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EDITORIAL

Changes

As everyone knows, nothing ever stays the same. Change is something we all must deal with, and how well we deal with it often determines how well we succeed in our careers—and our lives. Fortunately, most of the time, changes turn out for the best. Other times . . . well, let's just say that whatever does not kill you makes you stronger.

Anyway, as you might have guessed from the preceding, changes are afoot here at **Electronics Now**. The good news is that they all fall into the first category. In fact, one of those changes has already arrived.

Regular readers of our "Computer Connections" column might have noticed a new though perhaps familiar name on the byline. Jeff Holtzman, our long-time computer editor, has left to pursue other interests. In his place is Konstantinos Karagiannis. Konstantinos is the editor of our sister magazine, **Popular Electronics**. He's also served as the technical editor for *PC Upgrade*, *Computer Buyer's Guide and Handbook*, and *Laptop Buyer's Guide and Handbook* magazines. With his excellent contacts within the PC industry, Konstantinos is in a unique position to bring our readers the lowdown on what's happening today in computer hardware, and what to look forward to tomorrow. You'll also see expanded coverage within the column on practical hints and tips to get the most out of your current hardware, how to do repairs and upgrades, and what to look for when shopping for a first or replacement computer.

We also will be adding a couple of new columns in the coming months. While I can't reveal the details at present, I can tell you that they focus on some of the most popular aspects of the electronics hobby. We know you will enjoy them.

However, no matter how much things change, there is one thing I can promise will stay the same. That is our commitment to providing our readers with the best, most comprehensive coverage of the entire gamut that is electronics. We think the changes will help us to better fulfill that commitment, and we think you'll agree.

Carl Laron
Editor

Q & A

CONDUCTED BY MICHAL A. COVINGTON, N4TMI

Audio Induction Coil

Q *I am 90 years old and have been reading Gernsback electronics magazines for many years. I once learned from your magazine how to hook up a Morse code key to a Model T spark coil to make a radio transmitter. It worked then, but today it would mess up a lot of people's TV reception.*

My problem now is different. I need a schematic for a device to take the signal from a telephone circuit, amplify it, and feed it into a loop around a room. This should set up a magnetic field that can be detected by hearing aids with T coils. I know it has been done before. If you can be of any help on this, I and many of my senior friends would appreciate it.—H. B. A., Bay Village, OH

A What you describe is called audio induction. A large coil around the room and a small coil on the pickup unit form a big transformer, transferring the audio signal from one to the other magnetically. This isn't radio; little or no electromagnetic radiation is produced. (The coil is a monstrously inefficient antenna at audio frequencies.) Instead, what you're doing is exactly what goes on in transformers.

Some hearing aids use induction coils to pick up the signal from telephone receivers—it's more reliable than picking up the sound. Not having one of these hearing aids handy, we're not sure how sensitive they are, but Fig. 1 shows an audio induction circuit we've experimented with. The big coil has a resistance of about 16 ohms and is fed with a few watts of audio, just as if it were a speaker. The small coil picks up a tiny audio-frequency signal, which is stepped up by the matching transformer and then fed to the microphone input of an amplifier. Pickup coils with substantially more turns may not need the transformer.

We trust you can adapt this circuit to your needs; you'll be using a hearing aid with an induction pickup in place of the pickup coil and amplifier. Others will find it useful as a way to transmit audio without wires to listeners who are free to move around and may even be on the other side of a wall.

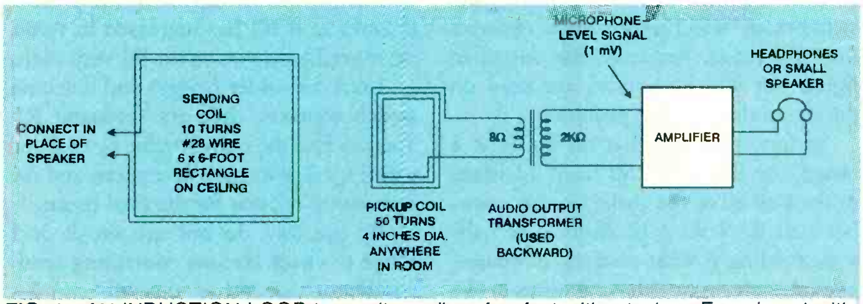


FIG. 1—AN INDUCTION LOOP transmits audio a few feet without wires. Experiment with different pickup coils; some might not need a transformer.

Remote Control Repeater

Q *I'm sitting in my living room in my favorite chair trying to find the right angle at which to bounce the infrared remote control signal off the hall mirror and change the CD. What I need is a remote control extender. I tried to use the RadioShack IR receiver to modulate an IR emitter but I had no luck. What am I doing wrong?—T. P., St. Albert, Alberta, Canada*

A The solution to the mystery is that the IR signal is chopped (turned on and off) at about 40 kHz to distinguish it from ambient IR light. The receiver module supplies un-chopped output, so you have to chop it again if you want to use it to control an IR-emitting LED. We published a circuit that does this in the December, 1995 installment of this column.

Sick Ohmmeter

Q *I recently dusted off my Simpson 260-5 (circa 1965) volt-ohm-milliammeter (VOM) and I'm having some trouble with the R × 1 scale readings. Fresh batteries and clean battery connections allow a full-scale 0 reading when I short the test leads, but the readings seem to be high by a factor of 4: 50-ohm resistors read 200 ohms, and so forth. I verified the test resistors with a DMM, VTVM, and another VOM. They all concur—the Simpson is off. The R × 100 and R × 10K scales read normally, as do all voltage and current scales.*

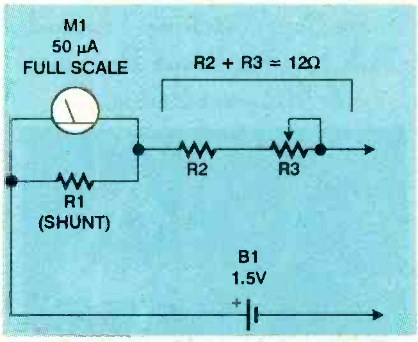


FIG. 2—THIS IS THE BASIC CIRCUIT of an ohmmeter that reads 12 ohms at half scale. The value of R1 is determined by the resistance of M1, the meter movement.

If anyone recognizes this anomaly, or has service experience with the 260, I would greatly appreciate any suggestions. It's a great meter that's worth saving. Also, I'd like to get a schematic and owner's manual for it; any ideas on where or how? Thanks.—J.A., Stony Point, NY

A Your second question is easy: Simpson Electric Company is still in business and still making the 260, although they're now up to model 260-8 instead of 260-5. You can reach them at 8853 Dundee Ave., Elgin, IL 60120, Tel: 847-

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org

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

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

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising over 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 (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.

697-2260, Web: www.simpsonelectric.com. Many technicians prefer a traditional VOM because it can't be damaged by static electricity.

We don't have the schematic ourselves, nor is it necessary; the ohmmeter portion of a classic VOM always has roughly the circuit shown in Fig. 2, plus switches to select appropriate resistors for each range. just trace the circuit to figure out which resistors are used on the range that has the problem.

In fact, knowing that on the R × 1 range, the Simpson 260 reads 12 ohms in the middle of the scale, we can calculate that R2 + R3 = 12 ohms. The half-scale reading is what matters, of course; all ohmmeter ranges have 0 ohms at the right and infinity at the left. When you short the test leads together and the meter reads 0 ohms, it's putting 125 milliamperes through R2, R3, and the test leads, but we know the meter has a 50-microampere movement, so nearly all the current must be going through the shunt (R1).

Most likely, R1 has decreased in value or there is a short circuit across it. Also, it looks as if R2 has increased in value, or, more likely, you've set R3 very high.

Look for solder bridges and defective switch contacts, then try replacing R1. You can find the correct value by trial and error; try 2 ohms as a first guess, and use a precision resistor for the final repair.

By the way, do not use the R × 1 range to check circuits containing semiconductors or other delicate components—the heavy current can damage them. Use a digital meter for that.

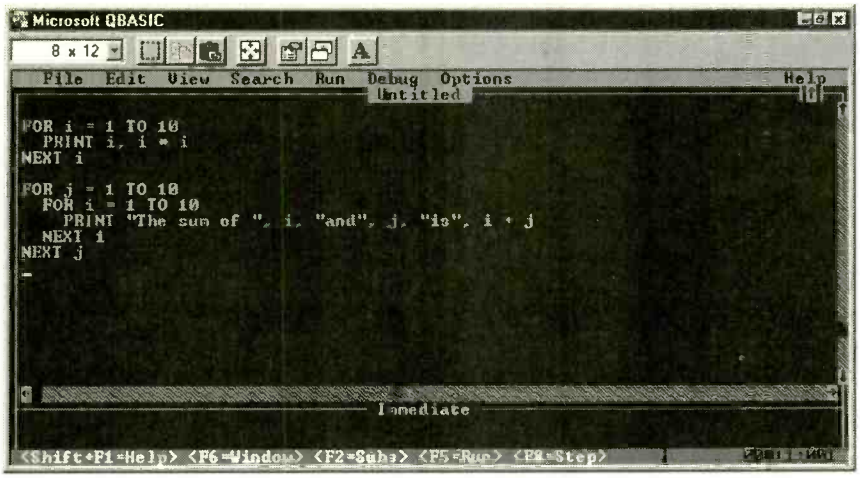


FIG. 3—QBASIC IS A DOS product that is still distributed with Windows 95 and 98.

Back To Basic

Q *I would like to know where to obtain updated versions of the useful do-it-yourself programming language BASIC. My versions are XBASIC and GW-BASIC, and they are 10 to 12 years old.—R. A. R., Los Angeles, CA*

A You'll feel like Rip Van Winkle when you discover what BASIC has grown up to be.

BASIC (originally Beginner's All-purpose Symbolic Instruction Code) was invented at Dartmouth University in 1964 to give math students a quick way to do calculations on a computer. It remains a popular general-purpose programming language. Unlike Pascal, C, C++, and Java, which are based on particular theories of how programs ought to be constructed, BASIC is all practice, no theory. The language is essentially a collection of things programmers have found useful, and it keeps growing.

If you run Windows 95 or 98, or a late version of DOS, you probably already have Microsoft QBASIC (Fig. 3), a full-screen programming environment that includes instant online help so you don't need a manual. If you're a Windows user, you probably didn't install QBASIC, but you'll find it on your Windows 95 or 98 CD-ROM in a directory called \other\oldmsdos or \tools\oldmsdos, respectively. To install it, copy QBASIC.EXE and QBASIC.HLP into your \windows\ command directory and establish a shortcut to QBASIC.EXE. It's a DOS application and runs in a DOS window.

QBASIC will run all your GW-BASIC programs, but line numbers are no longer necessary because you have a full-screen editor. Although QBASIC itself can't generate .EXE files, a related product, Microsoft QuickBasic, can do so; it's no longer marketed, but you can probably pick up a secondhand copy from an old-timer.

For Windows itself, Microsoft produces Visual Basic, a widely used professional program development environment (Fig. 4). Visual Basic lets you design windowed programs graphically, then write the BASIC code that should execute when the user clicks on each button or other object. You don't have to do the whole design at the beginning; you can add and delete objects and code at any time.

Visual Basic generates compact .EXE files that require a large .DLL file (supplied, and freely redistributable) in order to run. If you like the Visual Basic idea but would like to program in Pascal, C, or C++ and generate .EXEs that don't require a .DLL, try Inprise (formerly Borland) Delphi or C++ Builder respectively.

The alert reader will note that some time in the 1980s, between QBASIC and QuickBasic, Microsoft stopped writing BASIC in all capitals; we don't know why.

Low-Power FM Transmitters

Q *I live in a small community in northern British Columbia, Canada; am 13 years old; and ever since I was old enough to walk, I have been in love with science. Even*

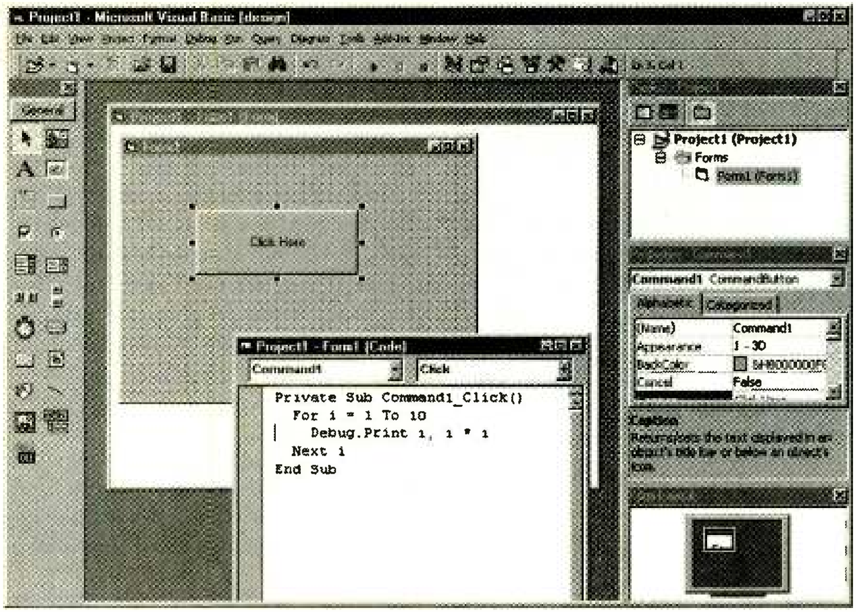


FIG. 4—VISUAL BASIC is a professional Windows programming environment based on the BASIC programming language.

though I'm a girl, I do a lot of "boyish" things (e.g., loving science, insects, reptiles), and my father has built me a lab down in the basement, complete with soldering station, electronic components, and microscope.

My friends and I have a 4-person "Mad Scientists' Club" and would like to have a way to communicate. Could you print some circuit diagrams of small, short-range FM radio transmitters that would transmit 5 or 10 miles?—K. S., Telkwa, B.C., Canada

A Keep it up—science needs more girls! Seriously, it's unfortunate the way so many girls are persuaded not to use their scientific or engineering talents.

The transmitters you describe will need a license for two reasons: the laws of Canada say so, and anything that can reliably cover 5 miles will sometimes interfere with communications 50 or 100 miles away. Thus, it's important to keep everything on carefully allocated frequencies.

Fortunately, you can get a license, as well as lots of information about how to build transmitters, by becoming a radio amateur (ham). For information, contact Radio Amateurs of Canada, 720 Belfast Road, Suite 217, Ottawa, Ontario K1G 0Z5, Web: www.rac.ca You do not have to learn Morse code in order to use FM above 30 MHz.

Carbon Monoxide Detector

Q *I have a CO (carbon monoxide) detector located in the basement, near the furnace. If it goes off in the middle of the night, there's no way we can hear it from the second-story bedroom. Can you suggest a way to connect it to a buzzer or bell upstairs?—J. H., Belmont, MA*

A You could probably just remove the sounder from a cheap CO detector and locate it elsewhere, connected by a long cable, but if you want real reliability—as you should, in a potentially life-saving device—it would be better to get a detector that is designed to connect to a fire alarm or other external indicators. Such detectors are available from Fireboy-Xintex, 100 Commerce Ave. SW, Grand Rapids, MI 49501-0152, Tel: 616-454-8337. Also contact local fire-alarm and boating-supply companies; both are likely to have CO detectors that are easy to interface to external alarms.

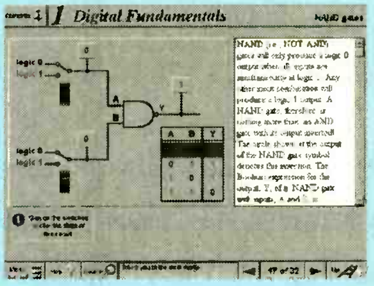
Writing to Q&A

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

EQUIPMENT REPORT

Matrix Multimedia Digital Electronics CD-ROM

Learn the basic principles and concepts behind digital electronics at your own pace with this valuable interactive CD-ROM



While some might not see it that way, the worlds of electronics and computers overlap a great deal. Computer-based virtual test gear has earned acceptance on many professional workbenches and is now making inroads with electronics hobbyists. Many of the electronic products you buy, and projects you build, have a microcontroller as their key component.

But computers can have another role, and one that is especially important to the electronics beginner. That is the role of teacher. There are many programs out there that help the novice gain insight into all the aspects of electronics. With those insights, an individual can get more out of his hobby, or perhaps take the first steps toward a rewarding career. In the realm of digital electronics, one of the best computer-based teaching aids we've seen is Matrix Multimedia's *Digital Electronics* CD-ROM.

The *Digital Electronics* CD-ROM is an interactive computer-based multimedia laboratory/textbook that moves along at whatever speed the user is comfortable with, teaching the basics behind digital electronics—the theories, circuits, parts, and all. While those already knowledgeable in digital electronics might not learn much new information from using this disc, beginners in digital theory will find it quite interesting. And those who don't want or need to learn about digital electronics might just want to have the disc around for informational purposes. Digital Electronics is written by Mike Tooley and published in the UK by Matrix Multimedia Limited. It's available here in the United States for $75 from CLAGGK Inc. (that price includes shipping in the US; foreign buyers must contact the company for shipping information).

Digital Electronics

Intended for educational and training purposes, *Digital Electronics* is useful for teachers, students, and professionals. The disc includes all support materials and printable and editable worksheets, plus supervisor notes. Text on the disc can be heard by clicking a play button. System requirements are hardly steep: an IBM-compatible 486/25MHz or better PC, Windows 3.1 or Windows 95, a mouse, CD-ROM drive, VGA graphics with 256 colors, 8MB of RAM, about 10MB of hard-disk space, and a Sound Blaster-compatible sound card for audio playback.

Digital Electronics proved easy to install, and we were rummaging through its resources in minutes. A series of menus and sub-menus take the user through different lessons in digital electronics. Each lesson is accompanied by circuit diagrams, text, drawings, and photographs of actual parts. *Digital Electronics* introduces users to the principles of digital electronics, including logic gates, combination and sequential logic circuits, clocks, counters, shift registers, and displays. There's also an introduction to microprocessor-based systems.

What's interesting about *Digital Electronics* is that many of the circuits are "interactive." These circuits—logic circuits in particular—are shown in a steady state along with the logic states of each terminal listed on-screen. The user can toggle inputs to circuits and see the effect that the input conditions have on the output. It's a neat way to learn how digital circuitry works.

The first section of the disc covers digital fundamentals. This is where basic logic gates and truth tables are introduced. Also included are monostable and bi-stable circuits, master-slaves, various flip-flops, and more. Another section on combination logic covers circuits with multiple AND and OR gates, equivalent logic functions, comparators, parity checkers, scramblers, code converters, half- and full-adders, Karnaugh maps, Karnaugh simplification, and lots more.

The disc includes a section that covers sequential logic. Here you'll find clocks, counters, shift registers, and the like. Digital systems are also discussed, with details on traffic-light controllers, A/D and D/A converters, memory, microprocessors, and other critical sections of digital systems.

Along with all of the circuitry shown in the disc's many nooks and crannies, you'll find a section that includes a definition of basic logic gates, an introduction to the 7400 TTL series of integrated circuits as well as the CMOS 4000 series. A picture gallery shows many examples of digital circuitry and components.

While the *Digital Electronics* CD-ROM and some free time on a PC is no substitute for a college degree in electronics, it is a good resource to have on hand for electronics professionals and amateurs at all levels. It's also a great way for parents to introduce digital electronics to their children. To order Matrix Multimedia's *Digital Electronics* CD-ROM, contact CLAGGK Inc. (P.O. Box 4099, Farmingdale, NY 11735-0792; e-mail: claggk@poptronix.com) directly. EN

BY SAM GOLDWASSER
SERVICE EDITOR

Monitor Deflection Circuits

THIS MONTH, WE'LL ADDRESS THE BASIC PRINCIPLES OF OPERATION OF THE HORIZONTAL-DEFLECTION SYSTEMS USED IN MONITORS. WHILE MOST PEOPLE WITH ANY FAMILIARITY WITH TV OR MONITOR OPERATION OR REPAIR HAVE SOME VAGUE idea of how these circuits work (probably just enough to be dangerous), many of their assumptions are incorrect or at least very incomplete. In addition to monitors, TVs (direct-view as well 3-CRT and light-valve projection types), tube-based video cameras (*e.g.*, vidicon), and other magnetically-deflected CRT devices also use the same techniques.

Note that vertical-deflection circuits are much less complex due to the lower scan rate (*e.g.*, 50 to 120 Hz as compared to 15.734 kHz for an NTSC TV or up to 120 kHz or more for a high-resolution computer monitor). Most of the control and output drive circuitry is contained in a special vertical chip in modern equipment.

TVs and most computer and video monitors depend on the use of similar (at least in concept) circuit configurations to generate several outputs:

- Current waveform required in the deflection yoke coils of the CRT for linear sweep of the electron beam to create a high quality (geometry and linearity) picture. This is close to a sawtooth but not quite.
- CRT high voltage (20 to 30 kV or more) as well as other related voltages—focus and screen (G2).
- Various auxiliary power and signals for other subsystems of the equipment (low voltage, CRT filament, feedback, etc.).

How It Works

Although there are many variations, the basic operation of the horizontal-deflection/high-voltage power-supply circuits in most TVs, monitors, and other CRT displays is very similar.

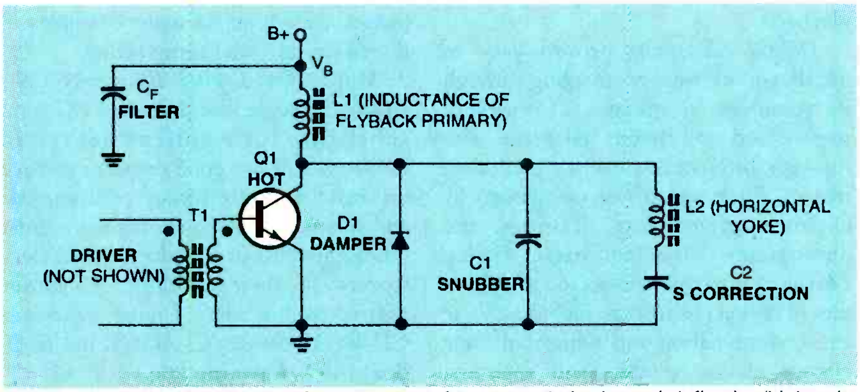


FIG. 1—A VERY SIMPLIFIED SCHEMATIC of a monitor's horizontal-deflection/high-voltage power-supply circuits is shown here. Note that many components needed to create a practical design have been omitted for clarity.

To better understand how the deflection circuit works, regard the flyback transformer as an inductor. The airgap stores energy, some of which might be tapped off during flyback by secondary rectifiers (*e.g.*, vertical deflection, signal circuits, and high-voltage supplies) and non-rectified loads (*e.g.*, filament supply), but those have hardly any influence on the basic working principles.

The scenario described next is only true in the steady state—the first few scans are different because the picture-tube capacitance is still discharged.

A very simplified circuit is shown in Fig. 1. Note that many components needed to create a practical design have been omitted for clarity.

We begin our adventure at the end of the scan—called retrace—when the flyback period begins.. At the end of the scan, current is flowing through the flyback primary to horizontal-output transistor (HOT) Q1. At the start of the flyback period, Q1 turns off. (This must be done in a controlled manner—not just a hard shutoff to minimize stresses on the HOT—but that is another story). Since current in an inductor cannot change instantaneously, the current is diverted into the snubber capacitor, C1. The inductance of the flyback primary (L1) and C1 forms a resonant circuit so that the voltage climbs on C1 as the current goes down. At its peak, this voltage will be 1000 V to 1500 V. Snubber capacitor C1 now begins to discharge in reverse through the primary of L1 (back into the B+ supply—the filter capacitor will stabilize the B+ output) until its voltage (and also the collector-emitter voltage of the HOT) reaches 0.

If there were no damper diode (D1), that voltage would go negative and continue to oscillate as a damped sinusoid due to the resonant circuit formed by L1 and C1 (and the other components). However, D1 turns on as the voltage goes negative and diverts the current through it, clamping the voltage near 0 ($-V_F$ for the diode).

Note that in inexpensive or small screen TVs, damper-diode D1 may be built into the HOT. That's also true for some monitors that don't have any circuitry for E/W correction (more on that later).

The steps we've just described perform the flyback function of quickly and cleanly reversing the current in L2 (and, as we will see, the deflection yoke as well). The full flyback (and yoke current) are now flowing through the forward-biased damper diode, D1.

Therefore, at the beginning of scan, the damper diode (forward biased) carries the bulk of the current from the yoke and flyback. The nearly constant voltage of the B+ across L1 results in a linear ramp of current through the damper diode since it is still negative and decreasing in magnitude.

At approximately mid-scan, the current passes through zero and changes polarity from minus to plus. As it does so, the damper diode cuts off and the HOT picks up the current (with a voltage drop of $+VCE_{sat}$). Current is now flowing out of the B+ supply.

Note that the base-drive to the HOT must have been switched on at some time before this point!

During the second half of the scan, the HOT current ramps up approximately linearly. That is again due to the nearly constant voltage of B+ across the inductance of the flyback primary.

Near the end of scan, the HOT turns off and the cycle repeats.

Thus, the current in the flyback (ignoring the yoke components) is a nearly perfect sawtooth. The ramp portion is quite linear due to the essentially constant B+ across the flyback primary's

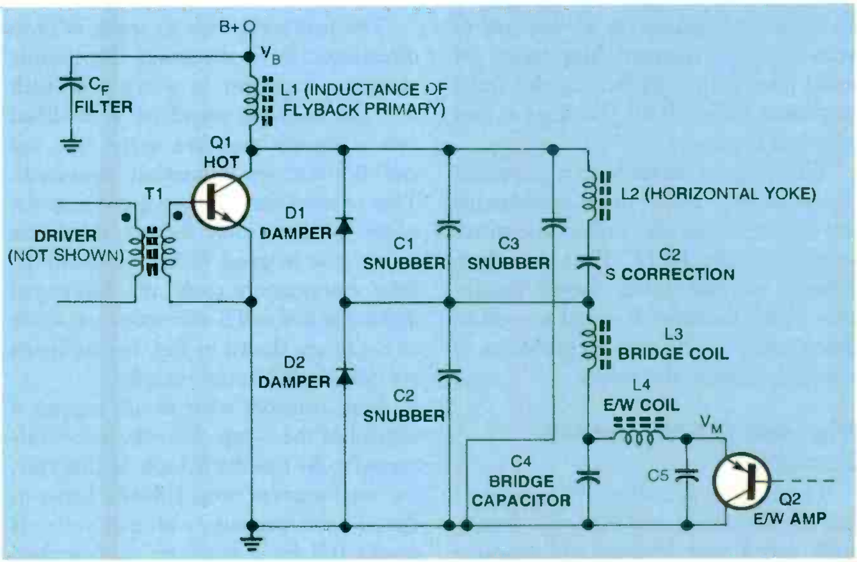


FIG. 2—HERE THE E/W CORRECTION circuit has been added to the power supply of Fig. 1. Again, note that this is a simplified schematic.

inductance. The current waveform can be easily viewed on an oscilloscope with a high-frequency current probe. I'll even tell you how to build one safely for next to no cost in a future installment!

The voltage across the collector-emitter junction of the HOT is a half sinusoid pulse during the flyback (scan retrace) period and close to zero at all other times ($-V_F$ of the damper diode during the first half of scan; $+VCE_{sat}$ for the HOT during the second half of scan).

Caution: Without a proper high-frequency, high-voltage probe, it is not possible or safe to observe this point on an oscilloscope with full B+. However, where the equipment can be run on a Variac, this clean pulse waveform can be observed at very reduced B+. Excessive ringing or other corruption would indicate a problem in the flyback, yoke, or elsewhere.

The current through Q1 and D1 is several amps peak-peak. There's a lot of power circulating here, making this a **dangerous** circuit in every way!

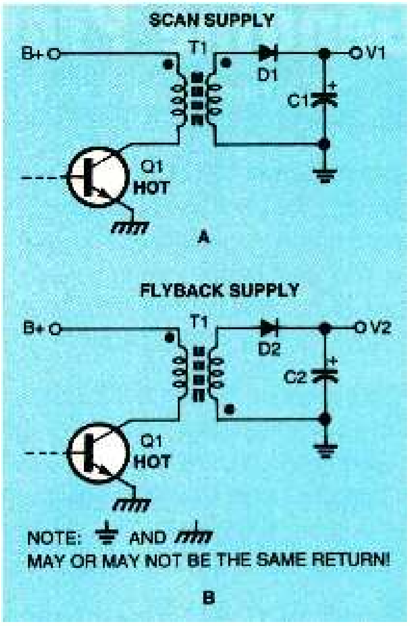


FIG. 3—THE CIRCUIT IN A is just a typical example of an auxiliary supply derived from a scan rectifier. The circuit in B is an example of the use of a flyback rectifier.

The Deflection-Yoke Connection

So, you ask: "Why can't the yoke just be placed in series or parallel with the flyback primary?" There are several reasons including:

• The desired yoke current is not quite a sawtooth, but includes two major corrections: S and E/W (described below). These cannot be applied easily with such a configuration.

• The flyback also generates the HV and secondary output voltages, and the primary current might then be affected by these and change as a function of beam current (picture brightness) or audio level (although feeding the audio amplifiers from HOT windings is not common anymore).

The yoke in series with a capacitor (S-correction) and other components are placed across the collector-emitter junction of the HOT. That, in effect, forms a variable power supply (analogous to the constant B+) that is used to compensate for the various problems of scanning a nearly flat screen.

What Are S, E/W, and N/S Correction?

Those terms actually refer to the various corrections to deal with what is normally called scan linearity and pincushion distortion. Most larger TVs and nearly all high-quality monitors will have various user and internal controls to optimize the corrections for each scan rate (multiscan monitors).

Because the screen of most CRTs is relatively flat (even those not advertised as flat) and the electron gun is relatively close, any picture tube would naturally have serious linearity problems and pincushion distortion if there were no corrections applied. The spot will move faster near the edges and corners of the screen because the same angular speed translates to a larger linear speed.

S-Correction Circuit Operation

The first correction to apply, in both directions, is S-correction. By simply putting a capacitor in series with each coil, the sawtooth waveform is modified into a slightly sinewave shape (the top and bottom are somewhat squashed). This reduces the scanning speed near the edges. Linearity over the two main axes should now be good. When we add in the yoke components (only the horizontal deflection coil and S-correction capacitor or S-cap are shown in Fig. 1) conditions are only slightly more complex.

First, consider what would happen if instead of the S-cap, the yoke were connected to B+ like the flyback. In that case, the total current would divide between the flyback primary and the yoke. It would still be a sawtooth as described above. Of course, component values would need to be changed to provide the proper resonant circuit behavior.

That's called "tuning of the flyback capacitor." The goal is to get the proper duration of the flyback pulse, matching the blanking time of the video signal, and to achieve the proper peak flyback voltage, matching the V_{CES} specification of the HOT with a reserve of about 20%. That's two conditions, requiring two degrees of design freedom. There are three freedoms: supply voltage, flyback capacitor, and yoke inductance.

With the S-cap and yoke wired as shown in Fig. 1, the inductance of the yoke and S-cap form a low-pass filter such that the voltage on the S-cap will be a smoothed version of the pulses on the HOT collector (similar in effect to the B+ feeding the flyback but not a constant value). The average value of the S-cap voltage will be positive.

The S-capacitor together with the yoke inductance forms a resonant circuit whose frequency is tuned lower than the line frequency. It has the effect of modifying the sawtooth current into a sinewave shape. This is called "S-correction." It reduces the scanning speed at the left and right edges of the screen.

The value of the S-cap can be selected so that the voltage varies in such a way as to squash the current sawtooth by the appropriate amount to largely compensate for the fact that the electron beam scans a greater distance with respect to deflection angle near the edges of the screen.

Think of it this way: When the scan begins, the yoke current is at the maximum value in the direction to charge the S-cap. The voltage across the S-cap is causing the current to decrease, but the S-cap is also gaining charge, so the rate of decrease is increasing. At the time the current passes through 0, the S-cap is charged to its maximum. The current now reverses direction, retracing its steps. This is an example of a portion of a resonant circuit. The voltage on the S-cap is varying by just the right amount to compensate for the geometry error.

For multiscan monitors, S-caps must be selected for each scan range since the timing varies with scan rate. These are only approximate corrections, but are good enough for most purposes. MOSFET or relay circuits are used to select the correct combination of S-correction capacitors for each range of scanning frequencies.

As an example, consider a multiscan monitor that supports VGA (31.4 kHz, 800 × 600 at 56 Hz (35 kHz), and 800 × 600 at 60 Hz (38 kHz):

For good geometry between 31, 35, and 38 kHz, two discrete values for the S-cap are barely enough. Actually a third value optimized for 35 kHz would be better. If there is only one S-cap and it is optimized for 38 kHz, then at 31 kHz you will be using a too large an angle of the sine (of the resonant frequency between the S-cap C and the deflection coil inductance). Possibly even more than 180 degrees, making the current fold back. Apart from an obvious geometric distortion, there is also increased risk of HOT failure because you're operating too close to the resonant frequency.

E/W Correction-Circuit Operation

There are also N/S and E/W errors, meaning that near the corners the scanning speed is still too large. To a large extent the N/S errors can be corrected by a suitable yoke-coil design. For smaller tubes (90 to 100 degrees types) that could also take care of E/W errors. However, for larger (110 degrees) or high-quality tubes, electronic E/W correction is required. E/W errors are what cause the well-known pincushion effect.

E/W correction is modulation (which implies multiplication) as a function of the vertical-beam position. The amplitude of the horizontal-deflection current is modulated with a parabola waveform that is derived from the vertical-deflection circuit. That squeezes the top and bottom lines back into the left and right screen borders.

This is how the diode modulator for E/W correction works (refer to Fig. 2 as we proceed):

The deflection supply B+ gives a constant voltage V_B. At the output of the E/W amplifier there is a variable voltage V_M. Because there can not be an average voltage over any coil, the average voltage over the deflection circuit (L2 + C2) is V_B.-V_M. The scanning width is proportional with this voltage. Modulating V_M as a field-frequency parabola that is higher for the top and bottom lines causes the scanning width to be reduced for the corners of the screen.

The required field-parabola waveform is derived from the field-deflection circuit. Amplitude and DC-level are adjustable as needed for correcting pincushion distortion and setting the screen width.

The E/W amplifier usually has a PNP emitter follower only, because it must only sink current and dissipate a bit of power. Coils L3 and L4 ensure that the E/W amplifier sees no line-frequency. The "bridge" components, L3 and C5, resemble the deflection coil with its S-correction capacitor and carry the large amplitude alternating current. The L3/C5 circuit is tuned to approximately the same frequency as the L2/C2 circuit.

Capacitors C1, C3, and C4 must be tuned so that EHT is independent of V_M and peak voltage over D2/C2 is high enough but not too high when Q2 is off. Capacitor C4 is usually a small (approximately 1 nF) ceramic capacitor mounted close to the HOT (Q1); it also suppresses EMI. Flyback capacitors are critical components. Wrong types may overheat and burn. Bad contacts here or elsewhere in the deflection circuit might arc and also cause fire.

There are many variants to this circuit, *e.g.* for dynamic S-correction. Multi-sync monitors need added circuitry to make the EHT independent of the line frequency (if there is not a separate EHT supply, that is).

If the E/W modulator fails, you will see that the top and bottom lines will be much too wide. There are several parts that could have failed. It's usually not too difficult to find why there's no parabola. If you have partial loss of E/W modulation, notably in the extreme corners, then you should suspect the tuning of the three flyback capacitors that belong to the diode modulator circuit. That's a specialist job...

S-Correction Problems

So, then, what are the problems associated with the S-Correction capacitor, and what are their symptoms? Here goes:

• An open S-cap will result in no horizontal deflection—a vertical line.

• A shorted S-cap will likely load down the B+ possibly resulting in a blown fuse or other power supply components.

• An S-cap that changed value (or in the case of a multiscan monitor, selected to be the wrong value) will result in distortion at the left and right sides of the screen. If it is too low, the picture will be squashed towards the edges. If it is too high, the picture will be stretched towards the edges.

Note that this is not the same as what is commonly called linearity, which would likely affect only one side or gradually change across the screen.

Horizontal-Linearity Correction

Since there is a non-zero resistance associated with the components (mainly coil losses) in the yoke circuit (yoke winding, ESR of S-cap, etc.), the world is not quite as ideal as one would hope. Without compensation, that resistance would result in non-linearity of the picture—it would tend to be squashed on the right side as the resistance saps energy from the yoke circuit.

The waveform becomes a damped sinewave, which will be "undamped' by restoring energy during the flyback.

One way to deal with this is to add a magnetically biased saturable inductor in series with the horizontal-deflection yoke. That inductor is called the linearity coil.

Its core is magnetically biased near the point of saturation such that the inductance decreases with increasing current, and that helps to stretch the right-hand side of the scan. In other words, during the scan the coil saturates so that the inductance decreases. At the end of scan there is practically no voltage left over the linearity coil, so that the deflection coil gets maximum voltage.

E/W Correction Problems

The common name for the adjustment controls is likely to be "Pincushion Amp" and "Pincushion Phase." They affect the E/W correction circuits. Pincushion Amp adjusts the amplitude of the correction signal. Pincushion Phase adjusts where the correction is applied on the vertical scan.

Problems in the E/W correction circuits will show up as follows:

• Failure of the E/W correction circuit will result in very noticeable pincushioning distortion of the vertical edges.

• Excessive E/W correction will result in barrel distortion of the vertical edges.

• A bad power supply derived from the flyback could also result in similar symptoms due to ripple or lack of power to the pincushion circuitry.

N/S and E/W Circuit Differences

While the desired effects are largely the same—modulate the amplitude of one component of the deflection circuit (H or V) by the other (V or H), the implementations of the N/S and E/W circuits will differ substantially. The reasons should be obvious: The line frequency is much higher than the field frequency.

E/W correction is easy—the lower frequency modulates the higher frequency. That reduces to simple amplitude modulation. Well, simple in principle. The line circuit is a high-energy circuit. That's why the diode modulator circuit has been invented for this application. It allows an energy exchange between the line-deflection circuit and a pseudo deflection circuit.

N/S correction is difficult—the higher frequency modulates the lower frequency. It **can** be done with sort-of amplitude modulation by using a "transductor." This is not a transformer but a component with 2 coils and a saturable core where the current through 1 coil modulates the inductance of the other coil. If there are tuned parts in the circuit, then the correction will be highly sensitive to line-frequency variations.

It can also be done with a regular transformer by injecting a strong signal (from an amplifier) with line-frequency components into the field-deflection circuit.

Either way, it's an expensive solution that should be avoided by designing the deflection coils so that the picture tube needs no active N/S correction.

Deflection Derived Power Supplies

Several types of auxiliary power may be obtained from the flyback, somewhat as a byproduct of the deflection-system operation.

Although not always well known, the coupling factor with the primary is decent for a flyback transformer, and so there can be scan rectifiers as well as flyback rectifiers.

• Scan power is obtained during the forward stroke as with a "normal" transformer. Energy is transferred while the HOT/damper diode is conducting. The output rectifier is oriented so that current flows during scan time (dots on the transformer winding match). See Fig. 3A.

Scan rectifiers make no use of the stored magnetic energy; they load the primary directly during the scan part. They do not cause an increase of the stored magnetic energy, so a heavy load is not a problem.

• Flyback power is obtained from the stored energy in the flyback transformer's inductance when the HOT shuts off. The output rectifier is oriented so that current flows at flyback time (dots on the transformer windings oppose). See Fig. 3B.

Unlike scan rectifiers, flyback rectifiers (especially the EHT) draw from the stored magnetic energy. When the secondary load increases, the magnetization current will also increase. Ultimately this will cause saturation of the ferrite core. Excess beam current is a common cause for this and should be avoided by the beam-current limiter. The advantage of a flyback rectifier is that it provides 7 times more volts per winding than a scan rectifier.

• AC power (usually only for the filament or a feedback signal) flows during both scan and flyback.

EHT (High-Voltage) Generation

The EHT (Extra High Tension or HV to the CRT) is generated from a secondary winding on the flyback transformer having several thousand turns of very fine wire. Being a flyback supply, the actual output voltage is many times what would be calculated based on turns ratios alone. The HV rectifer consists of a stack of silicon diodes with a total PIV rating of 50 KV or more. Because the flyback pulse is so narrow, the rectifier diode will conduct only a short time. Thus the peak current in the winding will be quite high, resulting in a significant voltage drop when loaded. The internal impedance of the EHT source is in the order of 1 megohm, so with a load of, for example, 1 mA, the EHT will drop 1000 V = -3%. Usually the EHT voltage is far from stable; a 10% drop is quite normal.

If the EHT voltage drops, then the electrons will be accelerated less and will move through the deflection field at a lower velocity. As a result they will be easier to deflect by the magnetic field, and the picture size will grow. Without special measures, brighter pictures will be larger. The way to prevent that is to feed some EHT information or beam-current information to the deflection circuits, reducing the deflection current amplitude a bit for bright pictures. For horizontal deflection, that is done by the E/W modulator. This technique is called anti-breathing.

Sets with raster-correction-free picture tubes don't have an E/W modulator. There the correction might be done by means of a power resistor in series with the B+ supply. A large beam current causes more power consumption; this lowers the B+ supply voltage and thus reduces the line-deflection current. That also reduces the EHT even further, but the deflection current has a stronger effect on the picture width than the EHT. Better methods exist as well.

The EHT information is also used to protect the flyback transformer from overload. As the load increases, the average primary current rises. Ultimately it may reach a level where the transformer core may go into saturation. This causes large peak currents in the HOT, which might lead to destruction. To prevent that, some EHT information is fed to the contrast controller to automatically reduce the picture brightness whenever the white content is too high. That is called the average beam-current limiter.

A failure in the video path, like a video output amplifier stuck at 0 V, causes a high beam current that will not react to the contrast controller. In that case, the beam-current limiter will not work; and the set should switch off automatically, usually within a few seconds after applying power. When the cathodes heat up, you'll see an even picture with diagonal retrace lines, and then it will switch off.

"Real-World" Circuits

Don't expect to find the circuits shown this month to be staring you in the face when you get your *Sams' Photofacts* or service manual. There are a semi-infinite number of variations on this basic theme. Some of them will, to put it mildly, appear quite obscure (or to put it more positively, creative) at first.

You might see all sorts of additional passive components as well as transformers for generating additional voltages not provided by the flyback. There could be diodes in places you would think would be impossible. Therefore, to really understand even approximately how each design works could require some head scratching—but the basic operation of them all seems to be very similar.

Wrap Up

That's it for now. Next time we will continue our discussion of deflection-system operation with some information about horizontal-output transistors and deflection system problems. Until then, check out my Web site: www.repairfaq.org. I welcome comments (via e-mail please at sam@stdavids.picker.com) of all types and will reply to requests for information. See you next time! EN

BY KONSTANTINOS KARAGIANNIS
COMPUTER EDITOR

Intel's Coming CPUs

IF YOU'RE A REGULAR READER OF THIS COLUMN, YOU MIGHT HAVE NOTICED THERE'S A DIFFERENT NAME LISTED ABOVE. RATHER THAN GOING INTO A LONG-WINDED INTRODUCTION, LET ME SIMPLY TAKE THIS OPPORTUNITY TO SAY THAT I'M delighted to take over this assignment and happy to be able to promise many great installments of *Computer Connections* in the coming months and years.

Expect hands-on advice for upgrading your PC, as well as details on just what makes its components (both old and cutting edge) tick. If it's a new technology, application, or industry trend, there's a good chance you'll find it covered in these pages. We don't need to stress how important computers are to the electronics world (and *vice versa*); and if you want to be a hands-on part of the state of high-tech, you have to keep abreast of the PC world.

While other magazines rely primarily on computer product reviews, this column will focus on making you truly savvy about what's inside (or could soon be inside) that cream-colored box on your desk. To get things started, this and next month we'll be focusing on the most important component in a PC. We're talking, of course, about the CPU. While in the past picking a computer was an easy decision (most people would simply look for the highest CPU clock speed they could afford), it's now become a task performed in a blurry market. Intel is no longer the only company supplying chips.

How do you decide which CPU is best for your needs? Sure, all new processors are touting some pretty high clock speeds. But are all, say, 350-MHz chips created equal? Not by a long shot. Find out who the players are, how their products stack up, and, perhaps most interesting of all, what secrets these vendors have in store for us throughout the coming year.

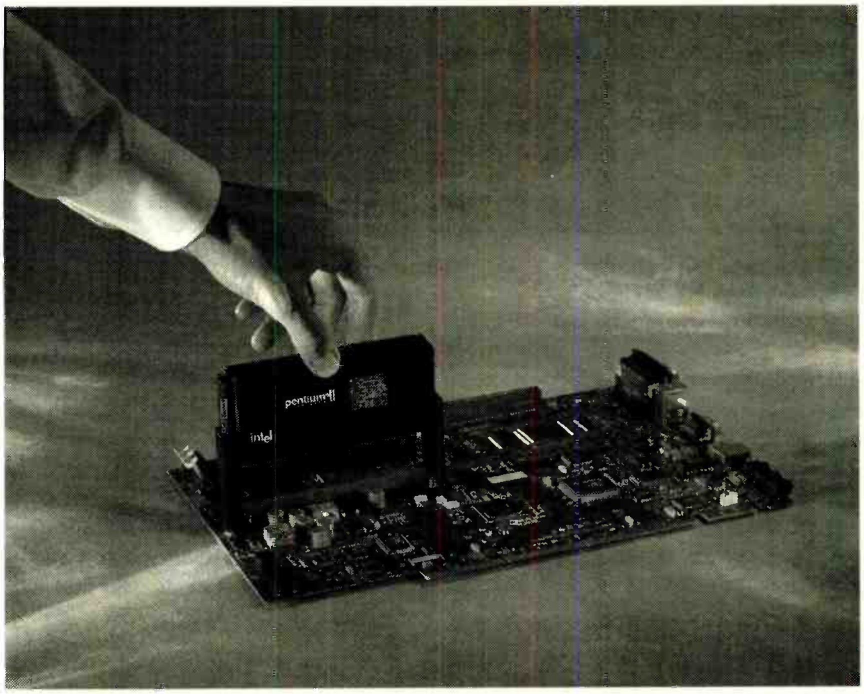
We've got some secrets to share.

The Father Of It All

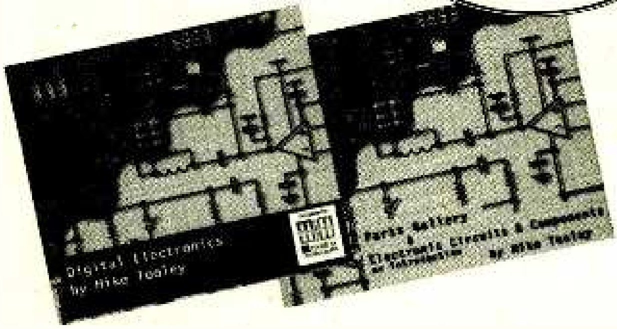
No discussion of CPU manufacturers can begin without an analysis of what Intel's up to—in fact, its past and future contributions are so significant that we'll only be dealing with this giant Santa Clara corporation this month. We will deal with Intel's competition (such as AMD) in detail next time.

Since the first days of the home PC, Intel has pretty much dominated the silicon market for these devices. The engineers there have come a long way, too. Within the past couple of years alone, Intel has come out with several ground-breaking technologies.

The real beginning of the hyper jumps that CPUs have been making recently was MMX Technology. These new instructions, which were added to



INTEL'S PENTIUM II WILL REMAIN THE FASTEST CPU in town this year, with Katmai 3-D-enhanced versions being released soon in 450- and 500-MHz clock speeds. The new PIIs will still use the single-edge contact cartridge form factor.



the old x86 instruction set, helped CPUs perform about 10 to 20 percent better when running multimedia software designed for MMX. It was Intel's first real step toward bringing to the world a more "visual" PC.

Then came the real rocket: Pentium II. While the Pentium was an impressive chip, it's literally only half as impressive as a PII with a similar clock speed. In short, a typical 233-MHz Pentium II machine will benchmark almost twice as fast as a 233-MHz Pentium with MMX. (Just to clarify, all Pentium II chips have MMX Technology, but all Pentiums do not, which is why we differentiate when the latter has it present, and say "Pentium with MMX" or "MMX Pentium.")

What makes PII so powerful? For starters, the core of the chip contains 7.5 million transistors—about twice as many as a typical MMX Pentium. Like MMX Pentium CPUs, the Pentium II has two separate 16K, on-chip Level-1 caches, which run at processor speed and provide fast access to heavily used data. However, the PII also has a closely coupled 512K Level-2 cache that helps achieve higher performance.

Having an L2 cache right in the processor package—the PII comes in a single-edge contact cartridge (SECC) form factor—eliminates data-transfer speed bottlenecks. Rather than the L2-cache bus controller used in the older Socket 7 architecture, where the L2 cache was separate on the motherboard, a dedicated 64-bit bus handles transfer between the processor and L2 cache housed within the silicon and does so at half the processor speed.

The Pentium II's Dynamic Execution Technology is another great boost to its power, allowing the CPU to execute instructions out of order and take full advantage of each clock tick. Better yet, the Pentium II can speculate as to which instructions might be needed in the near future and perform those in advance.

VENDOR INFORMATION

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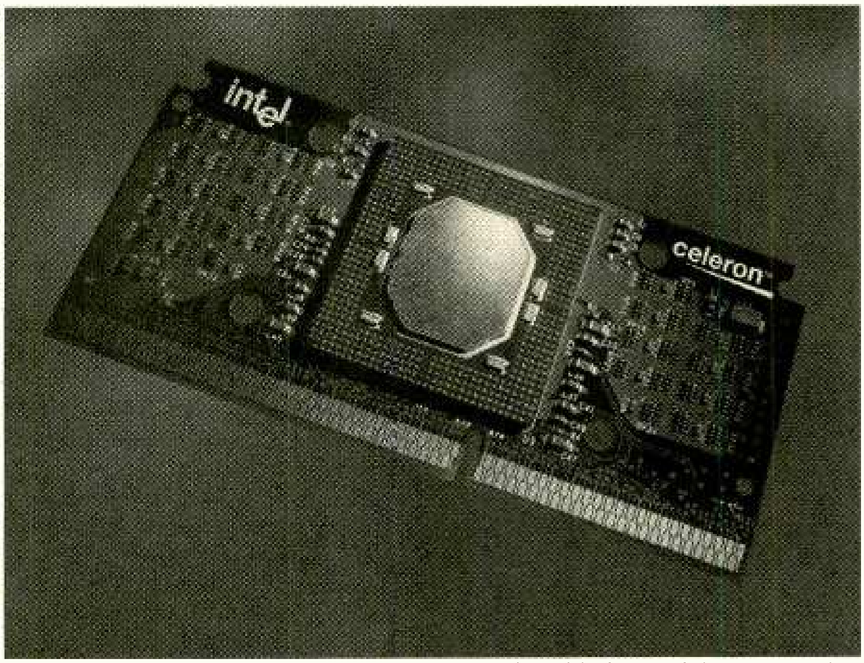

IF YOU OPEN UP A PII CARTRIDGE, remove the board inside, and then reduce that board's L2 cache to 128K, you end up with a basic PC chip known as Celeron. Intel will be bringing out 366- and 400-MHz versions of the CPU this year.

The chip is also superscalar, which means its internal pipeline architecture lets it execute multiple transactions simultaneously.

Another boon to the Pentium II's speed is the dawn of Deschutes technology. While in the past processors were being manufactured with 0.35-micron traces, Intel got that distance between traces down to 0.25 microns, cutting down on power use and increasing clock frequencies (electrons don't have to travel as far). As we'll see later on, the Deschutes manufacturing process will not be this year's miniaturization limit.

Combined with the 440LX and later 440BX chipsets, the Pentium II has remained the fastest chip available for a PC. From benchmark testing, we have concluded that MHz for MHz, no other CPU outclasses the PII yet. For this reason, the Pentium II's performance is the standard against which all competitors will be judged. Again, more on them next month.

3-D Wars

Chances are that you've already heard of AMD's *3DNow!* technology. With all the print and TV advertising going on, it's pretty hard not to have noticed the hype. That might lead some people to believe that AMD has finally beaten Intel in terms of innovation—after all, Intel hasn't released a 3-D in-processor technology yet. However, the truth is a bit more complicated than that.

The idea of in-chip 3-D technology is to enable a CPU to handle more floating-point operations per clock tick (say, four instead of one). It is floating-point operations that handle most of the multimedia magic that appears onscreen. With extra floating-point horsepower available, game and graphics-program designers can write code that performs more smoothly yet doesn't overload a PC video system. AMD was indeed the first company to release such a technology.

However, while 3DNow! technology is available in the K6-2 processor (more on this chip next month), AMD's market share is still not so large that software developers can easily invest in supporting the K6-2. There are a couple of games that have 3-DNow! patches available for download, but the majority of vendors are instead busying themselves preparing for the release of what's certain to be a faster 3-D CPU with more market penetration—Intel's Katmai.

Which brings us to this month's real "goody"....

Intel's Roadmap

As you might have guessed, processor manufacturers know quite a bit in advance what CPUs they're going to bring out. We got Intel to share with us a few of its secrets for the rest of the year. Because of space considerations, we'll only be dealing with desktop processors. Laptop chips and technology will be a topic for another day.

If all goes as scheduled, Intel's much-awaited Katmai processor will soon be appearing in desktop computers. This is a Pentium II with 3-D enhancements in the form of 70 new instructions. But the fact that almost every software manufacturer on the planet is writing to support Katmai is not its only benefit over 3DNow! Katmai can handle real-time MPEG-2 encoding, which will make it possible to record DVD-quality video and audio on your computer.

The new PII will launch in clock speeds of 450 and 500 MHz. While there is currently a 450-MHz PII, Katmai's floating-point enhancements will make both chips perform faster than existing PIIs. Katmai will also use the 440BX chipset, which means that current 350- to 450-MHz Pentium II systems may be upgradeable to the chip (depending on whether the BIOS can handle or be upgraded to handle the CPU).

In addition to its high-end performer, Intel will also expand its Celeron line of processors this year. Soon after this issue hits the stands, Intel should be announcing a 366-MHz version of this "basic PC" chip. Like its 300- and 333-MHz predecessors, the new Celeron is basically a Pentium II with only a 128K integrated L2 cache. Expect a 400-MHz Celeron soon after.

Moving back to the high-end CPUs, we have to address the exciting advances coming in the second half of '99. As you might have guessed, we will definitely see faster-than-500-MHz chips. The first of these from Intel is code-named Coppermine, because of its new copper-interconnect assembly technology. This is a cheaper method of creating CPU traces and will result in faster chips because it is a 0.18-micron process. While Intel is sketchy on the details, expect Coppermine to use a bus speed that's even faster than the 440BX—maybe 133 MHz? We'll likely see 600-MHz Coppermine chips this year, if not faster ones.

And that's pretty much what Intel has in store for the desktop PC market. Join us here next time for a look at what the competition is up to. If you'd like to drop me a line in the meantime, feel free to e-mail me at connections@gernsback.com, or send a USPS letter to *Computer Connections*, **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735.

NEW PRODUCTS

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Hardware Simulator

OFFERING LOW-COST SYSTEM debugging for base-line PICmicro 8-bit RISC microcontrollers, such as PIC12C5XX, PIC12CE5XX, and PIC16C5XX, the SIMICE hardware simulator works in conjunction with Microchip's MPLAB-SIM software simulator to provide non-real-time I/O port emulation.

SIMICE enables a developer to run simulator code for driving the target system. The target system can give input to the simulator code, which allows simple and interactive debugging without having to manually generate MPLAB-SIM stimulus files. Features of this simulator include unlimited software breakpoints, PC communication via serial interface at speeds up to 57k baud, and support of source-level debugging.

MPLAB Integrated Development Environment (IDE) reduces microcontroller development time by giving users the flexibility to edit, compile, and emulate, as well as program, all devices from a single user interface. A project manager and program text editor, a user-configurable toolbar containing four predefined sets, and a status bar that communicates editing and debugging information are contained in the MPLAB software. A dynamic error capability allows rapid application development with a simple click on any error listing, returning the user to the source code for quick editing.

MPLAB is available for free by downloading the software program from the Web site listed below. The complete SIMICE Hardware Simulator system features a hardware I/O port emulator board, RS-232 cable, PICmicro target probe cables, and MPLAB IDE software. For more information, contact any Microchip sales representative or authorized worldwide distributor. SIMICE has a list price of $129.

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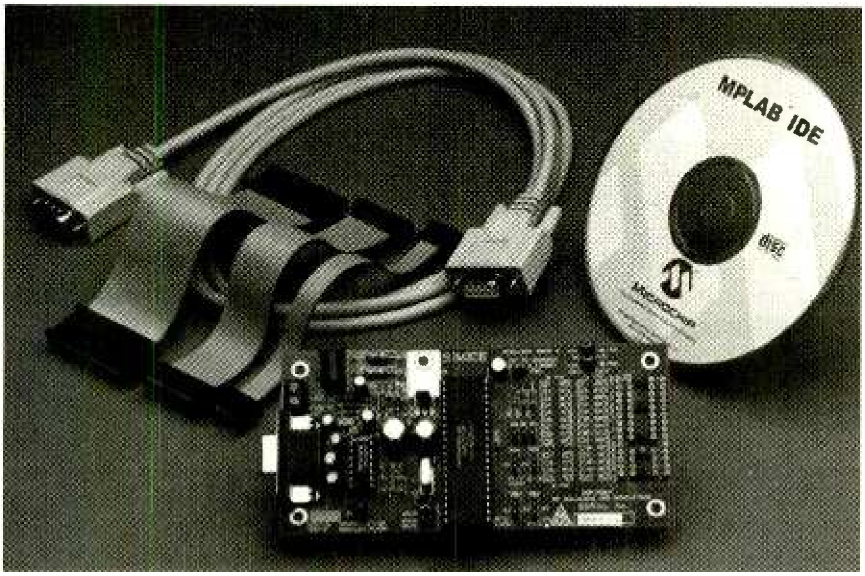
Fax: 602-899-9210
Web: www.microchip.com



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Dual-Display Digital Multimeter

DESIGNED TO PROVIDE PRICE/performance value, the Model 2880A is a high-performance, dual-display DMM. This hand-held device is ideal for use in electronic and electrical field service, plant maintenance, and engineering/R&D applications.

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"These products offer unique and useful features not normally found in a typical DMM, especially at this price," said Mark Albert, director of marketing, as well as "....RS-232 computer interface and the added functionality of in-depth, long-term signal analysis utilizing the dual display."

Other features include two user-selectable operating resolutions (4000/40,000 counts), voltage to 1000VDC/750 VAC, and current to 10 amps. There is also a dual-display providing frequency to 200 kHz with AC signal measurement, resistance to 40 megohms, and capacitance to 9999 μF, as well as diode check and continuity. User-friendly features, such as: data hold, relative mode (displays the difference between a set input and subsequent inputs), and max/min/avg reading of an input with an elapsed timer, make this a very practical test instrument for the professional or serious hobbyist.

The 2880A offers true rms measurements to accurately display non-linear and traditional loads and is IEC1010-1 Cat III approved. An optional accessory

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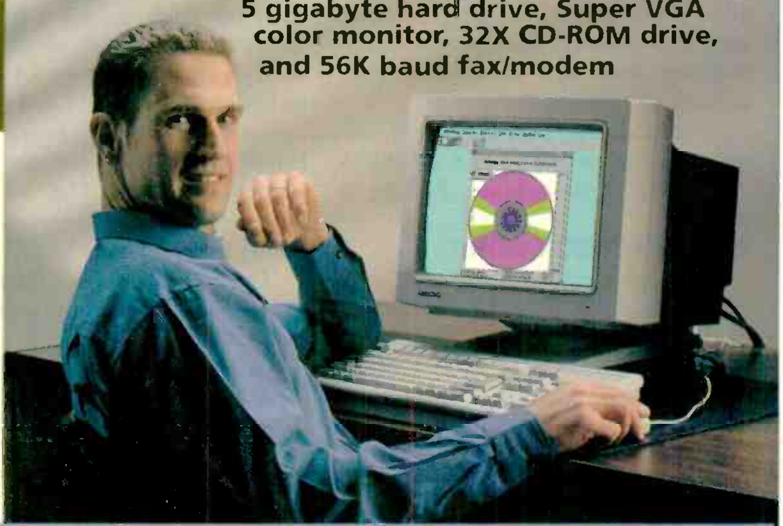

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- Troubleshooting training—includes McGraw-Hill's easy-to-follow guides on troubleshooting and interactive computer-aided electronics diskettes relating to four key areas: AC electronics, DC electronics, semiconductors, and electronic circuits.
- Windows 98—this long-awaited version of Windows has more power, a new Web look, e-mail capabilities, single-click functionality, and System File Checker.

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Accredited Member, Distance Education and Training Council 0003-0399 package that includes software and a cable with an optical receiver that connects to the meter permits RS-232 communication between the 2880A handheld DMM and a PC. The software allows for saving, loading, making reports, displaying multimeter readings, printing data and controlling data recording.

The Model 2880A sells for $199 (single quantity pricing). The AK2880A Accessory Communications Package is $15.

B&K PRECISION CORP.
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High-Accuracy Resistance Standards

THE SRL SERIES IS A VIRTUALLY zero temperature coefficient set of high-accuracy resistance standards. The series exhibits virtually zero TC near 23°C and typically less than 1 ppm change between 18 and 28°C.

Tests have shown this series to be highly stable, usually varying less than 1 ppm per year, yet the SRL Series is more economical and cost effective than other standard resistors. The SRL standards are available in a broad range of values, from 1 ohm to 19 megohms. Other IET series extend from 1 megohm to 190 gigaohms. Custom values and special values suitable for RTD (Resistance Temperature Detectors), such as 25 ohms, are available.

There are four 5-way binding posts for 4-terminal measurement and two binding posts for 1 megohm and over. The binding posts are constructed of tellurium copper for low thermal EMF and low resistance. A case ground terminal is also provided.

CIRCLE 22 ON FREE INFORMATION CARD

These compact standards, which are designed not to require an oil bath, are much more convenient to use than the older can types that need tedious temperature bath stabilization. The dimensions of the standards are 3.4 × 4.2 × 5 inches, and the weight is 1.6 lbs. The optional lightweight carrying case with handle (SRC-100) is designed for transporting two units. The case provides insulation from temperature changes during transportation.

The SRL Series basic price is $1569, and the SRC-100 carrying case costs $185.

IET LABS, INC.
534 Main St.
Westbury, NY 11590
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Web: www.ietlabs.com

PC-Based Harness Tester

WITH WINDOWS-BASED SOFTware and features such as sequential and random build/test modes, single and continuous test, and graphical guided-assembly capabilities, the *easy-wire* CR harness/ backplane tester makes harness assembly and testing easier and more efficient.

The CR offers on-screen graphical representations of connectors, sound prompts for correct/incorrect wire placement, and blinking LEDs on the harness board to guide assembly. Among the additional features are repetitive continuous testing and the ability to add wire names and colors. The data base can be backed up to import and export across networks for multiple testing.

These features make it easy for operators to quickly learn an assembly and to identify wiring errors and defects (opens, shorts, miswires, twisted-pair defects, and terminations with high resistance) as the harness is built. The tester's small size (each 256-point box measures 5.4 × 6.6 × 2.6 inches and weighs under 3 lbs.) and daisy-chain architecture allow users to distribute the test points around the device under test, reducing the length and complexity of the interface cabling. With expandability up to 65,024 points, the *easy-wire* CR should meet the largest test requirements.

The *easy-wire* CR Base Unit (256 points) has a list price of $1745. Scanner Add-ons (256 points) cost $895 each.

CIRCLE 23 ON FREE INFORMATION CARD

CIRRIS SYSTEMS CORP.
1991 Parkway Blvd.
Salt Lake City, UT 84119
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Fax: 801-973-4609
Web: www.cirris.com

All-Mode Transceiver

IDEAL FOR PORTABLE, MOBILE or fixed (base) operation, the IC-746 is a DSP, high-performance radio. Featuring all-mode performance, including FSK (RTTY) on all bands and HF through two meters, the receiver has a host of interference-fighting abilities. Among them are twin passband tuning, auto notch, and audio peak filtering.

CIRCLE 24 ON FREE INFORMATION CARD

Three additional (optional) IF filters can be accommodated for maximum selectivity. Weak signal reception is enhanced by the 1C-746's IF DSP features and its two-stage preamplifier (single-stage on 2 meters). There is also variable digital noise reduction and a noise blanker .

The compact 1C-746 (approximately 11½ × 4¾ × 12½ inches and weighing under 20 lbs.) provides 100 watts of output on all modes and all bands, including two meters. A band scope is included on the large, easily read display window to monitor band activity. Standard on the IC-746 is a full-featured memory keyer, including a serial number generator for contests and an adjustable weight control. A triple-band stacking register and 100 memories (with alphanumeric tagging capability) offer maximum operation capability.

The transceiver's auto-tuner for

160–6-meter operation has memories for tuner settings every 100 kHz for quick, efficient antenna tuning. Three antenna inputs are provided on the IC-746.

The IC-746 has a suggested list price of $2228.

ICOM AMERICA, INC.
2380 116th Avenue NE
Bellevue, WA 98004
Tel: 425-454-8155
Fax: 425-454-1509
Web: www. icomamerica.com.

Notebook Digital Camera

THE FIRST DIGITAL CAMERA built especially for notebook computers users, the PDR-5 offers out-of-the-box functionality with Windows and Macintosh notebooks. Designed as a companion for on-the-go professionals—field engineers, project managers, security personnel and marketing staff—the camera is optimized for notebook use because its back-panel doubles as a built-in PC Card interface.

To use the PC Card, simply flip it open, and plug it into any Type II slot. Once the card is inserted, the computer automatically recognizes it as a drive for file-transfer purposes. The JPEG format images are then retrieved via Sierra Imaging's drag-and-drop Image Expert Album software format on the computer screen, thus simplifying photo selection.

With the PDR-5, there is no scanning and no film developing. Its VGA-quality images are instantly available on a notebook, and it can be used to create e-mail attachments; Web-page graphics; professional-looking brochures, flyers and field reports; as well as for presentations.

Other outstanding features of the digital camera include: a wide-angle 39mm all-glass lens with macro, a reflective 2.5-inch color LCD, SmartMedia storage, video-out, and a four-mode flash. The camera weighs just 6.4 ounces and fits inside a shirt or jacket pocket.

Accessories for the PDR-5 include a long-life CR123A lithium battery, a hand strap, a 2-MB SmartMedia card, and a carrying case. The estimated street price is $399.

CIRCLE 25 ON FREE INFORMATION CARD

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Irvine, CA 92618
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Fax: 800-640-8674
Web: www.toshiba.com/taisisd

Switching Power Supply

THE 25-AMP MIGHTYLITE switching power supply can power HF transceivers or 2-meter/440 MHz mobile or base and accessories in the shack, or anywhere else you need it. Its three-inch dual meters are brightly illuminated to make it easy to monitor voltage and current.

CIRCLE 26 ON FREE INFORMATION CARD

MightyLites are so lightweight and small that they can be carried in the palm of the hand—no more heavy, bulky power supplies. The 25-amp version, the MFJ-4225MV, weighs just 3.7 lbs., five times lighter than an equivalent switching power supply, and measures only 5¾ by 4½ by 6 inches.

The unit features a front-panel voltage control to vary the output voltage from 9 to 15 VDC and yields a highly regulated voltage output. It gives less than 35 mV of peak-to-peak ripple and a better than 1.5% load regulation under a 25-amp full load. Users won't hear hash in the signal, and their buddies won't hear it on their end either.

The MFJ-4225MV has three sets of output terminals, including a pair of heavy-duty five-way binding posts and a cigarette lighter socket for mobile accessories. In addition, in the rear there are two sets of quick-connects for accessories.

The power supply is fully protected with over-voltage and over-current protection circuits and with a quiet internal fan to cool it. The MightyLite is fused, has a switchable AC input voltage, works from 85 to 135 VAC, meets FCC Class B regulations, and provides 25 amps maximum or 22 amps continuous.

The MFJ-4225MV sells for $149.95. The MFJ-4245MV MightyLite, a 45-amp version, is also available for $199.95.

MFJ ENTERPRISES, INC.
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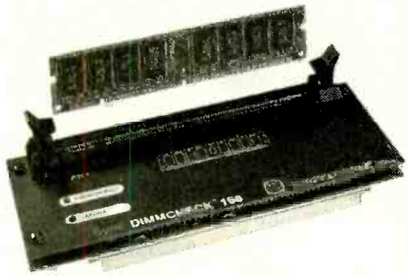
Mississippi State, MS 39762
Tel: 800-647-1800
Fax: 601-323-6551
e-mail: mfj@mfjenterprises.com
Web: www.mfjenterprises.com

SDRAM Memory Tester

WITH THE COMPUTER INDUSTRY'S move to the Intel PC100 motherboard standard, there is a great demand for true 100-MHz testing equipment. The 125-MHz test engine and the 1-ns speed resolution technology of the Sync DIMMCHECK 168 adapter combine to provide an affordable testing solution for SDRAM and standard EDO/FPM 168-pin DIMM modules.



CIRCLE 27 ON FREE INFORMATION CARD

The adapter snaps into the Simcheck II or Simcheck IIse. With the push of a single button, the fully automatic test programs allow even non-technical personnel to test memory. The adapter quickly tests the module's functionality, size, speed, type, and gives detailed structure information.

It then proceeds with full SDRAM mode tests and comprehensive Page Burst and Blank Interleave tests. The Sync DIMMCHECK 168 adapter provides full support for SPD data (Serial Presence Detect), including reading, editing, and programming. The adapter retails for $995.

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NEW LITERATURE

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The ARRl Handbook for Radio Amateurs: 1999 Edition

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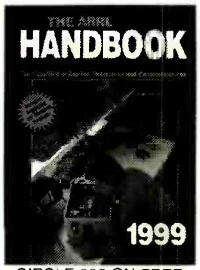

CIRCLE 338 ON FREE INFORMATION CARD

The 76th edition of the handbook maintains its reputation as the best all-around electronics reference. Over the past 75 years, this guide has meant many things to generations of hams, students, engineers, and technicians. It's been an extensive resource for projects for all levels of building experience, an invaluable source of reference material, and a thorough foundation of electronics and communications theory.

This 1200-page book has served as an overview of what hams do and how they do it. For newcomers to the hobby, it's provided an introduction to the modes and equipment hams use, as well as to the theory.

The new projects in this edition include a 13.8-V/40-A switching power supply, a legal-limit Svetlana 4CX1600B amplifier, and a voice keyer, as well as an enhancement to the high-power antenna tuner introduced in the Handbook's last edition. In response to reader's comments, this volume includes PC templates for the weekend projects. The larger more complex templates are on the ARRL Web site listed above.

The handbook is divided into 30 chapters grouped under five headings: Introduction, Fundamental Theory, Practical Design and Projects, Construction Techniques, and Operating Practices. In addition, the software for the book is now available separately. It can be downloaded from either the League's Web site or from its *Hiram* BBS, or it can be ordered for a nominal cost.

ECG Semiconductor Master Replacement Guide,18th Edition

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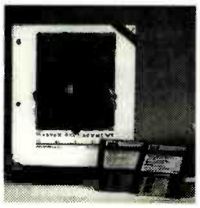

The latest ECG Master Replacement Guide contains a wide variety of high quality replacement devices for the entertainment industry and commercial and industrial companies. The most comprehensive, single source of replacement information available today, the 18th edition of this guide features new products, new product families, additions to existing lines, and approximately 300,000 cross-references. Using the expanded cross-reference guide and other selector guides makes it easy to select the best ECG part for an application.

ECG now offers the most complete user cross-reference library in the industry—the entire data base has been updated from the recently published 212T Master Guide and the software has been upgraded. The Philips *ECG Instant Cross* program is available in both DOS format and Microsoft Windows 3.1 and 95.

Philips ECG semiconductors are available through a global network of distributors. The *ECG Semiconductor Master Replacement Guide,18th Edition* is free upon request from your local distributor. Contact Philips ECG at the phone number or Web site listed above to locate the nearest distributor.

Stopping Spam

by Alan Schwartz and Simson Garfinkel
O'Reilly & Associates, Inc.
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Sebastopol, CA 95472
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CIRCLE 339 ON FREE INFORMATION CARD

Why are we getting spam—junk messages, unsolicited ads, come-ons, and pornography in our e-mail mailboxes, and newsgroups—and who is sending them? This book answers these questions about unwanted e-mail messages and inappropriate news articles, discussing what can be done about them and how they can be stopped and even outlawed. According to the authors, "Spam is the Internet's version of junk mail and telemarketing calls … all rolled into a single annoying electronic bundle."

Meant for everyone who surfs the net; for administrators of systems, newsgroups, and networks; and for Internet service providers (ISPs); *Stopping Spam* covers methods to help stop junk e-mail. The top three weapons in this battle are keeping your e-mail address private or disguising it, using filters, and registering complaints about spam to ISPs.

In addition to technical details, readers will find entertaining stories about famous Internet chain letters and court cases. This book is enjoyable and timely, and it arms you against Internet abusers.

Winter 1999 Short Form Designer's Guide

Analog Devices
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106
Tel: 800-262-5463 or 781-329-4700
Fax: 508-894-5114
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Analog Devices designs, manufactures, and sells sophisticated electronic components and subsystems for use in signal processing. In the last year, they introduced more than 100 new products, bringing their total product lines to over 1500 items. To provide maximum usefulness to designers of new equipment, the contents of the selection guide are limited to products most likely to be used for the design of new circuits and systems.

This catalog is organized for quickly narrowing the product search using its "Trees" or "Selection Guides." The text begins with an introduction to new products, including ADμC812 MicroConverters; dual access accelerometers; and DSP processors, such as the ADSP-21061. At the back of this volume, readers will find a list of older products still in production, as well as a guide to substitutions and those part numbers that are on lifetime buy.

This publication, coupled with the CD-ROM (available separately), makes for a paper/paperless data book. Once readers have found a solution, they can print the data sheet from the CD-ROM or use the Web or the faxback system to download it. The CD-ROM contains all the data sheets, along with parametric search engines, application notes, SPICE models, and a cross-reference guide.

Combinatorial Optimization

by William J. Cook, William H. Cunningham, William R. Pulleyblank, and Alexander Schrijver
Wiley-Interscience
John Wiley & Sons, Inc.
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New York, NY 10158-0012
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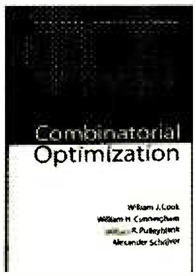

CIRCLE 341 ON FREE INFORMATION CARD

One of the most vital areas of applied mathematics, combinatorial optimization integrates techniques from combinatorics, linear programming, and the theory of algorithms. Because of its success in solving difficult problems in areas from telecommunications to VLSI and in areas from product distribution to airline crew scheduling, the field has grown over the past decade.

Written by a team of experts, the text offers a thorough, highly accessible treatment of both classical concepts and recent results. It is an ideal introduction to this mathematical discipline for advanced undergraduates and graduate students of discrete mathematics, computer science, and operations research. Topics include network flow problems, optimal matching, integrality of polyhedra, matroids, and NP-completeness.

Featuring logical and consistent writing, clear explanations, real-world examples, and helpful exercises, this volume is sure to become a standard in the field.

1998/99 Jensen Tools Catalog

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Jensen Tools—supplier to the electronics industry since 1954—has completely redesigned and expanded their catalog; this edition is 308 full-color pages. This comprehensive reference guide features premium Jensen-brand products, including 50 pages of original JTK tool kits, a new line of high quality handheld JTM multimeters, and an extensive selection of hand tools.

Over 5000 total products from all major manufacturers are available, including test equipment, computer and LAN support, wire and cable, telecom, power tools, soldering, storage and handling, work stations, lighting and optical, shop supplies, and communications products. Hundreds of new products—many new to the industry—have been added.

A complete online catalog with secure e-commerce is also available at the Web site above.

Semiconductor Material and Device Characterization, 2nd Edition

by Dieter K. Schroder
Wiley-Interscience
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
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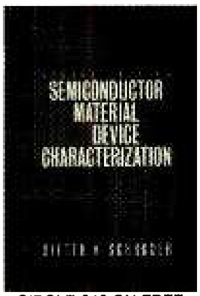

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Devoted to the characterization techniques used by the modern semiconductor industry to measure diverse semiconductor materials and devices, this book covers the full range of electrical and optical characterization methods, while thoroughly treating the more specialized chemical and physical techniques. It is a practical and an essential reference for research and development in the industry, as well as for students at the graduate level.

This edition covers the many innovations in the field during the last decade. The easy-to-use text includes a real-world mix of units, rather than strictly MKS units. From the detection of metallic impurities in silicon wafers to the use of microwave reflection to measure contactless resistivitity, each chapter presents state-of-the-art tools and techniques. There are numerous examples, and end-of-chapter problems have been added for this edition. In addition, there's a new chapter on reliability and probe microscopy. Five hundred illustrations were also revised.

1999 Catalog

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Fax: 800-706-6789 or 602-820-4643
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Offering the most diverse line of products for all types of tube gear, including vacuum tubes, transformers, capacitors, parts, supplies, and literature, this 72-page catalog contains many new products. Among them are ferrite rods, inductor coils, gift items, a line of Hammond classic 300-series power transformers, a line of telegraph keys, books, and many other products. There are also newly packaged "Screamin' Deals."

The telegraph keys are high quality, beautifully made, and reasonably priced; and they are great gifts for the ham in your life. Three types of keys are available: straight key, iambic paddle, and a dual straight key and iambic paddle. They are imported from Spain, have gold-plated brass keys on an olive wood base, and the handles and knobs are teakwood. EN

Prototype

Crash-Data Recorders for Your Car

As tragedy has shown us, the "black boxes" carried by airliners are often the most important source of evidence in helping the investigators determine the precise reasons for an aircraft crash. Now that same concept is moving to the family automobile: Though less sophisticated, nine different 1999 General Motors cars feature "black box" crash-data recording capability. The 1999 models scheduled to be fitted with the new system include the Buick Century, Park Avenue and Regal; Cadillac Eldorado, Deville and Seville; Chevrolet Camaro and Corvette; and Pontiac Firebird.

The system, which GM calls an advanced event-data recorder, is an enhancement of the air-bag sensing and diagnostic module (SDM) that has been installed in GM-built vehicles for several years. The SDM records information about the readiness of the air-bag systems when the sensors are activated and if the driver's safety belt is being used at air-bag deployment or in a near-deployment crash.

NOT ONLY WILL AIR BAGS DEPLOY in frontal crashes In many 1999 General Motors cars, but five seconds of critical pre-crash data will be recorded that could help reconstruct the accident and provide information for designing safer vehicles.

Gathering More Information

The new enhanced system adds vehicle speed, engine RPM, throttle position, and brake use for the five-second period before the crash. The data is captured in one-second intervals by a method conceptually similar to an endless-loop tape. Actually, the term "black box" is a misnomer since enhancements included in the SDM required no additional hardware, just connections to a local area network within the vehicle so the SDM can "talk to" the other computers and sensors in the vehicle.

In the event of a crash, an SDM senses any frontal impact and determines when to deploy the air bags. Now it also provides a signal to store the data on four additional parameters taken during the previous five seconds. The recorded data can be retrieved even if the battery is disconnected or the SDM box is unplugged.

The enhanced SDM stores information whenever a severe impact causes the air bags to deploy; under certain circumstances, it may also store data for a "near-deployment" event. An impact at about 12 mph or greater into a rigid barrier will trigger data collection as will a crash into a parked car at 24-30 mph. Data storage will occur only during frontal collisions—the major cause of death or serious injury in crashes.

Making Safer Cars

Like black boxes in airliners, which provide important research data that can prevent future crashes, event data recorders installed in automobiles could also help design safer vehicles. Last year, the NTSB recommended to the National Highway Traffic Safety Administration (NHTSA) and the automotive industry that they "gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices." This system answers this recommendation.

The GM advanced event data recorder will provide significant real-world data to improve automotive safety. Researchers will have new information on how drivers react to hazards and interact with their vehicles. That information can help provide critical insight into crashes and resulting injury patterns. The bottom line is data that can eventually lead to improved designs that are more crashworthy.

Post-crash reconstruction will also be easier and more precise thanks to these units. Data from the recorders will be available to augment data collected by law-enforcement and insurance investigators. Future vehicle-defect investigations and rule making can also benefit by having a more objective and scientific basis.—**By Bill Siuru** PT

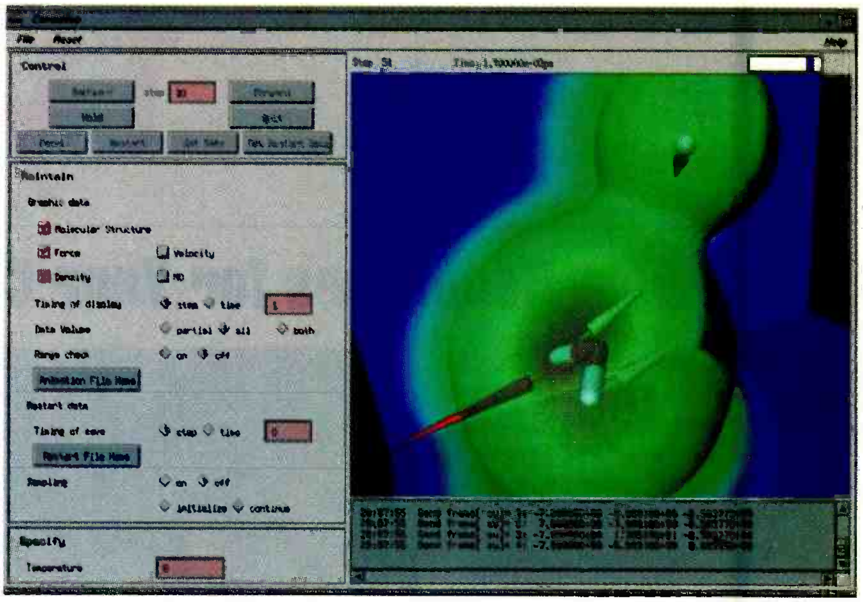
Virtual Reactions

The development of the virtual microscope is still in the early stages, but NEC's latest computer-simulation technologies have advanced to the point that scientists can "watch" and replay the complex mechanisms of chemical reactions at the atomic and molecular level. A detailed understanding of such mechanisms should make it possible to make existing production methods safer and more efficient.

The virtual microscope is a molecular simulation system that uses a supercomputer to recreate the chemical reaction process—as understood by quantum mechanics—that occurs when molecules collide and displays the process using computer graphics. Chemical reactions occur on the picosecond (one trillionth of a second) scale. The virtual microscope can solve Schrodinger's equations in femtoseconds (one quadrillionth of a second). When one cycle of calculations is completed every 1/30th of a second and the results are continuously displayed via computer graphics, the chemical reaction process can be portrayed with smooth animation. Because it is an on-line simulation, the scientists' commands, such as degree of rotation and magnification of the graphics, can be processed during the calculation step. Parameters that in a laboratory experiment would correspond to variables such as temperature can also be changed during the simulation.

Where the virtual microscope differs from conventional simulation systems is that when the scientists actively intervene in the simulation, they can observe chemical reactions as if they were watching them through a microscope in the lab. Using a virtual microscope, scientists can watch chemical reactions occurring at slow-motion speeds of 10 to the 14th power and magnifications of 10 to the 9th power.

Among the benefits of the virtual microscope are that 1) chemical behavior of molecules unseen in the natural world can be observed; 2) simulations can be run to mimic extreme conditions of pressure and temperature; 3) the time scale can be controlled at will—slowing down the reaction, stopping it, or even running it backwards; 4) magnification and rotation of the graphics display is also possible, meaning that observers can voluntarily change their visual perspective of the reaction; and 5) computer simulations are perfectly safe, with no danger of accidents or mishaps.



THE CONTROL SCREEN FOR NEC's virtual microscope. The settings on the left affect the speed, viewing angle, and other parameters of the atomic-level reaction seen at the right.

With this virtual microscope system, a graphic work station is in charge of the image processing. In the upper left corner of the screen, there are control buttons similar to the pause and rewind buttons on video recorders. Clicking on these buttons makes the simulation stop or back up. The chemical reaction can be seen developing over time on the right side of the screen. While watching the reactions unfold, the viewer's perspective and variables such as temperature can be changed to give a true understanding of the mechanisms involved.—Courtesy *Look Japan*, (November 1998); reprinted with permission PT

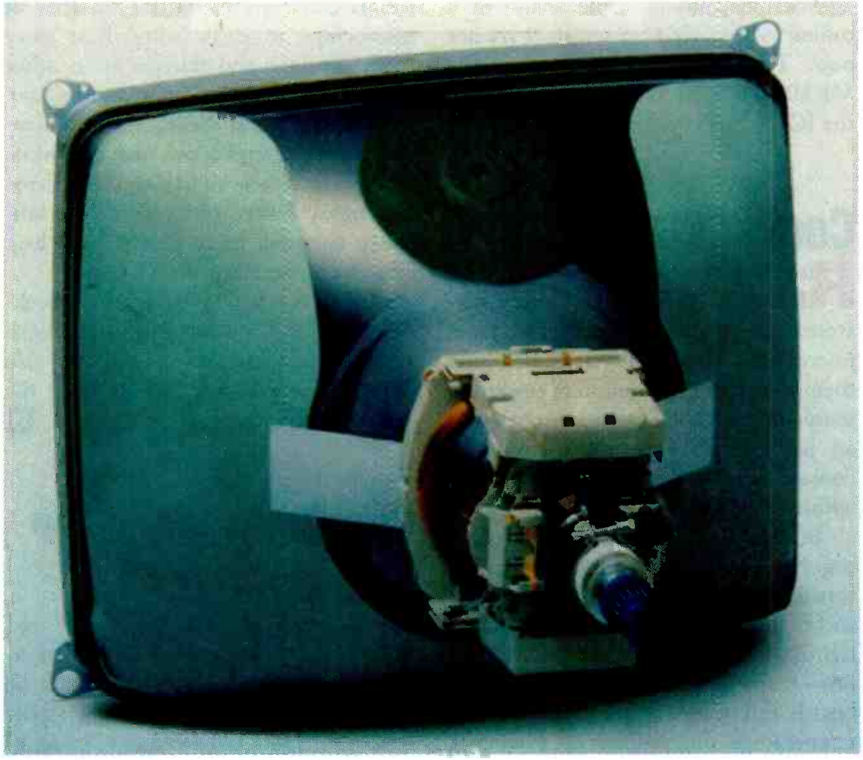
Reduce Stress: Stare at Your Computer Monitor

With computer users and TV viewers spending increasingly more time in front of the screen on the job and at home, scientists have expressed increased concern about the extent of long-term exposure to CRTs. The Fresh BioDisplay CRT (Cathode Ray Tube) from Samsung Display Device (SDD) is a "major breakthrough" in CRT technology values for computer monitors and televisions.

"Fresh BioDisplay is engineered to be environmentally safer than a standard CRT," said Hunsoo Kim, general manager of SDD. This CRT's technology increases the delivery of carefully modulated light waves in the far-infrared portion of the spectrum, strongly reducing stress on the viewer.

In a study conducted by Dr. Machi Yoshio, a professor at Tokyo Denki University and an expert in the physiological measurements of "subtle energy," subjects who viewed Fresh BioDisplays over long periods displayed a marked reduction of stress. According to Dr. Yoshio, the far-infrared ray (FIR) emissions from these CRTs increased alpha wave production in viewers, a bio-beneficial effect that resulted in less stressful brain wave patterns.

Aside from stress, another concern is the physical impact of CRTs on users. Standard CRTs generate positive ions caused by high voltage and heat, thus breaking the "ion balance." Aging, caused by high-speed heavy ions in dust colliding with the face, is promoted by long-term exposure to electrostatic



A REAR-VIEW of Samsung's Fresh BioDisplay. A ceramic coating on the CRT's funnel increases negative ions, and a variety of techniques have been used to reduce possibly harmful EMF radiation.

fields. According to scientific research, the reduction of electrostatic charges collecting on the surface of the case can slow premature aging of facial skin through the development of a dust-reduction feature.

Fresh BioDisplay's dust-reduction feature—made possible by a special ceramic coating on the CRT funnel—supplies continuous bio-beneficial negative ions that decreases the induced electrostatic charges on the monitor case. Even the manufacturing process reduces electrostatic charges and generates negative ions during the arc discharge. As an example, by "ion-count" measurement, 4000±250/cc of negative ions are detected from the Fresh BioDisplay when the negative ions in the atmosphere are only approximately 80/cc.

On the surface of a Fresh BioDisplay 15-inch monitor, dust absorption is reduced by 50%. SDD has also reduced possibly harmful EMF (electromagnetic fields) generated from the deflection yoke by coating the exterior cone with a conductive material and connecting the cone to the external conductive graphite coating and grounding. At the same time, the CRT's panel is coated with conductive material, and lastly this thin film is connected to the screen with conductive tape. PT

Code Red—Putting The Pieces Together

An earthquake rocks a large modern city, injuring hundreds of people, producing major structural damage, knocking out electrical power, breaking gas mains, and causing an industrial plant to leak toxic chemicals. Collapsed bridges and buildings prevent emergency vehicles from reaching the injured, from attending to dozens of small fires before they become big ones, and from carrying supplies to hospitals and rescue workers.

How do emergency responders and city official cope with the situation? How do they deploy resources where they are most needed? How can they prepare in advance for such disasters, and what can they do to recover from them?

Taking advantage of the Los Alamos National Laboratory's high-performance computing capability, the Lab's researchers are working on a project to give city officials, regional planners, police, and other agencies a tool to help them plan for and respond to all kinds of disasters. The project, called the Urban Security Initiative, links a wide range of urban subsystems—transportation, energy and water distribution, weather, infrastructure, ecosystems, economic activities, geology, and demographics—into an integrated system that contains all the pieces of the project and combines them into common databases along with geographic information.

"The tools being developed through this project can be used to help deal with natural disasters, environmental problems, the threat of chemical or biological attacks, industrial accidents, and other events," said geologist Grant Heiken, a member of the Urban Security Team. The project, now in its second year, involves many scientific disciplines, huge amounts of data, dozens of computer programs and tricky interfaces, and numerous collaborations. Heiken likens it to a big jigsaw puzzle being assembled by different groups, with various sections emerging and then needing to be connected properly to make a complete picture.

In addition to improving the responses to emergencies, the project is designed to help prepare for catastrophic events more effectively. "In order for a user community to know how to deal with the immediate aftermath of an earthquake, it would be very helpful to conduct training simulations," said astrophysicist Eric Jones. "People also want to find out where to locate their resources before a disaster happens to provide the most effective response."

One collaboration is with the Southern California Earthquake Center and other California agencies on a project to link computer models of seismic ground motion, earthquake-damage predictions, and the infrastructure of the city of Los Angeles to enhance pre-planning and emergency responses. One of the models is of the effects of a major earthquake in the L.A. area.

In addition to collaborating on earthquake modeling in Southern California, the team is working with other cities, federal agencies, and professional organizations. In one program, they are urging additional studies of urban systems, including a request for a declaration of the years 2001 to 2010 as the "Decade of Science in the Cities." Since almost all growth worldwide is in cities, which are the places most vulnerable to disasters, Heiken believes that "Developing a science-based understanding of their vulnerabilities will help them survive." PT

Seeing Machines in A Grain of Pollen

Jim Smith, manager of Sandia's Intelligent Micromachine Department—together with researchers Trey Roessig, Al Pisano, and Roger Howe from UC Berkeley—have built a microelectromechanical systems (MEMS) prototype that functions as a clock source. The minuscule machine, with moving parts the size of a pollen grain, performs the same job as quartz crystals.

Micromachines are made from polysilicon—the same material used in manufacturing ICs. Because of this, the micromachines and ICs can be constructed on one chip.

The micromachined clock source, conventional ICs, and other micromachined elements can be built simultaneously to form a complete "system on a chip," Smith says. If mass produced, the chips could dramatically reduce prices and increase reliability.

Hundreds of thousands of the chips can be built on a single silicon wafer. Manufacturing costs would decrease sharply, because assembly would be unnecessary. Currently, quartz-crystal timing devices and ICs are manufactured separately and then assembled.

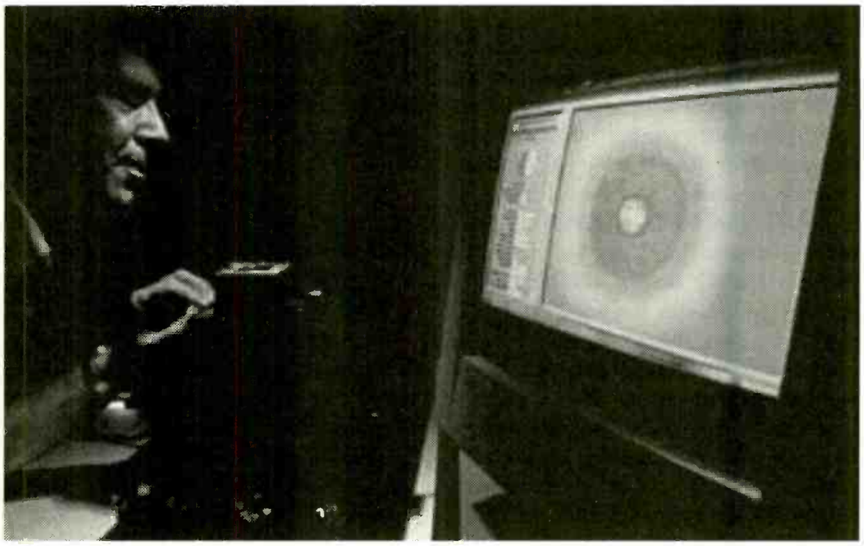
The MEMS prototype would serve as a replacement clock source. It consists of two very fine strings or tines—ten would fit on a pin head—anchored in parallel to actuator frames the size of red blood cells. The process of building these devices at Sandia appears capable of fabricating integrated oscillators with frequencies above 10 MHz. Despite the high frequencies, these micromachines are producing very low noise. The frequencies provide the constant timing signals necessary for the digital electronics device to operate.

Micromachines, in the shape of a tuning fork, serving as oscillators are not new. The uniqueness is putting the MEMS oscillator on the same chip as the ICs. PT

Cool Chips

Researchers at Sandia National Laboratories have developed a substrate that removes heat from microchips and PC boards, keeping them closer to their optimum operating temperatures. The Sandia approach uses an intricate network of microscopic, coolant-filled passages formed directly within the substrate.

In a few years, a dime-size microchip may house as many as 10 million transistors. But the electrical resistance created within that tiny world even cause today's tightly packed microprocessors to get hot—really hot! Hot microchips and PC boards fail faster. More damaging are temperature differences, or gradients, across chips that can cause tiny cracks and stress voids in the wiring.



A NEW MICROCHIP SUBSTRATE loaded with built-in "micro-heat pipes" is examined through an infrared thermal imaging microscope.

Various heat-removal methods have been devised for high-end microelectronics but not for everyday electronics devices—because of the cost. As these get smaller and operate hotter, even the most common devices may soon require heat-removal technology.

Manufacturers have added small tubular heat pipes to the surfaces of microchips to carry some heat away from circuitry and transfer it to other elements, such as the external surfaces of the PC board. But these surface connections are very ineffective heat removers. In the new Sandia substrate, the "micro-heat pipes" built directly within the substrate material, carry much more heat away from the chip.

Sandia is working to license the technology to a California firm. Research and development agreements are also being discussed with end users in the U.S. microelectronics industry. PT

Quantum Computer Calculations

Scientists have manipulated the atomic spin of molecules to demonstrate that reliable calculations can be made by a quantum computer. A report was published in a recent issue of *Physical Review Letters* (PRL) on the first experimental use of quantum error correction and on a demonstration of a three-bit quantum computing system.

Working with David Cory at MIT, Los Alamos National Laboratory physicists Raymond Laflamme, Wojciech Zurek, and Emanuel Knill are using nuclear magnetic resonance (NMR) to test their theories. "We have demon-

SHOWN HERE IS A THIMBLEFUL OF 1-Wire chips (actual-size), and in the upper right corner is a chip magnified many times.

strated for the first time that our quantum error correction works as expected. It is also the first time anyone has manipulated three bits in a quantum mechanical way," said Laflamme. "This is the most interesting proof to date that quantum computing is not just a crazy idea."

Unlike today's "classical" computers that make calculations with a binary system of zeroes and ones from digital switches, first-generation quantum computers are assembled from molecular switches called qubits. A qubit can represent one, zero, or potentially any state in between. A functional quantum computer will manipulate atoms to perform many calculations at once by taking advantage of quantum mechanics, which allows qubits to represent many states simultaneously.

"Suddenly you have information encoded on single atoms, and you can do things that you never thought you would be able to do before," said Laflamme. Until recently, the main problem for quantum computing was believed to be an inability to correct errors. Two years ago, the Los Alamos team developed a scheme that uses repetitive processing to reduce the probability of errors. For the general error type, every encoded qubit is checked for errors, corrected, then multiplied five times. Those five qubits also get checked for errors, then corrected and multiplied, etc. Knowing how many steps a particular calculation takes, the theorists can determine the number of checks needed to ensure the calculation's accuracy.

Now the physicists have adopted NMR techniques for experimenting with qubits. NMR allows scientists to manipulate the atomic spins of nuclei by applying an electromagnetic pulse to molecules diluted in a liquid. The signal is amplified by the molecules acting in parallel. Because the researchers knew the most common errors in NMR were of a specific type, they could test quantum error correction ideas using only a three-qubit system.

Functional quantum computers that exceed current machines are years away. However, these experiments show the hurdles to overcome are merely mechanical—the difficulty of manipulating individual atoms. PT

Intelligence Comes in Small Packages

To meet the industry's needs for simplified mounting and reduced size, Dallas Semiconductor's "1-Wire" chips merge bi-directional, digital communication and power into just one signal plus a ground return. Using flip-chip methodology, the wafer-level solder bumping process produces a ready-to use package no bigger than the silicon chip itself. These silicon-size packages will benefit designers trying to solve board-layout problems.

"It's the lowest-cost way for one chip to talk to another chip," said Michael Bolan, vice-president of product development. "The electron path goes in one bump and out the other. This is in contrast to the higher number of connections needed for traditional chips."

The smallest Chip-Scale Package (CSP) in the industry, these 1-Wire CSPs can be the size of a pin head (as small as 0.77mm × 1.3mm × 0.43mm), yet are as rugged as their larger, plastic-packaged counterparts. Chips in this package range from a simple silicon serial number to devices that include memory and temperature sensors, and all of them attach directly to printed circuit boards with on-chip solder-bump connections.

The solder bump adds just 0.004 inches (0.1mm), an insignificant increase to the 0.77-mm height of the chip. When placed and reflowed on printed board traces, these solder bumps form strong joints. Shear and pull strength tests show that the solder-bump method of board attachment exhibits performance equal to traditional plastic packages. The new 1-Wire CSP packaging passes tests for temperature cycling (1000 cycles of -55°C to +125°C), accelerated operating life, biased moisture, and autoclave.

Manufacturing is simplified as electronic assemblers won't have to retool their automated pick-and-place equipment to place the 1-Wire CSPs on circuit boards; they can use the same equipment that places other components, such as surface-mount chip resistors and capacitors.

"Innumerable everyday things—like printer cartridges, battery packs, medical consumables, and even weather sensors for digitizing the wind—can be more intelligent because the chip can fit into a tight space and survive the use environment," Bolan said. "Often design engineers run out of room as they seek to integrate more and more functionality into ever smaller form factors. Until now, we needed to seal the chip from outside contaminants using a package many times larger than the chip it housed."

For more information, see Dallas Semiconductors' Web site: *www.dalsemi.com*. PT

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Monitoring Lightning

We have discovered that there was a printer's error in the schematic diagram for the "Storm- Warning Lightning Monitor" (**Electronics Now**, October 1998). The anode of D1 should be connected to the center conductor of J1 along with S2. Figure 1 in the article does not show that connection extending all the way; someone might think (incorrectly) that it should be connected to the outer conductor, grounding the input to IC1.

We apologize for any problems that this misprint might have caused.—*Editor*

. . . and Running Lights

It has come to our attention that the foil pattern that appeared in the article, "Daytime Running Lights for Your Car" (**Electronics Now**, October 1998) had an error. A corrected foil pattern as well as an updated parts-placement diagram (Fig. 1) appears to the right. We regret any inconvenience that might have occurred.—*Editor*

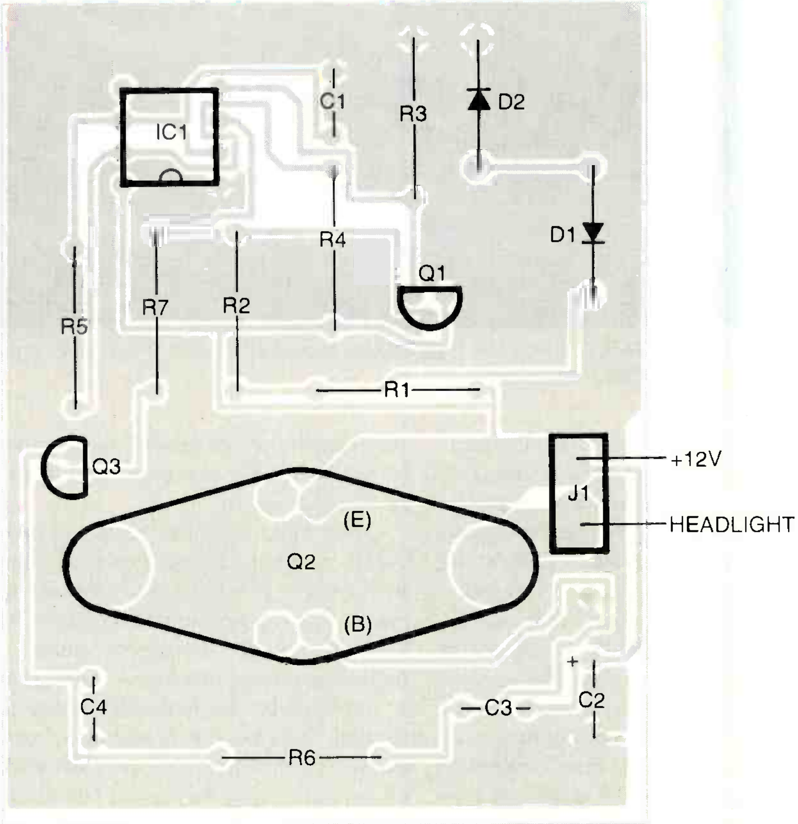
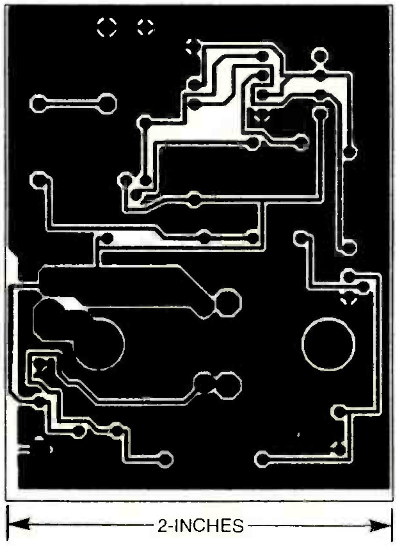


FIG. 1—PARTS-PLACEMENT DIAGRAM for the updated foil pattern



UPDATED FOIL PATTERN

Input and Information

I am writing about three things that have been mentioned either in editorials or in "Letters" in **Electronics Now**.

First, I like "Prototype." Its coverage of new science and technology, the type of material covered, and the way it is covered make "Prototype" one of the first sections I read in each issue. Second, I like the idea of having a column something like "Try This One" and "Technotes," which were in **Radio Electronics** in the 1950s and 1960s. I had a few items published in those columns at that time, and I already have plans for two short items to submit to the new "Try This One."

Third, there have been several questions about clocks that are self-correcting using radio signals from WWVB. I have just seen a catalog from Klockit (P.O. Box 636, Lake Geneva, WI 53137-0636; Tel: 800-556-2548). As their name implies, they sell kits for building clocks. They also sell several types of clock movements or replacements for old movements. Two of their clock kits include a WWVB receiver. Probably of more interest to **Electronics Now** readers are clock movements, powered by one AA cell, which have a WWVB receiver. These sell for $27.95 plus shipping.

BILL STILES
Hillsboro, MO

Airport Chatter

I would like to point out a couple of items not originally mentioned in the article by Anthony Caristi, "The Airport Buddy" (**Electronics Now**, January 1999).

The 108–136-MHz AM aircraft band covers ALL commercial communication, including ground-to-air as well as air-to-air and navigation. The frequencies between 108 and 118 MHz are for navigation, where you will hear mostly VOR guidance beacons, with occasional voice messages from Flight Service Stations (FSS) to help identify a particular beacon. All non-military communications and navigation uses this band, including airlines, cargo haulers, helicopters, and general aviation aircraft (which includes private aircraft). Most ground control frequencies, by the way, are located at the 121-MHz range and will be referred to by the tower as "point 9."

The other item concerns the usage of this receiver on board the aircraft. It shouldn't be used during a flight for several reasons. First, it is not a device approved by the FAA. Second, because of the lack of an RF preselector, there is probably substantial RF harmonics coming out of the antenna to interfere with aircraft communications and navigation.

P.S. I also have a private pilot's license and a General Class FCC license.

TODD SESTERO
Towson, MD

Letter-Writing Etiquette

Okay, so you've finally completed that really neat project from the latest issue—but it doesn't quite work correctly. Who can help you out? The author is the best person for the job, in all cases. We authors are always eager to help, and indeed, your inquiry lets us know that somebody is actually building this stuff! We sometimes wonder....

Yes, most of us are rather secretive—we don't publish our phone numbers or addresses for a simple reason: privacy! We are, however, easily reached through the publication. Before you even take that approach, consider the following so that you might better expect a reply.

Firstly, do as much troubleshooting on the project as you can. Look for incorrect wiring or wrong values on components. Don't expect the authors to do all the troubleshooting for you. The more information you can provide, the sooner you can expect a solution to your problem. Most requests for help turn out to be builder's construction errors.

Secondly, read the *entire* article once again to make sure that you didn't miss anything.

You have to realize that a project appearing in the latest issue was probably conceived by the author over a year ago. Yes, it takes that much time to actually prepare everything for publication, both by the author and the publisher. We go to great lengths to publish everything correctly. But, as many people are involved in the process, errors will sometimes creep in. These are normally caught right after publication by the author (or editors) and corrections are noted in future issues and on the publisher's Web site. Try them first.

As most authors write for a living, the article you're inquiring about was probably written about fifty or more articles ago. We tend to get a little hazy after all that time. In order to give an accurate answer, authors have to spend a considerable amount of time in researching the design and refreshing their memory. We do this quite happily. However, time is always in short supply for a writer.

So now you've done all the groundwork, but still haven't had any luck. Now it's time to contact the author. Keep your inquiry brief and to the point. Describe your problem accurately. Above all, be courteous. Here's how to get a prompt response: Send your inquiry along with a self-addressed stamped envelope (S.A.S.E) to the author, in care of the magazine. I don't know how many inquiries I've received without the S.A.S.E. This usually means an extra delay in responding, especially when the reader is from another country, which requires getting the correct postage.

One of this author's *pet peeves* is someone looking for free design information. I recently received a two-page letter listing over two dozen questions on formulas used for every facet of a complex design. A genuine reply to this type of letter would require writing an entire book. Besides, we actually incorporate a few of our own *trade secrets* in our designs. We don't intend to give these away for free—do you blame us?

If you ever do manage to find an author's address or phone number, or if he chooses to make it public, please be considerate. Typically, a writer's schedule is 24/7—he doesn't have time to chat with you, no matter how nice or how desperate you are. The editors themselves are pretty much in the same boat.

So there you have it—the proper method of contacting an author for help. It's dirt simple, and we're always available to help get the circuit going. We even enjoy it! We value ALL of our readers—don't forget that.

SKIP CAMPISI

EN

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

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

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Electronic Service Prod.
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Miami, FL 33166

Georgia

Normans Electronics Inc.
3653 Clairmont Road
Chamblee, GA 30341

Illinois

Tri State Elex
200 W. Northwest Hwy.
Mt. Prospect, IL 60056

Maryland

Mark Elec. Supply Inc.
5015 Herzel Place
Beltsville, MD 20705

Amateur Radio Center
1117 West 36th Street
Baltimore, MD 21211

Massachusetts

U-Do-It Electronics
40 Franklin Street
Needham, MA 02194

Michigan

Purchase Radio Supply
327 East Hoover Avenue
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Norwest Electronics
33760 Plymouth Rd.
Livonia, MI 48150

The Elec. Connection
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Westland, MI 48185

Elec. Parts Specialists
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BUILD A Surface-Mount Shortwave Radio

Build this radio using either surface-mount components, through-hole components, or a mix of the two—the choice is yours.

PAUL YOST

Like many other professionals in the electronics field, electronics instructors must keep current with the latest technical changes and products. As technology advances, the skills and knowledge of the technician must advance as well. Therefore, it is often a challenge to develop new classroom projects that demonstrate such advances.

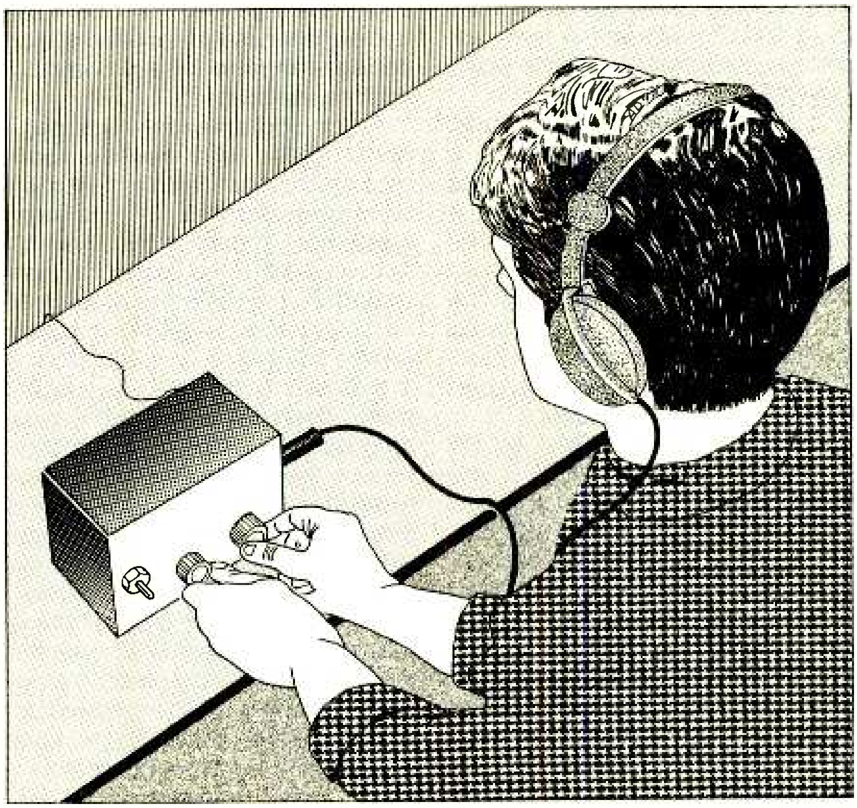
The focus for many new designs is to make the product smaller, lighter, and faster. Because of that, surface-mount devices (SMDs) have rapidly replaced the older traditional through-hole components in many products. Therefore, students (as well as established electronics professionals) should learn about those devices as well. However, demonstration is not enough. To truly educate, the project must be just as interesting as it is educational—nothing is less instructional than a boring project. Fortunately, the Surface-Mount Shortwave Radio presented here combines learning with entertainment by introducing the builder to the fascinating world of shortwave listening.

Although the Surface-Mount Shortwave Radio is a well-designed shortwave receiver, its main purpose is to educate. In many ways, it is a self-contained semiconductor course and lab exercise. During its construction, we will be working with (and learning about) Field-Effect Transistor (FET) circuits, oscillators, operational amplifiers, varactor diodes, L-C circuits, Zener diodes, ceramic filters, bipolar transistors, power amplifiers, specialized IC circuits, and modern surface-mount devices. Yet, what truly makes the Surface-Mount Shortwave Radio project unique is its construction versatility. The board design works with either standard components or their surface-mount equivalents. The builder has the option to use either type or both in any combination on the board. That means that you can practice with SMDs as much—or as little—as you want.

Theory of Operation. The Surface-Mount Shortwave Radio is a superheterodyne receiver with varactor tuning. It operates in the high-frequency (HF) band and is capable of receiving shortwave broadcasts from around the world. On a good night, stations from Africa, Australia, Europe, Asia, and South America can often be heard.

The circuit's block diagram is shown in Fig. 1. It consists of seven main sections: the tuning oscillator, the RF amplifier/mixer, the IF filter, the IF amplifier/detector, the audio preamplifier, the audio power driver, and the voltage regulator. Figure 2 shows the schematic for the circuit. Follow along with those diagrams as we discuss each section in turn.

The Tuning Oscillator. The heart of any good superheterodyne receiver is its tuning oscillator. While that circuit mainly determines the frequency range of operation, it can also affect the sensitivity and clarity



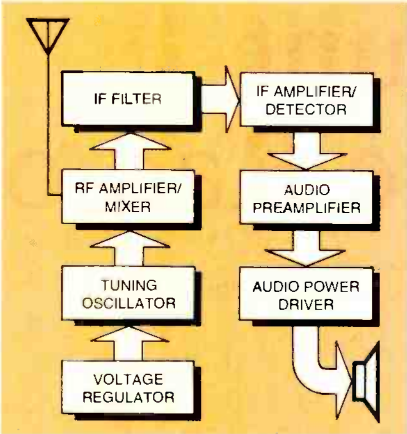


Fig. 1. When reduced to basics, the Surface-Mount Shortwave Radio is simply a superhetrodyne AM receiver that can pick up stations that broadcast on frequencies as high as 17 MHz.

of the station being heard. A properly designed and functioning oscillator is therefore critical for proper operation of the entire receiver. For the Surface-Mount Shortwave Radio, the oscillator section is built around Q1, an MPF102 general-purpose N-channel JFET (Junction Field-Effect Transistor). The tuned part of the circuit is a parallel-resonant LC "tank" circuit, located on the drain lead of Q1. The tank circuit is made up of L1, C8, and D2; those components set the frequency of operation. The part that actually tunes the oscillator is D2, a varactor diode. The term *varactor* is a contraction of the words "variable capacitor."

To understand how it works, remember that a capacitor is made from two conductors that are separated by an insulator. A reverse-biased diode fits that description because it has two conductors (the anode and the cathode) that are separated by an insulator (the reverse-biased junction). That is why a reverse-biased diode acts like a capacitor.

Although every diode or PN junction exhibits that effect, a varactor diode is specifically designed to take advantage of it. In our oscillator, the varactor's cathode is connected to the positive power supply through L1 while its anode is connected to a variable voltage source from R6. As R6 is adjusted, the amount of reverse bias applied to D2 is varied. That, in turn, varies the size of D2's depletion zone and, consequently, its capacitance. In our tank circuit, D2 can be varied from 30 to 90 pF.

The frequency of an LC circuit is determined by the formula:

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

where FR is the resonant frequency in Hz, L is the inductance value in henries, and C is the capacitance value in farads. In our circuit, the C value is the combination of C8 and D2. However, the capacitance value of C8 is far larger than that of D2 and, because the smaller value rules when capacatances are in series, the total capacitance effectively equals that of the varactor alone. Therefore, we can calculate the operating range of the oscillator by using the upper and lower values of D2's capacitance range (30 to 90 pF) along with the 3.3 microhenry inductor value of L1. Doing the math (which is straightforward and left as an exercise for interested readers) reveals that: FR_{MIN}=9.235 MHz and FR_{MAX}=15.95 MHz.

Theoretically, the oscillator should operate between 9.2 and 16 MHz, but it usually tunes an approximate 5-MHz range somewhere between 7 and 17 MHz. That is caused by component placement and tolerances. Fortunately, that is more than enough range to tune in dozens of stations worldwide.

An analog sinewave oscillator is an amplifier with positive feedback. For the Surface-Mount Shortwave Radio's RF oscillator, feedback is provided by C7, which couples part of the oscillation generated in the tank circuit back to the source lead of Q1. Since output current flows from source to drain in a JFET, they form the same current path. Therefore, the signal is coupled back in phase and oscillation occurs. Source resistor R13 is used to set the proper bias voltage. The actual adjustment of that control will be discussed in detail in the construction section of this article.

Note that there is a Zener diode placed across R6. Because the receiver is battery powered, a problem can occur as the battery discharges and its voltage level declines. Since the oscillator is electrically tuned, any voltage change to D2 will cause a corresponding shift in frequency. The battery voltage for D2 is regulated by D1 to help maintain a steady voltage level in order to minimize that effect.

PARTS LIST FOR THE SURFACE-MOUNT SHORTWAVE RADIO

SEMICONDUCTORS

IC1—NE602A or SA602N RF/IF mixer, integrated circuit, see text
IC2—Not used
IC3—LM741 op-amp, integrated circuit
Q1—MPF102 N-channel field-effect transistor
Q2—2N4401 NPN transistor
Q3—2N3904 NPN transistor
D1—1N4738 8.2-volt Zener diode
D2—MV2209 varactor diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—470-ohm
R2—15,000-ohm
R3, R8–R11—1000-ohm
R4—220,000-ohm
R5—10-ohm
R6, R7—50,000-ohm potentiometer
R12—Not used
R13, R14—10,000-ohm potentiometer

CAPACITORS

C1, C4, C5—100-pF, ceramic-disc
C2, C6, C7—47-pF, ceramic-disc
C3, C8—0.001-µF, ceramic-disc
C9—0.01-µF, ceramic-disc
C10—Not used
C11, C12—1-µF, 25-WVDC, electrolytic
C13, C14—10-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

ANT1—Whip or wire antenna (see text)
B1—9-volt battery
FL1—4.5-MHz ceramic filter
J1—⅛-inch headphone jack
L1—3.3-µH coil
L2—1-mH coil
S1—Single-pole, single-throw switch
9-volt battery clip, case, hardware, etc.

Note: The following items are available from Paul E. Yost, PO Box 32291, Louisville, KY 40232: Complete kit of parts with all the parts listed above including both surface-mount and through-hole components, $24.95 plus $1.25 shipping; Blank PC board, $11.95 plus $1.00 shipping. Kentucky residents must include 6% sales tax. No credit card, C.O.D., or orders outside of the USA or Canada will be accepted.

The RF Amplifier/Mixer. This section is built around IC1, an NE602 /SA602 chip. Although the NE602 is no longer being manufactured, it is still available from several sources including JDR Microdevices, 1850 South 10th St. San Jose, CA 95112 Tel: 800-538-5000. That chip also comes as part of a kit available from the supplier provided in the Parts List. The SA602, A drop-in replacement, is currently being manufactured.

The NE602 is an IC that has been specifically designed as an RF amplifier and mixer. It first amplifies the weak incoming radio signal on pin 1 and then mixes or "heterodynes" it with the oscillator output coupled to pin 6 through C6. Both signals are sinewaves; whenever two sinewaves mix, four signals result. Besides the two original signals, two new signals are formed at the sum and difference frequencies of the originals. For example, if a 7-MHz signal is mixed with an 11.5-MHz signal, two new sinewaves would occur at 18.5 MHz (the sum) and 4.5 MHz (the difference). As we will see, the difference signal will be used to select the desired station.

The IF Filter. Two important receiver characteristics are *sensitivity* and *selectivity*. Sensitivity is the ability to receive weak or distant stations; selectivity is the ability to receive only the station you want despite the presence of other, possibly stronger, stations. Sensitivity is obtained by proper antenna connection and RF amplification. Selectivity is obtained by the use of FL1, a special filter that is located just after the mixer stage. That filter is known as the IF filter; the letters "IF" stand for *I*ntermediate *F*requency. For most receivers, the IF signal is the difference frequency created by the mixer circuit. It is called the intermediate frequency because it is a middle- or intermediate-frequency signal that is between the higher frequency of the RF input and the lower frequency of the audio output. The Surface-Mount Shortwave Radio uses 4.5 MHz as the IF frequency. It was chosen because 4.5 MHz is a very common and inexpensive filter to obtain. Two other common IF frequencies are 455 kHz and 10.7 MHz—some radio designs use those values instead.

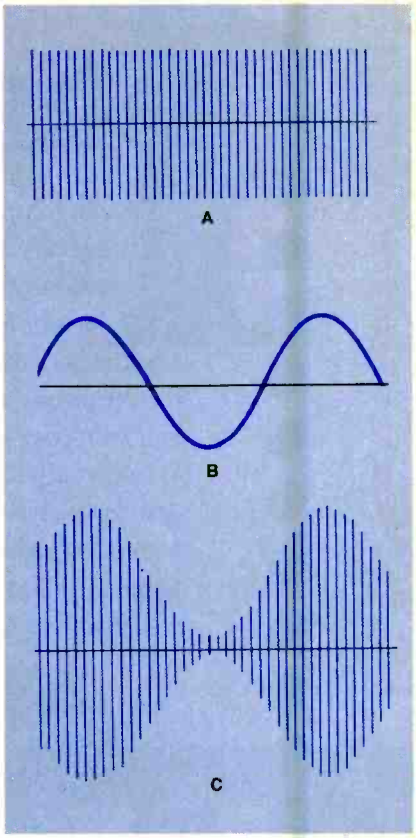


Fig. 3. To create an AM-broadcast signal, you take a carrier at the frequency that you want to broadcast on (A) and modulate it with an audio signal (B). The combined signal is a carrier wave that fluctuates at the rate of the audio signal (C).

Tuning a radio receiver is quite simple. Although many stations broadcast simultaneously throughout the world, only a station on a frequency that is *exactly* 4.5 MHz away from the oscillator signal will be heard. That occurs because only 4.5 MHz can pass through the IF filter. An example of that effect is the mixing that would occur for the shortwave stations of the *BBC* in England and *Radio Nacional* in Ecuador. Those two stations broadcast at 9.825 MHz and 9.745 MHz respectively. To receive the *BBC*, the oscillator could be tuned to 14.325 MHz. When the two signals mix inside IC1, the resulting difference frequency is 4.5 MHz (14.325 MHz –

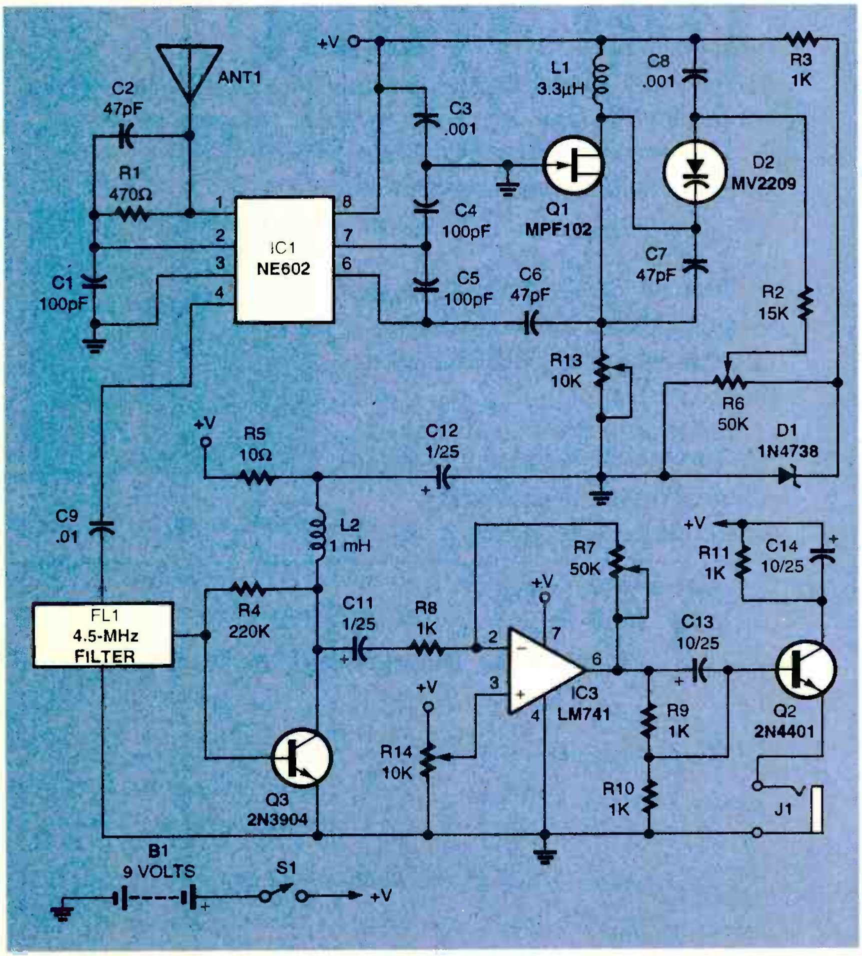


Fig. 2. The Surface-Mount Shortwave Radio is designed for low parts count as well as low cost.

9.825 MHz = 4.5 MHz). That signal would then pass through FL1 for processing by the rest of the receiver; the result is that the *BBC* broadcast would be heard. By contrast, the *Radio Nacional* signal would not be heard because its difference frequency would be 4.58 MHz, which is much too high to pass through the filter.

It should be apparent by now

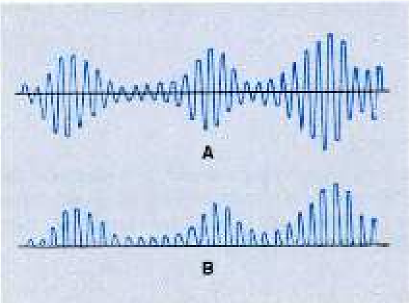


Fig. 4. When an audio signal (A) is half-wave rectified, the resulting signal (B), while odd looking, is nonetheless very usable in recreating the station's audio signal.

that the oscillator/mixer/filter combination of circuits makes selective tuning possible. However, that tuning method does create a potential problem. Occasionally, two separate stations can each be located 4.5 MHz away from the oscillator frequency. For example, while the BBC broadcasts at 9.825 MHz (4.5 MHz *below*), another station could also be transmitting at 18.825 MHz (4.5 MHz *above*)—both of which are exactly 4.5 MHz away from the 14.325 MHz oscillator signal. In that case, the radio would try to receive *both* stations simultaneously. Not surprisingly, that would cause a tremendous interference and neither station would be heard clearly.

That phenomenon is called the

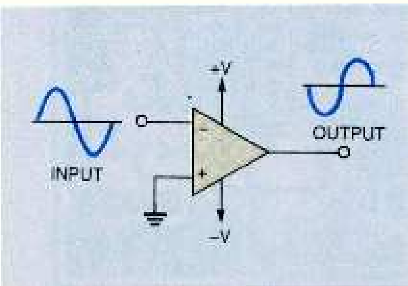


Fig. 5. When a ground-referenced audio signal is applied to the inverting input of an op-amp, the output signal is an exact mirror image of the original signal. Even though the output signal is 180° out of phase with the input signal, our ears can't tell the difference between the two unless we hear them side by side.

image frequency effect. The unwanted station is called the image because it is like an image one would see in a mirror—the exact same distance away from the mirror as the original but on the opposite side. Yet despite that potential problem, the heterodyning or IF system is still an excellent and efficient way to make a good, selective receiver.

The IF Amplifier. Although radio transmitters often use thousands of watts of power to broadcast, the signal is typically just a few microvolts in strength by the time it reaches the receiver. That is due for the most part to the long distance that the signal must travel—sometimes thousands of miles! While the signal level is increased by the RF-amplifier circuit, it is still only a few millivolts in amplitude by the time it exits the IF filter—a level far too weak to properly drive a detector circuit. Additional amplification is required. That amplification is done by Q3, a 2N3904 transistor.

The Detector. Shortwave stations broadcast in the High Frequency or "HF" band and use amplitude modulation (AM). The actual radio signal is called the *carrier* while the music or voice part is called the *intelligence* or *modulating* signal. Some texts also refer to that as the *baseband* signal. For AM systems, the audio actually rides the amplitude of the carrier wave. That is, the audio signal changes or modifies the amplitude of the carrier. The process is shown in Fig. 3. If you looked at a straight RF signal on an oscilloscope, it would look similar to the waveform shown in Fig. 3A. If an audio-frequency signal such as the one shown in Fig. 3B is used to amplitude modulate the RF signal, the result would be the signal shown in Fig. 3C.

Radio theory is a very broad subject area and is beyond the scope of this article. For our purposes, it is only important to know that a signal resembling the waveform in Fig. 3C will be present at the output of FL1 when you receive a station. That signal is amplified by Q3.

The modulated signal has two features that should be noted—it is

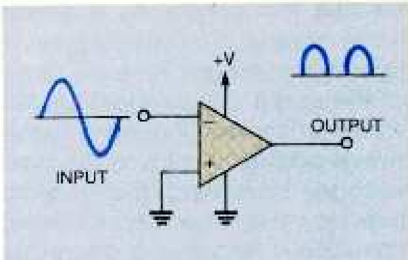


Fig. 6. If we try to feed a ground-referenced audio signal into an op-amp that does not have a negative-voltage source, the result is a half-wave rectified output that will sound terrible. What is needed is to change the reference level of the audio signal so that it is at half of the power-supply voltage.

an AC signal with both a negative- and positive-going peak, and it is symmetrical. With the modulating signal appearing on both halves of the carrier, only one half of the signal is needed to recover the audio signal.

Transistor Q3 also functions as the demodulator stage. Besides providing amplification, Q3 also rectifies the carrier signal of Fig. 4A into the half-wave shape shown in Fig. 4B. The action is similar to the rectifier method used in a power supply. That happens because Q3 uses only a single resistor (R4) to provide the base bias. Because the emitter lead connects straight to ground, the voltage across the emitter-base junction is the standard 0.7-volt drop of a silicon PN junction. That places the transistor right at the point of conduction, making it extremely sensitive to the slightest voltage change on the base.

Having Q3 biased just above ground serves two purposes. First, it creates the maximum gain possible for low-signal conditions. Second, it

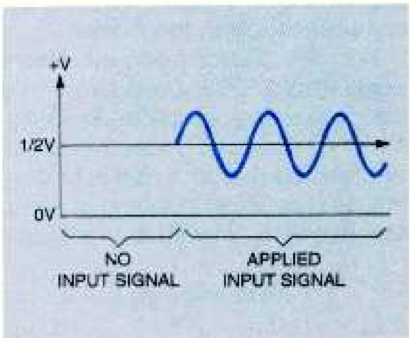


Fig. 7. When an audio signal is referenced at a voltage level above ground, amplifiers that have no negative-voltage source will be able to amplify the signal without clipping the negative-going parts of the waveform. The result is a clean-sounding signal that is not clipped.

rectifies the signal into the half-wave shape discussed earlier. It does that because the base bias is at the exact point of turn on (0.7 volts). When the incoming signal swings positive, it adds to the base voltage, increasing the forward bias. However, when the incoming signal goes negative, it decreases the base bias to a point below the conduction level, turning off Q3. The result is the rectified signal that is needed to complete the demodulation process.

Two signals are present in the resulting waveform—the carrier wave and the modulating wave. The modulation wave, being audio, typically varies between 50 and 5000 Hz, but some stations now broadcast a wider range (up to 15 kHz) to provide a high-fidelity service similar to the American FM broadcast system. The two signals must be separated so that only the audio signal passes through to the output. That is done by the audio preamp circuit, which will be discussed next.

The Audio Preamp. The rectified half-wave audio signal and 4.5-MHz carrier that appear across L2 are passed to IC3 through coupling capacitor C11. Integrated circuit IC3 is a 741-type op-amp. Being an early example of an IC amplifier, IC3 is severely frequency limited. In fact, it is specifically designed to provide no gain for signals above 1 MHz, so it cannot pass the 4.5-MHz carrier signal. However, for lower-frequency signals (like audio), the 741 can provide a gain as high as 100 or more. That is how the audio gets separated from the carrier. The op-amp passes and amplifies the audio signal while blocking the carrier.

For the Surface-Mount Shortwave Radio, IC3 is configured as a basic inverting amplifier. Potentiometer R7 provides a variable negative feedback path in order to control the gain. In an inverting op-amp circuit, gain is set with the formula:

$$\text{Gain} = R_F/R_{IN}$$

where R_F is the feedback resistance and R_{IN} is the input resistance.

Let's apply that formula to find the gain of our op-amp circuit. In the circuit, R7, with a variable range

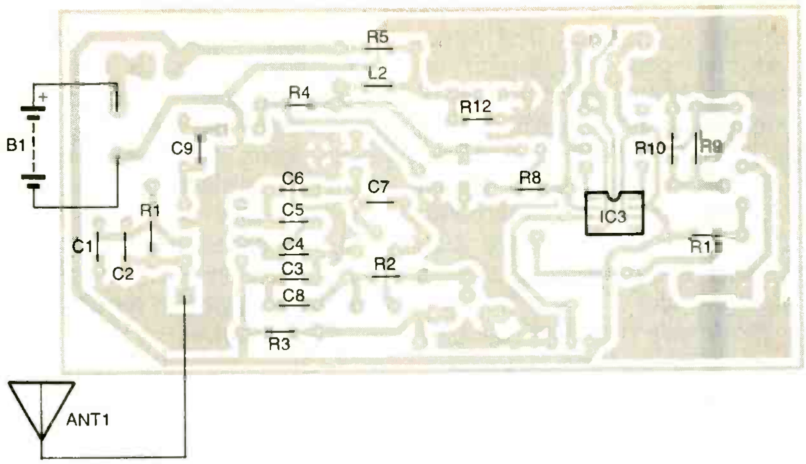


Fig. 8. This parts-placement diagram shows the locations of the surface-mount components for the Surface-Mount Shortwave Radio. Although most (if not all) of the components used in the circuit are available in surface-mount form, some items are too bulky to be used. Other components cannot be used because of constraints in the routing of the PC board's traces.

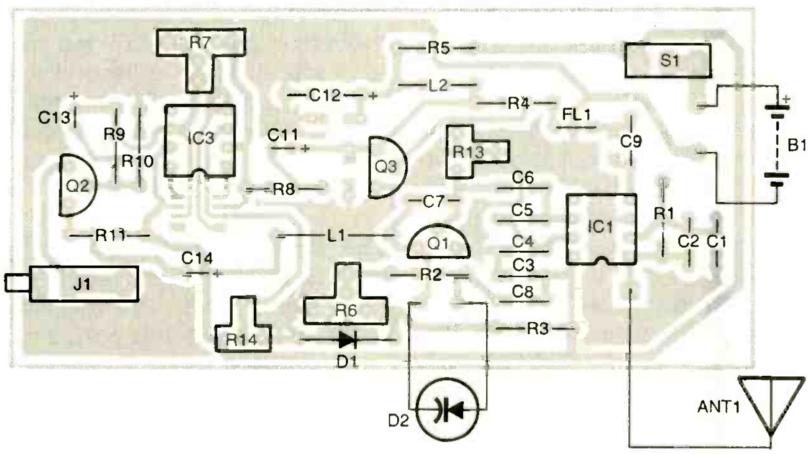
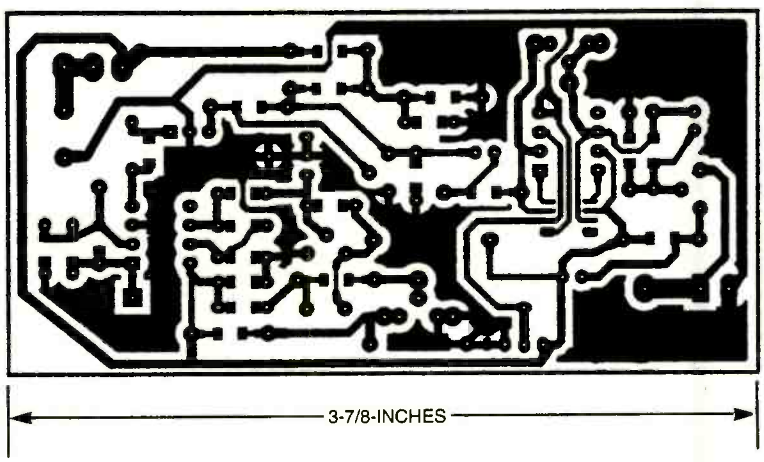


Fig. 9. Follow this parts-placement diagram for locating the through-hole components of the Surface-Mount Shortwave Radio. Remember, if you've used a surface-mount device for a particular component, do not use the through-hole part as well—only one of each type is needed.



Here's the foil pattern for the Surface-Mount Shortwave Radio. Despite using two widely-divergent technologies (surface-mount and through-hole), the entire unit can be built on a single-sided board.

HELPFUL CONSTRUCTION TIPS

Be sure to observe the polarity markings when installing an electrolytic capacitor.

Observe proper IC placement. Pin 1 is marked by either a dot or a notch on the chip.

If you use insertion-mount devices, the disk capacitors, transistors, and the varactor should be mounted above the board with some lead length showing. The other components should be mounted flush to the board with excess lead lengths clipped off.

Refer to the schematic diagram and parts-placement diagrams often in order to make sure that your construction is correct. Since this project is a relatively low-frequency device, actual parts positioning and lead lengths aren't critical but neatness should always be a primary concern.

Use good soldering practices during construction. Before soldering a joint, wipe the soldering iron tip clean on a wet sponge. Melt a small ball of solder on the iron tip. Touch that molten solder to the joint to be soldered first. The liquid solder forms a "heat bridge" that lets the joint area heat up to melting temperature quickly before the heat flows away to the surrounding area. Let the soldering tip heat each component lead and board trace just enough to make the solder flow smoothly. Although most of the parts used in this project are not overly heat sensitive, the copper pads and traces on the PC board can lift up if they are allowed to get too hot.

Mark off each part on the list as you install it. That will help keep track of your work.

of zero to 50,000 ohms, is R_F, and R8, at 1000 ohms, is R_{IN}. Plugging those values into the formula, we see that the maximum gain is 50 (50,000/1000) and that the minimum gain is zero (0/1000). It is easy to see that R7 can be used as the Surface-Mount Shortwave Radio's volume control.

Another feature of the audio preamplifier circuit is that it also provides the bias voltage that drives Q2, the audio output. An op-amp normally requires a dual-polarity power supply to operate. That lets the output signal swing both positive and negative across the ground reference. Unfortunately, dual-polarity supplies are both expensive and inconvenient to use—especially with battery-operated devices. Fortunately, op-amp circuits can be made to operate from a single supply by placing a DC offset voltage on one of its inputs.

An op-amp is a differential amplifier that has two inputs and one output. One of the inputs is "inverting" while the other is "noninverting." A signal applied to the inverting input will be phase shifted 180 degrees (or inverted) at the output. By contrast, a signal applied to the noninverting input will remain unchanged in phase at the output. If two signals are simultaneously applied to both inputs, their difference appears at the output multiplied by the gain of the circuit. Normally, only one of the inputs is used for the signal; the other is referenced to ground. A simplified example of that type of circuit is shown in Fig. 5. Since the unused input is grounded, it effectively stays at zero volts. Therefore, the difference between the two inputs automatically becomes the incoming signal, which is then amplified and passed through to the output. That circuit works fine when both a negative and positive supply are available. What would happen if only a positive supply is available?

In that case, the output signal could only swing positive as shown in Fig. 6. For the op-amp to work from a single supply voltage, the circuit must be able to produce both positive- and negative-going signal swings. The easiest way to do that is to offset the output reference above ground. That is done by referencing the unused input to one-half of the positive supply voltage instead of connecting it to ground as we've done with IC3. The bias voltage is supplied by R14. That will let the output signal swing both positive and negative around the bias level. The resulting waveform on an oscilloscope will look like the waveform shown in Fig. 7.

The output signal has effectively become an AC signal that is riding on top of a DC level. Normally, the DC component is removed before the signal passes on to the next stage (usually by coupling capacitor) but, in this project, we do not remove it. Instead, it is used to bias Q2, the audio power amplifier.

The Audio Power Amplifier. Transistor Q2 is the main component of the audio-output stage. Note that it is wired as a common-collector amplifier. That type of circuit was chosen because its low-impedance output allows a direct connection to a headset. Like all bipolar transistors, Q2 requires a certain amount of DC bias in order to operate. Often, a resistor divider network is used to provide bias; our circuit is no exception. Resistors R9 and R10 form the bias network for Q2. Normally, most amplifiers connect the bias resistors to the power supply. We will not be doing that here because the DC offset from IC3 is providing the bias.

Capacitors C13 and C14 are bypass capacitors that block any DC while passing the AC audio signal. They create a low-impedance audio-signal path around the bias-resistor network, increasing gain. From here, the signal goes on to drive the headset.

Construction. Building the Surface-Mount Shortwave Radio is as simple as mounting the parts to a printed-circuit board; no particular order is required. A foil pattern for a single-sided board has been included here. As an alternative, a pre-etched board is available from the source given in the Parts List. If you purchase a board or make one from the foil pattern, the parts-placement diagrams in Figs. 8 and 9 indicate where the various components should be mounted. Remember that you can use either surface-mount or through-hole components—the option is yours.

If you decide to use surface-mount components, you should place those items on the board first. Figure 8 is specifically for the surface-mount components. For those unfamiliar with the techniques involved, several sidebars on working with SMTs well as information related to them can be found elsewhere in this article. The Glue-Place-Solder method that is demonstrated is probably the best method to use when assembling the Surface-Mount Shortwave Radio. Please keep in mind that this project is "component versatile." If you have trouble in placing an SMD part, you can simply substitute the through-mount device instead; the PC board will accept either type. When deciding whether to use surface-mount or traditional components, remember that you can use as many or as few of the surface-mount components as you want. The receiver works just as well with either type of device installed on the board.

The most important thing to remember when building this project is that either a surface-mount or a through-hole component should be used for a particular component. **DO NOT** place both types on the board for the same reference designation.

One last note: While surface-mount components could be used for all parts, in a few instances using standard through-hole components is recommended. Those are C6 (because of a ground trace that the component would have to straddle, increasing the likelihood of a short) and C11-C14 (due to their size).

Figure 9 is the parts-placement diagram for any insertion-mount components you elect to use. None of the parts are particularly sensitive or difficult to mount. Neither S1 nor FL1 are polarity sensitive; you can install them in either direction on the board.

When all of the parts are installed on the board, the basic construction of the unit is complete. Only one more item is necessary for receiver operation—the antenna. The most convenient type to use is a straight piece of wire. The antenna wire should be 18 to 24 gauge with a length between 25 and 50 feet. One end of the wire connects to the PC board at the hole marked "ANT1" on the parts-placement diagrams. The rest of the wire should be stretched out full length away from the radio

The Surface-Mount Shortwave Radio can be mounted in any suitable case. After checking over your work for errors such as bad solder joints, solder bridges or incorrect or backward-mounted components, you can test the unit.

HELPFUL HINTS FOR INSTALLING SMDs

Because of their small size, surface-mount devices (SMDs) are easy to lose. When working with SMDs, you should place and keep all parts on a plain sheet of white paper.

Before you glue or place any parts, you need to clean the PC board. You can do that by using alcohol or some other non-residue cleaning solution specifically made to safely clean electronic equipment. **DO THAT EVEN IF THE BOARD APPEARS TO BE FINE.** If you do not clean the board first, then some of the solder connections that you make during construction might become intermittent and cause improper operation that will be difficult to trace.

Do your best to keep the glue between the trace runs and off the pads.

After you place the part on the board, you should allow the glue to dry first. That will prevent the part from shifting during the soldering process.

For easy soldering, smear some soldering paste (such as RadioShack 64-021) on the pads and terminal ends of the SMD after it has been glued in place. Also, you should use the smallest diameter solder available. For example, RadioShack 64-005 solder is only 0.032 inches in diameter.

None of the SMD resistors or capacitors used in the Surface-Mount Shortwave Radio are polarity sensitive. You may place them either way on the board.

DO NOT use a soldering iron larger than 25 watts and use the finest point possible. You should also have a good set of tweezers, a magnifying glass, and some desoldering wick when working on this project.

Testing and Adjustment. The Surface-Mount Shortwave Radio is designed to operate from a standard 9-volt battery. Apply power to the radio but **DO NOT** connect a pair of headphones to J1 yet—that will be done later.

The first step is to set the oscillator bias. Set both R6 and R12 to their center range and connect an oscilloscope to Q1's source lead. It is very important to use a 10X probe; any other type of probe will load the circuit and kill the signal. Adjust R12 until you see a sine wave on the oscilloscope that is a good compromise between signal amplitude and symmetrical shape. You need to check the signal across the entire oscillator range, though, so vary R6 (the tuning control) from end to end and readjust R12 as needed to compensate for any distortions that might occur. When the circuit is working properly, the oscillator signal will vary a few megahertz in frequency—somewhere between 7 and 17 MHz.

If the oscillator does not work, check for 9 volts on the drain lead of Q1. If that is missing, check to see if L1 is open, S1 is defective, or for a defective battery clip. If the voltage on the drain is correct, then check the voltage level on the anode of D2. That voltage should vary between zero and 8.2 volts as you turn R6. If you do not obtain those results, then either R2 or R6 might be open or D2 might be installed backwards on the board. If all of the tests check okay but no oscillation occurs, then either Q1 or D2 might be defective.

The audio section is adjusted next. Set R13 for about 4.5 volts on pin 3 of IC3. Plug a pair of headphones into J1. You will probably hear some noise or "hiss" from the headset. The volume should change as you adjust R7. The easiest and best way to adjust the sound is by using an actual shortwave reception. Adjust R6 until you hear a moderately strong station; adjust R13 until the audio sounds most clear to you.

The audio adjustment is quick and easy to make; however, the time of day and location can affect the quality of the Surface-Mount Shortwave Radio's output. The very best time to receive a shortwave signal is at night shortly after sunset. The antenna must also be fully extended and preferably outdoors. If you cannot stretch it outside, then do so inside a non-metallic-frame building. If you attempt to receive shortwave inside a metallic-frame building (like a commercial or industrial building) or during the day, you will hear few or no stations. Like most shortwave receivers, the Surface-Mount Shortwave Radio works best when referenced to an earth ground. The easiest way to do that is to make a strap connection to any cold-water pipe that runs into the ground.

Troubleshooting. Since the oscillator should have already been checked and adjusted, any problems will be located elsewhere. Before you begin the test procedures outlined below, you should first check all of your solder connections. Almost every problem is directly due to either an improper solder connection or an accidental solder bridge across adjacent traces. A lot of aggravation and trouble will be avoided if you thoroughly check the solder work first. If the soldering is okay and the receiver still does not work, then one of the following steps should help to isolate and solve any problems that might occur.

The first step in troubleshooting is to isolate the problem area. For example, is the problem in the RF or the audio portion of the circuit? Fortunately, you can determine that quite easily. Simply remove the antenna wire from its normal connecting point and reconnect it where FL1 meets the base of Q3. You should hear various local AM-broadcast stations through the headset when you do that. If you hear those stations, the receiver is operating properly from Q3 through to the headset; the problem exists between the antenna and the IF filter. Note that for that procedure to work well, you should use the earth grounding method discussed earlier.

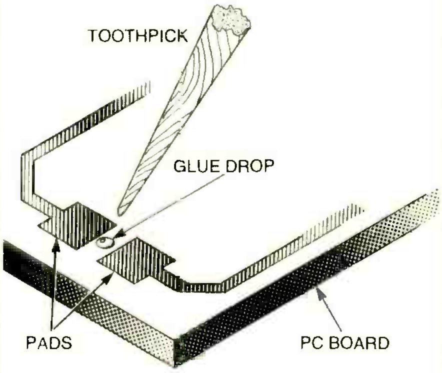
If the problem is in the RF section, you should check IC1, FL1, and the oscillator. The oscillator is the easiest to check—simply follow the adjustment procedure used earlier. If the signal still looks good on the oscillo-

HOW TO INSTALL A SURFACE-MOUNT DEVICE

Working with SMDs is a simple 3-step process when following the G-P-S (Glue-Place-Solder) method:

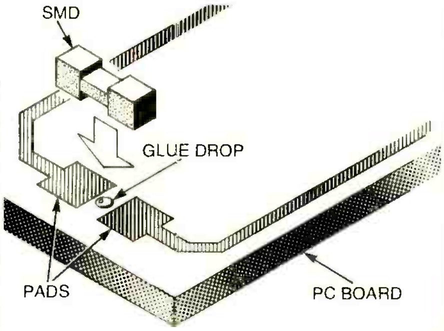
Step 1: Glue

Because glue is used to hold the SMD in place, gluing is the first step in the installation process. The author recommends the plastic glue used to build model cars, but any good plastic glue will work. To perform this step, find the pads on the board and use the tip of a toothpick to lightly smear a drop of glue between them. For best results, you should clean and paste the board first as described in the Helpful Hints sidebar.



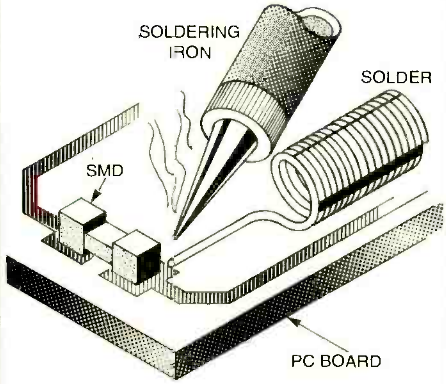
Step 2: Place

This is the most critical step in the assembly procedure. After you have placed the glue, you must position the SMD on the board. A good set of tweezers is often the best tool to use. Centering does not have to be perfect but you must make sure that the metallic ends of the component touch the pads to either side.



Step 3: Solder

Lightly touch the tip of the soldering iron to the metal end of the component. At the same time, place the tip of a solder strand against this point as well. Let this heat until the solder flows onto the part and board together making the connection. Remember, neatness is preferred but perfection is not required. Remove any excess solder with the wick.



SMT—ANSWERS TO FREQUENTLY-ASKED QUESTIONS

What is SMT? What is SMD?

The letters "SMT" stand for Surface-Mount Technology. The letters "SMD" stand for Surface-Mount Device. Those terms refer to a style of tiny, leadless electronic components that are made to mount on the PC board's surface as opposed to the larger through-hole style of components that we are more familiar with. Unlike those larger components, SMT devices have no leads. Instead, they use either small metal tabs or metallic terminals to make the electrical connections to the circuit board.

Why is SMT used?

Due to their small size, SMT is often used to construct miniaturized electronic devices such as pocket-sized cellular telephones or keychain-sized car lock controls. Also, SMT devices can be more easily installed in some automated assembly processes due to their lack of leads.

What components are available as SMT devices?

Resistors, capacitors, transistors, diodes, and ICs have been available in SMT style since the 1970s. Today, LEDs, potentiometers, crystals, inductors, fuses, connectors, and certain subassemblies like filters and oscillators are available in large quantities.

What is the size of an SMT device?

Like many electronic components, SMT devices come in various styles and sizes. SMT resistors, for example, commonly come in $^1/_{16}$, $^1/_{10}$-, $^1/_8$-, $^1/_4$-, and 1-watt sizes. The $^1/_{10}$-watt size is 2.00 mm by 1.25 mm by 0.60 mm, while the 1-watt device measures 6.40 mm by 3.20 mm by 1.10 mm. Not suprisingly, the chip-style capacitors and inductors are roughly the same size. The other components, such as transistors and ICs, come in various sizes as well. However, they are usually smaller than their through-hole counterparts.

Other than physical size, what differences are there between SMT and regular components?

Electrically speaking, no difference exists between SMT devices and their counterparts. An SMT resistor of 1000 ohms would act the same as a 1000-ohm leaded resistor. Their differences are purely physical and not electrical.

How can you identify the type and value of an SMT device?

SMT resistors are usually manufactured as small black rectangular chips with metallic-coated ends. Often, the value of the device is printed in a numerical code across its top. The number is similar to the more familiar color-code bands found on leaded resistors. For example, a 390-ohm resistor would have "391" (3, 9, and 1 zero) printed on it while a 3900-ohm unit would be marked "392".

Like resistors, capacitors also resemble a small rectangular chip but they are usually either a yellow or gray in color. Unfortunately, these components don't have a value printed on them. You either have to refer to a manufacturer's reference or physically measure their value.

SMT-style transistors and diodes often look like small black squares but with metal tabs instead of ends. Usually two of the tabs are located on one side of the device while the third tab appears on the opposite side.

SMT ICs look very similar to regular DIPs except that they are generally smaller in size with leads that lay flat to the board.

What tools are needed to work on SMT devices?

Virtually all electronic components are soldered to the board and SMT devices are no exception. Therefore, good soldering equipment is still required. While some shops use specialized (and expensive) equipment to do SMT soldering, a low-wattage standard iron with a fine point tip can still be used for many applications. Other good tools to have on hand are tweezers, a magnifying glass, glue, and soldering paste.

Why should I practice working with SMT devices?

Although most assembly processes are automated, most repairs are not. Employers need people with the knowledge and "hands-on" skill to work with SMT; that need will only grow with time. Practicing with SMT is one good way to prepare for the future.

scope, it is operating properly.

The IF filter is the next component to test. Actually, it's a very easy part to test if you have an RF signal generator. Set the signal generator for an AM modulated output at 4.5 MHz and connect it to the filter input at C9. If the filter is okay, you should hear the signal in the headset.

Check for 9 volts on pin 8 of IC1. If that voltage is present and the receiver still doesn't work, then IC1 might be defective or installed backwards. If it is in backwards, it is almost certain that if it wasn't defective to begin with, it probably is now!

If placing the antenna wire on Q3's base causes no sound to be heard from the headset, the problem is in the audio section and it will involve Q3, IC3, or the audio-output section. The easiest way to troubleshoot those sections is to use the signal injection and tracing method. To do that, simply inject a 10-millivolt peak-to-peak 1000-Hz audio signal into the positive side of C11. If you hear that tone through the headset and it varies in loudness as you turn R7, then IC3 and the output stage are okay; the problem is with the Q3 amplifier/demodulator circuit.

If you do not hear the tone, disconnect the generator. Check the voltage level on the base of Q2. It should read somewhere between 2 and 3 volts DC; the level should vary as you adjust R13. If the proper voltage is on the base, then check the level on the emitter. That voltage should be about 0.7 volts less than the level on the base. Note that the headset must be plugged into J1 for the measurements to be accurate. If that voltage is missing or high, then either Q2, R11, C14, the headset, or J1 might be defective.

Final Notes. Shortwave listening makes for an interesting and worthwhile hobby. Millions of people throughout the world enjoy listening to shortwave and there's quite a variety to hear. There are news broadcasts, religious broadcasts, and even commercial rock-and-roll stations. Many broadcasts occur in English as well as most every spoken language on Earth.

Most important, those broadcasts originate from faraway countries with different ideas, cultures, and perspectives. A very good example of that occurred in 1989 with the fall of the Berlin Wall. Although that was a truly major historical event, most Americans knew about it from only a few short minutes of news broadcast each evening on network television. By contrast, those with shortwave receivers heard first-hand reports continuously throughout the event. Yet we did not hear these broadcasts from American journalists. Instead, we heard from

(Continued on page 50)

TEST DIGITAL CIRCUITS WITH THE SMARTPROBE

Replace your old logic probe with one that comes with a cap and gown—and the ability to resolve voltages to four levels as well as remember them!

JAMES J. BARBARELLO

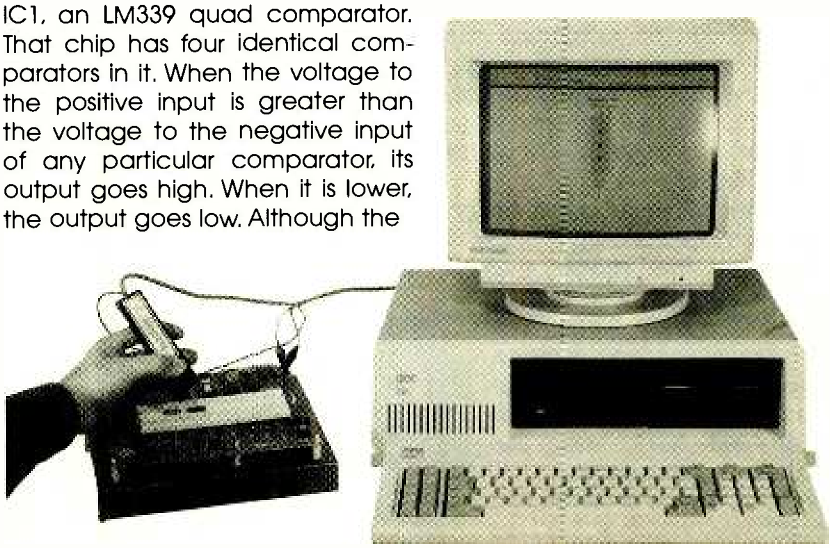
While a logic probe is an inexpensive piece of test gear that can be very handy when working with digital circuits, there are both positive and negative aspects to it. On the positive side, it's easy to use and gives you a quick view of what's going on in digital circuits. On the negative side, you get only three LEDs that tell you if the point being probed is low, high, or is pulsing between low and high. Of course, if all of the LEDs are off, the reading might be "floating" between the voltage thresholds for zero and one. That assumes that the instrument is working properly and that you've set it up correctly—like making sure not to accidentally switch the sensitivity to "CMOS" while testing a TTL-based circuit!

It's probably fair to characterize most basic logic probes as "dumb" instruments. Wouldn't it be nice to have a "smart" probe that gives you both visual and audible indications? How about adding the ability to display the status of the last 20 or so readings? While we're at it, let's add the ability to view the relative frequency and pulse width of signals on an oscilloscope-type display? Of course, it would be nice if you got all of those additional capabilities for about the same cost as that standard "dumb" logic probe.

The SmartProbe device presented here is such a device. Using an inexpensive LM339 comparator IC and a handful of other components, it connects to the parallel port of a PC. Like a standard logic probe, it senses the logic 0 and logic 1 "windows" of both TTL and CMOS devices, providing visual feedback of the detected logic state. The software lets your PC select a different audible tone for TTL and CMOS levels; keep a history of the last 20 readings; and show amplitude, frequency, and pulse-width characteristics on an oscilloscope-type display. Since it is a PC-based device, you can modify it to control other devices based on the sensed levels. It will work with any PC, from an old XT to tomorrow's newest model. The SmartProbe uses readily available components and doesn't require any special construction techniques. Even without any "junk-box" parts, the total cost is under $15.

How It Works. The schematic diagram for the SmartProbe is shown in Fig. 1; refer to it during the following discussion. The heart of the circuit is IC1, an LM339 quad comparator. That chip has four identical comparators in it. When the voltage to the positive input is greater than the voltage to the negative input of any particular comparator, its output goes high. When it is lower, the output goes low. Although the outputs of an LM339 do not actively produce a voltage to indicate a high output, we'll assume at this point in the description that they can do that; the outputs of IC1 will be discussed in greater detail later in this section.

The SmartProbe's tip is connected to one of the inputs on each comparator. Note that two of the comparators ("b" and "c") have the probe voltage going to their positive input, while the other two have the probe voltage going to their negative input. The other comparator inputs are connected to a voltage divider formed by R5–R9; that divider provides a reference level for each comparator. The resistor values chosen set the logic-low and logic-high voltage levels for both TTL and CMOS devices. With a 5-volt source, the reference voltage for comparator "a" is about



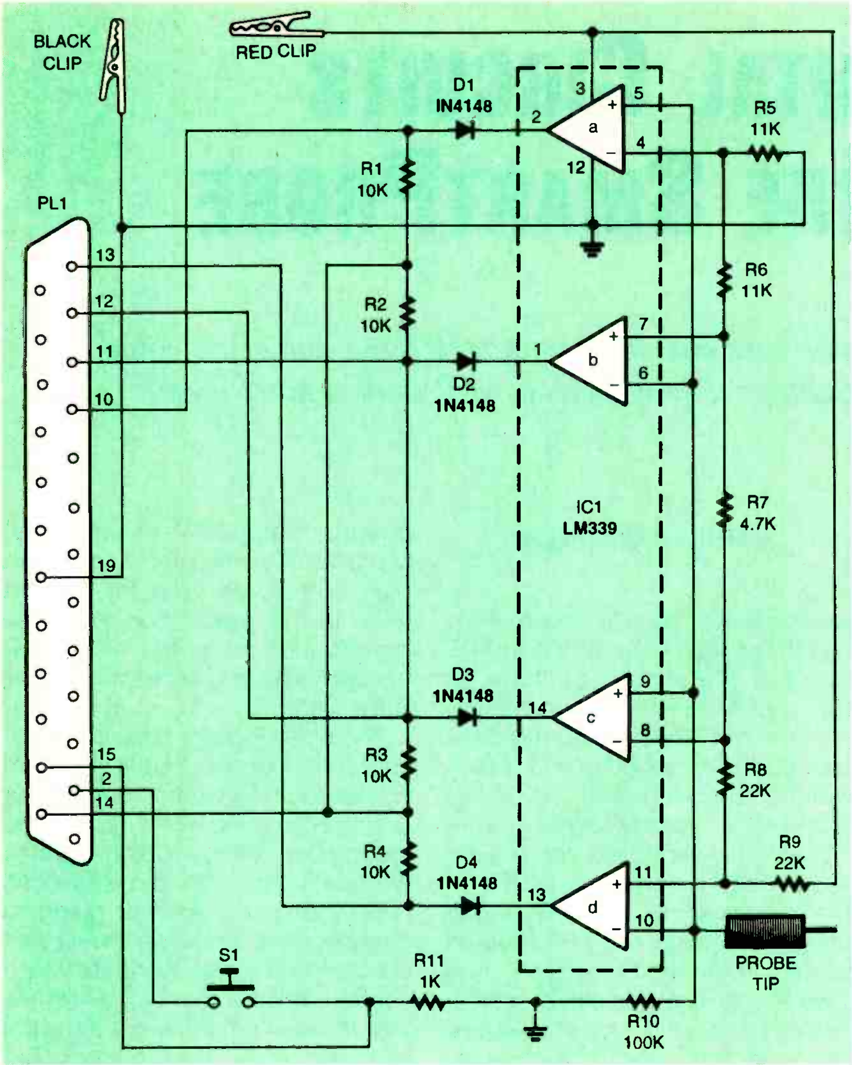


Fig. 1. The SmartProbe is built around a set of four comparators that can sense four different voltage levels. Those levels are set to the low and high logic levels of TTL and CMOS devices. Using an LM339 as well as a set of diodes lets the SmartProbe work with higher voltages without damaging the TTL circuitry in a PC's parallel port.

0.8 volts (TTL low) and about 2 volts for comparator "c" (TTL high). Since CMOS uses a percentage of the supply voltage to determine the logic-low and logic-high thresholds, comparator "b" is referenced to 30% of the supply voltage while comparator "d" is set to 70% of the supply voltage.

To better understand the action of the comparators, we'll apply a voltage to the probe that is between ground and 15% of the power supply. Since that level is lower than the reference voltage at R5/R6, IC1-a's output will go low. The same thing will happen with IC1-c since the input level is also lower than the reference voltage at R7/R8. The opposite occurs with IC1-b and IC1-d because the probe voltage is being applied to the inverting inputs. Table 1 shows the resulting outputs on IC1 for the various voltage thresholds.

Note that with the probe unconnected, R10 provides a ground reference, effectively keeping all of the comparator inputs at ground, avoiding any spurious responses.

A trigger switch, S1, is connected to two pins of PL1. Pin 2 supplies voltage to S1 (which will be set through the software) and pin 15 reads the current state of S1 (closed or open). When S1 is opened, R11 keeps pin 15 at ground level.

TABLE 1—COMPARATOR RESPONSES

Probe Voltage	"a"	"b"	"c"	"d"
0%–15%	0	1	0	1
15%–30%	1	1	0	1
30%–40%	1	0	0	1
40%–70%	1	0	1	1
70%–100%	1	0	1	0

Using an LM339 for IC1 is the secret to powering the SmartProbe with voltages (as high as 18 volts for CMOS) that would otherwise destroy the circuitry in the computer's parallel port. Although the output of IC1 does not supply an active voltage when high (only grounding the output when low), blocking diodes D1–D4 and their associated pull-up resistors, R1–R4, give the open-collector outputs of IC1 additional protection in case something goes wrong with IC1.

Reading SmartProbe Information. First, let's review how a parallel port on a PC works. We'll assume that we're using LPT1; the decimal address of that port is 888. That port address is for outputting to the data lines of the printer. We want to read the five input pins that normally send feedback from the printer to the computer. That address is the base address + 1, or 889 in our example. If we want to look at a particular pin, we simply AND the read value with a "masking" value that strips away the data that we're not interested in. For example, if we want to look at pin 10, we would AND the reading from input port 889 with the value 64. If the result is 64, pin 10 is high; if it is zero, then the pin is low. The state of the other pins are forced to zero by the AND operation.

An oddity to remember is that pin 11 *inverts* its signal. Our software has to consider that in order to read data from the SmartProbe correctly.

Table 2 is simply Table 1 with the logic levels replaced with the values that our software would see when the input port is read. An additional column has been included: a sum of the read values. For example, if we read port 889, AND that data with 240 (to mask our four input pins), and find that the result is 208, we know that the SmartProbe is reading a voltage that is between 30% and 40% of its power supply.

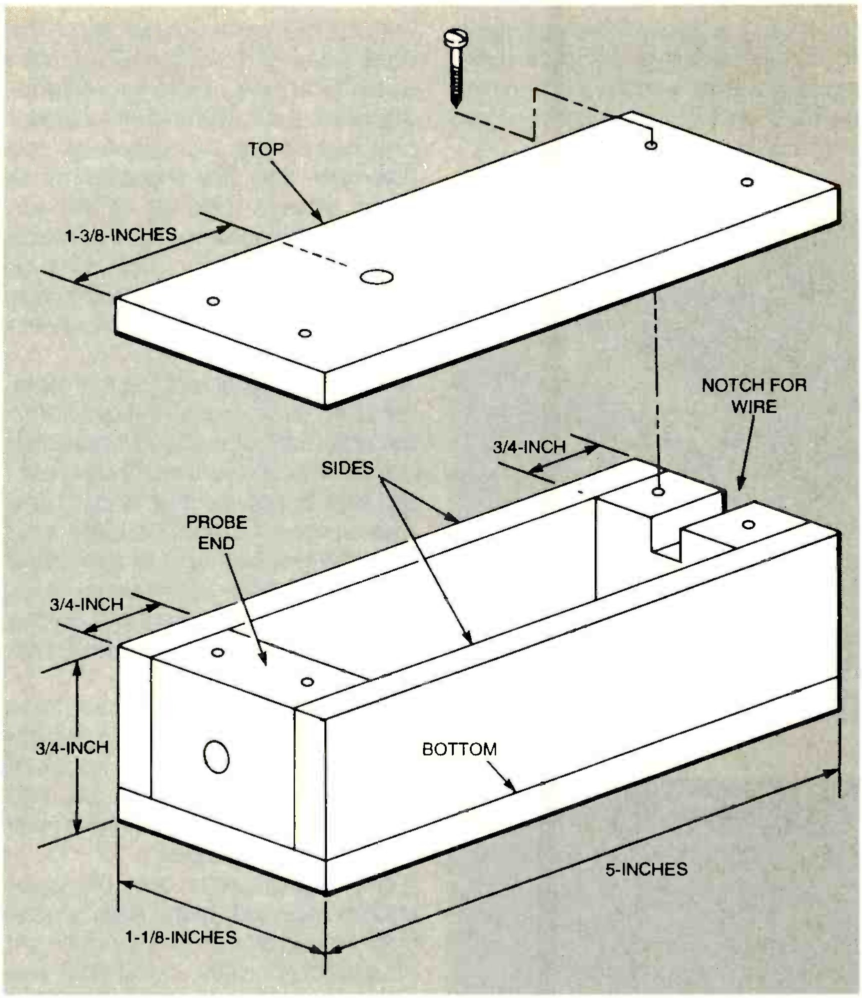


Fig. 2. The SmartProbe's case can be made from pieces of wood or plastic that are glued together. The result is a custom-designed unit that is comfortable to hold and use.

PARTS LIST FOR THE SMARTPROBE

SEMICONDUCTORS

IC1—LM339 quad comparator, integrated circuit
D1–D4—1N4148 silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1-R4—10,000-ohm
R5, R6—11,000-ohm, ¼-watt, 1%
R7—4700-ohm
R8, R9—22,000-ohm
R10—100,000-ohm
R11—1000-ohm

ADDITIONAL PARTS AND MATERIALS

PL1—DB-25 male connector
S1—Single-pole, single-throw, momentary-contact switch, normally open
DB-25 non-shielded hood, 9-conductor cable, black and red mini-alligator clips, wire, hardware, etc.

Note: The following item is available from James J. Barbarello, 817 Tennent Road, Manalapan, NJ 07726: A 3½-inch floppy disk containing the SmartProbe software plus additional material (both source and executable code), Part No. SP-S, $12.00. Check or money order must be payable in US funds. NJ residents must add appropriate sales tax. The author will be happy to answer any questions that are accompanied by a stamped, self-addressed envelope.

How those numbers relate to the logic levels of the SmartProbe are detailed in Table 3. For example, if the SmartProbe is sensing a voltage between 40% and 70% of its power supply, the read value is 240. That value represents a valid logic high for TTL circuitry, but is below the logic-high threshold for CMOS devices.

One final detail is how S1 is read: simply mask the input data with 8. A value of 8 means that S1 is closed; if it is open, the value will be zero.

Construction. Building the SmartProbe is very simple and straightforward. None of the circuitry is sensitive or high-speed. You can use a piece of perfboard and standard construction techniques.

Before building the circuit, we will need the case to know how much room we have to work with. The author's prototype was built from ⅛-inch-thick wood. The overall dimensions are shown in Fig. 2. Those dimensions result in a case that is large enough inside to hold all of the electronics, yet is comfortable to hold like an oversized pencil. The author's prototype can be seen in Fig. 3, showing all of the parts that go into building the SmartProbe.

A notch will be needed in the back end of the case for the power clips and the cable that will be attached to the parallel port. Don't forget to drill a hole for S1. If you mount S1 on the bottom side of the case, it will be easier to assemble the unit—no wires will need to be attached to the top of the case.

The probe tip itself can be a solderless tip jack or, if one is not avail-

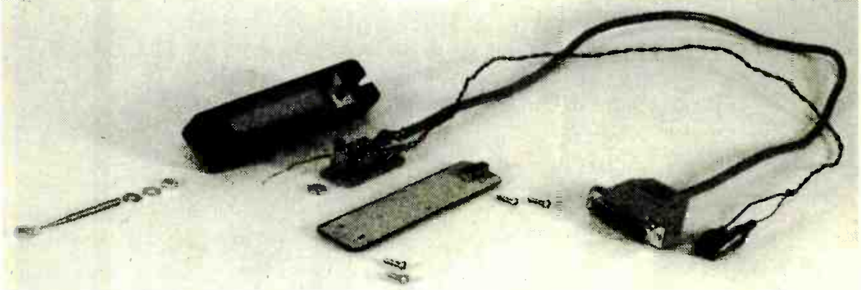


Fig. 3. The author's prototype uses a stacked-board arrangement for the circuit board; a single board will fit in the space just as well.

able, it can be formed from a machine screw. If you're using a tip jack, drill the mounting hole slightly smaller than the threads on the probe tip. To form a probe tip from the machine screw, file its end down to a point, forming a smooth taper approximately ¾-inch long from the pointed end. Drill a clearance hole in the probe end of the case.

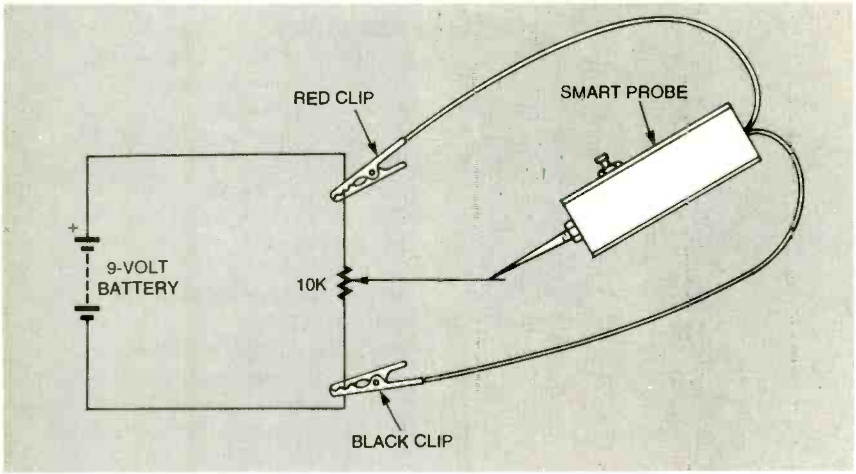


Fig. 4. To test the SmartProbe, a simple variable voltage is applied to the tip. When the software indicates that the SmartProbe has changed from one level to the next, the voltage is measured with a voltmeter to verify that the unit is working correctly.

Fig. 5. The main screen of the SmartProbe software lets you easily choose the various settings and options.

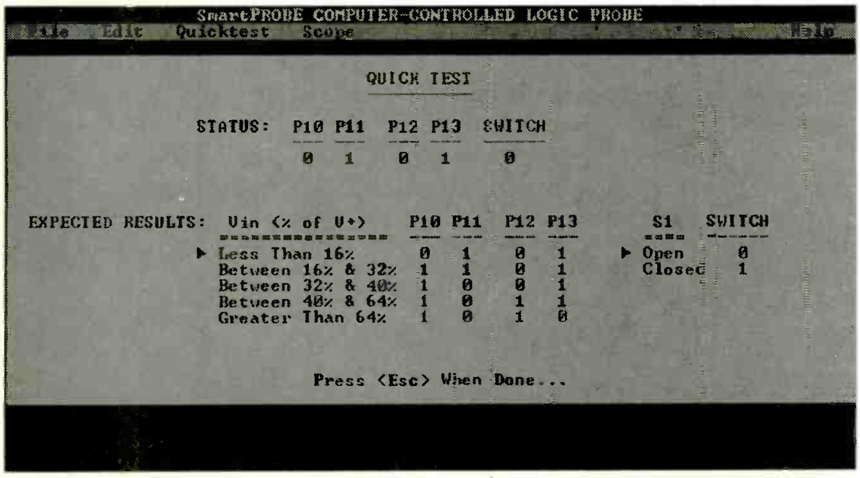


Fig. 6. When testing the unit, this screen tells you what the SmartProbe is reporting. The information at the bottom of the screen is a handy reference for testing the hardware.

Coat the mating surfaces of the ends, sides, and bottom pieces with wood glue and clamp together for about an hour. Remove the clamps and mount the top piece on the assembly with four sheet metal or wood screws. Sand all of the surfaces smooth and chamfer or round all 12 edges. Apply a finish such as paint or varnish to seal the surfaces of the wood. When dry, remove the four screws and the top.

Mount the probe tip to the case. For a tip jack, simply thread it into the hole that was drilled earlier. For a machine screw, install two washers and a nut on the end of the screw, place it inside the case, and pass the pointed end of the screw through the hole in the probe end. Loosely install a second nut on the part of the probe screw that is outside of the case.

With the case finished, you can cut a piece of perfboard for the circuit that fits the available space. If you mount S1 on the board, you can use the switch to hold the board inside the case.

The power wires can be color coded red and black with similar-colored alligator clips. A short length of insulated wire connects the probe tip to the circuit board. If you are using a machine screw, wrap the bare end of the wire around the screw between the two washers and tighten one of the nuts; the outside nut might be easier to reach. The data cable should be shorter than ten feet—four to six feet is a common length. Once it is wired up, install a DB-25 hood on PL1.

Once everything is mounted in the case, inspect your work before closing it up.

Testing and Using the SmartProbe. Basic software for the SmartProbe is available from the Gernsback FTP site (ftp.gernsback.com/pub/EN/smartprobe.zip); it contains the set of compiled programs that will let the SmartProbe be used in its basic functions. The software available from the source given in the Parts List includes additional programs as well as source code. While the main application can be run on even the oldest non-graphics PC, the Scope function (discussed later) requires an EGA or

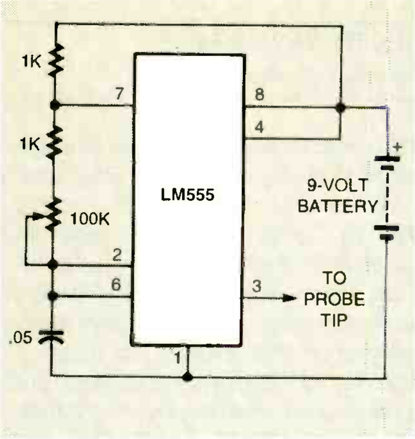


Fig. 7. This simple LM555-based oscillator shows the SmartProbe's ability to act like a poor-man's digital-storage oscilloscope.

TABLE 2—PARALLEL PORT RESPONSES

Probe Voltage	Pin 10	Pin 11	Pin 12	Pin 13	Read Value
0%–15%	0	0	0	16	16
15%–30%	64	0	0	16	80
30%–40%	64	128	0	16	208
40%–70%	64	128	32	16	240
70%–100%	64	128	32	0	224

better monitor.

The simple test circuit shown in Fig. 4 will be used to test the SmartProbe. Although a 10,000-ohm value is shown for the potentiometer, any value between 1000 ohms and 1 megohm can be used; the voltage source can be anywhere between 5 and 15 volts.

Connect the red and black power leads of the SmartProbe as shown and plug the SmartProbe into the printer port. After the software has been stored on the PC in a directory of your choice, type "SP" at the DOS prompt to start the program.

Once you see a startup screen with some initial instructions, press any key. The instructions will be replaced by a graphical representation of a logic probe as shown in Fig. 5. Press <ALT> Q to perform a Quick Test. You should see a screen similar to the one shown in Fig. 6. Note that the SmartProbe's current status is to the right of the STATUS indication; expected results are listed in the lower half of the screen. Press S1 on the SmartProbe and notice that the switch indication changes from "0" to "1". Release S1 and the indication should return to "0". Hold the SmartProbe's tip against the wiper of the potentiometer and turn the potentiometer's shaft. The "P10 P11 P12 P13" indications should change to one of the five conditions listed under EXPECTED RESULTS. If you do not get one of those indications, check the unit for component, connection, or construction errors; fix any errors as needed.

When the SmartProbe is giving a correct indication, measure the DC voltage at the point when the SmartProbe changes from one condition to the next. The voltage should be approximately as expected; there might be some variation based on the actual value of the components used. For example, the voltage between the "0 1 0 1" and "1 1 0 1" transition should be about 1.35 volts with a battery voltage of 9 volts. If you do not get those results, check the value and placement of resistors R5–R9 and correct any problems that are found.

To complete initial testing, press the <ESC> key to return to the program's main screen.

Now that you've used the Quick Test function, let's quickly review the other four menu choices (File, Edit, Scope, and Help) available from the main screen (Fig. 5). The File menu (accessed by pressing <ALT> F) contains the DOS Shell and Exit commands. Pressing S for DOS Shell temporarily brings you to a DOS prompt where you can perform normal DOS functions. Type EXIT and press <ENTER> to exit the DOS shell and return to the pro-

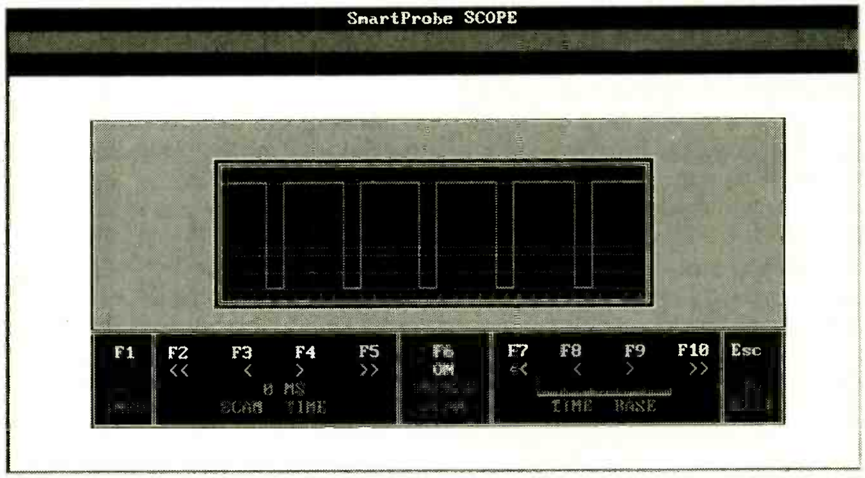


Fig. 8. When using the SmartProbe to check the output of the circuit shown in Fig. 7, the output pulse is accurately displayed.

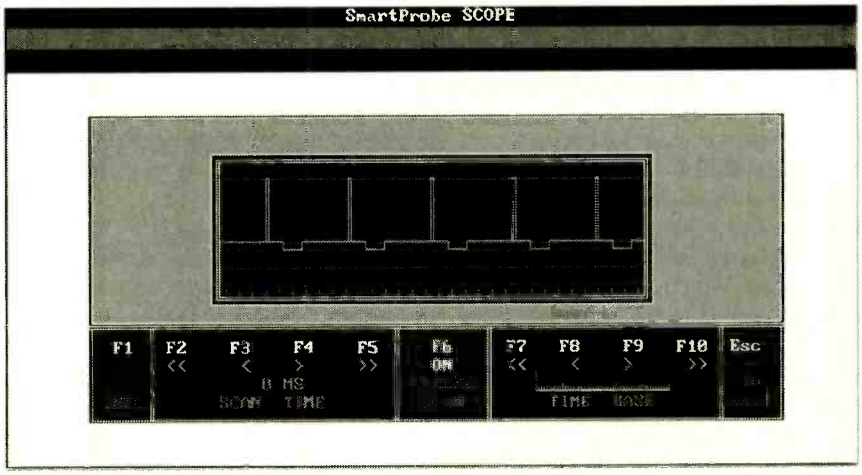


Fig. 9. Since the SmartProbe can sense four different voltage levels, it can be used to read simple analog signals. Here is the signal on the capacitor of the circuit shown in Fig. 7.

gram. To end the program, press X for Exit.

The Edit menu contains five commands: Toggle History, Toggle Sound, Toggle S1, TTL, and CMOS. Pressing H for Toggle History turns the History display on (if it was previously off), or off (if it was previously on). The History On command displays the previous 20 readings; each reading is stored when S1 is closed or the last 20 changes in reading if S1 is disabled. Toggle S1 enables and disables S1. With S1 enabled, a reading will only be taken when S1 is depressed. Disabling S1 allows for continuous readings. Pressing S for Toggle Sound turns the audible indication on or off accordingly. Pressing T for TTL switches the SmartProbe to the TTL mode. Pressing C for CMOS switches the SmartProbe to the CMOS mode. The current status of History, S1 status, Sound, and TTL or CMOS mode are displayed directly above the graphical representation of the SmartProbe.

The Scope function turns SmartProbe into a simple form of digital-signal oscilloscope that can resolve signals up to about 10 kHz. To try out that function, build the test circuit shown in Fig. 7. That circuit is a standard LM555-based oscillator with its output at pin 3. Pin 2 is connected to pin 6 and makes the oscillator run by charging and discharging the 0.05-µF capacitor. The results of measuring the signals at pins 3 and 2 of the LM555 are shown in Figures 8 and 9 respectively. Since the output of pin 3 is a digital signal varying between logic low and logic high, Fig. 8 is a true representation of that signal. The signal at pin 2, however, is an analog signal created as the capacitor charges and discharges. It will therefore have a sharp rise and an exponential decay. Figure 9 shows how the SmartProbe creates a digital approximation of that signal. Although it can't show the exponential decay, it can show the width of each pulse and the time between each voltage level. Even with that limitation, the SmartProbe provides a lot of information for the low cost of the unit.

You can select the various scope functions with the ten function keys. For instance, F2 through F5 adjust the scan time (the time between subsequent scans). Since there is no sync input, the display tends to jitter; increasing the scan time reduces that jitter. When you want to examine a particular scan, you can freeze the display by pressing F6. Function keys F7 through F10 control the time base (somewhat like a time base on a standard oscilloscope). Pressing the Escape key returns you to the main screen.

TABLE 3—TTL, CMOS LEVELS

Value	TTL	CMOS
16	Low	Low
80	open	Low
208	open	open
240	High	open
224	High	High
0	S1 Open	S1 Open
8	S1 Closed	S1 Closed

The Help function is a non-context sensitive help file that provides user information on the operation of the program and on the SmartProbe hardware.

Expanding the SmartProbe. Since the SmartProbe is computer controlled, adding new or different functions and features is simply a matter of writing custom programs for those who have the tools and need. For instance, those doing digital-electronics manufacturing and repair are always looking for a quicker and easier way to repetitively check circuits. One such application is included in the software bundle available from the source given in the Parts List. It lets you quickly and repetitively test circuits based on a test specification that you develop (and document) in a plain text file. It provides a running pass-fail indication (with an audible beep if something does not comply) and a printed test report if needed.

You can also use the parallel port's unused output pins (along with appropriate external circuitry) to control external devices based on the levels sensed by the SmartProbe. Even if you choose not to expand its capabilities, you'll find the SmartProbe to be an inexpensive yet extremely versatile addition to your test bench. Why not build one today! Ω

SHORTWAVE RADIO

(continued from page 44)

the Germans themselves through such stations as *Radio Deutsche Welle* in Cologne and *Radio Berlin International in Berlin*. In contrast to their American counterparts, the German commentators were far more informed and informative on the subject. To them, it was not just another news story, but a miraculous, healing event for their people and their country. They not only reported the facts of the event but told the stories, the meanings, and the emotions behind it as well. Through the power of shortwave radio, they both clearly and eloquently convyed to the world just what the fall of the Wall meant to Germany and did so in a depth and style that the other journalists could not understand, much less appreciate or convey.

Another fine example of shortwave listening occurred during the Persian Gulf War. When the American public discovered that some of the international stations were continuously broadcasting the war news both day and night, most stores selling shortwave receivers sold out in a few hours time.

Simply put, shortwave listening can be both educational and entertaining in itself. Many of the broadcasts, whether in English or another language, give a glimpse of another place and people. Listen for awhile; you just might enjoy what you hear. Ω

MEASURING RF POWER

Your transmitter's RF power output is a key indicator of its health, and here are the circuits, instruments, and techniques you can use to accurately "take its temperature."

JOSEPH J. CARR

Radio frequency (RF) power is one of the principal performance indicators of radio transmitters. Whether you are a ham-radio operator, citizen's-band operator, or a commercial radio-communications technician, the RF-power output of your transmitters is a key indicator of its health. RF power measurements vary from a few milliwatts up to many kilowatts. In this article we will take a look at some of the principal methods for measuring RF power.

RF power measurement is no different from other alternating-current (AC) power measurements, although the increased frequencies involved cause some problems. Power is still described by the standard equations ($P = V \times I$, $P = I^2 \times R$ and $P = V^2/R$), so if you can measure the current or voltage and know the resistance, you can measure power. The problem is relatively easy with sine-wave RF, such as unkeyed continuous wave (CW) signals, but becomes a bit more complicated on modulated, chopped, keyed, or pulse RF waveforms. In any event, the most basic power level measured is the root-mean-square (rms) value, which equates the power's heating ability to a like amount of heating from a DC source. The trick is in making rms readings.

RF Ammeter Methods. The thermocouple RF ammeter (see Fig. 1) is an inherently rms-reading device because it relies on heating a very low value resistive heating element (R). The temperature of the heating element is measured by a thermocouple device (TC in Fig. 1), which produces a voltage proportional to the temperature of the thermocouple junction. A DC voltmeter is used to measure the thermocouple output, but its scale is calibrated in units of current (amperes, milliamperes).

When the RF ammeter is in series with the transmission line from the transmitter to a resistive load (R_L) or a resonant antenna, the rms RF power level can be calculated from $I^2 \times R_L$. The advantage of the thermocouple RF ammeter is that it can be used with any load resistance, while other meters are designed for a specific load (usually 50-ohms). The disadvantages include the need to make a calculation, and the fact that RF ammeters tend to fade out above some frequency in the 40- to 70-MHz range.

Calorimeter/Bolometer Methods. A number of professional-grade RF-power meters are based on the fact that the temperature change in a resistive load is proportional to the rms value of the applied RF waveform. Figure 2 shows a basic form of calorimeter or bolometer: A heat-dissipating resistor with a resistance value equal to the desired load impedance is enclosed in an assembly with some sort of temperature-measurement device.

Theoretically, you could put a big dummy load in a room and use a glass-mercury thermometer to measure the air temperature of the room before and after the power was turned on, but that's hardly practical. If, however, you embed a dummy load and some temperature sensor (thermistors and thermocouples are used) in a small assembly, then the before and after temperature rise of the resistor can be measured.

A low-cost instrument can be built using only the dummy load and Temperature Sensor 1, but that would ignore the problem that ambient temperature also affects the measurement sensor. It is not uncommon to include a second sensor to measure ambient temperature, so that changes in ambient temperature can be factored into the measurement. The results can then be displayed on an analog or digital meter.

Some calorimeter methods use two sensors (three could be used if ambient is accounted for) in a comparison measurement. A low-frequency (e.g. 60-Hz) AC power source is used to drive one sensor/resistor, while the RF power is used to drive the other. A differential

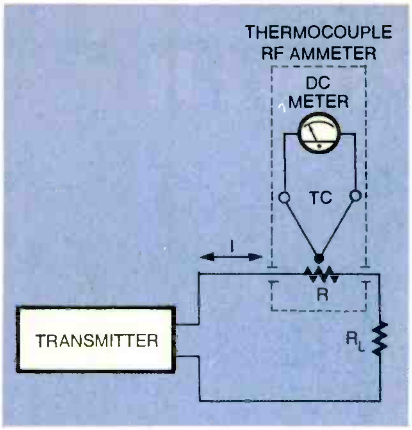


Fig. 1. The thermocouple RF ammeter relies on heating a very low value resistive heating element (R) to measure RF power.

meter will show when the two output levels are the same. At this point, the easily measured 60-Hz AC power level is equal to the applied RF power.

Simple Diode Detector Methods. A simple diode detector scheme (see Fig. 3) can be used to measure the RF power applied to a load. The scheme shown was used on the Heathkit *Cantenna* dummy load that was popular some years ago, and is still used on similar products today.

The diode is an envelope detector, and produces a pulsating DC output from the RF voltage applied across the load (R_L). Capacitor C1 filters out the pulsations to pure DC. The power can be inferred from V_o^2/R_L.

The actual voltage applied to the diode is reduced by a resistive voltage divider (R1/R2) and is only a fraction of the applied voltage. This allows higher power levels to be measured. A diode such as a germanium 1N60, a silicon 1N914 or 1N4148, or a Schottky diode can be used for D1. Note that both R1 and R2 should be much larger than the load (R_L). Typical values for the circuit are R1 = 100,000 ohms, R2 = 1000 ohms, and C1 = 0.05-µF.

The diode detector circuit of Fig. 3 remains popular because it is simple and easy to implement. But it suffers from the fact that it measures the approximate peak power, not the rms power. On a sinewave CW signal, the rms power can be approximated by $(0.707 \times V_o^2)/R_L$.

In-Line RF Wattmeters. Perhaps the most common forms of RF power meter is the in-line wattmeter (see Fig. 4). The instrument is inserted in the coaxial line between the transmitter and either the antenna or a dummy load. Instruments designed for use with an antenna often have the ability to measure the forward and reflected power, so they can also be used to determine the standing wave ratio (SWR).

The classic Wheatstone bridge can theoretically be used for making an in-line RF wattmeter, but that is not a practical approach. Such bridges are useful for making antenna impedance measurements at low power levels, but they cannot be left in-line because of the huge insertion loss involved. Other bridges, such as the micromatch bridge, discussed next, are used instead.

Micromatch Bridge. Figure 5 shows the basic capacitor-resistor micromatch-bridge circuit. Immediately we see that the micromatch is better for those applications than a conventional Wheatstone bridge because it only places a 1-ohm resistor

TABLE 1—METER READINGS BASED ON 100-WATT RMS CW CARRIER

Waveform	PEV_{rms}	$PEP(PEV^2/Z_o)$	Thermal Power
CW	100/1.414 V	100 W	100 W
AM (100%)	200/1.414 V	400 W	150 W
AM (73%)	173/1.414 V	300 W	127 W
SSB (1 tone)	100/1.414 V	100 W	100 W
SSB (2 tone)	100/1.414 V	100 W	50 W

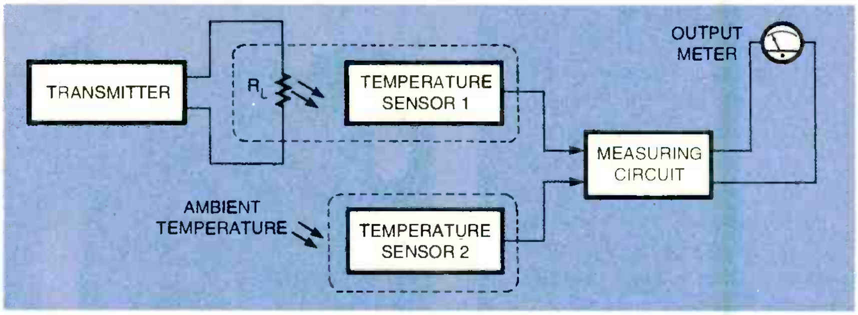


Fig. 2. In the bolometer/calorimeter approach to measuring RF power, a heat-dissipating resistor with a resistance value equal to the desired load impedance is enclosed in an assembly with some sort of temperature-measurement device. A number of commercial devices are based on this approach.

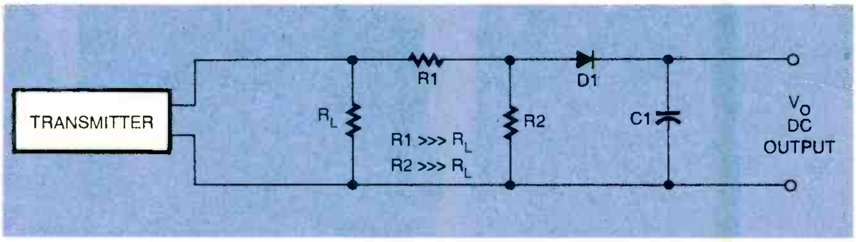


Fig. 3. A simple diode detector scheme shown here was used on the Heathkit Cantenna *dummy load that was popular some years ago, and is still used on similar products today.*

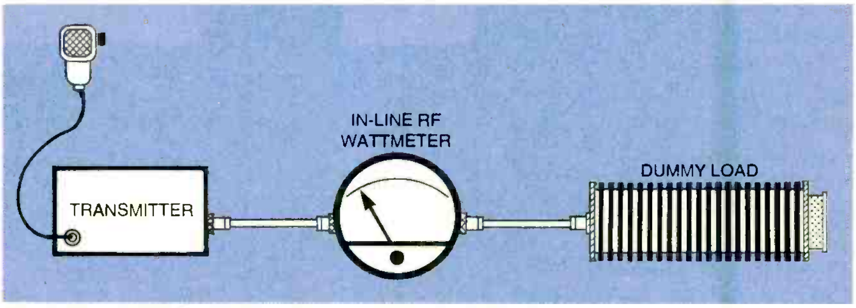


Fig. 4. Almost all RF wattmeters in use today are the in-line type.

(R1) in series with the transmission line. That resistor dissipates considerably less power than the resistors typically used in Wheatstone bridges. Because of that low-value resistance we can leave the micromatch in the line while transmitting.

As with Wheatstone bridges, the ratio of the resistances and/or reactances in the arms must be equal to create a null output to the meter. In that case, the ratio of the capacitive reactances of C1 and C2 must match the ratio of R1 and the antenna or load resistance R_L:

$$X_{C1}/X_{C2} = R1/R_L$$

For a 50-ohm load, the ratio is 1/50, while for 75-ohm loads it is 1/75. A compromise situation that yields a small error on both 50-ohm and 75-ohm systems is to use a 68-ohm value for R_L, and make the ratio X_{C1}/X_{C2} = 1/68. These ratios occur when C2 ≈ 15 pF for 50-ohm systems, C2 ≈ 10 pF for 75-ohm systems, or C2 ≈ 12 pF for the compromise 68-ohm value.

The sensitivity control can be used to calibrate the meter. For fixed power meters, that potentiometer can be a trimmer type that is set when the meter is calibrated, and then left alone. At least one commercial micromatch bridge that was once popular with CB service technicians used a three-position switch to select three different sensitivity controls for 10-watt, 100-watt or 1000-watt power levels. Each range has its own sensitivity control, and those are used as needed.

Monomatch Bridge. The monomatch bridge of Fig. 6 is one of the "instruments of choice" for hams and other users for measuring RF power in the HF and low VHF ranges. In the monomatch design, the transmission line is segment "B", while the directional coupler transmission line segments are "A" and "B". The directional coupler lines are used for sampling the forward and reverse RF signals. Although some instruments used modified coaxial transmission lines, later versions use PC-board elements for A, B and C.

The sensor unit is basically a directional coupler with a diode detector element for both forward

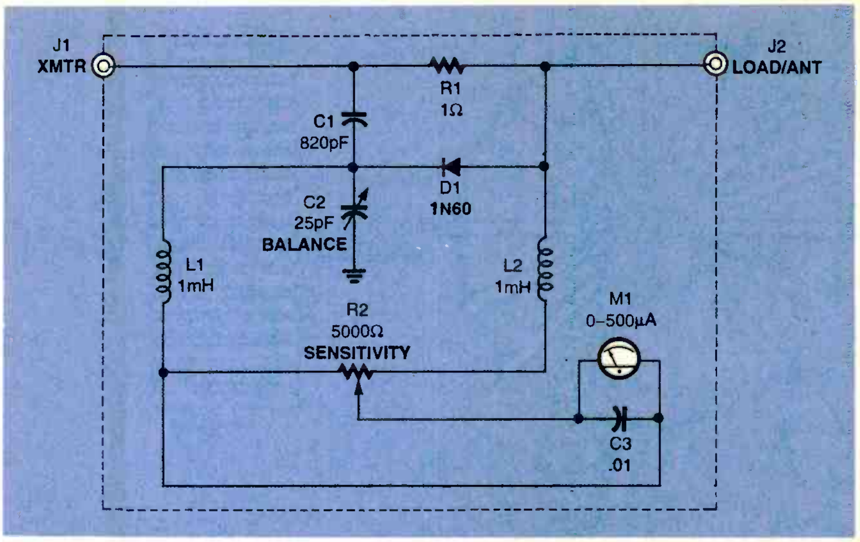


Fig. 5. The micromatch RF wattmeters offer important advantages over traditional Wheatstone bridges in RF power meter applications because they dissipate less power, allowing them to be left in the line.

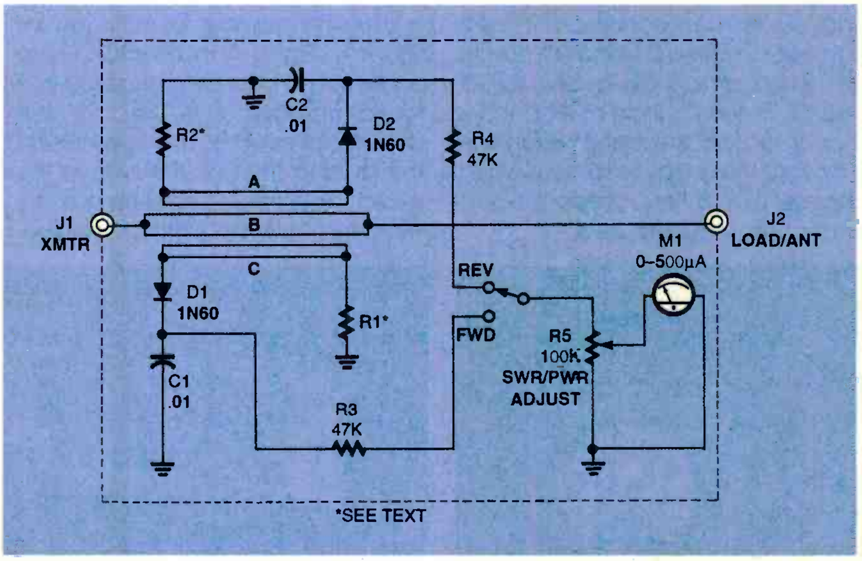


Fig. 6. The monomatch RF wattmeter is one of the "instruments of choice" for hams and other users for measuring RF power in the HF and low VHF ranges.

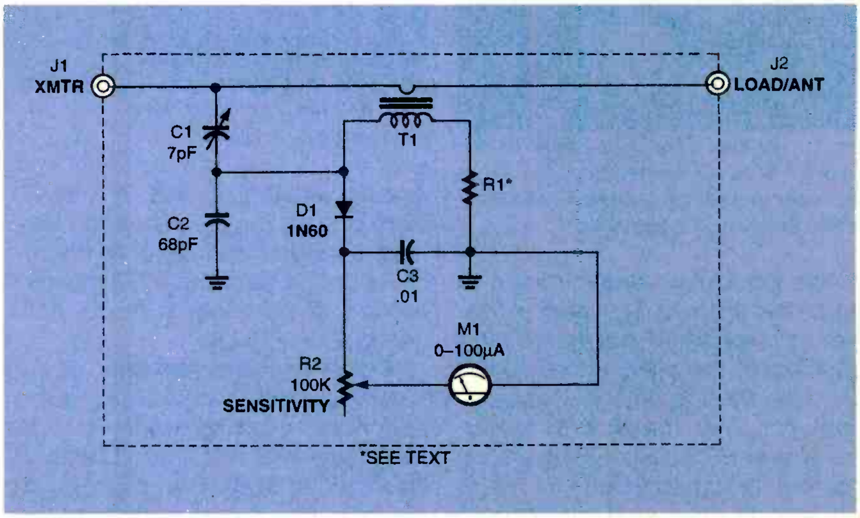


Fig. 7. In this version of the monomatch RF wattmeter, a single-turn ferrite or powdered-iron toroid transformer is used as the directional coupler.

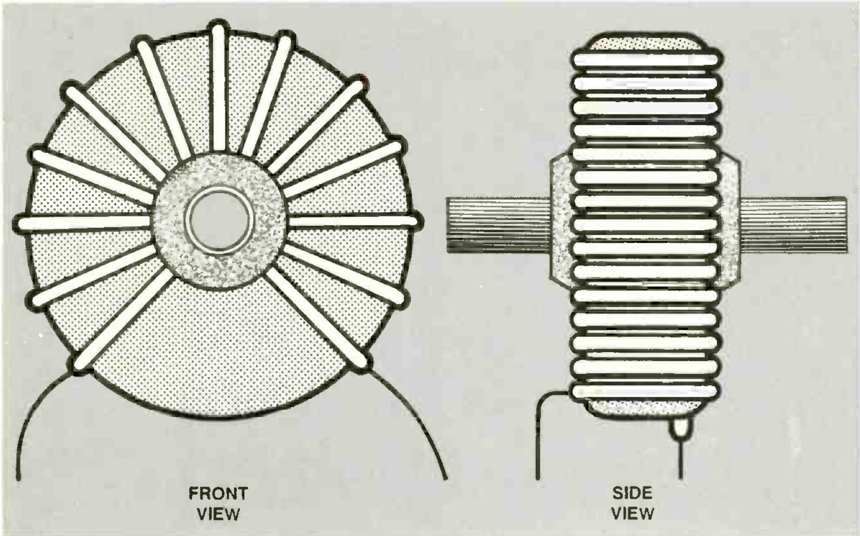


Fig. 8. Here are the winding details for the toroid transformer in the monomatch RF wattmeter in Fig. 7.

and reverse directions. For best accuracy, diodes D1 and D2 should be a matched pair, as should R1 and R2. The resistance of R1 and R2 should match the transmission-line characteristic impedance, although in many cases the 68-ohm compromise is used.

Fig. 9. The Bird Electronics Model 43 RF wattmeter is an old war horse that has served the author well over the years (photo courtesy of Bird Electronics Corporation).

The particular version shown in Fig. 6 uses a single DC meter movement to monitor RF power. With the addition of the switch and potentiometer R5, the circuit becomes both an SWR meter and a forward/reverse RF-power meter. Many modern instruments use two meter movements, one each for forward and reverse power.

A variation on the theme uses a transmission-line transformer as shown in Fig. 7. In that instrument, a single-turn ferrite or powdered-iron toroid transformer is used as the directional coupler. The transmission line passing through the hole in the toroid "doughnut" forms the primary winding of the transformer. The secondary winding consists of 10 to 20 turns of small gauge enameled wire and is connected to a measurement bridge circuit (C1, C2, plus the load) that produces a diode-rectified output voltage.

Fig. 10. Bird Electronics Model 4421 RF wattmeter (photo courtesy of Bird Electronics Corporation).

Details for the construction of the sensor assembly is shown in Fig. 8. The secondary winding, made of 24- to 30-gauge enameled wire, is wound as shown in Fig. 8, with at least a 30 degree separation between the ends to minimize distributed capacitance. A rubber grommet is inserted into the hole of the toroid. The primary winding is a single conductor passing through the hole. It is common to find 1/8-, 3/16-, or 1/4-inch brass tubing used for the primary. Note: When counting turns on a toroidal transformer, each pass through the hole is a "turn," so passing a straight wire or tube through the toroid hole once counts as one turn.

The value of R1 should match the transmission-line impedance, although, as usual, the 68-ohm compromise is often seen. If you opt to use the exact value in any of those circuits, then you can use either a single 51-ohm resistor, or two 100-ohm resistors in parallel. If you can find a precision 50-ohm resistor, however, use it (in standard carbon-composition or metal-film resistors, 51 ohms is a standard value, but 50 ohms is not).

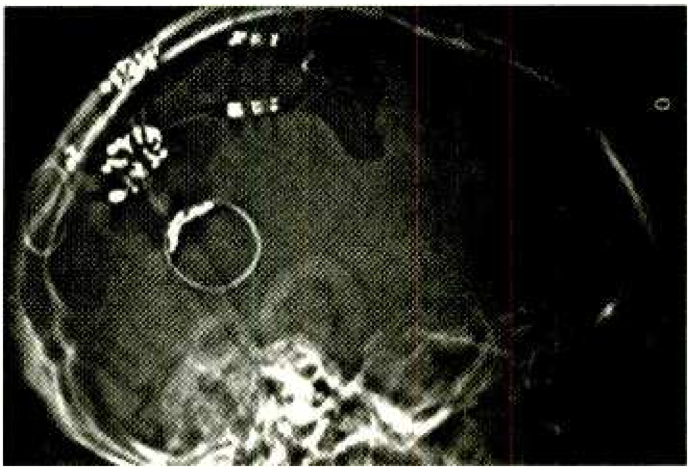
Complex Waveforms. Measuring the RF power of unkeyed CW waveforms is relatively easy, but when modulation is applied, many instruments will read incorrectly. Table 1 shows some of the factors that compare the listed waveform's power, peak envelope voltage (PEV), peak envelope power (PEP) and equivalent thermal power with a 100-watt unmodulated, unkeyed CW carrier.

Some Commercial Instruments. Figure 9 shows a commercial RF power meter that the author bought nearly thirty years ago and has used heavily ever since. It is the Bird Electronics Corporation (30303 Aurora

(Continued on page 56)

A BRAIN/COMPUTER INTERFACE

An amazing breakthrough could one day allow the paralyzed to communicate and interact with the world around them.



BILL SIURU

As someone who has experienced complete paralysis from spinal cord surgery, this author knows the utterly demoralizing frustration of not being able to communicate with the outside world. Fortunately, I recovered (essentially) completely. Many people don't, and as a result have to live in complete isolation with ideas and words that can't be shared with anyone.

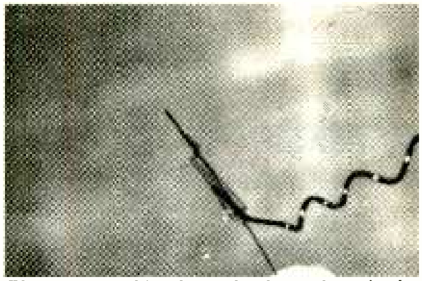
There is a chance, however, that all of that could change. Dr. Roy E. Bakay and Dr. Phillip R. Kennedy, neuroscience researchers at Emory University in Atlanta, GA have achieved a breakthrough that promises a way for those left paralyzed and unable to speak from a spinal cord injury, stroke, or diseases like Lou Gehrig's disease to communicate.

More than 700,000 Americans suffer from stroke each year and tens of thousands more suffer spinal cord injuries or from diseases like Lou Gehrig's that threaten their ability to communicate. Stroke is currently the leading cause of permanent adult disability in the U.S.

The researchers have developed a neurotrophic electrode (an electrode implanted with nerve-growth factors) that can be implanted in the brain to allow speech-incapable patients to communicate via a computer. According to Dr. Bakay, "A person can interact with the world if they can use a computer." If someone can move the cursor on a computer, that person can stop on icons to produce phrases, send e-mail, turn on or off a light, and, in general, interact with the outside world in an effective manner.

How It Works. The heart of the concept is the neurotrophic electrode that makes the connection with the brain. The neurotrophic electrode, which is housed in a tiny cone-shaped glass casing, is implanted into the motor cortex. The electrode is about 1.5 mm long and 0.1 to 0.4 mm in diameter. Nerve growth factors are implanted into the glass cone, and the cortical brain cells are induced to grow into the electrode's tip and form contacts. It takes several weeks to three months for the cortical tissue to grow into the electrode; the process is considered complete when the resulting signals become stable.

The neurons in the brain transmit an electronic signal when they "fire." Gold recording wires are placed inside the glass cone to pick up the neural signals from the ingrown brain tissue and transmit them through the skin to a receiver and amplifier outside the scalp. The system is powered by an induction coil placed over the scalp so wires for powering the device do not have to pass through the skull. Signal processors are used to separate individual signals from the multiple signals that are recorded from inside the conical electrode tip. These signals are used to drive the computer cursor in the same way a computer mouse is moved back and forth. Indeed, the recorded neural signals substitute for the mouse cursor.



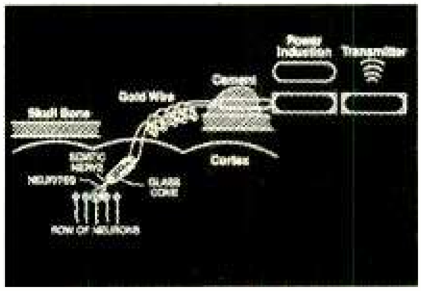
The neurotrophic electrode shown here is the key development in a new system that could someday help paralyzed individuals communicate with the world around them.

Unlike other electrode techniques that have been tried in the past—those primarily used miniature antennae that pierced the surface of the brain and usually lasted for only short periods—this electrode forms an intimate and long-lasting connection with the brain. This basic neurotrophic electrode technology was developed and patented by Dr. Kennedy while at the Georgia Institute of Technology. It was tested and developed using animals for over 12 years before it was implanted in humans. Both Federal Drug Administration and Institutional ethical approvals were obtained before the implants were made.

"The trick is teaching the patient to control the strength and pattern of the electric impulses being produced in the brain," Dr. Bakay said. "After some training, they are able to 'will' a cursor to move and then stop on a specific point on the computer screen."

First Tests. The electrodes have been successfully implanted into the brains of two patients at Emory University Hospital, one with amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease) and one with a brainstem stroke. The first patient was able to control computer signals in an on/off manner for 76 days before she died from her terminal ALS condition.

The second patient, who is at the Atlanta Veterans Affairs Medical Center, is paralyzed except for his face due to a stroke and a subsequent heart attack. While dependent on a ventilator and unable to speak, he is fully alert and intelligent.



As shown in this block diagram, the electrode, which is housed in a cone-shaped glass enclosure, is implanted into the cortex of the brain and brain cells are induced to grow onto its tip. Neurons transmit an electronic signal when they "fire." Gold recording wires pick up the neural signals and transmit them through the skull. The system is powered by an induction coil placed over the scalp.

The electrodes were implanted in the part of the patient's brain that once controlled his arm and facial motion. All he has to do is think about moving his arm to create the electrical signals that are translated by the computer into movement of the cursor from icon to icon in a horizontal direction. As each icon is encountered, a phrase such as "See you later. Nice talking with you." is spoken by the computer.

The researchers are now working to help the patient communicate with the computer to produce speech, as well as provide word processing, control of his environment, and maybe even access the internet. The future includes implanting the electrode in the brains of other "locked-in" patients.

Other Applications. The brain-implant technology has other applications. For instance, it could be used as a "spinal bypass" for those with spinal cord injuries that left them with stiff and uncontrollable muscles. Here neural signals could provide some control of electrical stimulators that activate the paralyzed muscles, therefore bypassing the area of spinal-cord injury.

The technique can also be used for basic research on understanding how the brain works. Never before have recordings been made from a human brain for so long and with such stability. For example, the firings of recorded neurons may change in response to differing inputs from different body parts: If neurons fire with taps to the arm, their firing may change over time from repeated taps to the face. This will help researchers understand how the brain communicates with other parts of the body. Ω

RF POWER

(continued from page 54)

Road, Cleveland, OH, 44139; Tel: 1-440-248-1200) *Model 43 Thruline* meter. It's a tough old war horse! That instrument is an in-line meter that uses a plug-in directional coupler and detector element to customize the meter for different RF power levels and frequency ranges. The tip of the plug-in element comes in close proximity to the coaxial line that runs inside the meter case from connector-to-connector. The analog meter displays the value of the RF power being measured.

The case of the *Model 43* has two sockets for additional plug-in elements to accommodate other power and frequency ranges. The heavy leather case that protects the meter in transit has space for several more elements. I have elements for amateur radio HF (10 watts for QRP, 100 watts for my transceiver, and 1000 watts for my linear amplifier), amateur radio VHF (50 watts), and lower power VHF (for marine radios).

Notice in Fig. 9 that the element has an arrow on it. The arrow points in the direction of power measurement. For example, if the load is connected to the right-hand coaxial connector, and the transmitter is connected to the left-hand coaxial connector, then the meter (as shown) will measure the forward power. If the direction of the arrow is reversed, then the reflected power can be measured. Once both the forward power (P_F) and reflected power (P_R) are known, the SWR can be calculated; but to makes things easy, the Model 43 comes with a nomograph in the instruction book that makes the calculation graphically.

The Bird *APM-16* Advance Power Meter, shown at the beginning of this article, is similar in concept to the older Model 43, but is considerably advanced. While the Model 43 measures rms CW power, the APM-16 will measure analog and digital complex waveforms, as well as CW (*e.g.* CDMA, TDMA, FDMA, COFDM and other modulation). It will measure both peak and rms power levels.

Figure 10 shows a Bird meter that uses a different approach. That meter uses a remote sensor head connected in-line between the source and load, and a multi-range digital readout display.

That wraps up our look at RF power-measurement circuits and instruments. Whether you need to measure RF power as part of your hobby or for your profession, keep the concepts we've discussed here in mind and you won't go wrong. Ω

BY DON LANCASTER

AC and DC Lamp-Dimmer Circuits, and More

THE WEB SURE MAKES ELECTRONICS DESIGN MUCH SIMPLER AND FAR EASIER THAN BEFORE. FOR EXAMPLE, WWW.QUESTLINK.COM CAN ALMOST INSTANTLY PROVIDE YOU WITH ANY AVAILABLE DATA SHEET OR APPLICATIONS NOTE ON just about anything from anyone. There are also a number of newsgroups that anyone into electronics will find handy, including:

- sci.electronics.design
- sci.electronics.equipment
- sci.electronics.misc
- sci.electronics.repair

I have recently added several more key electrical engineering links to my www.tinaja.com/eeweb01.html

Lamp Dimming Fundamentals

Let's assume you have some lamps that you want to cheaply control with a PC, a PIC, or another microprocessor: How would you go about it?

We saw last November (MUSE129. PDF on my Web site) how theaters and concerts use the fancy DMX512 communications standard. Also see RESBN76.PDF on my Web site for information on how home automation often makes use of X-10 dimmer controllers.

Anyway, any incandescent lamp might be brightened or dimmed by changing the DC or rms voltage sent to it. The obvious method involves putting a variable resistor in series with your light. Unfortunately, that technique has big-time inefficiency and heat problems. When you control a 100-watt bulb, as much as 25 watts of heat would have to be burned up in the series controller.

One ancient alternative is to use a Variac, or variable AC transformer. In those, a knob twists a contact to select a changing turns ratio. Early theater lighting controls used ganged banks of motor driven Variacs.

Incandescent lamps can be better brightened or dimmed by changing a duty cycle—the percentage of time voltage is applied. Duty cycling can be very efficient, since the controller is always either on or off. The ratio of on time to off time helps set the brightness. The switching frequency is usually 120-hertz or higher. The thermal inertia from the light bulb's filament and human persistence of vision should integrate or "average out" on and off times, reducing or eliminating flicker.

Your approaches to lamp dimming will differ between AC and DC power systems. The DC routes of Fig. 1 could be used in automobiles, for caving helmets, or in flashlights. In Fig. 1A, a power semiconductor such as a MOS field-effect transistor is placed between lamp and ground. The lamp turns on by making the gate positive by five volts or so. It will turn off by leaving the gate voltage near ground. Very little gate current is needed, so the MOS device acts as a powerful linear or switched "amplifier." One source of white LED caving lights that use those techniques can be found at www.hdssystems.com

In Fig. 1B, a newer style of integrated circuit known as a high-side driver is used. A high-side driver is basically a series power MOSFET with some additional control circuitry. The high-side driving eliminates the need for more than one wire going to the lamp. The return path can be via the vehicle frame or chassis. High-side driver circuits also sense open bulbs, detect other faults, and shut down on short-circuit currents.

One-piece chips that can combine dimming and high-side driving are available. Figure 1C shows how to use the new SGS-Thomson L9830. Its intended use is dimming dashboard lights in an instrument cluster.

The AC dimmers of Fig. 2 all provide a way to switch line-voltage bipolar currents that can be positive or negative. This leaves most power semiconductors out; the exception is a very popular switching device called a Triac.

A Triac has three terminals, called gate, T1, and T2. There is no current between T1 and T2 until a brief and small gate-current pulse is delivered. At that time, the Triac turns on and heavily conducts between T1 and T2. Above a rather small load-holding current, the Triac will latch and stay on. The Triac will stay on until such time as the main current returns to zero. Turn off will usually occur at the next current zero

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Don Lancaster
Synergetics
Box 809-EN
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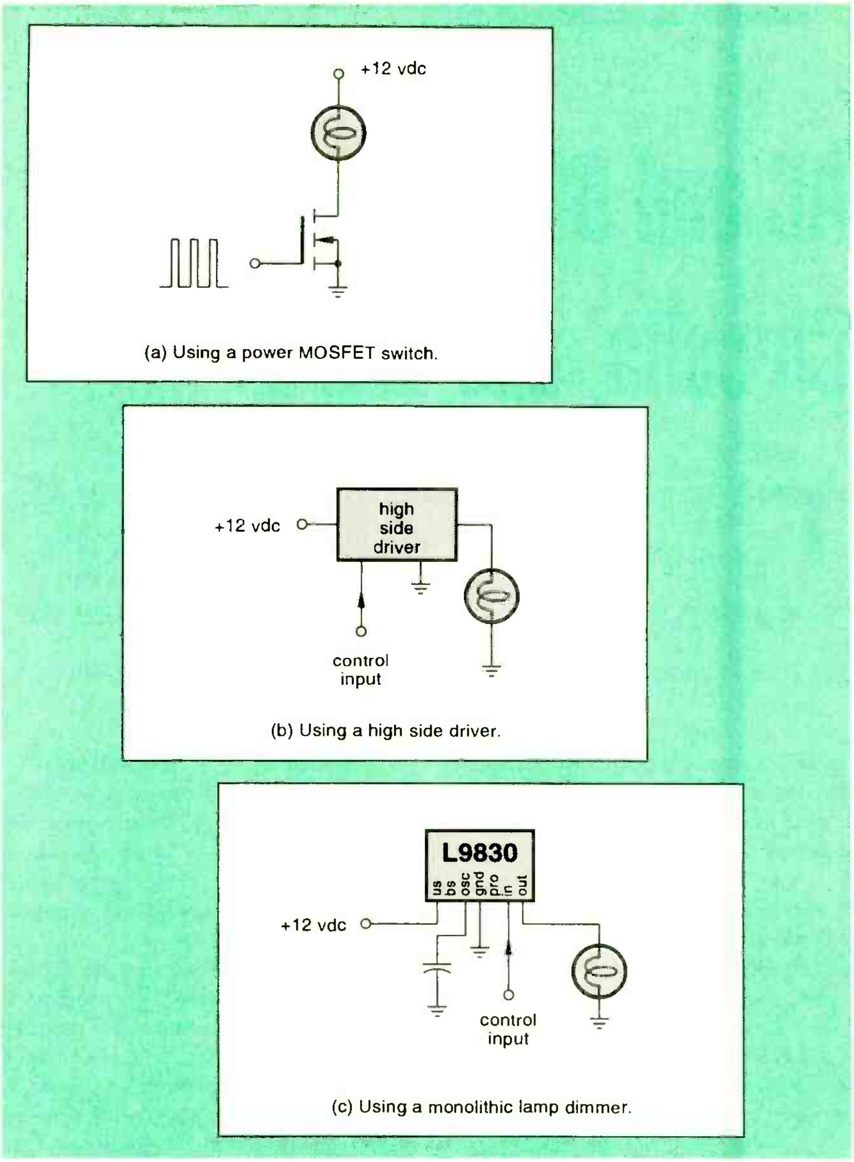

(a) Using a power MOSFET switch.

(b) Using a high side driver.

(c) Using a monolithic lamp dimmer.

FIG. 1—THREE DIFFERENT APPROACHES to dimming a DC lamp.

crossing of the line AC sinewave.

The simple Triac on-off switching circuit appears in Fig 2A. Closing the switch turns the Triac on; opening the switch will turn the Triac back off just after the next zero crossing. The sensitivity of a Triac's gate changes a little with the changing line and gate polarity. But proper gate drive can switch either polarity load with either polarity gate pulse.

Your classic Triac wall dimmer is shown in Fig. 2B. The diac shown is a bilateral switching diode. A diac turns on whenever its lead voltage exceeds a set amount—often 30 volts or so. Each AC half cycle, the potentiometer starts charging the capacitor. When the capacitor reaches the threshold voltage, the diac will turn on, in turn tripping the main Triac.

The lower the potentiometer's resistance, the earlier in the half cycle that turn on occurs, and the brighter the lamp. The higher the resistance, the later in the cycle that turn on occurs, and the dimmer the lamp. Such a circuit is called a proportional phase control. A second resistor and capacitor (not shown here) will often be added to eliminate any "jumping" problems at very low light levels. You can see the waveforms on this in MUSE108.PDF on my Web site.

One big "gotcha" with Triacs is that they are connected to one side of the AC power line, which creates serious "hot chassis" shock-safety issues.

Figure 2C shows us the standard and safe way of interfacing a Triac to a PIC or a personal computer port. A small and low cost photo-Triac—an optoisolator with a Triac output—is used. That device is just a light-emitting diode that shines onto a photo-Triac. Pulse the LED with suitably limited current (typically 10 mils) and both the little Triac inside the device and the big main one it drives turn on.

There are a few different ways to use this circuit: You can simply use it for on-off control. Alternately, for heaters and such, you can sense power-line zero crossings somehow and then provide turn on only just after a zero crossing. Such a zero-voltage switch eliminates annoying clicks and radio noise, and it is gentler on both the power line and your load. But note that zero crossing switching is not usable for dimming because the frequency is too low; flicker would be unacceptable.

Instead, you have the option of carefully pulsing the optoisolator's LED on at an exact position inside of each AC half cycle, thus creating a proportional phase control. This gives you a wide flicker-free brightness range.

You can also get combination Triacs and optoisolators. These are called AC solid-state relays and are offered in a wide variety, but tend to be more expensive than going with discrete devices.

A PIC or PC port can also be programmed to do fancy tricks such as slow dimming, stepped brightness, random "somebody is home" security lights, or for theater-lighting scene sequences.

Note that the brightness versus duty cycle is not linear. Why? Because there is more energy at a half sinewave peak than at the "corners". Table lookup software can easily adjust for linear voltage versus current, linear power versus current, log compression for input audio, or can even create flickering "flame" effects. You can find more on those concepts on www.tinaja.com; look for EMERGOP5.PDF and MUSE109.PDF.

Be sure to observe the "backwards" LED connection. Because many computer ports and interface drivers are a lot better at sinking current than they are at sourcing, an active-low scheme is normally used; that turns the LED and the Triac on with a low input and off with a high input—watch that detail.

A Triac that switches in mid cycle could generate severe radio noise and other interference. Series LC filters and suitable shielding is often needed to keep that to acceptable levels.

The leading Triac and optoisolators

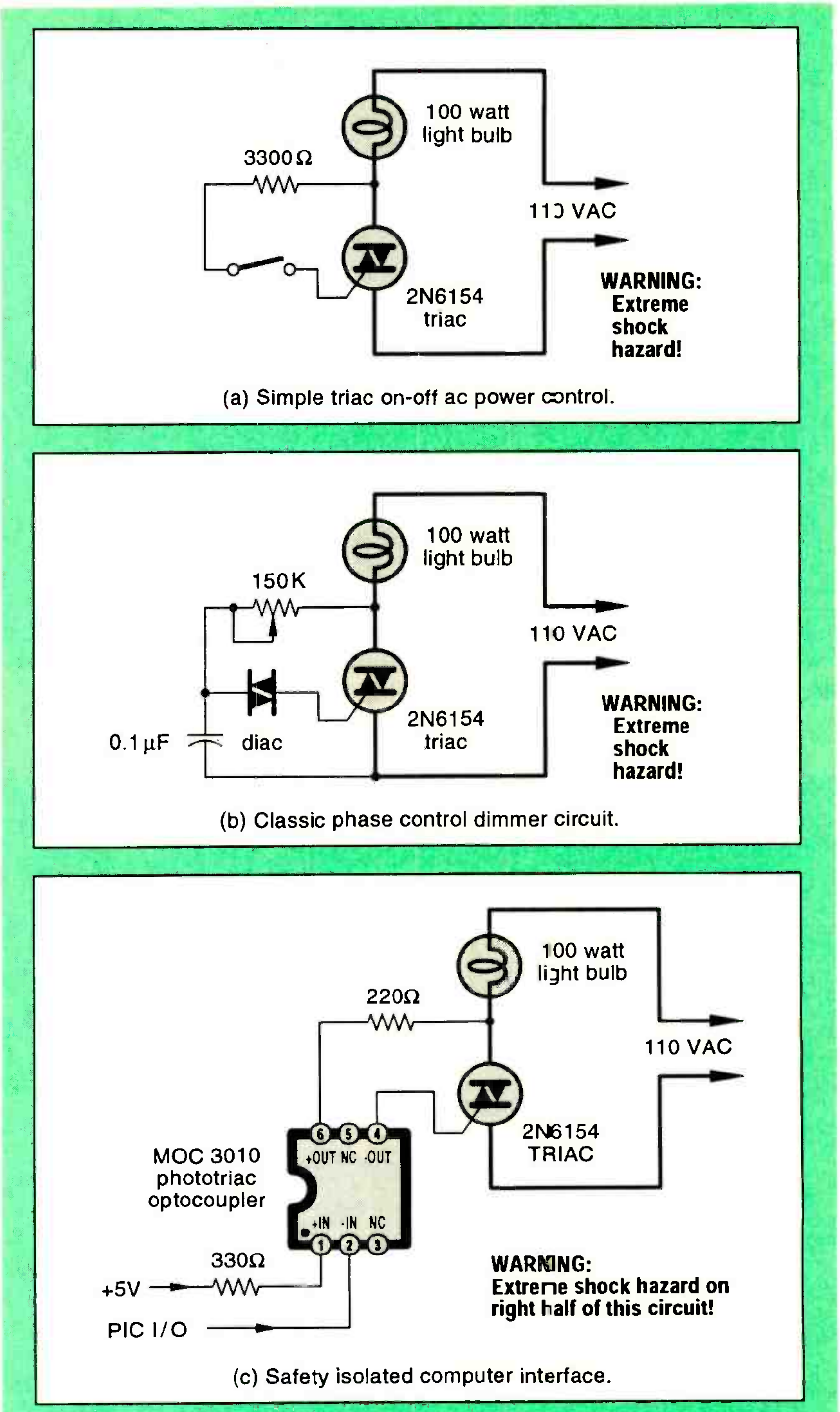

FIG. 2—THREE DIFFERENT line-operated lamp dimming circuits. All are built around a Triac.

manufacturers include Motorola, Teccor, and Texas Instruments. A color organ is an older name for psychedelic lighting or audio control of lamps. Design tips and ideas can be found in MUSE108.PDF on my Web site.

A Selection of Dimmer Chips

You have a choice of building up a dimmer from bits and pieces, by use of a PIC or other microcontroller, or by going to new specialized dimmer chips. A surprising variety of custom chips are available and are summarized in Fig. 3.

Two companies that seem to be in the dimmer forefront are Holtek and LSI/CSI. The Basic Stamp from Parallax or the PIC or baby PIC from Microchip Technology are often superb choices. Control can be by way of an up

Holtek HT7620	PIC Controller with Dimmer
Holtek HT7700	Key and Touch Linear Dimmer
Holtek HT7703	Touch Linear Dimmer
Holtek HT7704	Touch Dimmer
Holtek HT7712	Minimum Component Touch Dimmer
LSI/CSI 7234	Touch Control Continuous Dimmer
LSI/CSI 7237	Touch Control Stepped Dimmer
LSI/CSI 7338	Touch Control with Timed ON
LSI/CSI 7314	Multi-level Touch Control Dimmer
LSI/CSI 7534	Up-Down Touch Control Dimmer
Microchip 12C08	Low Cost Baby Programmable PIC
Microchip 16C70	Extra I/O Programmable PIC
SGS L9830	Monolithic DC Lamp Dimmer
Siemens SLB0587	Dimmer IC for Halogen Lamps
Unitrode UC3871	Fluorescent Dimmer Ballast Chip

FIG. 3—A SAMPLER OF some commercial dimmer integrated circuits.

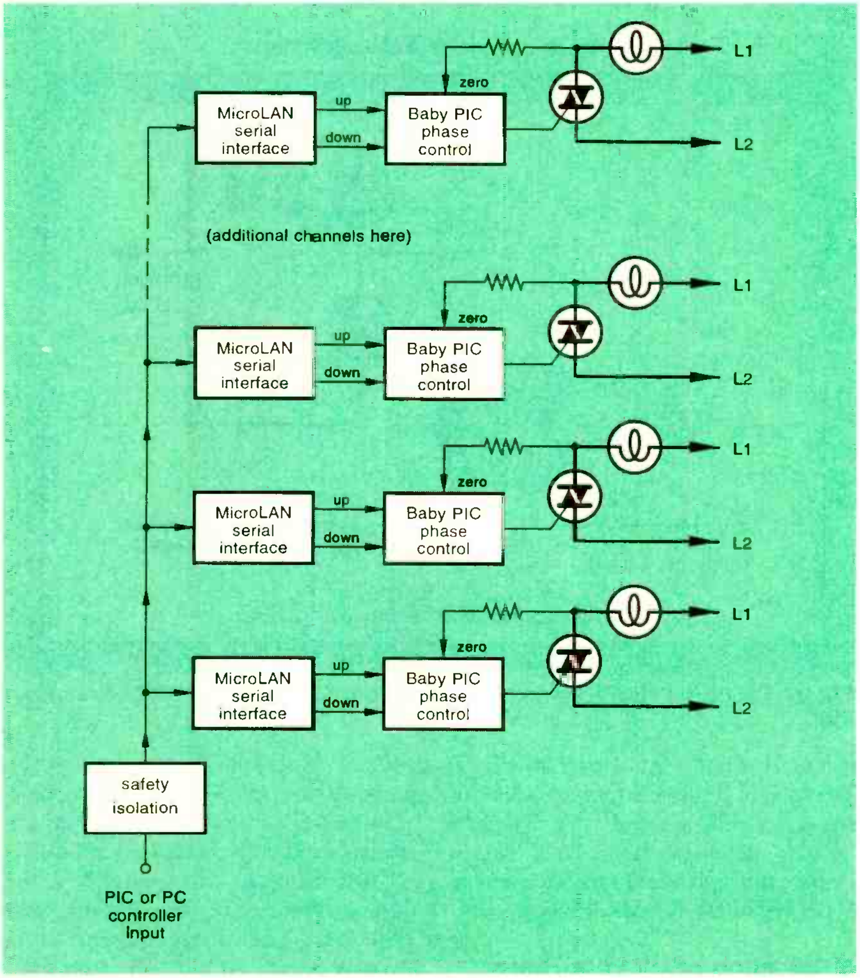

FIG. 4—ONE POSSIBLE SCHEME to remotely dim many lamps using only a single interconnecting wire.

and down pair of input pins, by a resistor going to an A/D converter, parallel "set level" inputs, serial data, or an analog voltage.

A number of useful PIC-dimmer applications notes are downloadable directly from Microchip Technology. To download, use the Questlink listings or the links at www.tinaja.com/picwb01.html

One very interesting combination for multiple control of lots of lamps would be to drive a slew of up-down PICs with several of the new Dallas DS2407 dual addressable switches (from their MicroLAN series). That would let you cheaply and independently control dozens or even hundreds of lamps using a one-wire simple networking system. Each PIC would test every so often to decide if the brightness needed to be changed. With 64 brightness levels, the slew rate from full off to full on would be just over half a second with half cycle sampling if the elaborate MicroLAN comm scheme could be made fast enough. Each addressed up or down command would be carefully synchronized and adjusted to last for a precise line-cycle interval. Levels would be synchronized either with a master reset or simply by supplying enough down commands in a row to guarantee everything is off.

A possible block diagram for this appears in Fig. 4. Should the best data rates of a MicroLAN end up too slow, a second baby PIC might be used instead of turning to higher baud rates.

Even simpler might be a "one long serial word" setup. Your first six bits go to lamp 1, the second six bits go to lamp 2, and so on. Sort of a "mini" DMX512.

Yes, a PIC can directly drive a Triac gate. That would eliminate the cost of your Triac-output optoisolator. But the extreme shock hazard would have to be addressed at other points in your circuit or system.

Zero-crossing detection could be simplified by sensing only positive, zero-going transitions and deriving turn on pulses for both half cycles. For further consulting and design information, see www.tinaja.com/info01.html

What About Fluorescents?

Fluorescent lamp-dimming needs special circuits. Ordinary dimmers must definitely not ever be used with fluorescents! But new concepts are available that let you dim from full brightness down to as low as four percent.

NAMES & NUMBERS

Advance Transformer
10275 W Higgins Rd.
Rosemont, IL 60018
(708) 390-5000

Argonne National Lab
9700 S Cass Ave.
Argonne, IL 60439
(800) 627-2596

Ark-Plas Products
Hwy 178 N
Flippin, AR 72634
(870) 453-2343

Dallas Semiconductor
4401 Beltwood Pkwy. S
Dallas, TX 75244
(972) 450-0400

Data Storage
10 Tara Blvd., 5th Fl
Nashua, NH 03062
(603) 891-0123

Galco
26010 Pinehurst Dr.
Madison Heights, MI 48071
(800) 575-5549

Holtek Technology
1342 Ridder Park Dr.
San Jose, CA 95131
(408) 573-8050

Horizon MapInfo
3990 Ruffin Road
San Diego, CA 92123
(800) 828-2808

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
(800) 536-4316

JKL Components
13343 Paxton St.
Pacoima, CA 91331
(800) 421-7244

Levy/Latham
6263 N Scottsdale #371
Scottsdale, AZ 85250
(602) 367-1100

Lindsay Publications
PO Box 538
Bradley, IL 60915
(815) 935-5353

LSI/CSI Systems
1235 Walt Whitman Road
Melville, NY 11747
(516) 271-0400

Map One
PO Box 999
Dewey, AZ 86327
(520) 632-8774

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

Parallax
3805 Atherton Rd. #102
Rocklin, CA 95765
(916) 624-8333

Planetary Society
65 N Catalina Ave.
Pasadena, CA 91106
(818) 793-5100

SGS-Thomson
1000 E Bell Rd.
Phoenix, AZ 85022
(602) 867-6259

Siemens Components
2191 Laurelwood Rd.
Santa Clara, CA 95054
(408) 980-4500

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

Teccor Electronics
1801 Hurd Dr.
Irving, TX 75038
(214) 580-1515

Unitrode
7 Continental Blvd.
Merrimack, NH 03054
(603) 424-8610

One source of suitable ballasts is Advance Transformer, while useful chips and applications notes can be found at Unitrode. Small laptop fluorescents and suitable dimming technique information is offered by JKL Components.

We just might look at fluorescent dimming further in a future column. Meanwhile, do not try it unless you really know what you are doing!

Magnetic Recording Books

A list of magnetic recording books shows up for this month's resource sidebar. More information on any of these is available at www.tinaja.com/amlink01.html A useful new trade journal on this topic is *Data Storage*.

Custom research into any technical field is available at surprisingly low cost at www.tinaja.com/info01.html. This is especially useful in gathering essential broad-based primary and background material on any emerging or unfamiliar tech topic you might want to get into big time.

Surplus Update

At present, the administrative expenses of selling military surplus electronics seem to be running something like $1.60 for each dollar in public sales. Thus, your tax dollars are being used to pay people to haul away surplus bargains. Your best defense here is to recycle your tax dollars by grabbing some of these for yourself!

To improve their bottom line, the Feds appear to be experimenting with DRMO office closures; "term" sales (in which you agree to accept a full year's worth of stuff); other new types of sales; and privatization. An asset-management outfit by the name of Levy/Latham is now doing a few of the Fed's surplus sales—so far mostly big-ticket items like machinery and boats. Supposedly a lot more of this will be done in the future. For more details on getting involved, you can visit www.levylatham.com

Although seldom advertised, most DRMO sites stock lists of people and firms who will photograph, bid, pack, and ship items for you. These lists are usually available on request. The type and quality of their services offered seems to vary with the base and who happens to live nearby. The major problem here is triage, where you literally will want to lighten up a lot before you ship.

A pair of tutorials on military-surplus bidding insider secrets can be found at www.tinaja.com/resbn01.html Hot buttons on my home page take you directly to the various DRMS access pages. Examples of the actual surplus bargains available these days are up at www.tinaja.com/barg01.html

New Tech Lit

You are invited to participate in a new SETI extraterrestrial intelligence search. An ongoing quest that needs zillions of net-linked computers. For info, see setiathome.ssl.berkeley.edu or pick up the summary invitation in the October 30, 1998 issue of *Science*. Meanwhile, you also might follow the separate Planetary Society billion-channel extraterrestrial assay in real time at seti.planetary.org

Volume 9, #4 of the *Tech Transfer Highlights* by the Argonne National Lab describes some magic new ionic conductor filters. One can be used to extract oxygen from air. Another can separate hydrogen from gas streams.

USGS topographic maps are at long last finding their way onto the Web and CD-ROM. Although not yet in full resolution, full quality, or in the zoomable and compact Adobe Acrobat format, at

SOME MAGNETIC RECORDING BOOKS

Complete Handbook of Magnetic Recording (Finn Jorgensen)
Ferromagnetic Materials: Structure and Properties (R. A. McCurie)
Ferromagnetism (Richard Bozorth)
The Foundation of Magnetic Recording (John Mallinson)
Handbook of Electromagnetic Materials (Perambur Neelakanta)
Magnetic Disk Drive Technology: Heads... (Kanu Ashar)
Magnetic Measurements Handbook (J.M. Janicke)
Magnetic Storage Handbook (Eric Daniel)
Magneto-Resistive Heads: Fundamentals... (John Mallinson)
Modern Recording Techniques (D. M. Huber)
The Physics of Magnetic Recording (C.D. Mee)
Practical Recording Techniques (Bruce Bartlett)
Theory of Magnetic Recording (Neal Bertram)
Theory of Magnetism (Kei Yosida)
Troubleshooting and Repairing Audio & Video.... (Homer Davidson)

least they are continuous without page breaks. One low cost CD-ROM source in my neighborhood is Map One found at www.bslnet.com/map1 Included will be 64 seven-minute quads to TIFF quality, three reference maps, and a viewer for $16!

MapInfo, a division of Horizons Technology, has a much more pricey new Web and CD-ROM-based service. Check their Web site at www.horizons.com/suremaps These two are obviously the first two early tricklings of a deluge. I'd predict free viewing of USGS topographic maps routinely provided on hundreds of Web sites within a year or so, and snap-in GPS receiver modules within two.

From Jameco comes the latest electronic components catalog 984. Get this one free by clicking on their banner on my Web site. From Galco, their latest industrial electronics catalog. Galco specializes in high-power electronics.

Nomadics, human-scale transport, and energy efficiency are all nicely covered by Steve Roberts through his Microship site at www.microship.com Grab his free e-zine newsletter.

Free samples this month include a TLC5615 ten-bit serial D/A converter from Texas Instruments, along with plastic fittings, tubing, and such from the folks at Ark-Plas Products.

The latest of "new-old" books by Lindsay Publications now include the *Harper's Aircraft Book*, *Manufacture of Wireless Components*, and *Electrical Designs*. All of these are unique turn-of-the-century reprints. *The Ultimate Modem Handbook* is a Cass Lewart book from Prentice Hall. More details on all these titles at www.tinaja.com/amlink01.html

For most individuals and smaller scale startups most of the time, any involvement with patents is virtually certain to result in a net loss of your time, energy, money, and sanity. Find out why, along with proven and tested real-world alternatives in my *Case Against Patents* package as per my nearby Synergetics ad.

The latest Web site additions at my www.tinaja.com include an expanded PIC libary, lots more classic Blatant Opportunist uploads, plus improved layout and navigation. The newest surplus bargains that you will now find at www.tinaja.com/bargte01.html include mystery cryogenics, military tube testers, distortion analyzers, superb luminance probes, radiosondes, and much more.

As usual, most of the mentioned resources show up in the Names & Numbers or the Magnetic Recording sidebars. Always check here before using our US technical helpline that is shown in the nearby box.

Let's hear from you. EN

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RAMSEY

World's Smallest TV Transmitters

We call them the 'Cubes'.... Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies- that's a nickel in the picture!

Transmits color or B&W with fantastic quality - almost like a direct wired connection to any TV tuned to cable channel 59. Crystal controlled for no frequency drift with performance that equals law enforcement models that cost hundreds more! Basic 20 mW model transmits up to 300' while the high power 100 mW unit goes up to 1/4 mile. Audio units include sound using a sensitive built-in mike that will hear a whisper 15 feet away! Units run on 9 volts and hook-up to most any CCD camera. Any of our cameras have been tested to mate perfectly with our Cubes and work great. Fully assembled - just hook-up power and you're on the air!

C-2000, Basic Video Transmitter Cube....................$89.95
C-3000, Basic Video and Audio Transmitter Cube..............$149.95
C-2001, High Power Video Transmitter Cube....................$179.95
C-3001, High Power Video and Audio Transmitter Cube.....$229.95

Super Pro FM Stereo Radio Transmitter

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

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

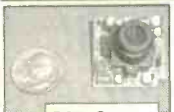
FM-100, Professional FM Stereo Transmitter Kit.............$299.95
FM-100WT, Fully Wired High Power FM Transmitter..........$429.95

AM Band Radio Transmitter

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

AM-25, Professional AM Transmitter Kit.............................$129.95
AM-1, Entry level AM Radio Transmitter Kit..........................$29.95
CAM, Matching Case Set for AM-1.......................................$14.95

CCD Video Cameras



B&W Camera

Color Camera

If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays with over 440 line line resolution, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. Also, a new strain of CMOS single chip cameras are entering the market, those units have about 1/2 the resolution and draw over twice the current that these cameras do - don't be fooled! Our cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, the black & white models are super IR (Infra-Red) sensitive. Our IR-1 Illuminator kit is invisible to the human eye, but lights the scene like a flashlight at night! Color camera has Auto White Balance, Auto Gain, Back Light Compensation and DSP! Available with Wide-angle (80°) or super slim Pin-hole style lens. They run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our IB-1 Interface board for audio sound pick-up and super easy direct wire hook-up connection to any Video monitor, VCR or TV with video/audio input jacks. Cameras fully assembled, including pre-wired connector.

CCDWA-2, B&W CCD Camera, wide-angle lens..........$99.95
CCDPH-2, B&W CCD Camera, slim fit pin-hole len......$99.95
CCDPH-2, Color CCD Camera, wide-angle lens.........$149.95
IR-1, IR Illuminator Kit for B&W cameras....................$24.95
IB-1, Interface Board Kit..$24.95

FM Stereo Radio Transmitters

Microprocessor controlled for easy frequency programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

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

A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit..............$34.95
CFM, Matching Case and Antenna Set.....................$14.95
AC12-5, 12 Volt DC Wall Plug Adapter.........................$9.95

RF Power Booster

Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat, professionally finished look, add the optional matching case set.

LPA-1, Power Booster Amplifier Kit..............................$39.95
CLPA, Matching Case Set for LPA-1 Kit.......................$14.95
LPA-1WT, Fully Wired LPA-1 with Case.......................$99.95

Treasure Finder Kit

Search for buried treasure at the beach, backyard or park. This professional quality kit can detect metal at a depth of up to 6 inches. Easy to use, just listen for the change in tone as you 'sweep' the unit across the surface - the larger the tone change - the larger the object. Has built-in speaker or earphone connection, runs on standard 9 volt battery. Complete kit includes handsome case, rugged PVC handle assembly that 'breaks down' for easy transportation and shielded Faraday search coil. Easy one evening assembly. This nifty kit will literally pay for itself! That guy in the picture looks like he found something - what do you think it is - gold, silver, Rogaine, Viagra? You'll have fun with this kit.

TF-1, Treasure Finder Kit..$39.95

Binocular Special

We came across these nice binoculars in an importers close-out deal. Not some cheap in-line lens jobs, these beauties have roof prisms, a super nice rubber armored housing over light weight aluminum. 10 x 25 power with fully coated optics. Includes lens cleaner cloth, neck lanyard and nice carry case. For extra demanding use in bright sun, choose the EX module with ruby coated Objective lens. First quality at a close-out price! We've seen the exact same units with the 'Bushnell' name on them being sold for $30 more!

BNO-1, Binoculars and case...$24.95
BNO-1EX, Ruby Coated Lens Binoculars and case.....$29.95

Speech Descrambler

Decode all that gibberish! This is the popular descrambler / scrambler that you've read about in all the Scanner and Electronic magazines. Speech inversion technology is used, which is compatible with most cordless phones and many police department systems, hook it up to your scanner speaker terminals and you're in business. Easily configured for any use: mike, line level and speaker output/inputs are provided. Also communicate in total privacy over telephone or radio, full duplex operation - scramble and unscramble at the same time. Easy to build, all complex circuitry contained in new custom ASIC chip for clear, clean audio. Runs on 9 to 15VDC. Our matching case set adds a professional look to your kit.

SS-70A, Speech Descrambler/Scrambler Kit............$39.95
CSS, Custom Matching Case and Knob Set...............$14.95
SS-70AWT, Fully Wired SS-70A with Case................$79.95
AC12-5, 12 Volt DC Wall Plug Adapter..........................$9.95

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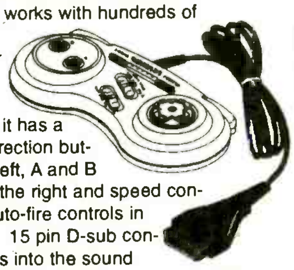
Interact ProPad GAME CONTROLLER

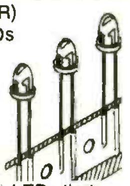


Interact Game Products # SV-230 PC ProPad works with hundreds of PC games. Very similar to Super Nintendo controllers, it has a four-way direction button on the left, A and B buttons on the right and speed controls and auto-fire controls in the middle. 15 pin D-sub connector plugs into the sound card on most Windows based computers.

$3.00 each CAT # SV-230

2 for $5.00

3000 MCD ULTRA-BRIGHT RED LED



Everlight # 383URC-2/TR1-C(R) Red, "Ultra-bright" T 1 3/4 LEDs now at our lowest price ever. Due to a special purchase of "tape-and-reel" parts we are able to offer these LEDs at an incredibly low price when purchased on the reel. These are 5 mm diameter water-clear LEDs that light bright red at 20 ma.

CAT# LED-50

2 for $1.00

100 for $35.00
1000 for $250.00
(25¢ each)

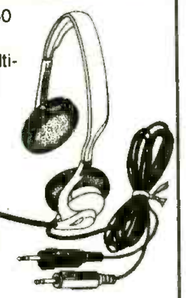
S-VHS Tape (Used)

Super VHS tape users! Save a bundle on name-brand S-VHS, T-120 tapes. These tapes were used for a brief period, then bulk erased. The record-protect tabs have been broken out, so you will have to cover the notch with a piece of tape, but they work great and cost a fraction of the "new" price.

CAT #S-VHS **$3.00 each**

10 for $28.00 • 100 for $250.00

STEREO HEADSET with Electret Mike



Andrea Electronics # M-150 Designed for use with personal computers for multi-media, speech recognition, internet telephone, etc. Stereo headset and boom mike has two separate 3.5mm stereo plugs for connection to mike and speaker jacks. Lightweight headphones with adjustable headband. 6' cord.

CAT# PHN-15 **$8.75 each**

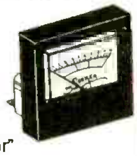
10K THERMISTOR

Semitec # 103AT-2 10K ohm (± 1 %) @ 25 deg. C. Rated 10 mW. Time constant: 15 sec. 2 mm x 3mm. 2.5mm lead spacing. CAT #THR-20

$1.00 each

10 for $8.50
200 for $130.00

250 uh PANEL METER



Good-looking 1.65" x 1.68" panel meter. Matte-black frame with a 1.43" x 0.84" viewing window. Scale calibrated from 1 to 10, divided into green (1-4), yellow (4-6) and red (6-10) areas. Logo, "The Seeker" is written under the scale.

CAT #MET-51

$1.50 each

10 for $12.50

Encased Piezoelectric Element

0.82" DIAMETER X 0.15"
AVX/Kyocera # PCRT21BGX Black plastic front, vented metal back. Solder loop terminals. Louder than non encased piezo elements. Requires external signal to produce sound. CAT # PE-38

3 for $1.00

100 for $25.00
1000 for $125.00

BIG Flashing LED

Big, bright red flashing LED. 10 mm diameter. Red diffused lens. Great for attention getting displays. Operates on 3-12 Vdc. Flash rate approx. 2 times per second.

CAT# LED-60

2 for $1.50

10 for $6.50
100 for $50.00

UV Blacklight

New black-light lamps designed by Avon Cosmetics to highlight dry skin. They have a built-in timer that shuts-off the lamp after approximately one minute. Ideal for lighting fluorescence in black-light posters, gemstones, hand stamps and US currency. 5" lamp, F4T5BLB, is housed in a lightweight plastic case. 7" x 3.25" x 2.3" high. Powered by a 12 Vdc, 500 ma wall transformer (included). Individually boxed.

CAT# UVL-1 **$10.00 each**

F4T5-BLB Replacement lamp for above fixture. CAT # BLB-5 $3.00 each

470 Mfd 450 Vdc

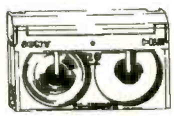
Nichicon #LGQ2W471MHSC 1.375" dia x 2" high. 0.4" lead spacing.

CAT# EC-4745

$3.00 each

10 for $22.50

"HI-8" Video Cassette



SONY Hi-8 Top quality, metal particle 120 minute video cassettes. *Used for a short time, then bulk-erased.* Each cassette has its own plastic storage box.

CAT # VCU-8 **$3.00 each**

10 for $28.00 • 100 for $250.00

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If you haven't received a copy of our current 260 page catalog ... have one added to your order or give us a call and we will send one out to you immediately.

6-1/2" Two Way System

This is our most popular in-wall. You won't believe how good these really sound. Big enough to produce great home theatre sound and still fit everyone's budget. Put a pair in every room of your house. Great for front or rear speakers in your surround system. The 6-1/2" polypropylene woofer and 1" textile dome tweeter were specially designed with home theatre in mind. The crossover network utilizes a mylar capacitor for crisp clean highs. 3 piece design make installation in new or existing walls a snap. **Specifications:** ◆6-1/2" polypropylene cone woofer with poly foam surround ◆1" textile dome tweeter/midrange ◆8 ohm impedance ◆3 component L/C crossover network ◆Frequency response: 50-20,000 Hz ◆Power handling capability: 60 watts RMS/85 watts max ◆Sensitivity: 89 dB 1W/1m ◆Overall dimensions: 8-1/2" W x 12" L x 3-1/2" D ◆Hole size: 7-1/4" x 10-3/4" ◆Fits into standard 2" x 4" wall ◆Net weight: 12 lbs. per pair.

#300-036 .... **$89.90** (1-3 PRS) **$79.50** (4 PRS-UP)

Satellite Speaker Stands

These quality speaker stands are perfect for mini or rear surround speakers. The heavy die cast base provides stability. Textured black satin finish blends in well with any decor. The height is adjustable from 26-1/2" to 47-1/2" and the speaker wire can be run inside the pole for a better appearance. The top base is adjustable from 4-1/8" to 7-1/2" to accommodate most mini speakers. Includes foam pads to prevent marring of speaker cabinet. Sold in pairs. Net weight: 12 lbs.

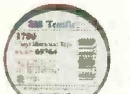
#240-762 .... **$39.80** (1-3 PRS) **$35.50** (4 PRS-UP)

5 Function Remote

◆Operates five devices (TV, VCR, Cable, Satellite, A/V Receiver) ◆Lighted component keys which indicate what device is currently being used ◆Preprogrammed, 621 codes that work over 6,400 models ◆New ergonomic design features a contoured case, index finger grooves, and keys grouped in clusters for easy operation ◆Satellite cursor control is tailored for use with a Home Theatre system, keypad design allows movement through menus with ease ◆Retains codes when replacing batteries ◆New flat back design for easy operation ◆Money back guarantee ensures customer satisfaction ◆Toll free customer service number provides the customer with friendly, knowledgeable assistance ◆Requires 2 AAA batteries (#140-150 not included)

#180-806 .... **$29.95** (1-3) **$26.95** (4-UP)

3M 3/4" Temflex™ 1700 Vinyl Electrical Tape



General purpose 7 mil electrical tape. UL listed and CSA approved. 3/4" x 60' rolls.

#350-052 .... **75¢** (1-9) **59¢** (10-UP)

Gold Plated A/V Cables

A super quality, "siamesed" type cable. Two RCA cables for stereo (audio) signal from VCR to receiver/stereo TV and one low noise coaxial type cable for video.

Part #	Length	Price (1-9)	Price (10-UP)
180-120	3 ft.	$4.25	$3.95
180-118	6 ft.	4.90	4.50
180-121	12 ft.	8.95	7.95
180-124	20 ft.	12.75	11.50

6-1/2" Round Coaxial System

Designed for the home and office, these 6-1/2" round in-walls are ideal for ceiling installations, or for use as rear channel surround speakers. Adding music to the kitchen, den, bath, or patio has never been easier! System features a weather resistant 6-1/2" treated paper cone with poly foam surround, coaxially mounted 1/2" polymer dome tweeter, and built-in crossover with a mylar capacitor in the tweeter feed. Retrofit design allows installation in both new and existing construction in just minutes. System includes removable steel mesh grills, built-in mounting bracket, hardware, and installation instructions. **Specifications:** ◆Impedance: 8 ohms ◆Frequency response: 60-20,000 Hz ◆Power handling capability: 30 watts RMS/45 watts max. ◆Sensitivity: 89 dB 1W/1m ◆Dimensions: 9" round x 2-7/8" deep. ◆Net weight: 5 lbs. per pair.

#300-408 .... **$69.95** (1-3 PRS) **$62.75** (4PRS-UP)

3 Amp Power Supply

ZURICH

This fully regulated power supply is perfect for powering CBs, car radios, and other 12 VDC devices that draw up to 3 amps. Heavy duty steel housing with front mounted switch and binding posts. Short circuit and overload protection! **Specifications:** ◆Output Voltage: 13.8 VDC (fixed) ◆Output Current: 3A (cont), 5 amps (surge) ◆Ripple Voltage: Less than 3mV at rated output ◆Input Voltage: 120 VAC, 60Hz ◆Dimensions: 5-1/2" x 3-1/2" x 6-1/2" ◆Weight: 5 lbs.

#120-530 .... **$19.95** (1-3) **$18.50** (4-UP)

DMM and LCR Meter

In addition to functions found in regular DMM's, this meter can also measure inductance in 5 ranges (4mH, 40mH, 400mH, 4H, 40H), capacitance in 5 ranges (4nF, 40nF, 400nF, 4uF, 400uF), frequency in 4 ranges (4KHz, 40KHz, 400KHz, 4MHz), TTL logic test, diode test and transistor hFE test. 5 AC/DC ranges up to 1000V (AC750V), 3 AC/DC current ranges up to 20A and 7 resistance ranges up to 4000 M ohms. Includes test leads, battery, spare fuse, and manual. Net weight: 1 lb.

#390-513 .... **$85.90** EACH

2.5W Mini Audio Amplifier

This amp contains both pre-amplifier and power amplifier on a super small board measuring only 1-5/8"x1-1/4". Maximum output power is 2.5W into 4 ohms with 12VDC input power. No adjustments required. Short circuit protected.

#320-215 .... **$9.95** EACH

Weller WLC100 Soldering Station

The Weller WLC100 solder station is ideal for the professional, serious hobbyist, or kit builder who demands higher performance than usual of a standard iron, but without the high cost of an industrial unit. Power is adjustable from 5 to 40 watts. Includes 40 watt pencil iron. UL approved. Net weight: 1-3/4 lbs. Replacement sponge #372-119.

#372-120 .... **$39.95** EACH

"44" Solder

KESTER

Kester "44" rosin core solder is designed for electronic and electrical work. It uses a fast acting, instant wetting, non-corrosive, and non-conductive flux for faster soldering and a strong, long lasting bond.

Part #	Alloy Lead/Tin	Spool	Dia.	Price (1-3)	Price (4-UP)
370-080	60/40	1 lb.	.031"	$8.50	$7.95
370-090	60/40	1 lb.	.050"	8.50	7.95
370-098	60/40	4 lb.	.031"	33.90	31.80
370-088	60/40	1/2 lb.	.020"	6.95	5.75
370-072	63/37	1 lb.	.020"	14.90	13.50
370-086	63/37	1/2 lb.	.031"	9.95	8.50
370-074	63/37	1 lb.	.031"	12.50	11.50
370-087	36/37	1/2 lb.	.031"	7.95	6.75

Pro Wick

TECH SPRAY

Pro Wick's advanced fine braid design provides wicking action that is second to none.

Part #	TS #	Size	Length	Price (1-9)	Price (10-UP)
341-415	1802-5	.06"	5'	$1.40	$1.25
341-416	1803-5	.08"	5'	1.45	1.30
341-417	1804-5	.10"	5'	1.60	1.45
341-424	1802-10	.06"	10'	2.75	2.50
341-425	1803-10	.08"	10'	2.80	2.55
341-426	1804-10	.10"	10'	2.95	2.70
341-440	1802-25F	.06"	25'	6.80	6.30
341-441	1803-25F	.08"	25'	6.85	6.35
341-442	1804-25F	.10"	25'	7.60	7.00
341-418	1802-100	.06"	100'	21.90	20.50
341-419	1803-100	.08"	100'	21.90	20.50
341-423	1804-100	.10"	100'	23.90	22.50

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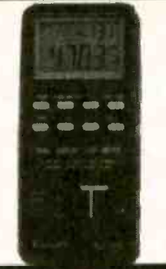
DMM

DMM-89S ($179.00): true rms, AC/DC (V,A), Ω, bar graph, freq, capac., dBm, logic, diode
DMM-23T ($99.95): 4½ digit, true rms, high resol. (10µV, 10nA, 10mΩ), hFE, diode, contin.
DMM-20 ($74.95): AC/DC (V, A), Freq, cont., Capac, Induct., Ω, hFE, diode, duty cycle
DMM-122 ($59.95): DC/AC(V,A), Ω, hFE, diode, capacitance, freq, logic, continuity
DMM-123 ($44.95): DMM + capacitance, DC/AC(V,A), Ω, hFE, diode, continuity
DMM-10 ($19.95): 3½ digit, DC/AC V, Ω, hFE, diode, signal output(+3V,-0.5Vsq.,50%duty)



LCR/COUNTER

CAP-15 (*$49.95*): 3½ digit, 0.1pF-20mF, 9 Ranges, 0.1pF resolution, zero adjustment.
LCR-24 (*$119.95*): 0.1µH-200H, 0.1pF-2000µF, 0.01Ω-20MΩ, diode test. *New Model*
LCR-131D (*$219.95*): autorange, 0.1µH-10kH, 0.1pF-10mF, 1mΩ-10MΩ, Q Factor, serial/parallel, 120Hz/1kHz testing mode.
FC-1200 (*$129.95*): 1.25GHz Handheld, 8 digits display, 10ppm accurary, sensitivity 5mV (130-350MHz), 30mV (440MHz)

FLUKE

12B	$ 94.95
70-III	$ 99.00
73-III	$125.00
75-III	$155.00
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79-III	$195.00
87-III	$325.00
92B-III	$1,445
96B-II	$1,695
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105B	$2,495
123-III	$1,130
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SPECIALTY

• AC Current Probe	$34.95
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• Watt Meter	$129.95
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• pH Meter	$79.95
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- Constant current, constant voltage mode
- Short Circuit and overload protected

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PS-305 ($219.95) 30V/5A
PS-8112 ($399.95) 60V/5A
PS-1610 ($289.00) 16V/10A
PS-8107 ($399.95) 30V/10A

Digital Volt, Analog Current
PS-8200 ($179.95) 30V/3A
PS-8201 ($239.95) 30V/5A

Digital Volt & Current Display
PS-8300 ($199.95) 30V/3A
PS-8301 ($259.95) 30V/5A

Triple Output

- Independence or Tracking operation
- Parallel to double current output (PS-8102 & PS-8103 only)

Triple Output (Analog displays)
PS-8102 ($399.95) 30V/3A/30V/3A
PS-8103 ($489.95) 30V/5A/30V/5A

Digital Displays
PS-8202 ($499.95) 30V/3A/30V/3A
PS-8203 ($549.95) 30V/5A/30V/5A

AUDIO/RF/FUNCT. GEN.

RF Generator • **SG-4160** ($124.95) 100kHz-150MHz sinewaves in 8 ranges
• **SG-4162AD**($229.95) with 6 digit counter
Audio Generator • AG-2601 ($124.95) 10Hz-1MHz, 0-8Vpp sine, 0-10Vpp squarewave
• **AG-2603AD** ($229.95) with 6 digit counter
Function Generator • **FG-2100A ($154.95)** 0.2Hz-2MHz,5mV-20V$_{pp}$
• **FG-2103** ($329.95) *Sweep* 0.5Hz-5MHz

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DC POWER SUPPLIES · FUNCTION GENERATOR · BENCHTOP DMM

20 MHz Scope

• OS-620 $324.95
- Most economical scope
- Dual CH/X-Y operation
- 1 mV/div sensitivity
- Z-axis input,CH1 output
- TV syn, ALT trigger
- 2 probes (x1, x10)

Cursor Readout

• OS-626G $599.95
- **Readout & Cursor meas**
- Dual CH / Delay sweep
- Built-in delay line
- ALT trigger, Hold-Off
- Z-axis input,CH1 output
- 2 probes (x1, x10)

Triple Output

- 2 variable out 0-30V,0-3A
- One fixed 5V,3A output
- Auto track, serial, parallel
- Const. volt, current mode
- 4 analog or 2 digital display

PC-3030 ($499.95)
PC-3030D ($549.95) digital

Single Output

- Const voltage, current mode
- Voltage regulation ≤0.01%
- Current regulation ≤0.2%

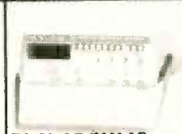
PS-1830 ($198.95) 18V/3A
PS-1850 ($214.95) 18V/5A
PS-1830D($214.95)18V/3A
PS-1850D($244.95)18V/5A

Programmable

- Auto serial/parall.(PPT ser)
- Auto track (PPT series), IEEE-488.2 and SCPI compatible command set

PPS-1860G($1,149.95)18V/6A
PPS-3635G($1,149.95)36V/3.5A
PPT-1830G($1,499.95)18V/3A
PPT-3615G($1,499.95)36V1.5A

Function Generator



FG-8020G ($209.95)
- 0.02Hz-2MHz w/counter
- Sine/Squ/Tri/pulse/Ramp

FG-8020G ($209.95)
- 0.02Hz-2MHz w/counter

FG-8050 ($449.95) Sweep
- 0.05Hz-5MHz w/counter
- INT/EXT AM/FM mod

Benchtop DMM

DM-8034($179.95) 3½ dgt
- AC/DV(V,A),C,Ω,diode

DM-8040($339.95) 3¾ dgt
- ACV to 50kHz, true rms

DM-8055G($889.95)5½dgt
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MINIATURE AUDIO AMPLIFIER KIT
Big sound from a small unit !
Small PCB with both pre- and power amp
Short circuit protected
Input sensitivity : 20mV
Max. output power : 2.5W
Power supply : 4.5 to 15VDC

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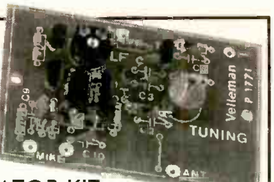


K1771
FM OSCILLATOR KIT

$12.95

Use for home broadcasts, baby monitoring, security
Frequency range : 100-108MHz
Microphone input
No coils to wind
Power supply : 9-12VDC

17pc•kit

$9.95

K1803
UNIVERSAL MONO PRE-AMPLIFIER KIT
Boost any audio signal up to 40dB (x100)
Max input signal : 40mV
Frequency range : 20Hz to 20KHz
Power supply : 10-30VDC/10mA

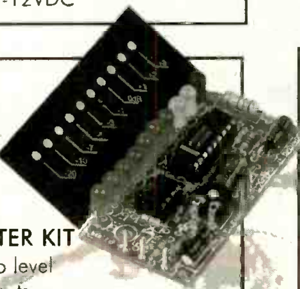
19pc•kit

$19.95

K5300
STROBOSCOPE KIT
Stage effects at home
Adjustable flash rate: 2-20 flashes/second
Powerful flash tube
Supply voltage : 110-125V AC

36pc•kit

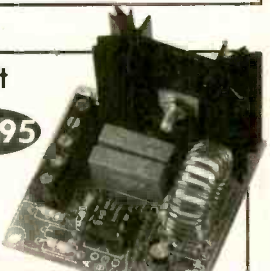
$18.95



K4304
10 LED VU METER KIT
Visualise any audio level
Line or speaker inputs
DOT or BAR mode. Range : -20 to +3dB
Front panel included. Vertical or horizontal mounting. Power supply 10-15VDC

27pc•kit

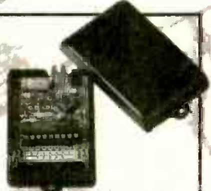
$24.95



K5002
HALOGEN LAMP DIMMER KIT
Light control at the touch of a button
Suitable for loads up to 3A
Can control small motors with brushes
Push button operation
Add any number of buttons
Power supply : 110-125V AC

16pc•kit

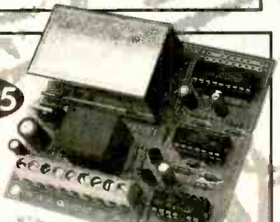
$14.95



K6708
IR REMOTE CONTROL KEY CHAIN TRANSMITTER For K6709 Kit
Range : Up to 24 feet
LED operation indicator
8748 different code settings
Power supply : 12V battery

66pc•kit

$24.95



K6709
IR REMOTE RECEIVER
For K6708 Kit
The easy way to add a remote control
10A relay with mom. or pulse changeover contact
Allows control of alarm systems, garage doors, outdoor lighting, garden pumps, etc
LED reception indicator
Accepts multiple transmitters K6708
Power supply 2x9VAC or 12 to 16VDC

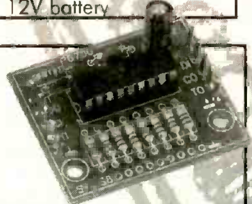
12pc•kit

$12.95

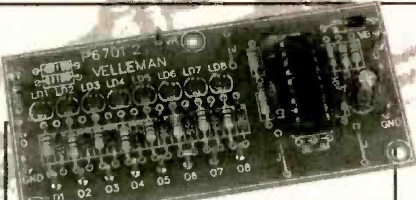
K1823
1 AMP POWER SUPPLY
Just add a transformer
Adjustable output voltage
1,5V to 35V/1A max.
Short circuit and thermal protection
Max input voltage : 37VDC
Max dissipation : 15W

18pc•kit

$14.95



K6700
2-WIRE REMOTE CONTROL TRANSMITTER
Transmitter For K6701 Kit
Control up to 16 devices*, with only 2 wires ! Remotely control 8 (*16 with 2 units) devices up to 160 feet away. Transmitter is powered over the data wires. Simple operation by means of switches (not included)
Transmitter can drive multiple receivers

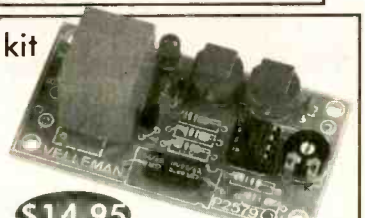


46pc•kit

$24.95

K6701
2-WIRE REMOTE CONTROL RECEIVER For K6700 Kit
8 open collector outputs (max 200mA)
LED output status indication
Daisy chain 2 units for 16 outputs
Power supply : 6-16V DC

18pc•kit



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K2579
UNIVERSAL START STOP TIMER KIT
0-15 Minutes Adjustable Delay
3A changeover relay contact
Start and Stop button included
LED function indicator
Can be modified for longer delays
Power supply : 12V/55mA

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- 20MS/s Sampling Rate
- RS232 Output

S-1360 $749
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- Component Tester

100MHz

S-1390 $895
- Analog w/ delayed sweep
- Dual Time Base
- TV Sync

40MHz

S-1345 $569
- Analog with Delayed Sweep
- Component Tester

S-1340 $475
- Analog / TV Sync
- 1mV Sensitivity

2 Year Warranty

25/30MHz

DS-303 30MHz $895
- Analog / Digital Storage
- 20MS/s Sampling Rate
- RS232 Output

DS-203 20MHz $695
- Analog / Digital Storage

S-1330 $439
- 25MHz Analog
- Delayed Sweep

S-1325 $325
- 25MHz Analog
- TV Sync
- 1mV Sensitivity

Fluke Multimeter Specials

F-73III $119 List $135

F-T1III $165 List $185

F-79II $175 List $199

F-87 $289 List $335

B&K Precision Multimeter Specials

- Accurately measures capacitance, resistance and inductance.
- Measures dissipation factor of capacitors and Q of inductors.
- Simultaneously displays measured value and Q or dissipation factor.
- Displays the difference between measures and reference values.

Model 878 $219.95

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- 0.025% DCV
- 0.07% ohms
- Min/Max/Avg
- True RMS, AC, or AC+DC
- 100kHz AC response
- Capacitance to 50,000µF
- Frequency, duty cycle, pulse width
- dB across 1Ω to 10kΩ
- Disturbance indicator
- Autograph, bargraph with zoom
- Sealed case, Splachproof
- IEC 1010, class 2 safety compliance

Model 5390 $295.00

MX-9300

Four Functions in One Instrument

Features:
- One instrument with four test and measuring systems:
  - 1.3GHz Frequency Counter
  - 2MHz Sweep Function Generator
  - Digital Multimeter
  - Digital Triple Power Supply
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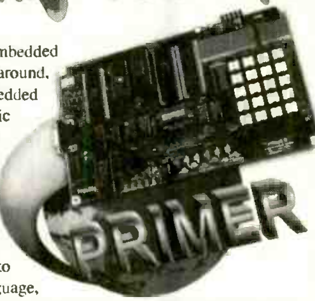

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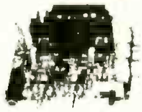

Operated from AC source as well as 12V DC car battery. Used as a microphone PA amplifier while simultaneously mixing with an auxillary input souce such as CD & MD player.

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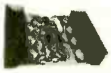

300W RMS into 4 ohms, 200W RMS into 8 ohms. Frequency response: 10Hz-20KHz. THD < 0.03%. S/N 91 dB. Input Sensitivity & Load impedance at 1KHz, 1V 47K & 4-16 ohm. Power Requirement: ±55V - ±65V DC at 8A(each channel). A speaker protection circuit which provides time delayed speaker turn on.

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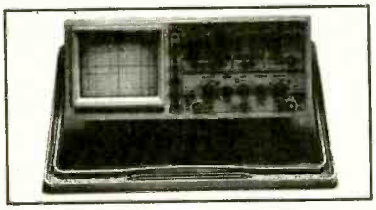

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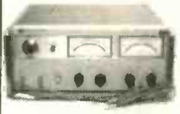

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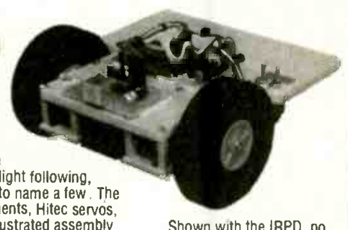

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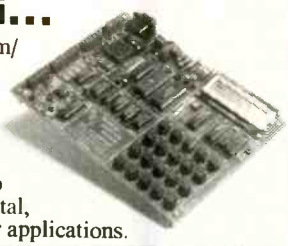

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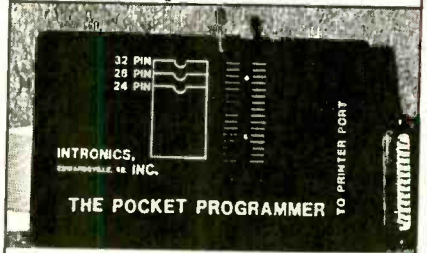

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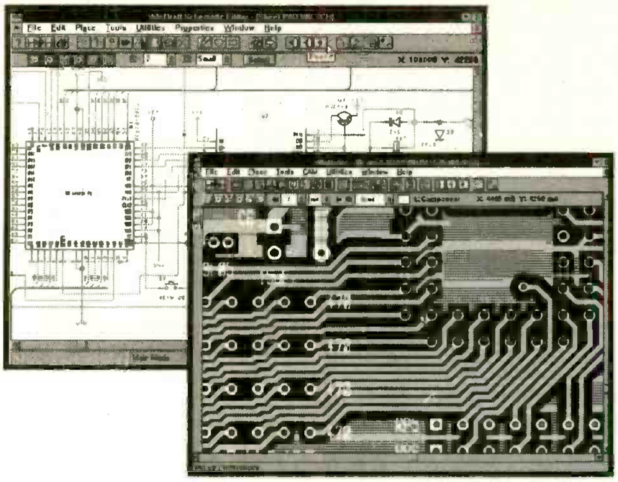

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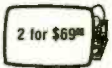

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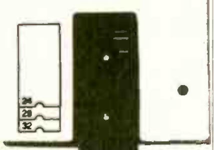

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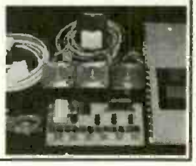

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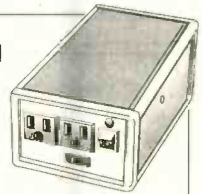

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