

Part	Price	Part	Price	Part	Price
2N4037	1.40	2N697	1.30	MPSA14	.30
2N4123	.23	2N718A	1.15	MPSA42	.45
2N3124	.23	2N1132A	2.04	MPSA43	.45
2N4125	.23	2N1613	.92	MPSA92	.45
2N4126	.23	2N1893	1.14	MPSA93	.45
2N4208	1.25	2N2218	.95	MPSL01	.36
2N4209	2.10	2N2218A	.95	PN2222	.24
2N4234	2.10	2N2219	.76	MPSL51	.36
2N4235	2.30	2N2219A	.76	PN2222A	.23
2N4236	2.30	2N2221	.80	PN2369	.25
2N4237	2.30	2N2221A	.80	PN2369A	.25
2N4238	2.30	2N2222	.60	PN2484	.30
2N4239	2.30	2N2222A	.60	PN2907	.23
2N4400	.23	2N2369	.60	PN2907A	.23
2N4401	.23	2N2369A	.60	PN3251	.39
2N4402	.23	2N2405	1.45	PN3565	.28
2N4403	.23	2N2484	.84	PN3566	.31
2N4410	.36	2N2904	.95	PN3567	.28
2N4896	2.90	2N2904A	.95	PN3569	.24
2N5086	.28	2N2905	.76	PN3639	.30
2N5087	.28	2N2905A	.76	PN3640	.30
2N5088	.28	2N2906	.80	PN3641	.30
2N5089	.28	2N2906A	.80	PN3643	.23
2N5210	.29	2N2907	.60	PN3644	.32
2N5224	.24	2N2907A	.60	PN3645	.32
2N5225	.23	2N3013	.90	PN4121	.35
2N5226	.23	2N3014	1.10	PN4122	.32
2N5227	.23	2N3019	1.04	PN4248	.34
2N5320	2.30	2N3020	1.04	PN4249	.34
2N5321	2.60	2N3053	1.04	PN4250	.34
2N5322	2.30	2N3107	1.30	PN4250A	.40
2N5323	1.84	2N3108	1.30	PN4258	.30
2N5400	.31	MPS2907A	.23	PN4274	.29
2N5401	.31	MPS2924	.36	PN4275	.29
2N5415	1.80	MPS3392	.24	PN4355	.36

1 AMP SILICON RECTIFIERS

Part No.	Description	Pkg.	1	10	100	1,000
1N4001	50 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4002	100 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4003	200 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4004	400 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4005	600 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4006	800 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]
1N4007	1000 PIV	DO-41	[illegible]	[illegible]	[illegible]	[illegible]

5% CARBON FILM RESISTORS

Available in 1/8, 1/4 & 1/2 Watt

How To Order: Take any standard resistor value (i.e. 3.2) and add an "E" for 1/8 watt or a "Q" for 1/4 watt or an "H" for 1/2 watt (i.e. 3.2Q for 3.2Ω 1/4 watt), this is the Digi-Key part number.

Pricing	5	200	1,000
1/8 Watt	.25	6.40	25.00
1/4 Watt	.25	3.40	13.00
1/2 Watt	.25	3.50	16.00

1/8 Watt Resistor Assortments

RS112 Set of 5 each of the 73 standard 5% 1/8 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pieces) $9.90

RS212 Set of 5 each of the 72 standard 5% 1/8 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces) $9.90

1/4 Watt Resistor Assortments

RS125 Set of 5 each of the 73 standard 5% 1/4 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pieces) $9.90

RS225 Set of 5 each of the 72 standard 5% 1/4 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces) $9.90

1/2 Watt Resistor Assortments

RS150 Set of 5 each of the 73 standard 5% 1/2 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohms (365 total pieces) $9.90

RS250 Set of 5 each of the 72 standard 5% 1/2 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces) $9.90

5% WIREWOUND REC. RESISTORS

Available in 5 & 10 Watt

How To Order: Take any standard resistor value (i.e. 7.5) and add "W5" for 5 watt, or add a "W10" for 10 watt (i.e. 7.5W5 for 7.5Ω 5 watt), this is the Digi-Key part number.

Pricing	1	10	100	500	1,000
5 Watt	.36	3.25	26.90	100.80	162.00
10 Watt	.41	3.78	31.90	118.00	212.00

5 Watt Metal Resistor Assortments

RS105 5 each of values 0.30Ω to 0.91Ω (300 total pieces) $20.10

RS205 4 each of values 1.0Ω to 9.1Ω (384 total pieces) $31.30

RS305 4 each of values 10Ω to 91Ω (384 total pieces) $31.30

RS405 4 each of values 100Ω to 2.0KΩ (288 total pieces) $31.30

10 Watt Resistor Assortments

R110 2 each of all 10 watt standard resistor values listed in the Digi-Key catalog. (166 total pieces) $58.95

5% METAL OXIDE FILM RESISTORS

Available in 1 & 2 Watt

How To Order: Take any standard resistor value (i.e. 1.5K) and add a "W1" for 1 watt, or add a "W2" for 2 watt (i.e. 1.5KW1 for 1.5KΩ 1 watt), this is the Digi-Key part number.

Pricing	1	5	100	500	1,000
1 Watt (0.47-0.91Ω)	.21	.98	12.60	56.00	101.50
1 Watt (1.0-1.0MΩ)	.15	.70	9.00	40.00	72.50
2 Watt (0.47-0.91Ω)	.23	1.06	13.15	59.40	109.40
2 Watt (1.0-1.0MΩ)	.18	.85	10.50	47.50	87.50

1 Watt Metal Resistor Assortments

RS101 5 each of values 0.47Ω to 56Ω (255 total pieces) $26.95

RS201 5 each of values 62Ω to 7.5KΩ (255 total pieces) $26.95

RS301 5 each of values 8.2KΩ to 1.0M (255 total pieces) $26.95

2 Watt Resistor Assortments

RS102 5 each of values 0.47Ω to 56Ω (255 total pieces) $29.95

RS202 5 each of values 62Ω to 7.5KΩ (255 total pieces) $29.95

RS302 5 each of values 8.2KΩ to 1.0M (255 total pieces) $29.95

1% METAL OXIDE FILM RESISTORS

Available in 1/4 Watt

How To Order: Take any standard resistor value (i.e. 1.69K) and add an "X" (i.e. 1.69KX), this is the Digi-Key part number.

Pricing	5	200	1,000
1/4 Watt	.50	7.80	30.00

1/4 Watt Metal Film Resistor Assortments

RS1X 5 each of values 10Ω to 97.6Ω (480 total pieces) $29.95

RS2X 5 each of values 100Ω to 976Ω (480 total pieces) $29.95

RS3X 5 each of values 1.00KΩ to 9.76KΩ (480 total pieces) $29.95

RS4X 5 each of values 10.0KΩ to 97.6KΩ (480 total pieces) $29.95

RS5X 5 each of values 100KΩ to 1.00MΩ (480 total pieces) $29.95

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6.3/100	P6302	.26	P6201	.16
6.3/220	P6303	.35	P6202	.21
6.3/330	P6304	.42	P6203	.22
6.3/470	P6305	.46	P6204	.23
6.3/1,000	P6306	.64	P6205	.38
6.3/2,200	P6307	.81	P6206	.62
6.3/3,300	P6308	.95	P6207	.81
6.3/4,700	P6309	1.13	P6208	1.01
6.3/6,800	P6310	1.48	P6209	1.22

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Miniature Aluminum Electrolytic Capacitors

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DISC CAPACITORS

[illegible]

DISC CAPACITORS

Part No.	Cap./Volt.	Price	Part No.	Cap./Volt.	Price
P4129	1200/1K	2.25	P4307	.047 μf/25	.79
P4130	1500/1K	2.25	P4311	.1 μf/25	1.61
P4131	1800/1K	2.25	P4418	1000/25	.75
P4132	2200/1K	2.93	P4419	1500/25	.75
P4133	2700/1K	2.93	P4420	2200/25	.75
P4134	3300/1K	2.93	P4421	3300/25	.75
P4135	3900/1K	4.46	P4422	4700/25	.75
P4136	4700/1K	5.36	P4423	6800/25	.83
P4137	5600/1K	5.36	P4424	10000/25	.83
P4138	6800/1K	8.44	P4425	15000/25	.90
P4139	8200/1K	8.44	P4426	22000/25	.94
P4140	10000/1K	8.44	P4427	33000/25	.94
P4161	10000/50	.86	P4428	47000/25	1.55
P4162	22000/50	.94	P4429	68000/25	1.73
P4163	47000/50	1.01	P4430	100000/25	1.91
P4164	100000/50	1.13	P4431	1000/50	.86
DH682	6800/50	.90	P4432	1500/50	.86
P4200	1000/100	.68	P4433	2200/50	.86
P4202	1500/100	.68	P4434	3300/50	.86
P4203	2200/100	.79	P4435	4700/50	.86
P4205	3300/100	.79	P4436	6800/50	.94
P4206	4700/100	1.09	P4437	10000/50	1.01
P4209	6800/100	.71	P4438	15000/50	1.01
P4300	.01μf/25	.56	P4439	22000/50	1.09
P4303	.022 μf/25	.64	P4440	33000/50	1.73
P4305	.033 μf/25	.64	P4441	47000/50	1.73

NPO NPO NPO NPO NPO NPO NPO NPO

Part No.	Cap./Volt.	Price	Part No.	Cap./Volt.	Price
P4400	10/500	.68	P4409	56/500	1.13
P4402	15/500	.79	P4410	68/500	1.28
P4403	18/500	.79	P4411	82/500	1.91
P4404	22/500	.79	P4412	100/500	1.91
P4405	27/500	.79	P4413	120/500	1.91
P4406	33/500	.98	P4414	150/500	2.03
P4407	39/500	.98	P4415	180/500	2.70
P4408	47/500	1.13	P4416	220/500	2.70

TANTALUM CAPACITORS

Part No.	Cap./Volt. (μF)/DC	Price 1	Part No.	Cap./Volt. (μF)/DC	Price 1
P2011	4.7/6.3	.31	P2045	2.2/25	.34
P2012	6.8/6.3	.34	P2046	3.3/25	.42
P2013	10/6.3	.42	P2047	4.7/25	.54
P2014	15/6.3	.50	P2048	6.8/25	.65
P2015	22/6.3	.60	P2049	10/25	1.06
P2016	33/6.3	.72	P2050	15/25	1.19
P2017	47/6.3	.85	P2051	22/25	1.68
P2018	68/6.3	1.18	P2052	33/25	2.39
P2019	100/6.3	1.82	P2053	0.1/35	.27
P2020	150/6.3	3.60	P2054	0.15/35	.27
P2094	220/6.3	7.85	P2055	0.22/35	.27
P2095	330/6.3	11.65	P2056	0.33/35	.27
P2022	2.2/10	.28	P2057	0.47/35	.27
P2023	3.3/10	.31	P2058	0.68/35	.28
P2024	4.7/10	.34	P2059	1.0/35	.31
P2025	6.8/10	.42	P2060	1.5/35	.34
P2026	10/10	.50	P2061	2.2/35	.42
P2027	15/10	.60	P2062	3.3/35	.51
P2028	22/10	.72	P2063	4.7/35	.65
P2029	33/10	.85	P2064	6.8/35	.90
P2030	47/10	1.18	P2065	10/35	1.19
P2031	68/10	1.82	P2066	15/35	1.88
P2032	100/10	3.60	P2099	.047/35	.43
P2083	150/10	6.98	P2100	.068/35	.43
P2084	220/10	9.63	P2101	22/35	2.56
P2033	1.5/16	.23	P2102	33/35	4.46
P2034	2.2/16	.31	P2103	47/35	13.36
P2035	3.3/16	.33	P2067	0.1/50	.28
P2036	4.7/16	.42	P2068	0.15/50	.30
P2037	6.8/16	.50	P2069	0.22/50	.30
P2038	10/16	.60	P2070	0.33/50	.30
P2039	15/16	.74	P2071	0.47/50	.33
P2040	22/16	.88	P2072	0.68/50	.37
P2041	33/16	1.18	P2073	1.0/50	.50
P2042	47/16	1.82	P2074	1.5/50	.84
P2043	68/16	3.60	P2075	2.2/50	.90
P2086	150/16	9.08	P2076	3.3/50	1.48
P2096	100/16	6.98	P2077	4.7/50	1.89
P2044	1.5/25	.31	P2078	6.8/50	3.90
			P2104	10/50	5.40
			P2093	15/50	8.37

PANASONIC® V SERIES

Stacked Metalized Film Capacitors

Part No.	Cap./Volt. (μF)/VAC	Price 10	Part No.	Cap./Volt. (μF)/VAC	Price 10
P4513	0.01/50	1.23	P4535	0.68/50	4.83
P4514	0.012/50	1.26	P4536	0.82/50	5.74
P4515	0.015/50	1.28	P4537	1.0/50	6.62
P4516	0.018/50	1.32	P4713	0.01/100	1.81
P4517	0.022/50	1.35	P4714	0.012/100	1.38
P4518	0.027/50	1.38	P4715	0.015/100	1.81
P4519	0.033/50	1.41	P4716	0.018/100	1.81
P4520	0.039/50	1.44	P4717	0.022/100	1.85
P4521	0.047/50	1.47	P4718	0.027/100	1.89
[illegible]	[illegible]	[illegible]	P4719	0.033/100	1.93
			P4720	0.039/100	[illegible]
			[illegible]	[illegible]	[illegible]
P4528	0.18/50	2.01	P4727	0.15/100	2.65
P4529	0.22/50	2.10	P4728	0.18/100	2.75
P4530	0.27/50	2.45	P4729	0.22/100	2.94
P4531	0.33/50	2.79	P4730	0.27/100	3.34
P4532	0.39/50	3.10	P4731	0.33/100	3.81
P4533	0.47/50	3.45	P4732	0.39/100	4.22
P4534	0.56/50	4.14	P4733	0.47/100	4.71

PANASONIC® B SERIES

Polyester Capacitors

Part No.	Cap./Volt. (μF)/VAC	Price 10	Part No.	Cap./Volt. (μF)/VAC	Price 10
P4551	.001/50	1.05	P4556	.0027/50	1.05
P4552	.0012/50	1.05	P4557	.0033/50	1.05
P4553	.0015/50	1.05	P4558	.0039/50	1.05
P4554	.0018/50	1.05	P4559	.0047/50	1.05
P4555	.0022/50	1.05	P4560	.0056/50	1.05
			P4561	.0068/50	1.05
			P4562	.0082/50	1.05

QUARTZ CRYSTALS

Freq. MHz	Digi-Key Part No.	Case	Pricing 1	Pricing 10
1.000	X045	HC-33	10.08	84.00
1.0000	X066	HC-18	9.65	79.50
1.8432	X046	HC-33	3.96	33.00
1.8432	X067	HC-18	3.42	28.50
2.000	X001	HC-33	3.78	31.50
2.0000	X068	HC-18	3.24	27.00
2.4576	X047	HC-33	3.78	31.50
2.4576	X069	HC-18	3.06	25.50
2.5000	X070	HC-18	3.42	28.50
3.000	X048	HC-33	3.78	31.50
3.2768	X022	HC-18	1.73	14.40
3.579545	X005	HC-33	2.34	19.50
3.579545	X049	HC-18	1.62	13.50
3.6864	X071	HC-18	1.62	13.50
3.700	X012	HC-6/U	2.60	22.00
4.000	X006	HC-18	1.62	13.50
4.0320	X072	HC-18	1.62	13.50
4.194304	X007	HC-18	1.62	13.50
4.91520	X050	HC-18	1.62	13.50
5.000	X051	HC-18	1.62	13.50
5.0688	X052	HC-18	1.62	13.50
5.1850	X053	HC-18	1.62	13.50
5.9904	X073	HC-18	1.62	13.50
6.000	X026	HC-18	1.62	13.50
6.144	X054	HC-18	1.62	13.50
7.3728	X074	HC-18	1.62	13.50
8.000	X056	HC-18	1.62	13.50
9.2160	X075	HC-18	1.62	13.50
10.000	X057	HC-18	1.62	13.50
11.0592	X078	HC-18	1.98	16.50
12.000	X058	HC-18	1.62	13.50
15.000	X059	HC-18	1.62	13.50
16.000	X077	HC-18	1.62	13.40
18.000	X060	HC-18	1.80	15.00
18.432	X061	HC-18	1.80	15.00
20.000	X062	HC-18	1.98	16.50
22.1184	X063	HC-18	1.98	16.50
48.000	X065	HC-18	1.98	16.50

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$1000 & Up	Less 25%

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ALL ELECTRONICS CORP.

12 VOLT DC MINI FAN

Howard Industries#
3-15-810. Operates on
12 Vdc, 0.10 amp, 1.0 watt.
Compact plastic housing,
2.35" square X 1.275" thick.
9 blade fan. Two 9" pigtail leads.
CAT# CF-121 $9.00 each

115 VAC COOLING FAN

STANDARD SIZE
COOLING FAN.
Features die cast metal housing
for strength and durability.
IMPEDANCE PROTECTED
4 11/16" square X 1 1/2" deep.
Factory new 120 Vac fans. **CF1-N $9.50 each**

LED CHASER KIT

Build this variable speed led chaser.
10 leds flash sequentially at whatever
speed you set them for. Easy to build kit
includes pc board, parts and instructions.
Ideal for special lighting effects, costumes,
etc. Operates on 3 to 9 volts. PC board is
5" X 2.25". A great one hour project.
CAT# AEC $6.50 each

STEPPER MOTOR

Airpax# A82743-M4
Brand new 12 volt
dc stepper motor.
35 ohm coil.
7.5 degrees per
step. 2.25" diameter,
0.93" long excluding shaft. 0.22" dia.
shaft is 0.75" long. 2 hole mounting
flange, 2.675" mounting centers.
6 wire leads.
CAT# SMT-5 $10.00 each

RECHARGEABLE BATTERY PACK (USED)

Four AA nickel cadmium batteries
connected in series to make a
4.8 volt pack. Batteries are in a
2 X 2 configuration with a 2 pin
connector attached. The four
batteries can be separated into
single AA size solder tab nickel
cadmium batteries or resoldered
into other configurations.
SPECIAL SALE PRICE NOW
$3.00 per pack • 10 packs for $25.00
CAT# NCB-41AAU

TIL-99 PHOTO TRANSISTOR

TO-18 case with window. For
wide-angle viewing applications. Spectrally and
mechanically compatible with TIL-31B.
CAT# TIL-99 $1.00 each • 10 for $9.00

TIL-31B PHOTO DIODE

TO-18 case with window.
Infrared emitting photo diode.
CAT# TIL-31B $1.00 ea. • 10 for $9.50

SWITCHES

ITT PUSH BUTTON

ITT MDPL series. 3/4" X
1/2" grey rectangular
key cap. S.P.S.T. N.O.
Push to close. RATED: 0.1 amp switching,
0.25 amp carry current. P.C. mount.
**CAT# PB-8 65¢ each • 10 for $6.00
100 for $50.00**

SPDT PUSHBUTTON

Marquardt# 1843
Rated 6 amps @ 125/250 Vac.
Black plastic pushbutton.
Switch body: .92" X .94" X .65".
CAT# PB-18 $1.65 ea. • 10 for $15.00 ea.

PUSHBUTTON SWITCH

GC/Thomsen# 35-420
S.P.S.T. normally open momentary
pushbutton switch. Red plastic
actuator 0.57" diameter. Chrome
bezel 0.68" diameter. Threaded
bushing mounts in .50" diameter hole. Rated
3 amp @ 250Vac. Solder loop terminals.
CAT# PB-20 $1.00 each

WALL TRANSFORMERS

ALL PLUG
DIRECTLY
INTO
120 VAC
OUTLET

12 Vdc @ 500 ma. **CAT# DCTX-125 $4.50**
6 Vdc @ 200 ma. **CAT# DCTX-620 $2.25**
9 Vdc @ 1 amp **CAT# DCXT-951 $5.00**
24 Vac @ 625 ma. **CAT# ACTX-2462 $3.25**

SERVO MOTOR

3 Vdc servo with potentiometer.
Ideal for robotics or remote
control model experimentation.
Rotates approx. 140 degrees.
Pot connected to motor varies
from either 500 to 3000 ohms. 1.53" X 0.95" X 1.65".
0.87" diameter rubber wheel attached to motor shaft
can be used as a capstan or can be easily removed.
Prepped with capaciors, chokes and wire leads.
CAT# SVO-2 2 for $1.00

NICKEL-CAD BATTERIES (RECHARGEABLE)

AAA SIZE $1.50 each
1.2 volts 180 mAh
CAT# NCB-AAA

AA SIZE $2.00 each
1.25 volts 500 mAh
CAT# NCB-AA

AA SIZE $2.20 each
WITH SOLDER TABS
CAT# NCB-SAA

C SIZE $4.25 each
1.2 volts 1200 mAh
CAT# NCB-C

D SIZE $4.50 each
1.2 volts 1200 mAh
CAT# NCB-D

XENON TUBE

1" long flashtube with 3 1/2" red and
black leads. Ideal for
electronic flash or strobe projects.
CAT# FLT-3 2 for $1.00

RELAYS

5-6 VDC SIP REED RELAY

Electrol
"Blue Boy"#
BBS1A05A10
5-6 Vdc, 500 ohm coil.S.P.S.T. normally open reed relay.
0.5 amp contacts. SIP configuration.
1" X .375" X .3".
**CAT# RRLY-SIP5
$1.10 each • 10 for $10.00**

5 VDC LATCHING RELAY

Aromat# RSL2D-5V
Miniature SPDT,
dual coil latching
relay. 5 Vdc,
170 ohm coils. 1 amp. TTL compatible. UL and CSA recognized. 0.787"
X 0.394" X 0.394"
CAT# LRLY-5DC $2.50 each

12 VOLT D.C. COIL S.P.D.T.

Omron# G2E-184P
4 amp contacts.
335 ohm coil.
Sugar cube size.
.61" X .42" X .44" high.P.C. mount
with pins on DIP spacing.
CAT# RLY-787 $1.50 each

0-30 MINUTE AUTO-SHUTOFF TIMER

Sankyo Seike Mfg.# TMCF35MYB9
120 Vac 60 hz. 10 amp contacts.
UL rated. Turn shaft to turn on
lights or other electrical devices.
Bell rings and circuit breaks after specified
amount of time. Ideal for any device that needs
to shut off automatically. 2.92" X 1.9" X 2.54"
behind face plate. 1/4" half-round shaft.
CAT# TMC-30 $3.00 each

PHOTO FLASH CAPACITOR

Rubycon# FKX
200 mfd. 330 volts.
0.79" diameter X 1.11" high
Solder loop terminals.
CAT# PPC-200 $3.25 each
10 for $30.00 • 100 for $275.00

22/44 PIN CONNECTOR

.156" pin spacing, 0.200" between double
rows, gold contacts, P.C. mounting.
SPECIAL. Same as AMP# 2-530655-6.
CAT# EBC-1G $1.00 each • 10 for $8.00

ELECTRONIC GAME BOARD

The inner workings of an electronic Scrabble game.
Operates on 6 Vdc. 8 digit alpha-numeric readout,
45 button keypad, 14 transistors, 2 I.C.'s, 1 piezo element
and other goodies. Top and bottom row of keypad buttons
are function keys, middle 3 rows are alphabetic.
No instructions available. 6" X 4.45".
CAT# ST-4 $1.75 each 10 for $15.00

TELEPHONE COUPLING TRANSFORMER

Multi Products International#
A19N-HO-1D/1
Primary: 600 ohm
Secondary: 600/600 ohm
0.77" X 0.61" X 0.63" high.
6 p.c. pins on 0.187" centers.
Primary inductance: 300 mH min., at 1kHz, 1 volt.
CAT# TCTX-1 $1.25 each • 10 for $11.00

LED'S

STANDARD JUMBO
DIFFUSED T 1-3/4 size
RED **CAT# LED-1**
10 for $1.50 • 100 for $13.00
GREEN **CAT# LED-2**
10 for $2.00 • 100 for $17.00
YELLOW **CAT# LED-3**
10 for $2.00 • 100 for $17.00

FLASHING LED

with built in flashing circuit
operates on 5 volts...
RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED

Lights RED one direction,
GREEN the other. Two leads.
CAT# LED-6 2 for $1.70

LED HOLDER

Two piece holder.
CAT# HLED 10 for 65¢

10 AMP SOLID STATE RELAY

ELECTROL#
S2178
CONTROL:
Rated 5.5 to 10 Vdc
(will operate on 3-32 Vdc).
LOAD: 10 amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8".
CAT# SSRLY-10B $9.50 ea.
QUANTITY DISCOUNT
10 for $85.00 • 25 for $175.00
50 for $300.00 • 100 for $500.00

OPTO SENSOR

U shaped package
with mounting ears.
1/8" opening.
3/4" mounting ears.
CAT# OSU-6
50¢ each
10 for $4.50 • 100 for $40.00

A.C. LINE CORDS

Black 6ft., 18/2, SPT-2

**NON POLARIZED PLUG
CAT# LCAC 2 for $1.00**
100 for $45.00

**POLARIZED PLUG
CAT# LCP-1 60¢ each**
100 for $50.00

L.E.D. FLASHER KIT

Two L.E.D.'s flash in
unison when a 9 volt
battery is attached.
This kit includes a p.c. board,
all the parts and instructions
to make a simple flasher circuit. A quick and easy
project for anyone with basic soldering skills.
CAT# LEDKIT $1.75 per kit

LOOK WHAT $1.00 WILL BUY

**200 ASSORTED
1/4 WATT RESISTORS**
Bent leads, carbon comp. and carbon film.
CAT# GRES $1.00 per assortment

**200 ASSORTED
1/2 WATT RESISTORS**
Bent leads, carbon comp. and film.
CAT# GRABRE $1.00 per assortment

**50 ASSORTED
DISC CAPACITORS**
Most are cut (p.c. leads). Some to 500 volts.
CAT# GRABDC $1.00 per assortment

**15 VALUES OF
ELECTROLYTICS**
Contains both axial and
radial styles from 1 mfd.
CAT# GRABCP $1.00 per assortment

LOOK WHAT $2.00 WILL BUY

15 AMP SNAP-ACTION SWITCH
5 pieces of a 15 amp
125,250 Vac normally
open switch. Body is
1 3/4" X 5/8" X 5/8".
Button extends 3/16" above switch body.
CAT# GRABMS $2.00 per package

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20 assorted TO-92 plastic case
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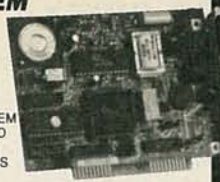

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2400 BAUD MODEM

$89.95

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- FULL HAYES COMPATIBILITY
- CONFIGURE AS COM1, COM2, COM3 OR COM 4 • BUILT-IN SPEAKER • AUTO WAIT-FOR-DIAL TONE AND AUTO-REDIAL • PROCOMM COMMUNICATIONS SOFTWARE • MADE IN THE USA

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SMALL FOOTPRINT MINI-UPRIGHT FOR 8088 OR MINI 286/386 MOTHERBOARDS
- ROOM FOR 6 EXPANSION CARDS
- HOLDS 3 5-1/4 & 1 3-1/2 DRIVES (1/2 HT)
- 200 WATT POWER SUPPLY
- 2-DIGIT LED SPEED DISPLAY
- 12" H X 16"L X 8" W

CASE-120

UPRIGHT CASE $249.95

SPACE SAVING DESIGN HOLDS ALL SIZES OF MOTHERBOARDS AND INCLUDES: • 250W POWER SUPPLY
- MOUNTS FOR 3 FLOPPY & 4 HARD DRIVES
- TURBO & RESET SWITCH • LED SPEED DISPLAY • POWER & DISK LED'S
- ALL HARDWARE, FACEPLATES & SPEAKER

CASE-100

CASE-FLIP	FOR 8088 MB'S	$39.95
CASE-SLIDE	FOR 8088 MB'S	$39.95
CASE-70	FOR 286 MB'S	$89.95
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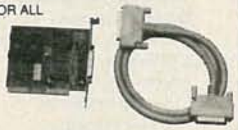

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