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MARCH 1999

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CIRCLE 174 ON FREE INFORMATION CARD

MARCH 1999, Vol. 16, No. 3

Popular Electronics®

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

CONSTRUCTION ARTICLES

FEATURE ARTICLE

PRODUCT REVIEWS

COLUMNS

DEPARTMENTS

Popular Electronics (ISSN 1042-170-X) Published monthly by Gernsback Publications, Inc. 500 Bi-County Boulevard, Farmingdale, NY 11735. Second-Class postage paid at Farmingdale, NY and at additional mailing offices. One-year, twelve issues, subscription rate U.S. and possessions $24.99, Canada $33.15 (includes G.S.T. Canadian Goods and Services Tax Registration No. R125166280), all other countries $33.99. Subscription orders payable in U.S. funds only. International Postal Money Order or check drawn on a U.S. bank. U.S. single copy price $4.99. Printed in U.S.A.
Postmaster: Please send address changes to Popular Electronics, Subscription Dept., P.O. Box 338, Mount Morris, IL 61054-9932

BUSINESS AND EDITORIAL OFFICES
Gernsback Publications, Inc.
500 Bi-County Blvd.
Farmingdale, NY 11735
516-293-3000
Fax: 516-293-3115
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Composition by Mates Graphics

Cover by Loewy Design

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Editorial

Change—The Only Constant

It's nice to return to an old friend.

Some of you might remember that I was the Editor of this magazine a couple of years ago. Though I've stopped using my old nickname of "Dan," I assure you it's me.

It can safely be said that change is the only constant in the worlds of electronics, computing, and technology. The same applies to our magazine—the only way to keep up with the fields we cover is to change with them. We're moving in some exciting new directions, and I'm happy to be back to help this happen.

For starters, we haven't forgotten one of the basic reasons why our readers pick up this title on a monthly basis. Rather than just wanting to read about electronics and computers, most of you want to actually be a part of technology, both old and new. We're here to help.

As far as non-computer-related electronics go, count on finding more projects to build than you've seen in a long time. Like you, I'm a hobbyist, and I know it's very fulfilling to have something worthwhile to build. Already lined up are an exciting project-builder's special and a high-voltage issue. Watch for them.

Also, we're not going to neglect the computer aspect of electronics. Whether you're a hobbyist, working in an electronics-related field, or both, chances are you've noticed how much more is possible with the use of PCs. That's why we'll be including more construction projects that can interface with your computer.

To get things rolling, this month's cover story, *CrystalSynth*, is a wavetable MIDI synthesizer that you can use with your PC's soundcard to create incredible-sounding music. Those without a computer, but with a flair for music, will be happy to know that the project works with a standard MIDI keyboard, too. The story begins on page 31.

A project almost every hobbyist can use is a *Cordless Voltage Probe*. Turn to page 47 if you want to learn how to build this wonderful troubleshooting tool.

But before you turn to the pages that follow, please keep this in mind: Our logo on the Table of Contents page has a subhead: "The Magazine for the Electronics Activist!" We plan to fully live up to that statement and hope you'll join us as we do so. The new millennium is coming fast, and we guarantee we won't let you fall behind the technological curve.

Konstantinos Karagiannis
Editor

LETTERS

MORE CONSTRUCTION, PLEASE

I've been a reader of **Popular Electronics** for a long time, and I have to say that for the past year or so I have become increasingly disappointed with your magazine. While the columns have pretty much maintained their quality, the number of useful construction articles has diminished.

Just a couple of months ago, in your November issue, there was only one project you could build: the *Millennium Clock*. Then, the very next issue, there were *no* construction projects at all. Is this a trend that will continue? I'm sure I speak for many readers when I say: I hope not. Some of us actually like to build things.

D.V.
Los Angeles, CA

Thanks for writing—we appreciate your input. To answer your question, we're very aware of how things have been going and are dedicated to making a change. Count on a killer project or two (or more) in every issue, and plan to keep that soldering iron warm in the months to come.

If you or any other readers have any comments as to the type of construction articles you'd like to see in our pages, please feel free to send them to us here at Letters, ***Popular Electronics****, 500 Bi-County Blvd., Farmingdale, NY 11735. You can also e-mail me at peeditor@gernsback.com, should you want to get your opinions heard in the fastest possible manner.*

Remember ... we're listening.
—Editor

ROBOT HAPPINESS

I always found robotics to be one of the most fascinating areas of electronics. It blends so many different aspects of our art into something that can one day transcend the barrier between man and machine. While I don't plan on seeing droids like C-3PO and R2-D2 walking the streets any time soon, I still think that robotics is making huge advances. We should keep up on this important science.

That's why I wanted to thank you for your wonderful *Seeing Eye Robot* in the January issue. It's a perfect example of a robotics project that could start someone on the path to bigger and better achievements. We all have to start somewhere, and building this little rover will probably strike a chord with more than a few hobbyists.

I hope to see more great articles like this in the future.

J.S.
Boston, MA

I agree that robotics is a great example of how different technologies can converge to create something remarkable. As with most articles we publish, the one you refer to was written out of house by a freelance author. Should another great robot piece come our way, we'd be happy to publish it.

In the meantime, don't be surprised if you see robots appear elsewhere in this magazine in the coming months. Some of our columns may touch on the subject, too—in fact, I can think of one that will, in our next issue, address this very aspect of our hobby.
—Editor

"FLIGHT TIMER" DISTURBANCES

I discovered there were some errors that crept into my article "Flight Timer" (**Popular Electronics**, January 1999). As published, the description of the mode of operation of the timer is not clear.

This is how it actually works. Before power is applied to the circuit, both C2 and C3 are discharged. The low on its trigger input forces the 555 timer to power up in its "on" state, that is, with its output pin high. Thus the motor switches on immediately when power is applied. Capacitor C2 then charges through R3. After ten seconds, the voltage on C2 reaches the threshold voltage of the 555, causing its output to go low and to turn off the motor. C2 remains charged and holds the 555 off until the power is switched off when it discharges through D1 and R1.

—Tom Napier

HAVES & NEEDS

I recently dusted off my Simpson 260 Series 5 (circa 1965) VOM, and I'm having some difficulty with the R × 1 scale readings. Fresh alkalines and clean battery connections allow full-scale "zero" deflection when I short the test leads, but the readings seem to be over by a factor of 4; 10-ohm resistors read about 40 ohms, 50-ohm resistors read about 200 ohms, *etc.*

I verified the test resistors with a DMM, VTVM, and another VOM. They all concur—the Simpson is off. Both R × 100 and R × 10k scales read normally on the Simpson, as do all voltage and current-reading scales. If anyone recognizes this anomaly or has service experience with the 260, I would be grateful for any suggestions. I would also like to get schematics and an owner's manual on this "puppy." I'd appreciate any help on where and how to locate such material.

John Agugliaro
e-mail: jagugl4546@aol.com

I need help in locating schematics for these open-reel tape recorders: Akai X2000S and Akai GX266II. I will be happy to pay all copying and mailing costs. Congratulations on keeping such a well-balanced magazine.

Leon Howe
PO Box 4413 AAFB Br.
Yigo, Guam 96929

I would like to have an indicator in the dining room that lets me know when the waffle cooking in the kitchen is done. In other words, I'd like a device that will detect the reduction in power draw and energize a relay (to which I can attach a light or bell).

If I worked at it long enough, I could figure out how to build such a device. However, If one of your clever readers has already built one, I'd sure like to take advantage of that expertise.

I've read **Popular Electronics** since the 50s and still really enjoy it. Thanks for your help and a great magazine.

Bill Englander
PO Box 3962
Carmel, CA 93921

SCANNER SCENE

Listening for the Calls of the Wild

MARC SAXON

A reasonably priced handheld scanner—that's what the world wants and shall have! It's called the *PRO-70* and comes courtesy of RadioShack. Listed in their catalog at $149.99, the PRO-70 answers a myriad of needs.

Users get 50 memory channels in the 29–54, 137–174, and 380–512 MHz action bands. There's also an extra temporary monitor-memory channel for storing discoveries made during band searches, which can be made through any of the set's ten preset frequency ranges. Instant one-touch NOAA weather band access is provided, too.

The PRO-70 scans at up to 25 channels/second and searches at twice that speed. The double conversion receiver has a selectivity of -6 dB at 10 kHz, -50dB at ±18 kHz. Spurious rejection is 5±0 dB and sensitivity is 1.0 μV on all frequencies.

The PRO-70 operates from six "AA" batteries, an optional rechargeable battery pack, or an AC or DC adapter. It comes with a rubberized antenna (BNC connector) and can be used with an earphone. A soft leather carrying case with a belt clip is available as an accessory.

All in all, a goodly assortment of basic features in a small package, and a choice candidate for discreetly taking along when you don't want or need to "shlep" your big, expensive handheld with all the bells and whistles. You know just what I mean, right?

CALLS OF THE WILD

A reader writing from cyberspace brings up an interesting point. He says that bears, cougars, deer, elk, and many other wildlife species are fitted with tracking transmitters. Often, on TV, conservation officials are shown using tracking receivers having directional VHF yagi antennas. Presumably, those frequencies are within the range of scanners. So, he asks, can we be the first and only publication to reveal those wildlife tracking frequencies?

Generally, conservation agencies don't release the frequencies they use. I suppose they are trying to avoid well-meaning but unwanted volunteer assistance from citizens who will interfere with their research programs.

State agencies utilize the following frequencies for wildlife tracking on a shared basis with other conservation activities (±1 kHz): 31.18, 31.22.31.26, 31.30, 31.34, 31.38, 31.42, 31.46, 31.50, 31.54, 31.58, 31.62, 31.66, 31.70, 31.74, 31.78, 31.82, 31.86, 31.90, 31.94, 31.98, 44.64, 44.68, 44.72, 44.76, 44.80, 44.84, 44.88, 44.92, 44.96, 45.00, and 45.04 MHz. Also any frequency between 151.145–151.745, and 159.225–159. 465 MHz.

The U.S. Fish and Wildlife Service uses 30.06 and 30.07 MHz, then nine frequencies in ten-kHz steps from 30.17–30.25 MHz (i.e., 30.17, 30,18, 30.19, *etc.*). Plus 12 frequencies in 25-kHz steps from 164.4375–164.7125 MHz (i.e., 164.4375, 164.4625, 164.4875, *etc.*).

Wildlife tracking transmitters run low power (something in the order of 5 milliwatts), so there are no strong signals. Even using a directional yagi, I don't believe the signals can be received by conservation people from more than a mile or two away. I think if someone can pick up a cougar or bear's tracking signal on a standard handheld scanner, they're probably far too close for comfort.

HEY, MIKE!

A frequent inquiry here at *Scanner Scene* relates to wireless microphones. Typically, Dale Sanderson, of St. Louis Park, MN, just wrote to mention that he had his scanner with him during a sports event. On 171.845 MHz, he could receive signals from the wireless microphone of the on-field TV announcer, including his great private remarks during moments while he was off the air.

In fact, wireless microphones can make for fascinating scanner fare; yet they have been given very little attention within the hobby. They are heavily used by TV news crews as well as for all other TV and film productions in the field and in the studio. Their use is widespread at all types of events, from rock concerts and sports events to theatrical productions to lectures; at theme parks and museums; and for electronic surveillance (body microphones). Some have even been adapted for use by fast-food drive-through window use.

There are a few frequencies designated for wireless microphones in the FCC's regulations, but many, many more than that are in actual use. Far too many to list here. Within the past year, I have collected information on more than 100 frequencies than were reported as having been monitored, as well as those used in professional wireless microphones. If you would like a copy of these frequencies, I'll be pleased to

(Continued on page 62)

NEW PRODUCTS

SOLDERING SYSTEM

Ideal for most through-hole and surface-mount soldering applications, the *ST20A* production soldering system delivers both performance and accuracy. The system, which measures 3.5 by 4.76 by 6 inches, has an adjustable display dial with a locking mechanism, a multicolor LED indicator, a multi-unit stacking capability, and feed-throughs for desoldering.

This adaptable system provides versatility with its ability to expand quickly. The ST20A also offers the SensaTemp Control, which lets the user change handpieces or tips instantly without recalibration. The Auto-Off safety system increases the life of tips and heaters while conserving energy. The locking mechanism on the display dial prevents unauthorized tampering of temperature settings.

The ST20A has a suggested retail price (U.S. only) of $220. For prices outside the United States and for more

information, contact Pace, Inc., 9893 Brewers Court, Laurel, MD 20723-1990; Tel. 888-535-PACE or 301-490-9860; Fax: 301-604-8782; Web: *www.paceusa.com.*

CIRCLE 80 ON FREE INFORMATION CARD

CD PROTECTION SYSTEM

For CD owners, keeping music discs free from damage—scratches, abrasions, dust, fingerprints, sunlight, *etc.*—has been next to impossible. Now, *CD Armor* shields both sides of the music CD from damage with no perceptible reduction in sound quality.

Unlike kits that try to fix the damage once it's occurred, CD Armor prevents it from happening. Made of an optically transparent polymer shield, it attaches to both sides of the disc, forming a rigid protective shield that is thin enough to play in most CD players without reducing the sound quality.

CD Armor can be removed and replaced at a fraction of the cost of a new disc, and it installs easily with the included CD Armor Install Kit. Your protected CDs can be replaced in their jewel cases and can still be organized in CD storage devices. The top shield can also be personalized with labels, stickers, or markers.

The CD Armor Install Kit includes a CD Armor Installer and six shield sets, and has a suggested retail price of $19.95. The CD Armor 15 pack of shield replacements has a suggested retail price of $9.95. To order directly, call 877-CD ARMOR. For more information, contact Digital Armor Inc., 520 5^{th} Avenue SW, Suite 600, Calgary, Alberta, Canada T2P 3R7; Tel. 800-942-5224 or 403-265-7225; Fax: 403-716-4324; Web: *www.cdarmor.com.*

CIRCLE 81 ON FREE INFORMATION CARD

BENCH DMM

Offering a versatile bench test instrument, the *Model 5490 Bench DMM* is a 50,000-count unit with an accuracy of 0.025%. It is capable of wide-ranging test measurements at a low cost.

The 5490 features full DMM-measuring capabilities, including DC voltages to 1000 volts, AC voltage with true rms (AC or AC+DC), and overvoltage protection (1100 volts DC+AC

peak). Measuring ranges for DC and AC current are from 500 mA to 10 amps, ranges for resistance are 0.01 ohms to 50 megohms, and ranges for capacitance are from 10 pF to 50,000 µF. The unit offers 600 volts DC capacitance/resistance protection and frequency measurement ranging from 0.5 Hz to 500 kHz.

A 50,000 count resolution LCD provides an easy-to-read display, supported by a 34-segment analog bargraph. Weighing only 3.8 lb. and measuring $11\frac{3}{4}$ by $10\frac{3}{4}$ by $3\frac{3}{4}$ inches, the 5490 is compact and comes equipped with non-skid pads—ideal for bench or lab use. For data logging and record/printout capability, the unit features a built-in RS-232 port. Calibration software is an optional accessory.

The 5490 has a list price of $675. For more information, contact B&K Precision, 4353 West Lawrence Ave., Chicago, IL 60630; Tel. 773-725-9252; Fax: 773-725-9385; Web:*www.bkprecision.com.*

CIRCLE 82 ON FREE INFORMATION CARD

LCD PROJECTOR

The *TLP-511A MediaStar XGA LCD Multimedia Projector* uses today's most advanced glass technologies, substantially increasing the brightness over earlier models from 600 to 700 lumens. With the TLP-511A, computer and video sources are displayed with brilliance and clarity (1024 × 768 XGA and 1280 × 1024 SXGA resolution when compressed) even in fully lighted rooms. In addition to the increased brightness, the projector now includes plug-and-play compatibility with most popular computer workstations, and provides users with the ability to adjust colors individually through an on-screen menu system—there's a palette of over 16.7 million colors.

Weighing just 17.6 pounds and measuring 13.39 × 5.04 × 14.29 inches, the TLP-511A is designed to be taken on the road for professional presentations. Ideal for use with all computers, VCRs, camcorders, and DVD players, the LCD projector displays images in sizes ranging from just 25 inches for small-room presentations to 25-foot pictures for large audiences. Its swivel lens switches easily between portrait and landscape images.

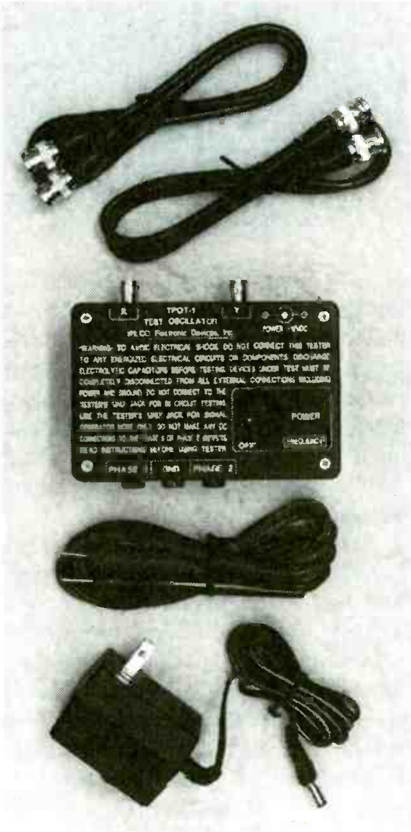
The built-in "visualizer" is a color document camera capable of projecting written materials and three-dimensional objects directly from the surface of the projector. This unique feature allows presenters to place meeting notes, photographs, engineering drawings—even actual products—on the projector surface itself, casting high-resolution images on a wall or screen. Other advanced features include an easy-to-use zoom focus lens system; Toshiba's 2000-hour long-life metal-halide lamp; triple 1.3-inch LCD poly-silicon TFT panels; and ceiling, tabletop, and rear-projection capabilities. The TLP-511A also provides a wireless, full-function remote control with an ability to control a PC mouse. MediaStar projectors are compatible with all video formats: NTSC, PAL, SECAM, and S-Video.

The TLP-511A MediaStar Multimedia LCD Projector comes with a VGA-, a video/audio-, and a power-cable; a MAC adapter; a remote control; lens cap; a built-in carry handle; battery; and an owner's guide. It has an MSRP of $9995. For more information, contact Toshiba American Consumer Products, Inc., 82 Totowa Road, Wayne, NJ 07470; Tel. 800-346-6672; Web: *www.toshiba.com/tacp*.

CIRCLE 83 ON FREE INFORMATION CARD

OSCILLATOR/TESTER

A multi-purpose tester that can be used as both a two-phase signal generator and as an in-circuit component tester, the *TPOT-1* will test most transistors, diodes, ICs, capacitors, resistors, and more. It is a handy instrument (4.8 by 3.2 by 2.3) for bench technicians.



The easy-to-use tester attaches to an oscilloscope, which must be capable of "XY" operation @ 50 mV/cm, to provide a visual display of component characteristics. The TPOT-1 shows much more than go/no go testers or multimeters do. It helps users see bad or out-of-tolerance parts. The unit allows components to be tested in or out of circuit with the power off.

The unit can help repair completely dead equipment fast. It can find bad parts in switching power supplies; compare good parts for bad parts; and find leaky, shorted, and open capacitors.

The TPOT-1 is also an audio-frequency oscillator for testing audio circuits in TVs, stereos, and radio equipment. In addition, it is a two-phase sinewave signal generator useful for testing phase-shift circuits and networks. Its list price is $149.95 plus S & H. For more information, contact WILCO Electronic Devices, Inc., 16895 Beverly Drive, Eden Prairie, MN 55347; Tel. 612-937-9372; E-mail: wilco@minn.net; Web: *www1.minn.net/~wilco/*.

CIRCLE 84 ON FREE INFORMATION CARD

SWR ANALYZER

With the *MFJ-259B*, users get a complete picture of their antenna's performance, obtaining readings of antenna SWR and complex impedance from 1.8 to 170 MHz. A complete ham-radio test station, the MFJ-259B combines the functions of a RF signal generator and resistance and reactance analyzer, SWR analyzer, coax analyzer, capacitance and inductance meter, and more. Just setting the bandswitch and tuning the dial—the same way you'd do with a transceiver—gives instantaneous displays of SWR and complex impedance.

The analyzer perfectly tunes critical HF mobile antennas in seconds for super DX—without subjecting the transceiver to high SWR. The analyzer has powerful new features. It reads complex impedance as either series resistance and reactance (R+jX) or as magnitude and phase; reads SWR, return loss and reflection coefficient at

any frequency simultaneously at a single glance; reads inductance in µH and capacitance in pF at RF frequencies; as well as determines velocity factor, coax cable loss in dB, and length of coax and distance in feet to a short or open. The unit measures the approximate Q of traps, stubs, transmission lines, RF chokes, tuned circuits, and baluns.

The portable SWR analyzer goes anywhere—remote sites, up towers, or on DX-peditions. Its rugged, all-metal case is a compact 4 × 2 × 6¾ inches. It uses ten AA or NiCD batteries, not included, or a 110-VAC power source. The unit contains a NiCD battery charger, has a battery-saver function, and a low-battery warning.

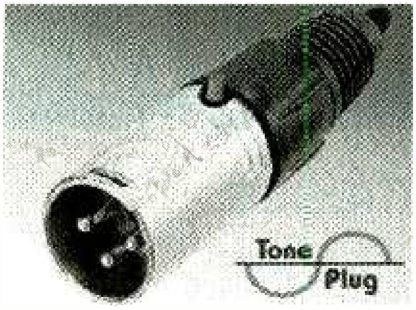
A free comprehensive instruction manual packed with useful applications is available if readers want to check out the analyzer before purchasing it. The MFJ-259B sells for $249.95. For more information, contact MFJ Enterprises, Inc., PO Box 494, Mississippi State, MS 39762; Tel. 800-647-1800; Fax: 601-323-6551; E-mail: mfj@mfjenterprises.com; Web: *www.mfjenterprises.com*.

CIRCLE 85 ON FREE INFORMATION CARD

AUDIO SIGNAL GENERATOR

A complete audio signal generator, the *Tone Plug* is especially useful to the video sound engineer, since most of the small mixing boards used for that purpose do not provide a test-tone function. No larger than a standard microphone connector, the unit is a unique audio test instrument that's ideal for field use. It is capable of generating 11 distinct test functions for the rapid troubleshooting and calibration of audio systems.

In addition to providing a phantom tone test, the Tone Plug offers five user-selectable sine-wave test tones at frequencies of 100, 250, and 400 Hz, as well as 1 and 10 kHz. There are also five special-function test signals. These include a 40/2400 Hz signal for testing the VLF components of a system, such as subwoofers, crossovers, and amplifiers; and a short duration, multi-frequency pulse for adjusting time delays, reverbs, and echo units. Among the other test signals are an amplitude sweep function for adjusting compressors, limiters, and tape levels; automatic frequency stepping; and a unique sweep tone for tracing wiring.



The Tone Plug includes a bright LED indicator for checking microphone cables and connections. A single button on the side allows for quick selection of all test functions. And because the plug is phantom powered, it requires no batteries or external power supply.

The Tone Plug has a suggested list price of $49.95. For more information, contact GTC Industries Inc., PO Box 2493, Napierville, IL 60567; Tel. 630-369-9815; Fax: 630-369-9198.

CIRCLE 86 ON FREE INFORMATION CARD

DATA INTERFACE ADAPTERS

Use your personal computer to log

(Continued on page 12)

Multimedia Watch

A PalmPilot Compass, DVD-to-Go, and More

MARC SPIWAK
TECHNICAL EDITOR
COMPUTER RESELLER NEWS

I've talked about navigation equipment here in the past, such as GPS navigation systems for notebook computers. This month I've got something less complicated, but it's even more portable and it works anywhere.

PALMTOP NAVIGATION

Anyone who has a PalmPilot will be interested to know that there's a new attachment for it that turns the handheld into a digital compass. Precision Navigation's *Palm Navigator* plugs into a PalmPilot, and the included *MapSync* software lets you download maps from the Web turning the PalmPilot into a compass-aided map navigation system. Direction changes can be simulated by pressing the PalmPilot's up and down buttons.

With the Palm Navigator attached, the PalmPilot displays a large compass with cardinal points and numeric digits in degrees. A compass-arrow displayed over the map always points north to show your direction in relation to north. The cardinal points indicate one of the basic eight directions, and the numeric display is accurate to the nearest two degrees. GPS receivers require line-of-sight satellite reception, but this digital compass works anywhere.

The Palm Navigator weighs less than three ounces, and it's powered by two AAA batteries. It costs $39.95.

Precision Navigation's Palm Navigator turns a PalmPilot into a compass-aided map navigation system.

NEW HP SCANNERS

Color flatbed scanners have become so affordable that it doesn't make sense not to have one anymore. Even products from Hewlett-Packard (HP) are reasonably priced, so you can get a top quality, name-brand scanner without breaking the bank. New models are available with a Universal Serial Bus (USB) interface; therefore, connecting these peripherals is easier and less expensive than ever before, because you no longer need a SCSI adapter. Scanners are useful for making presentations, publications, copies, faxing documents, OCRing text, and more.

The *ScanJet 4100C* is HP's entry-level USB scanner, but it's not at all short on functionality. The unit comes with everything you need including software to scan, copy, edit, store, and print color images. Setup is simple with the USB—there's no need to open your PC and add a SCSI card, for instance. The TWAIN-compliant 4100C scans directly to or from any compatible application.

The 4100C flatbed scanner has a maximum scan size of 8.5 × 11.7 inches, and it does 600-dpi scanning in hardware with a software-enhanced 1200-dpi mode. The unit has a 36-bit color image processor, and it processes grayscale in 10 bits. Perfect for small offices, the ScanJet 4100C measures only 11.2 inches wide by 18.3 inches deep by 3.3 inches high. Best of all, this scanner costs only $199.

The *ScanJet 6200C* is a more capable unit, available with either a USB or SCSI interface. The unit offers hardware 1200-dpi scanning and virtually unlimited software-enhanced resolution, up to 999,999 dpi. The unit converts black-and-white line art into infinitely scalable vector files, so scanned graphics can be enlarged with no jagged effects. The 6200C also automatically creates editable text from scanned documents with its integrated OCR software.

The ScanJet 6200C does color processing in 36 bits and grayscale levels in 12 bits. Maximum scan size is 8.5 by 14 inches, and the unit includes an adapter for scanning 35mm slides. All the software necessary for networking this scanner is included with it. An optional 25-page automatic document feeder allows hands-free scanning. The 6200C measures 19.6 inches deep by 12.3 inches wide by 4.7 inches high. This one costs $399, while model 6250C, which includes a 25-page automatic document feeder, is $499.

DVD-TO-GO

DVD is really taking off. The most basic DVD-ROM disc holds about seven times the data of a CD-ROM. Further, DVD-ROM drives can read

DVD-ROM discs as well as CD-ROM discs. One of the best uses for a DVD-ROM drive is to play DVD movies, which are awesome and play well on computers with hardware decoding. A lot of new desktop systems feature DVD-ROM drives, and high-end notebook computers also come with DVD-ROM drives. There's no better entertainment on a long airplane ride than watching your own DVD movie—the audio and video are much better than those of airline movies, and you don't have to pay the $5 or wear those stupid headphones.

DVD-to-Go offers digital Surround Sound with 5.1 channels, sharp slow motion and freeze-frame, and multiple camera angles with compatible source material. It's also compatible with region codes so it'll work anywhere in the world. DVD-to-Go supports NTSC, PAL, composite, and S-Video, and is useful for entertainment, business presentations, computer-based training, and more.

If your notebook computer comes with or can be upgraded with a DVD-ROM drive, but doesn't have a built-in MPEG-2 decoder, DVD-to-Go is perfect. The card itself costs $349 and comes with a dongle that lets you connect it to composite or S-Video input on a big-screen TV. Margi also sells DVD-to-Go as part of a bundle that includes an external SCSI DVD-ROM drive and a PC Card SCSI decoder for $699. The bundle fully equips any notebook computer with DVD.

Margi Systems' DVD-to-Go is a PC Card that decodes DVD video for notebook computers. You can get this card with or without an external DVD-ROM drive.

The problem with DVD and notebook computers is that most notebook computers don't have DVD-ROM drives. And if your vendor adds a drive to a pre-existing model, it won't have any hardware decoding built in. That means you'll have to rely on software to do the job, which unfortunately drops frames in all but the fastest desktops—it's even worse in laptops.

Fortunately Margi Systems has a DVD solution for notebook computers. *DVD-to-Go* is a zoomed-video (ZV) compliant Type II PC Card that decodes MPEG-2 video, which includes Dolby Digital AC3 audio. Video plays in full color, full screen, and at 30 frames per second. Because it's a hardware accelerator, you can use the computer for other applications while playing DVD video.

SOUND BLASTER LIVE

Anyone who thought the Sound Blaster AWE64 was one of the best sound cards around was right—until now. Creative Labs' *Sound Blaster Live* adds new dimension to computer sound. Sound Blaster Live features patented Environmental Audio, which creates spatial and environmental sound effects. The card supports multiple speaker setups with Surround Sound so objects in games seem to fly around you.

Sound Blaster Live is based on E-mu Systems' EMU10K1 audio processor. Signals are processed in with 48-kHz sampling using 8-point interpolation. It provides real-time reverb, chorus, flange, echo, and pitch-shifter effects. The sound card has an average noise floor of −120 dB and features a digital S/PDIF I/O to connect devices such as DAT recorders. Sound Blaster Live offers preset environments such as hall, cave, underwater, and so on that can be applied to any sound. As always, Sound Blaster Live offers the best Sound Blaster compatibility available, only this time on the PCI bus. The card costs $200.

Environmental Audio works well with two speakers, but it's best with multichannel speaker systems. Of course, Creative Labs offers such speaker systems, like the *PC Works Four Point Surround* system with its four satellite speakers and powered subwoofer. It sells for $100. The *Desktop Theater 5.1* features five-satellites plus the powered subwoofer and an amplifier with a built-in Dolby Digital decoder. This complete bundle costs $300.

BACKPACK CD-REWRITER

MicroSolutions is one of the biggest manufacturers of parallel-port peripherals, and I have to say that these units do deliver impressive performance through the interface. Not that they can match the performance of conventional, internal units, but parallel-port peripherals do have certain advantages. For one, you can connect a parallel-port peripheral to any PC, be it notebook or desktop. And you don't have to open up a system to install a parallel-port peripheral—you simply connect it externally.

Parallel-port peripherals are particularly useful when a single peripheral is used to support a large number of systems, especially something like MicroSolutions' *Backpack CD-Rewriter.* While every system has its own regular CD-ROM drive, almost none have a CD-RW drive; and it doesn't usually make sense to install such a drive in multiple systems. And that's where the Backpack CD-Rewriter comes in.

The Backpack CD-Rewriter is a removable plug-and-play CD-ReWritable (CD-RW) drive. This drive lets you create audio and data CDs without the worry of ruining blanks. Rewritable blank discs cost a lot more than write-once CD-R discs, which can now be had for around a dollar apiece. But rewritable discs are better for backup applications or for perfecting a master disc that will then be duplicated. The beauty of a CD-RW drive is that it can read and write to standard CD-R discs as well as CD-RW discs. Of course, they can also read all types of CD-ROM discs.

The Backpack CD-Rewriter requires a Pentium-class system, a minimum of 16MB of memory, and an enhanced parallel port (EPP). A printer-pass-through port lets users print without disconnecting the drive. The drive comes with Adaptec's *Easy CD Creator* and *DirectCD*, which are authoring and editing tools for making audio and data discs. A one-time driver installation allows the drive to work automatically whenever it's connected to the parallel port. Drivers are included for Windows 98, Windows 95, and Windows NT 4.0.

The Backpack CD-Rewriter is available as a 2X or 4X recorder. The 2X unit costs $499 and requires a Pentium processor, while the 4X costs $549 and requires a 300-MHz Pentium II.

NEW SOFTWARE

There's a neat new CD-ROM title available from LucasArts that any devout *Star Wars* fan will not want to be without. I'm talking about the *Star Wars: Behind the Magic* two-CD set. This is a complete behind-the-scenes guide to what makes *Star Wars* movies tick. Plus the discs include never-before-seen footage from the trilogy and a special sneak preview of the movie everyone has been waiting for, *Star Wars: Episode I*.

Behind the Magic reveals the characters, equipment, and talent that put the science-fiction stories on the screen. The two-CD set is well organized and incredibly detailed, with scene-by-scene reviews. You'll also find story timelines plus information about other *Star Wars* product lines such as books and games. There's even a glossary filled with over 700 entries.

Star Wars fans and collectors will also want to snatch up the *LucasArts Archives Vol. IV: Star Wars Collection II*. You get the full versions of *Dark Forces*, *TIE Fighter Collector's CD-ROM*, *X-Wing Collector's CD-ROM*, and *Yoda Stories*, which includes a demo of *Behind the Magic*. Condensed editions of *Jedi Knight: Dark Forces II*, *Jedi Knight: Mysteries of the Sith*, and *X-Wing vs. TIE Fighter* are also included.

New from Infogrames Entertainment comes *Hexplore*, a medieval world of mystery, magic, treasure, and more. In this game, Garkham, Grand Master of the Black Magicians, must take possession of the Book of Hexplore, which explains how to get to the Garden of Eden where the Divine Power rests. The 3D environment has over 250 maps to investigate, and it'll take you at least 70 hours to fully explore everything. This title costs $29.95.

I've got another new DVD title from Palm Pictures, and this one's just a bit weird. *The Secret Adventures of Tom Thumb* is an hour-long film that combines 3D animation and human animation creating a bizarre world indeed. Tom Thumb's parents are happily surprised when the little freak is born, brightening their lives in a dark world ruled by giants. But then Tom is abducted into a laboratory for freaks and mutants where he suffers at the hands of scientists. Fortunately he makes friends with other freaks in the lab, and the story enjoys some twists and turns.

A lot of movies that might be hard to find on videotape are easy to get on DVD. Palm Pictures' *Dancehall Queen* is a lively Jamaican movie that takes

(continued on page 58)

WHERE TO GET IT

Creative Labs
1901 McCarthy Blvd.
Milpitas, CA 95035
Tel. 800-998-5227
Web: *www.creativelabs.com*
CIRCLE 60 ON FREE INFORMATION CARD

Hewlett-Packard Company
3000 Hanover Street
Palo Alto, CA 94304
Tel. 800-722-6538
Web: *www.hp.com*
CIRCLE 61 ON FREE INFORMATION CARD

Humongous Entertainment
16932 Woodinville-Redmond Rd. NE
Woodinville, WA 98072
Tel. 800-499-8386
Web: *www.humongous.com*
CIRCLE 62 ON FREE INFORMATION CARD

Infogrames Entertainment, Inc.
333 W. Santa Clara St., Suite 820
San Jose, CA 95113
Tel. 877-INFOGRAMES
Web: *www.infogrames.net*
CIRCLE 63 ON FREE INFORMATION CARD

Jamsa Press
2975 S. Rainbow, Suite I
Las Vegas, NV 89102
Tel. 702-248-6111
Web: *www.jamsa.com*
CIRCLE 64 ON FREE INFORMATION CARD

LucasArts Entertainment Company
P.O. Box 10307
San Rafael, CA 94912
Tel. 415-472-3400
Web: *www.lucasarts.com*
CIRCLE 65 ON FREE INFORMATION CARD

Margi Systems, Inc.
3155 Kearney Street
Fremont, CA 94538
Tel. 510-657-4435
Web: *www.margi.com*
CIRCLE 66 ON FREE INFORMATION CARD

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052
Tel. 425-486-9258
Web: *www.microsoft.com*
CIRCLE 67 ON FREE INFORMATION CARD

MicroSolutions
132 W. Lincoln Highway
DeKalb, IL 60115
Tel. 800-890-7227
Web: *www.micro-solutions.com.*
CIRCLE 68 ON FREE INFORMATION CARD

Multimedia 2000
1100 Olive Way, 12th Floor
Seattle, WA 98101
Tel. 206-622-5530
Web: *www.m-2k.com*
CIRCLE 69 ON FREE INFORMATION CARD

Palm Pictures
727 North Hudson Street, Suite 100
Chicago, IL 60610
Tel. 312-751-0020
Web: *www.islandlife.com*
CIRCLE 70 ON FREE INFORMATION CARD

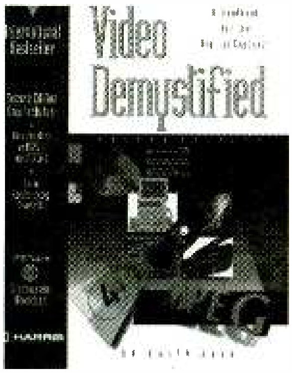
Precision Navigation, Inc.
1235 Pear Ave., Suite 111
Mountain View, CA 94043
Tel. 707-566-2260
Web: *www.precisionnav.com*
CIRCLE 71 ON FREE INFORMATION CARD

ELECTRONICS LIBRARY

VIDEO DEMYSTIFIED, 2nd EDITION

by Keith Jack

This comprehensive reference is packed with 800 pages of hard-to-find extensive reference information and provides a complete introduction to the principles of digital video. Everything from the basics of NTSC to complex color space conversion, as well as the relationships between video and computer graphics is discussed in depth. All material is explained in clear, easy-to-understand language, and the book is well illustrated.



This edition covers the latest digital video techniques, videoconferencing standards, all international video standards (NTSC, PAL, and SECAM), MPEG-1 and MPEG-2 compression and decompression, design architectures for incorporating video into computer systems, digital encoding and decoding techniques, high-definition production standards, and more. Appendixes contain additional material, such as video-test and measurement methods, SCART and S-Video connectors, multimedia PC specifications, and CD-ROM contents. A useful glossary of terms and an index completes the book.

The accompanying CD-ROM for PC and Macintosh is loaded with design tools to assist in testing and evaluating video systems. Files include still images at various resolutions; QuickTime movies; source code for MPEG, H.261, and H.263 encoders/decoders; and more.

Video Demystified, 2nd Edition costs $59,95 and is published by LLH Technology Publishing, 3578 Old Rail Road, Eagle Rock, VA 24085; Tel. 800-247-6553 or 540-567-2000; Fax: 540-567-2000; Web: www.LLH-Publishing.com.

CIRCLE 90 ON FREE INFORMATION CARD

MECHATRONICS POWERPAK

from Microchip Technology Inc.

Designed to educate mechanical and electromechanical engineers on the basics and benefits of converting their designs to an electronics-based solution and enhancing them with electronics intelligence—including microcontrollers and related components—this package provides a *Microcontroller Primer*, which introduces the reader to microcontrollers and describes how to use them in their designs, reference designs, and other support material.

The *PIC12CXXX Applications Handbook,* which is included, illustrates hundreds of simple electromechanical functions that have been converted into real-world microcontroller-based designs. These include timers and switches used in lawn sprinklers, water softeners, freezer compressors, egg timers, light timers/dimmers, capacitive sensor buttons, automotive air conditioners, windshield wiper control, turn signals, and remote car starters.

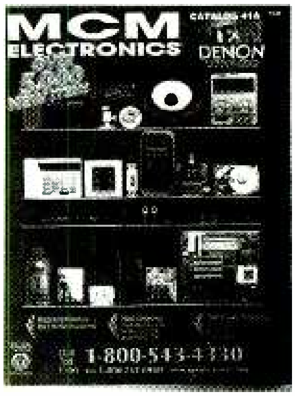
The Mechatronics PowerPak is free upon request from Microchip Technology Inc., 2355 Chandler Blvd., Chandler, AZ 85224-6199; Tel. 602-786-7668; Web: www.microchip.com/mechatronics.

CIRCLE 91 ON FREE INFORMATION CARD

CATALOG 41A

from MCM Electronics

This latest catalog features more that 5000 new products including project accessories, semiconductors, connectors, test equipment, computer and home audio products, plus thousands of OEM TV/VCR repair parts.



Among the brand names included are Weller, Xcelite, Klein, Fluke, Hitachi, Sencore, Tektronix, Tenma, RCA, GE, Panasonic, ECG, Philips, Magnavox, Proscan, Quasar, Technics, Lexmark, Pioneer, Monster Cable, and Sony. MCM is now an authorized distributor for the complete line of Denon replacement parts.

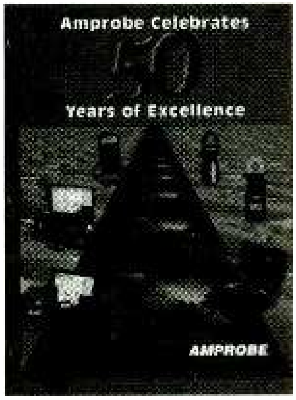
Catalog 41A is free upon request from MCM Electronics, 650 Congress Park Drive, Centerville, OH 45459-4072; Tel. 800-543-4330; Web: www.mcmelectronics.com.

CIRCLE 92 ON FREE INFORMATION CARD

50th ANNIVERSARY CATALOG

from Amprobe Instrument, Division of United Dominion Company

A leading supplier of test tools for tradesmen, this company's catalog provides a broad range of test equip-



ment—from harmonic analyzers to voltage probes. It covers the entire product range, including clamp-ons, chartless recorders, DMMs, tracers, motor protectors, analyzers, leak detectors, sound meters, and earth testers.

The glossy 114-page catalog has extensive cross-reference charts and product in-use photographs enabling customers to quickly find the tool that provides the best solution for their needs. A glossary, a guide to briefs and repair manuals, an alphabetic listing, as well as a listing by product number are included.

The 50th Anniversary Catalog is free upon request from Amprobe Instruments, 6350 Merrick Road PO Box 329, Lynbrook, NY 11563; Tel. 516-593-5600; E-mail: info@ amprobe.com; Web: www.amprobe.com.

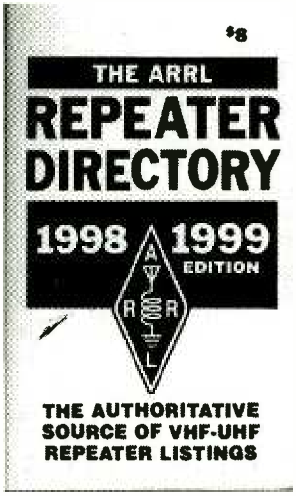
CIRCLE 94 ON FREE INFORMATION CARD

THE ARRL REPEATER DIRECTORY: 1998-1999

Edited by Jay Mabey, NU0X

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 that are 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 directory. Updated information on all clubs is now found on the League's Web page.

The ARRL Repeater Directory: 1998-1999 Edition costs $8 and is published by the American Radio Relay League, 225 Main St., Newington, CT 06111; Tel. 800-243-7767; Fax: 860-594-0303; Web: www.arrl.org. ■

CIRCLE 93 ON FREE INFORMATION CARD

NEW PRODUCTS

(continued from page 7)

data from GPS, depth sounders, radar, and other marine navigational devices with these data-interface adapters. The two models suit either the older NMEA (National Marine Electronics Assn.) or the latest NMEA specifications.

The plug-in connectors convert NMEA standard data signals so they can communicate with any RS-232, RS-422, or RS-485 device, such as a personal computer or printer. *Model 183COR* converts the 1.x data signal to EIA RS-232, RS-422, or RS-485 signals. It also converts any of these three EIA specifications to NMEA0183 volt-

age levels. The unit is powered by a 12-30 VDC power supply (not included).

Model 183V2C is for NMEA version 2.x, which converts one data signal in each direction between the NMEA and EIA specifications. Since this unit derives power from the RS-232 handshake and data lines, no power supply is necessary. The RS-232 connections provide straight-through connection to a PC. The converter can sit in-line near the PC or it can be mounted to a panel.

Prices for either converter is $99.95. For more information, contact B&B Electronics Manufacturing Co., 707 Dayton Road, PO Box 1040, Ottawa, IL 61350; Tel. 815-433-5100; Fax; 815-434-7094; Web: *www.bb-elec.com.*

CIRCLE 87 ON FREE INFORMATION CARD ■

Spying on Earth from Space

KONSTANTINOS KARAGIANNIS

Before you all get riled up, let us make it clear that we haven't found a site on the Internet that lets you zoom in on what your friends, neighbors, and enemies are doing. While various governments are rumored to have the ability to read license plates from space, computer access to such satellites by a civilian is not likely (and definitely not legal). However, there is a way to get a view of our planet from space without going to jail as a hacker legend.

This month we're going to take a look at a real accomplishment—the biggest joint-venture site on the Web. Called TerraServer, it's an incredible site to visit. Actually, let us clarify that: TerraServer's actually the *biggest* site on the Web, containing more data than all the HTML pages on the Web combined—over one terabyte (TB). That's a trillion bytes, which is about a billion pages of text or four million books.

What's filling all that storage space? Black and white images, and lots of them. Add an "r" to the prefix *tera* and you get a word meaning earth or ground. TerraServer lets you see almost any inhabited spot in the U.S. (including your neighborhood), as well as several other countries, as satellite images—it's much better than just looking at drawings in an atlas. As you'll see, TerraServer represents more than a neat way to spend your mouse-clicking time. It's a site that is putting technology into action in such a way as to push the envelope of what can be done with Web servers, e-commerce, and the Net itself.

WEST MEETS EAST

Before we talk about the site's online user interface and hardware layout, it's important to first identify where all these images are coming from. No, this online marvel is not a real-time site that lets you request that a snapshot be taken of a certain area. Rather, TerraServer is an actual array of hard disks that stores and serves up on demand images taken by two services, which are separated by a great distance.

An easy way to browse the power of TerraServer is to click on one of the green areas on the map shown here. While only five percent of Earth's above-water surface is currently represented, the U.S. coverage is extensive, and the site is growing regularly.

TerraServer is made possible by the cooperation of both the United States Geological Survey (USGS) and Sovinformsputnik, the Russian Space Agency. While the USGS has captured, via satellite, most of the populated areas of our country, it hasn't focused heavily on the rest of the world, which is where Sovinformsputnik comes in. The data the Russians presented to the project is called SPIN-2, referring to its two square terameters (not to be confused with terabytes) of Earth coverage.

Combined with the data from the USGS, the site contains about five square terameters worth of the world in images. To put this into perspective, the earth has about 500 square terameters of surface, only about 100 of which are above water. Of these 100 square terameters, only about four are populated, the rest being desert, farmland, and mountains.

HOT SITE

TerraServer
www.terraserver.microsoft.com

All together, the data from the two sources adds up to a little over a terabyte, after compression. Before compression, these images total about four terabytes. As new data is supposed to continue being made available, this site should keep growing.

How good are these images? The ones obtained from the USGS (the site indicates the source of each image you view) are at a wonderful resolution of a meter per pixel. This is good enough to show individual cars in a parking lot, but not the people in the stands of a football game.

The SPIN-2 images are just about as good, too, but you can't access them in high-resolution form for free. When browsing through the site, SPIN-2 images will show onscreen as anywhere from 8 to 32 meters per pixel in resolution. You can then buy 1.56-meter-per-pixel-images online of those shots you like. We'll talk more about the e-commerce aspect later on.

Most people using the site, however, will be more than happy viewing what's free, which is what makes the site such an educational spot to visit. Just think, even if the technology making TerraServer possible was around during the Cold War, the joint venture wouldn't have even been attempted. It's refreshing progress indeed.

A TECHNICAL GLANCE

While the technical details of how a particular Web site is run are not usually covered in this column, TerraServer's remarkable accomplishment merits a change in our policy. Doing so can only make it more clear why the site is such a marvel.

First, if you took a peek at the "Hot Site" box to see the URL for TerraServer, you would notice that it contains the magic "M" word in the computer industry: Microsoft. Now, before anyone expresses dislike of this company, give it credit where credit is due. TerraServer shows off quite nicely the power of NT Server 4.0 and the *SQL Server*. If this operating system and database-server combo can handle the world's largest multimedia database, and do so 24 hours a day, seven days a week, then it's quite a technological advance.

Here's a USGS view of Manhattan. If you're interested in a particular part of this bustling island, just click on the image and the quadrant you select will zoom in to fill the available window.

America's most easily distinguishable building is shown here. It's no surprise that this is as close as you can zoom in to the Pentagon, but the shot still demonstrates quite nicely the power of the satellites used to capture TerraServer images.

The Microsoft software is running on a Digital Alpha 8400 system with eight 440-MHz Digital Alpha processors and 10GB of memory—yes memory, not storage. While it can handle 160 PCI slots, the machine is connected to seven dual-ported Ultra SCSI host-bus adapters. Each of these adapters interfaces with a storage cabinet containing 46 9GB drives. Between all seven cabinets, there are 324 drives totaling 2.9 terabytes of storage.

Using a Redundant Array of Independent Disks (RAID) setup, the drives are configured to act as four logical drives of 595GB each. *SQL Server, Enterprise Edition* stripes the database across these four logical volumes. After all the data-management overhead involved, the array turns into 2.4TB of storage capacity. Should something go wrong, there's a remarkable tape-backup system that can handle 5TB of data.

This giant server accesses four smaller map servers currently being used by other Microsoft sites (Expedia Travel Services, Sidewalk, and others). These four machines are Compaq servers that each feature four Intel processors and 256MB of RAM.

That's a lot of total computing horsepower, and we didn't even mention the two other large servers involved in the site. When you buy a SPIN-2 image, you access another Digital Alpha server with 100GB of disk storage. SPIN-2 images are marketed by Aerial Images, whose e-commerce server is in North Carolina. The USGS images are stored in a multi-processor, Gateway server with Intel chips; this server is in South Dakota.

USING THE SITE

Now that you've got a good idea of what the TerraServer contains and how it has been made possible, you might want to actually give it a try. You'll be happy to know that the user interface couldn't be made much simpler. In a matter of moments anyone with even a small amount of Web experience should have the basics figured out.

The core of this database site is, of course, a search/query engine. You can look for a spot by clicking on map after zoomed-in map and narrowing down a region or by typing in a place name, state, country, or whatever regional characteristics you know. To ensure the server knows what you're looking for when doing a text query, it has a pull-down menu that lets you clearly identify whether the name of your query refers to an Airport/railroad station, Bay/gulf, Cape/peninsula, City, Hill/mountain, Island, Lake, Other land feature, Other water feature, Park/beach, Point of interest, or River.

If you feel like taking a quick look at an image and can't decide on where to search, check out the Famous Places link, which has dozens of images from Alcatraz to Yankee Stadium. The clarity of some of these is great—you can see the shadow that the Statue of Liberty casts, for instance.

Regardless of which method you use to get an image onscreen, there eventually comes a point where you can't zoom in any closer. Depending on which source the image came from, there might not be a better view available, and you can simply capture the image using your browser's right-click menu. If there is a better image available (indicated when you press the Download button), it's time to decide if you want the image enough to pay for it. The USGS lets users download a free JPEG. Aerial Images, however, charges for SPIN-2 image downloads. Both offer delivery of actual Kodak photos, if you need a hard copy of an image for some reason.

Whether you have a professional application for TerraServer or not, we should stress once again that it's an incredible achievement. It's hard to find a combined megabyte's worth of Web content that's of interest to everyone. At TerraServer, one million times as much space is dedicated to presenting something all of us can appreciate: views of our home.

That's all for this month. As usual, you can send questions or comments via snail-mail to *Net Watch*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735, or e-mail to netwatch@comports.com. ■

DX LISTENING

Urban DXing

DON JENSEN

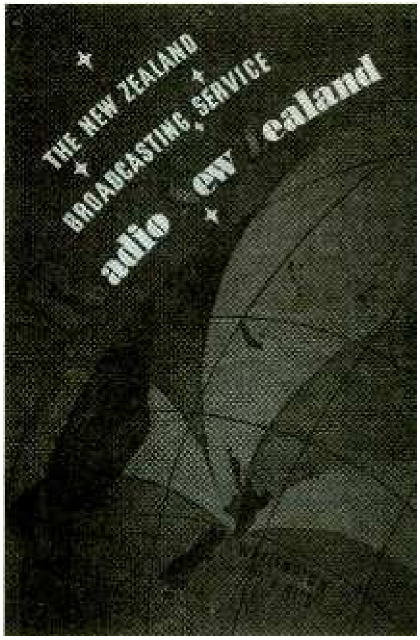
What's a city-dwelling SWL to do? How do you DX when urban electrical interference turns every listening session into a battle with a buzz? What chance do you have to pull in real DX signals when the building super won't let you put up an antenna on the roof?

Urban shortwave listeners often confront these sorts of problems. And some have found an answer: Moving their listening to their cars.

Hans Johnson, writing in *Monitoring Times* and the North American SW Association's (NASWA) *The Journal*, says that DXing from your car is a good way to escape the QRM at home. The most important aspect of this sort of SWLing is the location you choose, he says. The idea is to find a quiet spot where interference is less of a problem, a place where you can quickly and easily string a temporary antenna and enjoy your listening.

Longtime DX friend Dan Henderson began this sort of remote SWLing years ago. At the time, he was making frequent business trips from his East Coast home to the Pacific Northwest. Naturally, he wanted to take advantage of these opportunities to hear some of the low-powered and elusive Indonesian SW stations he couldn't hope to hear back home.

So he outfitted his rental car as a rolling DX shack, plugging his SW receiver into the auto's 12-volt cigarette lighter. Eventually, he found a pull-off area on a remote road overlooking the vast sweep of the Pacific Ocean. At first he strung makeshift antennas, but, in time, he found it more efficient to put up a virtually invisible and more-or-less permanent long wire, stretching between several tall pines along the highway. After that, he'd return to the same spot every time to find his antenna already waiting for him.



New Zealand's shortwave service marked its 50th anniversary last year with major cuts in the station's budget, staff, and broadcasting hours.

Ah, the DX that Dan nabbed from his remote coastal site.

Johnson says he does his DXing on wheels from locations closer to his home. If it isn't easy and convenient to get to, you probably won't go very often because it is too much trouble.

"A good site five minutes from the house is better than an excellent one an hour away."

Quiet parks are one choice, he writes, but he prefers what he calls "no-man's-land," areas with access roads but few if any buildings. These could be failed housing developments or commercial areas that still remain only marginally developed. Avoid locations near or under electric power lines.

Johnson's SW receiver also can operate on 12 volts from the car battery, although a portable receiver is another answer. For his antenna he uses 500 feet of flexible insulated wire wound on a plastic reel intended for electrical extension cords. To use the antenna, he merely unrolls the wire on the ground—yes, on the ground. When you finish your listening session, according to Johnson, you can easily roll in your temporary antenna on the cord reel.

This sort of antenna receives best when pointed in the direction of the target stations, be they Asian, African, or Latin American. You can experiment with antenna direction to find the best orientation for the region of the world you want to DX.

Johnson says he keeps all his listening accessories, reference books, tape recorder, headphones, paper and pen in a canvas bag, ready to go SWLing at virtually a moment's notice.

"Several of the most active listeners in North America are Car DXing on a regular basis," writes Johnson. "The reason is that they are hearing things from their cars that they never would hear from home."

MORE BUDGET WHACKING

Cut the budget! That's becoming a familiar refrain as governmental bodies around the world continue to reduce funding of their nations' international shortwave broadcasting agencies.

Tighten the belt! Trim the fat! Become lean and trim! But, at some point, this sort of "efficiency" can lead to extinction. That's a danger facing Radio New Zealand International (RNZI) following some fiscal crunching late last summer that cut 13 percent from the "Down Under" station's budget.

The savings? In U.S. dollars, only about $85,000. That doesn't sound like much, but with RNZI already running on a shoestring budget, the result has been significant.

Transmissions have been cut by 12 hours a week. Staff has been cut by 25 percent, leaving only nine employees. RNZI-produced programming is cut from 11 to 5 hours daily, with the rest of the schedule consisting of relays of home-service medium-wave programming.

(CREDITS — Jim Clar, NY; Peter Costello, NJ; David Krause, OH; William McGuire, MD; Jim Moats, OH; Jay Novello, NC; Sheryl Paszkiewicz, WI; Chuck Rippel, VA; Betsy Robinson, TN; David Ross, ONT; Dan Ziolkowski, NY; World DX Club, c/o Richard D'Angelo, 2216 Burkey Drive, Wyomissing, PA 19610; North American SW Association, 45 Wildflower Road, Levittown PA 19057).

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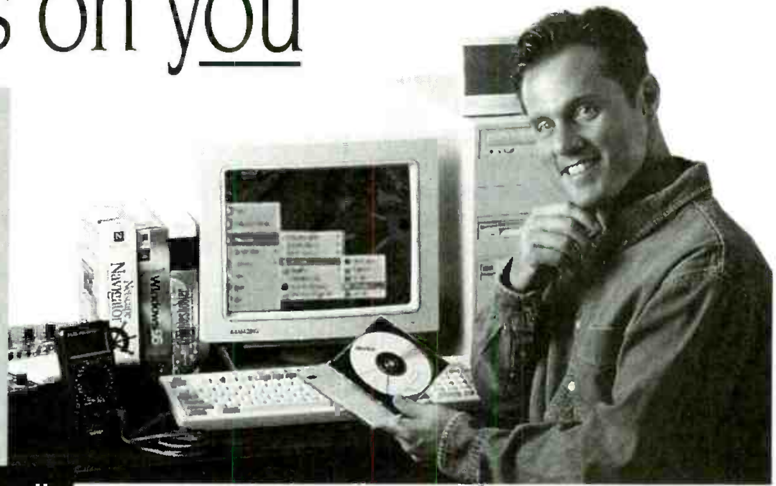

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Gone are regionally popular programs such as *Calling Samoa* and *Calling the Cook Islands*. In fact, Pacific island language programming is limited to short newscasts in Samoan, Maori, Niuean, and Tongan.

It was only a few years ago that New Zealand's shortwave voice was threatened because its aging transmitters were obsolete and inefficient. The government bit the bullet then and, in 1990, installed a new 100-kilowatt transmitter. Stable funding seemed likely, particularly since three subsequent government-sponsored studies of the country's international broadcasting concluded that the service not only was cost effective, but was important to maintaining New Zealand's traditional links with outlying Pacific island nations.

How ironic that Radio New Zealand International marked its 50th birthday only a little more than a month after the new budget cut took effect.

How much longer will RNZI be around? Who can say? But you may want to tune in while it is still on the air. At this writing, it can be found on 17675 kHz during the North American evening hours until 0500 UTC.

HAIL COLOMBIA

Henrik Klemetz, writing from this South American nation, reports in NASWA's *The Journal*, that there are several English language programs aired by a Colombian SW outlet.

The station is Radiodifusion Nacional in the capital of Bogota on 4955 kHz. One English program is called *On Line*, with Fernando Camelo. It is broadcast Tuesday through Saturday from 0200 to 0300 UTC.

ABBREVIATIONS

DX, DXing = Distant shortwave signals, listening to these far away shortwave stations.

kHz = kiloHertz, unit of radio frequency, equals 1,000 cycles per second.

QRM = Electrical noise or other man-made interference.

SW, SWL, SWLing = Shortwave; shortwave listener; the hobby of shortwave listening.

UTC = Universal Coordinated Time, a standard used by most international SW broadcasters; also known in the military as Zulu or Z-Time; equivalent to Eastern Standard Time (EST) plus 5 hours, CST+6, MST+7, and PST+8 hours.

The other, also in English despite the Spanish program title, is *Un Ingles en Bogota*, meaning An Englishman in Bogota. The presenter, and the Englishman in question, is Johnny Welsh, Klemetz says. Welsh is the press officer at the British Embassy in Bogota.

Un Ingles en Bogota is aired on Saturday, usually from 2330 until 0000 UTC, although Klemetz adds that the half hour show has been heard two hours later on occasion.

WHEN CAN I HEAR....

"China?" asks reader Ernie Snipes of Tampa, FL.

Try for Beijing's Radio China International English transmissions to North America at 0300 UTC on 9690 kHz, although this transmission is relayed from a transmitter in Spain, in fact; or at 0400 UTC on 9560 kHz (relayed from French Guiana) or 9730 kHz (relayed from Canada).

Now if you want an RCI English transmission actually transmitted from a station in China, you might try 7405 kHz between 1300 and 1500 UTC.

"Iran?" requests Bill Bartoch of Dayton, OH.

Look for Teheran's programming in English, Bill, from 0030 to 0130 UTC on 6055, 9022 (probably your best shot), or 9685 kHz.

"Yugoslavia?" asks Myron Felsch, Omaha, NE.

Best times and frequencies for English transmissions from Belgrade's Radio Yugoslavia are 0000 to 0030 UTC and 0430 to 0500 UTC on 9580 and 11,870 kHz. Other English programming is scheduled at 1830 UTC on 6100 and 9720 kHz; 1900 on 7230 kHz, and 2100 UTC on 6100 and 6185 kHz.

DOWN THE DIAL

Here are some interesting shortwave stations to look for.

BOTSWANA — 7340 kHz, Voice of America programming is relayed from a transmitter in this southern African country around 2225 UTC. Look for the English newscast, *News Now*.

DOMINICAN REPUBLIC — 4960 kHz, Radio Cima is logged with all Spanish programming at various times between 2230 and 0400 UTC. Programming includes rhythmic merengues, many ads, and identification announcements.

EQUATORIAL AFRICA — 15185 kHz, Radio Africa broadcasts recorded religious programming in English from around 2130 until signoff, with an identification, at 2300 UTC.

GUATEMALA — 4835 kHz, Radio Tezulutlan is quite easy to identify with its programs of marimba music, even though announcements are in Spanish. Try this one at about 0100 UTC.

INDONESIA — 15150 kHz, Voice of Indonesia from Jakarta operates in English from 2000 UTC. Listen for the station's interval signal and identification, followed by program notes, news, and travel promotion.

ISRAEL — 9435 kHz, Kol Israel is heard in English at 0400 UTC with Israeli news, press reviews, and a weather report.

ITALY — 6010 kHz, RAI, Rome is noted at 0050 UTC with English identification and a news report.

JAPAN — 17825 kHz, Tokyo's Radio Japan has been heard with a program of listeners' letters around 0350 UTC.

KUWAIT — 11990 kHz, Radio Kuwait can be heard after 1800 UTC with English programming, including political and economic news and a weather forecast for the Gulf region.

NICARAGUA — 5770 kHz, Radio Miskut has Spanish programming and popular music on this frequency until signoff around 0315 UTC.

NORTHERN MARIANAS — 15665 kHz, KHBI, on the Pacific island of Saipan is heard after 1100 UTC with a *Bible Lesson* and Christian Science programming in English. The station can also be heard on 9385 kHz at this time.

PERU — 5522 kHz, Radio Sudamerica has Spanish announcements and identifications with plenty of indigenous huayno music during the evening hours. The station signs off around 0230 UTC.

PHILIPPINES — 11635 kHz, Far East Broadcasting Corp. from Manila was noted here at 0940 UTC with English programming. The signal reportedly improved by 1000 UTC.

SENEGAL — 7170 kHz, RadioTV du Senegal is logged on this frequency after 2200 UTC, with French programming and lively West African music.

SYRIA — 12085 kHz, Radio Damascus is noted here in English at 2045 UTC, with identification, musical interludes, short talks, and a newscast.

TAIWAN — 9610 kHz, Voice of Free China from Taipei has English at 1200 UTC. It was heard with classical music, a newscast, and feature talk. ■

COMPUTER BITS

Mass Storage for the Millennium

JEFF HOLTZMAN

Do you have to move large files among physically isolated machines? Are you looking for a way to create semi-permanent archives? If your answer to either of these questions is yes, then you'll be happy to know that removable-storage options are proliferating. Here's a snapshot of three leading contenders: Iomega Zip, Imation SuperDisk, and CD-R (recordable—write-once) and CD-RW (rewriteable) technologies.

Zip-drive technology is made exclusively by Iomega Corp., although other manufacturers like Epson have been licensed to package their own Zip drives. Drives are available for internal and external use, with IDE, SCSI, and parallel-port interfaces, for Macintosh and Wintel architectures.

The cartridges used in Zip drives are made by several media manufacturers. The cartridges are slightly larger than a floppy disk, and about twice as thick. Each cartridge holds 100MB of data.

SuperDisk or LS120 technology was developed by Imation, a spin-off of 3M Corporation. Drives that read and write to LS120 media are made by Far-East firms including Panasonic, Mitsubishi, and NEC. These drives are available in internal and external models for Macintosh and Wintel machines. External models connect via parallel port and are not bootable. Internal models—which are available on new laptop and desktop PCs from Compaq, Gateway, HP, NEC, and others—are bootable.

Each LS120 disk can hold as much as 120MB. Unlike Zip drives, SuperDisk drives can read older 1.44MB floppies in addition to their own high-capacity media (of course, LS120 disks cannot be read or written to by a standard 1.44MB drive). This backwards compatibility, combined with the fact that you can boot a machine off a SuperDisk drive, makes SuperDisk a logical successor to 1.44MB floppies, but only time will tell if this transition will come about.

CD-R and CD-RW technologies have recently descended from their former stratospheric price levels, and are now cost-effective for regular users.

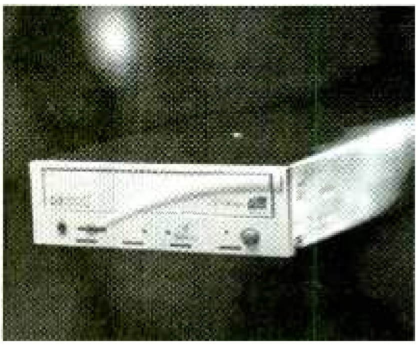


Fig. 1. HP's SureStore line of recordable (CD-R) and rewritable (CD-RW) drives makes creating your own data and audio CDs easy, inexpensive, and fun. The 8100, shown here, allows you to record 650MB of data in about 15 minutes and comes with an extensive suite of applications and utilities.

Because the underlying technologies are based on widely accepted international standards, most major drive and media manufacturers supply compatible wares for most major platforms, including Macintosh, Wintel, and UNIX.

For purposes of this article, I examined one or more models of each technology, including a parallel-port SuperDisk with the Imation brand name, parallel and SCSI ZIP drives, and the recently released Hewlett-Packard CD-Writer Plus 8110i.

HP SURESTORE

Building off the success of its earlier 7200 series, HP has introduced the 8100 series, shown in Fig. 1. The 8100 has a different software bundle and much-improved performance, as shown in Table , though both lines will continue to be sold. Both drives support Windows 95/98/NT only. Discs created by either should be readable by any conforming audio player or data drive on any platform.

Installation of the 8100 proved mildly traumatic. I had recently upgraded the test machine (a 180-MHz Pentium Pro) with a new IBM Deskstar 14GXP 10GB Ultra DMA drive (the DTTA-371010), along with an Ultra DMA (33MB/s) controller from Promise Technology. The 7200-rpm speed of that drive gives it performance close to that of SCSI. The combination provides about 30% better performance, and is highly recommended.

The test machine also had an older 8X CD-ROM and an Intel VS440FX motherboard. At the time that machine was put into service, it required a special driver (PIIXIDE.SYS) so that the CD-ROM drive would function under NT 4—and it did just that for several years. When doing the upgrade to the 8100, however, it turned out that there was a conflict between the Intel driver and the driver required by the 8100. Fortunately, it also turned out the current version of the standard ATAPI driver (ATAPI.SYS) could now handle the CD-ROM. After removing PIIXIDE.SYS and installing ATAPI.SYS, the 8100 worked just fine.

HP's installation program runs system tests to help verify component operation and determine optimum settings. I applaud the concept; however, in my case the machine locked up tight during system tests and had to be rebooted. That is *not* plug and play.

Once over the installation hurdle, the 8100 actually exceeded my expectations. For example, it unerringly allowed me to create audio CDs at the full 4X write rate, a feat normally expected only of a SCSI-based system. I attribute success in this area primarily to the speed of the IBM hard drive.

The 8100 can write to both CD-R and CD-RW discs. CD-R is write-once technology; CD-RW allows each sector of each disc to be written to as many as 1000 times. CD-RW discs must be formatted before use, a process that can take an hour with some manufacturer's drives, but takes only five minutes with the 8100. You can purchase CD-R blanks in bulk for about $1.50; CD-RW discs cost about $15 apiece.

With either a CD-R or a CD-RW disc loaded, the 8100 can function as a normal read/write drive in Windows Explorer. You can "delete" files from a CD-R disc, but the space is not recoverable—a deleted file will simply not show up. CD-RW discs support full read, write, and delete operations with no loss of space. CD-RW discs can be read by other CD-RW drives, and by MultiRead-certified CD-ROM drives. A disc used in read/write mode as a drive letter must be *finalized* before it can be read by a standard CD-ROM drive (the included software can handle this).

Using the included DirectCD application, you can *master* an original disc that should be readable by any CD-ROM drive on any operating system. As part of installation, an icon gets installed in the system tray; it allows you to set overall parameters of drive operation, and format new discs. Bundled utilities allow you to create a disaster recovery disc/diskette set, print CD case labels, maintain a database of discs and their contents, and more. All in all, the 8100 is a highly professional product, easy to use, and useful.

Fig. 2. Imation's SuperDrive packs 120MB of storage into a cartridge very similar to the familiar, ten-year old, 1.44MB diskette. An optical servo track allows the LS120 to achieve track density almost 20 times that of a 1.44MB diskette.

TABLE 1 —HP FEATURE COMPARISON

	7200	8100
Read	6X	24X
Write (CD-R)	1X, 2X	1X, 2X,4X
Write (CD-RW)	1X, 2X	1X, 2X,4X
Access speed (ms)	350	150
EIDE	Yes	Yes
SCSI	Yes	n/a
Parallel port	n/a	n/a
Write methods	Track at once, incremental (packet), multisession, disc at once	Track at once, incremental (packet), multisession
Bundled software	Direct CD, Easy CD Creator, Easy CD Audio, Jewel Case Designer (Adaptec), PhotoDeluxe (Adobe), Print House Magic (Corel), PaperMaster Live (Documagix),SimpleTrax (HP), AntiVirus (Norton), PhotoOrganizer	Fast Format (HP), Direct CD, Easy CD Creator, Easy CD Audio, Jewel Case Designer (Adaptec), Disaster Recovery, Simple Trax (HP), Print House Magic (Corel), Jet Fax PaperMaster Live, PhotoOrganizer
Estimated street price	$299 internal, $399 external	$399

IMATION SUPERDISK

The SuperDisk is an interesting but ultimately disappointing technology. The SuperDisk combines magnetic and optical technology. While most people can figure out what the number in the LS120 trademark stands for (data capacity), few know what the "LS" represents. This two-letter combo indicates that track alignment is attained using a Laser Servo system.

On a standard 1.44MB diskette, track density runs 135 tracks per inch (TPI); LS120 pushes that to 2500 TPI. The basic principles of reading and writing normal magnetic media also apply to the SuperDisk; however, the laser servo mechanism helps attain the much finer alignment that is required. The disks used in LS120 drives look very similar to standard 1.44MB floppies, although the shutter mechanism is noticeably different (see Fig. 2).

As mentioned earlier, SuperDisk drives can write to and read both LS120 and standard diskettes. In addition, the BIOSes of new-model desktop and laptop machines can even boot from a SuperDisk. This means you can have an LS120 drive as your only removable drive.

So far, Imation's primary focus has been the DOS/Windows (3.1, 95, 98, NT) market, although a new USB-based model runs on Apple's new iMac.

We installed a parallel version of the drive on our PC. Installation was a minor hassle, involving numerous system lockups and reboots. Eventually all problems were resolved by downloading a new driver from the company's Web site. Contrary to what is stated in the manual, tech support is available free via an 800 number. Wait time is typically about 5–10 minutes, and the technicians were knowledgeable and friendly. LS120 diskettes cost about $15, although you can get them for about $10 each if you buy them as ten-packs.

In operation, the external drive is noisy and slow. Formatting an LS120

(Continued on page 65)

GIZMO®

Here Comes HDTV!

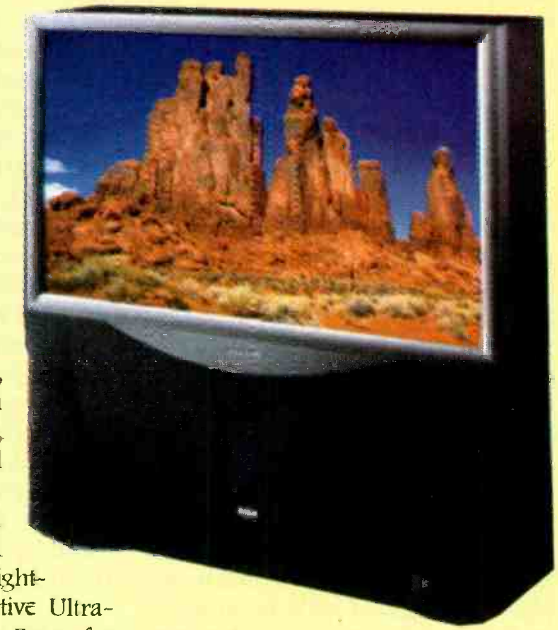
The first generation of digital television sets has arrived, and the *RCA P55000* ($6999) from Thomson Consumer Electronics (10330 North Meridian Street, Indianapolis, IN 46290-1024; Tel. 317-587-4450; Web: *www.rca.com*) is a good example of what they offer. The 55-inch (diagonal) widescreen rear-projection set will receive all analog and digital signals. The fully integrated set requires no external devices or additional hookups, other than appropriate antennas, to receive all formats of digital programming. The P55000 can process digital picture resolution up to and including 1920 × 1080 pixels. The digital set performs NTSC up-conversion to 540 progressive lines for an impressive display of standard TV signals. A Dolby Digital decoder is built into the set.

An on-screen program guide offers a comprehensive listing of available programs and lets you program favorite-channel listings, one-touch VCR recording, and one-touch tuning. A built-in twin tuner allows you to monitor two NTSC programs simultaneously. On-board Picture Format Control lets you choose between the widescreen 16:9 mode or conventional 4:3 format.

The P55000 provides front- and rear-S-Video-inputs and A/V-connections and rear-panel inputs for terrestrial RF and satellite antennas. Outputs for audio subwoofer, optical audio, telephone modem, and headphone jack are also provided.

USB-Compatible Monitors

Two new monitors from Samsung Electronics America (105 Challenger Road, Ridgefield Park, NJ 07660-0511; Tel. 800-933-4110; Web: *www.sosimple.com*) offer enhanced displays and an affordable Universal Serial Bus (USB) solution with an optional self-powered USB Hub. The *"s" Series* monitors include the 15-inch *SyncMaster 510s* (13.8-inch viewable) and the 17-inch *SyncMaster 710s* (15.7-inch viewable). Aimed at SOHO and family users, they offer higher refresh rates than previous models, as well as an expanded array of on-screen controls.



Both .28-mm-dot-pitch displays feature an INVAR shadow mask for extra brightness, as well as anti-reflective Ultra-Clear coating and Dynamic Focus for crisp images. The 510s, which has an estimated street price of $179, features a maximum resolution of 1024 × 768 at 75 Hz (PC and Mac); the 710s, street priced at about $309, has maximum resolutions of 120 × 1024 at 60 Hz (PC) and 1152 × 870 at 75 Hz (Mac).

The optional *Model 415US USB Hub* ($49) attaches easily to the monitor's base. The device simplifies hookup of desktop peripherals, such as the keyboard, mouse, and printer, and offers improved PC-to-peripheral performance. The self-powered USB Hub includes four downstream ports and one upstream port, eliminating desktop clutter by allowing USB peripherals to be connected to the PC through the monitor instead of via the computer's parallel and serial ports.

Digital Sound System

The first PC speaker system from Microsoft (One Microsoft Way, Redmond, WA 98052-6399; Tel. 425-882-8080; Web: *www.microsoft.com*) is the *Digital Sound System 80* ($259.95), a three-piece, 80-watt array that includes two satellite speakers and a subwoofer with a built-in digital amplifier. Its all-digital design is based on the latest PC technology—including the USB interface. (It can also be connected to a Sound-Blaster-compatible audio board with a MIDI-enabled game port.)

When used with a USB-compatible PC running Windows 98, the Digital Sound System 80 features a 10-band programmable graphic equalizer. A built-in digital signal processor lets you create personalized sound profiles to instantly fine-tune the system's sonic qualities for specific types of audio programming.

GIZMO®

Satellite and subwoofer controls, which automatically synchronize with software-based volume controls, are located on the right satellite speaker for easy access. Patented wOOx technology from Philips delivers maximum bass response.

Focus On Floppy Convenience

When planning a recent family reunion in New Orleans, we relied heavily on e-mail to coordinate the travel and lodging plans of several far-flung relatives. It saved us a fortune in long-distance phone bills, and by "CC"ing each person, we could be sure that everybody got precisely the same information at more or less the same time.

We knew we'd be taking a lot of photos during the trip, because it's rare that all of us are gathered in one place. We figured we'd be ordering multiple copies of every shot that came out well and mailing them out to each of the subjects. Wouldn't it be great if we could e-mail the images to everyone involved, just as we'd e-mailed the travel plans?

Any digital camera would allow us to do just that. But most models have limited storage capacity, and, while on the road, we wouldn't be able to download the images to a PC to free up the camera's memory for more picture taking. Nor would we have the time, money, or inclination to track down the memory cards on which most digital cameras rely for additional storage space.

A couple of days before we were scheduled to leave, we thought of Sony's (One Sony Drive, Park Ridge, NJ 07656; Tel. 800-222-SONY; Web: *www.sony.com*) *Mavica* line of digital cameras, which doesn't suffer from that problem. Rather than relying on built-in memory, they store images directly to floppy disk. Run out of disk space? Simply swap disks and start shooting again. It's even easier than changing the film in a standard camera.

We tried out the top-of-the-line *Mavica MVC-FD91* ($1099), which offers another feature not found on the typical digital camera—the ability to record MPEG motion video and audio. These recordings can also be easily downloaded to a PC and incorporated into e-mail, Web sites, or PC presentations. Granted, the quality's not great. In Presentation Mode, you can record up to 15 seconds of video at 320 × 240 pixels, while Video Mail Mode provides up to 60 seconds of recording time at 160 × 112 pixels.

Still images, on the other hand, can be displayed in XGA resolution (1024 × 768) if they're recorded in fine mode. Standard still shots have a resolution of 640 × 480. Two sizes are available in each resolution, and as many as 40 still images can be stored on a floppy in the compressed JPEG file format.

The MVC-FD91 looks like a cross between a 35-mm SLR and a small camcorder. That's due in part to its large lens. The 14X optical zoom is the longest optical zoom currently available on a digital still camera. The lens is comparable to a professional 35-mm zoom with a range from 37 to 518 mm, and it has a manual focus-ring for more flexibility in composing images. The auto macro capability allows you to get as close as one inch to your subject.

Like many of today's camcorders, the Mavica boasts an LCD screen as well as a color viewfinder with 180k pixels. The 2.5-inch LCD, with a resolution of 85k pixels, allows you to immediately view the pictures you've taken. Index mode provides a "contact sheet" of up to six thumbnail images at a time, or you can scroll backward or forward through each of the shots—you don't have to wait until you're at your computer to see what you've got. If you're unhappy with one or more of the images, you can delete them on the spot to free up more disk space.

There's a drawback to the "camcorder look": With its telephoto lens and LCD display, the MVC-FD91 measures about $5^5/_8 \times 4^1/_8 \times 6^1/_2$ inches, and it weighs more than two pounds. If you're used to toting a pocket camera, this one seems a bit unwieldy. (In fact, our vacation needs would have been better met by the MVC-FD91's little brother, the MVC-FD81. Featuring a low-profile 3X zoom lens, it's much more portable, not to mention a few hundred dollars more affordable. But that 14X zoom did come in handy on several occasions!)

The MVC-FD91 is worth its weight in digital convenience, however. If, for instance, you'd like to send everyone home with a vacation memento, you can do so easily, taking advantage of the Mavica's copy features. The camera has enough built-in memory to hold a floppy's worth of images (all/select), allowing you to swap disks and copy all the photos to a clean disk in a matter of seconds. It's possible to select and copy individual photos, and motion-video images.

You'll want to have a lot of disks on hand if you plan to take advantage of the MVC-FD91's MPEG video capabilities. It takes a whole disk to store 60 seconds worth of audio and full-motion, 160 × 112-resolution video. For recording vacation and family events, we'd much rather use a cam-

Gizmo® is published by Gernsback Publications, Inc., 500 Bi-County Blvd., Farmingdale, NY 11735. Senior Writers: Christopher Scott and Teri Scaduto.

On our recent family reunion trip, we splashed around ....

corder. For adding motion video to a Web site, however, things can't get much easier than with the Mavica.

Another convenient feature is the camera's self-timer. The LCD screen flips up and around, allowing you to see yourself and compose the picture to your liking. The self-timer gives you ten seconds to get into the picture with the rest of your group.

The Mavica provides great picture-taking flexibility. You can opt for automatic everything, turn on the electronic image stabilizer, and let the camera do all the work. Or you can make manual adjustments to exposure, white balance, and focus. Seven different preprogrammed exposure settings (from −1.5 to +1.5 EV) are provided, along with three exposure modes. Shutter-priority mode is used for fast-action shots, aperture-priority mode for setting the depth of field, and twilight mode for shooting at night (*i.e.*, fireworks) without losing the dark atmosphere.

Many of the camera's features—selecting the recording mode, image size, and quality—can be accessed via its onscreen menu system. The manual settings can be selected and adjusted using buttons found along the right side of the camera itself. On-screen indicators keep you apprised of your choices, and they can be removed at the press of a button for clear picture viewing.

On the next leg of our trip, we visited still more family in Houston, where we also attended a large quilt show. We'd promised to bring back pictures of the prize-winning quilts to show to friends back home, along with pertinent facts such as who made each one and what prize it had won. That's where the Mavica's voice memo feature was particularly handy. Instead of juggling a note pad and camera, we could take a shot and simultaneously narrate the particulars.

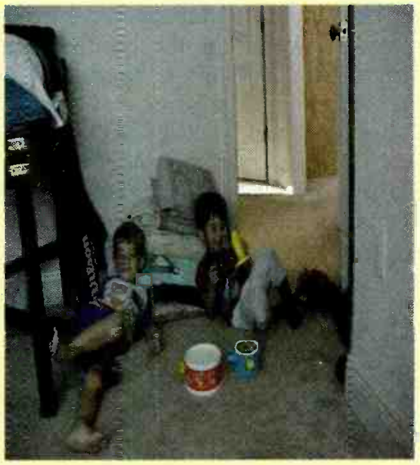
After viewing those quilt shots on a PC, however, we went back to the show the next day with slide film loaded in our trusty pocket camera. Digital cameras simply do not provide the picture resolution of 35-mm cameras, and even in fine-photo mode, the Mavica's resolution is not up to par with some digital cameras that cost less. Fine details were lost in the digital images.

On the other hand, viewing the images captured with the Mavica was a breeze on a PC! There are no cables to mess with—just insert the floppy and you're ready to go. We could take the digital images and download them directly into the Quilt Guild newsletter. Sending images or MPEG files over the Internet is just as easy, especially in e-mail mode, which reduces the size of the file to one quarter of the standard file for fast downloads.

There's no need to send the images as-is—one of the best things about digital photography is the ability to doctor your photos: removing red-eye, cropping distracting backgrounds (or unwanted people), and adjusting color and contrast. ArcSoft's *PhotoStudio* photo-editing program is included with the Mavica. Its point-and-click tools are easy for beginners to master, and the program is sophisticated enough for professional use. It allows you to adjust the color and brightness, resize and rotate images, add text, clone parts of the image, merge two or more images, make photo collages, and paint with colors and textures.

The Mavica's digital images can be manipulated using any available photo-editing programs.

For the casual, non-techie photographer who takes snapshots at birth-



... and young cousin met for the first time. All images were recorded using the Mavica's standard mode.

day parties and graduations, there's really no need to make the move to digital photography. But if you have your own Web site, edit your club's newsletter, or maintain e-mail correspondence with plenty of long-distance friends and relatives, adding digital images can make an enormous difference in the effectiveness of your communications. For taking such shots, you can't get a more readily available, inexpensive storage medium than a standard floppy disk. And for adding such images to e-mail or Web sites, you simply can't beat the Mavica's cable-free convenience.

The Historical Perspective

When your family makes vacation plans, what destinations are tossed around? Disney World, a beach-front house rental, a ski trip, the Grand Canyon, maybe a cruise? There's another place that belongs near the top of every family's vacation wish list—Washington, DC. We don't recommend it solely for its governmental and historical attractions, though those abound: the White House, the Lincoln Memorial, the Jefferson Memorial, the Supreme Court. Those might be worthwhile stops for adults, but may draw yawns from the kids.

What's sure to keep every member

of the family entertained and enlightened, however, is the Smithsonian Institution. Not just a museum, the Smithsonian is a group of several museums and "collections" which, jointly, serve as a repository for historical and cultural artifacts of the United States—ranging from the original *Star Spangled Banner* to the Wright Brothers' plane—and scientific, artistic, archeological, anthropological, and zoological treasures from the beginning of time and around the world. We guarantee that no one will walk away bored.

But don't take our word for it. Check it out from the comfort of your own home with *The Smithsonian Museum Collections* CD-ROM from Synthonics Technologies (31324 Via Colinas #106, Westlake Village, CA 91362; Tel. 800-707-6000; Web: *www.synthonics.com*). Its $24.95 price tag is less than you'd pay for a family meal on vacation, and you'll feel as if you've traveled far and wide.

Be forewarned, however, that the program's system requirements are steep. If you're using a PC that's more than a couple of years old, you'll feel as if your family trip just got stalled in traffic. At the least, a Pentium 120-MHz CPU and an 8X CD-ROM drive are required; the recommended 200-MHz Pentium and 16X CD-ROM drive will keep you speeding along at a nice clip. A Sound Blaster-compatible 64-bit audio card and Microsoft DirectShow are also required.

The Smithsonian Museum Collections takes you on a guided tour of the entire museum. Curators from each museum have selected items of interest from the Smithsonian's close to 150 million artifacts (most of which are in storage, rarely or never on public display). The CD-ROM provides just a glimpse: 670 images, including some never seen by the public. Using "Rapid Virtual Reality" technology, the disc allows some of the objects to be viewed in 3D, and manipulated by rotating, zooming, measuring, and even peeling away layers to reveal inner workings.

The main menu provides access to the National Museum of Natural History, The National Air and Space Museum, The National Museum of American History, the Freer Gallery of Art/Sackler Gallery (Asian and 19th and 20th Century American art), the National Museum of American Art, the Renwick Gallery, the National Portrait Gallery, the National Postal Museum, the Anacostia Museum (African American history and culture), the Cooper-Hewitt National Design Museum, the Office of Smithsonian Institution Archives, and the Smithsonian Institution Libraries.

We made the National Museum of American History our first stop, because we'd so enjoyed its unique and eclectic mix of political history and popular culture when we visited the Smithsonian in person. Its index included Abraham Lincoln's tall hat and the chairs on which Kennedy and Nixon sat during the first of their historic 1960 debates; the artist-formerly-known-as-Prince's Yellow Cloud guitar and Benny Goodman's clarinet; Edison's Triumph phonograph and original incandescent light bulb, and the converter panel from the ENIAC computer; artifacts from Negro League baseball teams and Jack Dempsey's boxing gloves; a Stradivari Violoncello and a Wurlitzer "Bubbler" jukebox; George Washington's tent, uniform, sword, and camp chest; General Custer's buckskin jacket and Teddy Roosevelt's chaps. Each item is accompanied by a brief but enlightening description; the availability of a 3D image is announced with a short audio trill.

The 3D effects require the use of special "viewing glasses"—two pairs of cardboard glasses, each with one red and one blue lens, are provided. It's a bit hokey, yet effective, particularly when the other 3D functions are used. Those allow you to take measurements; see the top, bottom, front, and back of the item; and zoom in and out.

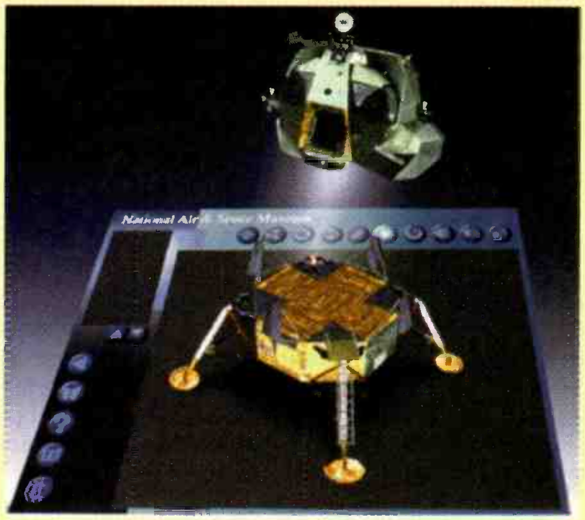
At the Air and Space Museum, we viewed the space suit worn by Neil Armstrong on his 1969 moon walk and the Apollo 11 command module *Columbia* in which he traveled with Buzz Aldrin and Scott Carpenter. We took a look at the *Spirit of St. Louis*, in which Charles Lindbergh made the first non-stop trans-Atlantic flight from New York to Paris in 1927, and saw the check in the amount of $25,000 presented to him upon his return by a New York hotelier. John Glenn's space suit could be viewed in 3D, as could the Flyer in which the Wright brothers made the first powered flight at Kitty Hawk, North Carolina in 1903.

The Museum of Natural History, with its goals of "enhancing understanding of the natural world and humanity's place in it" and "documenting the cultural and natural diversity" of our planet, contains departments of anthropology, archeology, botany, ethnology, and paleobiology—as well as animals, vegetables, and minerals, and bugs, fishes, and birds. You'll find dinosaur bones, the exquisite Hope diamond, a Mars rock, old arrowheads, and star dust. There's a bit of the macabre—a wren's nest in a human skull, of which its original owner, Dr. A.K. Fisher wrote: "Sing Sing, NY. Placed a human skull in a tree first week of May. A pair of wrens found it and built a nest on May 15. On May 25 it contained 6 fresh eggs, which are now in the U.S. Natural History Museum." No explanation of where the skull came from or why Dr. Fisher put it in a tree!

With no real interest in stamp collecting, we almost skipped our next

In 3D mode, you can remove an Egyptian mummy from its sarcophagus and examine it in detail: freely rotate it in any direction, remove its outer layers, and zoom in for a closer look.

stop, the National Postal Museum, altogether. We're glad we didn't, because it's a good example of how a seemingly dull subject area can come to life when properly presented. Think today's postal workers have cause to be disgruntled? The text accompanying an airmail mask worn during the first New York to Chicago airmail service (1918-1920) noted that it was needed in the frigid open-cockpit bi-planes, in which 31 of the first 40 airmail pilots were killed (their life expectancy was 900 flight hours). The man who owned the mask on display survived several airmail crashes, only to be killed in a barnstorming show a few years later.



Magnify and measure the lunar lander, and watch it separate from its landing gear, on your virtual visit to the Air and Space Museum.

The Postal Museum also displayed the bomb detonator used in a mail-train robbery in which several people were killed. On a less dangerous note, there was an entire small-town Post Office, V-mail letters and containers (we didn't know that microfilm was used to reduce the bulk of mail during World War II, with 556 million V-mail letters sent abroad and 510 million sent back home), and the USPS uniform worn by Cliff Claven on *Cheers*.

The only disappointing stop was the Cooper-Hewitt National Design Museum. It had some lovely and interesting items on display—an Eames chair, a place setting from the Imperial Hotel in Tokyo designed by Frank Lloyd Wright, an Alice in Wonderland pop-up book—but no background information was offered. Luckily for us, this museum is not located on the Mall in Washington, but at the Andrew Carnegie Mansion right here in New York City, so we can visit it in person and fill in the gaps.

The National Zoological Park—which provided ample information and some video clips—would also be better live. The whole idea of a zoo, after all, is to allow people to view exotic animals up close and in person.

Actually, our CD-ROM visit to the Smithsonian, fun and informative though it was, simply whet our appetite for a return visit to the real thing. It's fine to see a picture of the original Old Glory, and read about its maker and its history, and Francis Scott Key's musical tribute, but that just can't compare with seeing the real thing, as it is raised into the light (it's displayed only a few minutes at a time in an effort to preserve it) accompanied by *The Star Spangled Banner*. Nor can an on-screen look at a space capsule (even with 3D rotation) compare with actually climbing inside one—it's so *tiny!*—as you can do at the (non-virtual) Air and Space Museum.

But what more can you ask of a family CD-ROM than that it spurs the imagination and quest for more knowledge?

PC-Free E-Mail

What do you *really* use your laptop for when you're on a business trip? Can you actually write a report while on an airplane? Do you spend your travel time updating files? Or do you just drag the thing around so that, when you get to your hotel, you can check your e-mail and maybe send a few quick faxes—if the phone in your room has a data port, that is?

If your laptop is just an e-mail device, why not replace it with a truly portable one? The *HC-E100* from JVC Company of America (1700 Valley Road, Wayne, NJ 07470; Web: *www.jvc.com*) is just that. For a suggested retail price of $129.95, plus a monthly fee of $9.95 for the *PocketMail* mobile e-mail service, business travelers have an easy-to-use way to keep in touch from any location with associates. The device can also send faxes as well as sending text messages to any alphanumeric pager.

The HC-E100 weighs just over half a pound, without its two "AA" batteries; measures approximately $6^1/_4 \times 3^1/_2 \times 1$ inches; and looks a good deal like an electronic organizer. Under its flip-open lid, you'll find a 40-character, 8-line display, surrounded by function keys. The main body holds a QWERTY-style keyboard that's small but usable. The extra "@" key (no shifting required!) comes in handy when typing e-mail addresses, but most punctuation involves the use of a second SHIFT key to activate the punctuation marks that are printed

above the letter keys. That can be a bit tricky, and (because they're not in their standard positions) takes some getting used to.

To get started, you must first sign up for the PocketMail service—online at any time or by phone during PST business hours. With your account initialized, you're ready to send e-mail. To compose your message, you simply press the CREATE MSG key, input the information in the given fields, and then press the DONE key. The message is stored in the unit's "outbox," along with any other messages you've created and stored, until you are ready to send the entire batch.

No cables or connectors—in fact, no computer at all—are required, making the HC-E100 a good e-mail solution for folks who don't have access to a PC. The only outside "gear" needed is a telephone. A microphone is mounted on a slide-out arm on the back of the HC-E100. That microphone must be positioned snugly against the earpiece of a telephone, and the unit's built-in speaker placed as close as possible to the phone's mouthpiece. When you are sure of the fit, you dial the PocketMail 800-number, reposition the HC-E100 against the phone, and press one button. You can hear the "chatter" as the device "talks" to the PocketMail network, and you can monitor the progress of the transmission by watching the bar lights on the top of the unit. (Each light represents one-quarter of the estimated connection time.) A single beep means that the transmission has been successfully completed. (If there's a problem, you'll hear two beeps.)

Whenever you "connect" the device to a phone, the communications are two-way: Messages are received as well as sent. Incoming e-mails are placed in the unit's "inbox" and accessed with a press of the INBOX key. From within the inbox, they can be read, replied to, forwarded, or deleted. It's also possible, from the inbox, to add the sender's e-mail address to the HC-E100's address book.

The address book is a terrific convenience feature, allowing you to store frequently used e-mail addresses in memory, along with other vital information (phone number, fax number, snail-mail address). It simplifies sending e-mail messages to one person, and it even allows you to send the same message to as many as ten of the addresses in your book.

The portable e-mail device offers other convenience features. For those users who already have a primary e-mail address at home or work, PocketMail provides mailbox consolidation. Copies of mail received at your primary e-mail address can be automatically copied and sent to your PocketMail address as well. Most ISPs allow e-mail forwarding, and most corporate e-mail software also allows it (although some corporations deliberately disable the function). The largest ISP, America Online, does not currently support auto forwarding, however.

You can configure the HC-E100 so that your primary e-mail address appears as the reply-to address on your outgoing messages. For confidentiality, a password feature is provided.

Sending a fax message is just as easy as sending an e-mail; you simply input the fax number instead of the e-mail address, and press the f1 key to access the fax feature. You can even fax the message to some people, and e-mail it to others (up to ten recipients in all), all with one call.

There is a drawback to the cable-free, portable e-mail system. Messages (both incoming and outgoing) are limited to 4000 characters, and you can't attach files to them as you can with a PC. Of course, if you've bought the HC-E100 as an alternative to a PC, you won't have any files to attach anyway. And if you bought it to supplement your PC while away from the office, you can use your PC to retrieve messages with attachments or messages that exceed the 4000-character limit.

The sliding arm on which the microphone resides allows you to accommodate all size phones, from tiny cellular units to standard handsets—we couldn't find a phone with which it was incompatible. The device won't, however, work with every telephone; it will not work with digital and PCS cellular phones, for instance.

If you're a technophobe whose family and friends are all sending e-mail messages back and forth and you feel as if you're out of the loop because you haven't broken down and bought a PC yet, here's a way to get into the action without feeling intimidated. And if you're a Road Warrior who needs your e-mail like you need air to breathe, the HC-E100 is an easy-to-use, easy-to-carry alternative to a laptop.

Balancing Act

Any audiophile will tell you that speakers are the most important part of any stereo system. But no matter how much time you spend auditioning speakers and how much money you shell out to buy them, they won't sound just right unless they are precisely positioned for an optimal listening experience. The same goes for home-theater speakers, whose placement determines whether the surround-sound effects are delivered properly.

Most of us use one of two methods to place our speakers. We might move them around the room, hoping to somehow get the "sweet spot" to fall upon our favorite seat. Or we might opt for convenience, placing the speakers wherever the furniture/paintings/accessories allow space.

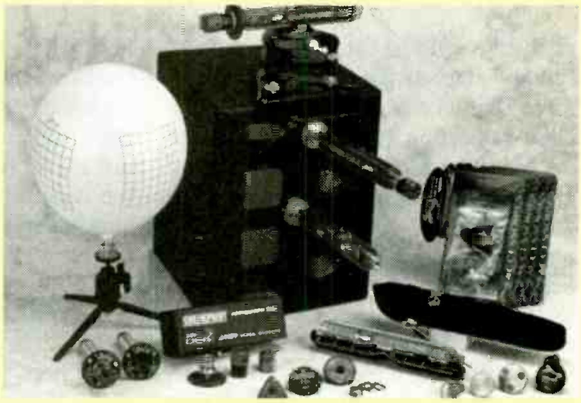
You can be sure that neither method is how professional installers do it. Just like any other specialists, they rely upon tools of the trade to make their jobs easier and the results more reliable. And many of them depend upon the *Sound Alignment System*, or *SA-S*, from Checkpoint Laser Tools (4025 Spencer St., Suite 304, Torrance, CA 90503; Tel. 310-793-5500; Web: *www.checkpoint3d.com*) to help them get it right. (The professional system, with all its numerous accessories and options, is pictured above.)

Speakers, and, for that matter, sound itself, are directional. The SA-S system allows the sound emanating from speakers to be accurately directed to a location of your choice using a laser pointer. The concept is actually very simple, and so is the process, particularly if you opt for the consumer version of the Sound Alignment System, the SA-S 770 ($159.95).

(The professional system, pictured above, requires a bit of study, not to mention layout and angle guide, and layout plots. Options include several lenses for advanced and unique installation requirements and rotary bases for advanced users. An SA-S trained professional can certify that the speakers are properly situated under a system that's been endorsed by Lucasfilm's THX division for setup and calibration.)

The SA-S 770 is a rectangular metal tool measuring approximately 7 × 1 × 1 inches. In the photo above, it is the cylinder shown protruding horizontally from the speaker. A bubble level set into the tool is clearly visible from either side. The front end of the SA-S 770 is a metal threaded insert that can accept screw-on accessories. The laser beam is emitted from that end. The "back" end of the device has a metal screw covering the tool's recessed on/off switch. A "Standard Alignment Switch"—basically, a large screw with a $1^1/_4$-inch-diameter flat head—is included.

To use the SA-S 770, you remove the screw from the back end and replace it with the standard alignment switch. The large, flat head on the alignment switch allows you to place it flush against a flat part of the front speaker cabinet, preferably near the center, so that the SA-S 770 is held perpendicular to the front of the speaker. After verifying that it is level, screw in the switch until the laser beam is activated (that's why the accessory is called a switch). Then move the speaker until the dot of laser light is pointed directly at the listening spot.



It couldn't be easier—unless you opt to buy some "Mag Alignment Switches" ($29.95 each) and "Base Plates" ($16.95 each), that is. The base plates require (shudder) drilling a screw hole into the speaker cabinet. Once mounted, however, they can allow flush attachment of the SA-S system, including the Mag Alignment Switches, and magnetically hold in place the SA-S 770 for hands-free speaker alignment. (Some high-end speakers, including a few models from M&K, come with built-in base plates and magnets.)

The Mag Alignment Switches offer the added benefit of allowing you to test your speakers' housing stability as well as their placement. The visual stability test is as quick and easy as the alignment process. With the SA-S attached, try out the speaker under varying load. If the dot moves little or not at all, your speakers are stable; if it bounces all over the place, you know you've got a problem.

Checkpoint notes one more advantage to the Mag Switch: "It provides a permanent residence for the SA-S 770 when not in use—a very impressive display component!" Their words, not ours. We actually think it looks a bit silly sticking out from a speaker, unless it's actively doing its job.

And it does that job admirably, quickly, and painlessly. It takes just minutes to arrange a multi-speaker system so that each component is aimed directly at the same listening spot. No one's going to hand you a professional installation certificate—but you have the satisfaction, all the same, of knowing that your speakers are positioned as accurately as possible, and that you did it yourself.

GIZMO NEWS

Win Some, Lose Some

This past October, Web sites delivering recordable music cleared a major legal hurdle, while those offering classic literary works online were dealt a major blow by a new law.

In the first case, a federal judge denied a request by the recording industry to stop production of a handheld device that can store and play back digital music, including that found on the Internet. The product, known as Rio, is made by Diamond Multimedia Systems and carries a price tag of $199. It can store up to 60 minutes of near-CD-quality digital music that can be downloaded off the Internet with the click of a mouse. This music comes in the form of MPEG Layer-3 or MP3 files.

The Recording Industry Association of America (RIAA) plans to appeal the decision, which it fears opens the door to unchecked music piracy. The group, which represents 90% of the creators, manufacturers, and distributors of commercial recordings, filed for a preliminary injunction on the grounds that the Rio was a digital audio recording device as defined by the *Audio Home Recording Act of 1992*. Under that act, manufacturers of digital recording devices are required to pay to artist organizations a royalty amounting to 2% of the wholesale price of the device.

The court did not decide whether or not the Rio met that definition, although Judge Audrey Collins said it probably could be categorized as such. But she refused the RIAA's request to force Diamond Multimedia to install a copy-protection system on the device on the grounds that, with no digital output, the Rio could not be used for "downstream" serial copying. She noted that requiring the inclusion of Serial Copy Management System (SCMS) on such a device would be "an exercise in futility." The manufacturer successfully argued that the RIAA could not be allowed to "derail new technology" in an effort to protect its members and noted that the injunction, which would coincide with the holiday gift-buying season, would cause Rio irreparable harm.

Meanwhile, President Clinton dealt a blow to free book sites when he signed a law that adds 20 years to the existing copyright protection of books, films, songs, and other intellectual property. The previous U.S. copyright term lasted 50 years after the author's death or 75 years after the publication of a corporate work. The new law was supported by the Association of American Publishers, the film industry, music publishers, and the heirs of copyright owners, all of whom argued that the change was necessary in light of longer copyright terms in European publishing and the greater longevity of heirs.

There are several sites that offer free access to classic literature. Eric Eldred, founder of Eldritch Press, actually plans to cease operation because of the new *Copyright Term Extension Act*, which he said, "marginalizes me and my Web site." He added, "If everything is private property forever ... then there can't be a growing, global, free public library." According to Michael S. Hart, director of one of the largest online free book sites, Project Gutenberg, the new law will stop about an estimated one million books from entering the public domain over the next 20 years. Instead of closing the site, he is increasing his efforts to find and post books that were published before 1923.

Likening the situation to the response to book burning in Fahrenheit 451, "where people became books to preserve literature," Eldred declared, "Well, I am Hawthorne on the Internet." Eldred planned to close his site on November 11 in protest of the law and donate his digital library to other free book sites.

Super Surround

If there's an action film playing at a few theaters in your area, and you have a choice of going to one with Dolby Digital sound or one with a THX sound system, how do you decide between the two? Well, you won't have to choose between them for long. Lucasfilm THX and Dolby Laboratories Inc. have introduced Dolby Digital - Surround EX, a 6.1-channel theatrical surround-sound format that was co-developed and is jointly owned. The new surround-sound format will make its debut with the May 21st release of George Lucas' new film, *Star Wars: Episode 1—The Phantom Menace*.

Unlike conventional surround technology, in which the sound field in the back of the theater can sound blurred and seem to come from a general area to one side of the auditorium, with Dolby Digital - Surround EX center-surround information is reproduced by the speakers at the rear of the theater while left- and right-surround information is reproduced by speakers at the sides. Adding a new surround channel and more speakers is said to allow a sound designer to create true "fly over" and "fly around" effects that are smoother and more accurately placed.

Surround EX is fully compatible with all existing 5.1 digital systems, requiring only the addition of a Dolby SA-10 surround adapter, proper speaker wiring, and an extra channel of surround amplification. The SA-10 adapter will cost $2500. THX-certified theaters, while not a requirement, are ideally suited to take advantage of Surround EX. They meet specific acoustic requirements and have most of the necessary equipment, including the center-rear speakers, already in place.

"Dolby Digital - Surround EX realizes the long-held dream for surround sound that is truly all-enveloping," said Dolby Laboratories President Bill Jasper. "With the new format, we've taken the technology to an additional level that makes an amazing difference in sound possibilities."

Monica Dashwood, general manager of Lucasfilm THX, called Surround EX "a system that raises the bar on quality," and pointed out that the technology "is not going to make a moviegoer's theatrical audio experience inherently louder" but will "deliver the ultimate theater experience."

Progressive-Video DVD Player Shelved

Toshiba is temporarily postponing the introduction of its *Platinum Standard SD7108 DVD-Video player*. In a statement issued in early November, the company noted that it "respects the concerns of the motion picture industry regarding copyright protection." Despite "diligent work with hardware and software companies alike," no agreement was reached regarding copy protection for progressive-video outputs on a DVD-Video player. "A lack of consensus within the Copy Protection Technical Working Group concerning this issue has delayed the introduction of the SD7108."

Toshiba believes that DVD players equipped with ColorStream Pro progressive component video outputs are "of critical importance in extending the potential of DVD in a digital world." The company will continue to work with hardware and software companies to reach a satisfactory resolution of this issue and will include ColorStream Pro progressive video inputs on its DTV-ready and DTV color television products. Toshiba vows to "work aggressively to insure that consumers will be able to enjoy true progressive-video DVD picture quality in the near future." ■

BUILD THE CRYSTALSYNTH

DAVID DULEY

This standalone MIDI wavetable music synthesizer allows you to create band and orchestral accompaniments that can be blended with your own voice to produce recordings that sound like they were generated in a professional recording studio!

Without doubt, the Musical Instrument Digital interface (MIDI) is one of the greatest things to happen to music since the piano. It enables one performer to sound like an entire orchestra, or it can be used to simply fill in for an orchestra or musical group that is shy a few musicians. Music synthesis has come a long way since the days when a few dedicated experimenters threw together a couple of squarewave oscillators to produce the spacey sounds of the early sixties. Today, however, the synthesized music field is dominated by highly sophisticated devices, based upon single- and multi-IC chipsets. Such chipsets enable the average table-top experimenter to put together awesome music synthesizers capable of rivaling some commercially available units.

Dubbed *CrystalSynth*, the project presented here is a MIDI-controlled wavetable synthesizer that is suitable for stage work. CrystalSynth is completely standalone, and it accepts standard MIDI inputs and provides both amplified and line-level music outputs. It is suitable for use as a budget stage synthesizer, or it can be used as a background fill-in synthesizer for live performances or studio work. It is great for the hobbyist who wants to spruce up the available sounds of an older MIDI keyboard. CrystalSynth can be used to add wavetable sounds to cheap PC sound cards, and is fully compatible with *Windows* MIDI-output drivers or any software that can drive the external MPU401-compatible MIDI output on most *SoundBlaster*-type cards.

Wavetable Synthesis. Wavetable synthesis is a technique by which electronic synthesizers are made to produce sounds that very closely emulate the actual instruments they are designed to replace. That's accomplished by scanning a table containing a recording of the actual instrument sounds. The instruments are usually recorded at different pitches to allow the synthesizer to produce sounds that more closely emulate the real thing. That's done because low notes played on a grand piano, for instance, sound much different than middle- or high-range notes played on the same piano. The difference is more than just pitch. The low notes last longer, and the sound of the hammer striking the string is different from that of the high notes.

CrystalSynth emulates real instruments in great detail! The bulk of the work is performed by Crystal Semiconductor's CS9236 wavetable synthesizer. The chip is designed to accept MIDI data directly and process it to produce an all-digital, serial-audio data stream that is turned back into analog audio by Crystal Semiconductor's CS4333 serial digital-to-analog (D/A) converter. The wavetable synthesizer (CS9236) can emulate 128 pre-defined instruments and 47 percussion sounds (see Tables 1 and 2). It also processes all MIDI-effects commands, such as pitch bending, program change, volume control, left-right stereo pan-

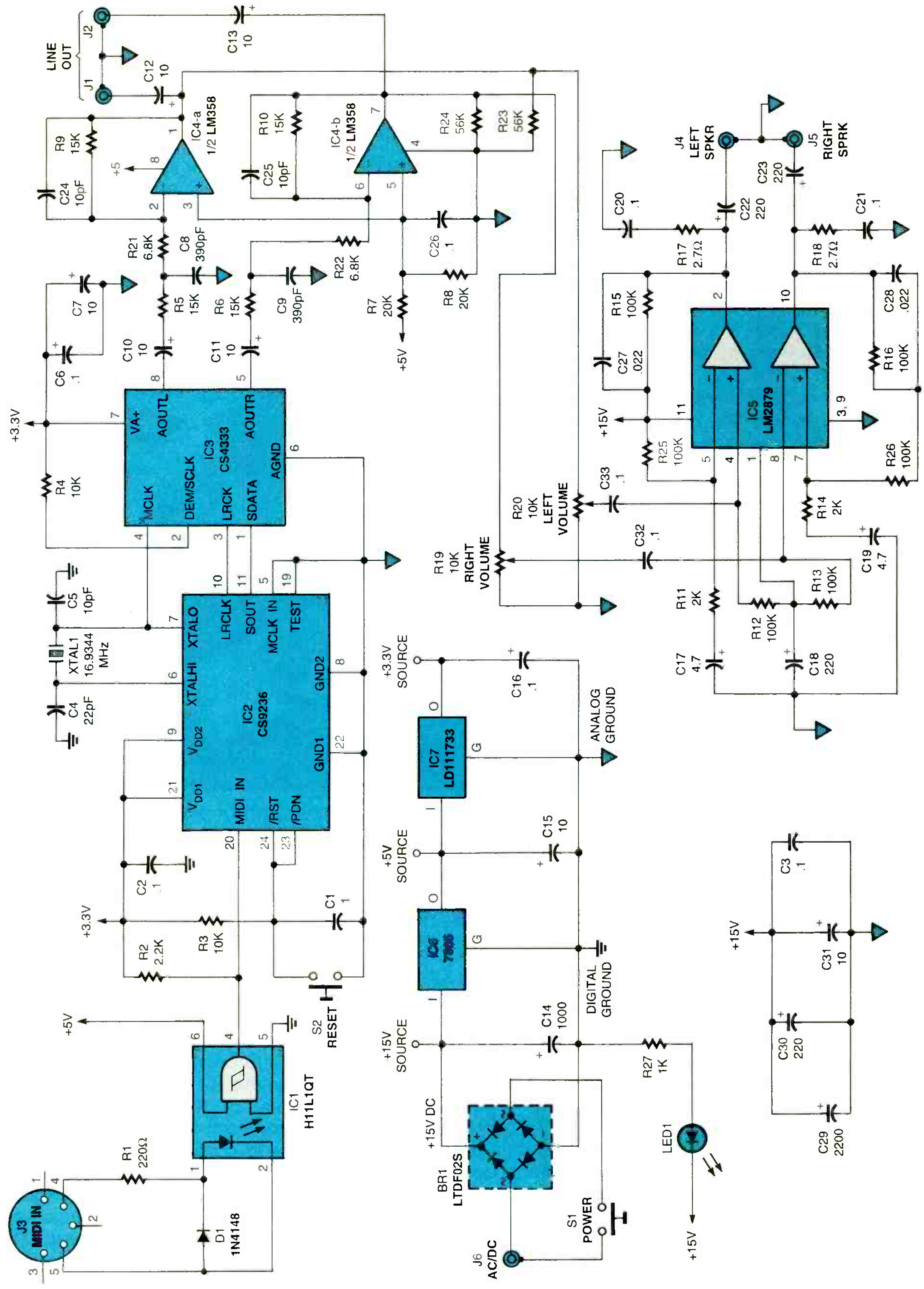


Fig. 1. CrystalSynth is a relatively simple circuit comprised of seven integrated circuits, a fullwave bridge rectifier, a small-signal diode, a light-emitting diode, and a handful of support components. MIDI data is fed to CrystalSynth through a standard 5-pin DIN connector (J3).

ning, echo and delay effects, chorusing effects, and key-press velocity (an effect that changes the sound slightly depending on whether the keyboard is pressed hard or soft).

It supports all 16 MIDI channels; Channel 10 is reserved for percussion. The percussion instruments are key mapped, so that Channel 10 does not respond to program changes (instrument change commands). Instead each key, in a 47-key range, is assigned to a different percussion instrument, since percussion instruments typically do not have a specific pitch. Therefore, devoting the entire keyboard to a snare drum would be pointless. That conforms to what has become a MIDI standard.

How It Works. A schematic diagram of the CrystalSynth circuit is shown in Fig. 1. For all that it can do, CrystalSynth is a relatively simple circuit comprised of seven integrated circuits—IC1-a, an H11L1QT optoisolator/coupler with Schmitt trigger output; IC2 and IC3, Crystal Semiconductor's CS9236 CrystalClear wavetable synthesizer and CS4333 stereo serial digital-to-analog converter, respectively; IC4, an LM358 dual, low-power, op-amp; IC5, an LM2879 8-watt audio-power amp; IC6, a 7805 fixed 5-volt, 1-amp, voltage regulator; and IC7, an LD111733 3.3-volt voltage regulator—BR1, an LTDF02S fullwave, bridge rectifier; D1, a 1N4148 small-signal diode; LED1, and a handful of support components.

MIDI data is fed to the CrystalSynth circuit through a standard 5-pin DIN connector, and from there it is applied to the input of IC1 (the H11L1QT optoisolator/coupler), which provides the current loop interface required by the MIDI standard. The H11L1QT optoisolator/coupler was chosen because of its

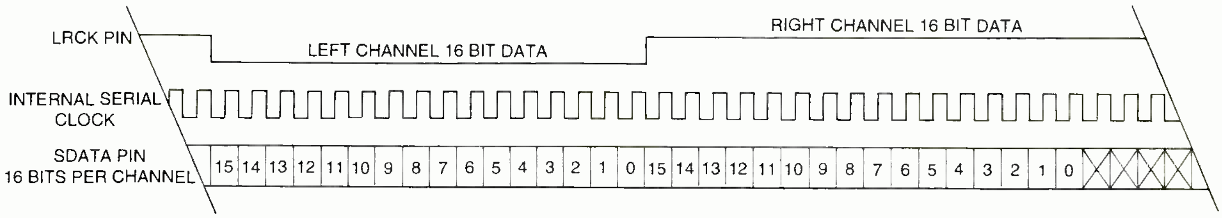


Fig. 2. This timing diagram illustrates the relationship between IC2's LRCLK signal, its internal clock, and its serial-data stream.

TABLE 1—CS9236 MELODIC INSTRUMENT LIST

1	Grand Piano	33	Acoustic Bass	65	Soprano Sax	97	Rain
2	Bright Piano	34	Fingered Bass	66	Alto Sax	98	Soundtrack
3	Electric Grand Piano	35	Pick Bass	67	Tenor Sax	99	Crystal
4	Honky-Tonk Piano	36	Fretless Bass	68	Baritone Sax	100	Atmosphere
5	Electric Piano 1	37	Slap Bass 1	69	Oboe	101	Brightness
6	Electric Piano 2	38	Slap Bass 2	70	English Horn	102	Goblins
7	Harpsichord	39	Synth Bass 1	71	Bassoon	103	Echoes
8	Clavi	40	Synth Bass 2	72	Clarinet	104	Sci-Fi
9	Celesta	41	Violin	73	Piccolo	105	Sitar
10	Glockenspiel	42	Viola	74	Flute	106	Banjo
11	Music Box	43	Cello	75	Recorder	107	Shamisen
12	Vibraphone	44	Contrabass	76	Pan Flute	108	Koto
13	Marimba	45	Tremolo Strings	77	Blown Bottle	109	Kalimba
14	Xylophone	46	Pizzicato Strings	78	Shakuhachi	110	Bag Pipe
15	Tubular Bells	47	Orchestral Harp	79	Whistle	111	Fiddle
16	Dulcimer	48	Timpani	80	Ocarina	112	Shanai
17	Drawbar Organ	49	String Ensemble 1	81	Square Wave	113	Tinkle Bell
18	Percussive Organ	50	String Ensemble 2	82	Sawtooth Wave	114	Agogo
19	Rock Organ	51	Synth Strings 1	83	Calliope	115	Steel Drums
20	Church Organ	52	Synth Strings 2	84	Chiff	116	Woodblock
21	Reed Organ	53	Choir Aahs	85	Charang	117	Taiko Drum
22	Accordion	54	Voice Oohs	86	Voice	118	Melodic Tom
23	Harmonica	55	Synth Voice	87	Fifths	119	Synth Drum
24	Tango Accordion	56	Orchestra Hit	88	Bass + Lead	120	Reverse Cymbal
25	Nylon Guitar	57	Trumpet	89	New Age	121	Fret Noise
26	Steel Guitar	58	Trombone	90	Warm Pad	122	Breath Noise
27	Jazz Guitar	59	Tuba	91	Poly Synth Pad	123	Seashore
28	Clean Guitar	60	Muted Trumpet	92	Choir Pad	124	Bird Tweet
29	Muted Guitar	61	French Horn	93	Bowed Pad	125	Telephone
30	Overdriven Guitar	62	Brass Section	94	Metallic Pad	126	Helicopter
31	Distortion Guitar	63	Synth Brass 1	95	Halo Pad	127	Applause
32	Guitar Harmonics	64	Synth Brass 2	96	Sweep Pad	128	Gunshot

switching speed (standard optoisolators can't handle the 31.250-kHz data rate required for MIDI). The output of IC1 at pin 4 is fed to IC2 (the CS9236 wavetable synthesizer) at pin 20.

The wavetable synthesizer has a built-in MIDI processor, which decodes MIDI data, controls the chip's various internal systems, and is responsible for generating all the necessary clock signals for itself and the rest of the circuit. The operating frequency of IC2's internal oscillator is set by a 16.9344-MHz crystal (XTAL1). The clock frequency is used by the CS9236 to generate the stereo 44.1-kHz digital-audio data that appears at IC2's serial-audio data output (SOUT) terminal at pin 11. The signal that appears at pin 11 of IC2 is applied to the serial-audio data (SDATA) input of IC3 (the CS4333 stereo serial digital-to-analog converter) at pin 1. The serial-cudio data left/right clock (LRCLK) output of IC2 at pin 10 is fed to IC3 at pin 3, where it is used by the DAC to determine the start of a data stream and whether the incoming data is for the left or the right channel.

Figure 2 shows the timing relationship between the LRCLK signal, the internal data clock, and the serial-data stream. (The stereo serial digital-to-analog converter is commonly found in portable CD players, where it is used to convert the serial-audio data from the CD back into analog signals.) The MCLK (pin 4) and LRCLK (pin 3) inputs to IC3, which are derived from IC2, are used to control timing for the serial-audio data stream.

The signal applied to the DEM/SCLK terminal (pin 2) of IC3 is used to place the DAC in either the internal or external clock mode. That pin, which is tied high through R2, places IC3 in permanent internal clock mode, allowing asynchronous data transfers between IC2 and IC3. Resistor R2 also prevents CMOS latch-up (which occurs when any pin of a CMOS device goes higher than the device's power-supply input). The CMOS circuitry acts as a *S*ilicon *C*ontrolled *R*ectifier (SCR) would in a DC circuit—it turns on but never turns off.

The outputs of IC3 are fed to a pair of low-pass filter/buffer amplifiers built around an LM358 dual op-amp (IC4). The filtering is required to eliminate any digital noise that might creep into the analog output. Acting as a near unity-gain amplifier, IC4 boosts the output of IC3 to sufficient capacity to drive cables, external amplifiers, and the like, through the LINE OUT jacks, J1 and J2. The outputs of the dual filter circuit are also fed to an LM2879 dual 8-watt audio amplifier (IC5), which boosts the line-output signal to a level sufficient to drive a pair of stereo speakers.

Power for the circuit is supplied by a fullwave bridge rectifier (BR1) and a pair of fixed voltage regulators (IC6, a 7805 5-volt unit and IC7, an LD111733 3.3-volt unit). The bridge rectifier allows the voltage applied to the circuit to be derived from a 15-volt AC or DC wall transformer. Note that the unregulated 15-volt input to the power-supply circuit directly powers the LM2879 dual 8-watt audio amplifier (IC5).

Construction. Although the CrystalSynth is simple enough to be assembled on perfboard using point-to-point wiring techniques, it is recommended that the circuit be fabricated on a printed-circuit board, as was the author's unit, because the circuit contains several components that are available *only* in surface-mount packages. Using assembly techniques other than printed circuit may require that an adapter board be used for the surface-mount ICs. The adapter boards reconfigure the lead spacing of surface-mount chips so that they conform to standard, easy-to-solder, 0.1-inch pin spacing. In addition, there should be separate digital and analog grounds, which should be connected together

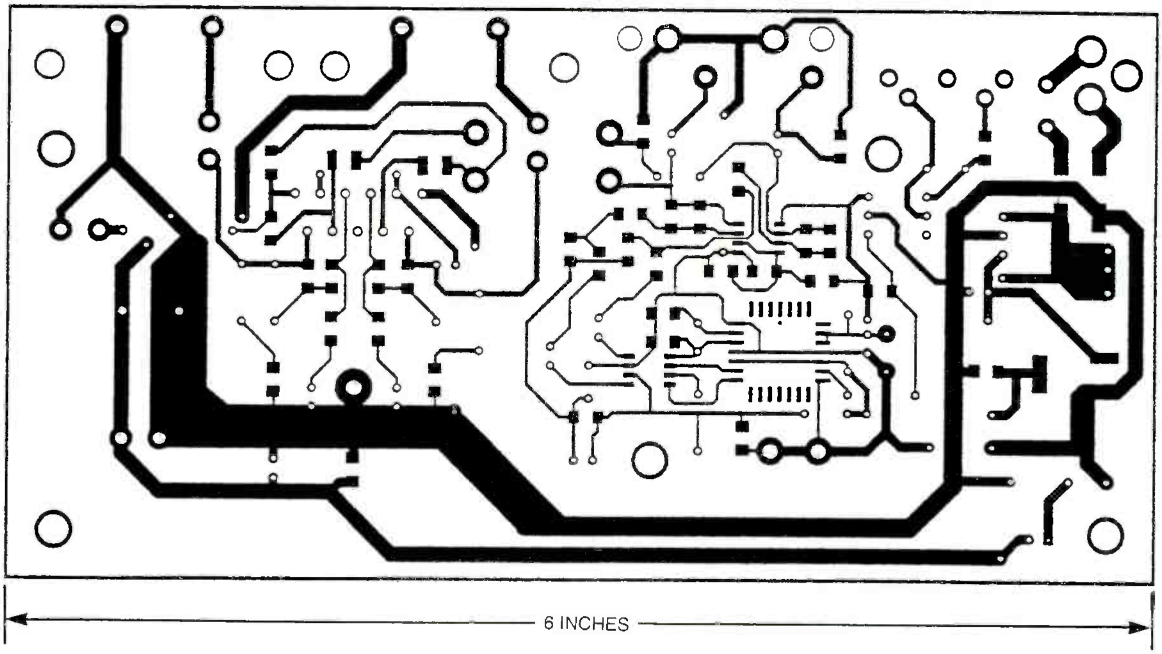


Fig. 3. A template of the author's single-sided, printed-circuit layout for CrystalSynth, which measures 6 by 3 inches, is shown here full-scale.

only at one point very close to the voltage regulators.

However, for those who prefer less hassle-prone assembly, printed-circuit construction is the way to go. A full-size template of the author's single-sided, printed-circuit layout, which measures 6 by 3 inches, is shown in Fig. 3. That pattern can be lifted from the page and used to etch your own printed-circuit board. Or, you may elect to purchase the board from the source listed in the Parts List.

Note: A partial kit—containing the board, all ICs (except IC4, the LM358), and the crystal—as well as a fully assembled and tested unit are also available.

Once you've obtained a printed-circuit board and all of the parts listed in the Parts List, construction can begin. But before we get started, it is worth mentioning that not all of the components for this project are mounted in the conventional manner (through-the-hole components installed from the non-copper side of the board). Instead, some components—several surface-mount units—are mounted to the foil side of the board. Because several components are surface-mount units, when soldering those units a low-wattage soldering iron with a very fine tip is required. (If you are not familiar with surface-mount construction techniques, see the section on *Surface-Mount Assembly* before proceeding.)

Begin construction by mounting and soldering the components shown in Fig. 4 to the component side (in the conventional sense) of the board. Note that the board layout contains several jumper (J) connections. The wire jumpers eliminate the need for a double-sided printed-circuit board. Install the jumper wires first, followed by the passive components and semiconductors. Note that all circuit-board-mounted components for this project are soldered directly to the board. When soldering the semiconductors in place, it's a good idea to temporarily connect a heatsink to the lead being soldered, so that any potentially damaging heat can be channeled away from the unit.

After mounting and soldering IC5 to the board, connect a heatsink to the tab of IC5 and run a wire from the heatsink-mounting hardware to the ground pad indicated in Fig. 4. Attach the off-board components to the appropriate points on the circuit board through hook-up wire. Be careful when connecting the two volume controls (R19 and R20) to the circuit board. Note that the wipers (center terminals) of R19 and R20 connect to C32 and C33, respec-

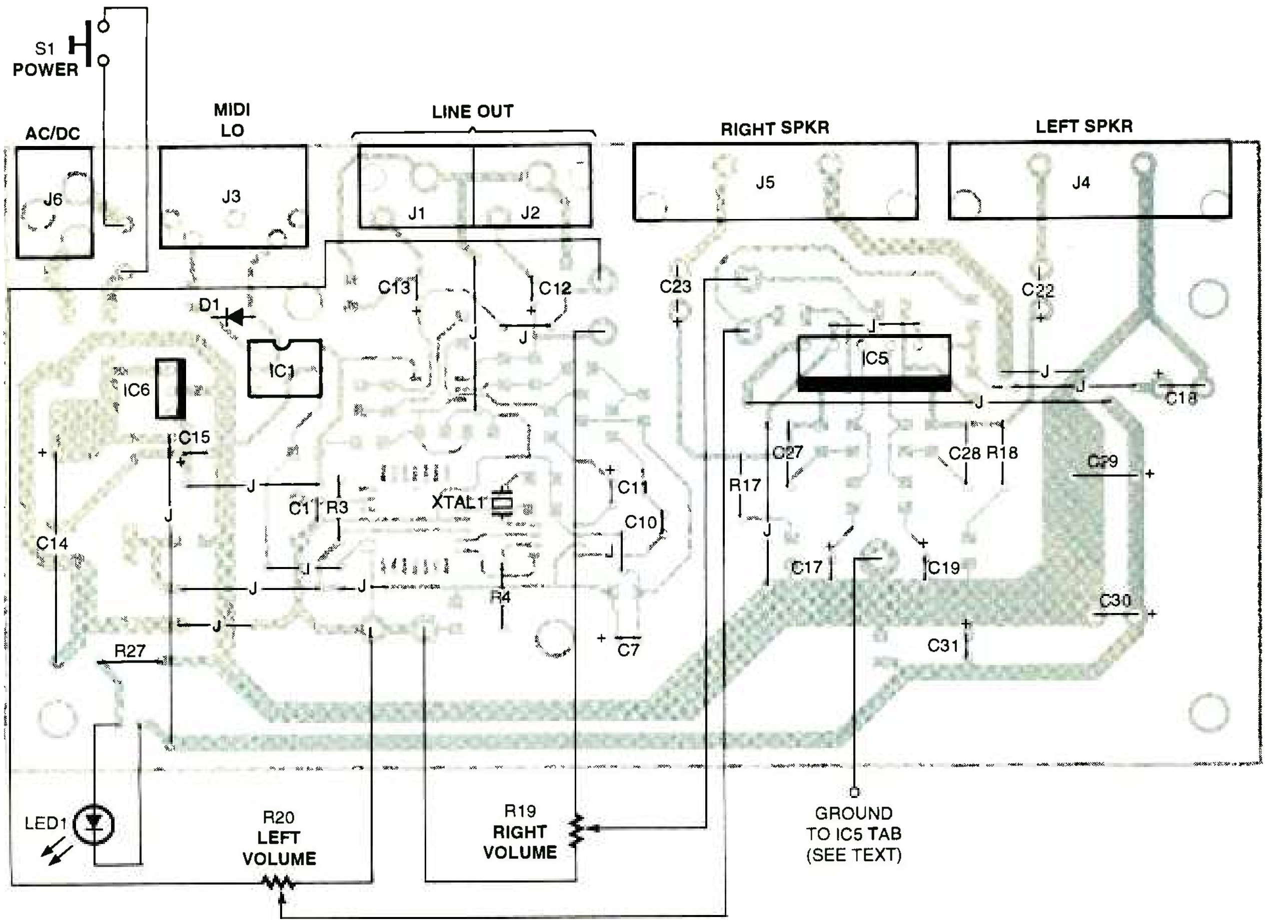


Fig. 4. Although the CrystalSynth prototype was assembled on a conventional single-sided board, its actual construction is carried out in a rather unconventional manner—encompassing both conventional (through-the-hole) and surface-mount components. The through-the-hole components are mounted to what's normally deemed the component side of the board. That portion of the circuit's assembly is shown here.

tively. The author used 6-inch lengths of 3-conductor cable to attach the volume controls to the circuit board. In addition, 6-inch lengths of 2-conductor cable were used to attach the switches and the LED to the board. Since the connectors mounted directly to the circuit board and are designed to be bolted to the back panel, using such cabling on the potentiometers, switches, and LED make for greater versatility in selecting an enclosure in which to house the project. After the non-copper-side components have been secured, check your work for the usual construction errors: solder bridges, cold solder joints, misoriented or misplaced components, *etc.*

Once you are satisfied that all is well, flip the board over and begin installing the surface-mount components to the copper side of the board, guided by Fig. 5. Because the surface-mount components are so small, it is wise to take your time installing these components. Also be sure that they are properly oriented, before soldering the first pin (terminal).

After mounting all of the parts, carefully inspect the assembly to ensure that there are no construction errors, and when satisfied that all is well, put the board to the side while you prepare the enclosure that will house the project. The author's unit was housed in a metal enclosure, measuring about $8^1/_8$ by $6^1/_{16}$ by 2 inches. Prepare the front panel of the enclosure by drilling holes in the front panel to accommodate the front-panel-mounted components—S1 (POWER), S2 (RESET), R19 (RIGHT VOLUME), and R20 (LEFT VOLUME). After preparing the front panel, prepare the rear panel by drilling holes and making cutouts to accommodate the unit's jack assortment.

Once all of the front and rear panel holes and cutouts have been made, dry-transfer lettering can be used to label each position as to control or jack function.

Surface-Mount Assembly. Many hobbyists are intimidated by the prospect of assembling a circuit board designed for surface-mount components, but that needn't be the case. Any hobbyist can assemble printed-circuit boards containing surface-mount components. With a few minor changes in your normal routine and a couple of "special" tools, the task can easily be accomplished.

Because of the small size and close lead spacing of surface-mount components, the first thing you'll need is a low-wattage, soldering-iron heating element with a very fine tip. You'll also need a small pair of tweezers; tweezers are very useful for placing and maneuvering small parts on the printed-circuit board. Using the tweezers, position the component over its mounting area, making sure that the item is properly oriented.

Fine-gauge solder is a must, as is flux cleaner. Flux remover is required because flux is electrically conductive; therefore, flux allowed to migrate across component leads or copper traces and pads constitutes a direct short, which will surely render the circuit inoperative (at best), and might even lead to the destruction of one or more critical components. You should also keep a small-gauge solder wick handy, in case it becomes necessary to remove solder from a component or printed-circuit pad.

In addition, a magnifier with a built-in light is also useful when working with surface-mount components, as is a clean, neat, and well-organized work area. (Small components can easily be misplaced in a cluttered environment.) Make sure that the soldering iron has had ample time to get hot and that the tip has been tinned. Tinning the soldering-iron tip enhances it heat-transference properties—that's important since holding the soldering iron against the component and/or cir-

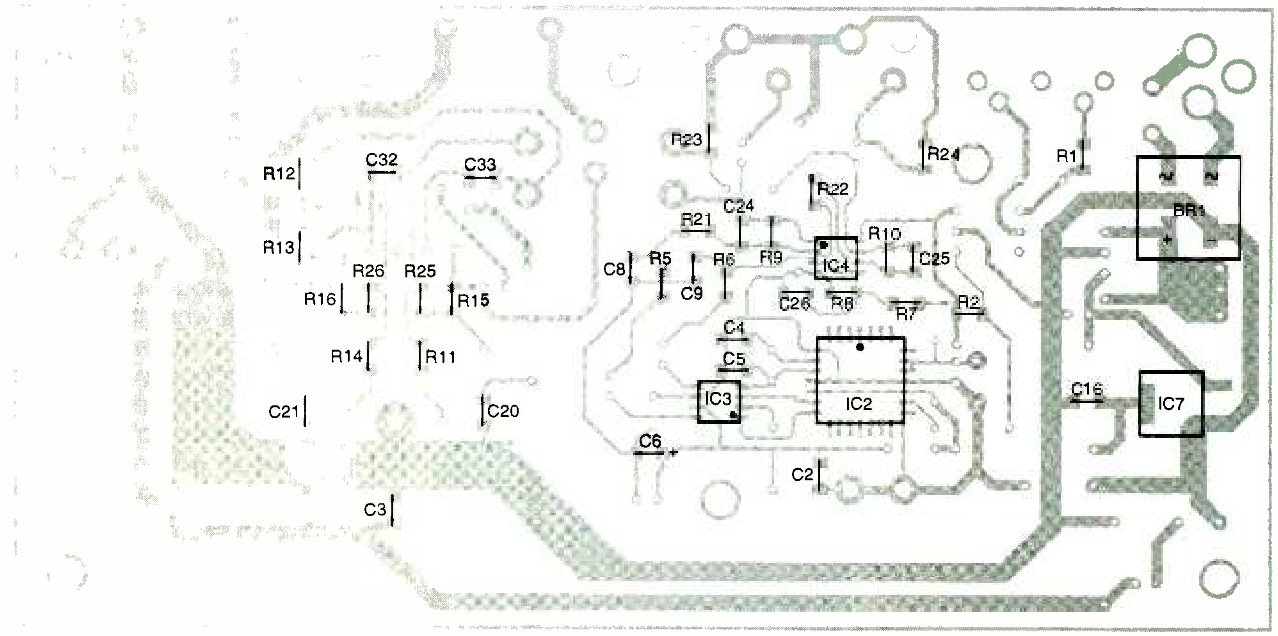


Fig. 5. After mounting the conventional components, flip the board over, and begin installing the surface-mount components to the copper side of the board, guided by this diagram.

cuit board for too long can damage the component, as well as cause the copper traces and pads to separate from their substrates. Before beginning assembly, the required components should be laid out before you so that they can easily be located as needed. Remember that this is a surface-mount assembly; thus the components are soldered to the foil side of the board.

The easiest way to work with surface-mount components is to trickle a dab of molten solder onto one pad of the IC and on one of the two-point pads (those intended for the resistors and the bypass capacitors) to which a component is to be mounted. Then, after determining the correct component orientation, place the components flat to the component pads, and reflow (reapply heat to) the solder and component terminal to form a solder joint. Heat should be applied to the component just long enough to cause the solder to become molten and adhere to the component terminal and circuit pad. Continue the process until one side of each component is mounted. Because of the small size of surface-mount components, they are more heat sensitive than conventional devices. Once the solder becomes molten, the soldering iron (heat) should be quickly removed. You'll have a little time to quickly make final alignment adjustments until the solder cools and sets.

At this point, it is a good idea to double-check for proper component orientation. Desoldering a single lead or terminal is a lot easier than attempting to desolder multiple leads or terminals. Once it has been determined that the component(s) has been properly oriented, secure the other terminal of each component in place. When done, check to be sure that all soldered components are firmly mounted and that the soldered joints are mechanically sound. At the same time, look for shorts or open solder connections. Also, clean any excess flux from the board.

PARTS LIST FOR CRYSTALSYNTH

SEMICONDUCTORS

BR1—LTDF02S surface-mount, fullwave, bridge rectifier (Digi-Key DF02S-ND)
D1—1N4148 general-purpose, small-signal silicon diode
IC1—H11L1QT or PC900V optoisolator/coupler (Digi-Key H11L1QT-ND)
IC2—CS9236 CrystalClear wavetable synthesizer, surface-mount, integrated circuit (Insight Electronics)
IC3—CS4333 stereo serial digital-to-analog converter, surface-mount, integrated circuit (Insight Electronics)
IC4—LM358 dual low-power op-amp, surface-mount, integrated circuit (Digi-Key LM358M-ND)
IC5—LM2879 8-watt audio power amp (Digi-Key LM289T-ND)
IC6—7805 fixed 5-volt, 1-amp, voltage regulator (Digi-Key NJM78M05FA-ND)
IC7—LD111733 3.3-volt voltage regulator (Mouser 511-LD1117DT33C)
LED1—Light-emitting diode

RESISTORS

(All fixed resistors are 1206-series, 1/8-watt, surface-mount chip units, unless otherwise noted.)
R1—220-ohm
R2—2200-ohm
R3, R4—10,000-ohm, 1/4-watt, 5%, axial-lead
R5, R6, R9, R10—15,000-ohm
R7, R8—20,000-ohm
R11, R14—2000-ohm
R12, R13, R15, R16, R25, R26—100,000-ohm
R17, R18—2.7-ohm, 1/4-watt, axial-lead
R19, R20—10,000-ohm, panel-mount potentiometer
R21, R22—6800-ohm
R23, R24—56,000-ohm
R27—1000-ohm, 1/4 watt, 5%, axial-lead

CAPACITORS

C1—1-µF, 35-WVDC, radial-lead electrolytic
C2, C3, C6, C16, C20, C21, C26, C32, C33—0.1-µF, 1206-series, surface-mount, ceramic-chip
C4—22-pF, 1206-series, surface-mount, ceramic-chip
C5, C24, C25—10-pF, 1206-series, surface-mount, ceramic-chip
C7, C10–C13, C15, C31—10-µF, 35-WVDC, radial-lead, electrolytic
C8, C9—390-pF, 1206-series, surface-mount, ceramic-chip
C14—1000-µF, 50-WVDC, axial-lead, electrolytic
C17, C19—4.7-µF, 35-WVDC radial-lead, electrolytic
C18, C22, C23, C30—220-µF, 35-WVDC, radial-lead electrolytic
C27, C28—0.022-µF, 35-WVDC, polyester
C29—2200-µF, 35-WVDC, radial-lead, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1, J2—PC-mount RCA jack (Mouser 161-4218)
J3—5-pin DIN, PC-mount connector (Mouser 161-0503)
J4, J5—PC-mount speaker terminals (Mouser 151-0300)
J6—2.5-mm, right-angle power jack (Mouser 163-5003)
S1—Panel-mount SPST push-on/push-off switch
XTAL1—16.9344-MHz crystal (Newark 50F1205)
Printed-circuit materials, 15-volt wall transformer, enclosure, knobs, wire, solder, hardware, *etc.*

Note: The following items are available from David Duley, PO Box 658, San Marcos, CA 92079-0658: A single-sided printed-circuit board, solder-plated with parts-placement silkscreened on both sides for $17; a kit of critical parts, containing the CS9236 (IC2), the CS43333 (IC3), the LM2879 (IC5), the H11L1QT (IC1), the 7805 (IC6), the LD111733 (IC7), the 16.9344-MHz crystal, and a printed-circuit board for $70; a complete kit of all parts without enclosure for $125; or a completely assembled and tested unit in studio enclosure for $279. Send check or money order only and include $8 S&H.

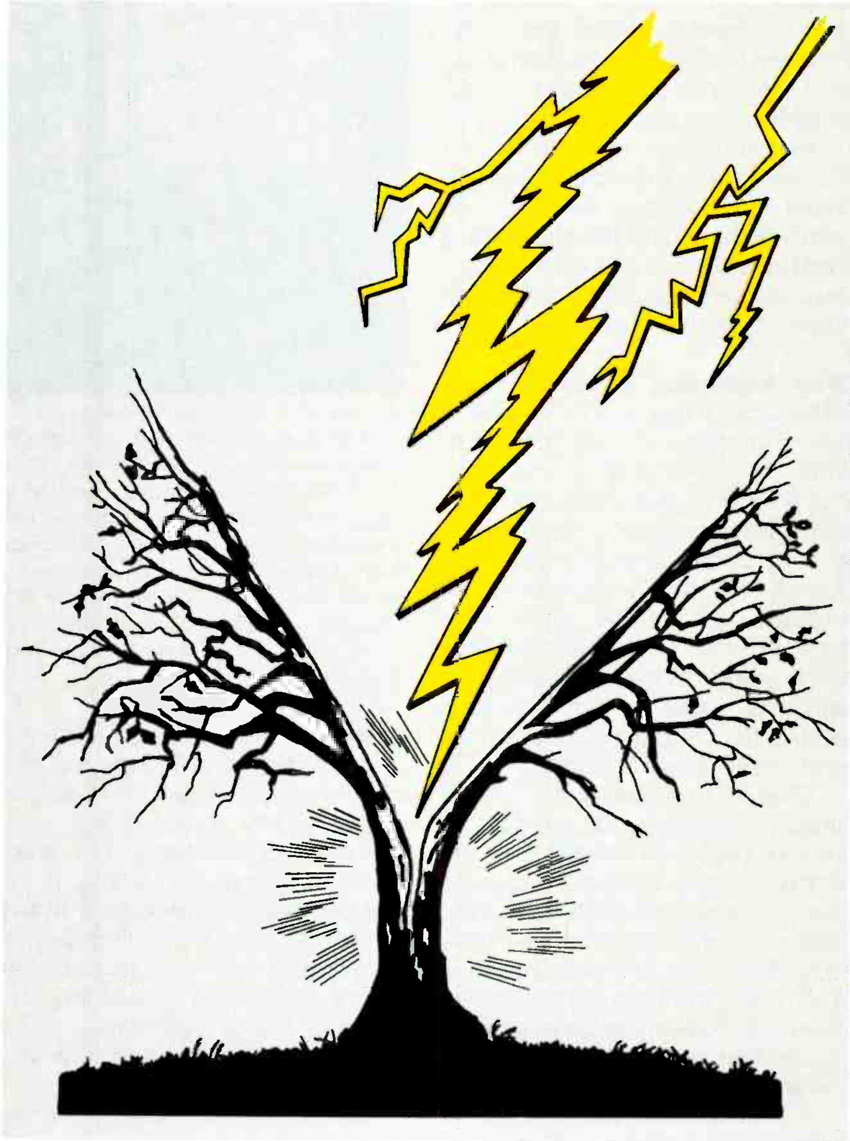
Testing. To test the power-supply portion of the circuit, apply power through a wall adapter or transformer and check that the LED lights. Measure the voltage at the positive (+) output terminal of the bridge rectifier (BR1). The reading at the positive terminal should be between 9 and 25 volts, depending on the wall transformer you are using. If the voltage is less than 9 or greater than 25 volts, select another wall transformer. (I have seen wall transformers rated at 12 volts DC actually outputting 20 volts DC with no load, so check the output of yours! Don't rely on the label.)

Check the outputs of IC6 (the 7805) and IC7 (the LD111733). The output of IC6 should be between 4.9 and 5.2 volts, while the output of IC7 should be between 3.1 and 3.5 volts. Check the positive-supply terminal of all the semiconductors. The positive-supply terminals of IC2 and IC3 must be at 3.3 volts, and the positive-supply terminals of IC1 and IC4 (the H11L1QT and the LM358, respectively), should be at 5 volts. The positive-supply terminal of the LM2879 (IC5) should produce a reading of +15 volts (the equivalent to unregulated supply). To test the

(Continued on page 66)

ZAP, CRACKLE, POP!

KARL T. THURBER, JR.



Electronic equipment, while touted as a boon to modern man, also provides endless hours of frustration, particularly when it comes to figuring out ways to protect high-tech gizmos from the various natural and man-made voltage anomalies.

There's no fun in having your home or business invaded by electrical power surges and spikes, which can seriously damage Personal Computers (PCs), electrical appliances, electronic and radio gear, and home electrical wiring. In this article, we'll discuss various methods of protecting your home appliances/equipment and even the electrical wiring from abrupt power fluctuations. We'll also cover the nature and dangerous character of lightning; early storm warning; surges, spikes, and sags; basic and comprehensive protection strategies and concepts; grounds; secondary surge arresters and suppressors; amateur and SWL antenna and tower protection; and steps to take inside the radio hamshack.

Before we dig in, let's take a close look at one of the main causes of surges and spikes—lightning.

The Nature of Lightning. The movement of air in the earth's weather patterns causes *static charges* (voltage) to build up, developing negative and positive regions of highly charged particles within the clouds. Negatively charged regions generally develop near the cloud bases, while positively charged areas develop near the tops. When the static charge reaches a level where the air can't insulate the cloud, a lightning bolt is produced.

The bolt, essentially an electrical arc or discharge, is generated when the static voltage exceeds the air's insulating capacity. The lightning strike equalizes the potential difference by moving along the conductive paths between oppositely charged regions. Usually, that happens within a cloud, but can also occur cloud-to-cloud or cloud-to-ground. When an object is struck, it is because it's a better conductor than air, offering a better ground path. When that occurs, we see *lightning.* Lightning takes on various forms. The different forms of lightning—*sheet, ribbon, bead,* and *ball*—often produce spectacular visual effects.

Tall buildings and antenna towers can induce discharges, as can aircraft flying through a storm. Sometimes, an electrical leader even appears to originate around the top of towers, traveling upward into the cloud.

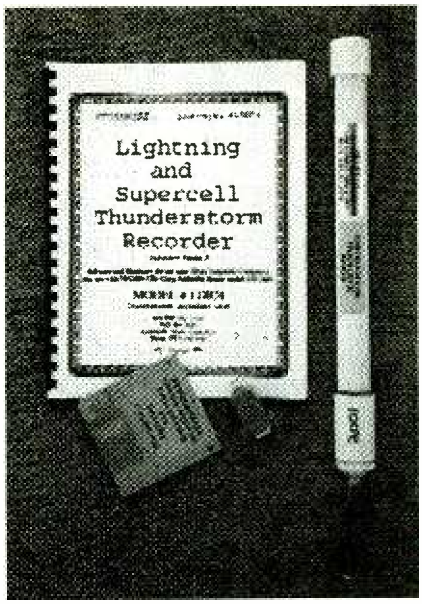
What we hear as thunder is the sound wave generated by the strike. The sound produced by the strike appears to lag behind the lightning because of the slow speed of sound compared with light. There is a simple method that can be used to estimate the distance between your position and a lightning strike by noting the *flash-to-bang time*—*i.e.*, counting the number of seconds from the time you see the flash to the moment you hear the thunder. A lag of five seconds (from flash to bang) roughly equals one mile.

As electronics enthusiasts and PC users, we're concerned less with visual and audible displays than with the damaging effects lightning can have on us and our homes and businesses, bringing us closer to the heart of this article.

Why Lightning is Dangerous. Worldwide, more than one million lightning strikes occur each day, from the 1500–2000 storms that occur at any given time. The "typical" area sees about 40 storms yearly, with about 40 to 80 strikes per square mile. Ninety percent of discharges are of the intra-cloud type, with the discharge harmlessly occurring within the cloud. But when lightning seeks a path through earth, it's dangerous, destructive, and utterly unpredictable.

Over 100 people in the US are killed by lightning, 500 people are injured, and over 10,000 fires are started yearly. Annually, lightning also accounts for more than $250 million in property damage. More than 90 percent of insurance settlements for lightning-related damages are from strikes picked up by power lines and transmitted downstream into a home or business.

A strike's power is enormous, the currents in a lightning bolt are high, and the temperatures (up to 50,000°F) can vaporize almost any material. A single discharge pulse can produce potentials of 100-million volts, which can generate transient currents of over 200,000 amperes. The current reaches its peak in under 80 microseconds; the discharge declines less rapidly, in 200 microseconds or less. The lightning affects a frequency range from zero (DC) to tens of MHz, and multiple strikes are common—up to 40 discharges per second. The discharge exacts a toll on buildings, trees, antennas, power lines, and anything else in its path.



McCallie offers a software/hardware system—the Stormwise Lightning Alert and Supercell Thunderstorm Detector and Recorder, which includes the LSU-2001 Lightning Sensor Unit to detect the ELF/VLF emissions associated with approaching storms—that allows you to graph severe thunderstorms on your PC. The output of the LSU-2001, coupled optically to your PC's serial port, lets you plot, graph, and analyze the storm-generated electrical activity on your monitor screen.

Early Storm Warning. Even if lightning isn't always physically damaging, the high voltages involved can cause costly breakdowns and damage to electrical and electronic equipment, including transmission lines and antennas. It would be nice to have a lightning proximity alarm to warn of approaching storms, above and beyond the standard NOAA weather warnings. That kind of personalized warning now is possible.

Several firms, including McCallie Mfg. Co., manufacture sensors capable of detecting approaching thunderstorms (some claiming several hours lead time), thereby, providing ample time to shut down and/or disconnect valuable equipment and take other precautions. McCallie's Stormwise designs use ELF/VLF impulse-detection sensors—which can register over 1000 detections per second and automatically resets itself—to identify incoming storms, reportedly, at distances of up to 250 miles. When the storms are distant, the sensor sounds a buzzer for less than one second. As the storm activity and lightning approaches, the buzzer sounds for longer periods. If approaching storms are severe, the alarm s

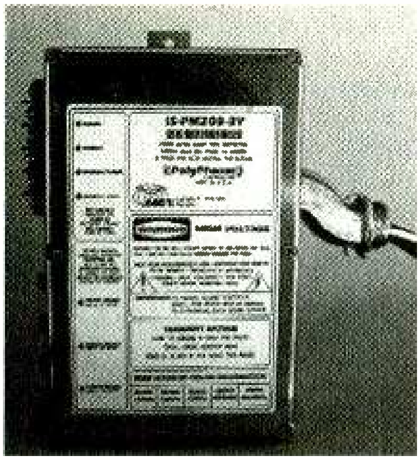
McCallie also offers a software/hardware system—the Stormwise Lightning Alert Lightning and Supercell Thunderstorm Detector and Recorder—that lets you graph severe thunderstorms on your PC. It's adept at dealing with dangerous "supercell" thunderstorms (and may even give you some indication of hail and tornado activity). The system includes a remote LSU2001 lightning sensor, a PC serial-port optical interface, and the DOS-based *Lightning and Supercell Storm Detection Software*.

The Lightning Alert features an automatic lightning-proximity alarm and recording to warn of approaching storms, graphical display of lightning-detection rates, a severe-storm alarm, a weather log, an ability to save lightning-activity and storm-intensity data to disk, color display and supercell loggings, and more.

Surges, Spikes, Sags, and Other Power Events. Lightning strikes produce strong electromagnetic fields that can induce huge voltage surges in power and telephone lines. The anomalies travel along the lines, seeking a path to ground, or they enter buildings and cause damage. Even buried lines are not immune to surges. Surges can cause costly breakdowns and damage to equipment and facilities; the financial losses due to surges almost always exceeds the cost of installing effective surge protection.

Most of the damage caused by overvoltage "power events" is caused either by longer duration high-voltage transients (surges) or shorter-duration transients (spikes) entering via the power mains. Surges and spikes can reach 3000 to 6000 volts or more.

Power surges are significant short-term increases in voltage, typically $^{1}/_{120}$ second or longer. Power surges have many causes, mostly external to the premises, such as inductive switching, power switching, malfunctions in utility company equipment, and of course, lightning. It's common to find several 1000-volt-plus increases daily over the normal 115–125 volts coming down the utili-



This PolyPhaser AC Line Protector is representative of secondary suppression systems, wherein lightning-based energy is diverted to an outside ground before it enters a building. For best protection, you also should have additional inline, point-of-service surge protectors installed near sensitive equipment.

ty lines to your electrical panel.

Although lightning produces the majority of power-line irregularities, it isn't the only source of anomalies. The AC power entering your home or business is relatively "dirty," and it gets worse when you consider devices within the structure that can further pollute power to sensitive equipment. In fact, each day, hundreds of momentary ($^1/_{120}$ second or less) potentially destructive high-voltage spikes occur in and around your home's wiring.

The most serious spikes are caused by external factors, such as motors in nearby businesses, automobile accidents involving utility poles, and lightning strikes—even those occurring miles away. In many areas, spikes are caused by the utility itself. Company switching of loads, lines, and generators causes serious problems.

Short-duration, lower-voltage spikes ranging from 750 to 1000 volts or more can appear on normally tame residential lines. Within your home, the main cause of spikes is the cycling on and off of induction devices, such as electrical motors. Typical spike sources include heating systems, furnace blowers, air conditioners, power tools, refrigerators, and other appliances; the energizing or de-energizing of relays, solenoids, or transformers, *etc.*

In addition, electrical appliances and electronic equipment (especially PCs) are very sensitive to other AC-line anomalies, such as sags—short-term, momentary undervoltage conditions of 15% or more and lasting 1 second or less. Sags as short as 10 milliseconds can cause PCs to malfunction. When longer-term undervoltage conditions lasting more than a second—brownouts and blackouts—are corrected, there is often a surge following power restoration. Those anomalies can have precipitous effects, or they can insidiously degrade insulation and components in appliances and equipment to the extent that they eventually fail.

In addition, AC-line voltage varies over the course of a day. Most of the time, it's around 115–125 volts, but it's not unusual for it to drop to as low as 105 volts or even lower during periods of heavy demand and then climb to 130 volts or so during off-peak hours. Such variations can cause less-than-optimum equipment performance, but that normally isn't serious, provided that the voltage doesn't "stray" outside a range of, say, 110 to 130 volts.

You may want to keep a voltmeter near PCs and other sensitive electronic gear online at all times, calling in your utility company to record the swings you find, especially if they're pronounced. Of course, those procedures don't yield a positive indication of the more dangerous overvoltage transients we've mentioned.

Basic Protection Strategies and Concepts. A direct lightning hit can be catastrophic, although of relatively low probability. Nothing can save your equipment from becoming toast—after a direct hit, your main concern is salvaging your premises. A more realistic danger is that a nearby strike may be transmitted through utility lines as a potentially damaging "power event."

Over the years, many protection schemes have been devised to prevent or at least lessen the effects of voltage irregularities on sensitive electronic equipment. One popular and practical solution is to physically disconnect electronic equipment from power lines whenever a storm is brewing. Such actions afford a certain peace of mind. A variation on that theme is to disconnect sensitive electronic equipment when it's not being used. It's also wise not to operate sensitive electronic equipment just prior to, during, or after passage of a severe electrical storm, since damaging transients may well be present.

This PolyPhaser device is designed to protect military and other high-end equipment. Designed to provide both MOV- and high-current gas-tube protection internally, the unit is intended to be hardwired and soldered into place within the electronic equipment or appliance it protects.

There's a question that arises as to whether a home requires extensive protection. The answer to that is one of "insurance:" Any lightning-protection equipment merely constitutes a form of insurance policy protecting equipment and facilities. Most people feel that the replacement cost of their equipment is worth a one-time investment in protective devices. But rather than proceed haphazardly with protection, you might consider a "layered" system to protect your premises and the equipment therein. Any protection scheme should include a good ground, plus a combination of whole-house and plug-in, point-of-use suppressors to be effective.

A practical three-tiered approach starts with a good, low-impedance ground system for the premises, and it continues with a high-quality secondary surge arrester connected at the main AC panel. The final stage might be comprised of a series of high-quality, plug-in, transient-voltage surge suppressors connected at the receptacles that serve delicate equipment.

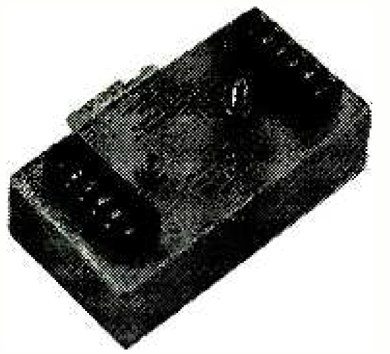
Tier I: A Low-Impedance Ground System. There's an old radio axiom that says, "*When in doubt, ground it.*" The most important factor in the overall effectiveness of conventional protection equipment and devices is the integrity of the ground to which they are connected. Since you can't actually ground the "hot" power conductors entering the house from the electric utility company's mains, the best that can be done for voltage surges is to divert them harmlessly to a ground system.

Not just any old ground affords adequate protection. The amount of voltage induced in the ground system is inversely related to the ground system effectiveness when a lightning strike occurs. A good ground should be of low impedance and develop *only* a very small, harmless surge. High-impedance grounding systems develop large voltage surges. Without a low-impedance ground system, even expensive protective devices may not work properly.

Ground Rods—Ground rods are the basis for residential grounding systems. Ground rods should be used, rather than rely on the rebar in foundation footings as the only ground path, especially since lightning can vaporize the moisture in the concrete and crack it. The rods themselves should be copper-clad or galvanized steel, 8- to 10-feet long with a minimum diameter of $^5/_8$ inches. Normally, at least two ground rods (preferably more) are driven into moist soil to get the ground resistance low (below about 25 ohms). Connections to the grounding rod should be tight, permanent, and exhibit zero-resistance; a poor connection can add significant resistance.

While the resistance of copper grounding wire is insignificant when compared with the ground resistance, electrical codes usually require a minimum of No. 6 copper wire; heavier No. 4 wire is even better.

Improving Conductivity—In order to handle and safely disperse lightning currents, a low-impedance, high-conductivity earth ground system is needed. There are several ways in which to improve conductivity, including increasing the surface



The PolyPhaser Model IS-DPTL is an inline, twisted-pair telephone line protector suitable for business and industrial use. A sort of "whole house and office" device for telephones, it's an example of the series of sophisticated, high-end products available to protect telephone trunks from line anomalies.

area of the conductors to decrease inductance. The most effective conductor you can use is copper strap, preferably at least 1-$^1/_2$-inch, 26-gauge material. If the soil around your property is dry and sandy, a minimum of two ground rods spaced at least 6 feet apart and bonded together by heavy wire or copper ground braid or strap is recommended for best protection.

As an alternative, several radials at least 50 feet long with several 8-ft. ground rods along the entire length of each radial could be used. In addition, soil conductivity (water retention properties) can be increased by "*doping*" the soil with Epson or rock-salt compounds to form a saline solution around the grounding system.

Tier II: AC Secondary Surge Arresters. Installing inline, point-of-use, AC-transient-voltage suppressors near sensitive equipment offers limited protection from overvoltage conditions. Such devices—which can handle surges of only 6000 volts or so—clamp voltages to a level that won't damage equipment. While such products provide some measure of protection for the devices to which they are connected, they can't protect the complete electrical system or hardwired appliances.

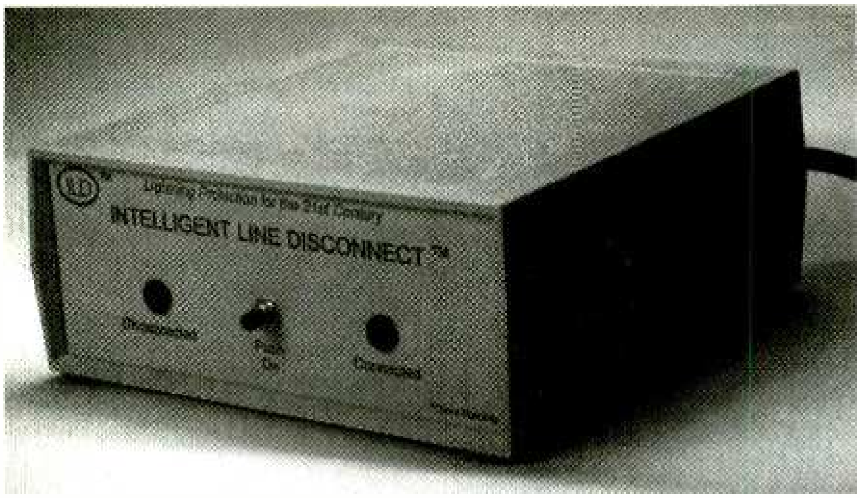
Adding to the problem, ordinary circuit-breaker panels react much too slowly to lightning-induced surges to effectively protect household and office equipment and appliances. For that, specially designed secondary surge arresters, which typically can withstand surges up to 20,000 volts, reacting within a few nanoseconds (billionths of a second) or less are offered by several manufacturers. Longer response times of, say, 5 nanoseconds or more mean that overvoltage conditions will be well past the protective device and into your equipment before it reacts. A fast arrester also "buys" valuable fractions of seconds to give circuit breakers the extra time they need to trip and save down-line equipment from damage.

For those reasons, even with a good ground, you still need a secondary suppression system—a secondary surge arrester. Installed at the electrical panel, such a device may "sacrifice itself" rather than allow a surge pass. The device is a passive unit without transistors, resistors, or capacitors, which can't withstand high voltages.

The trend is toward use of "whole-house" secondary surge arresters that can protect all of the secondary AC wiring, including hard-wired appliances, from electrical surges. Secondary surge arresters divert excess energy to ground, reducing voltage surges to a level that can be absorbed by your electrical system and point-of-use surge suppressors downstream from the service panel.

You can mount the device on the circuit-breaker panel or install it behind your electric meter. The newest, least expensive, and arguably easiest-to-install whole-house surge arresters are built into a standard double circuit breaker. To install them, you mount them in your electric breaker panel like any other circuit breaker and attach a single wire to ground.

Secondary Surge-Arrester Performance—What should you look for in a "whole-house" protector? Secondary surge-arrester performance is determined by two basic factors—*clamping capability* (which describes the level at which a unit begins to suppress and dissipate surges) and *response time* (how fast it responds to the surge and begins clamping it off). A good unit has a response time of under 2 nanoseconds, clamping to within 20 percent



The Rabun Labs ILD is a protection system that automatically disconnects and grounds everything plugged into it when equipment is turned off; when the equipment is turned back on, all connections are restored. The simple "plug-and-play" unit, shown here, offers solid-state indicators, one-button operation, a "goof-proof" auto-disconnect timer, and filtering for power-line noise.

of the rated current. Such units should meet ANSI/IEEE C62.1 standards, which include withstanding induced electrical-surge current of at least 15,000 amperes.

Even whole-house protectors can't save your property from a direct hit, but they can do wonders in fortifying your equipment and appliances against lesser but, nonetheless, damaging events. In fact, some manufacturers are so sure of their whole-house protectors and circuit breakers that they'll replace any damaged electronic appliances up to a specified dollar amount.

Tier III: Point-of-Use AC Transient Voltage Surge Suppressors. As we've already pointed out, a secondary-surge arrester connected at the main electrical panel can handle large current and voltage surges that make it in from outside. However, those arresters don't filter out the small externally and internally generated surges and spikes that may remain. For that task what's needed is a series of inline, point-of-use devices. Inline, point-of-use, AC-transient-voltage surge suppressors offer protection from momentary, but potentially destructive, overvoltages by clamping voltages to a safe level. Some high-end and military equipment has built-in surge suppressors.

Note: The term "*surge arrester*" is often *misused* to describe small devices that plug into a single outlet to protect one circuit. The proper term for such devices is "*AC-transient-voltage surge suppressor,*" which works by absorbing the surge (a shunt-type suppressor), by blocking the surge (a series type suppressor), or by a combination of the two methods.

Transient-Voltage Surge-Suppressor Performance. When selecting a suppressor, compare the devices' performance specifications. The protection provided by such devices varies widely among similar-looking units. Transient-voltage surge suppressors should at least meet Underwriters Laboratories, Inc. (UL) Standard 1449, which is primarily a safety specification. Be especially suspicious of "no-name" suppressors for which no specifications are provided. (Incidentally, there's no such thing as a "UL-approved" product. If a product is "UL listed," it meets UL safety requirements.)

What's a "Good" Unit?—The suppressor should be capable of withstanding a surge voltage of at least 6500 volts and preferably 10,000 volts or more. The best models block (without burning out) surges of 200 joules within a few nanoseconds, preferably well under 5 nanoseconds. (A joule is a unit of energy: one joule for one second is equal to one watt of power.) Another key specification to look for is the unit's clamping voltage; *i.e.*, the voltage at which the suppressor begins to block the surge. For 3-wire residential 120/240-volt lines, look for a unit that has a low clamping voltage of around 330 volts or less.

How Can You Check Out a New Surge Suppressor?—Realistically, you probably can't test the surge suppressor. While you surely recognize the need for power-line surge protection, it's not until you experience a serious surge that you may discover your protection is inadequate. Things are changing, however. The US government, UL, and the Canadian Standards Association (CSA) all have upgraded their power-line-surge-suppression specifications. The change was brought about by the dismal safety and performance record of the then-available devices and government dissatisfaction with their performance.

Telephone Line Protection. Theoretically, no damage to your telephone line-connected equipment should occur if your telephone line is properly installed and surge protected by the telephone company. That's because most home telephone circuits are protected where the line enters the home by a device designed to short to ground when line voltage exceeds a preset level. But that voltage is relatively high, and the suppressor may not react fast enough to be effective. It also may be burned out.

The bottom line is that telephone wiring entering the home can transmit dangerous transients to your equipment. Microprocessors and other solid-state devices are highly susceptible to phone-line spikes that are of insufficient magnitude to trigger the telephone company's line protector, but are strong enough to "zap" individual devices connected to the line, even if they're AC-line protected.

In addition, the telephone ground may have deteriorated or be ineffective at the outset—telephone lines are often poorly grounded, so it may be prudent to upgrade the telephone ground. One solution is to run a short length of heavy-gauge, grounding wire from the protector box outside the house (where the line enters) to your main ground-rod system.

Practical Telephone Line Protection—Most of us protect sensi-

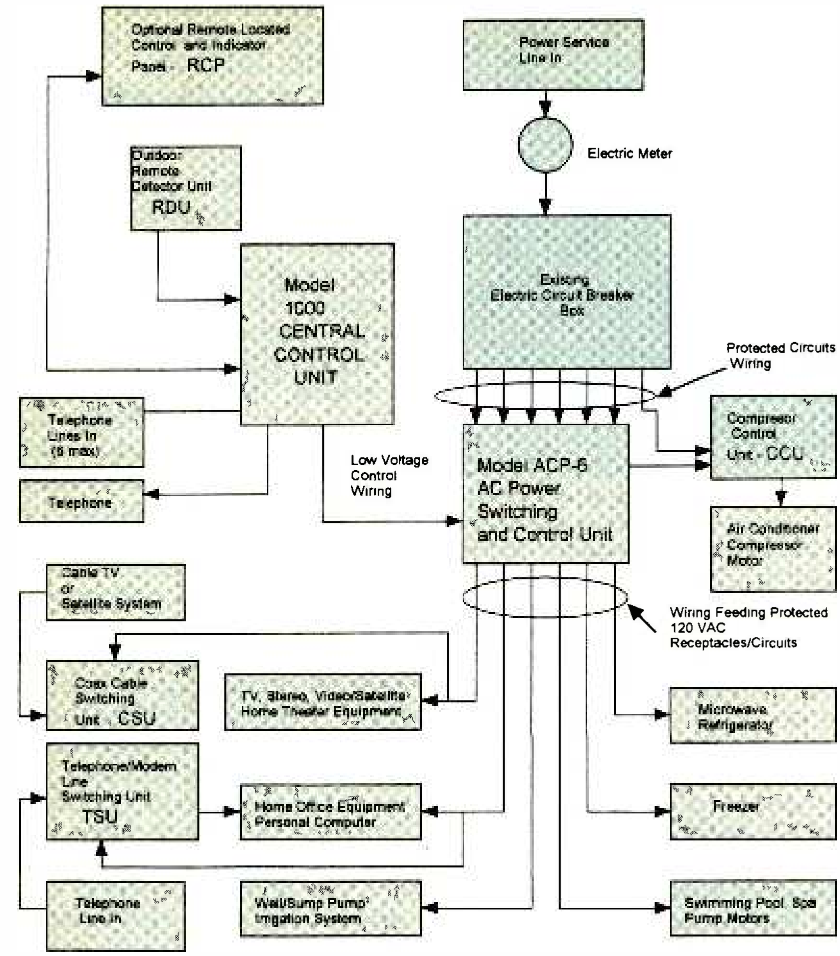


Fig. 1. For larger premises, Rabun Labs offers the Whole House and Office Equipment Protection System, a system block diagram of which is shown here. The system consists of the Model 1000 Central Control Unit, the Model ACP-6 AC Power Switching and Control Unit, and other accessories. These devices interface with all household and office equipment to provide the protection each requires.

tive equipment (such as PCs) from power line surges, but you should seriously consider applying similar protection to telephone lines to protect modems, electronic telephones, fax machines, and other devices. Plug-in, telephone-line surge suppressors can reduce or eliminate that source of damage. Inexpensive commercial protectors are available from most computer, electronics, and office-supply houses and distributors. Also, many AC transient-voltage, surge-suppressor power strips offer telephone protection as an added feature.

Besides protecting each telephone with a surge suppressor, a plug-in protector should be connected at the telephone receptacle closest to where the telephone line enters the house, regardless of whether a telephone is connected to that receptacle. In addition, for businesses that depend on a great deal of telephone-line connected gear, it may be prudent to install some sort of "whole-house" telephone protector. For those with modest needs, "the belt and suspenders approach"—disconnecting modems and other delicate solid-state devices from the telephone line during dangerous weather conditions—may suffice.

Comprehensive Protection Strategies—While buildings usually survive nearby lightning strikes, the electronic equipment and appliances within are less forgiving, since they tend to be low-power, low-voltage devices. The circuitry in such device is highly sensitive to voltage surges—today, even relatively low-tech devices like furnaces and clothes dryers may be microprocessor controlled. Sophisticated devices such as shortwave receivers, scanners, VCRs, TV sets, amateur radio, and CB equipment are even more prone to electrical damage.

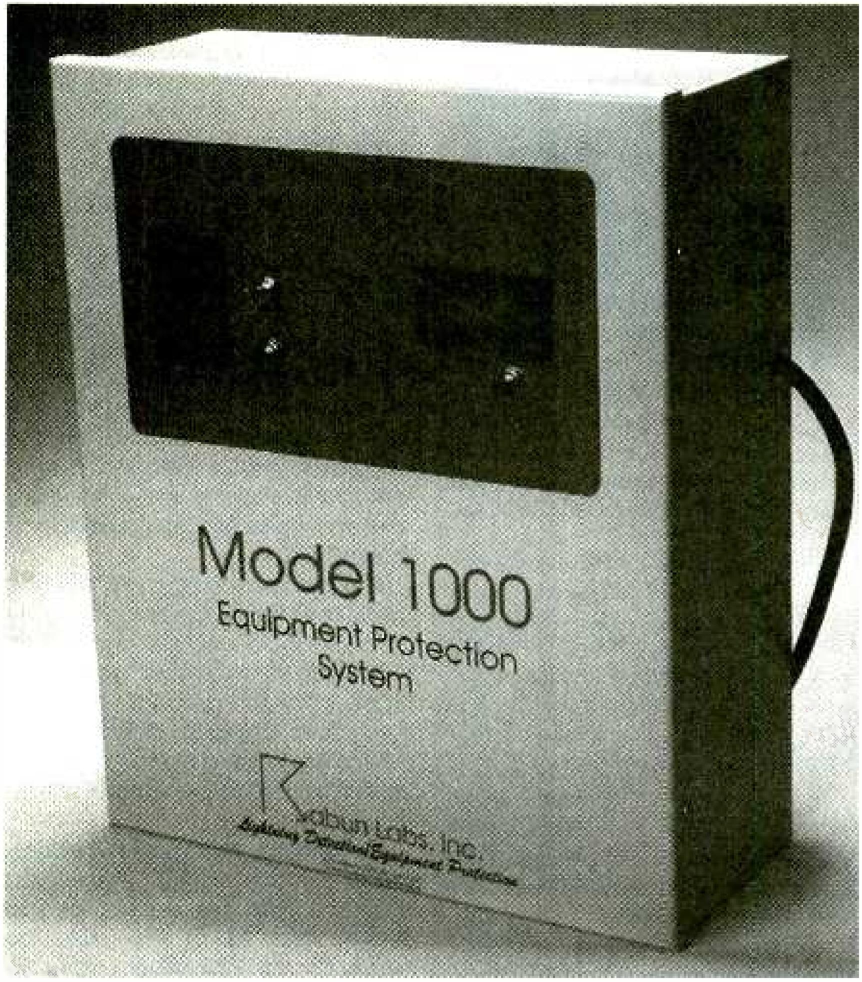
Further, the printed circuitry in PCs is unable to withstand even moderate surges. Some PCs and other electronic systems include an internal suppressor, such as a metal-oxide varistor (MOV), but the protection offered is limited.

Line Conditioners and UPS/SPS Protectors—If you can't afford to have power interrupted, even for a short duration, it may be wise to install an Uninterruptible Power Supply (UPS)—a device commonly used to protect critical computer systems from momentary outages. The UPS provides continuous, conditioned, and regulated power to the connected loads regardless of the input power supplied. The device maintains power continuity in the event of brownouts, sags, power surges, short-term total power outages, and the like.

Don't confuse the UPS with the Standby Power System (SPS), which does nothing most of the time: They simply furnish backup power from an engine, or a DC/AC converter operating from battery power, to handle sustained, total-power outages (blackouts). To add to the confusion, the term *line conditioner* is frequently used to describe any device that filters or regulates the UPS; an UPS that includes some degree of line conditioning may be called a *line-interactive UPS*. Some include EMI/RFI noise filtering, as well.

Both the UPS and the SPS are designed to be connected between the PC or other equipment and the AC outlet. Current from the outlet keeps a battery charged. Should power fail momentarily, the UPS/SPS takes charge, generating what appears to the PC like normal AC power. UPS and SPS generally are dismissed as unnecessary by most people, especially for home use, until the day when important, difficult- or impossible-to-replace data is lost.

Research shows that more than 90 percent of power outages last less than two seconds, while over 98 percent last less than a minute. Although many lower-priced UPSs can only keep the computer up and running for a few minutes, it is enough in most cases.



Rabun Labs also offers the Whole House and Office Equipment Protection System—a sophisticated package, consisting primarily of the Model 1000 Central Control Unit (shown) and the Model ACP-6 AC Power Switching and Control Unit—which reacts to equipment damage by detecting lightning when it is a safe distance away.

Fully Automatic Equipment Protection—It's often said that, during a storm, the only safe conductor is a grounded conductor. That means that AC power, telephone, antenna, control, and other cables are best disconnected and grounded whenever a storm develops. That can be done manually or automatically via comprehensive detection/protection devices.

In what may be the ultimate in equipment safeguarding, *Rabun Labs* offers home and office "intelligent" protection devices, which provide automatic solutions to the equipment protection dilemma that go beyond those offered by conventional protectors. With ordinary protectors, your equipment remains connected to the power source, coax, or telephone wiring even when turned off or not in use.

For use in the typical home or hamshack, *Rabun Labs* offers the popularly-priced ($99) Intelligent Line Disconnect (ILD). The ILD automatic protection system disconnects the connected devices, as if someone physically pulled their AC plugs and/or disconnected coaxial cables and telephone lines from the electronic equipment when it was not in use and turned off. Not only does the device disconnect equipment from external wiring, it also "bundles" device I/Os, connecting them together and to a common ground. When the equipment is turned back on, all connections are automatically restored.

For larger home/office environments, Rabun Labs offers the Whole House and Office Equipment Protection System. At a price of $3800, the system continually monitors the atmosphere and detects lightning when electrical storms are miles away. When storm activity reaches a level likely to cause equipment damage, the system protects equipment by selectively and automatically disconnecting sensitive equipment's AC power, coaxial cable, and telephone lines.

The package consists of the Model 1000 Central Control Unit, Model ACP-6 AC Power Switching and Control Unit, and several other accessories (see Fig. 1). It interfaces with all household or office equipment, and provides the protection each unit requires. The system automatically restores power and other connections after the storm has moved away or the lightning has subsided. The unit can handle a variety of circuits, including wells, irrigation systems, air conditioners, freezers, and swimming pool and spa pumps, in addition to more common home and office electrical circuits.

Controlling the Strike's Energy. If there's a secret to protecting antennas, towers, transmission lines, and the radio hamshack, it lies in taking control of lightning energy. Lightning behaves like other natural elements in that it seeks the path of least resistance—be that path through a structure on your property, your equipment, your body, or any other conductive medium—to ground. Thus, it's important to quickly divert as much of the strike energy as possible by providing a direct path to ground.

Antenna Vulnerability—By the very nature of their construction, all-metal beam antennas are generally self-protecting: *i.e.*, they're usually set at ground potential through the mast and tower that support them. Balanced dipoles, on the other hand, are vulnerable; therefore, placing a balun at the antenna to allow coaxial feedline to be used should be considered. Most baluns put the antenna at DC ground potential, offering at least a limited degree of static buildup and lightning protection.

Ground-mounted vertical antennas behave much like ground-mounted towers, both having a low-impedance connection to ground. But when ground-plane vertical antennas are elevated above the ground, it is necessary to run a direct ground wire to its radial system. **Don't** rely on the coax shield to provide grounding and lightning protection.

Transmission Line Protection—Although the antenna proper may be well grounded, the transmission line—even coax—can cause damage to your home or radio equipment, if left unprotected, by acting as a conduit for static discharges. A good place to protect the coax is where it enters the building. For receiving equipment, ladder-line or twin-lead fed wire antennas can be protected with a TV-type lightning arrester; just remember not to transmit into the device. Transmitting-type balanced-line suppressors also are available. For example, The *Wireman, Inc.* offers an inexpensive air-gap lightning arrester for ladder line, plus a heavy-duty Double-Pole Double-Throw (DPDT) knife switch to shunt parallel lines to ground when you're not using them.

Coax Surge Protectors—*Alpha Delta Communications* offers several protectors for amateurs and SWLs, including its Transi-Trap line of surge protectors (which uses gas-tube Arc-Plug cartridges to protect equipment from transients). At least one firm—Design Electronics Ohio (DEO)—offers units for receiver protection, which are available from Universal Radio, Inc. Comparable transmitting units are offered by Lynics and others.

Antenna-Selector Switches—It's good practice to use an antenna-selector switch that automatically grounds all antennas except the one operating and that can turned to a free position when you're not using your equipment. Alpha Delta offers several gas-tube surge-protected two- and four-position RF coax switches rated at 1500 watts.

Protecting Other Cables—Protectors should not only be installed on transmission lines, but on all cables entering the premises, including rotor and other control lines. If they're not protected, surges can enter the structure and damage equipment. For maximum safety, guard rotor-control cables using protectors at the top of the tower at the point where the lines enter the control motor housing, at the main station grounding panel

Lynics International offers "Super-Grade" Lightning Surge Protectors, which feature easily replaceable, tube-type elements that help protect equipment from voltage surges up to 2500 volts.

where the cable enters the house, and inside the hamshack.

For that purpose, PolyPhaser Corporation offers the Model IS-RCT series rotor control protector, which is designed to safeguard eight-line rotor controllers. The Model IS-RCT helps keep motors, the control box, and other nearby equipment safe from damage and prevents strike energy from entering the premises. It's suitable for mounting on ground rods and tower legs.

Tower Protection and External Grounding—There are many types of supports that can used for wire antennas: trees, poles, masts, towers, buildings, roofs, chimneys, and the like. Short masts on roofs and chimneys are convenient and inexpensive, but they bring the antenna close to the house and possibly increase strike-damage risk. Antennas and towers should be kept as far away from buildings as possible; avoid using buildings to support both ends of wire antennas; and consider using buried feedlines so as little energy as possible enters the premises. Preferably, use only conductive structures as antenna supports.

Grounding Towers and Masts—All towers and masts should be grounded, including those mounted on roofs. Metal towers usually are well grounded, and normally don't require that ground wires be run up through the tower. With wooden towers or trees (not recommended from a protection standpoint), a heavy ground wire or strap should be run all the way up to the antennas or hardware at the top.

Towers must be grounded at the base; that's best done by attaching several grounding rods to the legs. If that's not done, the voltages on the tower can arc over to the cables and travel into the premises. Several eight-foot ground rods connected together with heavy wire, braid, or strap usually forms a good tower ground—the more rods the better.

Ensure Good External Grounding—Again, the primary rule for surviving a lightning strike requires that all equipment—including antennas, the support structures, and all I/O protectors for antenna, power, telephone, rotors, *etc.*—be connected to a single, low-impedance ground system.

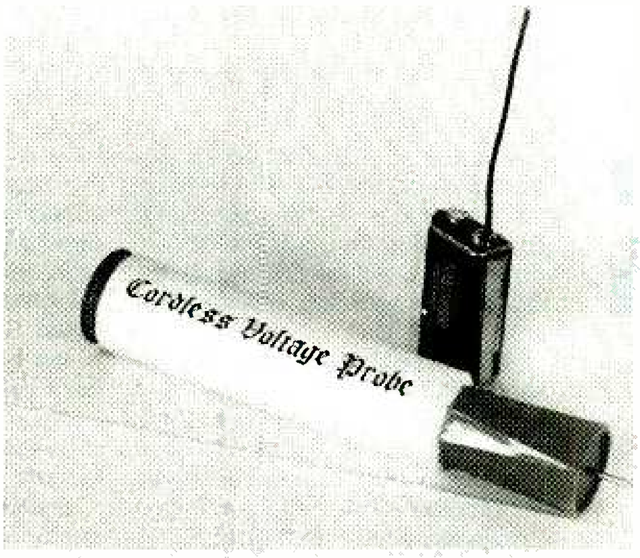
A single grounding rod should be used for utility grounding. The utility ground should also be connected to the telephone cable "entrance" ground, CATV ground, and the grounding cable(s) coming from the tower(s). That ground should also be connected to the internal station ground bus.

Grounding Hardware Considerations—Don't skimp: The main ground conductor should be no smaller than #8 or #10 wire. The heavy #8 or #10 aluminum wire sold for grounding TV antennas is adequate, as are TV-type ground clamps. While the ground lead can be solid insulated or bare wire or heavy copper braid, it should be sheltered from damage by mowing, digging, and gardening. It should be connected to the ground rod through the shortest possible path. Be leery of standard TV ground rods, as they usually are shorter than they should be (8 to 10 ft.).

Protection and Grounding Inside the Radio Hamshack. Surges can enter the hamshack through two avenues—either as a result of a strike on power or telephone lines or due to a strike to the tower or antenna system. Once again, the most important rule for protecting radio gear is connecting all elements of the system—including antenna supports and towers, the antennas themselves; and transmission lines; plus elements of the station's Input/Output (I/O), such as AC power, telephone, and rotor and

(Continued on page 51)

BUILD A
CORDLESS VOLTAGE PROBE



Add this hassle-free cordless tester to your troubleshooting arsenal and make your voltage and continuity tests a bit easier.

JOHN F. MASTROMORO

The idea of a "cordless voltage probe" is certainly not new. Cordless probes, as well as other "touch-sensitive" gizmos, have been around for quite some time. The idea behind such probes is that the ground wire with clip that's normally used to complete an electrical circuit path can be replaced by the user's body. That is accomplished by the user holding the tester in one hand (which is also in contact with a ground strip or some other conductive terminal on the test instrument), while using the other hand to touch a ground return line on the circuit-under-test. Then when the probe tip contacts a point in the circuit where there is a positive voltage, the circuit path is completed, causing the test instrument to indicate that voltage is present in the circuit—just as if a ground-wire with clip had been used.

Most voltage probes, cordless or otherwise, visually (using a lamp or an LED) indicate a voltage presence, but the *Cordless Voltage Probe* described in this article uses a piezoelectric buzzer as an annunciator. That eliminates the need to look away from the circuit-under-test, reducing the possibility that the user might accidentally short component terminals or circuit traces. And that almost eliminates the chance that the circuit-under-test will be further damaged or completely destroyed.

The Cordless Voltage Probe can detect the presence of a DC potential ranging between 4.5 and 80 volts and sound a steady tone alarm when it senses such a voltage. In addition to its DC voltage applications, the Cordless Voltage Probe can also be used to check for the presence of AC voltage. When checking for AC voltage, the probe should be held in one hand, with part of your hand touching the grounding ("finger") strip on the probe body, and the probe tip should be inserted into an AC socket slot. The "hot" side of the socket (ungrounded slot) should cause the probe to produce a chirping sound. You needn't touch a grounded area when checking for AC as is required when checking for the presence of DC.

With the addition of a 9-volt battery, the Cordless Voltage Probe becomes a continuity tester. (The only *real* difference between a voltage probe and a continuity tester is that the voltage probe normally "pirates" operating power from the circuit-under-test, while a continuity tester injects a voltage into the circuit-under-test in order to determine the location of an open circuit.)

Circuit Operation. A schematic diagram of the Cordless Voltage-Probe is shown in Fig. 1. The circuit is comprised of little more than a 4093 quad NAND Schmitt trigger, a buzzer, and a few resistors and capacitors. In order to understand how the probe works, recall that all inputs to any NAND gate must be high to produce a low output. If one or more inputs go low, the output is forced high. Note that in Fig. 1, the probe tip is tied directly to one end of R3, while the other end of R3 is tied to one input of IC1-b at pin 6. Resistor R4 is also tied to pin 6 from ground to act as a *pull-down* resistor. With no voltage detected at the probe tip, pin 6 is pulled to ground through R4. Note that R4 and R3 form a voltage divider network (with a 10:1 resistance ratio). If a positive voltage is applied to the probe tip, almost all of it appears across resistor R4, causing the voltage at pin 6 of IC1-b to rise to the level applied to the probe tip.

Note that IC1-a is configured as an inverter, with R2 (a 10-megohm unit) serving as a *pull-up* resistor (essentially the direct opposite of R4 at pin 6 of IC1-b). Resistors R2 and R1 form another voltage-divider network (this one with more than a 5500:1 resistance ratio). That pretty much guarantees that the output of IC1-a at pin 3 remains in the low state, so long as the finger

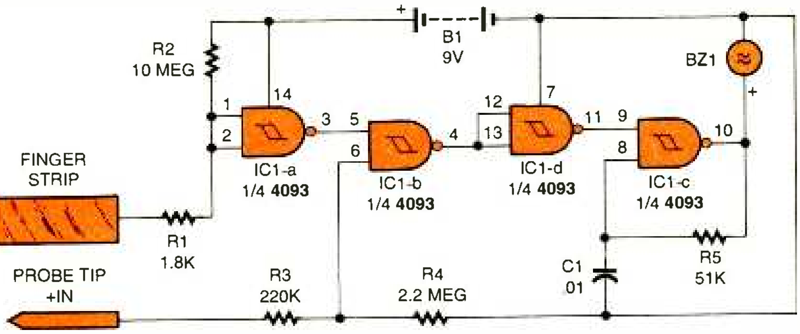


Fig. 1. The Cordless Voltage Probe is comprised of little more than a 4093 quad NAND Schmitt trigger, a buzzer, and a few resistors and capacitors.

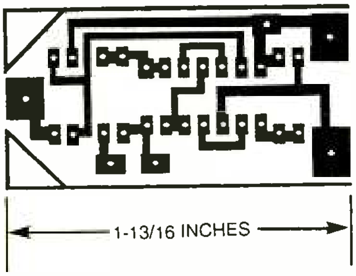


Fig. 2. The Cordless Voltage Probe is simple enough that it could be assembled using the construction method of choice; however, it is highly recommend that the circuit be assembled on a printed-circuit board like this one, which measures 1 13/16 by 15/16 inches.

strip is not touched. Should the inputs of IC1-a at pins 1 and 2 go low, the output of the NAND gate at pin 3 goes high. That high is applied to the pin-5 input of IC1-b. The trick now is to get pins 5 and 6 of IC1-b to both go high at the same time. When that happens, the output of IC1-b at pin 4 goes low. That low is applied to the inputs of IC1-d—which, like IC1-a, is wired as an inverter—at pins 12 and 13.

With a low applied to pins 12 and 13 of IC1-d, its output at pin 11 goes high. That high is applied to one input (pin 9) of IC1-c, which is configured as an oscillator. The output of IC1-c at pin 10 is fed back to IC1-c's input at pin 8 through R5 (a 51k resistor); the pin 8 input to IC1-c is also connected to one side of C1, a 0.01-µF capacitor. As long as pin 9 of IC1-c is high, the circuit oscillates, producing a signal that is applied to a piezoelectric buzzer (BZ1), causing it to sound at a frequency determined by the RC time constant of R5 and C1. The values specified for R5 and C1 can be altered to suit the user's taste.

Because IC manufacturer's specifications vary somewhat, it may be necessary to vary the value of R5 (plus or minus) from 51k. The 0.01-µF value specified for C1 should be adequate regardless of the value selected for R5.

There is no shut-off switch to contend with because of the extremely low battery drain when the probe is not actually in use. (The probe that the author built several years ago still has the same battery in it and continues to work perfectly!)

Circuit Construction. The Cordless Voltage Probe is simple enough that it could be assembled using the construction method of choice; however, it is highly recommend that the circuit be assembled on a printed-circuit board. A template of the author's printed-circuit layout, which measures 1 13/16 by 15/16 inches, is shown in Fig. 2. That pattern can be lifted from the page and used to etch your own printed-circuit board.

Once you've etched your circuit board and obtained all of the components listed in the Parts List, assemble the circuit guided by the parts-placement diagram shown in Fig. 3. The printed-circuit board was housed in a plastic enclosure salvaged from an old Dennison Dry-Eraser Marker (Item #24-416), which is readily available from most office-supply stores.

Other than needing a little creativity on securing the probe tip through the front opening of the enclosure, the circuit board is easy to assemble; all of its components, the 9-volt battery and battery connector, and the finger strip, all fit absolutely perfectly! Even the rear plastic plug went back on with a perfect fit after all parts were secured inside the tube. The enclosure is also a good handling size.

Prepare the enclosure by removing the ink filler and felt tip from the Dennison marker; take care when removing the end plug. Use a flat-head screwdriver to evenly pry the end plug out and place it to the side for replacement later. For the finger strip, the author used a 2 3/4-inch metal paper-fastener, with the tab areas at each end clipped to about 1/2-inch (see Fig. 4). Lay the fastener flat on the outside edge of the tube so that one tab can be folded down, under, and inside the open end at the back of the tube. Mark the tube where the tab on the other end of the fastener folds down. Cut the appropriate size slit in the tube so that the tab, when bent down, can be inserted and bent up from inside the tube using a pencil, but don't attach the strip just yet.

Solder all components to the circuit board with care. The finger-strip wire should be about 5 inches long from the circuit board end and the

PARTS LIST FOR THE CORDLESS VOLTAGE PROBE

RESISTORS

R1—1800-ohm, ¼-watt, 5% resistor
R2—10-megohm, ¼-watt, 5% resistor
R3—220,000-ohm, ¼-watt, 5% resistor
R4—2.2-megohm, ¼-watt, 5% resistor
R5—51,000-ohm, ¼-watt, 5% resistor

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery (Duracell or similar long-life unit)
BZ1—Piezoelectric buzzer (#MS-3 or equivalent: Floyd Bell, Inc., Columbus, OH: Tel. 614-294-4000)
C1—0.01-µF, ceramic-disc capacitor
IC1—4093B quad 2-input NAND Schmitt trigger, integrated circuit
Printed-circuit materials, 9-volt battery connector (RS#270-324), metal strip (paper fastener), plastic enclosure (Dennison Dry-Eraser Marker, Item #24-416 suggested), probe tip rod material, wire, solder, hardware, *etc.*

Note: A pre-drilled circuit board can be purchased for $6, which includes S&H. Send check or money order to: JFM Compositions, 9 Mechanic St., St. Johnsville, NY 13452. Please allow 4 to 6 weeks for delivery.

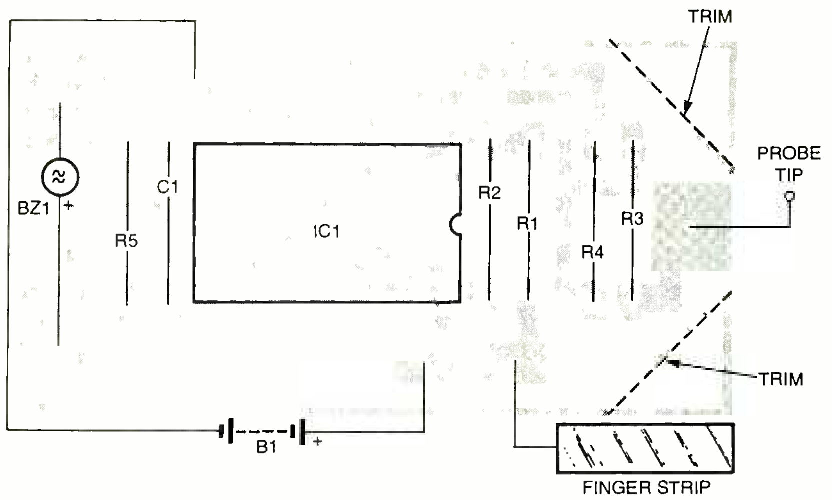


Fig. 3. Assemble the printed-circuit board guided by this parts-placement diagram.

insulation should be stripped $^1/_4$-inch from the free wire end so that it can be soldered to the top side of the finger-strip prong tab. The metal strip will then be placed on the outside of the tube with the tab folded down, and up again, inside the rear end of the tube. Place and fold the other tab down inside the slit made for it. With a pencil, from the front opening of the tube, push the tab inside the tube and up to secure it. Do not insert the circuit board or the battery into the enclosure (tube) yet. The probe tip has to be prepared and mounted.

The probe tip can be any sturdy small metal rod. The author cut a section from a jumbo paperclip (about 1$^3/_4$-inch) and soldered it to the probe-tip pad on the circuit board. A wire can also be soldered to an off-board probe tip if you like. It's OK to be inventive with what you have on hand. A $^3/_4$-inch diameter metal washer with a $^5/_{16}$-inch center hole was used to encase the probe tip, which was made from a banana-jack tip with a plastic housing.

The author pierced a hole in the center of the marker cap and pushed the banana-jack tip up to the plastic housing, through it. With the washer placed around the plastic housing, inside of the cap, it's quite secure. Now the probe tip, made from the paper clip and attached to the circuit board, is cut to fit and slide into the opening of the banana-jack tip when the cap is placed on the marker case. Putting an appropriate-sized dab of solder on the tip of the paper clip helps ensure good contact inside the test-lead tip. That method works quite well and allows the style of the probe tip to be changed at any time without removing the circuit board.

The piezoelectric buzzer used in the circuit (Part #MS-3) is manufactured by Floyd Bell, Inc., Columbus, OH; but, if you use a different unit, you may have to change the values of R5 and C1 for optimum sound level.

Testing the Circuit. Before encasing the components, you will want to test the circuit. Connect a 9-volt battery to the battery clip and then attach the probe tip to the positive terminal of another 9-volt battery while touching the finger strip with the fingers of one hand. With your other hand, touch the negative terminal of the battery. You should get a clear loud tone. If you do have a problem, it could only be a bad solder connection.

If you used a piezoelectric element other than the one specified, it may just be that the R5 and C1 values need to be changed in order to accommodate the circuit modification. If all is well, you're ready to shove all the components into the enclosure.

While being careful of the wire attached to the finger strip, arrange the leads of the battery clip so that they are pulled back towards the end of the circuit board with the piezoelectric element connected. With a good pair of cutters, carefully cut the circuit board into a "V" shape, as indicated in the Fig. 3 board layout. Now gently push the circuit board and battery (end to end) into the tube. Make sure that the probe tip goes through the front opening of the tube without getting hung up on the tabs of the metal finger strip.

You can now drill a small ($^3/_{16}$-inch) hole into the enclosure approximately 3 $^1/_8$ inches from the rear of the enclosure and in line with the finger strip. Where you cut the circuit board will determine the exact position in where the hole should be cut to allow a louder sound output.

Now, if everything is satisfactory, replace the plastic plug on the rear end of the tube to lock everything in position. Place some foam insulation around the probe tip coming through the front-enclosure opening to secure it. Insert the banana-jack tip over the probe tip and push the cap into place. With a very fine piece of sand paper or emery cloth, lightly rub over the surface of the enclosure body to roughen it to provide a better grip when handling the tester.

Use. Using a 9-volt battery, solder a long probe (paperclip) to the unit's positive (+) terminal as shown in Fig. 5. For a finger strip, use the prong part of a 2$^3/_4$-inch metal paper-fastener. Just snip off one end of the prong to about 7/16 inch. Clean and solder it to the negative (−) terminal of the battery and bend the remainder of the prong lengthwise around the battery. Cut the prong where it meets the end of the battery (near the + terminal) but does not extend over it. Tape it securely in place at that point only.

To test for continuity in a line, hold the battery in one hand in such a position that you touch the battery probe tip to a point in the line, at the same time pressing on the metal strip with your finger. Now, holding the cordless voltage probe tip in the other hand (in the same manner as the battery probe), place it on another point in the line. If the line is continuous, you should hear the probe sound off.

The continuity tester works by simply injecting a voltage into the line, using the line itself as half of the voltage path from the positive battery source to the probe tip. Your body completes the other half of the circuit path, through your fingers, while pressing the metal strips on both the battery and the voltage probe itself.

You can also attach (via tape or wire clip) the battery probe tip to a line, while using a jumper wire to clip the metal fastener to a common ground (such as a water pipe). Then using the voltage probe (as described) with one hand, while pressing a finger on your other hand to the closest common ground, should generate a continuous alert. That method is great when working alone and checking out non-powered electrical lines throughout the house.

Another adaptation of the above, although not cordless, is in checking various line continuities with a helper over a long distance area. Simply run one long single piece of wire between you and your helper if no common ground is available as mentioned above. While using the battery probe and voltage probe (as indicated above), each of you then holds on to your end of the single wire (or common ground point) to complete the circuit path. That scheme is very handy when testing continuity over long cable lines made up of numerous wire pairs. You can also go over a very long distance using this method.

The voltage probe proved itself extremely useful when checking for good grounds around the house. Testing AC outlets with it was so easy, I tested every AC outlet throughout the entire house and basement in about as much time as it took me to get to them. All that was necessary was to insert the voltage probe tip into each AC outlet opening and listen for a "chirping" tone. I did find one bad connection in a basement outlet when both sides of a ceiling outlet "chirped," indicating that I had no ground. I corrected the problem later.

In addition to all of the above, it is

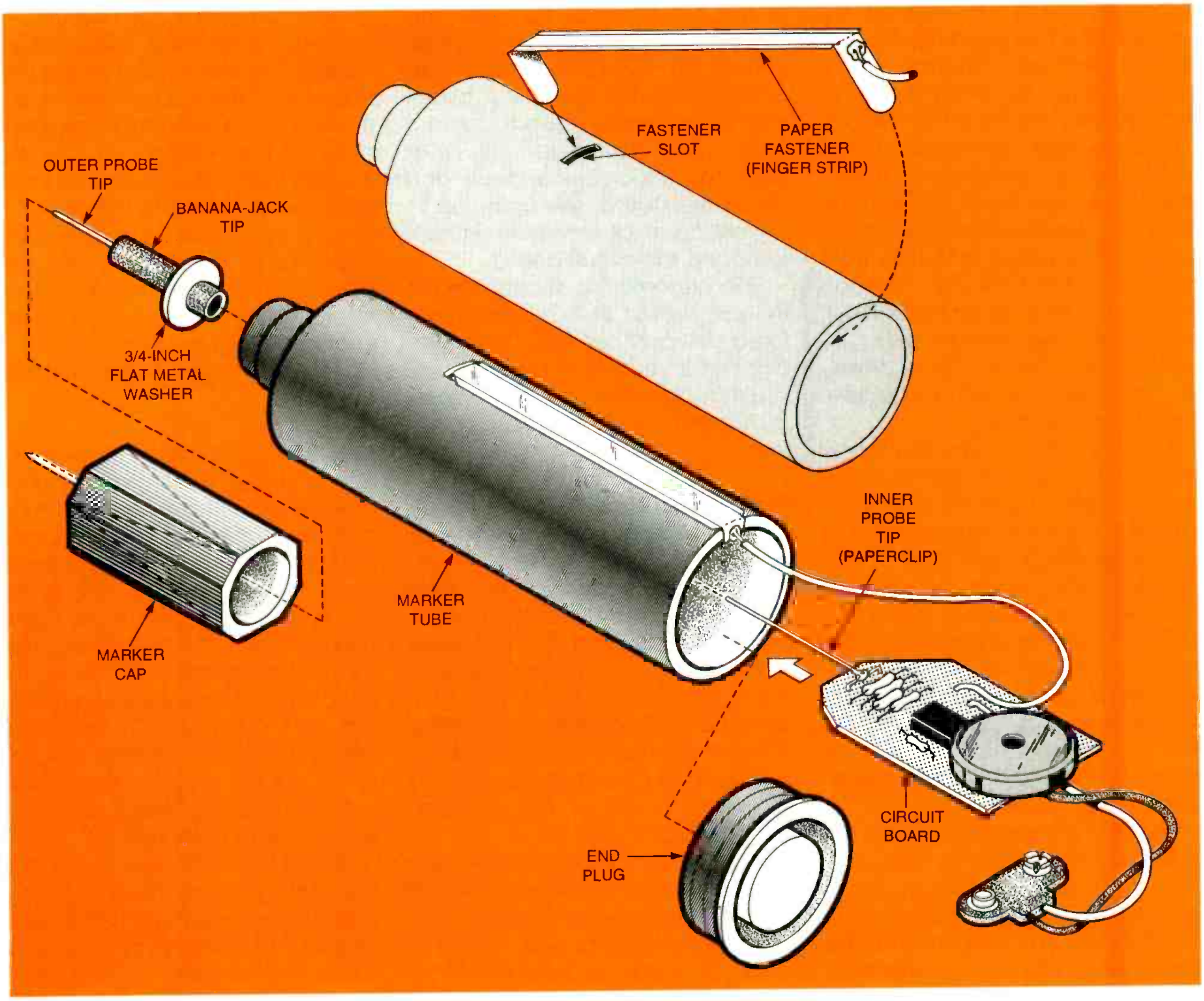


Fig. 4. The printed-circuit board along with its 9-volt battery power source was housed in a plastic enclosure salvaged from an old wide-diameter marker. Prepare the enclosure guided by this diagram and the instructions given in text.

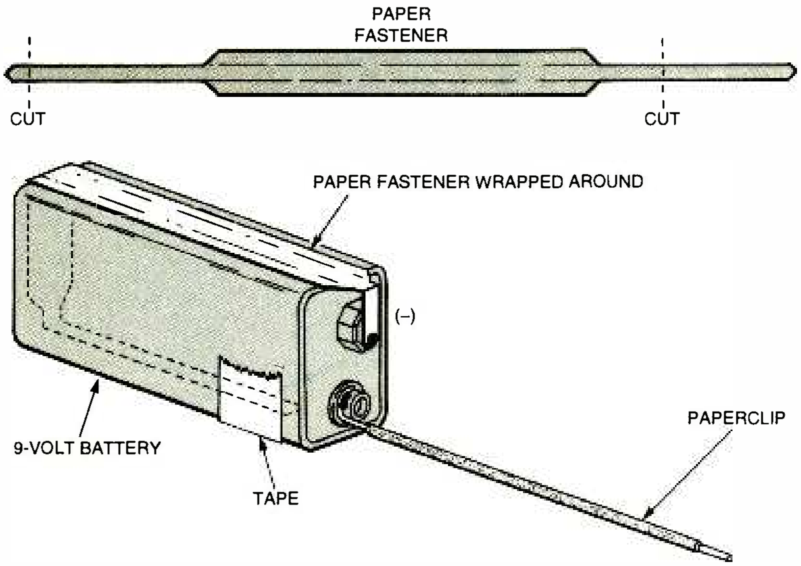


Fig. 5. Solder a long probe (paperclip) to the positive (+) terminal a of a 9-volt battery. Attach a finger strip (a 2¹/₄-inch metal paper-fastener) to the negative (−) terminal of the battery and bend the remainder of the prong lengthwise around the battery as shown here.

also very handy when checking automobile electrical systems. As an example, when checking for voltages inside the automobile, use the key-slot frame for a good finger ground. Any metal part can be used for a ground outside the auto. Those auto fuses, with their elements partially exposed on top, can also be checked while they are in the fuse panel by touching the probe tip to both exposed sides of the element. If the fuse is good, you'll get sound on both exposed sides of the fuse element.

I did experiment with other uses for the probe such as testing telephone lines and low-voltage power supplies and batteries. If you "drag" the probe tip across the face of a computer monitor or television set, you'll get a buzzing sound, according to the high-voltage present. I'm sure there are other uses that I've not thought of, but maybe you'll come up with a few as you get to use it.

Caution: The values on the probe given are well within its safety limits for voltages from 4.5 to 80 volts DC. **DO NOT** exceed those values. AC voltages from 20 to 220 volts were safely tested, but caution should always be used when testing for any voltages. **Never** test for continuity on any line until you make absolutely sure there is *no power applied to it!*

A Parting Thought. That's about it. I'm sure you will find this probe a pretty handy gadget to have around, especially if you work around automobiles. Remember, the probe is also "polarity" sensitive, acting like a diode. It will only sound off when the probe is on a "positive" voltage source and your body is touching a "ground." ■

ZAP, CRACKLE, POP!

(continued from page 46)

control cables—to a single, low-impedance ground system.

All Routes Lead Home—All radio antenna and tower grounds should be tied back to the grounding points of the coax cable leading to the hamshack and the house's utility entrance. Connections should be made with a bare, low-inductance conductor. If a low-impedance ground is provided, most of the strike energy will be harmlessly dispersed, with little or no energy entering the premises.

Never use coax cable shield as the only interconnection between ground systems. If you do, the current that would have traveled along the lower-impedance tie-back ground cable will instead flow through the coax, rotator control lines, *etc.* Once reaching the house, the energy is likely to find a direct but undesirable path to ground by whatever means available.

Ensure Good Internal Grounding—The radiated fields from nearby strikes don't stop at the house walls. Indoor cables, including AC wiring, coax, rotor control cables, and equipment pick up induced as well as conducted energy from the strike. To minimize risk, a single-point ground reference should be created within the hamshack. If that is not created, differential voltages can be induced in equipment and flow through cables in the hamshack.

The single-point reference should be used to provide a common ground for all equipment, cables, and protectors. Within the hamshack, connect all metal equipment cabinets (radios, coax switches, control boxes, amplifiers, PCs, *etc.*), rotor cable protectors, and shielded cables to a common ground bus. Doing so maintains all chassis at the same potential during nearby strikes and minimizes chassis-to-chassis current flow.

At least one firm offers an inexpensive means of effecting common-point grounding of all radio equipment. J. Martin Systems offers the "Ground It" bus to help protect equipment and make chassis-ground connections short, while providing all the benefits that good grounding brings. The system is a ¹/₈- by ¹/₂-inch solid-copper bus that has an equipment-grounding stud every six inches. Three bus lengths are offered, from two to four feet, ranging in price from $21.95 to $32.95, respectively. Also offered are heavy, solid-copper, flexible-rope wire straps with terminal ends at $2.50 per foot.

Summary. In this article, we've covered protecting home, office, communications, and other equipment from electrical surges and spikes, as well as the nature and dangerous character of lightning.

We can sum up lightning and surge/spike protection simply: you must do all in your power to arrest control of lightning energy from Mother Nature. While there is little that can be done to protect against a direct hit, much can be done to reduce the effects of a near miss. ■

From Vacuum Tubes to Laser Diodes!

ALEX BIE

Lasers are in widespread use today. They are used in a great number of products, including copying machines, printers, and CD drives, as well as more specialized applications—such as optical-fiber communications, medical surgery, some areas of IC manufacture, and a host of others. The reason for the mushrooming use of lasers is their high directionality. In addition, they're monochromatic, offer a coherent light source, and have a very high-power density. Laser diodes also possess a high switching speed, making them suitable for use in optical communications, where a wide bandwidth is a necessity in order to achieve the required data rates.

Background

The name *laser* comes from the words light amplification by stimulated emission of radiation. it is essentially the same as a *maser* (microwave amplification by stimulated emission of radiation), the basic difference being in the frequency range of the two devices. Lasers operate at light frequencies, and as the name implies, masers are for microwave radio frequencies.

Both masers and lasers operate based on a phenomenon known as "stimulated emission," which was first postulated by Albert Einstein before 1920. Although a number of mediums, including gas, liquids, and amorphous solids, can be used for lasers, the first devices using rubies were developed in the 1960s. A helium-neon gas laser followed in 1961, but it was not until 1970 that semiconductor lasers were made to run at room temperature. That represented the final step in research that had been undertaken by a number of individuals and organizations over the years. It required an in-depth study of the properties of Gallium Arsenide (GaAs), the material that is used as the basis for many laser diodes, and much of the work on the properties of the diode structures.

("Laser Diode" introduction printed by permission from Ian Poole, 5 Meadway, Staines, TW18 2PW, England.)

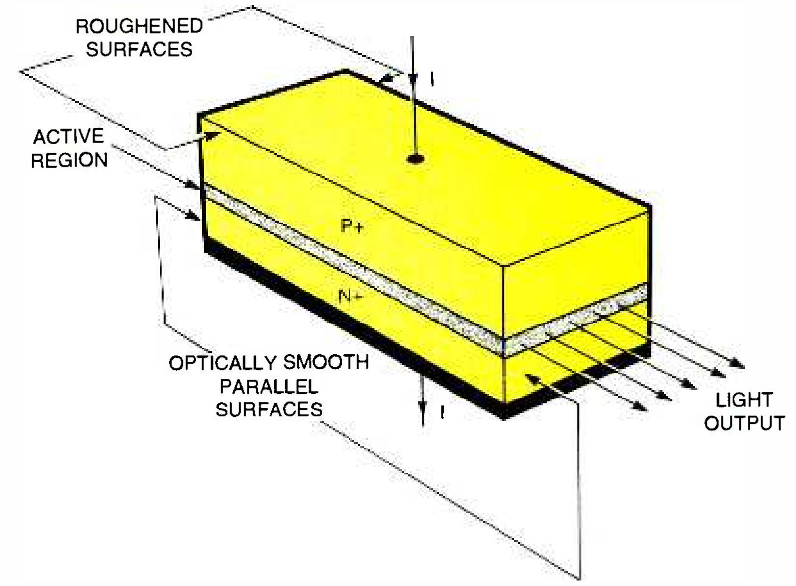


Fig. 1. Basic structure of a laser diode.

Construction

Although there may appear to be many similarities between a light-emitting diode and a laser diode, the two are fundamentally different from an operational point of view. The basic structure of a laser diode, which is comprised of heavily doped N+ and P+ regions, is illustrated in Fig. 1. For manufacturing, it is normal to start with an N+-type substrate, on which the top layer can be grown. This doping process can be accomplished in a variety of ways, either by diffusion, ion implantation, or even by being deposited during the epitaxy process (the growth on a crystal substrate of a crystal layer that duplicates the substrate's crystallographic structure).

A variety of materials can be used for the manufacture of laser diodes, although the most common starting substrates are GaAs and Indium Phosphate (InP), which are known as type III-V compounds because of their places in the chemical Periodic Table of Elements. Whatever material is used, it must be possible to heavily dope it as either a P-type or N-type semiconductor, thereby ruling out most of the type II-VI materials and leaving group III-V materials as the ideal option.

Apart from the basic semiconductor requirements, there are a number of optical criteria that must be met in order for a laser diode to operate. Chief among them is an optical resonator, which must occur in the plane of the required light output. To achieve that, the two walls of the diode that form the resonator must be almost perfectly smooth, forming a mirror-like surface from which the light can be internally reflected. One of the walls is made slightly less reflective to enable light to exit the diode. Another requirement is that the two mirror-like surfaces be perfectly perpendicular to the junction; otherwise, the lasing action does not occur satisfactorily. The two other surfaces, which are perpendicular to the one at the required light output, are roughened slightly to ensure that lasing does not occur in that plane as well. In that way, a resonant optical cavity is created. Although it is many wavelengths long, it still acts as a resonant cavity.

A variety of structures are used, but two types that are widely manufactured are shown in Fig. 2.

Operation

There are three main processes in semiconductors that are associated with light—*absorption*, *spontaneous emission*, and *stimulated emission*. Absorption occurs when light enters a semiconductor and its energy is transferred to the semiconductor to generate additional free electrons and holes. That widely used effect enables devices like photo-detectors and solar cells to operate.

The second effect, spontaneous emission, occurs in LEDs. The light produced as a result of spontaneous emission is termed *incoherent*; *i.e.*, the frequency and phase are random, although the light is situated in a given part of the spectrum.

Stimulated emission is different. A light photon entering the semiconductor lattice strikes an electron and releases energy in the form of another light photon that is of identical wavelength and phase. In that way, the light that is generated is said to be coherent.

The key to the process lies in the junction formed by the highly doped P- and N-type regions. In a normal PN junction, current flows across the junction. That action is possible because the holes from the P-type region and the electrons from the N-type region combine. With an electromagnetic wave (in this instance, light) passing through the laser-diode junction, the photoemission process occurs. The photons release additional photons of light when they strike electrons during the recombination of holes and electrons. Naturally, there is some light absorption—resulting in the generation of holes and electrons—but there is an overall gain in level.

The structure of the laser diode creates an optical cavity in which the light photons experience multiple reflections. When the photons are generated, only a small number are able to leave the cavity. Therefore, when one photon strikes an electron causing another photon to be generated, the process repeats itself; and the photon density (light level) starts building up. It is in the design of better optical cavities that much of the current work on lasers is being undertaken. Ensuring the light is properly reflected is the key to the operation of the device.

Summary

Laser diodes are now well established and used in a wide variety of

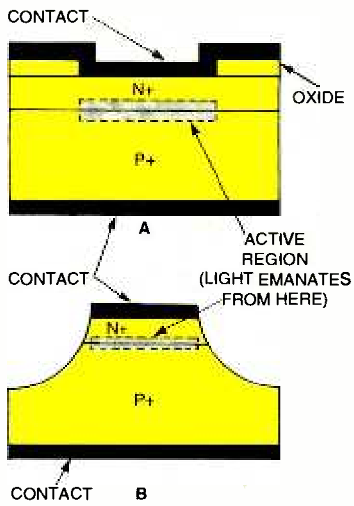


Fig. 2. Two types of structures that are widely used in laser-diode construction. Illustrated in A is a cross-section of a laser diode that was fabricated using an oxide isolation technique, while B shows a laser diode manufactured in a mesa structure.

applications. Although not nearly as cheap as many other forms of diode, they are still produced in large quantities at relatively low cost, as demonstrated by their inclusion in the laser pointers that are used in slide presentations. At the other end of the market, laser diodes that are appropriate for optical communications systems have been introduced with data rates in excess of 20 GBps (20,000 MBps). With performance levels in that region, they're becoming increasingly popular for many communications applications.

The definitions of many semiconductor terms can be found in Ian Poole's Radio and Electronics Web site: *website.lineone.net/~ian_poole*.

Well, that is it for now. Now on to the circuits!

POSITIVE-PULSE GENERATION

I read your column monthly, and I would like to share this design with other readers. I needed a circuit to generate positive pulses at both the leading and trailing edges of a gating signal, so I developed the circuit shown in Fig. 3, which is built around a 4070 CMOS quad 2-input exclusive-OR (XOR) gate. The first XOR gate (IC1-a) inverts the gating signal; while IC1-b and IC1-c each generate a positive pulse from the positive- and negative-going edges, respectively, of the input gate. The final XOR gate, IC1-d, ORs both pulses. (All input/output waveforms are shown in Fig 4B.) With the resistor and capacitor values shown, the approximate pulse-

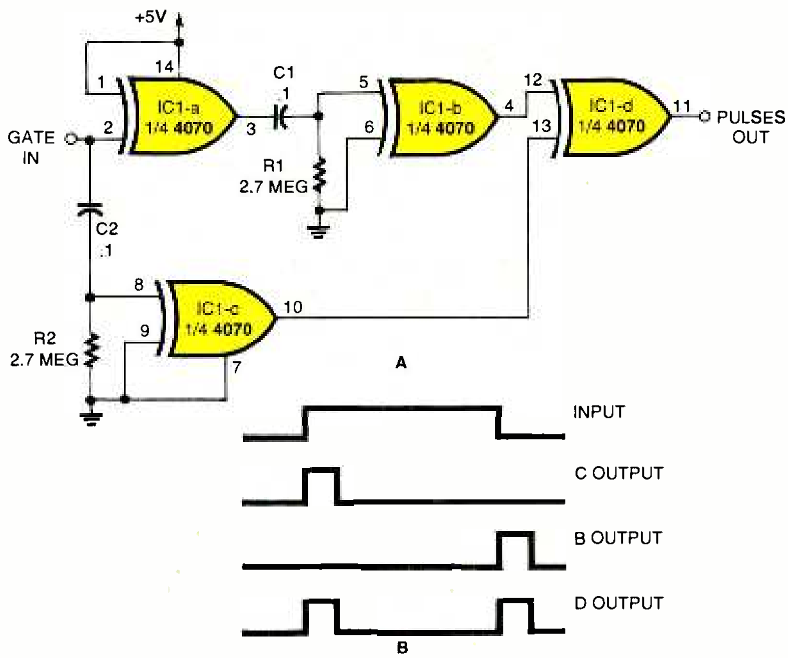


Fig. 3. The simple circuit in A generates positive-output pulses from both the leading and trailing edges of a input gate. The circuit's relevant waveforms are illustrated in B. The upper trace illustrates a typical gate-input signal, the next waveform illustrates the pulse generated by the leading edge of the input signal, while the third shows the positive pulse generated by the falling edge of the input. The final waveform represents the result of XORing the second and third waveforms.

width (t) of the signal output at pin 11 of IC1-d can be computed from: $t \approx 0.8RC$. With the specified resistor and capacitor values (R = 2.7 megohm and C = 0.1 μF), the pulse-width of each positive output is about 270 milliseconds.

—Ned E. Stevens, *Murray, UT*

Nice circuit Ned, and good use of a single 4070 (which can be replaced with an NTE4070B or Thomson SK4070B).

LABORATORY PULSE GENERATOR

This easy-to-build laboratory-type pulse generator is shown in Fig. 4A. The pulse-repetition rate (PRR) and pulse width (t_1), as shown in Fig. 4B, are produced by IC1 (the first of three 555 oscillator/timers), which is configured as an astable multivibrator. The output of IC1 at pin 3 is applied to a 2N3906 transistor, which inverts the pulse. The inverted pulse is then fed to pin 2 of IC2 (the second 555 that is configured as a monostable multivibrator) to form the pulse repetition interval (PRI) of the generator. The output of IC2 at pin 3 is then applied to pin 2 of the third 555 timer, IC3 (also configured as a monostable multivibrator), to form pulse-width t_2. The resulting output at pin 3 of IC3 is applied to Q2 (a 2N3904 transistor set up as an emitter follower). The 1N914 signal diodes allow only positive pulses to be applied to output-level control R17.

During operation, the pulse generator draws only 13 mA of current, so a 12-volt battery can supply power for quite a long time.

—Craig Kendrick Sellen, *Waymart, PA*

This circuit can be a very useful item in your instrument lineup. It can be simplified by substituting a 556 dual oscillator/timer for the two of the 555s. By the way, you can always use NTE955M or SK3564 equivalents for the 555 oscillator/timer, NTE159 or SK3466 equivalents for the 2N3906 PNP transistor, and NTE123AP or SK3854 equivalents for the 2N3904 NPN transistor.

WIRELESS-BROADCASTER AMPLIFIER—*REDUX*

I have a few comments and suggestions regarding the vacuum-tube based "Wireless-Broadcaster Amplifier" circuit presented in the November 1998 *Think Tank* column.

The text suggests a 1-amp isolation transformer. I noted that the tubes draw 0.15 amps of filament current and the B+ (DC plate-supply voltage) probably does not exceed 50 mA. Therefore, a 1-amp transformer is overkill, particularly as the cheapest one I have found is a Mouser 553-NE7A—a 1.3-amp transformer selling for \$42.24! But the same catalog lists a 0.3-amp transformer (part 553-N51X), which costs about \$14.98.

The original diagram shows R3 and C2 connecting the circuit ground with the chassis, a common system when AC-DC designs opted against the older "death-box" designs, which connected the two together directly. Resistor R3 reduced the amount of current to the chassis in case the circuit ground ended up connected to the hot side of the mains when plugged in, still resulting in a tickle if one touched the chassis while grounded—but avoiding a heart stoppage. Capacitor C2 in a radio was usually about 0.05 or 0.1 μF, which provided a low-reactance path to circuit ground for RF signals. That capacitor also gave a high reactance to audio frequencies, so it would in effect put additional resistance in between the ground side of the phono cartridge and circuit ground.

The author probably noted the problem and upped C2 to 0.47 μF, which may solve the reactance problem. However, if the set were operated without the isolation transformer, one could get a pretty good jolt from the AC line through that large a capacitor. All that would be rendered unnecessary if an isolation transformer were used. In other words, simply eliminate R3 and C2, and connect the input grounds to circuit ground. No shock hazard, as the isolation transformer isolates the AC line from circuit ground.

Dollars always enter the picture. I would have thought some system cheaper than using an isolation transformer would be available. Figure 5 shows the circuit redrawn without an isolation transformer; instead a dual-primary transformer (T2) is used to provide 120 volts AC, which is teamed up with a bridge rectifier (BR1) to provide B+ voltage of about 120 volts or better. The transformer can be a Marlin P. Jones and Associates part 7839-TR

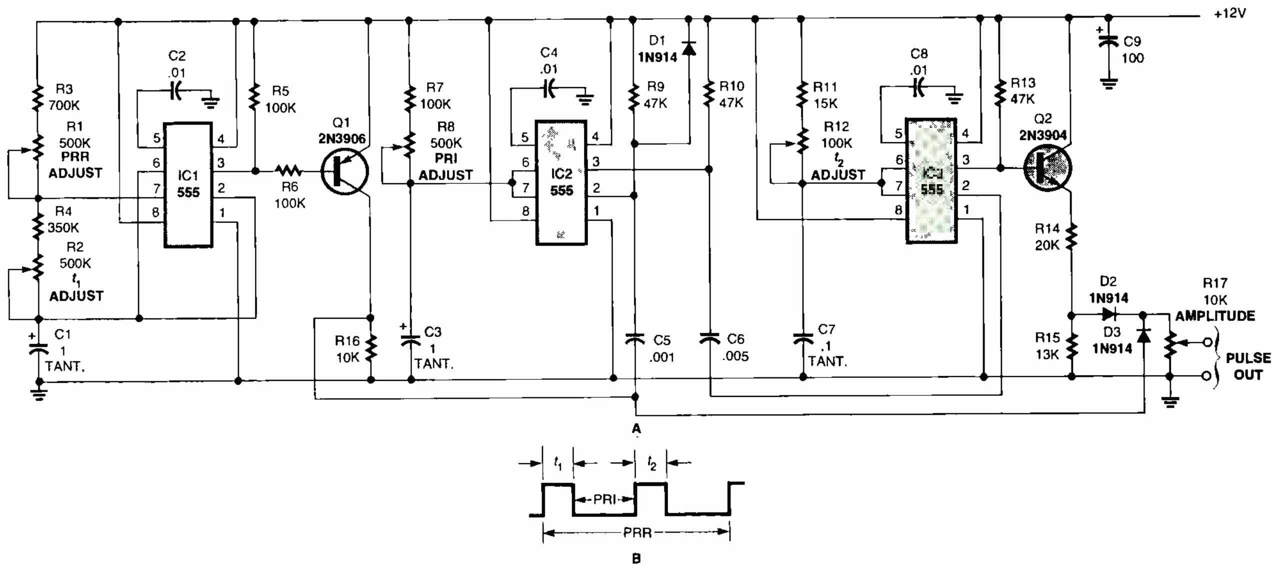


Fig. 4. Here's a neat little laboratory-type pulse generator (A) that can be useful in a variety of projects. The waveform provided through the circuit is illustrated in B.

(which has dual 110-volt primary and 6V-0V-6V secondary rated at 2.5 amps), or a Mouser 553-FD6-12 power transformer. That eliminates the necessity for the 35W4 tube.

A 400-volt, 1-amp semiconductor bridge not only is cheaper than a 35W4 half-wave rectifier, both in dollars and in power, but because it's a full-wave rectifier, it doubles the effectiveness of the filter capacitors in eliminating hum. If the secondary of such a transformer provides 12 volts, the 12AV6 tube can still be used; but 12AQ5s can be substituted for the 35C5s, probably with no circuit changes needed. I have not finalized the circuit, so I may find out that the cathode resistor, R10, at V2 may need adjustment.

The cost of the output transformer (T1) was available in catalogs only at prices that boggle my 1945 mind. I've used power transformers as output devices where fidelity was not required. Mouser has a nice multi-tapped unit (part 41FW300), which would match most output tubes, both single-ended and push-pull, to most speaker impedances. Marlin P. Jones does not have an identical unit, but they do offer a dual primary, 6V-0V-6V, 2-amp transformer (part 7838-TR). By using the 220-volt primary winding and half of the secondary winding and a 4-ohm speaker, one would get about 5000 ohms for the plate of the modulator/audio output tube (about what a 12AQ5 tube probably requires). Using an 8-ohm speaker would provide about 2500 ohms for the plate of a 35C5 tube. If one wishes to use a power transformer to match an 8-ohm speaker to a tube requiring a 2500-ohm load, the transformer should have a 110-volt primary and a 6-volt secondary.

As in the original circuit, the oscillator coil (L1) is comprised of a tube-tube radio IF transformer that was modified by removing the internal padder capacitors on each side of the transformer. As a final note, S1 is a SPDT make-before-break-type switch (Mouser part 10WW017), and S2 can be any SPST switch that is, perhaps, tied in with potentiometers R7 or R8.

My rule of thumb is *never short out* the secondary of an output transformer that is driven by a transistor and *never open* the secondary winding of an output transformer that is driven by a vacuum tube.

Finally, I've modified the original circuit by providing a shorting switch at the output transformer's secondary, making sure that no more than 4 ohms is connected to that transformer.

—Victor I. Smedstad, *Bainbridge Island, WA.*

Interesting comments Victor. Thanks for the new circuit. We would be interested hearing from our readers who built the first unit, and may be planning to build this unit, on the pros and cons of both approaches and results. For those readers who may not know, Mouser Electronics can be reached at 800-346-6873, and MPJ *at 800-652-6733.*

That's about it for this month's *Think Tank*. Remember—this is your column—keep those circuits, solutions, and ideas coming. For each circuit that appears in this column, the writer will receive a book from our library. Send in enough circuits to fill a whole column and you will get a nifty kit or electronics tool to make your construction easier. Write me—Alex Bie, *Think Tank*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735. ■

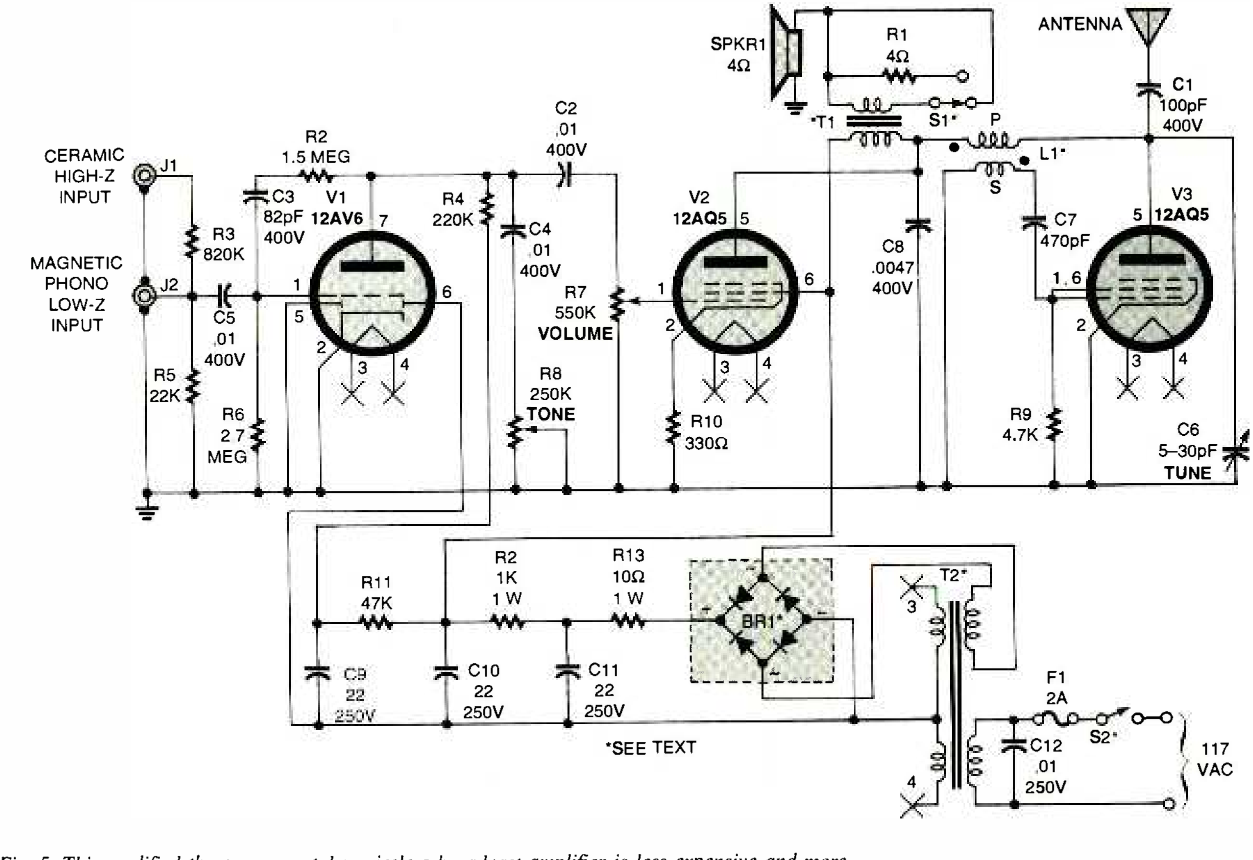


Fig. 5. This modified three-vacuum-tube, wireless-broadcast amplifier is less expensive and more efficient than the design that was shown in our November column.

HAM RADIO

Understanding Dummy Loads

JOSEPH J. CARR, K4IPV

What is a *dummy load*? You'll hear hams say that you ought to have one, but it's likely that these same hams never explained what a dummy load is. In the context of radio transmitters, a dummy load is a non-radiating substitute for an antenna. That is, perhaps, why the British hams have traditionally called these devices "artificial aerials."

So why use a dummy load instead of an antenna? First, it is at least moderately illegal in most countries to radiate a signal when testing transmitters. One is allowed to radiate only RF energy needed for communications. Another reason is that it is just plain rude to cause interference on a radio channel just because you want to test your transmitter. Rather than pressing the push-to-talk and saying, "Uhm ... testing, testing, one-two-three," we can silently key into a dummy load.

Finally, there's also a very good technical reason to use dummy loads: antennas cannot be relied upon to provide the constant and consistent test load that is necessary to make sense out of transmitter tests and adjustments. The measurements that you make will not match the specifications given in the transmitter's manual.

At one time, ham-radio operators used 120-volt-AC incandescent light bulbs as impromptu dummy loads. That was an unwise choice because the bulbs did not represent a truly constant impedance (cold *vs.* hot resistances were different), and they radiated at least some energy. Indeed, some ham operators worked each other across town using light-bulb dummy loads.

The classical dummy load (Fig. 1) is a non-inductive resistor mounted inside a shielded enclosure, with either a coaxial jack or other antenna terminals to allow access to the resistor from the outside world. The resistor has to be non-inductive so that the impedance it represents is similar to what would be seen on a resonant antenna. For most applications, an impedance of 50 ohms is used as the system impedance, although examples of 75-, 300-, 450-, and 600-ohm systems are also occasionally seen. Most modern transmitters are designed to work into a 50-ohm resistive load.

RESISTIVE LOADS

The impedance (Z) of any load can be described by:

$$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$$

where R is the resistive component, X_L is the inductive reactance component, and X_C is the capacitive reactance component.

If an antenna is resonant, then $X_C = X_L$, so the reactances would cancel out leaving only the resistive component. But not all antennas work directly on resonance, especially if they are required to work over a band of frequencies. When the transmitter frequency is lower than the resonant frequency, the antenna appears too short and exhibits some capacitive reactance (X_C). The usual solution is to add some inductive reactance (X_L) to cancel it out. Similarly, when the exciting frequency is above the resonant frequency, the antenna appears too long and exhibits inductive reactance.

The assumption that we will see only resistive loads is reasonable for some transmitters, but for others it is a fallacy. Whether or not it is true depends on the nature of the antenna system connected to the transmitter. For now, however, we will make the resistive assumption.

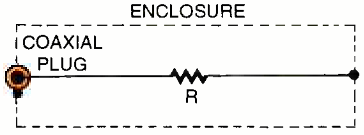


Fig. 1. Here's a schematic of a basic dummy load, encased within a shielded enclosure. R represents the system impedance provided by a resistor.

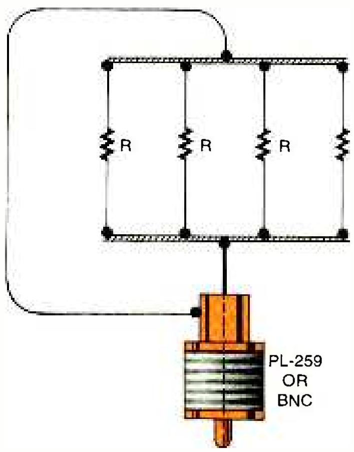


Fig. 2. This practical low-power dummy load can be customized easily; just calculate the desired parallel resistance and consider the total power of the resistors.

SIMPLE DUMMY LOADS

There are a number of dummy loads that you can buy from commercial sources, but let's first take a look at some that can be home-brewed. Figure 2 shows a simple low-power dummy load that can be used on HF QRP rigs or many VHF transmitters up to the 2-meter band. It consists of two or more parallel resistors (R) connected across either a male BNC connector or a PL-259 "UHF" coaxial connector, depending on the particular transmitter it is used to test.

The values of the resistors depend on the power level and the particular impedance being created. Let's assume 50 ohms for the overall impedance. If you place four 200-ohm resistors in parallel, then you will have a 50-ohm impedance. The power rating will be the total power rating of the resistors. For example, if you use 1-watt resistors, then it will be a four-watt dummy load. The resistors should be either carbon or metallic-film units. In no case should they be wire-wound resistors.

Higher power levels can be accommodated by using a larger number of resistors, with correspondingly higher-value resistances in Fig. 2. Twenty 1000-ohm, two-watt resistors can be used to make a 40-watt load. However, keep in mind that the higher the number of resistors the greater the distributed capacitances, which essentially limit the

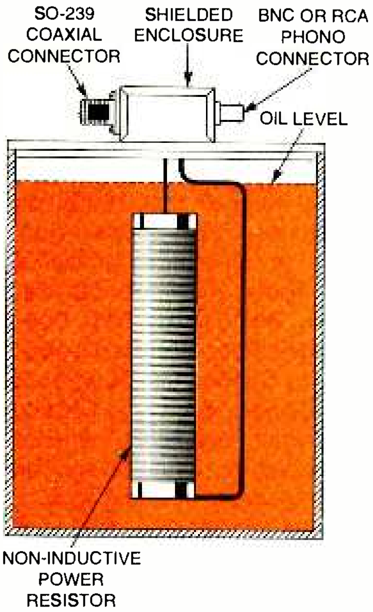


Fig. 3. Here's the general assembly of an oil-filled, paint-can dummy load. If you're making one, be certain to use a non-inductive power resistor, which will be covered with a carbon coating. Avoid wire-wound units.

frequency response of the load.

Several methods can be used to build this type of load. Perhaps the easiest way is to simply wire all the resistors in parallel using their leads. A better way is to cut two identical pieces of copper-clad perforated construction board, and solder the resistors between them. One end is connected to the coaxial-connector center conductor, while the other is connected to the coaxial-connector shield. Small dummy loads are built in this manner.

OIL-FILLED PAINT CANS

Thanks to an old device by Heathkit called the Cantenna, paint-can antennas have become popular high-power, ham-radio dummy loads. A representative load, based on a standard one-gallon paint can, is shown in Fig. 3. A non-inductive 50-ohm power resistor is placed inside the can, and the can is then filled with either motor oil or mineral oil (at least one commercial variant used a silicone oil, I am told). As for the resistors, you must find non-inductive units. Nearly all of the power resistors that you will find are wire wound and not usable for a dummy load. You can recognize a non-inductive resistor because it will be a ceramic cylinder with a coating of carbon-like material on the outer surface. In some cases (including the Cantenna), there will not be any connectors—the electrical connection is provided by hose clamps connected to the ends.

Note the shielded enclosure on top of the oil-filled dummy load. This box contains a small voltage divider and rectifier circuit (Fig. 4), which produce an output level that is proportional to the peak RF voltage across the dummy-load resistor, R_L. The values of the voltage-divider resistors depend on the maximum power level. The values shown (R1 = 100K, R2 = 1K) are suitable for up to 1000 watts, which will produce about 223 volts across 50 ohms. The voltage divider reduces the applied voltage a bit less than a factor of 100:1.

The diode used to rectify the signal is shown as a 1N60 germanium diode. This diode can be replaced with a 1N4148 silicon diode, but doing so will decrease the sensitivity at lower power levels.

Warning: Oil-filled paint-can antennas tend to be a bit messy. In fact, they are really messy. The oil tends to seep around the seams of the paint-can lid, as well as around the interface between the shielded metal enclosure on top of the lid and the lid. "Street-smart" hams always kept their Heathkit Cantennas in some sort of container that would catch oil spill. I used a heavy-duty plastic two-gallon bucket.

AIR-COOLED DUMMY LOADS

The air-cooled dummy load is probably a lot more practical than amateur oil-filled loads. The down side is that the power rating of the resistor element must be higher. Oil-filled loads can be operated at higher than rated power because the oil couples heat to the surface of the can where it can be radiated to the air around it. Commercial dummy loads at high powers (up to 50 kW are easily obtained) use either internal oil or an external water jacket to carry heat away from the resistor element.

There are also air-cooled dummy loads, used for 250- to 2500-watt ham-radio dummy loads. Most are built without a fan, although I've seen many commercially available models that have blower fan cut-outs on one end of a perforated aluminum cabinet. If you want to increase the power rating of the dummy load, then add the fan to get rid of the heat.

Another approach is to use a finned heatsink to radiate away the heat dissipated by the dummy-load resistor. Because the heatsink can be mounted to the outside of the shielded enclosure, the internal cavity of the dummy load can be filled with either oil or a silicone gel material that matches the thermal impedance of the resistor to that of the shielded enclosure wall.

Caution: A lot of ham-rated dummy loads have a short duty cycle. Look at the specifications of any load you obtain to find out how long you can keep the transmitter keyed without damaging the resistor. Some loads have remarkably short duty cycles. One model I saw said "60 seconds off for 10 seconds on." That means a one-minute cooling-off period is needed every time you key the transmitter for ten seconds. If a particular model looks a bit too small for the wattage rating printed in big letters, then look at the fine print to see the duty-cycle rating.

COMPLEX IMPEDANCE

Virtually every dummy load seen by hams is actually a resistive impedance. But not all antennas are resonant at all frequencies within their bands of operation. Some have reactive components as well as resistive. A friend of mine worked at a plant that served as a depot repair station for high-power HF SSB transmitters. They needed a dummy load that simulated a random-length wire antenna used on ships.

My friend was an electronics technician who repaired the transmitters, and he designed a dummy load that included capacitive and inductive reactances.

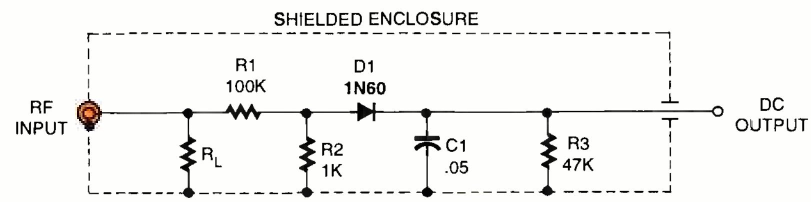


Fig. 4. This is the voltage divider and rectifier circuit inside the shielded enclosure shown in Fig. 3. The circuit will produce an output level that is proportional to the peak RF voltage across resistor R_L.

The overall impedance-*vs.*-frequency curve of his design matched the known curve for the antennas that the transmitters used. The foreman, who wasn't impressed, hollered at him, told him he wasn't "paid to think," and dismissed his effort. They hired a consulting engineer who came in and designed a dummy load that ... guess what? ... was identical. This dummy load, like my buddy's, used a large 18-mH roller inductor and a 500-pF Jennings vacuum variable capacitor. By use of relays they could place either reactance in either parallel or series with the resistor, just like my friend's design. But my buddy's design was free, while the consulting engineer charged $5,000. I wonder if that company is profitable.

TALES OF AN RF RESURGENCE

A friend of mine worked in avionics communications. He attended a design review in which the contractor presented the design for a 10-watt VHF/UHF airborne transmitter. When they put up the automatic load control (ALC) shutdown curve, he noted that the shutdown knee started at a VSWR of 1.1:1, and by 2:1 the shut-down was so severe that the 10 watts were reduced to 100 mW. That's a 20-dB loss. It also made the transmitter unusable because it is difficult to make the blade antennas used on commercial general aviation airplanes and major airliners show a VSWR less than 2:1. In other words, the 10-watt radio was useless!

I asked the guy who told me this story what happened. How come a couple-dozen vendor and customer electronic engineers didn't pick that up until the final design review? His answer: "All the hams had retired." He was quite convinced that the younger engineers who lacked some practical technician level or ham radio/hobbyist level experience didn't think to look.

Another guy told me that he had been re-hired by a radio-equipment company that had forced him into retirement several years before. His skills were "over the hill," so they pushed him into premature retirement. His specialty was designing high-frequency linear and class-C vacuum-tube power amplifiers. The power level of the new transmitters being designed was too high for solid-state amplifiers. Either the power level (which he didn't specify) was too high for the solid-state RF amplifiers of that time or it was not economic to use solid-state. So they opted for an RF power amplifier based on either zero-bias grounded grid power tubes or grounded cathode power tetrodes. But guess what? There wasn't anyone left in the company who could design using power vacuum tubes. I hope he charged a pretty *per diem* for his services!

Many hams go into electronics careers as either engineers or technicians. I recently learned that RF electronics is a really hot area and that employers cannot find these people. It seems that a large number of college electronics-technology and electrical-engineering programs opted some years ago for digital courses. The RF courses died out. But guess what happened? The telecommunications revolution that we are currently seeing requires a large number of RF systems, both receivers and transmitters. Cellular phones, GPS receivers, satcom, and a host of other services depend on radio waves. If you are inclined to seek an electronics career, then you might want to consider RF as an alternative.

Remember, I can be reached by snail mail at PO Box 1099, Falls Church, VA, 22041, or by e-mail at carrjj@aol.com. ■

MULTIMEDIA WATCH

(continued from page 10)

place in the streets of Kingston, where a down-on-her-luck woman figures out how to get her family out of the ghetto. In the dancehall, amateur entertainers get to strut their stuff at the microphone or on the stage. With her handmade, sexy outfits and wild makeup, she dances her way to the top as the mystery woman at the dancehall. These films from Palm Pictures cost $14.95 each.

DVD certainly is gaining momentum. *Webster's International DVD Encyclopedia 1998* from Multimedia 2000 is filled with information on everything. Included are more than 50,000 entries! You'll find 20,000 biographies and 12,000 photographs, plus tons of high-quality audio and video. It also includes a dictionary, world atlas, almanac, foreign phrase guide, and more. All for $99.95.

Another DVD title from Multimedia 2000 is great for do-it-yourselfers who have homes that need fixing—and whose doesn't? The *Home Depot Home Improvement 1-2-3* disc reveals the secrets to building and fixing with video, diagrams, narration, and more. There are more than 250 household projects to choose from. The disc costs $44.95.

DVD can really pack in the content, so it's no surprise that Multimedia 2000's *Ultimate DVD Cookbook* could contain all the content from ten individual *Better Homes & Gardens* CD-ROM cookbooks. The *Ultimate DVD Cookbook* includes *Great American Cooking*, *New Healthy Cooking*, and all eight volumes *of Cooking for Today*: *Chicken*, *Pasta*, *Stir-Fries*, *Vegetarian*, *Barbecue*, *Fish & Seafood*, *Pizza*, and *Salads*. This ultimate collection of thousands of recipes costs only $44.95.

New from Humongous Entertainment comes *Backyard Soccer*, a junior sports game for children ages 5 to 10. *Backyard Soccer* is just as action-packed as adult soccer games, but the controls are easy for children to use. The graphics, of course, are designed to be attractive to kids. This is a good way to give your kids a shot at some sports action on the computer. *Backyard Soccer* costs $19.99.

I have three great Microsoft CD-ROM titles for kids. The software works with or without the ActiMates Arthur and D.W. dolls, those toys I recently discussed in this column that have a life of their own. These early-learning titles for children ages 4 to 8 feature Arthur and friends D.W., Buster, Francine, Muffy, and the Brain. My son doesn't know how to read yet, but he's learning letter and word recognition, basic math, and problem solving because he loves Arthur and the software is well-done.

Arthur's Reading Round-Up teaches reading, spelling and other language skills. *Arthur's Math Carnival* teaches kids practical math skills as they play fun games at the carnival. *Arthur's Brainteasers* helps kids learn how to solve problems in a park and playground setting. These Microsoft Arthur titles cost $34.95 each.

Last this month is a collection of children's books that feature colorful, computer-generated graphics and fun stories. Of course each book comes with a CD-ROM version of the story as well. Jamsa Press' Happy and Max books are about the adventures of a boy and his dog. There's *Locked in the Attic*, *The Sunken Ship Adventure*, *The Night in the Tree House*, and *The Pirate Treasure*—$18.95 apiece. ■

Circuit Circus

Interfacing Logic Families

CHARLES D. RAKES

In our last outing, we took an introductory stroll through the basic functions and operating characteristics of the 7400 TTL and 4000 CMOS logic families, discussed how the four basic logic gates operate, and covered how to configure one or more NAND gates to emulate the other basic logic gates.

This month we'll explore how the CMOS and TTL families, with their differing input/output (I/O) parameters, can be "intermingled" in a single circuit. And since digital-logic circuits must inevitably interface with the non-digital world, we'll also present ways in which to accomplish that task.

LED DRIVER

We'll start with an easy task—using the output of a CMOS 4049 inverter to drive an LED. Several circuit configurations by which that task can be accomplished are shown in Fig. 1. The first circuit (see Fig. 1A) causes LED1 to light whenever IC1-a's input goes high. When IC1-a's input goes high, its output goes low, pulling the cathode of LED1 (whose anode terminal is tied high) to ground. The circuit in Fig. 1B performs in a similar manner to the Fig. 1A circuit, except that it uses complementary (opposite polarity) signals to accomplish the same task; *i.e.*, when IC1-a's input goes low, its output is forced high, causing LED1 to turn on.

The circuit in Fig. 1C follows the same output logic as the one in Fig. 1A, but accomplishes the task through a PNP transistor driver, Q1. Since the transistor can supply greater drive current than IC1-a, the LED produces a brighter output. The value of R2 can be selected to supply the desired LED-drive current. The circuit in Fig. 1D operates in a manner similar to that of the Fig. 1B circuit, except that this one uses an NPN transistor to drive LED1. As in the Fig. 1C circuit, R2 sets the level of drive current delivered to LED1, and thereby its illumination level.

FAN-OUT EXPANDER

The 4049's maximum-output current is limited to about what's required to drive a single LED. But with the aid of a transistor driver, a single 4049 inverter can drive multiple LEDs, as shown in Fig. 2. The output of IC1-a can drive as many as four 2N2222A transistors, allowing the circuit to light over 20 LEDs. If a greater number of LEDs is desired, duplicate the entire Fig. 2 circuit and tie the inputs of the two inverters together.

Since the interface (transistor) isolates the CMOS circuitry from the LEDs,

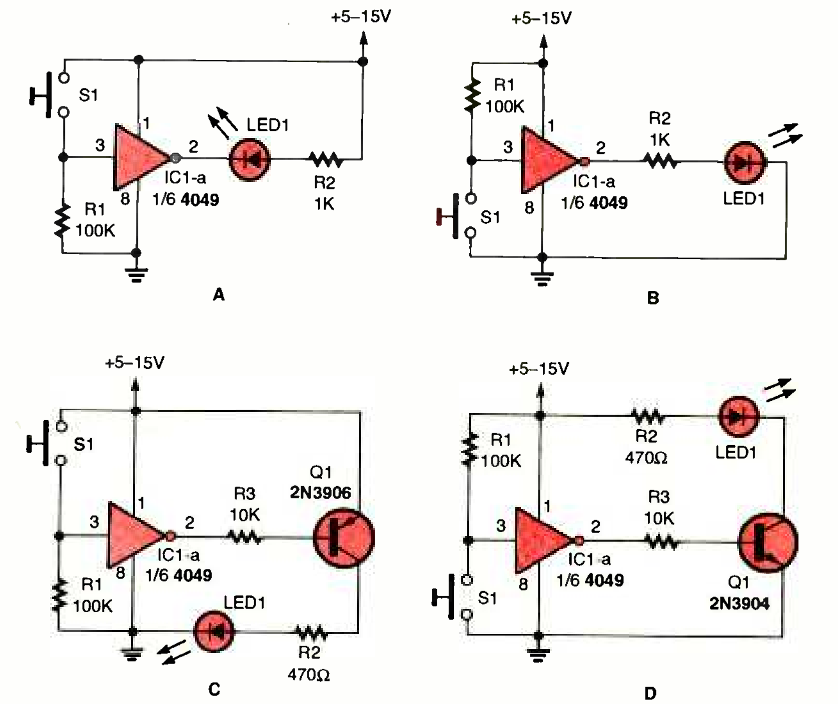


Fig. 1. The circuit in A causes LED1 to light whenever IC1-a's input is high. The circuit in B performs the same function, except that when IC1-a's input goes low, its output goes high, causing LED1 to turn on. The circuit in C follows the output logic of the circuit in A, but uses transistor driver Q1. The circuit in D operates similarly to the circuit in B, but it uses an NPN transistor to drive LED1.

PARTS LIST FOR FIGURE 1A AND 1B

IC1—4049 CMOS hex inverting buffer, integrated circuit
LED1—Light-emitting diode (any color)
R1—100,000-ohm, ¼-watt, 5% resistor
R2—1000-ohm, ¼-watt, 5% resistor
S1—Normally-open pushbutton switch

PARTS LIST FOR FIGURE 1C

IC1—4049 CMOS hex inverting buffer, integrated circuit
LED1—Light-emitting diode (any color)
Q1—2N3906 general-purpose, PNP, silicon transistor
R1—100,000-ohm, ¼-watt, 5% resistor
R2—470-ohm, ¼-watt, 5% resistor
R3—10,000-ohm, ¼-watt, 5% resistor
S1—Normally-open pushbutton switch

PARTS LIST FOR FIGURE 1D

IC1—4049 CMOS hex inverting buffer, integrated circuit
LED1—Light-emitting diode (any color)
Q1—2N3904 general-purpose, NPN, silicon transistor
R1—100,000-ohm, ¼-watt, 5% resistor
R2—470-ohm, ¼-watt, 5% resistor
R3—10,000-ohm, ¼-watt, 5% resistor
S1—Normally-open pushbutton switch

two separate power sources can be used to operate the circuit. Separating the power sources allows CMOS circuitry to safely operate within its own voltage and power limits, while controlling devices outside those parameters.

VOLTAGE-LEVEL TRANSLATION

In many applications, it is necessary to bring both CMOS and TTL logic together in a single circuit in order to take advantage of the best features of both families. Figure 3 illustrates how two circuits, operating from different source voltages, can be made to coexist. Notice that the Fig. 3 circuit uses a pair of CMOS ICs (operating from two different power sources) and a TTL IC (which shares a common supply voltage with one CMOS IC) to make the transition from one source voltage to the other.

The first CMOS gate (IC1-a, operating from a 12-volt supply) serves as a buffer, isolating the CMOS source from the translation circuit (IC2-a). The translation circuit, which is powered from a 5-volt source, accepts the 12-volt output of IC1-a and converts it to a 5-volt level, which is then used to drive IC3-a, the TTL gate. With the circuit arrangement shown, IC3-a outputs the complement to the original CMOS input. If a non-inverted output is desired, IC3-a can be replaced by a non-inverting TTL buffer, or a second inverter can be tacked to the output of IC3-a to return the signal to its input-logic state.

PARTS LIST FOR FIGURE 2

IC1—4049 CMOS hex inverting buffer, integrated circuit
Q1, Q2—2N2222A general-purpose, NPN, silicon transistor
LED1–LED6—Light-emitting diode (any color)
R1–R6—1000-ohm, 1/4-watt, 5% resistor
R7, R8—10,000-ohm, 1/4-watt, 5% resistor

PARTS LIST FOR FIGURE 3

IC1, IC2—4049 CMOS hex inverting buffer, integrated circuit
IC3—7404 TTL hex inverting buffer, integrated circuit

PARTS LIST FOR FIGURE 4A

IC1—4049 CMOS hex inverting buffer, integrated circuit
IC2—7404 TTL hex inverting buffer, integrated circuit

PARTS LIST FOR FIGURE 4B

IC1—4050 CMOS hex non-inverting buffer, integrated circuit
IC2—7404 TTL hex inverting buffer, integrated circuit

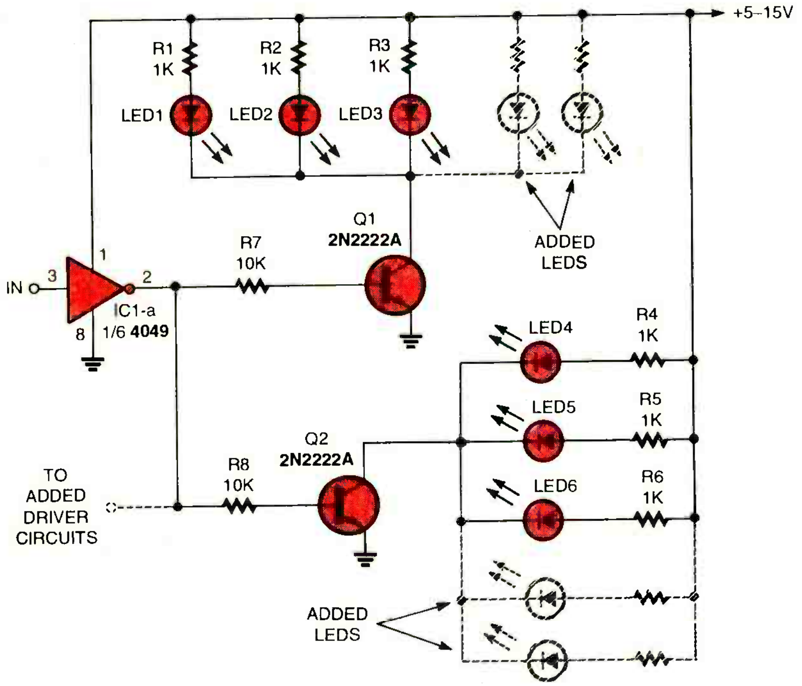


Fig. 2. The fan-out capabilities of a CMOS gate can be greatly enhanced with the aid of a transistor driver, as shown here.

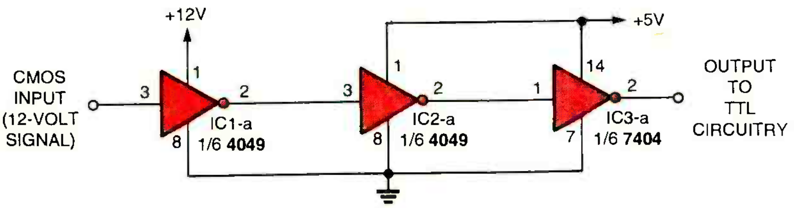


Fig. 3. Although CMOS and TTL circuit have differing operating characteristics and parameters, they can be made to coexist in a single circuit, as shown here, allowing you to take advantage of the best features of both families.

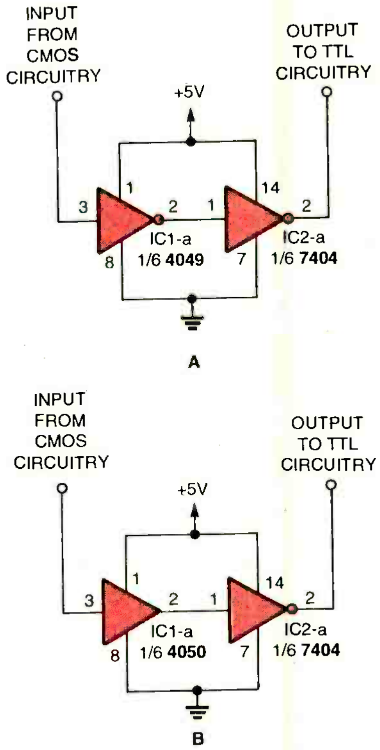


Fig. 4. CMOS logic can be used as an impedance-matching device between a high-input-impedance CMOS source and the low-impedance input of TTL circuitry, as shown here.

HIGH-TO-LOW-IMPEDANCE TRANSLATION

A CMOS IC, operating from a 5-volt supply, can be used as an impedance-matching device between a high-input-impedance source and the low- impedance input of TTL circuitry, as illustrated in Fig. 4. The circuit in Fig. 4A provides a non-inverted output while the circuit in Fig. 4B produces an inverted output.

FAN-OUT EXPANSION

Figure 5 shows an expanded CMOS-to-TTL logic driver, fabricated from a single CMOS 4049 hex inverting buffer, in which all six of its buffer inputs are tied together to accept a common input signal. Each CMOS buffer can drive two TTL inputs, giving a total drive capability of 12 for a single CMOS IC.

In addition to their other desirable qualities, CMOS logic can be used as input devices. Using them allows the builder or experimenter to take advantage of their excellent signal-to-noise (S/N) ratio, which generally is much better than their TTL counterparts. However, a circuit's S/N ratio (for both CMOS and TTL families) can be improved by using Schmitt-trigger ICs—such as the CMOS 4584 or the TTL 7414.

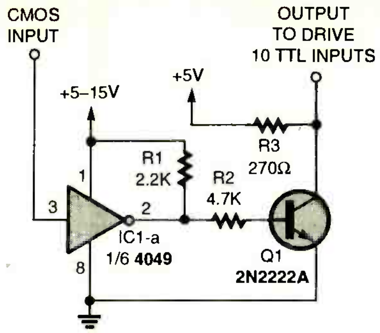


Fig. 6. Other fan-out expansion methods, like the one shown here, make use of a transistor driver. The input-to-output logic is non-inverting as the signal passes from the CMOS to the TTL circuitry.

ANOTHER OUTPUT EXPANDER

The circuit in Fig. 6 takes a slightly different approach to output expansion, where the output of IC1-a is used to drive an NPN transistor, increasing fan-out capability to ten. Applying a low at the pin-3 input of IC1-a produces a high output that supplies base current to Q1, turning it on and giving a low output to the TTL inputs. The input-to-output logic is non-inverting as the signal passes from the CMOS to the TTL circuitry.

MORE INTERFACE CIRCUITS

Three different TTL-to-CMOS interface circuits are shown in Figure 7. The first incarnation (see Fig. 7A) uses a 7401 open-collector TTL NAND gate to drive a non-inverting CMOS buffer. A 1k pull-up resistor, R1, supplies current to IC1-a's (1/4 of a 7401 NAND gate) output transistor and supplies input voltage for IC2-a (1/4 of a 4050 non-inverting

PARTS LIST FOR FIGURE 5

IC1—4049 CMOS hex inverting buffer, integrated circuit

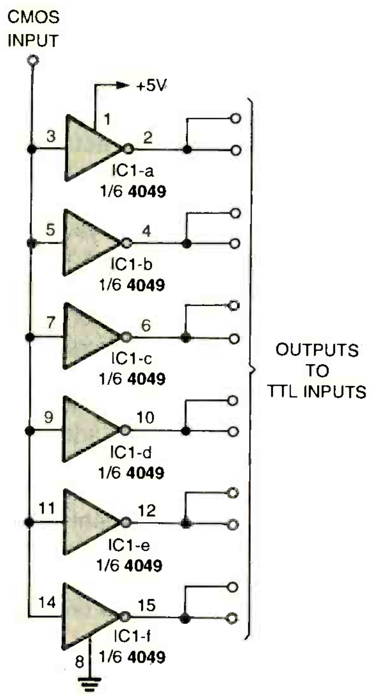


Fig. 5. Although a single CMOS gate has a limited fan-out capability, a network like the one shown here can be used to overcome that barrier.

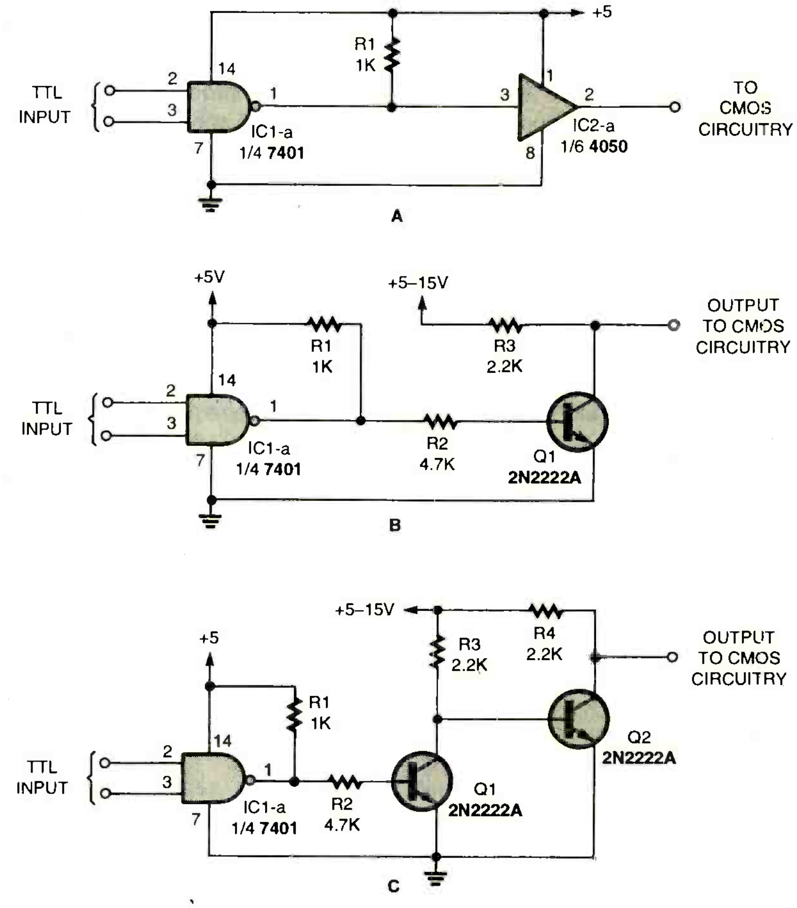


Fig. 7. The TTL-to-CMOS interface circuit in A uses a 7401 open-collector TTL NAND gate to drive a 4050 CMOS non-inverting buffer. The TTL-to-CMOS interface in B accepts the 5-volt logic-level output of a TTL system and produces a CMOS-compatible logic-output level. The circuit in C is nearly identical to the previous circuit, except that a second transistor inverter has been added to the mix.

PARTS LIST FOR FIGURE 6

IC1—4049 CMOS hex inverting buffer, integrated circuit
Q1—2N2222A general-purpose, NPN, silicon transistor
R1—2200-ohm, 1/4-watt, 5% resistor
R2—4700-ohm, 1/4-watt, 5% resistor
R3—270-ohm, 1/4-watt, 5% resistor

PARTS LIST FOR FIGURE 7

IC1—7401 TTL quad 2-input NAND gate, integrated circuit
IC2—4050 CMOS hex non-inverting buffer, integrated circuit
Q1, Q2—2N2222A general-purpose, NPN, silicon transistor
R1—1000-ohm, 1/4-watt, 5% resistor
R2—4700-ohm, 1/4-watt, 5% resistor
R3, R4—2200-ohm, 1/4-watt, 5% resistor

buffer). With both of IC1-a's inputs tied high, its output at pin 1 goes low; that low passes through IC2-a, appearing at its output at pin 2. If either or both inputs of IC1-a go low, its output switches high, causing the output of IC2-a to go high. The 4050 non-inverting buffer can be replaced by a 4049 inverter in order to obtain a non-inverted output.

MORE INTERFACE CIRCUITS

Our next TTL-to-CMOS interface, see Fig. 7B, accepts the 5-volt logic-level output of a TTL system and produces a CMOS-compatible logic output level. If both inputs to IC1-a are made high, its output goes low, causing Q1 to turn off, producing a CMOS-compatible output (in the 5- to 15-volt range). If, on the other hand, either or both inputs of IC1-a are made low, its output goes high. That turns on Q1 (which functions as an inverter), producing a logic-low output that can be used to drive almost any number of CMOS inputs. That's possible because of the extremely high input impedance of CMOS devices, which offer very little resistive loading. However, as the number of load devices increases, capacitance loading becomes a factor in determining how many gates can be driven from a single source. The Fig. 7C circuit is nearly identical to the previous circuit, except that a second transistor inverter has been added to the mix.

CMOS circuits operating at low frequencies aren't adversely affected by capacitive loading, but as operating frequency increases those effects become a factor in determining the number of gates that can be driven from a single source.

Even though we only took a brief glance at the many schemes for interfacing the CMOS and TTL families, at least one of the simple circuit ideas that we've reviewed is sure to be useful in a future project.

We'll "see" you here next month, same time, same station. Let's hear from you!—Contact me via e-mail at *cdrakes@ipa.net* or via snail mail at PO Box 445, Bentonville, AR. 72712. ■

SCANNER SCENE

(continued from page 4)

send it (at no cost) to all who send me a self-addressed stamped (U.S. 33 cent stamp) return envelope (SASE), and request the wireless microphone list. **NOTE**: The return envelope must have their name, address, and the right U.S. stamp.

TWISTER TIME

Each year, large areas of the nation are threatened and ripped up by tornadoes. We received a note from Michael C. Root, of Mount Pleasant, IA, asking about relevant scanner frequencies above and beyond the basic and vital NOAA weather broadcasts.

From what we understand, storm chasers in mobile vans use CB radio, plus 163.275, 173.10, and 409.75 MHz for communications. Also listen for twister spotter aircraft on 122.9, 122.925, 123.05, and 123.075 MHz. The vans may also have communications with the spotter aircraft.

The National Severe Storms Forecast Center, Kansas City, MO, is believed to operate on 163.225 and 172.10 MHz. RACES' (Radio Amateur Civil Emergency Service), SKYWARN's, and ARES' (Amateur Radio Emergency Service) frequencies relating to twister activity vary from area to area, but are most likely to be found in the 2-meter ham band (144–148 MHz). Also find out frequencies used by area private and public rescue squads as well as all other state, county, and municipal emergency services in your area.

Lastly, I'd suggest programming the more important national FEMA simplex and repeater frequencies into any scanner located in prime tornado territory. These include 138.225, 138.575, 139.825, 139.95,140.025, 140.90, 140,925, 141.725, 142.375, 142.40, 142.925, 142.975,143.625,164.8625, 168.075, 168.10, 168.35, 168.40, 168.70, 169.60, 169.875, and 170.20 MHz.

MAILBAG

Peter J., of Del Rio, TX, went to *Six Flags Magic Mountain* in California. He reports that the security force there was monitored on 154.515 and 151.805 MHz. From what we've been told, other frequencies used there include: 151.685, 151.715, 151.745, 151.895, 151.955, 154.54, 154.57, and 154.60 MHz. I'd take a guess that 151.625 MHz is also used!

By the way, gambling casinos and some theme parks take a dim view of visitors casually wandering around listening to their scanners. Best bet is to somehow use a stubby antenna on the scanner, then place the scanner under your jacket where it can't be seen. An earpiece to hear all of the action looks pretty much like a hearing aid, and nobody will know the difference! At least that's what you hope.

From Miami, we hear from Arnie Livingston, Jr., who doesn't quite understand what the big mystery about those digital federal agency communications is all about. He asks why the receiving circuitry from a digital cellphone or PCS simply can't be adapted to a scanner by some sharp tinker, which would open those hidden communications for all to monitor.

Arnie, it's important that you recognize that you are trying to kill two flies with one swat. Yes, it's true that the common scanner is capable of producing coherent voices only from analog signals. However, converting it to pick up digitals still isn't going to do what you want. That's because, in addition to being transmitted in digital format, those particular signals are also encrypted by a rather sophisticated method. So simple digital transmission isn't the main problem. The ogre is actually the complex digital encryption that you can't unravel.

Let's hear from you with any frequencies, ideas, and questions. Our e-mail address is: Sigintt@aol.com. Our postal or snail-mail address is: *Scanner Scene*, ***Popular Electronics***, 500 Bi-County Blvd., Farmingdale, NY 11735. ■

ANTIQUE RADIO

Power Supply for 1920s Battery Sets

MARC ELLIS

Last month, reader Victor Smedstad told us how he became an antique-radio hobbyist, and discussed some of the unique solutions he developed to the problems encountered during his first few restorations. This month, we'll discuss the novel and flexible power-supply system he devised for powering the 1920s battery radios currently in his collection—an Atwater Kent (AK) Model 32 and a Radiola Model 20—as well as any future such sets he might acquire.

Mr. Smedstad's scheme is not presented as a ready-to-use system for powering any battery set, but rather as a source of ideas for our more advanced readers who might like to develop similar systems of their own.

At the close of the last column, Victor called our attention to the fact that the power cables in his two battery radios were terminated in electronic circuit cards equipped with male edge connectors (see last month's photos). He went on to tell us that his basic "universal battery substitute" unit has a female edge connector as its output.

The circuit cards on the power cables mate with that female connector and contain resistor networks to adjust the voltages, as necessary, for the particular set. In order to demonstrate either set, he simply slips its edge connector into the output connector on the power supply and turns it on. All cards and connectors were salvaged from junk and surplus equipment.

POWER FROM GOODWILL

At the heart of Victor's power supply scheme is a standard Commodore computer supply providing 5 volts DC, regulated, and 9 volts AC. These power supplies show up frequently, at very reasonable prices, at thrift stores such as those operated by Goodwill, St. Vincent DePaul, and The Salvation Army. Two versions of the Commodore supply are found. The more common delivers the 5 volts DC at 1.5 amperes; a more robust, but somewhat harder to locate, version provides the 5 volts at

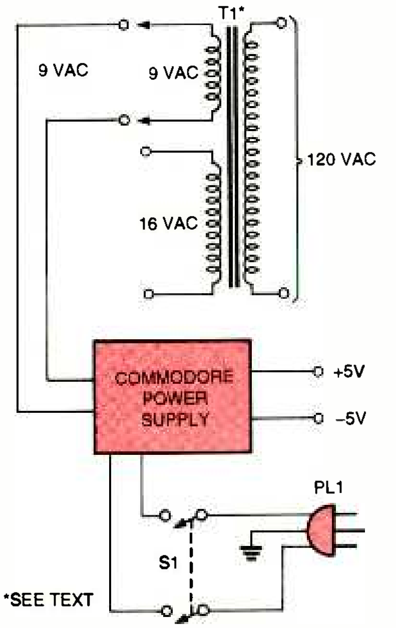


Fig. 1. With the addition of outboard transformer T1 (see text), a typical Commodore computer power supply can be used to provide the input voltages needed for filament, B+, and grid-bias supplies.

4.5 amps. The 9-volt AC output of either is rated at 1 amp.

Also required is a 120-volt transformer (T1) having 9- and 16-volt secondaries (as used in the author's unit), or separate 120- to 9-volt and 120- to 16-volt transformers. These, too, commonly turn up in the thrift stores at low prices. Watch for Atari transformers; they're particularly husky.

In Fig. 1, we see how the power supply and transformer are connected. The 9-volt AC output of the Commodore supply is wired to the 9-volt secondary of the transformer. When the 9-volt secondary (now serving as the primary) is energized, 120 volts AC becomes available at the former primary (now acting as a secondary) and 16 volts appears at the other secondary. The 16-volt and 120-volt outputs of the transformer and the 5 volts, regulated, from the power supply, are used, in turn, to power other circuits as will be described.

THE FILAMENT SUPPLY

The 30-series tubes installed in both of Victor's battery sets require 2 volts DC to light their filaments. This voltage was obtained via an LM317T regulator circuit (Fig. 2) requiring a DC input of 5 to 10 volts. The 5-volt regulated output of the Commodore supply (Fig. 1) will work well.

The 5-volt output of the Commodore supply could be used directly to power the filaments of battery sets equipped with 01-A tubes. However, the current drawn by a set with five 01-As is just a little under the 1.5-amp rating of the smaller Commodore supply. It would be better to use the larger, 4.5-amp version of the supply (if you can find one). That more robust supply would be a *must* for sets with more than five tubes.

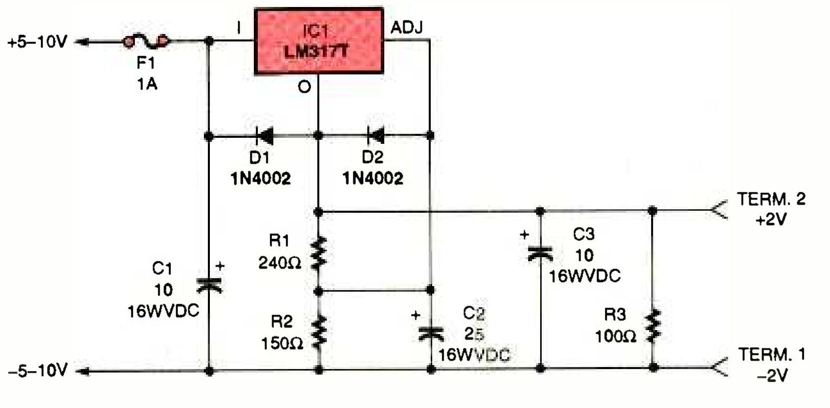


Fig. 2. This filament supply, based on an adjustable LM317T regulator (IC1), can get its power from the 5-volt output of the Commodore power brick.

THE B+ AND GRID-BIAS SUPPLIES

The circuit of Fig. 3 supplies basic B+ outputs of 120 and 90 volts. Other B+ voltages that a particular set might require are derived from these outputs by resistor networks mounted on that set's circuit card. The circuit receives its power from the 120-volt primary (now a secondary) of transformer T1 shown in Fig. 1 and described earlier. Of course, 120 volts is also available directly from the AC line, but connecting directly in such a fashion would create a dangerous shock hazard.

Note that for C2 in Fig. 3 you can use a capacitor of any value between 500 and 1450 µF.

Figure 4 shows the circuit of Victor's grid-bias, or "C−" supply, which provides a basic bias of −30 volts. Just as in the case of the "B" supply, other voltages that a particular set might require are derived from this value by resistor networks mounted on the set's circuit card (more on these cards in a moment). This circuit is powered from the 16-volt winding of T1 in Fig. 1.

THE CIRCUIT CARDS

You'll notice that each of the various output connections of the three power-supply circuits (Fig. 2, Fig. 3, and Fig. 4) is numbered to indicate which terminal of the female edge connector it is wired to ("Term. 1," "Term. 2," *etc.*). Space does not permit our including Victor's drawings of his edge-connector setup; in any case, the connection scheme is not critical and could be based on parts and materials found in your own junkbox.

The schematics of the circuit cards for the AK Model 32 and the Radiola 20 are shown as Figs. 5 and 6, respectively. The leads from the receiver's power cable are shown at the right of each schematic, and each lead is labeled to indicate the voltage it requires. The numbered arrows at the left represent the male-edge-connector positions on the receiver's circuit card. These contact the matching terminals on the power supply's female edge connector, as numbered in Figs. 2–4.

For example, referring to the AK Model 32 circuit card (Fig. 5), positions 8 and 9 connect to the points marked "Term. 8" (+120 volts) and "Term. 9" (+90 volts) on the B+ supply, shown in Fig. 3. You'll notice that positions 10, 11, 14, and 16 have no matching connec-

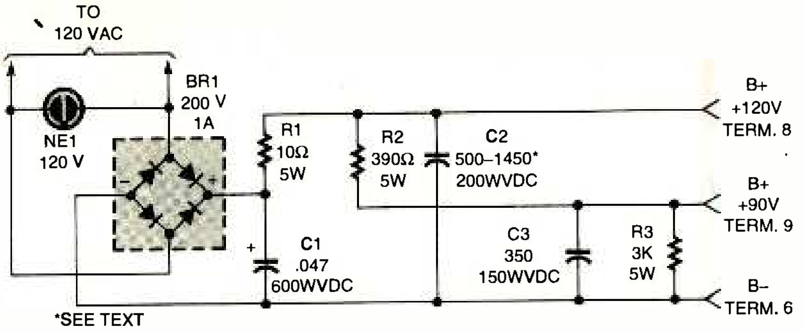


Fig. 3. Transformer T1 from the circuit in Fig.1 provides the 120-volts AC input for this B+ supply. Note that both +120- and +90-volt outputs are available from this design.

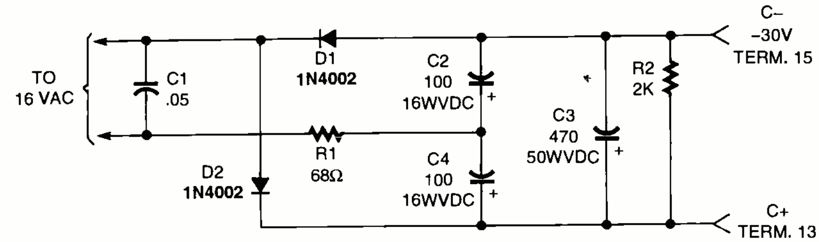


Fig. 4. While this grid-bias supply is designed to output −30 volts, resistor networks can be used to get other operating voltages. Like the other circuits, this one gets its power from a connection to T1 in Fig. 1.

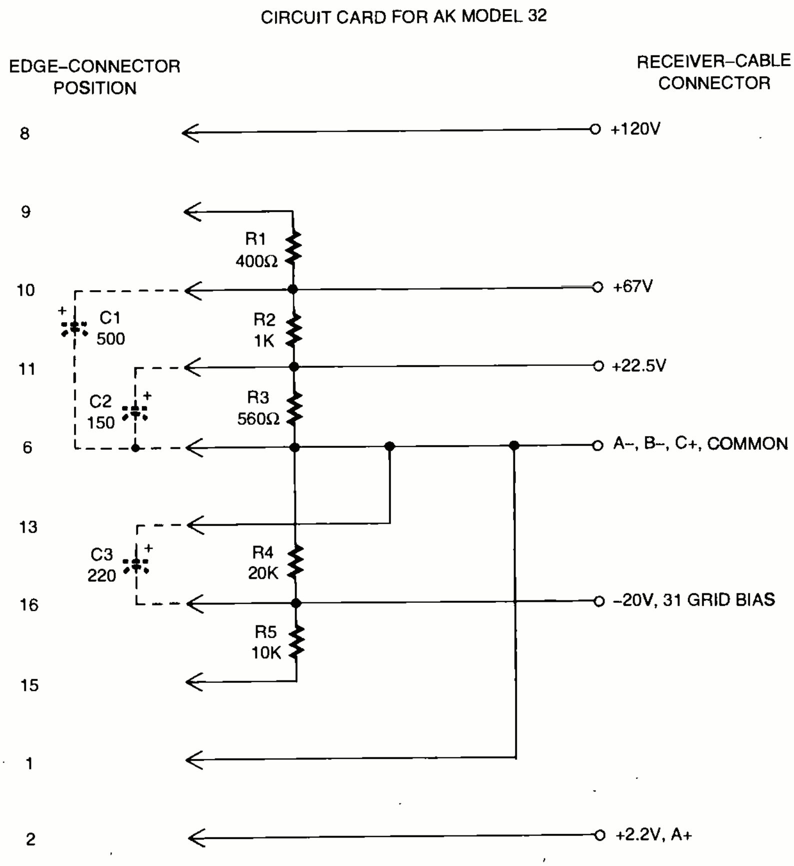


Fig. 5. Here's a circuit-card design for the AK Model 32 battery set. Capacitors C1–C3 (shown with dashed connections) are actually mounted on the power-supply edge-connector card (see text).

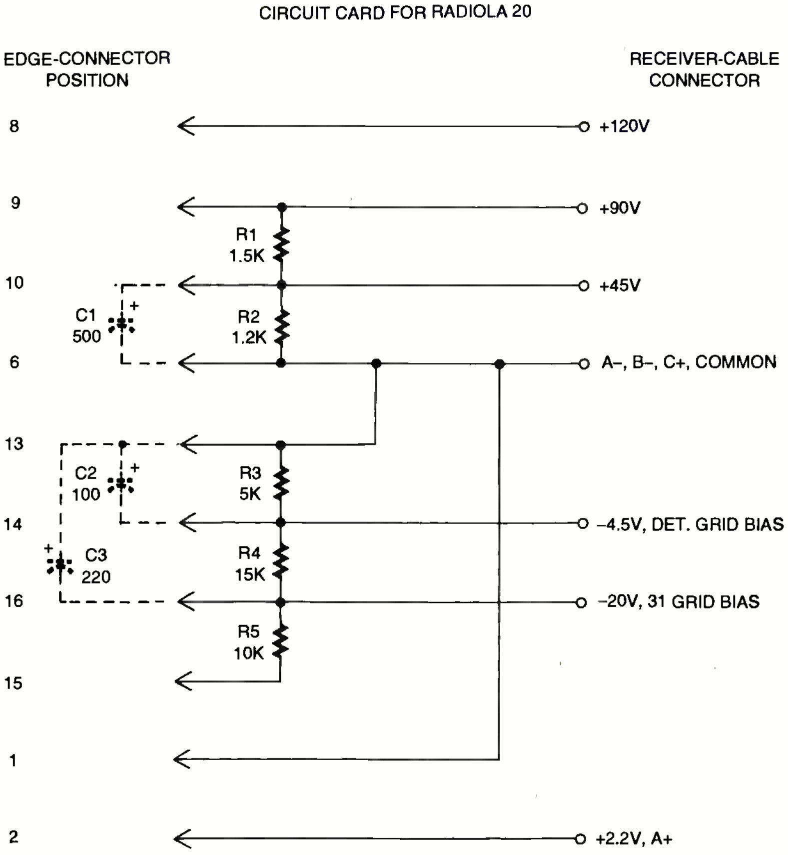


Fig 6. Though for another battery set in Victor's collection, this Radiola 20 circuit-card design has similar terminal connections to those found in Fig. 5. The most significant difference is that this design uses different resistor values to accommodate the Radiola's required output voltages.

tions noted on Figs. 2, 3, or 4. These are for connections to additional filter capacitors used at the intermediate voltage outputs developed by the resistor networks on the circuit cards.

For versatility, these capacitors (shown with dashed-line connections on Figs. 5 and 6) are mounted on the power-supply female edge-connector card rather than on the receiver circuit cards. This makes it possible, for instance, for the 500-µF capacitor (C1 in both figures) whose positive end is connected to position 10 to be used to filter the +67-volt output on the Atwater Kent card (Fig. 5) or the +45-volt output on the Radiola card (Fig. 6).

Readers who want to develop a power-supply system similar to Victor's will need to work out their own resistance-network values for sets requiring voltages not covered in Figs. 5 and 6. The extra filter capacitors on the power-supply female edge connector were junkbox parts, and almost any large capacity units with appropriate voltage ratings should work.

Mr. Smedstad would be happy to talk or correspond with readers who would like to discuss his power-supply ideas. Contact Victor I. Smedstad, 1307 Kings Place, Bainbridge Island, WA 98110; Tel. 206-842-6440. Please enclose an S.A.S.E. with mail queries. ■

COMPUTER BITS

(continued from page 22)

diskette takes about 20 minutes and uses lots of CPU cycles during the process, making other operations on the machine jerky.

ZIP DISKS

I have used Zip disks on both PC and Mac platforms for several years, with good results. Zip is available in both SCSI and parallel-port interfaces, The SCSI-based models provide good performance; the parallel-port units are tolerable.

At $10–15 per cartridge, media costs are still higher than they should be. Reliability has been good; once when a drive died, Iomega replaced it immediately without question. That's a nice trait to find in any vendor.

CONCLUSIONS

Bottom line on the SuperDisk is that it might be too late. To the extent that there is any standard for sharing high-density removable media, Zip is it. Almost everyone seems to have a Zip drive. While SuperDisk offers marginally more capacity, it seems to have slightly poorer performance. Also, Imation does not enjoy the market share of Iomega. Three years ago, SuperDisk would have made a hit, but today it's an also-ran in an increasingly crowded field.

The real comer is CD-R/CD-RW. The fully optical technology promises much better longevity than magnetic media. According to HP, CD-RW's lifespan is around 30 years, and CD-R is about 100 years. Now that's storage.

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SIGNING OFF

My mother used to say that people should change professions every ten years. I have been writing this column for more than ten years, so I guess it's time for a change. As much as I have enjoyed researching and writing these columns, my heart really is in more technical activities. At this point I need to focus and concentrate my energies on new opportunities. Technical writing is too much in my blood for me to simply disappear, so you can expect to see occasional articles from me here and elsewhere. I have really enjoyed corresponding and occasionally debating with you; that will be my real loss in leaving. Feel free to stay in touch via e-mail. I can be reached at jeff@ingeninc.com. ■

CRYSTALSYNTH

(continued from page 38)

synthesizer, you need a known-good MIDI cable and a MIDI source. Most sound-card manufacturers produce ready-made cables that are well suited to operation with the CrystalSynth.

Connect an audio amplifier to J1 and J2 and turn the volume of the amplifier to the mid-volume point. We will check the built-in audio amplifier later. There is a lot of circuitry between the output of IC3 and the input of IC5, so let's start off with as few variables as possible. Connect your MIDI source to J3 (the 5-pin DIN MIDI connector).

Apply power to the circuit. Press a key on your keyboard or send some MIDI data from your MIDI source. You should hear the synthesizer sound the notes you pressed. If not, check for MIDI data with a scope at pin 4 of IC1. Also check for MIDI data at pin 20 of IC2. Check to see that the crystal at pins 6 and 7 of IC2 is oscillating. Check the LRCLK terminal (pin 10) of IC2 and the LRCK terminal (pin 3) of IC3 for a 44.1-kHz squarewave input.

Take a look at the serial-audio data stream that's being transferred from pin 11 (SOUT) of IC2 to pin 1 (SDATA) of IC3. The serial-audio data stream should appear as a random squarewave. Check pin 23 (PDN) and pin 24 (RST) of IC2. Both of those pins must be high in order to enable normal operation. Finally check pin 2 (DEM/SCLK) of IC3, making sure that pin 2 is high and noise free. Any oscillation on pin 2 could cause IC3 to go into external clock mode, thereby causing the synthesizer to remain silent. Recheck all wiring and compare to the schematic. If the circuit isn't making noise, it is usually something silly like a ground wasn't wired up. If you have music, but it is noisy, try using smaller resistors for R9 and R10 (currently 15k). Those resistors set the gain of IC4. If the gain is too high, the signal might be clipping or overdriving the input of the audio amplifier. If the signal is faint, try increasing the values of R9 and R10.

If everything is good so far, connect speakers to J4 and J5. Set volume controls R19 and R20 to their mid-points. Send MIDI data to the synthesizer as before; you should hear sounds. Listen for 60-Hz hum or a high-pitched whine. If either is present, try making C29 (2200 µF) and C14 (1000 µF) larger. You might also tack some 0.1-µF and 0.01-µF capacitors between the +15-volt line and ground at various points close to the LM2879. If you are getting distortion when low bass notes are played, the speakers you are using may not be up to the task. Try larger speakers rated at 10 watts or more, or you can put a shorting jumper across R15 and another across R16 to remove the bass-boost feature of the power amp.

Using the CrystalSynth. Using the synthesizer should be as easy as plugging it into a source of MIDI data. It should work well with any device that conforms to the general MIDI standard, which defines what Instrument sounds there are to work with and to which program number they are assigned. For instance, according to the standard, it is expected that program 1 is a grand piano and program 41 is a violin, *etc.* Most MIDI devices today conform to that standard. I've had trouble on rare occasions when a device expects the drum track to be on channel 16 instead of channel 10. Usually that's easily remedied by a simple editing of the MIDI file with a sequencer or MIDI editor program.

Edit the drum track by changing any drum sounds to channel 10. I found the Internet to be a bottomless pit of MIDI resources. You can find files of all types, styles, and quality. Most files are created by amateurs who like to play the role of conductor. Some are created by professionals trying to sell their own creations. Either way, there is something for everyone. Just do a web search for MIDI.

Going Further. If the intended use is to mix the output of the synthesizer using other line-level processors, mixers, equalizers, *etc.*, and you don't intend to connect the unit to speakers, you can eliminate IC5 and all related circuitry.

A momentary pushbutton switch can be connected across C1, making the switch essentially a reset button. MIDI synthesizers are notorious for getting stuck on a note when the sequencer or computer to which they are connected suffers a glitch. The reset switch is a quick way to set the system back to a known state and silence any stuck sounds. The printed-circuit layout has pads close to C1 for that purpose. ■

TABLE 2—CS9236 PERCUSSIVE INSTRUMENT LIST

Note #	Drum Sound	Note #	Drum Sound
35	Acoustic Bass Drum	59	Ride Cymbal 2
36	Bass Drum 1	60	Hi Bongo
37	Side Kick	61	Low Bongo
38	Acoustic Snare	62	Mute Hi Conga
39	Hand Clap	63	Open Hi Conga
40	Electric Snare	64	Low Conga
41	Low Floor Tom	65	Hi Timbale
42	Closed Hi-Hat 1	66	Low Timbale
43	High Floor Tom	67	Hi Agogo
44	Pedal Hi-Hat 1	68	Low Agogo
45	Low Tom	69	Cabasa 81
46	Open Hi-Hat 1	70	Maracas
47	Low Mid Tom	71	Short Whistle
48	Hi Mid Tom	72	Long Whistle
49	Crash Cymbal 1	73	Short Guiro
50	Hi Tom	74	Long Guiro
51	Ride Cymbal 1	75	Claves
52	Chinese Cymbal	76	Hi Wood Block
53	Ride Bell	77	Low Wood Block
54	Tambourine	78	Mute Cuica
55	Splash Cymbal	79	Open Cuica
56	Cow Bell	80	Mute Triangle
57	Crash Cymbal 2	81	Open Triangle
58	Vibraslap		

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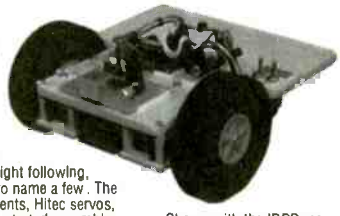

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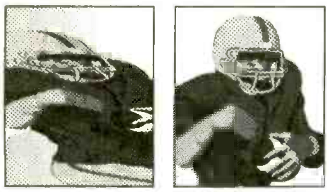

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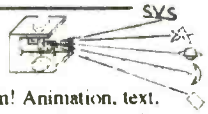

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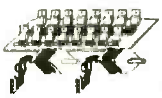

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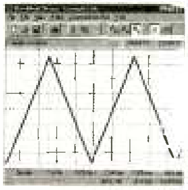

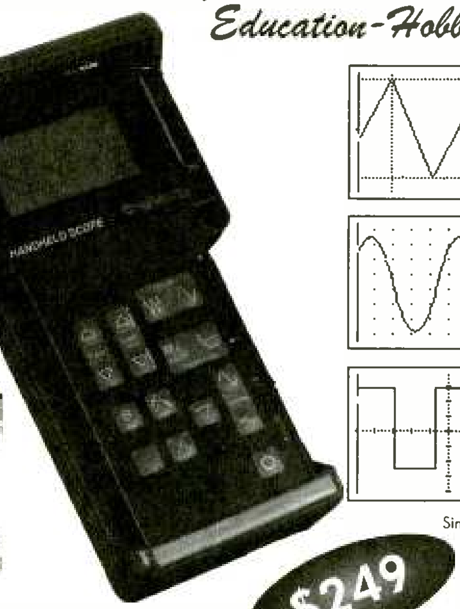

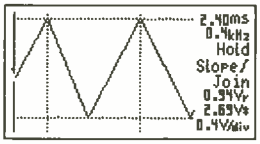

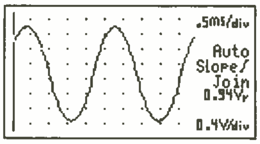

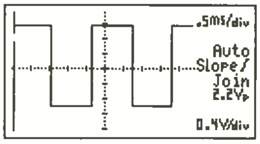

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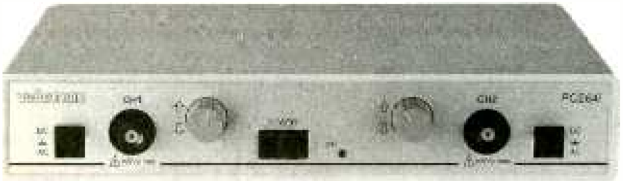

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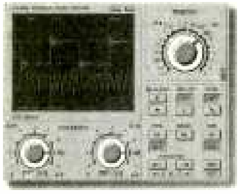
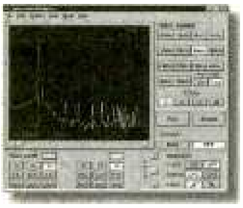
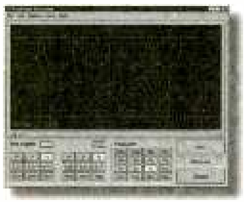
- Can also be used as a spectrum analyser up to 16 MHz, and as a transient signal recorder, for recording voltage variations or for comparing two voltages over a longer period (up to more than 1 year!).
- Connection is through the computer's parallel port.
- The oscilloscope and transient recorder have two completely separated channels with a sampling frequency up to 32 MHz in real time, oversampling of 64MHz is passible in the Windows software.
- Any waveform displayed on the screen can be stored for later use.



OSCILLOSCOPE [DOS-screen]
- timebase : 100ns to 100ms per division
- input sensitivity : 10mV to 5V/division
- pre-trigger function (not in 64MHz mode)
- true RMS readout (only AC component)



SPECTRUM ANALYSER [Windows-screen]
- frequency range : 0 .. 800Hz to 16MHz
- linear or logarithmic timescale
- operating principle : FFT (Fast Fourier Transform)



TRANSIENT RECORDER [Windows-screen]
- timescale : 20ms/Div to 2000s/Div
- max record time : 9.4hour/screen
- automatic storage of data
- automatic recording for more than 1 year
- record and display of screens
- data format : ASCII

SYSTEM REQUIREMENTS:
- IBM compatible PC
- Windows 95 or 3.11 or MS-DOS
- VGA display card (min. 800x600 for Windows) and mouse
- 480Kb free conventional memory (Dos software)

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- oscilloscope probes (2x) : PROBE60S (isolated)
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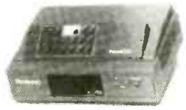

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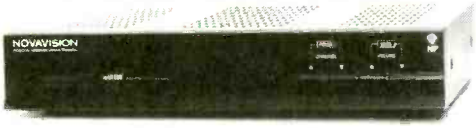

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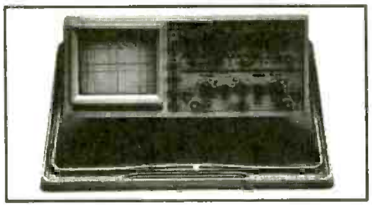

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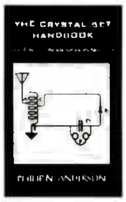

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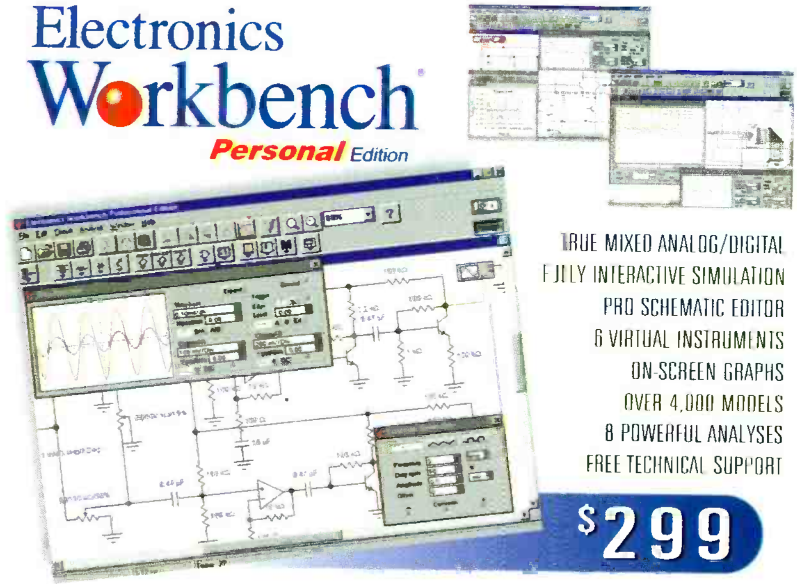

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