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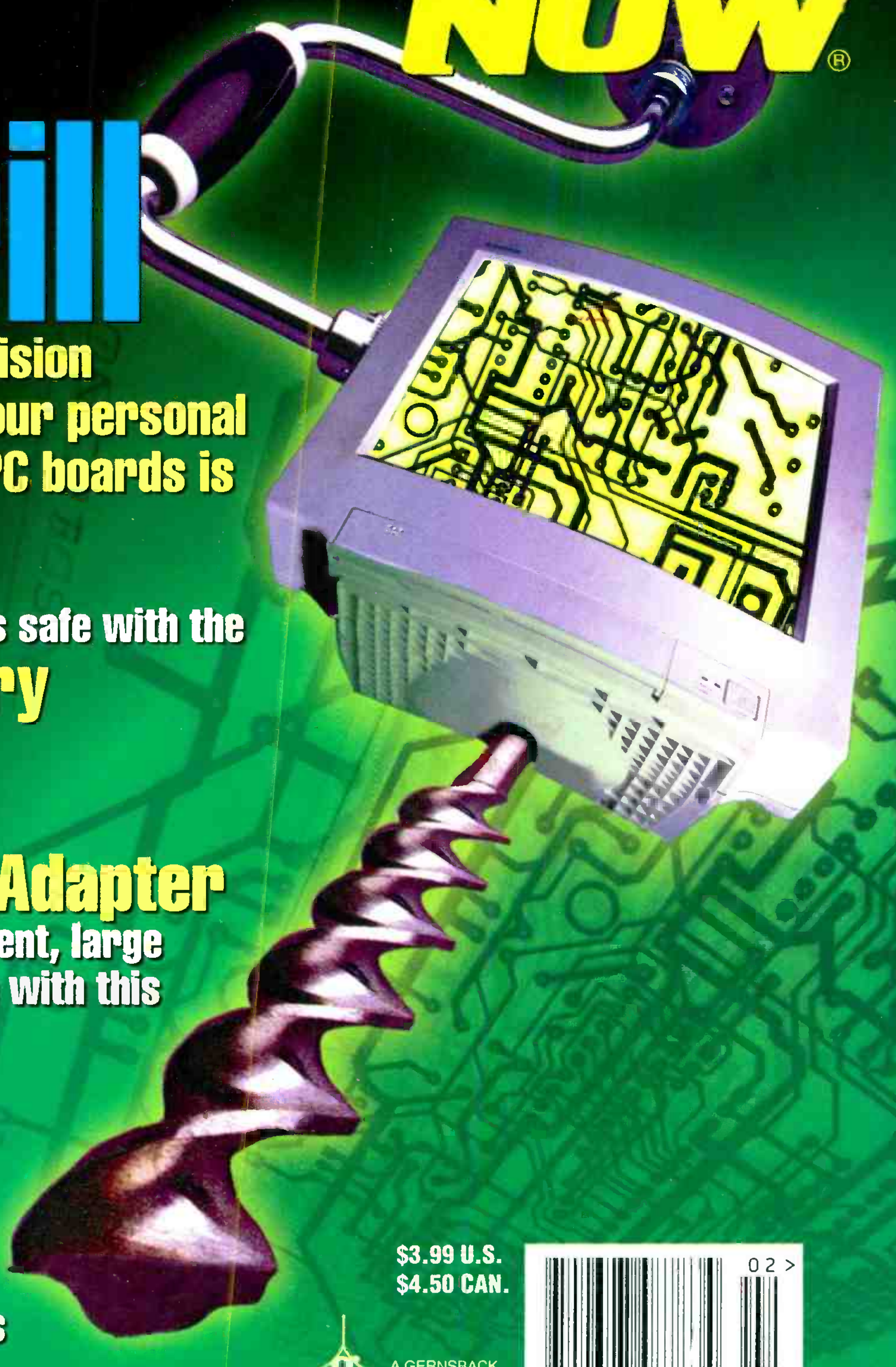

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Electronics NOW

Vol. 68 No. 2

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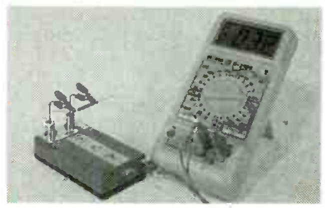
FEBRUARY 1997

ON THE COVER

Except when dealing with the simplest of circuits, electronics projects invariably turn out best when a PC board is used. The problem is that making the board is often more work than building the project itself. And if you need to make several of the same board, the task can get to be overwhelming. This month, we present a project that can simplify at least one part of the task. It is a precision x/y drilling table that lets you make perfectly centered holes on even the tiniest of pads. Best of all, at under $100 to build (including drill), it costs just a fraction of what a commercial unit would command. — *James J. Barbarello*

BUILD THIS

Keep your expensive frozen meats and other foods safe from disastrous thaws with this monitor that warns you before trouble strikes. — *Dave Sweeney*



Measure very large resistances, very small leakage currents, and more with this reliable, precision add-on for your DMM. — *Skip Campisi*

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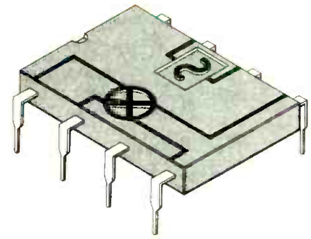
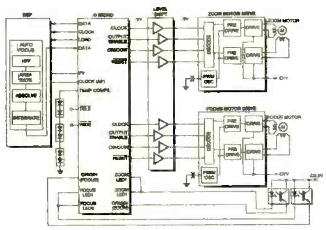
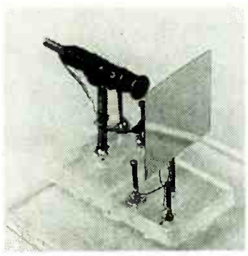


DEPARTMENTS





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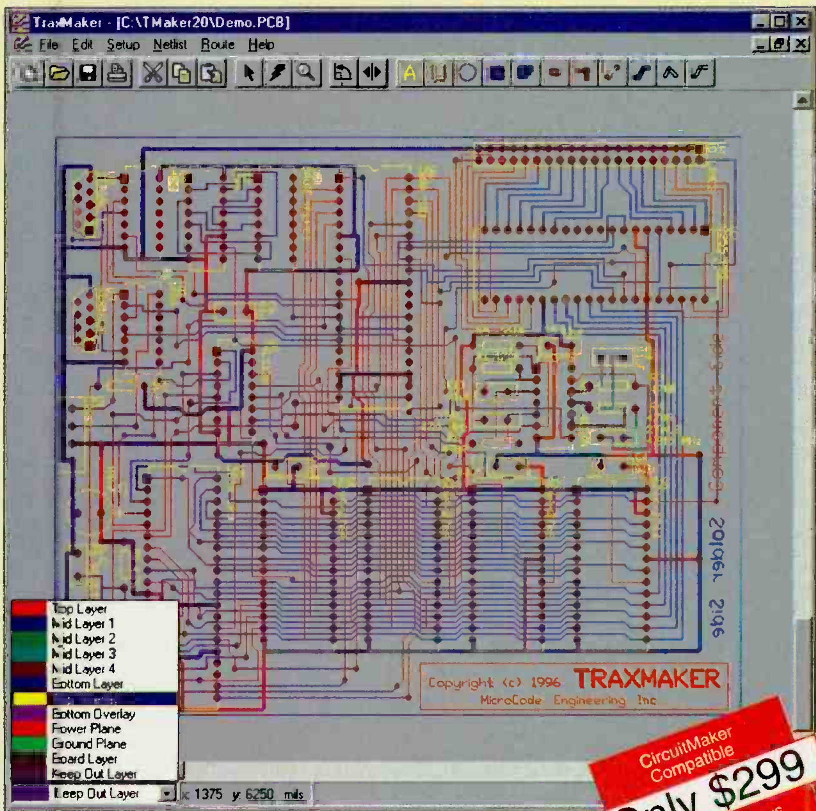

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EDITORIAL

One of a Kind

One of the nice things about this job is that you get to meet and work with some wonderful people. High up on that list is our *Video News* editor, David Lachenbruch. That's why the news that he had passed away suddenly, shortly after the last issue went to press, was such a shock and a loss to everyone here.

David was a rare writer. A true industry "insider," his ability to gather information and rumor from many sources, distill out what was correct and what was important, and bring that information to our readers in a concise, accurate, and readable format each and every month was unmatched.

The fact that he had done it for nearly 30 years, beginning with the *Looking Ahead* column in our predecessor, **Radio Electronics**, is nothing short of extraordinary. He was one of a kind and truly will be missed.

What of his column, *Video News*? Its future is undetermined. For the time being, it will be on hiatus. The search for David's successor has already begun. It will be a hard search, because David has left behind some big shoes to fill.

And even if those shoes are filled, the man himself can never be replaced.

Carl Laron
Editor

WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

No Risk in Ordinary EMF Exposure

According to the U.S. National Research Council, a 16-member panel that spent three years reviewing over 500 studies on electromagnetic fields (EMF), there is no evidence that exposure to ordinary household electric and magnetic fields causes harm to humans. There is an unexplained link, however, between living near large, high-current electric power lines and the incidence of childhood leukemia.

"Research has not shown in any convincing way that electromagnetic fields common in homes can cause problems," said Dr. Charles Stevens, head of the panel and a staff member at the Salk Institute in La Jolla, California. "Extensive laboratory tests have not shown that electromagnetic fields can damage the cell in any way that is harmful to human health."

As for the leukemia link, long-term effects have not been measured, and the possibility of other risk factors have not been taken into account. In light of those problems, the U.S. National Research Council committee reported that the findings "have been inconsistent and contradictory and do not constitute reliable evidence of an association [between EMF and leukemia]."

The committee's report provided no definitive answers to the questions of potential harm from EMF exposure. Other studies of the effects of EMF are under way. Congress has ordered a five-year, $65-million study into the possible relationships between EMF and breast cancer, nervous-system damage, and other health problems to be conducted at four federal laboratories. The federal government and the electric power industry are jointly funding another laboratory experiment in which biological samples will be exposed to electromagnetic radiation; unfavorable biological effects will be sought.

Electronics Engineers' Web Site

Eg3 Communications' Web site is a free resource for busy electronics design engineers. The EE Virtual Trade Conference (EE VTC) can be reached at http://www.eg3.com/vtc.htm. As part of EG3's Virtual Publishing Project, it is free to download, requires no registration, and is available worldwide via the Internet.

The EE VTC features more than 225 technical white papers on topics such as Object Oriented Programming, Virtual Distribution, DSP, the Set Top (Internet) Box, WWW for Embedded Systems, Embedded Java, Networking and Embedded Networking, Real-Time Operating Systems, and Designing with the 8051 or 68HC11.

As an experimental project, the EE VTC can be downloaded as a free software tool after registration, or it can be accessed at any of three Web sites: www.eg3.com, www.eetoolbox.com, and www.cera2.com. If you want more information, it can be obtained via e-mail at info@eg3.com.

Smithsonian Traveling Exhibition Web Site

The Smithsonian Institution Traveling Exhibition Service (SITES) has opened a World Wide Web site that lets people across the country click on a button to find the Smithsonian exhibit closest to them. The Web site, which can be reached at http://www.si.edu.organiza/offices/sites, gives viewers access to touring schedules, descriptions, and educational materials for SITES' many exhibits on art, history, and science.

"SITES' new Web page multiplies the possibilities of a 'Smithsonian Without Walls.' For the first time, viewers can peruse the Institution electronically and see when SITES exhibitions will be presented in their own communities," said SITES director Anna R. Cohn.

Viewers who check out the "Ocean Planet" page, for instance, not only see where that exhibit is traveling, but can also take a virtual tour of the show itself through a link to the Ocean Planet Web site (http://seawifs.gsfc.nasa.gov/ocean_planet.html).

Teachers will find the Web site especially useful. They can click on an "Exhibition Description" page, see when the exhibit will be in their area, view a sample curriculum guide, and locate their local Geographic Alliance Coordinators to request printed versions of the resource.

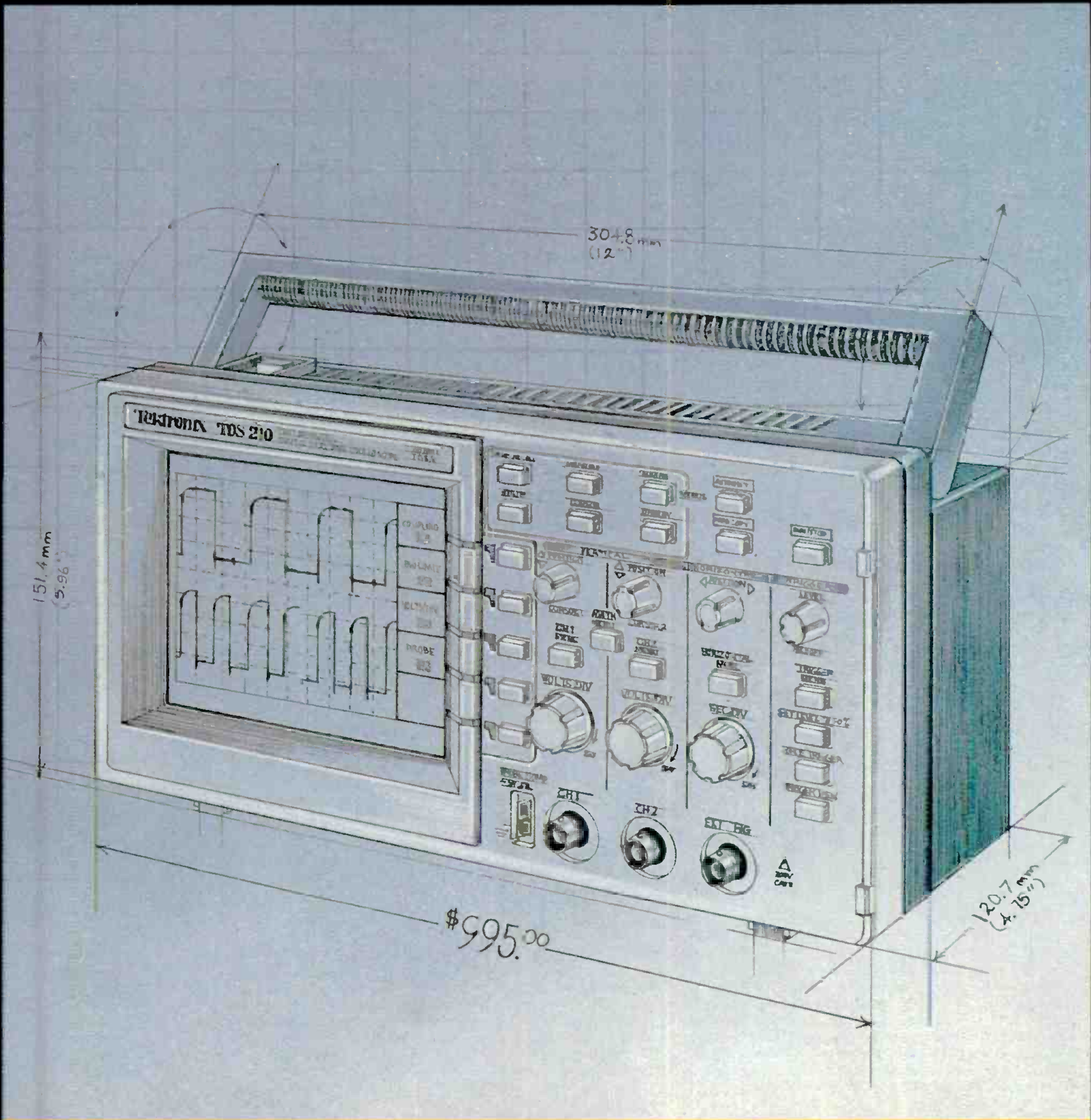
Each month, the "Hot News" page will be updated to provide an insider's view of SITES. Topics will range from in-depth articles on exhibitions and stories from museums and exhibit centers in the field to special features on new programs. The "Publications" page offers sales information about catalogs, brochures, and posters produced in conjunction with SITES exhibitions.

International Broadcasting Standards Task Force Formed

Senior executives of the Society of Motion Picture and Television Engineers (SMPTE) and the European Broadcasting Union (EBU) met last fall in Amsterdam to discuss technical matters—most notably, the need for a standardized means of data exchange.

With the increasing amount of computer-based equipment being used for television production, users require the ability to exchange audio, video, and associated data easily and reliably between different systems. The multiplicity of solutions, often proprietary, being implemented or proposed adds to the

continued on page 22



This digital scope is a major breakthrough no matter how you measure it.

It's never been easier to pick up a Tektronix digital scope. Just $995 will get you the 60 MHz TDS 210, while $1695 will get you its 100 MHz big brother, the TDS 220. Both come loaded with dozens of great features like triggering and automatic setup. They'll even store or recall your measurements at the push of a button. Yet despite all that, the actual scopes are as diminutive as their price tags. Making them easy to pick up in more ways than one. For more information, please contact your Tektronix distributor or call 1-800-479-4490, Action Code 313. Or, visit us at www.tek.com.

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Fan Speed Correction

I noticed an error in the schematic diagram for my article "Build This Fan Speed Control for Your Furnace" (**Electronics Now**, December 1996). Diode D2 should be shown connected across C1, and the ground terminal of IC1 should connect to the circuit's input terminal 4. I hope that this has not caused any inconvenience.—Anthony J. Caristi

7107 Update

We have become aware of several problems in the article "Using the 7107," which appeared in the November, 1996 issue. First of all, there is a mistake in the pinout of the device as shown in Fig. 1; pins 1 and 26 are reversed. The positive 5-volt supply should connect to pin 1, and the negative supply to pin 26.

*There are also some problems with several of the application circuits. Updated information and/or corrected drawings for Figs. 4, 5, 6, 9, 10, and 12 can be found on our FTP site (ftp.gernsback.com/pub/EN) in a file called 7107.zip. If you cannot access the site, the information can be requested by sending a self-addressed, stamped, business-size envelope to **Electronics Now**, 7107 Update, 500 Bi-County Blvd., Farmingdale, NY 11735.*

We are sorry for any inconvenience this might have caused.—Editor

Audio Musings

I'm writing to thank you for two very interesting, informative, and well-documented articles that appeared in the October 1996 issue of **Electronics Now:** "Where Has All the Good Stuff Gone?" by Gary McClellan, and Larry Klein's "Audio Update" column titled "Hi-Fi Fixes, Stealth Squeaks, and Bio EQ." The two articles, however, gave me the impression that many so-called audiophiles are becoming less interested in the quest for true sound reproduction and are leaning more toward nostalgia or some sort of status symbol.

I decided to listen to and compare for myself the sound of tube versus transistor power amplifiers. The tube amps were the Heathkit W5-M, a version of the once highly popular ultra-linear Williamson circuit, and the Harmon Karmon D1100A Festival, a 1956 receiver that uses a pair of 5881 tubes in push-pull. The solid-state unit was a Southwest Technical Products Corporation 215/A power amp, a 25-watt-per-channel version of their Tiger .01 (the original Tiger .01 appeared in the March 1973 issue of **Radio-Electronics**). Although the difference in sound quality was very small, I found that the 215/A solid-state unit had a more clear and pleasant sound quality, while the tube units were a little mushy. Tests with a sinewave audio generator, resistive load, and oscilloscope show that the tube amplifiers distorted at very low frequencies (sometimes as high as 30 Hz) at less than full rated power output. I suspect that is due to output transformer core saturation, because the more expensive transformers would go lower in frequency before the distortion occurred. Sadly, the Peerless output transformer in the Heathkit W5-M shorted primary to secondary. The Southwest Tech 215/A has been running 24 hours a day for almost 20 years. The only problem I have had was the power supply filter capacitors opening suddenly, causing a raucous buzzing sound.

Strangely, one of the latest trends in hi-fi has been the use of single-ended triodes, without the inverse feedback usually used to reduce distortion, to purposely accentuate second-order harmonic distortion. Because those amplifiers are very inefficient, low powered, horn-loaded speakers are often used with them. To obtain loud volume, speaker sensitivities must be about 100 dBa/1 watt/1 meter.

I agree with Mr. Klein that my music system, and other audio systems that I hear regularly, sound better some days than others. Although I think it is me, not the hardware, maybe the best way to determine for sure would be to have several critical-eared people listen at the same time and see if all or most hear the same changes in sound quality simultaneously. Frankly, I would like to see an audio system designed to produce the most clear and natural rendition of speech and music, using whatever technology is best, with minimum cost, complexity, and physical bulk. Unfortunately, I still find that it takes a 12-inch woofer, in at least a four-cubic-foot ported enclosure, to faithfully reproduce full, true, bass sounds.

Mr. McClellan mentioned that once the tube equipment is snatched up, older quality solid-state units will get big tickets. The early transistor amps sounded awful and were unreliable, even for their day. Furthermore, the germanium transistors used in the early models are now scarcer and more expensive than many tubes. The Southwest Technical Tiger .01 and other units of its vintage used a fully push-pull complimentary circuit, with controlled open loop gain. That was one of the most important breakthroughs in the history of high-fidelity transistor-amplifier design, and I think most current high-end models use some variation of it. Although Southwest Technical no longer makes electronic kits, the circuit can be scratch-built and is reasonably tolerant of transistor and power transformer substitutions. Maybe the Tiger .01 will become a hot collector's item someday.

MICHAEL KILEY
Midlothian, IL

EN

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

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

PIC Book Found

PIC microcontrollers are a "hot topic" right now, as that exciting new technology is becoming more and more accessible to experimenters.

In the November issue, a reader wrote to ask if there was a good introductory book on programming PIC microcontrollers. We've finally found one: *Easy PIC'n*, by David Benson. That 152-page paperback assumes you know some digital electronics but no assembly language. It demystifies PIC programming for beginners and includes many simple, complete example programs. The price is $29.95 plus $3.00 postage (and 7.25% tax if you live in California) from Square 1 Electronics, PO Box 501, Kelseyville, CA 95451.

Groundless Audio?

Q *The specifications of my Audiovox car stereo read: "Output wiring: Floating-ground type designed for 4-speaker use." Why am I warned to never ground the negative output wires? Why is it that when using only 2 speakers (instead of 4) I can splice together the positive wires for the front and rear speakers without shorting out?—M. G., McAllen, TX*

A Figure 1 shows the basic idea: Each stereo channel has an amplifier with two output stages that produce exactly opposite waveforms. One output stage goes to each side of the speaker. During an audio cycle, each side of the speaker swings positive, while the other swings to 0 volts. As a result, the speaker cone can undergo 24 volts' worth of movement even though the car stereo uses a 12-volt supply. The amplifier would be damaged if either of its outputs were shorted to ground.

You can't parallel the left and right channels because one of them might be swinging high while the other is swinging low. But you can join the corresponding speaker wires for front and rear left or front and rear right, because the front and rear speakers carry exactly the same signal; in fact the signal is divided up between them after it leaves the amplifier.

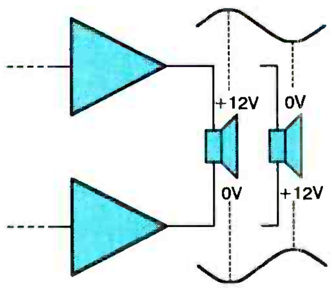

FIG. 1—IN A "FLOATING-GROUND" output stage, the two sides of the speaker are driven with opposite waveforms; neither side of the speaker is grounded.

Op-Amp Testing

Q *In electronics school, we discussed op-amps but not how to test them. Can you explain how to test them? I already know the theory behind them.—R. A., Los Lunas, NM*

A The circuit in Fig. 2 is a simple "dead or alive" test for an op-amp. It's an oscillator that produces a 1500-Hz squarewave, audible as a tone in the speaker. By looking at the output with an oscilloscope, you can measure the rise time. Several op-amps can be tested at once by cascading them as shown in the diagram. That would be a handy circuit to build in a small plastic case with sockets for common single, dual, and quad op-amps.

The other op-amp parameter that you're likely to want to measure is noise. The best way to do that is build the circuit you're interested in (such as an audio amplifier) with a socket for the op-amp, then try various types. If you do that you'll find that the TL071 and TL081 outperform the old 741 in practically all applications.

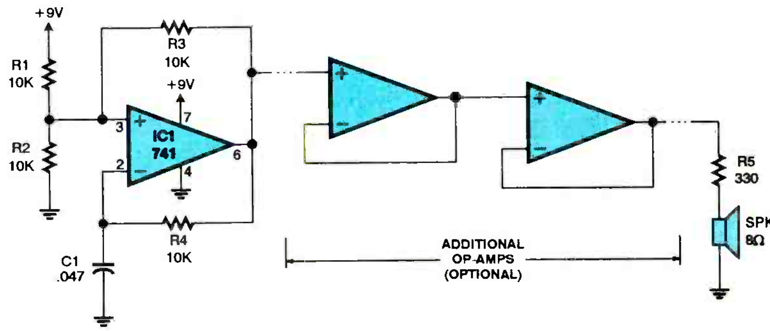

FIG. 2—THIS OP-AMP TESTER generates a 1500-Hz tone in the speaker. Any number of op-amps can be cascaded for testing at the same time.

Fan On Demand

Q *I am designing a circuit to monitor the temperature of a heat sink and proportionally control the speed of a 12-VDC fan. I plan on using an LM34 precision temperature sensor. I would like to find a circuit to convert the output voltage from the LM34 to a change in duty cycle to control fan speed through a driver stage.—N.G., Amherst, NY*

A The precision offered by a silicon temperature sensor is not needed in this application. Figure 3 shows a circuit that we breadboarded using a conventional 10K thermistor. The motor is fed with pulses whose duty cycle goes from 34% at room temperature (the mini-

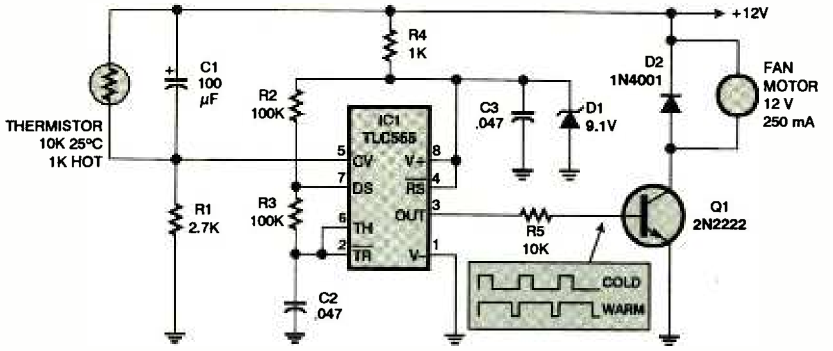

FIG. 3—THE SPEED OF THE FAN MOTOR increases as the thermistor gets warmer. The motor is fed with pulses whose duty cycle increases from 34% to 100%.

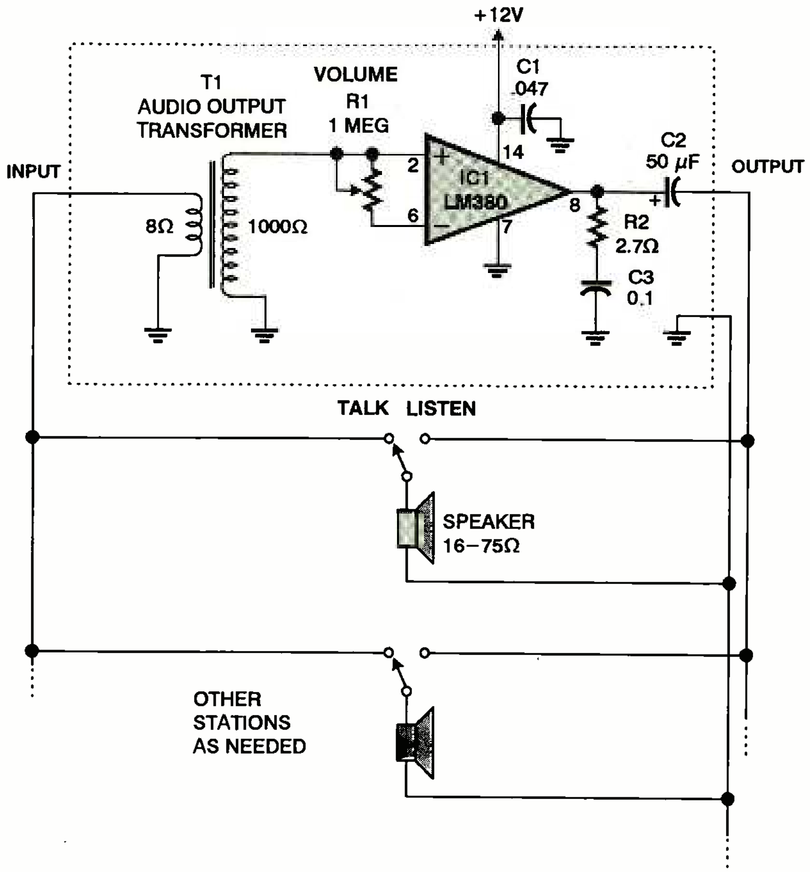

FIG. 4—TAKEN FROM A NATIONAL SEMICONDUCTOR application note, this intercom circuit is built using the LM380, though it could be easily adapted to use other op-amps. Additional stations should be wired in parallel with those shown.

mum that will run the motor reliably) to 100% at high temperatures.

The circuit design involves two subtleties. First, the TLC555 runs off its own 9.1-volt supply, regulated by a Zener diode. That ensures that the maximum control voltage from the thermistor circuit (about 9 volts) will indeed produce a 100% duty cycle. Second, the 100-μF capacitor across the thermistor simulates a high temperature for a few seconds when the circuit is turned on to ensure that the motor will start.

Make sure the fan is powerful enough to maintain the temperature you want. Otherwise, it will run all the time and temperatures will still be too high. To adjust the temperature at which the system stabilizes, change R1.

Design An Intercom

Q *I'm building a new house and would like to install a hard-wired intercom system. I've tried using 741 op-amps as well as the LM386 audio amp, and neither gives a high enough volume level to be heard comfortably. Can you help me out with this?—J. G., Royal Oak, MI*

The 741 isn't powerful enough to drive a speaker, and the LM386 is only barely so; you might want to use a more powerful amplifier chip. But your main problem is that you need more amplification and better impedance matching.

Most intercoms use speakers as microphones for two reasons. First, it allows each speaker to do double duty, so that each station doesn't need a separate microphone. Second, the low impedance of the speaker keeps the wiring from picking up crosstalk or radio interference.

But when you use a speaker as a microphone, the resulting signal is at a very low level (about 1 millivolt). You can step it up with an audio-output transformer working backward at the input to the amplifier. The transformer also matches the low-impedance speaker to the high-impedance input.

Figure 4 shows an intercom circuit based on National Semiconductor's data sheet for the LM380 audio amplifier; you can modify it to work with other ICs. With the LM380, be sure to keep all leads short, mount the 0.047-μF capacitor as close to the chip as possible, and glue a heat sink to the IC itself.

Distortion-Free CRT?

Q *A colleague tells me that no one has been able to manufacture a picture tube that produces an undistorted picture. Is that a real concern? Is it going to hold up HDTV?—R. A. E., Alfred Station, NY*

A Distortion is defined as an unwanted change in the shape of a picture, such as when straight lines become curved. You're probably familiar with pincushion distortion (sides of a rectangle bent inward), barrel distortion (sides of a rectangle bent outward), and keystoning (images wider at the top than at the bottom, or vice versa).

Most large CRTs inherently produce quite a bit of distortion, but the distortion is corrected electronically so that the image comes out correct. The sweep signals are made nonlinear in a way exactly opposite to the nonlinearity of the CRT. Computer users don't tolerate distortion, and computers use even higher video resolutions than HDTV. Basically, it's a solved problem, so don't worry about it.

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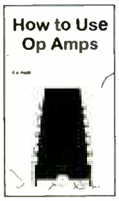
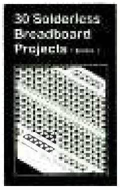
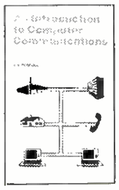


☐ **BP88—How to Use OpAmps...$5.95.** A designer's guide that covers operational amplifiers. Serving as both a source book of circuits and a reference book for design calculations. The text is non-mathematical and easy to understand by most readers.



☐ **BP113—30 Solderless Breadboard Projects-Book 2...$5.95.** Companion to BP107. Presented in exactly the same style using "Verobloc" breadboards. All the breadboard projects in this book are based on CMOS logic integrated circuits.



☐ **BP177—Introduction to Computer Communications...$5.95.** Details on types of modems and their suitability for specific application, plus details of connecting various computers to modems, and modems to the telephone system.

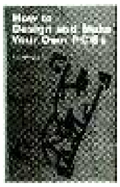
☐ **BP350—Electronic Board Games...$6.00.** Twenty novel electronic board games that you can build from the plans in this book. Some games are motor racing, searching for buried treasure or for gold in Fort Knox, — there is something for you to build and enjoy!

☐ **BP61—Beginners Guide to Digital Techniques...$5.00.** Covers the basics of digital techniques—decimal, binary, octal and hexadecimal numbering systems are covered plus insights on weighted and non-weighted binary-coded-decimal codes and alphanumeric codes. The basic building blocks of circuit logic, the common AND, OR, NAND, NOR and EXCLUSIVE-OR gates and bi-stables are thoroughly covered.

☐ **BP285—A Beginners Guide to Modern Electronics Components...$6.50.** It is easy for newcomers to electronics to become confused. There are a great many different types of components available often with numerous variations of each type. This book presents the reader with a vast amount of invaluable parts information to enable the right component to be selected every time for repairs and projects.

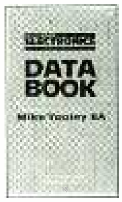
☐ **PCP103—Practical MIDI Handbook...$9.95.** The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding. This book is aimed at musicians and technicians who want to explore the vast capabilities of MIDI. It covers MIDI-based equipment you can use: keyboards, drum machines, sequencers, effects units, mixers, drum pads guitars. There's also a section on computer music.

☐ **PCP119—Electronic Music and MIDI Projects...$14.95.** Save cash by building the MIDI gadgets you need. Want a MIDI Thru box, program change pedal, Metronome, analog echo unit? Over 16 practical and very useful music and MIDI projects.



☐ **BP121—How to Design and Make Your Own PCBs...$5.75.** Simple methods for copying printed-circuit board designs from magazines and books on to copper. Covers all aspects of simple PCB construction as comprehensively as possible.

☐ **BP44—IC 555 Projects...$5.95.** Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer integrated-circuit chip is one such device. Included are basic and general circuits used by most hobbyists.



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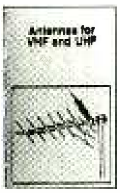

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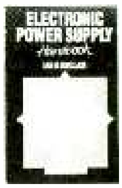

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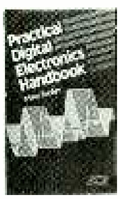

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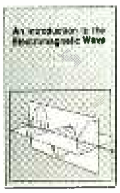

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EQUIPMENT REPORTS

RADIOSHACK PROBESCOPE PROBE-STYLE OSCILLOSCOPE

A hand-held, probe-style combination oscilloscope and DVM that can be used with a personal computer for detailed and expanded measurements.

CIRCLE 15 ON FREE INFORMATION CARD

The RadioShack ProbeScope Probe-Style Oscilloscope is a microprocessor-controlled oscilloscope and digital voltmeter combination housed in a small probe-style case with a backlit, miniature, liquid-crystal display (LCD). All oscilloscope parameters are menu-driven and selected by pressing one of two pushbuttons on the unit. You can quickly set all parameters while looking at the point of measurement, the probe's controls, and the display on the probe, which eliminates the need for any head movement. However, when cabled to a PC, the unit's measurement and display capabilities are greatly expanded.

In its oscilloscope mode, the ProbeScope offers the following features:

•*Ten Selectable Sampling Rates*—Displays measured signals in a wide variety of waveforms, from a small fraction of a waveform to multiple waveforms.

•*Multiple Trigger Sources*—The oscilloscope starts a measurement using either an internal or an external trigger.

•*Six Selectable Trigger Levels*—Selects both rising and falling signal events at different levels to trigger the sweep.

•*Selectable Input Voltage Ranges*—Selects the range of the measured signal for the most accurate readings.

•*Selectable Input Coupling*—Selects either DC- or AC-coupling of the signal to the oscilloscope, and provides a zero reference for zero adjustment.

The unit requires 9-13-volts. That can either be taken from the circuit under test or from an optional AC wall-plug adapter.

Probably its single most important feature is that the ProbeScope can be interfaced with your personal computer for displaying and recording measurements. The required software and an interface cable are provided in the package. To use ProbeScope's software with Microsoft Windows, you must have a computer with at least 80386 CPU, 400K bytes of available hard-disk storage space, and Windows 3.1 or later. To use ProbeScope's software with MS-DOS, your computer must have at least 800K bytes of available hard-disk storage space and DOS Version 3.3 or later.

Using the Instrument

The unit is controlled via tiny pushbuttons on the body's side. The Menu button, for example, is used to select between different operating modes, to select functions within each mode, and even to turn on the backlight on the unit's tiny LCD display.

When in the Oscilloscope mode, the Menu button is used to select the unit's sampling rate. The rate can be selected between 50 nS and 1 mS in ten steps.

On the LCD, the timebase displayed is the actual sampling rate—the rate at which measurements are taken—and is in seconds. On the computer display however, the timebase shown depends on whether or not you select a grid overlay to appear (via software—more on that later). If it is not selected, the timebase displayed is again the actual sampling rate and will exactly match that on the LCD. If the grid is displayed, the timebase on the computer's display is 10 times the LCD's sampling rate and is shown in seconds per grid division (the same as on a standard oscilloscope).

The user can also select an auto, internal or external trigger source. The trigger-source selection determines how a received pulse or signal is to be monitored or measured. The selectable trigger sources are:

•*Auto*—The ProbeScope continuously measures and records signals each time a trigger occurs regardless of its level (higher, lower, or equal to the incoming signal).

•±*External*—The ProbeScope records signals only when the defined trigger event occurs. The signal is recorded when the trigger level is equal to the incoming signal and moving in the selected direction(±). The trigger level is equal to the voltage present at the external trigger jack.

•±*Internal*—The ProbeScope records signals only when the defined trigger event occurs. The signal is recorded when the trigger level is equal to the incoming signal and moving in the selected direction(±).

The trigger mode is also selectable and determines when a new measurement is to be taken and displayed. There are two available trigger modes. The *run* mode records a new signal every time the defined trigger event occurs. That mode is used to measure or monitor a continuously running signal. The *single* mode records a new signal each time you press the *select* button and the defined trigger event occurs. That mode is used to measure or monitor a signal that occurs only once, such as a noise pulse.

Using the DVM

When the unit is placed into its DVM mode via the menu, it can be used to measure AC and DC voltages. In the AC mode, the ProbeScope rectifies the AC signal to convert it to DC. The DC is then converted to a digital value by a six-bit A/D converter and then multiplied by

0.707 to display the rms value. Since the unit does not measure true rms, any AC reading will be accurate only if the input signal is a relatively pure sinewave and at least two cycles of a waveform are measured. If you need to measure an AC signal on a DC bias, use the oscilloscope mode.

In the DC mode, the DC is directly converted to a digital value by the six-bit A/D converter. An average of up to 128 recorded values appear on the screen. A negative value is displayed when the average is below the reference line.

ProbeScope Software

While the unit can be used as a stand-alone instrument, when interfaced to a computer it begins to really shine. After you start the included ProbeScope V4.1 for Windows/DOS software, icons appear on your PC monitor's display. (You can also access the functions using keyboard shortcuts.) With the aid of icons, you can open an existing ProbeScope document, save the active document, and enter comments about the current ProbeScope document. Icons also let you show and hide the oscilloscope screen's grid, vertical cursors, horizontal cursors, and trigger-level line and more. The software makes this among the easiest-to-use pieces of test gear around.

We've barely scratched the surface of the RadioShack Probescope Probe-Style Oscilloscope's many features. In short, it offers many of the capabilities of more expensive conventional scopes, but at $99.99, it costs just a fraction of their price. For more information on the unit, contact RadioShack (One Tandy Center, Ft. Worth, TX 76102) directly, or visit your local RadioShack store. EN

Q&A

continued from page 14

Erratic Flip-Flops

Q *I designed a circuit using 7473 flip-flops as ripple counters. The input was from a Hall-effect device at about 1 Hz. The whole circuit was on a solderless breadboard inside a steel box. But the performance was not acceptable because it would skip counts or reset at various points. What steps could be taken to avoid those glitches?—V. N. H., Ephrata, PA*

A When working with TTL flip-flops, take these precautions:

(1) Ensure a clean power supply by putting a 100-µF filter capacitor on the circuit board and a 0.1-µF capacitor across the power supply terminals of each IC.

(2) Never leave any TTL inputs disconnected. A disconnected input is "logic high," but is very sensitive to noise. To protect it, connect it to +5V through a 10K resistor. With CMOS chips (74C, 74HC, 74HCT) you can connect inputs directly to +5V.

(3) Make sure the signal triggering the flip-flop has a good, fast rise time. Run it through a 7413 or similar Schmitt trigger to ensure that it switches on and off cleanly.

CCD Video Hacking

Q *I've been thinking about trying to build a video scanner to interface with a computer, but I can't find much information about charge coupled devices (CCDs). Could you direct me to a book that might go into some detail about the subject?—J. G., Bens Run, WV*

A A charge-coupled device (CCD) is a semiconductor device that picks up images optically; it's what video cameras use to pick up the image. In effect, a CCD is an array of thousands of silicon photodiodes, each of which stores a charge that depends on the amount of light that has reached it. The charges are then read out one at a time, in sequence, to create a video signal.

The most interesting CCD experiments right now are being done by amateur astronomers, many of whom build their own CCD cameras and write their own software. By using longer exposure times than a conventional camcorder, they get spectacular images of faint galaxies and nebulae. Even if you're not interested in astronomy, you'll find their storehouse of CCD knowledge useful. Write to Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235, and ask for their catalog of books about building CCD cameras. Also look for *CCD Astronomy* magazine on newsstands or you could write to the publisher directly at 49 Bay State Road, Cambridge, MA 02138.

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.

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

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

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

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1991 only) are available from Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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

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

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, Box 637, Spanaway, WA 98387.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including Radio Shack 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.

Writing to Q&A

As always, we welcome your questions. The most interesting ones are answered in print, usually within nine months. Please be sure to include plenty of background information (we'll shorten your letter for publication). If you are asking about a circuit, please include a complete diagram. We regret that, due to the volume of mail, we cannot give personal replies. EN

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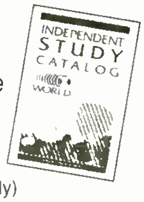

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WHAT'S NEWS

continued from page 6

problems experienced by the entire motion-imaging community.

Although they do not want to limit the variety of available products, the EBU and SMPTE would like to establish an agreed-upon method to move television signals within the production chain, which would provide a surer basis for consumer choice and encourage a variety of solutions without putting limits on innovation in product design. The two organizations have identified four areas in which a single option, or at least transparent gateways between different options, are of vital importance to users. Those are compression algorithms, file formats, multiplexing of components, and interfaces.

The SMPTE and EBU have established a joint task force to formulate a definitive list of user requirements against which proposed solutions can be measured. Task force meetings will alternate between Geneva and New York. All interested parties active in these areas are invited to participate. The task force expects to have its initial report completed by April 1997.

FCC Auctions Open Interactivity Opportunities

FCC auctions of Local Multipoint Distribution Service (LMDS) spectrum, scheduled for the end of 1996 and beginning of 1997, open the door for new interactive consumer applications. LMDS satellite systems can be used to provide a host of services, ranging from videoconferencing to messaging to wireless handheld voice and data systems. LMDS auction winners will have an easy, flexible entry into wireless, two-way, broadband interactive video, local telephony, and data services delivery.

The LMDS spectrum—found in the 28-GHz band—is especially attractive to cable operators as well as to telephone companies (also known as local exchange carriers, or LECs) because it provides a way to compete with the successful and quickly growing direct-broadcast satellite (DBS) services, such as DSS. LMDS offers operators a broadband digital connection that can be used locally. LMDS is expected to create more telephony competition as customers are offered an alternative to standard telco services. LMDS offers greater flexibility than its counterpart Multichannel Multipoint Distribution (MMDS) frequencies, allowing operators to use the spectrum for whatever services they want to offer.

Texas Instruments already has announced plans to offer a digital LMDS platform, and Hewlett-Packard and Motorola are expected to follow suit in the near future.

Before the auctions can take place, however, the FCC faces a major decision: Should LECs, be allowed to bid for licenses in their operating areas? A decision in their favor would allow local telcos to compete in video delivery—some say with an unfair advantage—with cable television operators. The FCC also must decide whether more than one full-service LMDS operator should be allowed in a single area. EN

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BY FRANKLIN J. MILLER

Design and Use of Microphone Splitters

MY COMPANY (SESCOM) HAS BEEN BUILDING AND SELLING MICROPHONE SPLITTERS TO INDUSTRIAL USERS, RADIO AND TV BROADCASTERS, SOUND-SYSTEM USERS, AND THE GENERAL PUBLIC FOR MANY YEARS. THE FIRST DESIGN THAT WE offered was the single-input/dual-output equal-winding transformer shown in Fig. 1. You can see that it has only one electrostatic shield shared between the two outputs and one input. The transformer was built into a sturdy metal box and marketed as a Sescom model MS-1. It was also sold as a model 66J0036 audio transformer. The full schematic of the unit is shown in Fig. 2.

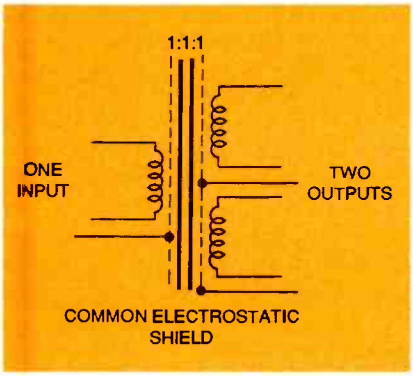

FIG. 1—THIS SINGLE-INPUT/DUAL-output transformer was one of the first microphone splitters the author designed.

A ground-lift switch was placed in the output circuit to help eliminate ground loop problems. Using that switch to open the ground connection does indeed help when ground-loop problems occur; unfortunately, it could also cause other problems. Those appear when any RFI (radio-frequency interference) or EMI (electromagnetic interference) signals are present. RFI problems are usually caused by radio transmitters, while EMI problems are generally traced back to electronic dimmers or motors. Either type of interference is not rare, and we've all run across them at one time or another.

Therefore, a new and improved version had to be developed to solve those problems once and for all. The solution we came up with was to install separate electrostatic shields for each winding, as shown in Fig. 3. With that setup, there are no ground connections between any of the windings, which solves the RFI and EMI problems. If any interference signals do appear in the input winding, they would have a path to ground via the AC coupling of the electrostatic shields. Those shields act as capacitors whose capacitive reactance is small and out of the audio band; they react only at the higher frequencies—just what we need to do the job.

That unit is wired as shown in Fig. 4. Note that there are no ground-lift switches in this circuit. With the new design we found that they were unnecessary more than 99% of the time. Rather than over-design our product with seldom-used features, the switches were intentionally left out. An external ground-lift switch or connector assembly could be easily added in those very few remaining instances where one was needed.

Other Problems, Other Solutions

Of course, when it comes to audio, few solutions are ever final. A new ground-loop problem did arise. It turned out to be related to the Switchcraft QG 3-pin audio connectors that were being widely used. A feature that made that connector unique was the ground solder lug that contacts the shell. Some people

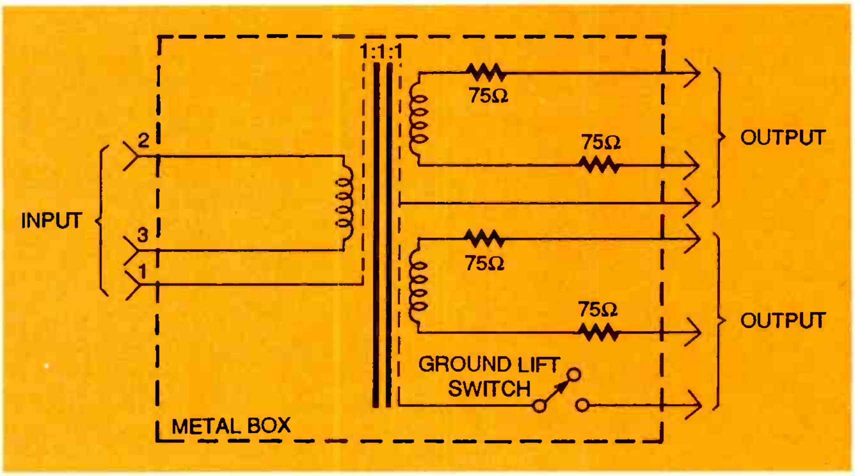

FIG. 2—THE TRANSFORMER SHOWN in Fig. 1 was installed in a metal box and a ground-lift switch was placed in the output circuit to eliminate ground-loop problems.

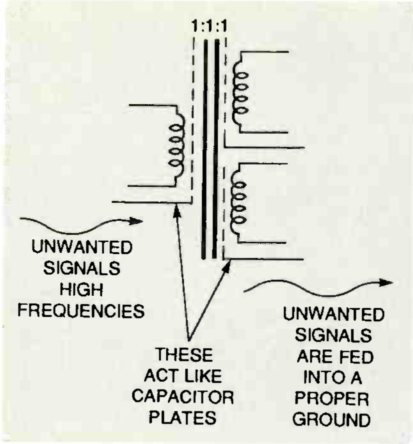

FIG. 3—USING SEPARATE electrostatic shields provides protection against most RFI and EMI signals.

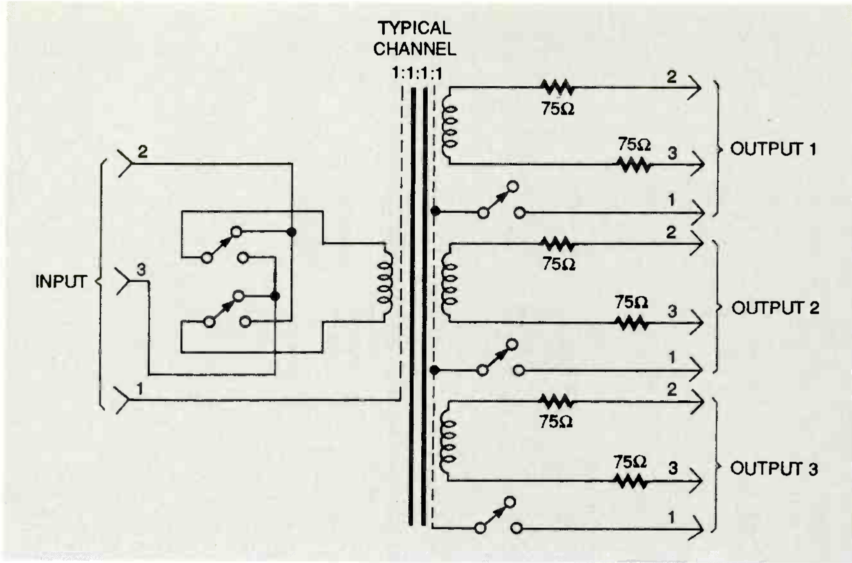

FIG. 5—PHASE-REVERSAL SWITCHES and separate ground-lift switches were used in microphone splitters of the 1970s.

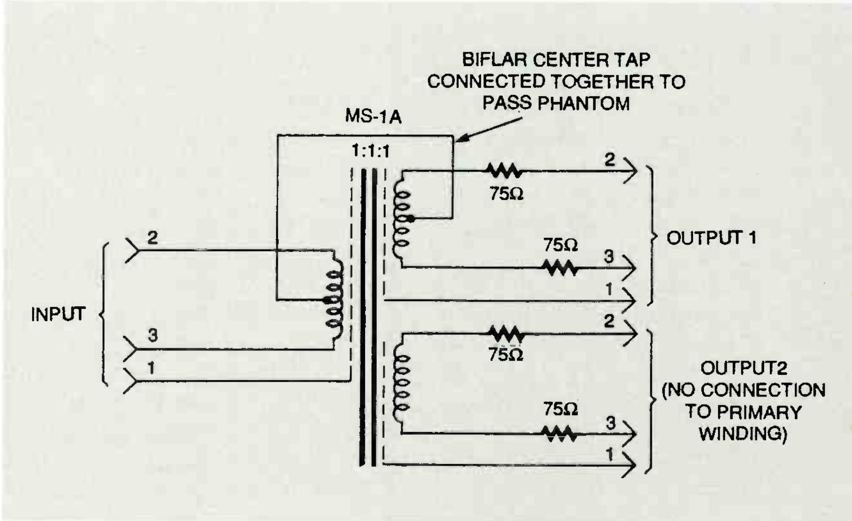

FIG. 6—TO AVOID THE NEED for an additional power source, this splitting transformer was developed to pass the phantom voltage to the microphone.

made audio cables with the shield of the cable tied to pin 1 and the ground lug. Of course doing that makes the male-female cable connection RF proof, but it also makes it impossible to break the ground connection by lifting pin 1 in the box. Fortunately, a better solution appeared in the form of all-plastic male and female connectors that have no possible electrical connection from pin 1 to the shell unless you make it yourself.

In the early 1970s, we began to manufacture splitter boxes with phase-reversal switches on each input, and separate ground-lift switches; called the Sescom 9 x 3 Mike-Splitter, it is shown in Fig. 5. Those units were built in a three-rack version (5¼ inches) with nine sets of inputs and three outputs. The unit was popular with sound-rental companies that needed many splits on a temporary basis.

One consideration with that splitter is that it would not pass phantom voltage to the microphone from the main supply. That meant that if electret condenser microphones were to be used, a separate power supply would be needed before the splitter. That could be a costly solution for the user.

Another version of the splitting transformer had to be designed to solve that new problem. Figure 6 shows the circuit that was developed. The product was marketed as our MS-1A. To meet the demand, other versions of the MS-1A were designed and built with four and even eight inputs.

Today, the newest versions of the microphone-splitting transformer boxes use printed circuits for greatest possible reliability. It also lowers the cost of construction. The previous versions are still being manufactured so that users can still design their own systems.

The Future

What comes next in microphone-splitting technology? One possibility is the use of special materials to improve the tonal quality. However, such improvements would only be incremental and in some cases not even measurable.

More noticeable would be the improvement that could be achieved using digital technology. Using A/D converters, the analog audio could be converted to a digital signal; they could then be distributed without any loss to various devices, where they would be converted back into their original analog form.

Only time will tell what the future will bring. The only thing certain is that right now, there is a bright young engineer out there with an idea that no one else has thought of yet! Maybe it is you! EN

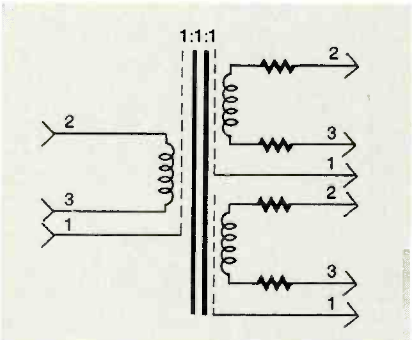

FIG. 4—THE TRANSFORMER SHOWN in Fig. 3 is wired as shown here. Note the lack of ground-lift switches; with this design they are not needed 99% of the time.

BY JEFF HOLTZMAN

Microsoft's Biggest Enemy

MICROSOFT IS IN HOT WATER AGAIN. ONE ISSUE CONCERNS ALLEGATIONS ABOUT STRONG-ARM TACTICS USED BY THE COMPANY TO PROMOTE USE OF ITS LATEST WEB BROWSER, INTERNET EXPLORER 3. THE OTHER ISSUE CONCERNS technical and marketing differences between NT Workstation and NT Server.

I don't have much to say about the browser issue, except that the Netscape people must be getting awfully nervous. Anybody remember a company called WordPerfect? What about Novell? Or Lotus?

The NT issue is more interesting. It appears that the core code of the workstation and server versions of NT 4.0 are essentially identical. In fact, Andrew Schulman (whose *Unauthorized Windows 95* is required reading for anyone who really wants to understand the details of how DOS still lives in Win95) noticed that doing a binary file compare on the kernel files (KERNEL32.DLL) of the two versions produces no differences. I have personally verified that the two files are identical. In fact, the OS versions distinguish themselves by entries in the system registry that affect start-up configuration.

One trade journal has blown its stack (so to speak) over the issue, because a top technical editor had questioned senior Microsoft officials in detail on that very issue, and was lied to. At the time, Microsoft claimed that common source code was used to generate both versions, but different compilation switches (using IFDEFs) were used to distinguish them, thereby generating "completely different" code. I'm not sure whether the publication in question was more angry about the substance of the lie or about being lied to, but I suspect it was the latter.

As I see it, there are two questions: 1) Are NT customers somehow being cheated? 2) If senior Microsoft officials lied to one of the industry's top two trade journals, can we trust anything the company says?

The brief answers: No and no.

Actually, there are several other interesting questions: What are the magic registry settings, and what must be done to get NT Workstation to function as NT Server? I fully expect those questions to be answered by the time this column reaches print.

Also, if Microsoft lies outright to the press, and indirectly to its customers, do its customers in turn owe the company anything better? I wouldn't presume to try to prescribe the behavior of other people. But I suspect that there will be a backlash. An increasingly alienated public will view Microsoft's behavior as justification for obverse kinds of abuses—such as publishing and using said registry settings.

I can draw but one conclusion from all this: Microsoft's biggest enemy is not Novell, or IBM, or the Federal Department of Justice, or . . . you name it. Microsoft's biggest enemy is . . . Microsoft.

Maybe what the company needs to

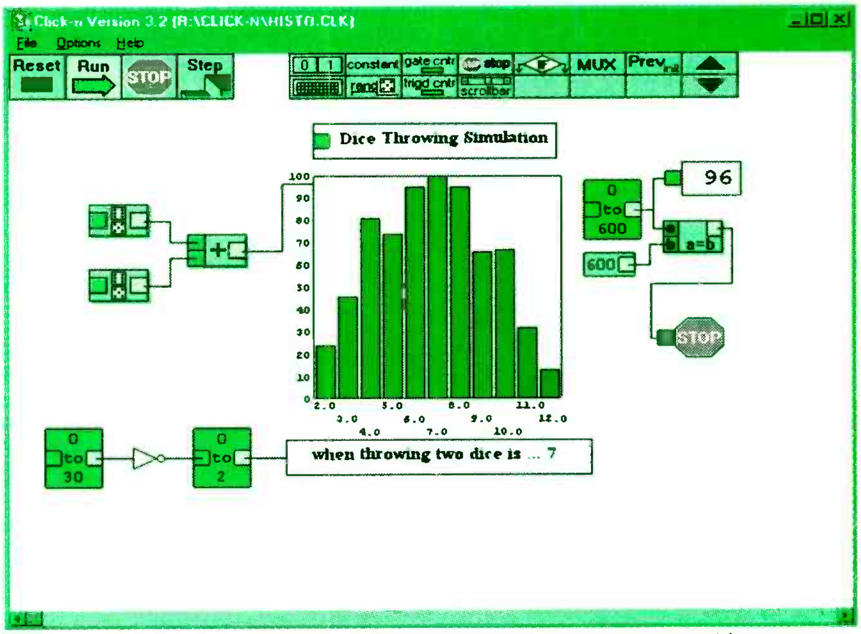

FIG. 1-CLICK-N IS A FREEWARE SIMULATOR that's both educational and fun. Here you can study probability with a dice-throwing simulation.

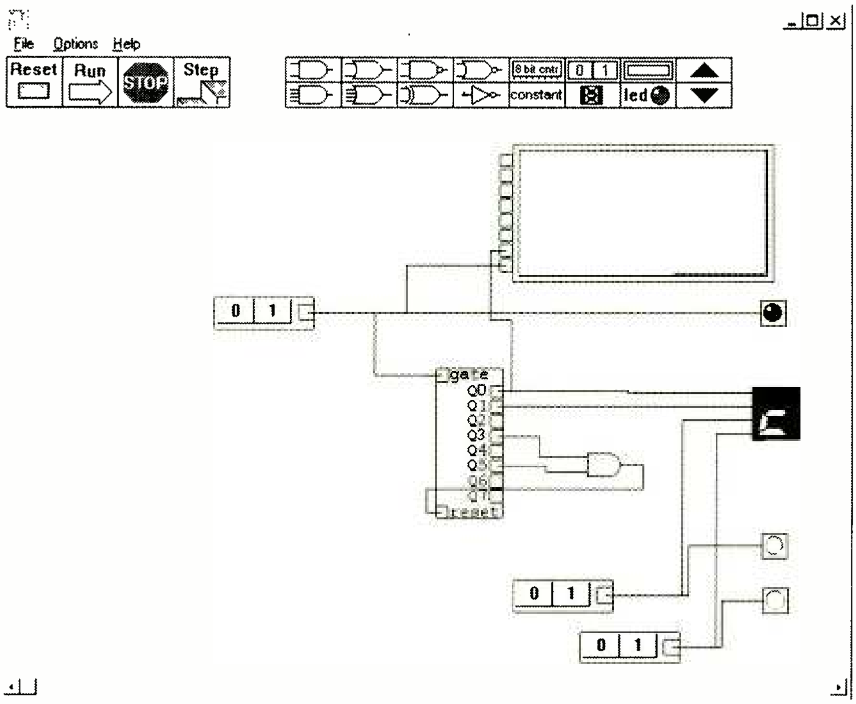

FIG. 2—HERE, CLICK-N is used to simulate a circuit and monitor its response.

learn is the old Middle Eastern saying: "The enemy of my enemy is my friend."

Click-N

Yes, it rhymes with Quicken, and no, it won't balance your checkbook. As a matter of fact, Click-n is a simulator of sorts. It's not a finished product, it's buggy, and it crashes easily and unpredictably. Despite its faults, however, Click-n is a lot of fun—and educational, too.

Click-n gives you a drag-and-drop way to create logic circuits and other types of discrete simulations. The program provides more than 60 inputs, outputs, functions, and controls. Inputs include random-number generators, scroll bars, keypads, and limited keyboard input. Outputs include 2D and 3D graphs, an eight-channel logic analyzer, a four-channel oscilloscope, a histogram, seven-segment LEDs, and discrete LEDs. Functions include logic blocks (AND, OR, NAND, NOR, XOR, NOT, and quad-input AND and OR) and mathematical functions (add, subtract, multiply, divide, sin, cos, sqr, inverse, power, max, min, and more).

To create a simulation, you drag components from a palette to a workspace. Next you connect outputs to inputs as desired, and then click the Run button. You can vary run speed, and single-step through a simulation. A couple of sample simulations are shown in Figs. 1 and 2.

The program includes several interesting and entertaining examples, including a game of sorts that randomly bounces a space ship and a ball around a rectangular area. Whenever their paths intersect, the spaceship blows up with both audio and visual effects.

Here are a couple of hints: 1) There is a trashcan icon for deleting components, but the mouse is restricted from reaching it. Instead, you can simply drag components off the bottom of the workspace. 2) Save often.

Why not give Click-n a try. You can get it from the author's (Ray Wilson) home page (www.csd.net/~rayw). Incidentally, version 3.2 was available when this was written; the author's home page hints at updates, though there were none all summer.

File-Print Utility

About ten years ago, I picked up a little printing utility called LJ2 from some BBS. The purpose of LJ2 is to print text files sideways, two pages per sheet, on an 8.5- × 11-inch sheet of paper. For years the utility worked fine with my trustworthy LaserJet II. But when I upgraded to a new printer (an Apple LaserWriter 360F), LJ2 stopped working. Rather, its pagination went *gaga.* The 360 is basically a PostScript printer with built-in PCL emulation, and the ability to switch between PCL and PostScript modes automatically. PCL is Hewlett-Packard's printer control language.

The print utility came with the source (in C); contributors included Joe Barnhart, Ray Duncan, Chip Rabinowitz, and Steven Stern. I thought it would be worthwhile fixing good old LJ2.

I did fix it, and updated the source to be compatible with modern file manipulation conventions, not to mention C syntax. The result is available on the Gernsback Web site; look for file LJ2A.ZIP at ftp.gernsback.com/pub/EN.

One interesting thing about the original source (included in the Zip, along with the updated source, and an executable) was its use of CP/M-derived file functions and data structures. If you don't know what a Disk Transfer Area (DTA) is, consider yourself lucky. Anyway, all that stuff is gone. If you're young enough to think that Windows or DOS just arose *ex nihilo* (from nothing)—well, here's concrete evidence (and a good reminder for us old-timers) that nothing just arises from nothing.

The program runs from a command line (DOS or DOS box under Windows or OS/2). It accepts multiple parameters, each of which specifies a file to print. Each parameter may have wildcards (? and *). So you could print all the C and H files like so:

```
C:\>lj2 *.c *.h
```

The code compiles under Microsoft C 1.52, the last 16-bit C compiler produced by Microsoft, but shouldn't be hard to adapt to Borland's product.

By the way, it turned out all I had to do to fix the program was to alter the setup string it sends to the printer. The original LJ2 set a margin of seven lines; by decreasing that to five, pagination once again lined up. Why was the change necessary at all? I suspect the LaserWriter may have a larger non-printable margin than the old LaserJet. I also added a somewhat more polite and descriptive help message. Planned enhancements (one of these days . . .) include long filename support, and a better (real) word-wrapping algorithm.

Delphi Grid Component

Before we jump into the technical stuff: Thanks to all of you Delphi fans who've been corresponding. The rapidly growing interest in Delphi actually makes me feel a bit less jaded and cynical about what it takes to succeed in the computer industry. At least in some segments, excellence is its own reward.

As part of a new Win32 coding-

continued on page 84

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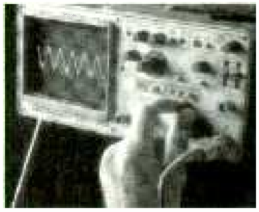

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THE ETAKGUIDE USA IS A DIGItal travel guide that offers road and highway map coverage of the entire continental United States. Available on its own or bundled with Sony's NVX-F160 mobile-navigation system, the guide provides detailed digital moving maps that track the motorist's progress in real-time throughout the 48 contiguous states. The software covers more than 500,000 miles of roads, including all major highways and detailed coverage down to the street level in 32 major cities. The NVX-F160 consists of a dashboard-mounted display, a CD-ROM player, a remote control, and a global positioning system (GPS) receiver. It receives positioning signals from the Navstar network of 24 satellites and pinpoints the vehicle's location on EtakGuide USA's maps.

The software's "moving maps" use clear graphics and text to identify interstate highways, toll roads, local streets, scenic routes, exit numbers, and ramp details. A multimedia combination of audio prompts and help screens, text descriptions of attractions, icons, photographs, illustrations, and music aids the navigation process. An extensive library of travel and tourist information—drawn from a variety of guidebooks and government information services—is linked directly to the moving maps and can be accessed at the touch of a button.

The EtakGuide USA allows travelers to search for information by general topics and more specific categories. Each listing within a category is marked on the map with an icon that, when selected, displays information including a full street address and usually a phone number. A database of toll-free numbers for lodging, car rentals, airlines, and road-conditions hot lines is also provided.

The Mileage Finder shows the road miles between cities, as well as the estimated driving time based on average speed. The Address Finder shows how to get to highway intersections on the map or specific street addresses in major cities. The Attraction Finder shows the driver how to get to a desired location, such as an amusement park or museum. More than 5000 attractions are listed, including sightseeing locations, zoos, sports arenas, RV sites, and airports.

The NVX-F160, with EtakGuide USA, has a suggested retail price of $2995. The guide is available separately for a suggested retail price of $149.95.

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Two small, quiet thermal printers from Eltron International can be used in a wide variety of printing applications, including retail (point-of-sale), health care, home shopping/banking, and home and office labeling. The Companion, said to have the smallest footprint of any printer, can be desktop- or wall-mounted. It prints at a sharp 203 dots per inch. Its sharp resolution, which translates into less paper consumption, results in lower operating costs than traditional dot-matrix printers.

The Companion printer uses Windows-compatible Eltron Programming Language, communicates like the Epson Model TM60 and TM80/85 printers, and supports most standard bar codes. The high-end Companion Plus also supports the latest two-dimensional symbol system—MaxiCode PDF-417.

The Companion and Companion Plus thermal printers cost $249 and $295 respectively.

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41 Moreland Road

CIRCLE 21 ON FREE INFORMATION CARD

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Fax: 805-579-1808
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Compuserve: 102251,1164

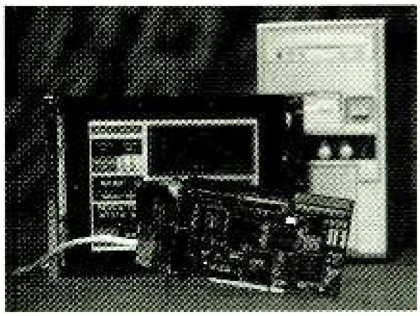
Flat-Panel Display Kit

The PCI-FP-Kit from Computer Dynamics is a customizable flat-panel display subsystem that runs from your PCI bus motherboard. The complete kit includes a half-size PCI bus flat-panel interface card (PCI-FP-Card) with LVDS (low-voltage differential signaling) or TTL output, your choice of display, optional touchscreen, optional enclosure, and all interface electronics and cabling.

The PCI-FP-Card directly drives both LVDS and TTL video, and delivers up to 1280×1024 resolution and 16.7-million colors. The noise immunity of LVDS allows the display to be placed as far as 10 meters from your PC, and fewer conductors result in a smaller cable. LVDS also lowers EMI. The LVDS connection is made either via a SCSI cable from the card or through a header connector that goes to the display via a ribbon cable. For applications in which the display is close to the PC, TTL output travels from a header connector via a ribbon cable to the panel.

The PCI-FP-Card outputs NTSC video, allowing you to display images on a TV, and accepts NTSC input from video cameras, CCD cameras, videotape, or MPEG and displays it on a flat panel. The card also has two megabytes of on-board video RAM, and permits simultaneous LCD and CRT operation.

Several flat-panel displays are available, including color TFT LCDs from 6.4 to 13.8 inches in XGA, SVGA, and VGA resolution; active-matrix monochrome LCDs; electroluminescent displays; and the exclusive "Ultra-HiBrite" color LCDs for high ambient-light conditions. Depending on the display, the PCI-FP-Kit is available with a guided wave, resistive, or infrared touchscreen. Power is taken from the PCI backplane for the touchscreen and display.



CIRCLE 22 ON FREE INFORMATION CARD

PCI-FP-Kits are priced starting at $1525 for the active-matrix monochrome display-based system.

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The ITT Night Cam 300 and 310 are versatile night-vision units that operate independently as night-vision monoculars, or they can be attached to a camera or camcorder to capture night experiences on film or video—opening up a previously unexplored range of photographic opportunities to photographers and videographers. Using the Night Cam creates "otherworldly" film or video in which layers of darkness are transformed into a green, glowing environment in near-daylight conditions.

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As a monocular, either unit can be used for safety and security purposes or to view nocturnal wildlife without a disturbing flashlight beam. For photographic or videographic purposes, you just remove the rubber eyecap and attach the unit to a camera or camcorder using the locking adapter bracket and step-up or step-down rings. The Night Cam 300 and Night Cam 310 are designed to work with a variety of lenses as well. If they wish users, can remove the Night Cam's objective lens and attach their favorite lens to its C-mount lens.

Each Night Cam is weather resistant, weighs only 10 ounces, and features $f/1.6$ optics with a 52-degree field of view. The Night Cam 300, which costs $1195, uses Generation II night-vision technology, while the $1795 model 310 features Generation III technology.

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CIRCLE 24 ON FREE INFORMATION CARD

The TE-64D tone encoder costs $129.95. The digital display portion of the TE-64D can be added to an existing TE-64 with the TE-64D-MOD, which costs $49.95. It is available as a kit, or the TE-64 can be returned for free factory installation.

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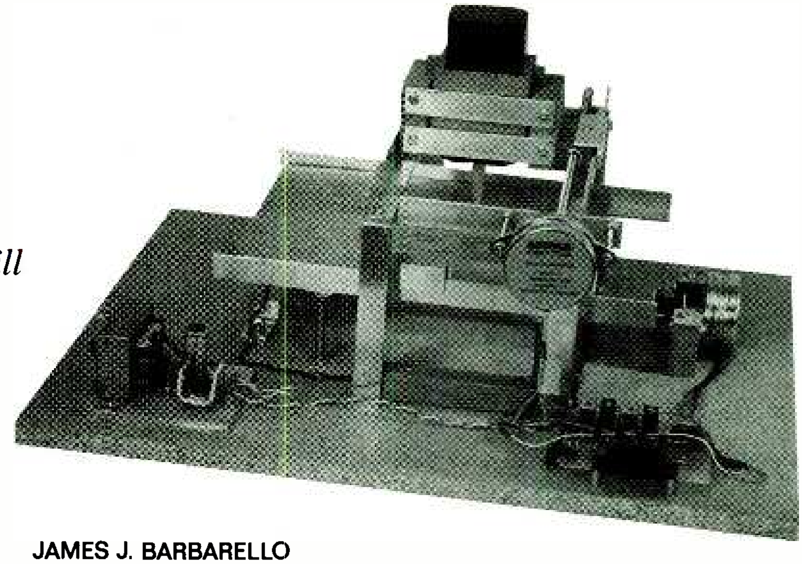


JAMES J. BARBARELLO

The printed circuit board is the foundation of many electronics projects, but creating PC boards in small quantities is always a problem. Several steps are involved in that process; those are:

1) Create the layout
2) Transfer it to the board
3) Etch the board
4) Drill the board

This project concerns Step 4.

Most people drill prototype PC-board holes manually. Typically, you use a very small, brittle drill bit that breaks easily—especially if you use a hand-held drill. Even if you use a drill stand, you must position the board for each hole. And you must prepare the board by marking each location with a center punch; otherwise you risk drill "wander" that can produce an off-center hole. In the age of 0.1-inch (and smaller) hole spacing, that can be disastrous! Further, stamping amounts to doubling the amount of work required per hole. Wouldn't it be nice to have a machine that lets you drill PC board holes precisely, effortlessly, and inexpensively?

Well, you can. For less than $100 (which includes a $30 mini-drill), you can build PCDrill, a computer controlled X-Y table that can locate any position on a 6-inch × 8-inch PC board with a resolution of 0.001-inch. Standard, easily available hardware is used throughout, and construction requires only hand tools, although some precise wood cutting is required for the drill caddy.

Any PC can drive PCDrill via a standard parallel port. The port controls two stepper motors, one for motion in each direction. In our design, the PC board table moves in the X direction, and the drill caddy moves in the Y direction. Also, the drill caddy is spring-loaded so that once the desired location is reached, a light downward force on the drill is all that's necessary to create a precisely located hole. The PC controls the stepper motors with a simple BASIC program that generates a series of X and Y coordinates based on input from a standard text file.

The project is straightforward to build, but there are many detailed steps. For that reason, we will go light on theory and heavy on hands-on construction details. For more detailed information on how stepper motors work, and how to control them, we refer you to the author's previous article, "Build an Automatic Parts Tray," which appeared in the November and December 1996 issues of **Electronics Now**.

The Motor and the Motion. This project uses a standard, off-the-shelf stepper motor that costs about $7 apiece. It is a bipolar device requiring a modest 5.75-volt DC power supply, and it has sufficient torque for this application. The motor moves 48 steps per revolution, or 7.5° per step. But how can we turn rotational motion into linear motion, and obtain 0.001-inch linear resolution in the bargain?

The secret is to couple the stepper motor's shaft to another, threaded shaft, and install a nut on that shaft, as shown in Fig. 1. If we prevent the nut from rotating while we turn the shaft, the nut will move back and forth across the shaft. Thus we convert rotational motion (R) into linear motion (L).

Let's assume that the threaded shaft has 20 threads per inch. In that case, one rotation of the shaft will move the nut $\frac{1}{20}$ inch (0.05 inch). However, the stepper motor can break that single rotation down into 48 discrete steps, so each step rotates the shaft 0.05 inch/48, or 0.00104 inch. A $\frac{5}{16}$-20 threaded rod, available at most hardware stores, contains 20 threads per inch. (Be careful not to get a $\frac{5}{16}$-16 rod, which contains 16 threads per inch; that $\frac{5}{16}$-inch rod type is even more common than the $\frac{5}{16}$-20 type.)

But how do we get the stepper to move in the first place? In a nutshell, a stepper has two windings. By applying DC voltages to the windings in various sequences and polarities, we can cause the shaft to move in one direc-

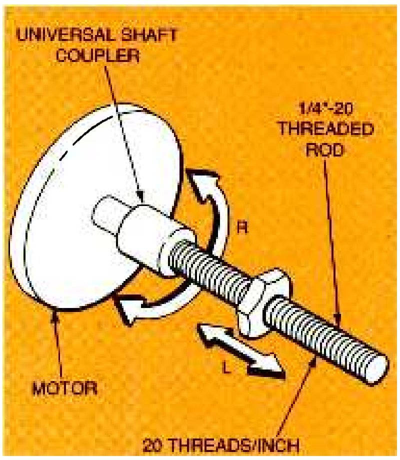


Fig. 1. The rotational motion of the threaded rod is converted to linear motion by the fixed nut.

TABLE 1—MOTION CONTROL SEQUENCE

Step	A(5)	B*(4)	B(3)	A*(2)	Decimal
1	1	0	1	0	10
2	0	0	1	1	3
3	0	1	0	1	5
4	1	1	0	0	12

tion or the other. Table 1 shows the motion-control sequence. By performing steps 1–4 sequentially, the tray rotates clockwise (CW). By performing the sequence backward (4–1), the tray rotates counterclockwise (CCW).

The Circuit. If you've seen the previous article mentioned earlier, the circuit shown in Fig. 2 should look familiar. Transistors Q1–Q12 and associated components are nearly identical to the circuits used in that project. The difference here appears in the bottom part of the figure, and involves Q13 and Q14, relay RY1, and their associated components. The purpose of the relay is simply to select one motor or the other. The remainder of the circuit serves to flip-flop the polarity of the voltage applied to the selected motor. The selected motor and polarities all depend on the states of the inputs at J1, which are of course driven by the PC's parallel port.

To give you an understanding of how the polarity-reversal mechanism works, let's examine the block consisting of Q1, Q3, Q5, R1, R2, R5, and R7. If pin 5 of J1 goes high, Q5 conducts, so its collector goes low. That low at the base of Q3 in turn forward-biases Q3, causing it to conduct, and bringing its emitter close to ground. Now look at the block consisting of Q8, Q10, Q12, R11, R12, R14, and R16. If pin 2 of J1 goes low, its collector goes high, causing Q8 to conduct and Q10 to remain off. At this point, we have a voltage difference between the emitters of Q3 and Q8, so if we connected the coil of a motor across them, the shaft would turn.

Each motor has four leads, denoted A, A*, B, and B*. Leads A and A* comprise one winding, and B and B* the other. Note that the A* ends of coil A in both stepper motors (MOT1 and MOT2) connect to the emitter of Q8. The A ends connect to the relay. Likewise, the B* motor leads connect to Q2, and the B ends to the relay. So depending on whether the relay is energized, one motor or the other will complete the current path from Q3 to Q8. Transistors Q13 and Q14 form a non-inverting buffer that provides enough current to drive the relay.

The remaining portion of the circuit consists of microswitches S1 and S2,

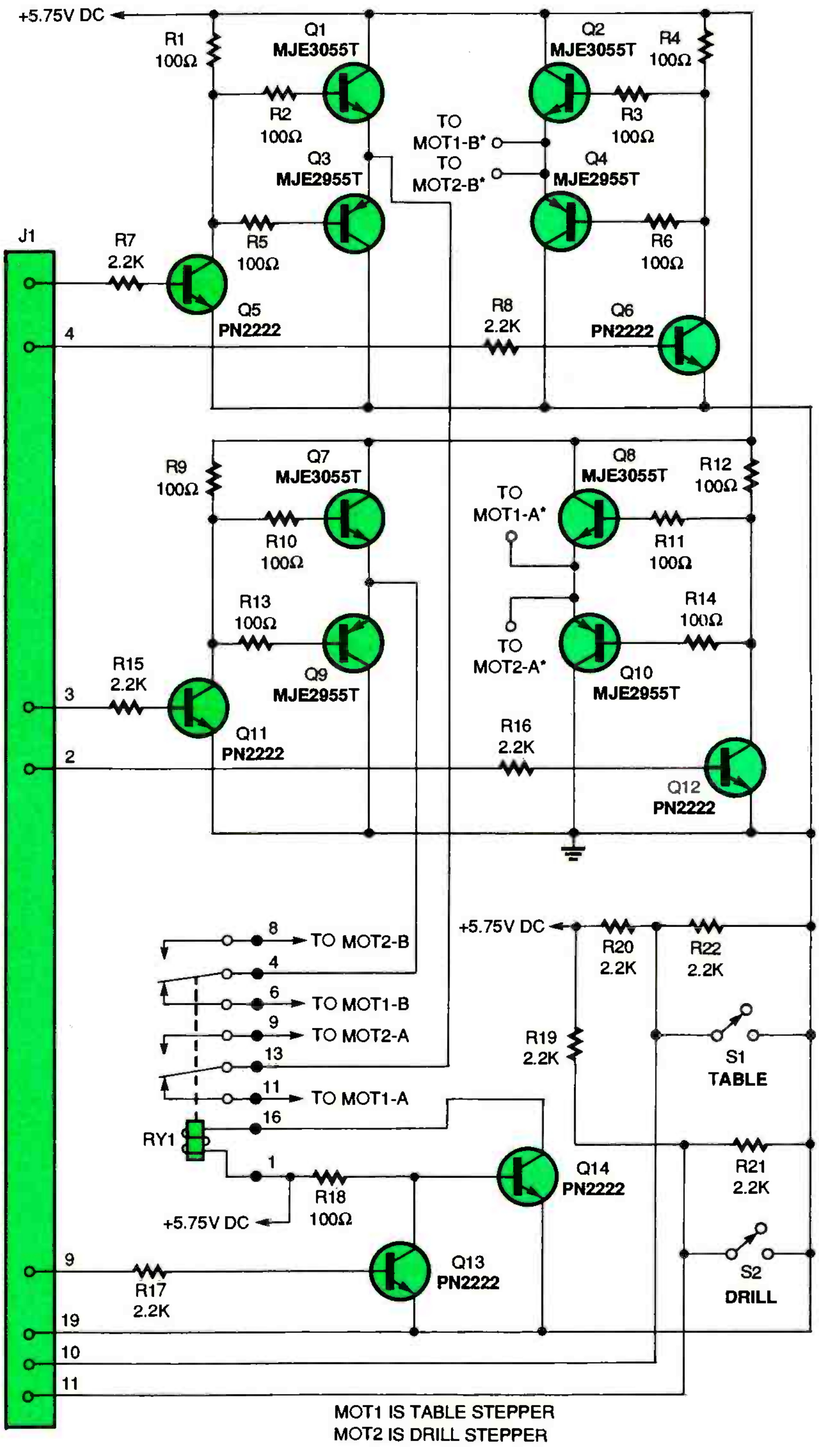


Fig. 2. The upper part of the circuit provides a digitally controllable way to swap the polarity of voltage applied to a motor. The lower portion allows one of two motors to be selected.

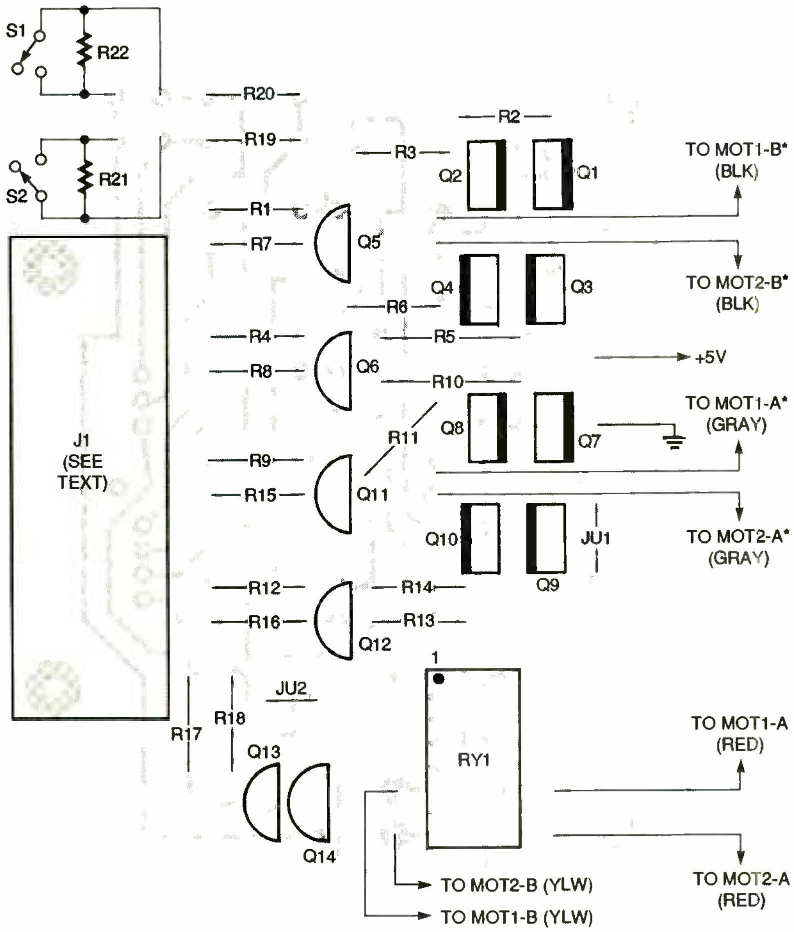
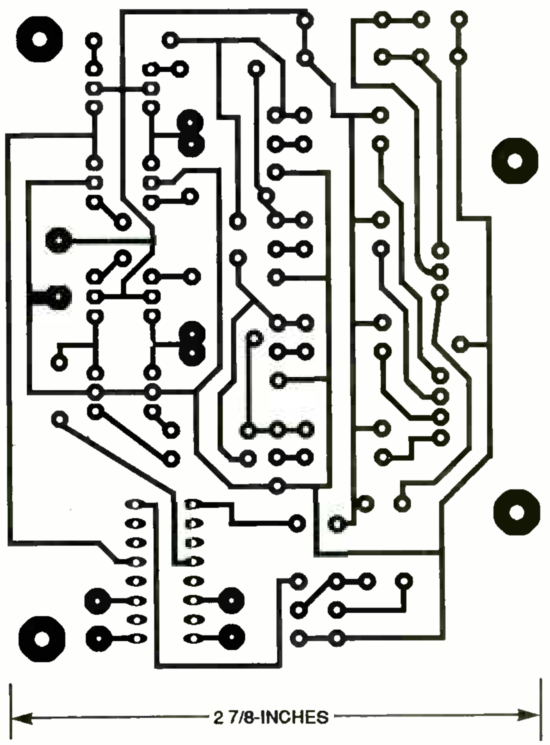


Fig. 3. Mount all components as shown here. Be careful with the orientation of all components, particularly the power transistors.



Here's the full-size PC pattern for the circuit board.

and the corresponding resistive voltage dividers. In operation, S1 and S2 function as limit switches that advise the software when the X or Y table has reached the end of travel. Both switches sit in the normally open state, providing a logic high (about 2.9-volts DC) to pins 10 and 11 of J1. When either switch closes, it grounds the associated pin on J1, indicating to the software that some action should be taken.

A note concerning current limiting: Many stepper-motor control circuits use current-limiting resistors to protect the motors against excessive current draw and consequent overheating. In our circuit, the relatively large current demand of the motor causes a measurable voltage drop across the power-providing transistors (in the example above, Q3 and Q8). Each will have a base-to-emitter drop approaching 1 volt. Therefore, the stepper motor coil sees only about 3.5-volts DC. With a coil resistance of 6.25 ohms, current is 3.5/6.25 = 560 mA. That's well within the motor's ability to dissipate the heat generated. Accordingly, no current limiting resistors are required.

MOTOR SPECIFICATIONS

Motor: Bipolar (2 Phase) AIRPAX Stepper Motor, P/N LB2773-MI
Mechanical: 2.25-inch D x 0.99-inch H, 0.61 lb.
Electrical: 5-volts DC, 800 mA, 6.25-ohms per coil
Resolution: 7.5°/step
Shaft: 0.25-inch D × 0.75- inch L
Mounting holes: 2 × 0.2 inch, 2.6-inches apart
Torque: 100 g-cm (detent), 1080 g-cm (holding)

Construction. There are seven major steps involved in building this project: 1) PC board, 2) base, 3) table tracks, 4) table, 5) drill-caddy support, 6) drill caddy, and 7) final assembly. We'll discuss them in order. Table 2 lists all required mechanical components.

Begin by fabricating the PC board using the foil pattern accompanying this article. Then install the resistors and transistors as shown in Fig. 3. We recommend use of a 16-pin DIP socket for RY1. Note the orientation of the

PARTS LIST FOR THE PCDRILL

SEMICONDUCTORS

Q1, Q2, Q7, Q8—MJE3055T NPN transistor, TO-220 case

Q3, Q4, Q9, Q10—MJE2955T PNP transistor, TO-220 case

Q5, Q6, Q11–Q14—PN2222 NPN transistor, TO-92 case

RESISTORS

(All resistors are ¼-watt, 5% units.)

R1–R6, R9–R14, R18—100-ohm

R7, R8, R15–R17, R19–R22—2200-ohm

ADDITIONAL PARTS AND MATERIALS

MOT1, MOT2—5-volt DC, 6.25-ohm coil, bipolar stepper motor, Airpax LB82773-M1 (Jameco 117954 or equiv.)

RY1—DPDT relay, 5-volt coil (Jameco 115060 or equivalent)

J1—DB-25 connector, female, PC-mount

S1, S2—SPST microswitch (Jameco 98781 or equivalent)

5.75-VDC, 1 amp or greater power supply (Jameco 107326 or equivalent, see text); 22-gage stranded wire; mini drill (Jameco 26702 or equivalent); no. 64 (0.036-inch) PC drill bit (Jameco 16598 or equivalent); heat-shrink tubing; PC board; mechanical parts and materials (see Table 1); etc.

NOTE: The following are available from James J. Barbarello, 817 Tennent Road, Manalapan, NJ 07726: Enhanced software, executable on all PC platforms from XT through Pentium (CD-S, $12, specify disk size); PCDrill PC board (PCD-PC, $17); Drill caddy kit, consisting of spring, drill caddy sides, drill caddy slides, and drill holder (PCD-DC, $15). The author will answer any questions sent to the address above, if accompanied by a self-addressed stamped envelope.

relay, and be sure to align the transistors as indicated. Use two excess resistor leads to form jumpers JU1 and JU2.

Prior to installing J1, enlarge the two PCB mounting holes to a diameter of 5/32 inch. Also, clip off leads 1, 6–8, 12–18, and 20–25, leaving pins 2–5, 9–11, and 19 intact. Solder the leads into place, but do not mount J1 to the PC board at this time.

The stepper-motor leads are not

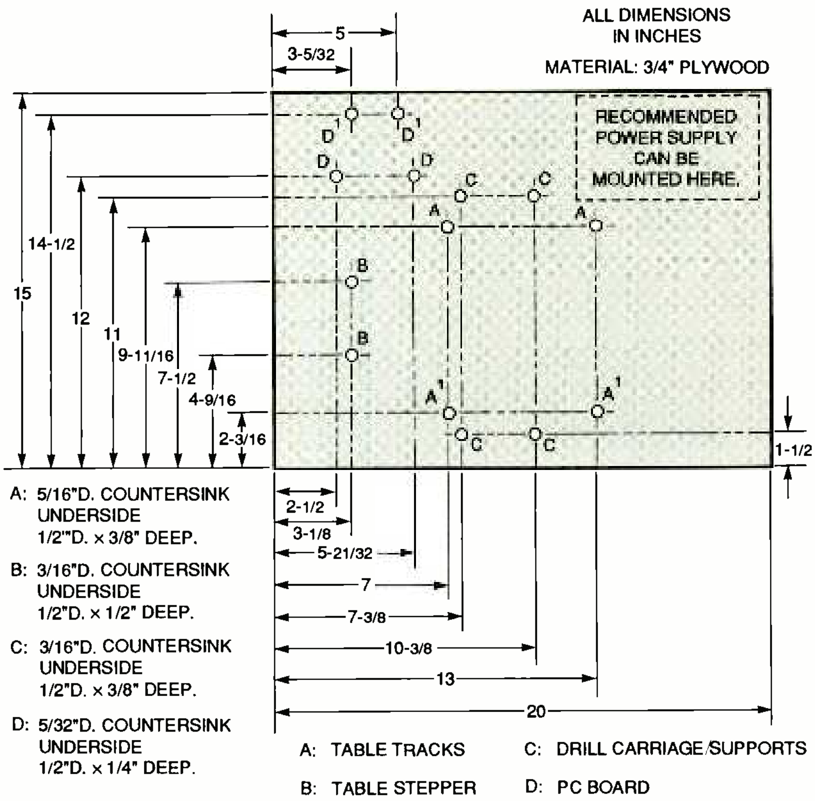


Fig. 4. The base plate has 14 holes in four groups (A, B, C, and D). Be sure to countersink all holes.

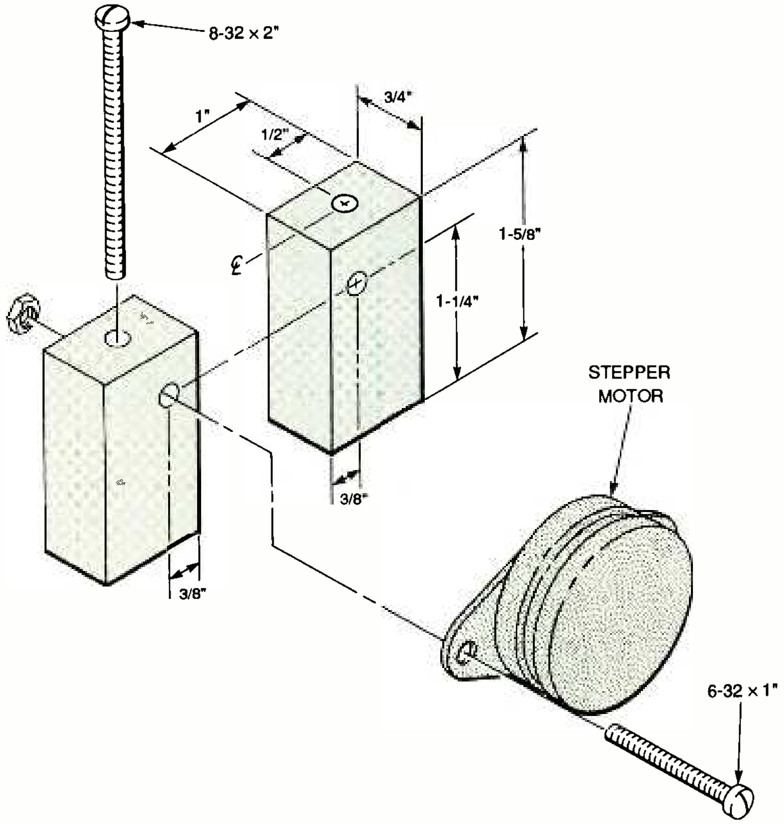


Fig. 5. The mounting blocks for the table stepper motor screw directly to the base plate.

long enough for our application, so remove the connectors on each motor. Obtain two sets of 22-gage yellow, gray, red, and black stranded wire (each about 4" long). Extend the motor leads to about 8 inches by splicing a sufficient length of like colored wire to each lead. Solder the splice and cover it with shrink sleeving or electrical tape. Mark one motor as MOT1, and the other as MOT2. Attach the leads to the appropriate points on the PC board.

Connect your power supply's leads to the PC board. If you use the supply cited in the Parts List, clip off the connector and attach the wires to the appropriate pads on the PC board. Adjust the PC-mounted potentiometer to obtain 5.75-volts DC.

The Base. As shown in Fig. 4, the base is a piece of plywood (or similar material) measuring 15 × 20 × ¾ inches. Drill 14 holes in the base, and countersink all 14 from the underside. That prevents mounting nuts from protruding from the bottom of the base.

Note in Fig. 4 that there are four groups of holes, denoted A, B, C, and D. Attach four threaded spacers to the D holes with 6-32 screws. Then attach the PC board to the spacers with 6-32 screws. Note that two of the screws will go through both J1 and the PC board. Also, mount the power supply in the indicated position at this time. For our prototype, we mounted the PC board and power transformer to a 4- × 3½- × ¼-inch scrap of plywood, and attached it to the base using #8 × ¾-inch sheet-metal screws.

Next, fabricate two table stepper mounts as shown in Fig. 5. Attach the mounts to the base with two 8-32 × 2-inch machine screws and nuts. Attach stepper motor MOT1 to the mounts as shown in Fig. 5. The motor's shaft should face the center of the base, and the leads should exit the top of the motor. We'll also need a support bracket for the table-zeroing switch, but we'll build it later, during the initial alignment.

Table and Tracks. Cut the table tracks from ¾- × ¾- × ⅛-inch aluminum angle stock. Cut two 12-inch lengths, then locate and drill four ¼-inch holes as shown in Fig. 6. Countersink the holes with a ½-inch drill bit so that the flat heads of the machine

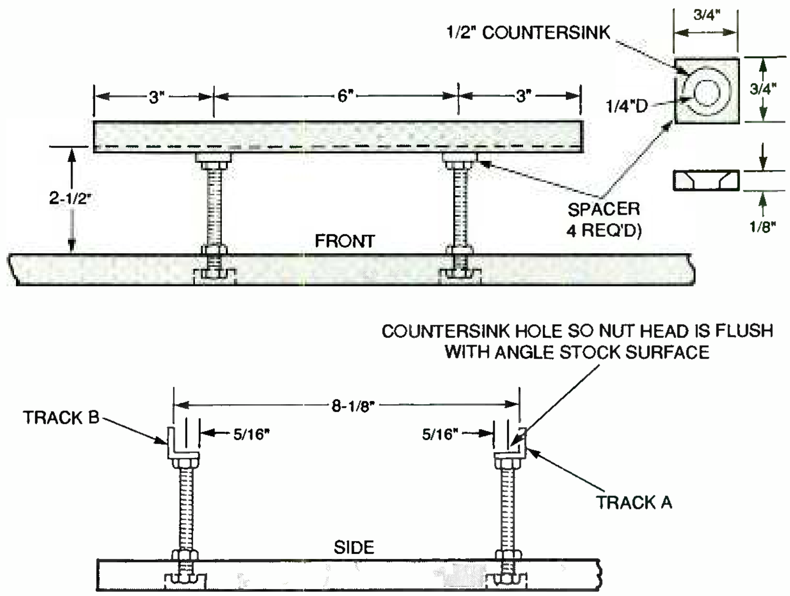


Fig. 6. Fabricate the table tracks from 12-inch lengths of ¾-inch aluminum angle stock.

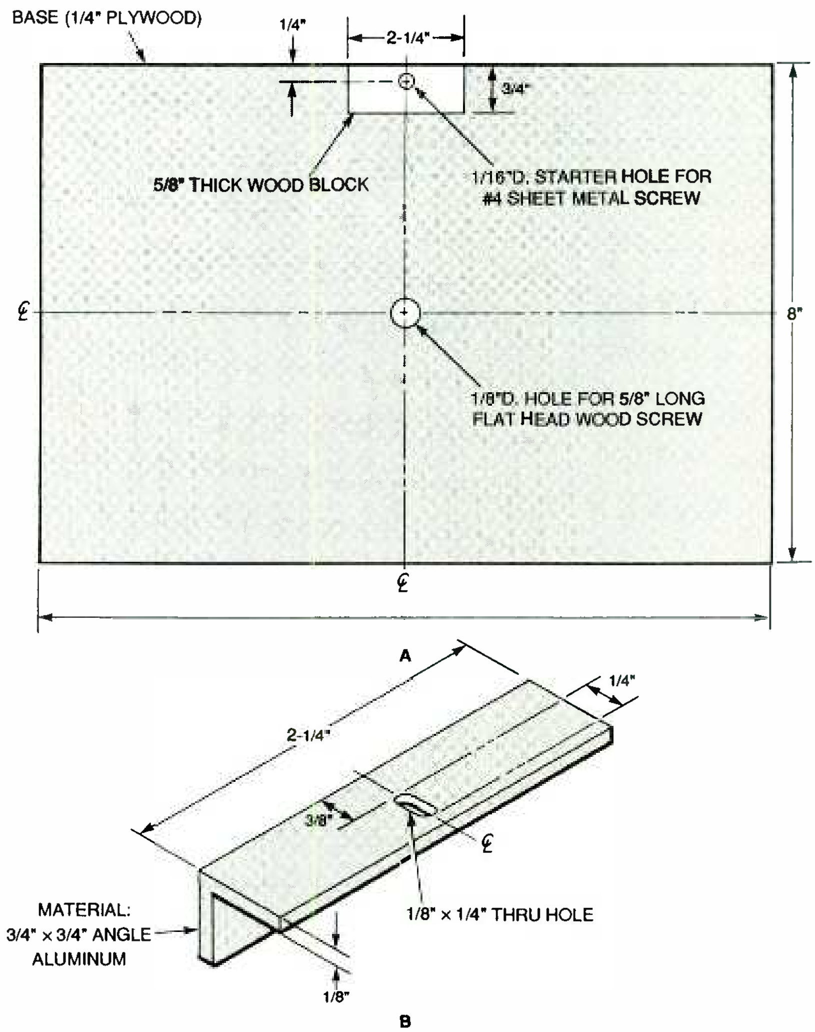


Fig. 7. As shown in A, the table base is fabricated from ¼-inch plywood. The small block is where the table guide (B) mounts. Make two table guides; the second is used in the support assembly.

screws sit flush with the surface.

Now form four spacers from ¾- × ⅛-inch flat aluminum stock, also as shown in Fig. 6. Pass a ¼-20 × 3-inch machine screw through each hole, place one spacer on each screw (countersunk side first), and then thread two ¼-inch nuts onto each screw. Tighten the first nut on each screw to secure the screw to the track, making sure each screw is perpendicular to the track. Thread the remaining nut on each screw about 1½-inch above the bottom of the screw.

Insert the screws into the A holes on the base (Fig. 4). Then, as shown in Fig. 6, thread another nut onto each screw and adjust the nut so that the inside horizontal surface of each track (on which the Table will rest) is exactly 2½-inch above the base. Secure the tracks to the base by tightening the top nuts. Adjust the tracks so that the inside vertical surfaces are 8⅛-inch apart.

The table comes next. The assembly consists of the table base (Fig. 7-a), two table guides (Fig. 7-b), and the table driver (Fig. 8). Begin by cutting

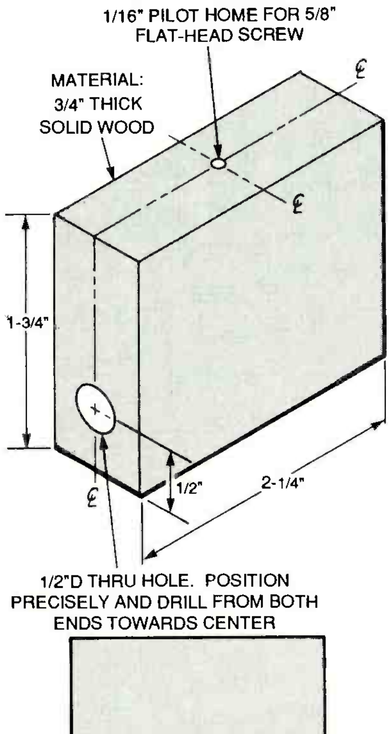


Fig. 8. The table driver has a precisely drilled ½-inch through-hole located ½-inch up from the bottom. Then press fit two 5/16-inch-20 nuts into the hole ends.

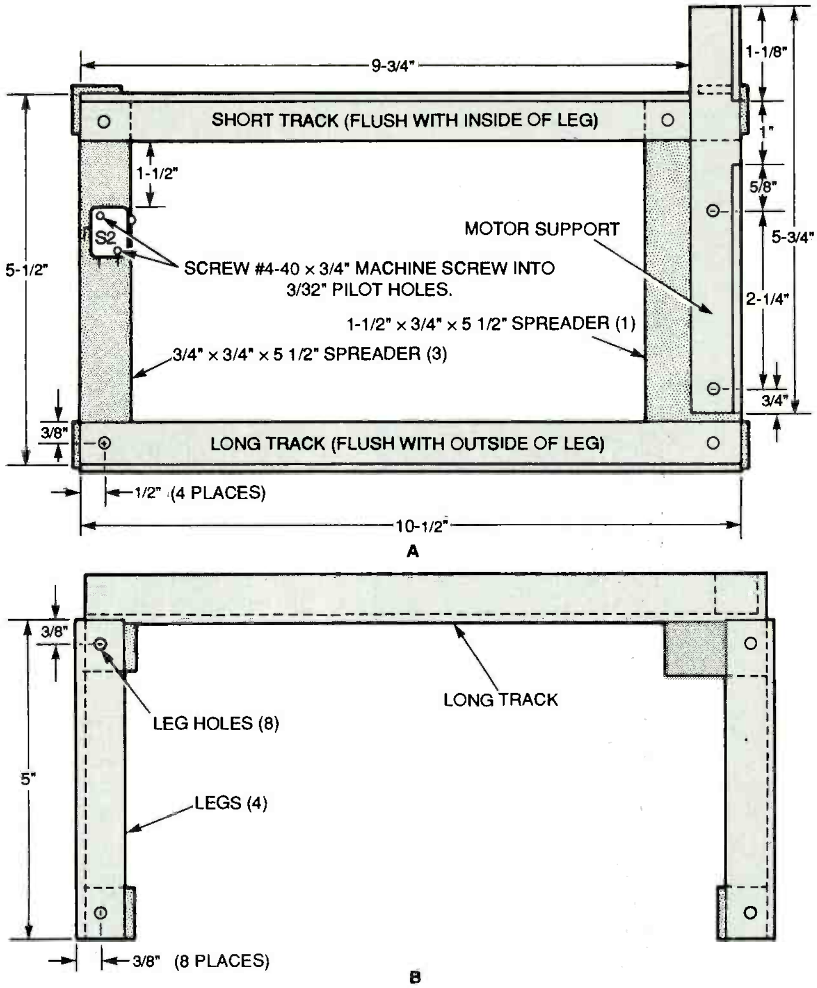


Fig. 9. The drill-caddy support framework supports the drill caddy above the table via four 5-inch legs. The top view (A) shows the short and long tracks, and the spreaders. The front view (B) shows the legs and the support track.

TABLE 2—MATERIALS LIST

QTY	DESCRIPTION	FOR
2	#4 × ½-inch sheet metal screw	table/drill guides
24	#8 × ¾-inch sheet metal screw	drill caddy support, drill caddy
1	#2 flat washer	spring holder
1	#2-56 × ½-inch machine screw and #2-56 nut	spring holder
4	#4-40 × ¾-inch machine screw	s1 & s2 mount
2	#4-40 nut	s1 mount
5	#6-32 × ⅜-inch machine screw	PC board/spacers and shaft couplers
4	#6-32 × ⅝-inch machine screw	spacers to base
2	#6-32 × 1-inch machine screw	table stepper mounting
2	#6-32 nut	—
4	#6-32 threaded spacer, ⅝-inch long (Jameco 77551)	spacers
2	#8-32 × 2-inch machine screw	table stepper mounts
4	#8-32 × 1¼-inch machine screw	drill caddy support to base
6	#8-32 nut	—
4	¼-20 × 3-inch flat head machine screw	table track supports
12	¼-20 nut	table track supports
2	5/16-inch × 12-inch long threaded rod	table & drill drive
4	5/16-inch nut	table/drill drivers
1	⅝-inch long flat head wood screw	table mount
1	¼-inch × 1-inch × .035-inch utility compression spring	drill caddy
1	8-inch × 12-inch × ¼-inch wood	table
2	2-inch × 2 21/64-inch × ¼-inch wood	drill holder sides
1	2-inch × 1 23/32-inch × ¼-inch wood	drill holder side
1	1¼-inch × 1 23/32-inch × ¼-inch plywood	drill holder side

the base from ¼-inch plywood and smoothing the ends with sandpaper. Next cut a small wood block as shown in Fig. 7-a, drill the 1/16-inch starter hole, and glue the block to the table with white (or carpenter's) glue. Next, fabricate a table guide per Fig. 7-b. To create the oblong hole, drill two ⅛-inch holes and file away the material between the holes.

After the glue dries, place the base on the table tracks with the block resting over Track A (see Fig. 6). Place the table guide on the block so it overlaps Track A. Push the block flush with the inside vertical surface of Track A. Place a piece of paper or a business card against Track A's outer surface and pull the guide flush to it. Secure the guide to the block with a #4 sheet-metal screw, and then remove the paper (or business card). Ensure that the table slides freely but does not wobble. Adjust as necessary.

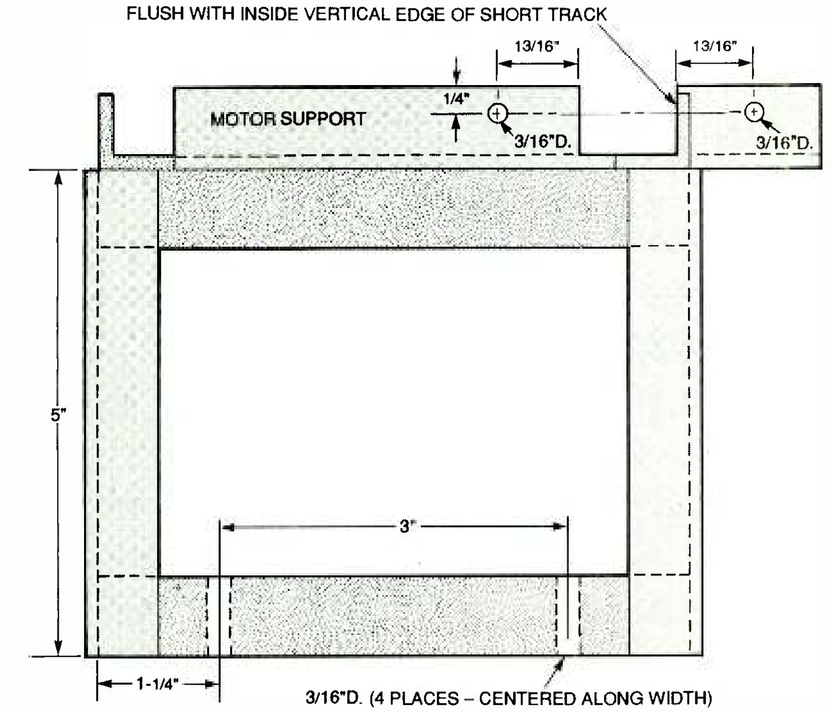


Fig. 10. This side view of the drill-caddy support details the holes where the motor mounts and the notch that provides clearance for the threaded rod.

The last part of the table, the table drive, is the most important. Referring to Fig. 8, cut a piece of wood to the dimensions shown. *Precisely* locate a point on each end that is ½-inch up from the bottom, and at the halfway point between the two sides. Starting with a small drill bit (1/16 or 3/32 inch), drill in from each side to create a pilot. Gradually increase the size of the hole using larger drill bits. You should eventually end up with a ½-inch through-hole. Now drill the 1/16-inch pilot hole on the top. Next, place a 5/16-inch hex nut over one end of the ½-inch through-hole, and temporarily secure it with some masking tape. Place the nut/block assembly in a vise and gently squeeze the nut into the hole until it is flush. Remove the tape and repeat the process with another nut in the other end.

Thread a 5/16-inch threaded rod through one of the nuts. As the rod approaches the other end, it will either thread through easily or begin to bind. If it binds, use another threaded rod from the outside and *gently* move the unthreaded nut slightly. Do this until the rod can be threaded through easily. Apply a light coating of oil to

1	15-inch × 20-inch × ¾-inch plywood or composition board	base
2	1/16-inch aluminum stock, ¾-inch w × 2⅜-inch long	retaining clips
2	¾-inch × ¾-inch × ⅛-inch angle aluminum, 2¼-inch long	table/drill guide
4	¾-inch × ¾-inch × ⅛-inch angle aluminum, 5-inch long	drill caddy support legs
1	¾-inch × ¾-inch × ⅛-inch angle aluminum, 5⅜-inch long	drill caddy motor support
1	¾-inch × ¾-inch × ⅛-inch angle aluminum, 9⅝-inch long	short drill caddy track
1	¾-inch × ¾-inch × ⅛-inch angle aluminum, 10⅜-inch long	long drill caddy track
2	¾-inch × ¾-inch × ⅛-inch angle aluminum, 12-inch long	table tracks
4	¾-inch × ¾-inch × ⅛-inch flat aluminum stock, 4½-inch long	drill caddy side stretcher
1	¾-inch × ¾-inch × ⅛-inch flat aluminum stock, 4½-inch long	table zeroer support
2	3/16-inch × 7/16-inch × 2-inch wood	drill caddy slide
1	¾-inch × ⅝-inch × 2 ¼-inch wood	table base wood block
3	¾-inch × ¾-inch × 5¾-inch wood	drill caddy spreader
1	¾-inch × 1-inch × 2¼-inch wood	drill driver
1	¾-inch × 1½-inch × 5½-inch wood	drill caddy spreader
1	¾-inch × 1¾-inch × 2¼-inch wood	table driver
2	¾-inch × 2-inch × 2½-inch wood	drill caddy side
4	universal shaft coupler (Jameco 106606)	motor coupler
2	rubber coupler (Jameco 106622)	motor coupler

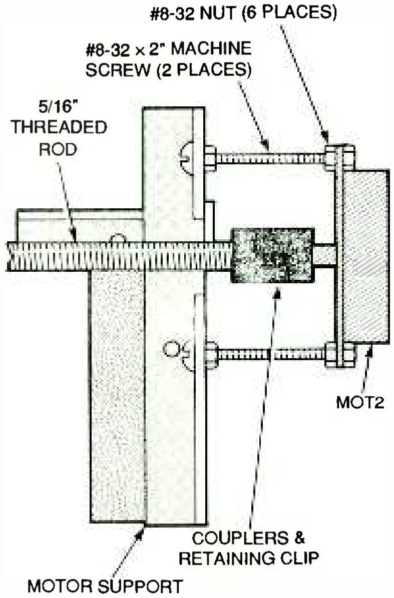


Fig. 11. As shown here, stepper motor MOT2 mounts against the motor support bracket.

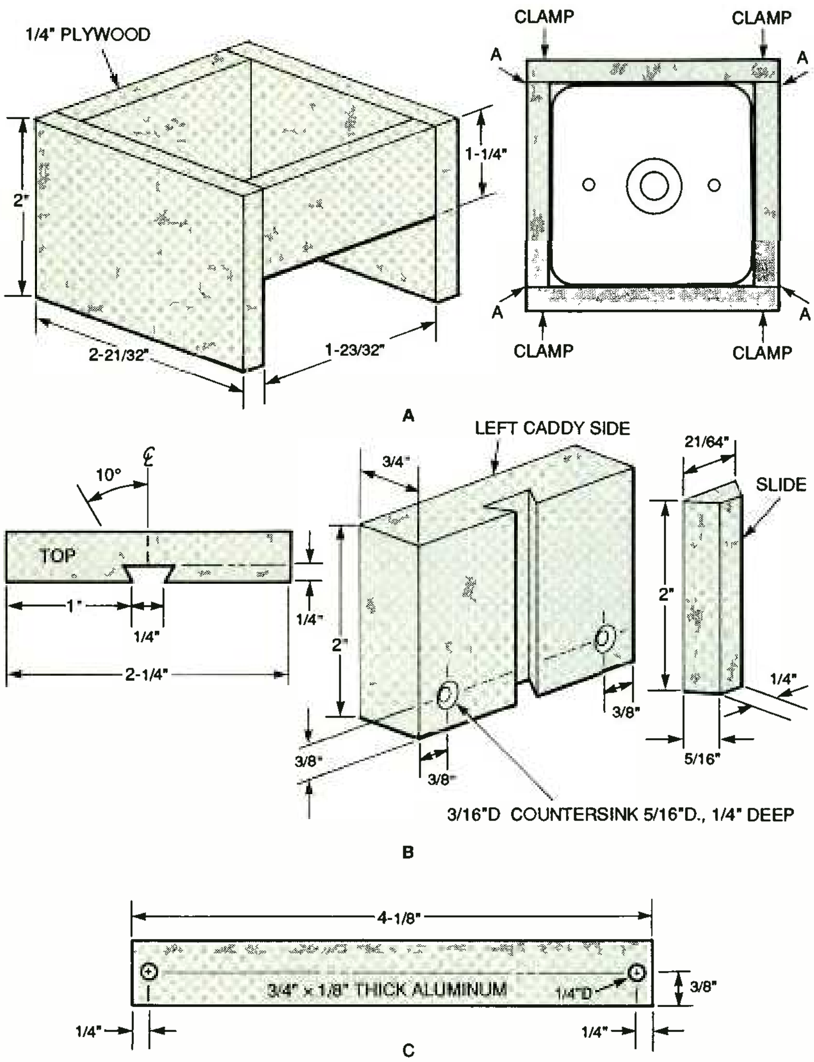


Fig. 12. The drill holder (A), the caddy sides and slide (B), and the side stretcher (C) are the drill-holder components shown here.

the rod and run the guide up and down the rod several times. You can do this quickly by chucking the rod into a variable-speed, reversible drill. The goal is for the rod to be able to move with no discernible resistance.

Place the guide on the underside of the table so both pilot holes align. Insert a ⅝-inch flat-head wood screw through the table into the guide. The screw's head should be flush with the table and the guide should be flush with the underside of the table, but the guide should be able to rotate without major resistance. That will allow the guide to move the table forward and back, but compensate for any minor misalignment of MOT1's threaded-rod drive after it is installed (during final assembly).

Drill Caddy and Support. Referring to Fig. 9-a, cut four legs and the short and long tracks from angle stock. Next, cut the four spreaders from ¾-inch wood stock. Drill and countersink two holes in each of the bottom spreaders as shown.

Drill two leg holes in each leg as shown in Fig. 9-b. Using #8 sheet-metal screws, connect the legs and stretchers to form two leg subassemblies, making sure they are square. Drill the track holes in each of the tracks and attach to the leg subassemblies. (Note that the short track is flush with the inside of the legs, but the long track is flush with the outside of the legs). Make sure the resulting top surface of the structure is square, and is of equal height on both ends.

Cut a 1-inch notch in the motor-support bracket and drill two spreader holes and two motor-mount holes. Secure the motor-support bracket with #8 sheet-metal screws. Make sure the notch aligns with and is perpendicular to the short track's inside vertical surface, as shown in Fig. 10. Secure the assembly to the base with four 8-32 × 1¼-inch machine screws in the base holes marked C. Mount microswitch S2 on the top spreader using two 4-40 × ¾-inch machine screws screwed into 3⁄32-inch pilot holes. The edge of the microswitch with the plunger should be flush with the edge of the spreader. Finally, attach motor MOT2 to the motor support as shown in Fig. 11, using two 8-32 × 2-inch machine screws and six nuts.

The Drill Caddy. The last and most critical assembly is the drill caddy. It must hold the drill in a vertical position, allow it to travel up and down, and have no slop in any direction. The assembly consists of a pair of dovetail slides and a drill holder that is custom-fit to the drill to be used. The Parts List mentions one suitable drill, though many others could be used.

Refer to Fig. 12 as we proceed. Begin by cutting two pieces of ¼-inch wood stock to 2-inches high by 2²¹⁄₃₂-inches long. Cut another piece to 2-inches high by 1²³⁄₃₂-inches long, and one more piece to 1¼-inches high by

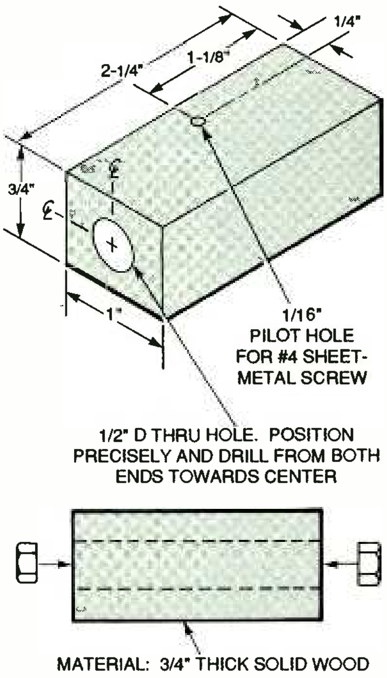


Fig. 13. The drill driver, like the table driver (Fig. 8), has a ½-inch through-hole.

LISTING 1—TEST PROGRAM

```
REM** PCDRL.BAS (c) 1995, JJ Barbarello, Manalapan, NJ 908-536-5499
REM** V951125
DEF SEG = 64: DEFINT A: add = 888: ON ERROR GOTO errortrap
DIM a(4), a$(5): a(1) = 5: a(2) = 3: a(3) = 10: a(4) = 12
OUT add, a(4): aseq = 4
a$(1) = "Table Towards Stepper": a$(2) = "Table Away From Stepper"
a$(3) = "Drill Towards Stepper": a$(4) = "Drill Away From Stepper"
a$(5) = "END"
start:
CLS : LOCATE 1, 25: PRINT "PC-DRILL CHECKOUT AND ALIGNMENT"
LOCATE 6, 5: PRINT "SELECT OPTION:"
FOR i = 1 TO 5
  LOCATE 8 + i, 10: PRINT USING "#. "; i;
  PRINT a$(i)
zNEXT i
getoption:
LOCATE 6, 20, 1: PRINT SPACE$(10); : LOCATE 6, 20
a$ = INPUT$(1): a = VAL(a$)
CLS
LOCATE 1, 25: PRINT "PC-DRILL CHECKOUT AND ALIGNMENT"
LOCATE 10, 16
SELECT CASE a
  CASE IS = 1
  steps = -1: which = 128: PRINT a$(1);
  CASE IS = 2
  steps = 1: which = 128: PRINT a$(2);
  CASE IS = 3
  steps = -1: which = 0: PRINT a$(3);
  CASE IS = 4
  steps = 1: which = 0: PRINT a$(4);
  CASE IS = 5
  CLS : OUT add, which: LOCATE 18, 1: END
  CASE ELSE
  BEEP: GOTO start
END SELECT
OUT add, a(4): aseq = 4
PRINT ". Press Enter to stop...";
motionloop:
  aseq = (aseq MOD 4) + steps
  IF aseq = 0 THEN aseq = 4
  IF aseq = -1 THEN aseq = 3
  OUT add, a(aseq) + which
start! = TIMER
WHILE (TIMER - start!) < .000001: WEND
  IF (INP(add + 1) AND 64) = 0 AND a = 2 AND which = 128 THEN GOTO start
  IF (INP(add + 1) AND 128) = 128 AND a = 4 AND which = 0 THEN GOTO start
  IF INKEY$ = "" THEN GOTO motionloop
OUT add, 0 + which
GOTO start
errortrap:
OUT add, 0 + which
RESUME start
```

1²³⁄₃₂-inches long. Using the selected drill as a mold, arrange those pieces around the drill to form a box, and temporarily clamp the sides as shown in Fig. 12-a. The drill should be held securely, only able to move if significant pressure is applied. If that is not the case, adjust the lengths of the shorter pieces as necessary. When done, remove the clamps, apply carpenter's glue on mating surfaces A, and re-clamp. **Note:** Make sure the box is square on all sides. Let the assembly sit for about an hour and then remove the drill, leaving the clamps in place. Let the assembly sit for another hour to ensure that the glue cures.

Cut two caddy sides from ¾-inch wood, as shown in Fig. 12-b. Form the dovetail slot centered in the 2¼-inch width of each piece. Cut two caddy slides and slide them into the dovetail slots. They should slide freely, but without any side-to-side or front-to-back wobble. If necessary, lightly sand the pieces until they fit properly. Drill two holes in the left caddy side.

Place the caddy slides in the caddy sides and position on each of the shorter sides of the drill box. Apply a thin line of glue along caddy-slide-surface G and clamp the complete assembly together, making sure the assembly is square on all sides. Let the glue cure for about one hour. Remove the clamp.

Cut four side stretchers from ¾- × ⅛-inch aluminum flat stock, as shown in Fig. 12-c. Screw the side stretchers onto the assembly after first drilling ³⁄₃₂-inch pilot holes. When done, the drill box should slide freely in the caddy without any side-to-side or front-to-back movement. If not, adjust the stretchers or lightly sand as necessary until free sliding occurs.

Referring to Fig. 13, fabricate a drill driver using the same methods as for the table driver. Remove screws from the side stretchers and left caddy side. Position the drill driver on the bottom outside of the left caddy side and temporarily clamp in place, making sure the bottoms of the caddy side and drill driver are flush. Drill two countersunk holes in the drill driver (Fig. 12-b) and secure with two #8 × ¾-inch sheet-metal screws. Ensure that the ends of the screws do not protrude into the cavity of the drill driver. If there is interference, remove the screws and file their ends down as necessary. Reassemble the drill caddy.

Remove screws from the side stretchers and right caddy side. Referring to Fig. 12-d, fabricate a ⅝ × ⁵⁄₁₆-inch square piece of wood to serve as the spring flange. After drilling the ⅛-inch hole, glue the flange to the caddy side as shown in Fig. 14. After the glue has cured, install a 1- × ¼-inch (diameter) spring by placing a flat washer in the end of the spring and inserting a 4-40 × ½-inch machine screw through the spring, washer, and flange. Secure in place with a 4-40 nut. Make sure the spring does not angle out into the path of the drill. Reassemble the drill caddy and thread a ⁵⁄₁₆-inch threaded rod about halfway into the drill driver.

Place the drill caddy assembly on

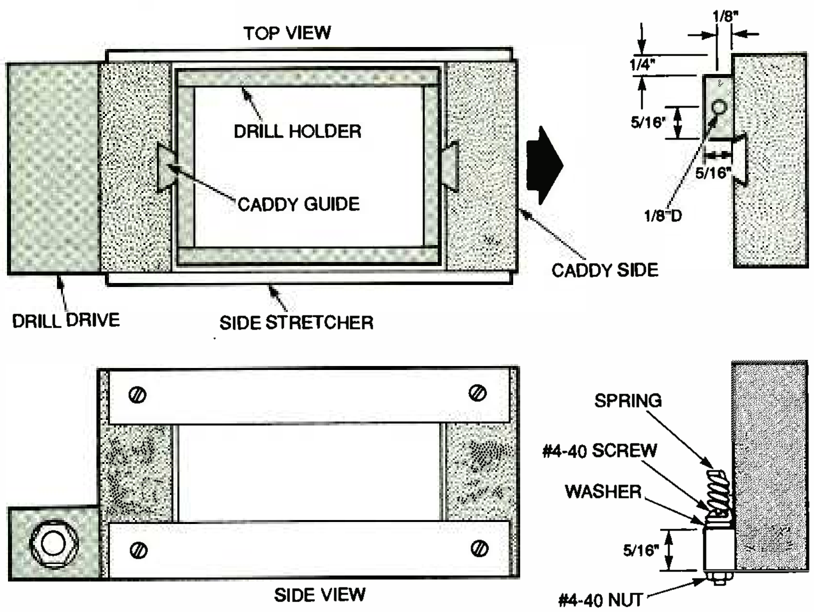


Fig. 14. The drill-caddy assembly contains all the components shown in Fig. 12 and Fig. 13.

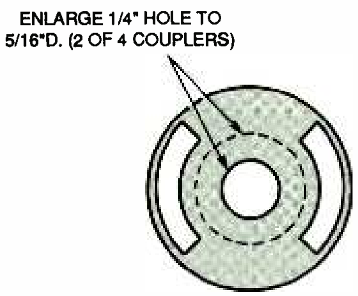


Fig. 15. You must modify the universal shaft coupler by enlarging the ¼-inch hole to 5/16-inch on half of each coupler. Optionally, replace the set screws with 6-32 screws.

the drill caddy support so the threaded rod protrudes through the 1-inch slot on the motor support. Form another guide as shown in Fig. 7-b, and position it on top of the drill driver. Fasten with a #4 sheet-metal screw, and adjust so the drill caddy moves freely with minimum wobble.

Final Assembly. We will couple the threaded rods to the motors using ¼-inch universal shaft couplers. First, however, we must modify the shaft couplers for our application, as shown in Fig. 15. When enlarging the ¼-inch hole, use progressively larger drill bits, and work slowly as the couplers are brittle. For safety, clamp the couplers in place when drilling. Enlarge only two couplers for the threaded rods; unmodified couplers fit the motors as-is. For convenience, you can optionally replace the set screws in the couplers with 6-32 × ⅜-inch machine screws.

Next, form two shaft coupler retaining clips from thin aluminum stock as shown in Fig. 16. If you cannot find thin aluminum anywhere else, the top of a used electronics hobby box works well.

Install a modified coupler on one end of each threaded rod, making sure the coupler is not cocked. If it is, loosen the set screw, rotate the rod slightly, and try again. Install an unmodified coupler on the shaft of each motor. Install one rubber coupler into each coupler on each motor.

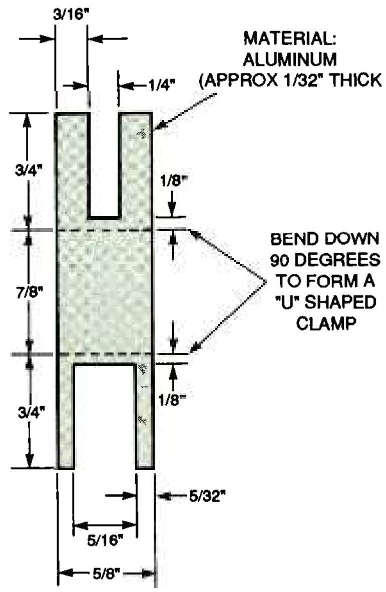


Fig. 16. The coupler retaining clip holds the universal-shaft-coupler components together. One clip is required for each motor/rod assembly.

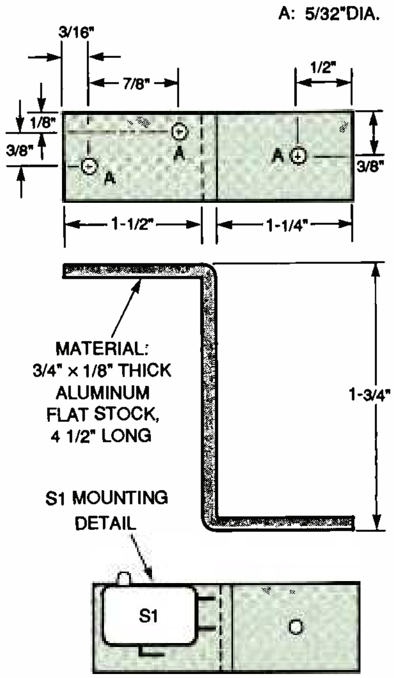


Fig. 17. The switch support bracket holds microswitch S1.

Place the table on the table supports and slide toward motor MOT1. Align the rubber coupler and metal coupler on the threaded rod and push together. Snap the retaining clip over the couplers.

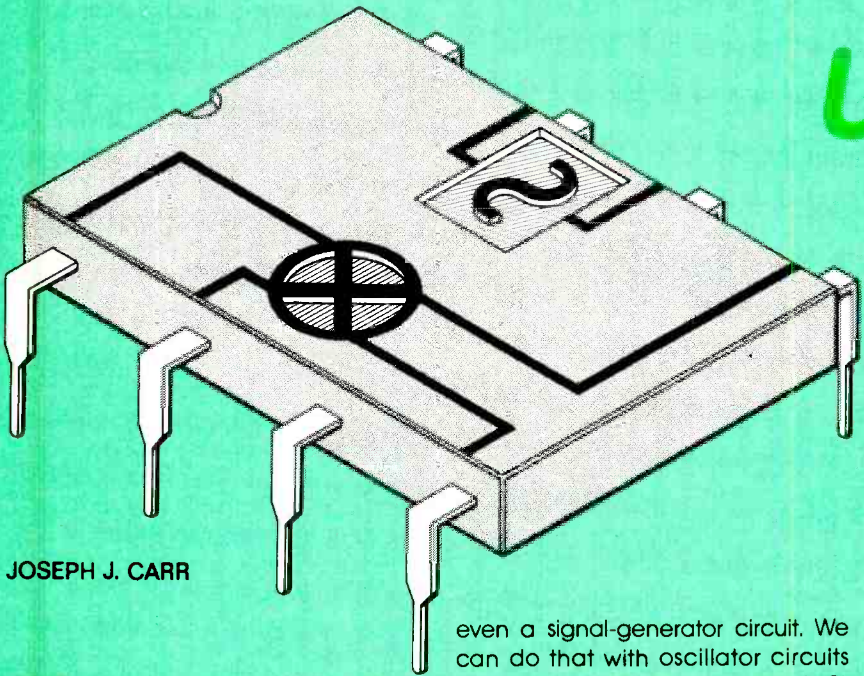
Slide the drill caddy assembly toward MOT2 and push onto the rubber coupler. Snap a retaining clip onto the couplers. Adjust MOT2 as necessary so it is in-line with the threaded rod. Carefully push the drill into the drill box until the bottom of the chuck is about ¾-inch above the table.

Fabricate a support bracket for switch S1 as shown in Fig. 17, and mount S1 using two 4-40 × ⅝-inch machine screws and nuts. Cut four 22-inch lengths of 22-gage stranded wire. Connect S1 and S2 to the PC board, routing the wires so as not to interfere with table or caddy movement. Mount R21 across S2's terminals and solder it in place. Mount R22 across S1's terminals and solder it in place.

Initial Checkout. Connect J1 to your PC's parallel port, and energize PCDrill's power supply. Next we'll run a test program. Either enter the QBasic program shown in Listing 1, or execute

(Continued on page 79)

The NE602 could very well become the RF experimenter's "555" chip. Learn about this fascinating and versatile device for your next RF project.



USING THE NE602

JOSEPH J. CARR

Every now and then a chip comes along that strikes the public imagination, so it gets used in a lot of projects. The 741 operational amplifier was like that in the early 1970s. Also reaching a high pitch of popularity was the 555 IC timer chip. Both of those chips reached such heights because they were both useful and well-behaved (i.e. they did what they did with little muss or fuss). The radio frequency (RF) hobbyist, however, only recently found a chip that meets those requirements: the NE602 from Signetics.

The NE602 device is a monolithic integrated circuit containing a double-balanced mixer (DBM) and an internal oscillator circuit. The DBM has balanced inputs (pins 1 and 2), balanced outputs (pins 4 and 5), and can operate at up to 500 MHz. The internal oscillator circuit provides an emitter connection and a base connection to the outside world. Figure 1-a shows the block diagram, and Fig. 1-b the pinouts for the NE602 device.

The NE602 is meant to be used as the receiver front-end in VHF portable telephones, but a lot of amateur radio and electronics enthusiasts have used the chip for a wider variety of applications, some of which we'll talk about here. The NE602 is a strong candidate whenever you want to build a frequency converter or translator, or even a signal-generator circuit. We can do that with oscillator circuits consisting of inductor-capacitor (L-C) variable-frequency oscillators, or piezoelectric crystals in either voltage-tuned or swept-frequency arrangements. We're going to explore some of the various configurations of circuits for the NE602 device, including the DC-power-supply connections, the RF-input configurations, the local-oscillator circuits, and the output circuits.

The NE602 version of the device operates over a temperature range of 0- to +70°C, while the related SA-602 device operates over an extended temperature range of −40- to +85°C. The most common form of the NE602, and most useful for the hobbyist and experimenter, is the NE602N, which is in an eight-pin mini-DIP package. An eight-lead surface-mount package (NE602D) is also available.

Heart of the NE602. Because the NE602 contains both a DBM and a local oscillator (LO), it can be used as the entire front-end of a radio receiver. Figure 2 shows a partial view of the internal circuit of the heart of the NE602: the double-balanced mixer stage. That configuration is known as a Gilbert transconductance cell. It consists of a pair of cross-coupled differential amplifiers. One feature of the design is that it offers a very good noise figure, which is typically 5 dB at 45 MHz. The third-order intercept point is −15-dBm referenced to a matched input. Unfortunately, the dynamic range is not what it could be, so a good idea is to be sure that the input signal levels do not exceed −25 dBm (≈3.16 mW). That signal level is similar to about 12.6 mV into a 50-ohm load, or 68 mV into the 1,500-ohm input impedance of the NE602. The NE602 is capable of providing 0.2-µV sensitivity without the need for external RF amplification. Although the straight NE602 suffers from dynamic range problems, the improved NE602A is said to solve that problem.

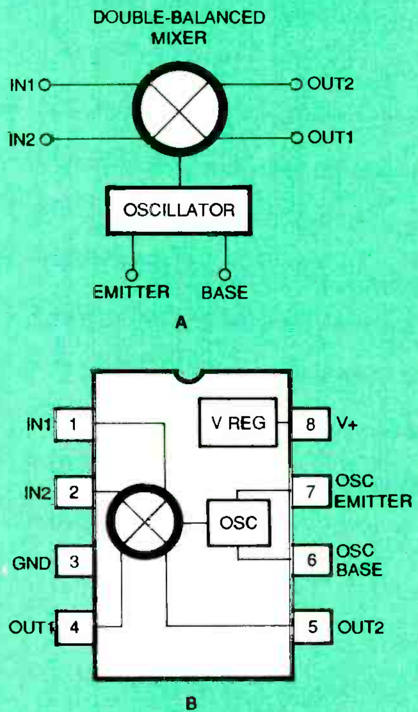


Fig. 1. The NE602 contains a double-balanced mixer and local oscillator. Here are its block diagram (A) and pinouts (B).

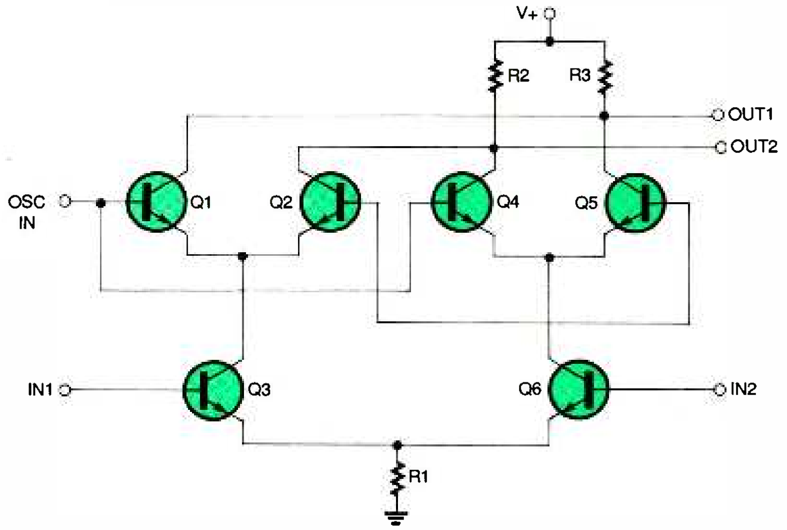


Fig. 2. The heart of the NE602: a Gilbert transconductance cell used for the double-balanced mixer.

Frequency Translation. The process of frequency translation or conversion is called heterodyning. When two frequencies (F1 and F2 in Fig. 3) are mixed together in a nonlinear circuit, a collection of different frequencies will appear at the output. Those frequencies are characterized as mF1+/–nF2m, where n and m are integers or zero (0, 1, 2, 3 . . .). For the sake of simplicity, we normally consider only the cases where m and n are either 0 or 1, so the output frequencies are F1, F2, F1 – F2 (difference), and F1 + F2 (sum). To make a superheterodyne receiver (the most common modern form), select either the sum (F1 + F2) or difference (F1 – F2) frequency as the receiver's intermediate frequency (IF). The NE602 contains a double-balanced mixer, so when it is properly impedance matched, it suppresses the two input frequencies (F1 and F2) at the output, and only produces the sum and difference frequencies.

In order to provide frequency translation by heterodyning, it is necessary to provide an LO circuit. The LO circuit inside the NE602 consists of a transistor with its base and emitter elements available to the outside world. Oscillators using that circuit will operate up to 200 MHz. Any form of oscillator can be built, as long as the circuit does not need a connection to the collector of the oscillator transistor. Because of that restriction, both L-C and crystal variants of the Colpitts, Clapp, Hartley, Butler and other oscillator circuits can be built, while the Pierce and Miller circuits are not possible.

DC Power Supply Connections. The power is applied to the NE602 between pins 3 (ground) and 8 (V+). The DC power supply voltage range is +4.5- to +8-volts DC, with a current drain ranging from 2.4 to 2.8 mA.

The DC power supply terminal (pin 8) must be decoupled with a 0.01- to 1-µF capacitor (0.1 µF is most common). The bypass capacitor must be mounted as close as possible to the body of the NE602, and must be capable of good performance at RF frequencies (some capacitors act like complex RLC networks at RF).

Figure 4 shows several possible DC power-supply configurations for the NE602. In Fig. 4-a, the DC power supply voltage is between +4.5 and +8-volts DC, which is the normal operating range of the device. A resistor, usually 100 to 180 ohms, is placed in series with the V+ line to the NE602. If the circuit is operated from a 9-volt DC power supply (*e.g.* a 9-volt DC transistor-radio battery), then the resistor should be increased to a value between 1,000 and 1,500 ohms, as in Fig. 4-b.

If the DC power supply voltage is either unstable, or at a value higher than 9-volts DC, you might want to use some form of voltage regulation. In

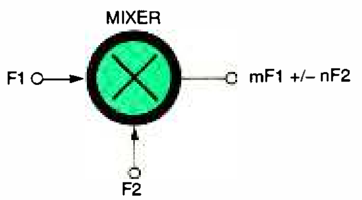


Fig. 3. In a basic mixer circuit, the sum (F1 + F2) and difference (F1 – F2) of two input frequencies appear at the output.

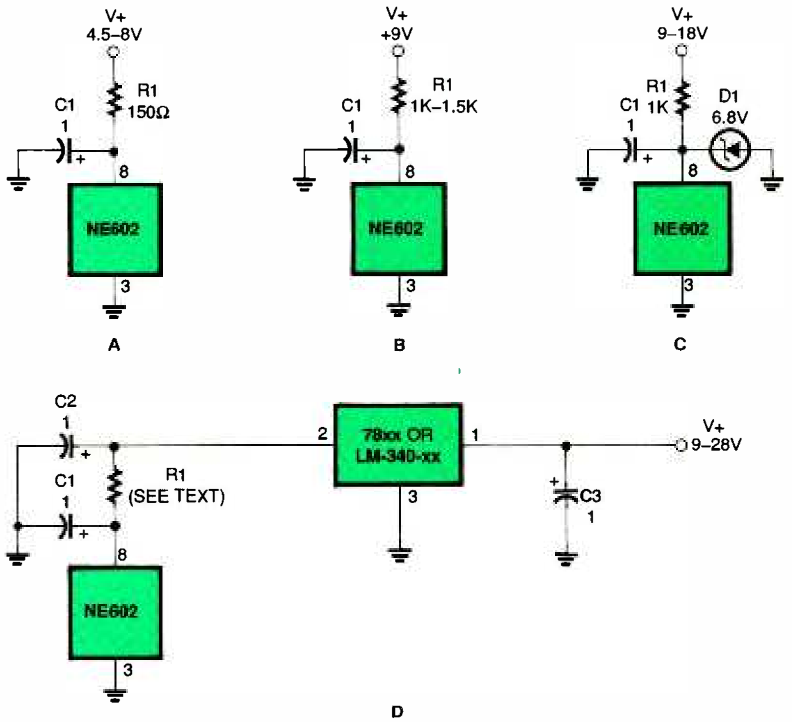


Fig. 4. There are several ways to power the NE602. A resistor should be placed in series between the power supply and the NE602 (a and b). A Zener diode (c) or a voltage regulator (d) can also be used.

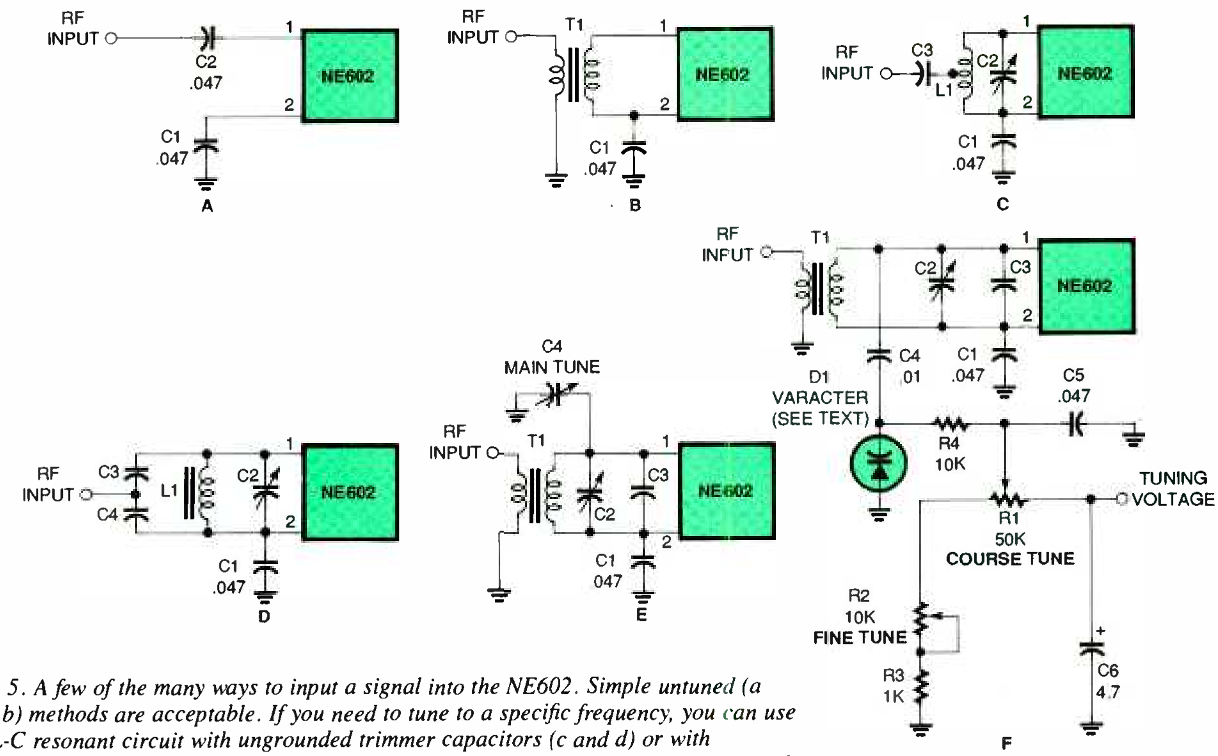


Fig. 5. A few of the many ways to input a signal into the NE602. Simple untuned (a and b) methods are acceptable. If you need to tune to a specific frequency, you can use an L-C resonant circuit with ungrounded trimmer capacitors (c and d) or with grounded variable capacitors (e). You can even use a tuning voltage in connection with a varactor (f).

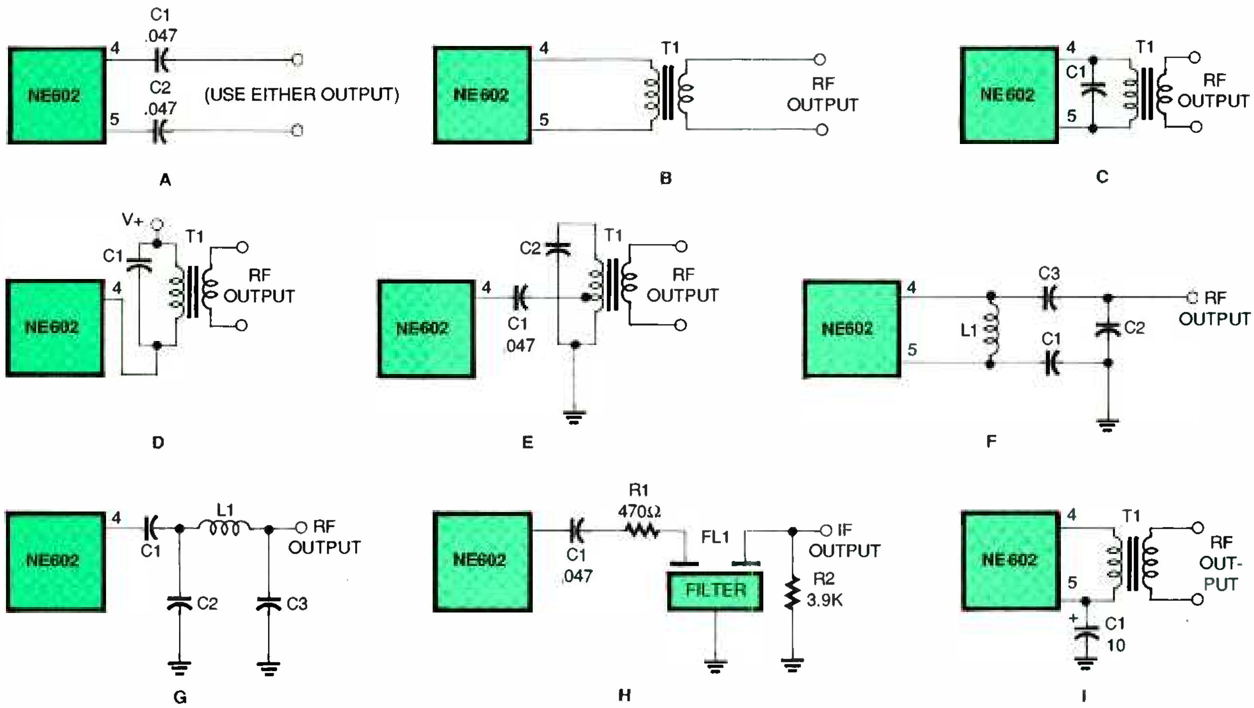


Fig. 6. The various output circuits shown here demonstrate how to either pass all the frequencies from the NE602, or allow only the sum or difference frequencies through, depending on which circuit is used.

fact, that's highly recommended. Figure 4-c shows the use of a Zener diode, rated at 6.8-volts DC, which keeps the supply voltage seen by the NE602 at that level even though the source power supply voltage might vary from 9 to 18 volts, or so.

The use of a three-terminal voltage regulator is shown in Fig. 4-d. Those devices provide a constant output voltage for a wide range of DC input voltages. A typical voltage regulator can accept input voltages from a minimum of about 2.5-volts higher than its rated output voltage, up to a maximum of about 30 to 38 volts. Almost any positive voltage regulator can be used in the circuit of Fig. 4-d if it

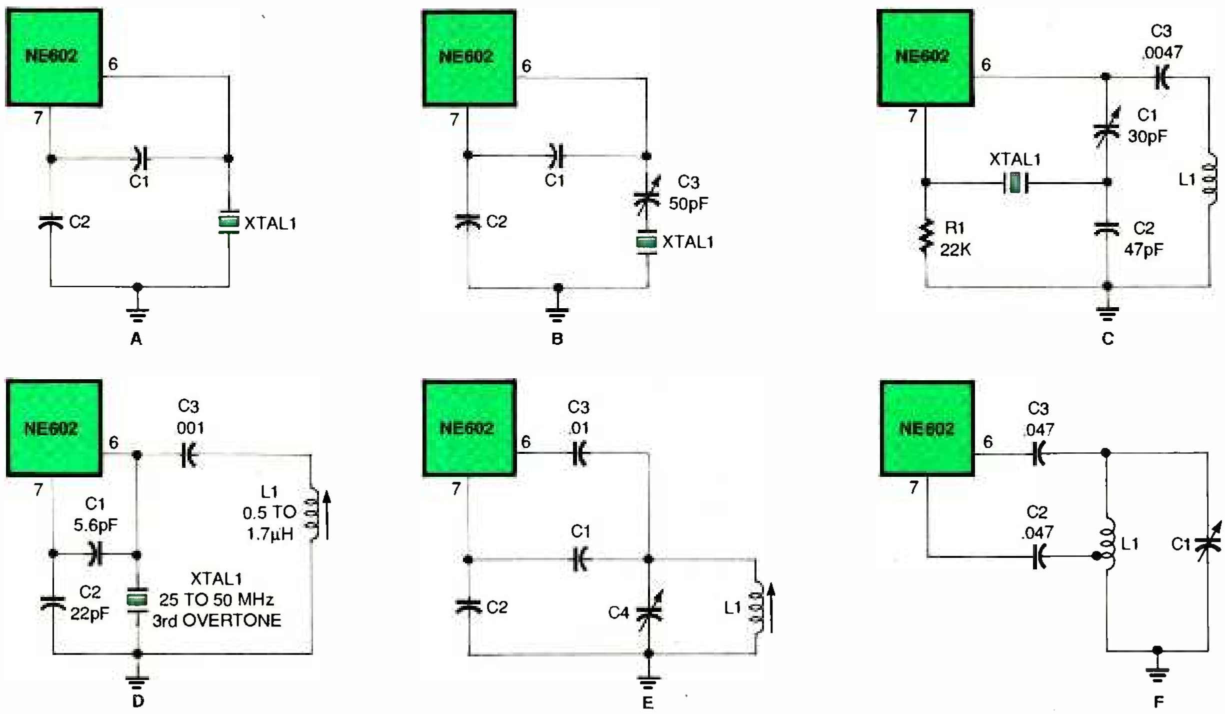


Fig. 7. The local oscillator for the NE602 can take the form of either a crystal-controlled (a through d) or a resonant-tank circuit (e and f).

has the correct output-voltage rating. The 78xx series and the LM-340-xx are essentially the same devices, with the "xx" replaced by the voltage rating. For example, the 7805 is a +5-volt DC voltage regulator. Because the NE602 device has such a low current requirement, it's possible to use the low-powered 78Lxx series. Good candidates are the 78L05, 78L06, 78L08 or 78L09 devices, with the first three preferred. The value of R1 in Fig. 4-d should follow the same rules as for Figs. 4-a and 4-b.

NE602 Input Circuits. The RF input side of the NE602 uses pins 1 and 2 (IN1 or IN2), which form a differential pair. The input impedance of the NE602 at lower frequencies is about 1,500 ohms shunted by 3 pF of capacitance, while at higher frequencies it drops to about 1,000 ohms. Both balanced and unbalanced input circuits can be used on the NE602. Unless a true differential configuration is used, the signal is usually applied to pin 1, and pin 2 is bypassed to ground.

Figure 5-a shows the simplest form of input circuit. A single capacitor (0.047-µF typical) couples the signal from the outside world to pin 1 of the NE602. The other input pin (pin 2) is bypassed to ground with another

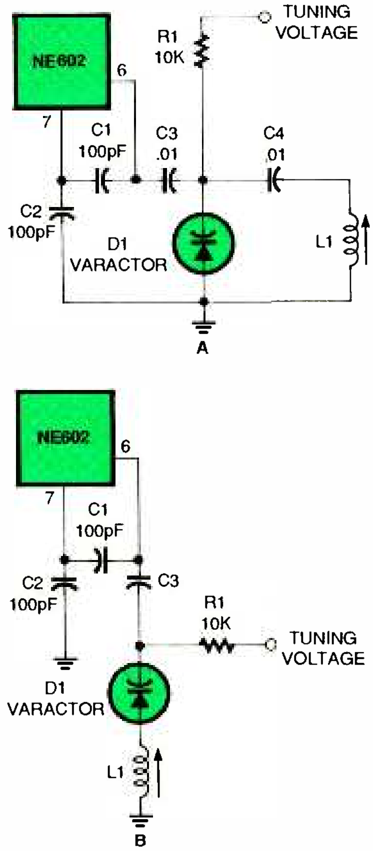


Fig. 8. The LO circuit for the NE602 can also be voltage-controlled. Here are two different methods of accomplishing that.

0.047-µF capacitor. With that configuration, the input signal should be kept around −25 dBm, or 180-mV peak-to-peak.

The use of a wideband RF transformer is shown in Fig. 5-b. In that configuration, the secondary of a wideband transformer is connected across pins 1 and 2 of the NE602, while the primary is connected between the antenna and ground. The turns ratio of the transformer is set to transform the 1,000- to 1,500-ohm input impedance of the NE602 to the system impedance (usually 50 ohms). A general rule for the transformer is to set the inductance of the secondary winding to provide four times the NE602 input impedance at the operating frequency, or about 4,000 to 6,000 ohms. Either conventional- or toroid-wound transformers can be used for T1 in that application. As we've seen before, one input of the NE602 is decoupled to ground through a capacitor.

The circuits shown in Fig. 5-c and 5-d are tuned to a single frequency, but use different methods to provide impedance matching between the source and the input of the NE602. Of course, a capacitor could also be used to resonate the secondary of the transformer in Fig. 5-b. In Fig. 5-c, we do just that by resonating coil L1 with variable capacitor C2. The input signal is coupled to coil L1 through an impedance-matching tap on L1 via capacitor C2. As with the other circuits, pin 2 is bypassed to ground.

The circuit in Fig. 5-d shows the use of a capacitor voltage divider (C3 and C4) to match the impedances. The resonant frequency is set by tuning L1 with variable capacitor C2, plus the series capacitance of C3 and C4. The tuning capacitance is:

$$C_{tune} = C2 + C3 \times C4/C3 + C4$$

The circuits shown in Figs. 5-c and 5-d are used when the source impedance to be matched is less than the 1,500-ohm input impedance of the NE602 device. When a transformer input such as Figs. 5-b and 5-e are used, then the source impedance can be either higher or lower than 1,500 ohms, provided that we have the correct transformer turns ratio. One difficulty with the resonant circuits discussed earlier is the fact that the capacitor is connected across L1, which means that it must be ungrounded. That's fine as long as you can use trimmer capacitors, or somehow insulate a normally grounded variable capacitor. But it's not always practical to do that, so you can use the circuit of Fig. 5-e instead. Three tuning capacitors are used in that circuit: C2, C3 and C4. Capacitor C4 is effectively across the secondary winding of T1, provided that the value decoupling capacitor C1 is very large compared to the value of C4. In that instance, the value of the series combination of C1 and C4 is very nearly the value of C4. Capacitor C4 is used as the main tuning capacitor, while C2 is an optional trimmer capacitor for fine tuning. Also optional is C3, which is used to make up any extra capacitance required to meet a minimum value. If C1 >> C4, the effective capacitance across the secondary of T1 is C2 + C3 + C4 + 3 pF.

A voltage-tuned variant of the input

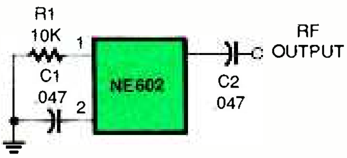


Fig. 9. If LO signal of the NE602 is sent directly to the output pins, the device can be used as a low-cost, high-frequency oscillator.

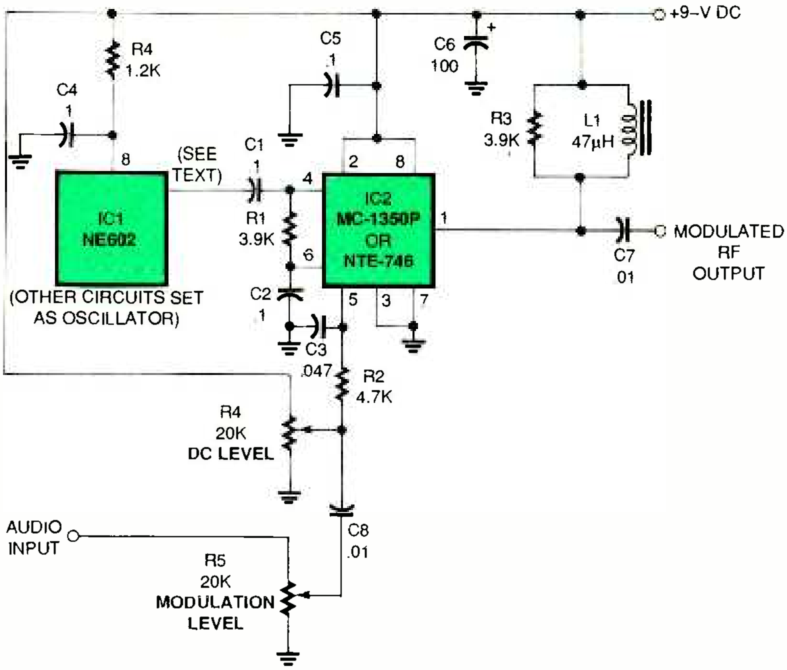


Fig. 10. By using an MC-1350P modulator IC, the output of the NE602 can easily be amplitude modulated.

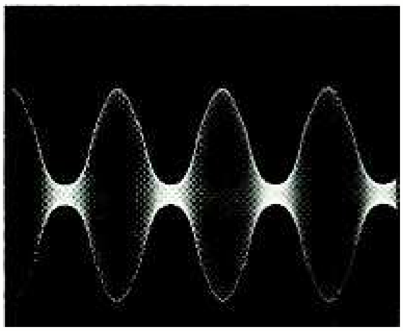


Fig. 11. This is the waveform of the circuit in Fig. 10, ready to be transmitted as an AM-radio signal.

circuit is shown in Fig. 5-f. That circuit is similar to Fig. 5-e, except that the variable "main tuning" capacitor (C4 in Fig. 5-e) is replaced with a voltage variable-capacitance (varactor) diode, D1. Those diodes provide a capacitance that drops as you increase the reverse voltage across the diode's terminals. As long as C4 is very much larger than the capacitance of D1 at any voltage, the tuning capacitance is that of D1. Resistor R1 is used to isolate the tuning voltage from the diode, so that it doesn't load the capacitance. Although a single "main tuning" potentiometer could be used, the circuit uses both course tune (R1) and fine tune (R2) potentiometers.

NE602 Output Circuits. The NE602 has two outputs that can be used as a balanced pair, or alone as single-ended outputs. Either pin 4 or pin 5 can be used alone for single-ended circuits, or pins 4 and 5 are used together as a balanced, or differential, output. The simplest form of output circuit is shown in Fig. 6-a. Either pin 4 or pin 5 can be used. The output signal is coupled through a 0.01- to 0.1-µF capacitor to whatever circuit the NE602 is to drive. The circuit of Fig. 6-a is a wideband configuration and cannot tell which signals are the sum (F1 + F2) or difference (F1 – F2) signals.

A wideband balanced-output circuit is shown in Fig. 6-b. The transformer is used to change the 1,500-ohm output impedance of the NE602 to the impedance of whatever circuit is being driven. If both input and output system impedances are the same, then the same type of transformer can be used for both input and output, although reversed relative to each other. As in the case of the input circuit, either standard or toroidal transformers can be used for T1.

Tuned-output circuits are shown in Figs. 6-c through 6-e. The circuit of Fig. 6-c is balanced. The primary of the transformer is connected across pins 4 and 5, and is resonated by capacitor C1. A single-ended variation is shown in Fig. 6-d. In that case, the parallel-tuned circuit consists of C1

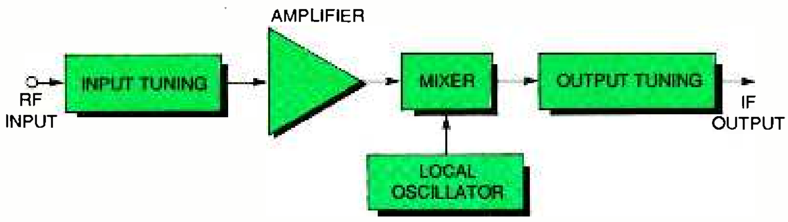


Fig. 12. If we add input and output tuning to the basic block diagram of Fig. 1-a, we can use the NE602 as a frequency translator.

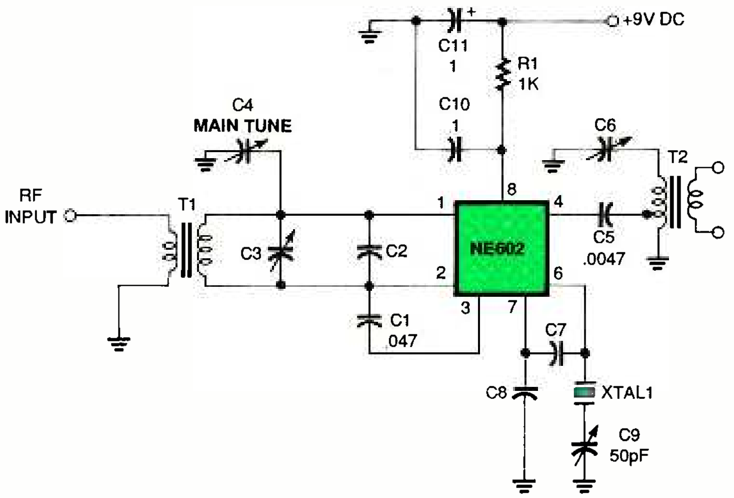


Fig. 13. This basic frequency translator/converter circuit is based on the block diagram of Fig. 12. It is useful as a demodulator in radio receivers.

and the primary of T1 as before, but the tank circuit is connected to either pin 4 or 5 and the DC-power-supply line. Another variation is shown in Fig. 6-e. There, impedance matching is provided between a higher impedance transformer primary and the output of the NE602 by using a tap on the transformer. Capacitor C1 (0.047-µF) is used to provide DC isolation between the output and the coil. That capacitor is needed because the coil is grounded. Still another variation (not shown) connects the capacitor to the top of T1, rather than a tap. That would be a grounded version of Fig. 6-d.

Still another single-ended output configuration is shown in Fig. 6-f. The inductor (L1) is connected across the balanced outputs, pins 4 and 5, but the pin 5 end is bypassed to ground through capacitor C1. The inductor is resonated by the series combination C2/C3, which also serves as a capacitor voltage divider for impedance transformation.

The output network in Fig. 6-g is an L-C low-pass filter circuit. That configuration will select the difference IF frequency (F1 − F2) if the −3-dB point of the filter is set correctly. If you want to select the sum IF frequency (F1 + F2), then use a high-pass L-C filter. That is done by replacing C2 and C3 with inductors, and L1 with a capacitor. The values of those components can be found using the normalized method in The ARRL Radio Amateur's Handbook (any recent edition), or by using the software FilterMaker for Windows (available from the author at P.O. Box 1099, Falls Church, VA, 22041 for $20. VA residents should add appropriate sales tax).

The network in Fig. 6-h is for use with fixed-frequency filters such as a crystal, ceramic, or mechanical types. Such filters are used to provide the IF-bandpass characteristic in receivers, and are available with characteristics from "sorta decent" for a few bucks, to real good for $100 and up. The center frequency of the filter is set to either the sum or difference IF, and its bandwidth is set according to application (*e.g.* 500 Hz for CW, 2.8 kHz for SSB, or 5 to 6 kHz for AM). An output circuit for a direct-conversion receiver is shown in Fig. 6-i. A direct-conversion receiver is similar to a superheterodyne, except that the LO and RF frequencies are very close to each other, so that the difference is the recovered audio. For example, to receive SSB, set the LO 2.8-kHz from the RF, or to receive CW set it 400- to 1,000-Hz (depending on the tone you'd like to hear). To receive an AM signal, set the LO to exactly the same frequency as the RF. Transformer T1 in Fig. 6-i is an audio transformer. It can be a 1,000:1,000-ohm transformer if the next stage has a high impedance input, or it can be a 1,000:8-ohm audio-output transformer.

NE602 Local Oscillator Circuits. There are two general methods for controlling the frequency of the LO in any oscillator circuit: inductor-capacitor (LC) resonant tank circuits, and piezoelectric-crystal resonators. We'll talk about both methods, starting with the crystal oscillator.

Figure 7-a shows a basic Colpitts crystal oscillator. It will operate with fundamental-mode crystals on frequencies up to about 20 MHz. The feedback network consists of a capacitor voltage divider (C1/C2). The values of those capacitors are critical, and should be approximately:

$$C1 = 100/\sqrt{F(MHz)}$$

$$C2 = 1000/F(MHz)$$

The values predicted by these formulas are approximate, but work well under circumstances where external stray capacitance does not dominate the total. However, the practical truth is that capacitors come in standard values and those may not be exactly the values calculated. When the capacitor values are correct, oscillation will be consistent. If you pull the crystal out, and then reinsert it, the oscillator will restart immediately. Alternatively, if the power is turned off and then back on again, the oscillator will always restart. If the capacitor values are incorrect, then the oscillator will either fail to run at all, or will operate intermittently. Generally, an increase in the capacitances will suffice to make operation consistent.

A problem with the circuit of Fig. 7-a is that the crystal frequency is not controllable except by replacing the crystal. The actual operating frequency of any crystal depends, in part, on the circuit capacitance seen by the crystal. Most crystals are designed for load capacitances of 20 or 32 pF, but that can be specified if crystals are being ordered directly from a manufacturer. In Fig. 7-b, a variable, or "trimmer" capacitor is placed in series with the crystal in order to set the frequency. The trimmer capacitor can be adjusted to set the oscillator to the desired frequency.

The two previous crystal oscillators operate in the fundamental mode of crystal oscillation. The resonant frequency in the fundamental mode is set by the dimensions of the slab of quartz used for the crystal; the thinner the slab, the higher the frequency. Fundamental-mode crystals work reliably up to about 20 MHz, but at higher frequencies the slabs become too thin for safe operation; at that point, the thinness of the slabs of fundamental-mode crystal causes them to fracture easily. An alternative is to use overtone-mode crystals. The overtone frequency of a crystal is not necessarily an exact harmonic of the fundamental mode, but is close to it. The overtones tend to be close to odd integer multiples of the fundamental (3rd, 5th, 7th, etc.). Overtone crystals are marked with the appropriate overtone frequency, rather than the fundamental.

Figures 7-c and 7-d are overtone-mode crystal-oscillator circuits. The circuit in Fig. 7-c is a Butler oscillator. The overtone crystal is connected between the oscillator emitter of the NE602 (pin 7) and a capacitive voltage divider that is connected between the oscillator base (pin 6) and ground. There is also an inductor in the circuit (L1) that must resonate with C1 to the overtone frequency of crystal XTAL1. Figure 7-c can use either 3rd- or 5th-overtone crystals up to about 80 MHz. The circuit in Fig. 7-d is a third-overtone crystal oscillator that works from 25 to about 50 MHz, and is simpler than Fig. 7-c.

A pair of variable-frequency oscillator (VFO) circuits are shown in Fig. 7-e and 7-f. The circuit in Fig. 7-e is a Colpitts-oscillator version, while Fig. 7-f is a Hartley-oscillator version. In both oscillators, the resonating element is an inductor-capacitor (LC) tuned-resonant circuit. In Fig. 7-e, however, the feedback network is a tapped-capacitor voltage divider, while in Fig. 7-f it is a tap on the resonating inductor. In both cases, a DC-blocking capacitor to pin 6 is needed in order to prevent the oscillator from being DC grounded through the resistance of the inductor.

Voltage Tuned NE602 Oscillator Circuits. Figure 8-a and 8-b show a pair of VFO circuits in which the capacitor element of the tuned circuit is a voltage-variable capacitance diode, or varactor (D1 in Fig. 8-a and 8-b). Those diodes exhibit a junction capacitance that varies in direct response to the reverse-bias voltage applied across the diode. Thus, the oscillating frequency of those circuits is controlled by a tuning voltage. The version shown in Fig. 8-a is a parallel-resonant Colpitts oscillator, while Fig. 8-b is a series-tuned Clapp oscillator.

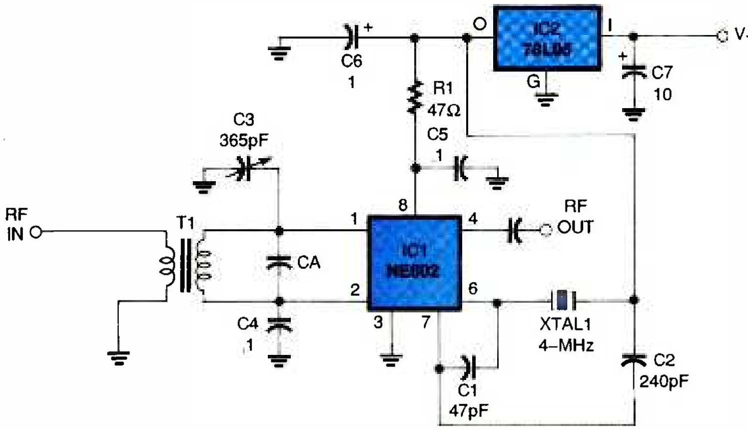


Fig. 14. Here is another simple frequency translator circuit; it does not select which frequency appears at the output.

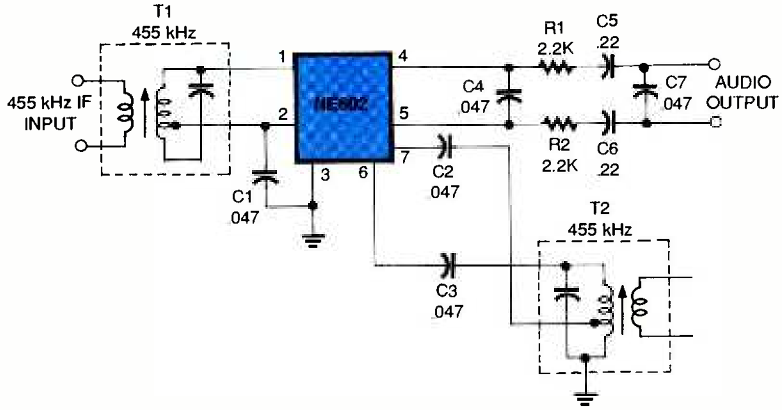


Fig. 15. After you've tuned in a particular radio frequency and demodulated it, this product-detector circuit can be used for Morse code (CW) or single-side band (SSB) reception.

Using the NE602 as a Signal Generator. The NE602 is normally used as a receiver front-end or as a frequency converter. It can also be used as a signal generator. Figure 9 shows the basic configuration for providing the LO signal at output pins 4 and 5; place a 10,000-ohm resistor (R1) between pin 1 and ground, while bypassing pin 2 to ground through a 0.047-µF capacitor. The output signal is taken from either pin 4 or 5 through another 0.047-µF capacitor.

The output signal of Fig. 9 will be a sinewave at the frequency of oscillation for the oscillator circuit connected to pins 6 and 7. That signal can be swept or frequency modulated by using one of the varactor LO circuits shown in Fig. 8. To sweep the frequency, make the tuning voltage a sawtooth waveform, while to frequency-modulate it, use a sinewave. If you want to amplitude-modulate the signal, then use a circuit such as Fig. 10.

The signal source is any of the NE602 oscillators (IC1 in Fig. 10), while the modulator is IC2, an MC-1350P chip. That chip is also available from the service-repair industry replacement lines as the NTE-746 or ECG-746. It is an RF-gain block with a gain-control terminal (pin 5), and that gain-control terminal can be used for the

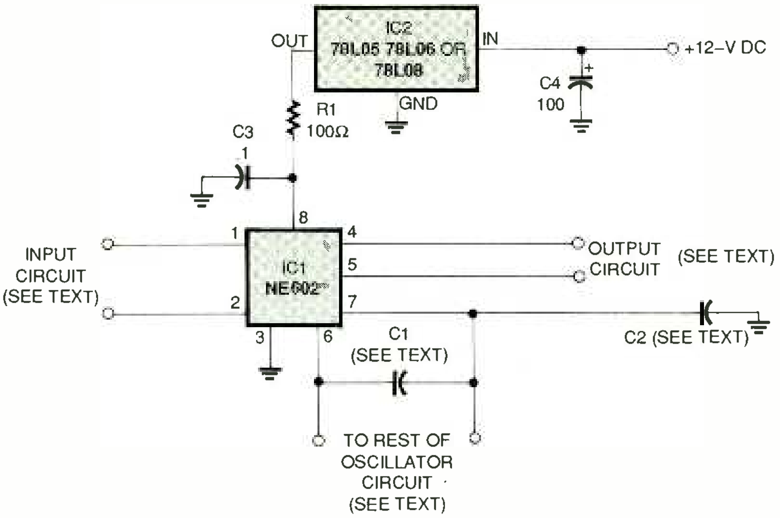


Fig. 16. There is just enough circuitry on the universal project board for NE602 to get you up and running with many different projects.

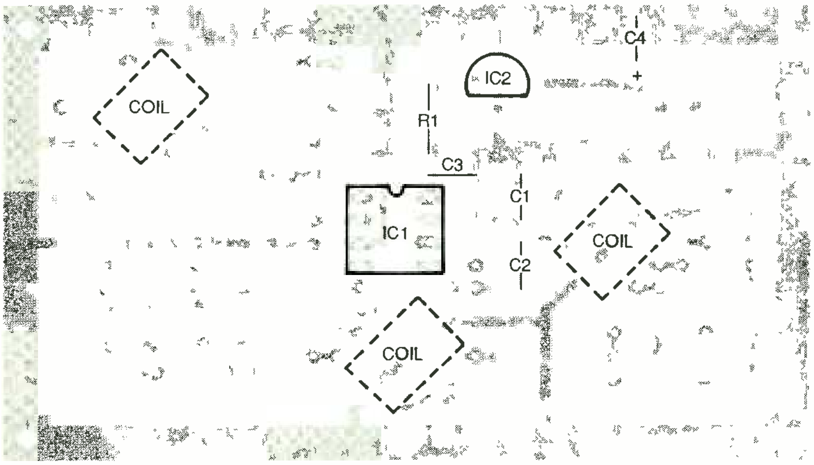
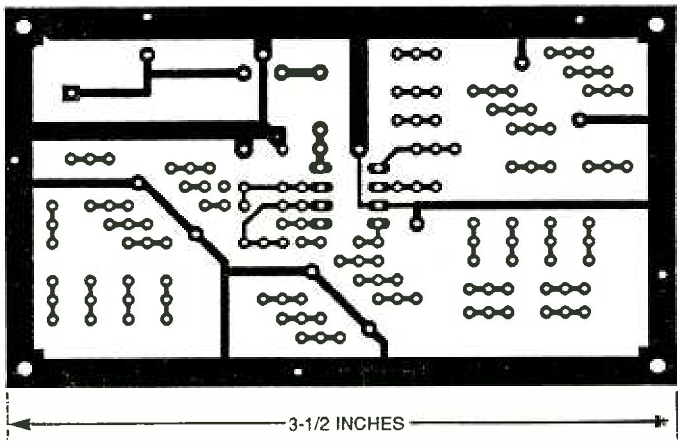


Fig. 17. Component placement on the universal project board leaves plenty of room for your own circuitry.



Here's the foil pattern for the NE602 universal project board. Many stand-alone pads are included to hold your circuitry.

amplitude-modulation function. Two signals are applied to the gain-control terminal as shown in Fig. 10; a DC level from potentiometer R4, and the audio signal from the MODULATION LEVEL control (R5). Adjust both DC LEVEL and MODULATION LEVEL until the output signal, as viewed on an oscilloscope, looks like Fig. 11. There should be good symmetry and no clipping of the peaks.

Using the NE602 in Converter Projects. The basic frequency converter was shown in block form back in Fig. 1-a; now it is time to expand upon that as shown in Fig. 12. The NE602 and its supporting circuitry might be used as the mixer and local oscillator. The amplifier is optional, and should only be used when sensitivity is poor. Poor sensitivity might be caused when insertion loss of the input tuning network is high.

The input and output tuning networks are used to segregate the signals. The input tuning selects the desired RF-input frequency (F1), and rejects all other frequencies. The output tuning network selects either F1 – F2 (difference), or F1 + F2 (sum) signals. Those filters can be L-C resonant-tank circuits, low-pass filters, high-pass filters, or band-pass filters as needed for the specific application.

Figure 13 shows a basic NE602 frequency-converter circuit. The input circuit consists of a transformer with a secondary winding resonated by C2, C3, and C4. The LO circuit is a crystal Colpitts circuit that uses a trimmer capacitor (C9) for adjusting the oscillation frequency over a small range. The output circuit is a variant of the parallel-resonant tank circuit in which the primary of the transformer (T2) is tapped to match the impedance of the NE602 output to the coil.

Another variant is shown in Fig. 14. That circuit is similar, except that the output is not tuned. The reason for that approach is that the frequency converter is used to drive the antenna input of a radio receiver, which performs the frequency selection (sum vs. difference) function.

Using the NE602 as a Product Detector. Figure 15 shows the circuit for a product detector based on the NE602. A product detector is a frequency converter that sets the LO frequency close enough to the RF or IF signal so a single-sideband (SSB) or CW signal is demodulated. For example, a 455-kHz IF signal from a receiver can be converted to an 800-Hz CW audio output ("beep-beep") by using an LO at 455.8 kHz or 454.2 kHz. The difference tone is found in the output.

(Continued on page 79)

BUILD THE FREEZER SENTRY— A FOOD FREEZER MONITOR

DAVE SWEENEY

Afraid that your freezer may not be as reliable as it used to be? Do you sometimes forget to close the door completely? Put your mind to rest—the Freezer Sentry will warn you of a problem before disaster strikes!

Having a separate food freezer in the home provides years of convenient, economical storage for perishable food. Stuffed with chicken, beef, fish and various specialty items, the home freezer offers a comforting feeling—until something goes wrong. Tucked away in a corner of the basement or garage, the freezer is conveniently forgotten. But with no warning or outward signs, a freezer malfunction might occur, easily costing you hundreds of dollars in thawed and spoiled food.

Imagine the horror of opening the freezer to select your dinner, and instead you're greeted by the odor of thawed and spoiling meat, poultry, and special desserts. The contents of your freezer could thaw overnight just because someone left the door open a crack or turned off a critical circuit breaker while servicing some other electrical device. With the freezer door closed, mechanical failures could also cause undetected problems. A Freon leak could weaken the ability of the freezer to maintain proper temperature. An overheated motor or compressor failure could leave you with soft or perhaps spoiled food if the freezer is down for a day or so.

For peace of mind, you can build the Freezer Sentry. An audio alert as well as a 5-volt remote-control output are activated if the freezer temperature rises or if there is a loss of AC power to the freezer. For a temperature problem, a special meltdown sensor inside the freezer detects a sustained temperature rise above 15° F. Regardless of the cause, a pulsating piezo-electric beeper sounds, and a 5-volt output for connection to a home-security system is activated. Because it latches in the on state once it is activated, the temperature alert will continue even if the temperature returns to normal. That feature will let you know that something went wrong, even if all appears OK when you examine the freezer.

Protecting A Freezer. To maintain the food for extended periods, a freezer is designed to keep the temperature of its storage area between −5° F and 0° F (well below 32° F, the freezing point of water). If a problem develops and you discover it in time, you might avoid a disaster. Even if the temperature in the freezer rises above freezing, the food will take a few hours to begin to thaw, and take even longer to spoil. If you detect a freezer meltdown in time, you might move your food to a neighbor's freezer, or, if there's room, to the freezer in the kitchen. A food loss might also be avoided by simply keeping the freezer door closed until the unit can be repaired.

The Freezer Sentry has to watch for two conditions: rising temperature in the freezer itself and a loss of AC power. The monitor itself is attached to the top or side of the freezer with a simple bar magnet glued to the Freezer Sentry's case. Inside the freezer, a special meltdown sensor is connected to the Freezer Sentry. The sensor is designed to close a switch if the temperature sustains a rise above 15° F. The Freezer Sentry runs on a power supply that plugs into the same electrical outlet the freezer is plugged into. If AC power to the freezer fails, then the Freezer Sentry also loses AC power. In that event, a set of 8 AA batteries keeps the Freezer Sentry running, sounding the alarm.

The meltdown sensor contains a solution that stays frozen as long as the temperature is well below 15° F. The sensor is simple to build, easy to adjust, and is designed to keep the alarm circuit as simple as possible. When the temperature rises, the sensor solution melts (before the meat has a chance to thaw) and falls on two copper electrodes. For added reliability, a piece of aluminum foil is frozen to the solution to ensure the closing of the contacts when the weight of the solution pushes down on them.

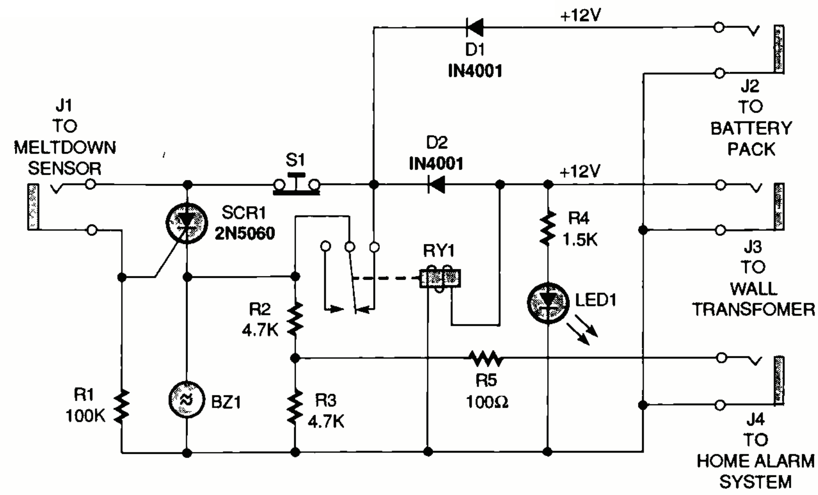


Fig. 1. The electronics for the Freezer Sentry is both simple and reliable. The meltdown sensor warns of a freezer malfunction and the relay together with the backup battery warns of AC power failure.

Using a liquid switch provides significant advantages over the use of a thermistor for sensing a temperature rise in a freezer. Short air-temperature variations, due to opening the door during normal use, will not trigger a false alarm. Additionally, testing and calibrating a thermistor-based design would require warming and cooling the freezer or the use of a laboratory test chamber. Thermistor resistance in the temperature region where a food freezer operates does not change abruptly with temperature. To adjust the point where the alarm should trigger, the freezer would need to be defrosted and frozen for each adjustment, which is not practical. A liquid switch, however, allows a simple approach to setting the temperature at which the switch triggers. Instead of changing the freezer temperature, you adjust the mixture of the liquid in the switch to just freeze at the unit's normal operating temperature.

WARNING: The meltdown sensor uses a mixture of automotive antifreeze and tap water. The main ingredient in antifreeze, ethylene glycol, is **EXTREMELY POISONOUS**. There is a possibility that the antifreeze solution will completely melt if, for example, there is a freezer failure while you're not at home for an extended period of time. If the meltdown sensor leaks in any way, antifreeze might contaminate the food in the freezer. As an added safety precaution, the meltdown sensor could be placed in a plastic container, such as an empty margarine or cottage cheese tub. Any leaking fluid would then be captured by the container, preventing contamination.

The Monitor Circuit. The electronic circuit for the Freezer Sentry, shown in Fig. 1, is quite simple. The heart of the circuit is SCR1, a silicon-controlled rectifier. That type of semiconductor acts like a solid-state switch—it will only conduct in one direction (like a diode) when a trigger voltage is applied to the gate terminal. That trigger voltage is supplied through J1 by the meltdown sensor when its contacts close. Resistor R1 is included to prevent any false triggering of SCR1 due to voltage fluctuations or noise from the power supply. Once SCR1 is triggered it latches on, sounding the alarm buzzer until the reset switch (S1) is pressed. The reset switch interrupts current flow through the SCR, letting it turn off.

Power for the circuit is supplied by a 12-volt DC wall-mounted transformer, which is connected to J3. As long as the wall-mounted power supply is working, relay RY1 will be activated, opening its normally-closed contact. Normal power will also be indicated by LED1, with R4 limiting the current flow through the light-emitting diode. If the AC power fails, LED1 will go out and RY1 will de-energize, closing the relay's normally-closed contacts. The relay contacts bypass SCR1, sounding the alarm. Backup power for that situation is supplied by a 12-volt battery pack, which is connected to the circuit through J2 and D1. Diode D1 prevents the AC-derived power supply

PARTS LIST FOR THE FOOD FREEZER MONITOR

SEMICONDUCTORS

D1, D2—1N4001 silicon diode
LED1—Light-emitting diode
SCR1—2N5060 silicon-controlled rectifier

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1—100,000-ohm
R2, R3—4,700-ohm
R4—1,500-ohm
R5—100-ohm

ADDITIONAL PARTS AND MATERIALS

BZ1—Piezo beeper (Radio Shack 273-066 or similar)
J1, J3—Male coaxial power jack
J2—Audio jack, 1/8-inch
J4—Audio jack, 3/64-inch
RY1—Single-pole double-throw relay, 12-volt coil, PC-mount (Radio Shack 275-248 or similar)
S1—Single-pole, single-throw, normally-closed pushbutton switch, panel-mount
Printed-circuit board, case, bar magnets, 8 AA batteries, Battery holder (Radio Shack 270-387 or similar), wall-mount 12-volt DC 200-mA power adapter, wire, suitable plugs for J1–J4, aluminum foil, 35mm film canister and lid, automotive antifreeze, epoxy, hot-melt glue

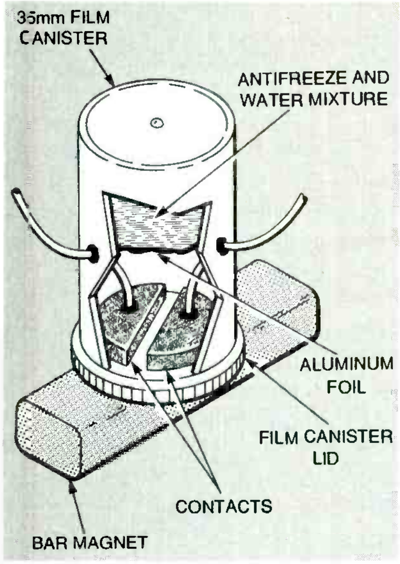
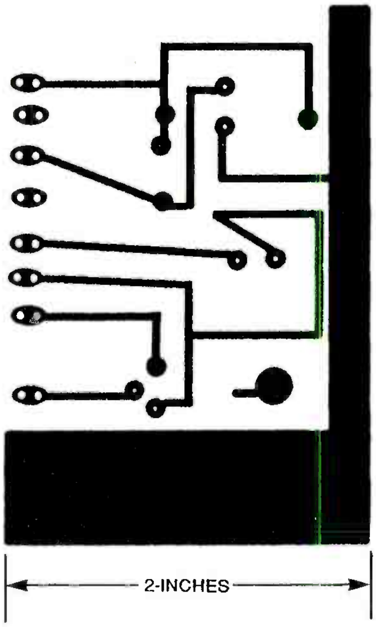


Fig. 2. The meltdown sensor contains a liquid that melts at about 15° F. When the liquid starts to melt, it falls down to the bottom of the canister, pushing an aluminum foil disc against the electrical contacts.



Here's the foil pattern for the Freezer Sentry. The circuit is simple enough to be built on a single-sided PC board.

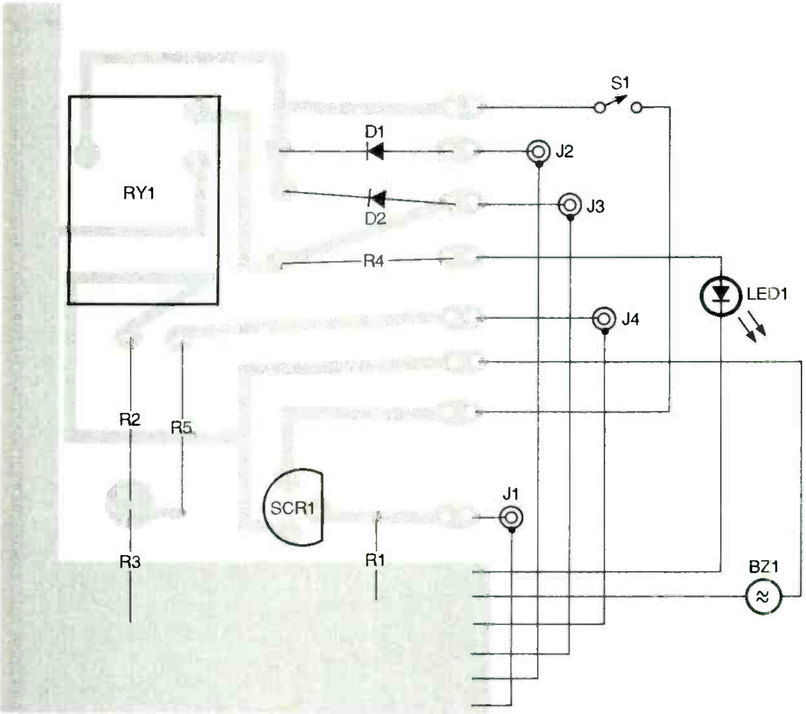


Fig. 3. If you want to etch a PC board from the foil pattern, use this placement diagram to locate the parts.

from attempting to charge the batteries, and D2 prevents the batteries from lighting the LED or energizing RY1 in the event of AC power failure. An additional feature of the circuit is that since the relay bypasses SCR1 during a loss of AC power, the reset button will not silence the alarm.

Regardless of which type of failure caused the alarm to sound, R2 and R3 form a voltage divider that provides a 5-volt signal to J4, with R5 limiting the current that can be drawn from J4. That signal could be connected to a home-alarm system or any other device you might wish to activate.

Assembling the Meltdown Sensor. You can easily build the meltdown sensor with only a few simple parts. The overall design of the sensor is shown in Fig. 2. The sensor housing itself is made from a plastic 35mm film canister. Attach a bar magnet to the lid of the film canister. The magnet will hold the unit in place on a freezer shelf. One method of attaching the magnet is to first drill a small hole in the film-canister lid. Using a screw with nut, attach a piece of flat aluminum plate to the lid. Glue a magnet to the aluminum with epoxy.

Cut two "D" shaped pieces of copper-clad printed-circuit board such that they will easily fit side by side on the inside of the film canister's lid without touching each other. Solder two very thin wires to the PC boards. The wires should be long enough to reach from the location where the meltdown sensor will be in the freezer to where the alarm circuit will be without being stretched tight. Those PC boards are the switch contacts. Drill two holes near the top of the film canister and run the wires through them. Use hot glue to hold the PC board contacts on the film can lid. Hot glue will hold the PC board contacts sufficiently as long as the wires are not severely pulled.

In a disposable plastic container, mix a solution of 3 parts water to 1 part antifreeze. An easy way to measure the ingredients is by using two additional film canisters—one for antifreeze and one for water. Pour one film canister of antifreeze and three film canisters of water into the plastic container and mix well. The mixture is designed to freeze at 0° F. Because of the poisonous nature of antifreeze, do not use a plastic mixing container that will be saved and used elsewhere later—residual antifreeze on the bowl might possibly come in contact with food. After creating the proper mix, the plastic bowl and canisters should be thrown away.

The mixture can be carefully tested in the freezer. Fill the meltdown sensor half full of the mixture. Cut a circular disc of aluminum foil slightly smaller than the inside diameter of the film canister. Carefully "float" the aluminum disc on the antifreeze mixture and set the container upright in the freezer with a freezer thermometer next to it. After 24 hours, check the

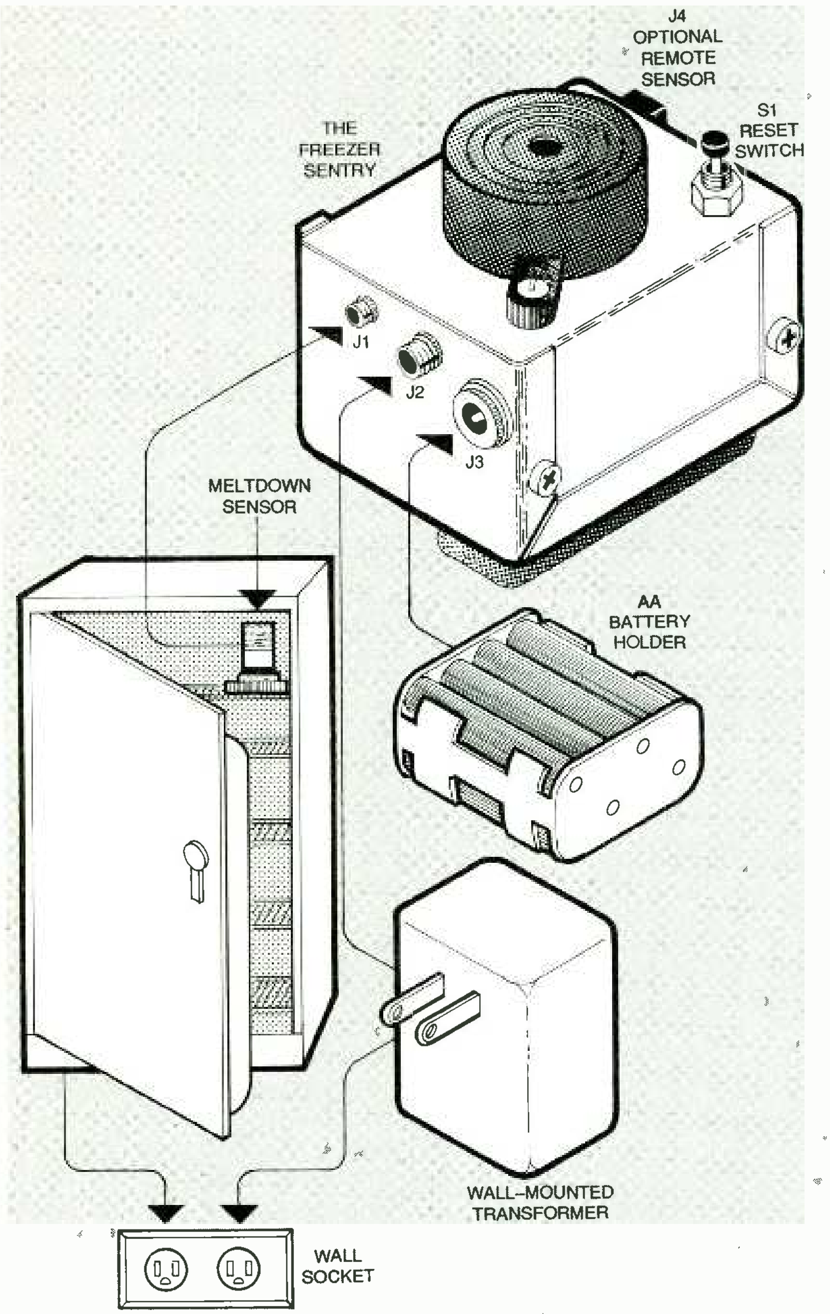


Fig. 4. A typical Freezer Sentry installation follows this general arrangement. The wall-mounted transformer should be connected to the same wall outlet that the freezer is plugged into.

temperature and the mixture. The temperature reading should be between 0° F and -5° F. The mixture should be frozen solid. If it is not, it will be "slushy". Add 3 teaspoons of water to the mixture to raise its freezing point and repeat the process for filling and freezing the switch. Once frozen, the switch must be kept frozen. After capping the sensor, turn it upside down so that the mixture will fall if it melts, and place it where it will operate in the freezer.

If you are concerned about putting antifreeze in the freezer even if placed in a second container for improved safety, you can try substituting 200-proof grain alcohol for the antifreeze. The mixture ratio will be different, so you'll have to experiment to find the proper amounts of alcohol and water for the sensor. Grain alcohol, also called medical alcohol, is 100% pure natural alcohol. It is not "denatured" like wood alcohol, so it is non-poisonous—that is, it will not cause blindness or death. It will just get you intoxicated at about 2 times the rate of most vodkas (about 50% alcohol), or about 3 times the rate of most whiskeys (about 35% alcohol) due to the relative content of alcohol.

Electronics Assembly. The Freezer Sentry circuit can be built using either a printed-circuit board or hand-wired on a perfboard. A PC board is not absolutely necessary, as the component placement is not critical. If you wish to build your own PC board, you may use the foil pattern published here and follow the parts-placement diagram in Fig. 3. It is a good idea to use different connector hardware for each connection to the circuit in order to avoid errors when plugging in the sensor and other connections. The connector combinations in the Parts List are by no means definitive—they just represent the choices made for the prototype.

A small aluminum chassis box holds the PC board, alarm buzzer, and connectors. A large magnet can be epoxied onto the aluminum chassis box for easy mounting of the unit on the freezer itself.

Testing And Installation. The overall arrangement in Fig. 4 is a typical Freezer Sentry installation. To test the unit, connect both power and battery, but not the meltdown sensor. Momentarily connect the inputs at J1 together, which simulates a closure of the meltdown sensor. The beeper should sound, and the remote output should change from 0 to 5 volts. The beeper should continue to ring until the reset button is pressed. At that point, the sound should stop and the remote output should return to 0 volts. Remove the power pack from the wall. Again, the beeper should sound and the remote output change from 0 to 5 volts.

Replace the power pack and press the reset button. Plug in the meltdown sensor, and the Freezer Sentry is ready to go. The next time that the freezer is defrosted, monitor the temperature with a thermometer to verify that the sensor triggers the alarm when the temperature rises to about 15° F. Ω

BUILD A CONDUCTANCE ADAPTER FOR YOUR MULTIMETER

Extend your digital multimeter's range dramatically to include resistance in gigohms and current in picoamps with this simple adapter.

SKIP CAMPISI

Have you ever tried to make an accurate, stable measurement on a resistor with a value over 10 megohms? Are you in need of an instrument to measure very low leakage currents in insulators or semiconductors? Both of those tasks become trivial with the Conductance Adapter discussed in this article.

If you have access to a 4-½-digit multimeter, you can use the Conductance Adapter to measure a 1-gigohm resistor—that's right, 1 *billion* ohms—with a resolution of 1%, and to measure currents down to 10 *pico*amps. You can also use a 3-½-digit multimeter; however, the resolution obviously will be reduced. You can either use the built-in temperature-compensated 1.000-volt reference or use an external voltage reference of your choice. The circuit is extremely stable, and does not suffer from noise like a standard ohmmeter working at high impedances.

Measuring Conductance. Because working with a large conductance value is easier than working with a small resistance value, measuring conductance rather than resistance is much more convenient when the current flowing through a device being measured becomes very small. Conductance is measured in *mhos.* A mho is the reciprocal of the resistance unit ohm, which is why a mho is called a mho: it is "ohm" spelled backwards.

The Conductance Adapter is so sensitive that precautions have to be taken to get an accurate measurement. Ordinary test probe leads just lying on the bench or across each other will show significant leakage currents due to their less than perfect insulation, which acts like a conductor at the extremely low currents needed to measure high resistances. The same can be said for printed-circuit board material, flux residue, and most plastics and other materials used as insulators. The only two insulators that can be trusted in the picoamp range are air and Teflon, which will both be used in the mechanical and electrical construction of the Adapter.

Incidentally, there is a new name for the mho, the *siemen.* Note that 1 mho equals 1 siemen. There is no change in definition of the unit—only its name. Since the abbreviation for siemen, "S", is easily confused with that for seconds, "s", we will use the older term in this article.

How It Works. The schematic diagram in Fig. 1 shows how simple the circuit actually is. A 1.000-volt reference is buffered by IC1, a TLC271, and is connected to J1 for use when measuring conductance. The voltage reference is derived from IC3, a 1.25-volt temperature-compensated band-gap reference. The current drop developed by the component under test at J1 and J2 is converted by IC2 to an output voltage that can be displayed on a digital voltmeter. The output voltage is limited to a maximum of 2.0 volts and a minimum of 1.0 volt. With the inverting input of IC2 at "virtual ground", that means the maximum input current that can be measured is −2.0 microamps.

In reading the conductance of an unknown resistor (labeled "R_x" in Fig. 1), −1.0 volt is applied to J1, with J2 being at virtual ground. Based on the maximum input current that can be converted by IC2, the smallest resistance that can be measured is 500,000 ohms. The values chosen for the circuit generate a conductance reading of 1.0 micromho-per-volt, or 1.0 nanomho-per-millivolt output. A 1.0-million-ohm resistor will have a conductance of 1.0 micromho, or 1000 nanomhos. A 1.0-billion-ohm resistor would be equal to 1.0 nanomho.

The current-to-voltage conversion is set by R10, which gives an output of 1-volt-per-microamp, or 1-millivolt-per-nanoamp. The unit you select for R10 should have as high a tolerance as you can find. Standard 5% units will not do—the lowest tolerance you should use for R10 is 1%. That value is easily purchased from various mail-

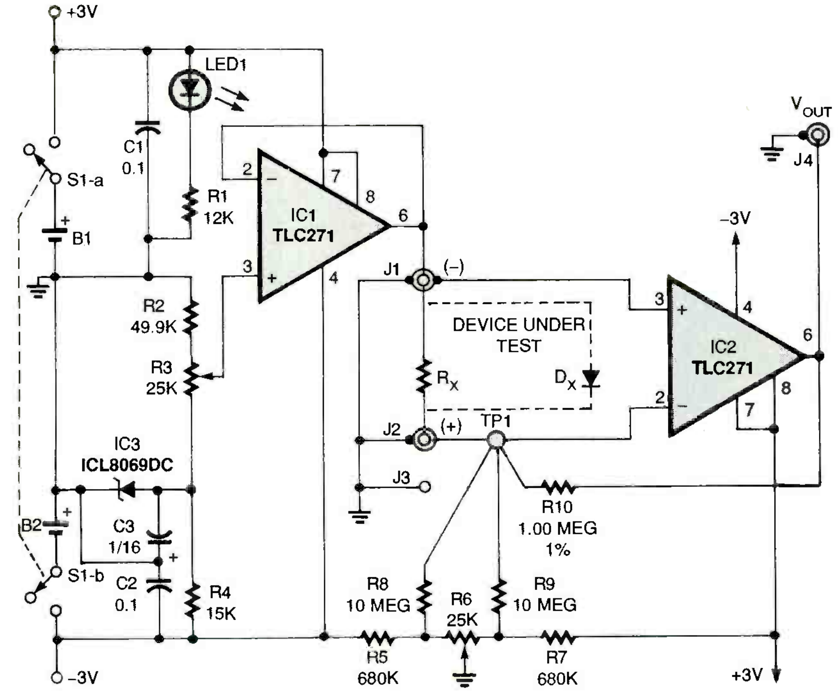


Fig. 1. The schematic diagram for the Conductance Adapter shows how simple a circuit is needed to accurately measure very high resistances and very low currents.

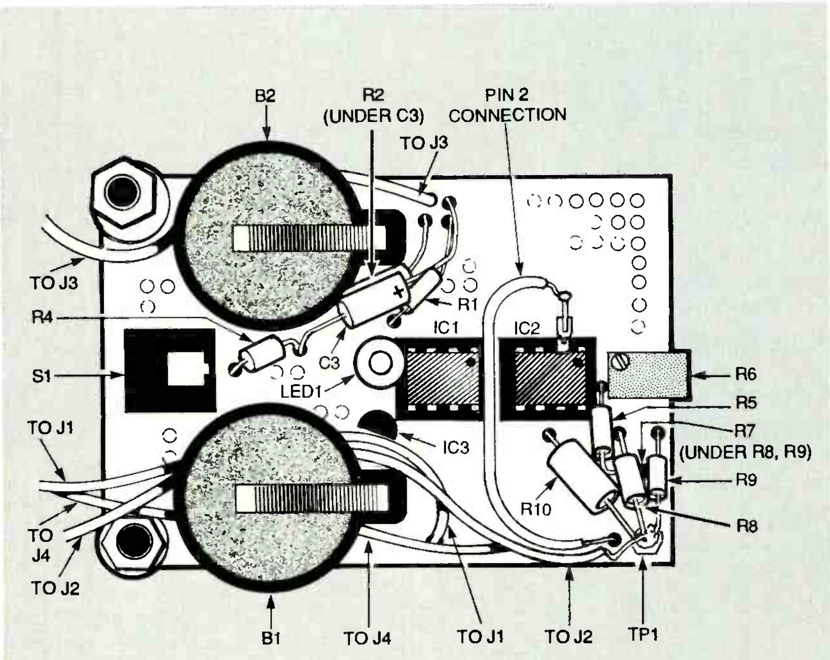


Fig. 2. Here is the top side of the Conductance Adapter. Because of the circuit's sensitivity to very high resistances, only Teflon-insulated wires should be used or the Adapter will not work properly.

order firms. For best accuracy, a 0.1% tolerance resistor is desirable. Unfortunately, a tolerance that tight is difficult to locate.

Power Supply. The ±3-volt power for the Conductance Adapter is supplied by two 3-volt lithium "coin"-type batteries installed right on the board in suitable holders. Since the total current draw for the Conductance Adapter is less than 150 microamps, the batteries should last a very long time. A "super-bright" LED is used for LED1, with the current through LED1 limited by R1. In order to keep current

PARTS LIST FOR THE CONDUCTANCE ADAPTER

SEMICONDUCTORS

IC1, IC2—TLC271 CMOS operational-amplifier (Mouser 511-TS271CN)
IC3—ICL8069 Band-Gap Reference integrated circuit (Mouser 570-ICL8069 DCZR)
LED1—Red LED, super-bright, T1 case (Mouser 509-EBR3368S)

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—12,000-ohm
R2—49,900-ohm, ¼-watt, 1%, metal film
R3, R6—25,000-ohm, multi-turn trimpot, cermet
R4—15,000-ohm
R5, R7—680,000-ohm
R8, R9—10-megohm
R10—1.00-megohm, ¼-watt, 1% or better, metal film (see text)

CAPACITORS

C1, C2—0.1µF, ceramic disc
C3—1.0µF, 16WVDC, solid tantalum

ADDITIONAL PARTS AND MATERIALS

S1—DPDT push-on/push-off or toggle switch
TP1—Teflon-insulated stand-off (Johnson STD-1, STD-2, or similar)
J1, J2—Teflon-insulated BNC jack (Pomona 4160)
J3—Banana jack
J4—RCA-style jack
B1, B2—CR2032 3-volt lithium batteries
Printed-circuit board (Radio Shack 276-150 or similar), 3/8- to 1/2-inch threaded spacers, screws, 22-gauge Teflon-insulated wire, enclosure, 14-gauge solid bus wire, alligator clips, 8-pin IC sockets, breakaway socket, battery holders, RCA-style plug

NOTE: All of the semiconductors, batteries, and battery holders are available through Mouser Electronics, Tel: 800-346-6873. Teflon-insulated BNC jacks and plugs are available from ITT Pomona, 1500 East 9th Street, Pomona, CA 91766-3835. Tel:1-800-ITT-POMONA. Teflon-insulated wire, standoffs, and all passive components are available from: Johnson Shop Products, P.O. Box 2843, Cupertino, CA 95015, Tel: 408-257-8614.

consumption to a minimum, LED1 is set to only put out a modest (but still discernible) glow.

Construction. The Conductance Adapter was built on standard perforated construction board. The actual placement of the parts is not critical, but if you want to follow the parts placement used in the prototype, that information is shown in the photographs of Fig. 2 (the component side) and Fig. 3 (the solder side). The balance of this article will assume that your board will resemble the author's prototype.

The board should be cut to fit the enclosure before starting construction. The board shown in Figs. 2 and 3 measures 1-7/8 inch × 2-3/4 inch.

Begin by installing the battery holders, the two 8-pin IC sockets, and potentiometer R6. You have the option of either mounting S1 on the board, or panel-mounting a slide or toggle switch on the case. Capacitors C1 and C2, along with resistor R3, are mounted on the underside of the board as shown in Fig. 3, but you may mount those components on top if you prefer.

Locate and install a Teflon-insulated standoff which has a solder terminal on its top near R6; that standoff will serve as TP1. Attach one end of resistors R8, R9, and R10 to TP1 with a mechanical crimp—**do not** solder them yet. Connect the other ends of those resistors to the appropriate locations as shown in Fig. 1, keeping the component bodies from touching the board. Attach two Teflon-insulated wires to TP1, then solder the joint. Make one wire long enough to reach J2, and the other long enough to reach pin 2 of IC2. Install one pin from a break-away type SIP socket on the wire for pin 2 of IC2. That socket pin will later be connected to pin 2 of IC2. Finish the board by installing the remaining components and make all of the interconnects on the board. Be sure to use Teflon-coated wires for insulated wires, and leave the lengths long enough to reach the panel-mounted components.

The case can be any convenient hand-held enclosure that will hold the entire circuit. Locate and install the four jacks and power switch. Drill clearance holes to mount the board and for LED1 and the adjustment

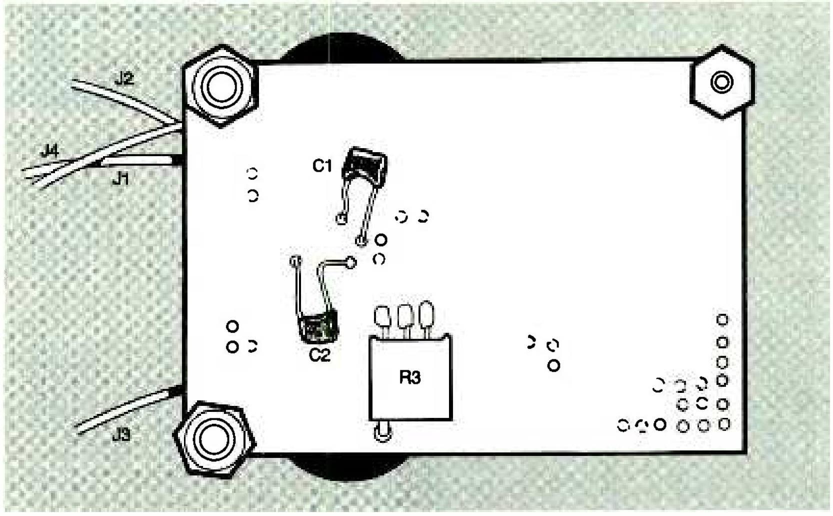


Fig. 3. Here is the bottom side of the Conductance Adapter. If you use a slightly larger board, these components can be placed on the top side along with the rest of the components.

screw of R6. If you have mounted S1 on the board instead, drill a hole for the push-button to protrude. Make sure that you use Teflon-insulated BNC jacks for J1 and J2.

Connect the board to the panel components and install IC1 in its socket. Install IC2 as follows: Carefully bend pin 2 out and away from its package so that it is at right angles to the rest of the pins. Install IC2 in its socket and slip the socket pin from the lead going to TP1 onto pin 2. That isolates pin 2 from all leakage paths. Inspect all of your connections and install the board in the enclosure with 3/8- to 1/2-inch spacers and screws.

Test Leads. Special attention must be given to both the input and output leads used on the adapter. Coaxial cable is NOT recommended for those leads, as the capacitance of the cable can cause oscillation at the outputs of IC1 and IC2. Prepare an output cable by twisting together a pair of foot-long Teflon-insulated wires. Attach one end of the twisted-wire pair to an RCA plug, and the other end to plugs that match your DMM's input sockets.

The input leads can be made similarly, using twisted pairs terminated in Teflon insulated BNC plugs. An easier method is to attach a single wire to a 1-inch length of 14-gauge bus wire. Pulling a conductor out of some 14-gauge Romex-type house wiring from a home-improvement center or hardware store will work fine for that. The 14-gauge wire will easily slide into the center of the BNC jack. If you need to, you can plug a separate ground lead into J3, but be sure to use only Teflon-insulated wire for all of your cables, and don't allow the component under test (or the hooks or clips used to connect it) to touch any medium except air. A simple but effective test jig can be made from two pieces of 14-gauge bus wire, about 2- to 3-inches long, with a small alligator clip soldered to one end of each and inserted into the BNC jacks. That arrangement works well when testing components such as resistors or diodes individually.

Calibration. To calibrate the Adapter, connect a DVM between J1 & J2 (the input jacks), turn on the Adapter's power, and adjust R3 (CAL) for a reading of exactly −1.0000 volts. Now connect the output from J4 (the RCA-style jack) to the DVM and adjust R6 (NULL) for a reading of 0.00 millivolts. Check the "null" reading occasionally—temperature drift may cause it to shift 10 to 20 microvolts.

Operation. The advantage to using the Conductance Adapter in measuring high impedances rather than an ohmmeter is that the Adapter applies a constant voltage to the device under test and then reads the resulting current. That is opposite to how an ohmmeter does the same task. Because of that, the Conductance Adapter has much better noise suppression. When using the Adapter,
(Continued on page 79)

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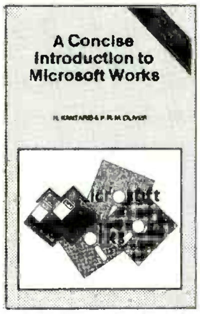

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BY DON LANCASTER

Miracle Energy Sources, New PICs, A History of Color Organs, and More

SUPPOSEDLY THERE IS THIS MAGIC, "SECRET" HINDU PLANT. MAKE A TEA OUT OF IT, SPRINKLE SOME LEMON JUICE ON IT, STEEP IT FOR A WHILE, AND PRESTO!—IT CHANGES INTO A CHEAP GASOLINE SUBSTITUTE. AT LEAST, THAT'S WHAT the very latest pseudo-science techno-myth tries to tell us. If you want to check that out for yourself, try the *Keelynet* for ongoing details (use the link on my http://www.tinaja.com Web site to reach them).

Incidentally, this one obviously and totally fails my "looks like a duck, quacks like a duck, and is about to lay eggs" subjective pseudo-science test, but how can you tell for sure? After all, gasoline grows on trees—you just have to let them rot for a geological epoch or two. It turns out that any plant can be used to make gasoline—Kudzu, grass clippings, tumbleweeds—you name it. But scant few plants are even remotely worth all the time and trouble for you to do so.

The key questions you have to ask are these: (A) How many pounds of plant will you need for one pound of gasoline? (B) How much total energy has to go into the process compared to the energy you get back? (C) How expandable is the process to larger scale production? (D) What is the time to economic break-even for the labor and capital that has to go into the production system? (E) What are the hidden and off-the-books societal costs for new infrastructure? And, of course, (F) How badly will the government screw it up?

Yes, the so-called experts can sometimes be wrong. They typically overreact., but they'll usually end up back on target once all of these key questions get properly asked.

For instance, what appeared to be an outright scam in the 1920s sort of wasn't. Magic tablets were sold that instantly changed water into a motor fuel. The "experts" said it was impossible, but they were all dead wrong. There definitely are magic tablets that let you convert water into motor fuel. I use those tablets all the time. Of course, there are a few minor and tiny side effects—such as getting only 25 miles per engine instead of per gallon, but let's not quibble. The tablets work. And yes, you can still buy them today, and they are not even expensive.

Of course, those tablets are an "underground" product; only cavers use them. Ask any spelunker for more details.

PIC's New Babies

We have already seen that the new PIC series of microcontrollers from Microchip Technology are easily the components of the decade. It has gotten to the point where it is, in my opinion, insane to ever again use a 555 timer or other bits-and-pieces solution to almost any electronic sensing or control application. The new PICs are incredibly fast, compact, and powerful microprocessors that literally blow the competition away. If you want to learn more, the Basic Stamp from Parallax and the Scott Edwards Tools can be your quickest and best ways to get yourself PIC-literate.

Well, there's now a brand new pair of baby PICs; see Fig. 1. The PIC12C508 and PIC12C509 both cost under a dollar in quantity and come in an eight-pin(!) mini-dip package. The '08 offers 512 bytes of EPROM and 25 bytes of RAM. The '09 doubles those values. Each offers several clock options: trimmable RC internal, external, or crystal. As with the other PICs, their powerful RISC instructions are mostly single cycle. Often executing three times faster in one-third the usual space.

There are up to six programmable

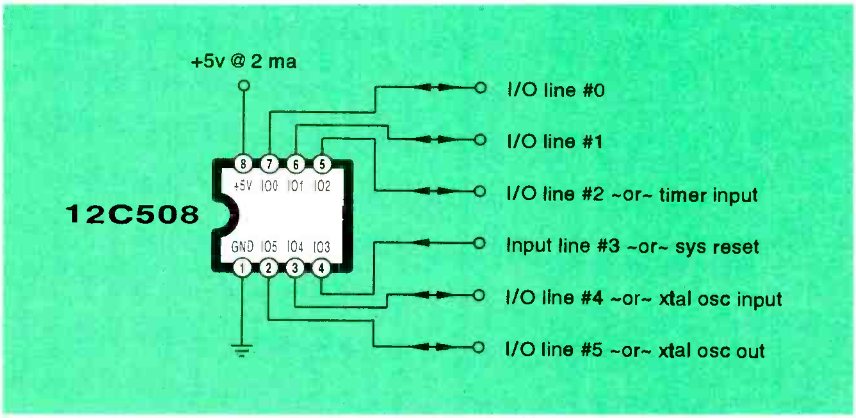

FIG. 1—MEMBERS OF THE "BABY PIC" family are among the smallest and the cheapest of microcontrollers, yet their capabilities are astounding.

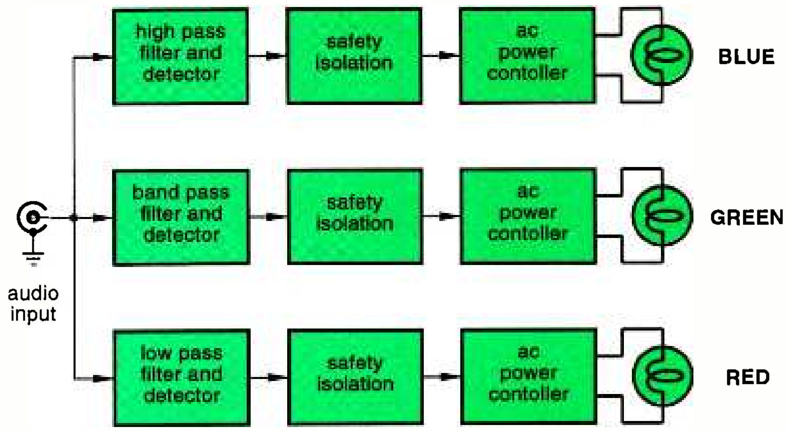

FIG. 2—HERE'S A BLOCK DIAGRAM of a classic color organ. The audio input gets filtered into three or more channels. Audio energy in each filter band sets the dynamic brightness of the chosen lamp color for that channel.

I/O pins. Pin 5 can be general I/O or a timer clock input. Pin 4 doubles as a master clear or an external wake-up call. You can hang a crystal on pins 2 and 3, or a system clock on pin 2. Analog input interface is easy. All you do is connect a capacitor and a resistor to any pin. Just briefly pull the capacitor low, and then loop recheck it until it charges to a logic one.

Although it may be a tad tricky to write a multitasking UNIX kernel for either chip (a free ISMM if you do), those baby PICs open up whole new worlds of low end applications. The free *PIC12C5XX Data Book* is published by Microchip Technology. Much more on PICs in general on my new Pick a Peck of Picks library shelf of www.tinaja.com.

Color Organs and Psychedelic Lighting

I guess it's way past time to update certain ancient history. People have long wanted to relate music to colors in one way or another. Back in the 16th century, a Jesuit monk by the name of James Bertrand Castell created his *Clavier au Lumier*. That was sort of a harp with flat colored strings. The strings were viewed edge on. As the string was plucked, you could see all the vibrating colors.

The first "classic" electronic color organ designs appeared in the 1950s. One used *thyratron* "vacuum" tubes in a half-wave design that only lit the lamps to partial brightness. Another used high-mu pentode audio-output vacuum tubes to drive scads of series-connected and easily-burned-out #49 pilot-light strings.

Figure 2 shows the block diagram for a classic lamps-style color organ. The speaker-level input audio is somehow safety isolated and then lowpass, bandpass, or highpass filtered into (usually) three or more channels. Each channel's output is then converted into some DC control voltage. That DC control voltage then modulates a "power amplifier" of some sort. Which in turn relates the amount of audio energy in the band to the brightness of one or more colored lights. For instance, the lows might be red, the mid-ranges green, and the highs blue.

I designed and published my first three-channel solid state-color organ in April of 1963 in the now defunct magazine, *Electronics World*. That used brand-new (at the time) Silicon Controlled Rectifiers to control a few-hundred watts of lamps-per-channel. The SCRs were preceded by a full-wave rectifier. That design let the lamps go more or less smoothly from zero to full brightness. Input audio went through some LC ferrite-cup core filters, was converted to DC with germanium-diode rectifiers, and then was used to control the phase advance of the unijunction-transistor timing circuits. That design was followed a year later, in the January 1964 *Electronics World*, by a version that substituted neon lamp triggers for those costly unijunctions.

The next version appeared in the October 1965 issue of **Radio Electronics** (this magazine's predecessor). That was the first unit to use voltage-

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modulated, four-layer trigger diodes, and the first to provide a line filter to attack the bad AM radio interference common to color organs.

Skipping a few designs which are best left forgotten, next in line was my *Musette*, which appeared in the July 1965 issue of **Popular Electronics.** That was a five-channel unit that still featured SCRs and trigger-diode modulation. Filtering was done using resonant transformers. Color-coded background controls were added to improve the sensitivity and linearity. Brand new dichromic-filter spotlights were used to dramatically improve color purity.

What I first called *Stereo Lamps*, but some editor renamed *Hi Fi a Go Go* appeared in the July 1966 **Popular Electronics**. That was just a low-priced, compact and unfiltered single channel version. It was useful for psychedelic lighting applications.

I considered my "definitive" color organ to be the *Psychedelia I*, which appeared in the September 1969 issue of **Popular Electronics**. Innovations in that unit included the use of new low cost full-wave Triacs having built-in heat sinks, a brand new $1 integrated-circuit phase-controller circuit, and steep-skirted two-pole active filters having broad between-channel guard bands. The use of prismatic lenses on the display gave hex "flower power" types of patterns. You had a choice of three or six channels.

Phase Control Fundamentals

The fundamentals of an AC-power phase control appear in Fig. 3. A Triac is a fast, efficient, and high voltage power AC switch that is turned on by a brief and low-level pulse on its gate. The Triac then stays on for the remainder of the power-line half cycle. It automatically turns off when your main current drops to zero on the half-cycle zero. Triacs are fully bi-directional: either polarity of gate pulse can be applied on either polarity cycle.

If the Triac is pulsed very late in each half cycle, the duty cycle is very low; very little power reaches the load, say a lamp, and the lamp lights only dimly. When the Triac gets pulsed in mid cycle, around one half of the power reaches the lamp. When it gets pulsed very early, the lamp lights to nearly full brightness. Thus, you might want your input control voltage to determine the time delay after a zero crossing when the Triac turns on. The higher the voltage the *less* your delay.

A modern Triac circuit appears in Fig. 4. For most applications, safety isolation is *essential* to prevent deadly "hot chassis" shock hazards. That is the purpose of the Motorola MOC3010 optoTriac isolator. While you can get Triacs from *Radio Shack*, *Texas Instruments or Motorola*, the definitive source is Teccor.

Usually, you will want to run your optoisolator "backwards" (as shown in

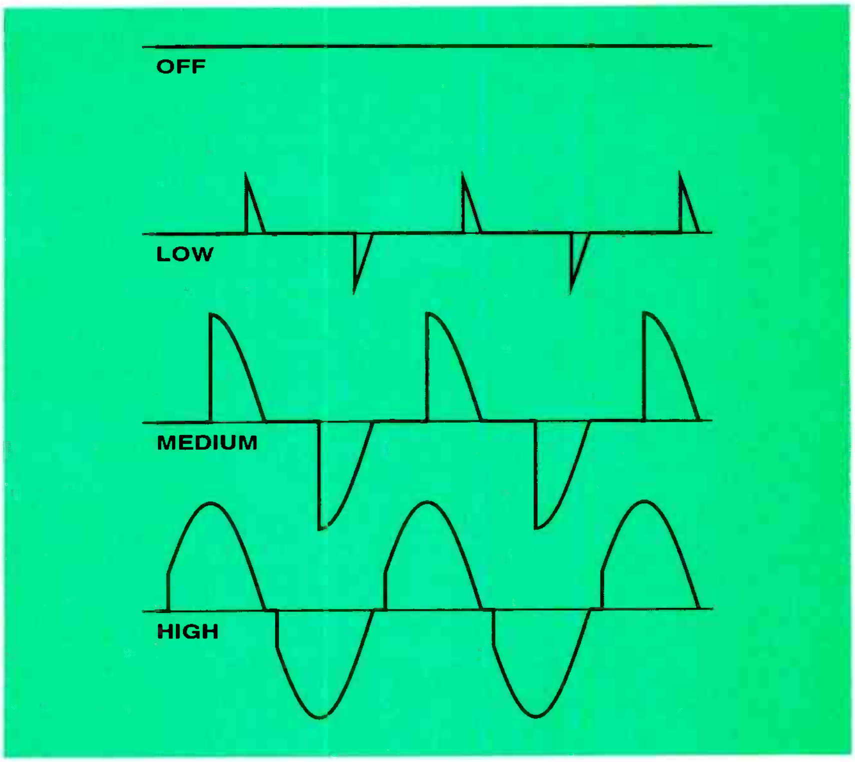

FIG. 3—THE FUNDAMENTALS BEHIND the phase control of AC power. The turn on of a Triac gets delayed after each AC half-power cycle. The longer the delay, the lower the load current. Simple phase control is useful for lamps, heaters, and AC/DC motors, But NOT for fluorescent lamps or induction motors.

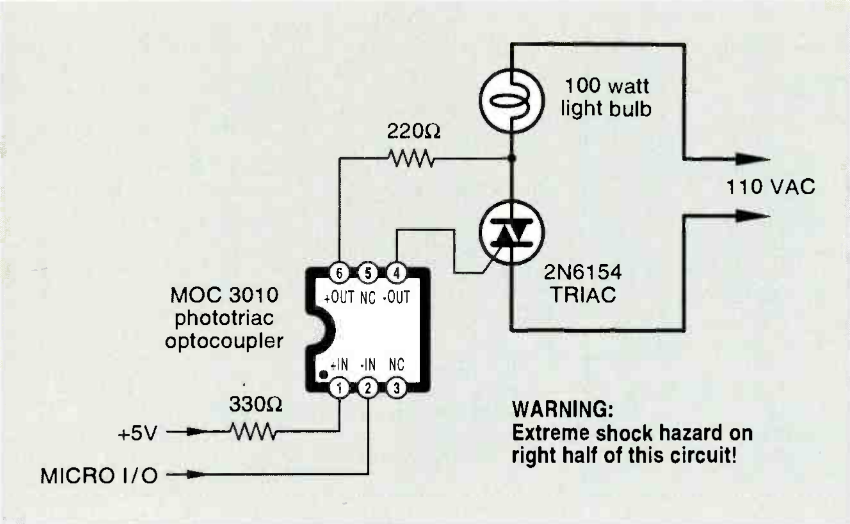

FIG. 4—A TYPICAL OUTPUT INTERFACE between a microcontroller and an AC power load. A one-piece solid state relay could be substituted. For a proportional phase control, a zero crossing reference must be provided.

the figure) so that a low or logic zero input turns the Triac on, and vice versa. That's simply because many microcontrollers and other digital ICs are better at sinking current to ground.

Two sources of specialized phase control integrated circuits are LSI/CSI and Signetics Philips. You can also get one-piece modules which include both Triac and optoisolation from CP Claire, International Rectifier, Crydom, or NTE. They are sometimes called *DC-in AC-out solid state relays*. A minimum rating of 200 volts is needed for AC-line operation, with 400 volts recommended. But at $8 to $12 each, the one-piece modules might not be cost effective against a pair of one dollar parts. The heat-sinking options are also limited using modules. The smaller module power limit is a few hundred watts. I have gathered several AC power-control suppliers together for you as this month's resource sidebar.

Back to the Present

What can we do to further improve color organ designs? Obviously, the new baby PIC is screaming to be used as a phase controller. With care, you might even get three channels out of a single low cost chip!

You would first have to question whether you'd prefer to use a classic design or something new. The crucial key to a classic color organ is some effective display. Even with the best designs, viewing can get boring.

At any rate, if I were doing a new "classic" color organ, two features I would add are input compression and linearization. As Fig. 5 shows us, typical audio has ridiculously too much dynamic range for useful phase control of lights. Your lamps will be off or on most of the time, instead of smoothly tracking the music. Analog Devices has their low price SSM2165 speech-compression chip that should be ideal for this application.

The perceived brightness of a lamp is not at all linearly related to the phase angle. There are three reasons for that. First, the phase-angle versus power is an "S"-shaped curve rather than linear. Secondly, the eye is a nonlinear device that perceives light logarithmically. And thirdly, an incandescent lamp has a very nonlinear resistance at low brightness levels.

So, we take our new baby PIC and convert each input control voltage into an 8-bit number between 0 and 255. Then we use table lookup to find a new number that sets up an acceptable phase delay for the desired apparent brightness level. The table lookup should be closely matched to the lamps in use. Since your eye perceives equal brightness light in the ratio of one part green, two parts of red and three parts blue, you might want to select a different lookup for each color.

The aim is to let music produce as many different brightness levels as possible. As before, you'd never let the lamps go completely off. A very low background level is a first step towards linearization. I guess I'd select digital bandpass filters these days. Both Maxim and Linear Technology have lots of fine selections for you.

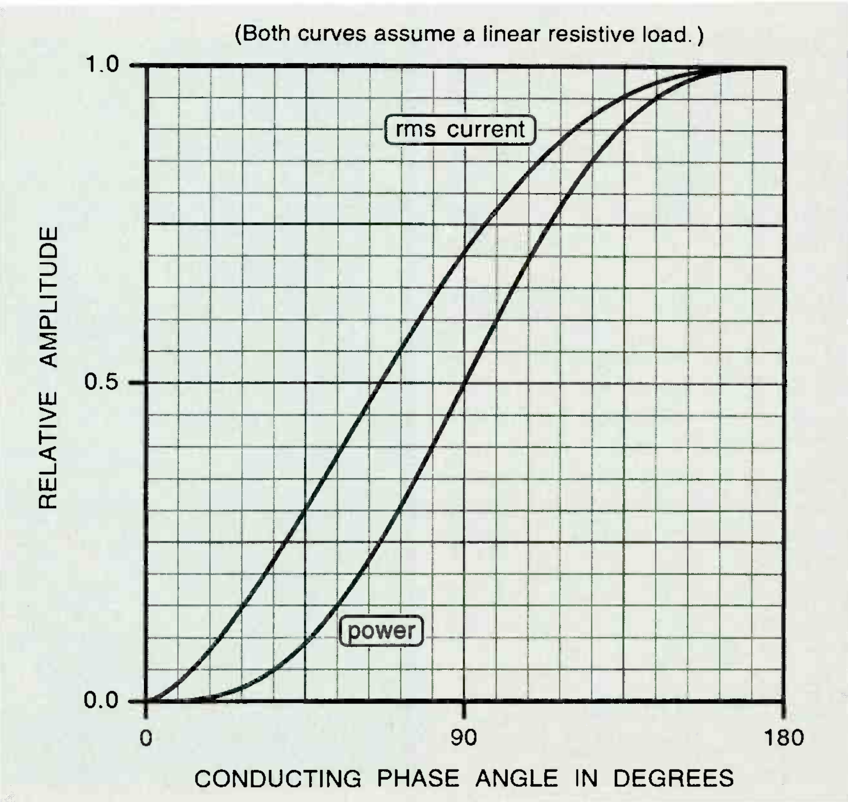

FIG. 5—THE "LINEAR" PORTION of an AC phase control has a sorely limited dynamic range of a mere ten to fifteen decibels. Linearity and dynamic range can both be greatly improved by using table lookup in a baby PIC.

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Sunnyvale, CA 94086
(800) 998-8800

Meredith Instruments
5035 N 55th Ave. #5
Glendale, AZ 85301
(602) 934-9387

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

MWK Industries
1440 S State College Blvd. 3B
Anaheim, CA 92806
(800) 356-7714

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

Rex Supply
3715 Harrisburg Blvd.
Houston, TX 77003
(800) 369-0669

Stemgas Publishing
PO Box 328
Lancaster, PA 17608
(717) 392-0733

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

Tapestry
431 Griggs Street N
St Paul, MN 55104
(800) 876-3776

When you do your own design, do not forget to provide reliable safety isolation, always add some effective line noise filtering and shielding, and treat your input audio gently. Use the purest colors you can get. Avoid yellow because it typically overwhelms. Since an incandescent lamp is pretty much yellow to start with, filtering for other colors very much limits the light output. Go out of your way to prevent any and all white light from any pinholes, leaks, color recombination, or poor filters. There's a lot more on lamps and lighting resources in MUSE95.PDF. Available on www.tinaja.com or in the *Tech Musings* reprints. Grainger, of course, is your prime source for lighting options.

Going Non-Traditional

What about non-traditional color organ architectures? LEDs are one possibility, but power levels may be restricted, the blues will still be expensive, and you'd still be stuck with limited display options. Lasers are another possibility, but again the blues are a problem. (If you are still interested, you can find more on laser approaches from MWK Industries or Meredith Instruments.)

What if you instead combined a spectrum analyzer chip with a screen saver? The ultimate would be to use very sophisticated DSP techniques to attempt to isolate music instruments. Let each instrument be a color blob on the screen. Some kind of tracking comb filter, maybe. The louder the instrument, the bigger and brighter the chosen blob.

Those blobs could wander around lava lamp style, continually showing new and interesting variations. Different algorithms could also be keyed to mood or music style. Texas Instruments has a new DSP demo board with a full real-time audio spectrum analyzer built in. It might make an interesting front end for audio-to-color displays.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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

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

New Tech Lit

The sudden demise of traditional data books might soon be upon us. That's because they have become outrageously expensive to produce and maintain. Instead they are being replaced by electronic versions. For example, new and free Acrobat-based CD-ROM versions of full-product data are freshly issued by Texas Instruments in a *Designer's Guide and Data Book*, and by Linear Technology in a similar publication.

A great source for the tech-education stuff is Brodhead-Garrett, who publish a free catalog. They stock everything from solar energy to injection molds.

Rex Supply prints a fat catalog chock full of machine-shop stuff. Stemgas Publishing has magazines and reprints of interest to collectors of antique gas or steam engines.

The Boy Mechanic III is the latest reissue from Lindsay Publications. It is a thick 1919 reprint full of wondrously essential projects such as full details on building your own cement kiln.

From Tapestry comes a complete line of fancier ink-jet media—glossies, clear, cling, golds, silvers, etc. Ace Plastics has a wide variety of unusual plastic shapes including tubing, rod, squares, rounds, balls, cubes, rings, diamonds, wedges, and more. From Castcraft comes a new flyer on casting and mold-making.

Contract Professional is a brand new magazine for independent tech consultants. If you are interested in that, you should also see the *Syergetics Consultant's Network* you'll find on www.tinaja.com.

I've still got some great surplus buys on Tektronics 1230 and Fluke 9010 logic analyzers. Most of the mentioned resources appear in our Names and Numbers or AC Phase-Control sidebars. Be sure to check there before calling our no charge U.S. help-line or visiting my www.tinaja.com Web site. EN

BY RAY FURLONG*

Camcorder Zoom-Lens Systems

A ZOOM LENS IS ACTUALLY A SYSTEM OF SEVERAL LENSES THAT ARE COMBINED TO PROVIDE VARIABLE MAGNIFICATION OF THE PICTURE WHILE SIMULTANEOUSLY KEEPING THE IMAGE SHARPLY FOCUSED. WHEN THOSE SYSTEMS FAIL AND require troubleshooting, you really need to know what you are doing. That requires a basic understanding of how each of the individual components that comprise the lens system operate, as well as how all those components interact.

There are four basic elements in every modern zoom-lens system. They are: the lens assembly, the zoom control, the focus control, and the iris control. We will look carefully at each of those elements; once we understand how and what they do, we will go on to troubleshooting techniques.

Basic Lens Assembly

The zoom-lens system is designed so that errors in magnification and focus are minimized whenever the system moves back and forth (zooms in or out). That is especially important at the beginning and ending positions of the zooming process. It is also important to keep those errors from becoming excessively large at any of the intermediate positions.

A lens system that is not very critical of the focus throughout the zoom range is called an optically compensated *varifocal* system. Figure 1 illustrates such a system. All three operating positions are shown in that figure. The focal length of the lens is determined by the camera operator who moves a zoom handle forward or backward on the camcorder. That can be either a manual or a powered adjustment. Either way, the lens elements that produce the zoom action are stationary in the lens cylinder. They move as a group, not individually in relationship to each other.

Some of the early variable focal-length lenses contained as many as 15 or more separate groups of elements. Modern camcorders have as few as four. As the number of element groups has been reduced, the complexity of the electronics required to maintain proper zoom/focus characteristics has increased. The optical zoom ratio (the ratio of maximum to minimum power) is, in general, 6:1. But in some designs that range is as large as 15:1 or more.

The lens shown in Fig. 2 is typical of

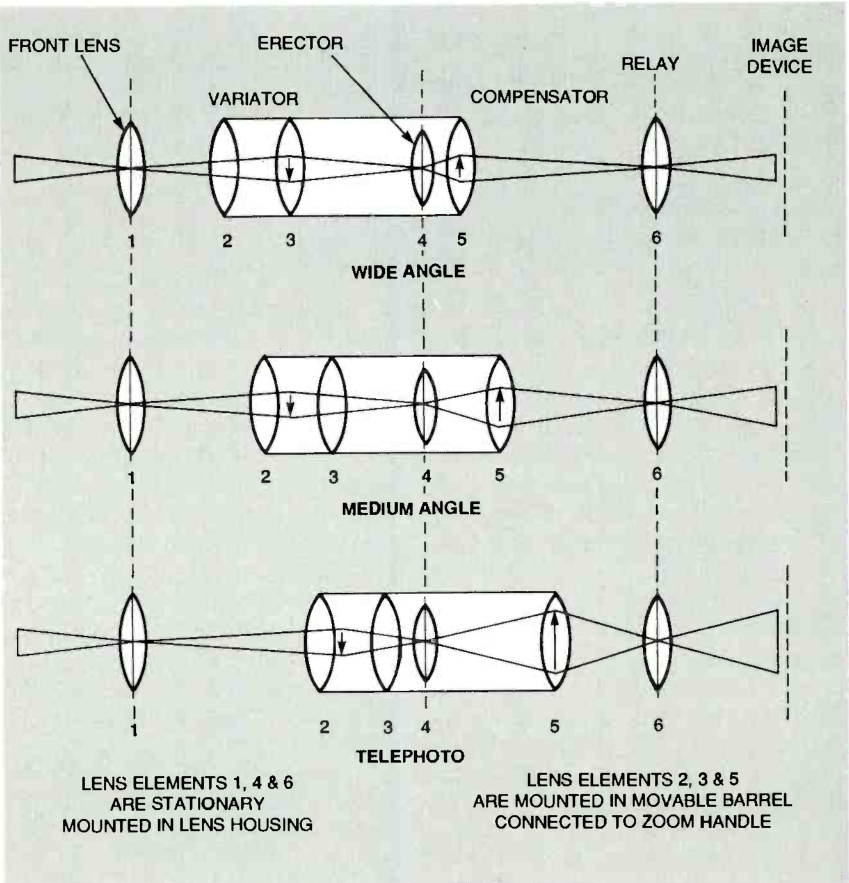

FIG. 1—A SIMPLE SLIDE ZOOM LENS SYSTEM that was used in early video camcorders. The lens elements are shown in all three common positions.

*Hitachi Hi-lite
Hitachi Home Electronics (America), Inc.
Suwanee, GA 30174

the lens system in many modern camcorders. It uses a device called a complicated cam to move the lens elements to produce the necessary zoom ratio. The complicated cam is a cylinder that has machined slots to position the lens elements in varying degrees of zoom or macro. (Macro is the opposite of zoom; it is used to focus on an object that is in close proximity to the lens.) The relationship of the two lens elements to each other changes according to the zoom and macro ranges. Also, the lens elements shift in direction depending on whether they are zooming in or zooming out.

The rear zoom element comes further forward during macro than it does during zoom. That is what moves the focal distance closer to the front lens. The precision of the lens group's movement is controlled by the complicated cam. To compensate for focus errors during the zoom process, an adjustable back-focus lens is located in the rear of the lens assembly. It is adjusted to eliminate errors throughout the full zooming range of the lens and to maintain image focus on the pickup device. No electronics are required to monitor movement of the lens-element groups.

In older camcorders, zoom controls were often simple electric motors that were fed a reversible voltage to change the rotational direction of the zoom barrel connected to the complicated cam. The zoom and focus functions were separate in those types of lenses.

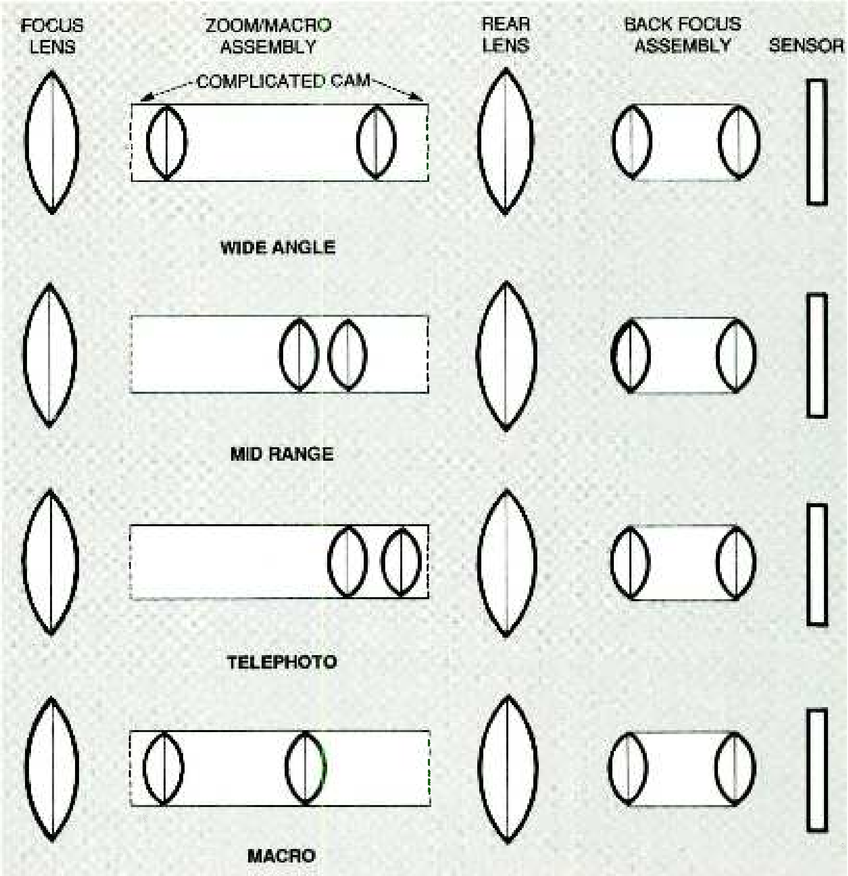

FIG. 2—MODERN CAMCORDER LENSES consist of fewer elements. Here's a look at how the elements appear in the four most commonly used positions.

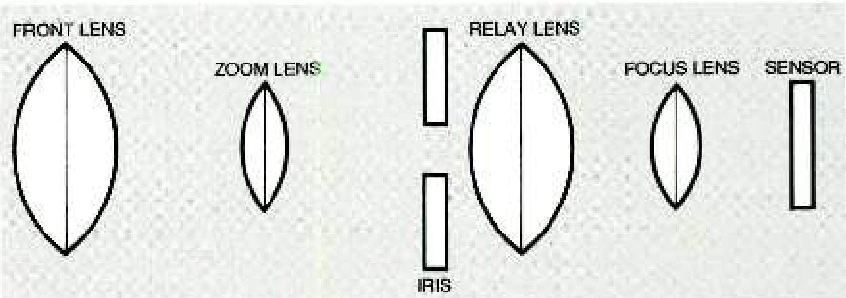

FIG. 3-THIS FOUR-ELEMENT INNER FOCUS LENS is used in many current Hitachi camcorders. Similar systems can be found in camcorders from other manufacturers.

How Focus Works

To produce sharp, high-resolution pictures, the camera lens must have good optical qualities. Equally important, the image that the lenses produce must be accurately focused on the sensor. The final element that determines picture resolution is the image sensor itself. It takes a high-quality lens coupled to a high-quality image sensor to produce a high-resolution picture.

Focusing is handled by moving the lens closer to or further away from the image sensor. The lens is closest to the sensor when it is focused on distant objects (such as landscapes), which are said to be at optical infinity. For most normal-focal-length camcorder lenses, infinity means anything further than 30 feet (10 meters) away. Focusing on subjects closer than infinity demands moving the lens away from the sensor. That is done with either a helical-thread lens (that can be operated manually or be driven by a gear-reduced miniature DC motor), or by an internal sliding lens assembly (that is driven by either a linear-drive or a stepping motor).

Focusing is very straightforward with manual-focus lenses. The helical-thread lens is rotated (manually or electronically) until the image in the viewfinder is sharp. That method leaves two variables: Is the viewfinder properly focused? Is the operator's eye properly focused to the viewfinder? An auto-focus system, on the other hand, removes the viewfinder from the focus system, leaving the alignment of the auto-focus system as the only remaining variable.

Figure 3 is a block diagram of the lens system that is used in many current Hitachi camcorders, and similar systems are found in many other brands of camcorders. The lens consists of only four elements and has a stationary front-lens element. The focus-lens element is located at the rear of the lens assembly, and functions as a back-focus element. The zoom lens has been reduced to a single lens-element group, and the complicated cam has been eliminated. Many lens-con-

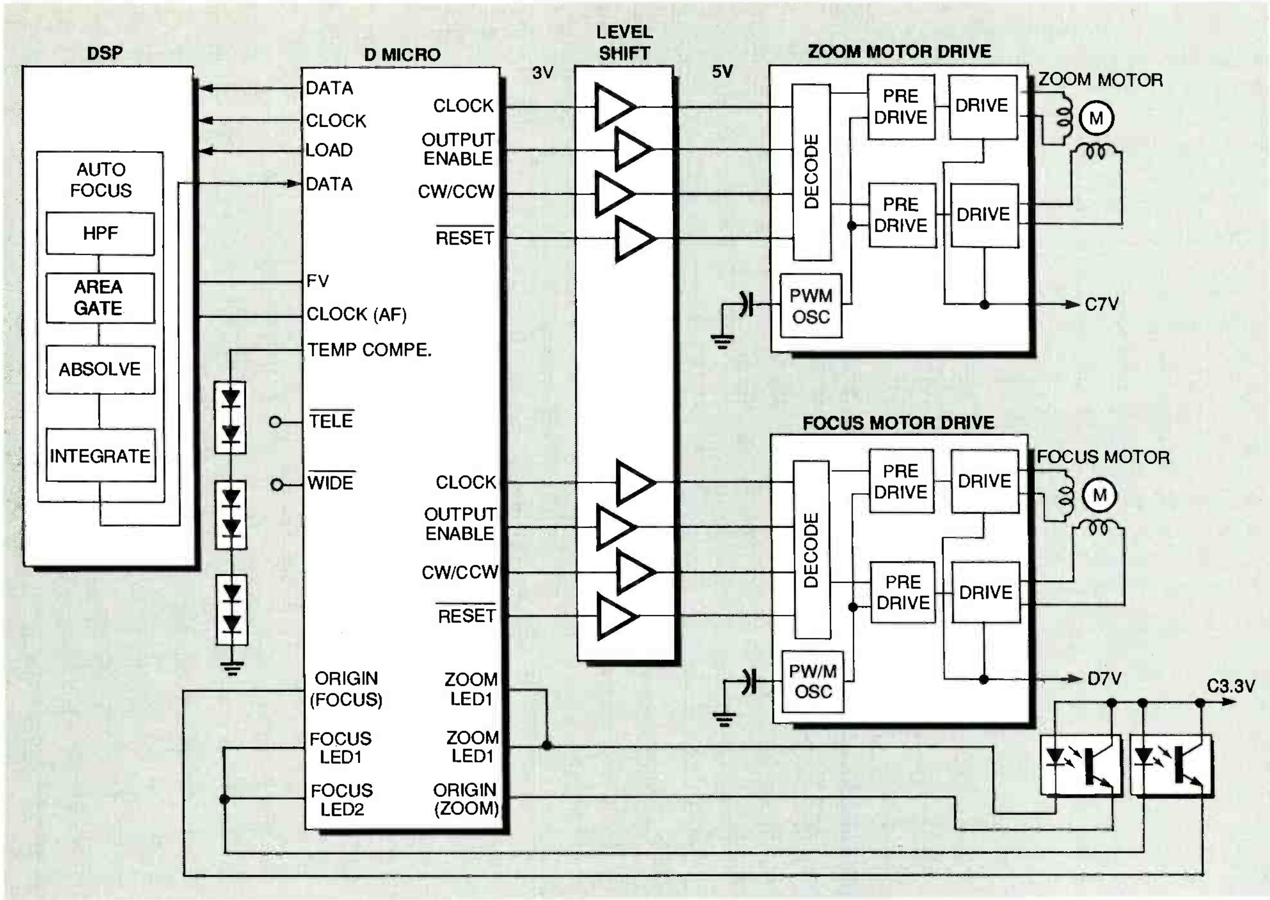

FIG. 4—A BLOCK DIAGRAM of the zoom/focus drive system. Note that zoom control circuitry is virtually identical to the focus control circuitry.

trol functions are now provided entirely by electronics.

The system relies on the actual video signal processed by the camcorder for focusing. As shown in Fig. 4, the luminance portion of the video signal is sampled and fed to the auto-focus portion of the digital-signal-processing (DSP) IC as an evaluation signal. A high-pass filter converts the signal to a voltage. The frequency characteristics of the luminance signal increase in proportion to the sharpness of the focused image, and the developed voltage increases accordingly—the higher the voltage, the sharper the luminance signal and the better the focus.

That signal goes through its own signal processor to provide information to the digital microprocessor, which evaluates the data and determines whether or not the image is in focus. If it is not, it outputs motor-control data to the drive circuit to move the focus motor in the appropriate direction to bring the image into focus. The control data consists of four elements: the output-enable signal, the direction of rotation signal (C/CCW), the clock signal, and the reset signal.

The focus-drive motor is a small stepping motor driven by a 6-volt pulse from the focus-drive IC to rotate the motor in the right direction. The focus-drive IC is powered by the C7V power bus originating from the DC-DC converter.

The zoom-control circuitry is identical to the focus-control circuitry, with the exception of the evaluation signal that starts the process. The input for the zoom control is a simple switch that grounds an input to the microprocessor to tell the zoom the direction in which it should go (telephoto/wide). That information is compiled by the microprocessor and is output to the motor drive IC to rotate the zoom motor in the proper direction.

Since there is no back-focus assembly, the focus and zoom circuits must constantly interact to compensate for lens irregularities as well as normal focusing. That information is calibrated by the focus portion of the alignment procedure.

The first step in adjusting auto focus is the zoom/focus tracking. The lens is automatically run through the full zoom range, and focus tracks along with zoom to eliminate any lens errors. When this process is finished, the information is stored and recalled to use as the zoom lens is moved. This means that the focus lens has become a back focus lens during the zooming process.

Now you know just about everything there is to tell about how the zoom-lens system works. Next time we will look at the troubleshooting procedures you will need to successfully service camcorder zoom-lens systems. EN

BY CARL J. BERGQUIST

Special Effects with a Galvanic Coil

WHEN LASER-LIGHT EFFECTS ARE WHAT YOU WANT TO PRODUCE, ANOTHER USEFUL COMPONENT TO HAVE IS A GALVANIC COIL OR GALVANOMETER. THE GALVANOMETER IS A DEVICE THAT IS USED TO MEASURE THE FLOW OF ELECTRIC CURrent. You can make a simple one by winding 40 or 50 turns of magnet wire around a compass, in a north/south direction. When a voltage is applied to the coil, the compass pointer will swing from the north position to either east or west.

The same effect can be obtained by placing an external coil next to the compass at the east or west position. An applied voltage will then pull the compass pointer to the coil. You can use this principle to create an oscillation effect, which can be used effectively in light shows; in fact, it is the basis for many of the commercial light-show machines. The principle is simple: Feed a modulated voltage to the galvanometer coil, and the pointer movement will follow the signal or data being introduced in much the same way the laser flickers from electronic modulation.

Building a Galvanometer

For our purposes, a compass is far too delicate to be of much use. The alternative is to build a galvanometer that has a more rugged pointer—one that will support a mirror. There are a couple of ways to do that. But first, we must remember that the compass pointer reacts to the electromagnet, or coil, because it is also magnetized. So the first step is to rig a magnetic field on a vertical shaft that will pivot back and forth. That field can be permanent or electric, depending on the need; the merits of each will be discussed later.

Next, an electromagnet has to be positioned perpendicular to the vertical field, and at a distance that will allow the first magnet to clear the second in a full swing. With both components in place, a current sent through the electromagnet will attract the opposite pole of the vertical magnet and bring it around. I know that this is a rather simplistic explanation, yet it is the physical principle that makes the galvanometer function, and makes it a useful tool for visual productions.

WARNING! ! !

This article deals with and involves subject matter and the use of materials and substances that may be hazardous to health and life. Do not attempt to implement or use the information contained herein unless you are experienced and skilled with respect to such subject matter, materials and substances. Neither the publisher nor the author make any representations as for the completeness or the accuracy of the information contained herein and disclaim any liability for damages or injuries, whether caused by or arising from the lack of completeness, inaccuracies of the information, misinterpretations of the directions, misapplication of the information or otherwise.

As mentioned before, the vertical field magnet could be either permanent or electric. A permanent magnet offers

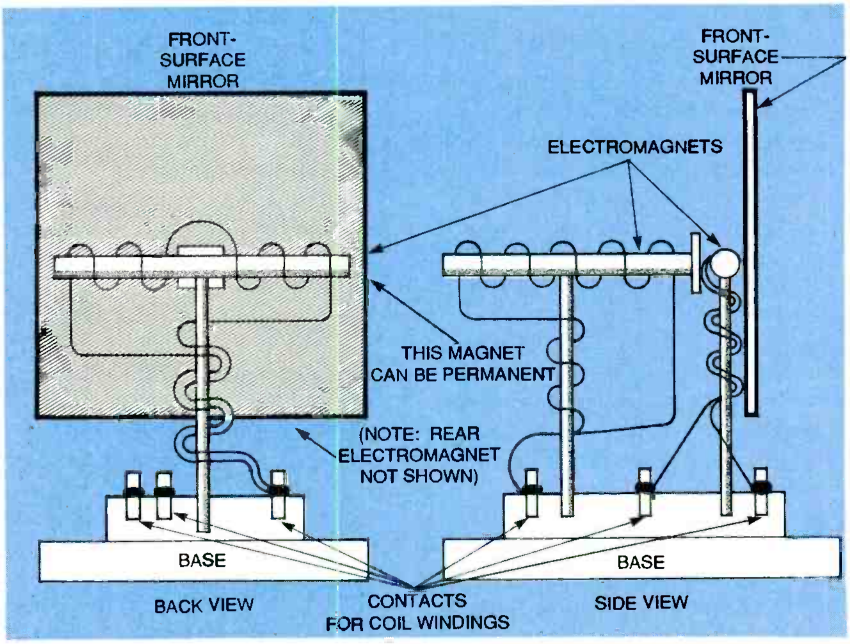

FIG. 1—A DETAILED LOOK AT A HOME-MADE galvanic-coil mirror assembly. It provides a great way to add a variety of movements to your light shows.

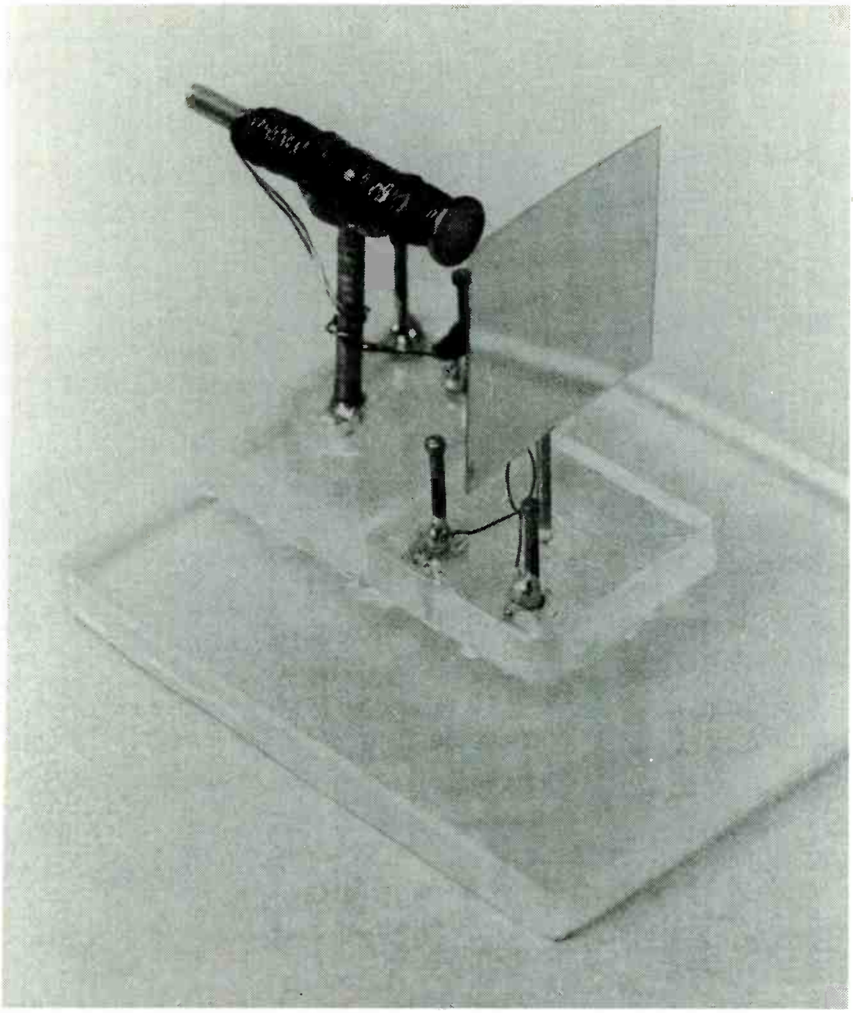

FIG. 2—THIS PHOTOGRAPH SHOWS the completed assembly. Note that the magnet-wire coils should be coated with glue or liquid rubber to hold them in place.

the advantage of not requiring a separate power source. The disadvantages are weight and mounting. If you use a permanent magnet, it will have to be a small bar magnet that is reasonably strong. Those tend to be a little on the heavy side. There are magnets that resemble rubberized strip material, with adhesive backing, that could also be used. However, while they are lighter in weight, they do not have as strong a magnetic field.

The next point to consider is mounting the magnet to the vertical shaft. In our unit, that will be a standard flat-head iron nail. Since permanent magnets can be damaged or destroyed by heat or shock, soldering, welding, or drilling a hole will not work. That leaves the use of some form of adhesive, such as epoxy, super glue, hot glue, or whatever else works for mounting.

The other alternative is an electromagnet. The power requirement is the primary disadvantage of using one. However, it can be turned to an advantage, since we could modulate the electromagnet's power source and further vary the patterns generated.

Figure 1 shows our galvanometer assembly. To build your own, start with a flat-top iron nail, and solder a second iron nail, with the top and point removed, to the head of the first to form a "T" shape. Using fine magnet wire, wind several hundred turns on the cross piece, and secure them with glue or liquid plastic. Bring the lead wires down to the base, leaving some slack for movement, and solder them to the connection posts. Again, small iron nails work well.

The second, or main, electromagnet is made in a similar fashion (though you can leave the head on the cross piece, if you wish) with 200 to 300 turns of wire on an iron nail. The coil is fixed in place with glue or plastic. The base that the magnets are attached to is made of wood or Plexiglas. A front-surface mirror is then attached to the vertical, or moving magnet, and the galvanic coil is ready for use. The photo in Fig. 2 shows the completed assembly.

In this configuration, the mirror will move on the X axis. To get Y-axis movement, merely turn the assembly on its side. Most of the commercial units, called scanners, use two coils, one for each axis. When connected to control circuitry, they develop an expansive variety of visual images.

Using the Galvanometer

Despite its relative simplicity, you can create a wide variety of visual effects with the equipment you have just made. The control circuit could be any audio source, including a portable-amp/microphone arrangement, or a pulse source for an established pattern. Figure 3 shows a simple pulse-generator circuit that could be used for that purpose.

When the signal from the control circuit is applied to the main electromagnet, the vertical field will be activated proportionally. That moves the mirror and creates the oscillation effect.

You could also use the galvanometer with one of the optical-table assemhlies we built in the previous months. For example, Fig, 4 shows one such modification—in this case from the December, 1996 column—with our galvanometer used in place of a speaker modulator. The reflected image that appears on the screen should be a combination of that produced by the revolving mirrors and the oscillating pattern generated by the coil. The dual revolving mirrors could also be replaced with additional galvanometers. If you incorporate beam splitters, a single laser can supply the light for various galvanic coils to produce a maze of intricate images. At the risk of sounding redundant, the only limit to a dramatic world of visual imagery is your imagination.

Once the combinations have been tested and a favorite light-table assembly has been selected, try introducing special effects to the presentation. Colloidal suspensions such as smoke, fog, dry ice in water, or fine powders puffed into the air all produce a reflective surface for the laser beam and make it visible when it passes through them. By introducing the suspensions at strategic locations, you can add another dimension to the show. Reflecting the beam off the surface of moving liquids provides an excellent

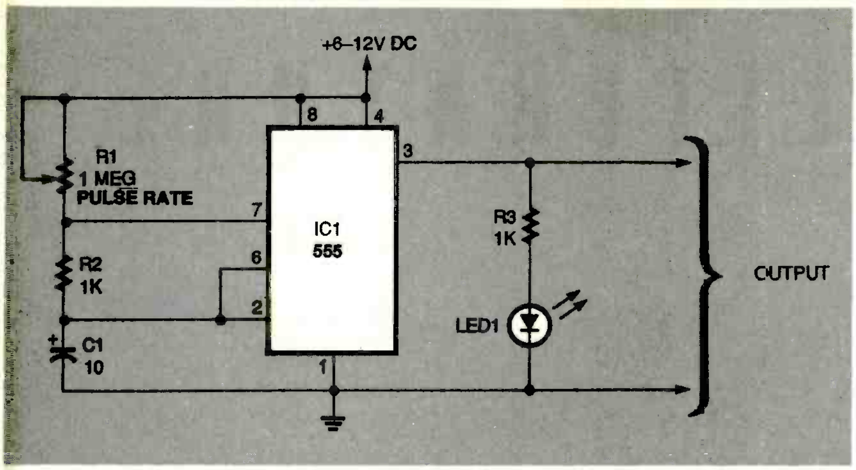

FIG. 3—THIS PULSE GENERATOR circuit could be used to drive the galvanic-coil/mirror assembly. Resistor R1 controls the pulse rate.

source of unexpected pattern variations. Try Mercury metal, if available, but be careful; it has a very high surface tension and will get away quite easily. That's why they call it quicksilver!

Warping the reflective surfaces is another method of obtaining weird fun-house effects that add spice to the production. Aluminized Mylar materials are especially suited to that application. High sensitivity luminous paints or tape can hold a trace of the beam for a short period of time and give some outstanding results. These are just a few of the ideas that come to mind at the mention of special effects. With some thought and general observation, many more will present themselves.

If you have some ideas of your own that you would like to share with other readers, please put them down on paper and send them to Laser Editor, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735, or via e-mail to lartonics@aol.com.

That wraps things up for this issue. Next time we will take a look at how you might use your laser to conduct scientific experiments or as the basis of fascinating science-fair projects. **EN**

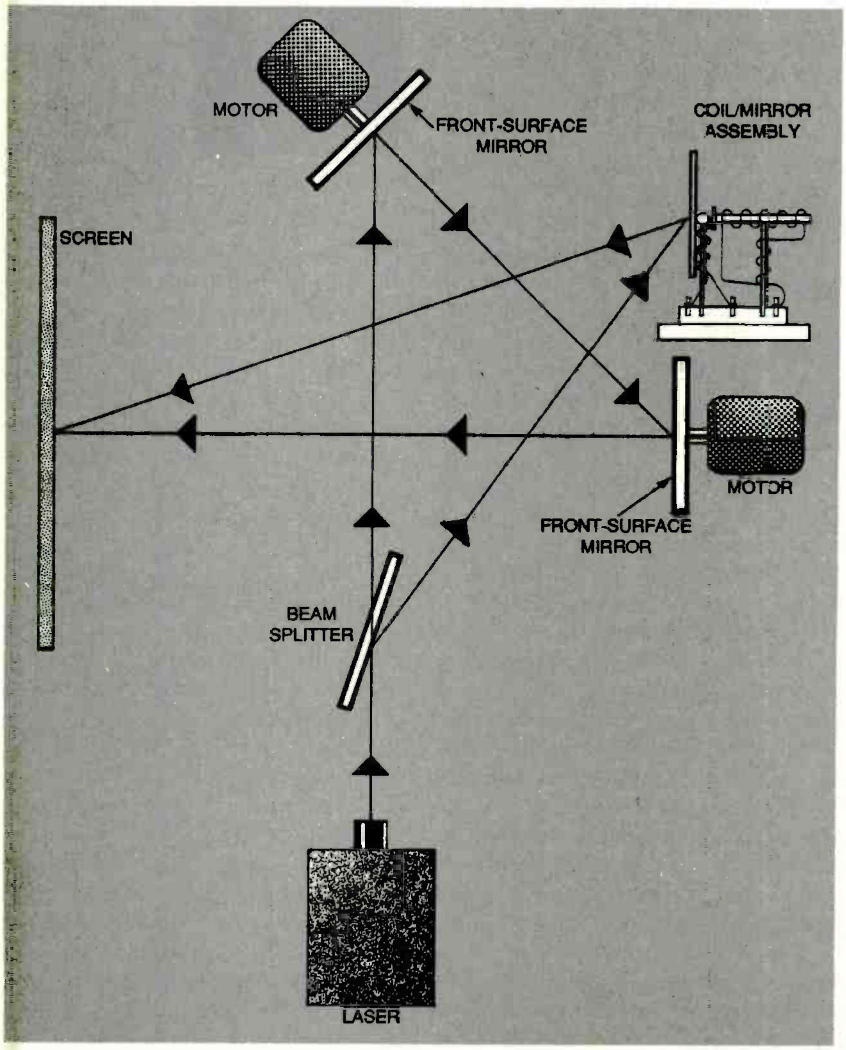

FIG. 4—HERE, THE GALVANIC-COIL ASSEMBLY has been combined with rotating mirrors and beam splitters to produce an intricate display. Note that the basic set-up was first presented in the December, 1996 issue; here a speaker modulator has been replaced with the galvanic assembly

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Dr. Bob's Painless Guide to the Internet & Amazing Things You Can Do With E-Mail

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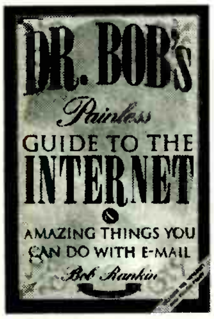


CIRCLE 337 ON FREE INFORMATION CARD

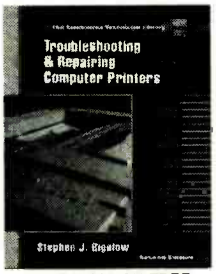
This relatively brief Internet guidebook stands out from the crowd for what it doesn't do: It never bogs down its readers in historical overviews, technical details, and complex jargon. Instead, it provides straightforward, plain-English advice on how to get connected to the Internet, quickly and easily.

The book is aimed at complete newcomers to online communications, as well as at folks who already use e-mail to send and receive messages. It gives readers a bit of background information on e-mail and the World Wide Web—what the basic rules of usage are, and how to find interesting and useful Web sites. It then explains how to use e-mail to access almost anything on the Internet, saving time and money in the process.

The book takes readers step-by-step through the Internet, starting with what is needed to get connected, and what type of account to get. It explains how to search the Internet for files (using Archie, Veronica, Gopher, and the World Wide Web) and then how to download them (using FTP) from computers worldwide. It shows readers how to use Telnet to log onto and use computers around the world, and how to chat online with Internet Relay Chat. The book also includes a glossary of terms and the "Internet Yellow Pages," which lists a lot of useful Internet resources.

Troubleshooting & Repairing Computer Printers: Second Edition

by Stephen J. Bigelow
TAB Electronic Technician Library
McGraw-Hill, Inc.
11 West 19th Street
New York, NY 10011
Tel: 212-337-5951
Fax: 212-337-4092
$24.95



CIRCLE 338 ON FREE INFORMATION CARD

This popular guidebook has been completely overhauled and updated to reflect the latest in computer-printer technology and troubleshooting. It offers comprehensive coverage of the latest trends and new technologies affecting printer servicing, including the problems associated with printing under Windows 95.

The book describes 150 symptoms of printer problems, and completely explains their solutions. Impact, thermal, ink jet, and electrophotographic printers are covered. The second edition features flowcharts and detailed schematics, block diagrams, and exploded-view illustrations throughout its pages. It describes specific, time-saving maintenance and repair techniques that help technicians get the job done right the first time. It offers complete details on how to use test equipment, along with troubleshooting tips and guidelines. A companion disk is available separately (priced at $20 with the order form in the back of the book).

Master Catalog 1996-1997

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7815 South 46th Street
Phoenix, AZ 85044-5399
Tel: 1-800-426-1194
Fax: 602-438-1690
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CIRCLE 339 ON FREE INFORMATION CARD

The 264 pages of this catalog are filled with tools and test instruments for the installation, service, and support of electronic products and systems. It includes inch and metric tools, ergonomic and insulated tools, scopes, probes, meters, and analyzers. Other items featured in the catalog are LAN products including cable assemblies, scanners, and testers; soldering and desoldering equipment; static-control workbenches and accessories; cases; shipping containers; and technical manuals. Many major manufacturers' products are represented. Throughout the catalog, helpful selection charts are provided.

The New Internet Business Book

by Jill H. Ellsworth and
Matthew V. Ellsworth
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 1-800-225-5945
Web site: http://www.wiley.com
$24.95

Aimed at small-business owners who are considering doing business on the Internet, this book answers all of the most commonly asked questions, including: Who is using the Internet? What are businesses and organizations doing on the Internet and the World Wide Web? Why are so many businesses of all sizes getting connected to the Internet?

CIRCLE 340 ON FREE INFORMATION CARD

Where can you get Internet access? And, once you're connected, how do you actually use the Internet for business?

The book provides step-by-step guidelines for putting a company on the Internet for the first time, including creating a Web site and integrating the Web and the Internet into a comprehensive marketing plan. It gives practical advice on such business basics as doing market research, obtaining competitive information, announcing products, and making sales—all on line. The book explains how to make on-line transactions secure, presents the rules and tools needed for creating an on-line business presence, and describes new "Netiquette" and Acceptable Use practices.

Test and Burn-In Sockets Brochure

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P. O. Box 3064
Cedar Rapids, IA 52406-8951
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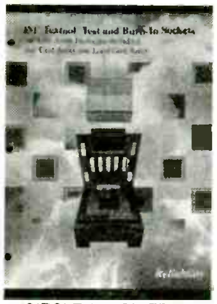
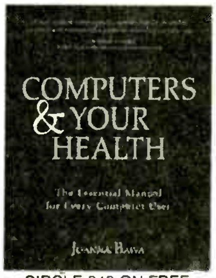


CIRCLE 341 ON FREE INFORMATION CARD

This 16-page booklet describes 3M's complete line of burn-in sockets for area array packages including ball grid array (BGA) and land grid array (LGA). The brochure contains color photos, technical illustrations, and a listing of more than 65 available socket configurations. It also includes specifications, board-mounting instructions, performance data, and ordering information for BGA sockets.

Computers & Your Health: The Essential Manual for Every Computer User

by Joanna Bawa
Celestial Arts Publishing
P. O. Box 7123
Berkeley, CA 94707
Tel: 510-559-1600 or 1-800-841-2665
Fax: 510-524-4588
$12.95



CIRCLE 342 ON FREE INFORMATION CARD

Computers are essential tools in the workplace, and are being used in more and more homes every day. Although they make our lives easier in many ways, computers can be hard on our bodies. Many computer users have experienced eye strain, aching hands and wrists, and stiff backs; some have developed more serious health problems. This book examines how those problems can be prevented.

Drawing on the expertise of ergonomists, physical therapists, osteopaths, and optometrists, this holistic guide to safe home and office computer use explains how to prepare a healthier working environment before you begin computing. It also pinpoints a variety of computer-related hazards and offers ways to deal with them.

The book includes information on repetitive strain injury (RSI), electromagnetic radiation, and eye strain. It examines the effects of software design on our mental well-being, and offers pointers on how to manage your child's computing time and deal with videogame addiction. The book covers specific accessories, such as ergonomic keyboards, lighting, and furniture, that can help avoid computer-related health problems; provides tips for coping with stress; describes available medical treatments such as massage, physical therapy, and postural training; and touches on lesser-known topics including children's health and health legislation for computer users.

Test and Measurement Equipment Catalog 596A

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P. O. Box 551419
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E-mail: sales@tucker.com
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CIRCLE 343 ON FREE INFORMATION CARD

This 111-page catalog features both new and reconditioned test and measurement equipment. Represented in its pages are major manufacturers including Tektronix, Hitachi, Hewlett-Packard, Hameg, B+K Precision, Leader, and Goldstar. Highlighted in this issue are new digital real-time oscilloscopes, digital storage scopes, handheld scopes, and digital multimeters from Tektronix. With most reconditioned equipment, Tucker can provide instruction manuals and standard accessories.

1997 World Wide Web Yellow Pages

Luckman Interactive, Inc.
1055 West 7th Street
Los Angeles, CA 90017
Tel: 213-614-0966
Web site: http://www.luckman.com
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CIRCLE 344 ON FREE INFORMATION CARD

This 1200-page directory offers current reviews and ratings of more than 10,000 Web sites, in all popular categories. Each site is rated by content, design, organization, and downloading time. The site is then assigned an overall rating of up to five stars. Only the best (three-, four-, and five-star) sites are included. The comprehensive guide to the Internet can save readers time and money by letting them know which sites are truly useful.

The book contains 18 general categories—art, business, children, computers, education, entertainment, government, health, humanities, Internet and the Web, life styles, music, news, regions, science, shopping, sports and recreation, and travel. Those topics are further divided into 400 secondary categories for quick reference.

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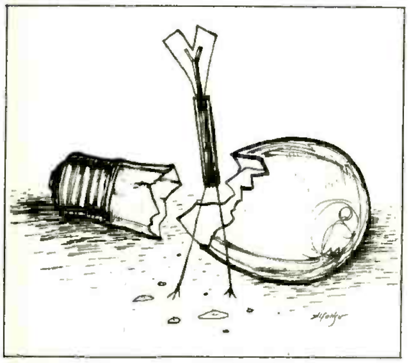
BUILD THE PCDRILL
(Continued from page 46)

the compiled version. (Look for PCDRILL.ZIP on the Gernsback FTP site —ftp.gernsback.com/pub/EN).

Select each of the first four options in turn. The table and the drill should move in the selected direction. The test program moves the table and caddy in "slow motion," but real applications (like the one that will be presented next time) produce quicker and smoother movement. If either motor stalls and the table or drill does not move, the associated guide is probably jamming against the track. Adjust the guide and try again. Repeat the process until both table and caddy move smoothly throughout the entire range of travel.

Several tweaks can improve the performance of PCDrill. For instance, apply paste wax to all moving wooden surfaces, including the drill caddy sides and drill slides. All moving metal surfaces should get a thin coat of light oil. That includes the driver nuts, threaded rods, and aluminum angle tracks. Those lubrication efforts will decrease friction and make for smoother operation.

Next time we'll align PCDrill, and introduce the application program and all of its functions. We'll also look at the application's data file and explain each of its entries, including the Speed entry that maximizes speed of movement. We'll also provide details for building a 5.75-volt power supply from scratch, and use PCDrill to fabricate its own PC board. To round things out, we'll provide an AC wiring option that allows you to energize the drill only during actual drilling, as opposed to having the drill run continuously. See you then. Ω



CONDUCTANCE ADAPTER
(Continued from page 63)

keep the input leads short to avoid 60-Hz line pickup. Although the ICs used in the Conductance Adapter are ESD protected, you should avoid letting any static discharges into J1 or J2.

Connect a 1-megohm resistor to J1 and J2 and the output on a DVM will be 1.000 volts, which is equal to 1.00 micromho or 1000 nanomhos. A 300-megohm resistor will read 3.33 millivolts, which is equal to 3.33 nanomhos. A diode (shown as D_x in Fig. 1) might show a reading of 2.55 millivolts when reverse biased. That is equal to a leakage current of 2.55 nanoamps. Leakages can be measured down to 10 picoamps. If you need a voltage greater than -1.00 volt for your tests, do not make any connection to J1. Apply an external voltage between the ground jack (J3) and the free lead of the device being tested. Do not let any voltages applied to J2 exceed 3 volts, or IC2 will be destroyed. Ω

USING THE NE602
(Continued from page 54)

If the signal is an SSB signal, then the LO is set at a frequency of 2.5- to 2.8-kHz higher or lower than the IF, depending on whether you want to demodulate an upper-sideband (USB) or lower-sideband (LSB) signal.

The input signal circuit in Fig. 15 uses a 455-kHz IF transformer of the sort used for transistor radios (see Digi-Key or Mouser catalogs for suitable types). The transformer that you want to use for T1 is the type that has a resonant secondary with a tapped inductance. The LO circuit uses the same type of transformer as the input, but configured as a Hartley oscillator.

The output signal is at audio frequencies, and is filtered by an R-C network. The audio output is balanced, so it should be fed to a differential audio amplifier such as an op-amp.

NE602 "Universal" Project Board. We've included a printed circuit pattern for a "universal" project board based on the NE602. The on-board circuitry (Fig. 16) is limited to the DC power connection, which is regulated by a three-terminal IC voltage regulator. All other functions can be set by you to make any project that you want. There are a large number of multi-pad stand-alone connections for various components depending on the circuit that you want to make, as well as positions for three six-pin standard shielded coils of the sort manufactured by Toko and sold by Digi-Key. You can also use these same holes for mounting home-brew toroid inductors. Figure 17 shows the parts placement of the universal project board. The universal NE602 board can be bought from FAR Circuits, 18N640 Field Court, Dundee, IL, 60118 for \$4 plus \$1.50 shipping for every four boards ordered (*i.e.* 1 to 4 boards shipped for \$1.50). IL residents will have to add appropriate sales tax.

Now you've seen how well-behaved the NE602 is. Here is an RF chip that will function in a variety of applications from receivers, to converters, to oscillators, to signal generators. With the universal project board, the task of testing a new design based on the NE602 becomes "duck soup." Ω

USE ELECTRONICS NOW CLASSIFIEDS

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

CONTENT

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

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160 -- Business Opportunities	330 -- Computer Software	510 -- Miscellaneous Electronics Wanted	690 -- Security
190 -- Cable TV	360 -- Education	540 -- Music & Accessories	710 -- Telephone
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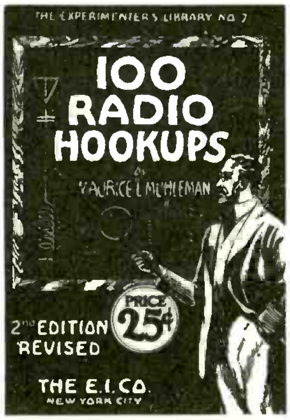

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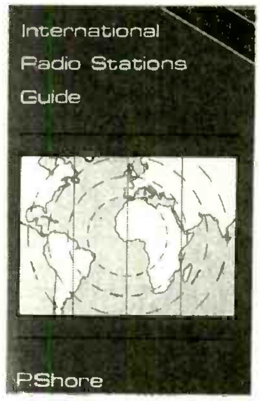

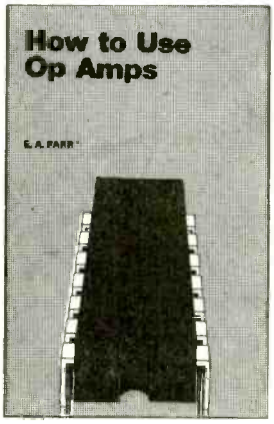

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A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period. Take a look at history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

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COMPUTER CONNECTIONS

continued from page 28

automation tool I'm developing in conjunction with another company, I've begun churning out Delphi components. One is a grid component. As the name suggests, it is a panel that displays a grid with user-selectable color, line style, and X and Y frequencies.

The grid is a descendant of Delphi's TCustomPanel. It's not a descendant of TPanel, because the latter has no paint events, so we have to move one level up the object hierarchy. As is often the case with Delphi components, TPanel exposes only some of the properties and methods of TCustomPanel. My grid component hooks into the Paint event, which is where it actually draws the lines. The component creates new properties for line color (GridColor), line style (GridStyle), and line frequency (GridX and GridY). Look for DEL_GRID.ZIP, which contains the source and a compiled DCU file.

Hardware Alert

The Seagate 43400N is a $5^1/_4$-inch 3-GB SCSI hard drive that is widely available for $300-$400. I've been using one for months with nary a problem. (I discussed it here in the August issue.) But I know several people who have had problems with them.

These things cook; they are serious heat generators. If you use one, be sure to mount it in a case with good air circulation. The typical mini-tower won't cut it, as a friend found out the hard way. I happened to have mounted mine in a huge old tower with lots of space and air flow. If you start getting any sort of intermittent results, check temperature, and if necessary, increase air flow.

Until next time, you can stay in touch with me via e-mail at jkh@acm.org. EN

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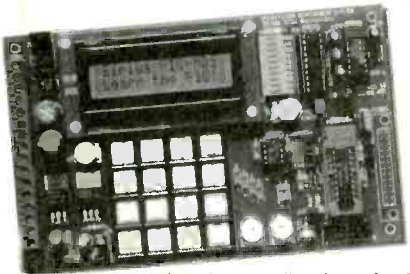

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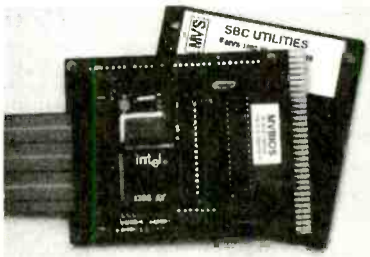
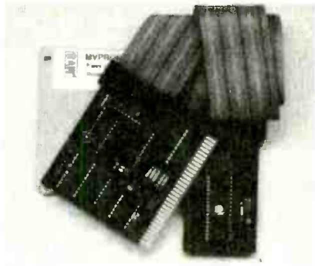
- CMOS NVRAM



USE TURBO C, BASIC, MASM
RUNS DOS AND WINDOWS
EVAL KIT $295

$95 SINGLE PIECE PRICE UNIVERSAL PROGRAMMER

- DOES 8 MEG EPROMS
- CMOS, EE, FLASH, NVRAM
- EASIER TO USE THAN MOST
- POWERFUL SCRIPT ABILITY
- MICROCONT. ADAPTERS
- PLCC, MINI-DIP ADAPTERS
- SUPER FAST ALGORITHMS



OTHER PRODUCTS:

8088 SINGLE BOARD COMPUTER	OEM $27	*95
PC FLASH/ROM DISKS (128K-16M)	21	75
16 BIT 16 CHAN ADC-DAC CARD	55	195
WATCHDOG (REBOOTS PC ON HANGUP)	27	95

*EVAL KITS INCLUDE MANUAL BRACKET AND SOFTWARE.
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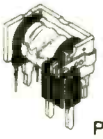
PC MOUNT POWER RELAY 24 Vdc

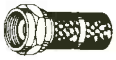


Potter & Brumfield # T90N5D12-24 24 Vdc, 675 ohm coil. SPDT contacts rated 20 amps (N.O.), 10 amps (N.C.) @ 240 Vac. 1.15" X 0.09" X 0.65". PC terminals. UL and CSA listed.

CAT# RLY-55 $2.00 each

10 for $18.50 • 100 for $150.00

SPECIAL PRICE! TWIST ON F-56 CONNECTOR



We recently made a large purchase of this twist-on co-ax connector for RG-6 cable. Special pricing while the supply lasts.

CAT #FTO-56R

100 for $15.00
500 for $50.00
1000 for $70.00

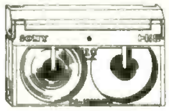
SPECIAL PRICE BI-COLOR LED

RED/ GREEN diffused.
T 1 3/4 (5mm) Three Legs
Center cathode.

CAT# LED-63 35¢ each

100 for $29.00 • 1000 for $250.00

(USED) "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. Satisfaction Guaranteed.

CAT # VCU-8 $3.00 each

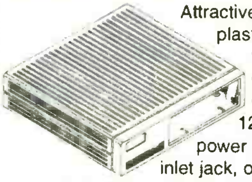
10 for $28.00 • 100 for $250.00

PADDED CARRYING CASE

Good-looking protective carrying case for Zip drives, Walkman players, tools, guns, photographic or electronic equipment. This well-made black canvas bag has 0.5" thick padding all around and a nylon inner liner. 1.5" wide webbed handle and detachable shoulder strap. Heavy-duty zipper. Interior pocket and adjustable velcro compartment. Interior area: 16" X 6" X 2.5". These are new bags with a company logo (Interactive Network) on a patch on one side.

CAT # CSE-10 $5.00 each

DRIVE CABINET W/ SUPPLY

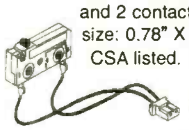


Attractive, heavy-gauge gray plastic cabinet designed to hold a 1/2 height CD ROM drive. Contains a 5 Vdc / 12 vdc switching power supply, IEC power inlet jack, on/off switch, cooling fan, LED indicator, DB-15 connector and two RCA jacks. 10.43" X 9.75" X 2.2" overall size. Drive opening in front of case is 5.87" X 1.68". IEC power cord not included.

CAT# MB-53 $15.00 each

SPST, N.C. SWITCH

SPECIAL PURCHASE!

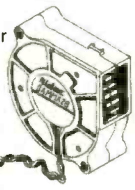


Marquardt # 1050.0141A
Small, normally-closed switch rated 2 amps @ 125/250 Vac. Prepped with 5" long wire leads and 2 contact socket connector. Body size: 0.78" X 0.4" X 0.25". UL and CSA listed. Large quantity available.

CAT# SMS-140 4 FOR $1.00

250 for $50.00
1000 for $150.00

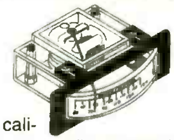
12 Vdc, MINI BLOWER



Nidec, Gamma 28 # A34342-55APP
12 Vdc, 0.18 amp brushless centrifugal blower designed for applications with space limitations. This small, lightweight blower features permanently lubricated ball bearings and a quiet thermoplastic housing. 3" diameter X 1.18" thick. Output port is 1.4" X 1". 5" leads.

CAT# CF-39 $7.00 each

EDGEVIEW PANEL METER FS=1 MICROAMP



Mura
Beautifully constructed edgeview meter movement. 2.75" X 0.8" face. Scale is labeled "BEATS/MINUTE" and is calibrated from 50-150. It can be easily removed or reversed to create a blank scale. The black bezel is 3.53" X 1.33" and can be adjusted or removed. 0.1" thick clear plexiglass case. Maximum case size behind mounting plane: 2.75" X 1.18" X 2.18". Solder lug terminals.

CAT # MET-47 $5.50 each

S-VHS VIDEO CORD

4' cable with miniature 4 pin mini DIN plugs on both ends.

CAT# CB-363 $3.00 each

10 for $25.00
100 for $150.00

BILATERAL TRIGGER (DIAC)

CAT # DB-3 28-36 volt
CAT# HT-40 35-45 volt

3 FOR $1.00

100 for $27.00

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CIRCLE 290 ON FREE INFORMATION CARD

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LIQUID CRYSTAL DISPLAYS

240x64 dot LCD with built-in controller.

AND 4021ST-EO. *Unit is EL back-lit.* **$79.⁰⁰ or 2 for $149.⁰⁰** *or*
OPTREX. DMF5005 *(non back-lit)* **$69.⁰⁰ or 2 for $129.⁰⁰**
20 character x 8 line 7¼L x 2½H
The built-in controller allows you to do text and graphics.

Alphanumeric—parallel interface

16x1 ....3 for $25.00	20x2 ....$12.00	40x1 ....$8.00
16x1 (lg. char.)....$12.00	20x4 ....$25.00	40x2 ....2 for $25.00
16x2 ....$8.00	20x4 (lg. char.)....$25.00	40x4 ....$25.00
16x2 (lg. char.)....$12.00	24x2 ....$12.00	4x2 ....$5.00
16x4 ....$15.00	32x4 ....$10.00	

5V power required • Built-in C-MOS LCD driver & controller • Easy "microprocessor" interface • 98 ASCII character generator • *Certain models are backlit, call for more info.*

Graphics and alphanumeric—serial interface

size	Mfr.	price	size	Mfr.	price
640x480 (backlit)	Epson	$35.00	480x128	Hitachi	$15.00
640x400 (backlit)	Panasonic	$25.00	256x128	Epson	$20.00
640x200	Toshiba	$15.00	240x128 (backlit)	Optrex	$20.00
480x128 (backlit)	ALPS	$15.00	240x64	Epson	$20.00
			160x128	Optrex	$15.00

6" VGA LCD 640X480, Sanyo LMDK55-22 **$35.⁰⁰**

LASER PRODUCTS

HeNe Laser Head (10Mw max. output) TEMOO. 15.5" long MFG: NEC **$99.⁰⁰**
Laser Power Supply (for HeNe tube) **$89.⁰⁰**

LASER SCANNER ASSEMBLY $29.⁰⁰
Assembly intended for a laser printer. Includes laser diode, polygon motor (6 sided) and misc. optics and lenses.

LASER DIODE (5mW) with collimator **$20.⁰⁰**

VISIBLE LASER DIODE: 5mw at 670nm **$15.⁰⁰**
Index guided. Threshold current 40 ma typical.

3 and 4mW, 1,300nm LASER DIODES, 5.6mm package, $35.⁰⁰
Mitsubishi Electric part number ML701BIR-E21A, General specs are:
1. Vop=1.25, Beam Divergence 25.6° x 28.6°; 2. Tc=24°C, Iop=19 to 20mA, ITH=10.7mA; 3. Wavelength range between 1,280nm and 1,330 nm

POLYGON MOTOR UNIT & DRIVER $79.⁰⁰
Ten-sided first surface mirror mounted on an armature that spins at 125 revolutions per second yielding a beam sweep rate of 1250 sweeps per second. The driver for the polygon unit requires 24 volts and plus and minus 12 volts to operate. There is also an f-theta lens in front of the polygon scanning mechanism with a three inch diameter. Great for optical experiments, etc. Very high quality units. (MFR: JAPAN ELECTRONICS)

NETWORK

Proteon ProNet-4 Model p1347 Token Ring Board $49.⁰⁰
16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

POS & BAR CODE

MAGNETIC CARD READER $25.⁰⁰
Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

HP bar code wand (HBCS 2300)......................$25.00

POWER SUPPLYS

SWITCHING POWER SUPPLYS $12.00 or 2 for $20.00 115/230 Volts
73 WATT (2) 4 pin power connectors attached • Dim: 8.5" L x 4.5" W x 2" H
Output: +5V @ 2-9.75, A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A
68 WATT Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A
60 WATT Dim: 8¾ x 4¼ x 3 • Output:5V @ 6A + 12V @ 1A - 5V @ 1A - 12V @ 1A

CHARGE COUPLED DEVICES

"The Spy In The Sky" $79.⁰⁰ **MATRIX TYPE**

Thomson 576X550 pixel CCD
400-1,100nm resolution and responsivity. **$500⁰⁰ Original cost device**

Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V) $29.⁰⁰
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um².
Ceramic 24 pin DIP package • Mfr: Sony, Part# 016AL

LINEAR TYPE

4096 element CCD $19.00
1024 element CCD $15.00
2048 element CCD $15.00 • 1728 element CCD $15.00

MONITORS

Non-Enclosed TTL
Comes with pinout. 12V at 1.4 Amp input • Horizontal frequency 15Khz. • Ability to do 40 and 80 column.
5 inch Amber $29.00 • 7 inch Amber $39.00
9 inch Amber or Green $29.95

5" COLOR MONITOR $49.⁰⁰

• Flat Faceplate • 320 x 200 Dot Resolution • CGA & Hercules Compatible
• 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
• Open Frame Construction • Standard Interface Connector • Degaussing Coil included • Mfr. Samtron

9" monochrome SVGA MONITOR $99.⁰⁰
Tilt and swivel type. **Mfr: WEN**

MISCELLANEOUS

ADAPTEC 4070A (RLL) OR 4000A (MFM), SCSI Controller, your choice $25⁰⁰

IBM 370 option XT and AT emulation boards $35⁰⁰

HACKER CORNER

POINT OF SALE BANK TERMINAL $49⁰⁰ or 2 for $89⁰⁰
• LCD Display 20 Char. x 4 Line • Printer 16 Column Dot Matrix - Epson • 24 Key Domed Membrane Keypad • Intel 80C32 Processor • 2 PCMCIA Sockets (ICC Slots) • Dallas DS1287 Realtime Clock • 2 Solid State Buzzers (Piezo Electric) • 4 Crystals • Rockwell Modem Chip • Telephone Line Interface (4 Pin "RJ" Connector) • RS-232 Interface (8 Pin "RJ" Connector) • NI-CAD Battery Pack Inside
Note: We have not been able to bypass an access code in the software. Thus, while time of day and other introductory things are displayed on LCD, the full original capabilities of this unit cannot be guaranteed. Also, we do not have a source for the smart cards that were to go in the PCM CIA sockets. Requires 12 volt adapter for power. (Not included) Dimensions: 9-1/2L x 6-1/4W x 2-1/2 D • Original cost over $450.00

CAMERA BLOCK $149⁰⁰ or 2 for $199⁰⁰
FOR ROBOTICS AND EVERYTHING ELSE
Unit is for Hi Band 8mm CamCorders, includes 8X zoom lenses, D/D converters, built-in CCD 2/3 in, 420 thousand picture elements, complementary mosaic filters. Excellent performance. High resolution, high sensitivity, low lag, low smear, good color reproduction, no distortion, 1/60-1/10000sec variable speed digital shutters, TTL auto focus, auto white balance, one-push auto white balance, auto/manual iris and gain up switch. Can be controlled by a 4bit micro computer. Remote controlling is possible for zoom and focusing. **NOTE:** We have Composit or PAL (European Standard) Units. **MFR: SONY**

CELL SITE TRANSCEIVER $79⁰⁰ 2 for $149⁰⁰
These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

Encased Black & White Composite CCD Camera with Adapter
IR viewing to 1000 nm 7 ½ L x 2 ¾ W x 1 ¾ H
Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **$89.00**
Great for: entryway security/remote monitoring, video conferencing/desktop video conferencing **2 for $159.00**
This miniature camera is perfect for multimedia computer applications as well as security and surveillance. NTSC output allows use with all popular video digitizing boards for Apple Macintosh and Microsoft video for Windows. Connects directly to any composite monitor or VCR with "video" input. Its razor-sharp wide-angle lens focuses from two inches to infinity and its state-of-the-art CCD technology accurately captures 16 level grayscale images for Quick Time movies and still pictures. Records at 30 frames per second and 260 lines resolution with excellent low light capability. Uses 12VDC (adapter supplied) and standard RCA cable.

US made Micronics 486 VLB ALL in ONE $99⁰⁰
motherboard, supports 3.4 or 5V CPU, at either 25 or 33 mhz basic clock. Can use AMD or Intel from 4865X25 thru 486DX4-100 to HOT new AMD 5X86-133 cpu. On board 2 serial ports, 1 printer port, floppy and IDE hard drive controller. On board 256K cache. Uses 72 pin simm memory.
Board will not fit standard All in One case because of non standard location of riser board. VLB riser board is included with motherboard.

.6" COMPOSITE MINIATURE COLOR DISPLAY $149.⁰⁰
Fully encased. Dim: 1.3" x 1.3" x 4". 12 Volts DC power. NTSC signal. 250 H x 300 V resolution. Focus adjustable eyepiece. Applications include camcorder viewfinder, helmet mounted display, etc... Original cost over $600.00

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17" tall, amplified FM antenna. Improves reception with weak FM signals. 18 dB of gain. Includes AC adaptor, gain control, and 75 ohm coaxial cable terminated with an "F" connector.

HOT NEW ITEM!

#EN-219-055 .... $12.90

Cable TV Stereo Decoder

When used in conjunction with a cable TV converter or cable ready VCR, this handy device allows you to feed the cable TV stereo signal into your home sound system for superb audio reproduction of your favorite shows, movies, and sporting events.

#EN-189-110 .... $19.90

Digital Video Stabilizer

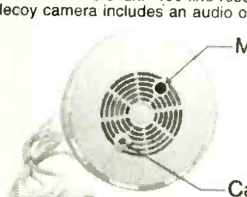
The digital video stabilizer will eliminate the constant picture distortion caused by the copyright protection on movie videotapes. This unit is fully automatic and operates on one 9V battery which is included.

#EN-180-320 .... $17.95

Decoy Cameras

These 1/3" CCD cameras offer a clever means of disguise. Both feature a 3.6mm wide angle lens, built-in electronic shutter, and a 12 VDC power supply. Minimum illumination: 0.3 lux. 400 line resolution. Smoke detector decoy camera includes an audio output.

AFFORDABLE HIGH TECH SURVEILLANCE!



Part #	Description	Price
EN-335-535	Smoke detector decoy	$249.50
EN-335-540	Decoy clock camera	299.95

"The Sound Bridge" FM Stereo Wireless Transmitter

The Sound Bridge is a mini FM wireless transmitter that can be used to broadcast stereo sound from any audio source like portable CD players, TVs, electronic games, CD-ROM, even computer soundcards, to your home stereo receiver! Adjustable from 89 to 95.5 MHz.

HOT NEW ITEM!

#EN-249-220 .... $14.95

Portasol/Weller Butane Soldering Tool

NO CORDS, NO BATTERIES!

This cordless, refillable, butane powered soldering tool is ideal for any on-site soldering job. Provides up to 35 watts with a temperature range up to 700 degrees F. Includes flint ignitor in plastic case, safety cut off switch, and C-2 chisel tip.

#EN-372-150 .... $25.95

150 MHz Oscilloscope Probe Kit

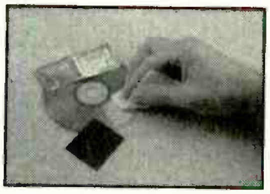
Deluxe probe kit features a modular design for longer life, switchable 10:1 probe with 150 MHz bandwidth, 2.8 ns rise time, and adjustable capacitance from 10-35 pF. 60" in length.

GREAT VALUE!

#EN-390-100 .... $29.95

Memorex CD Repair And Maintenance Kit

Don't throw away expensive CDs because of annoying mistracking and skipping errors! The Memorex CD Repair kit contains enough solution and materials to clean and repair 12 compact discs.



#EN-249-032 .... $1.95

5" Sealed Back Midrange

5" heavy duty sealed back midrange with deluxe mesh grill. 1" aluminum voice coil. Popular midrange for auto sound installations. •Power handling: 35 watts RMS/50 watts max •Voice coil diameter: 1 inch •Impedance: 8 ohms •Frequency response: 800-10,000 Hz.

#EN-280-030 .... $7.50

3 Channel Color Organ Kit

This sound to light unit features three separate outputs, which can be controlled independently. Each output reacts to three different bands of the musical spectrum: bass, midrange, and treble. Has built-in microphone, so no connection is required to music source, but a line input is provided.

SUPER QUALITY KIT!

velleman-kit

#EN-320-210 .... $59.95

1", Titanium Dome Tweeter

Features a ferro fluid cooled Kapton voice coil and a rubber surround. Very natural sounding high frequency reproduction with extended response to 30KHz.
•Power handling: 50 watts RMS/75 watts max
•Voice coil diameter: 1", •Impedance: 8 ohms
•Frequency response: 2500-30,000 Hz.

Dayton Loudspeaker Co.®

RESPONSE TO 30KHz!

#EN-275-050 .... $16.50

6-1/2" Woofer

Polymer resin treated paper cone with poly foam surround. Long throw voice coil design helps to deliver powerful bass output. Perfect for bookshelf type speakers. Mfg. #C16L020-51F. •Power handling: 60 watts RMS/120 watts max. •Voice coil diameter: 1-1/4 inches •Impedance: 8 ohms •Frequency response: 57-7000 Hz.

PIONEER®

#EN-290-023 .... $19.95

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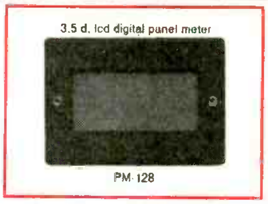
•30 day money back guarantee •$20.00 minimum order •We accept Mastercard, Visa, Discover, and company C.O.D. orders •24 hour shipping •Shipping charge = UPS chart rate + $1.90 ($5.00 minimum charge) •Hours 8:00 am - 8:00 pm ET, Monday - Friday •9:00 am - 5:00 pm Saturday. Mail order customers, please call for shipping estimate on orders exceeding 5 lbs. •Foreign destination customers please send $5.00 U.S. funds for catalog. •Quantity pricing available.

CIRCLE 262 ON FREE INFORMATION CARD

1-800-338-0531

Digital Panel Meters (LCD & LED)

Don't let the prices fool you. These digital panel meters are not surplus, so even if you design them into an ongoing manufactured product, you can be assured of continued availability. These high quality digital panel meters are decimal point selectable with guaranteed zero reading at zero volts input.



Applications Include:

- Voltmeter
- Thermometer
- pH Meter
- dB Meter
- Watt Meter
- Current Meter
- Capacitance Meter
- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

PM-128: 3-1/2D LCD Digital Panel Meter

PM-129: 3-1/2D LED Digital Panel Meter

Features

- 200mV Full Scale Input Sensitivity
- PM-128 - Single 9VDC Operation
- PM-129 - Single 9VDC Operation
- Decimal Point Selectable
- PM-128 - 13mm Figure Height
- Automatic Polarity Indication
- Guaranteed Zero Reading for 0 Volt Input
- High Input Impedance (>100Mohm)

Specifications - PM-128/PM-129

Maximum Input	: 199.9mV DC
Maximum Display	: 1999 counts (3-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: PM-128 - LCD Display PM-129 - LED Display
Measuring Method	: Dual-Slope Integration A/D Converter System
Overrange Indication	: "1" Shown in the Display
Reading Rate Time	: 2-3 Readings per sec.
Input Impedance	: >100 Mohm
Accuracy	: +-0.5% (23+-5°C, <80% RH)
Power Dissipation	: PM-128 - 1mA DC PM-129 - 60mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: PM-128 - 9V DC PM-129 - 9V DC
Size	: 67mm x 44mm

3-1/2 Digit LCD 3-1/2 Digit LED 4-1/2 Digit LCD

PM-328: 4-1/2D LCD Digital Panel Meter

Features

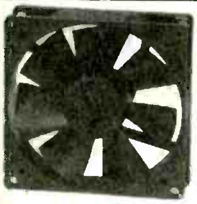
- 200.00mV Full Scale Input Sensitivity
- Single 9V DC Operation
- Decimal Point Selectable
- 11mm LCD Figure Height
- Automatic Polarity Indication
- Low Battery Detection and Indication
- High Input Impedance (>100 Mohm)

Specifications - PM-328

Maximum Input	: 199.99mV DC
Maximum Display	: 19999 counts (4-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: LCD Display
Overrange Indication	: "1" Shown in the Display
Input Impedance	: >100 Mohm
Accuracy	: +-0.05% (23+-5°C, <80% RH)
Power Dissipation	: 1mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: 9V DC
Size	: 67mm x 44mm

AS LOW AS $5.25 ea.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25	100	250
PM-128	3-1/2 Digit LCD Panel Meter	$ 9.90	$ 7.09	$ 6.40	$ 5.86	$ 5.25
PM-129	3-1/2 Digit LED Panel Meter	11.49	9.54	8.67	7.95	6.95
PM-328	4-1/2 Digit LCD Panel Meter	19.88	16.40	14.90	13.66	11.93



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CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

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CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

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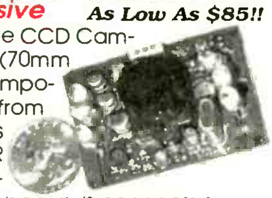

This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connectiong three wires: red to 12V, black to ground (power & video) and brown to video signal output.

Power Supply Regulating Kit for CA-H34 This simple kit is designed to fit onto the back of the CA-H34 CCD camera. It resolves the problem of hooking up the camera to an UNREGULATED supply (which damages the camera) by providing safe regulated power from any 12V-14V DC supply. It also provides regulated 12V DC from a 12V AC source.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$99.00	$85.00
A34	Power Supply Regulating Kit	$6.95	-----

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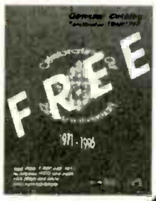

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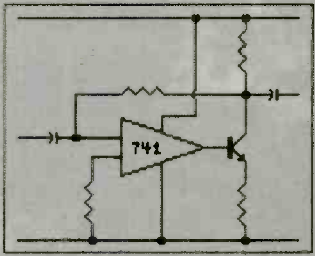
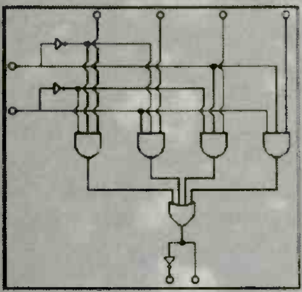
VT204	Power Supplies: Rectifier circuits, filter circuits, regular circuits, troubleshooting. 56 Minutes.	44.95	39.95
VT205	Amplifier: Amplifier basics, class A, class B, class C, operational amplifiers. 57 Minutes	44.95	39.95
VT206	Oscillators: LC and RC oscillators, crystal oscillators, crystal ovens. 56 Minutes	44.95	39.95





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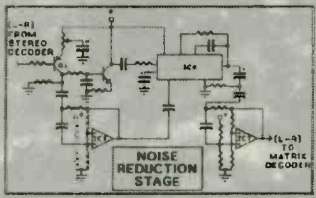

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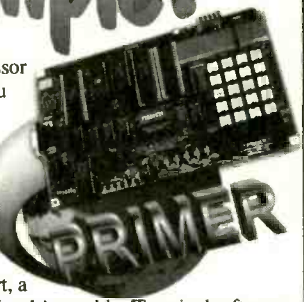

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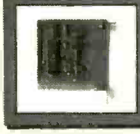

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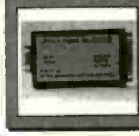

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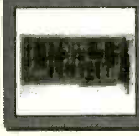

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- 3 TIMER COUNTERS
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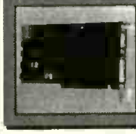

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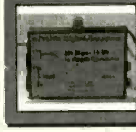

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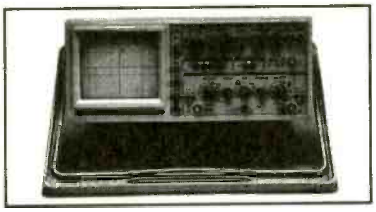

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- **Temperature Range**——300°C—400°C (572°F—842°F)
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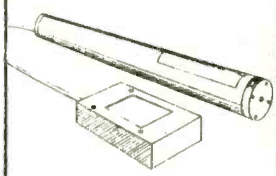

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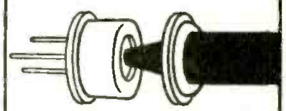

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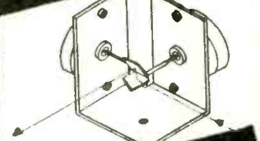

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*LD- Stainless Steel 0.7mm
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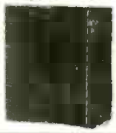

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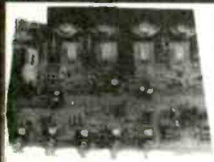
TA-800MK2 ▲▲ 120+120W Pre & Main Stereo Amp. (4 lbs.)



Kit:$ 67.92
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Power Output:120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response:10-20KHZ. THD: <0.01%. Tone Control: Bass ±12dB, Mid & Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40VDC @ 6A. Suggested Mark V model 001 or 008 transformer. Recommended Metal Cabinet LG-1924.

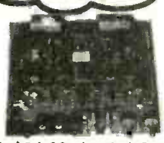
AF-3 ▲▲▲ 300W MOSFET High Power Mono Amp. (7 lbs.)

Kit:$ 165.00 Asmb.$ 195.00

Power Output: 300W into 4 ohms RMS. 200W into 8 ohms RMS. Frequency Response: 10HZ-20KHZ. THD: <0.03%. Signal to noise ratio: 91dB. Input Sensitivity & Impedance at 1KHZ, 1V 47K. Load Impedance 4-16 ohms. Power Requirement: ±55 to ±65VDC 8A. Suggested Mark V model 009 Transformer. Capacitor 10,000uf 80-100V model 016 or 019. Recommended Metal Cabinet LG-1925 for each channel.

TA-388 ▲▲▲ Class A FET Dynamic Buffer Stereo Pre-Amp (1 lb)

Best Pre-Amp



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Best Buy

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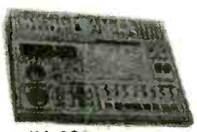

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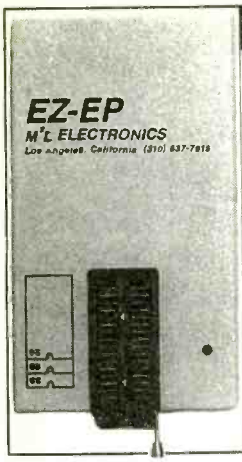

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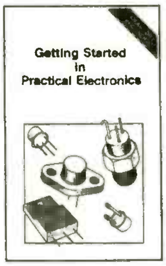

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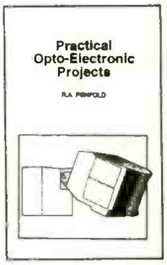

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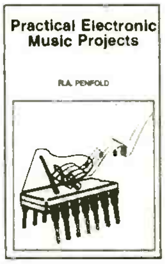

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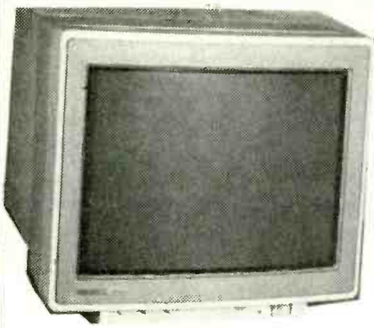

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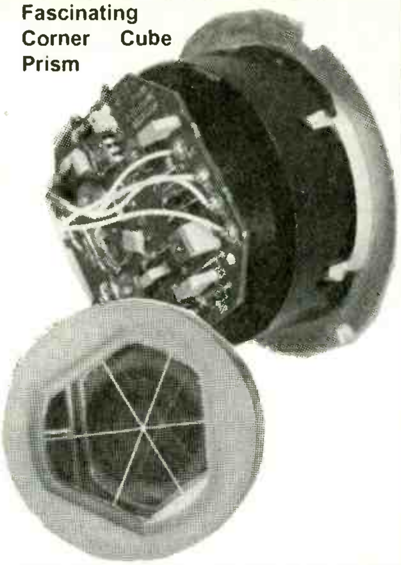

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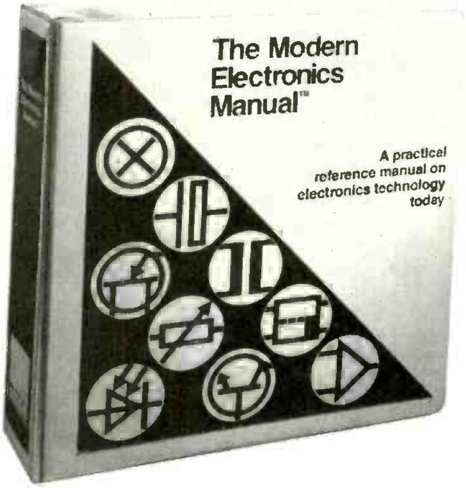

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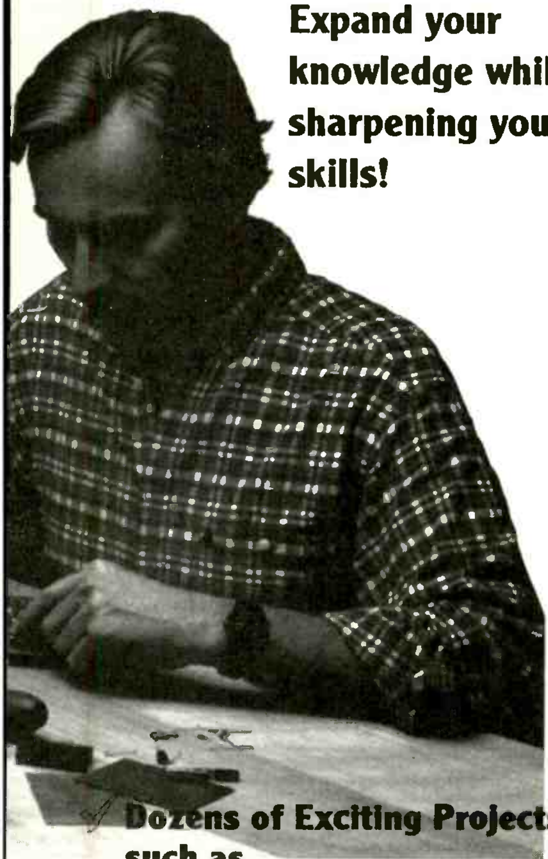

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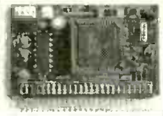

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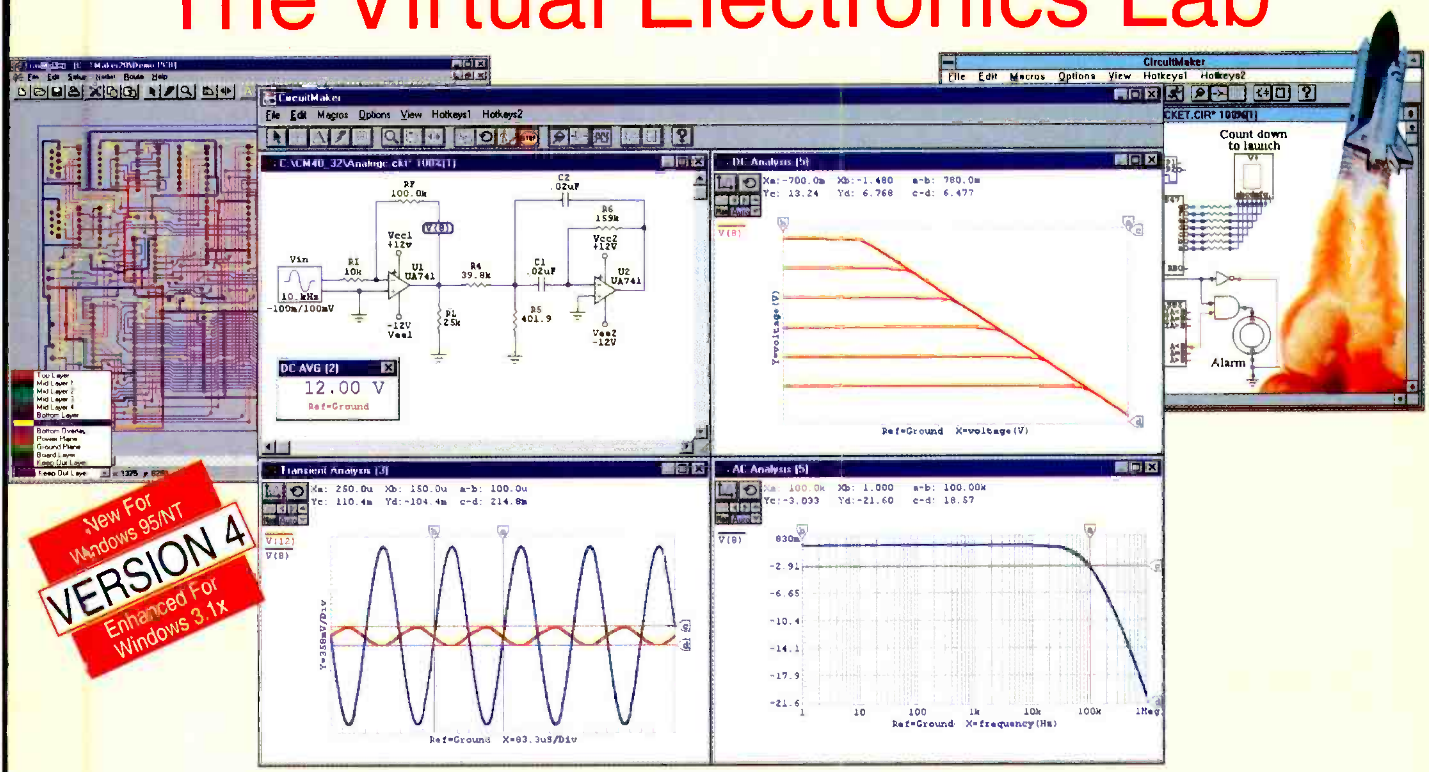
CircuitMaker®

The Virtual Electronics Lab™



Professional Schematic Layout

CircuitMaker's schematic capabilities are unmatched and include many advanced editing features not found in similar programs. These powerful features minimize the time and task associated with drawing a schematic and insure a professional looking final product. Printout and export options are numerous and results are of the highest quality. But that's what people have come to expect from CircuitMaker.

Unlimited, Indestructible Devices

CircuitMaker ships with over 1500 devices. That's more (at no additional cost) than any competing product. If you need a device that is not included, CircuitMaker provides industry standard SPICE import and a powerful macro capability. These indestructible devices accurately emulate actual devices and enable the user to try all those "what if" scenarios with no risk and at no additional cost.

Accurate Simulation & Advanced Analysis

CircuitMaker features analog, digital and mixed-mode simulation. Obviously, simulation is of no value if the results are not accurate. CircuitMaker's simulation engine is based on Berkeley SPICE3, which is renowned for it's accuracy. That's why we can factually state that CircuitMaker provides it's user with the most accurate simulation available. Furthermore, CircuitMaker provides a wealth of analysis capabilities not found in other products in it's class. No other product offers this much simulation muscle at such a reasonable price.

Printed Circuit Board Output

CircuitMaker's PCB output capability helps you complete your design cycle, by generating a netlist that can be imported into any compatible PCB program. This is not a costly "add-on module", it comes standard with every copy of CircuitMaker. MicroCode Engineering also offers TraxMaker, a professional level, PCB layout and autorouting program for just $299. Used in conjunction with CircuitMaker, TraxMaker completes a powerful end-to-end circuit design system.

	Schematic Capture	Advanced Schematic Features	Digital, Analog, and Mixed-Mode Simulation	Full SPICE Compatibility	SPICE Export/Import	PCB Export	Retail Price
CircuitMaker	YES	YES	YES	YES	YES	YES	$299
Electronics Workbench version 4	YES	NO	YES	NO	NO	NO	$299
Electronics Workbench Engineer's Pack	YES	NO	YES	NO	YES	YES	$599

"CircuitMaker Shocks The Competition, With An Unbeatable Bottom-line"

Total Customer Satisfaction

At MicroCode Engineering we are committed to total customer satisfaction. When you purchase CircuitMaker you have the confidence of knowing that a trained staff of professionals is available to serve you after the sale. Our free unlimited customer service is second to none! Whether you have general or technical questions they will be answered promptly by a knowledgeable representative.

FREE Functional Demo

A free functional demo is available on the Internet at http://www.microcode.com, on CompuServe (GO MICROCODE) and on America Online by doing a file search for CircuitMaker.

Call now to order or request additional information

800-419-4242

MicroCode Engineering Inc. • 573 W 1830 N Suite 4 Orem UT 84057-2030 USA • Phone 801-226-4470 Fax 801-226-6532 • Internet http://www.microcode.com

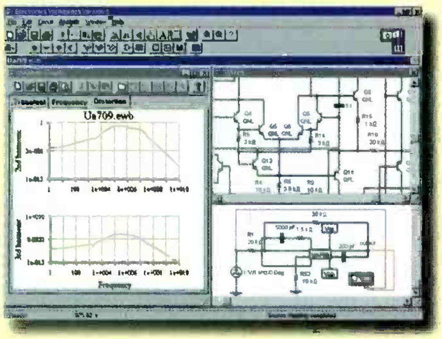
CIRCLE 128 ON FREE INFORMATION CARD

NEW VERSION!

Electronics Workbench Version 5 with analog, digital and mixed A/D SPICE simulation, a full suite of analyses and over 4,000 devices. Still the standard for power and ease of use. Now ten times faster. Still the same low price.

Join over 75,000 customers and find out why more engineers and hobbyists buy Electronics Workbench than any other SPICE simulator. You'll be working productively in 20 minutes, and creating better designs faster. We guarantee it!

$299 ← SAME GREAT PRICE!



High-End Features

TRUE MIXED ANALOG/DIGITAL	YES
FULLY INTERACTIVE SIMULATION	YES
ANALOG ENGINE	SPICE 3F5, 32-BIT
DIGITAL ENGINE	NATIVE, 32-BIT
TEMPERATURE CONTROL	EACH DEVICE
PRO SCHEMATIC EDITOR	YES
HIERARCHICAL CIRCUITS	YES
VIRTUAL INSTRUMENTS	YES
ON-SCREEN GRAPHS	YES
ANALOG COMPONENTS	OVER 100
DIGITAL COMPONENTS	OVER 200
DEVICE MODELS	OVER 4,000
MONEY-BACK GUARANTEE	30-DAY
TECHNICAL SUPPORT	FREE

Powerful Analyses

DC OPERATING POINT	YES
AC FREQUENCY	YES
TRANSIENT	YES
FOURIER	YES
NOISE	YES
DISTORTION	YES

POWERFUL NEW VERSION!

30-DAY MONEY-BACK GUARANTEE

VERSION 5.0 FOR WINDOWS 95/NT/3.1.
Upgrades from previous versions $79.

FEATURES OF ELECTRONICS WORKBENCH VERSION 5

WHAT'S NEW

Now 10 times faster. Handles 3 times larger circuits. More and better device models. New thermal modeling. New on-screen graphs. New analyses (Fourier, Noise and Distortion). 25 new components including vacuum tubes, arbitrary sources. 50 new ICs. Improved accuracy. Improved schematic editor with zoom and growing pages. Improved printing. Improved fonts. Improved interface. Redesigned word generator and logic analyzer.

GENERAL

Integrated Tool: Fully integrated schematic editing, SPICE simulation and waveform generation and analysis. Supports modifications to the circuit during simulation. Circuit analysis through virtual test instruments, or six analyses listed below.

Simulation Engine: Interactive 32-bit SPICE 3F5, enhanced with native-mode digital and mixed analog/digital support. Automatic insertion of signal translation interface. Supports multiple reuse of hierarchical blocks. GMIN stepping for better convergence. No preset limits on circuit size or complexity.

Schematic Capture: Click-and-drag interface, hierarchical workspace, automatic wire routing with manual adjustment, automatic reference designation. N[illegible] schematic size.

[illegible] instruments for quick and simple analys[illegible]yses for on-screen graphs and more flexible analysis (described below).

D[illegible]ll design information, including [illegible]ration, SPICE parameters, setup and [illegible] models s[illegible] a design file [illegible] facilitate design sharing [illegible]d reuse.

[illegible]port standard SPICE n[illegible]ith other simulators or to [illegible]ments. Imports manufacturers' models and netlists into reusable Electronics Workbench components. Exports to standard PCB layout packages such as OrCAD, Protel and Tango.

ANALYSES

DC Operating Point: Calculates DC operating point and reports voltage at each node.

Transient: Circuit voltages and currents over time at any number of nodes. Specify start and stop times.

AC Frequency Sweep: Small-signal gain and phase over range of AC frequencies at any number of nodes. Specify range, type (decade, octave or linear) and resolution (number of steps) of frequency sweep.

Fourier: Magnitude and phase of DC and Fourier spectral components of transient response. Specify fundamental frequency and an unlimited number of harmonics.

Noise: Resistor and semiconductor noise contribution reported as RMS sum. Specify device of interest, output and reference nodes, and range, type and resolution of frequency sweep.

Distortion: Small-signal steady-state harmonic and intermodulation products over a range of frequencies. Specify any number of nodes and sweep range, type and resolution. Optionally exclude devices on an individual basis.

VIRTUAL TEST INSTRUMENTS

Digital M[illegible]easures AC [illegible]bel loss [illegible] and [illegible] Hz to [illegible] Adjustable duty cycle, amplitude and DC offset.

Oscillo[illegible] [illegible] Internal [illegible] [illegible] negative [illegible] [illegible] two digital cursors. Save data to ASCII file.

Bode Plotter: Plots magnitude and phase for a frequency sweep. Supports frequencies from mHz to GHz. Log or linear scales.

Word Generator: Acts as a digital stimulus editor to drive a circuit with up to 32K 16-bit words. Display and edit data as ASCII, binary or hex. Load, save, cut and paste words. Supports breakpoints and single step, burst and continuous modes. External trigger and data ready indicator for synchronization.

Logic Analyzer: Supports pre- and post-trigger. Internal or external clock, negative or positive edge. Clock qualifier to synchronize data. User-defined trigger patterns and trigger qualifier.

Logic Converter: Converts among gate, truth table and Boolean logic representations.

COMPONENTS

Sources: DC Voltage, DC Current, AC Voltage, AC Current, Voltage-Controlled Voltage, Voltage-Controlled Current, Current-Controlled Voltage, Current-Controlled Current, AM, FM, Vcc, Clock, Pulse-Width Modulated, Frequency-Shift Keying, Polynomial, Piece-Wise Linear Controlled, Voltage-Controlled Oscillator and Nonlinear Dependent.

Basic: Resistor, Capacitor, Inductor, Transformer, Relay, Switch, Time-Delay Switch, Voltage-Controlled Switch, Current-Controlled Switch, Pull-Up Resistor, Variable Resistor, Resistor Pack, Polarized Capacitor, Variable Capacitor, Variable Inductor, Coupled Inductor and Nonlinear Transformer.

Diodes: Diode, Zener Diode, LED, Shockley Diode, Diac, SCR, Triac and Full-Wave Bridge Rectifier.

Transistors: NPN and PNP BJTs, N- and P-Channel JFETs, 3- and 4-Terminal Enhancement and Depletion N- and P-Channel MOSFETs.

Analog ICs: 3- and 5-Terminal Opamps, Comparator and Voltage Regulator.

Mixed ICs: A-to-D Converter, D-to-A Voltage and Current Converters, 555 Timer and Monostable.

Logic Gates: AND, OR, NOT, NOR, NAND, XOR, XNOR, Tristate Buffer, Buffer and Schmitt Trigger.

Digital: RS, JK, JK', D and D' Flip-Flops, Half and Full Adders, Multiplexer, Demultiplexer, Encoder and Decoder.

Indicators: Bulb, Voltmeter, Ammeter, Probe, Raw and Decoded 7-Segment Display, Buzzer and Raw and Decoded Bargraph.

Controls: Differentiator, Integrator, Gain Block, Transfer Function, Limiter, Multiplier, Divider and Summer.

Other: Fuse, Lossy and Lossless Transmission Lines, Crystal, DC motor, Vacuum Tube and Buck and Boost Converter.

74xx ICs: 7400, 7402, 7404, 7405, 7406, 7407, 7408, 7409, 7410, 7411, 7412, 7415, 7420, 7421, 7422, 7425, 7426, 7427, 7428, 7430, 7432, 7433, 7437, 7439, 7440, 7442, 7445, 7447, 7451, 7454, 7455, 7469, 7472, 7473, 7474, 7475, 7476, 7477, 7478, 7486, 7490, 7491, 7492, 7493.

74xxx ICs: 74107, 74109, 74112, 74113, 74114, 74116, 74125, 74126, 74133, 74134, 74138, 74139, 74145, 74147, 74148, 74151, 74153, 74154, 74155, 74156, 74157, 74158, 74159, 74160, 74162, 74163, 74164, 74165, 74166, 74169, 4173, 74174, 74175, 74181, 74190, 74191, 74192, 74194, 74195, 74198, 74199, 74238, 74240, 74241, 74244, 74251, 74253, 74257, 74258, 74273, 74280, 74290, 74293, 74298, 74350, 74352, 74353, 74365, 74367, 74368, 74373, 74374, 74375, 74377, 74378, 74379, 74393, 74395, 74445, 74465, 744[illegible]

4xxx ICs: [illegible]001, 4002, [illegible]008, 4011, 4012, [illegible], 4028, 4030, 4040, [illegible]069, 4070, 4071, 4073, [illegible], 4085, 408[illegible], 4107, 4019, 4024, 4027, [illegible]4050, 4069, 4072, 4075, 4077, 4078, [illegible] 4503, 4512, 4516, 40103

MODELS

Digital: Models for ICs, Gates and Flip-Flops in HC totem-pole, HC buffer, HC open-drain, LS totem-pole, LS buffer, LS open-collector and LS open-collector buffer configurations.

Diodes: Over 1,300 models for Diodes, Zener Diodes, LEDs, Shockley Diodes and Diacs from Motorola, General Instruments, International Rectifier, Zetex and Phillips.

Transistors: Over 1,400 models for NPN and PNP BJTs, JFETs, MOSFETs, SCRs, Triacs and IGBTs from Motorola, National Semiconductor, International Rectifier, Toshiba, Harris and Phillips.

Analog ICs: Over 1,200 models for Opamps, Comparators and Voltage Regulators from Motorola, Texas Instruments, Maxim, Elantec, Analog Devices, Zetex, Burr-Brown and Linear Technology.

Other Models: a variety of Relays, Transformers, Vacuum Tubes, Transmission Lines and Crystals.

Electronics Workbench®
VERSION 5

INTERACTIVE IMAGE TECHNOLOGIES LTD., 908 Niagara Falls Boulevard, #068, North Tonawanda, New York 14120-2060/Telephone 416-977-5550

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