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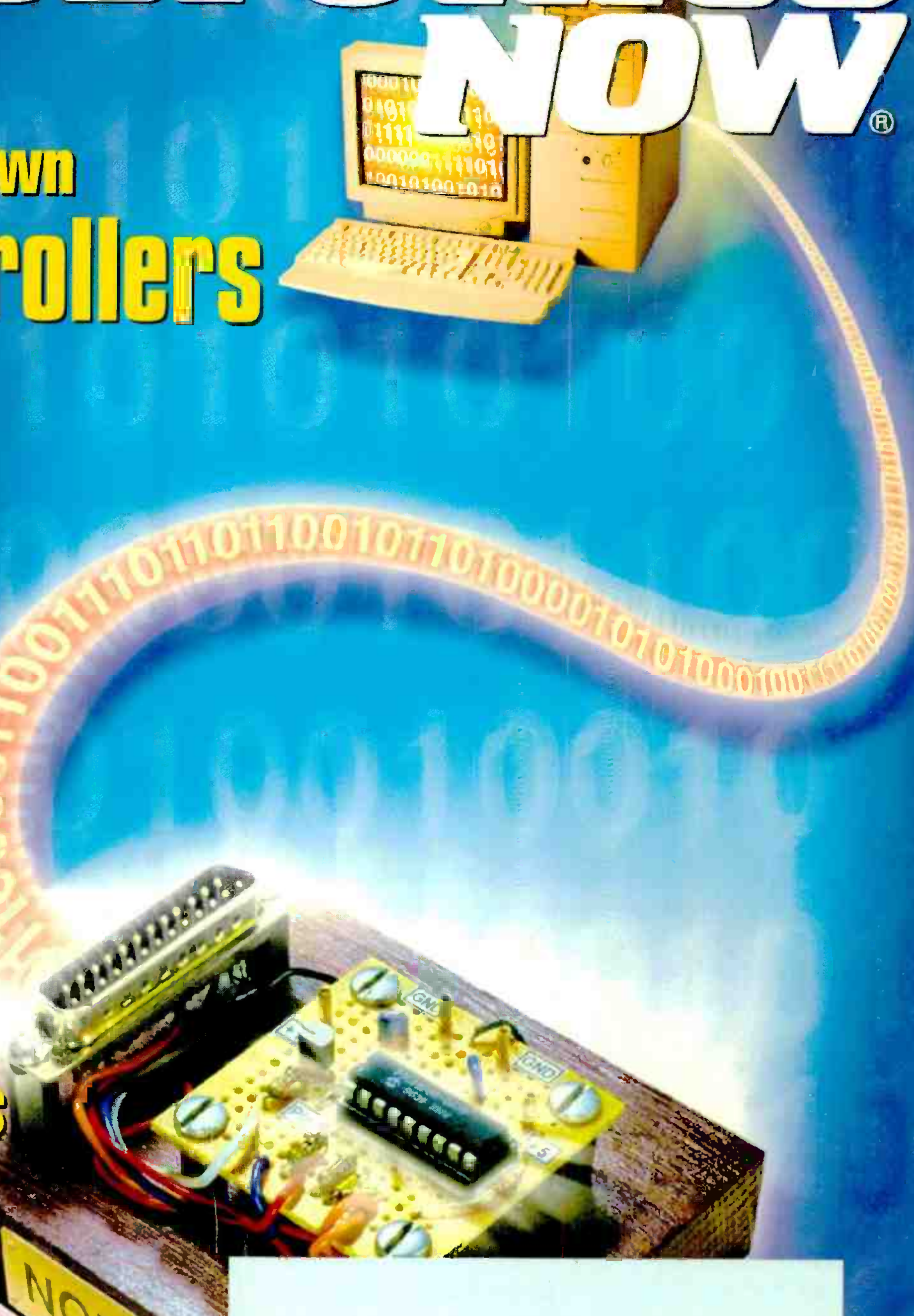

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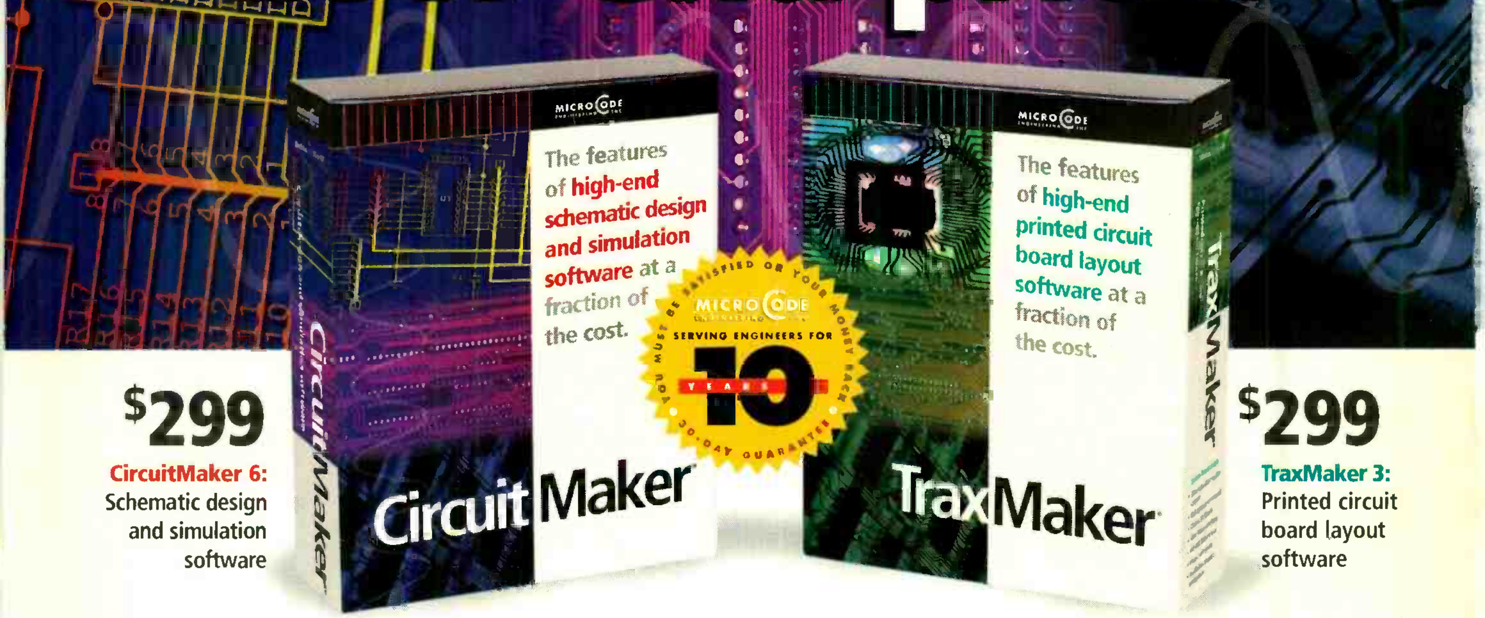

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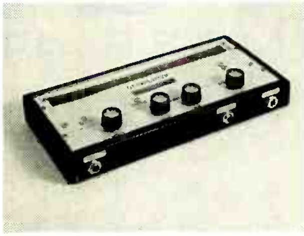

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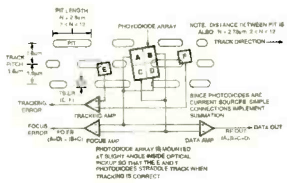

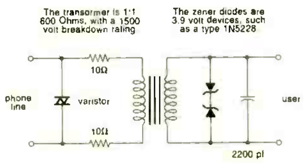

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EDITORIAL

Glad I Asked!

Putting together a magazine like **Electronics Now** is a tough job. It is made harder by the fact that the technology that we are writing about is always changing, as are the needs and interests of our audience. To do the best job possible, I felt I had to get a better handle on what our readers wanted and expected from this magazine. That was the reason behind my July 1998 Editorial ("Who Are You? What Do You Want?").

I expected (hoped for?) at least a few responses. What I received has exceeded my wildest expectations. My e-mail and regular mail boxes have been overflowing for days, and the letters keep pouring in. So you can see for yourself what your fellow readers are thinking, we've reprinted a few of the letters in this month's "Letters" column. Some more will follow in future issues.

So, what have I learned? For one thing, our readership is a very varied bunch. That said, there were a few traits most of you share.

For example, even if you never have built one, just about all of you enjoy our projects. One common request was for a few more simple projects for those without the time or experience to tackle the big ones. Without revealing too much, I'll just say that we are working on a way to do just that, without eliminating our more sophisticated circuits.

"Service Clinic," and its new author, Sam Goldwasser, received an almost universal thumbs up. The same is true of "Tech Musings," even if you don't always agree with some of Don Lancaster's views.

Most of you like the articles on new and coming technology. Most, though not all, liked the new "Prototype" section. Just about everyone liked the "Q&A" column. One common request was a little more coverage of basic electronics; it is on the way.

On computers, the majority want, or at least would not mind, coverage of computer hardware and circuits. One common request here was for interface circuits or circuits that let you use your computer as a test instrument. On the other hand, most who expressed a preference asked that we do not delve into computer software or usage, unless it dealt expressly with electronics. On that last point, let me put any remaining fears to rest: This is **ELECTRONICS Now**, and the core of our coverage will always remain centered on electronics, not computers.

One thing did bother me, however. Many of the letters began by thanking me for the invitation to write. The thing is, your input has always been welcome and needed. Sure, we love to hear what we are doing right, but we also need to know what we are doing wrong. And an occasional letter to let us know you are still out there and paying attention is always nice. Don't be bashful, and don't be a stranger!

Carl Laron

Carl Laron
Editor

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Control Via PC Parallel Port

Q *Could you explain how to turn a 12-volt DC relay on for 10 seconds, then off for 20 seconds, and repeat this cycle 1000 times, using a PC programmed in BASIC? The relay coil pulls about 250 mA. Ideally, I would like to be able to control three or four relays from a BASIC program. — L. H. B., Burton, MI*

Q *I want to write an automatic control program for a PC and send the input and output signals through the serial port or parallel port. Could you give me complete information about the serial and parallel ports? — Y. S. X., Trenton, NJ*

A PC parallel ports (printer ports) are extremely handy. Each port provides eight data lines plus several control lines; the whole thing is very similar to the bus of an 8-bit microprocessor, so it's easy to interface to digital ICs and other circuitry.

Taking the first question first, you can control up to eight relays with the data lines of a parallel port using the circuit shown in Fig. 1. The relay coils are controlled by IRF510 power switching transistors driven by the data from the PC. You'll need a separate source of 12 volts unless you're sure your PC can spare 250 mA for each relay coil; in that case, you can take 12 volts from a disk-drive power connector.

The program is shown in Listing 1. It retrieves the port address of printer port LPT1 and then transmits data directly to the port, bypassing the operating system in order to ignore printer status signals ("ready," "out of paper," and the like). If you want to use port LPT2, change the PEEK functions so that they look at locations 10 and 11 instead of 8 and 9 respectively.

To count seconds, the program uses a simple trick. The BASIC function TIME$ gives the time of day in hours, minutes, and seconds. The value of TIME$ therefore changes exactly once per second, and when it has changed ten times, ten seconds have elapsed.

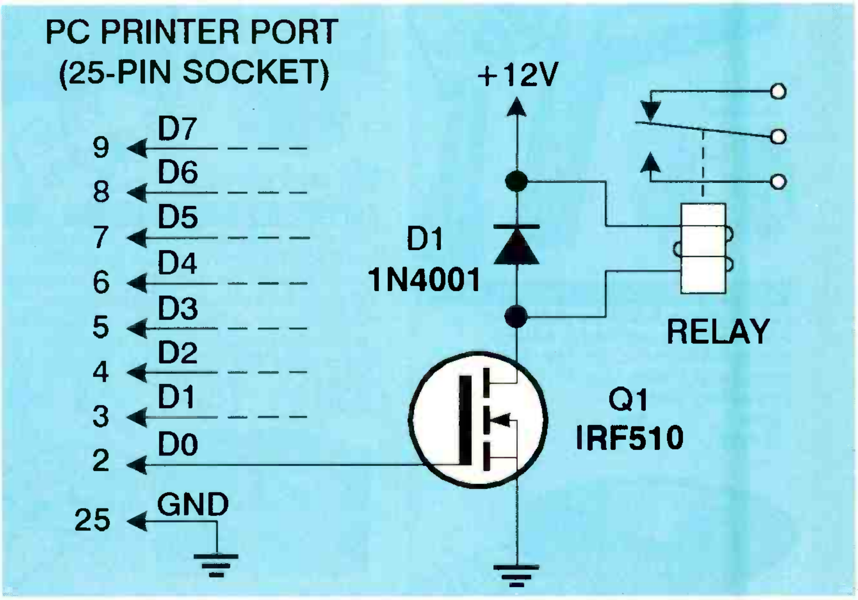

FIG. 1—EACH DATA BIT of a PC's parallel port can be used to control a relay using this simple interface circuit.

The sample program controls only one relay connected to data line D0. To control multiple relays independently of each other, use the statement

OUT p, INP(p) OR 2^N

to turn relay number N on, or

OUT p, INP(p) AND NOT 2^N

to turn relay N off, leaving the other relays unchanged. Here N ranges from 0 to 7.

You can also use the parallel port for input, as described in this column in October 1996. The definitive handbook on unconventional uses of parallel ports is *Parallel Port Complete*, by Jan Axelson, available through bookstores and by direct mail from Lakeview Research, Madison, WI 53704; Web: www.lvr.com. This is an easy-to-understand book full of practical circuits as well as valuable reference information. The companion volume, *Serial Port Complete*, will also be available by the time you read this.

LISTING 1

```
100 ' Get port address of LPT1
110 DEF SEG = &H40
120 P = PEEK(8) + 256 * PEEK(9)
130 ' Repeat 1000 times...
140 FOR I = 1 TO 1000
150   ' Turn D0 on
160   OUT P, 1
170   ' Wait 10 seconds
180   FOR J = 1 TO 10
190     T$ = TIME$
200     WHILE T$ = TIME$: WEND
210   NEXT J
220   ' Turn D0 off
230   OUT P, 0
240   ' Wait 20 seconds
250   FOR J = 1 TO 20
260     T$ = TIME$
270     WHILE T$ = TIME$: WEND
280   NEXT J
290 ' End of loop
300 NEXT I
```

One Button At A Time

Q *I am looking for a solid-state circuit that will perform the same function as a multi-position interlocking pushbutton switch, i.e., pressing any button momentarily will turn on one output while turning off all the others. It needs to be flexible as to the number of positions and each position must be capable of driving a small 12-volt relay. — C. B., Sebastian, FL*

A That function would normally be implemented as part of the keypad-scanning routine of a microcontroller. That is, when you make a selection by pressing a button on your stereo or digital car radio, its microprocessor is running a program that responds to the switch closure by selecting one choice and clearing all the others.

If you want to do it with off-the-shelf ICs, Fig. 2 shows one possibility. That circuit uses a 74HC273 octal flip-flop as an 8-bit memory. Whenever you press a button and then release it, the contents of the data lines are stored in the memory. Only one button will be pressed, of course, so only one output goes high. (If you press two buttons, the one that is released last will win out.) The outputs can drive relays just as in Fig. 1. If you need more than 8 outputs, use additional 273s with the RESET and CLK lines tied together.

The SPDT switches solve a pesky timing problem. Data is stored in the memory at the instant that you release the button, disconnecting CLK from ground. At that moment, the data input must still be valid. The switch takes care of this because it doesn't make contact in one position until about a millisecond after it releases contact in the other position.

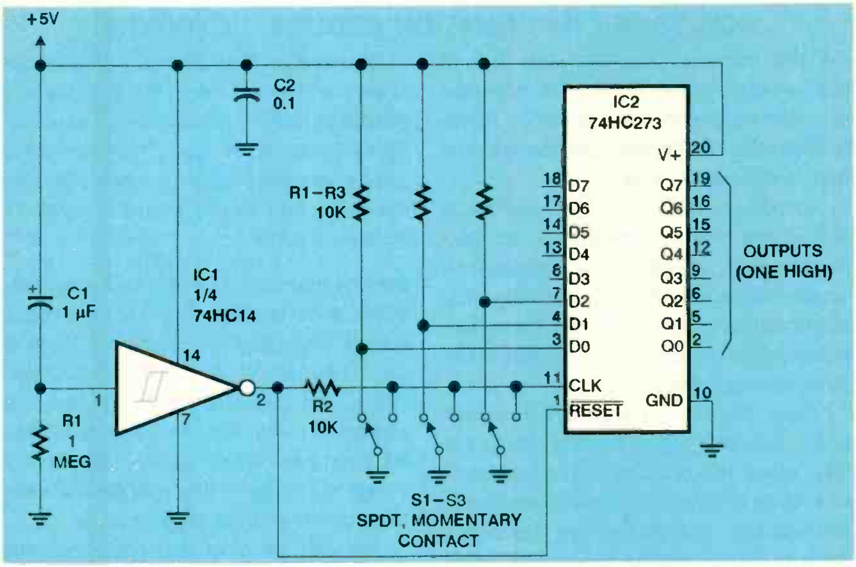

FIG. 2—THIS CIRCUIT SIMULATES the action of a multi-position interlocking pushbutton switch. The heart of the circuit is IC2, which "remembers" which switch was most recently closed.

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at http://www.gernsback.com for information and files relating to our magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

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. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org.

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.

Like all memories, the 74HC273 starts up in a random state when powered on, so we've included a 74HC14 to clear the memory at power-up.

Instead of 74HC chips, you can use the 74HCT14 and 74HCT273, which might be easier to find. Because the logic ICs require a 5-volt power supply, you may want to use 5-volt relays so that only one power supply is needed, or you can step 12 volts down to 5 with a chip such as the 78L05 regulator. See also the game-show timer that was discussed in the December 1997 installment of this column.

Faking A Keyboard

Q *I would like to use external switches to emulate the action of several of the keys on my PC keyboard. Do you have any suggestions? — S. O., Mississauga, Ontario, Canada*

A A PC keyboard is not a simple device; in fact, it contains its own 8048 microprocessor. Accordingly, you're looking at a microcontroller project here. Some information about reverse engineering the PC keyboard is given in Application Note AN434, "Connecting a PC Keyboard to the I²C Bus," available from Philips Semiconductors, 811 E. Arques Avenue, Sunnyvale, CA 94088; Web: www.philips.com. You might seriously consider attaching your switches to a bidirectional parallel port, or some other i/o device, and writing a program to accept data from that device. Or simply connect your switches across those in the keyboard you're already using.

Name That Disk

Q *I recently got a Seagate ST1381 30-megabyte hard drive from an IBM PS/2. Can I attach it to the IDE controller in my 80386 PC? — M. A. V., Brooklyn, NY*

A No, because it's an ESDI drive, not IDE. Seagate manufactured many versions of their popular ST138 drive, all with different interfaces. The ST138I was custom-built for IBM and has an ESDI interface. What you need is an ST138A, with an AT bus IDE interface. Other variations include the ST138N (SCSI), ST138R (RLL), and plain ST138 (MFM). We got this information from *Pocket PC Ref*, a handbook published by Sequoia Publishing, Littleton, CO 80162-0820.

ESDI (Enhanced Small Device Interface) was introduced by Maxtor in 1983 but was seldom used anywhere other than on IBM PS/2s. Most PCs today use IDE or SCSI interfaces. While you could look for an ESDI controller, it's probably cheaper to get an IDE hard disk. Besides, even the cheapest hard disks today are a lot bigger than 30 MB.

Stepper Motor Query

Q *Could you provide any good reference sources on the theory and use of stepper motors? Also, what about some sources to buy stepper motors? I have in mind to build a CNC milling machine. Thanks. — E. L. H., Travis AFB, CA*

A You can find some help in the August, 1996 installment of this column; for more detailed information, get a copy of the book *Stepping Motors and Their*

Microprocessor Controls, by T. Kenjo and A. Sugawara, published by Oxford University Press (you can order it through any good bookstore). To get stepper motors for free, ask a computer shop for some discarded disk drives—the older and bigger the better. Old $5^1/_4$-inch diskette drives from the PC-XT era have especially good stepper motors. You can also buy stepper motors from Jameco, 1355 Shoreway Road, Belmont, CA 94002; Tel: 800-831-4242; Web: www.jameco. com, and many other component suppliers. Your computer-controlled milling machine sounds interesting; when you get it working, let us know!

Tank Circuit Components

Q *I'm very new to electronics, and I'm interested in tank circuits (LC resonant circuits) used in radio receivers and the like. I realize it takes a myriad of equations to pinpoint components for specific frequencies, but couldn't someone devise a general chart to give a "ballpark" estimate of tank circuit component values versus frequency? — T. W. C., Fredonia, KS*

A Your question is a good one. Actually, there's only one equation needed to calculate the resonant frequency of a tank circuit:

$$f = 1 / (2\pi\sqrt{(LC)})$$

or, solving for L and C respectively,

$$L = 1 / (39.5 f^2C)$$

$$C = 1 / (39.5 f^2L)$$

where L is in henrys, C is in farads, and f is in hertz.

As you've noticed, though, the practical question is what values to use. You can't use a 1-microhenry coil with a 1000-microfarad capacitor because the stray inductance of the capacitor would swamp that of the coil. Similarly, you can't use a 1-pF capacitor with a 1-millihenry inductor because the inductor itself has more capacitance than that.

Fortunately, there's a trick. Most radio circuits work well when C in picofarads is roughly equal to L in microhenrys—or at least when they're not terribly far apart. For example, you can generally use a 30-pF capacitance with a 10-µH or 200-µH inductance, because both 10 and 200 are reasonably close to 30. But don't try 30 pF with 30,000 µH.

Inductance	Capacitance	Resonant frequency
1 µH	1 pF	160 MHz
3 µH	3 pF	53 MHz
10 µH	10 pF	16 MHz
30 µH	30 pF	5.3 MHz
100 µH	100 pF	1.6 MHz
300 µH	300 pF	530 kHz
1 mH	1000 pF	160 kHz

FIG. 3—USE THESE VALUES for L and C as starting points when designing a resonant tank circuit, then tweak them as needed for your particular circuit.

Figure 3 shows the resonant frequencies for some values where L in µH happens to equal C in pF. Use it to get "in the ballpark" and then choose more precise values for the circuit you're building. In fact, common practice is to wind your coil by measuring the resonant frequency in the circuit, rather than the inductance; that way, stray capacitances and inductances are automatically taken care of. The *ARRL Handbook for Radio Amateurs* gives lots of useful information about designing tank circuits and winding coils.

Separating Voices From Noise

Q *We have audio recordings of speech that is drowned out by static and noise. Do you know of a computer program or an electronic project we could build or buy to pull the voices out of the static? — B. S., Twentynine Palms, CA*

A For years, the FBI, the CIA, and, to a lesser extent, the recording industry have used digital signal processing to improve sound quality. Now that computer hobbyists have sound cards, large hard disks, and Pentiums, there's no reason they can't do the same. No reason, that is, except that the software is very specialized, and we know of no one who is marketing it to consumers. Wait a few years, and the situation should improve.

Meanwhile, we suggest you look at the digital-signal-processing (DSP) boxes that ham radio operators use to pull voices out of noise. One of the least expensive devices of this kind is the RadioShack 21-543, which has been discontinued. It worked well except that the speaker volume was rather low, which is irrelevant if you're feeding the output to a tape recorder. Maybe you can find one secondhand.

Ghost Story?

Q *I connected my camcorder to my VCR to copy a tape. Meanwhile, I listened to music from a tape player in the same room, not connected to the VCR or camcorder in any way. When I played the tape back, the video was OK but I was shocked to hear the music that I had been listening to on the tape player. Can you explain how this happened? — P. G., La Salle, Quebec, Canada*

A Does your camcorder have a mode that lets you record new sound over an existing video track? If so, maybe it was operating in that mode and recorded the sound through its microphone while copying the video from the existing tape. Or maybe the speaker of your tape player was close enough to induce some current in the audio cable between your camcorder and your VCR. Or maybe it's ghosts!

Writing to Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication) and give your full name and address (we'll only print your initials unless you want readers to contact you directly). *If you are asking about a circuit, please include a complete diagram.* Write to: "Q&A", **Electronics Now** 500 Bi-County Blvd., Farmingdale, NY 11735. Due to the volume of mail, we regret that we cannot give personal replies. EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Missing Connections

A few errors have been brought to our attention concerning the "Portable Pulse Generator" construction project in the July 1998 issue of Electronics Now. In Fig. 1 on page 41, the emitter arrows were left off of transistors Q1–Q4. Transistors Q1 and Q4, being PNP types, should have their emitters connected to the 5-volt supply along with R9 and R13. Transistors Q2 and Q3, which are NPN types, should have their emitters connected to ground. Also, the emitter of Q1, along with R9, should be connected to the 5-volt supply in the same way that Q4 and R13 are connected.

In Fig. 2 on page 42, the cathode of LED1, along with C30 and the several pins of IC3 shown connected together, should be connected to ground. The ground symbol was left out on that schematic diagram.

We are sorry for any inconvenience that might have been caused—*Editor*

What Time is It?

Due to a production error, a piece of information was left out of the "S-Video Distribution Amplifier" construction article in the July 1998 issue. The last sentence at the bottom of page 36 that finishes on page 48 should read, "As an alternative, simply set the gain pot to a position of about *one* o'clock and set the trimmer capacitor..."—*Editor*

Who We Are and What We Want

Thanks for the invitation to write. I am a 31-year-old male technical professional. I spent four years working for a major computer manufacturer providing Technical Support, then Second Tier Technical Support, and finally training to Technical Support. I now develop database applications in the bakery industry. I have been an electronics hobbyist since 1980 and a computer enthusiast since 1982.

I watched **Popular Electronics**, under Ziff-Davis' care, dwindle from a great technical magazine to consumer-drivel and then die not long after becoming *Computers and Electronics*. Gernsback picked up the title and returned it to its roots. I don't want to see **Electronics Now** go that road.

What do I want? I want a hardware-oriented techie mag for people who love the smell of rosin in the morning. In the arena of projects, I want test equipment I can build for my workbench (digital AND analog), "dongles" to dangle from my computers, and gizmos to help me better enjoy my stereo. All things I can build.

In the arena of more general articles, I would like to see articles on theory: How do diodes rectify, how does Boolean Logic work, etc. I'd like to see interfacing techniques: How to decode addresses on ISA, how to use IRQ lines, and how to write drivers for home-built ISA cards. I would like to see articles on techniques: Various approaches to home fabrication of printed circuit boards, how to make attractive case cutouts and front panels, and how to effectively use an oscilloscope.

What I DON'T want to see is stuff like "Prototype." I was disappointed to discover it when my subscription renewal began. Your title is **Electronics Now** not Electronics sometime in the indeterminate future. If I want to know what's around the corner, *Popular Science* and *Scientific American* can give me that information. That is not what I want from EN. I don't want to learn how to write HTML from EN. Sources for that information are as ubiquitous as death and taxes. I don't want to see what's new in consumer electronics unless it's a new technology that you are going to explain in detail. EN does not need to be contributing to the Gee Whiz marketing machine that sells TVs and Stereos. Do tell me how it will break and how to fix it. Do give me the theory of operation of any new technologies employed.

EN's value to me is in its focus on what makes technology tick and how to create it myself. I come to it to learn theories and techniques that allow me to increase my proficiency at my hobby. To learn what new tools and materials are out there to tinker with. Target the person who, either professionally or personally, works in a room that reeks of molten rosin. Focus on your core market: hobbyists and technicians seeking knowledge, theory, tools, and techniques for the creation and maintenance of digital and analog technologies.

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via e-mail

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Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

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.

I am a degreed electrical engineer. I studied mathematics as an undergraduate, and went to graduate school in electrical engineering. I am involved with the design of advanced radar systems for the military.

I subscribe to your publication because I am interested in the hobbyist aspect of electronics. I also subscribe to *Circuit Cellar INK* and *Nuts & Volts*, which in my view are your closest "competitors" in the marketplace.

I am not very knowledgeable of hands-on electronics, so I use your publication to gain a passing familiarity with what's out there. I have not purchased or put together any of the projects in your publication, although I enjoy reading about them. My time is limited, and my construction skill is fairly poor. In addition, although I am involved in the design of large-scale systems, I am not involved with the board-level design and assembly of subsystems.

In my spare time, I have done some work with electronics. I run a sound board at my local church and have fixed broken potentiometers on the board. I have also purchased scrap electronics through the advertisers I found in your magazine. I'll take the amps, fix switches or make simple connections on them, and then use them to provide sound to the church nursery, choir room, etc. I don't get involved with the assembly of the amp itself. I'm currently building a pair of speakers. I purchased the electronics from the advertisers in your magazine, and am building a plywood enclosure.

I like your magazine because it provides description of basic electronics. I'm not particularly interested in ham radio. I have some interest in computers, but my knowledge of software is good enough that I feel I could make a computer do whatever I wanted it to without the benefit of a publication of any sort to help me.

For me, in your magazine, "the simpler the better." I'm interested in basic circuits, so I read your "Q&A" column and short articles. I believe your magazine is unique and simply fills a void that is filled by no other publication.
JAY VIRTIS
via e-mail]

I am middle-aged, male, with two Associates Degrees, one in Electronics Technology, and the other in Computer Systems (hardware). My job listing is Technician, and I install, repair, and maintain computers and networks. I am the only Tech in a Division of 80-90 researchers.

My current position only requires me to "fire up the soldering iron" about once a month. Most of my computer repairs involve board swapping; I also build and string cable as needed. Some of the work involves 2-way radio, T-1 and 56 Kb phone lines, custom-built meteorology sensors, and video recording. We use Unix, Linux, and Microsoft software.

My hobby is also electronics. I've acquired a lot of test equipment from auction sales, and I repair consumer electronics in my home for friends and family. I've been on the Net for eight years and regularly read sci.electronics.xxx newsgroups. (Hi, Sam!)

What do I want? I also read last month's editorial about source code.

(Continued on page 28)

EQUIPMENT REPORT

IBM HOME DIRECTOR LIGHTING AND APPLIANCE CONTROLLER

Give your home that lived-in look and add computer-controlled automation of lights and appliances with the IBM Home Director Starter Kit.

There comes a time when every homeowner considers investing in home security equipment; often it's after being terrified by an item on the evening news. But then most people quickly pass on the idea when a more pleasant news item flashes across the screen or when the person considers how much money it might cost to install home-security equipment—not to mention the work that's involved in most installations that are not "professionally" done.

However, not all home-security products cost a lot of money, and some can be installed in no time. Consider, for example, IBM's Home Director Starter Kit. That $99 package provides a homeowner with automated security, control, and convenience, and the installation could be completed in a matter of minutes. The Starter Kit consists of three line-carrier controlled modules and an RF/infrared hand-held remote control. Additional modules can be purchased from IBM, and compatible modules are commonly available from multiple sources and multiple manufacturers. A PC-compatible computer running Windows 3.1 or Windows 95 is required.

Home Director can be used to turn on lights automatically. That's useful for giving your home a "lived-in" look when you are away. But the Home Director's usefulness does not stop at security. It also can be used to give your home a touch of automation. For example, it can be set to turn on you house lights shortly before you are scheduled to return home. You could also set it up to turn on certain groups of lights in the early morning hours so you don't have to stumble around in the dark while you are barely awake. Other possibilities include having your coffee ready when you wake up, even if you wake up at different times during the week and on weekends. Or perhaps you'd like to turn on an electric blanket every night before you go to bed so that the bed's not cold when you get there—all that, and more, is possible with the Home Director.

Home Director

The theory behind the operation of the Home Director is relatively simple. All of the modules plug into AC outlets connected to a home's electrical wiring. Information-bearing signals then ride on top of the AC voltage, allowing the modules to communicate with one another. Lights and appliances plug into the modules and turn on or off according to the commands received by the particular module.

One of the modules, the PC Connection Module, connects to a PC's serial port. Simple commands, or even complex routines, are set up on the PC and then downloaded to the PC Connection Module. The PC Connection Module is basically the controller of the Home Director system. Once routines are downloaded to the PC Connection Module and stored in memory, the computer can be turned off. The computer is needed only if it becomes necessary to change the routine.

Each of the three modules included with the Starter Kit is unique. The PC Connection Module not only receives and stores routines downloaded from the PC, it also has its own AC outlet that can power a plugged in light or appliance. The Remote Module also plugs into an AC outlet and has its own outlet to power a light or appliance, but it also has an antenna that receives RF commands from the Home Director remote control. The remote control can be used to manually turn on or off any light or appliance in the system from any room in the house.

The third module, a simple Lamp Module, receives commands only from the AC wiring. Any light or appliance plugged into the Lamp Module can be controlled from the PC Connection Module or the Remote Module. The Lamp Module can not only turn a connected light on and off, it can also be used to dim or brighten that light either manually or automatically. Each module has a code, or address, that is used to identify it in the system. Codes can be changed so that additional modules can be added to the setup.

The remote control is a lot more than just a remote control for the Home Director system. Not wanting to stick people with yet another remote control to keep on the coffee table, IBM equipped the remote with options to control nearly any TV, VCR, cable box, satellite tuner, and two auxiliary devices. All of the Home Director functions, plus the functions of any of the above devices, can be controlled via the remote.

Just like any other "smart" remote, the Home Director remote has buttons that put it in one of seven modes (Home Director, TV, VCR, Cable, Aux 1, Aux 2, and Satellite) to control a particular device. An included manual lists the command codes for almost every brand of electronics available in this country. The remote can even be set to try hundreds of code combinations until it finds

(Continued on page 24)

Prototype

Cruising Down the Asphalt and Information Highway

Caught in a traffic jam, you spend the downtime reading your e-mail, checking the balance in your bank account, and finding out last night's sports scores. Your wife in the passenger seat surfs the Internet. In the back seat, your daughter watches a movie while your son plays video games.

Sound pretty futuristic? Well, vehicles with those capabilities could be in dealer's showrooms in as short a period as four years, and some of the individual features could appear sooner. When high-power computers are combined with the Internet, wireless communications and other electronic technologies, drivers and passengers could be as productive as when they are in front of their desktop computers or as entertained as when sitting on their couches. Recognizing the huge potential of installing Internet-capable computer systems in vehicles, automakers working with their computer and electronic suppliers are developing vehicles in which modem speed and megabytes are of equal, and maybe greater, interest than top speed and miles-per-gallon.


THE NETWORK VEHICLE concept car is a joint effort of IBM, GM, Sun, and Netscape.

The *Network Vehicle* developed jointly by General Motors' Delphi Automotive Systems, IBM, Sun Microsystems, and Netscape is one showcase of the services that could be provided to drivers and passengers when "intelligent" vehicles are connected to the Internet. The Network Vehicle integrates "off-the-shelf" computer hardware and software technologies, wireless communication, Java operating system, Global Positioning System, and Internet/intranet capabilities. Voice recognition and speech synthesis, direct-broadcast satellite reception, reconfigurable heads-up display (HUD), center-console and passenger displays, and mobile media link (MML) are also featured in this electronic concept car.

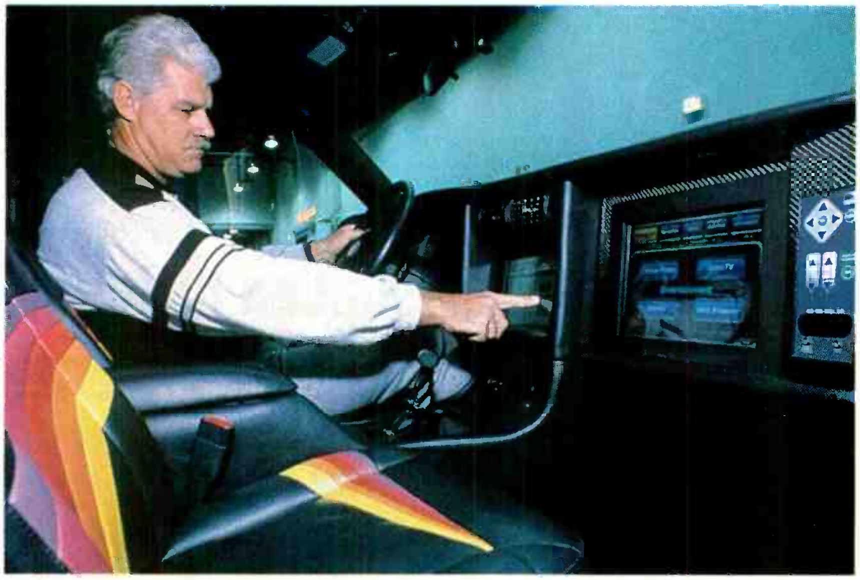
A flat satellite antenna embedded under the Network Vehicle's roof panel provides a direct link to the Internet through Hughes' DirecPC satellite. The system allows high-speed download of audio, full-motion video, and text data. Operating at 400 kbps, it is more than 15 times faster than a standard 28.8 k modem. The antenna also receives programming from Hughes' DirecTV, so passengers can watch their favorite television programs while traveling.

Keep Your Eyes on The Road

Operating a computer using a keyboard, mouse, or other normal input device is not appropriate in a mobile environment, especially for the driver. Therefore, the Network Vehicle uses voice-recognition with speaker identification and speech synthesis, a heads-up display (HUD), touch screens, and steering-wheel controls so these high-tech systems can be safely used without taking hands of the steering wheel and eyes off the road.

IBM modified its advanced ViaVoice speech recognition and text-to-speech response system for the Network Vehicle. The speech recognition system can understand most drivers instantly, requires no training, and has been tuned for optimal performance even inside a noisy vehicle. With ViaVoice, the driver can check e-mail and voicemail; get directions and information on traffic conditions from the on-board navigation system; locate a restaurant or hotel on the Internet, or obtain news, sports scores, and stock prices. Voice commands can also lock/unlock doors, play CDs, select radio stations, and so forth.

The reconfigurable HUD projects information onto the windshield so that drivers can view road speed, engine status, e-mail waiting messages, navigation information, microphone on/off status, and so forth without taking their eyes off the road. A text message area is available to provide feedback to voice commands



DRIVERS CAN ACCESS all the Network Vehicle's features using spoken commands or the reconfigurable touch-screen command console on the dashboard, located between the driver and passenger seats.

showing they have been received.

The center console's touch screen serves as a heads-down display (HDD) for nearly all of the functions on the Network Vehicle including the audio system, climate control, cellular phone, and mobile-office gadgetry for everything from e-mail to Web browsing. Using standard graphics, it displays the usual instrument-panel items like speedometer, tachometer, fuel level, oil pressure, coolant temperature, and door-ajar warning. The cluster display can be reconfigured uniquely to suit the mode currently being used. For instance, in the entertainment mode, the faceplate display looks like a radio or CD-player face with touch-activated controls. Other reconfigured displays include those for e-mail, Web browsing, navigation maps, or cellular phone. Likewise, steering wheel controls are reconfigured according to current function being used, with the configuration shown on the center-console screen. Voice-activated commands can be used with all of the center-console functions and, in some cases, text-to-speech to minimize driver distraction.

There are three individual passenger-color LCD displays with touch panels for the front-seat and back-seat passenger seats. They provide enhanced features beyond those found in the center console display. This includes programs from DirecTV, videos from DVD video players, Net surfing via DirecPC, and a variety of office functions. Like the other displays, these are reconfigurable according to the current function.

Wherever possible, the Internet, probably via a dedicated automotive ISP (Internet service provider), would be used to provide information and communications. For instance, trip planning including maps, route guidance, hotel and restaurant information, and concierge services while traveling would come off the Internet and be combined with GPS position data. Owners of the Network Vehicle use their Web browser to set up a personal profile, including preferences in radio stations, preferred personalized audio content, vehicle-service records, and emergency-service numbers.

A slot in the center console accepts an IBM WorkPad Personal Data Assistant (PDA), which interfaces with the Network Vehicle's computer to add speech recognition and text-to-speech capability. This PDA connection enables the driver to listen to schedules and to update files and other office data stored in the WorkPad. For example, the driver can give a voice command to read calendar entries from the WorkPad or dictate a to-do list while driving. As PDA and smart card technology advances, PDAs in the Network Vehicle could be used to access personal, financial, and business information while traveling.

The driver would have instant access to electronic maintenance and service records for the vehicle. The Network Vehicle also has capability to diagnose engine problems. Should the diagnosis indicate a problem, the computer could notify the automaker's customer service Web site where the severity of the problem would be determined. Depending on the problem, a service representative could alert the driver via the Internet and the Network Vehicle's HUD or text-to-speech capability, as well as set-up an appointment for repairs by, for example, e-mail.

Connecting all this in-vehicle electronics together is a low-cost, fiber-optic serial data link called Mobile Media Link (MML). With MML's high bandwidth, multiple audio, video, and control data can be transmitted across the fiber-optic bus at ultra high-speeds.

Other Vehicles

The Network Vehicle is not the only prototype/concept car with combined computing/entertainment/productivity/transportation features. For example, Delphi Delco Electronic System's Mecel AB division working with Saab developed the *Personal Productivity Vehicle* around a 1999 Saab 9-5. Choosing a Saab for the Personal Productivity Vehicle is not surprising since nearly 30% of Saab owners are already Web users. It features advanced technology for communications and mobile computing as well as more traditional entertainment. The Personal Productivity Vehicle uses the Microsoft Windows CE-based AutoPC platform with integrated AM/FM receiver, CD-ROM, serial-port interface, universal serial bus, COMPACTFLASH expansion slot, and a high-resolution 256 by 64 display. For safe usage while driving there are steering-wheel controls, plus interactive speech recognition and speech

FOR MORE INFORMATION

Network Vehicle
www.alphaworks.ibm.com/networkvehicle

Personal Productivity Vehicle
www.delco.com/delco/delcoprod.html

ICES
www.visteon.com

synthesis reading/sending e-mail as well as for receiving navigation, traffic, and weather information, or just to change the radio station.

Besides normal cellular communications, an infrared data link is available for transferring data between the vehicle and Windows CE-based devices such as handheld and palm PCs. Like the Network Vehicle, the Personal Productivity Vehicle uses the ultra-high-speed fiber-optic MML serial data link for high-bandwidth connectivity within the vehicle. MML, which is capable of signal transmissions rates of up to 110 Mb/s, and can support up to 50 channels of audio and 20 channels of TV-quality compressed video.

Ford's Visteon Automotive Systems has developed its *ICES* concept vehicle. The acronym stands for Information, Communications, Entertainment, Safety, and Security.

Visteon's multimedia "vehicle computing platform" uses Intel architecture microprocessors and the Microsoft Windows CE operating system. Drivers will be able to customize their personal computer on the road with their favorite features by simply installing new software just as with a home or office PC.

ICES extends the electronic environment of the home and office to the vehicle, delivering Internet access as well as emergency service and everything in between, including cell phone, climate control, high-quality audio, and even movies for rear-seat passengers. By using state-of-the-art voice and navigation technology, ICES will tell a driver about traffic snarls as they occur and suggest time-saving alternate routes. The system can also listen to and understand the driver's requests to map new routes. ICES uses Visteon's voice system, which is speaker-independent. This means it recognizes natural speech patterns as well a range of voices, languages, and dialects.

ICES also uses RESCU (Remote Emergency Satellite Cellular Unit) already offered in Lincoln Continentals. Combining GPS and a cellular phone network, RESCU provides emergency and breakdown assistance, automatic air bag deployment notification, and convenience features like route assistance and concierge services.—**Bill Siuru** PT

Micron Breakthrough in Semiconductor Technology

A University of Texas graduate student research team led by Dr. Grant Wilson, professor of chemistry and chemical engineering, has successfully completed a project to print 0.08-micron features on a semiconductor wafer. The project was funded by SEMATECH, a non-profit research consortium of ten semiconductor manufacturers.

The breakthrough is especially impressive since it was achieved with a 193-nm Deep Ultraviolet (DUV) ISI 103 stepper. Many industry experts had believed it would be necessary to develop new post-optical technology to produce feature sizes at or below 0.10 micron. One micron is the equivalent of approximately 1/25,000 of an inch.

The 0.08-micron features, which are approximately 320 atoms wide, were generated using an etched-quartz phase-shift photomask produced by DuPont Photomasks, Inc. Photomasks are high purity quartz plates that contain precision images of the features that are patterned onto semiconductor wafers with lithography steppers to build integrated circuits. Since building photomasks for semiconductor production becomes progressively more difficult as feature sizes shrink, special techniques such as phase shifting must be incorporated. Phase-shift photomasks function by allowing a small percentage of the light through while simultaneously altering the phase of the light transmitted, improving focus and increasing resolution.

Another essential component in semiconductor manufacturing is the photoresist. Amorphous polyolefin, the photoresist used by the University team, took three years to develop. The polymers had to be specifically designed to work with the 193-nm wavelength DUV light source used by the stepper to pattern the image at the required feature sizes onto the semiconductor wafer.

Currently, the most advanced commercial semiconductor designs are manufactured using 0.25-micron process technology. The Semiconductor Industry Association's most recent revised roadmap did not call for 0.08-micron feature sizes until the year 2009. According to Dr. Wilson, "I didn't believe it could be done at first. It really works better than my wildest imaginings, and it appears that the process latitude is there to generate smaller features yet."

Kyle Patterson, a University of Texas graduate student on the research team, presented the results of the project at a meeting of the Society of Photo-Optical Instrumentation Engineers (SPIE) in Santa Clara, CA. PT

The Hole Truth

Workers who have to handle radioactive, biological, or toxic materials could find better protection with a recently patented idea developed by Los Alamos researchers. The new method uses alternating layers of conducting and insulating materials in protective gear. Tests have demonstrated that even a small puncture can change the resistance or capacitance between the two layers, signaling a breach. Checking for changes in the electrical properties of the conductive layers produces signals of punctures or other breaches, in real time.

Various materials and techniques are available for manufacturing multi-layer protective barriers with the required electrical properties. Such materials could be used in containment bags; liners and covers for storage containers; or in protective apparel such as gloves, aprons, and boots.

Providing continuous monitoring and real-time detection, the method would improve worker safety, better protect the environment, and reduce costs—all by initiating a decontamination response before contaminants or toxins have spread significantly. PT

Tracing the Origin of Water

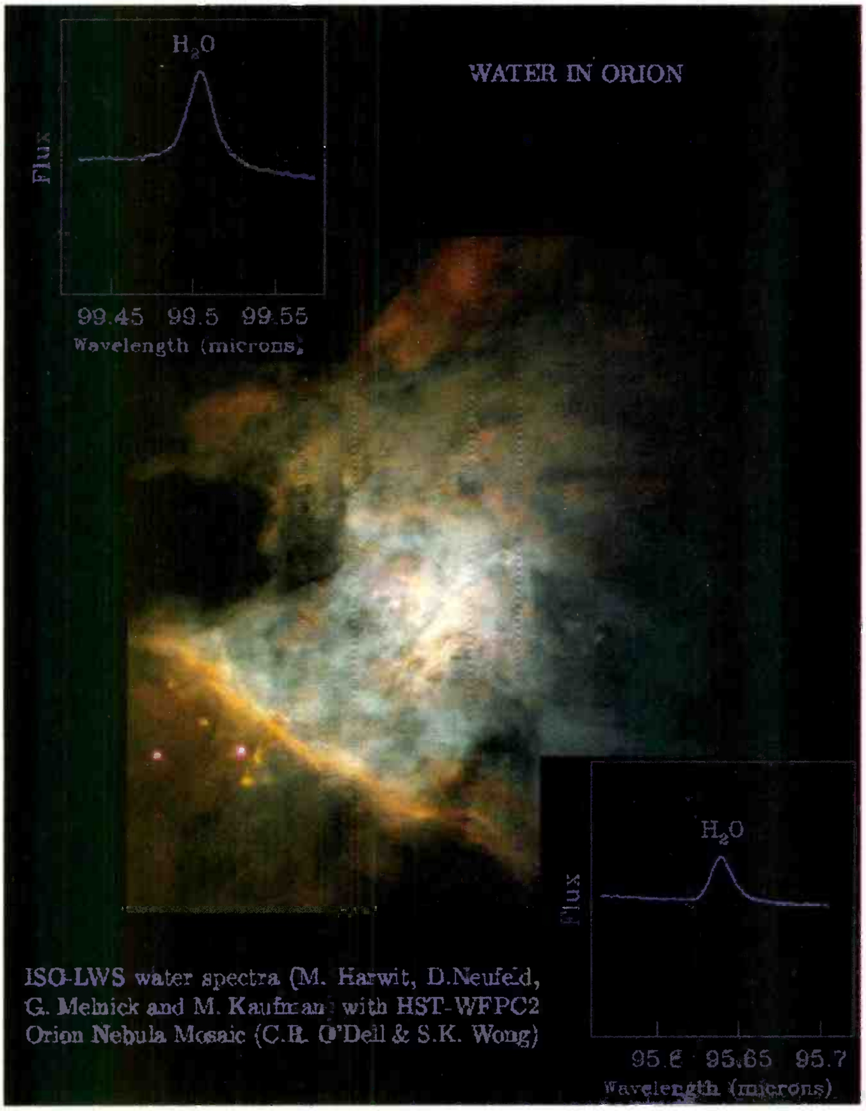
A team of U.S. astronomers has located a large concentration of water vapor within the Orion molecular cloud—a giant interstellar gas cloud 1500 light years from the Sun, composed primarily of hydrogen molecules. The concentration of water vapor in Orion—20 times larger than any previously detected—was measured using the long-wavelength spectrometer, one of four science instruments aboard the Infrared Space Observatory satellite. The data *signature* characteristic of water-vapor emission was observed in the far-infrared region of the electromagnetic spectrum.

According to the research team, the high concentration of water in Orion may be key to the origin of solar system water. The shock waves given off by young stars in the interstellar gas cloud function as a huge *chemical factory*, the team reported, generating enough water molecules in a single day to fill 60 Earth oceans. Eventually, the water vapor turns into ice particles, similar to those thought present within the gas cloud from which our solar system formed.

The water vapor concentrations measured were roughly one part in 2000 by volume. The cloud's fast-moving shock waves made the gas cloud abnormally warm. For more than 25 years, astrophysicists have predicted that, when the temperature exceeds 200 degrees F, chemical reactions will cause most oxygen atoms in the interstellar gas to combine with hydrogen atoms to form water.

"We've known for some time that a young star in Orion is ejecting material into the surrounding gas and dust cloud causing violent shock waves," said team member Dr. Michael Kaufman, an astrophysicist at NASA's Ames Research Center, Moffett Field, CA. "These new observations confirm our prediction that these shock waves produce large amounts of water."

NASA researchers will continue to study water vapor in the Orion cloud to better understand the role water plays in the formation of stars and planetary systems. NASA's forthcoming Stratospheric Observatory for Infrared Astronomy (SOFIA) will begin science research flights in November 2001 looking for this type of water emission, among other things. SOFIA is a next-generation flying research laboratory housed in a converted 747-SP aircraft that will conduct observations of the solar system, stars, and galaxies in the infrared region. PT



THE PRESENCE OF WATER VAPOR NEAR THE ORION nebula is indicated by an increased flux of infrared radiation at specific wavelengths.

Chaos and Secrecy

Research reported in the journal *Science* could lead to development of a new technique for encoding information sent across optical fiber systems that are now widely used for telecommunications. The technique mixes a confidential message with a chaotic carrier signal, transmits it, then subtracts the chaos to reveal the message. The key to success is synchronizing two nearly identical lasers to produce the same chaotic pattern on both the sending and receiving ends. The work is the first use of chaos to carry messages in an all-optical system. PT

1 Study at Home

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BY JEFF HOLTZMAN
COMPUTER EDITOR

Generating Random Numbers

DID YOU EVER THINK ABOUT DEVELOPING A FOOLPROOF METHOD OF WINNING THE STATE LOTTERY? AT THE HEART OF YOUR SYSTEM YOU PROBABLY HAD A RANDOM-NUMBER GENERATOR—PREFERABLY A PORTABLE ONE. DOESN'T SOUND THAT hard: Just slap together a little 16-character LCD, a microcontroller, and a way to generate random numbers. It couldn't be that difficult, could it? Guess again.

I'll tell you right now that hardware is your best bet. Nonetheless, for the sheer pleasure of it, we're going to beat our heads against the wall and see what we come up with software-wise. If that doesn't convince you, I've got 200 pages of dense mathematics for you to read.

What Is A Random Number?

Glad you asked. Actually, a number is just a number; there's no such thing as a random number. What's important is to be able to generate sequences of unrelated or apparently unrelated numbers. That "apparently unrelated" is the catch. It implies some sort of relationship between the generator and the user. The point is that even if a sequence is not random, if the user thinks it is, that's good enough.

People who are used to programming in high-level languages typically use a function like one of those shown in Table 1 to generate random numbers. Typically, you call the seed function first with some "random" value that kicks things somewhere in the middle of the sequence—hopefully differently from the last run.

Note that there is no assembly-language function. Life would be easier for lots of people if CPU designers incorporated a read-only "random" register that ripped along at some multiple of the basic clock frequency.

Of course, those high-level functions just call underlying library code, which is what does the work. People who analyze the output of library generators typically find them lacking, so be warned. If you need high-quality random number sequences, look elsewhere.

There are many methods for generating sequences of random numbers. The most popular is called the linear congruential method, which was invented by D. H. Lehmer in 1949. The chief characteristics of the Lehmer method are that it is simple, deceptive, insidious, and maddening.

The Lehmer Generator

The basic formula is simply:

$$x(i+1) = (a * x(i) + c) \bmod m$$

LISTING 1—QBASIC RANDOM-NUMBER GENERATOR

```
REM A multiplicative congruential random-number or Lehmer generator
REM basic formula: x(i+1) = (a*x(i) + c) mod m
REM from C User's Journal, June 1995, Jerry Dwyer
REM jkh, 2/28/98

DIM c AS INTEGER
DIM m AS INTEGER
DIM i AS INTEGER

DIM Count AS INTEGER
DIM Seed AS INTEGER

DIM x AS INTEGER
DIM y AS INTEGER

a = 5
c = 0
m = 7

Count = 100
Seed = 1

PRINT "————————————————————————————————"
x = Seed
FOR i = 1 TO Count
    y = (a * x + c) MOD m
    PRINT x;
    x = y
NEXT i
```

LISTING 2—LEHMER GENERATOR IN C

```
/*
** longrand() — generate 2**31-2 random numbers
**
** public domain by Ray Gardner
**
** based on "Random Number Generators: Good Ones Are Hard to Find",
** S.K. Park and K.W. Miller, Communications of the ACM 31:10 (Oct 1988),
** and "Two Fast Implementations of the 'Minimal Standard' Random
** Number Generator", David G. Carta, Comm. ACM 33, 1 (Jan 1990), p. 87-88
**
** linear congruential generator f(z) = 16807 z mod (2 ** 31 - 1)
**
** uses L. Schrage's method to avoid overflow problems
*/

#define a 16807        /* multiplier */
#define m 2147483647L  /* 2**31 - 1 */
#define q 127773L      /* m div a */
#define r 2836         /* m mod a */

long nextlongrand(long seed)
{
    unsigned long lo, hi;

    lo = a * (long)(seed & 0xFFFF);
    hi = a * (long)((unsigned long)seed >> 16);
    lo += (hi & 0x7FFF) << 16;
    if (lo > m)
    {
        lo &= m;
        ++lo;
    }
    lo += hi >> 15;
    if (lo > m)
    {
        lo &= m;
        ++lo;
    }
    return (long)lo;
}

static long randomnum = 1;

long longrand(void)            /* return next random long */
{
    randomnum = nextlongrand(randomnum);
    return randomnum;
}

void slongrand(unsigned long seed)     /* to seed it */
{
    randomnum = seed ? (seed & m) : 1;  /* nonzero seed */
}

#ifdef TEST

#include <stdio.h>
#include <stdlib.h>

int main(int argc. char *argv[])
{
    long reps, k, num;
    unsigned long seed;

    reps = 10000;
    seed = 1;

    /*
    ** correctness test: after 10000 reps starting with seed 1,
    ** result should be 1043618065
    */

    if (argc > 1)
        reps = atol(argv[1]);
    if (argc > 2)
        seed = atol(argv[2]);

    printf("seed %ld for %ld reps...\n", seed, reps);
    slongrand(seed);
    for (k = 0; k < reps; ++k)
        num = longrand();
    printf("%ld\n", num);

    return 0;
}

#endif
```

In words, to get the next value, take the current value, multiply it by a, add c to it, divide by m and take the remainder. Choosing good values for a, c, and m is not simple. Bad values quickly degenerate into non-random sequences. Listing 1 shows a little QBasic program to play with.

For short runs, the algorithm is worthless, because it repeats quickly. For example, suppose you wanted to create an electronic dice game, producing random numbers between 1 and 6. The QBasic program in Listing 1 produces the following results:

1 5 4 6 2 3 1 5 4 6 2 3 1 5 4 6
2 3 1 5 4 6 2 3 1 5 4 6 2 3 1 5
4 6 2 3 1 5 4 6 2 3 1 5 4 6 2 3
1 5 4 6 2 3 1 5 4 6 2 3 1 5 4 6
2 3 1 5 4 6 2 3 1 5 4 6 2 3 1 5
4 6 2 3 1 5 4 6 2 3 1 5 4 6 2 3
1 5 4 6

You probably wouldn't want to create a dice game based on that.

For best results, the value of m should be the data-bus width of your CPU ±1. On a 32-bit CPU, a good value is 2**32-1 (= 2,147,483,647), which happens to be a prime number. (By the way, m and a should be relatively prime.) A good value for a is 16807. Unfortunately, you can't use the value 2147483647 in QBasic (it's 16-bit). You can use 32767, which seems to work pretty well.

The C code in Listing 2 is a 32-bit variant that codes around potential overflow problems due to the use of signed integer arithmetic. Obviously that's not a problem on any modern computer, but it's a different story on, say, an 8-bit microcontroller.

Also Keep In Mind

As you think about the problem, here are a few other things to keep in mind:

- There are other algorithms, but they take lots of code.
- Verifying randomness and distribution are not trivial tasks. A degree in statistics would help.
- You can't simply feed the output of one random-number-generator routine to the input of another to increase randomness.

For some background and algorithms, see the 6/95, 6/96, and 8/96 issues of *C/C++ User Journal*. For a comprehensive treatment, the new version (Vol. 2, 1998) of Donald Knuth's *The Art of Computer Programming* has more than

TABLE 1—RANDOM NUMBER FUNCTIONS IN VARIOUS LANGUAGES

Language	Seed Function	Generator Function	Returns
MS QBasic	Randomize	Rnd	Single precision value 0.0 < n < 1.0
ANSI C	srand	rand	integer 0 <= n <= RAND_MAX
Java	srandom	random	single 0.0 < n < 1.0
Pascal (Borland Delphi)	Randomize	Random (range)	single, 0.0 <= n < 1.0, or integer 0 <= n < range

you'll ever want to know (nearly 200 pages) about random-number generation. He suggests using Chapter 3 as the basis of a semester course for college senior or grad students. He doesn't even acknowledge the existence of CPUs of less than 16 bits.

I don't believe there is an efficient random number generator for an 8-bit CPU. Depending on your needs, you'll probably have to do double- or quad-precision adds and multiplies.

Hardware Solutions

Perhaps the easiest way is to set a timer to fire at a rapid rate relative to the tasks done by your application. Then, each time it fires, increment the count in a register. It's like the "tick" count in a PC. For that to work, your usage will occur at random intervals relative to the clock (*e.g.*, user events such as pressing a switch). Of course, it assumes that you have a timer, and that you're not using it for anything else. If you are, multiplex the timer interrupt and maintain separate counts.

Registers and RAM are typically uninitialized (*i.e.*, they have "random" values). Use one such value to seed the timer. In this case, the timer would run at a different rate every time you boot.

Conclusions

Do you have an algorithm for generating pseudo-random number sequences on an 8-bit microcontroller? Are you confident that it works? If you can answer yes to both questions, send in your method. I'll run it through some tests, and if it survives, I'll publish the results here. See you next time; stay in touch via e-mail at jeff@ingeninc.com. **EN**

EQUIPMENT REPORT

continued from page 14

the right command set—it then tells you what the proper code is. To top it off, the remote even has a built-in light that illuminates the buttons—you might want to use it to replace your present remote control.

Setup

The Home Director Starter Kit is very easy to set up. First you have to install four AAA batteries in the remote and two AAA batteries in the PC Connection Module—those two batteries preserve the routines stored in the module's memory even in a power outage. The PC Connection Module must be plugged into an outlet near your computer. An included cable connects the module to the serial port on the PC. A light or appliance that you wish to control is then plugged into the PC Connection Module. The Lamp Module and Remote Module can be plugged into outlets anywhere in your home; their specific locations are determined by what items you want to control and where those devices are located.

Next you have to install the software that is provided on a CD-ROM. The software presents a simple graphical interface that lets you install and configure modules in the system. Each module and its functions are graphically depicted in the software interface, and a right mouse click brings up various options for each module. All of the lights and appliances in the system can be controlled directly from the PC, and at this point you can test any of the attached devices.

Included with the software are a couple of sample routines that you can test out. One routine turns on a lamp at 50% brightness, immediately turns on an appliance, turns the lamp up to 100% brightness after five minutes, turns off the appliance after 10 minutes, and then turns off the lamp after 15 minutes. You can write your own routines or edit the supplied routines according to your own needs. You can give each routine a unique name and even label the modules according to the appliances you have plugged into them. You might want to define wake-up and goodnight routines, or perhaps weekday and weekend routines.

The routines allow you to tailor your lighting and appliance scheduling for each day of the week. To save time, the software lets you duplicate and drag-and-drop parts of one routine into another routine. Because a PC keeps track of the date and time, advanced functions let you make custom routines for specific dates or even configure dawn and dusk routines once you have entered your time zone—the software then knows when the Sun comes up and when it goes down where you live, and it even accounts for Daylight Savings Time.

IBM's Home Director Starter Kit is just the ticket for people who would like to automate the lights and appliances in their home without spending a lot of money on equipment or a lot of time on installation. And with readily available expansion modules, the system is fully customizable. If you already have a PC, you already own the most expensive part of the system. Now all you need is the Home Director. For more information, contact IBM (Route 100, Somers, NY 10589; Tel: 800-426-7235, Ext.4340; Web: www.pc.ibm.com/ homedirector) directly, or circle 15 on the Free Information Card. **EN**

BY SAM GOLDWASSER
SERVICE EDITOR

Troubleshooting CD-Player Startup Problems

A STARTUP PROBLEM IS A CATCH-ALL TERM FOR ANY SITUATION WHERE A CD PLAYER OR CD-ROM DRIVE REFUSES TO RECOGNIZE OR PLAY/ACCESS A DISC. IN THIS MONTH'S INSTALLMENT WE'LL DESCRIBE IN DETAIL WHAT HAPPENS WHEN you insert a CD and push PLAY, and we'll look at what to do if the unit doesn't want to cooperate.

What's a Startup Problem?

With an old-style record player (you know, vinyl LPs, technology that was state-of-the-art sometime before dinosaurs roamed the earth), the tone arm could be plunked down anywhere to start play. Not so with a CD player. Aside from the fact that you cannot even get to the pickup on a CD player to move it by hand and plunk it down, a lot must take place successfully before the first note is sent to your loudspeakers.

Startup problems cover all situations where the player does not successfully read the disc directory. Nearly everything in the optical deck and much of the main-board electronics needs to be functional to read the directory. Therefore, any failure in any of a rather large number of places can prevent successful startup (and subsequent play).

On a changer, a startup-sequence failure will probably result in similar symptoms, but then the unit will move on to the next position in the carousel or cartridge. It is likely that the player will remember that it was unsuccessful at loading a disc for each position and eventually give up after all possible discs have been tried.

Possible causes of a startup-sequence failure include a defective disc, dirty lens, defective laser or photodiode array, bad focus or tracking actuator or driver, dirty track, insufficient or dried-up lubrication, dirty or bad limit switches or sensors, defective spindle motor, faulty electronics or control logic, damaged parts, faulty optical alignment, and/or need for servo adjustments. The bad news is that this is a large number of possibilities. The good news is that with such a large number of possibilities, there is a good chance that the problem will be minor and inexpensive to fix; actual failure of the (expensive) optical pickup itself is relatively far down the list of likely causes.

First, be sure that you do not overlook the trivial: Are you loading the disc correctly? Most CD players want the disc label-side up. However, there are some, like Pioneer magazine-type changers, that want the label-side down. If you have just acquired the CD player, don't overlook that possibility.

Startup Sequence

The exact sequence of startup events and the symptoms they cause when they fail will vary depending on the type of player and its design. For example, the display might flash, be blank, display "—:—" or the word "disc" or "error," etc. In any event, the unit won't play the disc. By understanding the following summary as it applies to your player, you should be able to determine what is going wrong.

When a CD is inserted, the player should go through the following routine:

1. Drawer closes (or with portables, lid is closed manually) and CD is clamped to the spindle.

2. Interlock engages, if present (always in portables). If there is no interlock, there may be an optical sensor or the optical pickup may act as its own disc sensor.

3. Pickup resets to starting (index) location towards center of disc, which is usually located using a limit switch or optical sensor.

Before describing the remaining steps, it would be helpful to explain a bit more about the organization of the photodetector. The illustration in Fig. 1 is typical of units that have a three-beam pickup. Blocks E and F are not present (or at least not used—they will be disabled and grounded) in units that have a single-beam pickup. The four-quadrant (ABCD) photodetector is found in all systems. The main return beam is detected by the ABCD array. The tracking beams return to E and F. Detector E is offset slightly off track to one side and F is offset to the other. Average signals from E and F will be equal when the array is centered on the track. Now, let's return to our discussion.

4. Laser is turned on and focus search routine is started to position the lens at the correct vertical position. Once correct focus is achieved, the focus servo is activated to maintain it. Focus, which must be accurate to 1 μm, operates as described in the next paragraph.

5. The optical path in the pickup includes a cylindrical lens or astigmatism that causes the laser-beam spot to be circular when it is correctly focused, but elliptical when it is not. When it is not correctly focused, the major axis of the ellipse is offset 90 degrees, depending upon whether the lens is too close or too far (*e.g.*, major axis of -45 degrees for too close and +45 degrees for too far). Focus

Error is equal to (A + D) - (B + C), which will be 0 when focus is correct since, with the circular spot, the outputs of all four quadrants will be equal.

6. The disc starts spinning up to 500 rpm and the constant linear velocity (CLV) servo is activated to maintain correct speed. The CLV servo uses a PLL (phase-locked loop) to lock to clock transitions derived from data read off the disc. Data is derived from A + B + C + D (look at Fig. 1).

7. Tracking servo is activated to keep the laser beam centered on the track. With a three-beam pickup, two additional laser spots are projected onto the disc, one in front of and one behind the main beam. Those are offset on each side of the track just enough so that the Tracking Error = E - F = 0 when the beam is centered. With a single-beam pickup, similar information is derived using only the main beam; Tracking Error = (A + B) - (C + D) = 0 when tracking is correct.

8. Disc directory is read and displayed.

9. Unit shuts down awaiting command or goes into play mode, depending upon how it was activated.

Some of the steps listed above may be performed concurrently. If any of the first nine steps fail, the laser is turned off and the machine will display some kind of error or no-disc message and then return to idle mode, or in the case of a changer, load the next disc and try again.

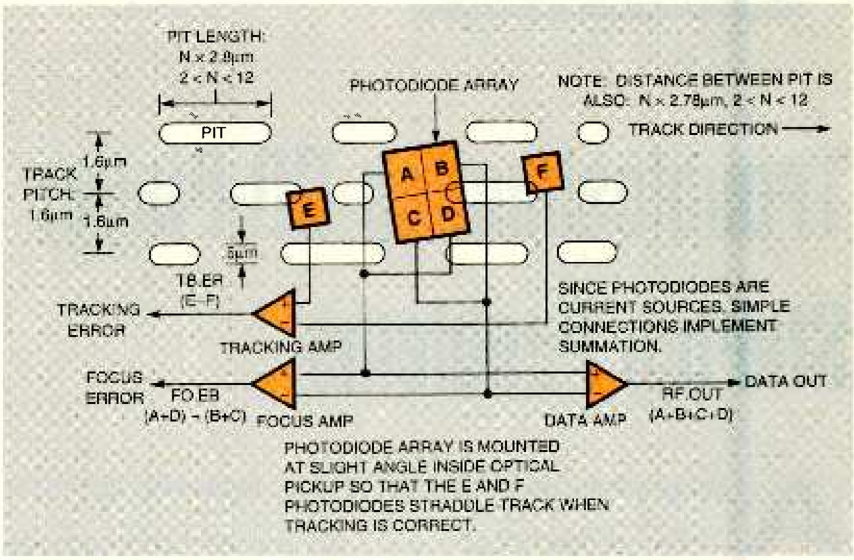

FIG. 1—HERE'S HOW THE PHOTODIODE ARRAY in a unit with a three-beam pickup is arranged. Also shown here is the geometry between the array and the information pits on a disc.

Validating the Startup Sequence

WARNING: The procedures below may require access to the optical pickup while the laser is powered. The laser diode is infrared (IR), 780 nm, and for all intents and purposes invisible. The only indication of laser output will be a tiny red-appearing dot of light when the lens is viewed from a safe position of at least 6 inches and an oblique angle of at least 45 degrees. Don't be fooled into thinking the laser is weak—the actual beam intensity may be 10,000 times greater than it appears! However, the red dot is a good indication that the laser is at least powered (though not necessarily that it is operating correctly—an IR detector and/or a laser-power meter are really needed for that; see below).

To narrow down possibilities, try following this procedure when the disc is not recognized, but the drawer closes completely:

Start by double checking the drawer closing/opening mechanism. Without exception, Sony CD players that have belts need them cleaned and eventually replaced. If the drawer does not really close completely, then the disc may not be clamped properly, or other erratic problems could occur.

Once you have verified that the drawer operation is fine, you need to determine that the lens is clean. In general, the lens should look shiny with a blue tinge. Any gunk or crud can and will degrade performance. You may have to remove part of the clamping mechanism to get at the lens. If the lens is not perfectly shiny, clean it carefully as explained previously in this series (see "Service Clinic," July, 1998). A dirty lens—perhaps one not even visibly dirty to your naked eye—can result in any number of startup (or other) problems. Therefore, cleaning the lens should be done before looking for more obscure mechanical or electronic faults.

If lens cleaning does not improve the situation, the next step is to verify that the pickup has reset itself to the inner (center) track of the disc. If necessary, manually move the pickup away from the center by turning the appropriate pulley or gear. If there is a linear actuator or rotary positioner (no gears or belts), just push the pickup gently and see what happens when a disc is loaded. If you are not able to move the pickup from one stop to the other, make sure any shipping lock is disengaged! The pickup should move smoothly toward the center, usually tripping a limit switch and stopping. If there is no movement, if the movement is jerky, or if the pickup gets stuck at some point, then either lubrication is needed or the motor or drive circuitry may be faulty. Also check for broken or damaged gear teeth, a slipping belt, and misaligned or damaged tracks. Measure the voltage across the motor that moves the pickup. If there is none, or if it is very low (under a volt or so), then there is a problem with the motor, its driver, or the system controller. (We'll discuss more about motors shortly).

Determine if the machine attempts to focus. On portables, you can simply bypass the door interlock to get the operations associated with reading the disc directory to begin (you may also need to press PLAY—that need is model-dependent). In some component CD players, a disc actually has to be present to block an optical sensor. You should see the lens moving about 2 mm up and down (at least one of these directions will have a smooth movement) one or two times. If a disc is in place, the lens should quickly stop at the appropriate focus position. Admittedly, however, observing the lens may be difficult or impossible with the disc in place. Dentists are probably good at this!

If the focus action is identical whether a disc is in place or not (it keeps up the search pattern and then gives up), verify that the laser is being powered. In most cases and as outlined above, you will be able to see a tiny spot of red light when the lens is viewed from an oblique angle during the focus search. From a safe distance of at least 6 inches and 45 degrees or more off to one side, you should be able to see this dim red light in a darkened room while the unit is attempting to focus.

If you do see this, you can assume that the laser is at least being powered, although this is not a sure test for an actual IR laser beam or proper optical-power output. In most cases, however, the red light indicates that the laser is working. An IR detector would confirm at least that there is an IR emission. If there is no dot of red light, then either the laser diode is bad, it is not being powered, or you are not looking from the correct angle.

For a more exact test, you can purchase an inexpensive IR-detector card from most electronics distributors or build your own using a photodiode, a few resistors, a general-purpose transistor, and a standard LED—all powered by a 9-volt battery. Figure 2 shows the circuit for this device. If you do build one, you will also find it useful for testing IR remote controls. (This is the same circuit we showed you when we discussed remote-control repair in the June 1997 installment of this column.)

If the lens is hitting the disc at the top of its excursion, there is a possibility that the spindle table has been pushed too far down, perhaps by something falling on it, for example. A bent shaft and wobbly spindle is also a possibility caused by this kind of damage. This kind of fault is much more likely to occur with a top-loading "boom-box" or portable than to a drawer-loading machine. While the lens hitting the disc with the spindle table set at the correct height is not impossible on some players, it is unlikely. On most lenses, a ring around the outside of the lens itself prevents the critical central area from actually contacting the disc, so accidental contact does not usually damage the lens. However, it can scratch the disc. Similarly, if the spindle is too high, the lens might not be able to reach high enough to focus properly.

On a player with the height adjusted properly, there is usually about 2 mm between the laser shroud and the bottom of the disc. The spindle height is not super-critical, but if it is way off, you cannot establish proper focus. Incorrectly adjusted focus offset or gain can also result in the search pattern being too high or too low. Either of those can result in inability to recognize discs, noise, or even erratic tracking during play.

Once focus is established (and sometimes concurrent with this operation), the spindle should start to rotate and quickly reach 500 rpm. The speed may be ramped up or controlled in some other search pattern since there is no speed feedback until the data coming off the disc becomes available. A partially shorted drive motor will keep the disc from reaching full speed even though the spindle and disc are turning.

Check the voltage on the spindle motor when it starts. It should reach 2 volts or more. If you read less than this, but not zero, a partially shorted motor or a weak driver is likely. A permanent-magnet-type motor can sometimes be revived by a quick squirt of degreaser through the ventilation holes and/or by **disconnecting** it (very important, or else you could fry your driver circuit and create a new problem!) from the circuit board and applying 9 VDC or so to it with each polarity for a few seconds to spin off the "gunk." If one of those fixes helps, you can continue to use the player until you get a replacement motor (which might never be needed depending on the severity of the original problem). In some models, the design of the driver circuits is the underlying cause of motor failure, and there are circuit-board changes that would need to be performed to avoid the problem in the future.

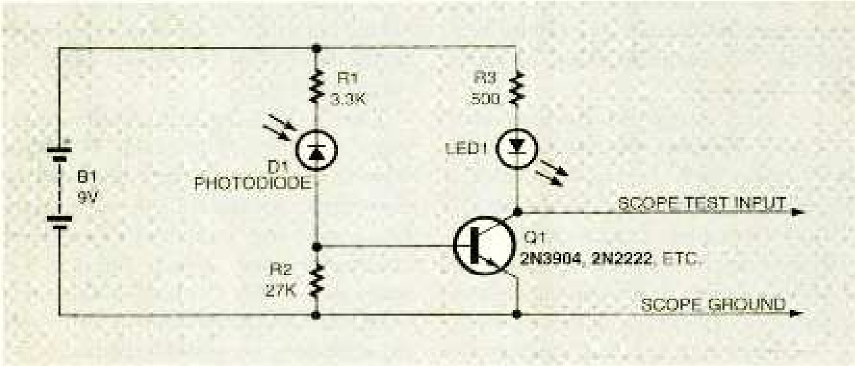

FIG. 2—THIS SIMPLE IR TESTER is a sure way to confirm that the laser is emitting an IR beam. You can also use it to test IR remote controls.

If the voltage reads zero at all times, there may be a bad driver, or the machine may not realize that focus was established and is not issuing the spindle-motor start command. The required speed of 500 rpm, just over 8 revolutions per second, can be estimated by using a disc that has a dramatic label, or you can simply put a small piece of tape on the side of the disc that is visible and watch it spin.

Keep in mind that a dirty lens can sometimes create symptoms that are similar to those of a bad spindle motor, so always clean the lens first when servicing a CD player. I almost learned this the hard way.

Once the disc is up to speed, the speed control (constant linear velocity—CLV) and tracking servos will be activated (in some equipment, the tracking servo may have been active all the time), and directory data will be read off the disc. Either of those could be faulty and/or misadjusted, making it impossible to access the disc directory.

During the time that the disc is spinning and the player is attempting to read the disc directory, listen for the "gritty" sound that CD players make during normal operation. It is a byproduct of the focus and tracking servos constantly adjusting the lens position. The rapid movements of the lens produces an audible sound, and its presence is a good indication that the laser is working and that focus is being maintained.

Related Problems

Before we wrap up for this month, Let's look at some related problems.

Pickup attempts to reset past inner track: In this case, the sled motor doesn't stop at the inner track but keeps clicking, clunking, or whirring until the controller gives up and displays an error. This might be due to a dirty, worn, or gummed-up limit switch, bad connections, bad mechanical alignment, broken parts, or logic problems.

Most limit switches are mechanical and easily checked with a multimeter. Those that use exposed contacts can be cleaned and burnished; sealed switches found to be erratic should be replaced, though spraying inside through any openings might help. I have disassembled and cleaned similar type switches (they snapped apart) but it is not fun. Make sure the limit switch actually gets tripped when the sled reaches the area of the innermost track. Check for bad connections between the switch and the controller.

Logic problems may be difficult or impossible to locate even with schematics. However, you might get lucky as I did once with a CD-ROM drive with a bad 74LS04 in the drawer-switch interface.

Player won't let you go near it and/or use your favorite lamp: Symptoms here could include a player where, if you touch or go near it, the audio becomes noisy, begins to stutter, skips or even stops completely. Note that this might be similar to other tracking (seek and play) problems. However, since a possible cause of this sort of behavior is more general in nature and can affect many different aspects of CD-player operation, these faults are described separately.

One area that may be overlooked as a cause is the shielding of the pickup's low-level signal cable and any metal parts of the optical deck. Those should all be connected to analog ground of the electronics board. If that ground is missing or broken, there can be all kinds of strange symptoms. If you have recently disassembled the unit and it is now behaving in the manner described, that is a very likely—and, fortunately, easy to fix—possibility. Check for a missing ground strap, jumper, or clip. (Hint: It has probably fallen under your workbench!)

Turning to other possibilities, external interference could make its way into the electronics and produce all sorts of strange behavior. On some poorly designed players—or where you are located close by a radio station—outside interference can get into the player via the audio cables or line cord. A light dimmer on the same circuit might also produce interference via the power supply. Once inside, almost any type of behavior is possible. If your problems seem to depend on the time of day, check out this possibility by relocating the CD player and seeing if the behavior changes substantially. Disconnect the audio cables and see if the unit now displays the disc directory and appears to play properly (try headphones for this, if possible).

It may be difficult to eliminate the effects of the interference without moving away from the radio station or not using your favorite lamp. However, relocating the CD player or even just its cables and/or plugging it into a different outlet might help. Fortunately, those sorts of problems are not that common.

Wrap Up

Once again we have reached the end of our allotted space. I do hope that you are finding this series both interesting and helpful. Next time we will continue with a look a tracking problems (play and seek). Join me again at that time. In the meantime if you have any problems or questions that just can't wait, go to my Web site at www.repairfaq.org. Questions to me should be addressed via e-mail to sam@stdavids.picker.com.

Important note: I regret that time (after all, there's only a finite number of hours in a day) keeps me from answering mail sent via the postal service, but I will respond to e-mail in a timely manner (often within 24 hours) as long as you provide a valid reply address (*e.g.*, I can hit the reply key for my mail program and not have the e-mail bounce!). See you next time.

EN

LETTERS

continued from page 13

Last year I e-mailed you about my opposition to writers not releasing their source code to allow us to modify their projects to fit our needs. I am not interested in any elaborate kit or series of articles that require me to buy pre-programmed chips from the author to make it work. My exception to this was the Dick Smith ESR meter I bought earlier this year, but the value of the finished project outweighs the locked-in Z80 chip. I have e-mailed the designer of that kit several times, and he is quite a helpful fellow.

I like the new "Prototype" section. I'm glad Covington and Goldwasser are working for you. I like both simple and elaborate project articles, whether they relate to computers or other stuff. I read "Hardware Hacker" or whatever Don calls it now. I gave the series of "Computer Connection" articles on the Palm Pilot to my boss who uses one.

As mentioned in my previous e-mail(s), it really helps to have the schematic on the same page (face) as the circuit description text, rather than flipping back and forth between schematics and text to find out how it works.

In general, I really like "our" magazine.
RON TESCHER
via e-mail

I am an engineer at a TV station in Atlanta. I read **Electronics Now** for fun. I enjoy seeing how others devise circuits and like to use ideas as starting points for ideas of my own. I enjoy Don Lancaster but miss the heck out of Jack Darr's "Service Clinic." Sam Goldwasser is doing fine, and I like his articles.

I really am not interested in the latest bleeding edge technology, as I see enough "It's digital because we can do it!" Digital is fine; however, I like to see it used when it makes sense. I like analog power supplies because they can be fixed, and they don't explode, chirp, or smoke like switchers do.

Let other magazines (such as sister magazine **Popular Electronics**) cover the newbie stuff. It would be nice if **Electronics Now** could be devoted to the more complex. I enjoy reading construction articles a great deal, although I rarely build them. I enjoy seeing the project schematics and circuit descriptions.

Modifications are fun. Secrets are better. Things like a secret key sequence that activates a hidden stopwatch in a calculator (HP45 had that) or hidden remote keystrokes that activate maintenance menus in VCRs and TVs.

Tell us things we did not know were possible, like extending a computer keyboard and joystick cord 100 feet with no modifications for extra circuitry other than an extension cord. (I used that trick for my TV station's prompter!)

Tell us that by cutting out a cap or two on a particular AM radio we can increase the fidelity. Or how about a hi-fi AM radio project?

How about modifying a cassette-clock-radio to record at slow speeds to capture entire talk shows to enjoy later? How about a TV Pro-Channel or radio SCA receiver so that we can hear producers talking to TV or radio news reporters in the field? Top 10 markets often use them for cueing.

Please don't become another computer magazine. Discussing PC hardware is fine, but we don't need discussions about software. Little suggestions like connecting an honest-to-goodness chassis-mounted 3-inch speaker (in series with 100 or so ohms) to the internal modem so that you can actually hear the call's progress would be great.
GARY PEARSEY
via e-mail

EN

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Computer Monitor

THE PS790 OFFERS A REVOLUTIONARY 19-INCH (18-inch viewable) "short-depth" display that is ideal for CAD/CAM, graphics, and advanced business users who require a large-screen performance in a small footprint. Comparable to a large-screen performance in a 15-inch (various-viewable) footprint, it's both PC- and MAC-compatible.

With its super-fine 0.25mm dot pitch and Invar shadow mask, the ViewSonic PS790 produces sharp images and easy-to-read text. The advanced SuperClear screen technology enhances brightness up to 30% over conventional CRTs; and it improves color fidelity, creating crisp, color-rich images. A special screen treatment reduces annoying glare and reflection.

Featuring a maximum resolution of 1600 × 1280 and a high refresh rate of 88Hz at a resolution of 1280 × 1024, the innovative short-depth technology of this monitor uses a new type of electron gun with a 100-degree CRT instead of the typical 90 degrees. The wider deflection design creates a smaller beam size that shortens the electron beam distance to produce the 18-inch viewable image. A double dynamic focus system produces better beam-landing accuracy and sharper focus, even in the corners.

Easy-to-use controls, a user-friendly on-screen menu for all screen adjustments, and Plug&Play+—which supports Windows 95 requirements for easy configuration and set up, are found on the PS790. The View Match Control allows users to adjust color temperature and individual color intensity for WYSIWYG screen-to-print matching. The monitor has an estimated street price of $849.

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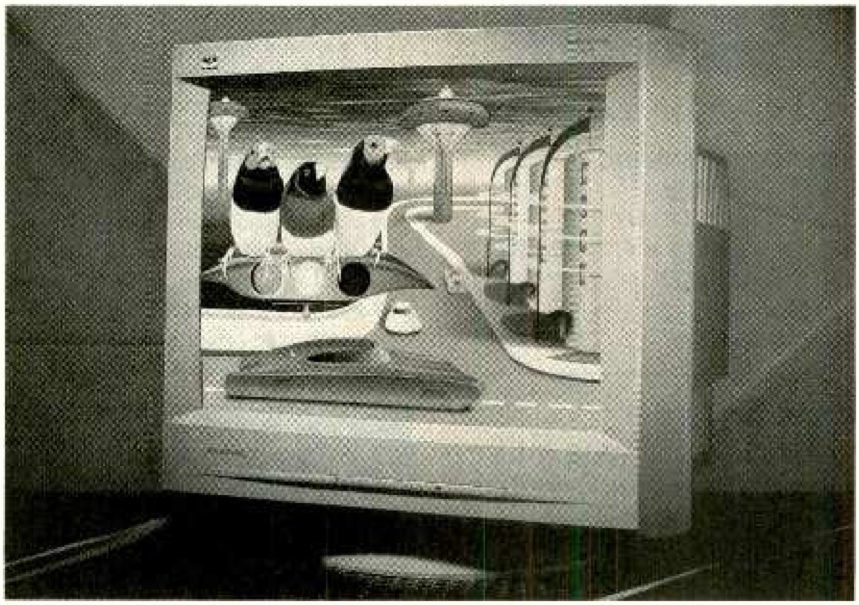
381 Brea Canyon Road
Walnut, CA 91789
Tel: 800-888-8583 or 909-869-7976
Fax: 909-468-3756
Web: www.viewsonic.com



CIRCLE 20 ON FREE INFORMATION CARD

Image-Editing Software

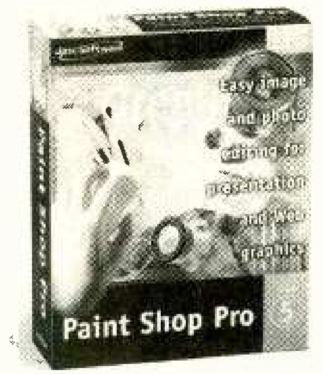
A COMPLETE IMAGE-CREATION and manipulation program, Paint Shop Pro 5 is designed for use in the office, at home, or on the Web. Developed for consumers looking for advanced functionality and for professionals seeking fast and intuitive tools, Paint Shop Pro 5 includes powerful new editing tools, added file management support, and a streamlined interface that makes importing images into Paint Shop Pro 5 a snap.

Other advanced features are designed to create and prepare images for use in business presentations, digital photography, the Web, and other platforms. Multiple layer support, layer-sensitive painting, image-compression options, and re-sizing and image-enhancement tools provide control of variations without affecting the whole image. The free-form deformation tool quickly moves, scales, rotates, skews, and adds perspective to individual layers or entire images in real time, while adjustable tools provide precise control over area selection and image cropping. Included with the software is an innovative Web animation program, Animation Shop.

With its expanded support for over 40 different graphic-file formats, designers can open and save virtually any image file. All the popular Web graphic file formats are supported, including Transparent GIF, PNG, Progressive JPG, and the Kodak FlashPix format. In addition, Paint Shop Pro5 also supports TWAIN scanners, pressure-sensitive tablets, and Photoshop-compatible custom device import and export plug-ins.

The program is designed to meet the needs of the digital photography market as well with a wide range of professional tools that make digital photos look their best. Retouching brushes correct image exposure and adjust saturation and luminance levels and hue. Gaussian blur helps photographers add natural focusing to images, while the clone brush allows users to easily copy and repaint any area of a picture.

Paint Shop Pro5 has a list price of $99. Upgrades for registered users of previous versions are $39. An evaluation copy may be downloaded from the Web site listed below.



CIRCLE 21 ON FREE INFORMATION CARD

JASC SOFTWARE INC.
1101 Smetana Blvd.
Minnetonka, MN 55343
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Fax: 612-930-9172
e-mail: sales@jasc.com
Web: www.jasc.com

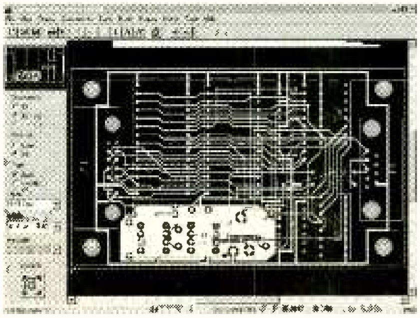
Circuit Simulator

ELECTRONICS WORKBENCH layout—personal edition, a printed circuit board (PCB) design tool that is tightly integrated with Electronics Workbench, Version 5 combines schematic design/capture and board layout in a single package. Both programs (Electronics Workbench plus EWB Layout) sold together are called Personal Design Solution. The complete package now offers designers a fast, convenient way to go from front-end design to back-end layout in a single integrated, comprehensive environment.

The developers have spent time to ensure that all schematic/simulation models are recognized in EWB Layout so users won't experience frustrating "footprint not recognized" errors. A back-annotation feature updates schematics to reflect all reference designator changes made during PCB layout. A netlist-compare function identifies how a schematic has changed since the last time it was saved to PCB, so schematics are easily identified at the layout stage.

EWB Layout comes with powerful features common to most high-end PCB design tools, including on-line design-rule-check to prevent design errors when they occur—eliminating the need to run batch-check programs to discover costly mistakes or design violations. A "force vectors" feature makes suggestions on where to place components to achieve optimal board placement.

It also contains one of the industry's largest libraries of more than 3500 footprints and a shapes editor to create new footprints in seconds. The program provides all the editing functions needed to create complex boards, including the support of power and ground planes, thermal relief, blind and buried vias, 32 board layers, board sizes of up to 50- by 50-inches, and more. A high-speed, high-completion autorouter offers advanced routing options for optimal and customized performance. Built-in support for all external film production and manufacturing methods includes the ability to transfer design data to Gerber files, Mechanical CAD in DXF formatted files, and Excellon Drill files for numeric controlled (N.C.) drilling machines.



CIRCLE 22 ON FREE INFORMATION CARD

Electronics Workbench—Personal Edition and EWB Layout—Personal Edition sell for $299 each and run on any Windows 95 or Windows NT computer. If purchased together, the Personal Design Solution sells for $549.

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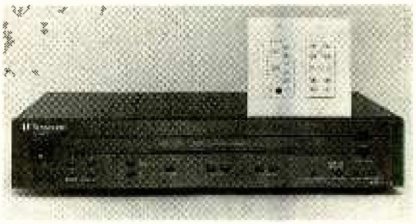
Fax: 416-977-1818
Web: www.interactive.com

Four-Zone Preamplifier

A VERSATILE FOUR-ZONE A/V preamplifier, the PR-4Z is capable of handling three audio-only sources and three A/V sources. The unit consists of four fully independent high-quality stereo pre-amps mounted and interconnected on a single (17- by 12- by 3-inch) chassis. It incorporates Russound's proprietary "source lock" and "source link" modes, which provide convenience benefits in party situations or in installations where playback of a single source is wanted.

In source lock, the PR-4Z automatically feeds the source selected from zone 1 to all other zones. The ability for each zone to change sources is locked out in this mode, while each zone still maintains control of its own volume. This allows a single source to be heard in the den, dining room, and patio—all at individually adjusted volumes. The source link mode allows source selection from any keypad in the system. The host, for instance, would not have to return to zone 1 to change the source from tuner to CD.

In addition to switching between the audio and A/V sources, each of the four independent pre-amps provides volume, bass, treble, and loudness controls for each zone. Zone memory allows preferred playback characteristics to be programmed for each zone. For complex systems, up to four PR-4Zs can be daisy chained, creating a fully integrated 16-zone system with each of the zones maintaining independent stereo operation.



CIRCLE 23 ON FREE INFORMATION CARD

A system-wide page can be activated via an optional push-to-talk keypad or through the paging output of a telephone system, and the volume can be user-adjusted. The PR-4Z can also accept "paging" from door bells, security systems, and other systems. The page overrides all other sources for every zone; and when it is completed, each zone reverts to its previous status. Russound's PR-4Z four-zone A/V preamplifier has a MSRP of $1850.

RUSSOUND
5 Forbes Road
Newmarket, NH 03857
Tel: 800-638-8055
Fax: 800-915-5519
Web: www.russound.com

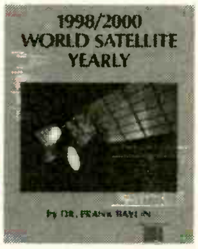
EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

The 1998/2000 World Satellite Yearly

by Dr. Frank Baylin
Baylin Publications
1905 Mariposa
Boulder, CO 80302
Tel: 303-449-4551
Fax: 303-939-8720
Web: www.baylin.com
$90, plus $5 S&H in U.S. and Canada; air shipping elsewhere is $40 per book



CIRCLE 338 ON FREE INFORMATION CARD

This 864-page, $8^1/_2$- × 11-inch, reference book, provides the up-to-date information necessary to determine the satellite programming available at any receive site on the globe as well as the equipment, including satellite dish and associated electronics, required to receive those signals. Written for the educated layman, the book is divided by easy-to-use tabs into four sections: technical, satellite, programming, and reference materials.

The technical section explores the function and use of broadcast satellites. It describes how to read footprint maps, outlines the components of a satellite earth station, and discusses techniques required to size and to aim satellite receive dishes and LNBs. In addition, this section covers broadcast formats, as well as an overview of audio transmission methods.

The latest details about compressed digital video and audio methods and the role of the MPEG2 standard are outlined, including an overview of recent developments in HDTV. Scrambling and encryption techniques; worldwide allocations of communication frequencies; spacecraft, systems, and channel frequency layouts; and mobile satellite-reception systems are presented.

The programming section lists the video programming available on all the world's geostationary broadcast satellites with details that include program name, polarity, frequency, bandwidth, encryption method and language. The 500-page satellites section presents a full data page on each of the world's operational geostationary broadcast satellites in a standardized and comprehensive format.

Also included is a complete directory of satellite programmers, operators, and manufacturers, as well as earth station component manufacturers. Complete and detailed tables, graphs, and equations are found in each chapter.

The ARRL Repeater Directory 1998-1999 Edition

Edited by Jay Mabey, NUOX
American Radio Relay League
225 Main Street
Newington, CT 06111
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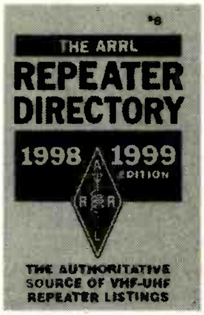


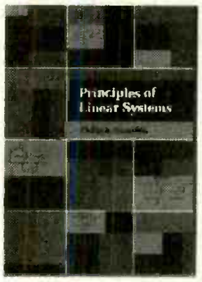
CIRCLE 339 ON FREE INFORMATION CARD

Every new edition of this pocket-size directory provides current frequency and mode information for repeaters throughout North America and, where available, the Caribbean, Central and South America, Pacific Islands under U.S. jurisdiction, Europe, and other areas. There is also information for contacting Frequency Coordinators and ARRL officers. In addition, the introductory chapters provide guidelines for repeater operating practices, autopatch guidelines, an explanation of notes and special features used in the directory, a discussion and listing of band plans, as well as repeater lingo/novice hints.

There have been some changes to the contents of the Repeater Directory. Updated information on all clubs is now found on the League's Web page: www.arl.org. The digital listings that were previously included are now on the Web site of the Tucson Amateur Packet Radio Corp. (TAPR): www.tapr.org/directory.

Principles of Linear Systems

by Philip E. Sarachik
Cambridge University Press
40 West 20th Street
New York, NY 10011-4211
$34.95



CIRCLE 340 ON FREE INFORMATION CARD

This textbook is invaluable for graduate students of aeronautical, electrical, and mechanical engineering, or anyone who wants a background in the fundamentals of linear systems and modern control systems. It concentrates on explaining state-space methods that form the basis of modern control theory, and how those methods are useful in the analysis of linear multiple-input, multiple-output dynamic systems.

Continuous-time and discrete-time systems are treated in parallel, throughout the book, as are time-varying and classical time-invariant systems, highlighting their similarities and differences. The first chapter presents the basic concepts and definitions, followed by a detailed discussion of state equations of finite dimensional systems and their solutions. Then, the principles of time-domain and frequency-domain analysis are covered, as are the properties and applications of the Z-transformation. Both the controllability and observability of linear systems, as well as their stability, are examined in detail.

A useful tutorial review of the key results from matrix theory and linear algebra is given in the Appendix. In addition to illustrative examples, which are completely worked out, numerous problems are available at the end of each chapter.

Radio Components Handbook for the Radio and Electronics Technician: Theory of Components, Book I

by Guido Sliva, I2EO
MFJ Enterprises, Inc.
P.O. Box 494
Mississippi State, MS 39762
Tel: 800-647-1800 or 601-323-5869
Fax: 601-323-6551

CIRCLE 341 ON FREE INFORMATION CARD

$29.95

Designed for engineers, technicians, amateur radio operators, and students, this book presents direct and clear needed information about inductors, loops, transmission lines, capacitors, and more. The author, who is himself an amateur-radio operator, emphasizes the building of circuits.

Everything from the basic theory of radio components to plans for accurate test instruments you can build, plus numerous circuit examples, is provided in this comprehensive guide for ham-radio operators and experimenters. The descriptions for designing and building parts and circuits are written in an easy-to-understand style. Over 100 full-page graphs are included, and formulas and examples are included to illustrate concepts or design questions.

Among the topics discussed are components, circuits, transmitters, power supplies, and transmitting loops and filters. The handbook also covers important data on many different component types. Instructions are given on how to build and use inductors of all types.

Easy PIC'n: A Beginner's Guide to Using PIC16/17 Microcontrollers

by David Benson
Square 1 Electronics
P.O. Box 501
Kelseyville, CA 95451
Tel: 707-279-8881
Web: www.sq-1.com

$29.95

CIRCLE 342 ON FREE INFORMATION CARD

The PIC16/17 from Microchip Technology, Inc. was originally designed to be a very fast I/O controller. The PIC16F84 microcontroller is unique because its program memory is made using FLASH technology. It can be programmed, tested in-circuit, and reprogrammed if necessary in a few minutes.

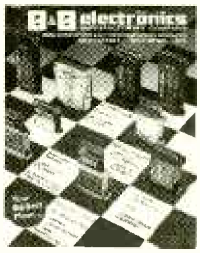
Intended to help the beginner with understanding and application of the PIC16/17 line of microcontrollers, this book uses a hands-on approach. There are many examples given throughout, all of which may be demonstrated using a very simple demo board—a project explained at the beginning of the book.

The author uses the MPASM assembler from Microchip Technology in the book, because, as he explains, it is in common use; is free from the manufacturer; is included in MPLAB, a popular Microchip development software package; and examples on the Internet are written in MPASM. The examples of assembly-language programs that are presented range from a simple one to turn on LEDs to more complex ones for timing and for event-counting. Writing programs is covered in-depth. The use of flow charts as an aid to visualizing what a program does is emphasized.

Data Acquisition and Communications Catalog

B&B Electronics Manufacturing Company
707 Dayton Road
P.O. Box 1040
Ottawa, IL 61350
Tel: 815-433-5100
Fax: 815-434-7094
e-mail: catrqst@bb-elec.com or sales@bb-elec.com
Web: www.bb-elec.com

Free



CIRCLE 343 ON FREE INFORMATION CARD

This 52-page catalog shows solutions to computer serial-port connection problems. Their port-mounted converters allow incompatible interfaces to be connected, and they communicate at distances up to 4000 feet.

New product highlights include 9-pin port-powered converters with SD control that change TD and RD RS-232 lines to balanced half-duplex, two-wire RS-485 signals; RS-232 asynchronous to synchronous converters that can interface with marine navigation equipment; PCI bus Ethernet cards; port intelligent controller cards; and software programming tools, such as CommLib 5.2 and ArchiveLib 2.12. Also featured are communications and PCMIA cards; fiber-optic products; data-acquisition modules; optoisolators, surge protectors, and security devices; and digital multimeters designed to read low-voltage communications-line signals, some with built-in memory and the ability to download to a PC.

In addition to product descriptions, the catalog presents technical data and application information. EN

BURN PIC MICROCONTROLLERS WITH A "NO PARTS" PIC PROGRAMMER

Now you can "magically" create your own custom PICs with this simple programmer.

MICHAEL A. COVINGTON

When creating and designing a new electronics project, the current trend is to try to keep the descriptive terms "low-cost," "full-featured," and "ultra-compact" in the top slots in a list of features. That used to be hard to do. Fortunately, over the last several years, designing a project with those attributes has become much easier thanks to the development of programmable devices such as the PIC microcontroller family from Microchip Technologies. Looking over the last year's worth of construction articles that have been published in **Electronics Now** shows just how commonplace those microcontrollers have become.

Unfortunately, some sort of programming device is needed to "burn" the software into those programmable chips. The cost of such a device could easily wipe out any savings from using a microcontroller in a project—until now.

Obviously, the PIC programmer presented here needs *some* parts in order to build it. The nicest feature of the unit is that it needs no specialized parts, and it's a very simple circuit. The unit can be built in about an hour with parts from either your junk box or the nearest RadioShack store. Connect it to the printer port of any handy PC (the port need not be bi-directional), run the free software, and you can get started programming PIC16F84, 16F83, and 16C84 microcontrollers immediately. With an adjustable power supply, you can even do production-grade work.

What's a PIC? A PIC, like most microcontrollers, is a tiny computer with CPU, ROM, RAM, and I/O circuits all on one chip. Microcontrollers are the fastest-growing segment of the electronics industry; the average home now contains about 100 of them in everything from microwave ovens to wristwatches.

Many microcontroller applications don't involve computing, at least not as you'd normally think of it. A microcontroller is best thought of as an IC that you can customize by writing a program in assembly language. You then download the program into the ROM area of the microcontroller, and the microcontroller becomes a custom IC. Sometimes the program is designed to be little more than a logic gate or an oscillator, but what's important is that it does exactly what you tell it to do.

Among the low-end microcontrollers, the PIC family from Microchip, Inc. is especially popular because of their simplicity and low cost. Additionally, much of the software used to create the program code needed for programming PICs is available free for downloading from Microchip's Web site (www.microchip.com).

Of the various types of PICs that are available, the 16F83, 16F84, and 16C84 are probably the easiest to work with. Those particular models are the ones that our programmer supports. They cost less than $6 each, and their ROM is electrically erasable so that you don't need an ultraviolet light to erase and reprogram the devices.

The 16F84 is the most popular of the three—it has 68 bytes of RAM and 1024 words of program memory. The program memory is a "flash"

EEPROM that can be rewritten over a million times. Any stored information will be preserved for over 40 years without any power. The 16C84 is very similar but uses an older type of EEPROM. The 16F83 can be considered a "little brother" in that it has only half as much memory; on the plus side, it is somewhat lower in cost.

Unlike most microcontrollers, Those PICs don't require quartz crystals or resonators for their clock; you can use a resistor and capacitor as the oscillating elements. They also do not need a tightly-regulated power supply. The supply voltage for the 16F84 can be anywhere from 4 to 6 volts. An extended-voltage-range version can work with the supply being as low as 2 volts. There are 13 input/output pins, each of which can be set individually to be either an output or an input—with or without a built-in pull-up resistor.

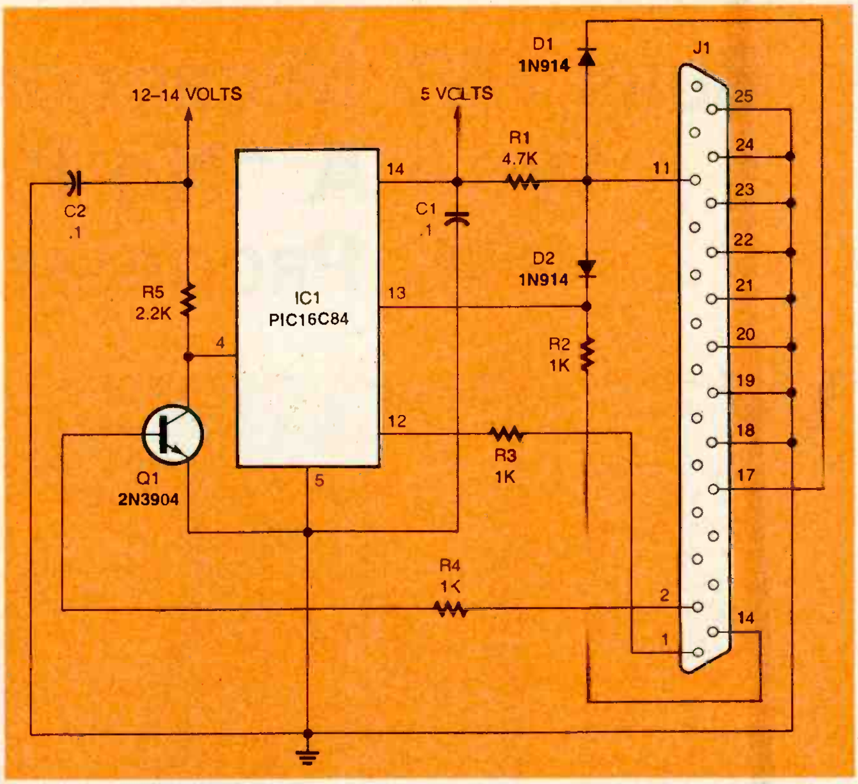


Fig. 1. The "No Parts" PIC Programmer is a simple circuit that attaches to the printer port of a PC. It can program, verify, and erase 16F84, 16C84, and 16C83 PIC chips.

The "No Parts" Programmer. Programming the above-mentioned PIC chips is unusually simple. Apply 5 volts to pin 14 (with pin 5 connected to ground) and raise the voltage on pin 4 to between 12 and 14 volts. The data is then clocked in one bit at a time through pins 13 and 12. The data itself is sent to pin 13. Once the bit is ready, the voltage on pin 12 is raised to 5 volts for at least 0.1 microseconds before being lowered back to ground. The data stream going into the chip contains both commands that specify the various steps in the programming process and the data that will be stored in the chip's ROM. To verify that the PIC was programmed correctly, the PIC can also send its contents back out through pin 13. For those who are interested in the full technical details on programming PIC chips, specifications for programming and verification can be found on Microchip's Web site (www.microchip.com).

The schematic diagram for the "No Parts" PIC Programmer, as shown in Fig. 1, is as simple as the programming process that it supports. The circuit is designed to plug into the printer port of any PC. The programming data and clock signals are applied to IC1—the PIC being programmed—through R2 and R3. Diodes D1, D2, and resistor R1 let pin 13 of IC1 be used as both an input for programming and as an output for verification. When pin 17 on the printer port is high, the PC can read data from pin 13 of IC1 through pin 11 of the printer port. In that mode, R1 and D2 provide pull-up for the data signal. When pin 11 of the printer port is low, D1 conducts. The anode of D2 is grounded, blocking current flow. The PIC chip is then free to receive data from pin 14 of the printer port. The connection that D1 creates between pins 11 and 17 on the printer port lets the programming software detect if the programmer is connected to the printer port.

Capacitors C1 and C2 eliminate noise in the DC power lines. The programming voltage is switched by Q1.

Two power supplies are needed to run the "No Parts" PIC Programmer: 5 volts and 12-14 volts. If you're doing any experimentation with digital circuits, you probably already have a power supply available that provides those voltage levels. Obviously, that supply can also be used for the programmer. Another alternative is to "borrow" the voltages from a diskette-drive power connector inside the PC. Make sure that the 12-volt line is not less than 12.0 volts. If you use that power source, you should be comfortable opening up your PC and working with the internal components. If you aren't and don't know someone qualified that can help you, you can use the power-supply schematic shown in Fig. 2. That schematic is taken from the data sheet for the LM317 adjustable-voltage regulator, and is provided here only for experimentation purposes. The complete data sheet for the LM317 is available

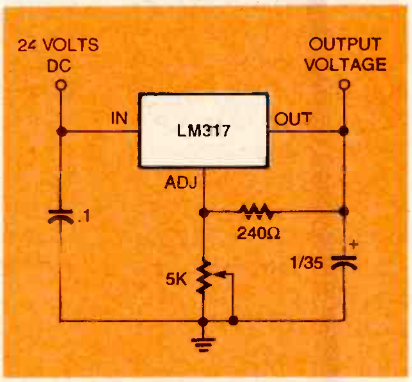


Fig. 2. With some testing, this power-supply schematic can be used with the "No Parts" PIC Programmer. By using two circuits, you can have an adjustable 5-volt power supply for production-grade verification of programmed PICs.

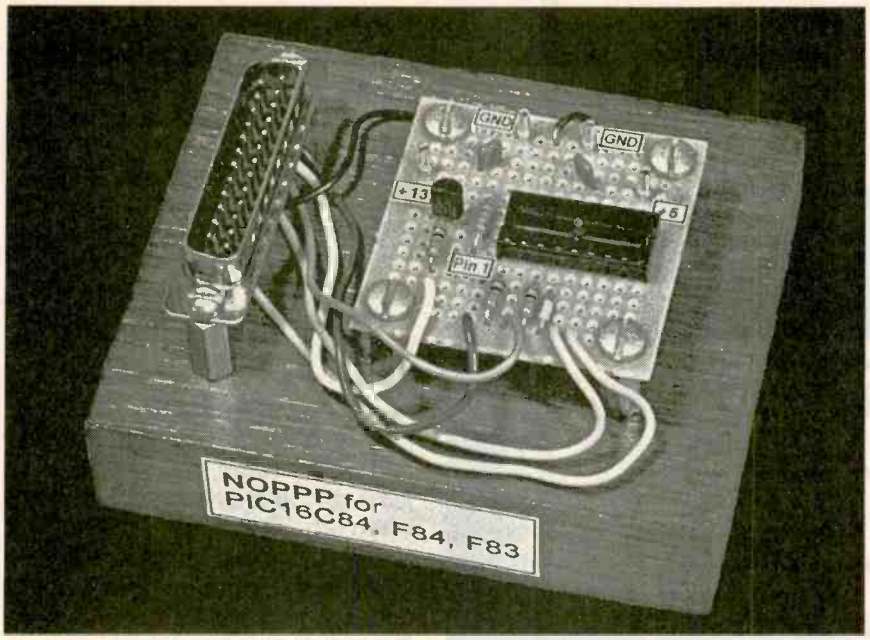


Fig. 3. The assembled "No Parts" PIC Programmer can be as simple or as fancy as you want.

from National Semiconductor's Web site (www.national.com).

The programmer's circuit is so simple, it can be easily built on a piece of perfboard using standard construction techniques. A zero-insertion-force (ZIF) socket can be used at IC1 as a professional touch but is not required. With a suitable adapter, surface-mount PICs can also be programmed. The packaging of the unit can be as simple or as fancy as you want. The author's prototype, shown in Fig. 3, was mounted on a hardwood base that was stained and varnished for a "home-built-with-old-world-pride" look. Mounting the cable connector separately as shown makes the "No Parts" PIC Programmer easy to use—simply connect it to the PC's printer port with a suitably-long 25-conductor cable.

PIC Programming. The easiest way to learn to use the "No Parts" PIC Programmer is to actually write a simple program and burn a chip. Learning about the programmer that way is also a good way to test out the hardware and software.

For example, let's look at the simple problem of building an LED "light chaser," a circuit that will light up one LED after another, in sequence, over and over. You could do it with three ICs: an oscillator, a binary counter, and a decoder/demultiplexer. A PIC version of the circuit is shown in Fig. 4.

Although that circuit might cost a bit more than a traditional digital circuit, it is certainly smaller in terms of the physical size of the board needed to hold all of the components. However, there is another feature to using a PIC for such a mundane task—intelligence. Different patterns can be generated or multiple patterns can be selected with the addition of a simple switch arrangement. With discrete components, the circuit would have to be scrapped and re-designed to accommodate changes like those. With a PIC, it is a simple matter of modifying the program, erasing the PIC, and re-programming it.

Let's get back to our example. The program itself, written in PIC assembly language, is shown in Listing 1. The most important part of any program is the documentation. If you leave notes in the program, you'll remember what you were trying to do if you have to review the program at some time in the future. In the program listing, those notes are any lines that start with a semicolon. Those lines will be ignored by the software, called an *assembler*, that will turn the text in the program into the binary numbers that the PIC recognizes as instructions.

The first three instructions, *processor*, *include*, and *__config*, are instructions to the assembler. The first instruction tells the assembler to use 16F84 instructions. The second instruction says to include a set of predefined constants in a file called P16F84.INC. Finally, the third instruction sets various configuration bits in the PIC to turn some hardware features on or off. In this example, the chip will be using its RC oscillator, its "watchdog" timer will be turned off, and the automatic power-up reset timer will be turned on. That way, the

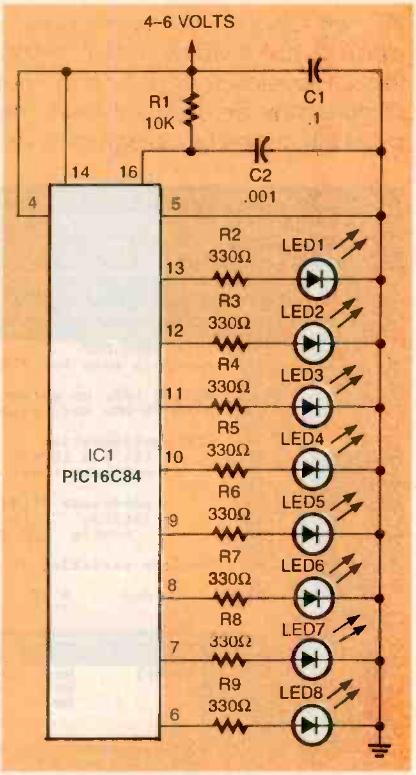


Fig. 4. Here is a simple PIC circuit that, with the accompanying software, flashes the LEDs in a "chaser" sequence.

PARTS LIST FOR THE "NO PARTS" PIC PROGRAMMER

SEMICONDUCTORS

IC1—PIC16C84, PIC16F84, or PIC16F83 microcontroller, unprogrammed
D1, D2—1N914 silicon diode
Q1—2N3904 NPN silicon transistor

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—4700-ohm
R2–R4—1000-ohm
R5—2200-ohm

ADDITIONAL PARTS AND MATERIALS

C1, C2—0.1-µF ceramic-disc capacitor
J1—DB25 male connector
Socket for IC1, 25-conductor cable, hardware, etc.

PIC will reboot whenever power is applied, but it won't automatically reboot several times a second. That feature may be used if there is the possibility of the PIC program "locking up" or for a special timing arrangement in a control application.

It is important to use the *__config* instruction in any programs used

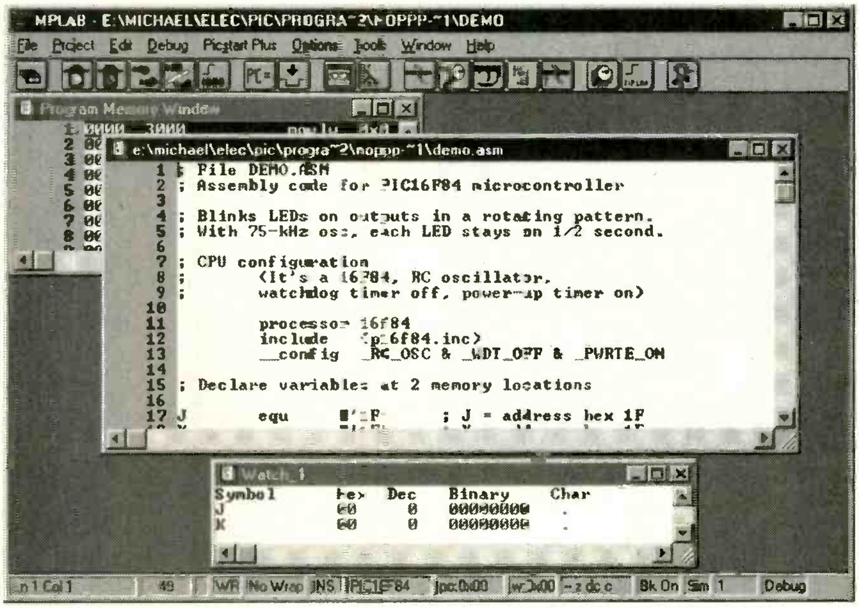


Fig. 5. MPLAB software, free from Microchip, lets you assemble and test PIC programs.

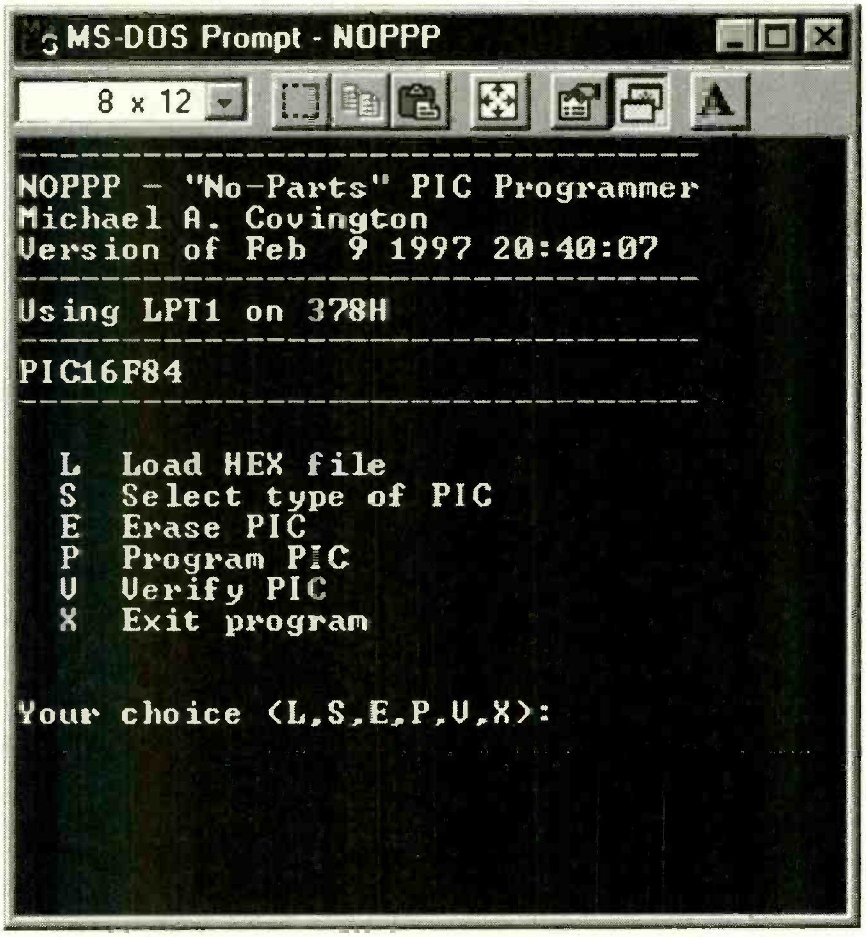


Fig. 6. The NOPPP software does the actual work of "burning" PICs. Shown here running under Windows 95, it also runs under DOS, Windows 3.1, and OS/2.

with the "No Parts" PIC Programmer. The assembler program will not be doing the actual programming—it will only be creating a file with the numbers that will be transferred to the PIC chip as a second step.

The two *equ* instructions reserve memory space in the PIC's RAM for two variables, which we'll be calling "J" and "K." It is just like declaring variables in BASIC, only we need to say which physical RAM locations will be used. In this case, those locations are (in hexadecimal numbering) 1E and 1F. Those locations will be used to store counters to keep track of how many times a loop has been repeated.

The *org* instruction tells the assembler that the program starts at location 0 in program memory and that the actual program is next.

The first real PIC instruction is a *movlw* instruction that clears the working register (called *W*). That number is then copied into the TRIS control register for port B, setting pins 6–13 to output pins instead of input pins. Next, the program puts binary 00000001 into the W register and copies it to Port B. That lights the LED connected to pin 6. But before you have time to actually see the LED come on, the program executes an *rlf* instruction that rotates the contents of Port B to the left, changing the data to 00000010. That will light the second LED attached to pin 7 instead. Repeating that instruction will give 00000100, then 00001000, and so on, making the LEDs flash in a marching pattern.

In between rotations, the program needs to wait about ½ second so that the action isn't too fast to see. That's why we have a delay loop in the program. It stores the decimal number 50 in memory locations "J" and "K," using the *decfsz* instruction to count down from 50 to 0.

Conditional instructions on the PIC are somewhat unusual, and decfsz is no exception. It stands for "Decrement and skip next instruction if zero." Translating the program into English, the instructions

```
kloop:   decfsz   K,f
         goto     kloop
```

mean "Subtract 1 from variable K,

LISTING 1

```
; File DEMO.ASM
; Assembly code for PIC16F84 microcontroller

; Blinks LEDs on outputs in a rotating pattern.
; With 75-kHz osc, each LED stays on 1/2 second.

; CPU configuration
;         (It's a 16F84, RC oscillator,
;         watchdog timer off, power-up timer on)

          processor 16f84
          include   <p16f84.inc>
          __config  _RC_OSC & _WDT_OFF & _PWRTE_ON

; Declare variables at 2 memory locations

J         equu      H'1F'       ; J = address hex 1F
K         equ       H'1E'       ; K = address hex 1E

; Program

          org       0           ; start at address 0

          ; Set port B as output and initialize it

          movlw     B'00000000'     ; w := 00000000 binary
          tris      PORTB           ; port B ctrl register := w
          movlw     B'00000001'     ; w := 00000001 binary
          movwf     PORTB           ; port B itself := w

          ; Rotate the bits of port B leftward

mloop:    rlf       PORTB,f

          ; Waste some time by executing nested loops

          movlw     D'50'       ; w := 50 decimal
          movwf     J           ; J := w
jloop:    movwf     K           ; K := w
kloop:    decfsz    K,f         ; K = K-1, skip next if zero
          goto      kloop
          decfsz    J,f         ; J = J-1, skip next if zero
          goto      jloop

          ; Do it all again

          goto      mloop

          end
```

and if the result is zero, skip the goto instruction." Normally, the result is not zero and the goto part of the instruction is not skipped. Instead, the loop executes repeatedly until K reaches zero. As you can see, if you like double negatives—or rather, *don't not* like double negatives, you'll love programming PICs. The actual program uses two loops, one nested within the other.

Finally, *goto mloop* sends execution back to the beginning of the program. The *end* instruction is not a CPU instruction; instead, it tells the assembler that the program is over.

The 16F84 has 35 different CPU instructions. As you can see from the simple program we just created, you don't have to master all of them in order to write useful programs.

Compiling Programs. At the Microchip Web site, you can get data sheets, application notes, and best of all, MPLAB, which is a full-featured development program for compiling and testing PIC programs. It is designed to run under Microsoft Windows. A sample screen shot seen in Fig. 5 shows our demo program being edited. The MPLAB software lets you edit assembly-language programs (also called *source code*), assemble them into object code, and then step through the resulting binary code to see what it will actually make the microcontroller do. That way, you can spot any logical errors in your programming before you actually commit any code to hardware.

The Microchip software is well documented on its use. We are going to be using MPLAB to create an object-code file from the source-code text we typed in from Listing 1. Be ready for an error message when compiling the program. MPASM will complain mildly that you're not supposed to use the *tris* instruction. Microchip has dropped support for that instruction and some future PIC processors might not support it. A nice feature of the PIC from a software point of view is what is called *source-code compatibility*. If your design outgrows the resources of the chip that you started with, you can use another chip with more resources without having to rewrite the program from scratch. For our purposes, using the *tris* instruction on the 16C84, 16F84, and 16F83 works fine. Besides, the alternative way of setting up Port B for output is much more complicated.

"Burning" a PIC. A second piece of software is needed for actually using the "No Parts" PIC Programmer. That software is available at the Gernsback Web site (ftp://ftp.gernsback.com/pub/EN/noppp.zip). That MS-DOS program runs well under Windows 3.x or Windows 95. If, however, you are running it under Windows 3.1, it will work best if you run the application "full screen" instead of in a window. Timing is critical for the programming pulses, and full-screen DOS applications get full control of the computer. If for some reason you have difficulty running the NOPPP program under Windows 3.1, try exiting to a DOS prompt and run it from there. You can even run the program under OS/2; if you do, be sure to set the HW_TIMER to "on" in the DOS settings for the program.

The first step is to connect the "No Parts" PIC Programmer to the PC's printer port and start the NOPPP program without any power connected to the programmer. If the 5-volt line is grounded, the software will not be able to detect D1, and will assume that the programmer is not attached to the printer port.

If all is well, you should see a screen similar to the one shown in Fig. 6. The menu of choices is self-explanatory. In general, you would want to load an object-code file (with a .HEX extension in the filename) into memory, select the type of PIC that you will be programming, program the part, and then verify that the code was programmed into the chip correctly. You can also erase a PIC that has already been programmed for re-use or updating of the programming. One note of caution: you should never insert or remove a PIC from the programmer while the power to the programmer is on. When programming a PIC, the software will tell you what to do and when to do it.

Since the programmer software requires some tricky timing, it was written to run as a DOS program. Recall that the clock pulses for programming the PIC have to last at least 0.1 microseconds. In practice, they are somewhat longer in order to overcome any signal "bounce" in the cables. However, they shouldn't be too long or the programming process will go too slowly. It is also important that the pulse timing not depend on the speed of the computer's CPU. Because the software was written with that in mind, it will run on any IBM-compatible from a 4.77-MHz XT up to the latest Pentiums.

To achieve that, the programmer software uses one of the timers built into the PC motherboard. One of the PC's built-in timers produces an interrupt 18.2 times per second (65,536 times in a 24-hour day). That timer is used to update DOS's time-of-day clock, and some software uses it to manage any concurrent processes. However, 18.2 times per second is far too slow to be useful for PIC programming. The software instead uses the other timer that is normally used to control the tones in the internal speaker. The time delay available from that timer can be set to 25 microseconds, so that even on the fastest Pentiums, the programming pulses are not too short. There will be some unpredictable software overhead, so the pulses will come out a bit too long on the slowest PCs, but not long enough to do any harm.

Production-Grade Programming. As cheap and as simple as it is, the "No Parts" PIC Programmer can qualify as a production-grade programmer for confirming the reliability of your programmed PICs. How? By varying the 5-volt supply over the entire specified range while verifying the PIC. To do that, you'll of course need an adjustable 5-volt supply. First program and verify the PIC with the 5-volt supply set to 5.0 volts. Next, set the 5-volt supply to 6.0 volts and verify again. Finally, verify the PIC a third time with the 5-volt supply set to 4.0 volts.

Why does that guarantee reliability? Because the main source of unreliability in EPROMs of any type is that some of the cells might not be completely programmed or completely erased. If a particular location is only "half on" or "half-off", it might read correctly for a while but then shift to the wrong value with age or changes in the supply voltage. The result is that the ROM contents change unpredictably and the microcontroller fails during use. By shifting the 5-volt supply voltage up and down, you change the threshold voltages that define 0 and 1 so that you can detect marginally programmed bits. The cheapest commercial programmers don't have that feature at all. Higher-quality units do it partly in that they raise the supply voltage but not lower it. The "No Parts" PIC Programmer gives you full control over the supply voltage, making it easy to test any programmed part over the chip's full voltage range.

The author would like to acknowledge David Tait in England for his work on TOPIC, a PIC programming package of which the "No Parts" PIC Programmer is a direct descendant. Mr. Tait's work has been distributed on the Internet, and he has given his permission for this adaptation. The TOPIC software works with "No Parts" PIC Programmer hardware and vice versa. Because of that compatibility, the TOPIC package has been included with the NOPPP software on the Gernsback Web site (www.gernsback.com). Ω

SOURCES OF PARTS AND INFORMATION

Digi-Key Corporation
701 Brooks Avenue, South
Thief River Falls, MN 56701
1-800-DIGIKEY
http://www.digikey.com
Sells PIC microcontrollers and development systems.

Dontronics
P.O. Box 595
Tullamarine 3043
Australia
http://www.dontronics.com
Circuit boards, software tools, kits, and other supplies for PIC programming, many of them available nowhere else. Quick shipment all over the world.

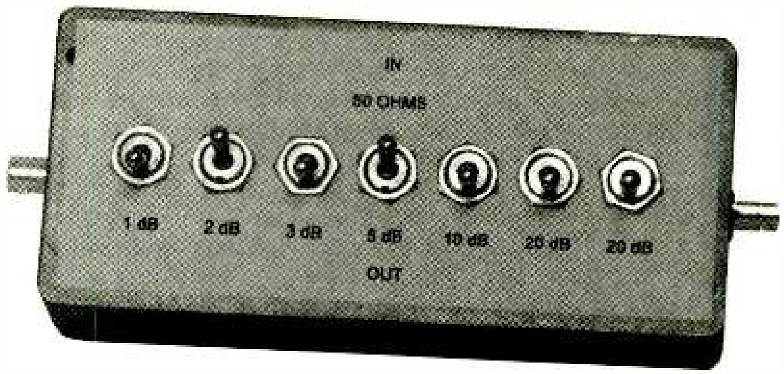
Jameco Electronic Components
1355 Shoreway Road
Belmont, CA 94002
1-415-592-8097
http://www.jameco.com
PIC microcontrollers, other digital ICs, parts, and kits for the experimenter.

Microchip, Inc.
2355 W. Chandler Boulevard
Chandler, AZ 85224
http://www.microchip.com
Maker of PIC microcontrollers. Data books and free software distributed from web site and on CD-ROM.

Square 1 Electronics
P.O. Box 501
Kelseyville, CA 95451
squareone@zapcom.net
Publishes and sells two books, Easy PIC'n and PIC'n Up the Pace, which are excellent guides to PIC programming for the beginner.

ALL ABOUT ATTENUATORS

RON TIPTON



Here's some information on how attenuators work, how they're used, and a small sampling of circuits you can use the next time you need one.

An attenuator is defined as "a device used to reduce the power (or voltage) level of a signal while introducing little or no distortion." They come in all shapes and sizes and can be arbitrarily placed in two general groups: active and passive, and the passive grouping can be further divided down into fixed and variable subgroups. As the name implies, the passive attenuators use only resistors to reduce the signal level, while the active devices use transistors or ICs to perform a resistance function. In this article, we are going to look into the various types of attenuators and attenuator circuits, show you how to use them, and show you how you can build your own.

Passive Fixed Attenuators. This type of attenuator is readily available as an off-the shelf commercial product and is most often packaged as coaxial or plug-in modules. The coaxial models are usually built with SMA, N, or BNC connectors, as well as with special connectors such as the General Radio type "GR874," and have a usefully flat response from DC to 6 GHz (6000 MHz). Typically, plug-in units have 0.030-inch diameter pins arranged on a tenth-inch grid to allow them to plug into sockets or socket pins on a printed circuit board. Plug-in units are usually rated for a flat response from DC to 1500 MHz.

Inside, a passive fixed attenuator is made up of resistors connected in a "tee" or "pi" configuration as shown in Fig. 1. Also shown in that figure are the values of resistors needed for various levels of attenuation. Those values assume a 50-ohm line impedance, but values can be calculated for 75- or 93-ohm lines if needed.

Coaxial models could be built using ordinary ¼- or ½-watt metal-film resistors, but then their high-frequency response would be limited to a few hundred megahertz at best. The 6-GHz (and higher) range is achieved using special coaxial resistors in which the thin resistive film is deposited on ceramic forms that physically match the size of the outer conductive shell.

Both coaxial and modular (plug-in) attenuators are used to reduce power levels, set mixer input levels, balance phase-detector inputs, and so forth. Fixed models are generally less expensive and perhaps more stable than a variable unit would be in those applications.

One final note before we move on. Both the tee and pi networks work equally well. If building your own attenuator, the choice of which to use is largely determined by available resistor values.

Passive Variable Attenuators. This category is much larger than the "fixed" group, because it contains switched-tee and -pi units, continuously-variable attenuators, and voltage dividers.

It is easy to build a switched-tee attenuator. All you need are some 1% metal-film resistors, DPDT toggle switches, input and output connectors, and a suitable case. The circuit diagram in Fig. 2 shows a 50-ohm attenuator that can be set from zero to 61 dB in 1-dB steps. A tee design was used because it proved to be a better fit to standard resistor values. The author's completed unit, which is shown at the beginning of this article, uses male BNC connectors and a cast aluminum case, such as those stocked by Mouser Electronics, Digi-Key Corporation and others (size isn't especially critical for this application). Some commercial attenuators use Teflon-body toggle switches to help extend the frequency range, but ordinary, off-the-shelf switches are usable to 50 MHz or higher if care is taken during construction.

This unit is used by the author for setting the output level of oscillators and function generators with inadequate internal attenuators, or none. It's also useful for checking the automatic gain control (AGC) range in a new receiver using a real off-the-air signal: just connect the attenuator between the receiver and antenna, tune in a signal, and increase the attenuation until the signal is lost.

Of course, any potentiometer, or "pot," is a continuously-variable attenuator. We use them in dimmer circuits for setting room illumination and controlling the sound level from all kinds of entertainment equipment, as well as in a myriad of other applications. But sometimes a simple pot won't do. Figure 3 shows a constant-impedance continuously-variable attenuator used to set a function generator's output level. This particular circuit was used in the Hewlett-Packard model 3300A function generator, but it is typical of the breed. It provides a fairly constant 600-ohm output impedance that is independent of the voltage setting. The spec sheet says it has a 40-dB range; actually it's about 45 dB. This is a useful circuit to keep in your bag of tricks, although finding the ganged pots might be a challenge.

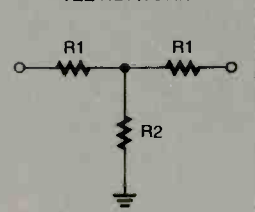
Voltage Dividers. Since all attenuators are also voltage dividers, you might wonder why they are treated as a separate group. Though the author has not seen it stated this way, the difference in general is that attenuators are matched to the impedance of their source and load, while voltage dividers aren't. Voltage dividers usually have a fairly high input impedance so they don't load the driving source. And they need a low enough output impedance so that their load does not appreciably change the output voltage.

Figure 4 shows a simple switched divider that the author built to increase the output voltage range of a function generator. It has a 10,000-ohm input resistance, which can be easily driven by the generator's 50- or 600-ohm output. A one-megohm or higher load, such as a voltmeter, changes the output voltage by no more than 1% at any switch setting. If built into a small cast aluminum case, this useful workbench accessory can be used wherever it is needed. The resistor values are easily scaled if you need either a higher or lower input resistance.

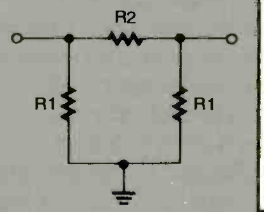
Precision voltage dividers are known as Kelvin-Varley dividers and often have large coin-silver switch contacts (for low resistance) as shown in Fig. 5. The circuit diagram for this unit (see Fig. 6.) shows a four-decade divider, though it could be extended to five, six, or even seven decades as needed. So, how does this divider work?

There are 11 equal-value resistors in the first or input decade. But two of those series resistors are always in parallel with the second decade. The second decade has a total series resistance equal to the paralleled pair in the first decade. Thus, the first decade looks like a simple 10-resistor divider.

TEE NETWORK



PI NETWORK



ATTENUATION (dB)	TEE R1 (Ω)	TEE R2(Ω)	PI R1 (Ω)	PI R2 (Ω)
1	2.9	433.3	870.0	5.8
2	5.7	215.2	436.0	11.6
3	8.5	141.9	292.0	17.6
4	11.3	104.8	221.0	23.8
5	14.0	82.2	178.6	30.4
6	16.6	66.9	150.5	37.3
7	19.0	55.8	130.7	44.8
8	21.5	47.3	116.0	52.8
9	23.8	40.6	105.0	61.6
10	26.0	35.0	96.2	71.2
11	28.0	30.6	89.2	81.6
12	30.0	26.8	83.5	93.2
13	31.7	23.5	78.8	106.0
14	33.3	20.8	74.9	120.3
15	35.0	18.4	71.6	136.1
16	36.3	16.2	68.8	153.8
17	37.6	14.4	66.4	173.4
18	38.8	12.8	64.4	195.4
19	40.0	11.4	62.6	220.0
20	41.0	10.0	61.0	247.5
21	41.8	9.0	59.7	278.2
22	42.6	8.0	58.6	312.7
23	43.4	7.1	57.6	351.9
24	44.0	6.3	56.7	394.6
25	44.7	5.6	56.0	443.1
30	47.0	3.2	53.2	789.7
35	48.2	1.8	51.8	1405.4
40	49.0	1.0	51.0	2500.0
45	49.4	0.56	50.5	4446.0
50	49.7	0.32	50.3	7905.6
55	49.8	0.18	50.2	14058.0
60	49.9	0.10	50.1	25000.0

Fig. 1. To build your own passive attenuators, a simple tee or pi network can be used. The table of values in this figure assumes a line impedance of 50 ohms.

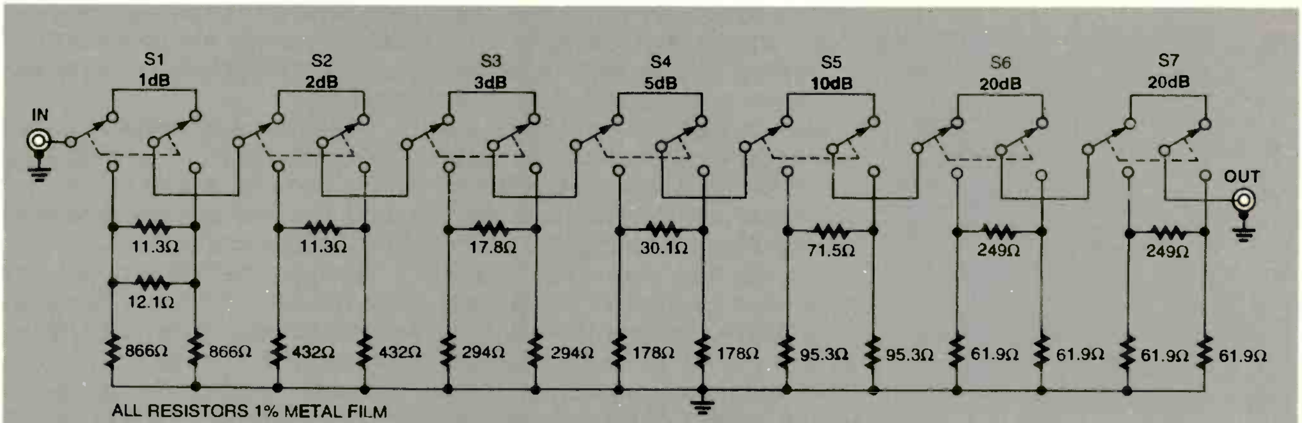


Fig. 2. Here's a 50-ohm attenuator that can be set from zero to 61 dB in 1-dB steps. A tee design was used because it proved to be a better fit to standard resistor values.

Continuing on, we see that this scheme is repeated: The third decade is always in parallel with two series resistors in the second decade, and so on. In short, we get a constant 5-to-1 resistance ratio between successive decades, which means that the resistance values can get rather small as we add decades. That becomes the practical limit on how many decades we can add. A seven-decade divider with a 100,000-ohm input resistance needs 0.64-ohm resistors in the last decade. The last decade is always a ten-step divider, or continuously variable pot, to enable a "unity" output. If that were not done, the maximum output would be 0.9999 (for four decades), which wouldn't quite do the job.

Kelvin-Varley dividers are usually built with highly accurate and stable resistors so as to have excellent linearity. Older models from companies such as General Radio, Electro Scientific Industries (ESI), John Fluke,

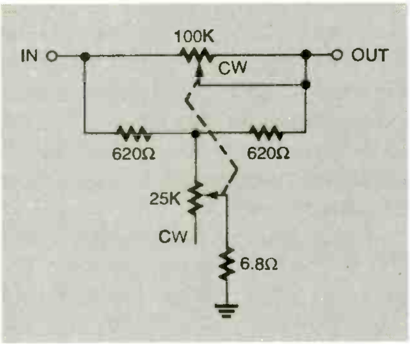


Fig. 3. Originally used in the HP-3000A function generator, this continuously variable attenuator provides a fairly constant 600-ohm output impedance that is independent of the voltage setting. Note that the potentiometers are ganged on a single shaft.

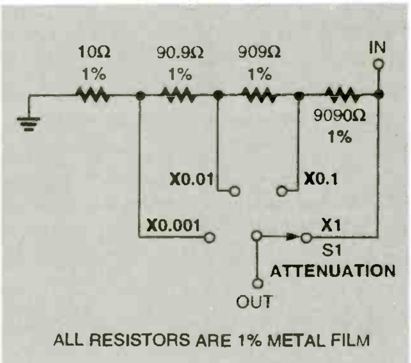


Fig. 4. This simple switched voltage divider was built by the author to increase the output voltage range of a function generator. It has a 10,000-ohm input resistance.

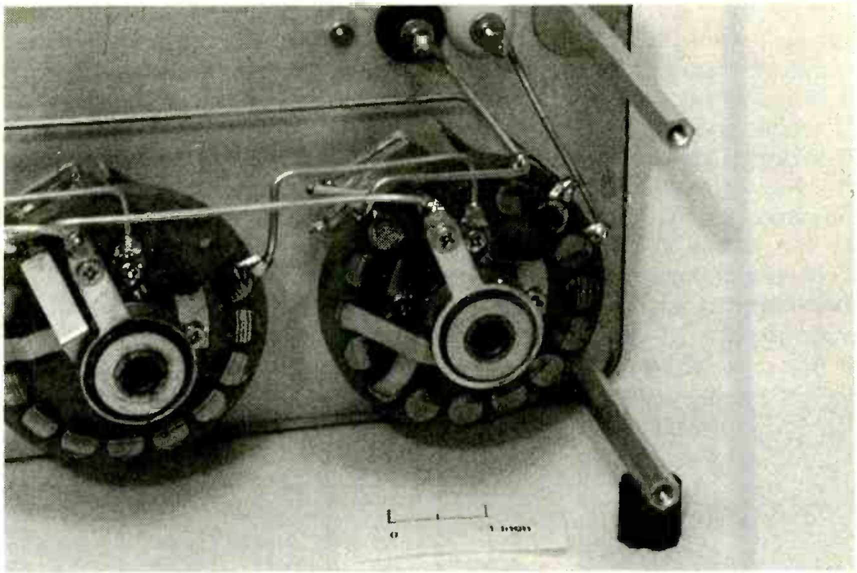


Fig. 5. This General Radio Kelvin-Varley voltage divider features low resistance coin-silver switch contacts and precision wire wound resistors.

and IET Labs often work as well as they did when new, even if that was 30 or 40 years ago!

Active Attenuators. Active attenuators are frequently designed so that the level of attenuation can be digitally controlled, say by a computer or microprocessor, but that is not always the case. For example, the Motorola Semiconductor MC3340P is controlled by a DC voltage or an external variable resistor (which controls a DC current). With a frequency response that's flat to about a megahertz and an attenuation range of more than 80 dB, that is quite a versatile component. The total harmonic distortion in the output signal rises to over 3% at attenuations of more than 40 dB. Whether that is acceptable or not will depend on your application.

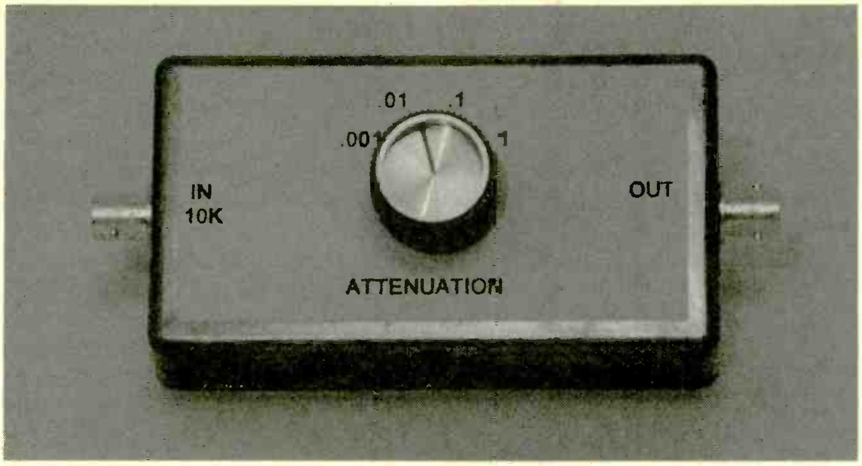
Analog Devices calls its AD8402 a "digital potentiometer," because it uses an 8-bit input to control the wiper setting of a three-terminal "pot." That is, the wiper can be set to 256 different positions, with a digital input of 128 setting the pot to mid-scale. That 14-pin DIP IC is programmed through a 3-wire serial interface. A microcontroller such as one of the PIC models from Microchip Technology Inc. can read the on/off settings of a group of eight toggle switches or a thumbwheel switch and do the programming.

The author has used the AD8402 to build tunable active filters and in the process has learned that it's not quite an ideal resistor. The device still has some resistance, about 50 ohms in the 10,000 ohm unit, even when the digital input is all zeros.

Another limitation is that the AD8402 prefers that its associated circuit operate using the same supply voltage as it does; that is, ground and +5 volts. If there are op-amps in your circuit, they also need to operate between ground and +5 volts, which means you'll need a +2.5-volt virtual ground to bias the op-amps to the power supply midpoint. Also the microcontroller clock will introduce some noise into your analog signal—if you let it: The AD8402 contains latches that store the last programmed data; that means you can minimize the clock-noise problem by putting the microcontroller to sleep except when actually programming.

Don't be discouraged by that litany of problems; the AD8402 is a very useful component. You just need to be aware of its limitations and design around them.

Another alternative here is the LM1972 from National Semiconductor. It is billed as an audio attenuator, and the author has successfully used it in several industrial-control applications. Like the AD8402, its attenuation is programmed over a 3-wire serial interface. But unlike the AD8402, its attenuation changes



Here's the author's version of the circuit shown in Fig. 4.

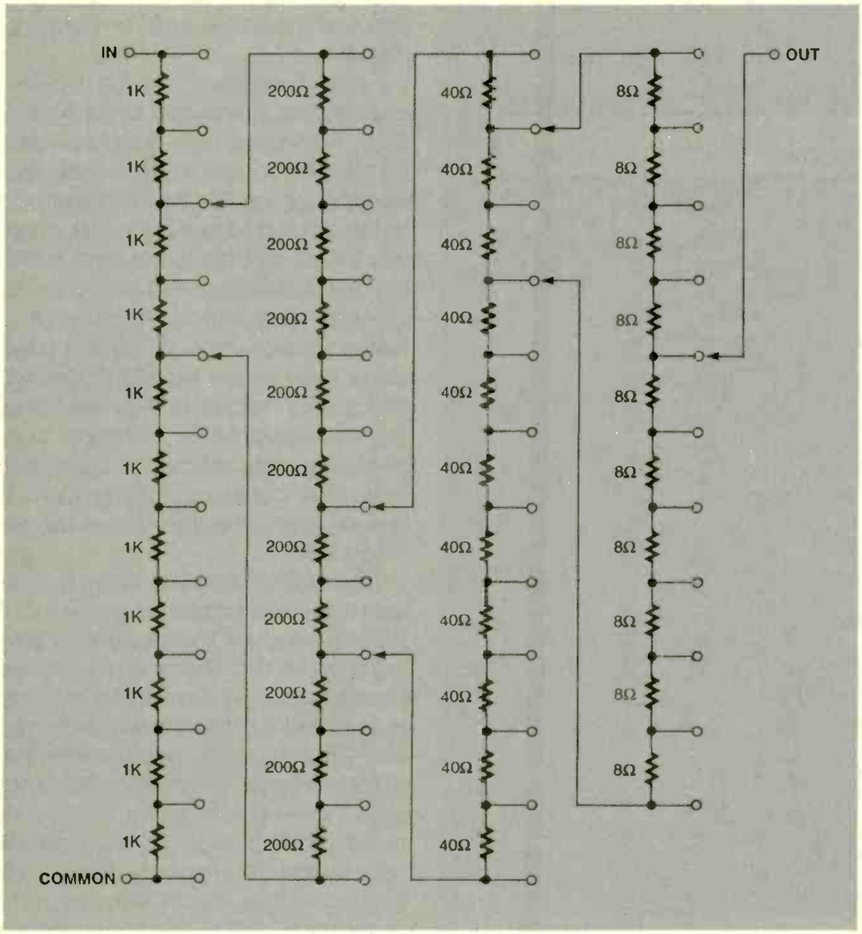
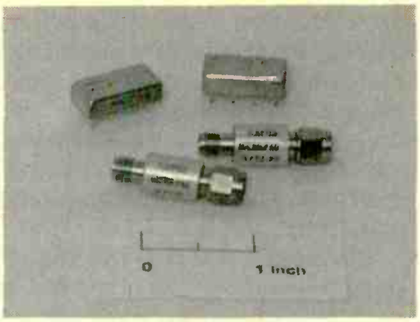


Fig. 6. The circuit diagram for the divider shown in Fig. 5 reveals that it is a four-decade device with a 5-to-1 resistance ratio between decades.



A pair of coaxial units with SMA connectors made by Narda Corporation (now Loral Microwave Narda), and a pair of plug-ins manufactured by Mini-Circuits.

RESOURCES

Analog Devices
PO Box 9106
Norwood, MA 02062-9106
Tel: 800-262-5643

Digi-Key Corporation
PO Box 677
Thief River Falls, MN 56701-0677
Tel: 800-344-4539

Loral Microwave Narda
435 Moreland Road
Hauppauge, NY 11788
Tel: 516-231-1700

Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 602-786-7200

Mini-Circuits
PO Box 350166
Brooklyn, NY 11235-0003
Tel: 800-654-7949

Motorola Semiconductor Products
2100 E. Elliot
Tempe, AZ 85284
Tel: 602-244-6900

Mouser Electronics
958 N. Main Street
Mansfield, TX 76063-4827
Tel: 800-346-6873

National Semiconductor
2900 Semiconductor Dr.
Santa Clara, CA 95052-8090
Tel: 800-272-9959

Scott Edwards Electronics
PO Box 160
Sierra Vista, AZ 85636-0160
Tel: 520-459-4802

from zero to 78 dB in 0.5-dB steps up to 48 dB and then in 1-dB steps on up to the maximum. The frequency response is down 3dB at 100 kHz, and the total harmonic distortion (THD) plus noise is specified at 0.003% maximum. (National has targeted music-system applications with this device so they wanted it to be really quiet!)

Figure 7 is a circuit diagram of a variable attenuator you can build around an LM1972. Let's take a look at how it works.

The circuit makes use of a 1-of-12 keypad, which the author had on hand, to enter the desired attenuation. The line from each key connects to one of twelve input pins on a PIC16C73 microcontroller (as indicated by the dots on the lines from the specific pins on the IC). Each of these inputs is normally pulled up to +5 volts through a 4700-ohm resistor

(R1-R12). When a key is pressed, the connected PIC input is pulled low and the firmware stores the key's value. In this design, the # key is used for "enter." When that key is pressed, the entered attenuation is programmed into the LM1972 over the clock, load, and data lines.

The LM1972 has an input impedance of about 40,000 ohms, but its output impedance is also high so an output buffer is needed. Most any JFET-input op-amp will work. The author selected an LF412 because it has a full power output bandwidth greater than 100 kHz and a low DC offset. You'll notice that this design is DC coupled, so it's ideal to use with a function generator that tunes to very low frequencies. But if

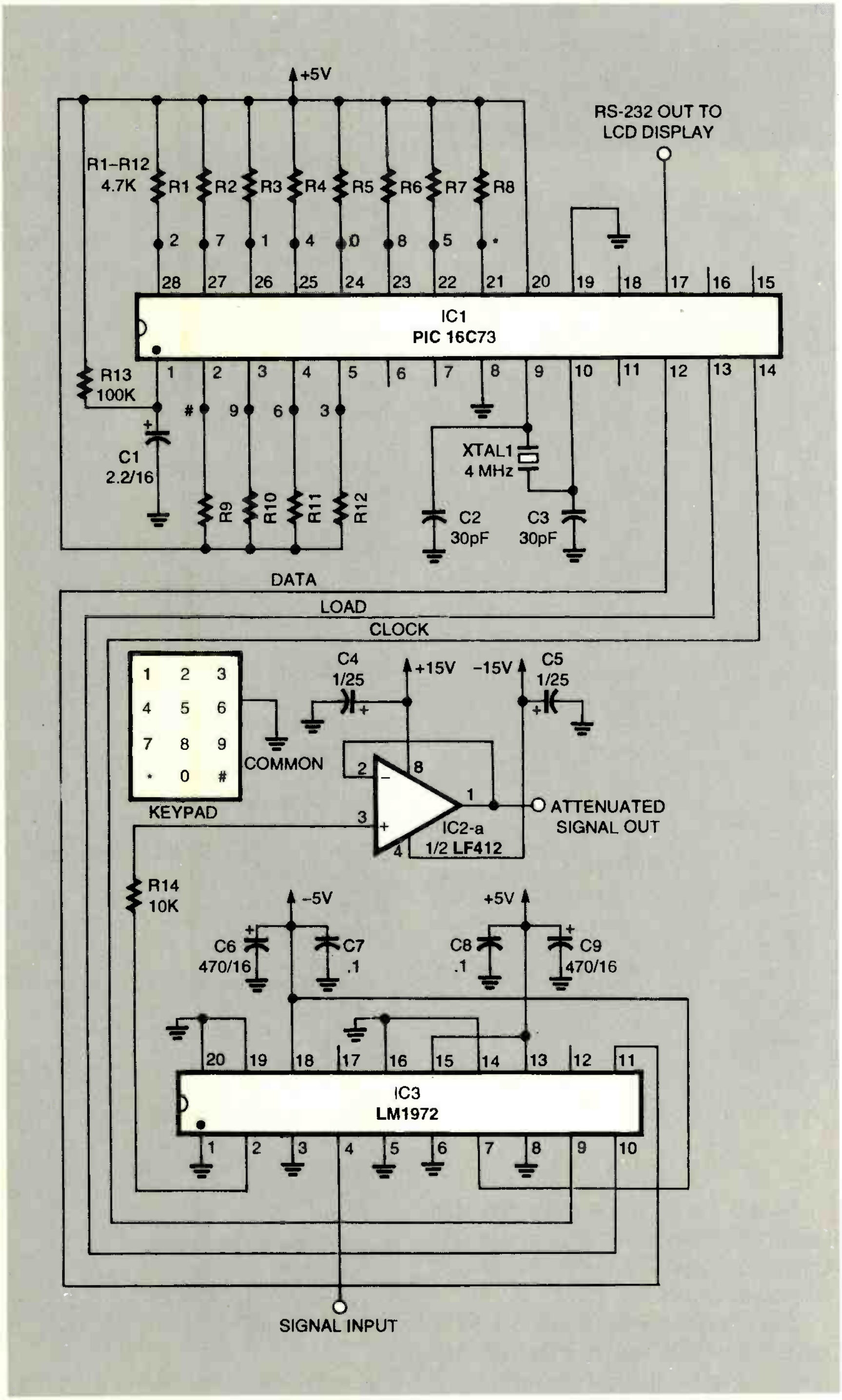


Fig. 7. Here's a digitally-controlled variable attenuator built around National's LM1972. It is ideal for audio/music applications. The program for the microcontroller can be downloaded from the **Electronics Now** *ftp site (ftp.gernsback.com/pub/EN).*

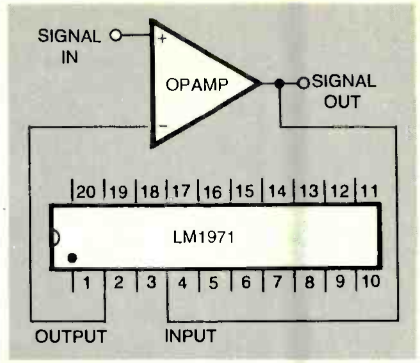


Fig. 8. This simple change lets you use the LM1972-based circuit in Fig. 7 as a variable-gain amplifier.

your input signal has much DC on it, you will need to use a coupling capacitor.

Lots of different display options are possible. The author used an LCD Serial Backpack from Scott Edwards Electronics to display the attenuation, though an RS-232 line driver had to be added to get it to work properly. If you decide to go that route, an "old-fashioned" LM1488 operating from the ±15-volt supplies is a better choice than a "+5-volt only" driver such as the MAX232A (Maxim Integrated Products). With the latter, the voltage-doubler switching transients are very difficult to decouple from the output signal, and that greatly limits the maximum usable attenuation.

The output signal voltage is limited to 10 volts peak-to-peak (about 3.5 volts rms) by the ±5 volts supplying the LM1972. That supply can be increased to ±7.5 volts (maximum) but ±5 volts is more convenient since the +5 volts can also power the microcontroller. The minimum output signal level is limited by microcontroller clock pickup, so it would be very useful to stop the clock. The firmware does that: After programming the LM1972 (which has latches to store the most recent data), the microcontroller goes to sleep which stops the clock. Pressing the star key (*) generates an interrupt that wakes up the PIC, which then waits for the next keypad entry.

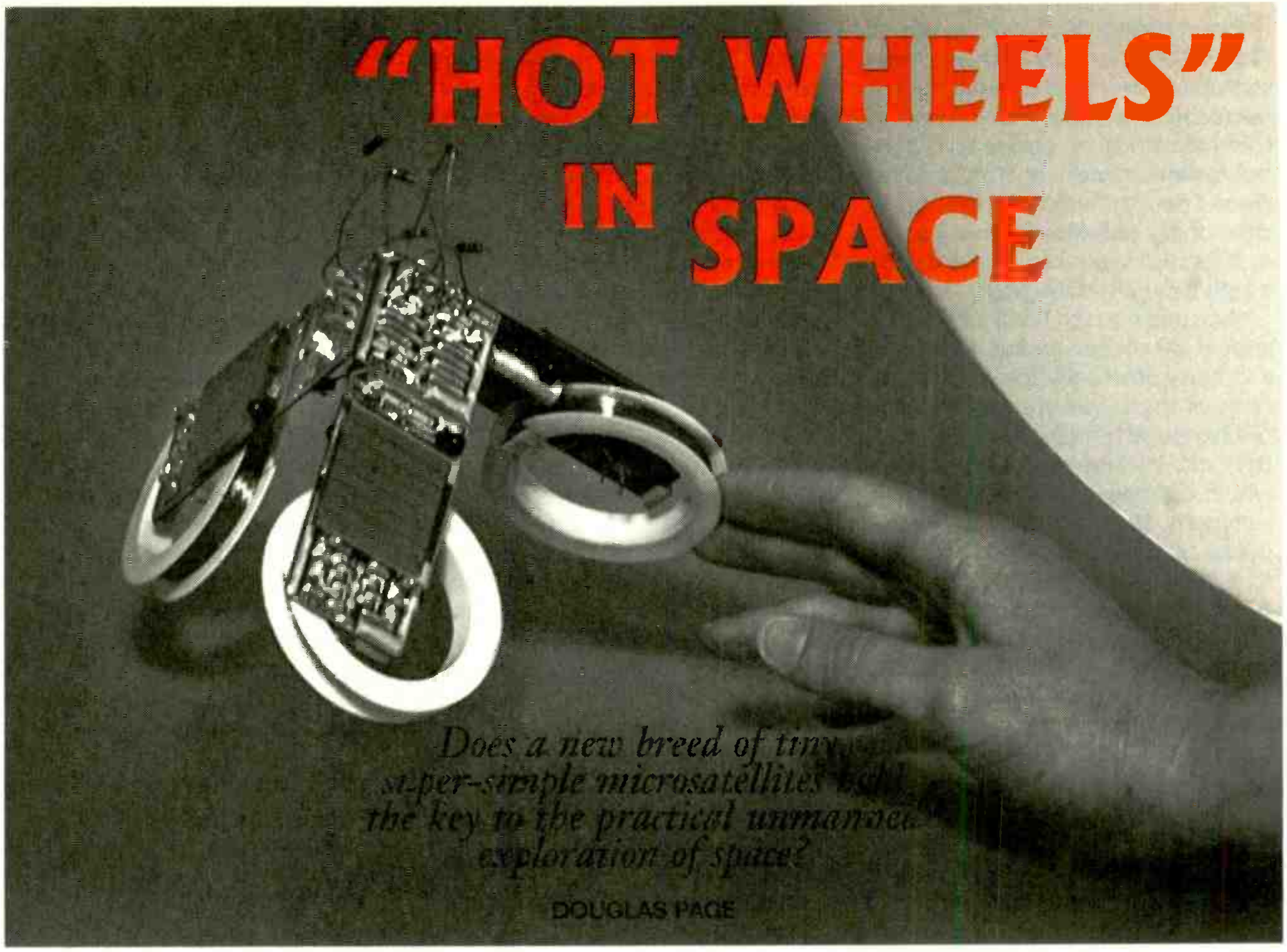
The well commented source code (written in C) and the hex file needed to program the PIC are available on the **Electronics Now** ftp site (ftp.gernsback.com/pub/EN) in file ATTEN.ZIP. Application Note

(Continued on page 50)

"HOT WHEELS" IN SPACE

Does a new breed of tiny, super-simple microsatellites hold the key to the practical unmanned exploration of space?

DOUGLAS PAGE



A FLEET OF THESE TINY MICROSATELLITES would cost less, but could also accomplish missions that would not even be attempted with a single, more complex craft.

In recent years, the trend in unmanned spacecraft design has been toward smaller, faster, and cheaper. We no longer lift so many high-performance "Bentleys" and "Lamborghinis" into orbit; there are now a number of "Ford Escort"-class spacecraft circling the planet and doing good work.

The reason behind that is not just tight budgets. Too many of the costly, complex satellites launched recently have failed. The more complex the designs, the more prone they seem to be to failure. Balky antennas refuse to deploy. Flashes of space radiation burn-out delicate microprocessors. Links with earth-control stations are lost. That vulnerability has lead some scientists to rethink traditional design philosophies that attempts to predict every anomaly and then pre-program the appropriate work-around.

"We can't anticipate everything that can go wrong, especially in space and especially under current cost/risk constraints that bind space programs," says robot designer Mark Tilden, a research scientist in the Physics Division at Los Alamos National Laboratory (LANL), New Mexico. "We need engineering solutions that respond to unanticipated events in non-catastrophic ways."

In other words, everything has to be done differently. Tilden thinks even the Escort-class satellites are too complicated. Instead, he'd like to fill parking orbits with "Hot Wheels."

What Tilden is suggesting is a paradigm shift away from the highly-evolved space systems currently in operation. Rather than design spacecraft systems primarily to perform work and hope that they survive all anticipated problems, Tilden has turned design conception around. "We must instead design systems that automatically attempt to survive all circumstances and then try to extract useful work," he says.

Tilden colleague Kurt Moore says, "They represent the logical end of one evolutionary trend in space exploration toward clusters of small, cheap satellites that can achieve results even when some of them fail. They're so robust they could even be used to investigate the Van Allen radiation belts, which most earth-orbiting satellites avoid.

"Instead of designing systems that withstand their environment, we're engineering systems that rely on their environment. We're working on satellites that have no microprocessors or fixed algorithmic behaviors. Instead, these satellites are survivors—designed from the bottom up and domesticated by their sensors and control payloads into performing high-reliability tasks."

How Small Can You Go? If smaller is better for survival, how small can you make a satellite? At this past December's American Geophysical

Union meeting, the LANL team of Tilden, Moore, and Janette Frigo presented an idea for a constellation of microsatellites, each weighing no more than half an ounce with control systems based on the simplest animal neuron "twitches." You could carry these satellites in your pocket and launch them out of the shuttle cargo bay with a slingshot.

According to Tilden, a well-known innovator in the close-knit robotics community, the control systems of these insect-sized satellites are based on simple "nervous nets" (Nv), an instinct-like neural net in which a single electronic neuron is sufficient to produce a control pulse, or twitch, in a robotic creature lacking an advanced processor or computer command. Nv technology is based on the notion that a brain is of no use without a spinal cord. Indeed, most life on earth survives just fine without any brain at all.

Their "satbot," resembling a carefully folded sheet of construction paper, has three solar cells, a long-range antenna dish the size of a button, a short-range antenna probe no longer than a toothpick, a local sensor array, and three alignment coils. It weighs 10 grams and would fit in your hand.

That weight, say the researchers, not only reduces cost, but improves accuracy and response of the satellites for ranging and orientation purposes. The basic idea is to launch these satbots by the hundreds, huge stacks of them shearing themselves in orbit as a sweeping array of sensory "pixels," giving a whole new spectrum on the potentials of data measurement.

The whole idea is founded on the fact that space exploration is expensive and risky. However, Tilden says, satellites can be built cheap, rugged, self-programming, and radiation hardened. Those microsats may be the first step toward a whole range of long-term, low-cost space missions that would otherwise be prohibitively expensive.

Big Missions for Small Craft. Beyond mapping the Van Allen Belt, other potential applications include measuring the solar wind and more precise earth imaging. And that's just the beginning.

"We've done work on everything from lunar dust clearers, lunar miners and sorters, self-organizing heat-resistant tiles, broad-field pixelsats that can image asteroids or vast areas of space, to low earth orbit debris removers and single-mechanism interstellar explorers," says Tilden. "And there's not a computer in any of them. Most of them aren't even as complex as a transistor radio. Maybe it's a paradigm shifting without a clutch, but at least our devices work.

"The real goal eventually is to set up a whole organized branch of alternate robotic sciences powerful enough to think about colonization, and not just interstellar exploration," Tilden says. "The benefits will come from cheap access to space for people other than the big boys, and in innovative techniques that don't require NASA dependence. Find a way to sell a Sharper Image satellite for a thousand dollars with your choice of small payload, accessible and/or controllable through the Internet, and you'll see a revolution in amateur astronomy equal to the first ground-glass lens."

Tilden's nervous nets work like the neurons in animal nervous systems, which put out spiked pulses that hold useful information in the timing between the pulses. In computer terms, he says, the information needed to do work lives in the firing rate, not in a coded voltage level.

The Los Alamos satellite model shown in the beginning of this article is a microsatellite controller whose primary mission is to orient itself in earth's magnetic field. Using only a few transistors, those space 'bots seek the brightest available source—the sun—and orient themselves precisely toward it.

Acting like a delay line, the researchers say, electronic pulses from photodetectors travel first to one neuron and then the next. By adjusting the timing relationship between the pulses, the control system seeks the light and uses the reaction of the controller's magnetic field against earth's magnetic field for the torque needed to orient the satellite. With six neurons on three axes, the controller can move or examine different points in three-dimensional space.

Moore says hundreds of microsatellites in orbit could relay simple streams of data to a communications mothership, which could integrate the data and pass it to ground stations. Measuring earth's magnetosphere is one potential mission. By locating a swarm of microsatellites on the sunward side of the magnetopause, scientists can take real-time measurements of the energy transferred to earth's magnetic field by the turbulent solar wind. "We've never been able to do real-time monitoring of the position of the magnetopause as the solar wind pushes it around," says Moore. "With hundreds of these microsatellites we should be able to do that." Ω

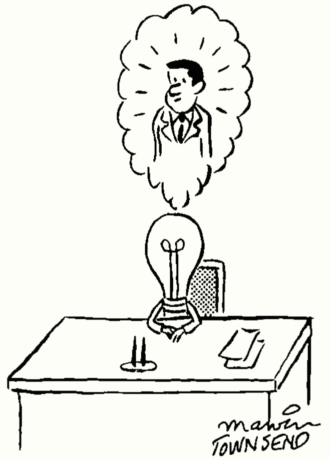
ATTENUATORS

(continued from page 48)

AN529, available from Microchip Technology Inc., describes a 4 3 4 sampled keypad and LED driver that could also be used to set and display the attenuation.

A simple change, shown in Figure 8, lets you use the LM1972 as a variable-gain amplifier. Since the op-amp shown in the figure has a low output impedance, a separate output buffer is usually not needed.

The author is available to answer (or try to answer) questions on any of the devices in this article. I'm usually difficult to reach by phone so please write, fax, or e-mail Ron Tipton, 5260 Cochise Trail, Las Cruces, NM 88012; Fax: 505-382-8810; e-mail: RTipton@zianet.com. Ω



SEE MUSICAL PITCHES WITH THE DIS·PLAYER

Frustrated by trying to play "in key" with your trombone or fretless base? Want to know what pitch someone is singing? This handy device is the next best thing to having a friend with "perfect pitch"!

FRED NACHBAUR

If you have a musical instrument that doesn't have keys, valves, or some other way to create a pitch that is in tune with the standard diatonic (chromatic) scale of Western music, you probably know the frustration connected with trying to play even the simplest tune. Learning how to play an instrument such as a violin, trombone, something as esoteric as a Theremin, or even something as simple as a slide whistle can frustrate even the most dedicated aspiring musician.

The DisPlayer project presented here is just the item needed in those situations. A visual indication of which note is being played helps you learn how to hit the correct pitch without hunting for it. The display is designed to look like a piano or organ keyboard. With a three-position switch, the three-octave display can be extended to five octaves. You'll be amazed at how quickly and easily you'll pick out recognizable tunes with the DisPlayer's help. As a bonus, the DisPlayer includes a VU meter that acts as a volume display. That circuit is completely separate from the rest of the DisPlayer. It comes in very handy if you're working with an electronic instrument or amplifying an acoustic one. In general, the DisPlayer's usefulness is limited only by your imagination.

How It Works. The schematic diagram for the DisPlayer is shown in Fig. 1. Although it looks complex at first glance, it is really quite simple and straightforward. The circuit can be divided into several sections.

The heart of the circuit is the tone- or pitch-display section, and it is based on the popular LM3914 display driver. That device drives ten LEDs in a linear display, with programmable endpoints and the choice of either a "dot" (one LED at a time) or a "bar" (from one to several LEDs in order) display. Furthermore, it is possible to "chain" multiple devices together to create displays of theoretically unlimited size, though the application notes from National Semiconductor usually recommend a limit of ten devices.

Display drivers IC7–IC10 are wired in a chained "minimum-parts" configuration with a dot display. Showing only one LED at a time makes it easy to interpret the display. It also places less demands on the power supply. The LED current is set to about 20 milliamps, making for a bright, easy-to-read display.

The display itself is made from LED10–LED50. Arranging them in a keyboard pattern makes notes easier to recognize by anyone with piano or keyboard experience. To further simplify reading the display, red LEDs were used to represent the white keys and green LEDs for the black keys of a piano. The lowest note is an "A," and the highest note is a "C" that is a bit over three octaves higher. That last LED (LED50) will remain lit when the input signal goes higher. If you prefer the display to go blank when out of range, LED50 can be left out. If you do use it, it would be a good idea to use yet another color such as orange or yellow for that device. That will remind you that the DisPlayer is at or beyond its upper limit, and that the display is not necessarily correct.

Note that there are resistors placed across the first and ninth LEDs of each LM3914. Those resistors are there to reduce or eliminate the dim glow that those LEDs would emit because of the small currents that pass through them. Those currents are by-products of the way that the LM391x family of devices connect to one another when in "dot" mode. If you aren't bothered with that dim glow, R22, R24, R25, R27, R28, R30, R31, and R33 can be omitted.

The resistors between pins 6 and 7 of each display driver and ground set the LED current. Note that they are not the same value; that is because the reference voltage of each successive driver is 1.25 volts higher than the previous one in the chain. The inputs of the LM3914s are tied together, resulting in a continuous linear display with a full-scale voltage of about 5 volts.

One quirk of the LM391x family of display drivers is that they need

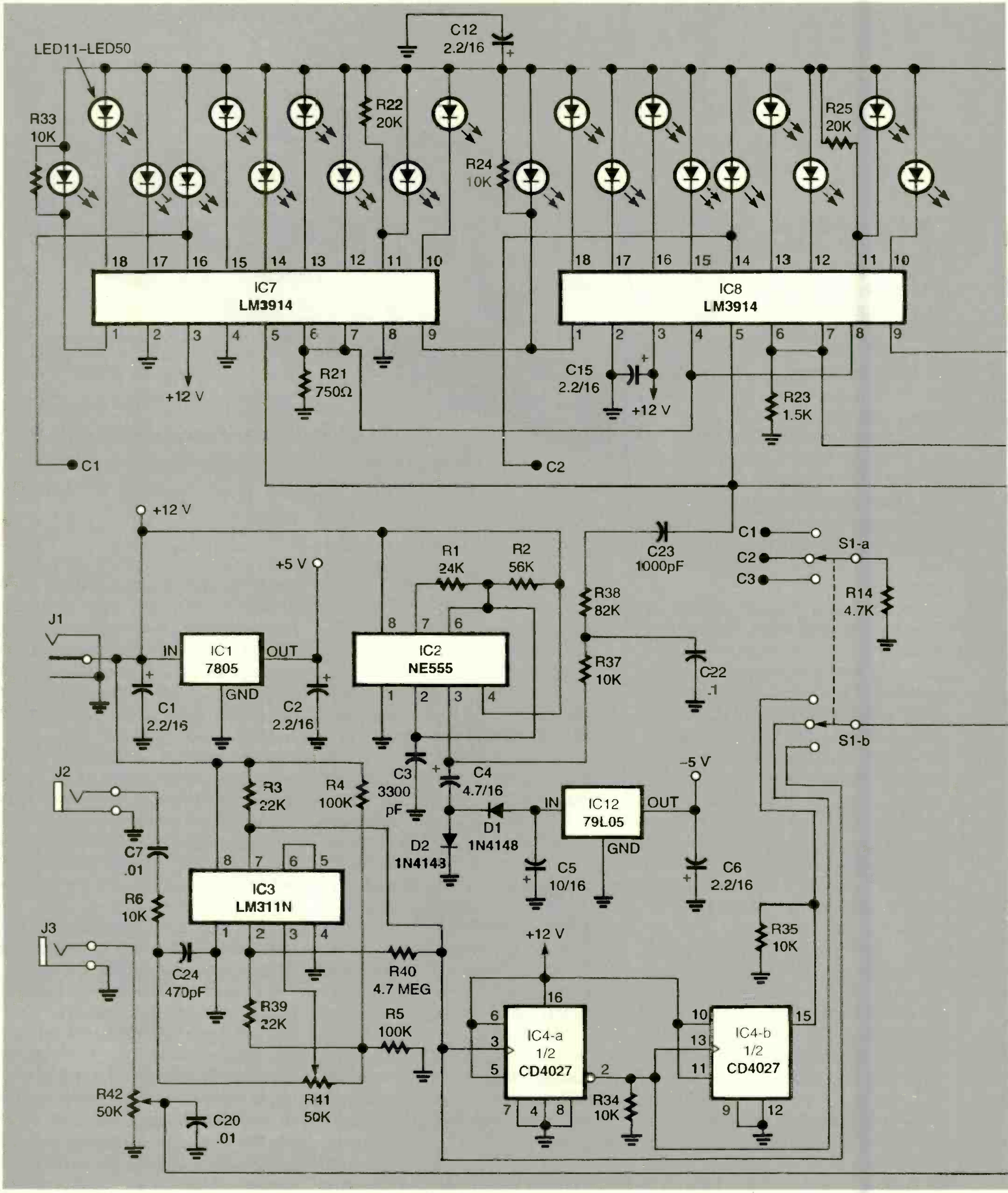
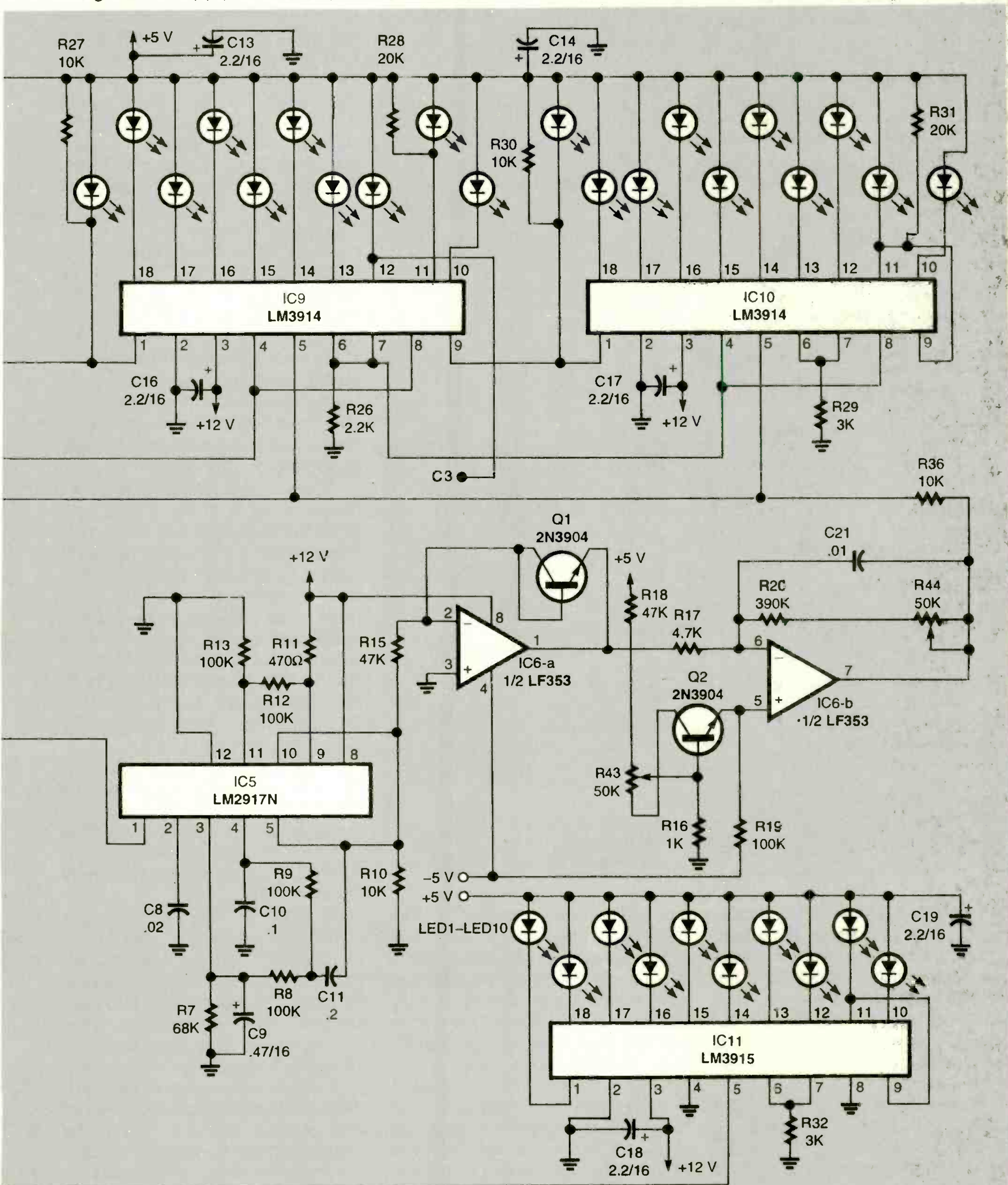


Fig. 1. The DisPlayer is built around a string of LM3914 LED display drivers.

to be well bypassed on both the LED supply and the main supply lines. That's why there are all of those 2.2–µF tantalum capacitors along the LED supply rail and on pin 3 of each LM3914. If you try omitting some or all of them, you might be lucky. However, there is a good chance that you will end up with bizarre displays due to oscillations.

"Scale" Conversion. At this point, we should note that the pitches that we are displaying represent a logarithmic scale: each time we double the frequency (go up an



PARTS LIST FOR THE DISPLAYER

SEMICONDUCTORS

IC1—LM7805 5-volt positive regulator, integrated circuit
IC2—NE555 timer, integrated circuit
IC3—LM311N dual comparator, integrated circuit
IC4—CD4027 dual J-K flip-flop, integrated circuit
IC5—LM2917N frequency-to-voltage converter, integrated circuit
IC6—LF353 dual op-amp, FET input, integrated circuit
IC7–IC10—LM3914 LED linear-display driver, integrated circuit
IC11—LM3915 LED logarithmic-display driver, integrated circuit
IC12—79L05 5-volt negative regulator
Q1, Q2—2N3904 NPN transistors (from same production run—see text)
LED1-LED3—Light-emitting diode, green (T-1 package)
LED4-LED6—Light-emitting diode, yel low (T-1 package)
LED7-LED10—Light-emitting diode, red (T-1 package)
LED11–LED50—Light-emitting diode, T-1¾ package (see text)
D1, D2—1N4148, silicon diode

RESISTORS

(All resistors are ¼-watt, 5% metal-film units unless otherwise noted.)
R1—24,000-ohm
R2—56,000-ohm
R3, R39—22,000-ohm
R4, R5, R8, R9, R12, R13, R19—100,000-ohm
R14, R17—4700-ohm
R6, R10, R24, R27, R30, R33–R37—10,000-ohm
R7—68,000-ohm
R11—470-ohm
R15, R18—47,000-ohm
R16—1000-ohm
R20—390,000-ohm
R21—750-ohm
R22, R25, R28, R31—20,000-ohm
R23—1500-ohm
R26—2200-ohm
R29, R32—3000-ohm
R38—82,000-ohm
R40—4.7-megohm
R41–R44—50,000-ohm potentiometer (see text)

CAPACITORS

C1, C2, C6, C12-C19—2.2-µF, 16-WVDC, electrolytic
C3—3300-pF, ceramic-disc
C4—4.7µF, 16-WVDC, electrolytic
C5—10µF, 16-WVDC, electrolytic
C7, C20, C21—0.01-µF, ceramic-disc
C8—0.02-µF, Mylar, 5%
C9—0.47-µF, 16-WVDC, electrolytic
C10, C22—0.1-µF, ceramic-disc
C11—0.2-µF, ceramic-disc
C23—1000-pF, ceramic-disc
C24—470-pF ceramic-disc

ADDITIONAL PARTS AND MATERIALS

J1—Hollow pin jack, 2.1 mm.
J2, J3—¼ mono phone jack
S1—2-pole, 3-position or 3-pole, 4-position rotary switch (see text)
PC board, 12-volt DC, 200 mA power supply, wire, hardware, case, etc.

Note: The following items are available from: SK Electronics, Kit Division, 902 Front St., Nelson, BC V1L 4R2, Canada; Tel: 250-352-7292; Fax: 250-354-4070; e-mail: skecomm@netidea.com: Complete kit of all parts, PC board, power supply, and front panel, $89.00 ($129.00 Canadian); Partial kit of PC board and parts, $79.00 ($119.00 Canadian); PC board only, $15.00 ($22.00 Canadian). Please add $3.00 ($5.00 Canadian) for shipping and handling on kits; $2.00 ($3.00 Canadian) for PC board shipping. Canadian residents must add 7% GST. BC residents must add 7% PST. Visa and MasterCard accepted. No COD orders will be accepted.

octave), the voltage to the display section should increase by a fixed amount—about 1.5 volts in practice. So how does a logarithmic frequency input get converted into a linear voltage for display on our "visual keyboard?" For that answer, we have to go to the opposite end of the circuit.

The incoming frequency signal is applied to IC3, an LM311 comparator that converts it into a squarewave with the proper levels to drive the next part of the circuit. Resistor R41 sets the amount of signal that is applied to the comparator. That helps make sure that there is enough signal for reliable operation across the usable range of the DisPlayer while minimizing the display of noise. Resistors R4 and R5 set the toggle point of the comparator at ½ of the supply voltage, and R3 forms the load for IC3's open-collector output.

The signal then passes through two frequency-divider stages, built around IC4. One of the outputs is selected by S1-b, letting us choose one of three octave ranges. The other part of S1 (S1-a) sinks a low current through one of the LEDs that represent "C" on the keyboard. The selected LED glows dimly, marking the location of "middle C".

The selected frequency is converted to a voltage by IC5. If you are using an electronic instrument that already generates a voltage that represents the frequency of the sound, the input circuit up to this point would not be needed. However, some instruments might not be as linear as they should be. Keeping the DisPlayer a universal design that can be used with any sound source makes the unit much more versatile as well as precise. An added advantage of IC5 is that it has a built-in op amp that can be used for filtering any ripple—a necessity to properly display the lower frequencies. Without ripple filtering, more than one LED would be lit in the lower ranges. The 14-pin version of the chip lets us access the op-amp's inputs—a necessity for filtering out the ripple.

Resistors R12 and R13 set IC5's reference at ½ of the supply voltage. R11 is a load for the built-in Zener diode. Capacitor C8 and resistor R7 program the chip's frequency-to-voltage range. They have been chosen to give a full-scale voltage of about 6.5 volts when the input frequency is at 550 Hz. The above-mentioned ripple filter is formed by R8, R9, C10, and C11. Finally, R10 forms the load for IC5's open-emitter output.

The values shown in the schematic are for a minimum frequency of 55 Hz, which is the A that is two octaves below middle C. With S1 in the third position, the highest frequency is 2093 Hz. The bottom end is a pretty low bass note,

So now that we finally have a voltage that is a linear analog of the incoming frequency, how do we take the logarithm of that voltage for proper display on our visual keyboard? The key to the answer is the fact that the voltage across a transistor with its base and collector tied together is proportional to the logarithm of the current passing through it. In practice, that means that the collector/base-to-emitter voltage increases by about 17 millivolts for every doubling of current.

The first section of IC6 makes use

of that fact. To briefly review op-amp theory, an ideal op-amp will have zero volts across its differential inputs (infinite voltage gain) and an infinite input resistance (zero input-bias current). Fortunately, the JFET op-amp that we're using approaches that ideal very closely. In the inverting-amplifier configuration, the current through Q1, the "feedback element" with its base and collector tied together, equals the current in "input element" R15. Furthermore, the current in R15 will be directly proportional to the applied voltage. The result is an output voltage that is proportional to the logarithm of the input voltage.

Using a JFET-input op-amp is important when doing linear-to-log conversions. Even the smallest input bias currents (like the 50-nanoamp rating of an LM358) are enough to mess up our linearity. The LF353 device typically has an input current that is three orders of magnitude less—50 picoamps—and is far better suited to our needs.

The logarithmic output voltage is inverted, so the second section of IC6 inverts it again. That section also sets the gain with R44 and the zero offset with R43. Making both stages inverters eliminates complications that result from trying to make a non-inverting log amp.

There is another very important job assigned to IC6-b: temperature compensation. Another interesting property of the transistor with its base and collector tied together is that, at a given current, the voltage across it is a linear representation of temperature. That feature is useful for any number of temperature-measuring applications, but a real drawback for log amps.

Transistor Q2 is included in the biasing network for IC6-b. A temperature-induced voltage change in Q1 will (presumably) cause the same degree of change in Q2. The circuit is wired in such a way that the effects of those voltage changes cancel each other out. That is why both Q1 and Q2 should be chosen from the same production run. While a dual transistor (two transistors on the same die) could also be used, cost and availability make any improvements not worth the effort. If you're really concerned about sta-

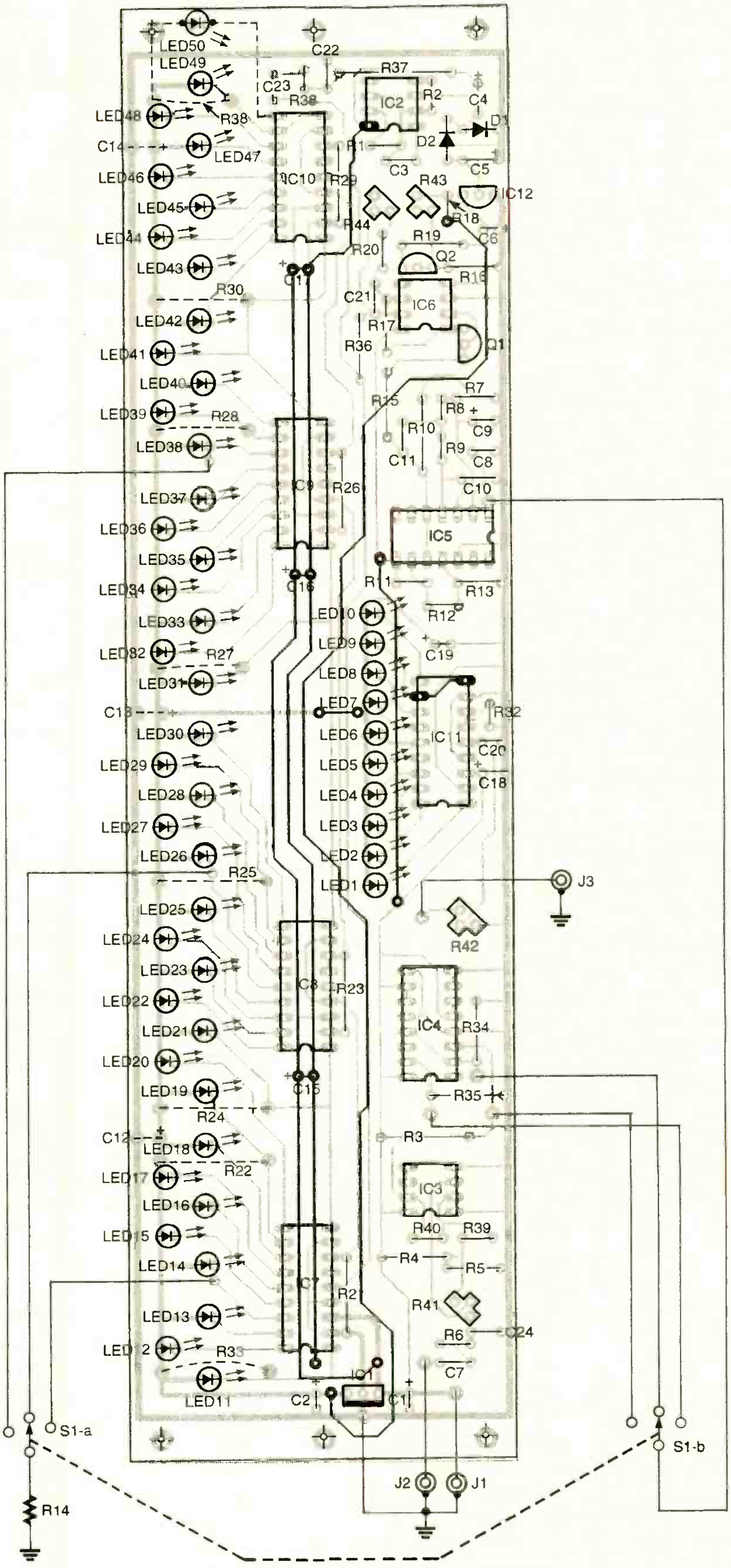
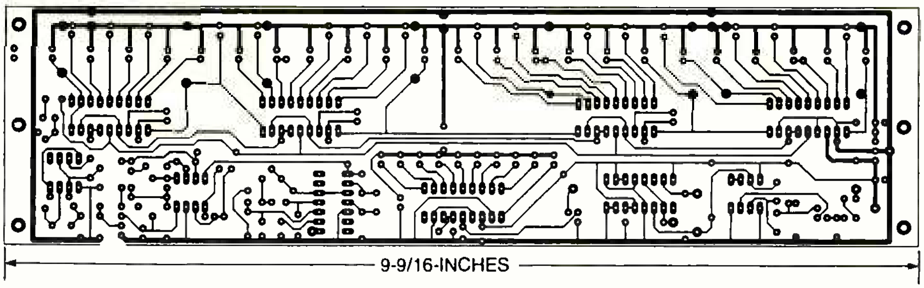


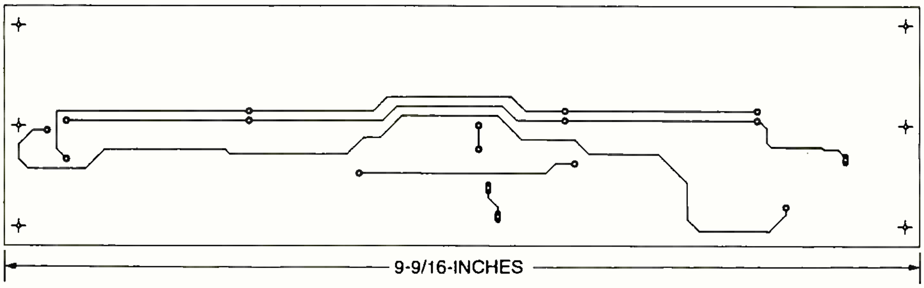
Fig. 2. Use this parts-placement diagram when building the DisPlayer with the PC board foil patterns. Some components are mounted on the underside of the board so that the LED "keyboard" looks neat and professional.

bility, you can use a dual-transistor package. An alternate method would be to use discrete transistors, leave their leads long enough so that they can be bent into physical contact with each other, and physically bond them together with a dab of thermal compound and a tiny elastic band. That will give virtually the same degree of stability as a dual transistor.

Capacitor C21 eliminates any residual ripple or other high-frequency noise picked up along the way. The output from IC6-b passes through summing resistor R36 to the inputs of the display driver ICs.



Here is the foil pattern for the solder side of the DisPlayer. It is shown here at 50%.



Here is the foil pattern for the component side of the DisPlayer. It is shown at 50%.

Power Supply. As mentioned earlier, IC5 has its own built-in Zener regulator, so any supply voltage in the range of 10–14 volts will be fine. Similarly, the other IC's power requirements are quite forgiving. The exception is IC6. While it doesn't really care about its supply voltage, the biasing network, including temperature compensator Q2, needs to have a well-regulated voltage. That is one reason for the use of IC1. As with the display drivers, using a 2.2-µF tantalum capacitor at its output prevents any possible oscillations that could ruin your day.

The regulator also supplies the LED current for the display drivers. Running the LED supply on a lower voltage greatly reduces the heating on the display driver ICs.

A negative-supply inverter is built around IC2, an NE555. The timer is being used in a variant of an astable-multivibrator circuit. It has been optimized to create as close to a 50%-duty-cycle output as possible. Resistors R1, R2, and capacitor C3 set the frequency of oscillation to about 3.8 kHz. The resulting squarewave is clamped by C4 and D1, rectified by D2, and filtered by C5. Note that the circuit consisting of C4, C5, and the two diodes is nothing more than a classic "voltage-doubler" circuit. In effect, we're "doubling" the peak value of the squarewave relative to its average level. The result is a negative voltage that is about equal to the original positive supply voltage, although it has poor regulation. That is taken care of by IC12, a 5-volt negative regulator.

Odds and Ends. Since we have a clean constant-frequency squarewave available, let's add another refinement: fine tuning. As the display section stands so far, we could be off by almost a quarter-tone with any given LED being lit. We can greatly improve that by superimposing a low-level (about 80 millivolts) triangle wave on top of the DC signal to the display drivers. That will cause a single lamp to light only if we're close to being "on pitch," since each LED represents a 125-millivolt increase. If we're even a little off pitch, the next light up or down will start lighting, giving an "overlap" effect.

It might seem odd that we'd want to add ripple to our display after all the trouble we went to getting rid of any ripple being generated by the frequency-to-voltage converter. The difference is that with a fixed-frequency source like a 555 oscillator, the ripple amplitude will be constant and predictable. The 3.8-kHz squarewave from IC2 is integrated into a reasonable approximation of a triangle wave by R37 and C22. It is injected into the inputs of the display drivers through the voltage divider formed by R38 and R36. Capacitor C23 provides DC isolation so that the fine-tuning circuit does not affect the DC level coming out of IC6-b.

Volume Display. After all of the design work that has gone into the DisPlayer, the volume-display section is almost trivial by comparison. An LM3915 and ten LEDs make up the circuit, automatically giving us a logarithmic scaling. If you want a "bar" display, tie pin 9 of IC11 to pin 3 instead of to pin 11 as shown. You don't even need to rectify and filter the incoming audio source; the LM3915 works fine straight from a line-level input with a maximum peak voltage of 1.25 volts or greater. If you use the dot mode as shown in Fig 1, the display will be a "quasi-bar" that shows the peak values and also suggests the average value.

Incidentally, if you're wondering why we didn't just use LM3915s in the tone-display section, it's because the logarithmic steps are fixed at 3 dB (about 41% increase per step) rather than the approximately 4% increase per step needed to display half-tones.

Building the DisPlayer. There is, of course, no reason why you can't build the DisPlayer on a piece of perfboard. However, using a printed-

circuit board results in a neater overall appearance of the unit. You can etch your own board using the foil patterns included here, (**note:** due to their size, the boards are reproduced here at 50%) or one may be purchased from the source given in the Parts List.

For a purchased PC board or one made from the foil patterns, the parts-placement diagram in Fig. 2 should be followed for component location. If you make your own board, you have a choice of making a single- or double-sided. For a single-sided board, you'll have to run jumper wires corresponding to the traces shown on the "component-side" artwork. All pads are shown on the component-side artwork to make it easier for you to locate the proper pads for the jumper wires. Note that the 12-volt and ground rails for the LM3914 tone-display drivers pass *under* the ICs; install the jumpers before inserting the chips. The jumpers should be insulated in order to prevent them from shorting against each other or any component leads. The foil patterns provide extra pads on either side of the bypass capacitors for the jumpers.

If you decide to use a double-sided board, you don't have to worry about installing any jumpers—but you'll have to run feed-through wires that will connect the traces on both sides of the board. You don't have to drill out the pads on either side of the bypass capacitors; simply solder the capacitor leads on both sides of the board.

There is no particular order for installing the components. However, since IC4 is sensitive to electrostatic discharge, it's a good idea to install that component last. As usual, be careful about proper orientation of polarized components, such as ICs, transistors, diodes, and electrolytic capacitors. The shorter lead on LEDs is generally the cathode, but for good measure check for the little flat spot on the base of the LED; that flat spot marks the cathode and goes towards the driver ICs. If you decide to install LED50, solder it into the holes indicated and run short jumper wires to the 5-volt rail and to pin 10 of IC10 as shown in Fig. 2.

Once the board is completed, prepare a suitable case by drilling appropriate holes for mounting the PC board and the various jacks. As an alternative, a custom enclosure like the one shown at the beginning of this article can be made by mounting the board to a piece of ¼-inch-thick clear acrylic plastic that measures 3 inches by 10 inches. The plastic, which will become the DisPlayer's front panel, can be mounted on a box or frame made from strips of wood or similar material.

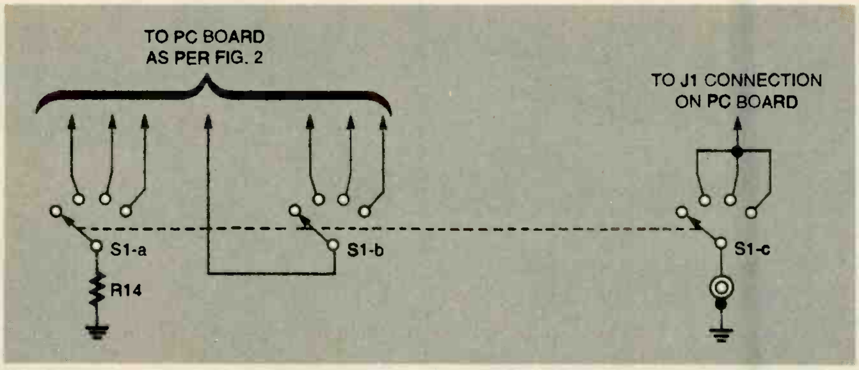


Fig. 3. You can replace S1 with a 4-position unit and use the additional pole as an on-off switch.

Power for the DisPlayer can be any suitable source of 12-volt DC power with a current capacity of at least 200 mA; a 500-mA unit with an internal 12-volt regulator to reduce ripple is preferred. If you want to switch the power supply, you can use a toggle switch between J1 and the PC board. An alternative method is shown in Fig. 3. In that arrangement, S1 is changed to a 3-pole, 4-position switch. The third pole, S1-c, is used as a power switch, applying power to the DisPlayer when any of the octaves are selected.

For now, don't connect S1-a or S1-b. Preliminary testing can be done by making a temporary connection between pin 1 of IC5 and pin 7 of IC3.

After checking your work for correct values, component orientation, and good solder joints, do some continuity checks with an ohmmeter. Make sure that you don't have direct shorts between supply and ground. When you're satisfied that everything looks okay, it's time to test the DisPlayer.

Testing and Adjustment. Set all of the pots to the center of their rotation. Apply a waveform of a known frequency to J2. One good source of a constant-frequency, constant-amplitude signal is a synthesizer or other electronic keyboard instrument; select the "cleanest" sound that is available. Turn off any effects, harmonics or after-touch dynamics. A clean "flute" sound would be perfect.

You might not see any lights at this point. However, if you vary the frequency generator through its lower range or play your instrument across its range, you should at some point see the pitch display come to life. If nothing lights up, try increasing the amplitude of the input signal. If the DisPlayer still doesn't respond, review the circuit-description section and trace the signal through the circuit (preferably with an oscilloscope) to see where it is disappearing. Check the output of IC5 (pin 5 or pin 10) with a DC voltmeter; you should get a varying voltage between zero and about 6.5 volts as you sweep through the frequency range.

Assuming that all is well so far, adjust R41 just beyond the point where the display stabilizes when you play a note or apply the signal generator. If you turn it too high, you might get funny displays due to harmonics or background noise.

Feed a 55-Hz signal into the DisPlayer. On a keyboard, that note would be the third A below middle C. Adjust R43 until LED11 comes on. Set the generator to 440 Hz (A above middle C). Adjust R44 until the high A (LED 47) lights. Repeat those two adjustments until they are stable.

Finish wiring S1 for the final test. Shielded wire for S1-b is suggested; that switch pole will be carrying high-level squarewaves that could

(Continued on page 68)

OnStar To The Rescue

More than a simple car navigation system, GM's OnStar and similar systems can be a driver's lifeline when trouble strikes on the road.

BILL SIURU

Vehicle navigation systems have been available on many upscale cars and SUVs, and as aftermarket accessories for the rest of us, for quite some time now. While they offer the promise of never getting lost on unfamiliar streets again, because most require some computer literacy to be used effectively, they often fail to meet that promise. Fortunately, that is now changing thanks to a new type of vehicle navigation system that is replacing the impersonal digital displays and digitized voices of existing systems with friendly, helpful, and live human assistance.

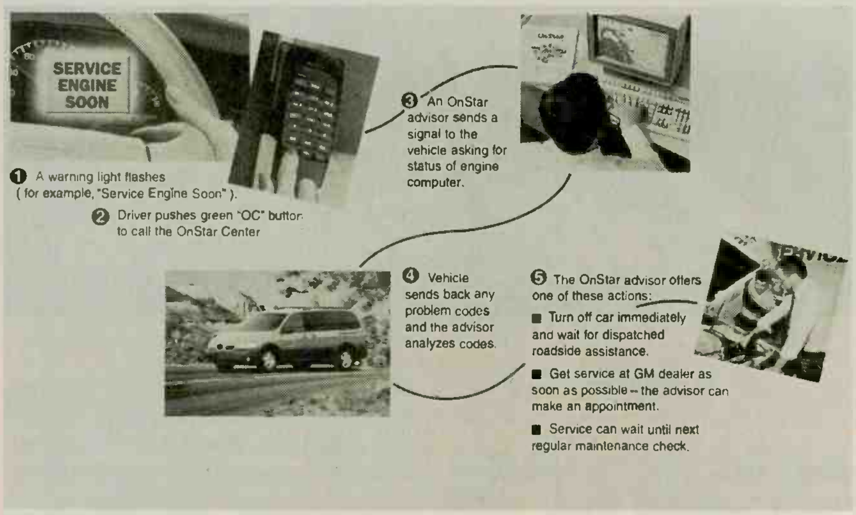
One such system is OnStar, now available on many 1998 General Motors vehicles. OnStar uses a voice-activated digital cellular telephone and the Global Positioning System. There is no display or keyboard. Drivers communicate directly with OnStar Centers in Troy and Farmington Hills, MI.

What it Does. OnStar at its heart is a vehicle-navigation system with a human touch. Using GPS, OnStar Center advisors can pinpoint an OnStar-equipped vehicle's location at all times. If you need directions, press the "OC" (OnStar Center) button on the phone to talk to an advisor, who after pinpointing your location, can provide routing to the destination. You can even record instructions to use while driving. The OnStar database contains about 3.2 million listings on everything from airlines to zoos. OnStar can even be used to make reservations at a hotel or restaurant, purchase airline tickets, or send flowers.

If that's all there were to it, OnStar would be a nice, but far from vital automotive accessory. It's when things go wrong on the road that the true benefits of OnStar become apparent. For example, if an OnStar-equipped vehicle breaks down, has a flat tire, or runs out of gas, the driver contacts the OnStar Center. After pinpointing the car's location, a Center advisor dispatches a tow truck. If the vehicle is involved in an accident where the airbags deploy—indicating the possibility of a severe crash—without action on the part of the driver OnStar automatically sends that information to the Center, which then dispatches emergency services to the scene.

Should a warning light on the instrument panels start flashing, the driver can contact the OnStar Center where an advisor uses OnStar's Remote Diagnostics to get an immediate analysis of the problem. OnStar advisors can now interrogate 266 system codes covering engine and powertrain, braking, and air bag systems. This includes codes for transmission-fluid temperature, engine misfiring, fuel-injector malfunction, and engine over-temperature protection—indeed more than half of

NEED A HAND while on the road? The OnStar Center is in operation 24-hours-a-day, 365-days-a-year.



IF A WARNING LIGHT FLASHES, the driver alerts the OnStar Center, which then electronically interrogates the vehicle to pinpoint the source of the problem. Using that information, the Center than advises the driver of the best course of action.

all problems that a GM owner might encounter. The advisor can let the driver know what action is needed, which could range from immediately pulling over to the side of the road and turning the engine off to scheduling an appointment at a GM dealer to get the problem checked.

In case of a medical problem or other emergency, the "Emergency" button on the phone is pressed and an advisor goes into action to alert the nearest emergency-services provider—police, fire department, or ambulance—giving information on the type of emergency, condition of the caller, and exact location.

From time to time, almost everyone has locked their keys inside the car. With OnStar, if it happens to you there is an easy solution. You can make a toll-free telephone call to the OnStar Center. After verifying the caller's identity to preclude a theft, an advisor sends a cellular message to the car's electronic-lock system to unlock the door at a specified time. Using an agreed upon time for unlocking ensures the car is not unlocked before you reach it.

A message can also be sent to the OnStar Center if the theft alarm is tripped. If the car is stolen—indicated by the alarm or a call from the owner—the Center can track the stolen vehicle continuously via GPS and provide that information to the police.

The OnStar Center serves customers 24-hours-a-day and 365-days-a-year. OnStar is available in all 50 states, and soon in Canada, and on all Cadillacs and Buicks; Oldsmobile Aurora and Silhouette; Pontiac Bonneville and Montana ; Chevrolet Lumina, Monte Carlo, Tahoe, Venture, Suburban and C/K pickups; and GMC Yukon, Envoy, Denali and Suburban. The additional cost for the unit is less than $1000, plus there is a service fee added to your monthly cellular-telephone bill.

Different Cars, Similar Systems. But what if you don't plan to buy a new GM? No problem. Like any good idea, other automakers are offering similar systems. For a couple of years, Ford has been offering the very similar RESCU (Remote Emergency Satellite Cellular Unit) as an option in Lincoln Continentals. Nissan is offering its Infiniti Communicator on its Infiniti Q45 and I30 luxury sedans. Developed for Nissan by Motorola, it includes features such as air-bag deployment notification, roadside assistance, remote assistance, remote door unlock, and stolen-vehicle tracking.

And similar systems are coming for other vehicles. For example, by the time you read this the Clarion Corporation of America will have begun offering Westar's ASSIST services for its all new Clarion AutoPC. Available for theoretically any vehicle, it offers basically the same services including emergency and roadside assistance, operator-assisted navigation, directory and concierge services, remote door unlock, stolen-vehicle recovery, and airbag notification. The AutoPC is the first system that integrates traditional car-audio capabilities with wireless communications, turn-by-turn GPS-based navigation, and many computing functions running on Microsoft Windows CE. Ω

FOR MORE INFORMATION

OnStar
888 W. Big Beaver Road, Suite 200
Troy, MI 48084
Tel: 888-OnStar7
Web: www.onstar.com

BY DON LANCASTER

"Free" Energy, Bounceback In Capacitors, and More

IS SOLAR ENERGY "FREE?" THERE SURE SEEMS TO BE QUITE A LOT OF MISUNDERSTANDING ON THAT KEY QUESTION. IT TURNS OUT THAT SOLAR ELECTRICAL ENERGY IS JUST AS "FREE" AS OIL IS. IN EITHER CASE, YOU JUST GO GET SOME AS THERE ARE pools of oil all over the place; they are only covered up with some rocks and dirt. Then, you'll gather up and concentrate the energy, purify it, convert it to some useful form, and finally transport it to an accessible place.

Your only tiny little trick lies in spending less already-existing energy doing the finding, conversion, purification, and concentration than you will get back. If you get more back than you put in, you have a net primary energy source. If you input more old energy than you get back, you have a secondary energy sink, and an overall net loss. All of which leads us up to an oft-ignored field known as *engineering economics.*

The term "money" can mean many different things to different people. Let us try this definition: *Dollar—The personal use and control of all the deliverable energy in one gallon of gasoline.* You vote for that definition every time you make any withdrawal from your nearby "Texaco" bank.

Using that definition, you could substitute "gallons of gasoline" for "dollars." Thus, if a solar array costs you $10,000, you can think of it as costing 10,000 gallons of gasoline. If interest is $1000 per year, that equals a thousand gallons of gasoline. And maintenance is something like nine gallons of gasoline per hour—gallons that are forever gone and hence unavailable for any other use.

Your key question is whether the net total lifetime new solar energy generated will ever exceed all of the gasoline needed to build, finance, and maintain the array.

If an oil company spends less than a gallon of gas to deliver any new gallon of gas, we say they make a "profit." When they spend more, they have a "loss" and are simply doing the equivalent of destroying gasoline. Overall, I'd guess around a quarter of a gallon of older gas gets spent delivering one new gallon.

From that point of view, virtually all solar electrical power so far is really an energy sink driven by the inefficient misuse of gasoline in disguise. Arguably, a rather strong case can also be made that most nuclear power to date is (and almost certainly will remain) a gross energy sink that is heavily subsidized by gasoline and other conventional fuels.

Now, it is just fine to spend energy on research and development. It's also fine to be temporarily inefficient in the interests of perfecting a future net energy source, provided, of course, that the target source remains viable. It is also sometimes fine to spend more energy than you'll get back for "Uh, compared to what?" needs.

But failing to recognize the hidden subsidies in any "free" energy "source" is sheer stupidity. So is failing to learn the fundamentals of engineering economics.

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher AZ, 85552
Tel: 520-428-4073

US email: don@tinaja.com
Web page: http://www.tinaja.com

A New DAA Phone Interface

The folks at Silicon Laboratories have just come up with a new chip set that makes telephone data access arrangements (DAA) a lot simpler, smaller, and cheaper. But first, let's review exactly what phone interface is all about.

The typical telephone subscriber loop is shown in Fig. 1. It consists of the wires that reach from your nearby central office to your property line. Power is delivered from a −48-volt battery, through a pair of 200-ohm resistors. Green or tip is closer to ground. Red or ring is closer to −48.

Capacitors are chosen to couple two-way or full-duplex audio onto the balanced lines. The balance reduces crosstalk in cables. Your audio can be analog voice, digital data, caller ID tones, dialing touch tones, or other supervisory signals.

Ringing is done by superimposing very large low-frequency intermittent sinewaves on top of the DC loop. A typical ring signal might be 50 volts at 28 Hz, but can range from 40 to 150 volts rms and from 20 to 40 Hz. Capacitor coupling is usually used to isolate the ring signals.

When on hook, there's around 48 volts on the line. Should any single phone be taken off hook, the voltage drops to around 8 volts. Measuring that voltage gives you a simple "the line is in use" detector.

What is the maximum power you can take off the phone lines? If you match the source impedance on a short distance

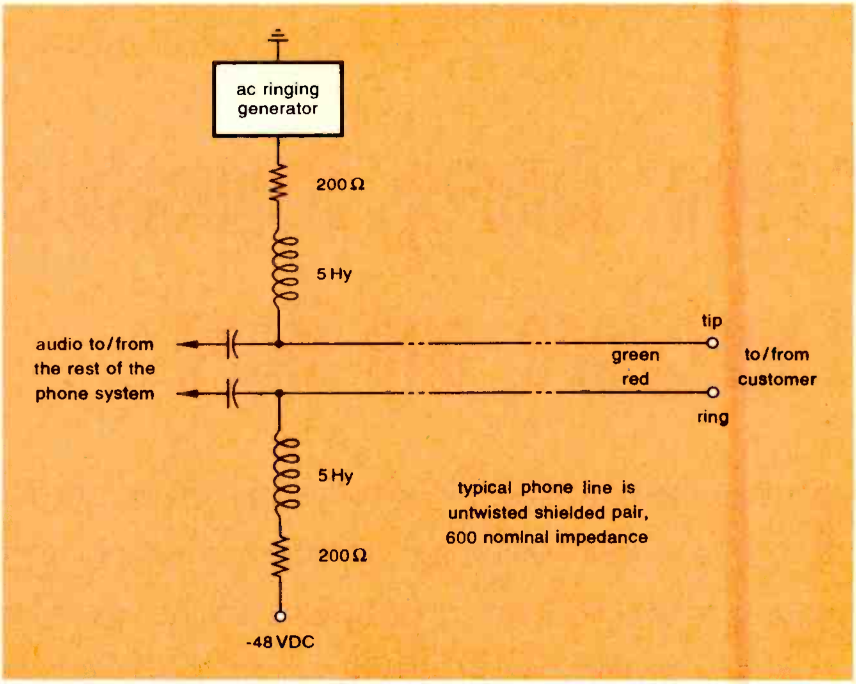


FIG. 1—HERE'S A SIMPLIFIED SCHEMATIC of a telephone local subscriber loop.

line, it is something just over one watt. If you use the load the phone company wants you to on a longer line, then something closer to half of a watt or so is available. All your local phone equipment has to share that meager power, unless they somehow access internal batteries or AC power connections.

The FCC places very strict rules on what you can and cannot do to the phone line. These rules appear in Part 68 of Title 47 of their *CFR Code of Federal Regulations*. That CFR web site is www.access.gpo.gov/nara/cfr. A CD with the full CFR is available from Solutions Software for $62.50.

Just being compliant with the rules is not enough. You also have to go through a very costly and gruesome certification process on all commercial gear. Yes, "pass through" certifications are sometimes available if you use a pre-approved module in a permitted manner inside your own product.

An older DAA interface appears in Fig. 2. We looked into Part 68 interface circuits way back in HACK61.PDF (March 1993 and available on my www.tinaja.com Web site) and HACK07. PDF, and in the Hardware Hacker reprints.

The key component is the isolation transformer. It is a 1:1 ratio unit with an impedance of 600 ohms and a 1500-volt breakdown voltage rating. The Part 68 transformers have gotten smaller and cheaper, but they still have to permit a DC primary current and do present size problems, especially when dealing with PCMCIA and similar cards. Part 68 transformers are found in the usual electronics trade journals and distributors.

Extra bells and whistles have to be added to Fig. 1 to make a full interface. Ring detection is normally done with an AC-linked optocoupler, while a relay's contacts are often used as the hook switch. Some sort of a hybrid, or a two-line to four-line converter, is also needed to separate the incoming and outgoing audio.

There's been several attempts in the past to get rid of the transformer by using high-voltage capacitors. The big "gotcha" here is that the FCC also insists upon a very stringent lateral balance specification. Common-mode signals must be rejected to between 40 and 60 decibels over the audio range.

The Silicon Laboratories approach appears in Fig. 3. They use two integrated circuits, the Si3032A (on your side) and the Si3032B (on the telephone-company side). Those two chips talk to each other by coupling pulses over isolation capacitors. One capacitor is in your signal path; the other two provide balanced ground coupling. All that goes on the phone side is a chip and a few transistors that act as a hook switch. The size is much smaller than any transformer DAA, and easily can fit in a corner of a memory card.

No special ring detection circuitry is needed either. A surprising amount of power can be coupled over their IsoLink technology—enough to power a conventional ringer, even.

It's all done by the chip set. While intended for modems and other data communications uses, there is an analog output. It is intended for call-progress monitoring during your dialing, but there's no obvious reason why you could not build up a phone recorder or other analog application around that output.

Figure 4 shows their usual audio-output circuit. Software poked into registers lets you mute incoming, outgoing, or all audio.

There's quite a bit of innovation involved here. As near as I can tell, a series of locked-pulse frames is set up between their two chips. Those apparently provide two-way data and voice communications, as well as providing the on-hook power for the "B" chip. Extremely elaborate transmit and receive filtering is provided for. That approach also eliminates any need for relays, hybrids, or optocouplers.

The chip set is controlled by an external microprocessor of some sort, which could be a digital signal processor or gate array inside the modem. But you can easily work up a PIC interface.

As with any micro-controlled chip, there will be a dozen or so internal registers that can be read or written to select various options or to input and output data. Full programming details appear on the data sheet.

Cost for the chip set is under $5 in quantity. Modem speeds up to 57.5 kilobaud are fully supported. A demo board and ready-to-use reference design is also available.

I have gathered a few additional DAA suppliers together for you as this month's resource sidebar. Your essential trade journal here will be *Compliance Engineering*. Secrets of caller ID are found in HACK43.PDF (August 1991 and available on line). Bargains on telephone-line lockouts can be found at www.tinaja.com/barg01.html. Those can prevent "modem blasting" should any extension phone get picked up.

Bounceback and Friends

A lot of webizens sure do end up surprised whenever some capacitor seems to magically acquire a charge and terminal voltage after just sitting around for a while. Those "magic" voltages are often attributed to free energy, extragalactic communication, petrovoltaics, or whatever else happens to be the *Scam Du Jour*.

Uh, of course it turns out there's usually no magic here at all. Chances are the

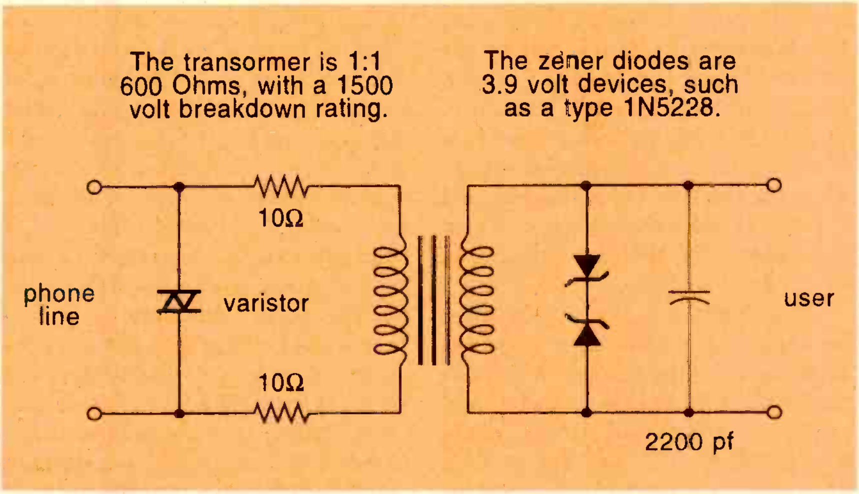


FIG. 2—THIS DATA ACCESS ARRANGEMENT (DAA) uses a special transformer that allows DC primary current.

NAMES AND NUMBERS

Amateur TV Quarterly
5931 Alma Dr.
Rockford, IL 61108
(815) 398-2683

Brand Electronics
421 Hilton Rd.
Whitefield, ME 04353
(888) 433-6600

Hewlett-Packard Journal
3000 Hanover St. M/S 20BH
Palo Alto, CA 94304
(415) 857-1501

HILTI
PO Box 21148
Tulsa, OK 74121
(800) 879-8000

Home Power
PO Box 520
Ashland, OR 97520
(800) 707-6585

Maxim
120 San Gabriel Dr.
Sunnyvale, CA 94086
(800) 998-8800

Microchip Technology
2355 W Chandler Blvd.
Chandler, AZ 85224
(602) 786-7200

Midwest Products
400 S Indiana St.
Hobart, IN 46342
(800) 348-3497

National Semiconductor
2900 Semiconductor Rd.
Santa Clara, CA 95052
(800) 272-9959

Omega Engineering
One Omega Dr.
Stamford, CT 06907
(800) 826-6342

Polycase
1305 Chester Industrial Pkwy.
Avon, OH 44011
(800) 248-1233

QuikVoice
16019 Kaplan Ave.
City of Industry, CA 91744
(626) 333-6394

Robot Science & Technology
2351 Sunset Blvd.
Rocklin, CA 95765
(916) 632-1000

Science/AAAS
1333 H St. NW
Washington, DC 20005
(202) 326-6400

Seiko Instuments
1130 Ringwood Ct.
San Jose, CA 95131
(408) 433-3208

Solutions Software
1795 Turtle Hill Rd.
Enterprise, FL 32725
(407) 321-7912

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

Ulano Corp
280 Bergen St.
Brooklyn, NY 11217
(718) 622-5200

apparent charge is created by inherent defects inside the capacitor and involve dielectric absorption, which is sometimes called "soak." Basically, because of lateral charge migration, there can be a lot of little capacitors scattered around inside the dielectric of your big one, and it sometimes takes those absorption caps an amazingly long time (even months) to charge and discharge.

The electric utilities call that effect bounceback. Any older large paper and oil capacitor might be charged to 30 kilovolts while in service. It might be thoroughly discharged and shorted out a dozen times. But let the cap sit for a while open circuited, and it may eventually end up with a deadly 3 kilovolts or so of highly unexpected terminal voltage.

Bounceback is sort of a second cousin to electrets and the buried charges in EEPROMS. It's just not quite as permanent.

The bounceback effect can be demonstrated using a Leyden Jar in a Physics 101 lecture. But let us ask an electrical safety Web site to summarize:

"All high-grade capacitors, if left on an open circuit after discharge, will recover a considerable portion of the original charging energy. Highly dangerous voltages can build up in open-circuited capacitors over a period of many months after they have last been discharged. This is particularly true where inexpensive paper dielectrics have been used."

There is a very simple test to find out which utility linemen remained awake during Bounceback Lecture #01-A on Day One, Session One of lineman school: They are the ones who are still alive.

The bounceback effect is most noticeable among the larger and older capacitors. The better new capacitors will carefully specify their dielectric absorption as a percentage. Thus 50 millivolts of bounceback might be expected from some previous 5-volt charge with a 1% dielectric absorption. Even small amounts of bounceback becomes critical in dual-slope integrators and other places where you are trying to measure a current over time.

While old paper capacitors might have 10% dielectric absorption, the finest of premium Teflon caps might offer 0.0% bounceback. Half a percent is typical for better mylar caps. Electrolytics in particular are a bizarre witches' brew of chaotic electrochemistry. They should never be used anywhere near any critical low level measurement of any sort.

All of which is not to say that new or unusual measurements cannot be made with capacitors. It is just that you will always have to rigorously eliminate bounceback, because that common and expected effect might end up much stronger than what you think you are measuring.

Another PIC Power Meter

Home energy management starts off 0appliance running costs. To help toward that end, I just received a review unit of the Brand Electronics model 4-1850 power meter. This one is in a five-inch square by two-inch high case. Power consumption, total energy used, runtime hours, plus monthly and average operating costs all is displayed. The costs assume a fixed ten cents per kilowatt-hour. Since many hundreds of samples are taken per half cycle, the ability to handle unusual waveforms and high crest factors seems inherent.

There is a single grounded outlet at the rear. You plug in the appliance whose energy consumption is to be measured and plug the unit into the wall outlet. List price is $149.

Power measurement and related home energy monitoring topics often show up in *Home Power* magazine. The Web site is www.homepower.com Circuit details of a reference design for a PIC-based wattmeter are available from Microchip Technology via their www.microchip.com Web site. Lots more on PICs in general is found at www.tinaja.com/picup01. html.

New Tech Lit

From Seiko Instruments, there is a new CD-ROM on all of their components and integrated circuits. From Maxim comes a thick new *Product Selector Guide* and CD. Omega Engineering offers a useful free wall chart about infrared measurement fundamentals. QuikVoice has a handy booklet full of solid-state answering-machine and ad-messaging circuits.

Interesting information on photopolymer films is available by way of Ulano. Tiny keychain-sized electronic cases are available from Polycase. Unusual microcut woods are stocked in depth by Midwest Products. From HILTI, there's a

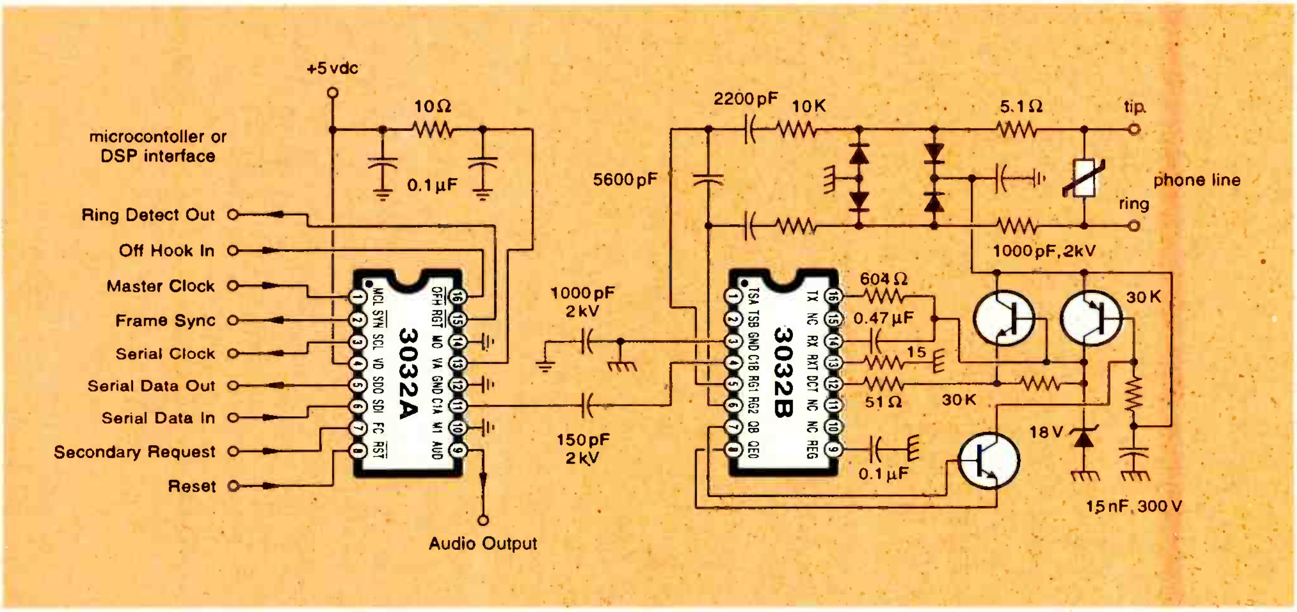


FIG. 3—A NEW DAA FROM SILICON LABORATORIES uses a pair of integrated circuits and balanced coupling capacitors to eliminate the transformer, hybrid, and ring detector.

SOME DATA ACCESS ARRANGEMENT (DAA) RESOURCES

Cermetek
1308 Borregas Ave.
Sunnyvale, CA 94088
(408) 752-5000

Compliance Engineering
1 Tech Drive
Andover, MA 01810
(508) 681-6600

Computer Telephony
12 West 21st Street
New York, NY 10010
(212) 691-8215

Comrex
65 Nonset Path
Acton, MA, 01720
(800) 237-1776

C.P. Clare
78 Cherry Hill Drive
Beverly, MA 01915
(978) 524-6700

Dallas Semiconductor
4401 Beltwood Pkwy. S
Dallas, TX 75244
(972) 371-4000

Harris Semiconductor
1025 West NASA Blvd.
Melbourne, FL 32919-0001
(800) 4-HARRIS

Hello Direct
140 Great Oaks Blvd.
San Jose, CA 95119
(800) HI-HELLO

Lucent Technologies
555 Union Blvd. #21Q-133BA
Allentown, PA 18103
(800) 372-2447

Maxim
120 San Gabriel Dr.
Sunnyvale, CA 94086
(800) 998-8800

Mitel
2321 Morena Blvd. #M
San Diego, CA 92110
(619) 276-3421

Siemens Components
10950 N Tantua Ave.
Cupertino, CA 95014
(408) 777-4968

Silicon Laboratories
2024 E St. Elmo Rd.
Austin, TX 78744
(512) 416-8500

Silicon Systems
14351 Myford Rd.
Tustin, CA 92680
(714) 573-6000

Teltone
22121 20th Ave. SE
Bothell, WA 98021
(800) 426-3926

Xecom
374 Turquoise St.
Milpitas, CA 95035
(408) 945-6640

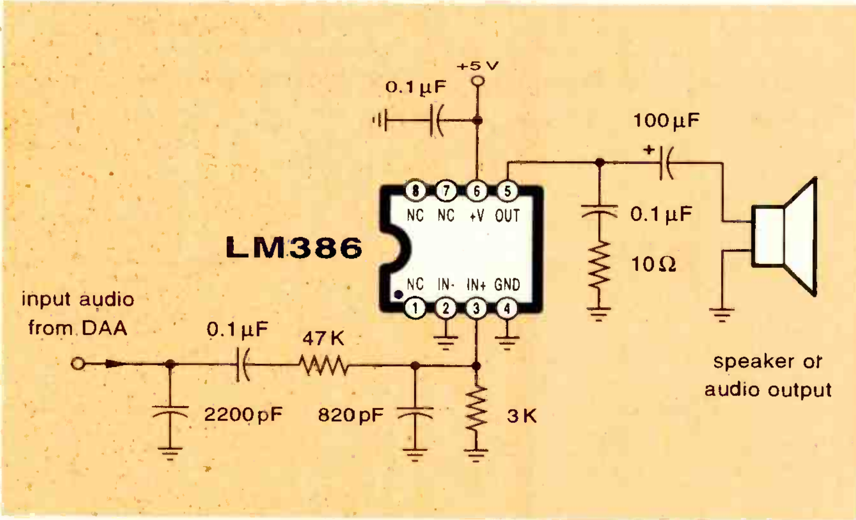


FIG. 4—THE DAA AUDIO OUTPUT CIRCUIT shown here can be used for digital call-progress monitoring or analog message recording.

line of laser instruments to measure, plumb, and level—all at once.

A scheme for directly converting solar energy into hydrogen in a single cell is described in *Science* for April 17, 1998 on pages 382 and 425-427. While the claimed efficiency is an outstanding 12.5%, their economics otherwise are likely to remain poor. Materials similar to those used in LEDs are involved.

Robot Science & Technology is a new robotics magazine published by Mike Greene. The *Amateur Television Quarterly* continues to be a well done labor-of-love newsletter.

Our featured trade journals include *PC-AI* on computer-based artificial intelligence. Plus lets give a mention to the good old *Hewlett-Packard Journal*.

Free chip samples for this month are the CLC5523 250-MHz low-power variable-gain amplifier from National Semiconductor. Plus a new S-8430AF combination step-up and step-down regulator from Seiko Instruments. Lots of great buys on Tektronics scopes and Ethernet cards can be found at www.tinaja.com/barg01.html.

Once you get beyond its obviously redundant title, *Windows Annoyances* is a really great book. Lots of useful tips here on speeding things up and reducing frustration. David Karp is the author. It sells for $29.95. Irvin Glassman's *Combustion* is apparently the definitive university text on everything involving flames. I have access to these titles and a full power search for just about any other book (technical or otherwise) at www.tinaja.com/amlink01.html

To receive instant and thorough answers to any technical subject, check out my new InfoPack service at www.tinaja.com/info01.html And the insider secrets of active filters are found in my *Active Filter Cookbook*, per my nearby Synergetics ad.

The latest additions to my Guru's Lair Web site at www.tinaja.com now include a new tutorial on cubic spline curve fitting, several of the latest newly discovered and delta-friendly magic sinewave sequences, plus a tutorial about offshore electronics resources. A new site search has also been added.

A reminder that most of the text-mentioned items appear in our Names and Numbers and DAA Resources sidebars. Always check here before calling our free US technical help line shown in the nearby box.

Let's hear from you.

DISPLAYER

(continued from page 60)

get into places you don't want them to be. Ground the shield at the PC board end only to prevent any ground loops.

As you flip the switch, you should see the appropriate "C" LED light dimly to indicate where middle C is. The note display should track correspondingly.

The volume display is easy to test. Connect the output of an instrument to J3 and play it at maximum volume. Adjust R42 until the last light is lit. The DisPlayer is now calibrated and ready to go.

If you want to check the operation of the temperature-compensating circuit, briefly touch a soldering iron to the case of Q1 while a constant frequency is being displayed. You'll see that the frequency display change rapidly as the transistor warms up even slightly. Now warm up Q2; you'll see the same change, but in the opposite direction.

Other Uses for the DisPlayer. One simple modification that will make the DisPlayer easy to use for a variety of pitch-sensing purposes would be to use panel-mount pots for R41-R44 as was done in the author's prototype. That will make it easier to readjust the DisPlayer to any particular situation.

There's no reason why you couldn't experiment with 11- or 13-note scales. Simply set up the pitch calibration so that one octave is covered by 11 or 13 lights. It will be somewhat confusing because the display will still apparently show 12 notes per octave, but the music you produce with such scales will be very different.

The input to the logarithmic op-amp can be just about anything you want. For example, a super-expanded VU meter can be created by disconnecting R15 from the output of IC5 and using it as a direct input to your signal source (either AC or DC). Each light will represent 0.5 dB, for a total dynamic range of 20 dB. If your input is from a light meter, you can adjust the display so that each LED could represent $^{1}/_{12}$ of an f-stop—a boon to photographers.

Happy DisPlayer-ing! Ω

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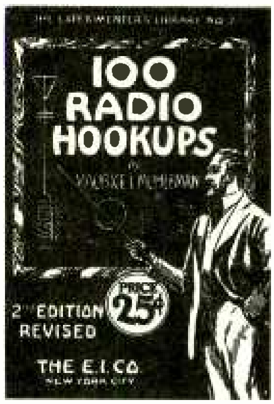
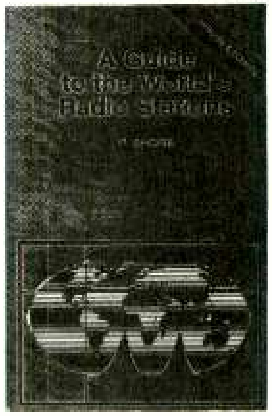
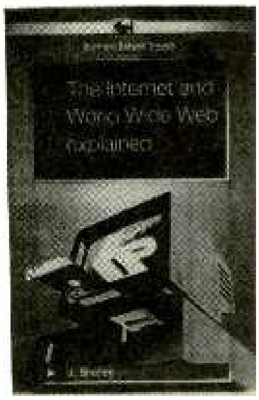
First published in May, 1923 this popular booklet went into reprint editions nine times. It is packed with circuits, theory, antenna installation and tips on consumer radio receivers that were popular in the early 1920's. Antique radio buffs and those inquisitive about the early days of radio will find this booklet an exciting, invaluable and excellent reference into the minds of early-day radio listeners. Sorry, we cannot honor the original 25-cent cover price.



☐ GUIDE TO THE WORLD'S RADIO STATIONS —BP355—$10.99

An easy-to-read guide for trhe casual listener and top notch QSL getter! The Guide is an essential reference work designed to steer the listener around the ever more complex radio bands. Listings cover world-wide shortwave stations with a special emphasis on international broadcasts in English. Medium and long-wave listings are also included for the US, Canada, European, Middle and Near East, and North Africa regions





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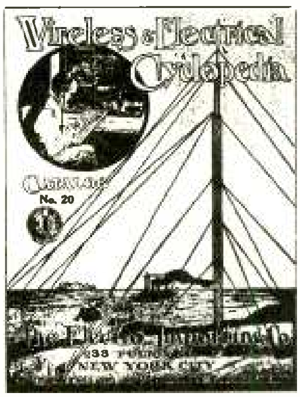

☐ WIRELESS & ELECTRICAL CYCLOPEDIA —ETT1—$5.75

A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period. Take a look at history and see how far we have come. And by the way, don't try to order any of the radio parts and receivers shown, it's very unlikely that it will be available.

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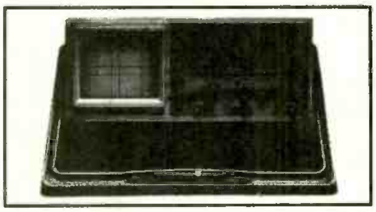

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FM-25, Synthesized FM Stereo Transmitter Kit........ $129.95

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LPA-1, Power Booster Amplifier Kit.................. $39.95
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FM-5 Micro FM Wireless Mike Kit.................... $19.95

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FM-6, Crystal Controlled FM Wireless Mike Kit......... $39.95
FM-6WT Fully Wired FM-6 .... $69.95

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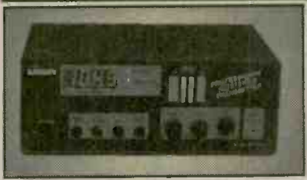

A truly professional frequency synthesized FM Stereo transmitter station in one easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set frequency easily with the Up/Down freq buttons and the big LED digital display. Plus there's input low pass filtering that gives great sound no matter what the source (no more squeals or swishing sounds from cheap CD player inputs!) Peak limiters for maximum 'punch' in your audio - without over modulation, LED bargraph meters for easy setting of audio levels and a built-in mixer with mike and line level inputs. Churches, drive-ins, schools and colleges find the FM-100 to be the answer to their transmitting needs, you will too. No one offers all these features at this price! Kit includes cabinet, whip antenna and 120 VAC supply.

We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

FM-100, Professional FM Stereo Transmitter Kit....... $299.95
FM-100WT, Fully Wired High Power FM-100........... $429.95

AM Band Radio Transmitter

Ramsey AM radio transmitters operate in the standard AM broadcast band and are easily set to any clear channel in your area. Our AM-25, 'pro' version, fully synthesized transmitter features easy frequency setting DIP switches for stable, no-drift frequency control, while being jumper setable for higher power output where regulations allow. The entry-level AM-1 uses a tunable transmit oscillator and runs the maximum 100 milliwatts of power. No FCC license is required, expected range is up to 1/4 mile depending upon antenna and conditions. Transmitters accept standard line-level inputs from tape decks, CD players or mike mixers, and run on 12 volts DC. The Pro AM-25 comes complete with AC power adapter, matching case set and bottom loaded wire antenna. Our entry-level AM-1 has an available matching case and knob set for a finished, professional look.

AM-25 Professional AM Transmitter Kit.......................$129.95
AM-1 Entry level AM Radio Transmitter Kit.......................$29.95
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Tone-Grabber Touch Tone Decoder / Reader

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TG-1, Tone Grabber Kit........................... $99.95
CTG, Matching Case Set for TG-1 Kit................ $14.95
TG-1WT, Fully Wired Tone Grabber with Case......... $149.95
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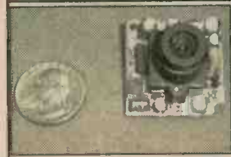
Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies- that's a nickel in the picture! Transmits color or B&W up to 150' to any TV tuned to cable channel 59 with a solid 20 mW of power. Crystal controlled for no frequency drift with performance that equals law enforcement models that cost hundreds more! Deluxe model includes sound using a sensitive built-in mike that will hear a whisper 15 feet away! Units run on 9 volts and hook-up to most any CCD camera. Our cameras shown below have been tested to mate perfectly with The Cube and work great. Fully assembled.

C-2000 Video Transmitter Cube.......................$89.95
C-3000 Video and Audio Transmitter Cube.......................$149.95

CCD Video Cameras



If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. These cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, these are super IR (Infra-Red) sensitive! Available with Wide-angle (80°) or super slim Pin-hole style lens. Both run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our Interface board (below) for Audio sound pick-up and direct wire connection to any Video monitor or TV video/audio input jacks. Fully assembled.

CCDWA-2 CCD Camera, wide-angle lens.......................$99.95
CCDPH-2 CCD Camera, slim fit pin-hole lens.......................$99.95
IR-1 IR Illuminator Kit.......................$24.95

CCD Camera Interface Board

Here's a nifty little kit that eases hook-up of your CCD camera module to any video monitor, VCR or video input TV set. The board provides a voltage regulated and filtered source to power the camera (CCD Cameras require a stable source of power for best operation), sensitive electret condensor mike for great sound pick-up and RCA Phono jacks for both audio and video outputs. Runs on 11 - 20 VDC.

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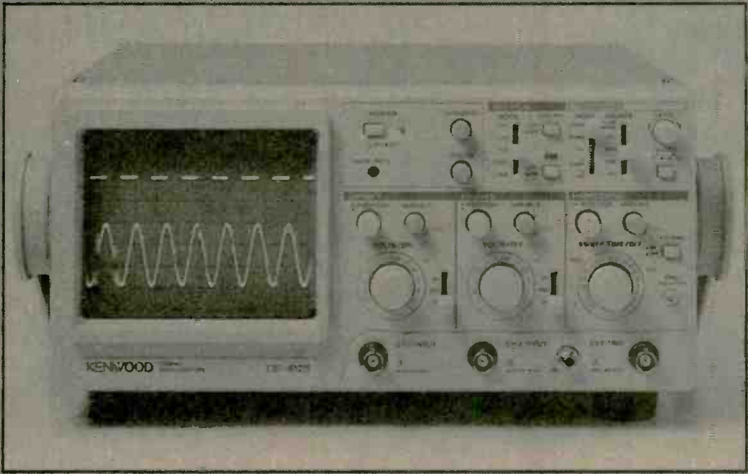

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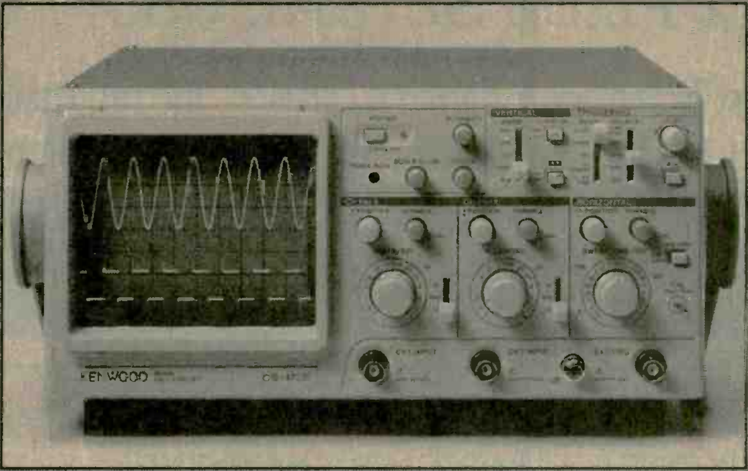
Sale $389



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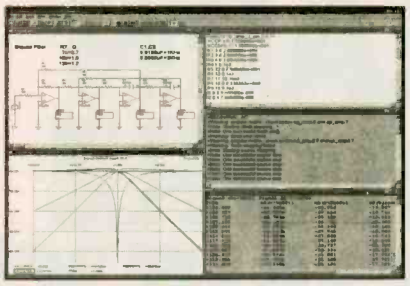

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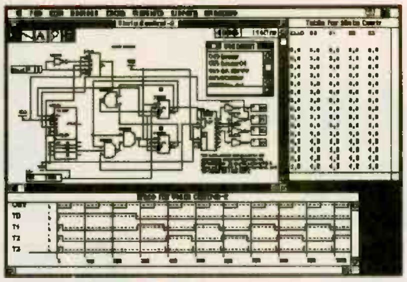

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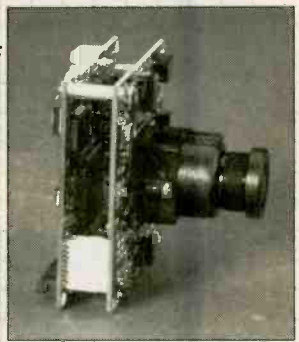

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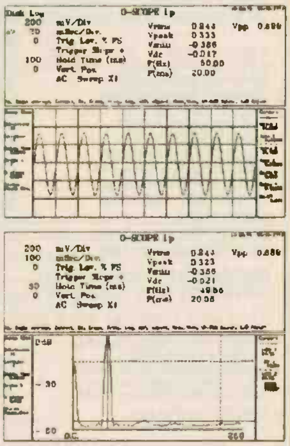

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- Totally ESD Safe. The housing contains carbon and the tip is at

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386 MINI-PC $83

1K PRICE
EVAL $295
8088 $27

includes:
- -5 Serial,3 Parallel (32bit max)
- -Up to 8 meg ROM (27C080)
- -32k RAM exp. to 64Mbyte
- -Battery backed RT Clock
- -LCD and Keyboard ports
- -IRQ x15, DMA x2, TIMER x4
- -On-board LED display
- -Industry Standard PC Bus

Perfect when a full-size PC is too large, expensive, or power hungry. A fully functional single board computer, needs only program and power source. Runs DOS / WINDOWS. Use Turbo C, BASIC, MASM. All utilities to do this included.

A to D D to A CONVERTERS

For PC or SBC
8,12,16 bit resolution
up to 24 channels
starting at $21 OEM (1k)
eval kit $75

$95 UNIVERSAL PROGRAMMER

FLASH, EEPROM, NVRAM, EPROM up to 8 meg (27C64-080). Adapters for micros, PLCC, etc. Parallel port version for notebook. FAST AND EASY TO USE.

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LOW RISC!

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$1.99
EVAL KIT 7.00

LOWER COST, FASTER, EASIER TO PROGRAM SINGLE CHIP COMPUTER

COMPARE:	16C54	MV1200
OEM (1K) PRICE	$2.57	$1.99
RS232 PROGRAM DOWNLOAD	NO	YES
SINGLE CHIP OPERATION	NO	YES
BUILT-IN BASIC	NO	YES
EEPROM DATA MEMORY	NONE	64
PROGRAM MEMORY	768 OTP	1K FLASH
MATH REGISTERS	1	32
MAX INSTRUCTIONS / SEC	5M	20M
MAX COUNTER BITS	16	18
INPUT / OUTPUT BITS	12	15
A TO D COMPARATOR	NO	YES
HARDWARE INTERRUPTS	NONE	3

PINOUT:

RESET	1	20	VCC
PD0	2	19	PB7
PD1	3	18	PB6
XOUT	4	17	PB5
XIN	5	16	PB4
PD2/INT	6	15	PB3
PD3	7	14	PB2
PD4/TMR	8	13	PB1/AD1
PD5	9	12	PB0/AD0
GND	10	11	PD6

- LONG WORD INSTRUCTION - FRIENDLY SYMMETRIC ARCHITECTURE -

PC SOLID STATE DISK

$21 OEM (1k) eval kit 75.00
FLASH / RAM / EPROM
256K-16M PCMCIA/DIPS

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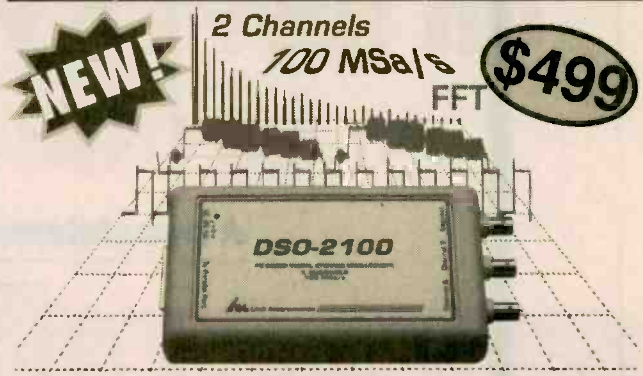
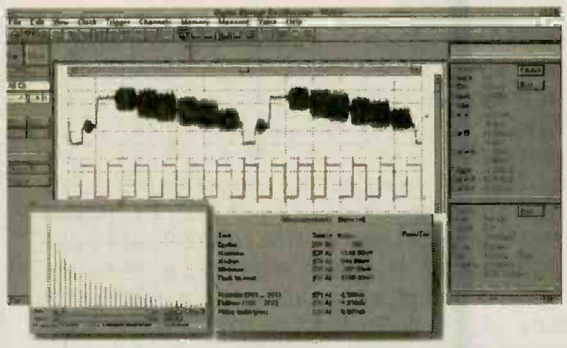
Digital Oscilloscopes

100 MSa/s Parallel Port Based DSO

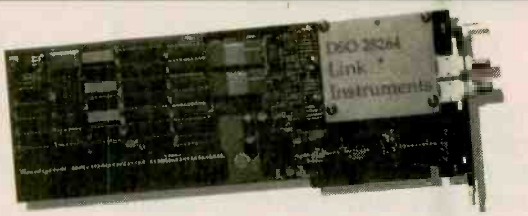


- **2 Ch.** Digital Oscilloscope
- **100 MSa/s** Max Single-Shot Rate on Both Channels
- **60MHz** Input Bandwidth
- **32K** Samples Per Channel
- Optional FFT Spectrum Analyzer*, Advanced Math* and TV Line Trigger**
- IEEE Pulse Parameter Measurements
- One touch **Auto-Setup**
- Advanced Pulse Triggering*
- Hands-Free Voice Control
- Easy to use Windows and DOS Software Included
- **Parallel Port** Interface to Laptop or Desktop PC
- Small and Lightweight (9 oz and 6.3" x 3.75" x 1.25")
- **Free** Demo Software on Web

For **$499** you get the model **DSO-2102S Oscilloscope**, Probes, Interface Cable, Power Adapter, and Windows and DOS Software.
*DSO-2102M **$599** **TV-Line Module **$149**



DSO w/Logic Analyzer (ISA based)



- **200 MSa/s** Max Single-Shot Sample Rate
- **2** Oscilloscope Channels
- **8** Logic Analyzer Channels
- **10** Channels Simultaneously
- **125 MHz** Single Shot Bandwidth
- Up to **128K** Samples/Channel
- FFT Spectrum Analyzer included

DSO-28264 (10Ch, 200MSa/s, 64k) **$1999**
DSO-28464 (20Ch, 200MSa/s, 64k) **$3799**
All prices include Probes and Software

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Our Best Offer Ever on a High Quality Full Sized DMM

$19.00 any qty

General — **Rubber Boot Included**

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
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)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.
Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
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

Positive Photofabrication Kit

Make your own PCB's

Kit includes the basic items needed to fabricate pre-sensitized printed circuit boards (does not include artwork). Also included is a basic process guide to assist the user in the basics of exposing, developing and etching a PCB. All items fit conveniently in the plastic development tray, and a tight fitting lid is included for handy storage. Additional recommended supplies for fabricating PCB's are: exposure bulb, etchant tank, eye protection, art-work, paper towels.

Kit Includes

- 1 each 3"x5" pre-sensitized single sided PCB
- 1 each 4"x6" pre-sensitized single sided PCB
- 1 each 6"x6" pre-sensitized single sided PCB
- 1 each 500ml developer liquid
- 1 each 500ml ferric chloride etching liquid
- 2 each foam brushes
- 1 each plastic development tray
- 1 each rubber gloves
- 1 each instruction sheet

new!

CAT NO	DESCRIPTION	PRICE
416-K	Photofabrication Kit	$27.95

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

Exposure System

Just place your presensitized board and artwork centered under the exposure fixture. Place the convenient acrylic sheet over the board and artwork to hold everything in place. Turn on light. Voila! Exposure takes about 5 minutes. Kit includes one fluorescent tube, stand and acrylic weight.

new!

Features

- Exposes boards in about 5 minutes!
- Convenient acrylic sheet to hold board in place during exposure (12.5" x 8.5")
- Fluorescent light fixture with plastic cover designed to aid in proper light refractions for even exposure

CAT NO	DESCRIPTION	PRICE
416-X	Fluorescent Exposure System	$31.95
416-B	Extra Replacement Fluorescent Tube	16.95

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

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

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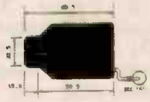
CIRCLE 332 ON FREE INFORMATION CARD

Color Weather Proof Bullet Camera

1/3" CCD with removeable rotation capable mounting bracket

new!

Specifications



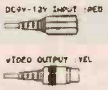


Image Sensor:	Interline transfer CCD 1/3" format
Effective Pixel:	512(H)x492(V) pixels/NTSC 512(H)x582(V) pixels/PAL
Scanning System:	2 : 1 interlaced
Sync System:	Internal sync
Sync Pulse:	15.734KHz+1%(H)/15.625KHz +1%(H) 59.94Hz +1%(V)/ 50Hz +1%(V) Sub-Carrier 3.57 MHz +30ppm
Resolution:	400 TV lines (H)
S/N Ratio:	More than 46dB (typ)
Gamma Characteristics:	0.45
Min. Illumination:	1 LUX (F1.2 10 IRE)
Video Out:	Composite video signal : 1.0Vp-p
White Balance:	Auto white balance
Electronic Shutter:	1/60 - 1/100,000 SEC(N) 1/50 - 1/100,000 SEC (P)
Power Supply:	DC 12V + 10%
Power Consumption:	240mA (typ)
Lens:	4mm (78 or 92 degree) F : 2.0
Ambient Operating Temp:	-5 deg. C +40 Deg. C
Ambient Storage Temp:	-10 Deg. C+50 Deg. C RH 95% MAX
Dimension:	2 1/8" (L) x 1 1/4" (D)
Weight:	3 oz.

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-5407S	Color Water Tight Bullet Camera	$299.00	$269.00

(water tight for outdoor use, not suitable for sustained underwater use)

CCD Bullet Cameras

new!

Available with standard or pinhole lens. Virtually indestructible bullet shaped casing. This sleek B&W camera can be mounted on walls or ceilings along narrow corridors or virtually any location for virtually any surveillance application. 0.5 lux minimum illumination with 380 lines of resolution. Even includes a built-in electronic iris for automatic light compensation.

Features

- Extremely low power consumption
- No blooming, no burning
- 0.5 LUX minimum illumination
- CCD area image sensor for long camera life
- Ultra small size allows for simple application and installation
- Built-in electronic auto iris for automatic light compensation
- Ultra compact camera

Specifications

Image Pick-Up Device:	1/3" CCD area sensor
No. of Pixels:	EIA = 512(H) x 492(V)
Pixel Pitch:	EIA = 9.6uM(H) x 7.5uM
Scanning System:	EIA=525 lines, 60 field/sec
Sync System:	Internal sync
H. Resolution:	430 TU line
V. Resolution:	400 TU line
Usable Illumination:	0.5 Lux F1.6
S/N Ratio:	More than 48dB
Gamma Characteristic:	0.45
Video Output:	1.0 - 1.1 up-p 75 Ohm
Electronic Shutter Time:	EIA=1/60 - 1/50,000 sec
Lens F No. Focal Length:	STD : 1.6 Open / 4.3mm(78 deg) Pinhole: 4.3 fixed/ 2.8mm(91.4 deg)
Power Consumption:	DC 9V (8-10V), 110mA
Operational Temp.:	-10 deg - +50 deg C RH95% max
Storage Temp:	-20 deg - +60 deg C RH95% max
Dimensions:	STD : 22mm(W) x 22mm(H) x 38mm(D) Pinhole: 22mm(W) x 22mm(H) x 30mm(D)
Weight:	35g max

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-07S	Standard Lens Version	$144.00	$129.00
WDB-07P	Pinhole Lens Version	144.00	129.00
WDP-07S/water	Standard Lens Weather Proof	169.00	152.00

CCD Dome Camera with Audio

B&W DOME camera with integrated microphone. Ideal security system application. 12 VDC operation.

new!

Specifications

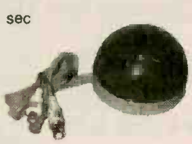


Image Device:	1/3" interline transfer CCD
Picture Elements:	EIA=542(H)x492(V)
Scanning System:	2:1 Interlace
Synchronization System:	Internal
Horizontal Resolution:	380 TV Lines
Sensitivity:	Under 0.3 LUX
Electronic Iris (linear):	EIA = 1/60~1/100,000 sec
Video Output:	1.0vp-p, 75 ohm
S/N Ratio:	More than 50dB
Power Supply:	12V DC (±20%)
Gamma:	r=1
Power Consumption:	110 mA max
Operating Temp.:	-10°C ~ +50° C
Operating Humidity:	RH 95% Max
Weight:	100g
Applied Lens:	3.6mm -92°, 4.3mm -78°
AI/EE/Flicker Less/Mirror Image:	Jump soldering selection
Audio Pick-up Sensitivity:	-60dB (0dB=1V/ubar)
Audio Frequency Range:	20 Hz ~ 20 kHz
Audio S/N Ratio:	More than 40dB
Audio Output Level:	1Vp-p/600 ohm
Dimensions:	87 x 55.5mm

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDDB-6500	B&W Dome Camera	$144.00	$129.00

1/3" CCD Board Cameras

Available with **PINHOLE LENS** with **AUDIO**; **STANDARD LENS** with **AUDIO**; and **STANDARD LENS** with **INFRA-RED and AUDIO**. These are the world's smallest commercially available CCD board cameras!

World's Smallest B&W Board Cameras

Specifications

WDP-2000

WDS-2005

WDI-4000

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 signal
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)

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 with Audio	89.00	77.00
WDPH-55BW	Plastic Housing Option for B&W Board Cameras (WDP-2000 & WDS-2005 ONLY)	13.00	12.00

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ESD Safe Soldering Stations

Standard Tip

- *Auto-Temp 136ESD & Auto-Temp 137ESD*
- *Meets applicable military standards*
- *ESD safe featuring ceramic heating element and state of the art P.T.C. sensor to ensure accurate temperature performance*

XYTRONICS

136ESD

137ESD w/ Digital R/O

Features

Fine Tune Temperature from 150° C (300° F) through 450° C (850° F) without unnecessary tip or heating element changes.
Precision "Tip Temperature" accuracy is mastered to within ±3° C (6° F) using state of the art circuit technology and a built-in P.T.C. sensor located at the top of each ceramic heater shaft for fail safe accuracy.
Fast Heat Up & Recovery. A long life Japanese made ceramic heating element facilitates fast heat up, fast recovery and exacting temperature control with minimal overshoot. Heat-up time to working temperature is attained in about 45 seconds. **Spike Free Circuit.** "Zero voltage" switching and fully grounded design meets military application standards for protection of electrosensitive devices against line transience and voltage spikes. Tip leakage is less than 0.4 mv or 0.5 ohm resistance. **External Calibration Port.** A calibration port is located on the face of the unit thus temperature adjustments are quick and convenient.
Lightweight Soldering Iron. Ergonomic mini handle that stays "cool". Handle assembly cord is made from silicone rubber that won't be damaged when coming into contact with high temperature irons.
Isolated Power Unit. The power unit is isolated from the AC line by a high quality transformer and only 24 Vac voltage is used to drive the heating element. **ESD Safe.** Exceeds all soldering equipment military specifications regarding electro static sensitive devices for critical applications. **Lock-Out Feature:** Constructed with a lock-out feature to allow supervisors only to set and lock specific soldering temperatures. Accomplished via a special sized allen head screw located on the front panel. **Superior High Insulation** ceramic heater provides insulation rated over 100Mohms at 750° F. **Optional SMD Tip Series** for re-work applications. **Range of Interchangeable Tips Available** for maximum system flexibility.

SEE *www.cir.com* FOR OUR SELECTION OF REPLACEMENT TIPS, REPLACEMENT IRONS AND SMD TIPS.

CAT NO	DESCRIPTION	PRICE EACH 1	5
136ESD	Electronic Temp Controlled ESD Safe Soldering Station	$99.00	$88.00
137ESD	Electronic Temp Controlled ESD Safe Soldering Station w/ Digital Readout	129.00	114.00

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▲▲ Intermediate
▲▲▲ Advanced
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- In business since 1985

FM Wireless TY-35 Microphone

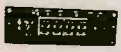
Clearance Sale

This is a low power real FM transmitter. Transmit frequency within 88-108 MHz. Transmit range about 200 ft. It has high sensitivity sound pickup by a capacitance microphone. May be used strictly for series purposes such as remote wireless monitering.

Kit $ ~~12.50~~ 6.99

4½ Digital LED Panel Meter

Clearance Sale SM-48



Kit $ ~~39.00~~ 20.00

This precision digital meter is a stand-alone voltmeter-ammeter or can interface with a computer! 4½ digit 0.55" LED display. Temperature compensated to 100 PPM/°C. Operating temperature range is 0°C to +70°C. Outputs include BCD date, Busy and strobe. Panel reading can be latched on hold.

SCHOOL PROJECT CORNER

po orders welcome from schools

Melody Generator	▲	Kit $ 13.85
6W Mini-Amplifier	▲	9.50
0-15V 5A Regulated DC PS	▲	17.50
36W Class A Power Amp.	▲▲	32.50
Dynamic Noise Reduction	▲	26.00
Multi-Function Control Switch	▲	10.50
20 Bar/Dot Level Display	▲▲	41.45
Microphone Mixer Mono Amp.	▲	20.79
Superior Electronic Roulette	▲	21.50
Digital Clock with Melody Alarm	▲	25.00
Stereo Pre-Amp with Mic Amp.	▲	10.78
Mini Stereo Multi-Input Amp.	▲	30.50
130-in-one Electronic Lab	▲	29.99

SEE OUR CATALOG FOR MORE KITS !

Stereo Loudspeaker Protector

TY-25 ▲

Kit: $ 16.75

Super fast acting relay protects speakers against destructive DC voltages. Can connect directly to a power amplifier or can use a separate power supply. Has a 3 second turn-on delay to avoid turn-on thumps.

Regulated DC Power Supply

TR-503 ▲▲

Kit: $ 18.75

It is short circuit proof & has overload protection. Output voltage is variable over a range of 0-50 volts. Current limit trip is adjustable up to max of 3A. May use Mark V #002 transformer.

Fluorescent Light Driver

TY-2 ▲ (1 lb.)

Kit:$ ~~14.75~~ 9.99

This unit drives 6-40 watts fluorescent light for portable and emergency use. Works from a 7.2 - 16 VDC battery. Includes a "Hi-Efficiency Switching Mode IC Driving Circuit" suitable for use with different lights.

120-250W Mosfet Power Mono Amplifier AF-2 (6 lbs.) ▲▲

Kit: $ ~~89.80~~ 76.33 Asmb.$ 114.80

Power Output: 250W into 4 ohms RMS(42VX2 6A transformer is used). 120W into 4 ohms RMS(33VX2 4A transformer is used). Frequency Response: 3Hz-22,000Hz. THD: <0.03%. Signal to Noise Ratio: 91dB. Sensitivity: 1V RMS at 47k. Load Impedance: 4 or 8 ohms. Power Requirement: ±46VDC 4A or ±60VDC 6A. May use Mark V model 012 Transformer. Suggested Capacitor 8,200uf 100V Model 020. Suggested Metal Cabinet LG-1925.

500-in-one Electronic Lab Kit

KA-904 $129.99

Contains its own computer with a simple explanation of the basic(Assembler) language required for operation. Compile programs to discover how computers operate while gaining an understanding of hardware & software. With easy-to-follow manual which explains by comprehensive diagrams. Requires 4 "AA" batteries.

300W High Power Mono Amplifier TA-3600 (5 lbs.) ▲▲▲

75.65

Kit:$ ~~89.00~~
Asmb.$ 115.00

Power Output: 300W into 8 ohms RMS. 540W music power into 8 ohms. Frequency Response: 10Hz-20KHz. THD: < 0.05%. Sensitivity: 1V RMS at 47K. Power Requirement: 60 to 75 VDC at 8A. May use Mark V Model 007 or 009 Transformer. Suggested Capacitor: 8,200uf 100V Model 020 Capacitor. Suggested Metal Cabinet LG-1925.

150MHz 8 Digit Frequency Counter

SM-100 (2 lbs.)

Kit:$ ~~79.00~~ 68.00
Asmb.$ 99.00

It is used for adjustment, test & repair of any kind of high frequency circuit products. It can give up to 8 digit of resolution for a wide frequency range 10Hz - 150 MHz. The last input frequency can HOLD on the display for future reference & comparison. The circuit structure is compact & reliable for the most updated A/D LSI circuitry. The input impedance is 1M ohm. ▲▲▲

120W + 120W Pre & Main Stereo Amplifier TA-800MK2 (4 lbs.) ▲▲

Kit: $ ~~67.92~~ 61.13 Asmb.$ 86.95

Power Output: 120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response: 10 - 20 KHZ. THD: < 0.01%. Tone Control: Bass ±12dB, Mid ±8dB, Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40V DC @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Metal Cabinet Model LG-1924.

80W + 80W Pure DC Stereo Main Power Amplifier TA-802 (4 lbs.) ▲▲

42.45

Kit: $ ~~49.94~~
Asmb.$ 69.94

Power Output: 80W per channel into 8 ohms. THD: < 0.05%. Frequency Response: DC to 200 KHZ, -0 dB, -3dB @ 1W. Power Requirement: 30V AC X 2 @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Capacitor 8,200uf 50V Model 017. Suggested Metal Cabinet LG-1924

60 + 60W Stereo Power Amp. ▲▲

SM-302 (11 lbs.)

Kit:$ ~~85.00~~ 76.50

It provides 3 input jack pairs. One pair accept a high impedance micro-phone. The two remaining pairs are for high & low level input sources. Power Output: 60W per channel into 4 ohms RMS. 20Hz-20KHz. THD:<0.1%. Input Sensitivity :Mic /Guitar 10mV, Hi 380mV, Lo 640mV. Ready to plug in when assembled.

30W + 30W Pre & Main Stereo Amplifier TA-323A (1 lb.) ▲

29.25

Kit: $ ~~32.50~~ Asmb.$ 50.50

Power Output: 30W into 8 ohms RMS per channel. THD: < 0.1% from 100 HZ to 10 KHZ. Sensitivity: Phono 3mV @ 47K. Tuner, Tape 130mV @47K. Signal to Noise ratio: 80dB. Power Requirement: 22 to 36V AC, 3A. May use Mark V Model 002 Transformer. Suggested Cabinet LG-1684.

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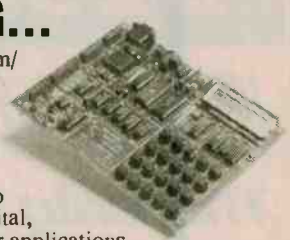

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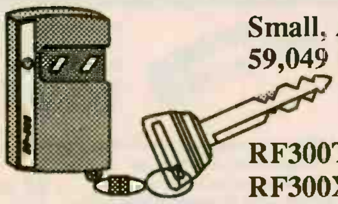

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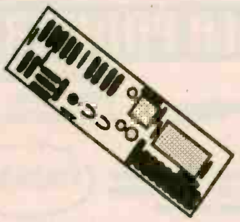

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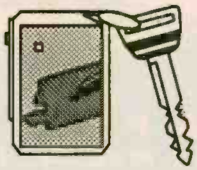

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