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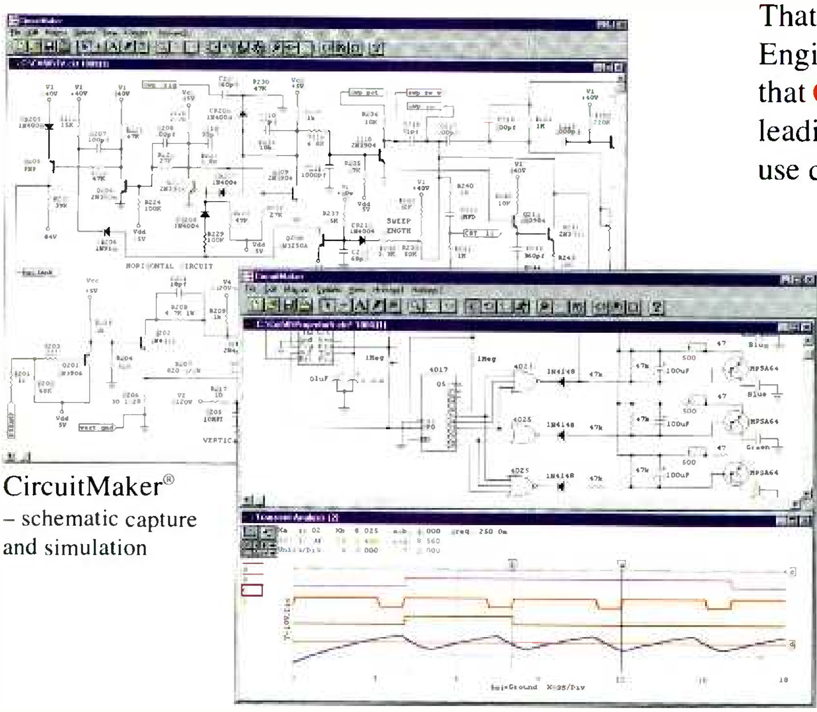

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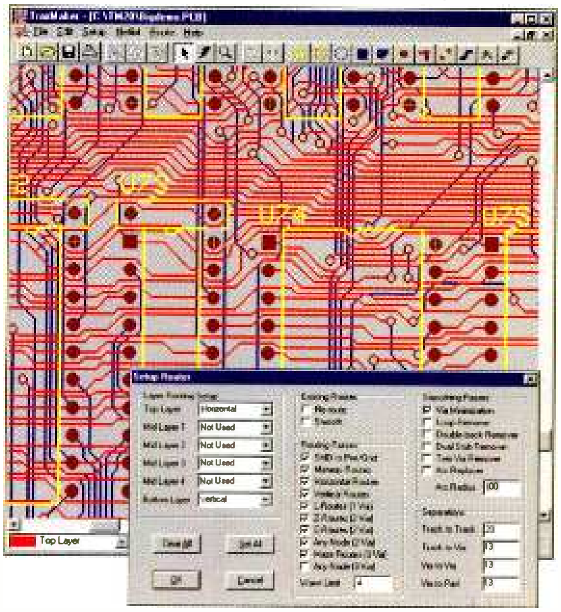

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MARCH 1998

ON THE COVER

TECHNOLOGY

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MARCH 1998

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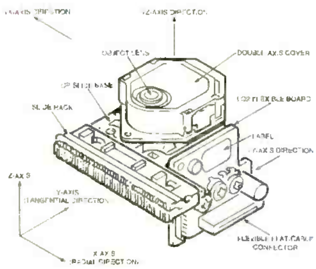
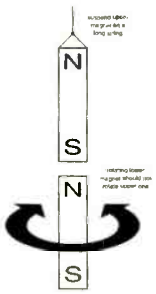
DEPARTMENTS





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NEW PRODUCTS

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Interactive Car Navigation System

CIRCLE 20 ON FREE INFORMATION CARD

Easy to install and use, Philips Car Systems' CARiN 520 expands consumer access to digital vehicle-navigation technology that previously was available only through luxury automobile accessory packages. Including a navigation computer, LCD monitor, remote control, and installation components, the system can be installed by a professional in as little as two hours.

CARiN's easy-to-use remote and route selection, automatic alternate routing, CD-ROM mapping, and emergency features combine into an accessory that makes driving safer and more enjoyable. The Philips system is one of the only systems employing dead reckoning as its primary navigational tool. Dead reckoning uses an integrated gyroscope and patented CD-ROM database to pinpoint the vehicle's location, and then checks itself with the Global Positioning System (GPS) for accuracy. That method eliminates problems caused by interference in places such as urban canyons or when a user is caught between satellite links.

Drivers receive both visual and audio directions through a five-inch LCD color display. They can choose from various options, including a male or female voice in one of six languages; an optional flexible stalk mount, which allows placement in several locations within the vehicle; and background monitor colors that can be changed from orange-red to green to blue.

CARiN 520 is controlled by an illuminated IR remote that may be handheld or permanently mounted. A personal-destination memory can store up to 100 addresses; the most recent 10 addresses are stored automatically. Seven U.S. regional CARiN CD-ROM maps are available.

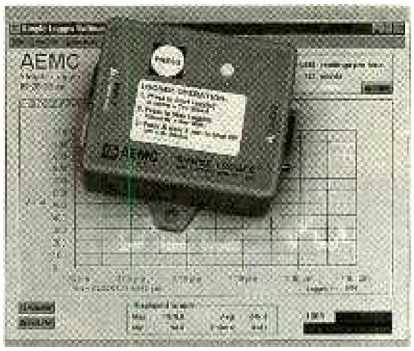
About the size of a vehicle CD player, the navigation computer is sufficiently compact to mount under the rear deck, in the trunk, beneath a seat, or on the floor of the cargo area. The CARiN 520 retails for $1999, plus installation and CD-ROM mapping.

Philips Car Systems
64 Perimeter Center East
Atlanta, GA 30346-6401
Tel: 770-821-2400
Fax: 770-821-3212

Temperature Logger

The low-cost data-logger family from AEMC is unique because they require no user set up and are able to automatically adjust the scale and sample rate to optimize to the recording. The Simple Logger, a temperature logger, has recently been added to this family.

One-button operation makes the data logger extremely easy and quick to use. Temperature inputs can be done either through an internal thermistor or an external thermistor probe. The unit is directly compatible with industry-standard 10,000-ohm thermistor probes. A 9-volt battery provides one year operation.



CIRCLE 21 ON FREE INFORMATION CARD

Included with the logger is Windows-based software, which allows plotting, statistical analysis, text annotation, and zoom capability. Graphs and tabular listings can be printed, or the graphs can be pasted directly to the Windows clipboard for insertion into other programs. Stored files can be imported by all popular spreadsheet, datasheet, and word processing programs. The Simple Logger stores over 8000 data points, and the device has a built-in RS-232 port for downloading.

The data logger's compact size ($2\frac{7}{8} \times 2\frac{5}{8} \times 1\frac{5}{16}$) makes it easy to take anywhere. Depending on the model, it is priced from $149 to $159, with the software and the interface cable included.

(Continued on page 22)

EDITORIAL

The Uncertain Face of TV

The buzzword at this year's Consumer Electronics Show (which will have passed by the time you read this) is slated to be DTV, or digital television. That's because manufacturers will be unveiling their first products for the new digital broadcasting standard at that show.

For those of you who haven't heard about it, or didn't read my Editorial last July ("The New Face of TV"), DTV is scheduled to completely replace the existing NTSC broadcasting standard by 2006, with the first digital broadcasts to begin this fall. Yet, with all this impending activity and change, no one is really sure what shape DTV will take.

Many assume that DTV automatically means HDTV. It doesn't. Another possible use of DTV—and the increased bandwidth broadcasters received to accommodate it—is multicasting: breaking up the signal into multiple standard-definition TV channels.

The problem for broadcasters is that regardless of which way they go, DTV is going to be an expensive proposition. Costs for converting each station is estimated at between $2 and $14 million dollars. And no one is quite sure if those costs are going to be recovered in the short term regardless of the type of DTV broadcast. Some station owners are even wondering if it makes any sense for them to stay in business at all.

Remember that almost all station revenues are derived from advertising. Will advertisers be willing to shell out extra dollars for their spots to run in HDTV? Without sufficient advertising, will stations be willing or able to broadcast a significant amount of HDTV material? If there is limited or no programming, will consumers spend the $3000 or so that the first-generation HDTV sets might cost? And, if there are few sets in the hands of consumers, will advertisers be willing to have their spots air during HDTV broadcasts at all?

If broadcasters go to multicasting, where will they get the programming to fill the extra channels, and what will they have to pay for it? The thought of premium subscription services has been tossed about, but the political backlash that such a use would generate—remember, the stations received their extra spectrum at no charge—likely makes that possibility a remote one for the time being.

But even free multicasting faces opposition from some quarters. In fact, this past fall Congress grew livid when some networks and broadcasters indicated that the multicasting approach might be the way to go. During hearings, the reaction was so strong that executives were forced to backtrack somewhat on that possibility.

To illustrate how much confusion and uncertainty exists, at those same hearings FCC Chairman Hundt went on record to say that he felt that multicasting offered a good use of the spectrum as it would offer a free and viable alternative to cable TV.

In short, the only thing certain about DTV is uncertainty. We'll keep you posted.

Carl Laron

Carl Laron
Editor

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

The Microcontroller Beginner's Handbook

by Lawrence A. Duarte
Prompt Publications
2647 Waterfront Parkway, East Drive
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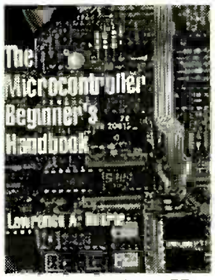


CIRCLE 343 ON FREE INFORMATION CARD

Today, microcontrollers are found in everything from microwave ovens and telephones to cars and toys. All elements of their use, including such industrial considerations as price *vs.* performance, firmware, and resistors, are discussed in the book. Third-party hardware and software development tools are also analyzed, with emphasis placed on new-project design. Everyone from the novice to the more experienced designer will find a wealth of information on understanding, repairing, and building devices incorporating microcontrollers.

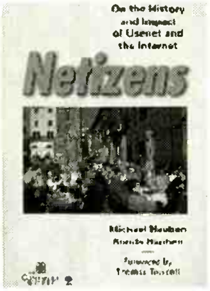
In over 224 pages—profusely illustrated with tables, schematics, photos, diagrams, and program listings—this technology, starting with the basics, continuing through project construction, and ending with practical design considerations, is thoroughly covered. All that's necessary to begin with is a knowledge of a first-year electronics course. Readers with an elementary grasp of electronics terms will find the material right at their level. Even those experienced with microcontroller use will find new ideas in this material.

After reading the handbook, the builder will be able to design, write, and build units that use a microcontroller. The first project, at a beginner's level, is the PK Tester (originally published in our sister publication, **Popular Electronics**, May 1995)—a device that tests for psychokinetic (PK) ability. Project difficulty increases as you progress, and the last, more advanced, project is a video-output thermometer that displays indoor and outdoor temperature on a standard television screen.

The Microcontroller Beginner's Handbook concludes with useful appendices: Appendix I contains listings of the firmware; Appendix II has parts lists for all the projects, organized by chapter; and Appendix III provides vendor information, including the type of products supplied.

Netizens: On the History and Impact of Usenet and the Internet

by Michael Hauben and Ronda Hauben
IEEE Computer Society Press
10662 Los Vaqueros Circle
Los Alamitos, CA 90720
Tel: 800-CS-BOOKS or 714-821-8380
Web: http://computer.org
$28.95



CIRCLE 344 ON FREE INFORMATION CARD

As a result of the online research the authors conducted, this book looks at the creation and development of the Internet through the eyes of its builders and users. A must-read history of the pioneering vision and actions that made the Net possible, Netizens explains what makes the Internet tick. Taking us on a step-by-step journey through the past, the present, and the future of the participatory global computer network, the book provides a detailed examination of the Internet's construction, examining its technical and social roots.

The authors focus on the role of Net citizens, or Netizens, who make positive contributions to the Net. Questions such as how they have impacted the future of our entire society, how to guide the future extension and growth of the Internet, and how it can be made more widely available are discussed. In addition, the economics of computer and Internet development is examined.

At the end, there's a glossary of acronyms, a bibliography, and an appendix that presents a declaration of Netizens' rights. This 300-plus page book is a useful reference for anyone interested in the Internet.

Telecommunications: Glossary of Telecommunications Terms

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4 Research Place
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Tel: 301-921-2355
Fax: 301-921-0373
E-mail: giinfo@goinst.com
Web: www.goinst.com
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Over 5000 technical definitions are covered on this comprehensive CD-ROM including computer and data communications (hardware and software): fiber optics; facsimile; frequency topics; Internet; ISDN; LANs; WANs; modems; multiplexing; network arrangement and architecture; cellular mobile, radio and satellite communications; security issues;

(Continued on page 14)

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Regenerative Correction

Q *Regarding the regenerative AM radio in the July 1997 installment of "Q&A" (on page 8), shouldn't the transistor be an NPN? The diagram shows a PNP. Also, what gauge of wire should L1 be wound with, and what is the length? Would a 250-μH ferrite bar coil work? — Pete Haas, Kent, OH*

A You're right—the 2N3904 transistor is an NPN even though the PNP symbol appears in the diagram. (Your author does his own drafting and can't blame anybody else for this one.) The coil is not critical; we used 36 turns of No. 28 magnet wire close-wound on a 4-inch spool that had originally held gift-wrapping ribbon. Any high-Q coil of about 250 μH should work just as well.

Regenerative Troubleshooting

Q *I tried using an LM386 audio amplifier with the regenerative receiver presented in July, and it started "motorboating" and displayed all sorts of spurious oscillations. Could you provide a simple circuit to drive a speaker from the regenerative receiver by means of an LM386 or an MC34119P?*

And, if possible, I would like to see a schematic of a simple superregenerative receiver to receive aircraft frequencies (117–136 MHz). Thanks. — L. H., Canoga Park, CA

A Taking the easy question first, plans for a VHF superregenerative receiver are given in the *ARRL Handbook for Radio Amateurs, 1998 Edition*, together with an explanation of how it works and the special "ugly bug" construction technique required. You can get that book from the American Radio Relay League, Newington, CT 06111.

Now for the motorboating problem. As you've discovered, regenerative receivers are very sensitive to power-supply coupling. For best results, power the receiver from one battery and the audio amplifier from another. If that's not possible, you can try isolating the two circuits as shown in Fig. 1. There are two bypass capacitors on each side because large capacitors aren't efficient at high frequencies.

Also, the LM386 itself is prone to oscillation at radio frequencies, and the LM386 circuit that you sent in (shown in Fig. 2) looks like it has too much gain. Regenerative receivers themselves have tremendous gain and don't need much audio amplification after them. Try removing C2 and R2, and make sure C3, C4, C6, and R3 are as close to the chip as possible.

Because of its low-impedance input and bridged output, the MC34119P might be a better choice for this application. Figure 3 shows Motorola's recommended circuit. For best results, use a 32- or 64-ohm speaker.

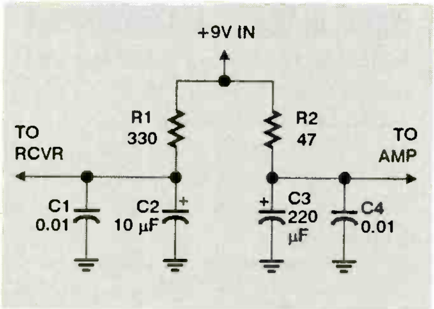

FIG. 1—HERE'S HOW TO POWER both your regenerative receiver and an audio amplifier from a single supply.

EPROMS Demystified

Q *I am new to electronics and would like to learn more about EPROMs and EEPROMs. Do they program through a language, or does the user have to plot the actual internal wiring? — G. G., Bradenton, FL*

A Let's distinguish three different devices: (1) ROMs (read-only memories); (2) microcontrollers, which are one-chip computers that include some form of ROM, together with CPU and input-output ports; and (3) programmable logic devices (PLDs), which are arrays of gates whose interconnections can be programmed by the user.

ROMs, or read-only memories, simply store information. A ROM chip has sixteen to twenty address inputs and eight data outputs. Information is repre-

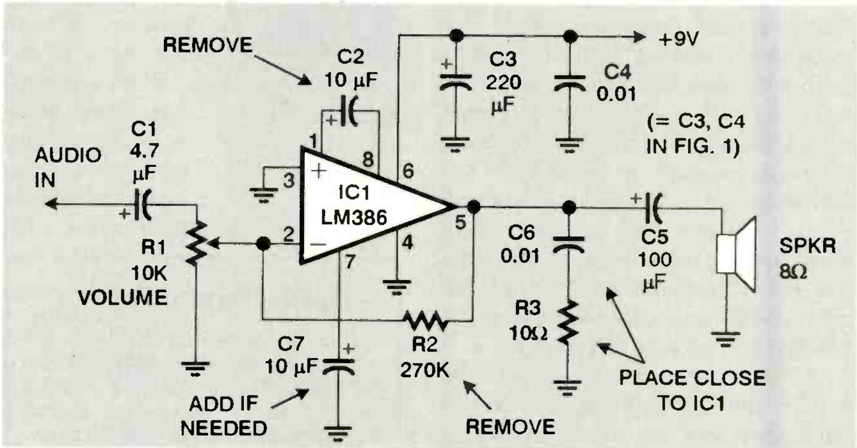

FIG. 2—FOR USE WITH A REGENERATIVE RECEIVER, the modifications shown to the reader's circuit will greatly improve stability.

sented as ones (+5V) and zeroes (0).
The address inputs identify locations within the ROM. For address
0001011000110111 could
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the ROM stores
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dress
emo-
dress,
data.
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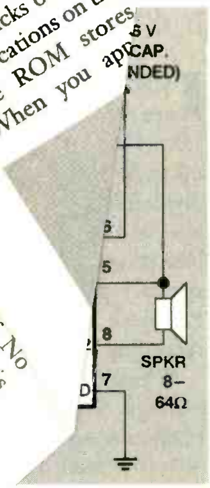

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A'S MC34119 AUDIO
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with. Note that capacitor C3 is
ecessary.

address inputs, the data stored at the corresponding location appears on the eight output lines. It could be any bit pattern whatsoever.

ROMs are usually used to store programs for computers, but they have some other uses as well. By connecting the address lines to a binary counter, you can step through all the addresses in sequence. You could use the output to produce patterns of blinking lights or messages in Morse code.

ROMs come in several types: mask-programmed (programmed at the factory), OTP (one-time-programmable, which means you can program them but not erase them), EPROM (erasable with UV light), and EEPROM (*e*lectrically *e*rasable *p*rogrammable *r*ead-*o*nly *m*emory). Flash memory is a variety of EEPROM where the whole chip has to be erased at once.

To program an EPROM, you use your PC to create a file of bits (or of hexadecimal digits that represent them); then download this file into the EPROM through a programmer.

Some good, inexpensive EPROM programmers include the EZ-EP from M²L Electronics (3526 Jasmine #4, Los Angeles, CA 90034; Web: www.m2l.com), and the Pocket Programmer from Intronics (Box 13723, Edwardsville, KS 66113); both are priced under $200. In a higher price range, the Needham's EMP-20 (about $450) gets good reviews. It's available from General Device Instruments; Tel:408-241-7376; Web: www.generaldevice.com.

To learn more about ROMs, see two articles in the November 1995 issue of **Electronics Now**, "Low Cost EEPROM Programmer" and "Five Easy EEPROM Projects;" reprints are available from the Reprint Bookstore (see the sidebar "How to Get Information About Electronics"). See also *Experiments with EPROMs*, by Dave Prochnow (McGraw-Hill, 1988).

The bits in an EPROM don't mean anything; they're just stored information. If the EPROM is connected to a CPU (central processing unit), the CPU will read the EPROM's contents and interpret it as instruction codes. If the CPU and EPROM are on a single chip, it's called a microcontroller. To program a microcontroller, you first write your

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To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online.

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1993 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549 Tooele, UT 84074.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League (Newington, CT 06111; http://www.arrl.org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

---

program in assembly language, C, or BASIC; then test it in a simulator on your PC; and finally download it into the microcontroller with equipment much like what you'd use to program EPROMs. Back in January and February 1994, we published plans for two microcontroller programmers. Many commercial EPROM programmers also program microcontrollers.

Programmable logic devices (PLDs) are arrays of gates whose interconnections you can either destroy (by blowing tiny fuses) or create (by melting "antifuses" to make connections). Their main advantage is that, because they consist only of gates, they respond to their inputs almost instantly rather than executing instructions one at a time like a microcontroller. PLDs are often used in address-decoding circuits inside computer peripherals. There are languages for describing the interconnections concisely. We covered PLDs in detail in the May 1994 issue, including plans for a programmer.

Ma... It Talk

Q *We ... toys. ... ment to pr... kinds of low-cost talking ordinary el... of expensive equip- state device ... or can I, using gered? I could ... ect a solid- a talking burgl... trig- H. D. K., Philad...*

A Voice-recordin... are as close as yo... store. For example, t... up to 20 seconds of au... divided into several mes... age is non-volatile—th... lose its memory when po... special programming eq... required; audio amplifiers ... recording and playback are on ...

These chips are made by Inf... Storage Devices (ISD), Inc., ... Hamilton Ave., San Jose, CA 9512... 408-369-2400; Web: www.isd.com. ... can view data sheets online at their W... site and learn more about their product...

RFI Emergency

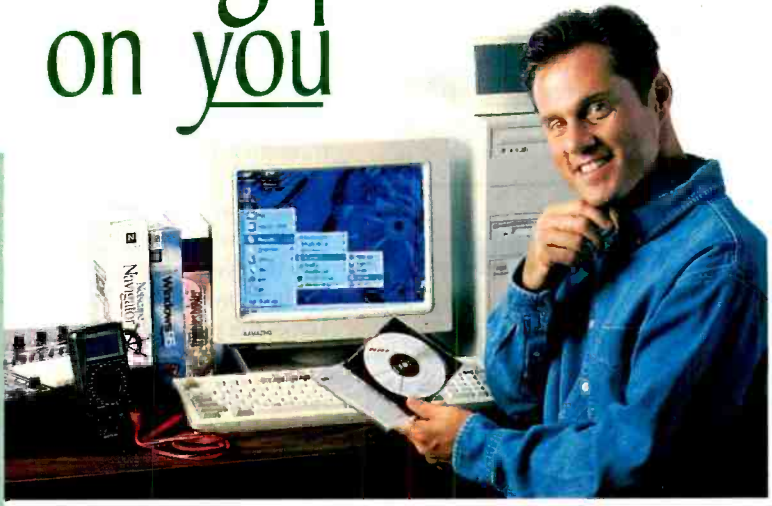
Q *My neighbor's CB interferes with my cordless phone, regular phone, TV speakers, and even new multimedia speakers. What can I do? — Name withheld*

A If only one piece of audio equipment were receiving interference, we'd suspect the problem might be on the receiving end. There is, unfortunately, no law that requires stereos, TVs, or telephones to block out radio signals, and some of them are shoddily built.

The fact that you're getting interference in so many different pieces of equipment strongly suggests that the problem is with the transmitter. Your neighbor may have defective equipment or an improperly installed antenna, or he may be running an illegal amount of power. CB is designed for short-range communication, but, unfortunately, some CBers get a kick out of blanketing North America with their signal, using a 1000-watt linear amplifier instead of the legal 4 watts. Some people just want to have the whole continent to themselves!

You should call the nearest Federal Communications Commission (FCC) field office; in your case, that's Atlanta at 770-279-4621. The FCC has imposed heavy fines on CBers who run illegal

5 Reasons why NRI Training in PC Servicing puts the emphasis on you



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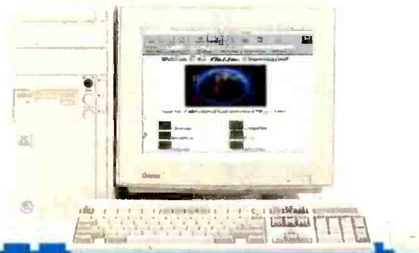

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amps. Your local ham-radio club may also be able to help; even though CB and ham radio are completely different services, the local hams will probably have the equipment and know-how to help you find out what's going on.

Finally, encourage your neighbor to get a ham license; that will allow him to use 1500 watts legally, provided he acquires the technical skill to do so without causing problems.

Computer Interferes With TV

Q *What can be done to get rid of interference on my TV when I turn on my computer? — B. G., Palmdale, CA*

A Several things. Plug the TV and the computer into separate outlets. Put a toroid (RadioShack 273-104) on the computer's power cord as close to the case as possible. Use an outdoor TV antenna or cable TV; an indoor antenna can't avoid picking up stray RF from a computer right next to it. Finally, watch a local TV station; if you tune in a station 50 or 100 miles away, the signal will be so weak that it is never totally free of interference.

Antenna Trick

Q *I have just purchased an AM/FM radio that is not sensitive enough to pick up an FM station of my choice. The radio has only a whip antenna, with no antenna terminals on the back of the receiver. What can I do? — H. F., Orleans, MA*

A Since you've just purchased it, the first thing to do is compare it with another unit of the same make and model; transistors vary in sensitivity, and you may have gotten a weaker-than-normal receiver. But given the amount of time it takes us to answer questions, it's probably too late to do that now.

An antenna trick that we've used with success is to extend the whip straight up, 30 inches long. Run another 30-inch whip, made of wire, straight downward; and connect it, not to the antenna, but to the outer ring of the headphone jack, which is grounded. You'll then have the receiver at the center of a vertical dipole. Whips longer than 30 inches are less efficient because their resonant frequency is below the FM band.

Surge Protector Question

Q *According to the manufacturer's catalog, an RS Electronics 238-845 surge protector is recommended for installation on telephone lines. Can I install it across a 230-volt power line? — M. P. J., Dammam, Saudi Arabia*

A No. Telephone lines carry about 50 volts (with surges to 200), delivered through a resistor that limits current to less than 1 ampere. Besides the higher voltage, an AC power line can deliver much heavier current, and there's a real risk that your surge protector would go up in flames. Never connect anything across the power line unless you are sure it is safe.

Modify CD-ROM?

Q *While shopping for an external CD-ROM drive for my old laptop, I found an external 4x-speed unit for $350, but internal 12x-speed units were on sale for $59. There has to be a way I can rig up the internal drive to operate from the PC Card (PCMCIA) slot or the parallel port. Any ideas? — Anonymous, Portage, IN*

A If the internal drive happens to have a SCSI interface, you can get a PC Card SCSI adapter and hook it up; of course, you'll also need a power supply and enclosure. If it's IDE (more likely), things aren't so easy; besides building an interface circuit, how much of Windows 95 do you want to rewrite? Still, someone may have solved the problem. Readers?

TV Service Tip

Q *Regarding a question in November's installment of "Q&A," tell W. A. E., whose TV intermittently loses brightness, to try tapping the base of the CRT gently with a long wooden stick or other insulated rod. It is common for older CRTs to develop a cathode-to-grid short. There is a technique for burning out such shorts; but if he can't tap it out, I suggest he treat himself to a new TV. — Tom Baasch, Ridge, NY*

A Thanks! Of course, no one should work near an energized CRT unless they are familiar with appropriate high-voltage precautions and also have a healthy respect for the risk of breaking the glass.

More Dimmer Interference

Q *Here's a follow-up to September's Q&A concerning AM radio interference from light dimmers; I've been experiencing the same problem for years. After reading the article, I bought new dimmers and installed them, but still had the same problem. I called the manufacturer of the dimmer, but there was no help forthcoming except a suggestion to install a filter on the power cord of the receiver. I tried one of these filters a few years back, but to no avail. What else can I do? — W. W., St. James, NY*

A If it were us, we might try different brands of dimmer, one at a time—it sounds like your new dimmers weren't appreciably different from the old ones. Also, you haven't indicated how severe the problem is. Some interference on weak signals will always be there; the receiver can't distinguish electrical noise from parts of the AM signal. On the other hand, if you can't receive local stations clearly, something is definitely wrong.

Have you tried a different radio? If a battery-powered radio doesn't suffer interference, try filtering the line cord of your line-powered radio—not by clamping a toroid on it (which would suffice at higher frequencies), but rather by plugging the radio into a power line filter such as RadioShack's 15-1111.

Dimmers are inherently noisy devices; the ultimate solution, if you need to hear weak AM signals, may be to simply do without them.

Writing to Q&A

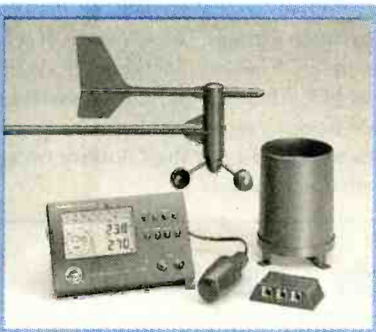
That's all for this month. As always, we welcome your questions; please write to: "Q&A," **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication). *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. EN

EQUIPMENT REPORT

RADIOSHACK ACCUWEATHER WEATHER STATION

Monitor every aspect of the weather with the RadioShack AccuWeather personal weather station.

CIRCLE 15 ON FREE INFORMATION CARD



The weather is important to different people for different reasons. Sometimes rain is good and sometimes it's not. Snow means a treacherous trip to work for many people, while others make money plowing it away. Kids certainly don't mind snow when school is closed because of it. On a more practical note, knowing what the temperature is outside before leaving for work makes it easier to select the right jacket.

Some people want to know more than just the temperature. For these people, RadioShack's *AccuWeather* personal weather station might just provide enough of a forecast. The compact unit can display indoor and outdoor temperature, humidity, and dew-point readings plus outdoor wind speed and direction, barometric pressure, wind chill, and rainfall. The highest and lowest readings for all measurements are stored in memory, and an alarm can be set in any mode to trigger when measurements go beyond user-specified limits. The system also keeps track of the time. AccuWeather even has a serial output that can connect to a computer. Software is included that lets you keep track of the weather readings as well as log data to a hard disk.

Although AccuWeather comes fully assembled, it does require some work installing the outdoor sensors and running the cables to the control unit indoors. AccuWeather (Model No. 63-1015) sells for $299.99 at any RadioShack store. That price includes everything you need: the control unit, three outdoor sensors, and all the cabling. If there is no RadioShack store near you, just call 800-THE-SHACK.

Setting It Up

AccuWeather consists of a small control unit that mounts indoors. It measures approximately 7 inches wide by 4¼ inches tall by 1¾ inches thick. A backlit LCD displays readings one mode at a time. The display can be set to show one of the following: the time and date, indoor and outdoor temperature, indoor and outdoor humidity, indoor and outdoor dew point, barometric pressure, wind speed and direction, wind chill, or rain accumulation. It can also be set to cycle through all modes, displaying each reading for five seconds.

Sensors for wind speed and direction, rainfall, and temperature/humidity must be installed outdoors. Each sensor has a 30-foot cable attached to it with a modular connector on the free end. The indoor sensors are contained inside the control unit. An AC adapter supplies power, and eight AAA backup batteries will power the weather station for up to 36 hours in the event of a power outage.

Installing the outdoor sensors takes a few hours. Before you can begin, though, some planning is required. First you have to decide where you want the control unit to be located, because you can't move it once you've installed the outdoor sensors and run the cables. Each outdoor sensor has a permanently attached 30-foot cable that cannot be lengthened. The cables have to reach from the sensors through a window or opening in an outside wall of your house to a connection box indoors. A 10-foot cable runs from the connection box to the control unit, so the sensor wires can enter the house up to 10 feet away from where you want the control unit. Because the control unit contains the indoor sensors, it should not be located near a heat source or cooling vent, or where it might be unusually humid.

If you can't run cables through a window without damaging them, it's best to install a length of PVC pipe through an outside wall and pass the cables though it. The pipe should be angled down toward the outside so that water will not seep inside. Pack the ends with putty that never hardens—that way you can always move the sensors if you have to without destroying the wires.

The anemometer assembly is designed to mount on an antenna mast away from any obstructions that would interfere with wind flow. The anemometer is a plastic arm with a wind vane on the top and wind cup on the bottom of one end. The arm is secured to the antenna mast with a pair of included U-bolts. RadioShack can supply an antenna mast and chimney mounting hardware. The anemometer arm must be mounted so that it points south—that calibrates wind direction with the control unit.

The rain gauge contains a two-sided flip-flop water ladle connected to a switch. A screened funnel directs rainfall into the ladle and causes it to toggle back and forth. The rain gauge should be mounted where it is level and blocked from crosswinds. It should not be blocked from above so that full rainfall will be collected, and it should be accessible so that debris caught in the screen can be removed.

The temperature/humidity sensor is factory sealed with an attached cable. The sensor should be mounted away from direct sunlight and wind in a place where snow and ice will not collect.

Be Your Own Weatherman

With all the sensors attached and power applied, AccuWeather lights up with weather data. The time and date have to be set when it's first powered up. The controls are easy to use, and they allow you to change display modes for different weather readings. You can also set the display units, say temperature between Fahrenheit and Celsius, wind speed in mph or kph, and so on. You can also recall daily highs and lows.

If you have a 386/33 or better PC and Windows 3.1 or higher, AccuWeather includes software that lets you monitor weather conditions from the computer as well as log data to disk. One nice thing about the software is that you see all the weather readings at once on-screen, rather than seeing only one reading at a time on the control unit's LCD. A serial port on the AccuWeather control unit connects to a serial port on the PC. The software defaults to COM1, but it's easy to change the port setting if it becomes necessary.

It seems that the weather forecast is always wrong these days. But with the power of AccuWeather at your fingertips, perhaps you can make better predictions on your own.

For more information on the RadioShack AccuWeather Weather Station, see your local RadioShack store, contact RadioShack (One Tandy Center, Ft. Worth, TX 76102) directly, or circle 15 on the Free Information Card. EN

NEW LITERATURE

. *continued from page 5*

switching techniques; transmission/propagation concerns; video technology; and more. Released by the General Services Administration (GSA), use of this glossary by is mandatory: "all federal departments and agencies shall use (this reference) as the authoritative source of definitions for terms used in preparation of all telecommunications documentation."

This official glossary is designated standard FED-STD-1037-C, superseding the 1991 version. It was developed by the Federal Telecommunications Standards Committee and issued by the GSA in order to improve the federal-acquisitions process by providing Federal departments and agencies with an authoritative and complete source of definitions that are used by national, international, and U.S. Government telecommunications specialists.

The CD-ROM contains two versions of the Glossary: an Adobe Acrobat version along with the Adobe free reader software, and a complete HTML Web site version of the glossary. Simply point your Web browser at the files on the CD to navigate through the Glossary. It will run under Windows, Windows95, Windows NT, Mac OS, and UNIX systems. LAN licenses are available for corporations wishing to put the Glossary on an internal network.

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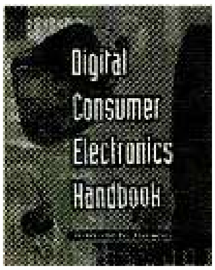

CIRCLE 346 ON FREE INFORMATION CARD

This title is an essential reference tool enabling readers to understand even the most complex digital technologies in today's fast-changing world of digital consumer electronics. A wealth of engineering information is presented as the handbook takes you step by step through the technologies for optical video systems; digital versatile disk (DVD); high-definition television (HDTV); digital VCRs, camcorders, and photography; digital cable systems; CD players; PCs; and more.

Readers will find complete details on fundamental digital concepts and on enabling technologies; the latest standards; delivery and reception systems; imaging, audio, and information and communication products; appliances; residential automation; and more. Each section is edited by experts in their particular field, and there are over 650 helpful illustrations packed into this volume.

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Fluke Corporation's 240-page catalog presents the full range of their instruments, accessories, and software for test and measurement, calibration, data acquisition, network testing, and many other application areas. The selection of products represented here is broader than ever, enabling users to choose the right tools for virtually every job. Professionals rely on Fluke's test tools to provide fast, top-quality information, as they are known to be rugged, accurate, and intuitively easy to operate.

Since a variety of new products were recently introduced and improvements were made to several others, a brief overview of the latest and most popular products is featured in the full-color Product Highlights section. Some of the products included there are the 5720A Calibrator; the 160 Series Multifunction Counter; and the CombiScope B, a combined digital-storage and analog oscilloscope. The remainder of the catalog is sub-divided into application-related categories, making it easy to find exactly what you need in the shortest possible time.

It is a user-friendly catalog with section headings at the top of each page. Almost all sections begin with a selection guide to let you easily compare key features and specifications. Details on calibration documentation and power cord options are in a section entitled "Working with Fluke." EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Oscillophones: "Son of the Tonal Voltmeter"

A method exists to probe breadboarded circuits (both analog and digital) without needing to look at a display or using a logic probe that measures more than ones and zeros. Oscillophones, the offspring of my "Tonal Voltmeter" (***Electronics Now***, September 1996), functions like a logic probe, a multimeter, and an oscilloscope; but it doesn't depend on an analog, digital, bargraph, or line-chart display.

Oscillophones converts the probe input into a balanced tone that is heard through headphones. This instrument makes troubleshooting easier. The schematic, which represents a simple, stand-alone device, is on the Web: http://home.att.net/~Lshaping. By adding just a little more than two diodes (a slight exaggeration) to the original tonal voltmeter, oscillophones was born. I thought your readers might like to take a look at this unit.

MARK O. BENDER
via e-mail

F.Y.I.

I've recently done tests on "stray" capacitance, which may be useful to your readers. Those who enjoy designing and breadboarding their own designs can relate to this problem.

In a high-speed analog circuit I designed, my breadboard layout exhibited the usual stray capacitance effects at high sweep rates on my oscilloscope display. After talking to an engineer, I began to suspect the "innocent" solderless breadboard itself. Sure enough, after making a direct capacitance measurement of adjacent terminal rows on the board, I found about 3 pF between each row of adjacent pin terminals! This indeed can play havoc with high-speed, fast rise-time circuitry.

My next question was "So how does a DIP socket affect circuit operation?" Measuring this capacitance was a bit more difficult; however, I came up with a method of hooking up alternate rows of DIP socket pins on a ZIF socket. This allowed me to measure the total capacitance of a series of standard DIP sockets by inserting them into the ZIF socket and taking the difference of the "fixture" capacitance with and without the socket-under-test. By dividing this result by the effective number of *capacitors* thus formed, I found the following results (average) between each pair of pins:

Standard, low-profile, solder-tail sockets measured about 0.25 pF between pins. The *double-leaf* variety also measured about 0.30 pF between pins. Not a lot to worry about, except in RF designs!

My conclusions: If your circuit works fairly well on a breadboard, it should improve on a socketed printed-circuit board. If you're experimenting with expensive chips, use DIP sockets—they can always be removed later, if necessary! If you're designing high-frequency RF circuits, avoid sockets and breadboards!

SKIP CAMPISI
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EN

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Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

BY JEFF HOLTZMAN
COMPUTER EDITOR

Pilot Graphing, Small C, E-mail, and More

WE'VE GOT THREE THINGS TO TALK ABOUT THIS TIME: CORRECTIONS TO LAST MONTH'S COLUMN, THE NEXT PART IN OUR SERIES ON PALMPILOT SERIAL I/O, AND A LONG-OVERDUE READER E-MAIL CATCH-UP.

Corrections

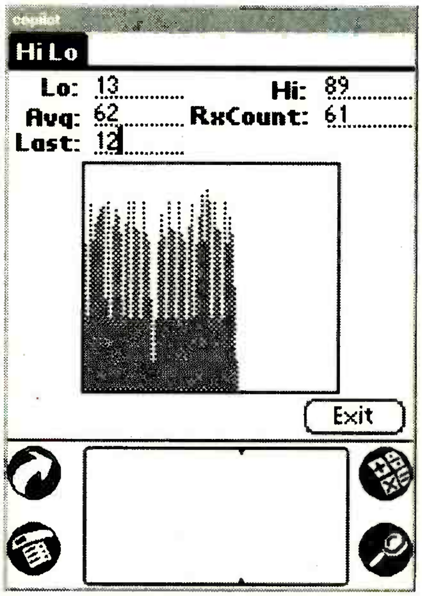
Last month I mentioned the PilotMain routine, which is the main processing loop of any Pilot application. Conceptually, it more or less corresponds with the main routine in a generic C program. A better analogy might be WinMain in a Windows program. In any case, I neglected to include the code for that routine. It's shown here as Listing 1. The code shown last time should have been tagged Listing 2, and all references to SerIOReceive should have referenced Listing 2. Sorry for the confusion.

Second, I stated that CoPilot, a freeware Win32-hosted Pilot emulator, can't do serial I/O. Whoops, it can. I must have had a configuration problem. In any case, I decided to give it one more try while developing the code for this month's installment and got it to work.

Third, I stated that the Pilot OS is not multitasking. Further research has proved that statement incorrect. The PalmPilot SDK documentation gives an extremely brief discussion of how the HotSync application works. Basically, there are two threads. One tends to serial I/O; the other tends to the user interface. There is no example showing how this works, however. Nonetheless, because of performance problems uncovered this time, it may be worth experimenting with

HiLo Version 2

You'll recall from last time that we started developing an application called HiLo. HiLo accepts byte-sized inputs from the serial port and tracks the minimum, maximum, average value, and count of values received. The new version adds a little graphics to the mix, as shown in Fig. 1. The chart occupying the central portion of the screen is the primary addition. My original plan was to implement a scrolling chart-recorder type of display. The current version is really just a graph that displays a maximum of 100 points from left to right. I still call it a chart recorder because that is the goal.



THIS MONTH'S INSTALLMENT of our Pilot programming series shows how to graph incoming data on the screen of our HiLo app.

This month's Listing 2 contains the differences between this and last month's code. Mostly there are additions. There is a new section of #defines, three new global variables, and two new functions. One function creates the chart recorder; the other displays new data points as they arrive.

The Pilot's screen measures 160 by 160 pixels. I thought a 100 by 100 chart would be nice and would simplify scaling. However, there wasn't enough space vertically in the current user interface, so I trimmed the chart to a height of 90 pixels. The size and location of the chart and the scale factor are determined by the #defines.

The new functions have been integrated as follows. PilotMain calls a routine named StartApplication. It in turn calls our new CreateChartRec function. CreateChartRec doesn't actually create any new user-interface objects. It simply displays on the current window a rectangle surrounding the space that will be used to plot points.

The other new routine is called AddPoint. It is called at the end of the primary I/O routine, SerIOReceive. What AddPoint does is add the current value to a global array called Data. The program then scales that value and displays it. If a value exceeds the height of the display area, it is truncated to the height. The routine also displays the numeric representation of the scaled value in the "Last Received" field.

The routine that plots the value is an OS call named WinDrawGrayLine that takes four parameters that refer to the start and end points of the line: x1, y1, x2, and y2. The routine doesn't actually draw a gray line; the PalmOS supports only 1-bit (monochrome) graphics. Instead it skips every other pixel.

Evaluation

The bad thing about this version of the program is that it is slooooooooow. It can't even keep up with 9600bps communications. If you send several values in quick succession, values are not lost, but screen drawing continues long after the last value has been sent.

There are several opportunities for optimization. The primary one is that we are retrieving characters one at a time from the serial receive buffer. Obviously, we could improve performance by getting several characters at once. But will that be enough to make screen-draw performance acceptable? We'll take that up next time. And while we're at it, let's see if we can make this thing work like a real (scrolling) chart recorder.

Incidentally, I use a handy little freeware utility called SimpleTerm to drive the CoPilot emulator. SimpleTerm allows you to send and receive data on the Pilot, just like ProComm, HyperTerminal, or similar programs. In that configuration, the Pilot remains in its cradle, which is attached to COM1 on my development machine. I developed the HiLo code in CodeWarrior, and when it compiles, load it into CoPilot. CoPilot is likewise configured to use COM1. For testing on the Pilot itself, I simply download HiLo. PRC to the Pilot using the InstApp utility that comes with every Pilot. Then, on the PC, I make sure HotSync is closed down (otherwise there will be port contention) and run HyperTerminal to drive the Pilot. The process is awkward, but doesn't require any cable swapping or extra ports. A cleaner solution would be an extra port connected to the pilot via a modem cable.

Also, I've developed a Windows-hosted shareware program that helps you organize and install files on your Pilot. The chief value of the program is that it lets you create sets of programs that may be installed as a group. Thus you might have one set for everyday use, another for development, *etc.* Check the Pilot section of my new Web site, www.ingen-inc.com for details and a free evaluation copy. I'll also be posting code and other information from previous and future columns.

LISTING 1—PilotMain

```
DWord PilotMain(Word cmd, Ptr cmdPBP,
Word launchFlags) {
        if (cmd ==
sysAppLaunchCmdNormalLaunch)     {
            StartApplication();
            EventLoop();
            StopApplication();
    }
    return 0;
}
```

LISTING 2—UPDATES FOR HILO

```
...
/* defines */
#define  ChartRectLeft     30
#define  ChartRectTop      52
#define  ChartRectWidth    100
#define  ChartRectHeight   90
#define  MaxDataPoints     ChartRectWidth
#define  VertScale         ChartRectHeight / 100
...
/* global variables */
...
static   RectangleType     ChartRecRect;
static   Short             Data[ChartRectWidth];
static   Short             DataPoints = 0;
...
/* Function prototypes */
...
static void CreateChartRec(void);
static void AddPoint (Short pt);
...
static void SerlOReceive(void) {
...
    ShowNumResultFld (HiLoMainFldLastField, SerlOCur);
    AddPoint (SerlOCur);
}
...
static void CreateChartRecRect(void) {
    ChartRecRect.topLeft.x = ChartRectLeft;
    ChartRecRect.topLeft.y = ChartRectTop;
    ChartRecRect.extent.x = ChartRectWidth;
    ChartRecRect.extent.y = ChartRectHeight;

    WinDrawRectangleFrame(simpleFrame, &ChartRecRect);
}
...
static void AddPoint (Short pt) {
    Short            LineHt;
    if (DataPoints < MaxDataPoints) {
        Data[DataPoints] = pt;
        LineHt = (int) (pt * VertScale + 1);
        LineHt = (LineHt > ChartRectHeight) ? ChartRectHeight : LineHt;
        ShowNumResultFld (HiLoMainFldLastField, LineHt);
        WinDrawGrayLine(ChartRectLeft + DataPoints,
                        ChartRectTop + ChartRectHeight - 1,
                        ChartRectLeft + DataPoints,
                        ChartRectTop + ChartRectHeight - LineHt);
        DataPoints++;
    }
}
```

E-mail

It seems that lots of people have an interest in small C compilers (discussed in the November column). Todd Sepke wrote to plug GCC running on Linux.

(Continued on page 22)

BY SAM GOLDWASSER
SERVICE EDITOR

Troubleshooting and Repairing CD Players and CD-ROM Drives

OVER THE NEXT FEW MONTHS WE ARE GOING TO LOOK INTO ALL THE CD AUDIO AND CD-ROM PLAYERS THAT ABOUND AROUND US. WE'LL BEGIN WITH A LOOK AT THE BASICS OF HOW THESE DEVICES WORK. THEN WE WILL MOVE ON TO maintenance, repair (including whether or not one of these units is worth repairing), disk care and repair, and more. We will conclude the series with some notes about specific equipment repairs.

Most of the information that we'll be presenting applies to CD players in component stereo systems, compact stereos, boom boxes, car units, and portables, as well as CD-ROM drives. The primary differences between those relate to how the disc is loaded; for example, portables are usually top loaders without a loading drawer. The one thing that is true regardless of the type of unit is that everything is tiny; and most or all of the electrical components are surface mounted on both sides of an often inaccessible printed-circuit board, with the entire unit assembled using screws that have minds of their own and a desire to be lost.

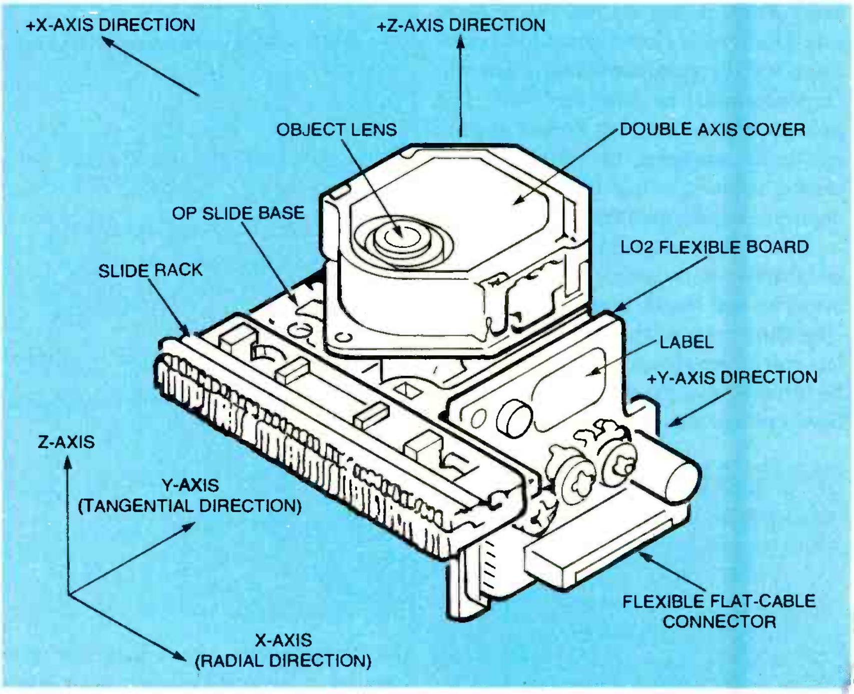
Note that Laserdisc players and optical-disk storage units have much in common with CD players. They tend to use similar mechanical components and front-end electronics. Therefore, this column will also help you get started troubleshooting these items as well.

Things That Go Wrong

Many common problems with CD players can be corrected without the service manual or the use of sophisticated test equipment. CD-player problems break down into specific groups:

- **Mechanical:** Problems here include dirt, lubrication, wear, deteriorated rubber parts, dirty/bad limit switches, and physical damage. A dirty lens—easily remedied—is probably the number one cause of common problems such as discs not being recognized, audible noise, and erratic tracking. Even professionals may be led to believe that those symptoms are being caused by much more serious (and expensive) faults. Don't be fooled!
- **Electronic Adjustments:** These include coarse tracking, fine tracking, focus, and laser power. Note that some newer CD players no longer have all of these adjustments.
- **Electronic Component Failure:** These are rare except for power-surge (storm and lightning strike) related damage, which, if you are lucky, will only blow out components in the power supply.

You can often repair a CD player that has a mechanical- or electronic-adjustment problem. The only real exception is a problem in the laser power supply, which I would not attempt to repair without a service manual and/or proper instrumentation, except as a last resort; im-



A CD PLAYER'S OPTICAL PICKUP must position the focal point of the laser beam to an accuracy of around 1 μm (micron or .000001 meter) and features complex electronic and mechanical components; yet the most common "repair" you'll need to do is to clean a dirty lens.

proper adjustment of the supply can ruin the laser. Note that if the player recognizes discs, or even if the unit only focuses correctly, then the laser diode and its power supply are probably fine. While laser diodes can and do fail, don't assume that every CD player problem is laser-related. In fact, only a small percentage (probably under 10%) are due to a failure of the laser diode or its supporting circuitry. Mechanical problems such as dirt and lubrication are the most common faults. Electronic (servo) adjustments come second.

Component failures in the power supply can be repaired fairly easily, but most other electronic failures are difficult to locate without the service manual, test equipment, and a detailed understanding and familiarity with audio CD technology. However, you might get lucky.

Repair or Replace?

While CD players with new, additional, and better convenience features are constantly introduced, the basic function of playing a CD has not changed significantly in the past 15 years. None of the advancements—including digital filters, oversampling, one-bit D/As, and such—are likely to make any difference in the listening pleasure of most mortals. Most people who care do so only because they are more concerned with the technology than the musical experience. Many of these so-called advances were done, at least in part, to reduce costs—not necessarily to improve performance.

So, unless you really do need a 250-disc CD changer with a remote control that has more buttons than a Boeing 777 cockpit and 2000-track programmability, a 10-year-old CD player will sound just about as good as a new unit and therefore might be worth repairing. Also, note that many older CD players were built more solidly than more recent models; even some of the new high-end CD players may be built around a mostly plastic optical deck and a flimsy chassis.

If you need to send or take the CD player or CD-ROM drive to a service center, the repair could easily exceed the cost of a new unit. Service centers charge up to $50 or more for providing an initial estimate of repair costs, but that is normally credited toward the total cost of the repair. It does take time to find problems, and a professional technician's time is costly these days.

If you can manage to do the repairs yourself, the equation changes dramatically. Your parts costs will be lower than what a professional will charge and, of course, your time is free. The educational aspects might also be appealing—you will learn a lot in the process. So it might make good sense to tackle that busted CD player in that bedraggled old boom box after all.

CD Technology

Information on a compact disc is encoded in minute pits that reside just under the label side of the CD. The CD itself is stamped in much the same way as an old style LP, but under much more stringent clean-room conditions. The CD pressing is then aluminum-coated in a vacuum chamber, and the label side is spin-coated with a protective plastic resin and printed with the label.

CD-Rs—recordable CDs—are slightly different. CD-R blanks are pre-stamped with a spiral guide groove and then coated with an organic dye layer followed by a gold film, resin, and label. The dye layer appears greenish and deforms upon exposure to the focused writing laser beam to form pits and lands..

The newest variation—DVDs (Digital Versatile Disks or Digital Video Disks, depending on whom you listen to)—implement a number of incremental but very significant improvements in technology that add up to a spectacular increase in information density—almost 10:1 for the same size disc. Those improvements include a higher-frequency laser, closer track spacing, better encoding, and a double-sided disc. According to early reports on the final specifications, DVDs are able to store 8 times the audio of current CDs at a higher sampling rate and bit resolution, 2 hours of MPEG-encoded high quality movies, and all kinds of other information. Raw data capacity is somewhere between 5 and 10 gigabites.

From here we are going to move on to maintenance and repair, but for those readers who would like an on-line introduction to CD and optical-disc technology, check out the www.philipsmagnavox.com/product/pe33.html (Philips/Magnavox Electronics Reference) Web site. There you will find links to a number of articles on the basic principles of operation of CD players, Laserdiscs, optical drives, TVs, VCRs, cassette decks, loudspeakers, amplifiers, satellite receivers, and other consumer A/V equipment.

If you go to www.umn.edu/nlhome/g496/ericOl39/Papers/paper.html (A Fundamental Introduction to the Compact Disc Player), you will find a somewhat more theoretical discussion of compact-disc audio technology with diagrams and even some equations.

Preventive Maintenance

Taking good care of a CD player is not difficult. There are four simple considerations. First, try to keep the player in a cool location. While CD players do not produce any significant amounts of heat, keeping them cool will minimize wear and tear on the internal components and assure a long, trouble-free life. Second, keep CD players out of dusty locations and avoid areas with high levels of tobacco smoke or cooking-grease vapors. I cannot force you to stop smoking, but it is amazing how difficult it is to remove the brown grime deposited by smoking on sensitive electronic equipment. Third, make sure that all audio cables are connected firmly and are tight and secure. That will go a long way toward minimizing intermittent or noisy sound. Finally, store all of your CDs away from heat. The polycarbonate plastic that they are made from is quite sturdy, but high temperatures will eventually take their toll. Always return them to their cases when they are not being played.

No doubt, you have heard that a CD player should be cleaned and checked periodically. For the most part, that is nonsense. CD players, despite the astonishing precision of the optical pickup, are remarkably robust. Optical alignment is almost never needed for a component CD player and is rarely required even for portable or automotive units.

An occasional internal inspection and cleaning is not a bad idea, but it is not nearly as important as for a VCR. Realistically, then, you are unlikely to do any preventive maintenance; so let me just point out the types of symptoms that indicate the need for a cleaning or other preventive or corrective maintenance. Those include problems like erratic loading, a need to convince the CD player to cooperate and play a disc, audio noise, skipping, sticking, or taking longer than usual to recognize a disc or complete a search. Of course, acute symptoms, like refusing to play or to open the door, are definite signs that immediate emergency treatment is needed.

Generally, I do not consider CD-lens cleaning discs to be of much value for preventive maintenance, since all too often they only move the crud around. However, for non-greasy dust, they might do a good enough job for a proper cleaning to be put off for a while longer.

Although CDs are much more tolerant of abuse than LPs, some precautions are still needed to assure long life. Also, even though only one side is played, serious damage to either side can cause problems during play or even make the CD totally useless. It is important to protect the label side from major scratches that could penetrate to the information layer. Even with the sophisticated error-correction systems used, damage to this layer, particularly if it runs parallel to the tracks, can make the CD unusable.

Remember, the CD is read by focusing a laser beam through the bottom 1.2 mm of polycarbonate. As a result of the design of the optical system used in the laser pickup, the beam diameter is about 1 mm at the bottom surface, and thus small surface scratches appear out of focus and in many cases are ignored. At the information layer, however, the beam diameter has been reduced (by precise focusing) to under 2 µm. Here, scratches running parallel to the tracks can cause the optical pickup to get "stuck," repeating a track, jumping forward or back a few seconds, or creating noise or other problems.

That's all for now. Until next time, if you have any specific problems or questions, contact me directly at sam@stdavids.picker.com. For general information on electronics troubleshooting and repair, you can visit my Web site at www.repairfaq.org. EN

COMPUTER CONNECTIONS

continued from page 17

SMALL C COMPILERS

Mix Power C: www.mixsoftware.com
Micro-C/PC: www.dunfield.com/downld.html
Pacific C: www.hitech.com.au/pacific.html
Dr. Dobb's Small-C Resource CD-ROM: www.ddj.com/cdrom
Cmm: www.nombas.com

Pilot Developer Resources

www.ingeninc.com
www.wademan.com/Pilot/Program/FAQ.htm
www.massena.com/darrin/pilot/index.html
www.sls.lcs.mit.edu/raylau/pilot/
www.usr.com/palm/pilotlinks.html
www.roadcoders.com/pilot/index.html
www.shoppersmart.com/jlehett/gccwin32.html
www.usr.com/palm/dresources.html
www.metrowerks.com (general info)
www.metrowerks.com/db/updates.qry?function=list&sw=CWPP3 (patches)

Newsgroups:

alt.comp.sys.palmtops.pilot
comp.sys.palmtops.pilot
news.massena.com/pilot.programmer
news.massena.com/pilot.programmer.codewarrior
news.massena.com/pilot.programmer.gcc
news.massena.com/pilot.programmer.jump
news.massena.com/pilot.programmer.pila

Regarding compilers *per se*, numerous people wrote to suggest various alternatives. One of the most popular is Mix Power C, suggested by several people, including Jim Goodman. Jim also recommended Pacific C and Micro-C/PC. Pacific C is available free for noncommercial use. Micro-C/PC is a targetable C compiler that generates code for several microprocessors and microcontrollers.

For learning purposes, I would recommend checking out *Dr. Dobb's Small-C Resource CD-ROM*, published by *Dr. Dobb's Journal*, one of the oldest PC-oriented programming magazines. I haven't seen the CD-ROM, but I have an old version of Small C on my system; it includes complete source code for the compiler and libraries. Alas, the version I have doesn't do pointers, but more recent versions might. Another interesting alternative is Cmm, (C-minus-minus) a sort of scripting environment heavily influenced by C, but without the hard stuff (pointers and memory management). EN

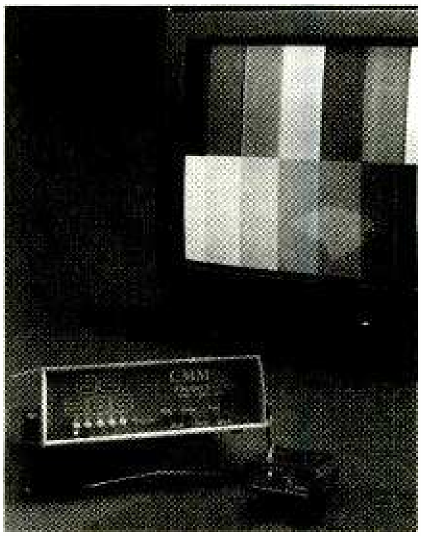
NEW PRODUCTS

continued from page 3

AEMC Instruments
99 Chauncy Street
Boston, MA 02111
Tel: 800-343-1391 or 617-451-0227
Fax: 617-423-2952

TV Test-Pattern Generator

Checker TV PRO and Checker TV Jr. are suitable for both test bench or field operation. Among TV PRO features are split-field color bars, gray scale, S-video output, RF output, and one-volt video. A stereo processor and tone generator allows the stereo detection and audio portions of the receiver to be tested. Patterns include a cross hatch with dots and white screen. Red, green, and blue signals are push-button selectable, as is the stereo signal and the audio tone. The unit can be AC or battery operated.



CIRCLE 22 ON FREE INFORMATION CARD

Small enough to fit into your hand (1×2×3-inches), the TV Jr. is convenient for field use, fitting easily into the technician's pocket or toolbox. The Jr. has colorbars; white, red, blue, green, and black screens; and cross hatch with dots. The various patterns are selectable by a single push button. Operating on a 9-volt battery, its output is 1-volt RS-170 NTSC color video.

Both generators are NTSC, RS-170 video compatible, and have complex synchronization. The suggested retail prices are $599.99 for the Checker TV PRO and $149.99 for the Checker TV Jr.

(Continued on page 28)

Prototype

Microflyers: The Ultimate in Unmanned Aircraft

The explosion had rendered the building extremely dangerous. Rescuers need more information on the condition of the building before they dare enter to search for survivors. To do this they release a dozen palm-sized "aircraft" that fly into the ruined building. Flying autonomously, they swarm through the building sending back pictures from their tiny video cameras.

ROBERT MICHELSON AND HIS FLAPPING WING "ENTOMOPTER." The goal is to make it even smaller. Advances in micro electro-mechanical systems and microelectronics technology give engineers confidence they can do so. (Georgia Tech photo by Stanley Leary)

Wait a second! What's this about an airplane small enough to fit in the palm of your hand that flies like an insect or a bird? Sounds far-fetched? Well, the Defense Advanced Research Project Agency (DARPA) and the Georgia Tech Research Institute (GTRI) don't think so. They along with others are now developing tiny microflyers.

The military is interested in those tiny aircraft for missions like detecting biological and chemical agents on the battlefield, "over-the-hill" reconnaissance, or delivering a disabling "sting" to enemy troops. Potential civilian applications include killing harmful insects, flying down smokestacks to measure emissions, monitoring chemical and oil spills, searching for survivors in damaged buildings, or tracking wild animal herds.

Some researchers are working on rather conventional fixed-wing designs, if you can call a four-ounce, six-inch long airplane conventional. Those could be powered by a micropulse jet engine, tiny jet turbine, or ducted fan engine. Whirling propellers or rotor blades are too dangerous for many of the missions planned for the microflyers. Fossil fuels would be used, at least initially, because a drop of gasoline contains more energy potential than current batteries of the same size.

The "Entomopter"

GTRI research engineer Robert Michelson has a more radical concept. His "entomopter," a name chosen because of his design's insect-like characteristics, uses reciprocating chemical muscle (RCM) for motion. Not only could the entomopter fly, it could also crawl and maybe even swim. With RCM, a monopropellant fuel is used to produce a reciprocating motion such as beating wings or scurrying feet. Additionally, RCM can generate electricity needed for the microflyer's controls and to power on-board electronic equipment. Gas generated as a byproduct of RCM can be used to change the lift on either wing to allow the otherwise-autonomous, symmetric wing beating to produce "rolling" so the entomopter can turn right or left.

Though flown under human control, microflyers will have to fly autonomously to avoid obstacles and maintain stable flight on their own. The smaller an aircraft gets, the more skittish it acts. Human operators often cannot react in time to control a tiny aircraft, especially when viewing the scene from an on-board camera on a TV monitor.

"Flying a remote-controlled helicopter is extremely difficult, and even experienced people crash them all the time," says Dr. Samuel Blankenship, coordinator for the Georgia Tech Focused Research Program for Microflyers. Furthermore, "These aircraft will need autonomy so we don't have to spend a lot of time training people to operate them." Autonomous navigation techniques under consideration include a geographic information system (GIS) for terrain-map following or use of the global positioning system (GPS).

Even though Michelson's current prototype is small, featuring a 10-inch wingspan, it has to be shrunk even further. The goal is a bird-like six inches at its largest point and a weight of a mere four ounces. Flight controls, power sources, propulsion systems, avionics, and payload are allowed a mere two ounces. Performance requirements include speeds of up to 50 mph and a range of 10 kilometers.

On-Board Electronics

Other researchers are working on miniaturizing the microflyer's electronic payloads. For instance, they are developing ultra-small and very simple sensors to detect toxic chemical and biological agents on the battlefield. Those sensors, basically small chips of glass with optical waveguides fabricated on their surfaces, would trap and manipulate light.

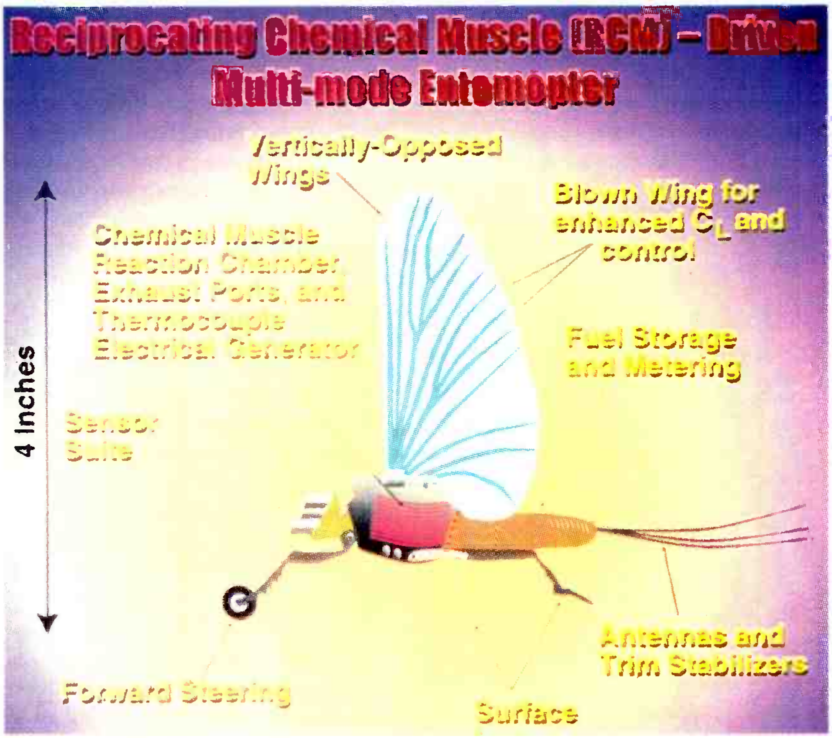
On the most basic level, the sensors would have only two channels, one for sensing and the other as a reference. When a toxic chemical or biological sample passes through the sensing channel, the change in refractive index alters the phase of the laser light. A solid-state detector array "reads" the fringe pattern created when laser light-beams from the sensing and reference channels are combined.

These simple sensors can be designed to detect a particular chemical species suspected of being used or a known emission to be measured. In cases where the exact chemical is unknown, multiple sensing/reference pairs on the same optical chip can be used along with pattern-recognition techniques to determine the chemistry. A dozen channels can be put on a single chip to determine what the microflyer is flying through. Already small, about 1 cm by 2 cm, the sensors would have to be made even smaller to fit on the microflyer, and they would have to include signal-processing electronics.

Researchers also are working on miniaturized visual sensors and communications devices. For instance, visual sensors could use miniaturized active-pixel arrays like those in the nose cones of missiles to provide real-time image processing. At least for military applications, they will probably not use cellular frequencies, which are crowded and easily jammed, but higher frequencies, which allow the use of a smaller antenna.

Speaking of smaller, microflyers require the ultimate in miniaturization and weight reduction. Every piece of the microflyer will probably have to do double or even triple duty. A radio antenna could serve as a stabilizer, while fuel would be stored in the legs. A self-consuming system is also being considered, where the entomopter itself would be used as fuel as it "eats on the run" to extend mission endurance.

Besides being tiny, microflyers have to be cheap since they most likely will be expendable. They could be consumed as fuel or not be recoverable because they have flown through toxic atmospheres. The goal is about a $1000 each for military applications.—*BILL SIURU* PT



THE RECIPROCATING CHEMICAL MUSCLE driven entomopter. Wind, rain, and air resistance as well as keeping weight to a minimum, represent significant challenges when the Entomopter is flown outdoors. (Georgia Tech photo by Stanley Leary)

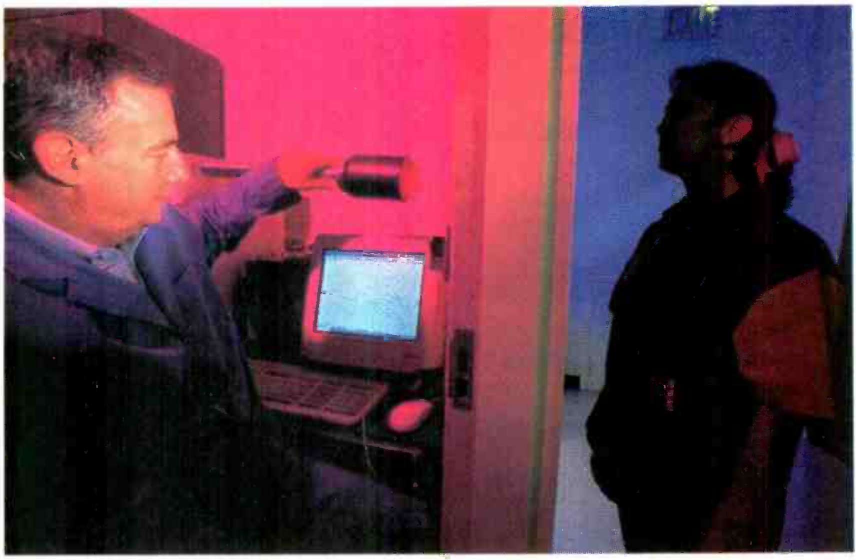
Radar Flashlight "Sees" Through Walls

A prototype radar flashlight that can detect someone's presence through walls and doors could one day be used by the police and others to make their jobs safer. Gene Greneker, principal researcher at the Georgia Tech Research Institute (GTRI), explained that the development is part of a family of technologies that also picks up the heartbeat. The device uses a rather narrow radar beam of about 15 to 20 degrees and a specialized signal processor to locate movement, and it discerns respiration from up to three meters away.

"Based on respiration signature alone, the radar flashlight allows us to detect a stationary individual behind a solid wooden door or standing four feet behind an eight-inch block wall," said Greneker. "These qualities make the flashlight potentially useful to police officers in ambush situations and to prison guards doing bed checks."

The radar technology has some advantages over other technologies. "The signal from the radar flashlight will penetrate clothes and detect respiration through a heavy jacket," Greneker stated. "In fact, the radar flashlight requires a body movement of only a few millimeters to detect human presence."

For now, the signal processor is outside the casing, and the respiration signature is displayed on a monitor driven by a computer-based radar-signal processor. Greneker plans to eventually make everything small enough to fit inside the flashlight housing by incorpo-



THE RADAR FLASHLIGHT in action—detecting someone's presence through walls and doors.

rating high-speed signal-processing technology.

Research that evolved into the radar flashlight began in the mid-1980s with the patenting of a frequency-modulated radar for remotely checking vital signs of battlefield wounded before risking medic's lives. (See the article, "High-Tech Battlefield Medicine," **Electronics Now**, April 1997.) That early technology also was tested for its ability to monitor vital signs of soldiers clothed in chemical or biological warfare suits, without requiring them to risk contamination by removing the protective gear.

Possible future applications include locating people in a room during a hostage situation and finding survivors in the rubble of earthquakes or after major disasters such as airplane crashes, bombings, or landslides.

Most recently, Greneker developed a prototype vital-signs monitor in hopes of displaying the heartbeats of archers and rifle competitors during television coverage of the 1997 Olympic Games. Such athletes are believed to sense their heartbeats and shoot between them to avoid the slight body movement—and potential shooting inaccuracy—created by each pulse. This application ascertains heartbeat signals 30 meters from the subject. The technology's potential to monitor heartbeat raises some interesting possibilities, Gene notes.

"This version of the system might be used as a biometric identification tool," he said. For example, if it could be shown that an individual's radar heartbeat signature is stable over long periods of time and is unique, the remotely sensed heartbeat could serve as a 'fingerprint' of sorts." PT

Blood Disorders Analyzed in Minutes

A revolutionary handheld device analyzes blood samples in minutes rather in the current turnaround time of hours to weeks. The Biological Microcavity Laser has been patented by scientists at Sandia National Laboratories and the National Institutes of Health (NIH). The unit is a kind of "lab-on-a-chip," using millions of tiny fingers of laser light from an area roughly the size of a postage stamp to image cells in a drop of blood placed in a small chamber.

According to investigators Paul Gourley of Sandia and his brother Dr. Mark Gourley of the NIH and the Washington Hospital Center, it's possible to take a blood sample containing millions of cells and extract information about each cell almost immediately. In just a few minutes, the laser device can find tiny changes in cell structure, such as those caused by the AIDS virus, or to detect disorders such as sickle-cell anemia. The microcavity laser is also better able to distinguish between cancerous and non-cancerous cells than Pap smear tests, which visually analyze only relatively small numbers of cervical cells. It also should permit observers to monitor unrestricted cell growth—cancer—and

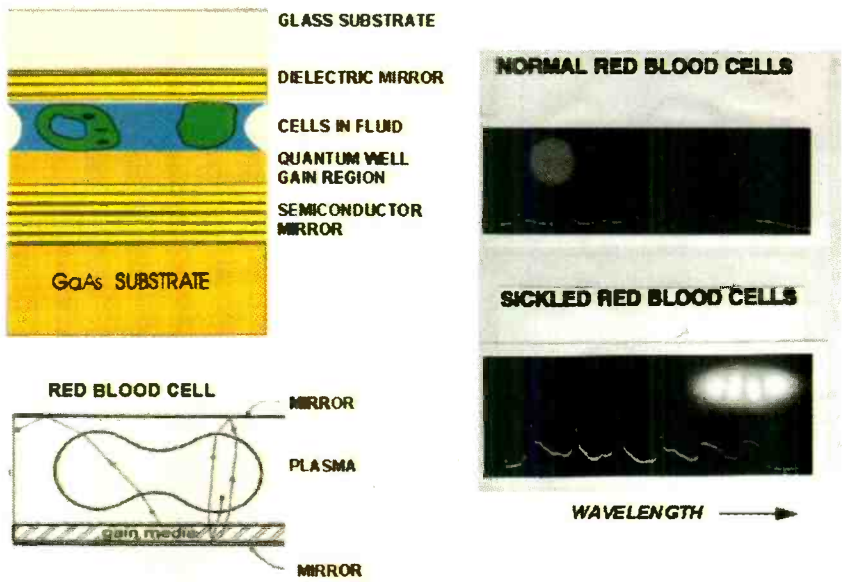
➢ Electronic Noise Prevents Piracy and Provides Protection

Researchers at Los Alamos National Laboratory have patented a new software technique that prevents pirating of copyrighted information and unauthorized manipulation of digital images. It also allows storage and open transmission of hidden data. The "data-embedding" technique uses electronic *noise*, associated with images and other data, as space to store additional information without increasing the size of the host document. The "C" programming language software being used conforms to virtually any digital-storage medium.

The technique could protect intellectual property rights of digital information with unique "watermarks" that would identify illegally copied software or CD recordings. It could also embed a patient's confidential medical history in electronic X-rays or other records. Another possible use could be sending digitized military maps over open communications lines with embedded information about targets and other secret information.

Currently under development is a potential application to improve security by embedding photo identification cards with positive biometric identifiers such as iris scans or infrared thermograms of a person's face. There are additional patents pending, and the developers are seeking a commercial partner. PT

BIOCAVITY LASER - A New Tool to Image Living Cells



SIDE VIEWS OF THE BIOCAVITY LASER and of a blood cell placed in the device, plus laser analysis showing what the viewer would see if the blood cells were normal or abnormal.

programmed cell death (apoptosis) as these processes take place.

Initial funding for the work came from the Department of Energy (DOE) for the purpose of developing a technology to help victims of biological or chemical attack by terrorists. Since its small size enables it to be taken anywhere easily, the time needed to analyze dangerous materials in the bloodstream of victims can be greatly reduced—minutes that could mean the difference between life or death. A portable field version using a laptop computer would cost between $5,000 and $15,000, Gourley estimates, and a hospital unit would cost about $70,000.

Based on a laser device called a VCSEL—a Vertical-Cavity Surface-Emitting Laser—the concept was invented at Sandia in the mid-1980s. Blood samples are inserted into the laser itself to become part of the generation process of the VCSEL laser beams. The light reflects many times through a sample so the deviation in image created by the blood particle is magnified, greatly increasing the chances of positive, error-free identification.

"It's basically a tool to study cell structure changes," said Paul Gourley, "and it could even be used for sequencing DNA." PT

Smartcard Chips

Smartcard users in 2000 will enjoy faster transaction times and greater information storage capacity as a result of a joint research and development project that was announced between Motorola's Semiconductor Products Sector and Japan's Matsushita Electronics Corp. The project will produce the next generation of chip technology for smartcards, based on FERAM (Ferroelectric Random Access Memory) rather than the EEPROM memory currently in use. The first chips are expected to be shipped by the end of 1999.

Mike Inglis, general manager, Motorola Smart Information Transfer Division, commented, "We expect to see an increasing demand for more complex applications using ever greater amounts of memory, but without an increase in transaction speed. Smartcard users won't stand at an ATM for three minutes waiting for their information to 'download.' FERAM technology will allow us to meet those demands, while maintaining the physical size and strength needed in a chip that's carried in pockets and wallets."

The challenge for smartcard chip manufacturers is to deliver chips with ever greater memory capacities to run the more complex applications, with no loss of transaction speed. FERAM technology offers the combination of speeds 20 times faster than existing EEPROM technology with up to 10 times the memory capacity. FERAM smartcard chips could have capacities of 64K or 128K, compared to the 8K to 16K currently available.

According to Dr. Gota Kano, managing director of Matsushita Electric, "FERAM has come to the forefront of memory development, due to its remarkable properties such as endurance 10 million times more than that of FLASH and EEPROM, incredible write speeds, and its use of only a fraction of the power of any other memory technology." He added: "The winner will be the consumer, as a myriad of applications which employ this technology will provide confidence for the information society." PT

Solar-Energy Mission

The National Park Service is using solar power to heat, cool, and light the visitor center at the Salinas Pueblo mission, a national monument attracting 70,000 visitors a year. Located in central New Mexico, the monument consists of stone-and-adobe walls originally built by the Anasazi between 700 and 1300 AD, mixed in with the ruins of an early 17th century Spanish mission.

Sandia National Laboratories' Photovoltaic Systems Assistance Center helped integrate photovoltaics into the visitor center's existing power system. The monument's PV system should meet a large portion of its summertime energy needs and nearly all of the wintertime load. The electric grid is still connected and can provide additional power when needed. According to a Sandia spokesman, the monument is a perfect place for solar power. No one wants to see power lines overhead in a remote location.

This work is a result of the ongoing partnership between the laboratory and the Park Service, the Bureau of Land Management, the Forest Service, and the Department of Defense. It's Sandia's job to assess what these agencies have done with photovoltaic (PV) systems and the potential for future use. PT

BY FRANKLIN J. MILLER
AUDIO EDITOR

Capacitance-Box Applications

NOW THAT YOU HAVE BUILT THE CAPACITANCE SUBSTITUTION BOX (C-BOX), YOU ARE READY TO START USING IT TO TEST ACTIVE AND PASSIVE CIRCUITS. TO GET YOU GOING, THIS MONTH I AM GOING TO PRESENT SOME EXAMPLES OF HOW you can put the box to work.

If you do any amount of circuit designing, you will find surely find the C-Box to be a handy test-bench accessory. That's because while any designer who knows what he is doing can use standard formulas to calculate any needed values, there is nothing like a real in-circuit trial to prove the theory.

Of course, using mathematics is certainly the right way to start the design process. But once the values have been calculated, it is important to build a working prototype of the new circuit. I have been fooled in the past, when something that I calculated did not work as planned. Test and measure is always a very good idea and good advice.

To illustrate what I consider to be the proper design procedure, let's consider the circuit shown in Fig. 1. The design equations we will be using are also shown in that figure.

The first thing we will be looking at is the effect changing a capacitor will have on the audio signal. Capacitor C1 is used to set the low-frequency point in the circuit. Take a look at Equation 1. It is the design formula used to determine frequency when the resistance and capacitance are known, and it is no doubt familiar to almost anyone who has studied even a little electronics math. The problem is that the equation is not in the most convenient form for our exercise as the unknown we are looking for is the capacitance. Fortunately, that is easy enough to fix; a little algebra allows us to rearrange the terms and gives us the formula shown in Equation 2. Since the lowest frequency of interest is 20 Hz and the impedance (resistance) is 100k, we can plug in those values to find that the capacitance needed to establish our -3-dB point is 79.57 nF.

Now let's see how this calculation works in the real world. Insert the C-Box in place of C1 and wire the rest of the circuit in the usual way. Set the C-Box to 79.57 nF. To do that, start with all of the buttons in the up position. Then depress the 4 button in the 10-nF column and then the 3 button in the same column. The next step would be to depress the 4, 3, and 2 buttons in the 1-nF column. Now push in the 4 and 1 buttons in the 100-pF column. For the final digit depress the 4 and 3 buttons in the 10-pF column. That should set the capacitance to 79.57 nF ± 1%.

Now, place a 20-Hz tone between C1 (the C-Box) and ground and measure the signal at the output of the first op-amp. If all is well, the output will be down 3 dB (the signal voltage will be reduced in half).

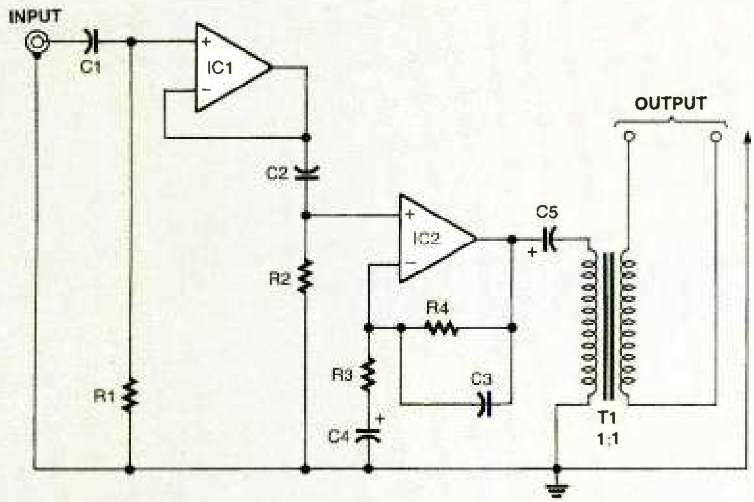
Now that we have confirmed that the real result matches the calculated one, let's try something different. Let's assume that we decide that the output should be flat at 20 Hz. That means that the -3-dB point must be moved to a lower frequency. The problem here is that we do not know what that frequency should be. But we can use the C-Box to easily solve this problem.

The same setup is used as above. If we look at the voltage output, we will see that it decreases as the value of capacitance increases. You can push the switches on the C-Box in and out and watch what happens at the meter. How close you get to a 0-dB loss is entirely up to you, the designer. I have found that replacing the 2 in the formula with a ¼ is a good way to start, though that is just my rule of thumb. If you do the calculation, to get a 0-dB loss you will come up with a value of 636.61 nF for C1. Of course, we cannot replace the C-Box with a capacitor of that exact value at a reasonable cost. The tolerance of the capacitor we do use will determine the exact value. For example, a 1-mF-electrolytic capacitor with a 20% tolerance will work well. Be sure to observe the proper polarity when installing the capacitor.

The High-Frequency End

The next capacitor to look at would be C3. It limits the high frequency of the op-amp system. The op-amp may be able to pass frequencies above 20 kHz, but there is little practical need for information above that frequency. As such, a good -3-dB point could be 30 kHz. Again use Equation 2 to solve for the needed value. Assuming a frequency of 30 kHz and a resistance for R4 of 100k, the answer is 53.05×10^{12}, or 53.05 pF. You cannot get that exact value with the C-Box. The closest value that you can get is 50 pF. Set up the C-Box for that value and test the circuit at the point where C5 connects to output of the IC2.

Next, set the audio oscillator to 30 kHz and put the level at +4 dBm. You should read a voltage of 1 dBm. Now look at the output when the frequency is set at 20 kHz. The voltage should be +4 dBm. If this is satisfactory, then you have



EQUATION 1: $f = \frac{1}{2\pi RC}$

EQUATION 2: $C = \frac{1}{2\pi f R}$

EQUATION 3: $g = 1 + \frac{R3}{R4}$

EQUATION 4: $20\log(\text{dB}) = 1 + \frac{R3}{R4}$

FIG. 1—HERE'S THE CIRCUIT WE'LL BE USING to demonstrate one of the best uses of the C-Box, which is to verify the capacitor values that are obtained using the standard design equations.

made a good choice. If not, you must use a lower value of capacitance. You might try designing for 40 kHz. Then the capacitance value will be 39.78 pF (use 40 pF). Continue to take readings and experiment with values until you are satisfied.

Setting The Low Frequency

The next capacitor in Fig. 1 that we need to look at is C4. It sets the low frequency of IC2. We will use Equation 2 again to calculate the value of the capacitor. But first we must calculate the value for resistor R3, which sets the gain of that op-amp. To do this we need to use Equation 3, or, if we already know the gain (specified in dBs), Equation 4. For this example, I selected a gain of 14 dB, and once again assumed a value of 100k for R4. That yields a resistance of 24,937 ohms for R3. For the sake of reality, use 24k. Plug that value into Equation 2, along with the frequency of 20 Hz, and your solution should be 331.5 nF.

Try that value in a real circuit and see how it works. Again, that is the -3-dB point. As resistance increases, the -3-dB point moves to a lower frequency. The exact value that you chose will depend on the use of the circuit. Use the C-Box to try different values and see what happens.

The final component that we will be dealing with in this circuit is C5, the output capacitor. That capacitor limits the low-frequency value. The only other factor that you do not know from Fig. 1 is the load impedance into which this circuit will work. Let us make two assumptions. First let's assume that the load impedance will be 600 ohms. Then let's look at a second load impedance at 10k. Again assuming a -3-dB point of 20 Hz, for the 600-ohm impedance the answer is 13.26 mF. As that value is out of the range of the C-Box, let's try 40 Hz instead of 20 Hz. That yields 6.63 mF, which can be set in the C-Box without any problems.

Now let's investigate an output impedance of 10k. Again use Equation 2 to solve for C. The answer is 795.7 nF. That value is easy for the C-Box. You might have noticed that the higher the impedance the lower the capacitor value. Knowing the load impedance with this capacitor is quite important. With this circuit you can investigate the effects of the capacitor on the frequency response. It will be a great learning experience for those of you that have not done this kind of work before. Practice makes perfect; experiment often and you will eventually be able to do this by instinct. EN

NEW PRODUCTS

continued from page 22

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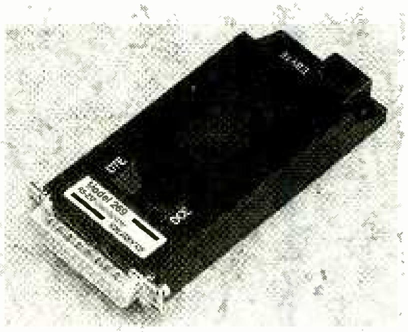
Optoisolation Unit

The continual appearance of new government regulations worldwide causes havoc with equipment suppliers. IEC 601-1 invokes higher limits of isolation for electronic equipment used in medical environments. That requirement led to Telebyte's development of the Model 269, IEC-compliant, Optoisolator.

Designed for medical electrical equipment, the Model 269 is a compact RS-232 to RS-232 optoisolation module that withstands 4000 volts AC for one minute and provides that level of isolation for the TD (Transmit Data), RD (Receive Data), and ground RS-232 signals.



CIRCLE 23 ON FREE INFORMATION CARD

The primary RS-232 port is a DB-25 male connector, which may be configured via switch selection as a DTE or DCE device. The secondary port is configured in an RJ-12 six-position modular jack with pins 3, 4, and 5 being Transmit Data, Receive Data, and Isolated Ground, respectively.

Packaged in a plastic case that measures 2 by 4.1 by 0.75 inches, the Model 269 retails for $120.

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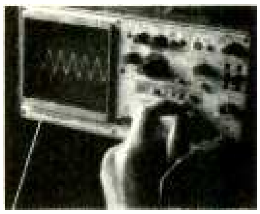

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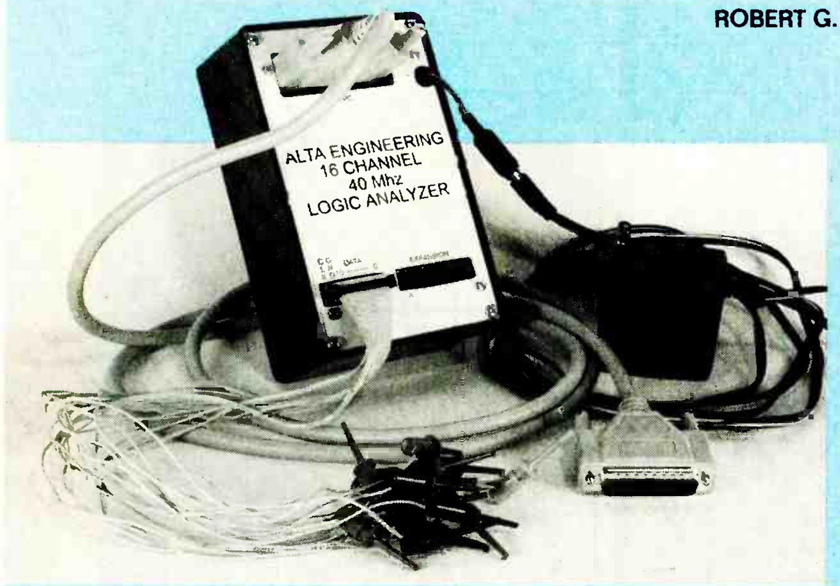


ROBERT G. BROWN

BUILD A HIGH-PERFORMANCE LOGIC ANALYZER

Turn any computer into a high-speed, high-performance, expandable logic analyzer that can grab samples at up to 40 million per second!

One of the most useful tools for anyone working with digital electronics is a logic analyzer. Of course, a logic analyzer is also very expensive. There have been several designs for personal-computer-based logic analyzers that connect directly to the computer's printer port. While those devices are very useful and low in cost, they suffer from a fairly low sampling rate and a limited number of channels that can be sampled.

The PC-based logic analyzer presented here, although a bit more expensive then those other units, has most of the features of the even more expensive commercial units. It features a 40-MHz maximum sampling rate with ten clock-speed selections—eight that are internal and range from 40 MHz to 312.5 kHz, and two external inputs. A total of 16 channels can be sampled simultaneously. The triggering is controlled by an 8-bit trigger word that includes high-level triggering, low-level triggering, and "don't care" states for each channel. A total of three triggering modes are provided. The sampled data is stored in a 2048-word memory buffer that is transferred to the PC after the sampling is completed.

In addition to those basic features, the logic analyzer is designed to be expandable. Other features and devices can be plugged into the logic analyzer for uses that a logic analyzer can not be used for by itself. For example, a future article will describe how to build an expansion module that will turn the logic analyzer into a full-featured digital-storage oscilloscope!

Theory of Operation. In general, a logic analyzer works by taking a sample of a set of digital signals at set time intervals after a certain triggering condition appears on the inputs. When the analyzer is triggered, the samples are read and stored for later viewing. The analyzer board has five main functional blocks: the PC interface, clock generation, data storage, trigger control, and 5-volt power supply. The schematic diagrams in Figs. 1 and 2 show how the circuit is put together. In order to keep the PC Board size down, the circuit is designed around two programmable-logic devices. A Lattice Semiconductor ispLSI1016E Complex PLD (or CPLD) is used for IC1. The ispLSI1016E holds a lot of digital logic within its 44-pin PLCC package. The particular programming that is used in the logic analyzer design is equivalent to about a dozen standard TTL chips. An additional PLD is used for IC2. That chip replaces about 4 standard TTL chip's worth of logic. Those two PLDs handle most of the logic on the analyzer board. Since much of the logic is contained in IC1, it plays a part in most of the different functional blocks.

The PC interface connects to any standard printer port through J1; a bi-directional port is not needed. All 12 output signals (8 data lines and 4 control signals) on the port are used by the analyzer. Four of the five possible inputs to the PC are used to read data and status information from the analyzer circuit. Each signal is terminated using a resistor-capacitor pair to make sure that the signal does not become garbled in any way. The signals that are edge sensitive are further buffered by IC9, a 74HCT14 hex inverter. The 74HCT14 is a Schmitt-trigger device that has "hysteresis" on the inputs. That causes the outputs to "snap" on or off even if the inputs rise or fall slowly. That action cleans up any poor-quality signals.

The software running on the PC passes information to and from the logic-analyzer board using a simple addressing method. Three address

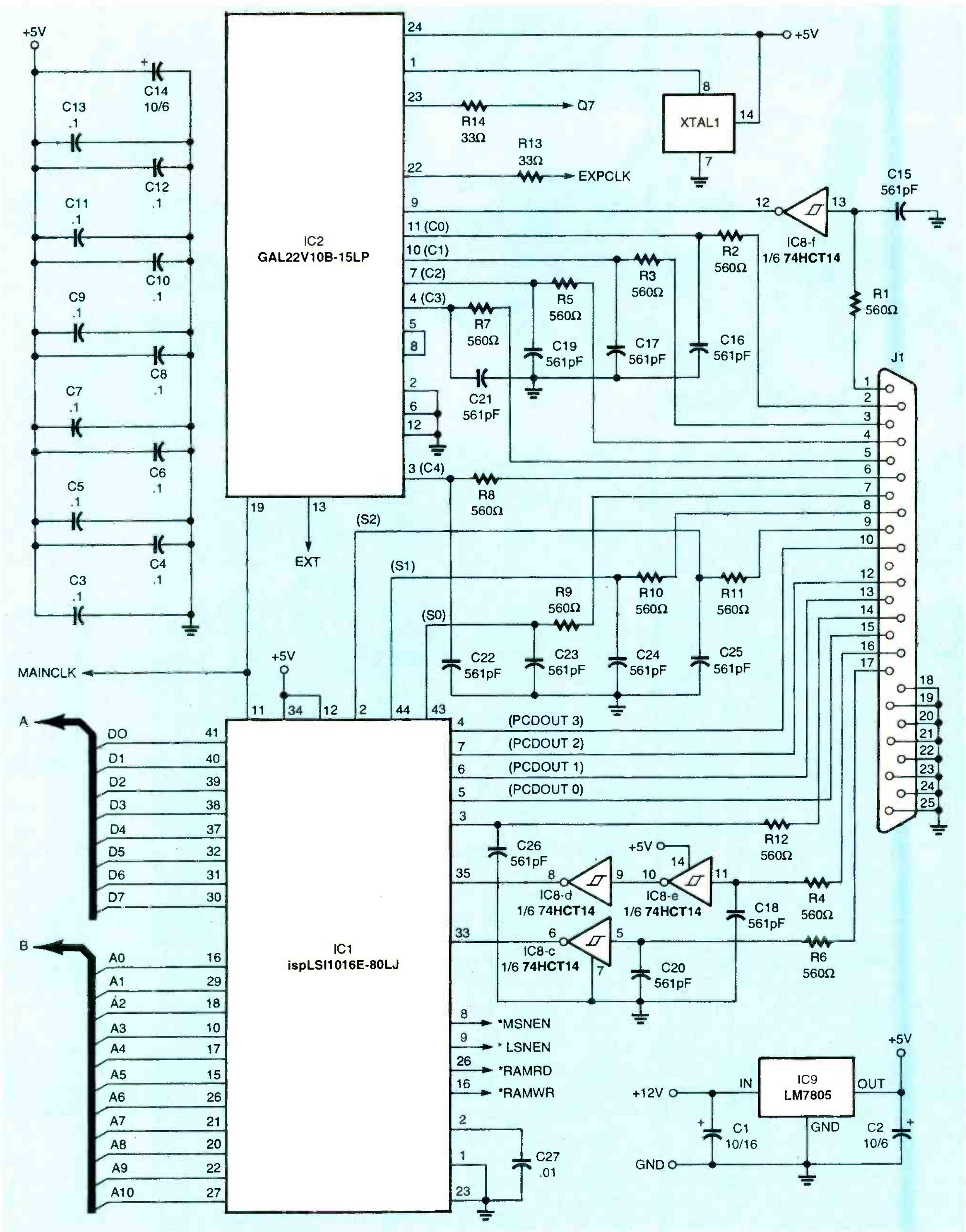


Fig. 1. The circuitry of the Alta Engineering Logic Analyzer is simplified by the use of programmable-logic devices (PLDs) that can replace a dozen or more individual integrated circuits.

signals are used to select one of eight address locations on the analyzer board. Once the address is set, the PC can read information from the signals PCDOUT0, PCDOUT1, PCDOUT2, and PCDOUT3 through the printer control register. Table 1 shows the different addresses and the information that is

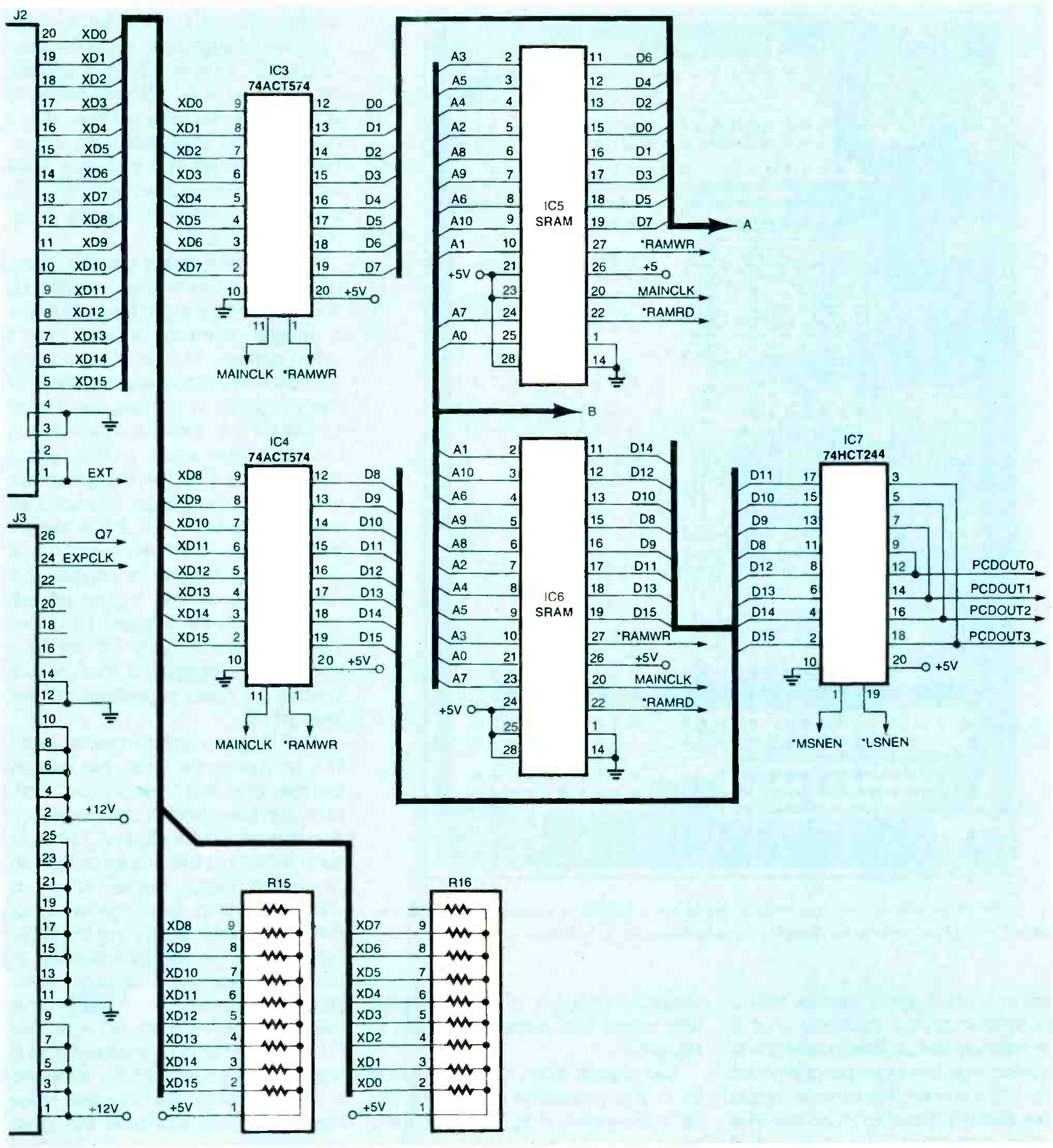


Fig. 2. The logic analyzer uses high-speed static Random-Access Memory (RAM) to store the collected samples at rates up to 40 MHz.

passed to the computer.

The signals D0–D7 and A0–A10 are the same signals indicated in Figs. 1 and 2. Those signals are routed through IC1. The T7, STOP, TRIG-VALID, and WRAP signals are generated by IC1 itself. Signals D8-D15 are routed through IC7. The signals *LSNEN and *MSNEN are generated by IC1 to control the transfer of data through IC7.

For the PC to write data to the logic analyzer requires only a slightly more complex procedure. Again, the control signals S0–S2 are used to select the address according to Table 2. Once the address has been selected, the data is transferred serially one bit at a time. Each bit from the PC is placed on pin 3 of IC1. The transfer takes place on the rising edge of the clock signal on pin 33 of IC1. For example, the trigger data (T7–T0 and X7–X0) is loaded into IC1 by placing the value for T7 on pin 3 of IC1, and then toggling the clock line on pin 33. That procedure is repeated for T6, T5, *etc.* to T0, then X7, X6, and so on until X0 has been transferred.

One of the key parts of the logic analyzer circuit is the clock generator for timing the sample interval. The

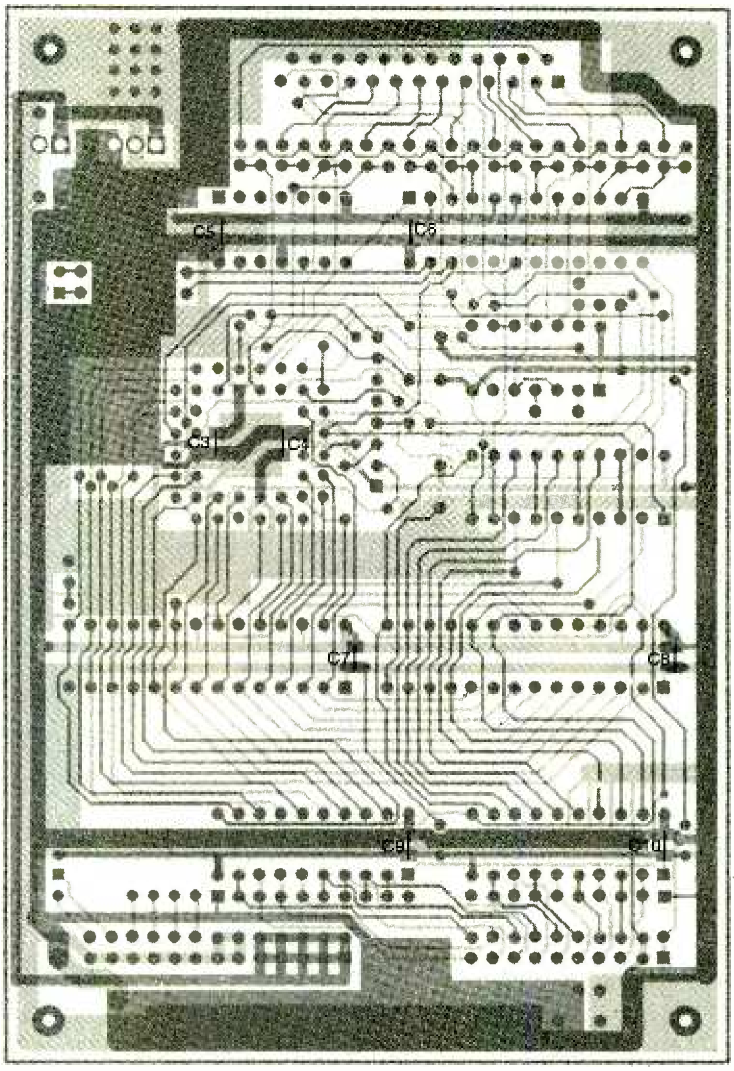


Fig. 3. The solder side of the logic analyzer board has a handful of surface-mount capacitors attached to it. Those components should be mounted before the through-hole components.

master clock is generated by XTAL1, an 80-MHz crystal oscillator that is connected to IC2. The master clock is divided by the logic programmed into IC2 to make the sample clocks from 40 MHz down to 312.5 kHz. The system clock that is used is selected by the signals C0–C4, which come from the PC. In addition to the internally-generated clock frequencies, the EXT signal can be a clock from an external source—usually from the system under test. An additional clock input from the PC to pin 9 of IC2 lets the software control the clock for retrieving data, control, and diagnostic functions. Regardless of the clock division selected by C0–C4, whenever the signal on pin 9 of IC2 is low, the MAINCLK signal is held low. That lets the PC turn the MAINCLK signal on and off. The possible clock selections are shown in Table 3.

Two signals from IC2 are routed to J3, the expansion connector. Pin 26 is connected to the 312.5-kHz clock and pin 24 is connected to the MAINCLK signal. Neither of those signals are used within the logic analyzer circuit, but will be used by future expansion modules.

During data capture, the outputs of IC3 and IC4 are enabled and data is strobed into the flip-flops from the probe assembly on the rising edge of the system clock. The system clock is also connected to the chip-select inputs of static RAMs IC5 and IC6. The captured data is written to the RAMs on the low half of the system clock cycle. The RAM address, A0–A10, is handled by IC1. On each rising edge of the system clock, IC1 increments the address by 1. When the address exceeds 2047 (or 7FF hex), the address wraps around to 0. In this way, data is continuously stored in successive RAM locations. When IC1 is reset (through pin 35), the address lines are automatically set to 0.

The trigger-control circuit is handled by IC1. The trigger condition is defined by two eight-bit patterns—a trigger pattern and a "don't care" pattern. The test for a trigger condition is performed on each of the data bits in parallel. We'll look at just bit 0 in order to understand how the test works. If the "don't care" bit is 0, then the trigger will be valid when the trigger bit matches the logic level on D0. If the trigger bit is set, say, to 1, then a high level on D0 will cause a trigger. Of course, a 0 on the trigger bit will only activate the trigger if D0 is low. With the "don't care" bit set to 1 instead, the trigger for that bit will always be valid regardless of the level of D0.

The trigger control checks eight bits at the same time. The match pattern and the "don't care" pattern can be mixed in any combination needed. The logic in IC1 checks for a match to the trigger condition on each clock cycle. When a match is found, the internal signal TRIGVALID is set, beginning the capture routine. An internal counter in IC1 keeps track of how many samples have been stored. When the counter reaches a value of 3FF hex (1023), all sampling is stopped and a signal is set to let the PC software know that all of the samples have been saved. In that way, the logic analyzer's memory will be holding 1024 samples before the trigger condition was met and 1024 samples after the circuit was triggered.

Once the data acquisition has stopped, the stored data must then be read from the logic analyzer to the PC. The PC reads the last address from the logic analyzer 4 bits at a time through the interface. The PC then resets IC1 and selects the PC-controlled clock on IC2. The RAMWR signal is cleared, which disables the outputs on IC3 and IC4, and puts the RAM ICs into the read

PARTS LIST FOR THE ALTA ENGINEERING LOGIC ANALYZER

SEMICONDUCTORS

IC1—ispLSI1016E-80LJ programmable-logic device, integrated circuit (Lattice Semiconductor)
IC2—GAL22V10B-15LP programmable-logic device, integrated circuit
IC3, IC4—74ACT574 octal flip-flop, integrated circuit
IC5, IC6—8K×8 static RAM, 12 nanosecond, integrated circuit
IC7—74HCT244 octal buffer, integrated circuit
IC8—74HCT14 hex Schmitt trigger, integrated circuit
IC9—LM7805 5-volt regulator, integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted)
R1–R12—560-ohm
R13, R14—33-ohm
R15, R16—1-megohm, 10-pin single-inline package, resistor network

CAPACITORS

C1—10-µF, 15-WVDC, electrolytic
C2, C14—10-µF, 6-WVDC, tantalum
C3–C10—0.1-µF, ceramic, surface-mount
C11–C13—0.1-µF, ceramic-disk
C15–C26—561-pF, ceramic-disk
C27—0.01-µF, ceramic-disk

ADDITIONAL PARTS AND MATERIALS

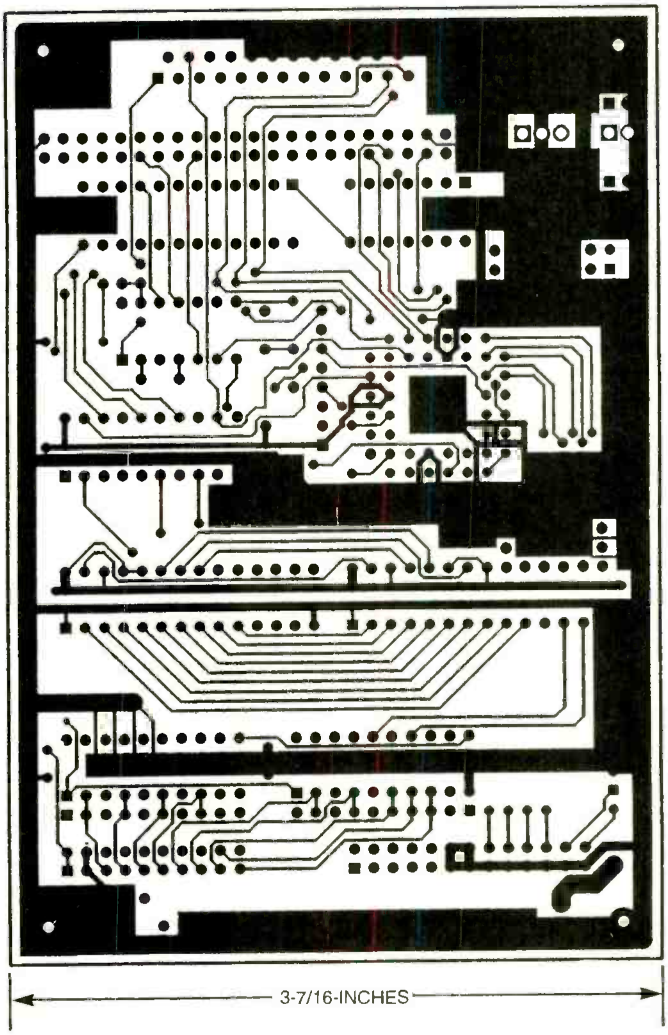
J1—DB25 female connector, PC-mount
J2—20-pin male header
J3—26-pin male header
J4—coaxial power jack
XTAL1—80-MHz oscillator
Heat sink for IC9, socket for IC1, 12-volt wall transformer, 20-conductor ribbon cable, 20-pin insulation-dis placement connector, test clips, DB25 male-to-male cable, PC board, wire, solder, hardware, case, etc.

Note: The following items are available from: Alta Engineering, 58 Cedar Lane, New Hartford, CT 06057-2905; Tel: (860)489-8003; e-mail: alta@gutbang.com; Web: www.gutbang.com/alta: Software on 3½-inch diskette, $10.00; Blank PC board, $45.00; Complete board-only kit with software, $139.00; Complete board-only kit with case and software, $169.00; Complete kit with power supply, probe kit, and cable, $209.00. Please include $5.00 for shipping and handling within the US; $10.00 (US) for international orders. CT resi-dents should add appropriate sales tax.

mode. The data is then read 4 bits at a time from each address starting at 0. After the data at a given address is read, the PC pulses the diagnostic/control clock on IC2 in order to increment the address counter to the next location. Once all of the data has been read from all of the RAM addresses, the PC program can then display the data.

The final section is the power supply. A 12-volt DC wall transformer rated at 800 mA provides power for the unit. The logic analyzer uses about 450 mA of regulated 5-volt current. That is supplied by IC9, a 7805 regulator. A heat sink is needed on IC9 to prevent overheating of the device. The expansion connector also has connections for the unregulated 12-volt supply so that other expansion modules can be powered by the wall transformer.

Building the Logic Analyzer. Before building the logic analyzer, get a copy of the software from the Alta Engineering web site (www.gutbang.com/alta) or the **Electronics Now** ftp site (ftp://ftp.gernsback.com/pub/EN/altalog.zip). You will need the software for both programming the PLDs and testing the analyzer. The program also doubles as a demo so you can see the capabilities of the unit before actually building it. Also, any last-minute suggestions or details that do not



Here is the component side of the logic analyzer board. If you will be making your own board and you will not be plating the holes, you will have to solder the connections on both sides of the board.

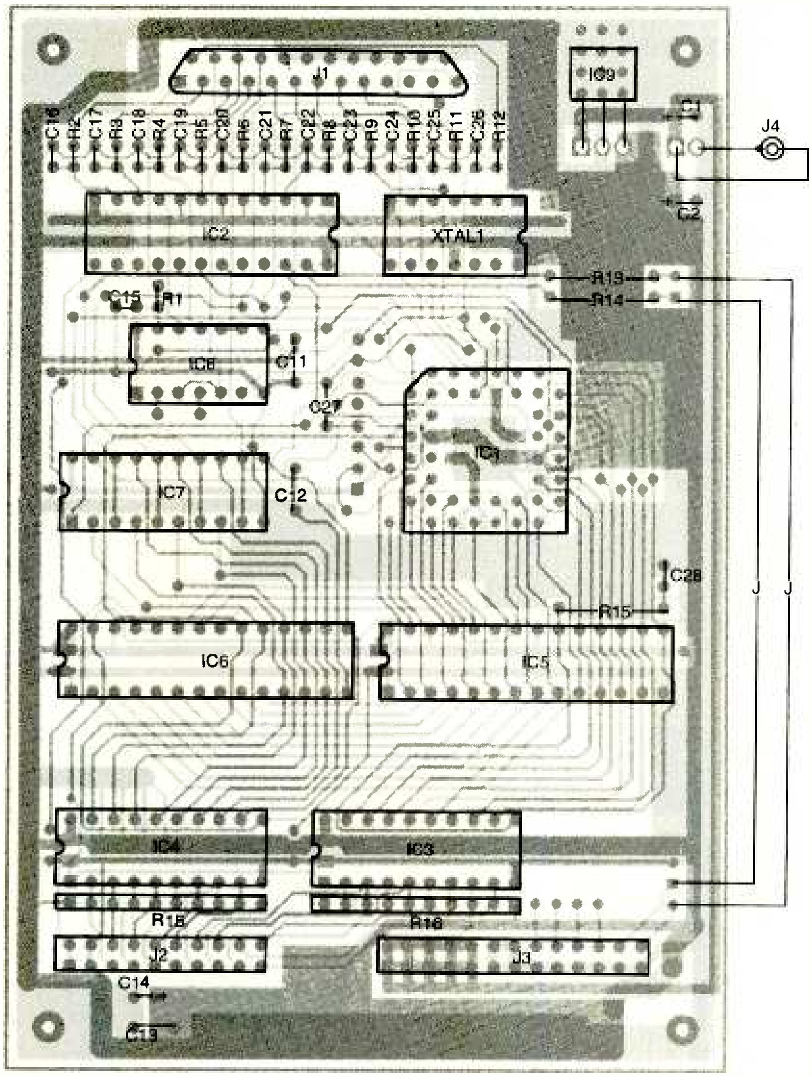


Fig. 4. The logic analyzer board has a neat, clean layout thanks to the use of PLDs to keep package count to a minimum. Be careful of IC orientation—some of the parts face in different directions. The jumper wires should be mounted on opposite sides of the board in order to minimize crosstalk between the signals they will be carrying.

Table 1

S2	S1	S0	PCDOUT3	PCDOUT2	PCDOUT1	PCDOUT0
0	0	0	D3	D2	D1	D0
0	0	1	D7	D6	D5	D4
0	1	0	A3	A2	A1	A0
0	1	1	A7	A6	A5	A4
1	0	0	T7	A10	A9	A8
1	0	1	STOP	TRIGVALID	WRAP	
1	1	0	D11	D10	D9	D8
1	1	1	D15	D14	D13	D11

make it into print will be included with the software.

The analyzer should only be built on a double-sided PC board with plated-through holes. The layout is very critical, so no other construction method is likely to work. You can make your own PC board from the foil patterns given here, or one can be purchased from the source given in the Parts List.

A small, low-wattage soldering iron should be used to assemble the board. Start by soldering the surface-mount capacitors onto the bottom of the board. The locations of those components are shown in Fig. 3. A simple method of soldering those parts is to first coat one of the pads with some solder. While holding the component in place with a small screwdriver, touch the same pad lightly with the soldering iron. The solder will re-melt and tack the capacitor in place. Carefully check the position of the capacitor to be sure it is properly seated on the pads. Now is the time to fix any alignment errors. If the part is properly aligned, solder the other end of the capacitor in place. Finally, go back to the first end and re-flow that solder joint. After each capacitor is soldered in place, use an ohmmeter to check between the 5-volt and ground traces to verify that it remains an open circuit. Checking for shorts each time will help catch and correct any errors. The rest o the remaining capacitors and th resistors can now be mounted usin the parts-placement diagram in Fig 4 as a guide. Most of the resistors must be mounted vertically to fit into the available space.

Before mounting IC9, slide the heat sink onto the regulator. Make a 90-degree bend in the leads at the point where they taper down. Mount the regulator so that the heat sink hangs over the end of the PC board. Once IC9 is soldered in place, connect a short pair of insulated wires and J4. Feed the wires through a rubber grommet if the unit will be mounted in a case. Before mounting any semiconductors, hook up the transformer and verify that 5 volts is present between the power and ground pins at each IC location.

The remainder of the parts can now be mounted. Although sockets are optional for the integrated circuits, a socket must be used for IC1. Be very careful about the location of pin 1 on all of the ICs—some components face in different directions on the board. The two jumpers should be installed on opposite sides of the PC board in order to reduce crosstalk between the signals that they will carry.

The Probe Assembly. While you can purchase the probe assembly

Table 2

S2	S1	S0	Function
X	0	0	Trigger data T7-T0 then X7-X0
X	0	1	Not Used
X	1	0	Trigger sequence/ length/mode

parts from the source given in the Parts List, it is a good idea to make your own probe assembly. That way, the assembly can be customized to your own requirements. Start by mounting a length of 20-conductor ribbon cable to an insulation-displacement connector. The cable should not be more then 18 inches in length; keeping the length as short as possible is better for both signal integrity and keeping the cables from getting tangled. If you are not sure what length you will be needing, 12 inches is a good starting point. A total of 18 clips will be needed—one for each data input, plus one for ground and one for the external clock signal. There are many choices for the clips—the ideal choice depends on the type of circuits that you will be testing. Several different probe assemblies with different lengths and probes can be made for different needs.

Following the diagram in Fig. 5, solder the clips to the ribbon cable. Split conductors 1 and 2 off from the rest of the cable. Solder both conductors 1 and 2 onto a clip and label that clip "CLOCK". Next, spilt wires 3 and 4 off and solder both of them onto a clip—that will be labeled "GROUND." Starting from conductor 20, separate each wire from the cable and solder it onto a clip. The labels will go from "C" to "15" (conductor 20 is labeled "0"). The cable should be split most of the way down the connector. If it is not split, the result will be crosstalk between the adjacent wires. Of course, the wires might become a tangled mess with use—just like an expensive analyzer. Unfortunately, there doesn't seem to be a good way to keep the probe wires neat without bundling them together and getting crosstalk.

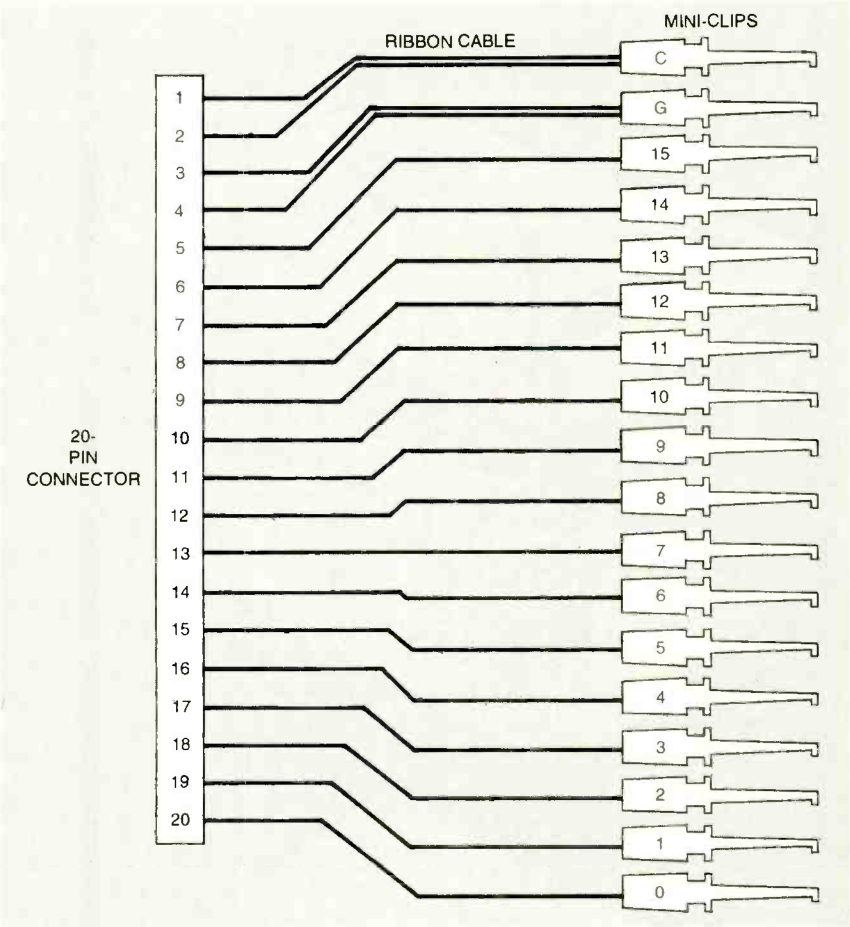


Fig. 5. The probe assembly is easily made from a length of ribbon cable and a handful of test clips. Note that two of the clips have two wires each attached to them.

Table 3

C4	C3	C2	C1	C0	MAINCLK
0	0	0	0	0	40 MHz
0	0	0	0	1	20 MHz
0	0	0	1	0	10 MHz
0	0	0	1	1	5 MHz
0	0	1	0	0	2.5 MHz
0	0	1	0	1	1.25 MHz
0	0	1	1	0	0.625 MHz
0	0	1	1	1	0.3125 MHz
0	1	0	0	0	EXT clock
1	0	0	0	0	EXT clock inverted
1	1	0	0	0	Software clock

Testing the Logic Analyzer. Double-check all of the solder joints and connections one more time. When you are completely sure about your work, plug in the power supply. Using a voltmeter, check to see that there is 12 volts at the expansion connector and that there is 5 volts between each IC's ground and power pins. Disconnect the power from the board. Connect the board to a printer port on a PC using a DB25 male-to-male cable with all conductors wired straight through (pins 1 to 1, 2 to 2, etc.). The cable should be 6 feet or less in length. Since there is a possibility that a defective logic analyzer could damage the printer port circuitry in the computer, you should not use a laptop computer with the analyzer until the analyzer has been given a clean bill of health. Start the computer and apply power to the analyzer board. Run the ALTALOG program. Select F9 to configure the program. Select the LPT port that the analyzer is connected to and then press any key at the prompt. The LPT port selection is stored in the config-

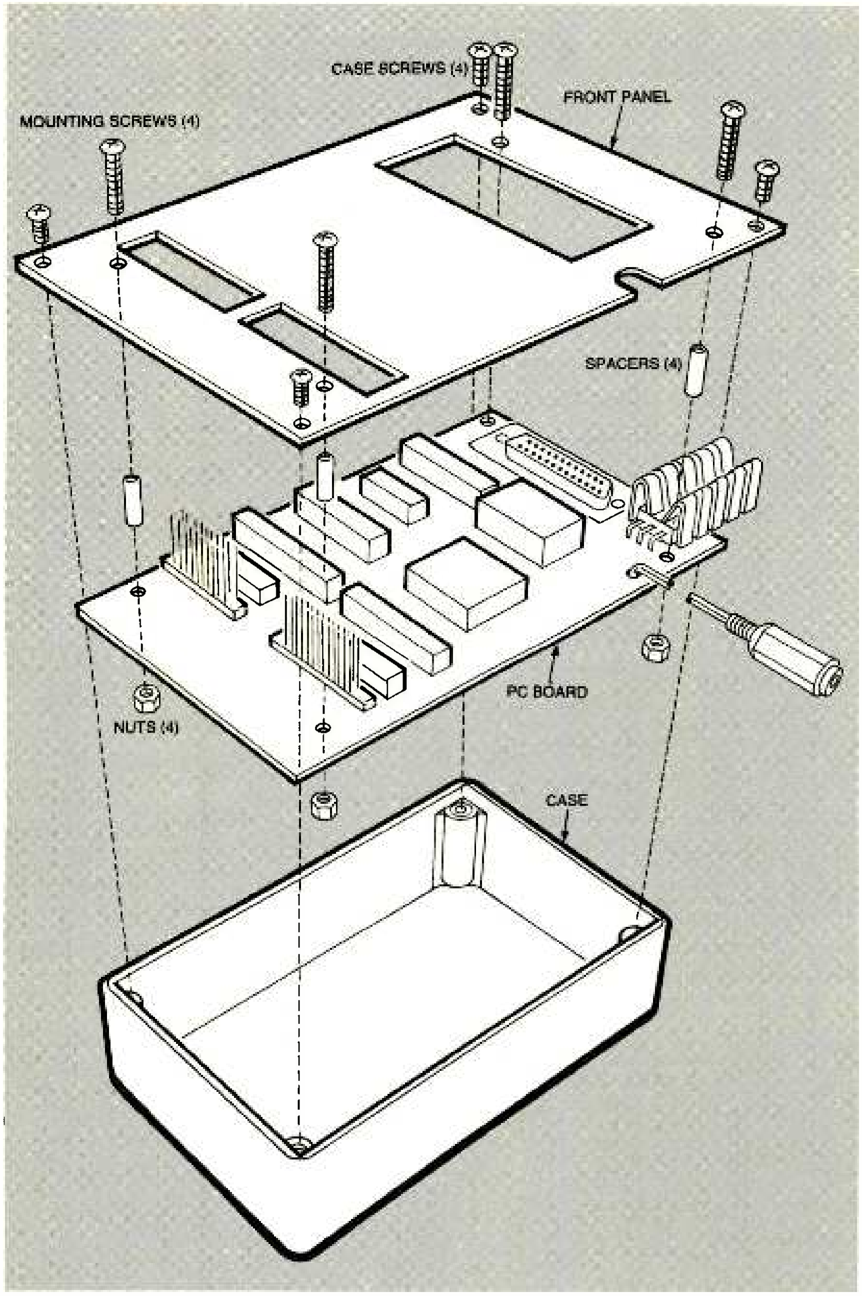


Fig. 6. Mounting the logic analyzer board in a suitable enclosure is very simple and straightforward. Don't forget to use a rubber grommet on the power leads if you are using a case with a metal front panel.

uration file ALTALOG.CFG.

The logic analyzer will be tested by using it on its own signals. Connect probe 0 to pin 26 on the expansion connector, and connect probe 1 to expansion connector pin 25. Those pins are toward the outside edge of the board. Do *not* connect the probe to the expansion-connector pins on the inside of the board—those pins carry 12 volts and will damage IC3 and IC4. Press F5 on the computer keyboard to acquire data. In a few seconds, acquiring the data should be complete and the menu will return. Press F6 to look at the state display of the data. The data is shown in binary toward the right side of the screen. Bit 1 (second from the right) should read 0 all the way up and down the page. Bit 0 (all the way on the right) should alternate between 64 zeros and 64 ones. Use the PageUp and PageDown keys to scan through the data and verify that the data has been captured correctly. If that is correct, most of the logic analyzer is working.

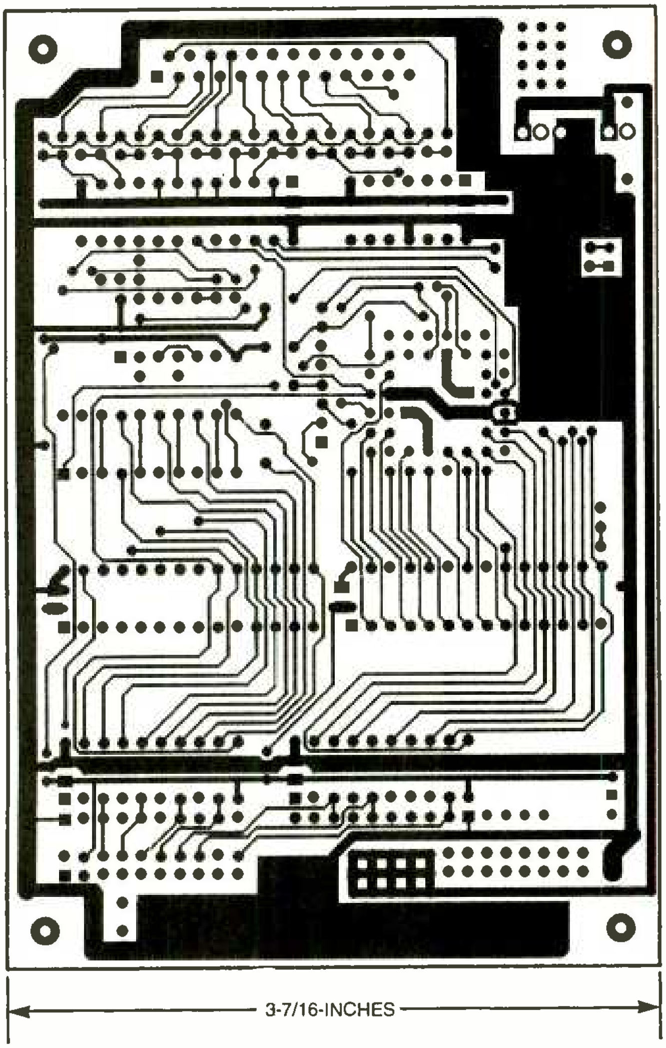
Additional testing will be done while learning how to use the analyzer. If you run into problems, you might have a cable problem, the wrong LPT port selected, or a board problem. The diagnostic program ALTADIAG that is described in the text file ALTADIAG.TXT will do some additional board troubleshooting. All of those files are included in the main file archive that was downloaded.

Once the logic analyzer passes its initial tests, the board can be mounted in a suitable enclosure. A method is shown in Fig. 6. Suitable holes are cut in the front panel for the three connectors and the power lead. The board is simply bolted to the back of the front panel using screws, nuts, and spacers. Any kind of labeling on the front panel to help identify the various pins and functions will help make the project more professional-looking.

Using The Logic Analyzer. There are a few non-obvious points that you should be aware of when using the logic analyzer. Always power up the logic analyzer before connecting the probes to the circuit under test. Hooking up a powered circuit when the logic analyzer is turned off can overheat and possibly damage IC3 and IC4. Another very important point is to make sure that there is no AC potential between the grounds of the circuit and the logic analyzer.

Like the initial test, we're going to use the analyzer on itself. Start the ALTALOG program and wait for the main menu to appear. As before, connect probe 0 to expansion connector pin 26 and probe 1 to expansion connector pin 25. This time, connect probe 2 to expansion connector pin 23 and probe 3 to expansion connector pin 21. We will not be needing the "ground" or "clock" probes.

Using menu choice F1, set the "A," or main, trigger to be XXXX XXX1, meaning that we want to trigger when probe 0 is high and we don't care about the state of the other bits. Press F2 to set up a "B" trigger condition and enter XXXX XXX0. With two different trigger conditions set, select the trigger mode with F3. The choices are



The solder side of the logic analyzer board has special pads for the surface-mount capacitors.

using the "A" trigger for one clock, the "A" trigger for two clocks, or the "A" trigger followed by the "B" trigger. For now, select the first option ("A" for one clock). We'll choose a 5-MHz clock rate with F4. Press F5 to start collecting data. Within a few seconds, the collection will be complete, and the program will return to the main menu.

Select F6 to view the data just gathered. For each clock cycle, the state display shows the clock-cycle number relative to the trigger point. The trigger point is clock-cycle zero; negative numbers are clock cycles before the trigger, and positive numbers are the cycles after the trigger. The next number is the time in microseconds relative to the trigger. The actual data is displayed two ways—first in hexadecimal and then in binary (remember, probe 15 is the most-significant bit, probe 0 the least). At the trigger point, we should see 0 0.000 XXX1 xxxx xxxx xxxx 0001 (the x is used to represent an unknown value because we did not connect probes 8–15). You can move forward or backward through the display by pressing various navigation keys on the keyboard. The Page Up and Page Down keys will move the display backward or forward one page at a time. The Home key will jump to the first data acquired and the End key will take the display to the last data acquired. The number 5 key on the numeric keypad (make sure that the number lock indicator on the keyboard is off) will bring you back to the trigger point.

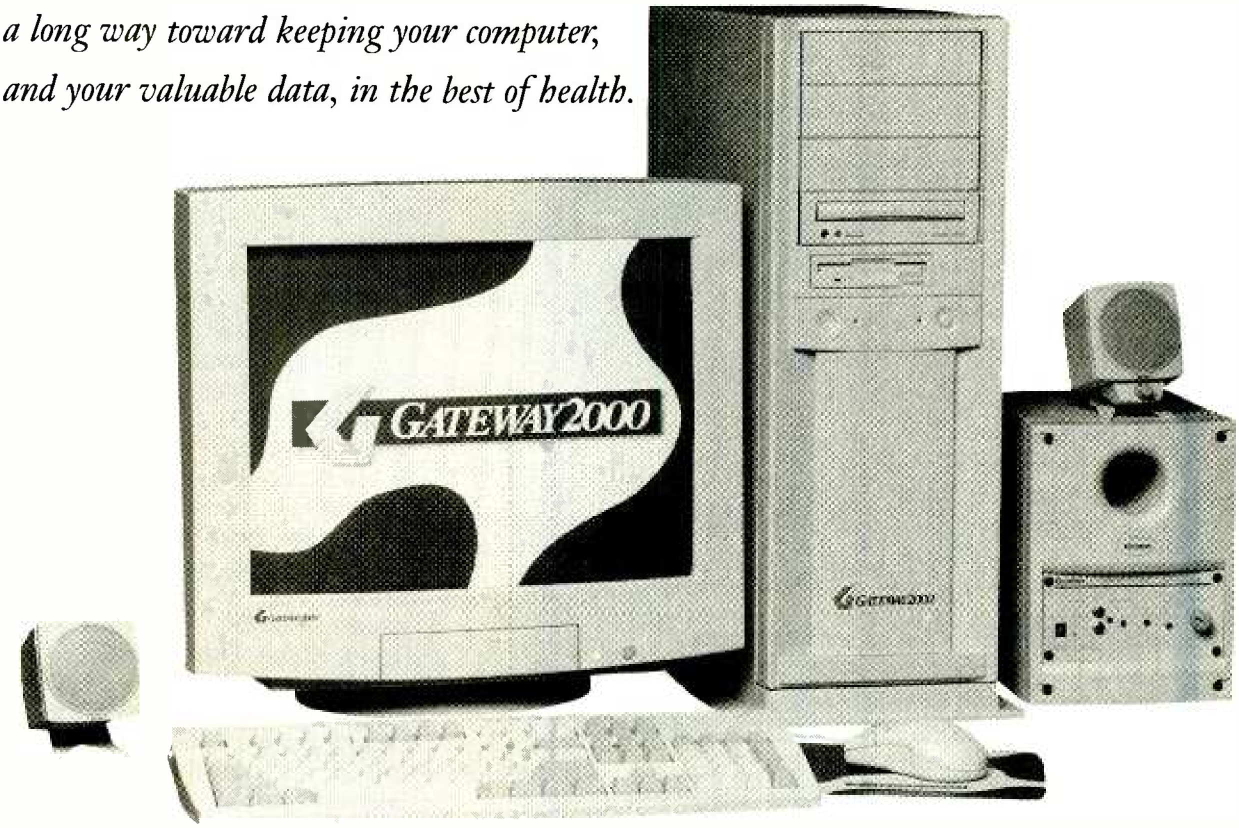
A special feature of the software is search capabilities. By pressing the S key, the search menu will appear. Type in the data pattern you want to find. It is typed in the same way a trigger condition is set (1, 0, and X). After pressing the return key, select F for forward search or R for a reverse search. The program will search for data that matches the search pattern and display that location on the screen. Pattern searching is a very powerful feature because of the large amount of data in 2048 samples.

Press ESC to exit the state display. The timing display is entered by pressing F7. That display mode requires a CGA or better graphics card and monitor on the computer. The data will be displayed in timing-diagram format. A cursor is at the trigger point, and the state information from the cursor position is displayed at the top of the screen. The ESC, Page Up, Page Down, Home, End, numeric 5 key, and the search option work the same way as with the state display. In addition, the left and right arrow keys can move the cursor back and forth through the data to display the state information for any point. The data and setup information (trigger patterns, clock rate, etc.) can be stored and recalled by pressing F8. That will let you save any collected data and view it at another time.

In the sample we just took, the timing display should show that bits 1, 2, and 3 are always at logic zero. Bit 0 should alternate between 0 and 1 every 16 samples, which works out to 3.2 microseconds. At time 0 (the trigger point), bit 0 should be a logic one, which is what we assigned as the trigger. Using F3, change the trigger mode to be "A" then "B". Select a 10-MHz clock rate using F4. Use F5 to start a new data acquisition. When the new data samples are done, look at the timing display. It should show that bit 0 is now a logic zero at time 0. Bit 0 should be a logic one for 3.2 microseconds just before time 0. Since we doubled the sampling rate, 3.2 microseconds is 32 samples. With the trigger condition set to "A" followed by "B," the "A" trigger condition had to be met first, in which bit 0 is a 1. Once the first condition is met, the B trigger condition

(Continued on page 50)

These simple maintenance procedures can go a long way toward keeping your computer, and your valuable data, in the best of health.



MAINTAINING YOUR OWN PC

STEPHEN J. BIGELOW

For most of us, the purchase of a personal computer, or PC, is a substantial investment of both time and money. But after the money is spent and the PC is in our home or office, few PC users ever take the time to properly maintain their PC. That's unfortunate, as routine maintenance is an important part of PC ownership and can go a long way toward keeping your computer's hardware and software error-free. Proper routine maintenance, following the schedule outlined in Table 1, can also help to avoid costly visits to your local repair shop; in the U.S., labor alone can run $50-$70/hour. That's where this article comes in: In the pages that follow we will provide you with a comprehensive, step-by-step procedure for protecting and maintaining your personal-computer investment.

Protecting Your Data. It's interesting to note that the data recorded on a computer's hard drive is often far more valuable than the drive itself. But if the drive fails, your precious data is usually lost along with the hardware. Months (perhaps years) of records and data could be irretrievably lost. It goes without saying then that one of the first steps in any routine maintenance plan is to make regular backups of your system's contents—as well as the system's configuration. Backups ensure that you can recover from any hardware glitch, accidental file erasure, or virus attack.

File backups are important for all types of PC users from major corporations to occasional home users. By creating a "copy" of your system files (or even just a part of them), you can restore the copy and continue working in the event of a disaster. Before you proceed with any type of system checks, consider performing a file backup.

You're going to need two items in order to backup your files; a "backup drive" and backup software. The actual choice of backup drive is really quite open. Tape drives such as the Iomega Ditto drive (www.iomega.com) or the MicroSolutions 8000t 8GB "Backpack" drive (www.micro-solutions.com) are the traditional choice, but other high-volume removable media drives like Iomega's 100MB Zip drive, their 1GB Jaz drive, or the SyQuest 1.5GB SyJet drive (www.syquest.com) are also very popular. Most drives are available in both internal and external configurations. One advantage of an external drive, particularly one that interfaces to your PC via its parallel port, is that it is portable—it can be shared between many PCs.

You'll also need some backup

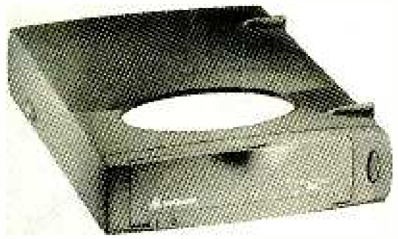
software to format the media, and handle your backup and restore operations. If you're using Windows 95, try the native Backup applet (click on *Start, Programs, Accessories, System Tools,* and *Backup*). If Backup doesn't suit your needs, many drives ship with a backup utility on diskette. Just make sure that the backup drive and backup software are compatible with one another.

Backups generally fall into two categories: incremental and complete. Both types of backups offer unique advantages and disadvantages. An incremental backup only records the "differences" from the last backup. That usually results in a faster backup procedure and uses less tape (or other media), but restores take longer because you need to walk through each "increment" in order. A complete backup records the drive's full contents. That takes much longer and uses a lot more media, but restores are easier. Many PC users use a combination of complete and incremental backups. For example, you might start with a complete backup on January 1, then make incremental backups each week until the end of February. By March 1, you'd make another complete backup and start the incremental backup process again.

Perhaps the most overlooked issue with backups is the frequency—how often should backups be performed? The answer to that question is not always a simple one, because everyone's needs are different. Major corporations with busy order-entry systems may backup several times each day, while individual home users may not even consider backups to be necessary. The standard that I use is this: can you afford to lose the data on this drive? if the answer is "no," it's time to back up.

Regardless of how you choose to handle file backups, there are some tips that will help you get the most from your backup efforts:

- Keep the backup(s) in a secure location (such as a fire-proof safe or cabinet).
- Keep the backup(s) in a different location than the original PC.



High-volume removable media, like this SyQuest 1.5GB SyJet drive, can make the job of backing up your data easier.

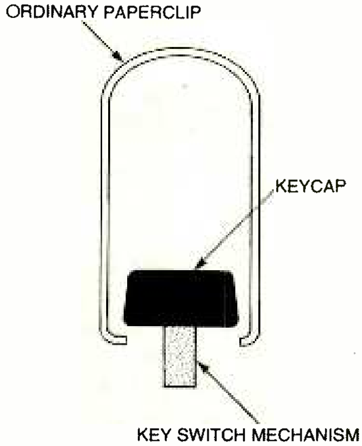


Fig. 1. To get at a sticky or unresponsive key switch, you can use an ordinary paper clip, bent as shown, to remove the keycap.

- Back up consistently—backups are useless if they are out of date.
- If time is a factor, start with a complete backup, and then use incremental backups.
- Use a parallel port tape drive (or other "backup" drive) for maximum portability between PCs.

CMOS Backups. All PCs use a sophisticated set of configuration settings (everything from "Date" and "Time" to "Video Palette Snoop" and "Memory Hole") that defines how the system should be operated. Those settings are stored in a small amount of very low power memory called CMOS RAM. Each time the PC starts, motherboard BIOS reads the CMOS RAM, and copies the contents into low system memory (the BIOS Data Area). While system power is off, CMOS RAM contents are maintained with a small battery. If that battery goes dead, CMOS contents can be lost. In most cases, that will prevent the system from even starting until you reconfigure the CMOS setup from scratch. By making a backup of the CMOS setup, you can restore lost settings in a matter of minutes. CMOS backups are simply printed screens of your CMOS setup pages.

From the above, it is obvious that the one item that you'll need to perform a CMOS backup is a printer—it really doesn't matter what kind of printer (*i.e.* dot-matrix, ink jet, or laser). The printer should be attached to the PC's parallel port. After starting the CMOS setup routine, visit each page of the setup, and use the <Print Screen> key to "capture" each page to the printer. Since every BIOS is written differently, be sure to check for submenus that might be buried under each main menu option.

CMOS backups are quick and simple, but you'll get the most benefit from a CMOS backup by following these pointers:

- Make it a point to print out *every* CMOS Setup page.
- Keep the printed pages taped to the PC's housing or with the system's original documentation.
- You should back up the CMOS setup whenever you make a change to the system's configuration.

Cleaning. Now that you've backed up the system's vital information, you can proceed with the actual maintenance procedures. The first set of procedures involves exterior cleaning. That hardly sounds like a glamorous process, but you'd be surprised how quickly dust, pet hair, and other debris can accumulate around a computer. You'll need four items for cleaning: a supply of Windex or another mild ammonia-based cleaner (a little ammonia in water will work just as well), a supply of paper towels or clean lint-free cloths, a canister of electronics-grade compressed air (which can be obtained from any electronics store), and a small static-safe vacuum cleaner.

Note: Avoid the use of ordinary household vacuum cleaners. The rush of air tends to generate significant amounts of static electricity along plastic hoses and tubes, which can accidentally damage the sensitive electronics in a PC. Also, *never* use harsh or industrial-grade cleaners around a PC. Harsh cleaners often contain chemicals that could damage the finish of (or even melt) the plastics used in PC housings. Use a highly diluted ammonia solution *only*.

As a rule, exterior cleaning should be performed every four months (three times per year) or as required. If the PC is operating in dusty, industrial, or other adverse environments, you may need to clean the system more frequently. Systems operating in clean office environments may only need to be cleaned once or twice each year. Always remember to turn off the computer, and unplug the AC cord from the wall outlet before cleaning.

To clean the case, use a clean cloth lightly dampened with ammonia cleaner to remove dust, dirt, or stains from the exterior of the PC. Start at the top and work down. Add a little bit of extra cleaner to remove stubborn stains. You'll find that the housing base is typically the dirtiest (especially for tower systems). When cleaning, be careful not to accidentally alter the CD-ROM volume or sound-card master-volume controls. Also do not dislodge any cables or connectors behind the PC.

Note: Always dampen a clean towel with cleaner—*never* spray cleaner directly onto any part of the computer.

While cleaning the case, pay particular attention to the air intake(s), usually located in the front (or front sides) of the housing. Check for accumulations of dust or debris around the intakes or caught in an intake filter. Clean away any accumulations from the intake area, and then use your static-safe vacuum to clean the intake filter if possible—you might need to remove the intake filter for better access. If the intake filter is washable, you might choose to rinse the filter in simple soap and water for the best cleaning (remember to dry the filter thoroughly before replacing it). Of course, if there is no intake filter, simply clean around the intake area.

Multimedia speakers offer a countless number of ridges and openings that are just perfect for accumulating dust and debris. Use your can of compressed air to gently blow out the speaker's openings. Do not insert the long, thin air nozzle into the speaker—you can easily puncture the speaker cone and ruin it. Instead, remove the long nozzle and spray air directly from the can. Afterward, use a clean cloth lightly dampened with ammonia solution to remove any dirt or stains from the speaker housings.

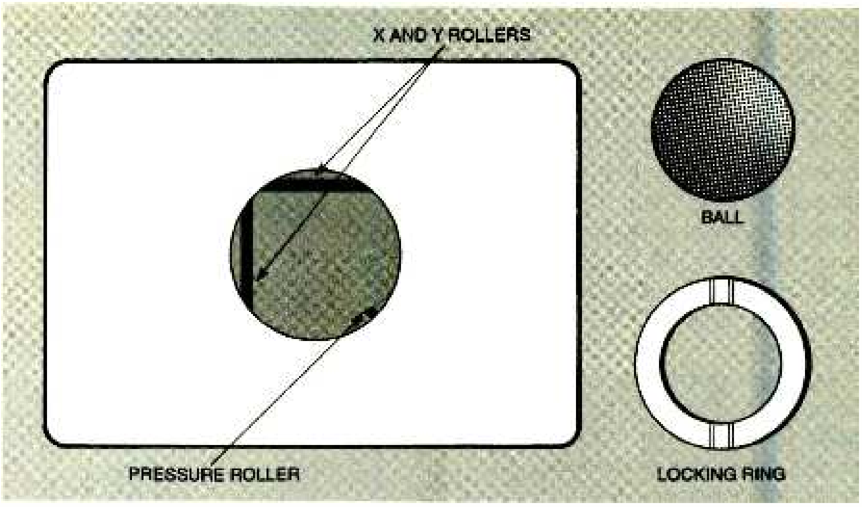


Fig. 2. An important part of cleaning a mouse is to make sure the internal rollers are free of dirt and grime build up.

Keyboards are open to the environment, so dust and debris readily settle between the keys. Over time, those accumulations can jam keys or cause repeated keystrokes. Attach the long thin nozzle to your can of compressed air, and use the air to blow through the horizontal gaps between key rows. Be careful—this will kick up a lot of dust—so keep the keyboard away from your face. Afterward, use a clean cloth lightly dampened with ammonia solution to remove dirt or stains from the keys and keyboard housing. If any keys seem unresponsive or "sticky," you can remove the corresponding keycap (see Fig. 1) and spray a bit of good-quality electronic contact cleaner into the key assembly; then gently replace the keycap.

Note: Do not remove the <Enter> key or <Space Bar>. Those keys are held in place by metal brackets that are *extremely* difficult to re-attach once the key is removed. Only the most experienced technicians should work with these keys.

There are several important areas to deal with when cleaning a monitor: ventilation, case, and CRT. Monitors rely on vent openings for proper cooling. Use your vacuum cleaner, and carefully remove any accumulations of dust and debris from the vents underneath the case, as well as those on top of the case. Make sure that none of the vent openings are blocked by paper or other objects (that can restrict ventilation and force the monitor to run hot).

Next, use a clean cloth lightly dampened with ammonia solution to clean the monitor's plastic case. There is active circuitry directly under the top vents, so under no circumstances should you spray cleaner directly onto the monitor housings. Do *not* use ammonia or *any* chemicals to clean the CRT face. The CRT is often treated with anti-glare and other coatings, and even mild chemicals can react with some coatings. Instead, use clean tap water only to clean the CRT face. Be sure to dry the CRT face completely.

Like the keyboard, a mouse is particularly susceptible to dust and

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debris, which are carried from the mouse pad up into the mouse ball and rollers. When enough foreign matter has accumulated, you'll find that the mouse cursor hesitates or refuses to move completely. Loosen the retaining ring and remove the mouse ball. Clean the mouse ball using a clean cloth and an ammonia solution. Dry the mouse ball thoroughly, and set it aside with the retaining ring. Next, locate three rollers inside the mouse (an "X" roller, a "Y" roller, and a small "pressure" roller as shown in Fig. 2). Use a clean cloth dampened with ammonia solution to clean all of the rollers completely. Use your can of compressed air to blow out any remaining dust or debris that may still be inside the mouse. Finally, replace the mouse ball, and secure it into place with its retaining ring.

Checking Cables and Connections. Now that the system is clean, it's time to perform a few practical checks of the system interconnections. There are a myriad of external cables interconnecting the computer to its peripheral devices. You should examine each cable and verify that it is securely connected. If the cable can be secured to its connector with screws, make sure that the cable is secured properly. As a minimum, check the following cables:

- AC power cable for the PC
- AC power cable for the monitor
- AC power cable for the printer
- AC/DC power pack for an external modem (if used)
- Keyboard cable
- Mouse cable
- Joystick cable (if used)
- Video cable to the monitor
- Speaker cable(s) from the sound board
- Microphone cable to the sound board (if used)
- Serial-port cable to external modem (if used)
- Parallel-port cable to printer
- RJ11 telephone-line cable to internal or external modem (if used)

Cleaning Drives. In spite of their age, floppy disks remain a reliable and highly-standardized media, and every new PC sold today still carries a 3.5-inch 1.44MB floppy drive. However, floppy disks are a "contact" media—the read/write heads of the floppy drive actually come into contact with the floppy disk. That contact transfers some of the magnetic oxides from the floppy disk to the drive's read/write heads. Eventually, enough oxides can accumulate on the read/write heads to cause reading or writing problems with the floppy drive. You should periodically clean the floppy drive to remove any excess oxides.

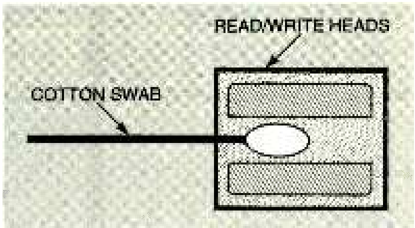

Fig. 3. If you don't have a drive-cleaning kit, use an electronics-grade swab dampened with isopropyl alcohol to scrub between the read/write heads. Note that the view here is looking into the drive from the floppy door.

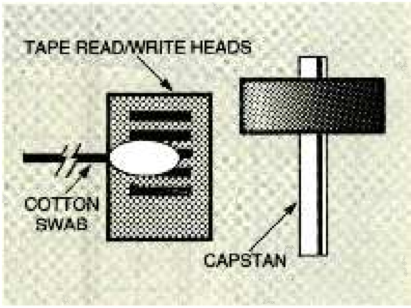

Fig. 4. You can also use an isopropyl-alcohol-dampened swab to clean the tape heads and capstan in a tape drive. Again, this view is looking into the drive from the tape door.

Cleaning can be accomplished in several ways: you can use a prepackaged "cleaning kit", or swab the read/write heads with fresh isopropyl alcohol. You can obtain prepackaged cleaning kits from almost any store with a computer or consumer-electronics department. With a cleaning kit, you simply dampen a mildly abrasive "cleaning diskette" with cleaning solution (typically alcohol-based), and then run the cleaning diskette in the drive for 15-30 seconds. You can often get 10 to 20 cleanings from a cleaning diskette before discarding it.

If you don't have a cleaning kit handy, you can use a long, thin, electronics-grade fabric swab dampened in fresh isopropyl alcohol, and gently scrub between the read/write heads (see Fig. 3). Remember to turn off and unplug the PC before attempting a manual cleaning. Repeat the scrubbing with several fresh swabs, and then use a dry swab to gently dry the heads. Allow several minutes for any residual alcohol to dry before turning the PC back on.

As with floppy drives, tape drives are also a "contact" media, and the tape head is in constant contact with the moving tape. That causes oxides from the tape to transfer to the tape head and capstans, and that can ultimately result in reading or writing errors from the tape drive. If a tape drive is present with your system, you should periodically clean the tape head(s) and capstans to remove any dust and excess oxides. You might be able to find a pre-packaged drive cleaning kit for your particular tape drive. Otherwise, you'll need to clean the tape drive manually.

Turn off and unplug the PC. As with the floppy drive, use an electronics-grade swab dampened in fresh isopropyl alcohol to gently scrub the tape head(s) and capstan (see Fig. 4). Repeat the scrubbing with several fresh swabs, then use a dry swab to gently dry the tape head(s). Allow several minutes for any residual alcohol to dry before turning the computer back on.

Miscellaneous Checks. Most CD-ROM drives operate using a "tray" to hold the CD. Try ejecting and closing the tray several times—make sure that the motion is smooth, and that there is no hesitation or grinding that might suggest a problem with the drive mechanism. While the tray is open, check for any accumulations of dust, pet hair, or other debris in the tray that might interfere with a CD. Clean the tray with a cloth lightly dampened in water (only). Be sure that the tray is completely dry before closing it again. Do not use ammonia or ammonia-based cleaners around the CD-ROM—prolonged exposure to ammonia vapors could damage a CD.

Next, you should make sure that your sound system is set properly.

Begin by playing an ordinary audio CD in the CD-ROM drive. Check the sound board itself, and locate the master volume control (not all sound boards have a physical volume knob). Make sure that the master volume is set at 75% or higher. If not, you might need to keep the speaker volume abnormally high, and that can result in a hum or other noise in the speakers. If the sound board does not have a master volume control, check the board's "mixer" applet (see Fig. 5), and see that the master volume is set properly. Once the sound board is set, you can adjust the speaker volume to achieve the best sound quality.

Note: Speakers are magnetic devices that can interfere with the color purity of a monitor. Keep unshielded speakers at least 6 inches away from your monitor.

Here's more on that topic: Color monitors use a fine metal screen located just behind the CRT face in order to isolate the individual color pixels in the display. That ensures that stray electrons don't strike adjacent phosphors and cause incorrect colors. If part or all of that metal screen becomes magnetized, it will deflect the electron beams and cause color distortion. Normally, a color CRT is demagnetized (or "degaussed") each time the monitor is turned on. That is accomplished through a "degaussing coil" located around the perimeter of the CRT face. However, if the CRT is subjected to external magnetic fields (such as unshielded speakers, motors, or other strong magnets), it may cause color problems across the entire CRT or in small localized areas as shown in Fig. 6.

Check the CRT for color purity by displaying an image of a known color (preferably white). Examine the image for discoloration or discolored areas. For example, if you display an image that you know is white, and it appears bluish (or there are bluish patches), chances are that you've got color purity problems.

There are three ways to correct color-purity problems. First, try moving anything that might be magnetic (such as speakers) away from the monitor. Second, try degaussing the monitor by turning it off, waiting 30 seconds, and then turning it on again. That allows the monitor's built-in degaussing coil to cycle. If the problem persists, wait 20-30 minutes and try cycling the monitor again. Finally, if the image is still discolored, you should take the monitor to a technician who can use a hand-held degaussing coil.

Fig. 5. If the sound board does not have a master volume control, check the board's "mixer" applet and make sure that the master volume is set properly.

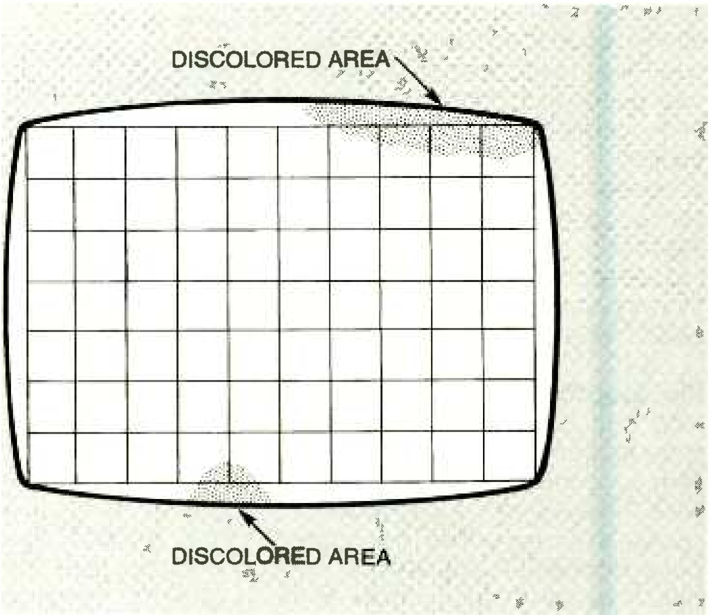

Fig. 6. Color purity problems, which are often caused by external magnetic fields like those generated by improperly shielded speakers, show up as discolored areas.

Internal Checks. At this point, we can move into the PC itself and perform some internal checks to verify that critical parts and cables are secure and that all cooling systems are working. Internal checks should usually be performed every six months (twice per year). Gather a small Philips screwdriver and an anti-static wrist strap. Use your screwdriver to unbolt the outer cover. Remove the outer cover (careful for sharp edges), and set it aside. Attach the wrist strap from your wrist to a good earth ground; that allows you to work safely inside the PC without the risk of accidental damage from electrostatic discharge (or ESD).

If you don't have a wrist strap, here's what and what not to do: Avoid wearing clothes made of synthetic materials or silk; cotton or cotton-blend clothing is better. Also, do not wear rubber-soled shoes. Keep some part of your skin in good contact with the PC's bare-metal frame, both before and while you are working inside the machine; that keeps both you and the circuitry (especially the $500 CPU) at the same electrical potential. The best way to meet that last requirement is to either grab the frame with one hand as you work or to roll up your sleeve and lean on the frame with your forearm.

PCs tend to generate a substantial amount of heat during normal operation, and that heat must be ventilated with fans. If one or more fans fail, excess heat can build up in the PC enclosure and result in system crashes or premature system

TABLE 1—PC MAINTENANCE SCHEDULE

Procedure	Frequency
File Backup	Whenever important data cannot be recreated Order Entry—daily Business/Art/Multimedia—weekly SOHO/Accounting—bi-weekly or monthly Home Use—every several months
CMOS Backup	Whenever changes are made to the system's configuration
Cleaning	Every 4 months, or as required Vacuum-clear accumulations of dust and debris as required
External Check	Every 4 months
CRT Degauss	Only if necessary
Internal Check	Every 6 months
Drive Check	Monthly, or when major files are added/deleted from the system
Boot Disk	Update disk whenever hardware changes are made to the system

failures. Now that the cover is off, your first check should be to see that all the fans are running. As a minimum, check the power-supply fan, the case-exhaust fan (both usually located at the rear of the enclosure), and the CPU heat sink/fan. Some PCs, such as those housed in full-sized tower enclosures, could sport even more fans. If any fans are not running, they should be replaced—or the system should be serviced by an experienced technician who can replace defective fans.

Pay particular attention to the CPU heat sink/fan. Virtually all Intel Pentium/Pentium MMX/Pentium II, AMD K5/K6, and Cyrix 6x86/M2 CPUs are fitted with a heat sink/fan. That fan *must* be running, or the CPU runs a very real risk of overheating and failing. If you notice that the fan has stopped, you should have the heat sink/fan assembly replaced *as soon as possible*.

Now for the cleaning: Turn off and unplug the PC, and then examine the fans and exhaust filters for accumulations of dust or other debris. Use your static-safe vacuum to clean the fan blades. Clean away any accumulations from the exhaust area, and then clean the exhaust filter if possible—you may need to remove the exhaust filter for better access. If the exhaust filter is washable, you may choose to rinse the filter in simple soap and water for best cleaning (remember to dry the filter thoroughly before replacing it). Of course, if there is no exhaust filter, simply clean around the exhaust area. Also vacuum away any other accumulations of dust that you might find on the motherboard or around the drives, but be very careful to avoid vacuuming up the little jumpers on the motherboard!

Note: Remember that PC electronics are *extremely* sensitive to ESD (electrostatic discharge), so make sure to use a static-safe vacuum inside the PC.

Most PCs use several expansion boards that are plugged into expansion slots on the motherboard. Internal modems, video boards, SCSI adapters, and network cards are just a few types of expansion boards. Each expansion board must be inserted completely into its corresponding slot, and the metal mounting bracket on the board should be secured to the chassis with a single screw. Make sure that every board is installed evenly and completely, and see that the mounting bolts are good and tight.

You'll notice that there are a large number of cables inside the PC. Each cable must be installed securely—especially the wide ribbon cable connectors that can easily be tugged off. Take a moment to check any wiring between the case and the motherboard such as the keyboard connector, power LED, on/off switch, drive activity LED, turbo switch, turbo LED, and so on. Next, check the following cables:

- Motherboard power connector(s)
- All four-pin drive-power cables
- Floppy-drive ribbon cable
- Hard-drive ribbon cable
- CD-ROM ribbon cable (usually separate from the hard-drive cable)
- CD four-wire audio cable (between the CD-ROM and sound board)
- SCSI ribbon cable (if used)
- SCSI terminating resistors (if used)

Memory is most often provided in the form of SIMMs (single in-line memory modules), which simply clip into sockets on the motherboard. Loose SIMMs can cause serious startup problems for the PC. Examine each SIMM—verify that they are inserted properly into each socket and that both ends of each SIMM are clipped into place. Some newer PCs use DIMMs (dual in-line memory modules) instead of SIMMs; those should also be checked as outlined above.

The CPU is the single largest IC on the motherboard and it is usually installed into a ZIF (zero insertion force) socket for easy replacement or upgrade. Examine the CPU, and see that it is inserted evenly into its socket. The ZIF socket lever should be in the "closed" position and locked down at the socket itself. Check the placement of the CPU's heat sink/fan next—it should sit flush against the top of the CPU. It should not slide around or be loose. If it is, the heat sink/fan should be secured or replaced.

The final step in your internal check should be to inspect the drive mountings. Each drive should be mounted in place with four screws—the use of fewer screws could allow excessive vibration in the drive, which could lead to premature failure. Make sure that each drive has four mounting screws, and use your Philips screwdriver to tighten each bolt.

Note: Do not overtighten the bolts. That can actually warp the drive frame and cause errors or drive failure.

Checking the Hard Drive. After the PC has been cleaned and checked inside and out, it's time to test the hard drive for potential problems. That involves checking the drive's file system, reorganizing files, and creating an updated boot disk. To perform a drive check, you'll need a copy of ScanDisk and Defrag. For those using Windows 95, those utilities are already built into the operating system so you can reboot the PC and use those utilities directly. If you are not running Windows 95 or are more comfortable with running those utilities from DOS, create a "startup disk" (more on that in a moment) and boot from that; then run ScanDisk and Defrag right from the startup disk. As a rule, you should perform the drive check very regularly—once a month is usually recommended; or whenever you make major additions or deletions from your system.

Your PC should always have a boot disk that can start the system from a floppy drive in the event of an emergency. Windows 95 has the ability to create a "startup disk" automatically. If you have access to a Windows 95 system, use the following procedure to create a DOS 7.x startup disk:

- Label a blank diskette, and insert it into your floppy drive.
- Click on *Start, Settings*, and *Control Panel*.
- Double-click on the *Add/Remove Programs* icon.
- Select the *Startup Disk* tab.
- Click on *Create Disk*.
- The utility will remind you to insert a diskette, then prepare the disk automatically. When the preparation is complete, test the diskette.

The preparation process takes several minutes, and will copy the following files to your diskette; ATTRIB, CHKDSK, COMMAND, DEBUG, DRVSPACE.BIN, EDIT, FDISK, FORMAT, REGEDIT, SCANDISK, SYS, and UNINSTAL. All of these files are DOS 7.x-based files, so you can run them from the DOS A: prompt.

The ScanDisk utility is designed to check your drive for file problems (such as lost or cross-linked clusters) and then correct those problems. If you're running from the startup disk, start ScanDisk by typing:

A:\> scandisk<Enter>

If you're running from Windows 95, click *Start, Programs, Accessories, System Tools*, and *ScanDisk*. Select the drive to be tested, and start the test cycle. ScanDisk will report any problems and give you the option of repairing the problems.

Operating systems like DOS and Windows 95 segregate drive space into groups of sectors called "clusters." Clusters are used on an "as found" basis, so it is possible for the clusters that compose a file to be scattered across a drive. That forces the drive to work harder (and take longer) to read or write the complete file because a lot of time is wasted moving around the drive. The Defrag utility allows file clusters to be relocated together. If you're running from the Startup Disk, start Defrag by typing:

A:\> defrag<Enter>

If you're running from Windows 95, click *Start, Programs, Accessories, System Tools*, and *Disk Defragmenter*. Select the drive to be tested, and start the cycle. Defrag will relocate every file on the disk so that all their clusters are together.

Note: You can run Defrag any time, but you do not *need* to run Defrag until your disk is more than 10% fragmented.

Conclusion. That concludes the maintenance procedure for your PC. Now you can replace the outer cover and bolt it back into place (be careful of sharp edges). After the enclosure is secure, reboot the system and perform a final test of some of the major applications—the system should perform exactly the same as it did before. By performing this routine maintenance, you can keep your PC running longer and save on expensive down-time or trips to the shop. Ω

LOGIC ANALYZER

(continued from page 43)

had to be met (with bit 0 at 0).

Experiment with the different clock rates, trigger modes, and trigger values. Also be sure to use all of the probes on signal Q7 in order to verify that all of the channels on the analyzer are working. One final note concerning the "A" then "B" trigger mode: only the lower 4 bits (0-3) of each trigger value are valid. Once you have tried all the options, you are ready to use the logic analyzer on other circuits.

A logic analyzer is a very valuable tool for working with digital logic. It can be used to verify timing relationships or for troubleshooting digital logic. The author welcomes any questions, comments, or suggestions on this project. He can be contacted by e-mail at alta@gutbang.com, by telephone at (860) 489-8003, or by visiting the Alta Engineering Web site at www.gutbang.com/alta.

Restoring A "Reel" Recorder

This month we take the first steps towards bringing our "golden oldie" back to its original splendor

PHIL VAN PRAAG

In the first part of this series (**Electronics Now**, February 1998) we explored some of the issues you should consider before beginning the repair or restoration of a vintage open-reel tape recorder. This month, we'll begin the actual restoration process. While we can't begin to cover each of the thousands of makes and models individually, the procedures we present are generally applicable to almost all machines. Where fundamental differences exist—such as tube *vs.* transistor or single-motor *vs.* three-motor designs, we'll point out any different approaches that might be necessary.

But before we get too much further, there are a few things we need to warn you about:

• Electricity can be dangerous. Do not attempt any electrical inspection or repair if you do not have the necessary general knowledge, experience, and tools. While low-voltage, battery-operated, all-transistor equipment, like the unit pictured in Fig. 1, might be relatively safe, anything with vacuum tubes, high-voltage batteries, or AC-line cords should be considered dangerous—with potentially lethal consequences.

• Mechanical inspection, troubleshooting, repair, and restoration attempts can also be dangerous. Many people have sustained permanent injury as a result of improper mechanical technique. Clothing and fingers get caught, eyes get hit with various projectiles, *etc.* Don't let that happen to you! Do not attempt any mechanical work if you do not have the necessary knowledge, experience, and tools.

• Never, ever succumb to the temptation of plugging in your newly-acquired vintage recorder "just to see if it works," if it has not been used for months or years and has not gone through the preliminary restoration steps described below. In short, doing so is just about the worst thing you could do! Okay, maybe not the worst thing; after all, you could bounce it down a flight of 30 concrete steps or use it as a boat anchor on your next ocean fishing trip! But, seriously, plugging in a tape recorder without first doing the necessary work could irreparably damage electrolytic capacitors, permanently bend or break "frozen" brake bands, cause totally unnecessary bearing wear, destroy what may still be some potential life in drive belts, or jam/seize-up mechanical levers, pulleys, or shafts.

On a different but related subject, as with any repair or restoration job, it is important to keep scrupulous notes. Don't rely on memory—write down every abnormality or questionable area you find as you go through the recorder. You may be amazed at the number of observations you have recorded by the time you are finished. Those notes, together with details of actual repairs, should become a permanent log for this particular machine, and it will be an invaluable future reference.

Initial Preparations. Before you begin, prepare your work area with the appropriate tools, lighting, cleaning stuff, lubricating stuff, a magnifying glass, a pencil and paper, and a "Variac" (variable-voltage AC transformer). The cleaners I use are: "Fantastik," any mild glass cleaner, isopropyl (rubbing) alcohol, "Endust," a good quality spray "tuner cleaner" (such as GC Elecronics 19-634), and mineral spirits. (For brevity, I have not included any wood-working or wood-cleaning considerations here.) You will also want to have a supply of paper towels and "Q-tips" handy, along with inexpensive ½- and 1-inch soft paint brushes.

Lubricants should include both oil and grease. The oil, for everything other than motors, should be a light machine oil housed in a small plastic vial—preferably with a telescopic-style nozzle. For motors, use a quality 20-weight motor oil. For very light grease applications, where no significant heat is present, "Vaseline" works remarkably well. For average or heavy-duty use, automotive-suspension grease will do the job.

Exterior Cleaning. The first step is to thoroughly clean and inspect all exterior surfaces of the recorder, beginning with the tape path. The tape path (see Fig. 2) must be meticulously cleaned from the first

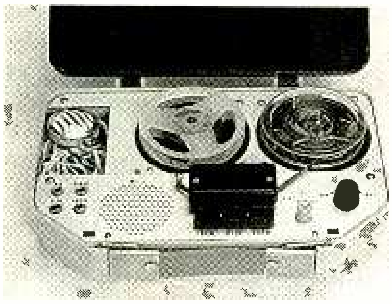

Fig. 1. A small, battery-operated tape recorder like this one might not produce dangerous internal voltages, but be very careful when working with AC-powered units as high, or even lethal, voltages could be present inside.

point of tape contact beyond the supply reel to the final point of tape contact, which is just ahead of the take-up reel. Every nook and cranny must be spotless. That includes all edges and corners of tape guides, posts, and heads. Use only isopropyl alcohol and Q-tips for this task. Never use abrasives of any kind; and, whatever you do, resist the temptation to scrape those guide edges with a small screwdriver. You will scratch the metal and forever cause abrasion against the tape (which not only wears out the tape, but also makes future oxide build-up an even greater problem).

I must confess I've been guilty of using my fingernails on occasion, or even breaking off a Q-tip end and using the paper Q-tip shaft, but that's the limit. This job might seem to take forever; it may appear as if the tape oxide has been deviously epoxied to the metal. That is normal; just keep at it. One other word of warning here: Don't use excessive force during the cleaning process. Heads can be pushed out of alignment and tape guides can be bent if you are not careful. Also, as you go through the cleaning process, be sure to note any abnormality or questionable area such as an apparently scratched head, a bent tape-guide lever, or potentially excessive wear.

By the way, it's okay to use isopropyl alcohol on the pinch roller. This roller is typically located to the right of the tape heads, as pictured in Fig. 3, though it might also be centered within the head assembly. Such a setup is occasionally found on auto-reversing machines. Also, a small number of models contained two pinch rollers, one on each side of the head assembly. Regardless of the setup, the cleaning procedure is basically the same: Simply hold the roller stationary with one hand, and clean the tape contact surface with the other using an alcohol-moistened paper towel.

Note: Do not attempt to clean the pinch roller when the machine is running—with the roller engaged against the capstan shaft—as this can be dangerous. I have never found isopropyl alcohol to damage the rubber (even after many applications over many years) if used only as the roller is being wiped clean.

Next, thoroughly clean the remaining front-panel area, using glass cleaner if it's only dusty, or a stronger cleaner (such as Fantastik) if it's dirty. As you do this, be careful not to wipe off old lettering. Mineral spirits is handy for removing household-tape adhesive remnants. Note that Fantastik sometimes leaves a film residue; that can be removed with an application of glass cleaner. Then clean the rear panel and/or compartment area. Take note of any broken connectors, frayed cables, missing "remote" plugs, etc. Now finish cleaning the remainder of the exterior cabinet.

As a last step, go back and take one more careful look at the tape path, using the magnifying glass this time to note any imperfections or oxide clumps you might have missed the first time. Also "sight down" the heads and guides to take note of any gross misalignments. By sighting down, I mean get your head down to the tape path area to gain a view similar to that shown in Fig. 4. Close one eye and visually bring adjacent tape contact points into view—carefully watching to see that surfaces are parallel or perpendicular where they should be. Don't bend or otherwise adjust anything at this time.

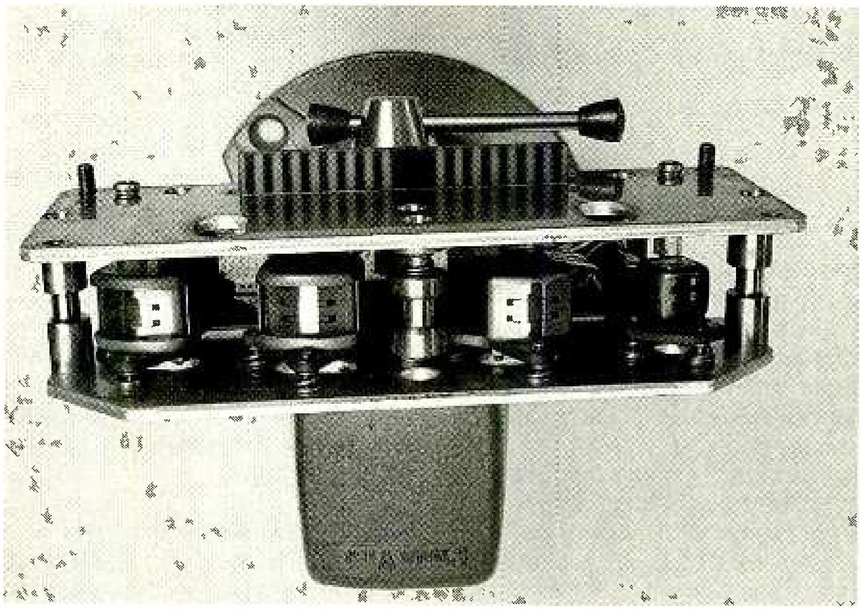

Fig. 2. The various tape heads and guides found in the tape path of a typical audio-tape recorder. This particular head assembly is from an auto-reverse machine. It contains four heads: one each for erase and record, plus two play heads—one for each playback direction.

General Interior Cleaning. Now let's tackle the interior cleaning and inspection. The goal of this step is to determine the overall state of the "internals" and perform some minor cleaning and lubrication in an attempt to condition the machine to the point where it can be safely powered up. It's only after power application that you will be able to determine, in detail, the extent of work needed to complete the restoration.

At this point, remove enough of the cabinetry to gain access to the major mechanical and electronic sections. Make sure you keep track of the disassembly sequence and all of the hardware you remove in the process. Using Endust or something similar sprayed onto a paint brush (just a little will do nicely), carefully brush out the interior—

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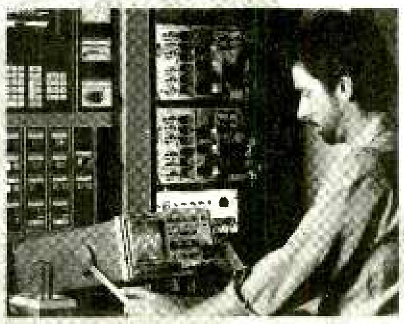

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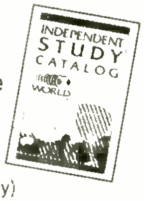

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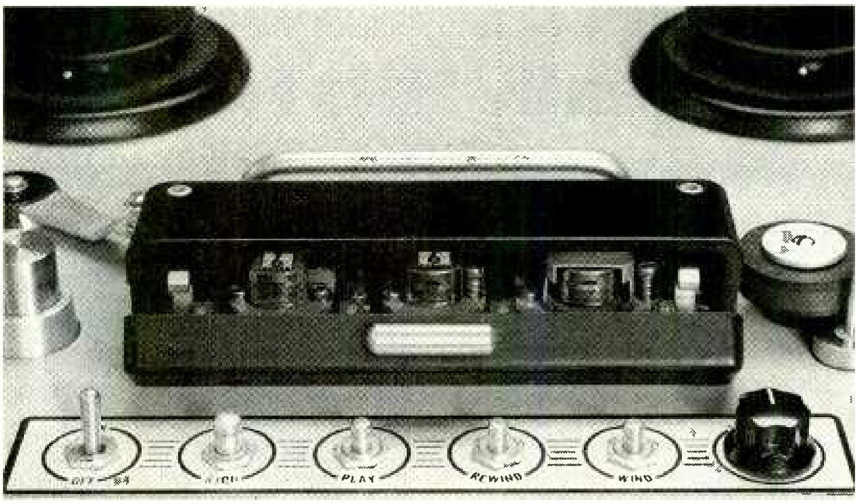


Fig. 3. In a typical type path, the pinch roller is located to the right of the tape heads, as shown here, though it might also be centered within the head assembly.

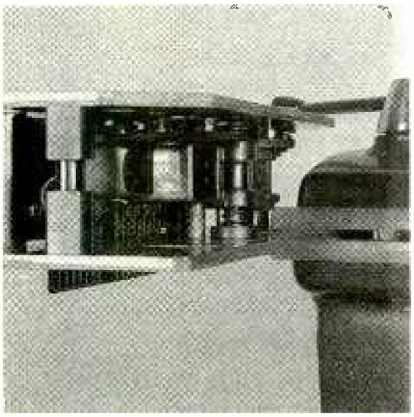


Fig. 4. One preliminary step when checking head alignment is to "sight down" the tape path as an initial check to ensure all tape contact surfaces are parallel to each other.

removing major clumps of dust and grit. Be very careful of the following as you do this:

• Do not dislodge or otherwise stress wires or components; transistors, for example, are often plugged in (as opposed to being soldered in place). If you brush too hard, you may inadvertently dislodge them.

• Do not brush areas containing grease; use Q-tips for those areas.

• Do not brush "into" mechanical components; doing so might cause dirt clumps to become lodged inside bearing surfaces.

A small vacuum cleaner could also be used here, but it would be most effective if used together with the brush. You might as well clean the inside of the cabinet as long as it's removed at this time.

Follow this with Fantastik-dampened paper towels to finish the cleanup task. Once again, be careful to observe the above warnings. The idea here is not to produce a "spit shine" but rather to do a general cleaning, removing dust and dirt that otherwise might find its way into the moving parts, to create a reasonably clean "work area" for the subsequent detailed restoration tasks, and as part of the general discovery/inspection process. After all, you can't inspect it if you can't see it!

Detailed Interior Cleaning. Once you are satisfied that the general interior cleaning is adequate, the next step is detail cleaning. Use Q-tips and paper towels, moistened with isopropyl alcohol, to clean all rubber idlers and belts, the metal surfaces those rubber parts contact, and any other metal or plastic areas too small to cover with the previous cleanup. The locations of some of those components within a typical vintage recorder is shown in Fig. 5. Note that, particularly on machines from the 1950s, you might encounter cloth belts. Those belts were tensioned via a spring-loaded intermediate pulley. Remarkably, many of those belts are still serviceable today! If your machine has one of them, do not attempt to clean it with isopropyl alcohol. In fact, don't get it wet at all.

Also, be very careful if you encounter any felt contact areas. Most likely that would be in the form of brake-band linings (if you have a three-motor machine), pressure pads in the tape-path area, or turntable "slip-clutch" pads. Do not get the felt wet; in fact, don't attempt to clean the felt or touch it at all. Rather, just inspect it—and make a note if it appears to have significantly disintegrated over time.

If the machine has brake bands, you'll most likely have to remove them in order to clean the mating contact surfaces. The bands may have one fixed end and one pivoting end, which is spring loaded. Often by very carefully removing the pivoting end (noting all points of attachment), the band can be gently folded back enough to allow you to clean thoroughly. Those mating surfaces must be absolutely spotless—no dirt, no adhesive residue, nothing! Be extremely careful not to crease the metal bands—it will not be possible to completely remove the crease, and that could cause rubbing.

Transport Lubrication. The next part of the detail cleaning gets into areas that require a greater degree of manual dexterity, concentration, and observation; it is vital to keep track of what you are doing, what parts you are removing, and in what sequence you are removing them. That's because the mechanical components we'll be discussing next must be removed in order to be properly cleaned, and certainly prior to lubrication.

If the recorder dates back only to the 1970s or 1980s, and was very clean on the inside when you first removed the cabinet, then you might be relieved of this chore. For all others, however, this next step involves the removal of all rubber idler wheels and the pinch roller in order to clean the shafts with isopropyl alcohol. It may be advisable to remove, clean, and re-assemble those one at a time to eliminate the possibility of putting them back in the wrong place. Also, keep your eye out for dried grease clumps adhering to the base of the shafts. All shafts should be shiny-metal colored when you are finished. Use a wet Q-tip to clean the bushing surface inside the wheels. As you re-assemble these wheels, put a drop or two of light oil on the shafts.

While the oil is in your hand, go

ahead and oil the capstan shaft (sometimes a tiny oil hole is provided for that purpose, and at other times you may find both a front and rear bearing support for the capstan/flywheel assembly; in either case, be certain that all bearing surfaces are oiled). Also apply one drop of oil at each pivot point, where friction and wear can occur. One word of warning here: never over-oil. One or two drops are sufficient. If you use too much, the oil will seep onto surfaces that shouldn't have oil contamination (*e.g.*, rubber) or will simply make a mess that will later become a "dirt farm."

Oiling the motor(s) can be a simple chore, or it can be very difficult—even virtually impossible—as a function of design. If you're lucky, the motors will have either an oil hole through the front and rear bushings (around the motor shaft) or a tiny metal tube protruding through a side opening of the motor enclosure. In either case, use three or four drops of 20 weight motor oil at each hole.

In other cases, however, you will find motors that are said to be "permanently lubricated" by their manufacturer. Sometimes, what that meant was a greased, sealed, bearing race on the front and rear motor-shaft support points. There's not much you can do with motors of that design without resorting to complete disassembly and replacement of the bearings (or somehow re-packing them). Note that no matter the quality of the original components, the grease is now 25 to 50 years old and probably not lubricating very well anymore. Even so, I do not recommend that you disassemble the motors, and certainly not at this point. Just add a drop or two of oil at the point where the shaft enters the motor housing (front and rear). If the motors later prove to work okay (without excessive motor noise), then just leave it go at that, and consider yourself lucky. If that doesn't work out, then you might need to find a motor repair shop for assistance.

You will generally find at least remnants of the areas where grease has been applied to movable chassis components at the factory. These areas should first be thoroughly cleaned, and then have grease applied. It might be best to clean, and then grease, one area at a time; otherwise, you might forget to re-grease some areas. Use Vaseline in those delicate areas where it's apparent that a heavier grease might upset the movement of low-mass, low-spring-tension, components.

The basic premise here is that if contacting metal parts slide against each other, or the chassis, then grease should be applied. If, on the other hand, parts rotate against each other (*i.e.*, there's a confined space there), then oil should be applied. The logic is that grease applied to confined spaces will eventually cause the rotating parts to seize as contamination, separation, and hardening take place over the years. I'm sure there are a few exceptions to this rule, but not very many.

Initial Electronics Check. Now that we've gotten most of the cleaning accomplished and have performed the basic lubrication operations for the mechanics, it's time to turn our attention to the electronics. Prior to the initial power-up, we want to do a bit of electronics cleaning and inspection.

First, carefully inspect the electronics area for signs of overheating. That includes bulging or cracked resistors (take your time and look very carefully here; use a small flashlight to help identify any abnormalities), burned wires, or capacitors with "stuff" oozing out. Make a detailed note of all such occurrences, and replace any suspicious components. For example, a cracked-open resistor in a power-supply section should not only be replaced but also carefully noted. It's possible that the reason it overheated was a shorted electrolytic capacitor on the output side.

Next, grab your can of tuner cleaner and carefully spray clean all potentiometers. To do that, place the can's extension nozzle at the opening where the three electrical contacts emerge from the body and give it a brief spray. Then rotate the control a few times through its complete range.

In some cases, you might find that the potentiometer is sealed; that is, it has no opening. In such cases you might have the best of all worlds or the worst: The "best" since that usually means the manufacturer used a superior quality potentiometer that was moisture sealed at the factory to prevent contamination; the "worst" is that if and when such potentiometers do become contaminated, there is no simple way to restore proper operation. As a last resort, some have been successful with drilling a tiny hole through the back of the device to allow entry of the spray cleaner. At this point or the operation, if the potentiometers are sealed, just make a note of it and go on.

Finally, while you still have the tuner cleaner in hand, spray clean all switches with exposed contacts, including rotary switches. By the way, most of the available spray cleaners also contain a light lubricant, such as silicone; that helps extend component life.

Final Inspection. At this point, check all fuses. That includes rear-panel-accessed fuses—with screw-on caps—as well as internal fuses. Internal fuses are sometimes hidden, so make sure you look all around; some may be "inline" fuses, mounted inside wire-lead holders, while others may be chassis-mounted fuse blocks. In addition to ensuring continuity, make sure that all fuses are of the proper ampere rating and "speed." By speed I mean the length of time before an over-current situation blows the fuse. So-called "slow blow" fuses are often designated "SB." Do not intermix these with the more-common fast-blow types. Make notes in your log of any abnormalities as you go. If a wrong fuse is inserted, it has obviously been replaced; later you must ask yourself "why?" If it has a larger current rating than the manufacturer designated, then you should consider the possibility that the electronics may be drawing excessive current. If that is the case, go back and double check for any over-heated components or wires. If none are found, proceed with the next step.

Okay, we're just about ready for power-up. But before we do, let's take one more look through the

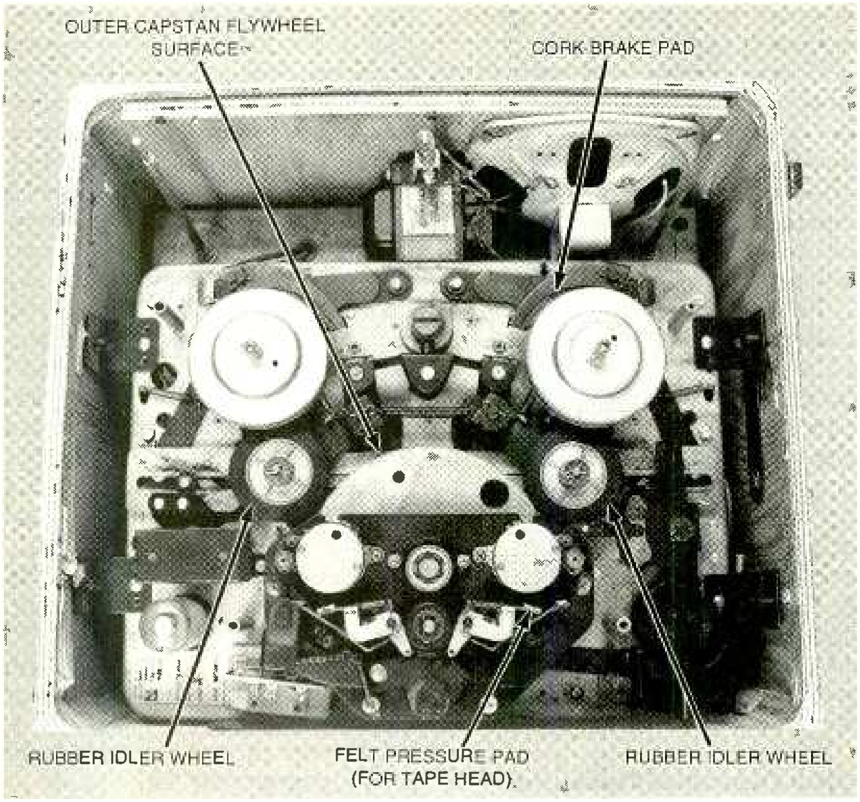


Fig. 5. Some of the internal mechanical components found within a typical recorder. Clean the contact surfaces of the rubber idler wheels and mating flywheel; inspect—but do not moisten—the felt and cork pads.

electronics. If the unit is transistorized, are all the transistors firmly seated in their sockets, with no twisted or "about-to-short-out" leads? Are all internal wires and cables dressed away from any mechanical components, and are they run so that they will not be pinched when the cabinet is re-assembled? Is the AC-line cord still supple and free from any cuts, abrasions, separation at the plug end, or wear at the chassis strain-relief end? Redress, repair, or replace any problems you find, and then re-assemble the cabinet.

Initial Power-Up. Finally, we are about ready to see what this recorder can do. I say "about ready" because first, there is a conditioning step that we must go through. What we are trying to accomplish with this next step is to re-condition the electrolytic capacitors in the hope that you will not need to replace them. Without going into detail, electrolytic capacitors deteriorate with time and lack of use, and that deterioration can be made worse by storage conditions, leading to a rather high probability of failure if the AC power is suddenly applied at full voltage. Instead, by gradually applying that voltage, the capacitors will sometimes re-condition themselves to a point of being quite serviceable again.

Now, connect your Variac to an AC supply. Making sure your recorder is off, with the Variac's voltage control at zero, plug the tape recorder into the Variac. With the recorder in stop mode, and with all volume controls at their minimum position, turn on the recorder. Now slowly increase the voltage up to about 40 volts and then stop. Leave the voltage at this level for about 10 minutes, and then increase the voltage by 10 volts and wait 5 more minutes. Keep repeating that process until you reach about 95 volts, carefully watching the recorder as you do this. Do not leave the room during this procedure! Look for any smoke, hum, noise, or other abnormalities that could be signs of problems. If any of these occur, shut off the Variac, disconnect the power, and correct the problem before proceeding.

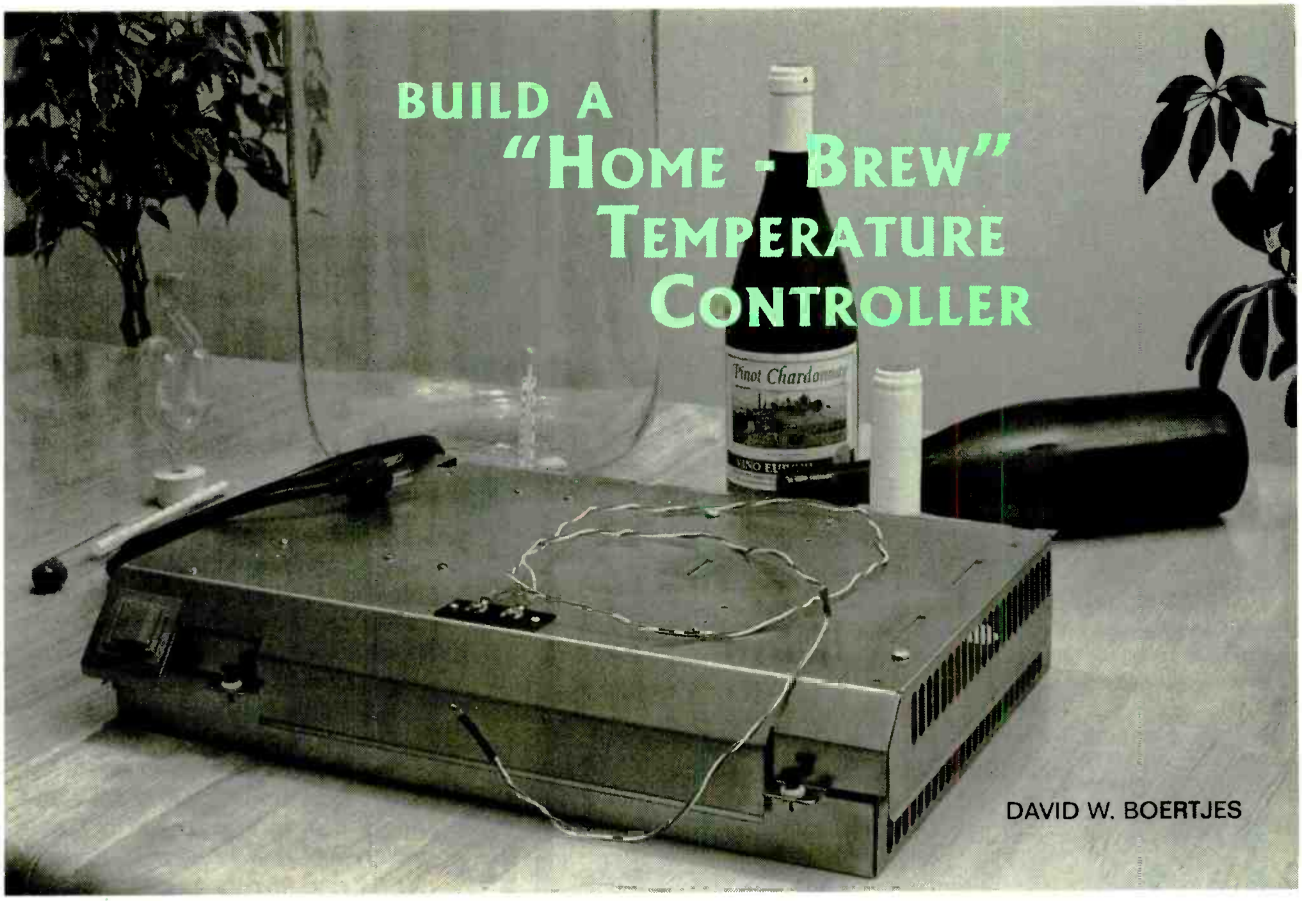
Assuming you've been successful to this point, let's do a quick check on the motors before we load tape on the machine. With the AC voltage still at 95, switch into play mode and, if there is a motor shutoff switch in the tape path (usually that will be on either side of the capstan/pinch-roller area), defeat that switch momentarily by using your finger to move it into the position it would have if tape were threaded. observe what happens.

What should happen is that the pinch roller should be solidly contacting the capstan shaft (that actually would have occurred before tripping the switch in a non-solenoid operated machine), and the take-up reel turntable should be rotating in a counter-clockwise direction. Depending on the type of drive, the supply turntable will probably also be rotating, in a clockwise direction. Before releasing the switch, use your other hand, to check if a light touch on the turntable platforms is sufficient to stop the rotation. (When you do this, stay away from the outer edge of the turntables and the center post, as the turntable edge and the post flanges could be sharp.) While we're not doing a formal calibration here, I do want you to make sure that there isn't an excessive amount of force needed to stop the turntable's motion.

All the turntables are supposed to do in the play or record modes is keep the tape from slackening. Any excessive pulling can stretch the tape, and any significant "jitter" or "fluttering" can increase W/F significantly. If there is excessive pulling, do not proceed until the cause is removed (some tips on that will be offered in the next installment of this series). If there is a little bit of jitter, go ahead and proceed, but make sure you take note of the problem.

Tape Path Demagnetization. The next step is to demagnetize the tape path. This is important, and really should be done on a regular basis—let's say after every 10 hours of use. The problem we are trying to correct here is the gradual magnetization of the metal tape guides and heads, which is caused by the electronics, stray external fields, the use

(Continued on page 70)



One of the secrets of successful home brewing of wines and beers is a constant temperature. Our temperature-controlled heater will keep the temperature of your brews precise and even!

Home brewing can be a very rewarding hobby. Not only is it less expensive to brew wine and beer at home, but depending on how much time and effort one puts into each batch, beverages of excellent quality can be produced.

All home brewers have their own secrets to success, which they may not be willing to share. Two details that most budding brewers tend to overlook have to do with temperature and light. The bacteria responsible for the fermenting process work best at temperatures between 68° and 75°F. Although it is a matter of opinion as to what exact temperature is best, most brewers agree that once a temperature is chosen it should remain constant.

The effect of light on fermentation has been debated among brewers for the longest time. It is the author's opinion that it is best to brew in the dark—especially for wine. The obvious location for brewing under those conditions is a dark basement.

Unfortunately, most basements are also too cold for effective fermentation. Some form of controlled heater would then be needed. One method that has been tried is a small cabinet just large enough to hold the carboy (the 6-gallon glass jug used for brewing), a household thermostat, and a 60-watt light bulb. The thermostat controls the light, which heats the inside of the cabinet. Unfortunately, there are a couple of drawbacks to this. For one, the bulb gives off light. You could wrap the bulb in aluminum foil to cut down on the light, but that would decrease the bulb's life. Even more of a concern is the fact that a household thermostat usually has a "swing" of several degrees—perfectly fine for a comfortable home, but not nearly accurate enough for proper brewing.

The solution to those dilemmas is the Home-Brew Temperature Controller presented here. This project is relatively easy and inexpensive to build. The parts can be purchased for about $70 if you don't have anything on hand already. The electronics are simple enough that the circuit can be constructed on perfboard.

Designing a Heater. While the circuitry for a heater with temperature feedback might seem to be an almost trivial matter, there are several finer points to keep in mind when devising such a circuit. The set point should be adjustable over a temperature range of 68°–75°F. The maintained temperature should be within 1 or 2 degrees of the set point so that the system does not "chatter" from rapid switching of the heater's power supply. Whatever switching method is chosen should be flexible enough to control different types of loads such as fans or lights. Choosing low-cost and readily-available components will help

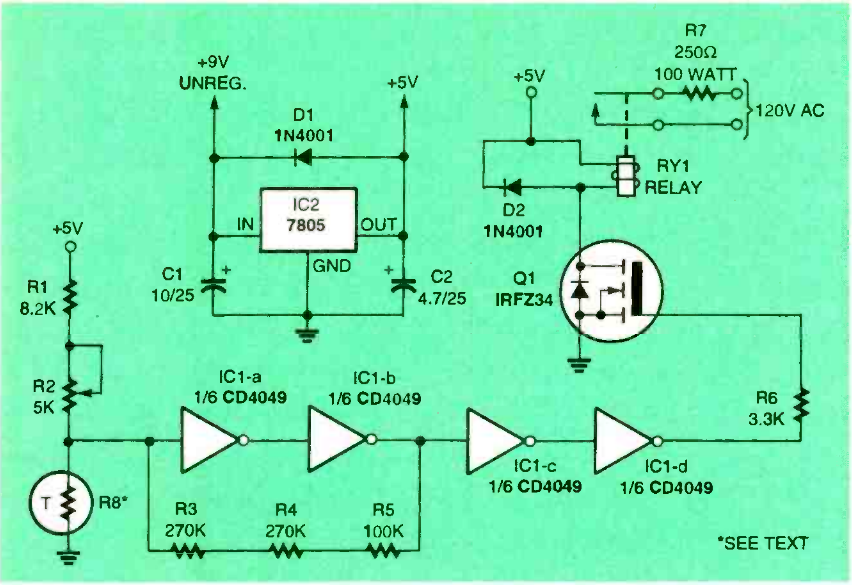


Fig. 1. Although the schematic of the Home-Brew Temperature Controller might appear simple, some sophisticted design work can be seen in the temperature-sensing portion of the circuit. For safety considerations, the "hot" side of the supply line for the heater should be connected to RY1 and the neutral is connected to R7.

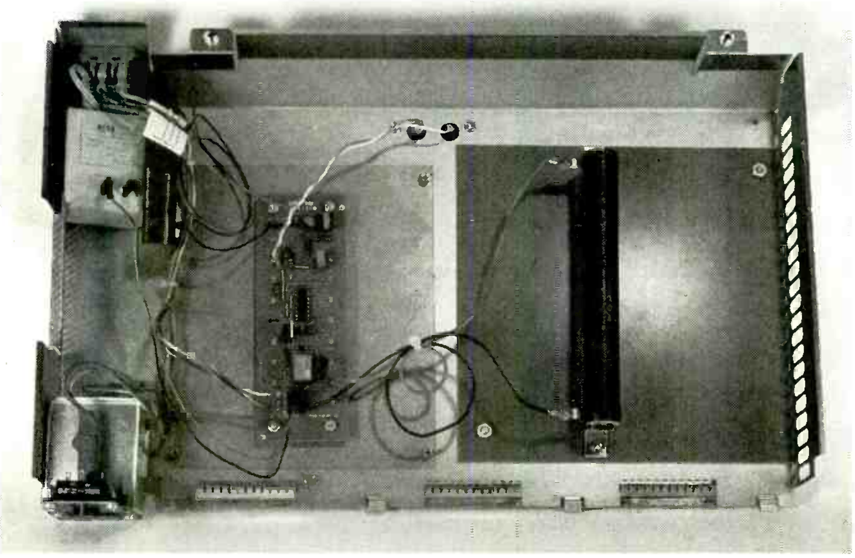


Fig. 2. Here is an inside view of the author's Home-Brew Temperature Controller. Note the use of a fiberglass PC board to insulate the large heating resistor from the metal case. The heating resistor has also been placed near some ventilation holes and is located as far away from the rest of the circuit as possible.

keep expenses to a reasonable level.

For the accuracy needed in this project, a thermistor will be used to sense temperature. That device is inexpensive and small, and different units can be selected depending on the temperature range needed. The one we will be using has a negative thermal coefficient. That means that as the temperature increases, the thermistor's resistance will decrease. The thermistor's resistances at some of the temperatures that we are interested in are listed in Table 1.

The thermistor will be used in a resistor network so that the temperature of the thermistor will generate a variable voltage. To provide the "hysteresis" so that the circuit does not chatter, we'll put an additional resistance in parallel with the thermistor's resistor network. That parallel resistor will be switched so that it is either electrically across the thermistor or across the adjustable set resistor. When placed across the thermistor, the apparent temperature of the thermistor will be higher because of Ohm's Law of resistors in parallel. When placed in parallel with the set-point resistor, the apparent setting will be changed in a similar fashion. The values for the resistors will be chosen so that the circuit will switch off when the temperature is 1°F above the set point and switch on when the temperature drops to 1°F below the set point.

With a digital signal that switches when additional head is called for, the rest of the circuit is simply a relay that turns a heating element on and off as needed.

Circuit Description. The schematic of the Home-Brew Temperature Controller is shown in Fig. 1. The temperature-sensing thermistor is R8, with R2 being the adjustment for the temperature-set point. The values for the combination of R1 and R2 let the set point be adjusted between 8200 ohms and 13,200 ohms—covering the temperature range in which we are interested. Resistors R3, R4, and R5 make up the hysteresis resistance that will be switched between R8 and R2. The 640,000-ohm value of the hysteresis resistors will change the apparent temperature being sensed by the circuit by 1°F. An unusual design point is the use of a CMOS inverter gate in its linear mode. The gate chosen for IC1 switches between its logic-low and logic-high outputs when the input voltage is *exactly* one-half of the device's supply voltage. The outputs can also be very close to the actual supply-voltage values.

The output of IC1-d drives Q1 so that enough current can be supplied to RY1. When the relay switches on, line current is supplied to R7, a 100-watt power resistor, which acts as the heating element. Power for the circuit is supplied by IC2, a 5-volt regulator.

Building the Heater. There are many options when building any circuit, even a relatively simple project such as the Home-Brew Temperature Controller. However, a few cautions are in order. Care must always be taken when using 120 volts AC in any project. With the Home-Brew Temperature Controller,

PARTS LIST FOR THE HOME-BREW TEMPERATURE CONTROLLER

SEMICONDUCTORS

IC1—CD4049 Hex CMOS inverter, integrated circuit
IC2—7805 5-volt regulator, integrated circuit
D1, D2—1N4001, silicon diode
Q1—IRFZ34, MOSFET transistor

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—8200-ohm
R2—5000-ohm, potentiometer
R3, R4—270,000-ohm
R5—100,000-ohm
R6—3300-ohm
R7—250-ohm, 100-watt
R8—Thermistor, 10,000-ohm@25° C (RadioShack 271-110 or similar)

CAPACITORS

C1—10-µF, 25-WVDC, electrolytic
C2—4.7-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

RY1—Single-pole, double-throw relay, 5-volt
9-volt DC wall adapter, case, line cord, brackets for R7, wire, hardware, etc.

TABLE 1

Temperature	Thermistor Resistance
68°F	12,100 ohms
69°F	11,900 ohms
70°F	11,600 ohms
71°F	11,400 ohms
72°F	11,200 ohms
73°F	10,900 ohms
74°F	10,700 ohms

however, there is also an element that will become hot. Take some extra time to think about the placement of the heating resistor within the chassis. Any plastic part or wire insulation that gets too close to the heating resistor could melt. Also make sure that all of the high-voltage connections are isolated in a safe manner. It is also a good idea that the unit's metal chassis be grounded and that a 1-amp fuse be wired into the power line.

An example of the author's arrangement is shown in Fig. 2. A ventilated metal chassis that measures 17 inches by 11 inches by 3 inches houses the circuit. Heating resistor R7 is located on one side of the cabinet, with the rest of the circuitry located on the other side. The resistor is also mounted on a sheet of single-sided PC board material. The board's fiberglass is a good insulator for both electricity and heat. The heat insulation helps prevent the top of the case from getting too hot and becoming a burn hazard. It can be seen that R7 is also mounted with brackets that let air circulate all around the resistor.

The temperature-set resistor, R2, is a PC-mounted trimpot. However, it can also be a panel-mounted potentiometer on the outside of the case. With that arrangement, adjusting the temperature becomes much easier. Unfortunately, accidentally bumping the control can just as easily change the temperature setting, so some type of protection or "lock-out" method would be needed.

Electrical power for the circuit is provided by a 9-volt, 500-mA wall adapter that has been tucked into one corner of the case. Using a surplus adapter can be less expensive in terms of cost and construction time over using a standard transformer, bridge rectifier, and filter capacitor.

The thermistor probe is best made by soldering a pair of twisted wires onto the device and shielding the connections and thermistor leads with two pieces of heat-shrink tubing. A suitable connector on the other end of the wires should mate with a jack mounted on the case. One way to do that is to use spade lugs on the probe wires and a dual-screw terminal on the case

To set up the Home-Brew Temperature Controller, fill a carboy with water and place an accurate thermometer in it. Set the carboy on the heater in a room where the temperature is always lower than the temperatures you will be needing—an unheated basement will do. Turn on the heater. Over a period of several days, the water will stabilize at a particular temperature. Small changes in the setting of R2 will change the temperature that the heater will maintain. If you used a panel-mounted potentiometer for R2, you could mark the settings for various temperatures. Once you have set R2 for a particular temperature you'd like to brew at, you're ready to mix your first batch of temperature-controlled brew.

With the addition of the Home-Brew Temperature Controller, the quality and consistency of your batches might improve. It will also give you a warm feeling to know that the heater is faithfully doing its job! Ω

BY DON LANCASTER

FM Transmitters, Understanding the Faraday Disc, and More

LET'S START OFF THIS MONTH WITH A HOT HELPLINE TOPIC THAT HAS BOTH A USEFUL NEW SOLUTION AND A RATHER LONG HISTORY OF CALLER INTEREST. IN PARTICULAR, LET'S TALK ABOUT DEVELOPMENTS IN . . . .

FM Transmitters

Lots of folks want to broadcast over the radio. Why? Perhaps for their own "underground" or "pirate" community radio station; to deliver a commercial "please buy my nice house" realtor message; to free a stage or studio performer from trailing wires; for use in wireless modems or in short-haul telemetry; for surveillance, alarms, or baby monitors; or simply to couple a portable CD player into any nearby home or car radio.

If you only want to broadcast over a few feet, you just need a few milliwatts. To go a hundred feet, you'll need a hundred milliwatts. To cover your neighborhood or town might require ten watts or so. As you might guess, the FCC places very stringent limits on what you are legally allowed to either transmit or broadcast. Anything more than 30 milliwatts or so is probably illegal (but check with your own legal adviser on this).

The FM band resides from 88.1 to 107.9 Megahertz. All the FM-station frequencies are precisely spaced every 200 kHz. Thus, the frequencies always end in an "odd" number such as 93.3 MHz or 99.9 MHz.

Long ago and far away, FM transmitters were built around a simple oscillator, often based on the superb 2N918 transistor. A Varactor or even plain old collector-voltage modulation was used to create mono frequency modulation.

Alas, in those days, most "analog" FM receivers all used powerful automatic frequency-control (AFC) circuits. Those receivers could easily follow any in-band FM carrier, no matter how far off-frequency it was or how much it drifted. But nearly all of today's better FM receivers are digitally synthesized and work only with signals that are both stable and precisely on-frequency. Thus, most of the older and simpler low cost FM-transmitter circuits will no longer work well.

The first step in correcting that situation was a potent chip known as the Rohm BA1404. That IC provided high-quality audio by way of its 38-kHz crystal-derived stereo modulation. But the internal RF oscillator was still flaky enough that it drifted unacceptably.

So, how can you build your own FM oscillator that is both stable and always on-frequency? There are two main routes that you can use, but before we go further, we need to clarify one concept: A stable FM system is really a contradiction in terms, as its frequency changes with the musical or voice content. What you want is its center frequency to be rock stable.

The "correct" and complex way to deal with this is with a variation on a PLL called the frequency-locked loop. You first build an FM oscillator. Then you build a crystal oscillator that operates at the same center frequency. The average frequency of the two are compared and integrated, or low-pass filtered. The resulting error voltage from the low-pass filtering is a near DC waveform that's used to continuously correct the FM oscillator, thus forcing it to the designed frequency.

The frequency-locked loop method is how the situation is handled in commercial FM transmitters. The big problem for the home builder or experimenter is that a lot of parts are needed in a fancy circuit.

The other technique is to use capacitive loading to pull a crystal in frequency. The question is can you pull an ordinary crystal enough to be useful here? The usual rule of thumb is that you can pull a crystal up to one tenth of a percent, which does translate to 100 kHz up at 100 MHz. But that tenth of a percent is usually an outside limit. Also, sadly, the pulling process is usually nonlinear.

Both Sony and Pioneer found that they could pull special crystals in hard-to-design but simple, low-cost circuits. The results were the old Pioneer CD-FM-1 and the Sony XA-7A FM-stereo modulators. No longer made and now hard-to-find, the Pioneer unit is single channel, but is easily modifiable and worked upon; the Sony version is dual channel, but smaller and difficult to adapt. Interestingly, Sony actually managed to linearly pull their special crystal over two adjacent FM channels using switched bias.

NEED HELP?

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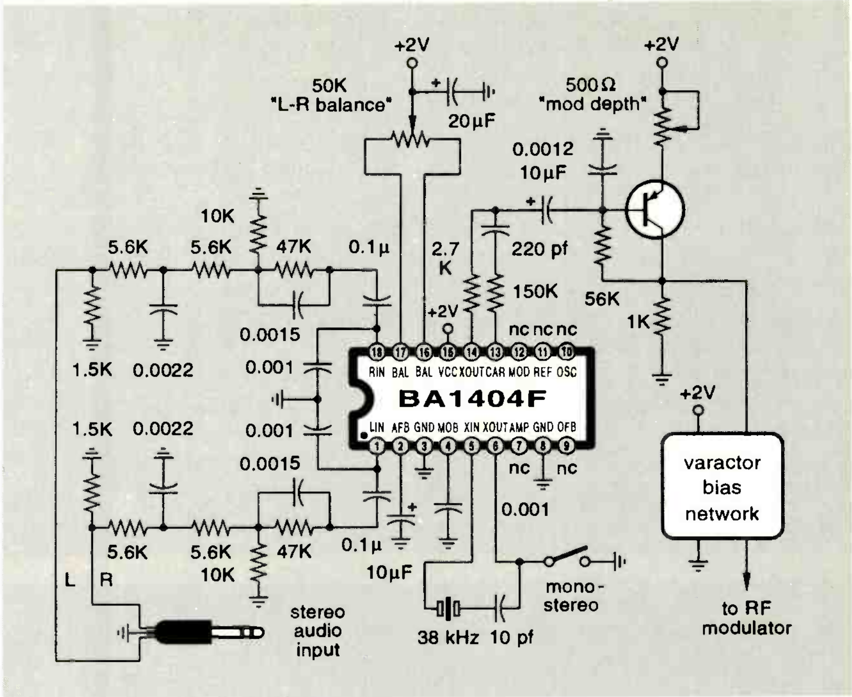

FIG. 1—THE FM-MULTIPLEX PORTION of the new RadioShack 12-2051 FM Stereo Transmitter. The BA1404 generates a stereo subcarrier.

Those small FM modulators were intended to let you add a CD player to your existing car radio; it installed between the car antenna and your radio's antenna input. We looked at a circuit and a detailed description of their innards in the Hardware Hacker IV reprints and in HACK52.PDF. Anyway, all of that just may be ancient history now thanks to a new device from RadioShack.

RadioShack's 12-2051

The new 12-2051 FM Stereo Transmitter sells for as little as $24. It has four channels. It is crystal stabilized. The intended use is to route audio from a CD player (or any other mono or stereo signal) a few feet into a hi-fi or a car-radio receiver. The unit can run off an internal battery or from an external 3-volt DC supply; the supply voltage is fed to an internal two-volt regulator IC and a special temperature-compensation circuit. Current draw is 9.5 mA on the low channels and 7 mA on the high ones. A pair of AA batteries are said to last 100 hours. An 800-mV input (the usual "line" level of 0 dBm) is needed for full modulation. Distortion specs are not all that great at one to three percent.

Several sneaky tricks are used to let you pick four stable channels. A switchable pair of crystals (17.78 and 17.82 MHz) is used and their frequencies are multiplied by either five or six. That means that the crystals now only have to be pulled one-fifth or one-sixth as far, greatly improving upon their linearity and simplifying the circuit design.

Note that the designers did cheat a little as the numbers don't quite work out exactly. The 17.78-MHz crystal hits 88.9 right on by using its fifth harmonic. But it slightly misses 106.7, landing at 106.68 with its sixth harmonic. Similarly, the 17.82-MHz crystal hits 89.10 exact, but misses 106.9, ending up at 106.92 MHz. So they fixed it with a little bit of Varactor DC bias that is channel-dependent.

The FM-multiplexing portion of the circuit is shown in Fig. 1. It seems to be a "me too" BA-1404 circuit, but lacking any internal RF-oscillator connections. That box I have labeled "Varactor bias network" is rather obtuse. What that all-passive resistor-diode-switch-capacitor circuit does is combine the multiplexed audio with a temperature-compensated master DC level and a custom switchable bias offset for each selected channel. Needed audio pre-emphasis is also increased a tad on the two high channels. The net result is a DC Varactor bias value that is appropriate for your selected channel, with properly emphasized audio superimposed. See the RadioShack documentation if you really need the gory details.

The discrete RF part of the circuit is shown in Fig. 2. The KV1561 Varactor diode is used as an electronically variable capacitor to pull one of two selected crys-

SOME FARADAY DISC RESOURCES

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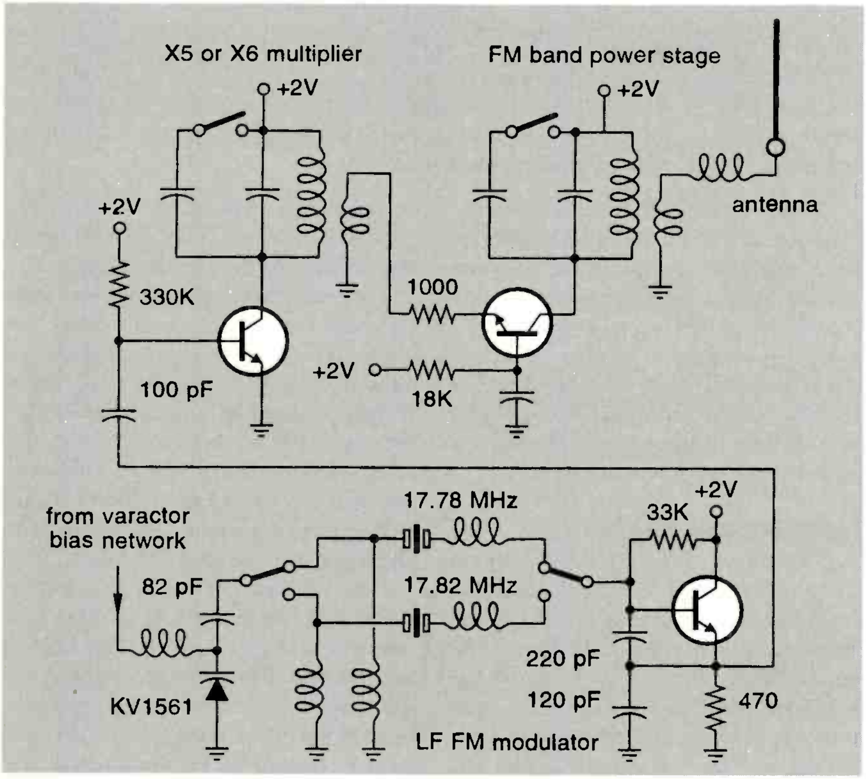

FIG. 2—THE RF-MODULATOR PORTION of the Radio Shack 12-2051 FM Stereo Transmitter. The use of 5× and 6× multiplication improves linearity and simplifies the circuit design.

tals. The voltage on the variable capacitor is the sum of the L+R mono audio channel, an L-R signal on a 38-kHz subcarrier, and possibly a DC fine-tuning value. The first stage oscillates in the 18-MHz region. The second stage then multiplies by five for the two low channels or by six for the two high channels. The final circuitry is a grounded-base linear amp that operates at FM-band frequencies.

Switching can add extra tuning capacitance to the multiplier and output stages. Shifting your tank resonance accommodates either the high or low channels.

Note that I've simplified Fig. 2 a tad for clarity. The high-low switching is really done with NPN transistors. Further, each of the stages is independently decoupled from +2 VDC by its own RC filter network. Again, see the RadioShack documentation if you need additional details.

Two mechanical switches are used for frequency selection. One picks the crystal; the other peaks for low-or high-frequency channels. Note particularly the 1000-ohm resistor in the final output stage. RadioShack apparently added this in their "-A" version to sharply reduce the range. That might have been done to meet an out-of-band harmonic spec, to lower distortion, or to discourage adding an illegal external power booster.

There's a small user's manual that comes with the modulator. The more detailed service manual (having full schematics and updates) is available as a special order for $7 or so. Ask your RadioShack dealer for details.

More On the Faraday Disc

Some enigmas are more enigmatic than others: It turns out the odd behavior of the Faraday disc is even stranger than I thought it was. In November, 1997 (MUSE117.PDF on www.tinaja.com), we looked at homopolar generators. The Faraday Disc is one variation on the homopolar generator where the input magnetic field is also rotated.

The key question is this: When you have any perfectly uniform magnetic field is there any way you can tell that the field is rotating? Well, a classicist would say "Of course you could tell if the field is spinning. The lines of force are busy cutting conductors and are inducing voltage." A relativist would instead say "There is no way to tell. There are no such things as magnetic lines; a uniform field is in fact uniform. Further, the laws of general relativity demand field motion independence, especially at high speeds."

It took well over a hundred years to sort this one out, and as far as we know today, the relativists are correct: You cannot tell if a perfectly uniform magnetic field is rotating or translating. One source for that hard-to-visualize and even harder-to-believe result is in Richard Feynman's *The Feynman Lectures on Physics* Volume II, section 13.10. A well-documented and peer-reviewed experiment (Valverde's "The Principle of Relativity as Applied to Motional Electromagnetic Induction") you can run yourself is found in the *American Journal of Physics*, Volume 63 #3 for March of 1995. All the nasty math involved lies in a Richard Becker's *Electromagnetic Fields and Interactions*, Dover 1982, sections 87 and 88; section 87 is background information and section 88 is on unipolar induction itself.

Figure 3 shows you a simple experiment. Hang a magnet vertically on a string. Position another vertical magnet below the first one and rotate it around the string axis. Your upper magnet should not rotate. It should only be attracted or repelled by the bottom one, but not spun. That strongly suggests that any magnetic "lines" do not move with a magnet's rotation.

Your easiest access to Faraday's original *Experimental Researches in Electricity* are in the Britannica Great Books series, volume 45. One quite readable book about Faraday is a Cantor, Gooding, and James' text entitled *Michael Faraday*. I've listed these and a bunch of additional key books and papers about Faraday Discs in the "Some Faraday Disc Resources" sidebar, which can be found elsewhere in this article.

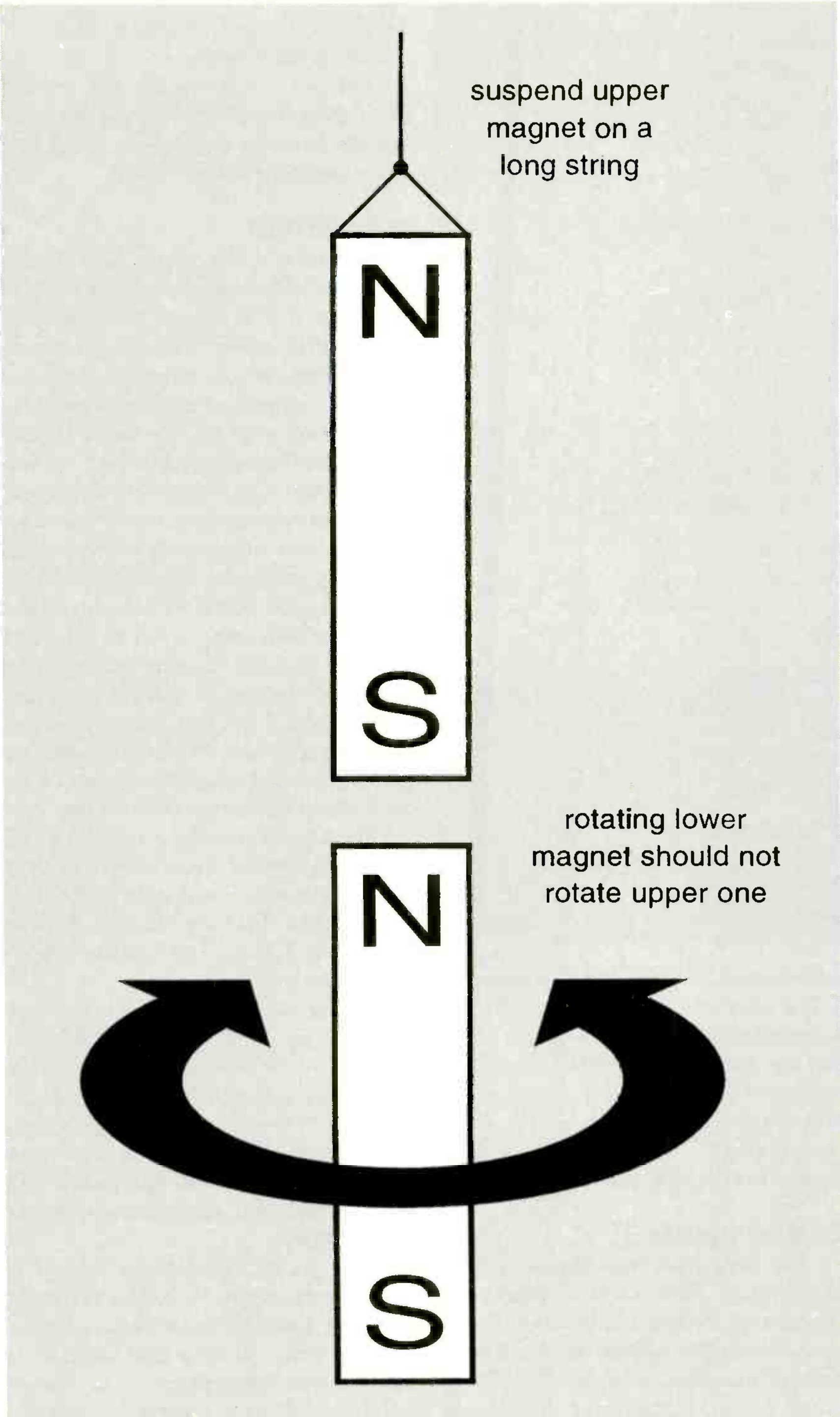

FIG. 3—THE LAWS OF GENERAL RELATIVITY demand that you cannot tell if a uniform magnetic field is rotating or translating. Therefore, if you rotate the bottom magnet about the string axis, the top magnet should remain stationary.

The Faraday disc output seems to depend only upon the strength of the input magnetic field and the relative speeds of the disc rotor, and the slip ring and meter stator. The speed or direction of the magnets do not seem to matter in the least!

Apparently, the E field and the H field cannot stand alone. They are both essential parts of your result. Thus, any motional energy seemingly missing from the one component is made up by the other. You'll have to consider both E and H together any and every time there is any relative reference motion!

Since it apparently does not matter whether the magnetic field rotates, there's probably not any point at all in purposely spinning your magnets, at least in machines of this type. Rotating magnets would add to the mass, wind resistance, and dynamic braking, and make closing the flux path a lot harder, while not otherwise changing the outcome in any useful way. Thus, there is no compelling use for a spinning magnet Faraday disc. At least none that I can think of, beyond "gee whiz" demos.

No matter whether its magnetic field rotates or not, all homopolar generators and all Faraday discs must obey the same laws of conservation of energy that other generators do. While counter EMFs and counter torque mechanisms are not obvious, they most certainly do exist. More on this in the superb Untried Homopolar Experiments Web site shown in the listing.

There is no magic here. Nor is there any way I see that any "overunity," "free-energy," or "zero-point" energy device can possibly ever result. All attempts to do otherwise to date have ludicrously and miserably failed. The usual problems are the inability to properly measure true AC power, inept failures to comprehend counter EMFs or torques, and outrageously absurd "not even wrong" theories.

After my much closer look, I now understand how any "free-energy" enthusiast could get severely mislead with such a counterintuitive and unobvious way of generating a plain old DC current. Thanks to Bill Beatty, Clarence Green, and John Vanco for all their considerable input on this topic. Let me know if you have any more "real science" references for me here. An Incredible Secret Money Machine II for your thoughts. Let's hear from you.

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B&B Auctions
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(602) 353-0016

Bentley Auctioneers
3801 Academy Pkwy North NE
Albuquerque, NM 87109
(505) 344-1812

Closeout News
500 Century Lane
Holland, MI 49423
(616) 392-9687

Cypress Semiconductor
3901 N First St.
San Jose, CA 95134
(800) 858-1810

Industrial Market Place
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Skokie, IL 60077
(800) 323-1818

Inframetrics
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(508) 670-5555

Integrity Research Institute
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Washington, DC 20005
(800) 295-7674

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New York, NY 10010
(888) 437-4636

Lindsay Publications
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A Homopolar Motor

A new homopolar motor intended for electric vehicles has been announced by the University of Texas Center for Electromechanics. The motor operates at 5000 amps peak from a 48 volt source. The claimed maximum power efficiency is a very-surprisingly high 87 percent.

The appeal of a homopolar traction motor lies in its high current and low voltage, translating to fewer series cells in an electric vehicle. But, on the other hand, the higher currents raise the controller costs and increase wiring losses, and ultra-high-current brushes or slip rings do not sound like all that great a thing to purposely design into a car.

While certainly a real interesting development, I'd bet upon switched-reluctance AC as the "best" solution to hybrid electric vehicles. I also feel that the optimum number of motors per car might end up something like 4000 to 40,000 millimotors instead of just four humongous ones, the same distributed way a dollar power FET is really half a million devices working together in parallel.

Surplus Update

The Feds have recently cleaned up their surplus Web site (www.drms.gov); it is arranged better and far easier to use than before. But military surplus doesn't seem all that great these days. You'll find much better bargains at downsizing research labs and commercial firms. One often-overlooked source for incredible test-instrument buys are outlying community colleges, many of whom seem to be sharply cutting back on electronics programs.

Two auction houses I have found interesting are Bentley Auctioneers in Albuquerque (mostly Los Alamos stuff) and B&B Auctions in Phoenix (mostly Intel). One guide to general surplus and distress merchandise is *Closeout News*. Another trade journal with lots of mechanical and electrical items is *Industrial Marketplace*.

I've got a new surplus and auction story up as RESBN73.PDF and for some surplus bargains of my own, check into www.tinaja.com/barg01.html.

New Tech Lit

The new MAX126 chip from Maxim is a switchable four-channel, 14-bit A/D converter that is able to simultaneously sample all its inputs. That is super important for real power measurement, especially when strange waveforms or nonlinear loads are involved. The device appears able to handle exceptionally high crest or pulse factors with ease. Up to now, accurate measurement of real power has usually been both outrageously expensive and painfully difficult. Thankfully, their MAX126 just might be able to singlehandedly blow away much of the "free energy" hogwash currently polluting the Web, and open up all sorts of great new motor control and home energy-conservation applications. More details and free samples are at www.maxim-ic.com I'll try to work up a PIC wattmeter on this.

From Cypress comes a new CD ROM on the Universal Serial Bus and their related low-cost microcontrollers. From Inframetrics, there are free demo disks on their new ThermaCAM infrared-imaging instruments.

Additional information on nitrogen powered cars appears at www.aa.washington.edu/AERP/CyroCar.htm and at www.mtsc.unt.edu/CoolN2Car.html. Among a few other compelling advantages (such as a potential 20× cost reduction over comparable pure EVs), this new idea sure simplifies summer air conditioning!

The pricey *International Journal of Refrigeration* seems to be the definitive scientific publication on cooling topics. Their Volume 20 has a tutorial on thermo-acoustic refrigerators in it. This is an apparently valid scheme to use high-pressure standing sound waves to move thermal energy.

(Continued on page 70)

REEL RECORDER

(continued from page 58)

of magnetized tools, or even improper previous use of the recorder. Whatever the cause, that condition could damage prerecorded tapes by erasing high-frequency passages.

With the demagnetizer at least three feet away from the recorder, and with the recorder turned off, plug in the demagnetizer and slowly bring it close to the recorder, sweeping close to—but not touching—the guides and heads. One or two passes are sufficient; then move the demagnetizer at least three feet away before unplugging it. The technique here is to always keep the demagnetizer moving slowly—never let it stop and never abruptly change direction. To do so could actually cause magnetization. Also, don't leave the demagnetizer plugged in for more than about 30 seconds as it typically draws lots of current and is not designed for continuous duty.

Time to Load the Tape! So, now—finally—we have gotten the machine into sufficient shape to where we can actually check it out with tape! We know it's clean (inside as well as outside); we've performed numerous safety checks (line cord, fuses, wiring, components); we know it has sufficient lubrication; we know the active electronic devices are all in place (tubes and transistors); and we are confident that any tape we thread on this machine will not become contaminated, stretched, or partially erased.

For this final step in our preliminary check-out procedure, thread a "work" tape (that is, a tape with some non-irreplaceable, but high-quality, pre-recorded stuff along with some room for new recordings) onto the machine. You may now directly power the recorder from the AC line; the Variac should no longer be needed.

You might begin by simply getting a feel for the transport controls. At first, don't allow the tape reels to move very fast. Instead, go into the fast-forward and rewind modes for just a second or two; then hit stop. Do this for progressively longer periods of time until you become confident that both the wind motors and the brakes are working well before moving on.

Take note of any abnormalities here, such as excessive initial force being applied to the tape when a fast-wind mode is begun or insufficient pulling force (slow wind). If the latter problem is present, check to see whether it is really due to low pulling force, or whether it's due to excessive back tension on the opposite reel. For example, in rewind mode, the take-up reel turntable should normally have only a very light amount of counter-clockwise rotational force. If that "back tension" is too great, the tape will not rewind quickly; in the worst case, the tape could be stretched in the process.

Remember that these are just initial gross-tension checks to ensure that we can safely move tape in all transport modes. We'll cover detailed tension measurements next time.

If all is well so far, turn up the volume a bit and note the quality of reproduced, pre-recorded sound. Assuming the original was good stuff, the playback should also be good. This is, of course, still a quick preliminary test—nothing scientific. Now proceed to make a recording; really anything will do here—familiar music is fine, or even a 1-kHz tone to get a quick feel for W/F. Again, note any problems encountered.

That concludes our preliminary conditioning and check. One final note though for those of you who were unable to complete these steps due to faulty electronic or mechanical parts. Any faulty components will have to be replaced before you can go on with the restoration. Broken belts; worn-out rollers or bearings; bad vacuum tubes, transistors, or other components; shorted motors; and even bad AC-line cords all must be replaced before you can proceed with the restoration.

That's all the room we have for now. Next time, we'll look deeper into what we must do to bring our old recorder back to its full, original glory. Ω

TECH MUSINGS

continued from page 66

The second trade journal this month is *Tech Capital*. As its name implies, this one is on venture funding.

Peavey's *Fuel from Water* is this month's misnamed but highly useful home and auto hydrogen book from Lindsay Publications. More details on their www.keynet.net/~lindsay web site. From Newnes comes the new *Audio Power Amplifier Design Handbook*, by Douglas Self.

By the way, I am now an Amazon Books associate. More information on that can be found at www.tinaja.com/amlink01.html

For most individuals and smaller-scale startups, nearly all of the time, patents are virtually certain to end up as a net loss of time, energy, money, and sanity. Find out why along with my tested and proven alternatives that do work in the real world in my *Case Against Patents* package per my nearby Synergetics ad, or view www.tinaja.com/patnt01.html.

I have recently added new Santa Claus Machines and Golly Gee Mr. Science library pages to my Guru's Lair at www.tinaja.com. You'll also find my freshly updated Synergetics catalog along with some new, free, and linked Hardware Insider Secrets. Be certain to check out meowwrrr's new SureGrip magnetic paws. As usual, most of our mentioned items should appear in the Names & Numbers or Faraday Disc Resources sidebars. Always be sure to look there before you phone our US technical helpline shown in that Need Help? box you'll find nearby. EN

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Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100µV	
2000mV	1mV	±(1%rdg+2dgts)
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200µA	100nA	
2000µA	1µA	±(1.2%rdg+2dgts)
20mA	10µA	
200mA	100µA	±(1.2%rdg+2dgts)
10A	10mA	

Overload Protection: mA Input, 2A/250V fuse.

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	±(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

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Frequency Range: 45Hz-450Hz
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Response: Average Responding, Calibrated in rms of a Sine Wave.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

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CAT NO	DESCRIPTION	PRICE
PROTEK506	Digital Multimeter	$139.00

Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12"	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12"	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12"	22.09	18.35	14.68

Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

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Specifications

Image Pick-Up Device	1/3" CCD area Sensor
Picture Elements	EIA=512(H) x 492(V)
Pixel Pitch	EIA=9.6UM (H) x 7.5UM (V)
Scanning System	2 : 1 Interlace
Scanning Frequency	EIA=525 lines, 60 field/sec (II) 15.750 KHz x 60 HK
Resolution	430 Lines
Minimum Illumination	0.03 LUX
S/N Ratio	45DB
Lens Mounting	4.3mm standard, 5mm pinhole
Video Output	1.0 VP-P/750OHM composite signa
Power Requirement	8-12 VDC (9VDC standard)
Power Consumption	100mA
Operating Temperature	-20C -+ 70 C RH 95% Max
Storage Temperature	-40C -= 85 C RH 95% Max
Audio Pick-Up Sensitivity	-60 DB (0DB = 1B/UBAR. 1KNZ)
Audio Frequency Range	20 Hz to 20KHz
Audio S/N Ratio	More than 35DB
Audio Output Level	1VP-P/600 OHM

Dimensions

WDP-2000	30mm (H) x 30mm (W)
WDS-2005	30mm (H) x 30mm (W)
WDI-4000	44mm (H) x 30mm (W)

WDP-2000

WDS-2005

WDI-4000

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDP-2000	1/3" B&W Pinhole Lens with Audio	$89.00	$77.00
WDS-2005	1/3" B&W Standard Lens with Audio	89.00	77.00
WDI-4000	1/3" B&W Infra-RED (no audio)	89.00	77.00
WDPH-55BW	Plastic Housing Option for B&W Board Cameras	13.00	12.00

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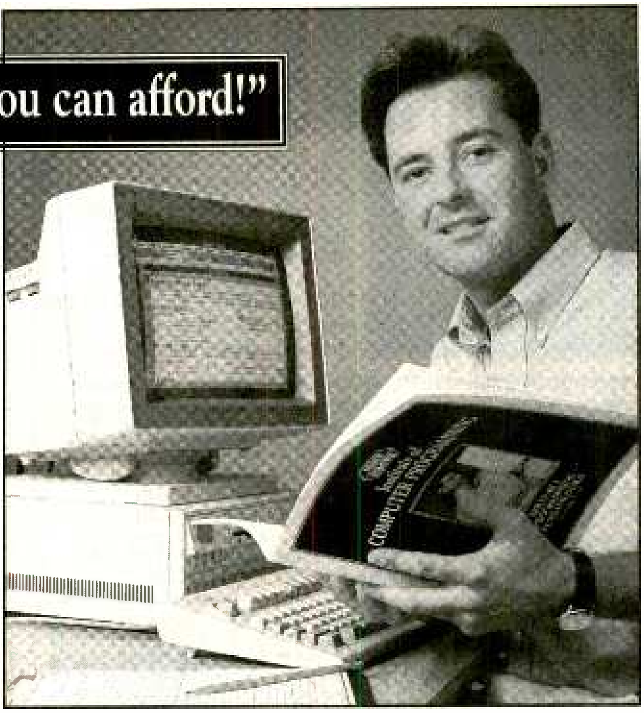

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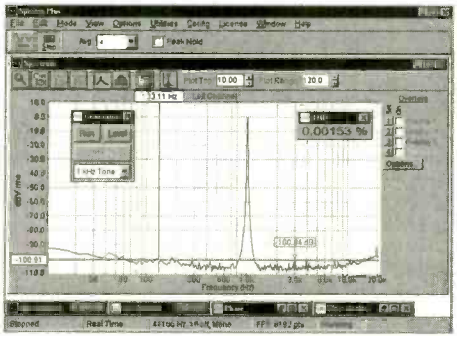

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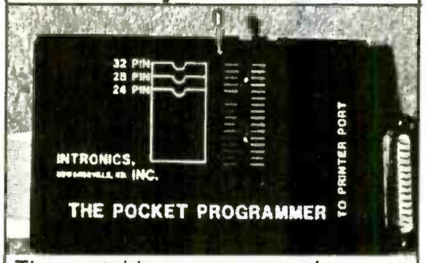

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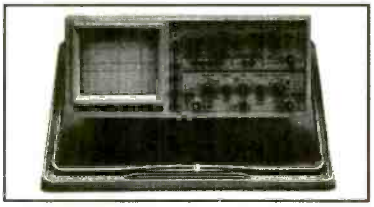

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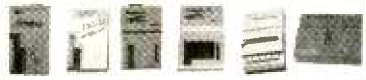

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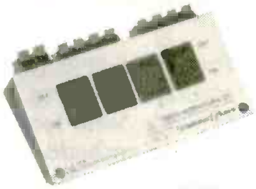

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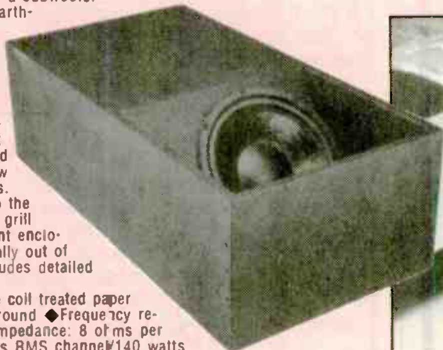

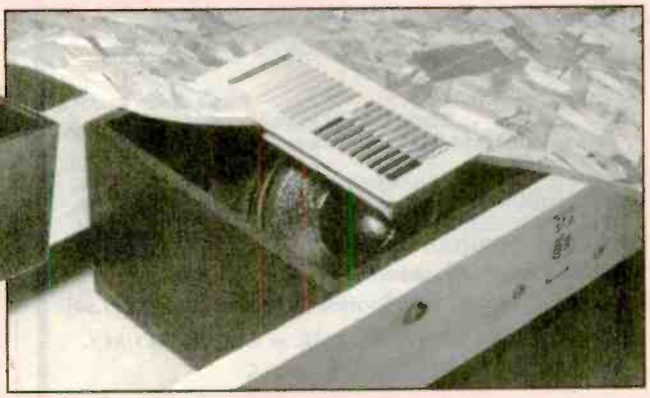

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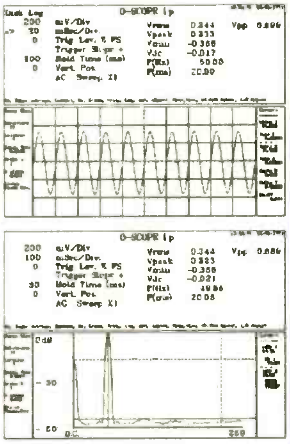

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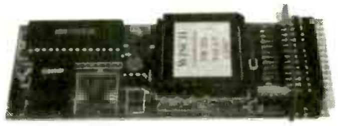

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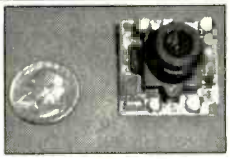

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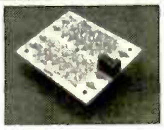

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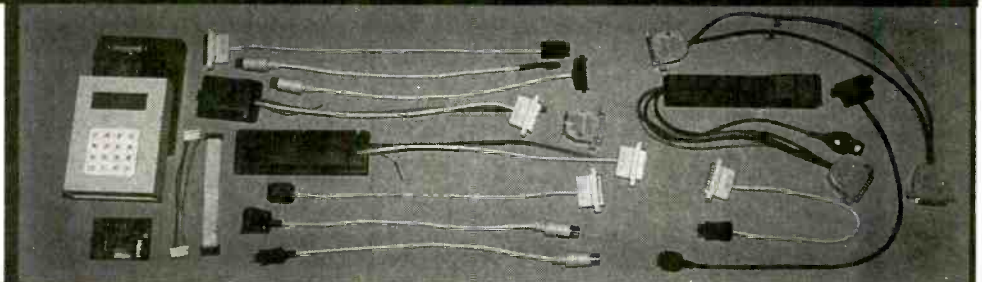

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If not, try one of my two favorites.

I have attended many trade shows worldwide in the last few years and these are the top two Desoldering Tools that I have found. You have probably seen the testimonials on the **DEN-ON SC-7000Z** in the last several issues. If you wish to see a copy or referrals from technicians in your state, call toll free and we will fax it to you immediately.

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Price includes one extra filter and tip cleaner

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- Totally Self Contained diaphragm vacuum pump and AC motor (In the handle) for high vacuum suction or reversible hot air blow for SMD removal.
- 100Watt Ceramic heater with zero-crossover switching heater control circuit which prevents spikes and leakage currents.
- Unique patented long lasting filter cartridge design. Solder builds up on easily cleaned baffle, while air flows around the outside of baffle.
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- Maximum vacuum of 650mmHg is attained in 100 milliseconds.
- Temperature adjustable from 300°C - 500°C (572°F - 932°F).

- **Voltage** — AC100v,120V,230V,50/60HZ
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- **Motor Output** — 2W
- **Vacuum Attained** — 650mmHg
- **Temperature Range** — 300°C—500°C (572°F—932°F)
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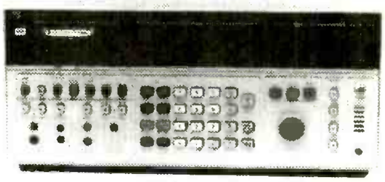
Selective Level Meter, makes carrier measurements to 32.5 MHz, voice channel measurements from 50 Hz to 100 kHz.



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Hewlett-Packard 8901B
Modulation Analyzer, frequency range 150 kHz to 1300 MHz, measures RF frequency and RF power, completely automatic, has RF rear panel connectors. Other options available.

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Hewlett-Packard 8903B
Audio Analyzer, 20 Hz to 100 kHz, low-distortion audio source, frequency counter, high performance distortion analyzer, ac/dc voltmeter, and SINAD meter. Options available.

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Signal Generator, 100 kHz to 1040 MHz, 10 Hz resolution, +13 to -143.5 dBm into 50Ω, opt 002 rf connectors on rear panel.

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Hewlett-Packard 8657D
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Hewlett-Packard 4934A
Transmission Impairment Measuring Set, level/frequency up to 110 kHz, noise and noise-to-ground, noise-with-tone and signal-to-noise ratio, three-level impulse noise, P/AR.

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Hewlett-Packard 1650A
Logic Analyzer, Timing:100 MHz on all 80 channels, State: 25 MHz on all 80 channels, Memory 1 kbit/channel, HP-IB, "auto-scale" sets up parameter with the push of a button.

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Hewlett-Packard 1650B
Logic Analyzer, Timing: 100 MHz on all 80 channels, State; to 35 MHz for all 80 channels, Memory; 1kbit/channel, HP-IB, supports most 8, 16 and 32 bit microprocessor.

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Hewlett-Packard 8642A
Synthesized Signal Generator, 100 kHz to 2.115 GHz, <-134 dBc/Hz SSB phase noise at 20 kHz offset, -100 dBc nonharmonic spurious, +20dBm maximum output level.

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Hewlett-Packard 8568A
Spectrum Analyzer, 1000 Hz to 1500 MHz, -137 dBm to +30 dBm amplitude range,features frequency counter accuracy, digital display, store and recall control settings, HP-IB.

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Hewlett-Packard 8568B Opt E96
Spectrum Analyzer, 100 Hz to 1500 MHz, resolution bw from 1 kHz to 3 MHz in a 1, 3, 10 sequence. Phase noise is 107 dBc. Amplitude is -135 to + 30 dBm.Call for option information.

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Microwave Frequency Counter, 10 Hz to 20 GHz, sensitivity to -40 dBm, 1 GHz/s tracking speed, 60-ms acquisition time, 100 measurements/s

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Distortion Analyzer, 5 Hz to 600 kHz range, measures total harmonic distortion down to 0.1% full-scale, residual noise below 25 μV, voltage measurement 300 μV to 300 V rms full scale.

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Dc to 18 GHz, Power 5W, Type n, male.

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Tektronix 2336 Oscilloscope
Dc to 100 MHz bw, 5 mV/div to 5V/ div. 5 ns/div sweep rate, delta time on the flip cover. Includes 2 probes.

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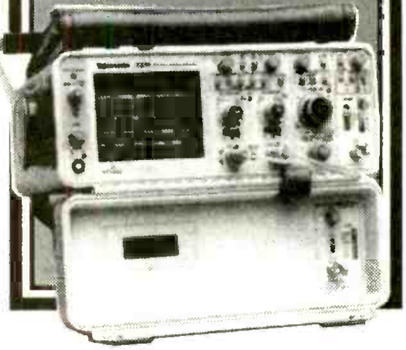

Tektronix 2235 Oscilloscope
DC to 100 MHz bw, 2 mV sensitivity, 5 ns/div sweep rate, advanced trigger system, delayed sweep measurements, easy to use, lightweight, includes 2 probes.

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Hewlett-Packard 5370B
Universal Time-Interval Counter, 11 digits/s frequency. resolution, 20 ps single shot LSD, +100 ps accuracy achievable, frequency and period to 100 MHz, 8000 measurements possible, built-in stats functions.

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Tektronix 494P
Spectrum Analyzer,10 kHz to 21 GHz, (capable of up to 325 GHz with external waveguide mixers, not supplied), nonvolatile memory storage, direct plot capability, keypad data entry.

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Bird 8327-300 ....$750.00
Coaxial Attenuator, 30 dB, 1000 Watts, 50Ω.

Bird 8329-300 ....$950.00
Coaxial Attenuator, 30 dB, 2000 Watts, 50Ω.

Bird 8890-300 ....$750.00
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ARE YOU BEING "BUGGED?"

EVEN AS YOU READ THIS, countless individuals and firms are being enormously damaged by having their private conversations overheard, monitored, and/or recorded.
Almost without exception and AFTER the fact, the victims make a statement something along the lines of "But, I never thought it could happen to ME!

OUR FINEST
Counter-Surveillance Device

THE ULTIMATE IN "BUG" DETECTION EQUIPMENT "DEBUGS" ROOMS AND TELEPHONES!

If you require GUARANTEED PROTECTION against electronic telephone monitoring devices and COMPLETE CONFIDENTIAL PRIVACY in certain rooms and areas, we highly recommend the COUNTER-SURVEILLANCE DETECTOR CSD-18.

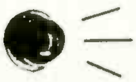
EXTREME SENSITIVITY!

This is our finest piece of detection equipment! The CSD-18 quickly locates electronic eavesdropping devices in telephones, homes, offices, vehicles, boats, or concealed on the body. It will actually pick up many eavesdropping transmitters at ranges up to 25 ft! Extreme sensitivity is obtained via ultra-efficient amplification circuitry directly following the RF detection stages. Excellent quality dynamic headphones exclude all external sounds to further enhance detector output.

Encompassing an extremely wide-band frequency coverage of under 1 Mhz to over 3 Ghz, the CSD-18 quickly "homes-in" on any eavesdropping transmitter and immediately pinpoints its location. The closer you get to the "bug", the further the needle moves to the right. It's as simple as that.

FULL RANGE DYNAMIC HEADPHONES

"FLASHING" LED WARNS YOU INSTANTLY!



And, for maximum telephone security, the CSD-18 automatically analyzes a pre-programmed series of electronic measurements along the telephone line and converts the analysis into an easy to follow, step by step, test procedure. No technical knowledge is required or necessary. A visual indication (via a flashing LED) immediately reveals the presence of the various types of telephone "taps" and the flashing sequence identifies the actual type of eavesdropping device.

DETECTS THE LATEST "SUPER-BUGS"

Exclusive GSS proprietary circuitry assures the utmost privacy protection possible today. The CSD-18 detects even the very latest ultra-sophisticated eavesdropping devices specifically designed to defeat detection, including sophisticated "Frequency Hoppers" and "Burst Bugs". Also includes multi-line option for testing business phones.

CONDUCT A PROFESSIONAL SEARCH...ANYTIME...ANYWHERE!

Every newspaper and magazine article and every radio and TV story discussing some new episode involving "Bugging" devices, continues to increase the ever growing demand for electronic Counter-Surveillance "sweeps" and equipment. The very limited supply of competently trained and equipped Counter-Surveillance specialists has created a situation where "sweep" rates exceeding $250 per hour are now considered reasonable and appropriate.

This is an exciting, immensely interesting and profitable field that you can enter with a minimum investment. Two hours actual practice with the CSD-18 will have you "reading" and "clearing" telephones and rooms with professional ease and competence. The average fee for "debugging" a single telephone is over $200.00 It requires about 45 minutes to complete the job and once it gets around that YOU can provide this service, you'll quickly have more clients than you can handle.
Even if you choose to provide "sweeps" for only a small number of friends and associates, your initial investment will quickly be returned many times over.

FREE WITH ORDER!

SUBMINIATURE "BODY WIRE" DETECTOR!

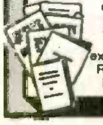
If you fear the possibility of being overheard and/or recorded during private conversations and require "silent" notification, we've also included our SBD-5 (regularly $225) as a FREE GIFT! Only 3" x 2" x 1", this exciting new development in micro-miniaturization will instantly detect hidden body wires at ranges up to 10 ft and alert you via a silent vibration.

BIG MONEY OPPORTUNITIES!

Also, complete information describing the fantastic opportunities now open to trained Counter-Surveillance technicians and how a number of individuals are reaping a Bonanza in this booming business! You'll learn exactly how the ever increasing use of Electronic Listening Devices by investigative agencies, government agencies, jealous suitors and unscrupulous business competitors, etc. has created huge demand for this service.

FASCINATING HI-TECH INFORMATION PACKAGE!

A detailed analysis of a variety of extremely fascinating hi-tech devices and procedures used for ultra-sophisticated audio and video eavesdropping including micro-wave and laser device monitoring; new methods for listening thru walls; all about scramblers, voice changers and exactly how neighbors eavesdrop. How missing persons are found, confidential data banks are broken into, lie detectors deceived and much more!



A comprehensive information package JAM-PACKED FULL of some of the most exciting and fascinating reading imaginable. Reads like a James Bond novel, with one important exception...IT'S NOT FICTION!

THE ONE "BUG" TO FEAR MOST!

While most individuals are now somewhat guarded in their telephone conversations, they still rather naively feel secure in the "privacy" of their own home or office. However, the most common type of "tap" presently used by eavesdroppers now picks up ALL SOUNDS AND CONVERSATION WITHIN A ROOM ... WITH THE TELEPHONE STILL ON THE HOOK!

Due to this devastating capability, this "Infinity" tap (variously referred to as Infinity Transmitter, Hookswitch Bypass, 3rd Wire, Harmonica Bug, etc.) has become the "bug of choice".

In flagrant violation of federal law prohibiting their use and sale, these devices in various forms are openly advertised in many technical publications for as little as $30. Literally thousands of these devices are now in the hands of unscrupulous individuals all over the country!

In response to this ever-growing threat, a uniquely engineered feature of the CSD-18 now also detects Infinity type devices anywhere "down the line".

In other words, if ANYONE ... ANYWHERE ... is utilizing the telephone tip and/or ring wires to monitor your private room conversations while your telephone is on the hook, you'll immediately be made aware of it via a flashing LED!

100% POSITIVE INDICATION

The CSD-18 also flawlessly detects "Series" and "Parallel" telephone transmitters and "Telephone Recording Devices". And, a separate feature silently indicates when extension phones are picked up or being used. The CSD-18 completely eliminates all doubt and guesswork.

EXCLUSIVE "LISTEN-IN" FEATURE!

The CSD-18 will even allow you to "listen-in" to exactly what the eavesdropper is surreptitiously monitoring. And, without the eavesdropper ever becoming aware that he has been detected! We are unaware of ANY other detection equipment having this combined capability AT ANY PRICE!

MAXIMUM PROTECTION

The CSD-18 detects and locates ALL major categories of surveillance equipment including:
BUMPER BEEPERS,
"BODY" TRANSMITTERS
TELEPHONE RECORDING DEVICES
SERIES & PARALLEL PHONE TRANSMITTERS
"INFINITY", MICRO-WAVE AND "LASER" BUGS
& ALL TYPES OF CONCEALED TRANSMITTERS
including Video, Computer and Fax Transmitters

CSD-18 **$495** Complete

Includes headphones, antenna/probe, all plugs and adapters, batteries, the Free SBD-5 & Info Packages.

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Inexpensive - Best for less than $200

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- Easy to use menu based software has binary editor, read, verify, copy, etc. Free updates via bbs or web page.
- Full over current detection on all device power supplies protects against bad chips and reverse insertion.
- Broad support for additional devices using adapters listed below.

Available Adapters

EP-PIC (16C5x,61,62x,71,84)	$49.95
EP-PIC64 (62-5,72-4)	$39.95
EP-PIC12 (12C50x)	$39.95
EP-PIC17 (17C4x)	$49.95
EP-51 (8751,C51)	$39.95
EP-11E (68HC11 E/A)	$59.95
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EP-16 (16bit 40pin EPROMS)	$49.95
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EP-SEE2 (93x,24x,25x,85x)	$39.95
EP-750 (87C750,1,2)	$59.95
EP-PEEL (ICT22v10,18v8)	$59.95
EP-1051 (89C1051,2051)	$39.95
EP-PLCC (PLCC EPROMs)	$49.95
EP-SOIC (SOIC EPROMs)	$49.95

Many Other Adapters Available

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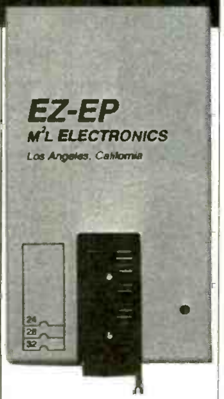
CA orders add 8.25% sales tax.
http://www.m2l.com



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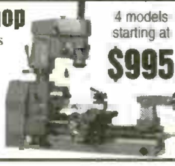

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READ BY ELECTRONIC BUYERS AND SELLERS AND TRADERS

INSTRUCTIONS FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues.**Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface**, add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $4.00 per word.

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. ELECTRONICS NOW is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in ELECTRONICS NOW is limited to electronics items only. All ads are subject to the publishers' approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
ELECTRONICS NOW 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 – Antique Electronics	270 – Computer Equipment Wanted	450 – Ham Gear Wanted	630 – Repairs-Services
130 – Audio-Video Lasers	300 – Computer Hardware	480 – Miscellaneous Electronics For Sale	660 – Satellite Equipment
160 – Business Opportunities	330 – Computer Software	510 – Miscellaneous Electronics Wanted	690 – Security
190 – Cable TV	360 – Education	540 – Music & Accessories	710 – Telephone
210 – CB-Scanners	390 – FAX	570 – Plans-Kits-Schematics	720 – Test Equipment
240 – Components	420 – Ham Gear For Sale	600 – Publications	730 – Wanted

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category #__________ **Special Category $30.00 Additional** ____________________

1 - $37.50	2 - $37.50	3 - $37.50	4 - $37.50	29 - $72.50	30 - $75.00	31 - $77.50	32 - $80.00
5 - $37.50	6 - $37.50	7 - $37.50	8 - $37.50	33 - $82.50	34 - $85.00	35 - $87.50	36 - $90.00
9 - $37.50	10 - $37.50	11 - $37.50	12 - $37.50	37 - $92.50	38 - $95.00	39 - $97.50	40- $100.00
13 - $37.50	14 - $37.50	15 - $37.50	16 - $40.00				
17 - $42.50	18 - $45.00	19 - $47.50	20 - $50.00				
21 - $52.50	22 - $55.00	23 - $57.50	24 - $60.00				
25 - $62.50	26 - $65.00	27 - $67.50	28 - $70.00				

Total words ________ $2.50 per word = $_______

Bold Face ________ $0.40 per word = $_______

Special Heading ________ $30.00 = $_______

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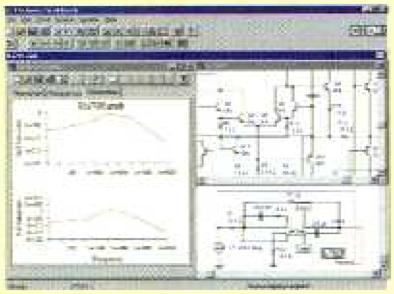

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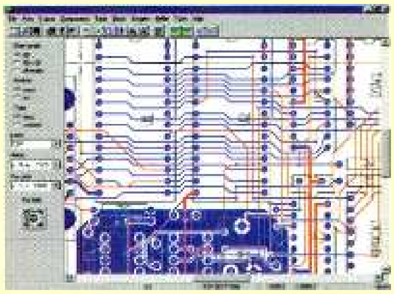

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