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# EDITORIAL

## Time Versus Money

In this month's Letters Column, reader Tom Gordon raises some serious disagreements with some of my earlier comments about the Internet (see the letter entitled "Editorial Comment" on page 12). In particular, he argues that the Internet is nothing more than another mass-communications media, and one that is expensive and supplies nothing that could not be obtained elsewhere. He is, of course, correct. He is also dead wrong. Let me explain.

Yes, the information on the Internet is largely advertising driven. Many sites exist to promote those that set them up, turn to advertising banners and the like to "pay the freight," or do both. This is not in and of itself a bad thing, and it is certainly not new. As most recognize, the magazine you are reading now would flat out not exist were it not for our advertisers. The same is true for virtually any source of news or information: radio, TV, newspapers, professional journals, consumer magazines, etc., etc.

And while reader Gordon contends that little current content is available for free, that is actually far from the truth. Yes, many media and other informational sites are available only by subscription or offer limited editorial content, but many others offer the full text of their current editions for free, with only the annoyance of an advertising banner to "spoil" things. What's more, many media sites provide more in-depth coverage than can be accommodated in their native format, with most of that available for the asking. There are also many sites on the Internet that offer information that is available nowhere else. Those range from Net-only magazines such as the recently re-born *Byte* magazine (www.byte.com) to hobbyist labor-of-love sites like our own Sam Goldwasser's www.repairfaq.org, a compendium of practical information for those seeking to service all sorts of electronics equipment.

And yes, there is a cost involved in using the Internet, but access costs are dropping steadily and now there are even some practical alternatives that cost exactly zero. For example, NetZero (www.netzero.com) offers free Web and e-mail access nationwide. There is no set-up fee, the software is free for download, and there are no monthly connect charges. The catch is that the service is advertising driven, which means that you have to keep a small 1- by 3-inch or so advertising window open on your desktop while on-line. Still, free is free.

Anyway, in my mind, the real issue is not cost, but timeliness and accessibility. Can most of the information found on the Internet also be obtained from a library? Of course it can. But how many have a library on their desktop? Can we get much of the information via brochures, bulletins, etc.? Of course we can. But how many times is it far more useful to get that information today instead of tomorrow, or a week from tomorrow?

It all comes down to a question of value, or more accurately, time versus money, and that is a question only you can answer for yourself.

Carl Laron

Carl Laron
Editor

# Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

## ER...That Was A Joke!

Our April Fools' Day joke, "The EC909-12 Analog Microprocessor," apparently fooled a number of people too well—we've received a flood of mail about it.

Note that Ecraf is *farce* spelled backward, no address is given for any person or company involved, the claims are outlandish (such as emission of huge amounts of light—enough to light a city—at tiny currents), and the last paragraph of the article says it's due for release on April 1, our national day of tomfoolery.

Two items in "Prototype" (the DVD rewinder and the WIG-WOM) were also put-ons and also specifically mentioned April 1. But the equally improbable-sounding quantum tunneling transistor (pp. 42-43, 50) is real; see www.sandia.gov/media/quantran.htm for more information.

April Fool's jokes are a decades-old tradition at **Electronics Now**; our founder, Hugo Gernsback, published facetious articles under the name of Mohammed Ulysses Fips. Interestingly, though improbable at the time, some of the concepts in those articles—such as an optical audio disc—were uncannily predictive of the future. And that's the problem—one person's fiction can easily be another person's invention.

## Ultrasonic Listener

**Q** *Where can I find plans or a kit for a circuit to allow me to hear ultrasonic sounds such as bats' squeaks?—L. S., Newton, MA*

**A** I'm not aware of a complete, published project or kit, but Fig. 1 shows a circuit you can experiment with. I used it successfully to listen to the squeaks of a domesticated rat.

The principle involved is *heterodyning* (mixing), a process that gives you the sum and difference of the original frequencies. For example, if you mix a 25-kHz incoming signal with the output of a 20-kHz oscillator, you get additional signals at 25 + 20 = 45 kHz and 25 – 20 = 5 kHz; the latter is audible.

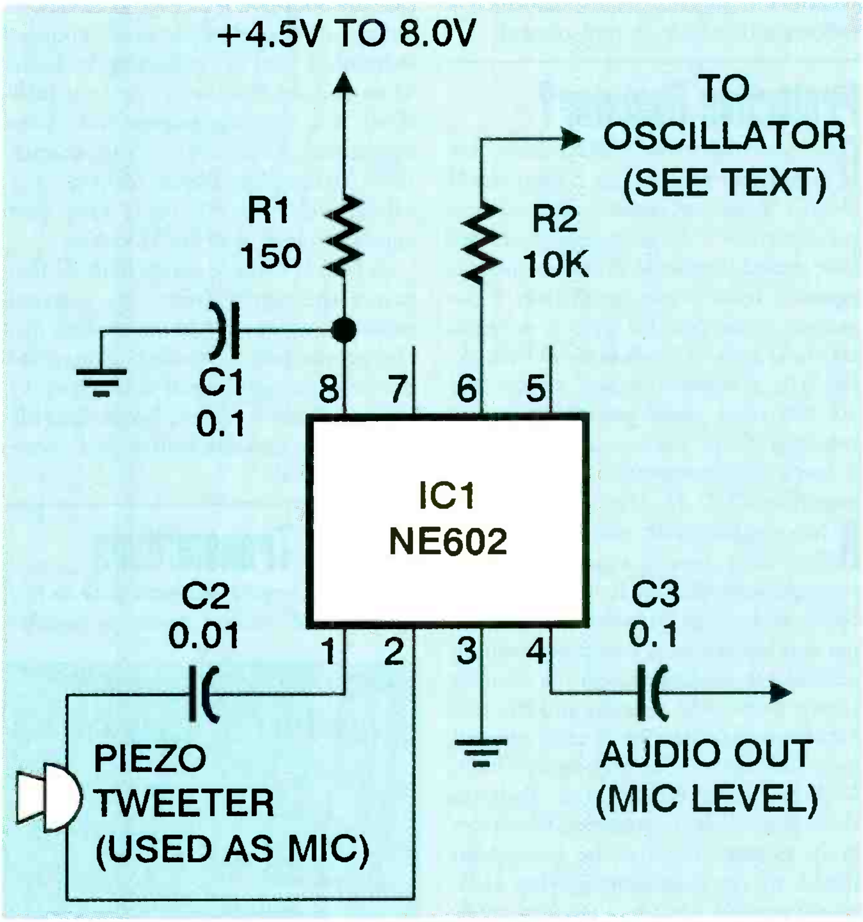


**FIG. 1**—HERE'S A GOOD STARTING POINT for an ultrasonic-listening circuit. The NE602 mixes 25-kHz ultrasound with a 20-kHz oscillator signal, yielding 5-kHz audio. If you can't find the now-discontinued NE602, the SA602 (still being made) is a direct replacement.

Heterodyning takes place when one signal is multiplied by the other; that is, when the amplification of one signal is proportional to the signal level of the other. Any nonlinear amplifier will do this, but the NE602 chip shown in the circuit uses a sophisticated mixer called a *Gilbert cell* whose advantage is that not much of the original signal appears at the output.

The NE602 was designed for radio receiver front-ends, and it works with low-level signals, so the microphone connects directly to its input. As shown, the microphone is connected differentially across pins 1 and 2. If one side of the microphone is grounded, you can connect the ungrounded microphone lead to C2 and add a capacitor, equal to C2, from pin 2 to circuit ground. Although the NE602 provides some amplification, the output signal is still microphone-level.

The design of the oscillator is up to you; its frequency should be adjustable so you can tune it near the ultrasonic signal you want to hear. From R2 it goes directly into the base of a transistor. Logic-level (5-volt) oscillators work well; I used a signal generator for experiments, but a 555 chip would be a good choice when building a self-contained unit.

Note that the NE602 is no longer being manufactured, but should still be available from a number of sources. If you can't locate one, the SA602, which is still made, is a drop-in replacement.

## Protective Resistor?

**Q** *In your September 1998 column, the answer and Fig. 1 (Fig. 2 here) should specify a "build-out" resistance on any external connections to PC printer port pins other than ground. Failure to do so is inviting an expensive repair to the parallel port if, for instance in this case, Q1 were to develop a defect and apply +12 volts to pin D0. For the IRF510, a resistor between 10,000 and 100,000 ohms would provide the needed protection. I hope you have already received at least a dozen comments about printer port protection.—J. C. H., Winston-Salem, NC*

**A** No, actually, yours was the only one. Your basic point is a good one; a few strategic resistors can help make interconnections safer. However, whether to put this resistor in is a judgment call; in general, we want to present the simplest circuit that works reliably, and the scenario that you describe is quite uncommon. Because of the way they're built, MOSFETs are much more likely to short from drain to substrate than from drain to gate. Even if the worst happened, it's not clear that applying +12V would actually damage a modern parallel port, which includes some protective resistance of its own; higher voltages certainly would, of course.

Because this circuit drives a relay, signal speed is not an issue, but in general, adding relays will slow down the charging of cable capacitance and gate capacitance. This can be good or bad. Small series resistors (on the order of 330 ohms) often make a long data cable work more reliably by reducing crosstalk. A resistor as large as 10,000 ohms, though, should be placed close to Q1, not at the PC, in order not to weaken the signal going into the cable.

## Bucket-Brigade Devices

**Q** *Back in the 1970s, there were audio delay chips called bucket-brigade analog delays. Are they still being made? Are books about them available?—C. K. S., Waymart, PA*

**A** Bucket-brigade delay devices are still made by Panasonic (Matsushita) and are available from Panasonic distributors, one of whom is Digi-Key, 701 Brooks Ave. S., Thief River Falls, MN 56701; Tel: 800-344-4539; Web: www.digikey.com. Digi-Key also sells the data book. Data sheets can be viewed online at www.mec.panasonic.co.jp/e-index.html (you're connecting to Japan when you do this, so it may be a little slow). You can also request data from Panasonic Electronic Components, 1600 McCandless Drive, Milpitas, CA 95035; Tel: 408-946-4311. One part number to look at is the MN3008.

A bucket-brigade device is an IC that passes the signal from one internal capacitor to another in succession, just like people passing buckets along, and can delay an audio signal as much as 0.4 second. Using feedback, bucket-brigade devices can generate echoes and reverberation effects.

## Dueling Transmitters

**Q** *We use a simple transmitter with an FM radio and outdoor speaker to monitor activity on the internal phone line of the coal mine where I work. Teenagers in the area have started a community FM-broadcast station which interferes with our reception no matter where we tune the transmitter and radio. Can our transmitter be modified to tune somewhere in the 30-50 MHz range so we can use a scanner to monitor the activity in the mine?—D. B., Jesse, WV*

**A** Probably, but let's solve the *real* problem instead. What you're experiencing is a conflict between two unlicensed transmitters, yours and theirs. Unlicensed transmitters are not allowed to interfere with licensed ones, so if the teenagers are keeping you from receiving FM broadcast stations (not just your own transmitter), you have a clear case against them. Contact the teenagers, explain the problem, and explain that you will report them to the FCC if they don't clean up their signal. Or, if you prefer, contact the Federal Communications Commission, Tel: 888-225-5322 and report the problem directly.

However, I believe that safety-critical communications should never rely on an unlicensed transmitter; you just have no assurance that your signals will not be interfered with. Consider relaying the

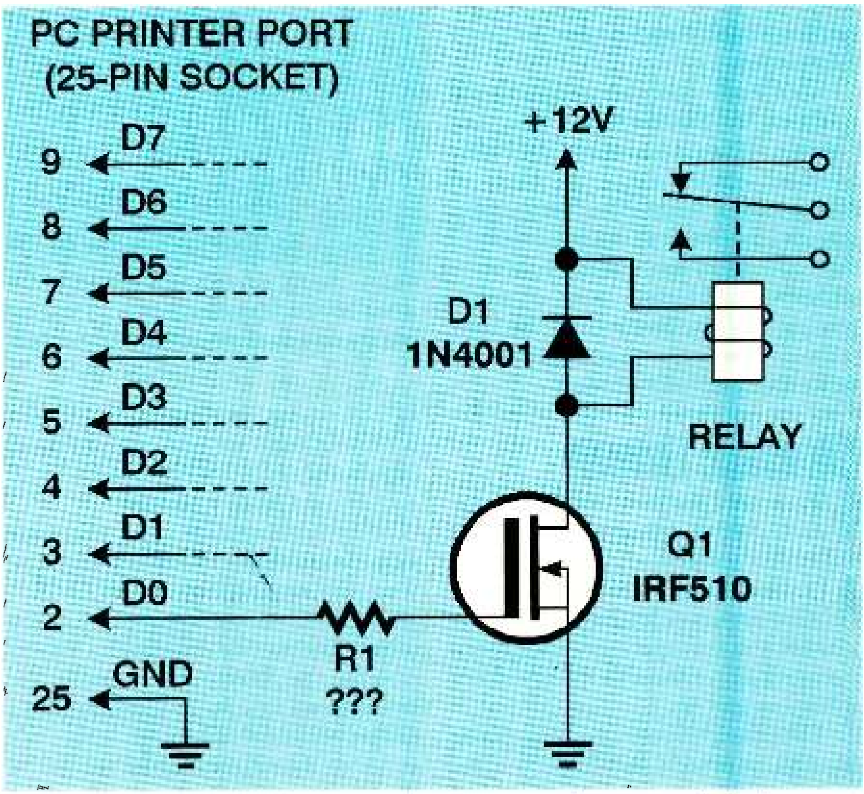


FIG. 2—ADDING A RESISTOR between the printer port and any external circuit connected to it could add protection in case of a failure, but is it really needed? See text.

signal by wire rather than by radio.

If you want to put your transmitter in the 49-MHz cordless-phone band, double the inductance of the tuning coil and double the capacitors in the tuned circuit (10 pF instead of 5 pF). However, you'll then be running a risk that your third harmonic (around 150 MHz) will interfere with police or public-safety communications. Go a little lower (120 MHz), and you'll interfere with aircraft communications instead. A low-pass filter and/or tuned antenna will be necessary to prevent these problems.

## Dueling VCRs

**Q** *When I record a program on my Magnavox VCR and play it back on my Zenith VCR, I get a picture but no sound. I'm feeding RF into my TV, so it isn't a broken audio cable. My Zenith VCR has no problem playing back pre-recorded tapes. What's wrong?—A. F., Glendora, CA*

**A** Obviously, one of the VCRs is slightly out of specification, but without a third VCR to break the tie, it's hard to say which. It's possible both of them are out of adjustment in opposite directions, so they're incompatible with each other even though they both play pre-recorded tapes. There are several electronic adjustments on a VCR that may need tweaking; if it were me, I'd take the Zenith unit in for a checkup first.

## Shielded Car Speakers

**Q** *My car stereo speakers create such a strong stray magnetic field that it is impossible to use a compass anywhere in the car. Is it possible to put some kind of magnetic shield around the speakers that will allow the compass to work undisturbed?—G. K., Euclid, OH*

**A** Those must be fairly big speakers, since most car stereos do not interfere with compasses. Steel or iron shields may help a little, but the best tactic is probably to try to balance out the magnetic field using more magnets.

You indicate that you've already tried relocating the compass; have you also tried adjusting its compensation? Many compasses include tiny magnets that can be adjusted to counteract an ambient magnetic field. Some stereo speakers, designed for use around computers, also include compensating magnets to reduce the total field strength outside the speaker enclosure.

We'd like to hear from readers who have addressed this problem.

## Preventing Acoustic Feedback

**Q** *I have a hearing problem and want to amplify the faint "beep-beep" from an electronic timer. Everything I build oscillates because of feedback from the microphone. Can you help?—J. B. W., Detroit, MI*

**A** As you know, feedback squeals result when the same sound wave gets amplified over and over—it goes in the microphone, out the speaker, in the microphone again, and so on.

The best solution is to get rid of the microphone by making a direct electrical connection from the sounder in the timer to the input of your amplifier. Second best is to put the timer in a closed box with the microphone inside.

### HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www. motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online. www.questlink.com features IC data sheets and gives you the ability to buy many of the ICs in small quantities using a credit card. You can also get detailed IC information from www.icmaster.com, which is now free of charge although it formerly required a subscr ption.Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org

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

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

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

**Copies of past articles:** Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1994 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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

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

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

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

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

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

## Reusing Exercise Bike Electronics

**Q** *I just threw out my home exercise bike, but I kept the digital readout that was attached. Is there any way I can use it on my workbench? It used to indicate mode, distance, calories, time, and speed, and had a 2-wire cable and 3-volt batteries.—P. C., New York, NY*

**A** That sounds like an interesting project; at the very least, you should be able to trick the timer into starting when you press a button. Readers?

## Salvaged CD Drive

**Q** *I recently salvaged the CD-ROM drive from an old computer. It has an audio headphone jack as well as an audio output on the back, but I can't get it to play a CD. Am I missing something obvious, or is it necessary to have the CPU and software wired in to make it work?—J. K., U. S. Air Force*

**A** Unless the drive has a "play" button on the front, you're right, it requires commands from the CPU. An interesting project would be for somebody to reverse-engineer these commands and program a microcontroller to generate them so that you could attach a simple one-chip circuit to the ATAPI (IDE) interface and turn an older CD-ROM drive into a CD player.

## Telescope-Drive Parts Found

William Braell, of Harvard University, tells us that the TTD62103P chip that reader T.Q. needed (April 1999, p. 3) is probably a Toshiba TD62103P Darlington transistor array. (The Toshiba logo looks like another T preceding the part number.) Readily available substitutes are the NTE2013 or ECG2013. However, this chip was probably not damaged by accidental application of 30 volts.

Frank L. Scheder e-mails to tell us that the PMM8713 chip, needed by the same reader, is a rather old stepping-motor controller. We confirmed that it is still available for $27.50 from B&D Enterprises, Main and Liberty St., Russell, PA 16345; Tel: 814-757-8300; Fax 814-757-5400; Web: www.bdent.com.

## Still More Pinball Wizardry

Staci Steddum, of Wichita, KS, writes again to tell us that the best source of information on pinball machines is *Star Tech Journal*, P.O. Box 35, Medford, NJ 08055; Tel: 609-654-5544; Web: www.startechjournal.com. They run a magazine, an online discussion forum, and a manual-reprint service covering coin-operated game machines of all ages.

## Writing to Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to:

(1) include plenty of background information (we'll shorten your letter for publication);

(2) give your full name and address on your letter (not just the envelope);

(3) type your letter if possible, or write very neatly; and

(4) if you are asking about a circuit, include a complete diagram.

Questions can be sent to Q&A, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735, or e-mailed to q&a@gernsback.com, but please do not expect an immediate reply (because of our backlog) and please don't send graphics files larger than 100K. Due to the volume of mail, we regret that we cannot give personal replies. EN

BY SAM GOLDWASSER
SERVICE EDITOR

# Monitor High-Voltage Problems

IN ADDITION TO THE OBVIOUS "MONITOR SCREEN IS AS BLACK AS A COAL MINE" SYMPTOM, PROBLEMS IN THE HIGH-VOLTAGE POWER SUPPLY CAN RESULT IN A VARIETY OF BRIGHTNESS, RASTER GEOMETRY, AND OTHER PICTURE PROBLEMS AS WELL AS arcing corona, or other sights, sounds, and smells not normally associated with a properly functioning monitor. This month we will deal with some of these symptoms. Other video-related problems will be dealt with next time.

## HV Power-Supply Fundamentals

Most monitors derive the high voltage for the CRT second anode (THE high voltage—called EHV by some), focus, and (sometimes) screen (G2) from the horizontal-deflection system (see Fig. 1). That technique was developed quite early in the history of commercial TV and has stuck for a very simple reason—it is very cost effective. A side effect is that if the horizontal deflection fails and threatens to burn a vertical line into the CRT phosphors, the high voltage dies as well. Of course, if the vertical deflection dies....

Some auto-scan monitors use a separate high-voltage supply. One reason for that approach is to decouple the horizontal deflection from the HV in auto-scan monitors, thus simplifying the design.

Usually that supply is a self-contained inverter module. It if can be opened, then repair may be possible. With a separate HV supply, there is no need for a HV flyback transformer on the mainboard. Some designs may use a separate HV supply including a flyback, which is part of the mainboard but is self contained and independent of the horizontal-deflection system.

Most TV and monitor (flyback) high-voltage supplies operate as follows:

**1.** The horizontal-output transistor (HOT) turns on during scan. The current increases linearly in the primary of the flyback transformer since it appears as an inductor. The magnetic field also increases linearly. Note: the flyback is constructed with an air gap in the core, which makes it behave more like an inductor than transformer as far as the primary drive is concerned.

**2.** The HOT shuts off at the end of the scan. The current decreases rapidly. The magnetic field collapses, inductively coupling to the secondary and generating a HV pulse. The inductance and capacitance of the flyback, snubber capacitors, and parasitic capacitance of circuitry and yoke form a resonant circuit. Ideally, the voltage waveform across the HOT during the flyback (retrace) period will be a single half cycle, and it is clamped by a damper diode across the HOT to prevent undershoot.

**3.** The secondary of the flyback is either a single large HV winding with HV rectifiers built in (most often) or an intermediate voltage winding and a voltage multiplier (see the section: "What is a tripler?" that follows). The output will be DC HV pulses.

**4.** The capacitance of the CRT envelope provides the needed filtering to adequately smooth the HV pulses into a DC voltage. Sometimes there is a separate HV capacitor as well.

**5.** A high-resistance voltage divider provides the several kV focus voltage and sometimes the several-hundred volt

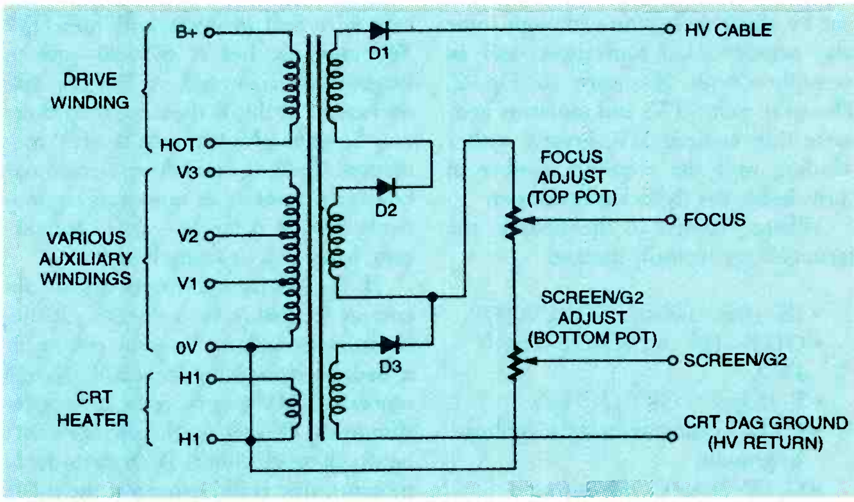


FIG. 1—MOST MONITORS DERIVE THE HIGH VOLTAGE for the CRT second anode, focus, and (sometimes) screen from the horizontal-deflection system.

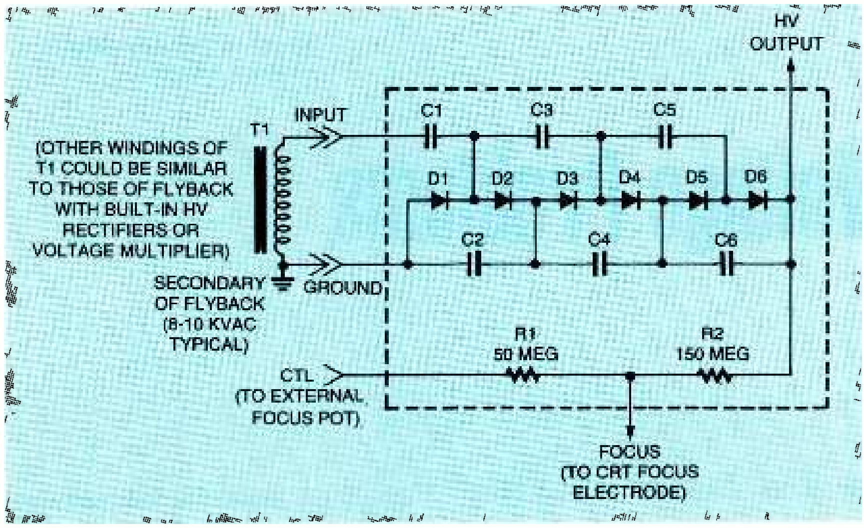


**FIG. 2**—THE FLYBACK TRANSFORMER only generates about 6-10 kV AC, which is then boosted by a capacitor-diode ladder (called a tripler) to the 18-30 kV needed for modern color CRTs.

screen (G2) voltage as well. Often, the adjustments for these voltages are built into the flyback. The focus and screen are generally the top and bottom knobs, respectively. Sometimes they are mounted separately. This or a similar divider may also provide feedback to control high-voltage regulation.

The operation of the deflection system was discussed in great detail in a pair of previous "Service Clinic" articles.

## What Is A Tripler?

In some TVs and monitors, the flyback transformer only generates about 6-10 kV AC, which is then boosted by a capacitor-diode ladder to the 18-30 kV needed for modern color CRTs. The unit that does this is commonly called a tripler since it multiplies the flyback output by about three times (though some may actually do it four times) and an example circuit is shown in Fig. 2. However, many TVs and monitors generate the required HV directly with a winding with the required number of turns inside the flyback transformer.

Where external to the flyback, the terminals are typically marked:

- IN—from flyback (6-10 kV AC).
- OUT—HV to CRT (20-30 kV DC).
- F—focus to CRT (2-8 kV).
- CTL—focus pot (many megohms to ground).
- G, GND, or COM—ground.

Symptoms of tripler failure are: lack of high voltage or insufficient high voltage, arcing at focus-protection spark gap, incorrect focus voltage, other arcing, overload of HOT and/or flyback, or focus adjustment affecting brightness (screen) setting or vice-versa.

## High-Voltage Shutdown

A monitor that runs for a while or starts to come on but then shuts down may have a problem with the X-ray protection circuitry correctly or incorrectly determining that the high voltage (HV) is too great (risking excessive X-ray emission) and shutting everything down.

A side effect of activation of this circuitry is that resetting may require pulling the plug or turning off the real (hard) power switch.

Was there anything else unusual about the picture lately that would indicate an actual problem with the HV? For example, has it suddenly gotten brighter than normal or has the size decreased? If this is the case, then there may be some problem with the HV regulation. If not, the shutdown circuit may be overly sensitive or one of its components may be defective—a bad connection, leaky cap, or faulty Zener.

If the horizontal frequency is not correct (probably low) due to a faulty horizontal-oscillator or -sync circuit, or a bad horizontal-hold control (should one exist!), HV may increase and trigger shutdown. Of course, the picture won't be worth much either! With a multiscan monitor, that could happen if the mode switching is faulty resulting in incorrect component settings for a given scan rate. A symptom might be HV shutdown when switching scan ranges.

The HV shutdown circuit usually monitors a winding off of the flyback for a voltage that exceeds some reference and then sets a flip flop shutting the horizontal drive off. On some Sony models, a HV-resistive divider performs that function and these do fail—quite often. The red block called the "HSTAT module" or just that "big red capacitor thing" is a common cause of immediate or delayed shutdown on certain Sony monitors and TVs.

## Low or No High Voltage

Most of these problems are due to faults in the horizontal deflection system—shorted HOT, shorted windings or HV rectifiers in the flyback, defective tripler, or other bad parts on the primary side of the flyback. In addition, with auto-scan monitors, the incorrect voltage or other component could be selected due to a logic fault or a problem with the selection relay or other circuitry.

However, if you discover an inch-deep layer of filth inside the monitor, the HV could simply be shorting out—clean it first.

In most cases, these sorts of faults will put an excessive load on the horizontal-output circuits so there may be excessive heating of the HOT or other components. You may hear an audible arcing or sizzling sound from internal shorts in the flyback or tripler. Either of those might get hot, crack, bulge, or exhibit visible damage if left on with the fault present.

Many modern monitors do not regulate HV directly but rather set it via control of the low-voltage power supply to the HOT (B+) via snubber capacitors across the HOT and the turns ratio of the flyback. The HV is directly related to the B+ so if that is low, the HV will be low as well. Faulty snubber capacitors will generally do the opposite—increase the HV and the X-ray protection circuits may kick in. However, low HV is also a possibility. The only way the turns ratio of the flyback can change is from a short, which will manifest its presence in other ways as well—excessive heating and load on the horizontal-output circuits.

While a shorted second anode connection to the CRT is theoretically possible, this is quite unlikely (except, as noted, due to dirt).

## Excessive High Voltage

Any significant increase in HV

should cause the X-ray protection circuits to kick in and either shut down the set or modify the deflection in such a way as to render it harmless. Symptoms include arcing/sparking of HV, smaller than normal picture, and under certain scenarios, possible excessive brightness.

The causes of the HV being too high are:

**1.** Excess B+ voltage to the HOT. The likely cause is a low-voltage regulator failure.

2. Open snubber capacitors across the HOT. These are under a lot of stress and are located near hot components so failure is possible.

**3.** Incorrect excessively long scan drive to the HOT caused by failure of the horizontal-oscillator/-sync circuits. However, other things like the HOT will probably blow up first. The picture will definitely be messed up. This is more likely with auto-scan monitors than TVs since what is too long for one scan range may be correct for another and the selection circuitry is confused or broken.

**4.** The failure of the HV regulator. Actual HV regulators are uncommon today but the HV may be controlled by a feedback voltage from a divider (focus or screen, or its own), or a secondary winding on the flyback is used to set the B+ or drive timing. That could result in a picture that is underscanned (smaller than normal) and likely excessively bright as well.

## Snaps, Crackles, and Other HV Breakdowns

Various problems can result in occasional or sustained sparking or arcing sounds from inside the monitor. Note that a static-electricity buildup is common on the front of the screen. It is harmless and there is nothing you can do about it anyhow.

The following sections deal with problems that could result in occasional or sustained sounds that are not commonly associated with a properly working TV or monitor. There may or may not be flashes or blanking of the screen at the same time as the audible noise.

## Arcing, Sparking, or Corona From CRT HV Anode

The CRT HV anode usually appears as a red wire/suction cup. Symptoms could include a sizzling corona or more likely, an occasional or rapid series of sharp snaps—possibly quite loud and quite visible—from the anode cap on the CRT to the grounded coating on the outside of the CRT or a chassis ground point (or any other conductor nearby). Corona is a high resistance leakage through the air without total breakdown. The snapping is caused by the sudden and nearly complete discharge of the CRT anode capacitance through a low resistance ionized path similar to lightning. There are two likely causes for this:

**1.** Dirt, dust, and grime around and under the suction cup on the CRT are providing a discharge path. This may be more severe in humid weather. Safely discharge the HV and then remove and thoroughly clean the HV suction cup and the area under it and on the CRT for several inches around the HV connection. Make sure there are no loose wires or other possible places for the HV to discharge to in the vicinity.

2. The high voltage has gone through the roof. Usually, the X-ray protection circuitry should kick in, but it can fail. If cleaning does not help, this is a likely possibility. See the "High Voltage Shutdown" and "Excessive High Voltage" sections earlier in this column for more.

## Arcing at CRT Spark Gaps or Gas-Discharge Tubes

Spark gaps (see Fig. 3) and gas-discharge tubes are protective devices intended to break down and divert excessive voltage away from the CRT (usually). Arcing there is rarely due to a defective spark gap or gas discharge tube but rather is a safety mechanism like a fuse designed to protect the internal electrodes of the CRT if the focus or screen voltage should become excessive. The spark gap breaks down first and prevents internal arcing in the CRT.

Arcing at a spark gap or a glowing or a flashing discharge tube may be accompanied by total loss of picture or bad focus or brightness, focus fluctuations, or any of a number of similar symptoms. A common cause is a breakdown inside the focus divider (usually part of the flyback or tripler) but could also be due to excessive uncontrolled high voltage due to a failure of the B+ regulator or HOT snubber capacitor, or (ironically) even a short inside the CRT.

Spark gaps may be actual two- or three-pin devices with seemingly no insides and could be part of the CRT socket or printed on the circuit board itself. Gas discharge tubes look like small neon lamps (*e.g.*, NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage. Since these are protective devices, like a fuse, don't just replace or disable them—locate and correct the underlying problem. The CRT makes an expensive fuse!

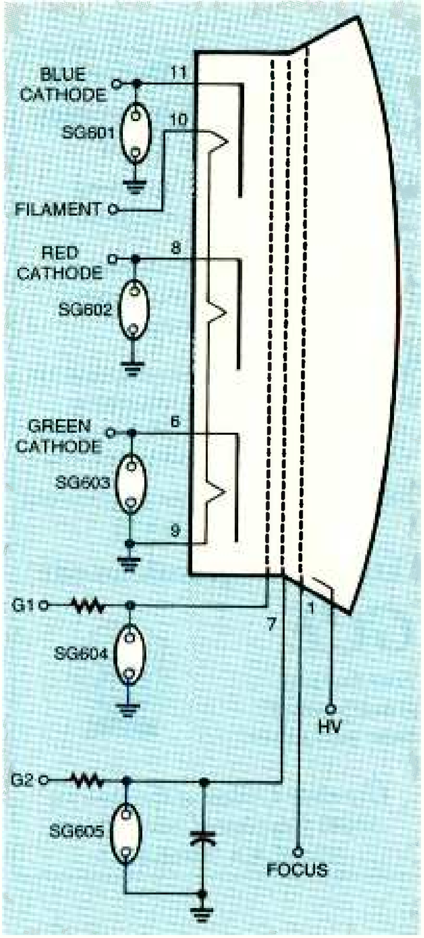


**FIG. 3**—SPARK GAPS are protective devices intended to break down and divert excessive voltage away from the CRT. If you see arcing within one, don't replace it—find out why.

## Arcing From Flyback or Vicinity

Arcing may be visible or audible and result in readily detectable levels of ozone. Note that very slight traces of ozone may not indicate anything significant, but if the TV smells like an office copier, there is probably some discharge taking place.

**WARNING:** It is possible for arcing to develop as a result of excessive high voltage. Symptoms might be a smaller than normal, excessively bright picture, but this may not be able to be confirmed until the flyback is repaired or replaced.

See the section: "Excessive High Voltage." Here's some of what you are likely to see or hear:

- On the HV output, it will probably be a loud snapping sound (due to the capacitance of the CRT) with associated blue/white sparks up to an inch or more in length. If the arc length is short enough, this may turn into a nearly continuous sizzling sound with yellow/orange arc and melting/burning plastic.
- Prior to the HV rectifier, it will likely be a continuous sizzle with orange/yellow/white arc and melting/burning plastic or circuit board material.
- Internal arcing in the flyback may be audible and eventually result in a bulging and/or cracked case (if some other component doesn't fail first as this would take some time to develop).
- A corona discharge without actual sparks or a visible well defined arc is also possible. This may be visible in a totally dark room, possibly more likely when the humidity is high. A thorough cleaning to remove all dust and grime may be all that is needed in this case.
- If the arc is coming from a specific point on the flyback—a crack or pinhole—this may be patched well enough to confirm that the rest of the monitor is operational and a new flyback is worth the money. Otherwise, there is no way of knowing if the arcing may have damaged other circuitry until a replacement flyback—possibly money wasted—arrives.

To attempt a repair when arcing is present, scrape off any dirt or carbon that is along the path of the arcing and its vicinity. Then clean the area thoroughly with alcohol and dry completely. Otherwise, the dirt and carbon will just act as a good conductor and the arcing will continue under your repair! Several layers of plastic electrical tape might be adequate for testing. Multiple coats of high-voltage sealer or *non-corroding* RTV silicone (if it smells like vinegar—acetic acid—as it cures, it could get in and affect the windings so don't use it) would be better if the objective is an actual repair. A thick layer of Epoxy may be even better and affected less by possible HV corona. Either of those might prove to be a permanent fix, although starting a search for a source for a new flyback would not hurt just in case. The arc most likely did damage the insulation internally, which may or may not be a problem in the future. Some more notes:

- In some cases, the pinhole or crack is an indication of a more serious problem—overheating due to shorted windings in the flyback or excessive secondary load.
- If the arc is from one of the spark gaps around the CRT or the CRT socket, this could also be a flyback problem indicating internal shorts in the focus/screen network.
- If the arcing is inside the CRT, this could indicate a bad CRT or a problem with the flyback focus/screen network and no or inadequate spark gap protection.

Where repair seems possible, first, clean the areas around the arc thoroughly and then try several layers of plastic electrical tape. If the monitor or TV works normally for say, an hour, then there is probably nothing else wrong and you can try for a proper sealing job or hope that tape holds out (put a few more layers on—each is good for about 8-10 kV theoretically).

However, replacement is really the best long-term solution both for reliability as well as fire risk.

## The CRT Return

The Aquadag coating on the outside of the CRT is the negative plate of the HV filter capacitor. If this is not solidly connected to the HV return, you will have your 25 kV+ trying to go where it should not be. There should be a wire solidly attached to the CRT neck board or chassis. Without this, voltage will build up until it is able to take some other path—possibly resulting in damage to sensitive solid-state components in the process. Therefore, it is important to rectify the situation.

Warning: If you find the CRT return disconnected, don't just attach it anywhere. You may instantly kill ICs or other solid state components. It must be connected to the proper return point on the CRT neck board or chassis.

## Flashovers Inside The CRT

Due to sharp edges on the electron-gun electrodes, impurities, and other manufacturing defects, there can be occasional arcing internal to the CRT. Properly designed HV, deflection, and power-supply circuits can deal with these without failing, but not all monitors are designed well.

If your HV is not excessive, there is nothing you can do about flashovers. If these persist and/or become more frequent, a new CRT or new monitor will be needed.

## Ozone Smell and/or Smoke From Monitor

Smoking is just as bad for monitors as for people, and usually more quickly terminal (no pun intended). White acrid smoke may indicate a failed electrolytic capacitor in the power supply, probably in conjunction with a shorted rectifier. Needless to say, pull the plug at once.

A visual inspection should be able to easily confirm the bad capacitor as it will probably be bulging and have condensed residue nearby. Check the rectifier diodes or bridge rectifier with an ohmmeter. Resistance across any pair of leads should be more than a few ohms in at least one direction. Remove the suspect device from the circuit to confirm. Both the faulty diode(s) and capacitor should be replaced (though the capacitor may work well enough to test with new diode(s).

If a visual inspection fails to identify the smoking part, you can probably plug the monitor in for a few seconds until the source of the smoke is obvious but be prepared to pull the plug in a real hurry. If the smell/smoke is coming from the flyback, then it has probably gone belly up. You may be able to see a crack or bulge in the case. While the flyback will definitely need to be replaced, it is likely that nothing else is wrong. However, it might be prudent to use a Variac when performing initial testing with the replacement just in case there is a secondary short circuit or excess HV problem.

## X-ray and Other EM Emissions

X-ray radiation is produced when a high-velocity electron beam strikes a target containing heavy metals. In a modern monitor, that can only take place at the shadow mask/aperture grille and phosphor screen of the CRT. Really old TVs (prior to around 1975) may still have HV rectifier and regulator tubes—other sources of X-rays. However, modern TVs and monitors implement these functions with solid-state components.

For X-rays, the amount of radiation (if any) will be proportional to brightness. The energy (determined by the CRT high voltage, called kVP in the medical-imaging field) is not affected. This is one reason many monitors and TVs are designed with brightness-limiting circuits.

In any case, there will be virtually no X-ray emissions from the front of the CRT as the glass is greater than an inch thick and probably contains some lead for added shielding, but there may be some emission from the thinner sides. At 25-30 kV (quite low as X-ray energies go) X-rays will be stopped by almost any metal so what you have to worry about is where there are no shields.

However, realistically, there is very little danger. I would not worry about exposure unless you plan to be sitting for hours on the sides, behind, or under the TV or monitor—with a picture (there will be none if the screen is black).

It is interesting that even those 1.5-inch Watchman and 0.5-inch camcorder viewfinder CRTs have X-ray warning labels even though the high voltage used with these isn't anywhere near high enough to be of any concern!

Electromagnetic radiation (EM) is produced mostly from the deflection yoke and to a lesser extent from some of the other magnetic components like transformers and inductors. Depending on monitor design (some are specifically designed to reduce this), EM emissions can vary quite a bit. Frequencies range from the 60 Hz of the power line or vertical scan rate to several hundred kHz in the AM-broadcast band. The intensity and spectral distribution will vary depending on horizontal and vertical scan rate.

As mentioned a second ago, a totally black screen will reduce X-ray emission to zero. It will not affect EM emissions significantly as most of this comes from the magnetic parts, particularly the deflection yoke.

There is no measurable microwave, IR, or UV radiation.

I refuse to get into the discussion of what, if any, health problems result from low level EM emissions. There is simply not enough data.

## Wet Flyback

You put your can of Coke where???? Needless to say, if a liquid gets into the back of a TV or monitor, unplug it immediately. Inspect around the target area for obviously blown or damaged components. Test fuses and fusable resistors. Remove all traces of liquid—especially sugary or corrosive liquid. Use water first and then alcohol to promote drying. Repair burnt solder connections and circuit board traces. Once the monitor is entirely dried out, power it up—preferably through a series light bulb and/or Variac until you are sure nothing else will let loose. Look, listen, and smell for any unusual behavior. If it now works, then consider yourself lucky. If not, there may be damage to transistors, ICs, or other components.

Another source of liquid-related damage is using spray cleaner or a too wet rag on the front of the CRT (or other parts of the monitor, for that matter). Any liquid that drips inside (all too likely) may short out circuitry on the mainboard with very expensive consequences.

## Erratic Focus or Screen Voltage

Symptoms here could include fluctuating focus or brightness. In extreme cases, the result may be a too bright or dark picture or other behavior caused by breakdown in the focus/screen(G2) divider network.

Usually, this problem will require flyback replacement to repair reliably. Sometimes, the section with the controls can be snapped apart and cleaned, but this is not common.

First, just try rotating the screen (G2) control back and forth a few times. This may clean up the contacts and eliminate the erratic behavior. Possibly, positioning it a bit to one side of the original location will help. Then, use the individual or other master background/bias adjustments to compensate for the improper brightness.

If pressing in on the erratic control helps to stabilize the setting, you might try adjusting it to the optimal position and then put a dab of hot-melt glue (or Superglue if you can manage not to stick your fingers together) on the shaft to hold it with a little more contact force.

If none of this helps, here's a "well it's going in the dumpster anyhow" procedure to try:

After discharging the CRT (so you don't get zapped) drill a tiny hole in the plastic cover near the bad control. Be careful you don't damage anything inside—you just want access to the contacts of the controls. Use a hand drill with, say, a 1/16-inch bit. Don't drill more than about 1/8-inch deep, which should enter the airspace. Then spray some contact cleaner through the hole and work the controls. Wait sufficient time (say, 24 hours) for everything to dry COMPLETELY and see if behavior changes (or if it works at all).

Again, this is a "you have got to be kidding" type of repair so no guarantees, and only use this as an absolute last resort before disposal. If by some miracle it does work, fill the hole with a drop of RTV or just put a couple of layers of electrical tape over it.

## Wrap Up

That's it for now. Next time we will continue our discussion of monitor troubleshooting and repair. Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail only please at sam@stdavids.picker.com) of all types and will reply promptly to requests for information. See you next time! EN

# LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

## Brainstorm Caution

I would like to comment on the project in the "Learn to Relax with a Brainwave Synchronizer" article in the April 1999 issue. There may be dangers in its use. First of all, a little background: I hold an M.Sc. in Electrical Engineering, with a specialty in biomedical instrumentation, and my 1979-80 thesis research and course work concentrated in electroencephalographic instruments and general neurology instruments. In 1981, I was board certified as a Certified Clinical Engineer. I am also an epileptic.

During the 1970s, when I was really deep into medical instruments, I became interested in biofeedback and did some preliminary research with the goal of building an alpha-wave monitor. After researching the issue and talking to a couple of neurophyisologists and neurologists, I elected to drop the project because I learned that alpha monitors can reinforce latent epileptic seizure activity.

I also learned during my studies that "photo driving" is one way to elicit an epileptic seizure. When I go for my regular EEG every five years, one of the things they do is place a mask over my face and flash a light at me. I am told that lights blinking, especially in the region of the flicker fusion frequency (about 8 Hz), can elicit a seizure. That's why some municipalities in the 1970s banned strobe lights in that frequency range from discos (of course, how can they tell the difference between a dance and a seizure in those places?). Recently, in Japan, a blinking television cartoon created widespread seizure activity in child viewers.

Blinking lights apparently can be dangerous. Because of what I have learned, I would be really reluctant to strap on one of those things. After all, a similar experience is used to artificially generate a seizure when the neurologist wants to examine my brain waves.

NAME WITHHELD

## Editorial Comment

Carl Laron's editorial in the February issue extolled the Internet as if it were a miracle rather than simply one mass communication medium among several. For many people, if not most, the necessity of another mass communication medium is moot. This is especially true in light of the fact that the Internet or Web is primarily a vehicle for advertising. That information offered by the Web which is not advertising is largely information which can be released for free, i.e. the kind of information we would typically get in free brochures, pamphlets, bulletins, listings, and the like.

On the other hand, information that is costly to produce and can be published for compensation is not going to appear on the Web. Exceptions to this can be found in texts and articles that have already been so published and are being recycled via the Web, e.g. ten-year-old magazine articles. In general, the Web cannot compete with well-stocked university libraries as a serious research tool.

In light of the above, it's interesting to note that Britannica, Inc. maintains a Web site at which articles from their encyclopedia can be downloaded, but this is a paid site. If one is going to pay monthly or yearly fees to use this site, then those fees must be weighed against what one is already paying in local taxes to support libraries, which will have the encyclopedia in it anyway. There are free encyclopedias available on the Web, but you can be certain that they are not on the scholarly level of the Britannica to say nothing of Britannica Inc.'s Macropedia.

Finally, we note that the Web doesn't replace anything. It only competes with already existing media even though many of those media use the Web as an extension of themselves: Every magazine and television station has a Web site. The objective is obvious. Further, when all costs and fees are considered, the Web from the standpoint of the individual is the most expensive mass communication medium yet developed. In order for me to embrace such a medium it would have to be extraordinarily inexpensive or of extraordinary quality. The Web is neither.

TOM GORDON
Sunnyvale, CA

*See the editorial on page 3 for our response to this letter—Editor*

Write To:
Letters,
**Electronics Now** Magazine,
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Farmingdale, NY 11735

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

## More April Fooled

I just got my April issue, and I read the article on the analog microprocessor replacement for the Pentium II. I'm ashamed to admit it, but you guys really had me going. I couldn't believe (or, worse yet, I did) the amazing capabilities of the microprocessor based on the new "Barrier Reflex Diode." I even went so far as to search for information about it with Yahoo! Boy, am I gullible!

All hail Dr. Ecraf and his incredible farcE!!

JOHN VOLTZ
via e-mail

Shame on you! Fake articles about super processors...what a cruel thing to do to a bunch of computer junkies. You got me!

CRAIG MCGREGOR
via e-mail

EN

BY DON JENSEN

# Hello, Again!

**D**ON JENSEN MAY BE NEW TO **ELECTRONICS NOW** BUT HE'S BEEN AROUND SHORTWAVE LISTENING SINCE 1947, WHEN AT AGE 11, HE TUNED HIS FIRST SW STATIONS ON AN OLD "ALL-BAND" CONSOLE RADIO. FOR A NUMBER OF YEARS, HIS "DX Listening" column has been a regular feature in our sister publication, **Popular Electronics**. Regular readers know his column is the place to go for all the latest...what's on shortwave, and where and when to tune. For those who haven't yet discovered the fun of SWLing, why not turn on and tune in to "DX Listening?"

Now that the introductions are out of the way, let's get right to this month's news and views.

## Shortwave in Venezuela

Once upon a time, Venezuela was one of the most "radio active" shortwave countries in South America. As recently as 1985, there were about 60 SW different outlets in this country of some 20 million people. From 1985 to 1988, the number dropped by two-thirds. And as this is written, there may be only four Venezuelan shortwave broadcasters still regularly on the air.

Part of the reason seems economic. In the 1980s, Venezuela was one of the region's more prosperous nations, thanks to its petroleum resources. But crude oil prices fell, and economic difficulties followed. A second reason for the decrease in the number of Venezuelan shortwave outlets has been the shift to FM broadcasting, a phenomenon also noted elsewhere in Latin America in recent years.

For shortwave listeners, the decline is particularly disappointing, since Venezuela has long been one of the most interesting DX targets in our hemisphere.

Venezuela, geographically the "crown" atop South America, is a land about seven times as large as New York State, composed of 20 states and two large interior federal territories, and is largely undeveloped and under populated. Most Venezuelans live in the urbanized northern valleys of the *Cordillera de Merida*, the upper end of the Andean chain. The country's white population comprises about 20 percent of this Spanish-speaking country, with some 70 percent *mestizo*, or mixed white and Indian,

Despite the language barrier—almost all shortwave programming has been and continues to be in Spanish—Yankee listeners enjoy tuning these SW stations. Traditionally, they have been quite easy to hear, with their signals often loud and clear in North America. But even more so, SWLs have long loved the Venezuelan music, galloping *cumbias*, and pepper-hot Latin rhythms.

And though the number of Venezuelan SW stations has dwindled down to a precious few, the quality of the musical programming remains. Who knows what the future holds, but for now, enjoy those stations that are left.

CREDITS: Dustin Brann, MO; David Clark, ONT; Fred Kohlbrenner, PA; David Krause, OH; William McGuire, MD; Conrad Routh, GA; Gerald Witham, HI; North American SW Association, 45 Wildflower Road, Levittown PA 19057.


LOGO OF ONE OF THE FEW VENEZUELAN shortwave stations still on the air. The Spanish slogan suggests listeners keep their radios tuned to Radio Valera.

Let's look at the last Venezuelan SW broadcasters, and one or two more that might return to the air in the future:

The two best bets for SWLs are *Ecos del Torbes* and *Radio Tachira*, both located in the same city, San Cristobal, an urban center about 400 miles southwest of Caracas, near the border with Colombia. Set in a mountain valley, along the Torbes River, San Cristobal, with a population of nearly a quarter million, is the largest city in Venezuela's Andean region. Founded in 1561, the city retains something of its colonial atmosphere.

Ecos del Torbes—identifying, phonetically, as "A-kos del TOR-bays"—is best heard on 4,980 kHz, and sometimes also on 9,640 kHz, Radio Tachira—phonetically, "RAHD-yo Tak-YEAR-ah"—broadcasts on 4,830 kHz, where there may be interference from another Spanish-speaking station in Costa Rica.

Look for both Venezuelan outlets during the evening hours, until 0400 UTC, and again in the early morning, from around 0900 UTC.

Further east, in the state of Trujillo, is Valera, located just south of the famed Pan American Highway and gateway to the oil-producing area around Lake Maracaibo. Valera is substantially smaller than San Cristobal, with a population of only 80,000. There is where you will find *Radio Valera*, which is heard reasonably often in the U.S., despite its only modest shortwave power of just 1 kilowatt. Radio Valera broadcasts on 4,840 kHz, on a similar schedule, between 0900 and 0400 UTC.

The fourth Venezuelan SW station still heard some days is *Radio Amazonas* in Puerto Ayacucho. As its name suggests, it broadcasts from the remote southern Amazon region on the Colombian border, in a small—10,000 population—riverport town on the Orinoco River. Shortwave tends to still thrive in such frontier towns. Radio Amazonas transmits on 4,940 kHz with 1 kilowatt power (like Radio Valera) from 0900 to 0400 UTC.

In the Venezuelan capital, Caracas, only the government station, *Radio Nacional* still has shortwave-transmitting facilities. But the station, which in the past has aired programs for listeners outside Venezuela, hasn't been heard on its normal frequency of 9,540 kHz during most of the last year.

Missing from shortwave for several years is *Radio Rumbos*, also in Caracas, which remains a major Venezuelan broadcaster, but, according to its Web site—www.tycom.com.ve/rumbos/—only on the FM band. It once was perhaps the easiest Venezuelan SWer to hear on 4,970 and 9,660 kHz, and, periodically, there are rumors that it may return.

Also in the "maybe someday" category is *Radio Barquisimeto*, in the city of the same name, which used to be heard on 9,510 kHz but is today silent on shortwave. There have been reports that this station intended to return to SW to broadcast Spanish-language baseball games of its local team, the Lara Cardinals. So far this hasn't happened, but stay tuned....

## Hurricane Hunting

This is the season for tropical storms and hurricanes in the Atlantic, Caribbean, and Gulf of Mexico, and that can mean some interesting listening for SW enthusiasts living far from the danger track. For those living in harm's way, potentially it can be far more important.

Geoff Williams, writing in *Contact*, the monthly publication of the World DX Club, is a self-described Hurricane Hunter, and offers some times and frequencies for like-minded listeners.

Worth checking are the frequencies used by *CAMSLANT*, the Coast Guard Area Master Station, Atlantic. Those shortwave voice signals are all in the Upper Sideband (USB) transmission mode, which can be tuned quite easily on most modern SW receivers.

Offshore forecasts are transmitted at 0330 and 0930 UTC on 4,426, 6,501, and 8,764 kHz, and at 1600 and 2200 UTC on 6,501, 8,764, and 13,089 kHz. These include the west central North Atlantic from 32 to 41 degrees North Latitude and west of 65 degrees West Longitude; south west North Atlantic; the Gulf of Mexico; the Caribbean, and (except for the 0330 UTC transmission), the offshore waters east of New England north of 41 degrees North Latitude and west of 60 degrees West Longitude.

The High Seas forecasts, Williams notes, are aired at 0500 UTC on 4,426, 6,501, and 8,764 kHz; 1130 and 2330 UTC on 6,501, 8,764, and 13,089 kHz; and 1730 UTC on 8,764, 13,089, and 17,314 kHz. These include forecasts for North Atlantic waters north of 03 degrees North Latitude and west of 35 degrees West Longitude, plus areas of the Gulf of Mexico and the Caribbean Sea.

Additionally, *WOM*, a marine communications station operated by AT&T from Rennsuco/Fort Lauderdale, FL, airs weather forecasts, including hurricane information, at 1300 and 2300 UTC, on 4,363, 8,722, 13,092, 17,242, and 22,738 kHz.

Williams suggests the SWLs get a large Atlantic area map and plot the hurricanes from the time they form, usually off the west coast of Africa, for four or five days, until they begin to threaten the West Indies and the south and east coasts of the U.S.

## One For The Zipper

*Radio Netherlands* is airing something it says is a refreshing change from dry and maybe somewhat stuffy traditional newscasts. If that's what you're looking for, you may want to check out the Dutch shortwaver's weekly news summary called "Europe Unzipped."

A zippy compilation of news and views is what Radio Netherlands calls its roundup of the previous week's happenings around Europe, including a mix of offbeat items that never made the headlines. James McDonald, one of the show's on-air personalities, says "It's important to give listeners an authoritative news service, but it still can be bright and lively."

Look for this one on Sundays at 0043 and 0443 UTC (Remember those would equate to Saturday night in North America). As of this writing, the frequencies are 6,165 and 9,845 kHz for the first transmission; 6,165 and 9,590 kHz for the second.

## Down The Dial

What are you hearing? Have you questions about shortwave listening, or when and where to tune certain world band stations? Would you like to send a photo showing you tuning your SW

**ABBREVIATIONS**

DX—Distant broadcasting stations
FM—Frequency modulation, a broadcasting mode
kHz—Kilohertz, unit of frequency measurement
SW—Shortwave
SWL—Shortwave listener
UTC—Universal Coordinated Time, the world time standard used by shortwave listeners and many broadcasters. It is equivalent to Eastern Daylight Time plus 4 hours; CDT plus 5 hours; MDT plus 6 hours, or PDT plus 7 hours.

receiver, to appear in the "DX Listening" column? If so, just send your letter to me, Don Jensen, at **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735. In the meantime, here are some SW targets, times and frequencies to try.

**GUYANA**—3,290 kHz, *Guyana Broadcasting Corp.* is noted from before 0400 UTC with local news, followed on the hour by a relay from the British Broadcasting Corp. Or look for this station during the early morning hours, after 0900 UTC, when it airs "The Early Bird Show."

**HUNGARY**—3,975 kHz, *Radio Budapest* is noted here at around 0500 UTC with music and identification. There is an interesting group of European broadcasters that operate in this offbeat frequency band during the late evening hours. Besides Budapest, they include the *British Broadcasting Corp.* on 3,955 kHz; *Radio France International* on 3,965 kHz and Germany's *Deutsche Welle* on 3,995 kHz.

**MEXICO**—9,705 kHz, *Radio Mexico International* has bi-lingual Spanish and English programming around 1330 UTC, with mellow Mexican music and sports.

**PARAGUAY**—9,736 kHz, *Radio Nacional* may not be the easiest Latin station to hear, but it is one of the few ways to log this South American country on shortwave. Try early mornings, after 1000 UTC, for the station's "Simbolia Nacional" program with lots of mellow music.

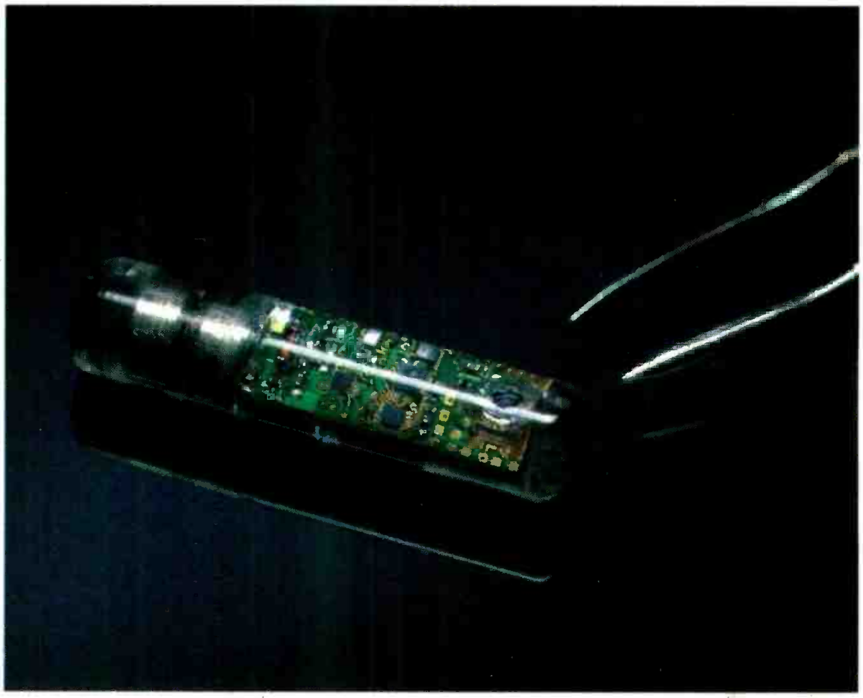
**UNITED ARAB EMIRATES**—13,675 kHz, *Radio Dubai* is one of the solid SW signals broadcast from this Persian Gulf station. It has English at 0330 UTC, with station identification, world news, and regional weather forecast, followed by feature programming.

**YUGOSLAVIA**—11,870 kHz, Belgrade's *Radio Yugoslavia* broadcasts in English at 0430 UTC, with tuning signal, identification, and a newscast. EN

# Prototype

## Tiny Pill Monitors Vital Signs From The Inside

By the end of this year, a NASA-developed "pill transmitter" is expected to begin monitoring mothers and their babies following corrective fetal surgery. The "pill" will monitor body temperature, pressure and other vital signs in the womb, radioing this critical information to physicians. NASA's Ames Research Center, Moffett Field, CA (www.arc.nasa.gov) is developing the tiny monitor, which is about the size and shape of a large vitamin pill—about ⅓ inch in diameter and 1⅓ inches long, in cooperation with the Fetal Treatment Center at the University of California, San Francisco.



THE NASA DEVELOPED "pill" monitor looks much like a large vitamin pill. (Photo by Tom Trower—NASA)

The search for a tiny sensor was made necessary by changes in surgical procedures. Previously, Pediatric surgeons at the Fetal Treatment Center pioneered a cesarean surgical approach to treat fetuses suffering from various birth defects including congenital diaphragmatic hernia. In that condition, a hole in the baby's diaphragm lets internal organs shift from inside the abdomen into the chest cavity, leaving insufficient room for lung development. Sixty to 75 percent of babies born with this condition perish.

Now, however, surgeons have shifted toward using endoscopic techniques. Normally, an endoscope is used to see into the interior of a body or hollow organ. Endoscopic instruments are now also used more frequently in surgeries requiring smaller incisions. During the endoscopic procedure, the surgeons make small incisions through the mother's abdominal wall through which tiny tubes are inserted. The surgery is then performed using long, thin instruments inserted through the tubes.

"This minimally invasive method represents the future of fetal surgery," said Michael Harrison, M.D., founding director of the Fetal Treatment Center, who in 1981 performed the world's first corrective surgery on a fetus before birth.

Operating on a fetus, however, presents some hard-to-solve difficulties. "Nearly every time doctors operate on a fetus, the mother will later undergo pre-term labor that must be monitored," said Dr. Carsten Mundt, an electrical engineer on the Sensors 2000 team at Ames. "Pre-term labor is a serious problem that is difficult to predict and monitor with conventional equipment, and often leads to the death of the baby." When doctors are able to monitor the magnitude and frequency of uterus contractions, they can identify the onset of pre-term labor early enough to prevent it from becoming life threatening to the fetus.

Previously, physicians implanted larger sensor-transmitters to monitor mother and baby. With the switch to endoscopic techniques, however, that was no longer practical. What was needed was a much smaller monitoring device. Since there were no commercially available sensors small enough for the task, NASA developed one that could fit through the endoscopic equipment. The result was the pill monitor.

The pill monitor measures the pressure of uterine contractions and temperature of amniotic fluid. The next generation of the monitor will also measure the pH of the fluid. Eventually, a smaller monitor will gauge the electrical

THE MONITOR IS SHOWN HERE with an endoscopic tube through which the "pill" can be placed inside the body.

activity of the fetal heart and transmit the data, along with measurements of the baby's body chemicals, including carbon dioxide, glucose, and ionic calcium. The pill transmits the information to the physicians at radio frequencies.

The tiny monitor could be used for other applications such as measuring core body temperature, monitoring patients for shock or checking intestinal pressure changes or stomach acidity in ulcer patients. In addition, NASA is developing a small, flat monitor that could be taped to the body like a bandage. It also is working on even smaller pills that could be swallowed by astronauts so that NASA can track their vital signs during space travel.—**By Bill Siuru** PT

## Beam Me Up

With a spark from a small laser, researchers from the Department of Energy's Los Alamos National Laboratory can analyze soils and rocks from more than 50 feet away. The prototype instrument they are developing for planetary exploration combines a laser the size of a small flashlight, optics, and a spectral analyzer into a compact, low-power package.

Laser-induced breakdown spectroscopy (LIBS) technology has been under development at Los Alamos for 18 years, but up to now has been applied to Earth-based purposes. It has been field tested for elemental analysis of rocks, soils, gases, and airborne aerosol particles. A private company is developing a field-portable LIBS unit for mining and environmental monitoring applications.

LIBS works by firing a brief, intense laser pulse at the surface of an object. The laser heats and vaporizes a small spot—about as wide as a pencil eraser—on the surface. A small telescope co-mounted with the laser captures light from the glowing vapor and feeds it into the spectral analyzer. Elements create unique spectral signatures that signal their presence; with correct calibration, the intensity of the emissions reveals the relative abundance of the elements.

"We can fire the laser every five seconds and within three minutes get enough data for an accurate measurement," said Los Alamos' David Cremers, principal investigator on the NASA-funded development effort. "The scientific returns for planetary exploration increases dramatically when you can conduct such rapid analyses."

The LIBS technique could be especially useful for planetary exploration because of its ability to conduct analyses at a distance. A rover would not have to cross hazardous terrain to sample important rocks or strata. LIBS could reach up to cliff faces or across craters or peek inside cracks and crevices. The laser also can blast through the weathered veneer on a rock and reveal the true composition hidden beneath.

Cremers and his colleagues have shown in lab tests that they can get accurate measurements for a variety of key elements from a sample some 60 feet away, and they expect the technique would be even more effective in the thin atmosphere of Mars.

The end product of the three-year, $1.1 million development effort will be a prototype LIBS instrument for field tests in the Mojave Desert. A flight model of the instrument would require additional development work to reduce the instrument's size and power requirements and increase its ruggedness.

In a related effort, a Los Alamos team led by Roger Wiens is combining a laser and a mass spectrometer to conduct standoff analyses of asteroids or other airless bodies. In LIMS, or laser ionization mass spectrometry, the laser ablates material from the surface of an object; and the freed, ionized atoms enter a mass spectrometer, which can provide compositional measurements based on the mass of an ion. The LIMS and LIBS techniques are complementary, and both can use the same laser to ablate a sample for analysis.

"Our intention through this effort is to come up with an instrument that eventually could be incorporated into a lander craft for the moon, an asteroid, or an outer solar system body," Wiens said. PT

## The Missing Link

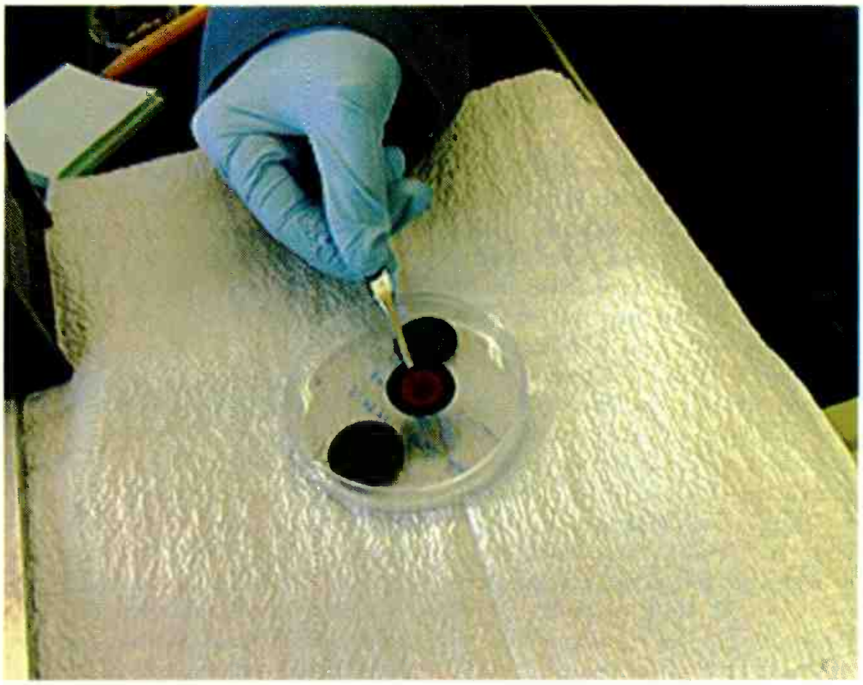
A society in which products truly "think and link" has come closer to reality. Motorola recently announced a $5 million grant to establish the Motorola DigitalDNA Laboratory in the MIT Media Lab in Cambridge.

"Smart" products, which anticipate and meet the needs of their users, are proliferating rapidly but cannot yet communicate with each other. The Laboratory will focus on actually linking these smart products, such as set-top TV boxes, automobiles, household appliances, personal digital assistants, and wireless communications systems. Instead of having independent gadgets and appliances, the goal is to develop a seamless society of intelligent mechanisms. For example, phones won't ring; they'll behave like well-mannered English butlers—knowing when and when not to interrupt you—with the full understanding of who's calling and maybe even why, according to Nicholas Negroponte, director and co-founder of the MIT Media Lab.

The grant combines major business and education resources for the purpose of developing leading edge embedded systems, software, architecture, and applications. The partnership between Motorola and MIT also increases opportunities for researchers at both organizations to actively collaborate on developing new, practical applications for embedded systems technology. PT

## Ultracapacitors Charge Ahead

Building upon an existing research patent in conducting polymers, Los Alamos scientists have created a new single-cell ultracapacitor with high-



HERE ARE THE COMPONENTS of the Los Alamos ultracapacitor prototype.

energy density—meaning it can hold a lot of energy in a small volume. The prototype ultracapacitor, a small paper-thin disk the size of a dime, contains microscopic carbon filters specially coated to act as charge-storage material. The ultracapacitor was created by electroplating a unique conducting polymer material onto the carbon filters, covering the active material with a porous separator, and adding electrolytic solution before sealing the device. It has the ability to deliver millions of discharge cycles.

According to Shimshon Gottesfeld, leader of the research team, "This is a very exciting advancement for us. Achieving 2.7 million charge/discharge cycles is a leap forward in the development of this new generation of ultracapacitors. I'd say we're well on our way to developing a product that has significant commercial value."

RESEARCHER STEVEN SHI is doing the final assembly of the ultracapacitor prototype.

In one sense, ultracapacitors lie somewhere between a battery and a capacitor. Conventional batteries provide stored energy for extended periods of time, but have peak-power and cycling limitations. Because of chemical reactions that occur within the battery, they have limited ability to charge and discharge energy repeatedly and quickly.

Conventional capacitors are capable of repeatedly providing high levels of power, but can hold very little energy. As a result, they often cannot discharge this power for more than a few microseconds.

Ultracapacitors store high levels of energy in a small volume and then release that energy in power bursts. In an automobile application, for example, a vehicle might use this burst of power to accelerate or climb a hill. Because ultracapacitors move electrical charges between conducting materials, rather than perform any chemistry, they maintain an ability to cycle far longer than batteries. Ultracapacitors, by design, are lighter and smaller than batteries with comparable peak-power levels.

According to Steven Shi, a member of the research team, "In many applications, ultracapacitors are superior to both batteries and conventional capacitors. You can cycle (recharge) them millions of times without any loss of performance. Because there's no chemical reaction, they don't deteriorate and you'll probably rarely need to replace them."

The advantage of the Los Alamos ultracapacitor over other ultracapacitors currently in development or on the market is its large surface area, achieved while maintaining an open structure that allows for shuttling of ions. This open structure combined with high surface area allows for higher electronic and ionic connectivity between the active material and the electrolyte. PT

## FAST On-The-Spot Training

Factory workers faced with unfamiliar tasks may soon be able to get the information they need to complete the job thanks to an electronic performance support system that provides "just in time" training whenever it is needed.

Known as Factory Automation Support Technology (FAST), the prototype system uses job performance support software, wireless communication, and a wearable computer that operates hands-free, Researchers at the Georgia Tech Research Institute (GTRI) have created two FAST applications for the poultry industry, though the system has applications in other industrial sectors as well.

"FAST is intended to support mobile employees as they perform a job, rather than train them before," said Chris Thompson, a senior research engineer.

The basic FAST hardware, which is undergoing a fourth generation of design, includes: a credit-card-sized computer and wireless-communication system worn on the belt, allowing portability and transmission of data in real time to other computer systems; a visor worn like safety glasses to display computer information to the user via a miniaturized display; earphones for listening to auditory information provided by the computer; a microphone to allow voice-activated, hands-free operation of

A POULTRY PLANT WORKER uses the FAST prototype system to collect quality assurance data.

the computer; and flexible eight-hour battery packs worn on the belt.

"We faced two challenges in designing the hardware system," Thompson said. "We had to make the wearable computer as small as possible to be comfortable for users. And robust voice recognition required a lot of processing power, which in turn necessitates a large battery. We are still working on these issues. The fourth generation of the system will greatly increase our processing power, while the flexible battery belt will allow an operator to work an entire shift without recharging."

On the software side of FAST, the design team encountered problems with their voice-recognition software because of high ambient noise in factories. So they limited the vocabulary needed to give commands to the system and used noise-canceling microphones.

Creating information databases for the poultry-plant applications of FAST also challenged researchers. Typical information databases include: reference information about a job task or closely related set of tasks; just-in-time, task-specific training; expert advice about a job task; advice on how to use the performance support system effectively; application-help functions; and automated tools for task performance.

FAST applications, which have been briefly field tested, help poultry-plant personnel collect quality-assurance data. The application now under development will collect data for USDA regulatory compliance requirements. The projects are a partnership between GTRI, the state of Georgia, and the Georgia poultry industry.

"In our field tests, employees have been very excited by the FAST system," Thompson said. "There's a 'cool' factor to it." PT

# Eyes In the Sky

A new satellite instrument was recently rolled out of its calibration vacuum tank after almost five months of pre-launch instrument calibration work at Los Alamos National Laboratory. The Multispectral Thermal Imager (MTI) carries instruments designed to provide unprecedented levels of accurate information across 15 spectral bands (colors), only three of which are visible to the human eye. The non-visible, infrared (IR) spectral bands will allow researchers to measure the atmosphere between the ground scene and the satellite and also look for more subtle attributes of the scene. Specific science tasks will include analyzing surface temperatures, water quality, and even vegetation health.

To gather its image data, MTI looks through a 36cm aperture and uses a bank of three sensor chip assemblies, each carrying 15 arrays of detectors. The arrays contain either 208 or 832 pixels, providing MTI with nearly 17,000 tiny detectors, each no larger than the period at the end of this sentence. The 510-pound instrument is designed to be self-correcting in its data gathering, adjusting for the effects of clouds, water vapor, and airborne particles present in each image of the ground.

One enormous advantage of these arrays is that they see far beyond the visible wavelength, providing researchers with a depth and complexity of data not available through simple visible-light photography. A standard photograph of a section of light-colored ground, from a distance, might resemble either sand or snow, but given the additional infrared or temperature data, the difference becomes clear. Different types of terrain, vegetation, and other surface features become highly distinguishable when images in 15 different wavelengths can be obtained at the same time.

MTI is scheduled to transmit up to six stereo images during 5- to 10-minute daily downloads that would fill a modern PC's hard disk in less than a week, offering a wealth of information to its users. Data from the satellite will come to the Los Alamos Data Process Analysis Center for analysis, and from there will be distributed to the various users for each type of information. With uses ranging from remote sensing of DOE installations and other cooperative installations in the US, to climate and vegetation monitoring , the satellite has its own MTI Users Group, with more than 100 members representing varied military and civilian agencies, including the Air Force, Navy, Army, NASA, the National Oceanic and Atmospheric Administration, and universities.

The satellite, scheduled to be launched into a low-earth orbit October 31 of this year from Vandenberg Air Force Base, has been undergoing instrument calibration at the Lab's advanced optical and infrared calibration facility, a multi-user resource used by researchers nationwide from a wide variety of fields.

The initial Los Alamos task was to provide a ground calibration with sophisticated standard light and infrared sources, as well as calibrating MTI's own on-board light and IR sources, ensuring that the spectral imaging hardware operates at peak performance for its three-year planned mission. Any degradation of the on-board equipment will be detected, measured, and corrected for if the system is operating at its most effective.

The Los Alamos calibration facility is unique in offering state-of-the-art calibration from blue visible light through the long-wave infrared in a single system. The calibration sources for this project were developed in collaboration with the National Institute of Standards and Technology (NIST), and they were calibrated directly at the NIST laboratories. Using a specially developed thermal vacuum tank and liquid nitrogen cooling at -320°F, researchers were able to simulate the frozen, airless conditions of space, perfecting the satellite's ability to take accurate measurements during the MTI flight. Following the joint development with NIST of the highly accurate infrared source for this project, NIST adopted its design and will use it in the new NIST advanced calibration facility in Gaithersburg, MD.

"The accuracy we're achieving here is pushing the state of the art," according to Steve Bender, calibration team leader. PT

BY MARC ELLIS

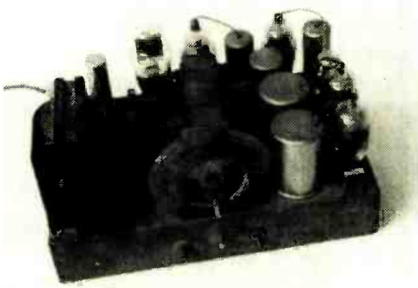
# Restoring a Classic Philco Cathedral

IN THE LAST COLUMN, WE CONCLUDED A DISCUSSION OF THE IMPACT, ON RADIO SET DESIGN, OF THE GREAT DEPRESSION OF THE 1930S. WITH THE ADVENT OF SUPER-EFFICIENT PENTODE TUBES AND THE INCREASE IN THE NUMBER AND SIZE OF broadcast stations, it was now possible to market a very minimal radio (with as few as three tubes plus rectifier) that would deliver very satisfactory performance—at least on local stations—without an outside antenna. Many new manufacturers sprang up to market these "el cheapo" sets to the cash-starved, but entertainment-hungry, populace.

As discussed in an earlier column, Philco had a different notion of depression marketing. Their response was to produce a line of sets that, though less expensive than established models, were far from minimal. They were essentially full-featured console radios in table-model cabinets. In fact, many models were optionally available in console cabinets for those with the cash and the inclination.

The marketing concept was remarkably successful and Philco turned out the new table models by the hundreds of thousands. Because of their rounded tops and the fact that their speaker grilles are reminiscent of stained glass windows, collectors call sets of this style (by Philco and others) "cathedrals." Arguably the most popular of the Philco cathedral models among collectors today are the Model 90; its somewhat smaller, but visually almost identical, Model 70; and the somewhat less well known Model 21. With cabinets by master industrial designer Edward L. Combs, these radios are true classics.

Though a Combs cathedral can be pricy, it is an item well worth pursuing. In fact, I'd say that no representative collection of American broadcast sets would be complete without one! I've been saving a Model 70 for some time to restore for the column, and it looks like the time has come!



THE PHILCO 70 AS RECEIVED. For better visibility, the hooded tube shield has been removed from group of three tubes at right edge of chassis.

## A Project Worthy of Frankenstein

My model 70 chassis came to me several years ago through the courtesy of a reader whose name unfortunately I no longer have. The set was cluttering up his basement and he wanted to find it a new home. Needless to say, I was very quick to take him up on his kind offer!

Now I had a chassis, but I needed a cabinet. Eventually my search led me to Norman Sandbach of the New Jersey Antique Radio Club. He was a Philco collector and had an extra 70 cabinet to sell me. Since we were both going to attend the Antique Wireless Association Annual Conference (Rochester, NY) that year, he offered to bring it along.

Norm's cabinet looked pretty decent, but it was missing the rear arch support. I understand this is a common problem in Philco cathedrals; the glue dries out, I suppose, and the piece falls out. The cabinet also needed a dial bezel. Thinking ahead, Norm had brought along another model 70 with an intact support, and we made a tracing for my use in cutting out a replacement piece. He also introduced me to a few other members of the NJARC who provided additional help with the project.

I believe it was Tony Flanagan (since a silent key), president of the club, who provided me with the missing dial bezel. He stripped it right off a Model 70 console cabinet that he had on his truck! I also met Joe Milano, who showed me some of the amazing refinishing work he had done on Philco cabinets. Joe was patient enough to explain his techniques slowly so I could take some good notes.

I still remember with pleasure Norm's whirlwind introductions to the various NJARC guys and the generosity and good fellowship with which they shared their parts and expertise! Now the time has finally come to put all of this together and, hopefully, come up with a complete, attractive and nicely-operating Model 70. I do feel a little bit like Baron Frankenstein, though, as I contemplate assembling a finished unit using the parts of so many deceased sets!

## Taking Stock of the 70 Chassis

My Model 70 chassis is quite possibly the cleanest set I have ever worked on. Though it has a light coating of dust

HERE'S THE CABINET I was fortunate enough to purchase from Norm Sandbach of the New Jersey Antique Radio Club. The missing rear arch support is now on order.

(probably from its long stay in my own basement), there is a total absence of that gummy dirt that so often must be cleaned from tubes and other components as the first step in a restoration. There is hardly a trace of corrosion above or below the chassis, and the anodized finish is completely intact, except for an area around the base of the power transformer where some material had apparently oozed out at one time.

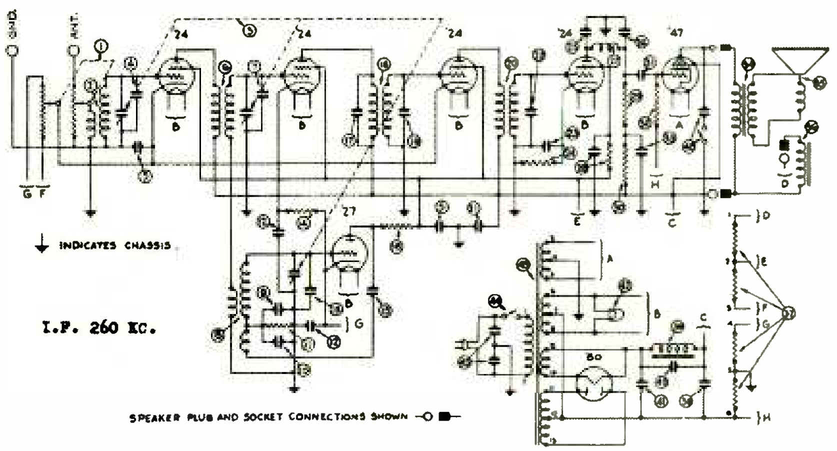
This material can be scraped off with a fingernail, but unfortunately it seems to take the finish with it, showing the bare steel beneath. It may be that the transformer did overheat at one time and lose some wax or other compound. I noted that the original electrolytic caps had been replaced, and it may be that the originals had shorted and caused this problem.

Studying the underside of the chassis carefully, I could find no other sign of overheating or other destructive problems. The paint on all of the charming old-style "body-end-dot" coded resistors was still bright, and I saw no signs of arcing or smoke. There are a few rubber-covered wires with brittle and cracked insulation, and these will have to be replaced, of course.

As many of you know, all of the paper capacitors in Philcos of this vintage are potted inside bakelite blocks, with their leads internally connected to solder lugs that are used to make connections to the rest of the circuitry. Comparing my chassis with the pictorial diagram of the set in the *Rider's Manual*, I noted that all six of the original blocks are still installed, though one was bridged with a couple of external paper caps—perhaps to replace open-circuited ones inside.

A comparison with *Rider's* also revealed that my set, being the earlier of the two Model 70 variations, lacks AVC, and it controls volume at the front end of the receiver rather than in the conventional manner at the detector stage. The tube lineup of this set is: RF amplifier, mixer, IF amplifier, detector—all type 24; local oscillator—type 27; audio output—type 47; rectifier—type 80. See my final **Popular Electronics** column (May, 1999) for a more complete discussion of the Model 70 and Model 90 variations.

Next, as I usually do in the early stages of examining a new radio, I pulled the rectifier tube (the usual type 80), plugged in the set, and turned it on. With the rectifier tube out, of course,




THE 70's CIRCUIT is a conventional superheterodyne with type 24s as RF amplifier, mixer, IF amplifier and detector; a type 27 oscillator; and a type 47 power amplifier. This version does not have AVC.

the set would receive no high voltage, which could wreak havoc in case of a (very likely) capacitor failure. All tube filaments glowed with normal brightness and a meter placed across the plate pins of the "80" socket showed proper high voltage. This was a relief, considering the signs already noted of an overheated power transformer.

## Parts "Want List"

With the preliminary exam over, I began to itemize the parts and services I knew I'd need for the restoration. I planned to completely recap the set, of course, and that meant looking up each of the bakelite-block condensers to see what parts were inside. *Rider's* yielded the part number of each of the blocks in my set. From there I referred to Ray Bintliff's comprehensive book *The Radio Collector's Guide to Philco Bakelite Block Condensers*, which showed the block wiring hookups as well as the values of the caps (and, in one case, a resistor) installed within. Ray's excellent source is still in print and available from most dealers who stock books for radio collectors.

At first, the original values of the electrolytic caps in the power supply were a mystery because the *Rider's* schematic offered only parts numbers. However, the mystery was solved soon after I logged onto my friend Chuck Schwark's web page (http://members.aol.com/caschwark/index.htm). In his very well organized "Philco Repair Bench" section, Chuck has assembled an impressive amount of information for Philco restorers. One section untangles the parts numbers, and I shortly discovered that the original "4916" capacitors had been rated at 6 mF at 450 volts.

If I hadn't already had the Bintliff book in my possession, Chuck's site would have also yielded the information I needed about the contents of the bakelite blocks. Browsing further, I also found a graph of serial number distributions by year originally worked out by Ron Ramirez, author of the popular book *Philco Radio 1928-1942* (ISBN: 0-88740-547-9). Using it, I discovered that my chassis (#656665) had been manufactured between September and October of 1931.

Elsewhere on the site, I discovered Dick Oliver of Elkhart, IN (219-522-4516), who supplies replacement rear arches for Philco sets ($20.00 plus $3.00

*(Continued on page 24)*

BY KONSTANTINOS KARAGIANNIS

# Digital Audio and MP3

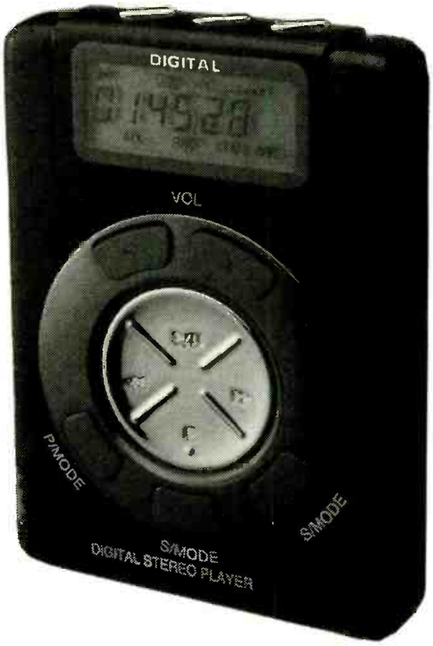
MULTIMEDIA FILES ARE LARGE—REALLY LARGE. A HALF-HOUR OF FULL-MOTION, FULL-SCREEN VIDEO COULD CONSUME OVER A GIGABYTE OF STORAGE SPACE. CD-QUALITY AUDIO, WHILE NOT AS BANDWIDTH INTENSIVE, STILL manages to fill up a little over half a gig per hour. With hard drives coming out in capacities over 20GB these days, such numbers might not seem so outrageous. However, when digital multimedia first started becoming popular in the early 90s, the typical hard drive (a few hundred MB) would have filled up with even one short video recording.

Because so many zeros and ones are necessary to capture audio or video in a binary form, various compression schemes or formats were developed. The most popular of these was created by the Moving Picture Experts Group (MPEG), and each version bears this organization's name. In the realm of encoding or compressing video, the two most common are MPEG-1 and MPEG-2, used for CD-ROM- and DVD-quality applications, respectively. These formats are a topic for another time. For now, we'll be examining the compression used for audio and its surprising recent effects on the Internet and the music industry.

## Digital-Audio Basics

The phrase *digital audio* covers any aspect of sound processing or recording where waveforms are converted into a digital format or file. To accomplish this conversion, a process called sampling is used.

Sampling occurs when an analog-to-digital converter (ADC) captures "samples" of an audio waveform. The size of the sample is measured in bits. CD-quality audio uses 16-bit samples, though newer, pro audio gear can sample as high as 24 bits of data at a time. It is these higher bit sizes that will be used in DVD-A or DVD audio discs when that specification is finalized; this medium is a must for such high quality, as the higher the sample size, the bigger the resulting audio files.




THE FIRST PORTABLE MP3 player still seems to be the best. Diamond's Rio PMP300 can hold 60 minutes of audio and will run for 12 hours on a single AA battery.

How often an ADC samples a waveform is measured in kHz and is known as the sample rate. To get CD quality, an ADC has to sample at 44.1 kHz, or 44,100 times a second. Having just mentioned the coming DVD-A spec, we might as well note that it will use 96 kHz. Like the bit size, the higher the sample rate, the larger the resulting audio.

Consider the two aspects of digital audio for a moment. Obviously, the higher the values of each, the better the quality. The more often you sample a waveform and the larger the size of those samples, the more accurately you can recreate sound. While DVD-A is on the way and provides ultra-realistic music with surround channels, for the rest of our discussion we'll use CD sampling as our base value for audio files.

Uncompressed CD audio requires a bandwidth of 1.5 megabits per second (Mbps). That means every eight seconds of CD audio will take up 1.5MB of storage (remember, eight bits make up a byte). To make it possible to easily store or transmit these files, it's clear that compression is needed.

## MPEG Audio

Everything in the computer biz comes about in stages. Granted, lately it seems like these advances are happening at a soaring rate but, still, most technologies evolve linearly. That too is the case with MPEG audio.

The first MPEG scheme used to encode sound was called Layer 1. Using its 1:4 compression format, CD-quality audio could be had with a 384-kilobits-per-second (Kbps) bandwidth. It was a large improvement over the uncompressed 1.5-Mbps rate, but still resulted in large file sizes. Layer 1 was used in

Philips's Digital Compact Cassette (DCC) ... remember that techno dinosaur?

As you might have guessed, the second MPEG scheme was called Layer 2. Twice as efficient as its predecessor, Layer 2 has a 1:8 compression, with a 192-Kbps bandwidth. Its most common use was in digital radio stations, where the standard is also known as MUSICAM. The relatively small file sizes of Layer 2 also became popular with Internet users, and for the first time, manageable, CD-quality files began appearing, saved in the .MP2 format.

The popularity of compressed audio exploded, however, with the introduction of Layer 3 or MP3 format. With a 1:12 compression, and minimum rate of 128 Kbps, MP3 made it possible to store about a minute of high-quality stereo audio in a megabyte. If you have 650MB of storage space free, you can store about 15 hours of music.

An interesting facet of Layer 3 is that you can increase the bit rate, say to 160 Kbps, to get even better quality. Except for that last variable rate capability, all MPEG Layer compressions work in a similar fashion. An MPEG encoder (usually software) takes a digital audio file and analyzes the frequencies that make it up. The encoder then removes the frequencies that the human ear cannot detect and stacks the remaining data in a new file. Layer 3 takes this process a step further by removing quiet tones that are similar to louder ones (*i.e.*, the softer ones won't be heard anyway) and by encoding repetitive patterns fewer times to save space.

To play back one of these MPEG audio files you naturally need a decoder, either software or hardware. The former are tiny apps that you can load onto your computer from the Internet; the latter are portable players that have appeared on the market in the past few months. Let's look at both types.

## Software Encoding/Decoding

The great majority of people enjoying the benefits of MP3 files are doing so exclusively on their PCs or Macs. Pentium-class and better machines can easily handle the task of encoding or decoding Layer 3 audio. The only other thing that's needed is the right software for the job.

First you'll need a way to get digital audio into your computer. You used to have to first use a "ripper"—which essentially copies all the songs off a CD (which you put in your ROM drive) and saves them as .WAV files—and then an encoder. Now, though, you can encode directly from CD using an innovative program, MusicMatch's *Jukebox*. It will even let you play the files back. This is shareware and will only let you encode five songs before it expires, but a $29.95 registration fee will get you up and running again.

For playback, though, I prefer *Winamp*, easily the best MP3 player around. This shareware program will never expire, but if you like it you really should send the company the $10 fee. With *Winamp* you can create playlists (and even let the program randomly shuffle the tracks) and use a 10-band graphic equalizer to fine tune sound. The EQ's great for computers with no bass and treble control.

**VENDOR INFORMATION**

**Diamond Multimedia Systems, Inc.**
2880 Junction Avenue
San Jose, CA 95134
Tel: 408-325-7000
Web: www.diamondmm.com

**MusicMatch**
Web: www.musicmatch.com

**Pontis**
Irrenloher Damm 17
D-92521 Schwarzenfeld
Germany
Tel: +49 (9435) 54 07-0
Web: www.mplayer3.com

**Winamp**
Web: www.winamp.com


*WINAMP* IS A SHAREWARE PROGRAM that will reproduce with crystal quality any .MP3 files you get onto your PC's hard drive. With its wideband EQ and intuitive playlist creator, *Winamp* has become quite popular.

PONTIS, A GERMAN COMPANY, recently announced its entry into the portable MP3 market. Called the MPlayer3, the device lets users download files to Multi-MediaCards or insert ROS prerecorded music cards.

## Portable Players

Last year the music business was in an uproar, with key companies trying to legally prevent the release of Diamond Multimedia's first US portable MP3 player, the Rio PMP300. Of course, the legal battle fell apart, analogous to record companies trying to prevent the sale of tape recorders. It was decided that the real legal offenders are those who post music they don't own the copyrights to (more on that later).

The Rio is an amazing little device. Weighing 2.4 ounces and fitting in the palm of your hand, it contains 32MB of memory (and a Flash memory slot for more) that will let you store about half an hour of CD-quality music, or an hour of radio-quality tunes (you can adjust the bit rate). With no moving parts, the Rio will operate skip-free for 12 hours on a single AA battery. If you're planning on getting one, don't invest in *Jukebox*—it's included. The Rio retails for $199.

A cheaper player ($159) just entered the market from the German company Pontis. Called the MPlayer3, the device uses Multi-MediaCards to store audio. The MPlayer3 comes with two slots, each filled with an 8MB MultiMediaCard, so it offers only half the base storage of the Rio. By the time you read this, 32MB cards should be available as add-ons, with capacities as high as 128MB expected soon. The MPlayer3 also uses ROS prerecorded music cards—a non-erasable format on which record companies are expected to release tracks and albums.

With either of the above players you are a little limited by the fact that you'll have to invest in extra memory to get real long-term listening on-the-go. However, it's a step in a great direction. With memory only getting cheaper, portable MPEG-audio players are going to be a hot product in the coming years.

## Are MP3s Legal?

As we hinted at earlier, the vast majority of MP3 files on the Net are illegal copyright violations. In other words, people encode store-bought CDs and post them for all to enjoy. For legal reasons we can't recommend any sites that will help you take part in such copyright infringement. We can only say that there are plenty of Web sites and Usenet newsgroups dedicated to the posting of MP3s.

If you want to get MP3s legally, and don't want to make your own, you have a couple of options. First, visit a site like *www.mp3.com* that offers free songs from upcoming artists, or download free MP3s offered by record companies. Some offer only clips, some provide complete songs or even tracks that were recorded purely for the Net.

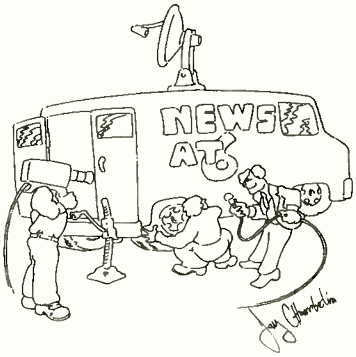
That about wraps it up for this month. As usual, if you'd like to get in touch with any comments or questions feel free to send e-mail to connections@gernsback.com, or snail-mail to *Computer Connections*, **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735. **EN**

## ANTIQUE RADIO

*(continued from page 21)*

shipping). With that information in hand, my plans for making my own arch using the tracing from Norm's set quickly evaporated! (Yes, I have a definite lazy streak—maybe "aversion" would be a better word—when it comes to woodworking or refinishing projects!)

As this column goes to press, I'll also be ordering the required parts so that I'll have the opportunity to carry the Philco 70 project far enough along to have a progress report next time. **EN**



# EQUIPMENT REPORT

MATRIX MULTIMEDIA PICTUTOR CD-ROM

*This PIC training package teaches you how to develop code for PICs and lets you program and control a working PIC from your PC.*


PICs, or Programmable Integrated Circuits, are unique little microcontrollers that are used in all types of circuitry. Their economy and scale is perfect for controlling circuits that are not too involved. Most readers of this magazine are probably familiar with PICs to some extent, but it can never hurt to know more. This Equipment Report details *PICtutor*, a CD-ROM/PIC trainer-board bundle—from Great Britain's Matrix Multimedia—that provides you with everything you need to write code for and operate a programmable PIC16C84 microcontroller.

Multimedia CD-ROMs make for great tutors in most subjects because they can contain multiple types of media and take users through different sections at the pace they are comfortable with. CD-ROMs also make it a simple matter to go back to a certain section or to search for a particular topic or item. The Matrix Multimedia's PICtutor CD-ROM is no exception. It contains all the theory, software, and sample material you need to program a PIC. The disc even contains sample files that can be downloaded directly to the PIC16C84 microcontroller board through your PC's parallel port.

## PICtutor

PICtutor is easy to benefit from. Not only can you brush up on the theory behind PIC circuitry, but you can also use PICtutor to help develop code for your own PIC microcontroller-based projects. PICtutor is useful for students, technicians, engineers, teachers, and the like.

The PICtutor software is easy to install, and you don't need a high-end PC to run it. System requirements include an IBM compatible 486/25MHz PC as a minimum, with a CD-ROM drive, VGA graphics with 256 colors, 8MB of RAM, about 10MB of hard disk space, a mouse, and Windows 3.1 or Windows 95/98. A sound card is not required.

Anyone familiar with basic Windows programs will have no trouble navigating the PICtutor software. Various menus take the user to different sections of the disc. One must also be comfortable using DOS to a certain extent because the software that writes PIC code and downloads it to the PIC circuit board runs in DOS.

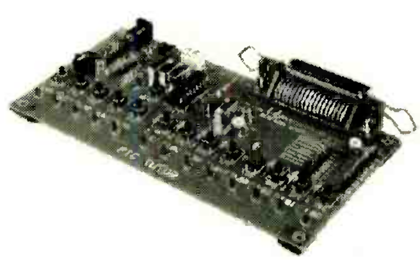
The fully assembled PICtutor training board is easy to hook up and use. It runs off a DC power supply and connects to a PC through the parallel port. While the PICtutor CD-ROM and trainer board are no substitute for a college degree or good old hands-on field experience, the bundle is a good place to start your self-education. And PICtutor does provide both PIC theory and hands-on programming activities.

The PICtutor CD-ROM teaches you how to write machine code to run PIC microcontrollers. The CD-ROM features 39 tutorial sections that cover PIC architecture, commands, and programming. Advanced programming techniques are also discussed, and examples of watchdog timers, interrupts, sleep modes, and more are provided.

Over 80 exercises featured in PICtutor interactively test the user, and an on-screen "virtual PIC" lets you write and test programs without touching any actual circuitry. PICtutor includes more than 30 working example programs and a shareware assembler. The tutorials have you modify some PIC assembly files and write your own command sets. Various messages will prompt you should you make an error.

The PIC training board can be used with or without the PICtutor CD-ROM. The fully assembled board houses a programmable PIC16C84 microcontroller along with switches, LEDs, and other circuitry that support the PIC. The PIC board connects to a PC through the parallel port using a standard Centronics printer. The board requires a 12- to 14-volt DC power supply, and a battery holder for eight AA cells is provided. The board can be upgraded to drive a quad 7-segment display and intelligent alphanumeric display.

A word processor or text editor is used to edit and create .ASM files for assembly through TASM, the shareware assembler included on the PICtutor CD-ROM. The disc also contains TASM documentation and the demonstration files used in the PICtutor tutorials. Demo files are supplied as ASCII text files with a .ASM extension and as assembled object code files with a .OBJ

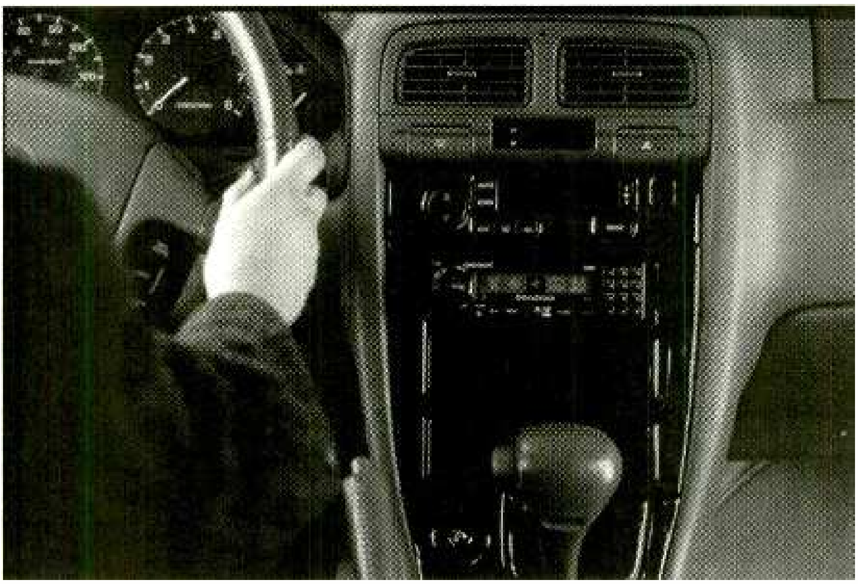


THIS FULLY ASSEMBLED PIC programmer is included in the PICtutor bundle.

*(Continued on page 29)*

## In Dash PC

THE CLARION AUTOPC INTEGRATES car audio, computing functions, navigation, and wireless communications into a 1-DIN unit in a car's dashboard. It is a high-powered AM/FM stereo with integrated digital stereo processing (DSP) equalization and a built-in 35-watt × 4-channel amplifier. In addition, Windows CE, Hitachi SH3 processor, and 8MB DRAM/8 MB ROM are all included with the system. The unit features the first ever in-dash USB CD audio and CD-ROM drive, which supports an optional six-disc CD/CD-ROM changer. The backlit, eight-color LCD screen provides the user with an easy-to-read, icon-driven user interface.



CIRCLE 20 ON FREE INFORMATION CARD

Designed with safety, efficiency, and convenience in mind, the unit recognizes over 200 simple voice commands, allowing use of the unit without drivers ever taking their eyes off the road. With its text-to-speech application, the Clarion AutoPC can provide status information and e-mail alerts through speech synthesis and text information presented on the unit's display.

To make finding destinations easier, the Clarion Auto PC comes with a basic point-to-point navigation system that provides route calculations from a user-specified starting location and destination, as well as accurate turn-by-turn directions. Other built-in applications include an address book, mileage log, and a hands-free voice memo feature.

The AutoPC supports an optional Compact Flash Memory Card that can be used to expand the on-board memory as well as provide an interface for other products such as paging and hardware accessories. Also included is an Infrared Data Port that allows easy data exchange with a handheld PC.

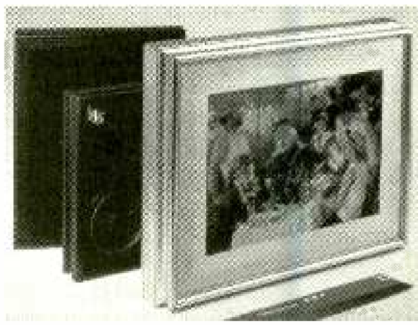
The optional Global Positioning System (GPS) receiver works in conjunction with the built-in navigation system to provide automatic starting-point identification and location updates. The GPS accessory, along with the cellular-phone interface, provides access to roadside emergency services, such as receiving directions when lost and pinpointing the location of a 911 call for immediate assistance.

The Clarion AutoPC has a suggested retail price of $1299.

**CLARION CORPORATION OF AMERICA**
*661 W. Redondo Beach Blvd.*
*Gardena, CA 90247*
*Tel: 310-327-9100*
*Fax: 310-327-1999*
*Web: www.autopc.com*

## Flat Speakers

USING FLAT-PANEL TRANSDUCER technology, Flat Speakers provide superior sound quality in a package less than two-inches thick. These speakers can be concealed behind art to complement the decor of any room.



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A standard black or white speaker screen can be replaced with any of more than 1000 framed art prints. Art covers are printed on a synthetic silk developed specifically to display vibrant color while simultaneously maintaining auto fidelity. Speaker wires can be concealed inside a wall or optional flat speaker wire can be hidden under wallpaper.

Flat speakers are available in sets of two. Small speakers (11 × 14 inches) are $595. Large models (18 × 24 inches) are $895.

**FRONTGATE**
*2800 Henkle Drive*
*Lebanon, OH 45036-8894*
*Tel: 800-626-6488 or 513-933-8050*
*Fax: 513-933-8055*
*Web: www.frontgate.com*

## DC Power Supply

THE PS402 TRIPLE OUTPUT DC Power Supply contains two 0- to 30-volt outputs with an adjustable 3-amp cur-

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rent limit. The outputs can be connected in series to double the voltage. There is also a fixed 5-volt output rated at 3 amps.

The unit monitors the DC voltage or current supplied to the load, using a selectable digital display. Two front-panel LEDs indicate the "Constant Current" and "Constant Voltage" crossover point automatically, eliminating the need to constantly adjust the output voltage or current. Other features of the power supply include adjustable current limiting; single, series, or parallel operation; and low ripple and noise.

The PS402 comes with test leads and manual and has a list price of $529.

**SENCORE INC.**
*3200 Sencore Drive*
*Sioux Falls, SD 57107*
*Tel: 800-SENCORE or 605-339-0100*
*Fax: 605-339-0317*
*Web: www.sencore.com*

## Two-Way Radio

FAMILY RADIO SERVICE HELPS people keep in touch, whether in a mall, a park, or out camping. These small, colorful, two-way Family Radios provide clear reception for two miles. A license is not required to operate the radios, which are FCC registered.

The radios operate with exceptional clarity and minimal interference at an ultra-high FM frequency (462-468 MHz). They feature 14-channel electronic tuning and a two-way page function, which can be set to communicate with other GE radios or with other brands of FRS units. The LED display provides information on the radio's channel, and LED indicators show transmission and battery life.

Available in blue and orange (models GE3-5873 and GE3-5877, respectively), the Family Radio Service (FRS) units have a suggested retail price of $69.99.

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**THOMSON CONSUMER ELECTRONICS**
*10330 N. Meridian Street*
*Indianapolis, IN 46290-1024*
*Tel: 317-587-4450*
*Fax: 317-587-6708*
*Web: www.rca-electronics.com*

## Toroidal Transformers

THESE LOW-PROFILE TOROIDAL power transformers are half the size and weight of conventional EI types of equal VA rating. Designed for rectifier circuitry applications, the step-down transformers are available in power ratings

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from 26VA to 1000VA for the international series with 117V/234V input voltages and up to 600VA for the North American series with a single 117V/60Hz input voltage. The transformers (whose core is made from a continuous strip of M3-grade high-flux grain-oriented silicon steel wound under controlled tension) come with dual output voltages and are certified to North American and international safety standards.

Mounting hardware consists of a metal washer and two rubber pads for power ranges under 600VA. Larger transformers are supplied with an epoxy potted center with a ¼-inch mounting hole. Other options include L-brackets for vertical mounting, termination with connectors, or supplying the transformers either fully potted or bare inside metal or plastic enclosures.

Prices for sample quantities (1-4 pieces) range from $33.40 for the 26VA to $109.75 for the 100VA. (Prices are slightly higher for the North American series.)

**TORTRAN, INC.**
*915 Pembrooke Street*
*Bridgeport, CT 06608*
*Tel: 877-TORTRAN*
*Web: www.tortran.com*

## Professional Multimeter

COMBINING A TRUE RMS MULTIMETER with a single-channel 100-kHz graphical oscilloscope, the Craftsman Professional handheld (4.2 × 8.3 × 2.2) Multimeter + Scope is ideal for household appliance testing, installation and service, electrical projects, electronic design and testing, and auto repair and tune-up. The oscilloscope provides glitch capture, pre/post trigger, and graphic LCD with a HELP mode. Among the multimeter functions are True RMS AC voltage/current, DC voltage/current, resistance, capacitance, frequency, dB, temperature (with adapter), % Duty Cycle, pulse width, period, TTL level generator, and diode and continuity tests.

Features of the meter include a built-in RS-232 interface (cable and software sold separately), minimum/maximum/average displays, 15 waveform memory, auto power off, and surge protection. The 4000-count (3¾-digit) multimeter display with analog bar graph also offers data-hold and over-range indication. The unit comes complete with built-in stand, six AA batteries, fuses, test leads,

*(Continued on page 92)*

# NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

## The 1999 Technical Library CD-ROM

*from Microchip Technology Inc.*
*2355 W. Chandler Blvd.*
*Chandler, AZ 85224-6199*
*Tel: 602-786-7668*
*Web: www.microchip.com*
**Free**

This CD-ROM contains a complete selection of technical documentation on Microchip's PICmicro 8-bit microcontrollers, non-volatile memory devices, secure data products, and associated development tools. The CD-ROM provides an extensive collection of Microchip product specifications, application notes and related source codes, development systems, software support for embedded control applications, programming specifications, users' guides,

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and more. Giving users the flexibility to edit, compile, emulate, and program PICmicro MCU devices—all from a single user interface, the library includes the most current release of the MPLAB Integrated Development Environment Software.

All documents are readable in Adobe Acrobat Portable Document Format (.pdf) and run under the included Adobe Acrobat Reader 3.0. A copy of Winzip is also provided to access very large files. In addition, hot links to the on-line Web site are established throughout the CD-ROM.

## Passport to Web Radio, 2nd Edition

*by Lawrence Magne, Editor*
*International Broadcasting Services Ltd.*
*Box 300*


CIRCLE 339 ON FREE INFORMATION CARD

*Penn's Park, PA 18943*
*Tel: 215-598-9018 or 215-598-3298*
*Web: www.passport.com*
**$19.95**

It is now possible to hear more stations on the Web than can be heard at any location through the airwaves, while continuing to use your computer for other tasks. Listeners anywhere with Web access and a multimedia PC can hear more than 1550 stations from over 100 countries. Examples of programming that can be heard include: Radio Beethoven from Santiago, Chile; Dixieland direct from New Orleans; a Mohawk Indian radio station; bluegrass, folk, and country music from the Czech Republic; rugby from New Zealand; and Moroccan music from Casablanca. While most Webcasting stations are live, some offer on-demand programming.

In its nine entertaining chapters, the book explains how to listen to Internet broadcasts; reviews the top stations in categories from African to Vietnamese; and presents the only country-by-country, city-by-city directory of Webcasting stations. It also discusses the future of Web radio.



## Internet Frauds Databook

*by John J. Williams*
*Consumertronics*
*P.O. Box 23097*
*Albuquerque, NM 87192*
*Tel: 505-237-2073*
*Fax: 505-292-4078*
*Web: www.tsc-global.com*
**$19**

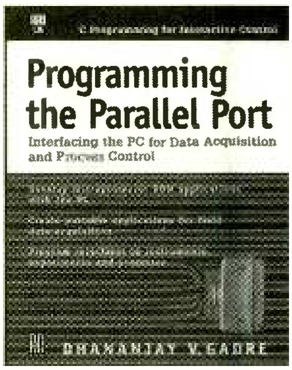
CIRCLE 340 ON FREE INFORMATION CARD

Internet cons, scams, and related frauds take in over $2 billion annually. Most are done anonymously and with little fear of prosecution. This book discusses how and why such fraud is accomplished. Other topics covered are how to protect yourself, ways to identify a swindler, how victims are chosen, hazards of the Internet, and more.

## Programming the Parallel Court

*by Dhannajay V. Gadre*
*R & D Books*
*1601 W. 23rd St., Suite 200*
*Lawrence, KS 66046*
*Tel: 800-444-4881 or 785-841-1631*
*Fax: 785-841-2624*
*Web: www.rdbooks.com*
**$44.95**

A wealth of information for C programmers and circuit designers who are creating interfaces to control external devices that are connected to PCs through the parallel port is contained in this book. The author guides you through a detailed tour of the parallel printer port and, in a master class of




CIRCLE 341 ON FREE INFORMATION CARD

techniques and sample programs, shows you how to exploit the power and versatility of this PC feature,

The text provides both a theoretical and practical foundation on which to build special-purpose applications. The early chapters can be used as a tutorial for educators and hobbyists looking for simple, low-cost interface solutions to replace expensive add-on cards or bus interfaces. The advanced sections help engineers working in control system design and device development, as well as those working with real-time and embedded systems.

## 1999 Master Catalog 1.0

*from L-Com*
*45 Beechwood Drive*
*N. Andover, MA 01845-1092*
*Tel: 800-343-1455*
*Fax: 978-689-9484*
*Web: www.L-com.com*
**Free**

This 144-page color catalog presents a complete guide to data, video, voice, and RF connectivity products. L-Com designs and manufactures copper and fiber cable assemblies, interconnection adaptors, connectors, and cable test equipment, as well as rack panels and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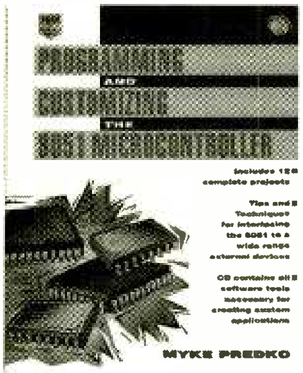
shelving. They also distribute related products, such as LANart and Unicom Ethernet equipment; Comtran, Mohawk, and Hitachi bulk cable; Stewart modular plugs; Clauss tools; and Fotrec fiber optic testers.

The catalog starts with a visual index of products organized by type and illustrated by color photos. It ends with two Tables of Contents, one alpha-numeric and the other organized by product. Complete pricing information is included.

## Programming and Customizing the 8051 Microcontroller

*by Myke Predko*
*McGraw Hill*
*1221 Avenue of the Americas*
*New York, NY 10020*
*Tel: 800-2MCGRAW*
*Web: www.ee.mcgraw-hill.com*
**$39.95**




CIRCLE 343 ON FREE INFORMATION CARD

Providing readers with a complete understanding of the 8051 chip compatibles, this tutorial/disk package includes all the information needed to design and debug tailor-made applications. It details the features of the 8051 and demonstrates how to use these embedded chips to access and control many different devices. The book shows what happens within the 8051 when an instruction is executed and demonstrates how to interface 8051s with external devices.

The volume gives readers over 30 experiments and 12 complete projects. It features full explanations of how the devices are electronically programmed. A design for building an Atmel 2010 microcontroller is also provided. The included CD-ROM contains all the software tools necessary for creating custom applications.

## 1999 New Product Catalog

*from B&K Precision Corp.*
*1031 Segovia Circle*
*Placentia, CA 92870-7137*



### EQUIPMENT REPORT

*(continued from page 25)*

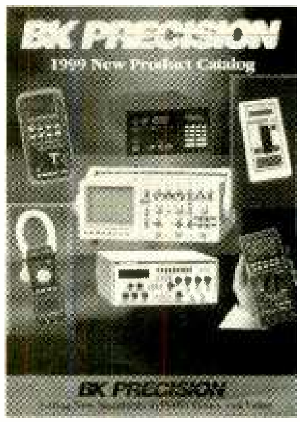
extension. These can be downloaded directly to the PIC16C84 microcontroller on the trainer board

The PICtutor CD-ROM/trainer board bundle will help tutor you in PIC theory, application, and programming. You might find it useful and informative even if you have just a passing interest in PICs. And those already using PICs in their own circuits should find PICtutor to be a time saver in developing code for those projects. PICtutor lets you test your code on the trainer, before building an actual circuit.

The PICtutor CD-ROM and PIC trainer board are available as a bundle from CLAGGK Inc. (PO Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751) for $179 postpaid in the U.S. and $184 (in U.S. funds) in Canada; NY state residents must also add sales tax. EN

*Tel: 714-237-9220*
*Fax: 714-237-9214*
*Web: www.bkprecision.com*
**Free**

The 16-page, full-color catalog features over 25 new products, including IC testers, programmable power supplies, and video monitor testers, as well as test instruments and accessories. It is an ideal source document for electronic



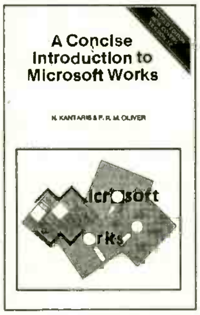

CIRCLE 344 ON FREE INFORMATION CARD

and electrical field service, depot service, and engineering/R&D personnel.

The most recent products are at the beginning. Among them are the Model 570 linear IC tester and the Model 575 digital IC tester; and the Model 1275 hand-held, battery-powered video monitor tester and Model 1280 benchtop tester. The catalog also presents selected

*(Continued on page 94)*

# Buyers' Budget Books Better Buys




☐ **BP294–A Concise Introduction to Microsoft Works $6.99.** In the shortest and most effective way, you can use the word processor to advantage to type, edit, print and save documents. It goes on to explain how Works can be used to build up simple spreadsheet examples, edit them, save them, print them and retrieve them. It informs you how to create simple macros, and enables you to simplify long repetitive tasks and to customize the program to your own needs.

☐ **BP349–Practical Opto-Electronic Projects $6.99.** If you shun opto-electronic projects for lack of knowledge, this is the book for you. A bit of introductory theory comes first and then a number of practical projects which utilize a range of opto devices, from a filament bulb to modern infrared sensors and emitters.

☐ **BP350–Electronic Board Games $6.99.** Twenty novel electronic board games that you can build from the plans in this book. Whether you are interested in motor racing, searching for buried treasure on a barren island or for gold in Fort Knox, spinning the wheel of fortune, or doing a musical quiz—there is something for you to build and enjoy!

☐ **BP378-45–Simple Electronic Terminal Block Projects $6.99.** Contains 45 easy-to-build electronic projects trhat can be built by an absolute beginner. Projects are assembled on terminal blocks using only a screwdriver and other simple hand tools. No soldering is required.

☐ **BP432–Simple Sensor Terminal Block Projects $6.99.** This book is the next logical step from *45 Simple Electronic Terminal Block Projects* (BP378), by the same author. The former describes an easy method of constructing transistor circuits without the need for soldering. It is an *open sesame* to the practical world of electronics for youngsters or beginners.

☐ **BP367–Electronic Projects for the Garden $6.99.** Electronics enters the Garden! New exciting book points out how gardeners can build simple gadgets to promote success where the elements work against you. Some of the projects are: over/under temperature monitoring, dusk/dawn switching, automatic plant watering, warming cables, etc.

☐ **BP368–Practical Electronics Musical Effect Units $6.99.** There is a constant hullabaloo for musical effects projects by the hobbyist community. This book provides practical circuits for several projects that range in complexity and are sure to work. All the circuits are easy to build and use readily-available parts.

☐ **BP385–Easy PC Interfacing $6.99.** The built-in ports in your PC provide an easy and hassle-free way of interfacing your circuits. This book provides useful PC add-on circuits including the following: Digital input/output ports; analog-to-digital and digital-to-analog converters; voltage and current measurement circuits; resistance and capacitance meters, temperature measurement interface, biofeedback monitor, and many other useful interfaces.

☐ **BP396–Electronic Hobbyists Data Book $7.99.** This book provides a wide range of data. If, for example, you require details of a modern five-band resistor code or an old color code for a ceramic capacitor, the formula for parallel resistance, or basic data on an NE5534AN operational amplifier, it is contained within these pages. The subjects covered are numerous and widespread to cover all hobbyist interests.

☐ **BP343–A Concise Introduction to Microsoft Works for Windows $7.99.** The book explains and details: How the Works for Windows package fits into the general Microsoft Windows environment; how to use the word processor to advantage; how to use Microsoft Draw to create and edit graphics and place them in your documents; how to build up simple spreadsheet examples; and how single, and multiple charts, or graphs, of different types can be generated. And there's much more!

☐ **BP282–Understanding PC Specifications $5.99.** This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, 80486, Pentium etc.); math co-processors; input devices (keyboards, mice, and digitizers); memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; floppy disk drive formats and compatibility; hard disk drives; and display adapters (CGA, Hercules, super VGA, etc.).

☐ **BP298–Concise Intro to the Macintosh System and Finder $5.99.** Although the Mac's WIMP user interface is designed to be easy to use, much of it only becomes clear when it is explained in simple terms. The book explains: The System and Finder, what they are and what they do; how to use the System and Finder to manipulate disks, files and folders; configuring and printing files from the Finder; getting the most from the system utility programs; and running MultiFinder.

☐ **BP88–How To Use OP Amps $5.99.** The Operational Amplifier is the most adaptable circuit module available to the circuit designer. It is possible to purchase a low-cost integrated circuit with several hundred components, very-high gain and predictable performance. This book has been written as a designer's guide for most Operational Amplifiers, serving both as a source book of circuits and a reference book for design calculations.

☐ **BP316–Practical Electric Design Data $7.99.** A builder's bargain book–a comprehensive ready-reference manual for electronic enthusiasts with over 150 practical circuits. It covers the main kinds of components (from pig-tail leads to surface mount), pin-outs, specs and type selection. Basic units are defined and most used formulae explained. Five additional sections are devoted to circuit design, covering analog, digital, display, radio and power supply circuits.

☐ **BP346–Programming in Visual Basic for Windows $7.99.** This book is a guide to programming. The reader is not expected to have any familiarity with the language as both the environment and statements are introduced and explained with the help of simple programs. The user is encouraged to build these, save them, and keep improving them as more complex language statements and commands are encountered.

☐ **BP345–Getting Started In Practical Electronics $6.99.** If you are looking into launching an exciting hobby activity, this text provides basic essentials for the builder and 30 easy-to-build fun projects with which every experimenter should toy. Printed-circuit designs are included to give your project the professional touch.

☐ **BP451–Troubleshooting Your PC Printer $8.99.** Explains the different printer types, their suitability for different tasks, the costs of running them, how to connect them and get the driver software running and, of course, what is most likely to go wrong and what you can do for yourself. Most important of all, it warns you of what you should quite definitely NOT try to do for yourself.

☐ **PCP112–Digital Electronics Projects $10.99.** Contains 12 digital electronics projects suitable for the beginner to build with the minimum of equipment — from instrumentation to home security, and a few "fun" projects too. With one exception, all projects are battery powered, and therefore, are completely safe for the beginner or young constructor.

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☐ **BP76–Power Supply Projects $3.99.** Presents a number of power-supply designs including simpled unbiased types, fixed voltage-regulated types and variable voltage stabilized designs. All are low-voltage types intended for use with semiconductor circuits. Apart from presenting a variety of designs that will satisfy most applications, the data in this book should help the reader to design his own power supplies. An essential addition to the experimenters electronics library.

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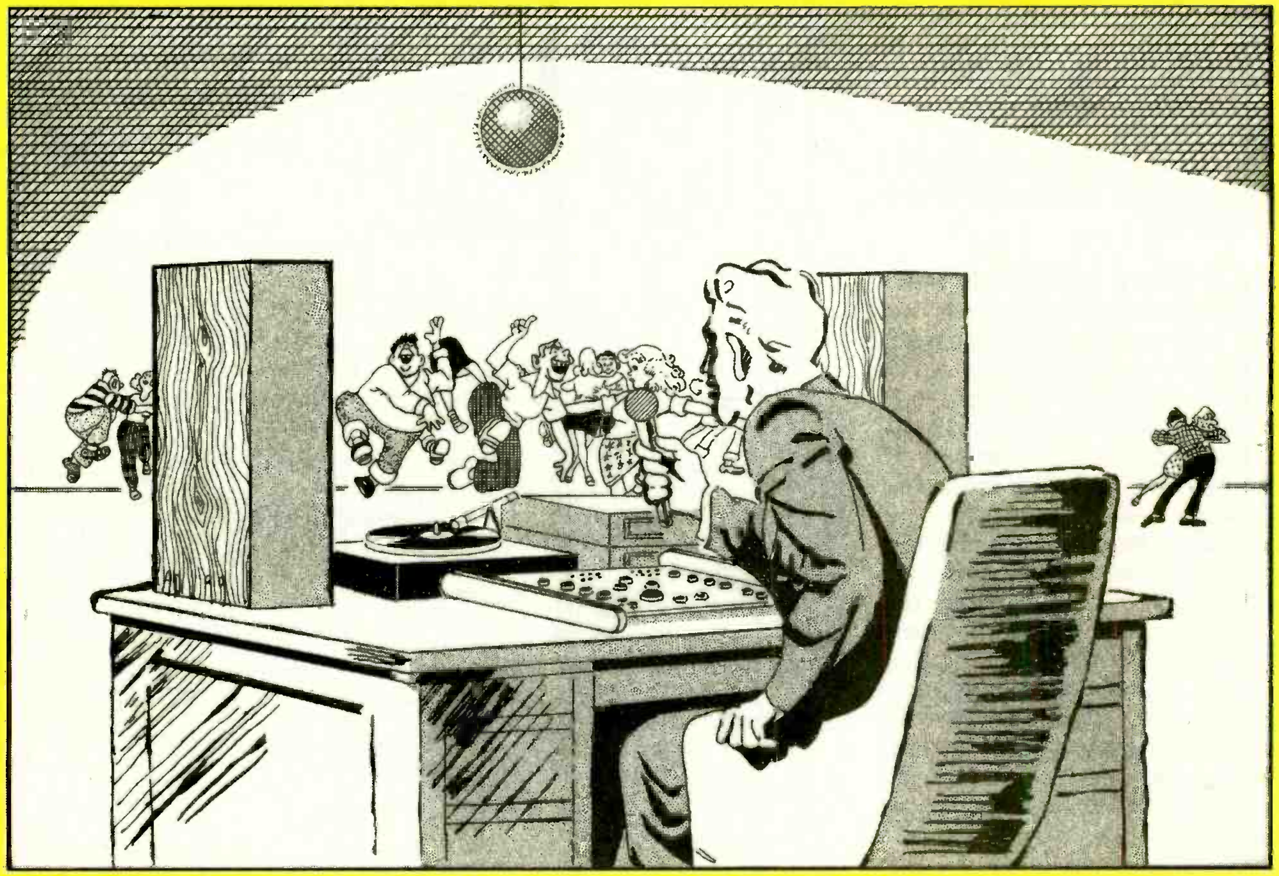
# Become the "Life of the Party" with The DJ MixMaster

*This portable mixing board is equally at home at a party, in the studio, or anywhere that you need to work with audio.*

JULES RYCKEBUSCH



If, like the author, you've done much work with audio in a studio or with live sound, you've probably been asked by friends or clients at one time or another if you could do some "on-site" work at a remote location or if you could "DJ" their next party. The available DJ-mixing equipment on the market of decent quality, unfortunately, tends to be a bit on the expensive side. What's more, much of the reasonably-priced gear for the occasional "record-spinner" uses very cheap components with the resulting questionable audio performance.

Because of that, the only "acceptable" solution this author had found until recently was to lug around his 16-input console—not the most desirable of solutions. Thanks to The DJ MixMaster presented here, those days are over.

The DJ MixMaster is the result of discussions with other DJs, studio engineers, and a personal desire for a mixing console that is a high-quality, low-cost unit with the features that are desired by both professional and amateur "party-fun managers!" It's a compact yet feature-laden small mixing board. Along with spinning tunes and being the life of the party, there are many uses for such a small DJ mixer. It can be used to put together party tapes that professionally fade from one cut to the next or as a way to practice your karoke skills. It also sports ideal audio specifications, allowing it to be used as a stand-alone phonograph pre-amp in a recording studio.

The DJ MixMaster provides several features only found on top-of-the-line DJ mixing boards. It features simultaneous access to two phonograph inputs, two line-level inputs, a microphone input, and an auxiliary stereo line-level input. Most DJ mixers force you to switch between the phonograph and line-level inputs. The DJ MixMaster also features a stereo auxiliary-send output, which can be used to feed the audio to a sampler or a digital-effects processor; we'll look at that feature and its use later in this article. Additionally, there is a full-featured headphone monitoring section that lets you have a separate headphone mix from all of the inputs. Another useful feature is an equalizing section. Although it is a simple tone-control-like shelving EQ with only bass and treble controls, the corner frequencies are set to more musically-useful values than most DJ mixers.

Now that you know what the DJ MixMaster is all about, let's look at how it works.

**How It Works.** The DJ MixMaster is a collection of simple circuits that form the overall circuit. While each circuit is small, the final circuit would yield a schematic diagram that would be overly cluttered and difficult of follow. In a departure from the normal way that schematic diagrams are presented in **Electronics Now**, each section of the DJ MixMaster will be presented separately. Note that when any particular circuit is either creating or modifying a signal or acting on such a signal, the connections between the circuits of the different sections are represented by a letter inside a circle. While that style of joining different portions of a circuit is familiar to those that have seen it before, a reminder or short explanation never hurts.

At the heart of each of the DJ MixMaster circuits is an NE5532 dual op-amp. The NE5532 has excellent audio specifications and will drive a 10-volt rms signal into a 600-ohm load, giving it the ability to drive headphones with a similar rating directly. Those specifications have made the NE5532 an "unofficial" industry standard for audio use. In fact, most manufacturers of op-amps tend to compare their device to the NE5532 when discussing audio use.

Several pin-compatible op-amps

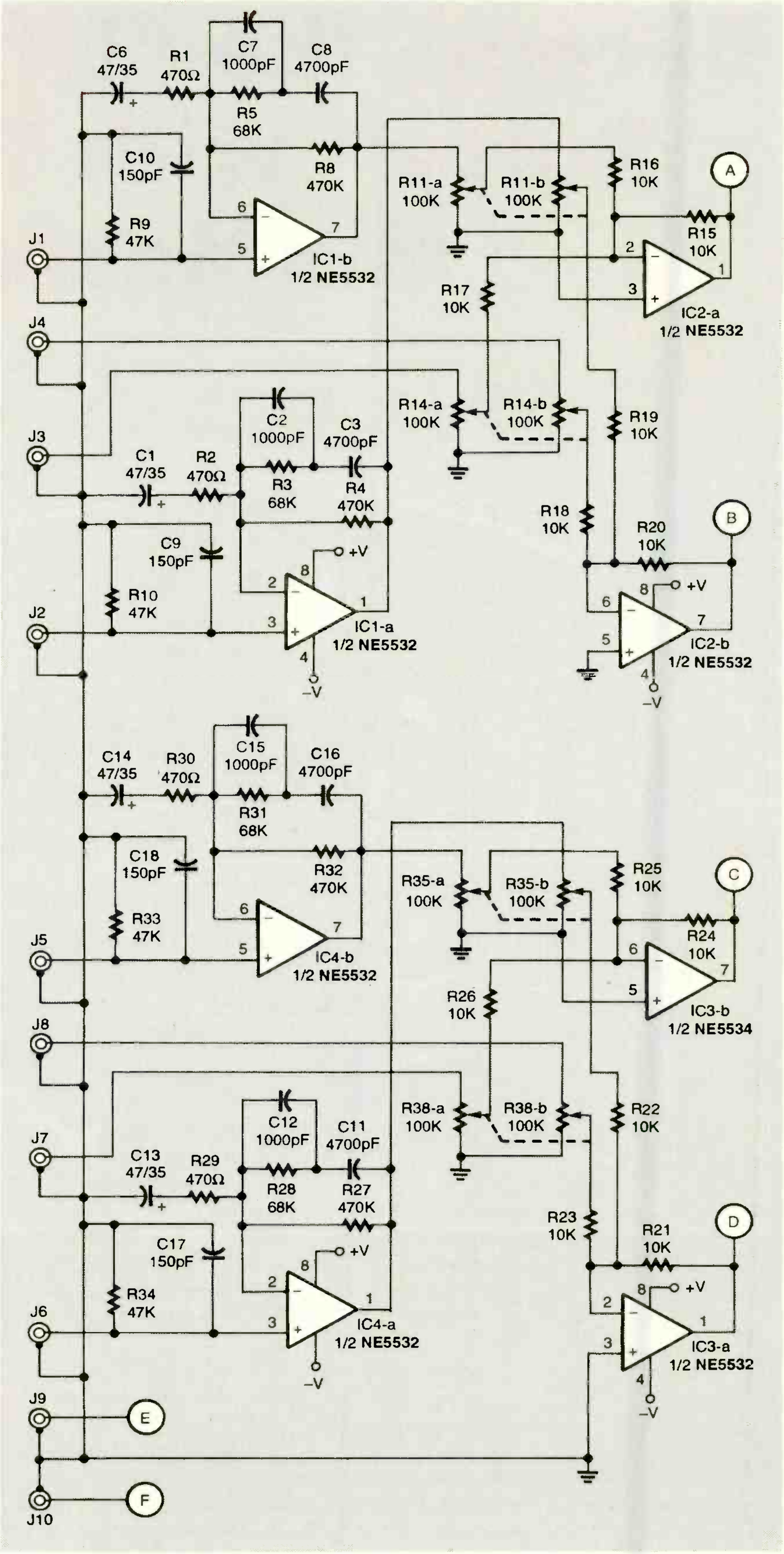



*Fig. 1. The DJ MixMaster has stereo inputs for two phonograph turntables and two line-level sources such as CD players or tape decks. Each input level can be set individually. An auxiliary input designed to accept the output of an effects processor can be used as a third line-level input. The phonograph-input preamplifiers are RIAA compensated.*

## PARTS LIST FOR THE DJ MIXMASTER

### SEMICONDUCTORS

IC1–IC10—NE5532 dual op-amp, integrated circuit
IC11—NJR7815 15-volt regulator, integrated circuit, see text
IC12—NJR7915 15-volt regulator, integrated circuit, 470-ohm
LED1—Light-emitting diode, red
BR1—50-volt, 1-amp, bridge rectifier

### RESISTORS

(All resistors are ¼-watt, 1%, metal-film units unless otherwise noted.)
R1, R2, R29, R30—470-ohm
R3, R5, R28, R31—68,000-ohm
R4, R8, R27, R32—470,000-ohm
R6, R7, R56–R59, R112, R113—47-ohm
R9, R10, R33, R34—47,000-ohm
R11, R14, R35, R38, R49, R51, R53, R61, R63, R88, R91, R92, R116—100,000-ohm potentiometer, panel-mount, audio taper, dual gang
R12, R13, R36, R37, R50, R52, R54, R62, R64, R66, R89, R109, R110, R115, R117—not used
R15–R26, R40–R44, R46–R48, R67, R68, R71, R72, R75, R76, R97–R104—10,000-ohm
R39, R45—100,000-ohm
R55, R60, R90—10,000-ohm potentiometer, panel-mount, audio taper
R65—10,000-ohm potentiometer, panel-mount, audio taper, dual gang
R69, R70, R74, R77–R80, R82–R85, R87—15,000-ohm
R73, R111—22,000-ohm
R81, R86—75,000-ohm
R93–R96, R105–R108—1000-ohm
R114—2200-ohm
R118, R121—33,000-ohm
R119, R120—600-ohm

### CAPACITORS

C1, C6, C13, C14—47-mF, 35-WVDC, electrolytic
C2, C7, C12, C15—1000-pF, ceramic-disc
C3, C8, C11, C16—4700-pF, ceramic-disc
C4, C5—470-mF, 35-WVDC, electrolytic
C9, C10, C17, C18—150-pF, ceramic-disc
C19, C22—1000-pF, ceramic-disc
C20, C21—0.68mF, Mylar
C23, C24—47-pF, ceramic-disc
C25, C26—1200-mF, 35-WVDC, electrolytic
C27, C28—0.1-mF, ceramic-disc

### ADDITIONAL PARTS AND MATERIALS

J1–J16—RCA-style phono jack
J17—Headphone jack, ¼-inch stereo
J18—Microphone jack, XLR-style
S1, S2—Double-pole, double-throw switch
T1—Wall-mounted transformer, 24-volt AC, 1 amp
Case, wire, hardware, etc.

can be substituted, although sometimes it is difficult to actually hear a difference. Examples of some of those devices include the OP-275 from Analog Devices, the LM833 from National Semiconductor, and the OPA2604 and OPA2134 from Burr Brown. Keep in mind that some of those substitutes, like the Burr-Brown devices, can cost as much as $3.00 each, whereas the NE5532 runs about 60 cents. For those readers with "golden ears", feel free to experiment with alternative devices. Do not use a 741-type of op-amp, such as the LM1458. They simply do not have the ability to function well in high-quality audio circuits.

**Input Section**. The main-input section shown in Fig. 1 is a good place to start. Note that there are two identical sections, each of which has a phonograph input and a line-level input for a CD or tape; only one section will be discussed for simplicity. The phonograph inputs from J1 and J2 go to a standard "textbook" RIAA pre-amp built around IC1. One pre-amp is needed for each stereo channel; again, we will only discuss one half of the circuit.

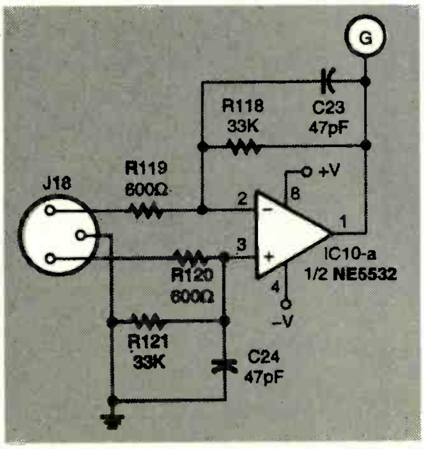



*Fig. 2. Any standard low-impedance microphone can be plugged into this preamplifier. The circuit is designed for microphones that have an XLR-type jack. Those microphones use a balanced-line arrangement.*

From J1, the input is coupled across R9 and C10 to IC1-b. Those components form a termination load for the phonograph cartridge. The pre-amp is set for a 40-dB gain and is a non-inverting configuration. Two RC networks, C7/R5 and C8/R8, are included in the feedback loop of IC1-b. They reduce the gain of the pre-amp as the frequency increases. The reason that we need to do that has to do with the way that grooves are cut in a record. Higher frequencies are boosted in comparison to low frequencies in a record so that the size of the actual grooves is consistent. The amount of boost is set by the Recording Industry Association of America (RIAA). We are reversing that equalization, restoring a flat-frequency response; hence the use of an RIAA-compensating pre-amp. Additionally, the phonograph pre-amp has a filter network consisting of C6 and R1 that filters out any low-frequency "rumble" from the turntable.

The output of the phonograph pre-amp and the line input are summed into a two-input mixer. The input-mixing stage consists of R11 and R14, both of which are dual potentiometers. The phonograph-input level is set by R11; R14 handles the line input. The signals from the potentiometers are combined by a summing amplifier formed by inverting op-amp IC2. The gain of that stage is set by the ratio of the feedback resistors (R15 and R20) and the input resistors (R16–R19). Note that each amplifier receives one channel from each input. The output of the summing amplifiers contains a mixed combination of the phonograph and line-level inputs, of which the level of each can be individually controlled. Additionally, the summing amplifier acts as a buffer amplifier to drive the rest of the circuits, which will be discussed in turn, with no loading effects.

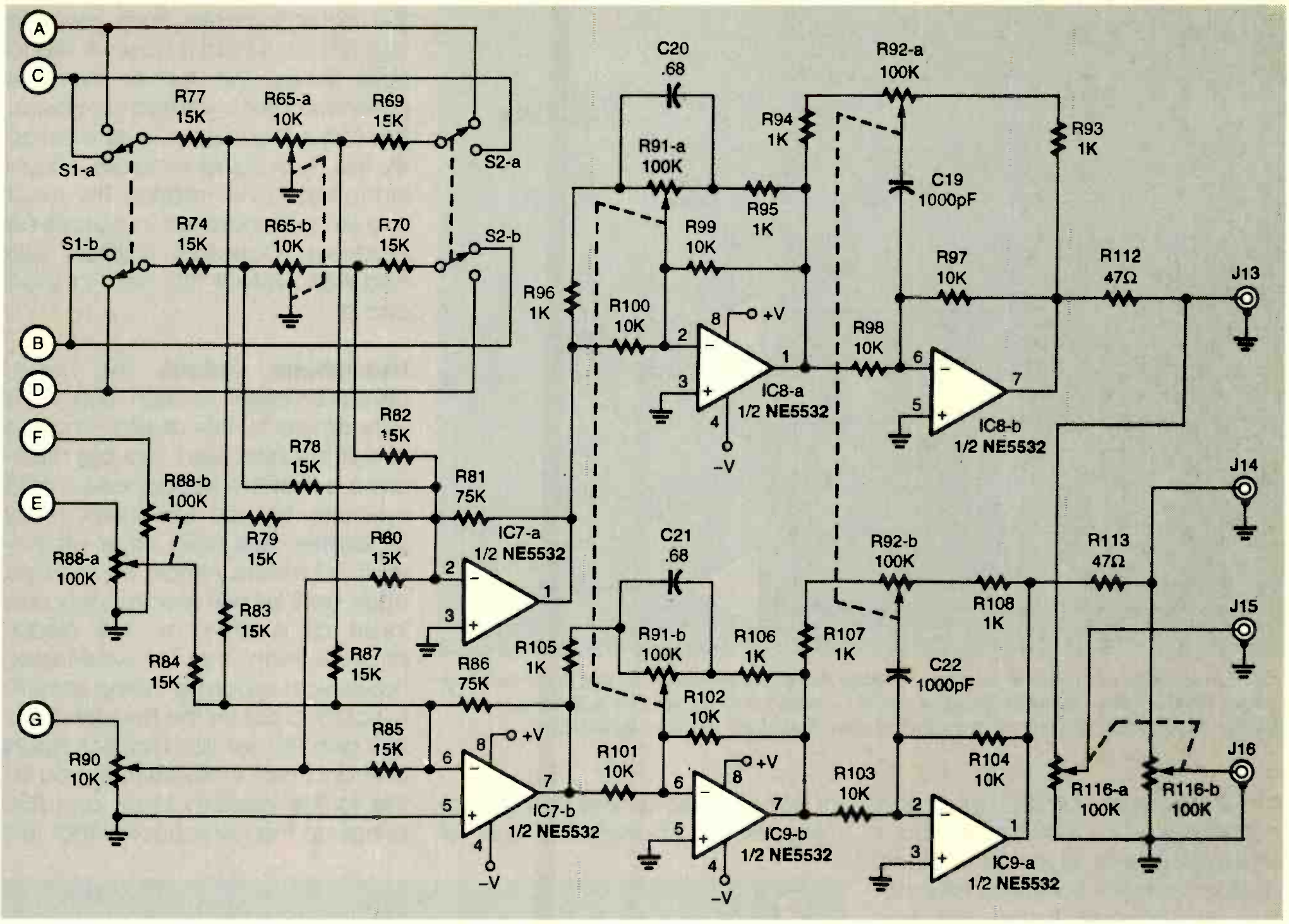



*Fig. 3. The "heart and soul" of the DJ MixMaster is the crossfade potentiometer and the transform switches. It is here that the auxiliary input is mixed with the other inputs. The final mixed signal can feed two external amplifiers, or one amplifier and a tape recorder for a "transcript of the proceedings." Bass and treble tone controls are included to help match the sound to the room characteristics and personal preferences.*

**Microphone Pre-Amp.** The microphone pre-amp, shown in Fig. 2, is an op-amp stage that is set up as a differential amplifier around IC10 with a gain of about 35 dB. That amount of gain should be plenty for even the loudest voice. Additional gain is possible as the microphone signal is summed into the other various sections. While such an approach might seem to be a somewhat "cheesy" way to build a microphone pre-amp, the high-quality audio op-amps that are used throughout the DJ MixMaster are up to the task. By using 1% metal-film resistors, noise and circuit complexity are kept to a minimum.

**Summing Amp and Output.** All of the various inputs are brought together in the summing circuit shown in Fig. 3. The line-level and phonograph inputs are first fed to a crossfade circuit. That circuit, built around R65, can be thought of as the opposite of a pan or balance control. It allows for a smooth transition from one input to another. Such a circuit is the heart of all DJ-style mixing boards. One of the interesting features incorporated into the DJ MixMaster are "transform" switches S1 and S2. In one set of positions for S1 and S2, R65 is fed with one source input on one side and the other source input on the other side. With that setting, R65 can be used to cross-fade from one input to the other. With the wiper of R65 set to its midrange, each signal is attenuated by about 3 dB. If both signals are identical in amplitude, the output will remain at a constant level as R65 is moved from one end to the other. By throwing one (but not both) of the transform switches, both sides of R65 are fed by the same source signal. That lets you change instantly between inputs without having to touch the setting of R65. That feature can be useful for special effects and instant changes in the music; no club DJ should be without one! Note that the microphone input (a monophonic signal) is mixed equally into both left and right stereo channels of the summing amplifiers IC7-a and IC7-b; the auxiliary input is mixed in through its own level adjust, R88.

The outputs of IC7 are fed to the EQ section, a standard high/low shelving equalizer very similar to most bass/treble controls. The bass control is built around IC8 and R91, while IC9 and R92 handle the treble. The big difference in the DJ MixMaster circuit is that the boost/cut frequencies are selected to be much more musically useful. The low frequency is centered at about 80 Hz and the high frequency is set

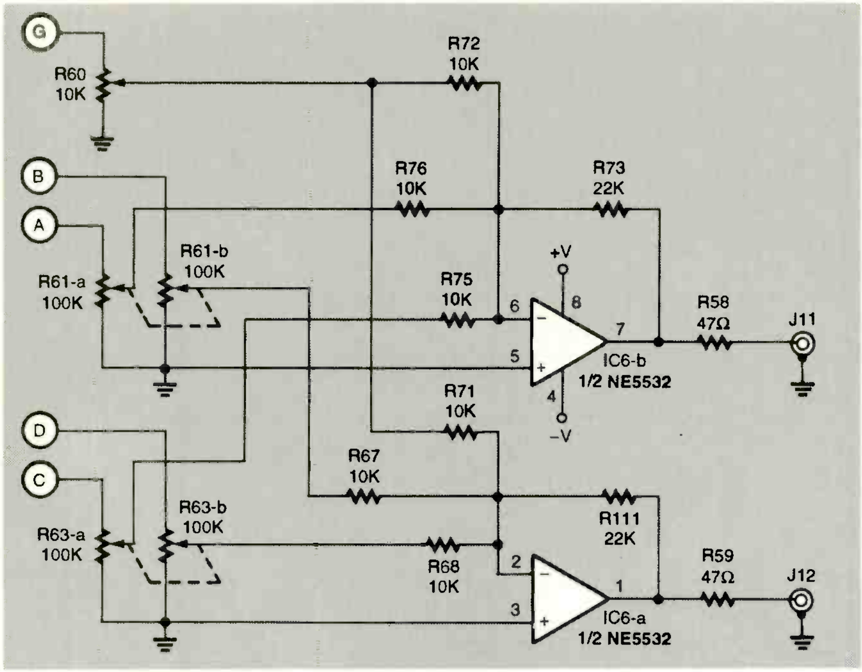



*Fig. 4. A separate mix of audio sources—including the microphone—can be sent to the auxiliary output. With an effects processor plugged into the auxiliary outputs, you can add external audio effects and mix them back into the main audio output through the auxiliary input jacks.*

for 12 kHz. The available boost and cut range works out to be about +/-14 dB—plenty of range to cause audio mayhem! For more information on equalizer design, two recommended resources are *Audio Application of Operational Amplifiers* by Walt Jung and Don Lancaster's timeless *Active Filter Cookbook*.

The output of the EQ section feeds master level control R116. Output jacks J15 and J16 would be hooked up to an external PA system, while J13 and J14 can be used to record the festivities.

**Auxiliary Output.** As mentioned before, the DJ MixMaster also has an auxiliary output; the circuit is shown in Fig. 4. The auxiliary output can be used to provide a separate stereo mix for driving another PA system or a tape machine. It can also be used to supply an input to an effects sampler or some other multi-effects processor when the output of such a processor is connected back into the DJ MixMaster through J9 and J10 (see Fig. 1). The two input sections as well as the microphone pre-amp are mixed together with their own potentiometers and summed by IC6.

Note that the choice of values for R61 and R63 as well as the summing resistors change the "feel" of the potentiometers from linear to logarithmic, which is how we like to hear things. The further that the potentiometer is rotated clockwise, the faster the output level increases. The most signal increase occurs in the last 1/3 of rotation. The result is a smooth increase in perceived loudness. Coupling resistors R58 and R59 protect IC6 from a short circuit.

**Headphone Output.** The headphone-amplifier section (Fig. 5) is very similar to the auxiliary output circuit just discussed. The big difference is that the headphone circuit is where the DJ MixMaster really separates itself from other off-the-shelf DJ mixers. Almost all of those other units let you monitor only one input at a time on the headphones. With the DJ MixMaster, however, a separate mixing section is included just for the headphones; R49 and R51 let you monitor inputs one and two, while R53 lets you listen to the auxiliary input and R55 brings up the microphone. That lets

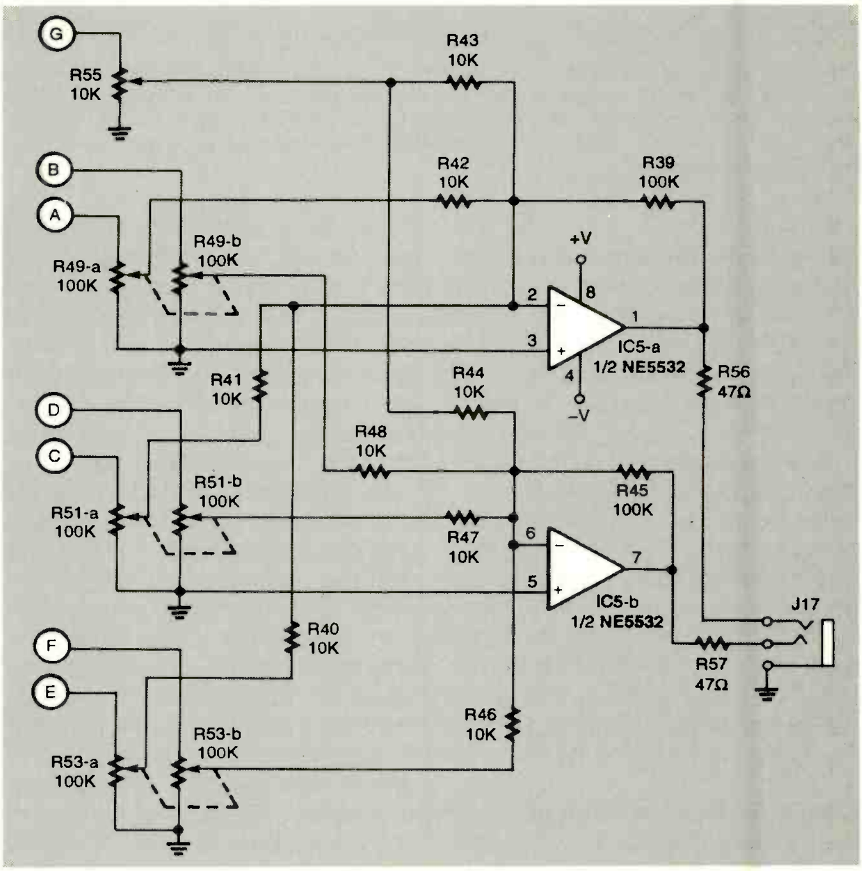



*Fig. 5. The headphone amplifier has its own set of mixing controls. With that feature, you can cue up or monitor a different input channel from the one that's playing through the main speakers.*

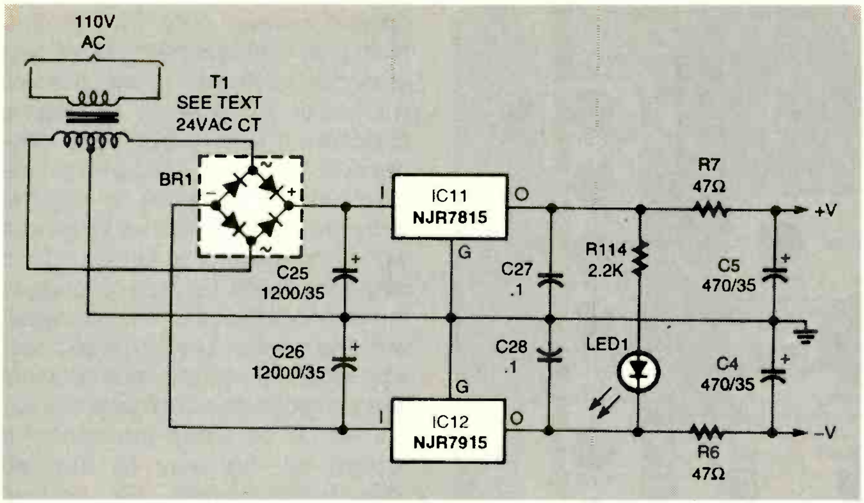



*Fig. 6. The DJ MixMaster's power supply uses three-terminal regulators that have an insulated tab; you don't have to worry about using a mica insulator when bolting them to a heatsink.*

you match beats, preview an upcoming song, or verify that the microphone is working before sending anything over the PA system.

Like their counterparts in Fig. 4, R56 and R57 protect IC5 from a short circuit; they also provide enough current drive for even 8-ohm headphones.

One final note on the handling of the microphone signal is that only a single-gang potentiometer is used to feed the signal equally to both stereo channels wherever it is sent. Although a stereo-panning potentiometer could have been included, such a function is never really needed in DJ work. For that reason, that feature has been left out of the DJ MixMaster in order to keep the circuit simple.

**Power**. The power-supply circuit for the DJ MixMaster, shown in Fig. 6, is simple and straightforward. The output of T1, a 24-volt center-tapped transformer, is rectified by BR1 and smoothed by C25 and C26. No fuse is shown because the author's prototype uses a wall-mounted transformer with integral protection. Light-emitting diode LED1 and current-limiting resistor R114 let you know when the unit is turned on.

Note the use of NJR7815 and NJR7915 regulators for IC11 and IC12. While any standard three-terminal regulator can be used, the specified units have the unique feature of an insulated tab. That means that you can mount them straight to a common heatsink without having to worry about electrically insulating them.

**Construction.** The DJ MixMaster, in spite of the complexity of the circuit, can easily be built on perfboard using standard construction techniques. One way to lay out the various circuits for the unit is to build each one on a separate piece of perfboard, one board per schematic figure. All interconnections that carry audio signals should be done with shielded audio cable. Be sure to ground the shield on one end only. If both ends are grounded, the possibility of a "ground loop" exists, the result being stray hum and noise in the audio output.

The case is also a matter of personal choice. The important consideration in that respect is the size of the front panel for all of the controls. The dimensions of the author's prototype case are shown in Fig. 7. The sides and frame are made from poplar wood (for looks) with 1/8-inch sheet aluminum for the front and rear panels. The front panel measures about 10 inches by 16 inches. Sources of sheet aluminum are a local sheet-metal shop or scrap yard. One great source if you live in a small town are used street signs from the local government.

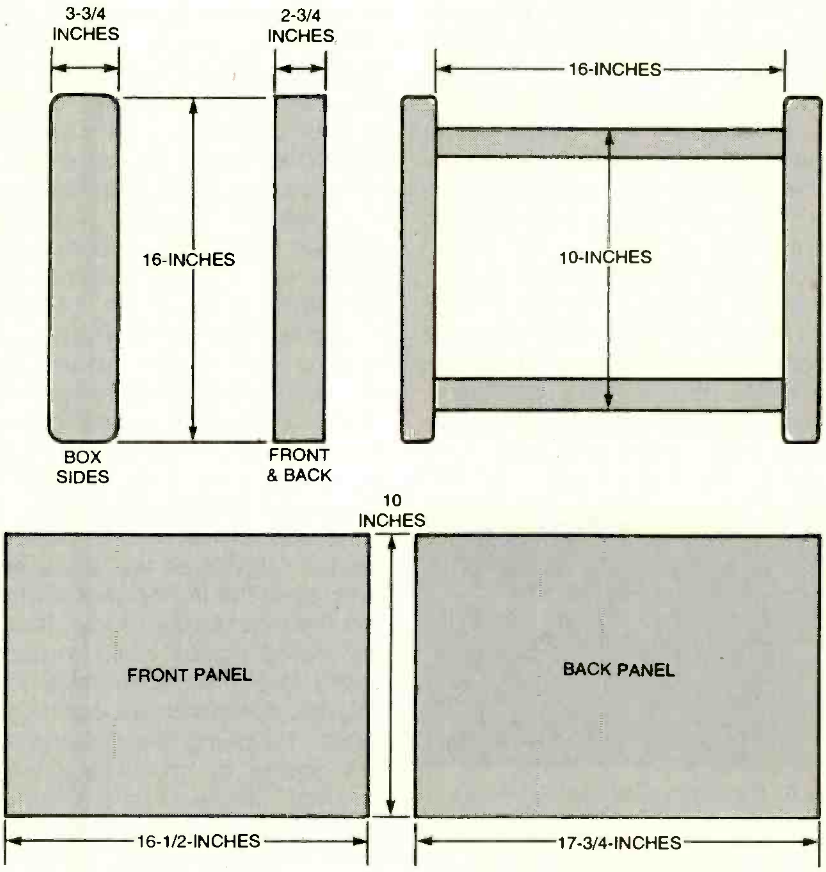



*Fig. 7. While any suitable enclosure can be used for the DJ MixMaster, the author's design is large enough to allow an easy-to-use front-panel layout. The unit can even comfortably fit in one's lap.*

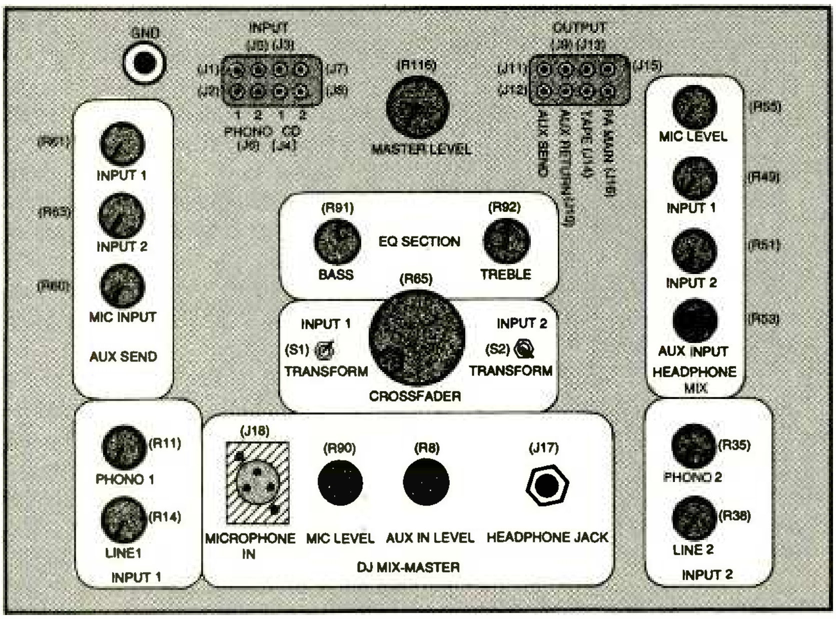
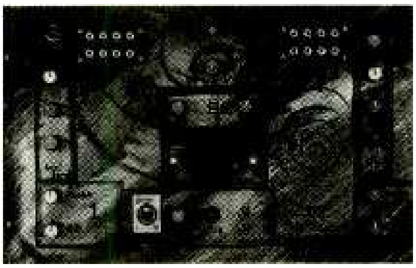



*Fig. 8. A clean and orderly layout of controls is essential to any well-designed mixer. Here's how the author organized his prototype DJ Mixer. Feel free to modify this arrangement to your liking.*

Along with being the right thickness, street signs are T-6066-grade aluminum. Old dented ones can usually be had for free.

Many mixers use slide pots. Unfortunately, those types of controls tend to be either expensive or not rugged enough for portable use. For that reason, the DJ MixMaster uses standard rotary potentiometers. Any control knob that feels comfortable to you is fine. One consideration that is forgotten by many electronics enthusiasts is that of style and image. The "look" of a piece of gear that will be used at a club or party is as important (if not more so) than the technical specifications of the unit itself! For example, the author's prototype uses collet knobs manufactured by Selco. Those knobs feature a snap-



*The DJ MixMaster can be decorated in any way that you choose. The front panel of the author's prototype was painted by a friend that decorates and custom-paints surfboards—an example of taking the concept of "style and image" to an extreme!*

in face that comes in many colors. Unfortunately, they are more expensive than the potentiometers that they control! For R65, you might consider an extra large knob with a handle. Being able to "crank" R65 is perfect for quick crossfades.

The front panel of the DJ MixMaster should be laid out for easy operation. While you can set up your controls to suit your own needs and desires, the author's layout, shown in Fig. 8, demonstrates how related controls can be grouped together as well as keeping the overall layout symmetrical. Note that there is an optional grounding jack in the upper left-hand corner of the panel. That jack, which can be anything from a "banana" jack to a simple screw, is a convenient grounding point for any audio gear such as phonograph turntables that require it.

The bulk of the work in building the DJ MixMaster will be spent wiring all of the front-panel controls and the input/output jacks. That is why mixing boards cost so much! What's important is to take your time and double check each connection. Applying the old carpenter's adage of "measure twice—cut once" will result in a unit that will work right the first time. The use of plastic tie wraps or cable lacing will aid in a neat and tidy job.

When wiring the dual-gang potentiometers, note that for the most part they are being used as a level control. Be sure to wire the two non-wiper terminals in the same direction. If you reverse one connection, the result will be that one channel will increase in volume while the other channel fades out when the control is turned. On a related subject, be sure to choose the terminal that shorts to the wiper with the control fully counter-clockwise when selecting which terminal is to be grounded. That way, the signal will be off when the control is turned all the way to the left (counter-clockwise). Of course, there's nothing wrong with wiring the DJ MixMaster so that it works opposite to the traditional arrangement that we are all used to when working with a rotary control. In fact, a DJ Mixmaster that reads "right to left" might be just the thing for those that like to march to the beat of a different drummer!

If you do not want to use a wall-mounted transformer, a standard transformer with a current rating between 300 mA and 1 amp can be used. However, you will have to include additional safety equipment such as a fuse and a power switch. The 110-volt wiring inside the DJ Mixmaster can not only be a problem as a source of hum pick-up, it can be very dangerous working around while repairing, modifying, or testing the unit. For those reasons, a wall-mounted transformer cannot be recommended enough from a safety standpoint. On the subject of safety, don't forget to ground any metal panels on the case; a good ground will be needed with some audio gear such as phonograph turntables mentioned before.

Once the DJ MixMaster is built, wired, and checked for any errors, it is ready for testing.

**Testing.** Because there are so many interrelated sections of the DJ MixMaster, testing must be done in a logical fashion to ensure that everything works properly. Let's start with the headphone section and the auxiliary-return input. Since that combination is a straight-through connection, once we know it works we can check out the other inputs using the headphone amplifier.

Set all of the controls to their minimum value. Connect a stereo line-level source such as a CD player to J9 and J10. Plug a set of headphones into J17. Start the CD player and turn up R53. You should hear clean, crisp audio with no distortion. Turn down R53 and turn up the other controls. You shouldn't hear any hiss or hum. Connect a microphone to J18 and turn up R55. When you speak into the microphone, you should hear yourself talking along with any other room noise. Go through all of the other inputs (J1-J8) in turn, checking them in the same way. Don't forget to ground any phonograph turntables or the result will be a horrible-sounding test!

Once you have verified that all of the inputs work through the headphone amplifier, connect J15 and J16 to an amplifier and speakers; your stereo will work fine. Repeat all of the different tests, verifying that you can send them to the main mix. Set S1 and S2 in various combinations to see if you can switch between inputs as well as crossfade from one to the other with R65. Any problems that turn up are most likely caused by an error in wiring or a possible solder bridge on one of the perfboards. Remember, even the most careful person can make a seemingly obvious mistake, especially with a circuit as involved as the DJ MixMaster. Once you have checked everything out successfully, it is time to see what cool things the DJ MixMaster can do.

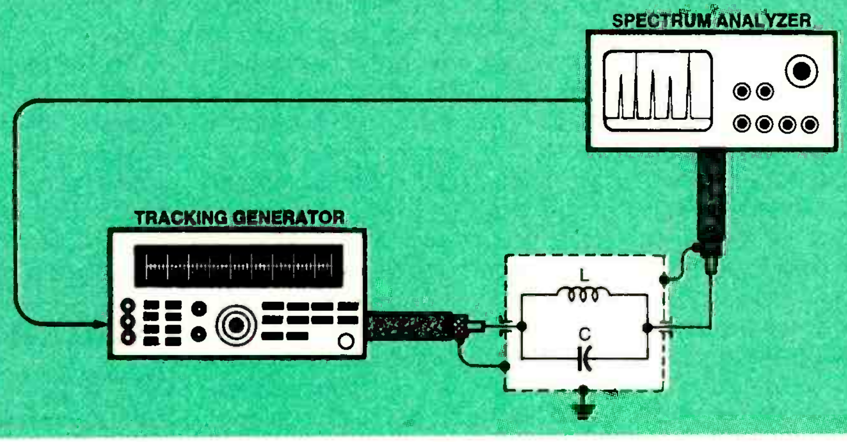
**Using the DJ MixMaster.** Using the DJ MixMaster is straightforward. Start by setting the input channel levels. Connect your turntables and CD players. Bring up some music on both the phonograph and CD player for the same channel—for example, J1-J4. Set S1 and S2 so that only that input is connected to R65. Adjust R11 and R14 for equal volume levels. Note that those controls should not be fully raised but somewhere in the one- to two-o'clock position. Phonograph signals are a little louder than the line signals, so R11 might be set a little lower. Repeat that procedure for the other input. Once both input levels are set, they will stay there; your mixing will be done with R65. However, you have the flexibility to do additional submixing. One interesting trick is to leave a turntable running with the needle at the end of a record. All that you will hear is the repetitive scratching sound of the record. Mix that in with music from CDs as an effect. That is easy to do with the DJ MixMaster because you can have two CD players and a turntable connected at the same time. Most other mixers force you to switch between the phonograph and line-level inputs.

Transform switches S1 and S2 take a little getting used to. They let you instantly switch between input channels. With a little practice, you'll be the hit of the dance floor. You can do things like create an "extended mix" of a song by having two copies of the song playing. At the end of one chorus or break, cue up the second copy at an earlier portion and hit the transform buttons. That is also how DJs bring in scratching from a turntable or other sound effects.

The auxiliary input and output circuits let you do all sorts of audio mayhem. For example, digital multi-effects processors for use in studios are available for less than $200. Almost any effect that you have heard on a song or the radio such as reverb, delays, flanging, chorusing, and pitch transposition are all available. Some will even "sample" the input applied to them; they will digitally record the audio fed to them for about five seconds and store it, ready to be played back at the push of a button. When used with the DJ MixMaster, you can process your voice when making announcements, process the music you are playing, and sample either your or someone else's voice. In a club, you will be right up with the best DJs. For example, you could use a pitch-transposing device to drop your voice down by a fifth and say something like, "You! In the red dress! You are evil and no one on this planet likes you!" At functions like weddings where some one is making a toast, sliding a little delay on their voice unexpectedly can result in all sorts of fun. Don't go overboard with an effect like that, but it is the perfect thing for a slightly-tipsy relative who is trying to make the "speech of the decade". The possibilities are endless. If you won't be using effects processors, the auxiliary input can be used as an additional CD player or tape deck.

The DJ Mix Master is a formidable audio tool. It is compact, yet has features not found on even top-of-the-line mixing boards. You can easily build it in a couple of evenings and then launch yourself into a new career as a Disc Jockey or at least have a lot of fun at parties! Ω

# Measuring Inductors and Capacitors at RF Frequencies




*At low frequencies, measuring inductance and/or capacitance is no big deal, but get to RF frequencies and things get a lot more interesting.*

JOSEPH J. CARR

The techniques needed to measure the values of inductors (L) and capacitors (C) at radio frequencies differs somewhat from what is needed to make the same measurements at low frequencies. In short, although similarities exist, the RF measurement is a bit more complicated. One of the reassons for that is that stray or "distributed" inductance and capacitance values of the test set-up will affect the results. Another reason is that capacitors and inductors are not ideal components, but rather all capacitors have some inductance, and all inductors have capacitance. In this article we will take a look at several effective methods for measuring inductance and capacitance at RF frequencies.

**VSWR Method.** When a load impedance is connected across an RF source, the maximum power transfer occurs when the load ($Z_L$) and source ($Z_S$) impedances are equal ($Z_L = Z_S$). If those impedances are not equal, then the *voltage standing wave ratio* (VSWR) will indicate the degree of mismatch. We can use that phenomenon to measure values of inductance and capacitance using the scheme shown in Fig. 1A. The instrumentation required includes a signal generator or other signal source, and a VSWR meter or VSWR analyzer.

Some VSWR instruments require a transmitter for excitation, but others will accept the lower signal levels that can be produced by a signal generator. An alternative device is an SWR-analyzer type of instrument. It contains the signal generator and VSWR meter, along with a frequency counter to be sure of the actual test frequency. Whatever signal source is used, however, it must have a variable output frequency. Further, the frequency readout must be accurate (the accuracy of the method depends on knowing the actual frequency).

The load impedance inside the shielded enclosure consists of a non-inductive resistor (R) that has a resistance equal to the desired system impedance resistive component (50 ohms in most RF applications, and 75 ohms in television and video). An inductive reactance ($X_L$) and a capacitive reactance ($X_C$) are connected in series with the load. The circuit containing a resistor, capacitor, and inductor simulates an antenna-feedpoint impedance. The overall impedance is:

$$Z_L = \sqrt{R^2 + (X_L - X_C)^2} \qquad (1)$$

Note the reactive portion of Equation 1. When the condition $|X_L| = |X_C|$ exists, the series network is at resonance, and VSWR is minimum (see Fig. 1B). This gives us a means for measuring the values of the capacitor or inductor, provided that the other is known. That is, if you want to measure a capacitance, then use an inductor of known value. Alternatively, if you want to know the value of an unknown inductor, use a capacitor of known value.

Using the test set-up in Fig. 1A, adjust the frequency of the signal source to produce minimum VSWR.

1. For finding an inductance from a known capacitance:

$$L_{\mu H} = \frac{10^{12}}{4\pi^2 f^2 C_{PF}} \qquad (2)$$

Where:

$L_{\mu H}$ = inductance in microhenrys (µH)
$C_{pF}$ is the capacitance in picofarads (pF)

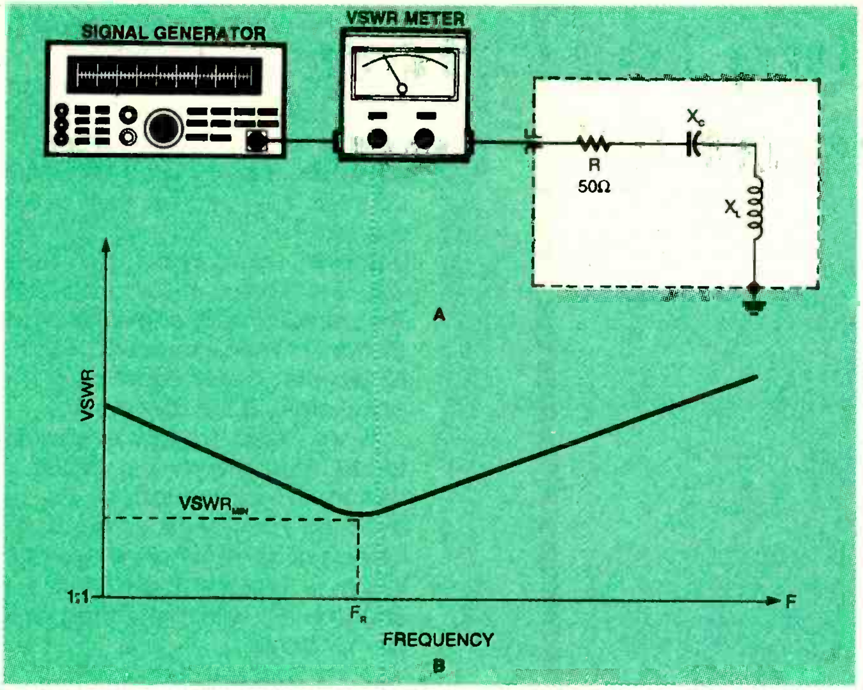



*Fig. 1. The VSWR method for measuring L and C is shown in A while the VSWR-vs.-frequency curve is shown in B.*

f is the frequency in hertz (Hz)

**2.** For finding a capacitance from a known inductance:

$$C_{pF} = \frac{10^{12}}{4\pi^2 f^2 L_{\mu H}} \qquad (3)$$

The accuracy of this approach depends on how accurately the frequency and the reactance are known, and how accurately the minimum VSWR frequency can be found.

**Voltage Divider Method.** A resistive voltage divider is shown in Fig. 2A. This circuit consists of two resistors (R1 and R2) in series across a voltage source V. The voltage drops across R1 and R2 are V1 and V2, respectively. We know that either voltage drop is found from:

$$V_X = \frac{V R_X}{R1 + R2} \qquad (4)$$

Where: $V_X$ is V1 and $R_X$ is R1 or, $V_X$ is V2 and $R_X$ is R2, depending on which voltage drop is being measured.

We can use the voltage divider concept to find either inductance or capacitance by replacing R2 with the unknown reactance. Consider first the inductive case. In Fig. 2B resistor R2 has been replaced by an inductor (L). Resistor R1 is the inductor series resistance. If we measure the voltage drop across R1 (*i.e.* "E" in Fig. 2B), then we can calculate the inductance from:

$$L = \frac{R}{2\pi f} \times \sqrt{\left(\frac{V}{E}\right)^2 - \left(1 + \frac{R_S}{R1}\right)^2} \qquad (5)$$

As can be noted in Equation 5, if R1 >> $R_S$, then the quotient $R_S$/R1 becomes negligible.

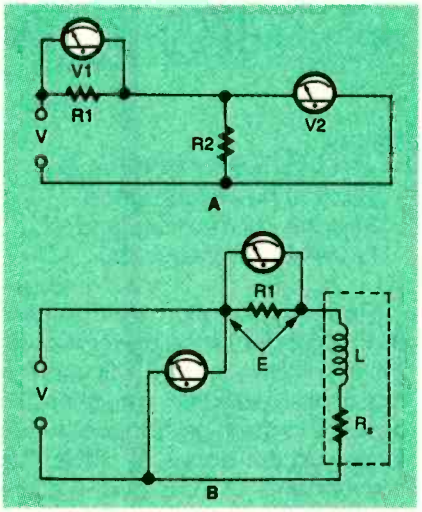



*Fig. 2. A simple voltage divider is shown in A and a reactance voltage divider is in B.*

In capacitors the series resistance is typically too small to be of consequence. We can replace L in the model of Fig. 2B with a capacitor, and again measurie voltage E. The value of the capacitor will be:

$$C = \frac{2\pi f \times 10^6}{R \times \sqrt{\left(\frac{V}{E}\right)^2 - 1}} \qquad (6)$$

The value of resistance selected for R1 should be approximately the same order of magnitude as the expected reactance of the capacitor or inductor being measured. For example, if you expect the reactance to be, say, between 1000- and 10,000-ohms at some frequency, then select a resistance for R1 in this same range. That will keep the voltage values manageable.

**Signal Generator Method.** If the frequency of a signal generator is accurately known, then we can use a known inductance to find an unknown capacitance, or a known capacitance to find an unknown inductance. Figure 3 shows the test set-up for this option. The known and unknown components (L and C) are connected together inside a shielded enclosure. The parallel-tuned circuit is lightly coupled to the signal source and the display through very low-value capacitors (C1 and C2). The rule is that the reactance of C1 and C2 should be very high compared with the reactances of L and C at resonance.

The signal generator is equipped with a 6-dB resistive attenuator in order to keep its output impedance stable. The output indicators should be any instrument that will read the RF voltage at the frequency of resonance. For example, you could use either an RF voltmeter or an oscilloscope.

The procedure requires tuning the frequency of the signal source to provide a peak output-voltage reading on the voltmeter or scope. If the value of one of the components (L or C) is known, then the value of the other can be calculated using Equation 2 or 3, as appropriate.

Alternate forms of coupling are

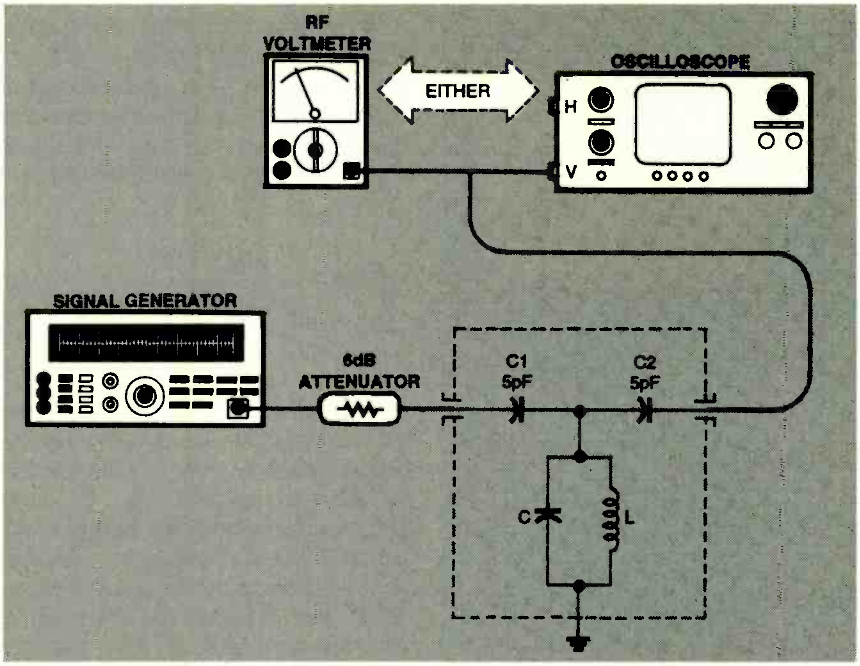



*Fig. 3. If the frequency output of a signal generator is accurately known, we can use a known inductance to find an unknown capacitance, or vice versa.*

shown in Fig. 4. In either case, the idea is to isolate the instruments from the L and C elements. In Fig. 4A the isolation is provided by a pair of high-value (10,000-ohm to 1 megohm) resistors, R1 and R2. In Fig. 4B the coupling and isolation is provided by a one- or two-turn link winding over the inductor. The links and the main inductor are lightly coupled to each other.

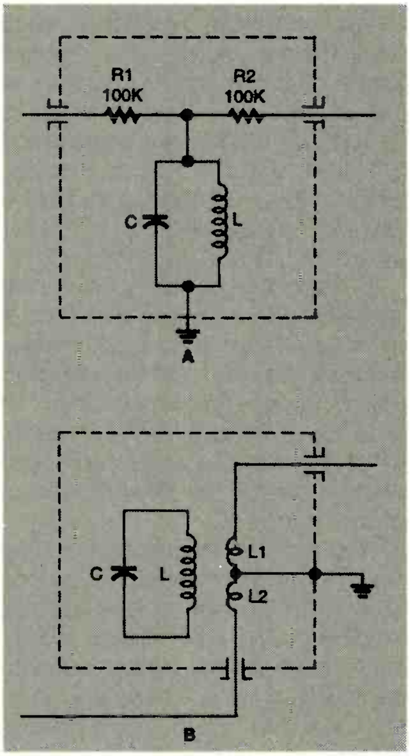



*Fig. 4. Different ways to couple L and C elements to the test instruments.*

**Frequency-Shifted Oscillator Method.** The frequency of a variable-frequency oscillator (VFO) is set by the combined action of an inductor and a capacitor. We know that a change in either capacitance or inductance produces a frequency change equal to the square of the component ratio. For example, for an inductance change:

$$L2 = L1 \times \left[\left(\frac{F1}{F2}\right)^2 - 1\right] \quad (7)$$

Where:

L1 is the original inductance
L2 is the new inductance
F1 is the original frequency
F2 is the new frequency

From this equation we can construct an inductance meter such as the one shown in Fig. 5. This circuit is a Clapp oscillator designed to oscillate in the high-frequency (HF) range up to about 12 MHz. The components L1, C1, and C2 are selected to resonate at some frequency. Inductor L1 should be of the same order of magnitude as $L_X$. The idea is to connect the unknown inductor across the test fixture terminals. Switch S1 is set to position "b" and the frequency (F1) is measured on a digital frequency counter. The switch is then set to position "a" in order to put the unknown inductance ($L_X$) in series with the known inductance (L1). The oscillator output frequency will shift to F2. When we know L1, F1 and F2 we can apply Equation (7) to calculate $L_X$ (L2 in Equation 7).

If we need to find a capacitance, then modify the circuit to permit a capacitance to be switched into the circuit across C1 instead of an inductance as shown in Fig. 5. Replace the "L" terms in Equation (7) with the corresponding "C" terms.

**Using RF Bridges.** Most RF bridges are based on the DC *Wheatstone bridge* circuit (see Fig. 6). In use since 1843, the Wheatstone bridge has formed the basis for many different measurement instruments. The *null condition* of the Wheatstone bridge exists when the voltage drop of R1/R2 is equal to the voltage drop of R3/R4. When the condition R1/R2 = R3/R4 is true, then the voltmeter (M1) will read zero. The basic measurement scheme is to know the values of three of the resistors, and use them to measure the value of the fourth. For example, one common scheme is to connect the unknown resistor in place of R4, make R1 and R3 fixed resistors of known value, and R2 is a calibrated potentiometer marked in ohms. By adjusting R2 for the null condition, and then reading its value, we can use the ratio (R2 x R3)/R1 = R4.

The Wheatstone bridge works well for finding unknown resistances from DC to some relatively low RF frequencies, but to measure L and C values at higher frequencies we need to modify the bridge. Three basic versions are used: Maxwell bridge (Fig. 7), Hay bridge (Fig. 8), and Schering bridge (Fig. 9).

**Maxwell Bridge.** The Maxwell bridge is shown in Fig. 7. The null condition for this bridge occurs when:

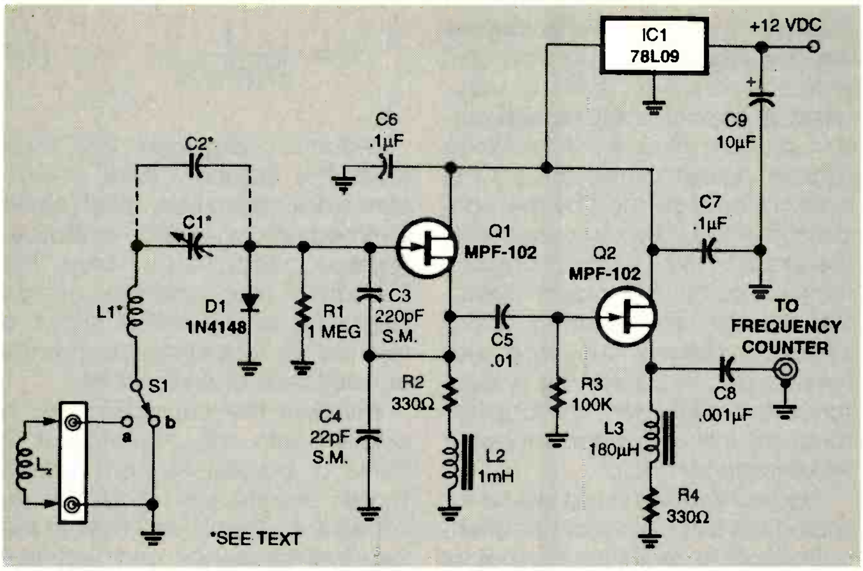



*Fig. 5. This circuit uses the frequency-shift method to measure the value of an unknown inductance. It is easily modified to measure an unknown capacitor instead.*

$$L1 = R2 \times R3 \times C1 \quad (8)$$

and

$$R4 = \frac{R2 \times R3}{R1} \quad (9)$$

The Maxwell bridge is often used to measure unknown values of inductance (*e.g.* L1) because the balance equations are totally independent of frequency. The bridge is also not too sensitive to resistive losses in the inductor (a failing of some other methods). Additionally, it is much easier to obtain calibrated standard capacitors for C1 than it is to obtain standard inductors for L1. As a result, one of the principal uses of this bridge is inductance measurements.

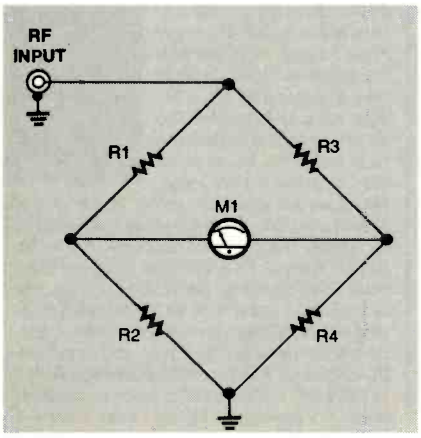



*Fig. 6. The Wheatstone bridge has been used since 1843.*

Maxwell bridge circuits are often used in measurement instruments called *Q-meters,* which measure the quality factor (Q) of inductors. The equation for Q is, however, frequency sensitive:

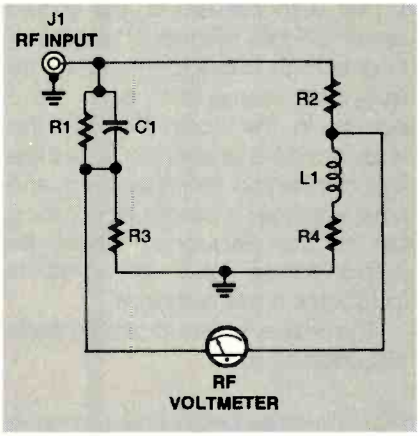



*Fig. 7. In the Maxwell bridge, the balance equations are independent of the frequency.*

$$Q = 2 \times \pi \times F \times R1 \times C1 \quad (10)$$

Where: F is in Hertz, R1 in ohms, and C1 in farads.

**Hay Bridge.** The Hay bridge (see Fig. 8) is physically similar to the Maxwell bridge, except that the R1/C1 combination is connected in series rather than parallel. Unlike the Maxwell bridge, the Hay bridge is frequency sensitive. The balance equations for the null condition are also a little more complex:

$$L1 = \frac{R2 \times R3 \times C1}{1 + \left[\frac{1}{Q}\right]^2} \quad (11)$$

$$R4 = \left[\frac{R2 \times R3}{R1}\right] \times \left[\frac{1}{Q^2 + 1}\right] \quad (12)$$

Where:

$$Q = \frac{1}{\omega \times R1 \times C1} \quad (13)$$

The Hay bridge is used for measuring inductances with high Q figures, while the Maxwell bridge is best with inductors that have a low Q value.

Note: A frequency-independent version of Equation (11) is possible when Q is very large (i.e. >100):

$$L1 = R2 \times R3 \times C1 \quad (14)$$

**Schering Bridge.** The Schering bridge circuit is shown in Fig. 9. The balance equations for the null condition are:

$$C3 = \frac{C2 \times R1}{R2} \quad (15)$$

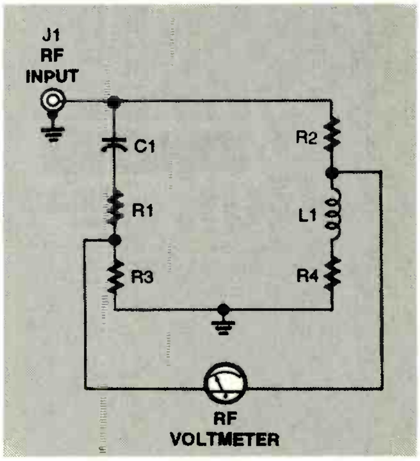



*Fig. 8. The Hay bridge is used to measure inductances with high Q values..*

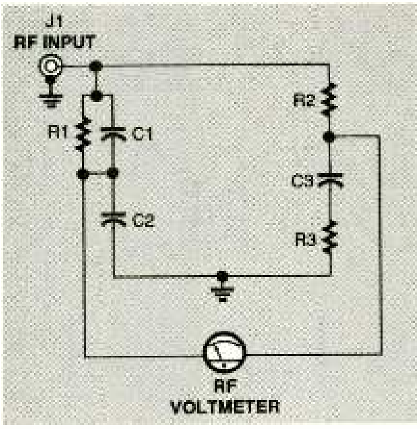



*Fig. 9. The Schering bridge is used to find the capacitance and power factor of capacitors.*

and

$$R3 = \frac{C2 \times R1}{R2} \qquad (16)$$

The Schering bridge is used primarily for finding the capacitance and the power factor of capacitors. In the latter applications no actual R3 is connected into the circuit, making the series resistance of the capacitor being tested (*e.g.* C3) the only resistance in that arm of the bridge. The capacitor's Q factor is found from:

$$Q_{C3} = \frac{1}{\omega \times R1 \times C1} \qquad (17)$$

**Finding Parasitic Capacitances and Inductances.** Capacitors and inductors are not ideal components. A capacitor will have a certain amount of series inductance (called "parasitic inductance"). This inductance is created by the conductors in the capacitor, especially the leads. In older forms of capacitor, such as the wax-paper dielectric devices used prior to about 1960, the series inductance was very large. Because the inductance is in series with the capacitance of the capacitor, it forms a series-resonant circuit.

Figure 10 shows a test set-up for finding the series-resonant frequency. A *tracking generator* is a special form of sweep generator that is synchronized to the frequency sweep of a spectrum analyzer. They are used with spectrum analyzers in order to perform stimulus-response measurements such as Fig. 10.

The nature of a series-resonant circuit is to present a low impedance at the resonant frequency, and a high impedance at all frequencies removed from resonance. In this case (Fig. 10), that impedance is across the signal line. The display on the spectrum analyzer will show a pronounced, sharp dip at the frequency where the capacitance and the parasitic inductance are resonant.

The value of the parasitic series inductance is:

$$L = \frac{1}{2^2 \pi^2 f^2 C} \qquad (18)$$

Inductors are also less than ideal. The adjacent turns of wire form small capacitors, which when summed up can result in a relatively large capacitance value. The illustration that appears at the beginning of this article shows a method for measuring the parallel capacitance of an inductor.

Because the capacitance is in parallel with the inductance, it forms a parallel-resonant circuit. Those circuits will produce an impedance that is very high at the resonant frequency, and very low at frequencies removed from resonance. In the lead illustration, the inductor and its parasitic parallel capacitance are in series with the signal line, so will (like the other circuit) produce a pronounced dip in the signal at the resonant frequency. The value of the parasitic inductance is:

$$C = \frac{1}{2^2 \pi^2 f^2 L} \qquad (19)$$

**Conclusion.** There are other forms of bridges, and other methods, for measuring L and C elements in RF circuits, but those discussed here are the most practical. That's especially true if you do not own or have access to specialized instruments.Ω

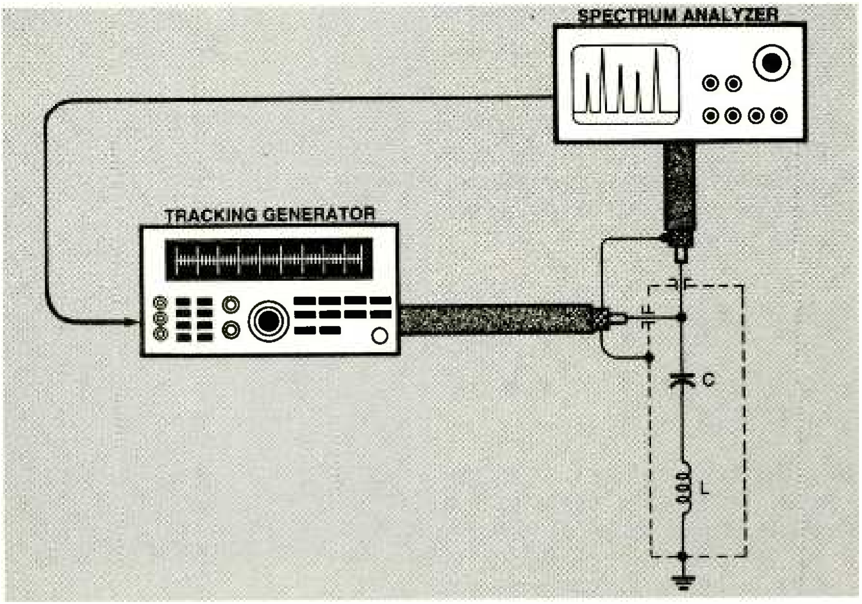



*Fig. 10. Use this set up to find the parasitic series inductance of a capacitor.*

# "Sniff" Out Transmitters with the RF Informant

*Do more than search for transmitters with this pocket-sized RF-strength meter.*

RICK DUKER

Mention the phrase "transmitter detector" and the first image that comes to mind is probably one of searching for hidden surveillance microphones, or "bugs". However, there is a use for such "bug sniffers" beyond the scope of the standard "James Bond" scenario. Examples of using an RF detector on the test bench include checking the operation of devices such as two-way transceivers, ham radios, cellular and cordless telephones, and baby-room monitors. Yet another somewhat unique and interesting application for this device is checking microwave ovens for leakage.

The pocket-sized RF Informant presented here is just such a device. Technically, it can be described as an AM/FM near-field radio-frequency receiver. The relative field strength of any RF signal that is in close proximity to the RF Informant's antenna is monitored, with the field strength displayed on a row of nine LEDs. An audio output is provided for earphone monitoring of the received signals.

The RF Informant operates in two reception modes—*wideband* and *highband*. In the wideband mode, the receiver is un-tuned and will detect practically any RF frequency from the low AM band below 500 kHz into the microwave range above 2 GHz. In the highband mode, the receiver is optimized for operation in the FM broadcast band.

And yes, the RF Informant can locate hidden transmitter surveillance "bugs".

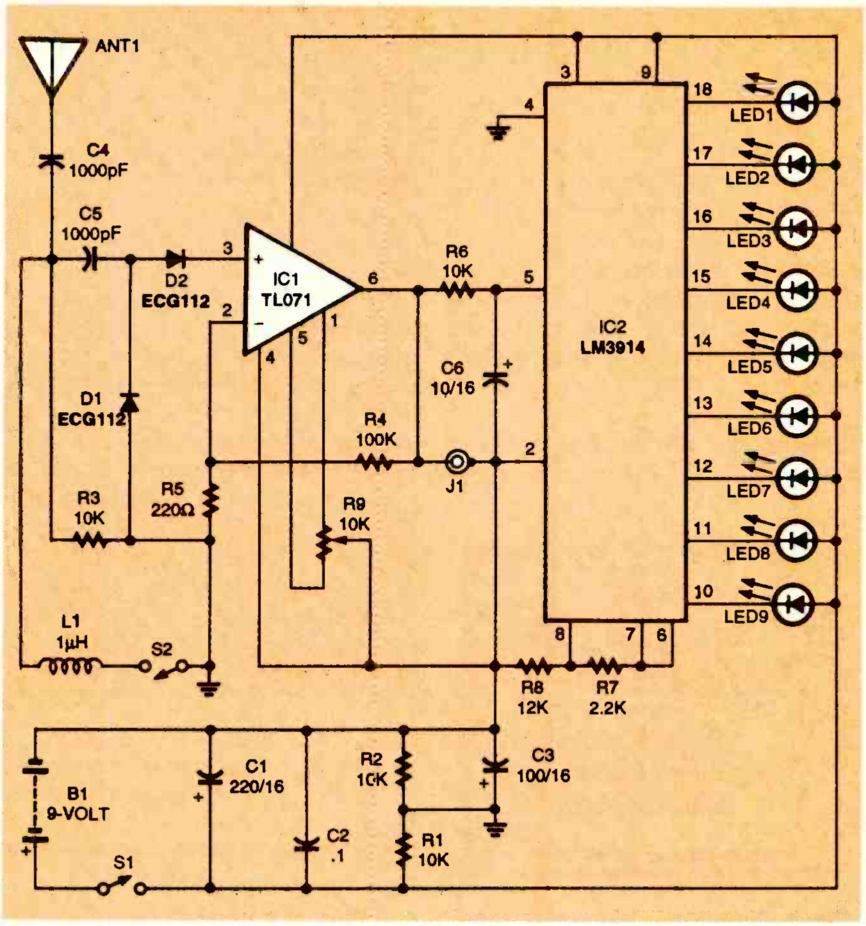



*Fig. 1. The RF Informant is a wideband receiver that can show the relative strength of the received signal on a series of LEDs. An earphone can also be used to listen to the received signal. Closing S2 can enhance sensitivity in the FM band.*

**Circuit Description.** The schematic diagram for the RF Informant is shown in Fig. 1. RF signals arriving at ANT1 are coupled by C5 to the detection circuit. A high-impedance ground connection for wideband reception is provided by R3. With L1 switched into the circuit by S2, the circuit is optimized for the FM band.

Diodes D1 and D2 do detection and demodulation. The detected signal is fed to the non-inverting input of IC1. That op-amp is configured as a non-inverting amplifier with a fixed gain of about 450. The particular device specified uses junction field-effect transistors (JFETs) on the inputs; that increases sensitivity due to their high impedance. Potentiometer R9 is a squelch control that adjusts the offset of IC1. The amplified detector output that appears on pin 6 of IC1 is fed to J1. A suitable high-impedance ear-

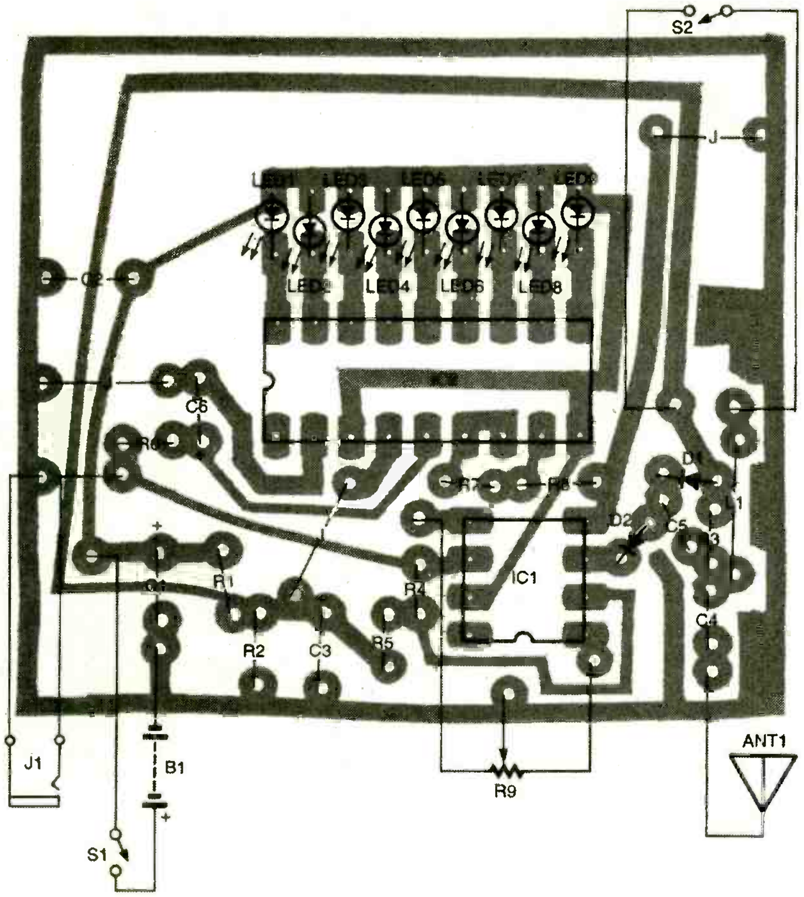



*Fig. 2. The RF Informant must be built on a PC board; use this parts-placement diagram if you are using the foil pattern provided in this article. Don't forget to install the jumpers where indicated.*

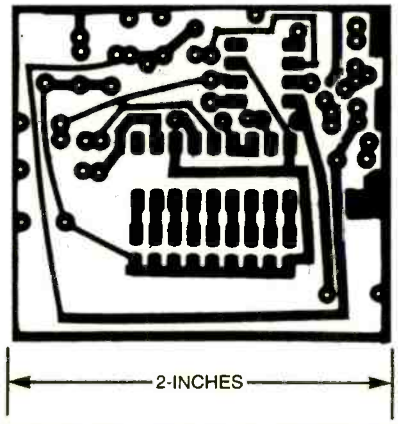
phone can be connected to J1 if you need to listen to the detected signal. Additionally, R6 and C6 smooth the signal.

The smoothed signal is then applied to the input of IC2, an LM3914 dot/bar display. That chip contains a resistor network and a set of comparators. Depending on the input voltage applied to pin 5, one or more LEDs will be turned on to display the relative voltage level. In the RF Informant, a bar display is selected by tying pin 3 to the positive supply voltage; at the lowest voltage, only LED9 will be illuminated. As the voltage increases, each LED comes on in turn until, at the highest voltage level, all nine devices are glowing. Resistors R7 and R8 set the reference voltage for a full-scale reading. Note that there are no current-limiting resistors for the LEDs; R7 and R8 limit the LED current as well.

Since IC1 requires a split power supply, R1, R2, and C3 create a "ground" reference. Even though power is supplied by B1, a 9-volt battery, C1 and C2 filter any noise that might stray into the supply lines.

**Building the RF Informant.** Since the RF Informant uses high frequencies, a printed-circuit board must be used. A foil pattern has been included for making your own board. If you don't want to etch a board, one is available from the source given in the Parts List.

Follow the parts-placement diagram shown in Fig. 2 for the locations of the various components. While there is no necessary order when installing the parts, it is best to always




*Here's the foil pattern for the RF Informant. Using a single-sided board makes the board easy to etch and the project easy to build.*

## PARTS LIST FOR THE RF INFORMANT

**SEMICONDUCTORS**

- IC1—TL071 operational amplifier, integrated circuit
- IC2—LM3914 Dot/bar display driver, integrated circuit
- DI, D2—ECG112 or similar silicon diode
- LED1–LED9—Light-emitting diode, red subminiature

**RESISTORS**

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

- R1–R3, R6—10,000-ohm
- R4—100,000-ohm
- R5—220-ohm
- R7—2200-ohm
- R8—12,000-ohm
- R9—10,000-ohm potentiometer, panel mount (see text)

**CAPACITORS**

- C1—220-µF, 16-WVDC, electrolytic
- C2—0.1-µF, ceramic-disc
- C3—100-µF, 16-WVDC, electrolytic
- C4, C5—1000-pF, ceramic-disc
- C6—10-µF, 16-WVDC, electrolytic

**ADDITIONAL PARTS AND MATERIALS**

- L1—1-µH inductor
- S1—Single-pole, single-throw switch (see text)
- S2—Single-pole, single-throw switch
- J1—Subminiature phone jack
- B1—9-volt battery
- ANT1—Telescoping antenna

**Note:** The following items are available from Quantum Research, 17919 77th Ave., Edmonton, AB, CA T5T 2S1: Etched and drilled PC board, $10.00; Kit of all parts, enclosure, and PC board, $69.95; Assembled RF Informant, $99.95. Please add $5.00 for shipping. All prices are in US dollars. Canadian residents must add appropriate PST and GST.

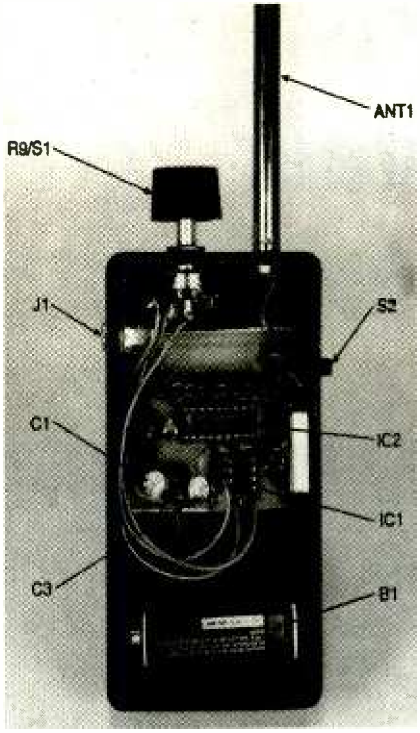



*Fig. 3. The completed RF Informant fits in a case that's comfortable to hold. Note that in the author's prototype shown here, R9 and S1 are combined into a single unit. That way, a single control can be used for both switching the RF Informant on and off as well as adjusting the gain of IC1—a method used on almost all radios.*

start with the smallest ones first; heat- and static-sensitive devices, such as semiconductors, should be saved for last. In light of that, start with the jumper wires. You can clip a short piece of lead from a resistor for use as a jumper. If you want to use sockets for the ICs, they should be mounted at this time, also.

The capacitors, resistors, and L1 are all mounted vertically. Note that C1, C3, and C6 are polarized components; double-check their orientation before installing them.

We are now ready for the semiconductors. Watch the orientation with those; be sure that they are facing the correct way before soldering them to the board. After mounting Dl and D2, install LED1-LED9. The light-emitting diodes must be mounted high enough off of the board so that they can be seen through the case cover. Most diodes have leads that will let you mount them so that the tips of the components are about 1 inch above the board. Keep them as long as possible.

Prepare the enclosure by drilling holes for S1, S2, R9, J1, and ANT1. An example arrangement is shown in Fig. 3. Note that in that example (the author's prototype), R9 and S1 are one physical component. Using a switched potentiometer like that gives the RF Informant the operational feel of a standard radio. Install those components in the enclosure. If you absolutely can't locate a switched potentiometer, separate components could be used.

A window is needed on the cover for the LEDs. An easy way to "mill" a slot is to mark the location for the "window" and drill a row of holes across the cover. Once the holes are drilled, file the rough edges so that a slot is created. With the PC board temporarily placed in the case and the cover on, the LEDs should be visible through the slot.

Insulated wires are used to connect the rest of the components to the board. When everything is connected, the board is fixed in place with double-sided foam tape or a couple of dabs of silicone adhesive.

Finally, install the ICs in their sockets, making sure that they are plugged in the right way around. Snap a fresh 9-volt battery in place, and the RF Informant is ready for testing.

**Testing and Use.** Plug an earphone into J1 and turn on S1. Select S2 for wideband reception. With the antenna extended, you should hear some sounds, and one or more LEDs will probably be lit. Rotate R9 and note the behavior of the display; you will note that you can control whether the LEDs are on or off. With LED1 just at the point of turning on, the receiver is adjusted for maximum sensitivity.

To test the unit further you will need an RF transmitter such as a cellular phone, cordless phone, baby-room monitor, FM wireless mike, walkie-talkie, or any other similar device. Hold the RF Informant away from yourself with the antenna vertical. Sweep the unit in an arc. You will see that there are two directions that have the strongest reading. If the signal gains strength as you move in the direction of the signal, you should be getting closer to the signal source. If the signal weakens, reverse your direction.

Adjust R9 for a reading on the LEDs that is not "pegged" to the limit. Continue to head in the direction of the strongest signal. You might need to correct your heading by sweeping the RF Informant in an arc to get a new bearing. You should also monitor the signal with an earphone plugged into J1. You might need to adjust the antenna length to pinpoint the RF source if it is quite strong.

If you are getting too much interference on the wideband setting, selecting the highband setting with S2 will usually give better reception—especially from an FM transmitter. Note that sources of interference can include light dimmers and fluorescent lighting.

Experience is the key to effectively using the RF Informant. Practice with hidden transmitters so that you can become familiar with the controls and monitoring techniques. You'll be amazed at how many sources of RF there are around you! Ω

# A Super-Safe Smart Crosswalk

*Here's a new safety system that can keep you from getting that "run-down" feeling when crossing a busy street.*

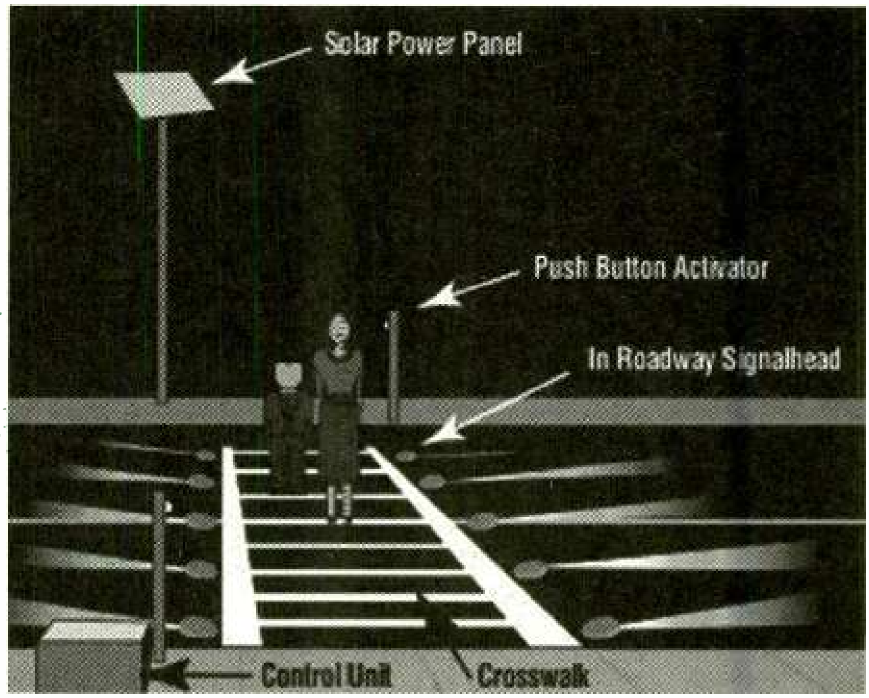
BILL SIURU

Crossing a busy street, especially at night, can be a dangerous affair, but it is also one that could soon be a lot safer. That's because the new "LightGuard System Smart Crosswalk" warning system makes it much easier for drivers to know when pedestrians are in a crosswalk. The system, from LightGuard Systems (LGS), Inc. (Santa Rosa, CA), works much like the flashing lights embedded in landing strips and taxi ways at airports. Indeed, this is where the system's inventor, Mike Harrison, a former commercial pilot, got the original idea.

The LightGuard System's flashing amber-color LED lights are embedded in the street on both sides of a pedestrian crosswalk. Installed so they face oncoming traffic, the lights can be seen by approaching motorists up to 1500-feet away. That greatly increases the warning that a driver has to step on the brakes, especially at night or in bad weather.

The warning system is automatically activated when a pedestrian passes between the Automatic Activation Bollards positioned near the crosswalk entrance zone. Those posts use break-beam technology that is already used extensively in industrial applications. The system determines the pedestrian's direction of movement and does not reactivate the warning when the pedestrian exits.

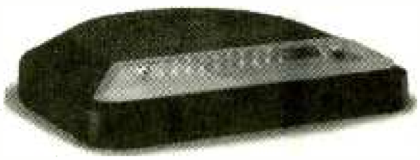
Pedestrians will not be aware of the activation, especially during daylight hours, but only that traffic is stopping. Pedestrians can also manually push buttons located on either side of the crosswalk. The flashing automatically shuts off after a set period of time, usually 15 to 20 seconds.



*The lightguard system's flashing LED lights are embedded in the street on both sides of a pedestrian crosswalk. The flashing lights warn oncoming drivers to slow down and stop for a crossing pedestrian.*

**Design Considerations.** Much effort went into selecting the right flash rate as well as light placement and aiming so that they get the attention of motorists and are visible down the entire motorist-viewing-path. The lights flash in unison at a pulse rate designed for maximum recognition. Challenges in getting the system right included making sure the lights were the right hue of amber and that they flickered in any direction, yet did not pulse at rates that might induce epileptic drivers to have seizures. Motorists say the strobe-like flash catches their eye without dangerously distracting them.

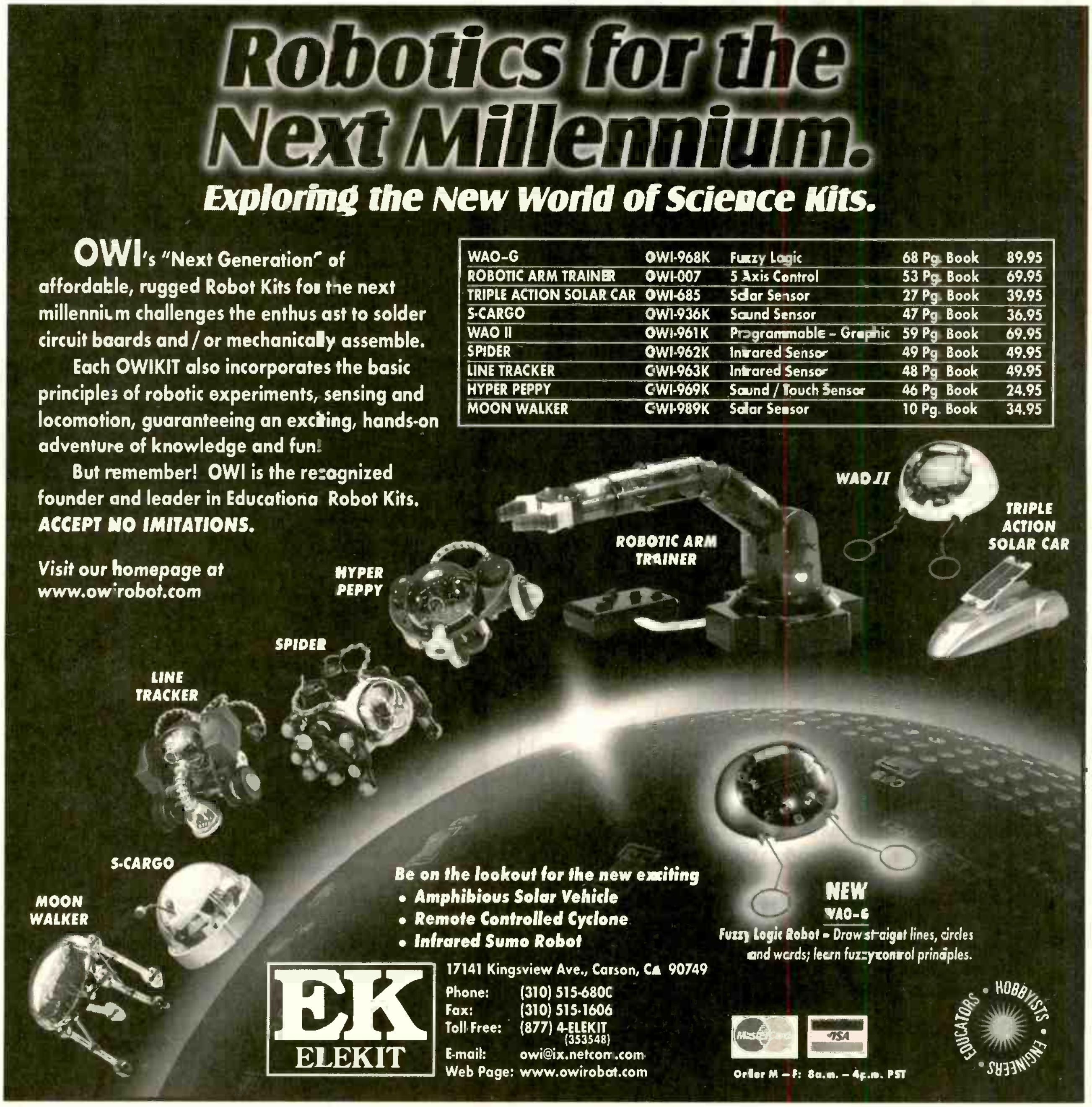
The amber LED provides good


*The system's low-profile signal heads project only about ½ inch above the pavement. A version that is more snowplow-friendly is under development.*

visibility in bright sunlight and in adverse weather, and the system is especially effective at night. Statistics show that pedestrians are 1100 times more likely to be hit by a car at night than during the day. Eight out of ten drivers who struck

*(Continued on page 86)*

# Electronic SHOPPER®

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| PROGRAM MEMORY | 768 OTP | 1K FLASH |
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| MAX INSTRUCTIONS / SEC | 5M | 20M |
| MAX COUNTER BITS | 16 | 18 |
| INPUT / OUTPUT BITS | 12 | 15 |
| A TO D COMPARATOR | NO | YES |
| HARDWARE INTERRUPTS | NONE | 3 |

PINOUT:

| | | | |
|---|---|---|---|
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| PD0 | 2 | 19 | PB7 |
| PD1 | 3 | 18 | PB6 |
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| XIN | 5 | 16 | PB4 |
| PD2/INT | 6 | 15 | PB3 |
| PD3 | 7 | 14 | PB2 |
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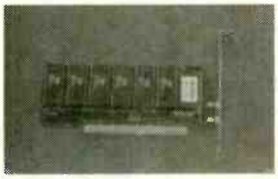
| PD5 | 9 | 12 | PB0/AD0 |
| GND | 10 | 11 | PD6 |

- LONG WORD INSTRUCTION - FRIENDLY SYMMETRIC ARCHITECTURE -



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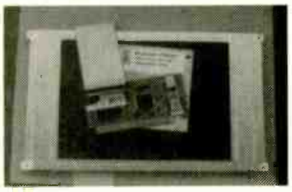

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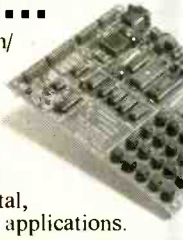

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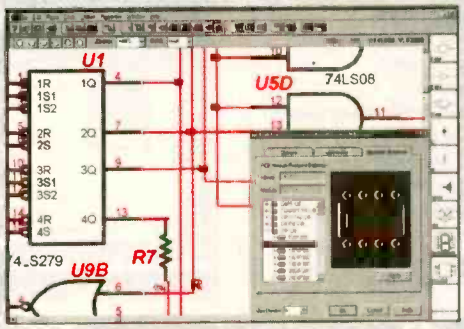


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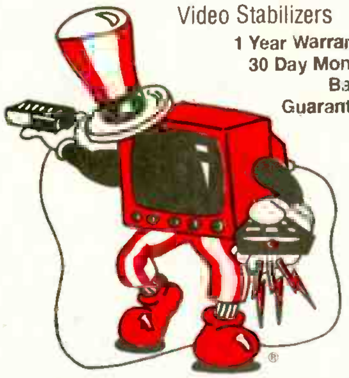

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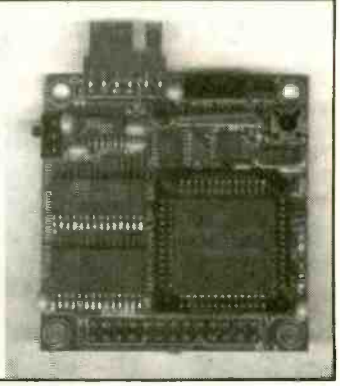

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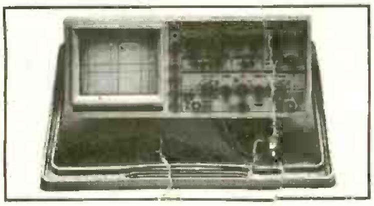

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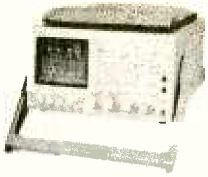

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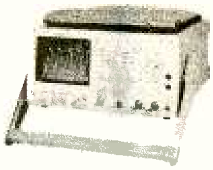

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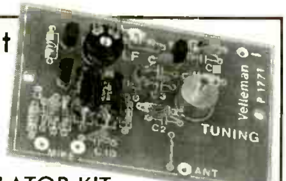


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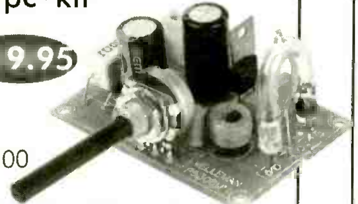

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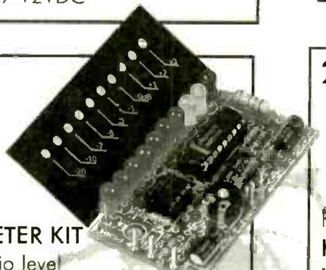

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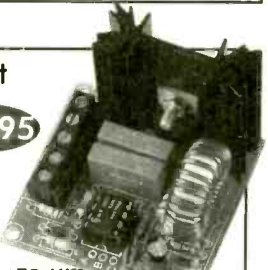

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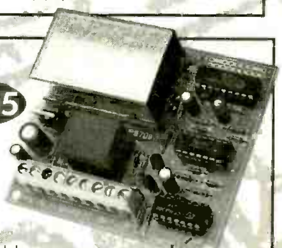

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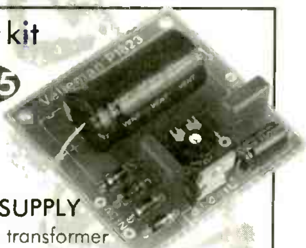

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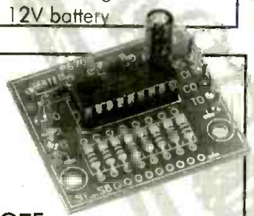

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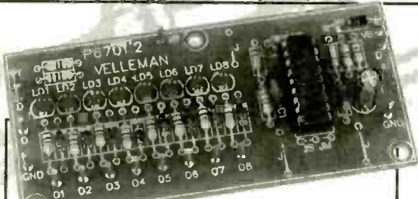


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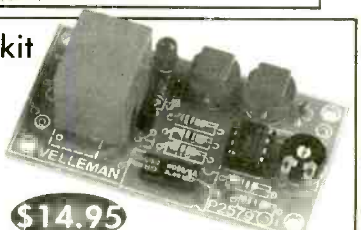


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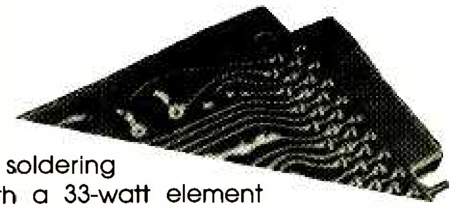
# How To Succeed In Soldering

*Using the right soldering tools along with tried and proven techniques are the keys to getting great solder joints every time.*

SKIP CAMPISI, JR.



With proper techniques and just basic equipment, an individual should be able to achieve a perfect solder joint each and every time. What's more, that joint should be formed in about three to four seconds after applying the iron. That said, many fail to achieve this ideal, even with expensive gear and hours of practice. If that describes you, don't despair—help is on the way!

By now I'm sure you'll all be asking, "Who does this guy think he is, trying to tell ME how to solder?" A fair question, to which I can give a fair answer: I have been an electronics hobbyist for over thirty-five years and have used most types of soldering systems at one time or another. This includes about twenty-five years as an electronics professional.

What I'll be describing in this article is based on my past experience with soldering: how to select the correct tools and solder, and techniques to use that guarantee success. Note that a lot of what follows goes against the "book" or conventional wisdom, so if you are already successful and happy with your own soldering methods—and they work well—don't change them! However, for those who aren't happy, this is for you.

**Getting Hot Over Heat.** The first thing we need for a good joint is HEAT, and plenty of it, to achieve a quick joint. For standard through-hole circuit boards I use only one iron: a soldering pencil with a 33-watt element running "flat-out" with no control (except for demanding jobs, I've found that temperature-controlled irons are often more trouble than they are worth). The tip is a standard 1/8-inch chisel style.

I can hear you all grumbling already: "Too much heat! You'll destroy your components!" This is not true at all. The secret lies in the tip: use only iron-clad soldering tips and keep them well tinned throughout the job. Mine always last for at least a year, and I do a lot of soldering!

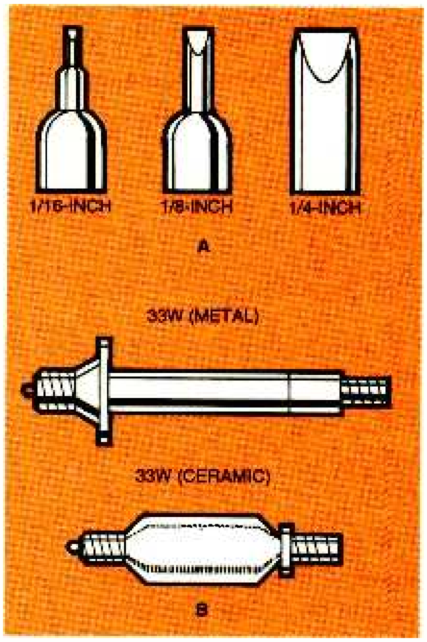
So, how about surface-mount devices? I still use the same heat element, this time with a 1/16-inch or smaller chisel tip. I know, still too much heat! In some cases, this can be true; however, judicious use of heat sinks on component leads is 100% effective. I'm definitely NOT talking about "grasping the lead with needle-nose pliers," as is so often mentioned in soldering tutorials. Have you ever tried that method? Whew!

In my experience, standard, "micro-gator" clips are extremely effective as heat sinks on components or component leads. Those are the clips that have flat jaws as opposed to the serrated jaws found in alligator clips. Sensitive devices such as precision resistors, capacitors, and of course all semiconductors can be soldered without damage using micro-gator clips, which are available from many sources including RadioShack. For tiny SMD transistor packages and the like, a clip snapped right onto the package itself is quite effective.

Your next question might be: "What element should I use for heavier joints, such as those involving wires and terminals?" Again, the 33-watt element is perfect for wires up to about 14 gauge, using the 1/8-inch chisel tip. For really heavy work, I switch to a 47-watt element with a ¼-inch tip for faster heat transfer.

Heat transfer is the number-one factor for successful solder joints. The faster it is accomplished (within reason!), the better your joints will be. Period. More components are damaged by applying lower-heat irons to joints for long time periods, as opposed to higher heat irons for the three or four seconds mentioned previously. And, of course, use of a soldering gun is definitely overkill! I don't even own a gun.

**Solder.** So then, what's the best all-around solder to use? The absolute BEST solder I've ever used is: KESTER "44" resin-core solder, with their #66 core. For general circuit-board soldering, I use their 60/40 alloy in 0.031-inch (1/32-inch) diameter. For SMT soldering, I switch to 0.015-inch or 0.020-inch diameter. Note, there may well be equivalent solder out there by another manufacturer, but this is what works for me so I stopped looking.




*Typical chisel tips shown here (A) are used for SMT, general work, and heavy-duty work. They should all be of the "iron-clad" variety and threaded to fit the correct heat element. The heat elements shown (B) are made in two styles: metal cased or ceramic cased. Both thread right into a handle, with a "cool-grip" handle being the best choice.*

The reason I consider this solder to be the best is due to the resin core itself. This is one brand of flux that you do NOT have to remove from your finished circuit board! Honest! I have many projects from over twenty years ago that are still functioning 100% correctly despite the fact that the boards are still "swimming" in the original flux residue. No type of corrosion or other type of damage was ever found in those units due to flux residue.

So, what's the big deal about de-fluxing a board? Well, if you've ever tried to de-flux a board, you already know what a messy job that can be. No matter what you do, all that you'll end up with is diluted flux residue spread over the entire board and its components. You can readily feel that as a sticky residue on everything. Erratic component and board functioning is often the direct result of this mess.

While hobbyists try to do it anyway, the proper method of de-fluxing boards is just not practical for the average hobbyist. To do it right requires industrial-strength flux-removing chemicals, a hot-soap ultrasonic cleaning, a thorough water rinse, some time baking in an oven to dry the board, and finally applying a chemical sealant to the finished board to prevent further contamination. If you can't do all of this, de-fluxing a board is just a waste of time. So, a flux that is inactive at normal ambient temperatures is obviously quite desirable.

Of course, there are situations where leaving even an inactive flux on the board could cause problems, such as when dealing with sensitive nodes at very low current levels where leakage through flux paths can be greater than the signals. The trick in those situations is to create an air gap or use a Teflon-insulated standoff terminal to keep the joint off of the surface of the board. This is 100% effective.

**Speed Does Not Kill.** So, now we know what solder and iron to use, what's the REAL trick to making a "quick" joint? This is where you have to develop the proper techniques in using a "hot" iron. That will take some practice to really get up to speed, especially if you've already developed some bad soldering habits.

Tip maintenance is extremely important when using a "hot" iron with an iron-clad tip. As already mentioned, the tip must be kept tinned at all times for protection of its surface. When first using a new tip, allow it to heat up while attempting to tin it every few seconds with the proper solder until you achieve a complete coating. DON'T allow the tip to overheat without any tinning to protect it!

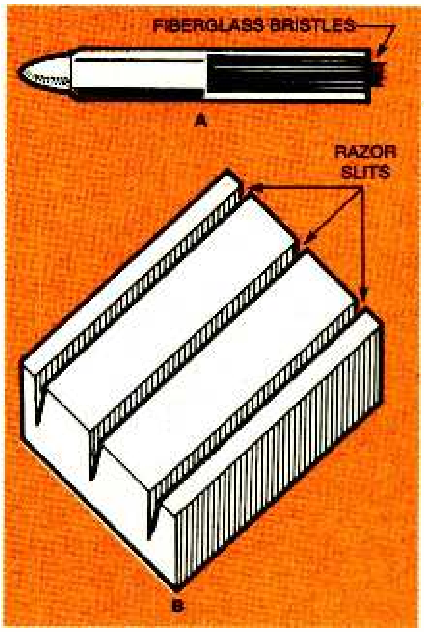
Once you have it completely tinned, shake off the excess solder with a quick flip of your wrist. I keep a standard "paper plate" on the floor next to my bench to catch the solder splats. After a few more seconds, apply more solder to the tip, shaking off the excess once again. Repeat until you're satisfied with the tinning job. (After completing your soldering job, re-tin the entire tip again before removing power from the iron.)

Before applying the tip to any joint, it has to be wiped properly to expose fresh, un-oxidized solder. The best method of doing this is to use a damp sponge. Obtain a standard soldering sponge and before applying water to it, use a razor blade or hobby knife to slit it lengthwise. Cut in about three or four slits without cutting through the sponge material, going down about only half-way through its thickness.

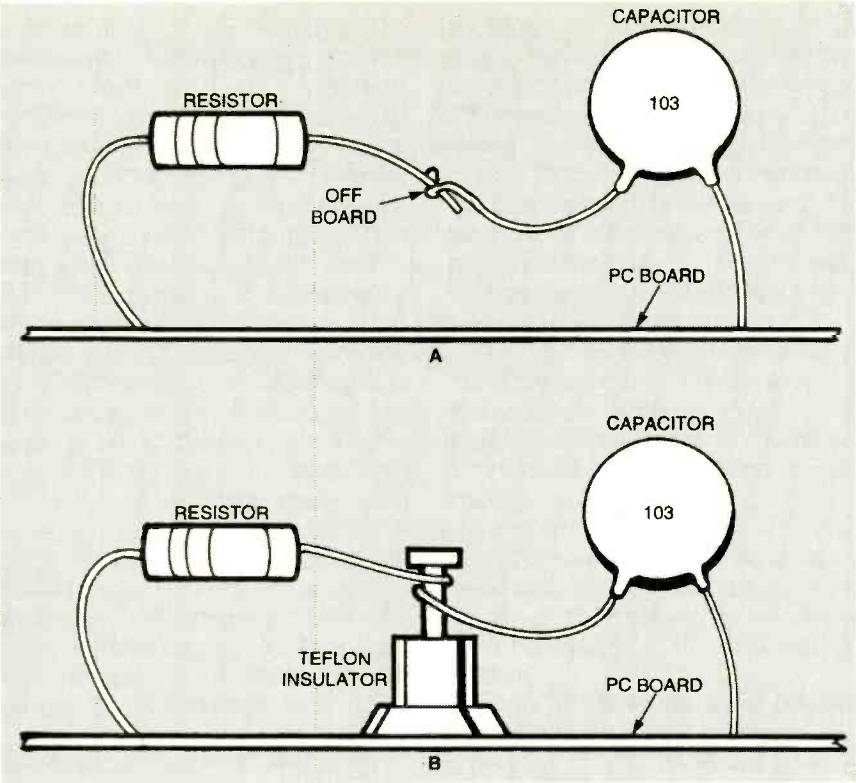
Soak the sponge with water, and squeeze out the excess. Insert the damp sponge into its tray, which you should tie down on your bench in a convenient location. Take your hot iron with its pre-tinned tip and wipe the chisel part of the tip only down one of the sponge slits a couple of times until it shines.

Shake off any excess solder or flux onto the paper plate, and quickly apply the tip to the desired joint. Place the tip so that maximum contact is achieved between both parts of the joint and the tip, and apply the solder directly to the tip where it contacts the joint.

Of course, this goes against the textbook techniques that say to apply the solder to the joint, never to the tip of the iron! Well, that's perfectly fine, if you don't mind cooking everything while waiting for the solder to melt. As I've already stated, I'm showing you




*A fiberglass eraser (A) is excellent for removing tarnish and rust. Note the brush full of fiberglass bristles which can be retracted when not in use. The sponge block (B) illustrates the slits made with a razor blade to facilitate proper cleaning of the chisel section of the tip.*




*To avoid signal leakage through flux residue on the PC board, create an air gap between the joint and the board as shown in A or use a Teflon-insulated terminal as shown in B.*

how to make a perfect joint quickly, without damaging anything. By applying the solder directly to the tip where it contacts the joint, it immediately melts, forming a pool of molten solder between the tip and joint. That allows additional solder to flow by quickly wetting the entire joint. (Remember fast heat transfer is what we are after.)

Once that happens, you can shift the solder feed to the joint itself for complete coverage if needed. If you've done all of this correctly, the entire process takes about three or four seconds. It may take some practice, but you'll note that all of your joints come out shiny and smooth, every time!

What about cold-solder joints? These can and do happen, and are almost always the result of oxidation or contamination of the metals in the joint. If you can't achieve a "wet" on a particular joint within about five seconds, remove the heat and select your favorite solder removing tool. I prefer a large, vacuum-type "solder-sucker" over solder-wicking materials. Re-tin the chisel tip, apply it to the joint, and remove the solder you first put on the joint. Be careful not to overheat the joint in this step!

Now take a standard, fiberglass "eraser" (found in office supply stores or at RadioShack) and use it to scrub the entire metal surface of the joint area. The fiberglass "brush" of the eraser does an excellent job in polishing the joint. It is also useful in removing rust from any ferrous materials. Now you may proceed to re-solder the joint; it should wet easily. By the way, it's a wise idea to polish any suspect metal with the eraser before attempting to apply solder; darkened areas of tarnish on switch contacts and some component leads are easily spotted beforehand.

So, there you have it: the quick and perfect solder joint. Sounds easy enough, doesn't it? I know a lot of you out there probably won't agree with my methods, but they DO work well! Why not fire up your old pencil iron and give it a shot. With a little practice, you too can make that perfect joint in under five seconds. Ω



## SAFE CROSSWALK

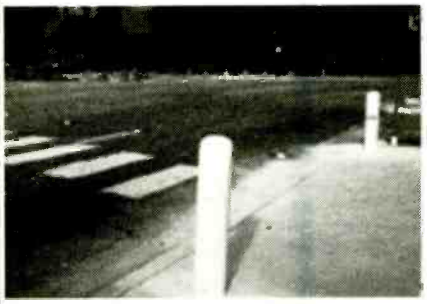
*(continued from page 48)*

**FOR MORE INFORMATION**
**LightGuard Systems, Inc.**
2292 Airport Blvd.
Santa Rosa, CA 95403
Tel: 707-542-4547
Web: www.crosswalks.com

people at night have reported that they simply did not see them in time.

**Where, and How Much?** All components of the system operate on 12-volts DC. The system could also be powered by 120-volt AC or by a stand-alone solar-powered battery system where electric power is not available. The units require little energy to operate—about as much a 20-watt light bulb.

According to LightGuard System, Inc., the system's cost is significantly less than a typical traffic-signal installation. Depending on the installation, selling prices range from $10,000 to $20,000.



*To activate the system in a typical setup, pedestrians simply walk between two Bollards at the top of the crosswalk.*

Currently, LightGuard Systems have been installed in Lafayette, Orinda, Petaluma, and Santa Rosa in California as well as in Florida, Nevada and Washington. Six solar-powered units are in operation in Saipan in the Mariana Islands. As of now, the LED signal heads project about ½-inch above the pavement surface, which could present problems for snowplows (though rubber-tipped plow blades could help here), but LGS plans to introduce a version that is more snowplow friendly. The system is also installed at the Reno-Tahoe International Airport. Ω

BY DON LANCASTER

# EIS Impedance Spectroscopy, New Current Sensors, and More

THIS MONTH, WE MIGHT LOOK AT AN ARCANE NEW FIELD KNOWN AS EIS (ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY), WHICH JUST MIGHT LEAD TO A FEW FASCINATING PAPERS AND LOTS OF EXCITing opportunities. But before we do, perhaps we should once again go over...

## Frequency and Spectra

Say you are in an orchard during a windstorm. You happen to notice that 240 apples per minute are falling on the average. From the dictionary definition, we could say the frequency of apple falling is four apples per second, or that the time period between apple fallings averages 0.25 seconds.

Electronic frequency has a rather more precise definition, but one that usually leads us to the same concept. Suppose you have a voltage on some terminal. Only one voltage is there at any given time, even though that one voltage might be the sum of a few wanted signals mixed with unwanted distortion or noise. You call the instantaneous voltage there a phase, and then can specially define frequency as being the rate of change of phase.

Often, the rate of change of phase will include identifiable components that look like one or more sinewaves. You can tell how large a sinewave is by its amplitude and how fast it is going by its frequency. The usual way to show this is:

$$e = A\sin(\omega t)$$

where A is the peak amplitude of your sinewave and ω is its radian frequency. (Radian frequency comes about because there are 2π or 6.2830 radians that run around a sine-cosine circle. For instance, 60 hertz has a radian frequency of 377.)

Things become further complicated

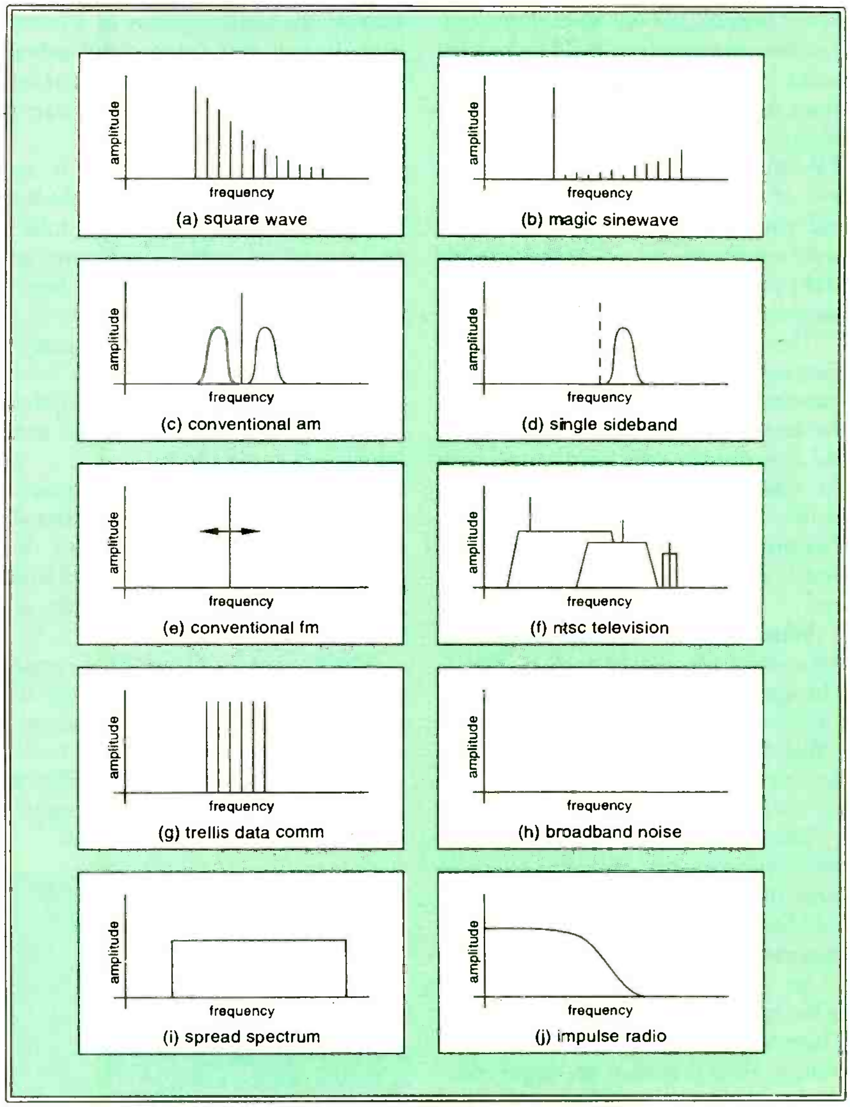



FIG. 1—SOME EXAMPLES of frequency spectra.

if they are changing. It is convenient to separate out the transient and steady-state conditions. Transients (such as when starting up) often may involve exponentials, while steady state tends towards sinewaves.

Frequencies of technical interest range as low as the few hertz found in earthquakes and brainwaves; up through audio, radio, microwaves, and the exotic terahertz mystery band; through heat, light, and ultraviolet; and on up to high-energy particles. The arrangement of all frequencies expected to be present is often called a spectrum. A spectrum is normally shown as a plot of amplitude versus frequency. An instrument to display a spectrum is often called, of all things, a spectrum analyzer.

The "old" techniques for building spectrum analyzers are to sweep a narrow band filter through all the frequencies of interest and see what comes out. Another approach is to build up parallel banks of narrow band filters, each of which displays a limited frequency range energy as its output. Ordinary Varactor TV tuners are one route to lower the cost of swept analog RF instruments, and the "thermometer" displays on audio equalizers give us a useful example of the parallel-filter method of spectrum analysis.

The "new" ways to build spectrum analyzers are much faster and more accurate. These operate by digitizing the time-versus-frequency information and then playing a few math games with the results. The usual techniques can involve DFT, short for Discrete Fourier Transform, or the FFT, short for the Fast Fourier Transform. Both see wide use.

What does a spectrum look like? Some examples can be seen in Fig. 1. The square wave of Fig. 1A consists of a fundamental sinewave along with its diminishing odd harmonics of one third the third harmonic, one fifth the fifth, one seventh the seventh...

The magic sinewave of Fig. 1B is an ultra-long sequence of digital ones and zeros that minimizes distortions of the low harmonics. The higher ones are removed by load filtering.

An AM or Amplitude Modulated radio spectrum is shown in Fig. 1C. There we can see that this consists of a continuous RF carrier, an upper sideband, and a lower sideband. AM is not efficient because the carrier conveys no useful information and the upper and lower sidebands are nearly identical.

The single sideband spectrum of Fig. 1D transmits only the chosen upper or lower sideband of an AM signal. It is more efficient in both bandwidth and power. But elaborate techniques are needed at the receiver to mimic the needed carrier for detection.

A frequency modulation spectrum (Fig. 1E) results when some carrier's frequency is moved back and forth. Rather than up and down in strength as in AM. FM communication gives you strong noise reduction because signals can be hard limited. The math behind FM signals gets nasty and often involves Bessell Function beasties.

The television spectrum of Fig. 1F is more complex. It is mainly AM, but the lower vestigial sideband is limited to lower frequencies, which allow stronger amplitudes for fringe sync signals. Further, the sampled nature of TV scanning lets you stuff a second AM subcarrier that holds the offset NTSC chrominance information plus a third, narrow FM sound subcarrier.

A trellis spectrum (Fig. 1G) is used for data communications. It might have six phases of six frequencies for a total of 64 transmitted states. Each state can efficiently represent up to six bits of transmitted data.

The noise spectra of Fig. 1H consists of random and changing signals over a broad band. This could be anything from undesirable interference to some intentional music effect.

A spread spectrum scheme appears in Fig. 1I. Here, a signal is intentionally made much wider in bandwidth than needed. In the process, you'll pick up all sorts of nice security, multipath, and interference benefits.

Finally, in Fig. 1J, we have impulse communications. It seems to be the ultimate in spread spectrum as energy is splattered out over all possible lower frequencies resulting in superb interference reduction when used for micropower communications or measurement.

**NEED HELP?**

Phone or write all your US Tech Musings questions to:

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

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



Don's best early stuff at a bargain price. Includes the CMOS Cookbook, The TTL Cookbook, Active Filter Cookbook, PostScript video, Case Against Patents, Incredible Secret Money Machine II, and Hardware Hacker II reprints. **$119.50**

**LOTS OF OTHER GOODIES**

| | |
|---|---|
| Tech Musings V or VI | $24.50 |
| Ask the Guru I or II or III | $24.50 |
| Hardware Hacker II, III or IV | $24.50 |
| Micro Cookbook I | $19.50 |
| PostScript Beginner Stuff | $29.50 |
| PostScript Show and Tell | $29.50 |
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| PostScript Tutorial/Cookbook | $22.50 |
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| Understanding PS Programming | $29.50 |
| PostScript: A Visual Approach | $22.50 |
| PostScript Program Design | $24.50 |
| Thinking in PostScript | $22.50 |
| LaserWriter Reference | $19.50 |
| Type 1 Font Format | $16.50 |
| Acrobat Reference | $24.50 |
| Whole works (all PostScript) | $380.00 |
| Technical Insider Secrets | FREE |

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Ongoing details on Book-on-demand publishing, a new method of producing books only when and as ordered. Reprints, sources, samples. **$39.50**

**THE CASE AGAINST PATENTS**
For most individuals, patents are virtually certain to result in a net loss of sanity, energy, time, and money. This reprint set shows you Don's tested and proven real-world alternatives **28.50**

More on these topics appears in www.tinaja.com/muse01.html on my Guru's Lair Web site. Specific details on magic sinewaves are found in the Magic Sinewaves tech library located there as well. Additional filtering details are in my Active Filter Cookbook. We recently looked at impulse communications, and a new Web page on this is now in the works. *Spread Spectrum Scene* is a useful trade journal on this subject.

## Electrochemical Impedance Spectroscopy

EIS is pretty much the opposite of spectrum analysis. Instead of seeing what frequencies are present, you'll purposely apply test frequencies to determine useful properties of some ionic liquid.

At any given frequency, a liquid or another substance has a resistive loss plus a reactive storage. More often than not, the storage component will be capacitive rather than inductive.

The losses of a substance tend to go up sharply with frequency, while the overall impedance decreases. Thus, EIS applies "by-frequency" measurement techniques to various electrochemical solids and liquids.

Important EIS uses include:

corrosion prevention
materials research
cancer therapy
paint development
concrete testing
battery monitoring

Finding an exact charge state and remaining lifetime for a battery can be extremely useful. In its spare time, EIS utterly demolishes the outrageous overunity claims of the hydrogen "pulse electrolysis" crowd.

Figure 2 shows us a general impedance measurement scheme. Here, you apply a single frequency of known amplitude through a variable resistor and capacitor. That frequency goes into a sample of the measured substance. The sample has to be of a fixed and known size, geometry, pressure, and working temperature. You then adjust the variable resistor and variable capacitor so that the terminal voltage "B" will be one half of the input voltage ("A") and that the phase shift is exactly zero. When your sample is inductive, you'll use an input inductor instead.

This same concept, of course, is used in compensating 10× oscilloscope probes. If the trimming cap is too small, the risetimes will be slow; too large and they overshoot.

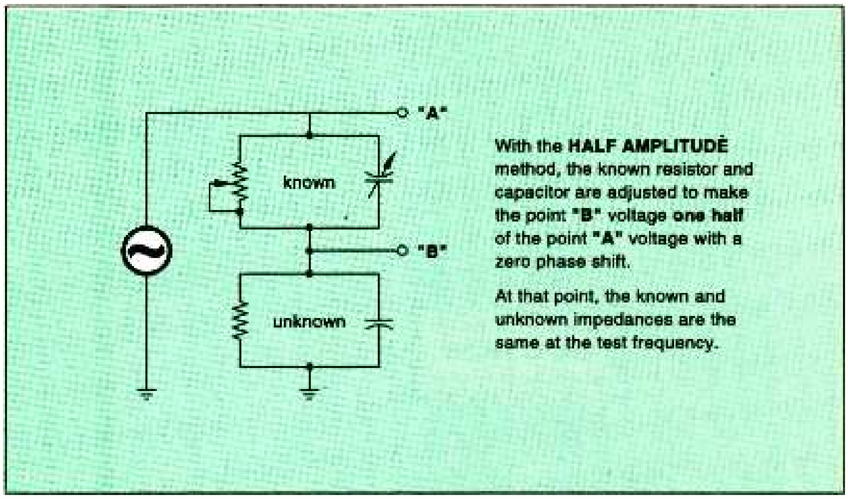



**FIG. 2—MEASURING THE IMPEDANCE** at a single frequency.

There are many bridge variations of this circuit. These are often more concerned with finding component values instead of determining how the values vary with frequency. With EIS, the frequency variations are not at all obvious.

In Fig. 3 we see another and improved approach. Here we place the sample in the feedback path of an operational amplifier. By stepping or sweeping input frequencies, an EIS curve of impedance versus frequency can be determined. A big advantage here is lower impedance drive to your cell. Through suitable electrode design, nondestructive and real-time testing can easily be handled.

That feedback resistor is usually in the high megohms. Its value is much higher than the normally expected EIS resistance and can be ignored or adjusted for. Circuit variations can simply measure the output amplitude and phase, or might continuously force a null balance.

By very careful evaluation of the EIS impedance versus frequency plot, the state of battery charge and life, the expected corrosion resistance of a coating, or even the status of a tumor treatment can be diagnosed.

EIS testing is both nondestructive and predictive. Test frequencies often go from tens of kHz on down to those ultra low frequencies used for battery charge-discharge cycles.

A summary of some EIS resources appears in the "Some EIS Resources" sidebar. The European studies and instruments appear to dominate this field. For more on EIS, enter "eis" and "electrochemical" in www.hotbot.com or into some other search engine, or use the convenient search buttons at my www.tinaja.com.

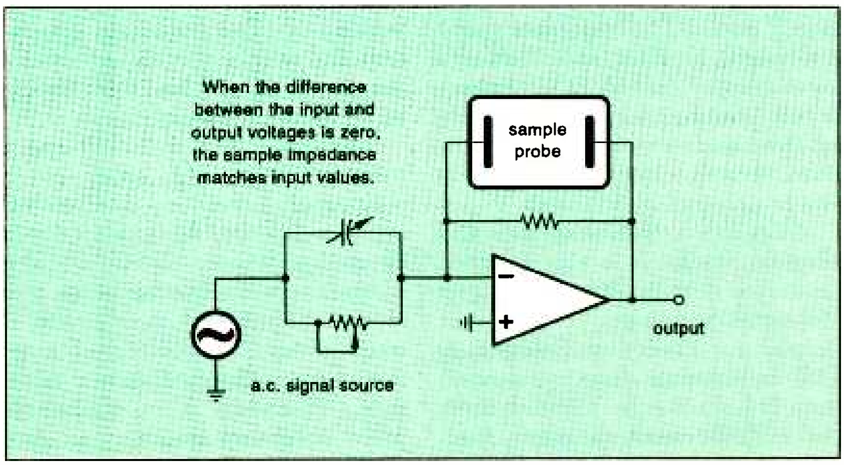



**FIG. 3—AN IMPROVED METHOD** of measuring impedance places the EIS cell in the feedback path of an operational amplifier.

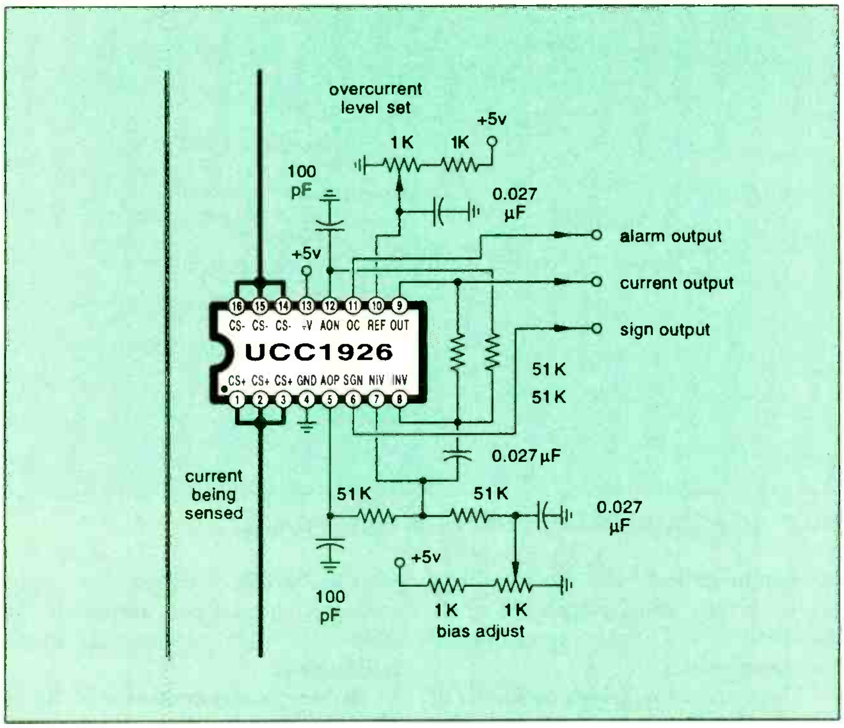



**FIG. 4**—THIS NEW CURRENT SENSOR has an internal shunt that is useful to 20 amperes. While ideal for AC power uses, the sensed frequencies can go as high as 40 MHz with suitable circuit variations.

The three leading manufacturers are Gamry Instruments, Solartron, and ACM Instruments. Solartron has just announced a new model 1275 EIS instrument. Additional details are at www.uniscan.co.uk/pr02.htm.

A good introduction to EIS can be found at www.bath.ac.uk/~chsacf/solartron/electro/html/int.htm. Topics here include electrode kinetics, mass transport, cyclic volt ammetry, and double layer effects.

A good book on the topic is *Macdonald's Impedance Spectroscopy*. See the *Electrochemical Society Proceedings*, Vol. 95-21, 1995, page 103 for more tutorial material. Several other useful texts might be Bard and Faulkner's *Electro-chemical Methods*, A.C. Fisher's *Electrode Dynamics*, Reiger's *Electrochemistry* and Delahays *Instrumentation Methods in Electrochemistry*. More details are at www.tinaja.com/amlink01.html.

NASA report 94-2082 on their EIS corrosion studies is a typical paper. Copies are downloadable by emailing corrosion@ksc.nasa.gov. Also see Electrochemical Impedance Spectroscopy (EIS) on Coatings from www.tno.nll/instit/kribc/ca-den_he lder/caeis.html. Use of EIS for electric car-battery modeling appears at www.rwth-aachen.de/isea/Ww/texte/abstract/ka_vrl a.html Very intriguing stuff.

A summer course on EIS and other electrochemical techniques is going to be offered by minerva.acc.virginia.edu/~cese/taylor/eisshort.html. Additional consulting on EIS and other technical topics is available by way of www.tinaja.com/info01.html

## Some New Current Sensors

I still could use a few low cost and snap-on wireless AC current sensors as this is the key to intelligent home energy management. Details on this isopod concept can be found by a search on my Web site. Karl Schmidt of Transtronix is working on a few interesting self-powered AC sensors that should solve at least part of the problem. Click through on his banner at www.tinaja.com.

Meanwhile, there are lots of new IC current sensors. As usual, go to www.questlink.com for a complete listing. For example, the new UCC3926 circuit by Unitrode directly measures currents to twenty amperes by use of an internal 1.3 milliohm shunt resistor. A transimpedance amplifier gives a sign output and differential current amplitudes. Bandwidth is an amazing 40 MHz! A separate amplifier and alarm comparator is provided on the same chip. More details on this device are in Fig. 4.

### Some EIS Resources

**Researchers & Instrument Manufacturers:**

**ACM Instruments**
125 Station Road
Clark Grange, LA11 7NY, UK
(44) 15395 59185

**Gamry Instruments**
734 Louis Drive
Warminster, PA 18974
(215) 682-9330

**ISEA**
Jagerstr 17/19
D-52066 Aachen GE
(49) 0-214-80-6920

**Northwestern ITI**
1801 Maple Avenue
Evanston, IL 60201
(847) 491-8165

**Solartron**
Victoria Road
Farnborough, Hampshire,
GU14 7PW, UK
(1) 610-2645034

**TNO Tech Institute**
1780 AB Den Helder
Netherlands
(31) 223-630867

**Journals:**

*CA Selects: Analytical Electrochemistry*
*CA Selects: Electrochemical Reactions*
*Corrosion Science*
*Journal of Electroanalytical Chemistry*
*Journal of the Electrochemical Society*
*Journal of Solid State Electrochemistry*
*Surface Engineering and Applied Electrochemistry*

**Books:**

*Electrochemical Methods* (Rossiter & Hamilton)
*Electrochemical Methods* (Bard & Faulkner)
*Impedance Spectroscopy* (Ross MacDonald)
*New Instrumental Methods in Electrochemistry* (Paul Delahay)

The supply voltage can vary from just under 5 to 12 volts. Current sensing can be on the high side, low side, or anywhere else between. I've left the supply

## Names And Numbers

**Advanced Linear Devices**
415 Tasman Dr.
Sunnyvale, CA 94089
(408) 747-1155

**AEMC Instruments**
99 Chauncy St.
Boston, MA 02111
(800) 343-1391

**Amprobe**
630 Merrick Rd.
Lynbrook, NY 11653
(516) 593-5600

**Armour Products**
PO Box 128
Wyckoff, NJ 07481
(201) 847-0404

**Bull Electrical**
250 Portland Rd.
Hove Sussex, BN3 5QT, UK
44 (0)1273 203500

**International Association of Calculator Collectors**
14561 Livingston St.
Tustin, CA 92780

**Computer Aided Engineering**
1100 Superior Ave.
Cleveland, OH 44114
(216) 696-7000

**Fuel Cell Bulletin**
Box 945
New York, NY 10159
(212) 633-7300

**Home Power**
PO Box 520
Ashland, OR 97520
(916) 475-3179

**InfoStor**
98 Spit Brook Rd.
Nashua, NH 03062
(603) 891-0123

**IVR**
12 West 21 Street
New York, NY 10010
(212) 691-8215

**LND**
3230 Lawson Blvd.
Oceanside, NY 11572
(516) 678-6141

**Reliable Power Meters**
400 Blossom Hill Rd.
Los Gatos, CA 95032
(408) 358-5100

**Jake Schwartz**
135 Saxby Terrace
Cherry Hill, NJ 08003
(609) 751-1310

**Simtek**
1465 Kelly Johnson Blvd.
Colorado Springs, CO 80920
(800) 637-1667

**Spread Spectrum Scene**
PO Box 2199
El Granada, CA 94018
(800) 524-9285

**STMicroelectronics**
55 Old Bedford Rd.
Lincoln, MA 01773
(781) 259-0300

**Surplus Record**
20 N Wacker Drive
Chicago, IL 60606
(312) 372-9077

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

**Transtronics**
3209 W 9th St.
Lawrence, KS 66049
(785) 841-3089

**Unitrode**
7 Continental Blvd.
Merrimack, NH 03054
(603) 424-2410

**Victoreen**
6000 Cochran Rd.
Cleveland, OH 44139
(440) 248-9300

bypassing and some gain options off this simplified circuit, so be certain to read the Unitrode data sheet and any applications notes before actually putting this IC to use.

Another interesting but pricey new development is a flexible current transducer. Instead of a clamp-around "glomper," you've got this rope-shaped transducer that could be carefully worked around individual wires in confined spaces.

An entire family of new AmpFlex flexible current probes is now being sold by AEMC Instruments. Their 30 models span from 0.5 to 30,000 amps and lengths of two to five feet. Typical list prices are $300.

Amprobe sells an ACF-3000 This one gives you one millivolt per amp on their 300-amp range, and one tenth that on the 3000-amp range. Another example is the Flexi-CT model from Reliable Power Meters

More on home energy management at *Home Power Magazine*. Bargains in older snap-on ammeter probes are at www.tinaja.com/barg01.html.

## New Tech Lit

From Advanced Linear Devices, comes a data book on a group of electrically programmable analog devices. These replace trimpots and can ease system calibration.

From Simtek, there's a new data book on non-volatile RAM. Micrel is offering a new MIC502 fan management chip. From STM comes a one piece TDA7521 analog front end for use in CD applications. A useful tutorial on gas-discharge lamps is found at www.intermarket.net/~don/dschlamp.html.

Jake Schwartz has a two-CD set on Hewlett Packard Calculating History at $23. Bunches of other useful information on old calculators can be found in the *Calculator Collector* newsletter from the International Association of Calculator Collectors.

Experimental fuel cells are offered by Bull Electrical. A very expensive but definitive *Fuel Cells Bulletin* is published by Elsevier Science.

Other featured trade journals for this month include *Computer Aided Engineering*, *IVR* (as in Interactive Voice Response), and *Infostor*. The latter is a new tabloid on disk drives, data sharing, and archiving.

*Surplus Record* is a thick monthly list that has tens of thousands of used machine tools. Its now in its 75th year.

Glass and mirror etching tools and supplies are stocked in depth by the folks at Armour Products. One source for radiation-detector sensors is LND. They also resell Geiger tubes, ionization chambers, counters, and neutron detectors. Also try Victoreen Instruments.

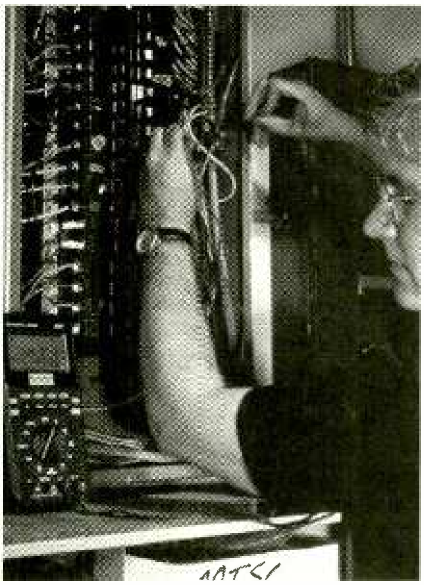
*(Continued on page 95)*

## NEW PRODUCTS

*(continued from page 27)*

and alligator clips.

The Craftsman Professional Multimeter + Scope (#82089) retails for $299.99.



CIRCLE 25 ON FREE INFORMATION CARD

**SEARS ROEBUCK, INC.**

*Tel: 800-390-8792 (information) or 800-377-7414 (sales)*

## Equipment Cleaner

THE GUST-AIR DUSTER EASILY removes dust and dirt from glass, computers, tools, plastics, rubber, or appliances. Using a clean, filtered, moisture-free, high pressure propellant that is colorless, odorless, and non-ozone depleting, the cleaner won't scratch or harm delicate surfaces.


CIRCLE 26 ON FREE INFORMATION CARD

GUST can be used to repair personal computers, stereos, TVs, and VCRs that may be faulty due to dust build up. Additional uses include dusting cameras, camcorders, computer keyboards, and other home or office equipment, as well as removing sawdust and metal filings from saw, drills, and other tools. Each GUST Cleaning Kit includes three 15-ounce cans of GUST. The GUST Cleaning Kit sells factory direct for $19.95 plus $4.50 S&H.

**STONER**

*1070 Robert Fulton Highway*
*P.O. Box 65*
*Quarryville, PA 17566*
*Tel: 888-STONERS*
*e-mail: STONER1@epix.net*
*Web: www.stonersolutions.com*

## S-Video Compensator

CIRCLE 27 ON FREE INFORMATION CARD

DESIGNED TO AMPLIFY AND correct S-video signal in all installations, the SA 201 Single Channel S-Video Compensator is a true S-video amplifier. The SA 201 provides one gold-plated S-video output with a dedicated set of controls (chroma gain, luminance gain, and a cable compensation control knob) allowing precise, customized calibration.

The SA 201 is compatible with S-video signals in NTSC, PAL, and SECAM standards. Setup and installation require one- to two-meter S-video cable lengths from the S-video output to the S-video in. The SA 201, housed in a compact, aluminum case, is powered by a 16-volt AC transformer. The SA 201 has a suggested retail price of $300.

**TRIBUTARIES**

*1307 East Landstreet Road*
*Orlando, FL 32824-7926*
*Tel: 800-521-1596*
*Web: www.tributariescable.com*

## PC-Label Printer

Merging the latest labeling technology with the ease of personal computing, the compact K2000-PC label and bar-code printer connects to a personal computer and prints graphics, logos, bar codes, and data records onto a wide range of labels. The user can choose from economical direct-thermal labels, heavy-duty industrial labels that are heat and chemical resistant, tamper-evident stock that alerts the user if the label has been tampered with, shrink tubing to mark wires or cables, and general-purpose or die-cut labels in a variety of sizes. Supplies are easily changed by simply dropping in a new cartridge.

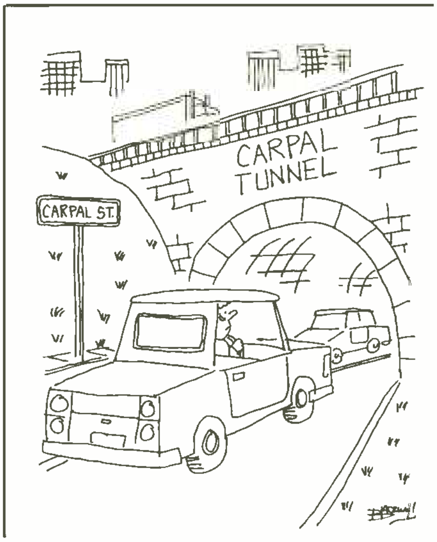
CIRCLE 28 ON FREE INFORMATION CARD

The K2000-PC printer comes with easy-to-use software so it's simple to create, edit, and save a variety of labels. Compatibility with most Windows software allows the user the time-saving option of updating and printing labels from data already entered into programs like Microsoft Word or Excel. The K-2000-PC label printer has a suggested retail price of $199.

**KROY LLC**

*7550 East Red Field*
*Scottsdale, AZ 85260-3443*
*Tel: 800-733-5769 or 602-948-2222*
*e-mail: info@kroy.com*
*Web: www.kroy.com*

EN



# Budget Project and Computer Books

☐ **BP317–Practical Electronic Timing $6.99.** Time measurement projects are among the most constructed gadgets by hobbyists. This book provides the theory and backs it with a wide range of practical construction projects. Each project has how-it-works theory and how to check it for correct operation.

☐ **BP415–Using Netscape on the Internet $8.99.** Get with the Internet and with surfing, or browsing, the World Wide Web, and with the Netscape Navigator in particular. The book explains: The Internet and how the World Wide Web fits into the general scenario; how do you go about getting an Internet connection of your own; how to download and install the various versions of Netscape browsing software that are available; and how to use Netscape Navigator to surf the Web, and to find and maintain lists of usful sites. There's a heck of a lot more, too!

☐ **BP325–A Concise User's Guide to Windows 3.1 $6.99.** Now you can manage Microsoft's Windows with confidence. Understand what hardware specification you need to run Windows 3.1 successfully, and how to install, customize, fine-tune and optimize your system. Then you'll get into understanding the Program Manager, File Manager and Print Manager. Next follows tips on the word processor, plus how to use Paintbrush. There's more on the Cardfile database with its auto-dial feature, Windows Calendar, Terminal, Notepad, etc.

☐ **BP327–DOS: One Step at a Time $5.99.** Although you spend most of your time working with a word processor, spreadsheet or database, and are probably quite happy using its file management facilities, there will be times when you absolutely need to use DOS to carry out 'housekeeping' functions. The book starts with an overview of DOS, and later chapters cover the commands for handling disks, directories and files.

☐ **PCP119–Electronic Music and Midi Projects $12.95.** Save cash by building the MIDI gadgets you need. Want a MIDI THRU box, program change pedal, Metronome, analog echo unit, MIDI patchbay or switcher? Over 16 practical and very useful music and MIDI projects—all in this book! The projects are explained in detail with full instructions on assembly.

☐ **PCP120—Multimedia on the PC! $14.95.** What is Multimedia? What can it do for you? It can do lots of nice things! This 184-page book helps you create your own multimedia presentation. Multimedia applications by people like you can revolutionize educational and business applications as well bring more fun, fun, fun into your leisure computer activities.

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☐ **BP379—30 Simple IC Terminal Block Projects $6.99.** Here are 30 easy-to-build IC projects almost anyone can build. Requiring an IC and a few additional components, the book's 'black-box' building technique enables and encourages the constructor to progress to more advanced projects. Some of which are: timer projects, op-amp projects, counter projects, NAND-gate projects, and more.

☐ **BP401—Transistor Data Tables $7.99.** The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

☐ **ETT1—Wireless & Electrical Cyclopedia $4.99.** Step back to the 1920's with this reprinted catalog from the Electro Importing Company. Antiquity displayed on every page with items priced as low as 3 cents. Product descriptions include: Radio components, kits, motors and dynamos, Leyden jars, hot-wire meters, carbon mikes and more. The perfect gift for a radio antique collector.

☐ **BP93–Electronic Timer Projects $2.99.** This book covers many of the possible applications of timer circuits. These circuits may turn on or off at either some preset time or after an elapsed time. Some of the more complicated timer and clock circuits are made up from a number of simpler circuits that the author deals with individually. Also included are several special interest circuits such as cars windshield wiper delay unit, a darkroom timer, metronome, etc.

☐ **BP88–How To Use Op-Amps $5.99.** Written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. There are chapters on Meet the Operational Amplifier, Basic Circuits, Oscillators, Audio Circuits, Filters, Miscellaneous Circuits, Common Op Amps, Power Supplies and Construction Notes and Fault Finding.

☐ **BP76–Power Supply Projects $3.99.** Presents a number of power-supply designs including simpled unbiased types, fixed voltage-regulated types and variable voltage stabilized designs. All are low-voltage types intended for use with semiconductor circuits. Apart from presenting a variety of designs that will satisfy most applications, the data in this book should help the reader to design his own power supplies. An essential addition to the experimenters electronics library.

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## NEW LITERATURE

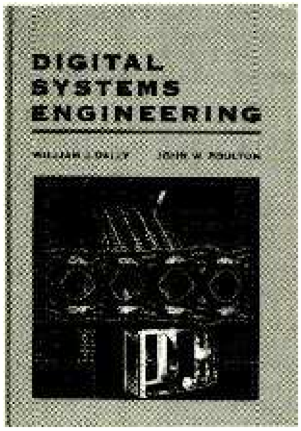
*(continued from page 29)*

digital and analog oscilloscopes and accessories, hand-held digital and clamp-on multimeters and accessories, component testers, and specimen analyzers. Specifications and ordering and pricing information are presented with each product.

### Digital Systems Engineering

*by William J. Dally and John W. Poulton*
*Cambridge University Press*
*40 W. 20th Street*
*New York, NY 10011-4211*
*Tel: 800-872-7423*
*Web: www.cup.org*
**$54.95**

Have you always wanted to know what makes some computers fast and others slow? Why do some digital systems operate reliably for years while others fail mysteriously every few hours? The answers to these questions of speed, reliability, and power are all determined by the system-level electrical design of a digital system.

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Combining a thorough discussion of the fundamental principles in each area with real-world examples of circuits and methods, the book presents a comprehensive treatment of these topics. Designed for both undergraduates and practicing digital designers, the book describes techniques, once only used in super-computers, that are now essential to the correct and efficient operation of any type of digital system.



### TV Video Systems for the Hobbyist & Technician

*by L.W. Pena and Brent A. Pena*
*Prompt Publications*
*Howard W. Sams & Company*
*2467 Waterfront Parkway, East Drive*
*Indianapolis, IN 46214-2041*
*Tel: 800-428-7267*
*Fax: 800-552-3910*
*Web: www.hwsams.com*
**$14.95**

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Covering standard hard-wired cable, large-dish satellite systems, wireless cable, and digital satellite systems, this book explains the different systems, how they are installed, their advantages and disadvantages, and how to troubleshoot problems. It was written for the hobbyist, technician, and do-it-yourselfer who likes to understand how things work, as well as to inform readers about the choices available to receive TV signals.

There are easy-to understand explanations of installations and connections, along with drawings and illustrations to guide and reinforce the subjects discussed. The nine chapters cover TV video systems, typical system components, apartment installations, home installations, troubleshooting tips, and more.

### 1999 Test and Measurement Product Guide

*from Tucker Electronics*
*P.O. Box 551419*
*Dallas, TX 75355-1419*
*Tel: 800-527-7642 or 214-348-8800*
*Fax: 214-348-0367*
*Web: www.tucker.com*
**Free**


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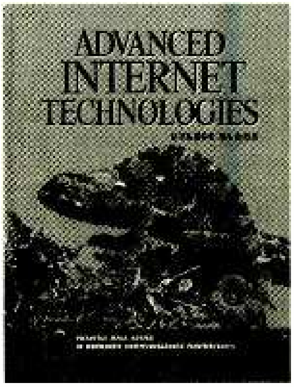
This catalog is a comprehensive guide for purchasing reconditioned equipment. It features 200 pages of new and reconditioned test and measurement instruments from Hewlett-Packard, Tektronix, Fluke, Anritsu, Elgar, IFR, Lambda, Marconi, Sorenson, Wavetek, Yokogawa, and hundreds of other leading manufacturers.

Among the new products are Yokogawa oscilloscope recorders and X-Y plotters, Huntron 4000 and 2500 component testers, Pomona oscilloscope probes, and FW Bell gaussmeters and milliammeters. Reconditioned products include Anritsu synthesized signal generators, Wiltron 6669A/03 programmable sweep generator, and Motorola R2008D communications system analyzer.

### Advanced Internet Technologies

*by Uyless Black*
*Prentice Hall*
*One Lake Street*
*Upper Saddle River, NJ 07458*
*Tel: 800-282-0693*
*Web: www.phptr.com*
**$49.99**

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This book introduces advanced Internet technology and the challenges of Internet communications. It covers the Internet's architecture, protocols, and traffic characteristics, and reviews the key issues involved in transforming the Internet from its data-only roots to a true multi-service network that can handle voice, video, and multimedia with comparable quality and reliability.

Every key IP protocol is covered, including voice-over IP, MPEG-2 and the H.32x series for multimedia applications, layer 3 switching, IPv6, IP multicasting protocols and systems, and multi-service protocols such as RSVP, RTP, and RTCP. There is also detailed coverage of routing, route discovery, and traffic integrity operations, as well as state-of-the-art techniques for minimizing packet delay, and a detailed discussion of Mobile IP.

## LFE/api by Triplett Catalog

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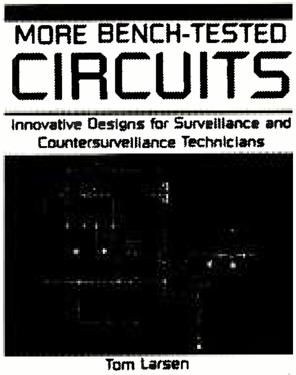
This 16-page full-color catalog features optical, solid-state, locking-coil and magnetic-contact meter-relay controllers. It also contains analog panel meters including models with removable scales, edgewise meters, and ruggedized-sealed meters, as well as programmable digital panel meters. Complete specifications are given for each product line.

## More Bench-Tested Circuits

*by Tom Larsen*
*Paladin Press*
*P.O. Box 1307*
*Boulder, CO 80306*
*Tel: 303-443-7250*
*Fax: 303-442-8741*
*Web: www.paladin-press.com*

**$21 plus S&H**

These updated, practical electronic circuits are designed for surveillance and countersurveillance technicians. The designs are inexpensive, simple, and fun. Every circuit has been benchtested by the author. One of the circuit designs is for a poor-man's component signature analyzer that will detect carrier-current transmitters and another is for bugging devices that are connected to the AC lines and are remote controlled. There are also some sophisticated yet simple circuits for detecting telephone line cuts and usage, as well as designs for building




CIRCLE 350 ON FREE INFORMATION CARD

inexpensive, undetectable phone taps.

The author shows readers how to use off-the-shelf components to remotely turn a bug or a telephone tap on or off. Also included are some clever, low-power-drain circuits great for marking hidden caches or rendezvous points. Each circuit has a detailed schematic illustrating why and how it works.

## Mobile Robots: Inspiration to Implementation, 2nd Edition

*by Joseph L. Jones, Bruce A. Seiger and Anita M. Flynn*
*A. K. Peters, Ltd.*
*63 South Avenue*
*Natick, MA 01760*
*Tel: 508-655-9933*
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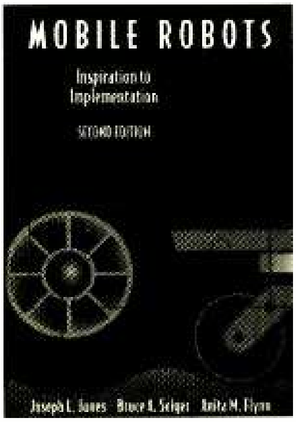
**$32**




CIRCLE 351 ON FREE INFORMATION CARD

Robotics has made quantum leaps since the first edition of this book was published. This edition keeps pace with the ever-growing and rapidly expanding field of robotics. Using photographs, illustrations, and informative text, this edition guides readers through the step-by-step process of constructing two robots—the TuteBot and the Rug Warrior.

Among the additions for this edition are a number of projects for the Rug Warrior, examples of robot projects and products by commercial and research groups, and heuristics and advice about robot design. The appendices have been revised and updated, and an appendix on robot contests has been added, as has information on programs and activities for robot enthusiasts. EN

## TECH MUSINGS

*(continued from page 91)*

One strange and wondrous book is David Lindsay's *Patent Files*. More on that is up at www.tinaja.com/amlink 01.html.

But remember, for most individuals and smaller scale startups most of the time, any involvement with patents is virtually certain to end up as a monumentally dumb waste of time, energy, money, and sanity. Find out why in my *Case Against Patents* package, available per my nearby Synergetics ad.

The latest surplus additions to my www.tinaja.com/barg01.html include a few 16-millimeter aerial-gun movie cameras that are superbly rugged and fast, besides being a collectible. Also some precision film platen robotics.

Detailed and custom solutions for most any tech question can be gotten at my www.tinaja.com/info01, while longer term consulting can be found at www.tinaja.com/consul01.html.

As usual, most of these mentioned companies are in the Names And Numbers or in the Some EIS Resources sidebars. And a no-charge US voice helpline remains available per the nearby box. But do note catalogs are no longer mailed. Instead, you download them online at www.tinaja.com/synlib01.html or at www.tinaja.com/barg 01.html. Similarly, all written help requests should include your e-mail address if you expect a personal answer. EN

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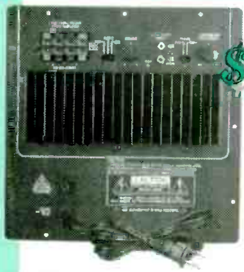

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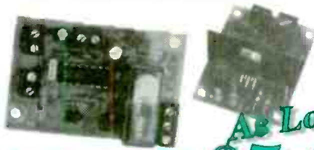

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