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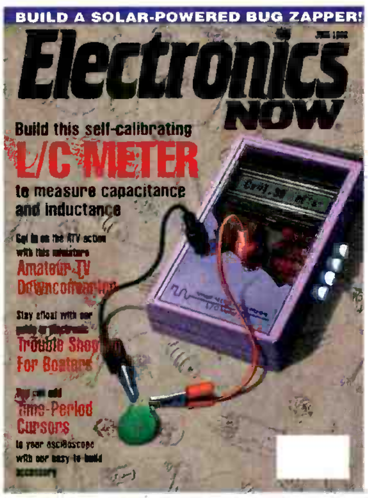


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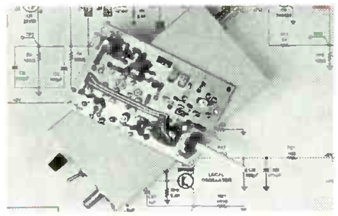



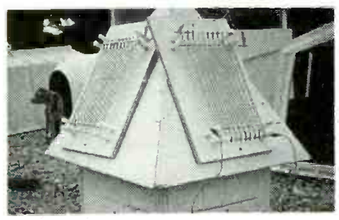






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# WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

## Molecules moved and positioned at room temperature

For the first time, scientists at IBM's Zurich Research Laboratory have succeeded in moving and precisely positioning individual molecules at room temperature. The procedure, which is viewed as an important step toward being able to do a wide range of "engineering" on the nanometer scale, was accomplished using the extremely fine tip of a scanning tunneling microscope (STM). It could help take miniaturization to its limits, and pave the way to fabricating molecules with specific properties and functions, building ultra-small computers, and even constructing tiny molecular machines that would be capable of, for instance, cleaning or repairing nano-scale electronic circuits.

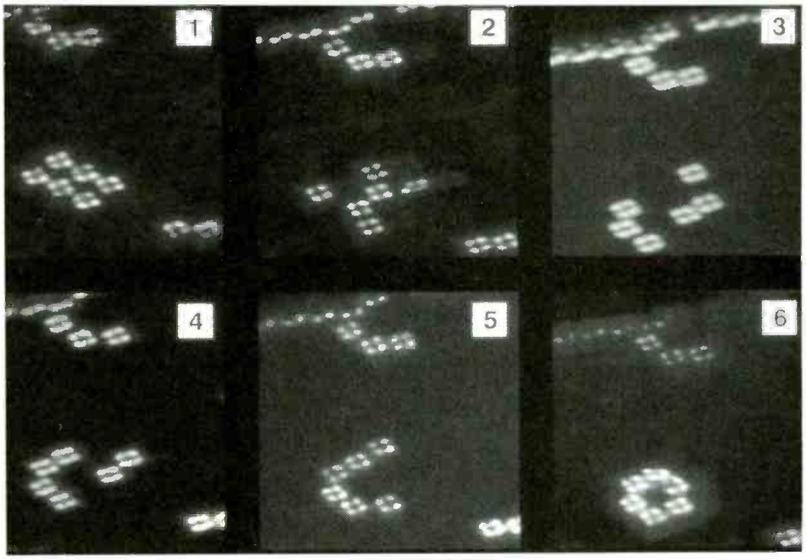
The scanning tunneling microscope, which was invented at IBM's Zurich Research Laboratory and whose inventors were granted a Nobel Prize in Physics in 1986, plays a major role in the creation of such a "nanocosmos." The STM can be used not only for imaging surfaces with atomic resolution, but also for positioning individual atoms and molecules.

There were some problems to overcome, however. Most atoms and molecules stick to the surface and to the STM tip, making it difficult to pick them up and release them in a precisely controlled way. Those that are less "sticky" tend to jitter and jump around at room temperature. Although the jitter problem can be overcome by cooling the sample to near absolute zero (as proven in 1989 by scientists at IBM's Almaden Research Center in San Jose), room-temperature positioning is required for broad practical uses, such as creating chemical reactions that build functional units from individual atoms and molecules. In 1991, scientists at IBM's T.J. Watson Research Center in Yorktown Heights, New York, used electrical pulses to pick up and release individual silicon atoms at room temperature. However, the strong electrical pulses required by that technique tore apart most molecules.

Now IBM scientists in Zurich have succeeded in positioning individual molecules at room temperature using purely mechanical means. For the mechanical method to work, the molecules must stick tightly enough to remain at their position but not so tightly that they cannot be moved. The chemical bonds within the molecule, on the other hand, must resist being changed or broken when the molecule is pushed by the tip of the STM.

After studying several possible molecules, the scientists selected Cu-tetra-(3,5 di-tertiary-butyl-phenyl)-porphyrin (Cu-TBP-porphyrin), an organic molecule that has a total of 173 atoms. At its core is a stable ring or atoms known as a phophyrin. Four strongly but flexibly bonded hydrocarbon groups attached vertically to the ring to make the molecule, which has a diameter of approximately 1.5 nanometers. Cu-TBP-porphyrin is ideal for displacement experiments: Its position and structure are easily identified by STM imaging, and the four hydrocarbon groups act as

*continued on page 12*




This sequence of images illustrates the manipulation of individual molecules. A group of six molecules (1) is first disordered (2) by cruising through the group with the scanning tunneling microscope (STM) tip. Subsequently, one molecule after the other is pushed by the tip in a precisely controlled manner (3-5). That allows a ring, which would not normally be found in nature, to be formed (6). Note that the process does not interfere with the other molecules visible at the top of the images; their positions remain unchanged.

# VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

## The satellite boom

Video's big story of 1996 may well turn out to be direct broadcasting via satellite (DBS). After years of forecasts and failures, DBS has finally taken off via high-powered satellites that require only a small home dish, 18 inches in diameter. The two major broadcast services, DirecTv and U.S. Satellite Broadcasting—both of which deliver many of the same channels carried by cable and have plans to increase their offerings to 150 or so channels—are sharing their success with Thomson Consumer Electronics, whose RCA-brand Digital Satellite System (DSS) receivers boomed last year to sales of one million.

Now other receiver makers are getting into the act. Sony was the second, but before the year is out there could be a dozen brands vying for the receiver market, along with new satellite systems to rival DSS. Following Sony came Toshiba and Uniden, with Philips (Magnavox), Hughes Communications, and even AT&T expected to offer receivers.

At the same time, new DBS broadcasters Echostar and AlphaStar are beginning to offer programming from their own satellite. And Primestar—originally established by cable-TV operators as a defensive measure against satellite—now appears ready to become an important venture on its own. AlphaStar receivers will be sold through direct-marketing Amway distributors.

TV isn't the only thing distributed by these new DBS satellites. They all offer a wide variety of "CD-quality" music programs. DirecTv is planning to offer a new service called DirecPC to bring online programming to computers, and Microsoft also will join the DSS system with a service to feed computers via satellite.

## PlayStation the winner

In the hotly competitive video-game business, an upstart newcomer has bumped Nintendo and Sega from their traditional lead position, and virtually forced two other rivals out of the field completely. Sony is an upstart because, for all of its electronics experience, it's new to the video-game business. But its PlayStation was an immediate success in Japan, the U.S., and Europe, and the demand is still higher than the availability of game consoles and software. More than one million PlayStations have been sold in this country since it was introduced in September 1995, and Sony is expecting to sell as many as 3 million consoles next year.

Sega's Saturn has proved to be a disappointment, with sales estimated at only 400,000 in the U.S. last year. Nintendo, which has been widely touting its upcoming 64-bit N64 model, has repeatedly failed to meet its introductory deadlines. Its fall 1995 introduction date was postponed to April 1996, and that


Sony's SAS-AD1 is the second brand OF DIGITAL SATELLITE SYSTEM to enter the fast-growing DSS market; Toshiba and Uniden came next, with Philips, AT&T, and several more companies to follow suit by year's end.

in turn was postponed again to June in Japan and September 30 in the U.S., giving PlayStation a clear field for most of this year. The N64 postponements were attributed to a shortage of not only components but software as well.

Two other games seem to have fallen by the wayside. 3DO, which once had high hopes of revolutionizing the video-game market, is currently in eclipse. The 3DO company sold primary rights for its upcoming M2 64-bit graphics technology to Matsushita (Panasonic), and since then there have been no significant developments on the 3DO game front. The dropout of Goldstar, which had planned to introduce a 3DO game console, leaves Panasonic as the only brand offering this game (and no longer pushing it vigorously). Atari, which had staked a great deal on its highly sophisticated Jaguar game, apparently has backed out, too, laying off most of its game-development team. Jaguar consoles have begun appearing at bargain-basement prices.

The pioneer in sophisticated games—Philips' CD-i—is no longer considered a consumer game system. It's being sold through channels aimed at the educational and commercial markets. So all of this leaves PlayStation as the undisputed leader, at least for the foreseeable future—and that means through Christmas of this year. Nobody else is close enough to catch up.

## Tubes for PC/TVs

Almost every manufacturer in the TV business and in the computer business is working on a new product known as the "network computer" or the "PC/TV." These products are halfway compromises or combinations of TV sets and personal computers. In the simplest form, a network computer will be able to access the via a TV attachment. More elaborate devices are TV sets that can play CD-ROMs or with other PC features, or complete PC's that also double as TVs, such as the Gateway 2000 "Destination" system (*Electronics Now*, May 1996).

All of those systems face a common problem: A TV picture tube can't get the resolution required for easy visibility and readability of computer data. Conversely, a truly high-resolution PC monitor can't achieve the brightness generally associated with today's TV sets. Those drawbacks are resulting in a series of compromises—so called "data-grade" or "fine-pitch" picture tubes. Several TV picture-tube manufacturers currently are offering those tubes to their customers.

Those tubes—generally in the larger sizes—aren't really computer monitor tubes, but they are capable of displaying VGA-quality graphics, without materially lowering the brightness. So far, Thomson (RCA) and Toshiba have announced such tubes, and most of their competitors will be doing so soon. The high resolution is achieved by using narrower phosphor stripes on the tube face and internal shadow masks with finer openings. Take the RCA 36-inch fine-pitch tube as an example. You couldn't use is as a desktop monitor, but from across the living room, it displays satisfactory and legible computer graphics as well as an extremely high-quality TV picture. EN

# Q & A

READERS QUESTIONS, EDITORS ANSWERS

## Controlling relays by serial port

**Q** *How can I use the serial (RS-232) port on my computer to control 8 to 16 relays? — R. S. C., Silver Spring, Md.*

**A** Controlling relays with a parallel port would be easier because the parallel port data lines are TTL logic-level signals. But there are several reasons you might want to use a serial port. First, fewer wires are required (just two, instead of nine or more). Second, serial cables can be a lot longer (up to a quarter of a mile at low baud rates) without degrading the signal. And third, serial ports are more standardized; they work the same way whether or not the computer is a PC-compatible. This is essential if your computer happens to be a Macintosh or a Sun workstation.

Decoding the RS-232 signals is a job for a microcontroller (single-chip computer). Fortunately, you don't have to program the microcontroller yourself; you can get a PIC 16C54A microcontroller already programmed for exactly this job from Stone Mountain Instruments (615 Field Cliff Drive, Stone Mountain, GA 30087, phone 770 413-6016, email 75377.1172@compuserve.com). What you need is part number SMI101B, priced at $7.50 (but there's a $25 minimum order). SMI sells a whole line of preprogrammed microcontrollers for common industrial control tasks, so you'll probably want to start by requesting a catalog.

Figure 1 shows the circuit, and Figure 2 shows a BASIC program to demonstrate how it works. Each SMI101B has eight logic-level outputs. Further, you can connect up to seven SMI101B's to a single serial port. The three "N" pins give each SMI101B a distinctive identifying number from 0 to 6. If all three are grounded, the identifier is 0; if N1 is connected to +5 volts, the identifier is 1, and so on.

At power-up, all the data outputs are off (logic "0"). To turn an output on, send a command of the form "*x*N*y*" where *x* is the identifier of the SMI101B and *y* indicates which data output you want to switch. For example, to turn on data output 3 of a processor whose ID is 0, transmit the command "0N3" followed by ASCII code 13 (carriage return). To turn the outputs back off, use an F in place of an N (e.g., "0F3"). All communication is done with 8 data bits and no parity bits. The baud rate is 9600 baud with a 4-MHz crystal, or 1200 baud with a 500-kHz ceramic resonator.

As shown in the diagram, each relay requires a transistor to drive it, along with a resistor and a protective diode. To cut down the total number of components, you can use a relay driver chip such as the Allegro UDN2987, which contains everything necessary to drive eight small relays from logic-level signals.

## Serial port start bit

**Q** *I am trying to drive an alphanumeric display from the serial port of my PC. The display requires a start bit*

*continued on page 14*

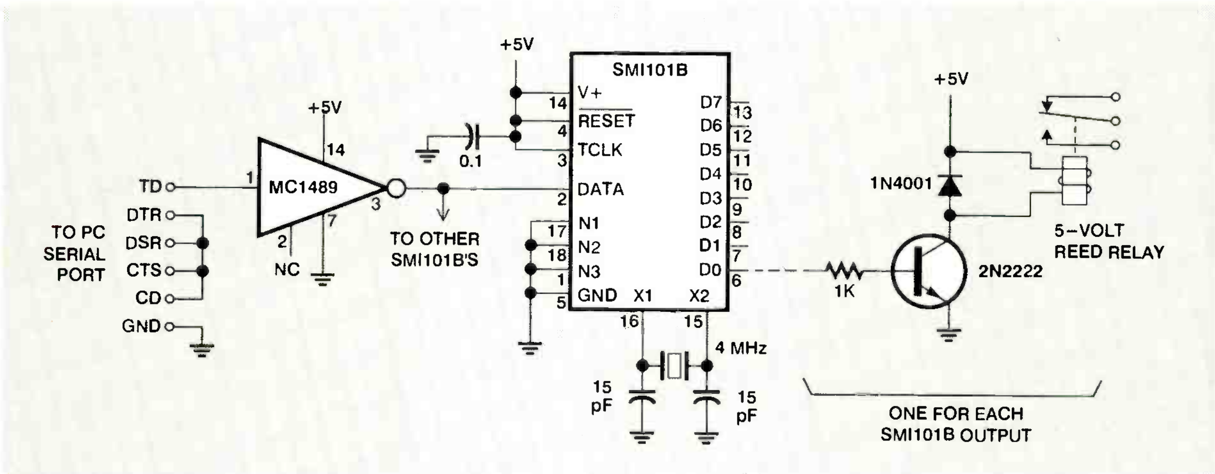


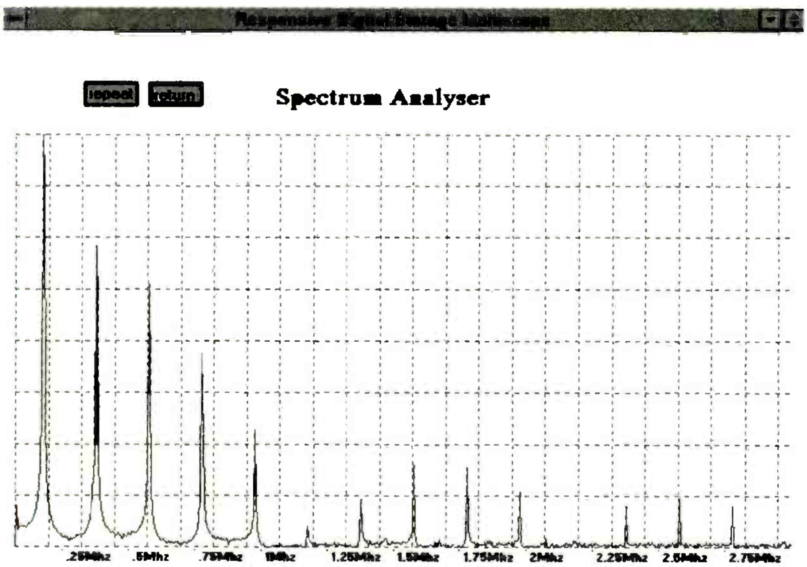

**FIG. 1**—THIS CIRCUIT LETS YOU CONTROL external devices from your serial port.

# LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

## MULTISCOPE CLARIFICATIONS

Thank you for reviewing Mission Technology's Multiscope in the May issue of *Electronics Now*. I was frankly a little disappointed with the choice of screen captures with irregular and noisy waveforms. I hope that they don't give readers an incorrect idea of the unit's capabilities.




An important feature of the multiscope—omitted in the article—is the use of the unique marker bars to find the true RMS and DC values of any waveform segment enclosed between the bars. That feature could be especially useful to students.

I think that the Wideview and Burstmode operating modes also could use further explanation. In the burst mode, measurement data is red directly into the PC's memory until a user-determined number of samples are acquired. That allows much faster operation because no screen updating is done as the data is being acquired. The Wideview mode also allows data acquisition with minimum software processing at one of ten sampling speeds ranging from 200 samples per second (0.5 milliseconds per sample) to 20 million samples per second (50 nanoseconds per sample). A total of 200 samples is taken by each sampling cycle, and then displayed on the screen. For full utility, users must modify the burst and Wideview software; source code costing $168 for both is available.

Readers who are interested in learning more about the Multiscope are welcome to browse the Multiscope web page at: http://members.gnn.com/mission/electrncl.htm. *(Editor's note: The software is available from the Electronics Now BBS; 516-293-2283.)*

NATHAN CHAO
*Mission Technology*

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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.

## MACINTOSH PCB SOFTWARE

I enjoyed TJ Byers' article, "Low-Cost Software for PC-Board Design" (*Electronics Now*, February 1996). I found it very timely because I'm in the market for a schematic-capture and PCB-layout application suite. However, I'd like to find software that will run on my Macintosh, yet have the designs portable to my PC workstation. Does such a product exist?

THRUSTON AWALT
*Santa Clara, CA*

*Check out Vamp Inc. in Los Angeles, California (phone: 213-466-5533). They have a complete line of schematic-capture, PCB-layout, and circuit-simulator (analog and logic) applications for the Macintosh platform. They also plan to have a Windows version of the same software, which will be portable between the Mac and a PC, by June of this year.—TJ Byers*

## MINI METROLOGY LAB

I have been following the "Mini Metrology Lab" series (*Electronics Now*, March, April, May 1996). It's terrific, offering real insights into metrology techniques. Author Conrad R. Hoffman deseves a big thank you.

I think some readers might won-der why the Null Detector project has only moderate, 200-kilohm input impedance, even though the LTC1050 itself has CMOS-level input Z, in the Tera-ohm range. They will be used to seeing meters and scopes with 1-megohm, 10-megohm, or 11-megohm input Zs, and might want to modify the circuit for higher input divider resistances.

The reason for moderate input divider resistance is to keep the amplifier zero setting stable independent of the differing input R of each sensitivity range. The LTC1050 draws its approximately 10 pA input bias current through the source R and/or the input divider resistors. Having to re-zero null detectors for each range is a real nuisance, so it makes sense to limit the input Z. The moderate input Z also tends to minimize offset problems due to leakage currents on the circuit board.

The LTC1050 is a similar amp with a typical input bias current of only 1 pA, but has the small disadvantage of needing two external capacitors for its chopping circuit. However, for those who need to work with high-impedance sources, the LTC1052 is a better choice. Other possibilities are the non-chopper-stabilized National LMC6001 or the very expensive Burr-Brown OPA-111B. Both offer very low input bias currents; however, both have much higher offset voltage drift with changing temperature than do the LTC chopper-stabilized amps.

DICK MOORE
*Grapeview, WA*

*Thank you for your interest and kind words. Your summary of the Null Detector input impedance is spot on. Commercial null detectors, past and present, tend to have a low input impedance, so the Mini Metrology version is typical in that respect.*

*Fortunately, a low input impedance is of little concern where the voltages being compared are nearly identical. Where they are not, you should always be aware of the impedances involved (including wires!), and determine if the resulting errors are acceptable. A case that comes to mind is the comparison of Weston standard cells, where even slight current flow results in significant errors (and possible cell damage).*

*If higher input Z is needed, the LTC1052 is certainly an excellent choice. The builder should be cautioned, however, that knowledgeable layout, guarding, and scrupulous cleaning will be required to achieve maximum performance from the null detector.*

*Finally, my first designs used conventional amplifiers, and I can't recommend them. Zero stability suffered severely, and, as you say, rezeroing null detectors is a real nuisance!—Conrad Hoffman*

## THE FUTURE IS NOW

Magnetically-propelled trains operating on conventional rails ("What's News," Electronics Now, January 1996) are not new. Such a system has been operating here for the past 10 years. SkyTrain, as it is called, operates on a 28-kilometer, mostly elevated guideway serving the cities of Surrey, New Westminster, Burnaby, and Vancouver.

On-board linear induction motors push against a central reaction rail, consisting of a series of aluminum plates located on the side of the guideway. The cars are driverless, controlled by on-board computers linked to a control center. The top speed is about 80 kilometers per hour, or 50 miles per hour. That does not seem particularly fast, but it appears quite rapid compared to the snail-paced, gridlocked automobile traffic over which it passes. The route, including 20 station stops, is covered in 39 minutes. Trains run regularly every five minutes.

Just because the cars are driverless does not mean the system is unmanned. On-board personnel check tickets and maintain order. As a result, the system is virtually graffiti-free and as safe, or safer, than any similar conventional system. Most of the public complaints about SkyTrain come from those who are not served by it and would like to see it extended to their areas.

Similar, smaller systems using the same technology operate around downtown Detroit and in the Toronto suburb of Scarborough.

DAVE ELEY
Surrey, British Columbia, Canada EN

# EQUIPMENT REPORTS

## *Staticide Laser Printer Cleaning Paper*

CIRCLE 15 ON FREE INFORMATION CARD


Smudges, spots, streaks, toner droppings and the like usually occur after changing toner cartridges or extensive copy output. The unsightly spots sometime occur when paper jams are cleared and the printer is jostled. That's when multiple passes with a sheet of Staticide Laser Printer Cleaning Paper removes deposits of toner and dust. Here's how we did it: The printer was set in manual mode. (Some printer manuals call it the bypass mode or hand-feed mode.) The cleaning paper is hand fed into the printer while a blank document (no type, lines, art, etc.) is transmitted from the computer to the printer. Repeat the procedure 4-5 times and discard the cleaning paper. That does it! The cleaning paper provides a quick and easy method for removing paper dust, dirt and toner deposits from inaccessible interior areas of your laser printer. A second run of the club's logo is sharp and clean.

Fax machines that make plain paper copies can benefit likewise from a few passes of the cleaning paper.

The Staticide Laser Printer Cleaning Paper in made with individual cellulose fibers saturated with latex polymers and sealed into a paper sheet. Loose toner and dust in the printer's paper path adheres to the cleaning paper and is sealed to the paper as the hot rollers melts the latex polymers. Image quality is improved after several passes of the cleaning paper because the dust (fine paper particles from prior passes) often cannot be seen but seriously degrades the printed image quality.

Routine maintenance of your laser printer will result in high-quality printouts, reduced waste and will reduce the risk of experiencing serious and costly printer problems. There are three different packages you can purchase to obtain Staticide's Laser Printer Cleaning Paper. You can pick up a 50-sheet pack (No. 8022, $26.50) or 12-sheet pack (#8023, $9.50). The Staticide Laser Printer Cleaning Kit (#8016, $30.95) includes a dozen cleaning papers plus a 2 ounce bottle of cleaning solution, 20 lint-free swabs, a lint-free anti-static wipe, and twelve ink-remover hand wipes. The kit is suitable for the periodic cleanings specified by the printer's manual. Just follow the directions of the manufacturer, and when completed, four or five passes with the cleaning paper will finish the job.

Suggested retail prices given above are usually discounted at major computer stores, office supply outlets and mail-order catalogs. Staticide printer/fax/computer products are distributed by ACL Incorporated, 1960 East Devon Avenue, Elk Grove Village, IL 60007; 708-981-9278. EN

## WHAT'S NEWS

*continued from page 4*

"legs" that lift the "body" of the molecule from the atomically flat copper surface. Computer simulation revealed that when pushed by the STM tip, the molecule "walks" in uncorrelated, slip-stick-like steps and exhibits precisely the desired degree of stickiness.

IBM scientists and colleagues at the University of Cambridge, United Kingdom, developed software that moves and positions the STM tip with extreme precision. The same STM can be switched to the imaging mode by slightly increasing the distance between the tip and the surface.

The long-term goal of the research is to create new and complex molecular structures and to customize their specific functions and properties. Cu-TBP-porphyrin has several potential technological uses. By replacing the single copper atom at its center with another metal atom with different electronic properties, for example, it could be used to construct data-storage devices with densities 100,000 times higher than today's most advanced disk drives. Also envisioned are wires only one molecule wide that could be used to build ultrasmall electronic components.

The research is part of the PRONANO project sponsored by the Swiss Federal Office of Education

*continued on page 66*

# Two ways to fit a 100 MHz benchtop scope in your hand.

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**Tektronix**

## Q & A

*continued from page 9*

*(logic low) and then 8 data bits and 2 stop bits. Converting the RS-232 signals to TTL is not a problem for me, but how do I generate the start bit before each character? — K. R., Rosamond, Calif.*

**A** Actually, the start bit (always binary 0) is already there; the reason you've never heard of it is that all RS-232 serial ports always use it, without exception, so it's not a setting that you ever have to change or to be concerned about.

```
10 OPEN "COM1:9600,N,8,1" FOR OUTPUT AS #1   ' open serial port
20 PRINT #1,"0N1" + CHR$(13)                 ' turn on relay 1 of processor 0
30 FOR I=1 TO 10000: NEXT I                  ' pause a moment
40 PRINT #1,"0F1" + CHR$(13)                 ' turn it off again
```

**FIG 2.** — A SAMPLE BASIC PROGRAM to demonstrate serial port control.

In RS-232 (EIA-232) serial communication, negative voltages represent binary 1 and positive voltages represent binary 0. Line drivers and receivers such as the MC1488 and MC1489 invert the voltages and output ordinary TTL-compatible logic levels.

When nothing is being transmitted, an RS-232 data line is in the negative (binary 1) state. Each character starts with a start bit (always positive, binary 0), followed by seven or eight bits of data (in reverse order, least significant bit first), an optional parity bit, and the stop bits (always logical 1, negative voltage).

While it's uncommon to use 2 stop bits with 8 data bits, it's easy to do: just use a statement such as OPEN "COM1:9600,8,N,2" to open the serial port.

## TV repair query

**Q** *My Panasonic CT5935R, which is 14 years old, has lost vertical deflection. R422, a fusible resistor, burns up instantly. Although the DC resistance of the vertical output transformer measures correct, I think it is the problem. Panasonic has obsoleted this part. My suppliers cannot help me. I cannot find an ECG or SK replacement. What can I do to save this TV set? — S. L., Brooklyn, N.Y.*

**A** Hmmm. If the transformer has the right DC resistances, there can't be very much wrong with it. We assume you took the transformer out of the circuit to measure it, of course.

We've sketched part of the circuit in Fig. 3. Have you confirmed that TR451, C412, and D402 aren't shorted, and that the base of TR451 is being driven by the correct waveform? It sounds as if maybe TR451 is shorted or is being held "on" by an improper input voltage, causing the transformer to saturate and conduct excessive current.

If the transformer is defective, it shouldn't be too hard to find another vertical output transformer that has similar characteristics, though perhaps not the same physical size or shape. Start by trying to match the DC resistances. Experimentation will be required, but the transformer itself is not a highly critical component, and as you've discovered, R422 will burn out if anything is seriously wrong. EN

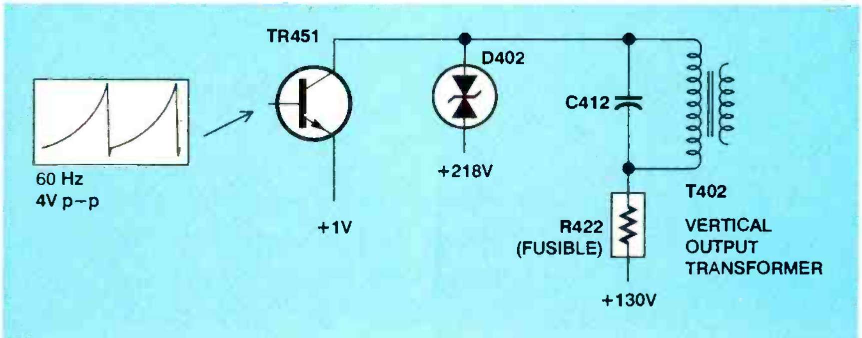



**FIG. 3**— WHY DOES THE FUSEABLE LINK repeatedly blow?

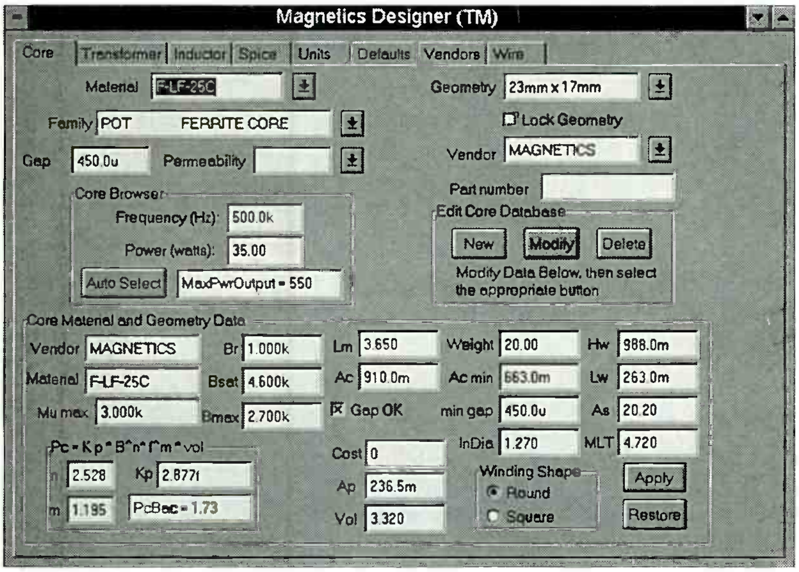
# NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

## MAGNETICS DESIGNER SOFTWARE

INTUSOFT'S MAGNETICS Designer is a Windows-based program that helps engineers design all types of transformers and inductors. Typical design applications include high-frequency switching regulator transformers and output chokes for off-line full-wave and forward converters, 60-Hz single-phase line transformers, AC inductors, planar magnetics, and 400-Hz aircraft transformers. Virtually any single-phase, layer-wound inductors or transformers from 10 Hz to over 1 MHz can be synthesized with Magnetics Designer.

The software produces a complete transformer or inductor design based on electrical specifications. A database with thousands of cores and a wide variety of materials is included. You can add your own core and material information to the database, using a supplied Excel spreadsheet template. A variety of core families from vendors such as TDK, Magnetics, Philips, Thomson, Micrometals, and Ferrite International is represented, each with its respective magnetic and geometric properties. The program predicts magnetizing and leakage inductance, interwinding capacitance, peak flux density, DC winding resistance, high-frequency AC resistance, copper loss (both AC and DC), core loss, weight, temperature rise, layer fill, and window fill percentage.




CIRCLE 20 ON FREE INFORMATION CARD

Magnetics Designer has three unique features. First, it exposes the mathematical equations and algorithms it uses to calculate the transformer or inductor performance. The second function is a SPICE-modeling capability; the software produces a Berkeley SPICE model of the transformer or inductor, which is customizable with different levels of complexity. Third is a specialized "winding sheet" that describes how to build the magnetic device, including information about the materials and test specifications for your device.

A detailed applications manual provides information for the engineer who wants to learn more about magnetics design. It describes the design equations and algorithms used, discusses core materials and geometries, and presents detailed examples. Virtually all of the program's documentation is also available on-line.

Magnetics Designer is available at a special introductory price of $1000 until June 28, 1996. After that, the price will be $1500.


**INTUSOFT**
*P. O. Box 710*
*San Pedro, CA 90733-0710*
*Phone: 310-322-0710*
*Fax: 310-833-9658*
*Website: http://www.intusoft.com*
*CompuServe: CADD/CAM/CAE Vendor forum, Library 21*


## ELECTRICAL CONTROL TOOL KIT

JENSEN TOOLS' JTK-67C IS A tool kit designed specifically to meet the rigid demands of electrical control officers. More than 100 high-quality, insulated and non-insulated tools make up the essential selection. The kit includes parts boxes to hold and display the many consumable-type items required on a daily basis by electrical-control engineers.

The tool assortment is securely housed in a three-sided Cordura

CIRCLE 21 ON FREE INFORMATION CARD

Plus nylon case that organizes the various items and has ample room for optional test and diagnostic equipment. The case, which measures 18×12×9 inches, features sturdy webstrap carrying handles and a shoulder strap. The outer two case compartments hold tools and optional gear, while the center compartment can accommodate manuals, paper work and diskettes. A padded pocket can hold a laptop or notebook computer.

The JTK-67C electrical-control engineer's kit costs $649 in single unit quantities; three or more cost $597 each.

**JENSEN TOOLS**
*7815 South 46th Street*
*Phoenix, AZ 85044*
*Phone: 1-800-426-1194*
*Fax: 1-800-366-9662*

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# 50,000-COUNT DIGITAL MULTIMETERS

THE ASYC II SERIES OF handheld digital multimeters from European-based Metrix Instrum-ents provides high levels of accuracy, resolution, and safety. All four models digitally display resolution of 50,000 counts, a 25-fold improvement over traditional 2000-count DMMs, and offer true-RMS measurement (AC and DC plus AC) for accurately handling irregular waveforms.

The four ASYC II series meters feature basic DC accuracy to 0.025% and bandwidths to 100 kHz, and will automatically store the last reading. Hold, fast, peak capture, and relative reading modes are provided. Also included are comprehensive autoranging voltage, current, capacitance, frequency (to 500 kHz) measurements, as well as percentage duty-cycle, positive or negative pulse width, and pulse-counting features. The top-of-the line model features a patent-pending resistive power function that offers a choice of reference resistances.

CIRCLE 22 ON FREE INFORMATION CARD

The ASYC—which stands for Advanced Safety Concept—meters provide a host of safety features, including full water and dust sealing to IP677 standards. A separate compartment allows the battery or fuses to be replaced without the need for metal tools and without breaking any calibration label, avoiding risks associated with opening the unit. Test lead retainers keep the leads from being accidentally disconnected.

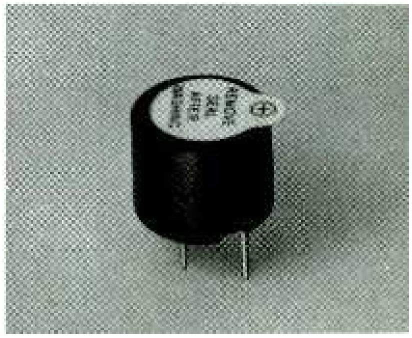
Prices for the ASYC II series of handheld digital multimeters range from $250 to $400.

**METRIX INSTRUMENTS**
*P. O. Box 332*
*Brea, CA 92622-0332*
*Phone: 714-992-1239*

---

# LOW-FREQUENCY TRANSDUCER

THE MODEL BRT 1612P-12 LOW-frequency transducer from the Intervox division of International Components Corporation is designed for use in communications equipment, automobiles, computers, and security systems. It boasts a frequency of just 1.7 kHz, compared to the 2.02-kHz frequency found in conventional units of its type. Only 12mm high, the transducer is also 14% shorter than standard models. To further distinguish it from other transducers, its case is gray instead of standard blue.



CIRCLE 23 ON FREE INFORMATION CARD

The Intervox BRT 1612P-12 has a flat frequency response of 1.7 to 2.2 kHz, allowing a wide bandwidth of 500 Hz. Its sound pressure level (dB) is 85 min./10cm, and its operating temperature range is -40° to 90°C. The device is wave solderable and washable.

The Intervox BRT 1612P-12 low-frequency transducer costs $0.55 each in quantities of 10,000 pieces.

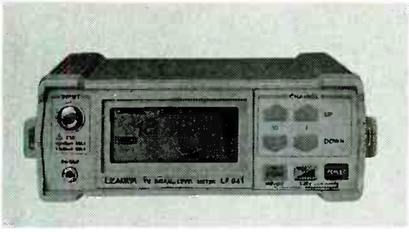
**INTERNATIONAL COMPONENTS CORPORATION**
*OEM Sales Department*
*107 Maxess Road*
*Melville, NY 11747*
*Phone: 516-293-1500*

---

# CATV SIGNAL-LEVEL METER

THE LF 941 IS AN EASY-TO-USE VHF/UHF CATV signal-level meter from Leader Instruments. Covering the 46 to 870-MHz range, the LF 941 provides eight user-selectable channel tables for worldwide operation. A PLL synthesizer ensures quick, accurate tuning throughout the selected measurement range. Coverage for the United States is channels 2 through 136, and 46 to 870 MHz.

Hands-free automatic level attenuation and tracking simplifies operation and speeds throughput within the measuring range of +50 to -30 dBmV. One button toggles between the mea-



CIRCLE 24 ON FREE INFORMATION CARD

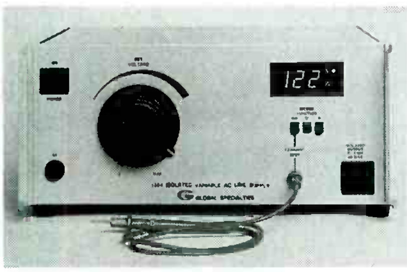
sured channels' visual or aural signal level measurement modes. Pressing the VHF/UHF or CATV button during power-up switches to the respective mode. A monitor phone output jack with adjustable volume control and on-screen indication is provided for quick sound checks. The large LCD readout shows visual or aural signal levels along with the engineering unit, volume control level, and a signal-level bar-graph for peak analysis during CATV alignments.

The LF 941 CATV signal-level meter costs $995.

**LEADER INSTRUMENTS CORPORATION**
*380 Oser Avenue*
*Hauppauge, NY 11788*
*Phone: 516-321-6900*
*(in NY) or 1-800-645-5104*

## AC POWER SUPPLY

GLOBAL SPECIALTIES' MODEL 1504 is a continually variable, triple-isolated, digital AC power source with line leakage and current tester and digital panel meter indicators. Designed specifically for situations in



CIRCLE 25 ON FREE INFORMATION CARD

which a clean, electrostatically and galvanically isolated variable-line supply is needed, it can be used in circuit design and development labs, production-line testing and repair facilities, companies that do incoming electronic inspection, and technical schools.

The transformer output voltage is

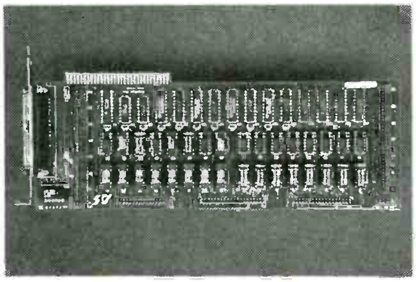
continuously adjustable from 0 to 150 volts AC at 0 to 4 amps. To protect the user against shock, the Model 1504 is triple-shielded from the input line. It can measure power-line leakage current via a probe and a switch-selected range of the output digital panel meter.

The Model 1504 AC power supply costs $420.

**GLOBAL SPECIALTIES**
*70 Fulton Terrace*
*New Haven, CT 06512*
*Phone: 1-800-572-1028*
*Fax: 203-468-0060*

# PC MASTER CONTROL CARD

THE MASTER CONTROL 64/32 switch card from AccuSys gives any personal computer the means to "power up" the world around it. Requiring just one ISA bus slot, the card enables a PC to switch up to 64 signals to automate homes or offices, control heating systems, turn industrial equipment on and off, connect test samples to a single data source, open irrigation channels, and more.



CIRCLE 26 ON FREE INFORMATION CARD

The Master Control card contains 32 relays that are operated with simple software commands that can be issued from within most applications. Software examples written in Assembler, Basic, Fortran, C, COBOL, FoxPro, and dBase are included, along with operating software for Windows and DOS to toggle the relays on and off. Users can operate one or many relays with the click of a mouse button. This lets your PC turn on lights, control heating systems, open irrigation systems, or handle almost any control application. A one-page guide, included in the user's manual, shows all board settings on a single page.

All of the 64/32 card's features are configurable. Users can replace relays, change signal access, modify wiring, and change board address selection. The card supports dry reed, mercury wetted, normally open, normally closed, and TTL drivers, which can be mixed on the same board. That means that applications are not limited to a single relay type, and users are not limited as to how signals are connected to the outside world. Signals can pass through the board individually or grouped to a common output. The card also includes wire wrap option headers that allow users to re-wire the board into any possible array of special relay/signal interactions. Its board selection of port addresses prevents system component conflicts and allows the installation of as many switch cards as there are available slots.

**ACCUSYS, INC.**
*Information Group*
*3695 Kings Row*
*Reno, NV 89053*
*Phone: 702-746-1111*

EN

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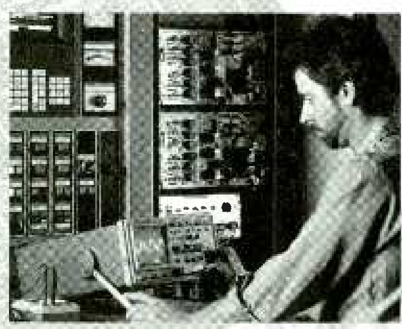

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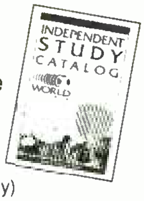


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# NEW LITERATURE

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*UTP Division*
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*Garden City, NY 11530*
*Phone: 516-227-1314*
*Credit Card Orders: 1-800-833-7138*
*Fax: 516-227-1453*
**4-Volume Catalog: $99**
**(plus $10 shipping)**
**CD-ROM for Windows: $115**

CIRCLE 337 ON FREE INFORMATION CARD

For the first time in its 38-year history, the *EEM/Electronic Engineers Master* catalog is available on a CD-ROM as well as in its traditional, multi-volume printed form. The electronic version combines the scope of the EEM database with the speed and ease of CD-ROM technology to provide fast and efficient access to all the information in the world's largest catalog of electronic products. Users can search by product or by manufacturer.

Both EEM versions feature updated and expanded information, including more than 4400 new and updated product pages from more than 1000 manufacturers; over 4100 different product listings with hundreds of new products; 5300 manufacturers listings with their local sales offices; 63 product sections, including new sections on LAN products, terminal blocks, and test accessories; 30 product selection guides; 20 mini-glossaries and charts, expanded with the latest hard-to-find technical details; and address and telephone changes for more than 1000 manufacturers.

## Transformers and Tubes in Power Amplifiers

*by Menno van der Veen*
*Plitron Manufacturing*
*250 Wildcat Road*
*Toronto, Ontario M3J 2N5*
*Canada*
*Phone: 416-667-9914*
*Fax: 416-667-8928*
**$26 (U.S)**
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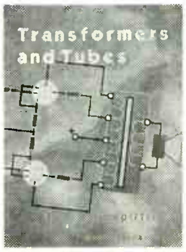



CIRCLE 338 ON FREE INFORMATION CARD

The rapid growth of transistor-based eletronics in the 1970's supposedly sounded the death knell for the vacuum tube. Yet, in the 1990's, audio amplifiers using vacuum tubes have found a niche in the marketplace.

This book, which is aimed at audio enthusiasts, hobbyists, and professional audio designers, deals with the importance of output transformers in vacuum-tube amplifiers. Beginning with a basic description of what an output transformer does, the book goes on to discuss the connection of power output tubes and loudspeakers to the transformer and the importance of frequency range and time behavior. One chapter is devoted to formulas that describe the complete mathematical model of time and frequency behavior of an output transformer. While the information can be applied to all tube amplifiers, special attention is given to the remarkable results that can be achieved with toroidal output transformers.

Subsequent chapters describe how to design and build a tube-power amplifier. The book also provides useful remarks about experiments, special solutions to specific problems, and many valuable old rules that will help readers to design and build a high-quality vacuum-tube amplifier.

## Radio on the Road: The Traveler's Companion

*by William Hutchings*
*Arrowhead Publishing*
*P.O. Box 1619*
*Lake Arrowhead, CA 92352-1619*
*Phone: 1-800-432-7274*
**$12.95 (plus $3 shipping and handling)**


CIRCLE 339 ON FREE INFORMATION CARD

What radio stations do you listen to when you're traveling on business or pleasure, or when you've reached your destination? Do you have a hard time finding the jazz or classical station you'd prefer to be hearing.

Aimed at RV owners, salespeople, commuters, and vacationers, this book provides a handy alternative to channel-surfing the radio dial when you're out of town. It lists more than 14,000 AM, FM, and TV stations in the United States and

Canada. Stations can be located by state, city, and(most important(by program format. More than 600 National Public Radio stations are included. The book also lists weather data, road-condition hot lines, and favorite points of interest for each one of the 50 states.

## The Intenet and World Wide Web Explained

*by J. Shelley*
*Electronics Technology Today Inc.*
*P.O. Box 240*
*Massapequa Park*
*NY 11762-0240*
*(Order No. BP 403)*
*Credit card orders 1-516-293-0467*
**$6.95 (plus $3 shipping and handling)**

CIRCLE 340 ON FREE INFORMATION CARD

This book cuts through all the media hype and technical jargon to explain what the Information Superhighway really is and how it relates to the Internet and the World Wide Web. It defines the terms you need to know(protocols, ftp, gopher, TCP, hypertext, http, URL, home pages, threads, HTML, domains, and the like(in plain and simple English. By reaching a thorough understanding of their meanings, the reader can talk to, and at the same level as, the techies who dreamed them up.

The book provides readers with the knowledge and expertise needed to use the Internet. It answers commonly asked questions, including: Where did the Internet come from? What can I get from it? How can I contact others with similar interests? How can I send e-mail and order things over the Internet? What will it cost to get hooked up and to use the Internet? Should I worry that my computer will be violated by hackers or infected with viruses?

Finally, the book takes a look what the future holds in store for the Internet.

## Programmer's Guide to Online Resources

*by Bob Kochem*
*John Wiley & Sons, Inc.*
*605 Third Avenue*
*New York, NY 10158-0012*
*Phone: 1-800-CALL-WILEY*
*Website: www.wiley.com/compbooks/*
**$24.95**


CIRCLE 341ON FREE INFORMATION CARD

Although the Internet is overflowing with valuable resources for programmers, trying to navigate through all the information can be time-consuming and frustrating. This book gives programmers a road map to all the technical data, programming utilities, software, and other valuable material available on the World Wide Web. It provides information on sources of code and tools; vendor support sites; programmer question-and-answer groups; magazine archives and databases; multimedia and virtual reality; security, encryption, and anti-virus material; networking and communications; and operating systems and environments.

## Amateur-Radio Kit Catalog No. A-96

*T-Kit Division of Ten-Tec, Inc.*
*1185 Dolly Parton Parkway*
*Sevierville, TN 37862-3710*
*Phone: 423-453-7172*
*Credit card orders: 1-800-833-7373*
*Fax: 423-428-4483*
**free**

CIRCLE 342 ON FREE INFORMATION CARD

This catalog aims to bring the good ol' days of kit-building back to the world of electronics in general, and ham radio in particular. Highlights of the 19-page booklet include a microprocessor-controlled 6-meter FM transceiver for just $195. Also featured are kits for building a 2-meter HT RF power amplifier, a 6-meter SSB/CW/ FM transverter, a 9-band shortwave receiver, mobile and desk microphones, a combination SWR bridge/RF wattmeter, a 2-meter FM transceiver with 15 memories, several budget-priced receivers, and more. "Little Kits"(module PC-boards(are offered for those who prefer to find their own kit-finishing hardware to custom finish their projects. The catalog also includes enclosures and Enclosure-Plus Hardware Paks.

## Datacom/Networking Cookbook No. 9

*Telebyte Technology, Inc.*
*270 Pulaski Road*
*Greenlawn, NY 11740*
*Phone: 1-800-TELEBYT*
*or 516-423-3232*
*Fax: 516-385-8184*
*Website: http://telebyteusa.com*
**free**

CIRCLE 343 ON FREE INFORMATION CARD

This catalog provides a host of solutions for premises and local data communications problems, and describes Telebyte's product lines, from modems to fiber-optic multiplexers and LAN media converters. To help datacom professionals, electronic design engineers, and people involved with process control and manufacturing make swift, informed purchasing decisions, it offers detailed product descriptions, specifications, and prices, along with convenient descriptions of common interfaces and a glossary of terms.

New products are featured in several categories, including short-haul modems, interface converters, datacom test equipment, lightning protection, and multiplexers. The Cookbook draws attention to the company's new approach of providing an LCD readout built into its power-stealing products. The LCD simplifies installation and network testing, and eliminates the need for a separate breakout box. EN

BY JEFF HOLTZMAN

# Bumpy rides

ONE OF MY THREE-YEAR-OLD'S FAVORITE GAMES IS CALLED "BUMPY RIDES." I HOLD HIM IN MY ARMS, AND WE GO BOUNCING UP AND DOWN THE STAIRS. HE ALWAYS ENDS UP SQUEALING WITH LAUGHTER.

Grownups, on the other hand, don't seem to enjoy bumpy rides quite as much—especially when the issue is cross-platform networking and connectivity. Here's the story to date of my recent bumpy ride in that domain. It has not left me squealing with laughter, but everything works, and most of my goals were achieved.

My goals were simple enough: I just wanted all of the computers in my office to be able to communicate with each other regardless of location, CPU, and operating system. I also wanted an integrated dial-in/dial-out modem capability, centralized backup, printer sharing, a minimal number of network protocols, and capability of running a Web server.

The list of machines includes a Power Macintosh running System 7.5; several desktop PC's running various combinations of Windows 3.11, Windows 95, Windows NT, OS/2 Warp, and Linux; and an "old" HP subnotebook, the OmniBook 300, running Windows 3.1.

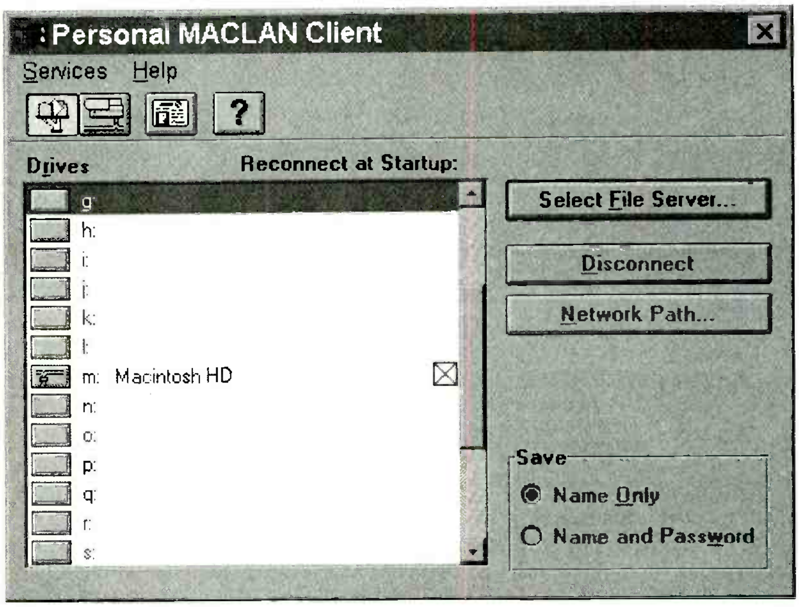
The whole process would have been considerably simpler if my budget had been larger. If so, I could have bought a better (dedicated) server and a modern (read *compatible*) laptop. But it wasn't, so I couldn't, so compromises were struck and workarounds developed.

What I ended up with is a mostly peer-to-peer network, with some peers being more equal than others. The most powerful machine serves as my main workstation; it also performs automated nightly backup of all the other machines, and provides server-like centralized storage for some of the other machines. It also runs three network protocols (TCP/IP, NetBEUI, and AppleTalk), and functions as a file and print server for the Power Mac.

Getting the basic PC network up and running was simple. Windows 95 does an admirable job of supporting multiple network protocols and clients. In fact, I had been using its peer networking features since early in the Windows 95 beta program. I had no trouble sharing files and printers across Windows 95, Windows 31, and DOS-only machines.

## Mac Integration

It had been a few years since I'd been directly involved in networking Macs, so I had some trepidation—totally unfounded, as it turned out. After doing some




Miramar's MacLan Connect allows seamless integration of Macintoshes in a PC network. The current version (5.51) is incompletely integrated with Win95, but the next version promises complete, transparent integration.

research, I settled on a product called MacLan Connect, by Miramar Systems. It has some limitations, and some awkward features, but it basically works. It seamlessly integrates the Power Mac with the Windows/DOS machines, to the point where: 1) The Mac can use my main workstation for storage, 2) My main workstation's SCSI DAT drive can back up the Mac's hard disk, and 3) All PC's and Mac's can share the 600-DPI PostScript/PCL laser printer.

MacLan will run on just about any network protocol, including EtherNet, Token Ring, or LocalTalk (Apple's low-speed, proprietary network protocol built into every Mac). Internal and external LocalTalk port adapters are available for PC's. My network currently runs 10-Mbps Ethernet. MacLan is optimized to coexist with Microsoft's NDIS 3.0 drivers, but it can work with other drivers, including Novell/ODI.

The MacLan software comes on two diskettes, which contain an AppleTalk protocol stack and several utility programs. All the software installs on a Windows (3.x or 95) machine; the Mac is not modified at all. Each copy of MacLan is serialized, so you cannot run more than one copy of the program on a network. Under Windows 95, the basic installation copies files to the proper locations and updates several system initialization files. However, the user still has to manually add the AppleTalk protocol and Miramar's client software through the Windows 95 Network icon in the Control Panel. Doing so gives basic client services. Separate, external applications provide print (PIN.EXE) and file (PMACLAN.EXE) sharing services so that Macs can use files and printers on the PC. A third application (ASHAREXE.EXE) allows you to map Mac drives to local drive letters.

At this point, I might as well mention MacLan's limitations, the first of which is incomplete integration into Windows 95's networking architecture. Essentially, it provides Windows 3.1-style integration, in which network resources are—and must be—mapped to drive letters. The implications of this are three-fold.

First, you can't get to LocalTalk resources through the normal Windows 95 user interface (e.g., the Network Neighborhood). Second, only 8.3 (eight-character plus 3-character extension) filenames are supported (in both directions). So, although I was able to back up the Mac's hard drive, the backup is basically useless, because if need be, I would only be able to restore 8.3-character filenames, and the Mac would not be happy about that. Third is that although you can log on to Mac drives from a DOS box under Windows 95, you cannot map drives using NET USE commands. You have to use the ASHAREXE utility mentioned above, which limits the ability to create scripts (batch files) for automating things like backups. The workaround is to mark drive assignments as auto connect, so that they're remapped each time you boot. Another workaround is that until long file names are supported, Mac users must limit filenames to the 8.3 format.

One nice feature is that only one copy of MacLan Connect is required to share a printer among multiple PC's and Mac's. Also, the printer connection feature in MacLan Connect allows "virtual" connections to printers physically located on other servers. So on my network, my main machine runs all the MacLan software, even though the printer is physically attached to another machine. MacLan simply redirects print jobs from both that machine and the Mac to the print server.

Miramar is aware of the limitations of the current version, and is working on an update, although timing was not set as of this writing. The MacLan User's Manual is poorly done. Anyone with any networking experience should have no trouble, but I suspect beginners would be sorely confused. It was obviously written for a Win311 version of the product, and has only been superficially adapted for Windows 95.

All in all, it's a pretty strange feeling to be traipsing through the directory structure of a Mac from a DOS command line running under Windows 95 across a network. But it does work. Retail price for a single-user copy is about $130. Multi-user licenses are available.

## Remote Access

Another piece of the puzzle is remote access. I need a dial-in system so that employees, contractors, and clients can dial in to obtain files. I also need to be able to dial in when I'm on the road. When I dial in, I want all rights to the system, but when anyone else dials, that person should have very limited rights.

One initial attraction of Windows 95 had been its inclusion (via the Plus! Pack) of a simple Remote Access Services (RAS) server. When you dial in to a RAS server, you essentially become another node on the network. Your physical connection to the network does not occur via a 10-Mbps Ethernet adapter, but through the pair of connecting modems. Obviously then, things work a bit more slowly. But they do work.

The Windows 95 RAS mechanism appears in Dialup Networking, accessible through My Computer. After installing RAS, a new item appears on the Connections menu. Select Dialup Server, and a simple dialog box appears, allowing you to set a few basic parameters (on/off, password, server type). Then, whatever security constraints you've set up on that machine apply. See Chapter 28 of the *Microsoft Windows 95 Resource Kit* for detailed information on everything required to get a RAS server running.

Windows 95's RAS server works. You can connect to it from another Windows 95 machine, a Windows NT 3.5x machine, or a Windows for Workgroups machine. I don't believe there's any other way to connect. And that's what blew the W95 RAS server for me.

What I opted for instead is a simple BBS program, written in the scripting language of a DOS character-mode telecommunications program running as a task under Windows 95.

On my network, an old but not quite obsolete PS/2 Model 70 (386/25, 8MB) functions as a communications and print server. The telecommunications program is a shareware program called Commo. Commo is available on CompuServe and directly from the author; in addition, I'll post a copy on the Gernsback BBS (516/293-2283, V.32bis). The "BBS" program runs in a DOS window automatically on boot via Win95's StartUp folder. The only thing that the BBS program doesn't do is provide a separate upload/download directory for each user, but that shouldn't be hard to code myself. It's only a question of making sure that I find the time to do it. For now, the default will suffice.

I'll continue this next time, with a discussion of remote access via LapLink for Windows 6.0b. We'll also talk about planned obsolescence (re HP's OmniBook 300), desktop PCMCIA adapters, and PCMCIA modem and network adapters. I'm also looking into disk-partitioning and boot-management tools (Partition Magic and System Commander), Windows Help development tools (HyperText Suite, Doc-To-Help, RoboHelp), Caldera's commercial Linux release, Visual Basic component software, C/C++ compilers, Web servers, Web page editors, Java, and more. If we get through all that by the end of the year, it'll be a miracle! Besides, there's bound to be a bunch of new stuff I don't even know about today.

## E-mail

David Brodbeck writes, "I found your column in the March issue of Electronics Now quite interesting. I find it disconcerting that the really innovative companies in the computer industry seem to get swept under by giants like Microsoft. It seems that any company capable of developing an innovative product is nearly always completely incapable of marketing it; witness Commodore and Apple. I fear Sun may be next."

Yup. Technical best does not automatically win.

Tom Decker asks, "Do you believe a big company exists that is smart enough to pick up Linux and package it for commercial release? This would be a low profit venture but the expenses of doing this would also be low. Possibly package a PC with Linux installed?"

Caldera is a company formed by Ray Noorda, formerly head of Novell.

### RESOURCES

**MacLan Connect**
Miramar Systems, Inc.
121 Gray Ave., #200B
Santa Barbara, CA 93101
(805) 966-2432

**Caldera**
(800) 850-7779
(801) 229-1675.

**Commo**
Fred P. Brucker
P.O. Box 141537
Columbus, OH 43214

Caldera's release of Linux has gotten some excellent reviews in the trade press. I hope to take a look at it within the next few months. In the meantime, contact information appears in the resources box above.

Long-time readers may recognize the name Pete Stark, who has been educating the computing public about 68xxx microprocessor technology for this magazine, *Byte*, and others for more than 15 years. Pete and I are old friends.

Nonetheless he says, "I've been reading your columns for some time, and have been quite perturbed by them. I've noticed your frequent pronouncements of how Microsoft is winning the software wars. Not only does is this disturbing, as I routinely root for the underdog, but I am beginning to think that your articles, and those of other authors and editors, are a self-fulfilling prophecy.

It bothers me an awful lot that your articles may in fact be contributing to the hegemony that Microsoft is trying to achieve. I do wish that you would point out the dangers more often of a single company so profoundly controlling the entire industry."

As I told Pete, I don't really think the complaint is justified. Nonetheless, Pete, here it is: Competition is good! Monopoly is dangerous! Examine all viable alternatives before making serious purchase decisions. Many voters these days do not really vote *for* particular candidates, but *against* others. Perhaps the same type of attitude is appropriate when purchasing computer products.

Let me know what you think: jkh@acm.org. EN

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Van Nuys, CA 91411

Gateway Electronics of CA
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37111 Post St., Suite 1
Fremont, CA 94536

HCS Electronics
6819 S. Redwood Drive
Cotati, CA 94931

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3500 Ryder Street
Santa Clara, CA 95051

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W. Hartford, CT 06110

Cables & Connectors
2198 Berlin Turnpike
Newington, CT 06111

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North Haven, CT 06473

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Chamblee, GA 30341

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Mt. Prospect, IL 60056

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Beltsville, MD 20705

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

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40 Franklin Street
Needham, MA 02194

**Michigan**

Purchase Radio Supply
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Ann Arbor, MI 48104

Norwest Electronics
33760 Plymouth Road
Livonia, MI 48150

The Elec. Connection
37387 Ford Road
Westland, MI 48185

Elec. Parts Specialists
711 Kelso Street
Flint, MI 48506

Professional Data Corp.
1332 US Highway 41 West
Ishpeming, MI 49849

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Minneapolis, MN 55401

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Accord, NY 12404

Unicorn Electronics
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Johnson City, NY 13790

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275 E. Market Street
Akron, OH 44308

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Norvac Electronics
7940 SW Nimbus Avenue
Beaverton, OR 97005

**Pennsylvania**

Business & Computer Bookstore
213 N. Easton Road
Willow Grove, PA 19090

**Texas**

Mouser Electronics
2401 Hwy. 287 N
Mansfield, TX 76063

Electronic Parts Outlet
17318 Highway 3
Webster, TX 77598

**Washington**

Amateur Radio Supply Co.
5963 Corson Ave., Ste 140
Seattle, WA 98108

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Chris Supply
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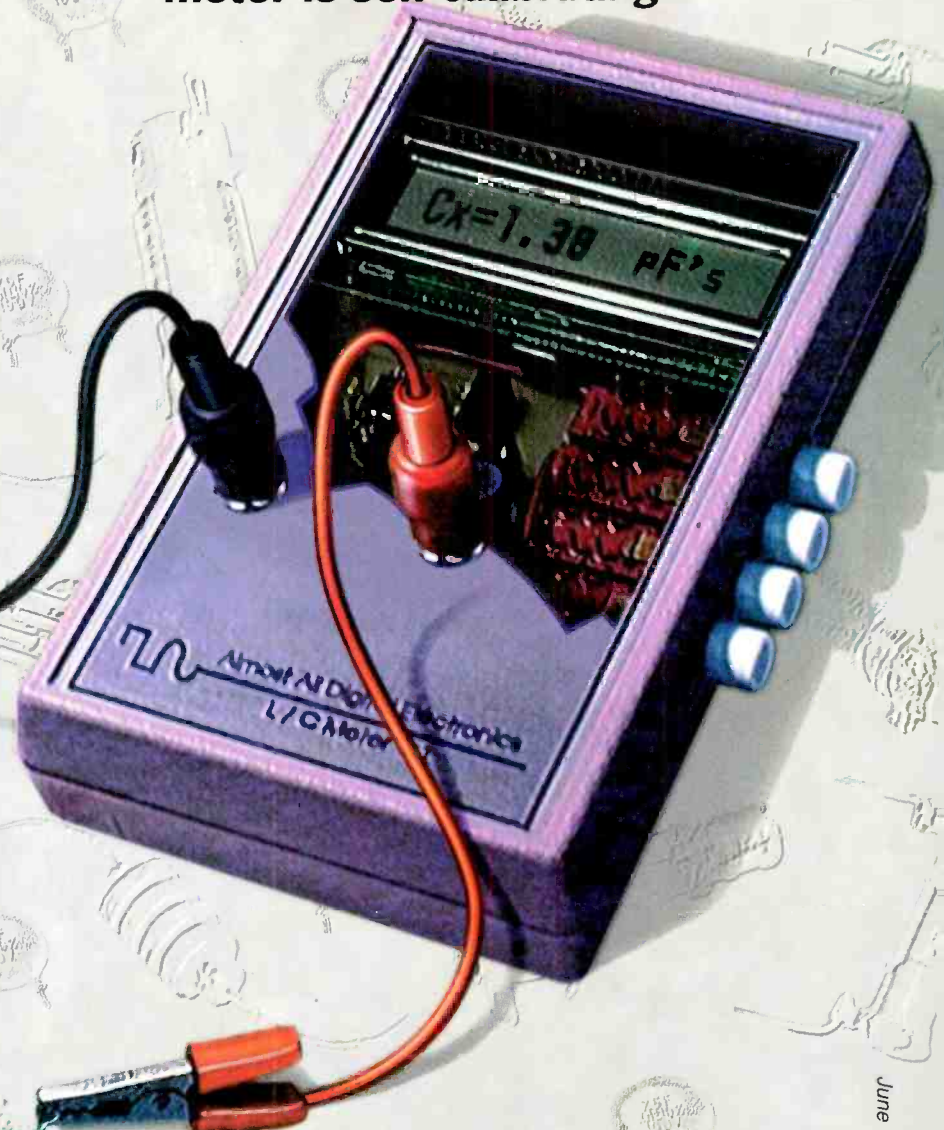
NEIL HECKT

# Build this self-calibrating L/C METER

***This microcontroller-based digital inductance and capacitance meter is self-calibrating.***




COMMUNICATIONS ENGINEERS, EXperimenters and technicians working with RF filters, oscillators and amplifiers need an instrument to accurately measure small values of inductors and capacitors. The instrument presented here will fill the bill perfectly.

The L/C (inductance/capacitance) meter features a measurement range of 0.001 to 100 microhenrys (μH) and 0.010 picofarads (pF) to 1 microfarad (μF).

The meter automatically selects the proper range, and provides a worst-case accuracy of 3% of reading, and a resolution of four digits. The measurements are displayed on a 16-character intelligent LCD. The meter's sampling rate is about four samples per second.

**Circuit description**

The heart of the L/C meter is the oscillator circuit on the left side of the schematic in Fig. 1. The oscillator's function can best be visualized by assuming that the output of the LM311 voltage comparator is a square wave at the resonant frequency of the tank circuit formed by L1 and C1. The square wave is applied to the tank circuit through R3 and AC-coupling capacitor C3. The tank circuit filters out the fundamental sine wave, which is then applied to the input of the voltage comparator and causes a square wave to be generated at its output, thus sustaining oscillation.

When power is first applied, the voltage at pin 2 of the LM311 quickly builds up to one half of the supply voltage through the voltage divider formed by R1 and R2. This causes the output, pin 7, to be at a high level equal to the supply voltage. This high level output charges C4 via R4 until the voltage at pin 3 is equal to the voltage at pin 2. The output then switches to a low level, introducing a transient in the tank circuit that causes it to ring at its resonant frequency. This ringing is turned into a square wave at the resonant frequency of the tank at the output pin, thus sustaining oscillation as described above. The square wave will have a 50% duty cycle causing C5 to remain charged to a voltage equal to that of pin 2.

The nominal values of L1 (68 μH) and C1 (680 pF) were chosen because an increase in L of 1 nH (.001 μH) produces a frequency change of slightly less than 5 Hz. The 0.2-second measuring period can resolve 5 Hz and therefore 0.001 μH.

Besides being simple, this oscillator circuit is very reliable. It always starts, and it can tolerate a large variation in the inductances and capacitances used in the tank circuit. The range of

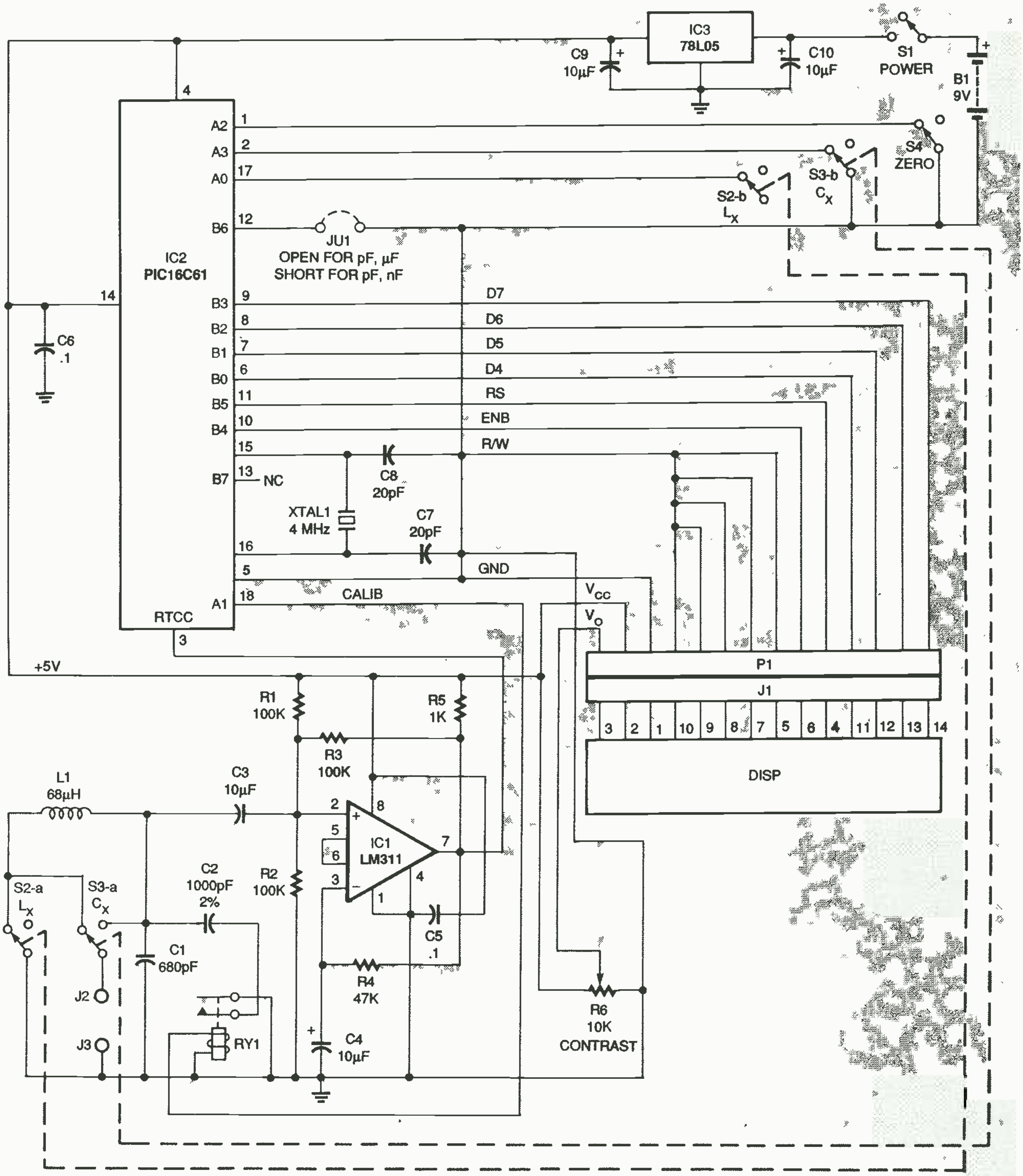



**FIG. 1—THE L/C METER SCHEMATIC. The oscillator built aroud IC1 is the heart of the circuit. IC2, a PIC16C61 microcontroller, is its brains.**

inductance and capacitance is limited by the amplitude of the sine wave voltage across the tank circuit. The minimum peak-to-peak voltage is equal to the offset voltage specification of the LM311—about 2 to 10 millivolts. The maximum peak-to-peak voltage is limited to about half the supply voltage, 2.5 volts. These voltage limits can be translated to inductance and capacitance limits in the simplified equivalent circuit of a parallel resonant tank shown in Fig. 2.

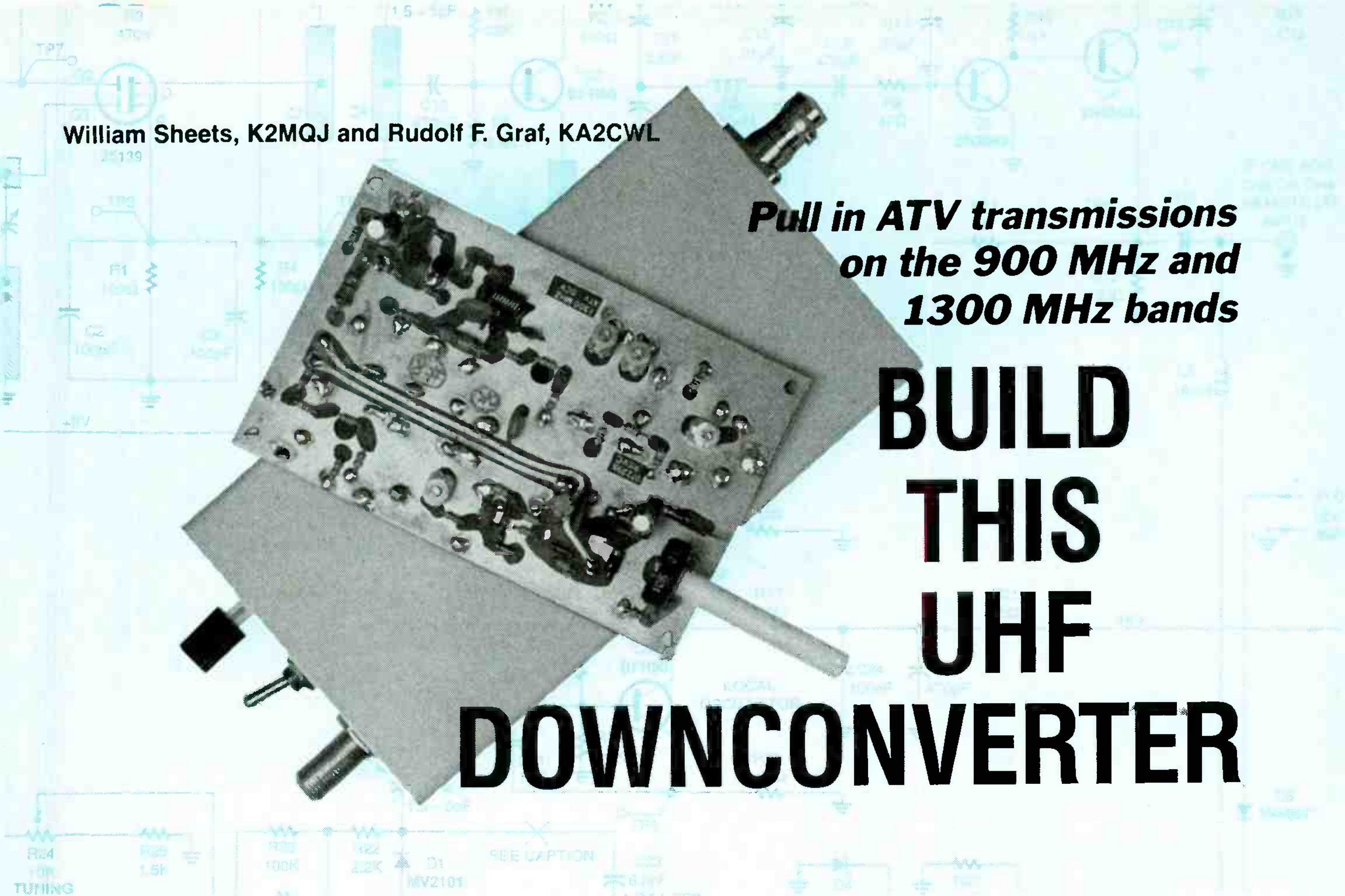
The resistor R is normally part of the inductor and is caused by the resistance of the wire from which it is wound. The maximum impedance of the parallel resonant tank is:

$$Z_{max} = Q\sqrt{L/C}$$

where Q $2\pi fL/R$.

*Continued on page 61*

William Sheets, K2MQJ and Rudolf F. Graf, KA2CWL



***Pull in ATV transmissions on the 900 MHz and 1300 MHz bands***

# BUILD THIS UHF DOWNCONVERTER

THE MINIATURE, TUNEABLE UHF downconverter described in this article is designed to receive amateur television (ATV) signals in the 900–1300-MHz band and convert them for display on an ordinary TV set. The downconverter is the perfect match for the 900-MHz ATV transmitter described in last month's issue of *Electronics Now*. It is also used to receive signals from low-powered video links operating in the 900 (33-centimeter) band.

As a bonus, a design for 1300 MHz downconverter is also presented to allow reception of any ATV activity in the 23-centimeter (1240-1300 MHz) amateur band. Both the 900-MHz and 1300-MHz converters are mechanically nearly identical and appear the same unless inspected closely. They differ slightly with regard to the PC board microstrip tuned elements and minor difference in the local oscillator circuit. Otherwise the same circuit architecture and parts are used for both. Their theory of operation and construction are closely paralleled. In the discussion that follows, reference is made only to the 900-MHz unit unless differences between the two units are noted.

The downconverter is not intended for reception of narrowband FM or SSB signals since the converter uses a tuneable local oscillator covering a 30 to 60 MHz range. The 900-MHz and 1300-MHz versions are useable for wide-band modes such as AMTV, FMTV or FM audio reception using a conventional FM broadcast receiver tuned to 90 MHz or so on the dial.

**Basic signal flow**

The downconverter block diagram is shown in Fig. 1. Signals from the RF input are fed to low-noise RF amplifier Q1, which boosts the antenna signal and feeds it to mixer transistor Q2. There the amplified signal is mixed with the output of the tuneable voltage-controlled local oscillator Q5 to an intermediate frequency (IF) of 60 MHz. The IF signal is fed from the mixer to an IF preamplifier stage.

Three tuned circuits, Z1-Z4, are used in the RF amplifier stage. These are not discrete components—they are of PC board stripline construction, and consist only of circuit-board traces. Other tuned stripline circuits, Z5-Z6 are also used in the downconverter.

Voltage-controlled oscillator Q5 is tuned by a DC voltage. This DC voltage can be selected from either a PC board potentiometer or via an external, coaxial-fed power supply that allows the downconverter to be tuned remotely. This arrangement enables the downconverter to be mounted on the right at the antenna feed point to eliminate feed-line losses that are significant at this frequency range. No separate DC feed is necessary since the coax (RG59/U or RG6/U recommended) carries both DC power, tuning voltage and IF signal.

The downconverter's input impedance is 50 ohms, and any matching 900-MHz or 1300-MHz antenna can be used. The overall gain of the downconverter is about 37-43 dB. The

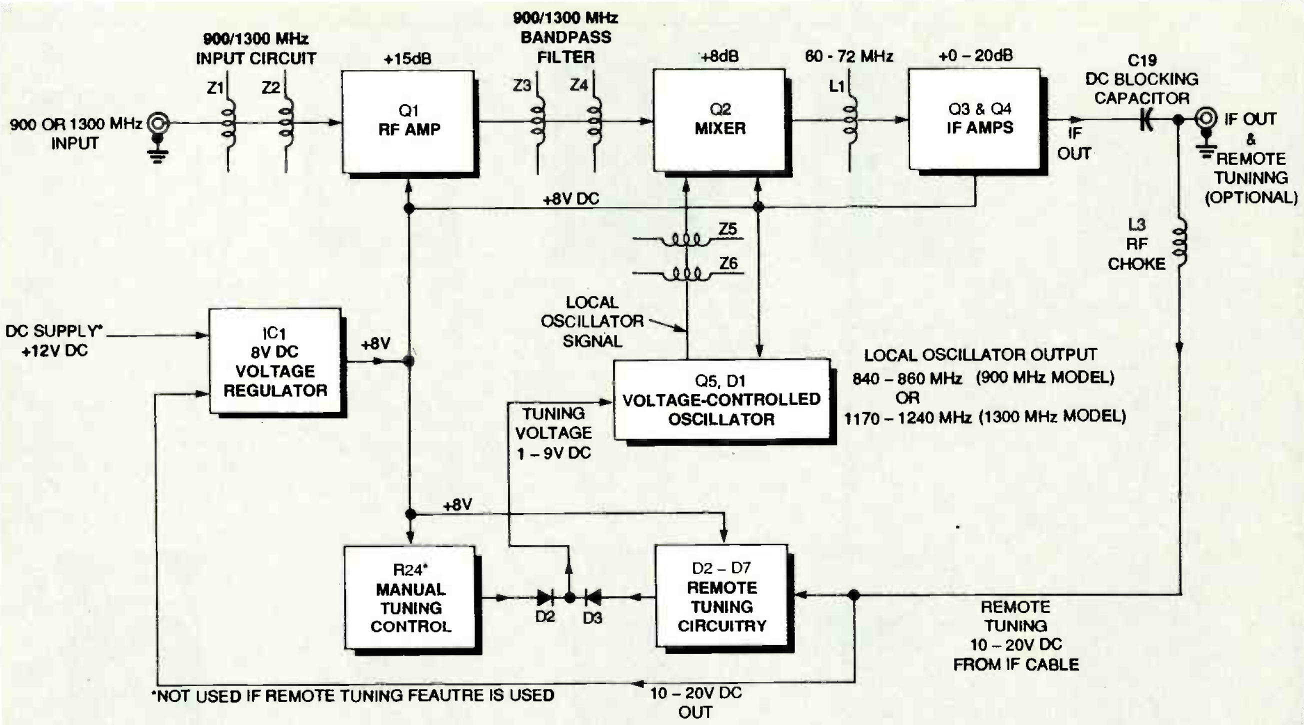



**FIG. 1—BLOCK DIAGRAM for the downconverter serves for both the 900 and 1300-MHz versions.**

gain can be changed as needed by changing a resistor value.

For portable operation or for use in a packaged ATV transceiver or a video handy talky (HT), the on-board tuning potentiometer may be used. The tuning voltage is tapped from the +8-volt DC voltage-regulator, IC1.

For on-board tuning, the external power supply must deliver a fixed 11 to 20 volts DC at approximately 30 milliamperes to the 8-volt DC regulator. For remote tuning, the supply must be variable.

### Circuit operation

The downconverter schematic is shown in Fig. 2. The input signal from antenna jack J1 is fed to a filter made up of Z1, C1, and Z2. Microstrip lines Z1 and Z2 are part of the PC board foil surface and form a tuning circuit. (All six microstrip lines are given Z designations.) Trimmer capacitor C1 is adjusted for best reception of a weak signal. The signal is then fed to gate G1 of Q1. Transistor Q1 is a low-noise MESFET with a noise figure about 1 dB. Unavoidable circuit losses will raise the actual noise figure to typically 1.5 to 2 dB, which is fairly good for the intended application. The source S of Q1 is biased by R1. The other gate, G2, is biased by R2 and R3. Two pairs of 100-pF capacitors (C2 through C5) bypass both the source and G2 of Q1 to ground, providing the necessary bypassing for inductance Z3. Chip capacitors were chosen for C2-C5 because conventional 100-pF disc capacitors function poorly at 900 or 1300 MHz.

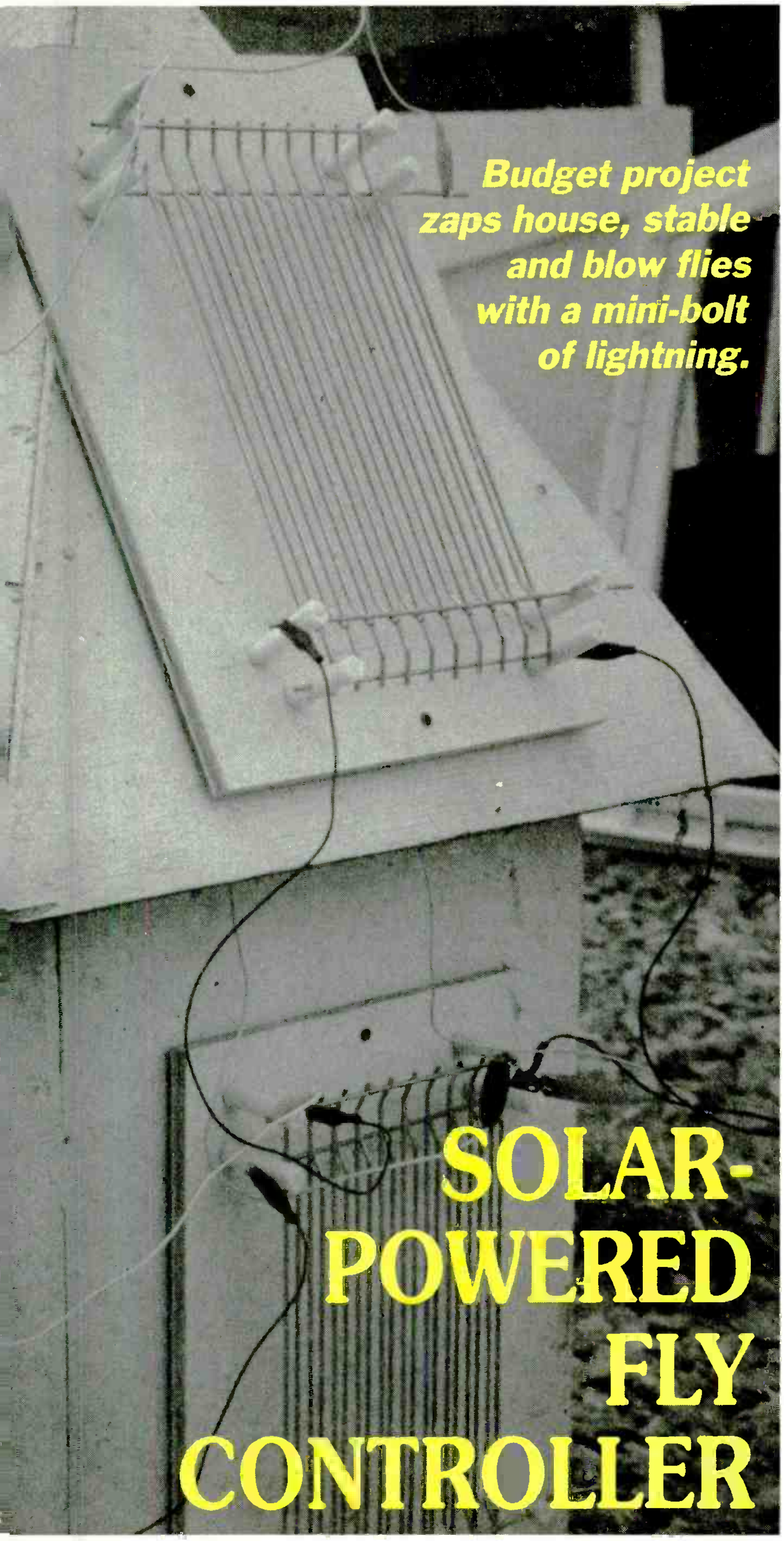
The amplified signal at the drain of Q1 is fed to a double-tuned coupling network consisting of Z3, C8, Z4, and C9. Trimmer capacitors C8 and C9 determine the bandpass characteristics of the network. Capacitors C6 and C7 provide RF grounding for the low end of Z4. The spacing of Z3 and Z4 on the PC board determines the amount of RF mutual coupling. This amount is fixed by the PC etched layout. The RF gain of the stage is about 12 to 15 dB. This gain figure is a net number that includes losses in the input and output tuned-circuit networks, and between the antenna input and the mixer input.

Transistor Q2 serves as a RF mixer. The bipolar transistor is biased by R5, R6, R7, R8, and a chip resistor network that consists of R14, R15 and R16. The mixer's emitter current is typically 1 milliampere.

The amplified RF signal from Q1 is fed via capacitor C10 to the base of Q2. The local oscillator's output signal is fed from Q5 to the emitter of Q2 via microstrip feedline Z5, R14, R15, and R16. Capacitor C13 provides a low impedance at the IF frequency (61.25 or 66.25 MHz) for the emitter of Q2. The local oscillator frequency is equal to the received RF signal *minus* the IF (low side). The signal gain from the mixer circuit is typically 6 to 8 dB. Overall gain so far is typically 20 dB.

The IF signal from the mixer is fed to a matching network consisting of C11, C12, L1, L2, and C14. The matching network rejects mixer-output signals above 100 MHz. The desired signal is then fed to an IF amplifier stage consisting of Q3 and Q4. Resistor R10 provides bias voltage while R9 provides termination for the matching network. Capacitor C16 blocks DC to the base of Q3. Current gain for the matching network is set by R11 and R12. Overall IF gain is about 20 dB.

*Continued on page 67*




# SOLAR-POWERED FLY CONTROLLER

*Budget project zaps house, stable and blow flies with a mini-bolt of lightning.*

**LAWRENCE PICKENS**

FLIES ARE A GREAT ANNOYANCE AND a health problem for man and beast. Flies breed in garbage cans, dumpsters, compost piles, and kennels, just to name a few sites. Most comon solutions to eliminate flies have their own problems. For example, chemical insecticide sprays can be applied to surfaces, and poisoned fly bait can be spread around the garbage cans, but both are environmentally unsafe, and they are not effective against every species of fly. Also, the poisons must be re-applied at regular intervals, compounding the pollution problem.

What is needed to keep the fly population down at breeding sites is a continuously working device that is environmentally safe; effective against house flies, stable flies and blow flies; and that requires limited maintenance. The Solar-Powered Fly Controller presented here is an effective fly-zapping device that you can build. It has a high-voltage electric grid that electrocutes flies that alight on it. Its advantage over commercial electric flying-insect traps is that it is driven by battery or solar power. Commercial units are powered by line current and are unsuited for use in backyards or other outdoor areas that are remote from power lines.

The controller's circuit is turned on or off either manually or automatically. A photoelectric cell automatically turns the controller off at night and during dense cloud cover that usually brings rain.

The controller remains in the off state until the ambient light is sufficient to cause the unit's phototransistor to restore power to the controller. The controller provides high-voltage pulses at one or two-second intervals in order to conserve battery life. The solar power feature provides power to drive the controller and keep the battery in an excellent charge state. The controller develops a peak-to-peak, high voltage of at least 3,000 volts that can jump across a 3-mm gap when a fly

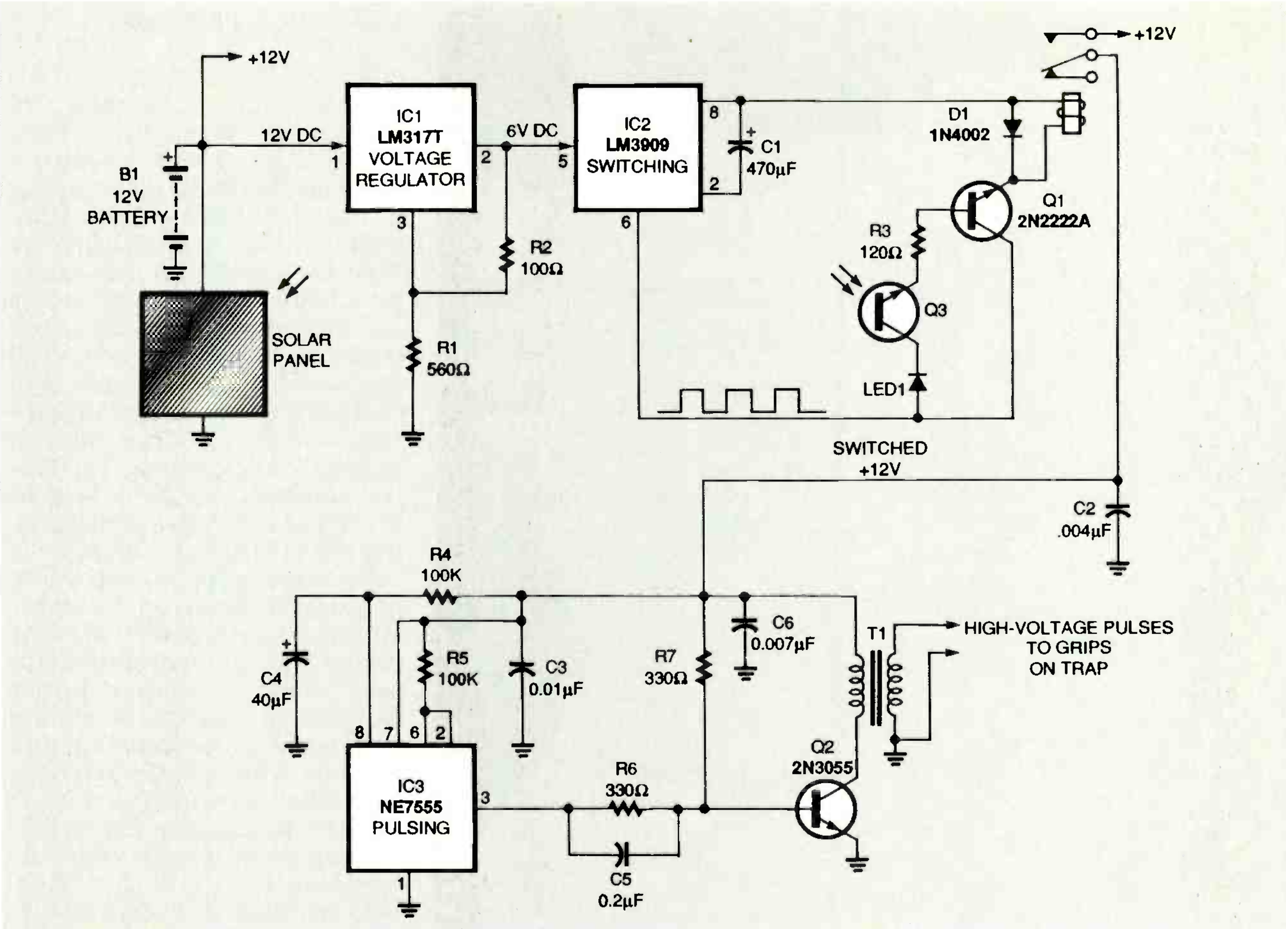



**FIG. 1—SCHEMATIC DIAGRAM of the solar-powered fly controller is surprisingly simple.**

alights in the gap. The high-voltage discharge current is below 8 mA which is considered safe for humans. Nevertheless, it is wise for humans to stay clear of the grid because an accidental shock may cause a person to involuntarily jump or slip into an obstacle and injure themselves.

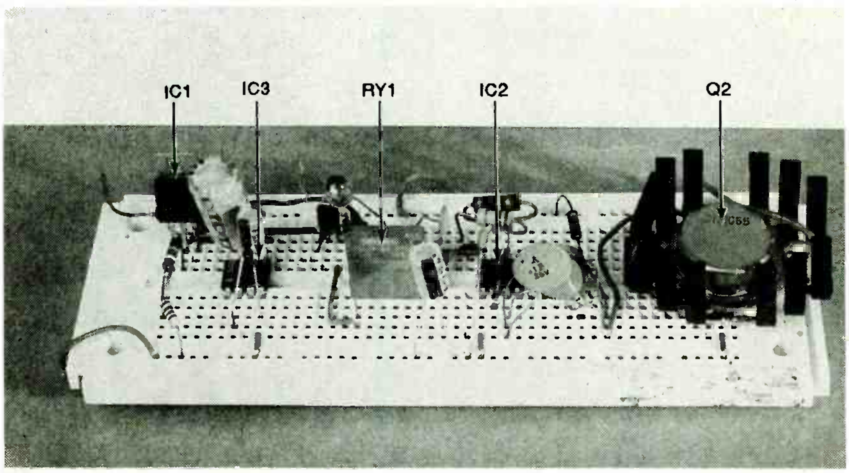



**FIG. 2—PARTS PLACEMENT for the Solar-Powered Fly Controller is not critical. The ignition coil, T1, grids, and power source are located off the circuit board. Once the circuit is tested and functioning normally, move part by part to a matching PC board and solder in place.**

### The circuit

The circuit for the solar-powered fly controller is shown in Fig. 1. It consists of a switching circuit, pulsing circuit, and a high-voltage output circuit. The external power components are a 1- to 5-watt solar panel and a 12-volt motorcycle or camcorder battery. The output of the high-voltage ignition coil connects to a network of paralleled electrodes, called a grid, upon which flies land and are destroyed.

Voltage input to the LM3909 LED-flasher/oscillator (IC2) is kept at 6 to 9-volts by a LM317T voltage regulator (IC1). The exact voltage is not critical as long as it is regulated. The LM3909 produces a series of pulses that are coupled to a 2N2222A transistor (Q1) to form a switching circuit. An output of positive pulses from IC2 to the 2N2222A transistor boosts the pulse current so that it closes a 5-volt relay (RY1) for approximately 0.1 second at intervals of 1 to 2 seconds. Diode D1 shunts out

*Continued on page 77*

# *Troubleshooting* For **BOATERS**

***Safety first and electrical maintenance go hand-in-hand to safeguard boating pleasure***

**VAUGHN D. MARTIN**

THIS ARTICLE IS DIRECTED TOWARD boating enthusiasts with an interest in maintaining their craft's electrical and electronic equipment. It will show you how to test and troubleshoot marine electrical systems, outboard motor magneto ignitions, and the integrity of your boat's corrosion protection system.

The marine environment can be especially harsh on the components of your boat's electrical system. When performing preventative maintenance or when trouble occurs, you will want the capability to make accurate and reliable electrical measurements quickly. The basic tool for this job is the digital multimeter.

**Work safety**

The voltages and currents present in electrical power systems can cause serious injury or death by electrocution. Consequently, when testing or troubleshooting, carefully adhere to all industry standard safety rules that apply to the situation. Read and follow directions and safety warnings provided by the equipment manufacturer. Don't be misled by low potentials of 12 and 24 volts DC. They may not electrocute you but they can set your boat afire or cause an explosion—with you and others on board!

Here are some troubleshooting safety tips you should know:

- Be sure that all electrical power has been turned off, locked out, and tagged in any situation where you will be in direct physical contact with live circuit components. This is especially important when 117-volt AC dockside power is available. Also, be certain that the power can not be turned on by anyone but you!
- Use only well maintained test equipment. Inspect all test leads (especially the probes) for breaks and cracks and check all on-board fuses before use. Repair or replace any test lead or probe with damaged insulation. Replace defective fuses with new units of the same rating as specified for the equipment by the manufacturer.

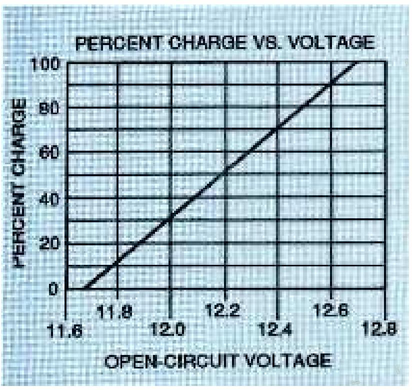



**FIG. 1—PERCENT CHARGE vs. lead-acid battery voltage for a common 6-cell battery under no load for 24 hours. Voltage readings will be slightly less for batteries recently used.**

- Be very cautious when working on electrical systems when fuel vapors are present. Remember that vapor from gasoline and propane are heavier than air and will collect in the bilge and closed compartments. Sparks generated by making connections with live electrical components can start a fire or cause an explosion when fuel vapors are present. Ventilate completely to eliminate all explosive vapors before proceeding and cease work immediately should you suspect the dangerous vapors are reoccurring.
- Be aware that charging an unsealed lead-acid batteries generates hydrogen gas. This hydrogen can explode if exposed to a spark generated at the battery terminals when connecting or disconnecting a battery charger. Always verify that the power to the battery charger is off before connecting or disconnecting the charger leads at the battery terminals. Also, carefully observe polarity of the battery chargers cables.

**Batteries**

Very often the first sign of a battery problem occurs when the starter won't turn the engine over. Use your multimeter to get an idea of the battery's charge. To perform a no-load test, set the digital multimeter function switch to measure volts DC and connect the leads across the battery's terminals. Compare your voltage reading to the graph in Fig. 1 to determine percent charge.

The above voltage test indicates only the state of charge, not the battery's condition. For example, a battery may register 100 percent charge but would be unable to crank the engines starter for more than five or six revolutions. To gain additional information about the battery's condition, test the specific gravity of the electrolyte in each cell using a hydrometer calibrated for that purpose. (This test is not possible for sealed batteries.) If the specific gravity is low but relatively the same across all cells, recharging may be able to bring the battery back to good health, unless the plates are sulfated. If they are sulfated, charging the battery will do little to improve its performance—the hydrometer reading would remain low. If one cell shows a specific gravity much lower than the rest, that cell is probably defective and recharging will not help. When you cannot correct the problem by recharging, replace the battery immediately!

Your marina service shop probably has a device that places a load across the battery and provides a voltage reading at the same time. If your battery is sealed and you cannot take a hydrometer reading, see if you can borrow this tool to check out your battery. The meter is usually calibrated Good, Fair, and Bad or Replace.

Sulfated plates can be detected by measuring the output voltage under load after the battery has been fully charged. The sulfate degeneration on the plates of a battery increases its internal resistance. Thus, under load the battery exhibits an internal voltage drop reducing the overall battery voltage to the load (starter), and seriously limiting the amount of current available to start a cold engine. Typical results for a good battery tested under load are given in Fig. 2. Note that the test probe tips must dig into the battery's soft lead terminal post and not the cable clamp-connector.

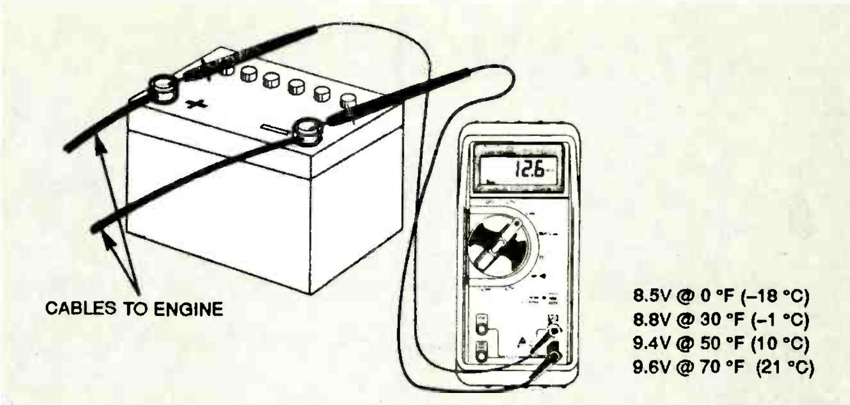



**FIG. 2—MEASURING THE BATTERY'S output voltage under load. The chart indicates typical voltage outputs for starter loads at various temperatures.**

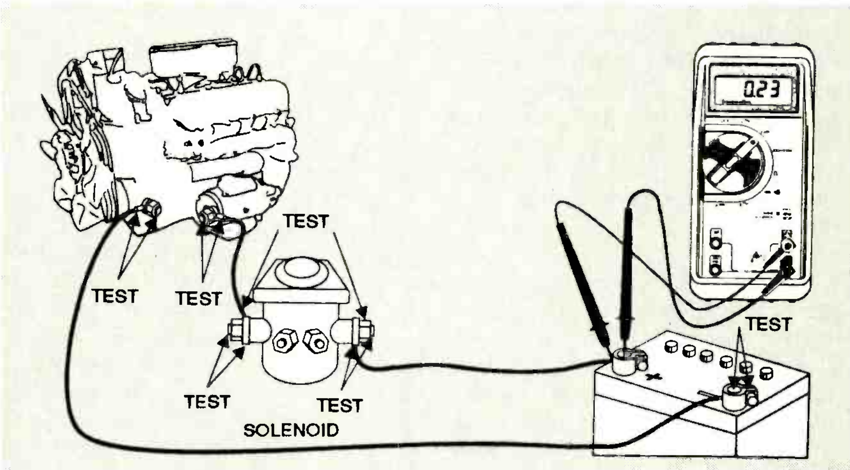



**FIG. 3— TO DISCOVER WHERE POWER is being lost when cranking the starter, each connection point in the circuit must be checked for excessive voltage drop. Check across the solenoid assembly; if the resistance is high, replace the unit.**

### Alternators

A digital multimeter's accuracy and display make diagnosing regulator/alternator troubles easy. First determine if the system has an integral (internal) regulator, then whether it's type A or B. Type A is sometimes referred to as P-Type and type B is sometimes referred to as N-type. A type-A regulator has one brush connected to the battery's + terminal and the other brush grounded through the regulator. The Type-B regulator has one brush directly grounded and the other connected to the regulator. (Alternator brushes ride on slip rings in order to connect the field coil mounted on the alternator's armature to a power source.)

Next, isolate the cause of the problem to the alternator or regulator by by-passing the regulator (full-fielding).

Ground the Type-A regulator's field terminal. Connect the Type-B regulator's field terminal to the battery's + terminal. If the system charges now, the regulator is faulty. Use a rheostat in series with the field connection if possible. Otherwise, just idle the engine (lights on) so the voltage doesn't exceed 15 volts.

### Starting systems

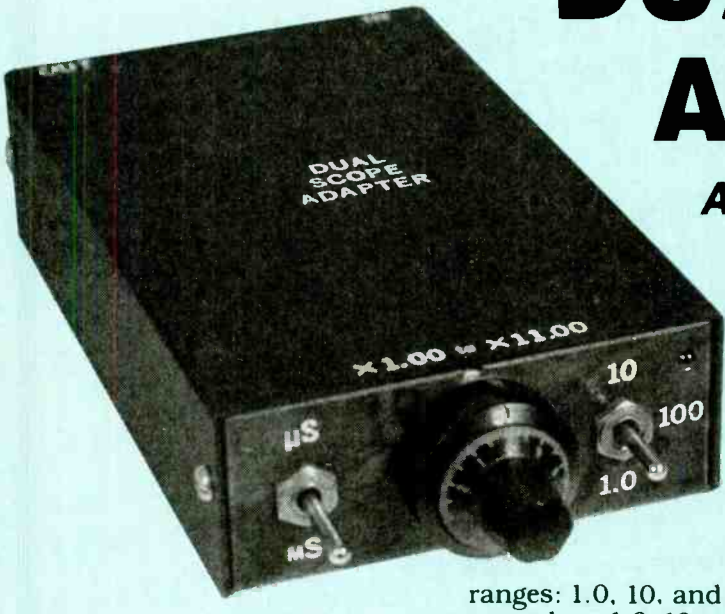
Starting system troubles are often confused with charging-system problems. Many dead batteries have been replaced when the real cause was a faulty charging system. Be sure that the charging system is functioning properly before you replace the battery. Make sure the battery is charged and passes a load test, then look for resistance in the starter circuit should the engine still crank slowly.

In a lead-acid battery, each cell produces about 2.1 volts at full charge. Therefore, a 12-volt battery has 6 cells in series and delivers about 12.6 volts when fully charged. If the no-load test on a fully charged battery reads about 10 volts, a dead cell is likely and the battery should be replaced immediately.

Resistance increases in a starting system when high-current cables are frayed, connections are loose, and terminals are corroded or dirty. Investi-

*Continued on page 79*

# DUAL SCOPE ADAPTER




***Add time period cursors and delayed sweep to your oscilloscope with this handy, precision adapter***

**SKIP CAMPISI**

WOULD YOU LIKE TO HAVE AN OSCILLOSCOPE accessory that makes precise pulse-width or time-period measurements so you do not have to count graticule graduations? Frustrating and time-consuming, manual counting frequently leads to measurement errors. Also, could you use an oscilloscope accessory that permits you to look closer at the leading edges of fast, low-duty cycle pulses at high sweep speeds so you can eliminate all the annoying oscillations in the circuit under test?

The Dual Oscilloscope Adapter offers both of these features. It will permit you to make both pulse-width or time-period measurements and observe leading edges of pulses. It gives you precise time measurements and a rock-solid delayed-sweep mode that requires only that the output cable be switched from one jack to the other. The Voltage Cursor Adapter (*Electronics Now*, May 1995) is the companion to the Dual Oscilloscope Adapter. Together, both accessories will endow your oscilloscope with features available only in far more costly laboratory models.

The Dual Oscilloscope Adapter is essentially a precise (±1%) monostable multivibrator with six, switch-selectable output ranges: 1.0, 10, and 100 microseconds or 1.0, 10, and 100 milliseconds. Each range can be varied with a precision ten-turn potentiometer equipped with a precise turns counter. With this ×1.00 to ×11.00 turns-counter scale, the total range will be 1.0 microsecond to 1.10 seconds.

The adapter output pulse is applied to your oscilloscope's Z axis input (EXT—blanking/intensity modulation input) to provide the time period cursor. It intensifies that part of the oscilloscope trace to be measured (to the exact pulse width set on the adapter), while dimming the rest of the trace.

This method makes reading the measurement both easy and precise. By adjusting the adapter's slope controls, either any section or the entire waveform period can be measured. The sweep is delayed by applying the output of the adapter to the TRIGGER input of your oscilloscope in the external trigger mode.

The adapter was designed to operate from an external ±5-volt supply to minimize the pickup of hum and noise from the AC line. A schematic diagram and parts list for a suitable wall-outlet-mounted dual power supply is included in this article for those who do not have a suitable one or cannot find a convenient source for purchasing one.

**How does it work?**

Figure 1 is the schematic for the dual oscilloscope adapter. The input stage is the trigger amplifier based on the two channels of an LM319 dual comparator (IC1-a and IC1-b). The input signal is taken from the CHANNEL 1 output jack of your oscilloscope, and it is applied to J1 on the adapter.

The author's prototype was designed to work with a Hitachi V-212 oscilloscope, which has an output of 25 millivolts per division on its vertical signal display into a 50-ohm load. Assuming a normal display of about six divisions, a trigger level of about ± 150 millivolts is desired. This range is set by the ratio of the values of resistor R4 to R5, and is varied by voltage divider R6, the TRIGGER LEVEL control.

This ratio can be altered to be compatible with your brand of oscilloscope, but be sure to maintain the ratio of R3 to R5, which gives the correct amount of hysteresis for proper triggering. The INPUT SLOPE is selected by switch S1, and the signal is coupled to C3 and IC2, the multivibrator stage.

Capacitor C3 provides the proper negative-going pulse to trigger IC2, a TLC555 CMOS timing IC circuit, and it also limits the minimum required input pulse width to about 500 nanoseconds. Switch S2 selects the desired range—either milliseconds or microseconds, and

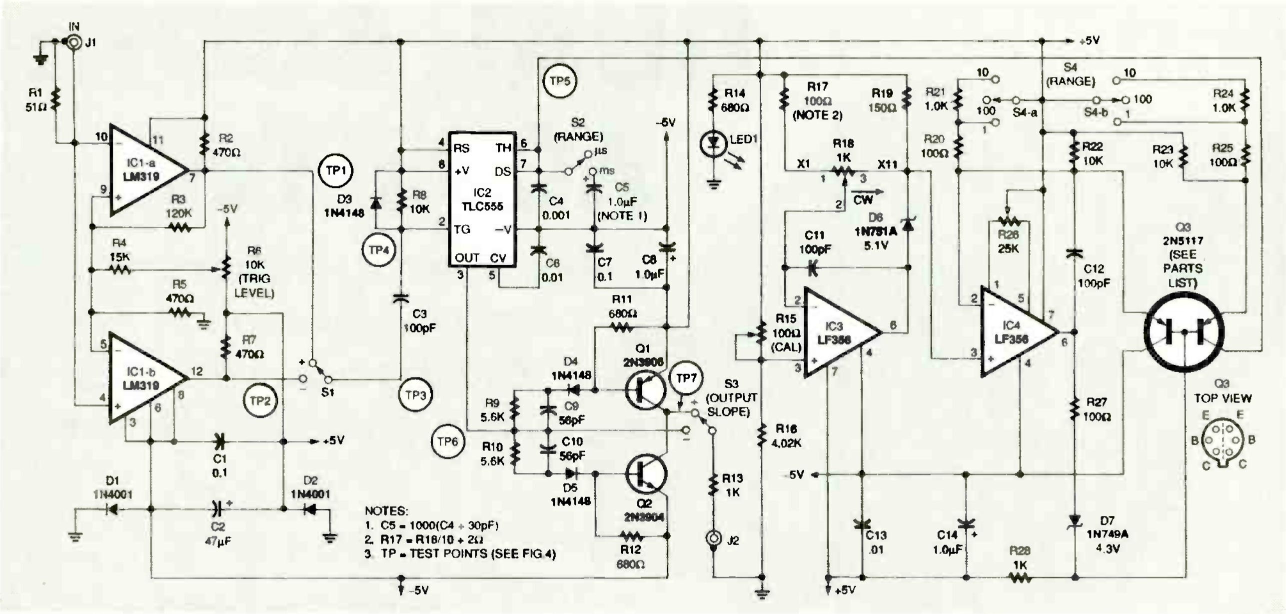



**FIG.1—SCHEMATIC FOR THE DUAL OSCILLOSCOPE ADAPTER. The components are assembled on a multipurpose PC board.**

switch S3 selects the polarity of the output slope. About 30 pF of stray capacitance exists at the junctions of C4, Q3, and IC2. Thus, to obtain the highest accuracy, select or trim capacitor C5 or C4 so that C5 = 1000 × (C4 + 30 pF).

Transistors Q1 and Q2 form a fast (less than 10-nanosecond delay ) inverting output stage. The output from switch S3 is ±5 volts, which is sufficient for excellent contrast in intensity modulation. It is also satisfactory for stable triggering in the adapter's delayed-sweep mode. Resistor R13 (1 kilohm) isolates the output stages from the capacitance of the connecting cable. This value provided the necessary isolation on a 3-foot length of RG-174 and 6-foot length of RG-58 coaxial cable. However, you might have to select a different value for your brand of oscilloscope.

Precise input current to capacitors C4 and C5 is supplied from the collector of dual transistor Q3, a 2N5117. It is a dual matched PNP pair in one package. Each transistor is electrically isolated but thermally coupled. Operational amplifier IC3, an LF356, is configured as a noninverting follower with gain. It supplies the correct reciprocal voltage reference function to IC4, the second LF356. It is a buffer with half of Q3 in its feedback loop.

Transistor Q3 is configured as an unusual "current mirror" that unloads the relatively slow operational amplifier, allowing the second half of Q3 to demonstrate its fast dynamic response. A reference voltage is developed across both sets of emitter resistors (R20 to R25) to produce the constant charging current for capacitors C4 and C5. The two sections of switch S4 (S4-a and S4-b)) select the range—either 1.0, 10, or 100, in conjunction with switch S2 (milliseconds or microseconds).

Zener diodes D6 and D7 permit the operational amplifier outputs to operate in their linear regions. Variable resistor R18 (1 kilohm, 10-turn) is the range multiplier. It has a 15-turn counting dial mounted on its shaft. See the directions in the construction section for mounting this dial to the shaft of the precision potentiometer.

## Building the adapter

All of the circuitry for the author's prototype fit in a standard, off-the-shelf, two-part aluminum case that measures approximately 1¼×3 ×5 inches. These cases are available from many different suppliers. The circuit board is a

*Continued on page 85*

**TABLE 1—SPECIFICATIONS FOR THE DUAL OSCILLOSCOPE ADAPTER**

**Power Supply: ±5 Volts (regulated), 100 mA**

| Parameter | Value | Units | Condition |
|---|---|---|---|
| Input voltage (max) | ±5 | V | |
| Input voltage (min) | ±25 | mV | |
| Trigger voltage range | 0.0±150 | mV | |
| Input rise/fall (max) | 00 | | |
| Input frequency (max) | 500 | KHz, | (min) |
| Input pulse width (min) | 500 | ns | (typ) |
| Propagation delay (J1 to J2) | 250-300 | ns | (typ) |
| Input Impedance | 51 | ohms, | (typ) |
| Output pulse range | 1.0-1.10 | ms-s | |
| Output pulse voltage | ±5 | V | |
| Output impedance | 1000 | ohms | (typ) |
| Output Pulse Accuracy | +1 | % | 10µs-1.10s |
| Output Rise/Fall Time | 20 | ns | (typ) |
| Reference Voltage (x1.00 to x11.00) | 670-61 | mV | (typ) |

BY DON LANCASTER

# Modern power-factor correction and Internet addressing

THE INTENT AND MEANING OF THE TERM *POWER FACTOR CORRECTION* SURE HAS CHANGED A LOT LATELY. THIS APPEARS TO BE CAUSING A LOT OF CONFUSTION ON MY HELP-LINE. TO STRAIGHTEN SOME OF THIS out, lets get back to the basics...

## Power factor: then and now

An electronic *component* is *passive* when there's zero net energy input from anywhere other than its input leads. A component is *linear* if it does not change in any manner with time. Also, in any linear component, the stimulus must be proportional to the response. Kick it twice as hard and it should "ouch" twice as loud.

There are only three possible *ideal* passive linear electronic components. All real components are made up of lumped or distributed combinations of these three.

The first component is the *resistor*. A resistor converts current into heat or light energy, following a *power = volts ( amps* equation. Since there is zero energy storage, there is no way your current can get behind or ahead of the voltage. Current and voltage are said to be *in phase*.

When a fixed-frequency sinewave voltage is applied, a sinewave current will result. This current follows the voltage per Ohm's law.

The second component is known as the *inductor*. An inductor is a coiled conductor with or without a field-intensifying core. An inductor *temporarily* will convert current into energy storage in a *magnetic field*.

The voltage-current rule for any inductor states that...

$$e = L\Delta i/\Delta t$$

This tells us that the voltage across an inductor is proportional to its size times the *rate of change* of a current through it. As the current increases, the magnetic field energy will go up and vice versa.

A pure inductor does *not* "waste" energy. It simply *stores* energy in its internal magnetic field. When a voltage gets applied to an inductor, its current will slowly build up. Thus, current will be "behind" the voltage in an inductor. If you apply a voltage sinewave, you should see a current *cosine* wave which is precisely one quarter cycle behind. Since there are 360 degrees of phase in one full cycle, we say that the inductor current *lags* in phase by exactly 90 degrees.

The third ideal component is called the *capacitor*. A capacitor is a pair of conducting plates separated by air or other insulating material. A capacitor *temporarily* converts voltage into energy storage in some *electric field*.

The current-voltage rule for a capacitor states that...

$$i = C\Delta V/\Delta t$$

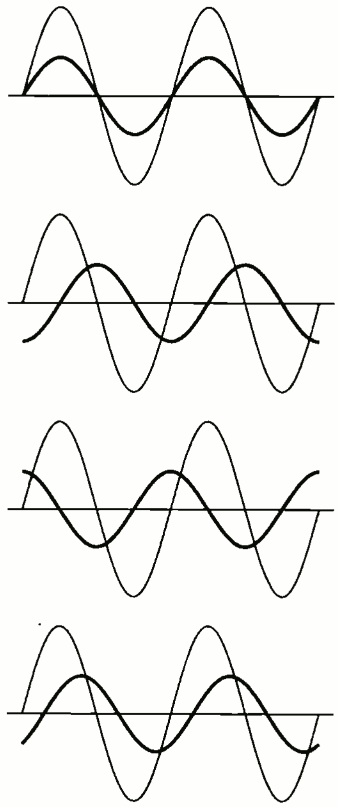
...telling us that the current into a capacitor is proportional to its size times the *rate of change* of voltage across it. As the voltage goes up, the electric field energy goes up and vice versa. Reversing the voltage also reverses the sense of the field energy.

As with the inductor, an ideal capacitor does *not* waste any energy. It stores that energy in its electric field. If a current is sent to a capacitor, its voltage will slowly build up. The current will usually be ahead of the voltage in a capacitor. Which has to mean that the voltage will usually be behind the current. If you apply a voltage sinewave, you'll get a current *negative cosine* that is precisely one quarter cycle *ahead*. Since there are 360 degrees of phase in one full cycle, we can say that the current *leads* by 90 degrees.

There's an easy and ancient way to remember all this: Good old *ELI the ICE* man. The *E* (voltage) is ahead of the *I* (current) in the *L* (inductor). The *I* is ahead of the *E* in the *C* (capacitor).

Ideal components do not occur in the real world. Because an insulator, conductor, or semiconductor above absolute zero *will* have resistance and unavoidable conversion of current into heat. Any conductor that routes between two separate points in space *will* have inductance and unavoidable magnetic field energy storage. And any two con-

## ELI THE ICE MAN



In an ideal **RESISTOR**, all incoming energy is converted to heat without any field storage. Voltage and current are in phase. The power factor is 1.0.

In an ideal **INDUCTOR**, all incoming energy is converted to energy storage in a magnetic field. Current **lags** voltage by 90 degrees. The power factor is 0.

In an ideal **CAPACITOR**, all incoming energy is converted to energy storage in an electic field. Current **leads** voltage by 90 degrees. The power factor is 0.

A real **MOTOR** has both inductive and resistive components. Current lags voltage by the ratio of real to reactive power. The power factor shown here is 0.8 lagging.

**FIG. 1**—THE POWER FACTOR of a circuit is the ratio of the real to reactive input power. Power factor is expressed as the cosine of the phase angle between the voltage and current. A classic power factor correction involves getting the input fundamental frequency voltage and current in phase.

ductors separated by an insulator *will* have capacitance and unavoidable electric field storage. I have summarized these lead-lag rules in Fig. 1.

### Enter the power company– stage left

The power company only charges you for the energy you actually *use*. Generating light, burning it as heat, converting it to a mechanical motion (which ultimately becomes heat), or by otherwise never returning it. On the other hand, the energy you store in an inductor gets returned early on in the next cycle. As does any energy you might store in any capacitor.

We can define *real* power as the energy you actually use. The *reactive* power is energy that swaps back and forth between you and your utility company, temporarily getting stored in electric or magnetic fields.

The *power factor* is defined as the ratio of the real energy to reactive energy. Specifically, it is the *cosine* of the *phase angle* of the current waveform compared with the voltage.

A purely resistive load would have a power factor of 1.0 or unity. Any load which stores as much magnetic energy in an inductor as gets actually used would lag by 45 degrees or have a power factor of 0.707 *lagging*. A load which retains as much electric energy in a capacitor as gets actually used would lead by 45 degrees or have a power factor of 0.707 *leading*.

The power factor of any ideal inductor or capacitor is zero. Why? Because the cosine of +90 or (90 degrees is precisely zero. Why should the power utility care how much reactive power you use? After all, you're going to give it right back a few milliseconds later. The problem is that line *current* is required *both* for real and reactive power. The *extra* current consumed by all your reactive loads still causes utility losses in the resistance of their lines. It also demands higher currents in all the generators and transformers and such. The utility's costs go up, yet they have sold no more electricity.

Most of your home loads are resistive (light bulbs, for example) or partially inductive (motors and compressors). Capacitive loads (such as an electroluminescent night light) are quite rare in normal home or industrial use. Thus, you are likely to have a lagging power factor.

The power company applies *power factor compensation* to clean up their own act. They might compensate their reactive power by hanging capacitors on poles every now and then, or by purposely overdriving a synchronous generator to intentionally produce a *leading* power factor.

But note that hanging capacitors on one line end to compensate for inductors on the other does not fix much, because the reactive current *between* the two still contributes to huge transformer and line losses. Thus, *a utility cannot "fix" a customer's power factor*. Utilities do punish large industrial electricity users if their power factor is too low. Their bill goes up when their power factor goes down. This encourages the industrial user to do its own power factor correction with capacitors or overdriven generators.

So, the classic definition of *power factor correction* was taking steps to reduce longer distance fundamental frequency reactive energy transfers. Getting the fundamental frequency voltage and current waveforms back in phase with each other.

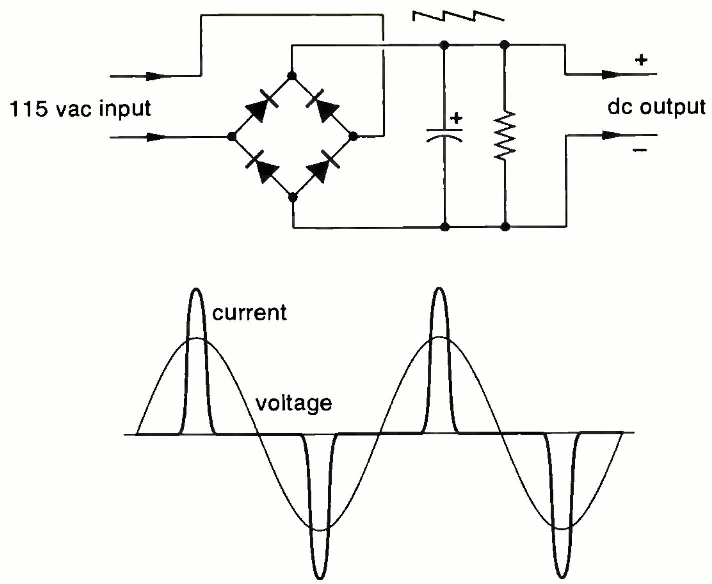



**FIG 2**—A TYPICAL LINE-OPERATED POWER SUPPLY draws its current in very large, very narrow, and high harmonic mid-cycle pulses. Modern power-factor correction involves both minimizing these harmonics and getting the input fundamental frequeny voltage and current in phase.

## The modern problem

All of that is ancient electrical engineering. But lately, things went nonlinear. Electronic circuits started needing lots of rectifiers for internal DC power. The loads were no longer time-invariant. Figure 2 shows the current waveform of a typical capacitor-input full-wave rectifier. For most of each half cycle, *zero* power is drawn. It is only very near the *peak* of each half cycle that the diodes switch on and draw a humongous and very narrow slug of current.

The utility has to provide this peak current. In spite of the fact that they are doing *absolutely nothing useful* for the rest of the cycle.

Well, the *fundamental frequency* voltage and current are still in phase with each other. At first glance, there appears to be no need for any classic power-factor correction.

But my oh my, the harmonics. As we have seen before, narrow pulses consist of a fundamental frequency and lots of harmonics. Mostly odd, some even. *Fourier* series and all. Besides having to provide ten or twenty times the peak fundamental current capability, there's bunches of harmonics overloading the utility's transformers and such.

Ordinary home electronics is bad enough. But we've now got lighting ballasts and industrial motor controls adding to the mess. Something has to be done to minimize these harmonics and outrageous current slugs.

The trick is to do what you have to so that your drawn current gets back to looking at least roughly like an in-phase fundamental frequency sinewave. And that is what modern power factor correction is really all about—harmonic stomping.

So, the definition for "new" power factor correction is making all of the current drawn to be in phase with the fundamental voltage *while* having as little harmonic energy as possible.

One way to handle this waveform improvement is with a *preregulator*. You still use a full wave rectifier, but you only *lightly* filter it with a small capacitor. The diodes now conduct over nearly the full cycle. You next take this changing full wave rectified waveshape and then *step it up* to a fixed and higher DC voltage. Say 200 volts. You can do this with a special regulator that involves a *power factor correction* integrated circuit.

Now for the tricky part: Not only do you have to step your voltage up differently in different parts of *each* half cycle, but you also want to draw *less* current with *large* stepups. And *more* current with *small* stepups!

The reason for all this is that you will want the *average* of your drawn current to look pretty much like a fundamental and in-phase sinewave. Thus, early in your half cycle, you'll want low currents but high voltage

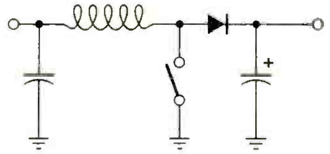



**FIG. 3**—A BOOST SWITCHING REGULATOR CIRCUIT is normally used for stepping up DC voltages. Repeatedly closing the switch ramps up the current. Opening it transfers the stepped-up voltage to the load. The same idea can be used for power-factor correction if you input a full-wave rectified waveform and if you use very fancy switch duty cycles and repetition rates. The tricky part involves drawing more average current mid-cycle and less near the edges.

stepups. A quarter way into the half cycle, you should want to be drawing more current but providing for less voltage stepup. And midway at the half cycle peak, you'll want lots of current but only a minimal stepup.

Figure 3 shows a switching circuit known as a *boost regulator*. You briefly close your switch. The current in the inductor starts at zero and begins ramping up. Open the switch. Because of good old ($\Delta i/\Delta t$), you can not immediately change the current through an inductor.

*The current through the inductor will be the same immediately before and immediately after you open the switch.*

The diode now conducts and the inductor delivers its current into the output capacitor and load.

The inductor's current should now start dropping, caused by the draw of any resistive load. Close the switch again to ramp up your current. Open the switch to transfer energy to the load. The inductor's current will be roughly constant but has a slight high frequency triangular ripple.

Your typical switching frequencies these days go from 20 kHz on upwards. As you vary the *duty cycle*, or the percentage of time the switch is on, you'll vary the output voltage. Feedback can hold the output voltage to any voltage you like.

Well, any voltage *above* the input supply that is. If you never close the switch, your input voltage appears at the output. Thus, a boost converter is just that–a method for controllably *increasing* an input voltage. To convert a boost regulator into a power factor corrector, we have to get sneaky with our switch timing. At mid waveform, we will want a *short* on-time for a limited step up. However, we will also want a *high frequency* for maximum current.

Near the waveform zeros, we will want a *long* on time for a *large* step up. But we'll also need a much *lower frequency* to do the stepups not as often for lower current. Thus, some really fancy footwork is required to continuously change *both* the step up ratio and the drawn current. All the while adjusting for a changing load current or a drifting supply voltage. But all you are doing is continuously changing the repetition rate and the pulse width in a magic way.

Note that the small input filter capacitor provides an averaging energy storage for these high frequency variations. All that the utility has to give us is a clean fundamental frequency current sinewave at unity power factor. Three primary sources for power factor correction chips include *Micro Linear*, *SGS* and *Unitrode*. Free applications notes are available. The trade magazines here include *Power Quality* and the *EPRI Journal*.

INTERNET RESOURCES

**Boardwatch**
8500 W Bowles Ave #210
Littleton CO 80123
(303) 973-6038

**InformationWeek**
PO Box 1093
Skokie IL 60076
(516) 562-5000

**Inter@ctive Week**
100 Q Roosevelt Blvd # 508
Garden City, NY 11530
(516) 229-3700

**Internet Market Report**
5841 Edison Place
Carlsbad CA 92008
(619) 438-8100

**Internet World**
20 Ketchum Street
Westport CT 06880
(203) 341-2872

**The Net**
1350 Old Bayshore #210
Burlingame CA 94010
(415) 696-1688

**NetGuide**
600 Community Drive
Manhasset Ny 11030
(516) 562-5000

**Network Solutions**
505 Hunter Park Drive
Herndon VA 22020
(703) 742-4777

**WEB Techniques**
600 Harrison Street
San Francisco CA 94107
(303) 661-1885

**WEBsmith**
Po Box 55549
Seattle WA 98155
(206) 782-7733

**WEB Week**
20 Ketchum Street
Westport CT 06880
(708) 564-1385

**Wired**
544 2nd St 3rd Fl
San Francisco CA 94107
(415) 904-0664

## Your own web page

How do you get your own private Internet address for email? How can you start your own web page? The Internet location addresses are specified by a *domain*. To get on the net, you'll need access to a domain. Internet domain addresses are groups of characters separated by periods. An "@" separates internal from external locations. Thus a *bowseretta@woof.com.us* may be a complete Internet address. The *.us* is the country. This can be eliminated for US addresses. But a *.uk* stands for England, and so on. The second domain level is usually a *.com* (if a for-profit company), *.org* (if a non-profit organization), *.gov* (if government), *.edu* (university), or a *.net* (for another network).

Here, *woof* is the *service provider*. That is someplace where a computer runs continuously to send and receive net contents for you. You hire a local service provider at $18.50 per month from the ads out of your local paper, or get limited free access from your long distance phone service, or subscribe to a commercial online service. Such as *Compuserve*, *GEnie*, *Prodigy*, or *AOL* at about $3 per hour.

Or, you can become your very own service provider. And dedicating your own computers and modems to full high speed access duty (hundreds of dollars per month plus big bucks in equipment and skills). And *bowseretta* is the woofer who is actually subscribing to the Internet access. Should Bowseretta go and start up her own kennel, her internal accounts would get separated by *rover@bowseretta@woof.com*

Should some version of automated processor be used, it might have an address of...

*server@bowseretta@woof.com*

My own two Internet addresses are currently *synergetics@genie.com* and my new *tinaja.com* web site.

You have two choices for internet addresses: *Unregistered* names can be anything that you and your access service can agree on. They are also usually free. But there is nothing to stop someone else on the net using the same name. *Registered* names are exclusively available for your use. Your service provider will offer a *pass thru* name for an additional fee. For instance, if Bowseretta registers, she can become *Bowseretta.com*. Pass-thru's give you a shorter address.

To find out if a registered name may be available, you get on the Net and go to *www.internic.net*. Select their *whois query form*. To actually register a name, click on the *new domain registration* link. A form and detailed instructions will be emailed back to you. Fill in and crop your form. Return your form to *hostmaster@internic.net* Use the words *New Domain* as the *Subject*.

The cost is $100 for the first two years. Then $50 per year afterward. Typical registration takes several weeks. The billing is by mail or online. Domain registration is by email only. Details are shown in Fig. 4. Internic is also *Network Solutions*. I have shown the address in this month's *Internet Resources* sidebar, along with a few of the Internet hard copy magazines.

NAMES AND NUMBERS

**American Science & Surplus**
3605 Howard St
Skokie IL 60076
(708) 982-0870

**Beyond Electronics**
213 Harding Way East
Galion OH 44833
(800) 747-2861

**Bunting Magnetics**
500 S spencer Avenue
Newton KS 67114
(316) 284-2020

**Commonwealth Trading Co**
1685 E Park Place Blvd
Stone Mountain GA 30087
(770) 469-7292

**Edmund Scientific**
101 E Gloucester Pike
Barrington NJ 08007
(609) 573-6250

**EPRI Journal**
PO Box 10412
Palo Alto CA 94303
(415) 855-2000

**Eriez Magnetics**
PO Box 10608
Erie PA 16514
(814) 833-9881

**Fujitsu**
3545 N First St
San Jose CA 95134
(800) 642-7616

**Littelfuse**
800 E Northwest Hwy
Des Plaines IL 60016
(708) 824-0400

**Magnet Source**
607 S Gilbert
Castle Rock CO 80104
(800) 525-3536

**Micro Linear**
2092 Concourse Dr
San Jose CA 95131
(408) 433-5200

**Oak Ridge Natl Labs**
PO Box 2008 MS-6087
Oak Ridge TN 37831
(423) 574-4281

**Physics Teacher**
5112 Berwyn Road
College Park MD 20740
(301) 345-4200

**Power Quality**
2742 Eastman Ave #33-34
Ventura CA 93003
(805) 650-7070

**Probe Master**
215 Denny Way
El Cajon CA 92020
(800) 772-1519

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

**Small Parts**
PO Box 4650
Miami Lakes FL 33014
(305) 557-8222

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

**Talking Electronics**
626 S Euclid Street
Anaheim CA 92802
(714) 533-4252

**Test Probes Inc**
9178 Brown Deer Road
San Diego CA 92121
(619) 552-2090

**Thomson Industries**
2 Channel Drive
Port Washington NY 11050
(800) 554-8466

**UFO**
Box 119A
Kingston NM 88042
(505) 895-5608

**Unitrode**
580 Pleasant St
Watertown MA 02172
(617) 926-0404

**Walker Scientific**
Rockdale St
Worcester MA 01606
(800) 962-4638

## Magnetic levitation

Everyone from physics students to perpetual motion machine fans have been fascinated by that ability of like-pole magnets to repel each other. Slide two or more ring magnets onto a wooden dowel and all of the upper magnets will mysteriously "float" in air, provided that the like poles of each magnet face each other. North to north or south to south. The effect seemingly exhibits "antigravity."

Actually, the vertical forces cancel at a height where your upward magnetic repulsive forces exactly balances the downward gravitational pull. Unfortunately, you can't take the stick away because there is no lateral stability. And, of course, there is no free lunch here. The energy needed to place two magnets in any position where they can repel each other will *always* exceed any energy that can be recovered.

Similar magnetic repulsion effects are often used in "frictionless" magnetic bearings and in maglev trains.

The *Levitron* is a fascinating new combination science toy, magic trick, and *Golly Gee Mister Science* party mind-blower. The Levitron uses the angular momentum of a spinning top to stabilize the magnetic repulsion of a pair of ring magnets. The spinning top literally floats in air for two or more minutes at a time. It appears eerily locked yet somehow alive in a fixed position in space an inch or two above a table.

No, there are no batteries. Nor any electricity or other energy source of any kind. Beyond that initial kinetic energy imparted as momentum. And no, it is not an illusion. You can wrap your hand totally around the floating top. You can even "capture" the top inside a glass and then actually put a lid on the glass!

Top operation is more than a little tricky. You'll need lots of patience to master the technique. You first place a plastic sheet above your magnetic base and *carefully* locate the center magnetic null point. Then, with your elbow held *very* high, you give the top a sharp spin. Next, you *slowly* raise the leveled plastic sheet until the top *just barely* launches itself upwards. Remove the sheet, and the top does its antigravity bit, at least until the air resistance slows the top below a stability limit.

The exact mass of the top is *very* critical, so there are some weighted washers and O-rings you can add or remove. If the top leaps up, it is too light. If it never floats at all, then it is a tad too heavy.

The magnetic base also has to be on a solid surface and *exactly* level. A pair of wedges are provided. If the floating top leaves to the east, you *raise* the east side of the base. Use one wedge for east-west; the other for north-south. All in all, the effect is well worth the time and effort to master it.

One Levitron source is *UFO*. Short for Mike Sherlock's *Unlimited Fun Options*. $44.95 for the Levitron plus a well-done 24 minute video. *Do not attempt to use the Levitron without carefully watching the entire video first!* More Levitron theory is in the April 1995 *Physics Teacher*.

**NON-EXCLUSIVE DOMAIN –**

Simply contact your service provider and ask for a name. There is usually no extra charge. Your domain will be in form *yourname@servprov.com* Others can still freely use *yourname*, and your full address *will* have to change when and if you switch service providers.

**EXCLUSIVE DOMAIN –**

First, *http://internic.net* and select their *whois query form* to find out if your intended name is still available. To find out if *yourname.com* is available, enter *whois yourname.com* This will tell you who *yourname.com* is. Or that the name *might* still be available for registration.

Second, email *mailserv@rs.internic.net* and request a domain registration form. Fill in the form and crop the instructions with your word processor. Then return it to *hostmaster@internic.net.*

There is a $100 registration fee for the first two years, then $50 per year afterwards. Your exclusive domain name will be in form *yourname.com* Registration *must* be done online. The process usually takes a few days.

Finally, go to your service provider and request a "pass through" or "direct" access service. An extra monthly premium may be charged.

**FIG. 4**—TWO ROUTES TOWARD your own Internet domain name.

## An antigravity contest

Alas, the Levitron is not very user friendly. It has only a strictly limited stability range. A bare *minimum* of two to three hours of solid practice is required to master its operation. This, of course, is also true for most real magic tricks. Once mastered, though, you levitate nearly every time. And you'll be the only one at the party that can get the beast to work at all—particularly when you add such misdirecting hogwash as "Well, you have to wear an orange shirt."

The Levitron is not at all suitable for smaller children because of its small, edible parts and the frustration involved in mastering it. For this month's contest, show me some modifications to the Levitron which will make it friendlier. A second base *above* the top might help, but this would hurt the illusion. Or we could include some sort of an active electronic feedback network.

Could you gimbal the magnets to automatically level? How can you do this at very low cost? How can that magnetic "stability well" be increased? It's been pretty much proven that two ring magnets producing inverse square repulsive fields can not be forced inherently stable—at least not without serious outside help. But can some tricks be pulled to improve the size, shape, and depth of the stability well? Possibly a lot of tiny magnets in a ring but tilted slightly inward?

Why is it necessary to recalibrate the top's mass? Does the temperature *really* make that much difference? Why? Can calibration be done with a real time base adjustment? Another possibility: If you capture the top inside a covered glass, could there be some way to *reduce* the air pressure in the glass? Even a vacuum of only one-fifth atmospheric might let the top float for a half an hour or more. Could something like a spray bottle pump help here?

To experiment on your own, tops and low cost magnets are available from *Edmund Scientific*. Or else from *American Science & Surplus*. O-rings and washers are available from *Small Parts*. Industrial magnet sources are *Bunting*, *Eriez*, and *Magnet Source*. Big time magnetic instrumentation is offered by *Walker Scientific*. As usual, there'll be copies of my *Incredible Secret Money Machine II* book going to the best dozen entries, along with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all. Be sure to send all of your *written* entries to me here at my

*continued on page 76*

BY CARL J. BERGQUIST

# Experiments With Laser Light

ONE OF THE MAJOR PURPOSES OF THIS MONTH'S COLUMN IS TO INTRODUCE FIRST-TIME LASER ADVENTURERS, AS WELL AS SEASONED EXPERIMENTERS TO SOME THE THOUSANDS OF WAYS THAT LASERS CAN AID,BENEFIT, and even entertain you. Hands on experiments and demonstrations are great ways to display the wonders, and applications of this unique light form. We hope to give you a far better understanding of the laser and to offer many new ideas for it's use. These should give you some ideas of your own and we invite you to share them with us. Send your ideas to *Laser Applications Editor, Electronics Now magazine, 500 Bicounty Boulevard, Farmingdale NY 11735, or via E-mail to lartronics@aol.com.*

## Light beam modulation

The term Modulation is a controlled change of an otherwise constant signal to convey information or data. There are two ways to modulate a laser beam: mechanically and electronically. Let's explore the mechanical methods first, as they produce the most dramatic effects.

If you shine the beam onto a reflective surface that can be moved, the resulting beam traces patterns caused by that movement. One interesting way to do this is to get the surface to move in tandem with speech, music, or other sounds. There are commercially available X-Y modulators and axis generators that do a great job at converting sound to patterns. They sell for $100 and up. An easy and far less expensive approach is to used an old 3- or 4-inch, 8-ohm speaker, together with a 1½- to 2-inch length of flexible spring, and a ¾-inch square of thin but rigid aluminized mylar.

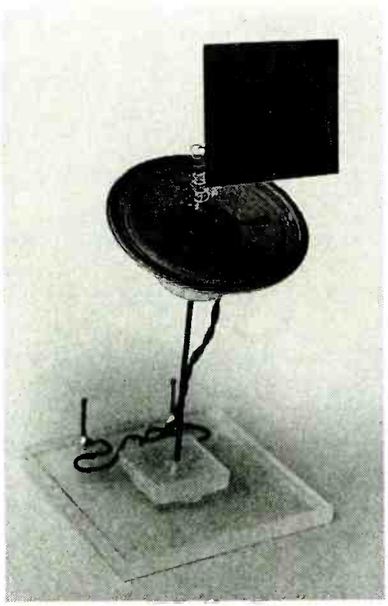


FIG. 1—A SPEAKER MODULATOR using flex-wire for positioning, and a small speaker with cone still intact.

You can use the speaker as is. I did, as you can see in Fig. 1. To reduce the sound output, which you might find disturbing, cut the cone out of the speaker, leaving the frame and the center circle covering the voice coil assembly. Use a dab of epoxy or silicon cement to attach one end of the spring to the center circle of the speaker—the less cement the better. When the cement is dry and the spring is in place, attach a corner or edge of the square of mylar to the loose end of the spring. Then mount the speaker on a stand with a swivel joint so the angle can be set anywhere within a 360-degree pattern, and you have a simple, but effective X-Y axis generator. A close-up photograph of the completed device is in Fig. 1.

To use your axis generator, connect the modified speaker to the output of a stereo, TV, radio, or other sound source. Then direct the angle of the speaker so that a laser beam aimed at the mylar creates a reflection that bounces back

**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.**

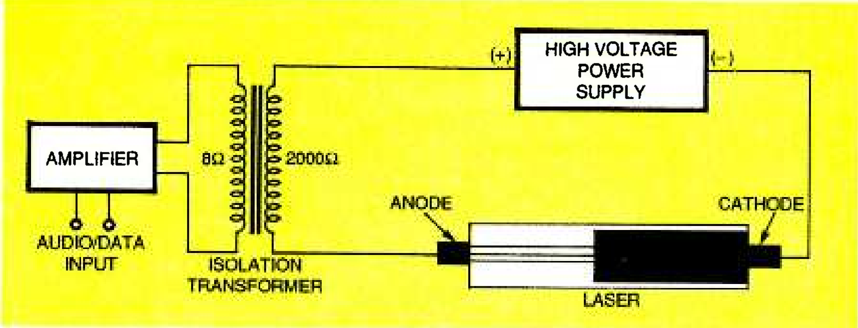



FIG. 2—ELECTRONIC MODULATION of a laser beam can be handled in this fashion. Obviously, the transformer you use must be able to handle the high voltage from the laser power supply without breaking down.

onto the surface you want it to strike—a movie screen, wall or ceiling. Now when music or some other audio signal is fed to the speaker, its center vibrates making the spring and mylar vibrate too. The reflected beam will swirl, circle, trace ovals, elongated shapes, and create broken and pulsating lines and patterns(no two designs ever seem to be quite the same. Viewing this produces hours of fascination and relaxation. Even though you have removed the speaker cone, a bit of the audio will be heard. If you want greater volume, don't cut the cone out. If you want to muffle the sound more, put the speaker assembly into an insulated box and cut a small window for the reflected laser beam.

### HOLOGRAM KITS

**METROLOGIC INSTRUMENTS, INC.**
143 Harding Avenue, P.O.Box 307
Bellmawr, NJ 08031

**MIDWEST LASER PRODUCTS**
P.O.Box 2187
Bridgeview, IL 60455
(708) 460-959524p20

Electronic modulation is the second way to control the output beam. Figure 2 is a block diagram of the setup to vary the intensity of the laser light. The data, sound, or other information to be carried by the beam is fed into the amplifier's input. Its output is connected to the primary of the isolation transformer. The secondary winding is connected in series with the laser's anode lead, between the high-voltage power supply and the laser. The laser's cathode lead remains unchanged. With this arrangement the beam intensity stays constant when there is no modulating signal. When a signal is applied to the amplifier, the impedance of the isolation transformers primary winding changes and in turn, changes the impedance of the secondary. These changes vary the voltage applied to the laser and make the laser beam brighter or darker. In this way any form of information that can be converted into sound energy can be transmitted over the laser beam.

The amount of change is minute and often cannot be seen by the human eye. That's why a receiver consisting of a photosensitive transistor and amplifier is needed to decode the transmitted information. Figure 3 is the schematic of a simple general-purpose audio amplifier to use as either the data input or data decoder. If you don't want to make your own amplifier you can buy a small modular style amplifier package at an electronics distributor. They are self contained, complete with speaker and jacks for input and output.

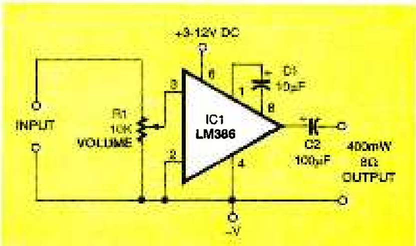



FIG. 3—SIMPLE IC AMPLIFIER for increasing gain of the received signal.

## Light-communications experiments

Once you have both a modulator and a receiver, you can use them to make an efficient "free air" light communications systems. Thanks to the intensity and collimation of the laser beam, these signals can be sent quite a distance, even in bright sunlight.

Beyond the line-of-sight free-air method of transmission, you can try a number of other interesting experiments involving reflecting and receiving laser light. For starters, try aiming the beam at various objects in and around your location. Buildings, windows, automobiles, signs, trees and other plants may amaze you with the variety of reflections they produce. Be sure and try this experiment both during the day and at night, as the results can be quite different. With the help of a friend, you can measure beam divergence or spread at various distances. Make a chart of your measurments and keep it with your laser.

Most 1-mW lasers will project a beam that will reach low clouds, up to about 2,000 feet. At night, the reflection and slight diffusion will create an eerie, almost UFO effect as the clouds move and change shape. Another fascinating observation calls for project-

### TABLE 1—LASER SUPPLIERS

**American Science and Surplus**
3605 Howard Street
Skokie, IL 60076
(708) 982-0870

**Electronics & Computers Surplus City**
1490 West Artesia Blvd.
Gardena, CA 90248
(310) 217-1922

**Electronic Rainbow, Inc.**
6254 LaPas Trail
Indianapolis, IN 46268
(317) 291-7262

**Information Unlimited**
Box 716
Amherst, NH 03031
(603) 673-4730

**Midwest Laser Products**
Box 2187
Bridgeview, IL 60455
(708) 460-9595

**MKW Industries**
1269 Pomona Road
Corona, CA 91720
(800) 356-7714

**Timeline, Inc.**
23605 Telco Avenue
Torrance, CA 90505
(301) 784-5488

## ELECTRONIC SUPPLIES OPTICS - MOTORS - HARDWARE

**ACCORD ELECTRONIC SYSTEMS, INC.**
1001 West Cypress Creek Road, #306-D
Fort Lauderdale, FL 33309
(305) 772-2242

**ALL ELECTRONICS CORPORATION**
P.O. Box 567
Van Nuys, CA 91408
(818) 904-0524

**ALLTRONICS**
2300 Zanker Road
San Jose, CA 95131
(408) 943-9773

**CIRCUIT SPECIALISTS, INC.**
220 South Country Club Drive
Mesa, CA 85210
(800) 528-1417

**D C ELECTRONICS**
P.O. Box 3203
Scottsdale, AZ 85271
(800) 423-0070

**EDMUND SCIENTIFIC**
Barrington, NJ

**ELECTRONIC GOLDMINE**
P.O. Box 5408
Scottsdale, AZ 85261
(602) 451-7454

**EXPRESS PARTS**
340 East First Street
Dayton, OH 45402
(800) 338-0531

**GATEWAY PRODUCTS CORPORATION**
P.O. Box 63-6397
Margate, FL 33063
(305) 974-6864

**GATEWAY ELECTRONICS, INC.**
8123 Page Blvd.
St. Louis, MO 63130
(800) 669-5810

**JDR MICRODEVICES**
1850 South 10th Street
San Jose, CA 95112
(800) 538-5000

**MARK V ELECTRONICS, INC.**
8019 East Slauson Avenue
Montebello, CA 90640
(213) 888-8988

**MONDO-TRONICS (MOTORLESS MOTION)**
524 San Anselmo Avenue, #107-52
San Anselmo, CA 94960
(415) 455-9330

**MOUSER ELECTRONICS**
2401 Highway 287
North Mansfield, TX 76063
(800) 992-9943

**OATLEY ELECTRONICS**
P.O. Box 89
Oatley, Sydney, NSW,
Austrailia 2223
011 61 2 5794985

**OCEAN STATE ELECTRONICS**
P.O. Box 1458
Westerly, RI 02891
(401) 596-3080

**RADIO SHACK**
500 One Tandy Center
Fort Worth, TX 76102

**RESOURCES UN-LTD**
Address not available
(603) 668-2499
FAX: (603) 644-7825

## GLOSSARY

**anode** —The positive (+) connection of a laser tube or diode.

**ambient light**—Existing light in and around a location.

**beam**—The narrow light emission from the anode of a laser.

**beam splitter**—An optical device used to divide the beam of light into two beams. Either prisms or partial mirrors.

**cathode**—The negative (-) connection of a laser tube or diode.

**collimation**—The property of laser light that keeps the beam from spreading out as it moves away from the laser.

**collimator**—A lens, or lens assembly that focuses the light into a beam.

**coherence**—The property of laser light where the beam emitted is largely of one frequency or color. In the case of the Helium-Neon laser, this color is red at 632.9 nm.

**concave**—The shape of a negative lens or mirror that allows for the spread of light. The surface curves inward.

**convex**—The shape of a positive lens or mirror that allows for the concentration of light. The surface curves outward.

**diode**—An electronic device that conducts in one direction only. In some applications, it changes alternating current to a pulsating direct current. The positive side of the diode is the anode, and the negative side the cathode.

**electrode**—A metal contact point for electrical connection as in the anode and cathode of the laser.

**electron**—The negatively charged particles of an atom that orbit the nucleus. It's the action of the particles, jumping back and forth in the orbits, that creates the laser light.

**fiber optic**—Plastic or glass rods that transmit light from one end to the other. Allows for bending of the beam.

**focus**—Also referred to as focal point, it is the distance from a lens, or lens assembly, where the light comes to a point or apex.

**helium**—The elemental, inert gas with atomic number 2 and the symbol He.

**hologram**—A photograph, made with laser light that appears to have three dimensions.

**holography**—The science and technique of producing holograms.

**infrared (IR)**—A form of electromagnetic radiation, between visible red and the microwave range, with a frequency of 780 nm to 100,000 nm.

**laser**—An acronym for Light Amplification by Stimulated Emission of Radiation. This electrical or mechanical device produces a very straight and narrow beam of light, usually visible, of one dominant color.

**nanometer (nm)**—A term used to describe the wavelength of light, it is equal to a $1 \times 10^{-9}$ meter.

**neon**—The elemental, inert gas with atomic number 10 and the symbol Ne.

**optics**—Any device used to control or manipulate light. Usually made of glass or plastic, these include lenses, mirrors, prisms, and filters.

**photon**—A quantum of light emitted by any source.

**population inversion**—The condition when more atoms are in an upper energy level than in a lower one.

**refraction**—The bending of light at the boundry of two surfaces.

**spectrum**—The entire range of electromagnetic energy. When applied to light, and/or lasers, it includes the frequencies from short wave ultraviolet through infrared energy.

**ultraviolet (uv)**—Light, invisible to the eye, from purple up, beginning at about 400 nm.

**visible light**—Electromagnetic radiation, from about 400 nm to 880 nm,

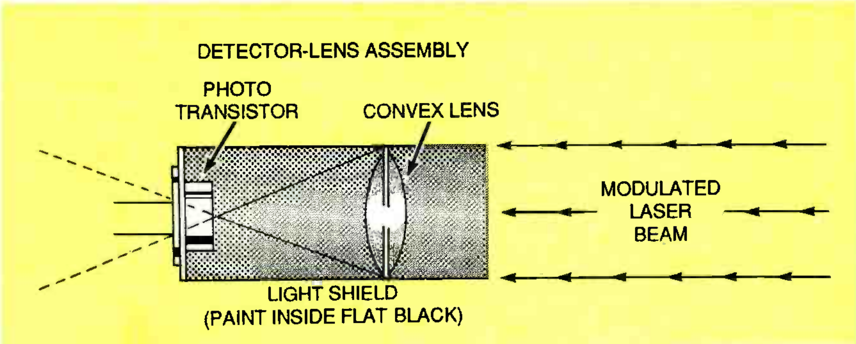



**FIG. 4**—DETECTOR-LENS ASSEMBLY is housed inside a tube that will fit the lens.

### HOLOGRAPHIC SUPPLIES

**AGFA-GAVAERT (FILM TYPE-10E)**
75 275 North Street
Teterboro, NJ 07608

**EASTMAN CHEMICAL PRODUCTS, INC.**
200 South Wilcox Drive
Kingsport, TN 37662
(615) 229-2000

**FREESTYLE PHOTO**
5120 Sunset Blvd.
Los Angeles, CA 90027
(800) 292-6137

**INTEGRAF**
745 North Waukegan Road
Lake Forrest, IL 60045
(312) 234-3756

**NEWPORT CORPORATION**
18235 Mount Baldy Circle
Fountain Valley, CA 92708
(714) 962-7701

ing the beam through rain drops at night. Shining the beam out across a field during a mild rain shower is a very pretty sight, even during daylight. The same applies to fog. With the right angle, the beam will be visible only in the areas where it encounters the fog.

While you bounce the beam off various surfaces, you will probably notice that the light sometimes reflected back towards the source. The intensity of the reflection depends on the surface of the reflector. This property is what makes the next three experiments work. In each one a form of modulation comes into play. Once you can receive a returning beam of varying strength you can transfer information and, at the same time, demonstrate the principle of data transmission via reflector movement.

Because the reflected light is less intense, you will need a more sensitive receiver. You will also need an with considerably higher gain. The detector assembly has to be far more efficient in collecting the returning light and concentrating it on the phototransistor. The problem of light collection/concentration can be solved by using a combination light shield and lens holder (see Fig. 4).

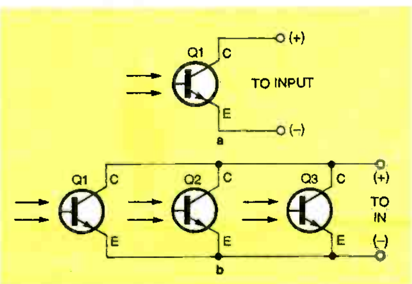



**FIG. 5**—SINGLE PHOTOTRANSISTOR used as laser modulation detector is shown in a. When more sensitivity is needed, multiple phototransistors can be connected as shown in b.

You can make one from either a cardboard, plastic, or metal tube. When properly focused, this lens condenses the collected light into a small spot on the photo-sensitive surface of the detector. If you need more sensitivity, use a cluster of phototransistors wired in parallel. Figure 5 shows how that is done. With the lens focused appropriately, this can be used to increase the photosensitive area. Paint the inside of the tube flat black to reduce ambient light interference. If this still does not adequately increase sensitivity, install a medium-density red filter at the front of the tube. Since the HeNe (Neon Helium) beam is red, it passes through the filter while green and blue light are rejected. This should reduce the ambient light to one third of its strength without the filter.

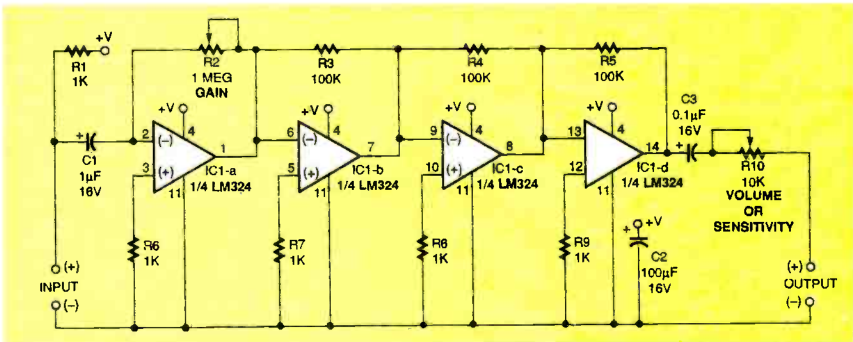



**FIG. 6**—FOUR-STAGE HIGH-GAIN amplifier uses a single LM324 quad amplifier.

The amplifier shown in Fig. 6 is a four-stage, operational amplifier (op-amp) circuit wired in a cascade arrangement. Potentiometer R2 acts as the gain control for the initial amplifier stage. It serves two functions. First it helps set volume. Second it inhibits distortion that might otherwise be caused by excessive gain. By feeding the output of the first stage into the inverting (negative) input of stage two, amplification is increased further. Stages three and four also boost gain. Potentiometer R10 is the final volume control for the signal being fed to the speakers or headphones. The final output can also be connected to a relay or some alarm device. If this is done, R10 acts as a sensitivity control.

Once the detector and amplifier are completed, mount the LM324 circuit in a small project box. Position the detector assembly on the outside so it can be aimed at the returning light beam. The amplifier is powered by a standard 9-volt battery. Mount an on-off toggle switch and an "on" indicator, together with an output jack, on the project box.

You are now ready to start working on some practical projects. EN

BY ED CARYL*

# Making Voltage Measurements with a DSO

BECAUSE THE OSCILLOSCOPE ALLOWS YOU TO ACTUALLY "SEE" WHAT YOU ARE MEASURING, IT IS AN INVALUABLE MEASUREMENT AID AND HAS LONG BEEN A MAINSTAY IN THE ENGINEERING TOOLBOX. TODAY, the digital storage oscilloscope (DSO) will help you make voltage measurements with a higher degree of accuracy and ease than ever before.

## Types of voltage measurements

Voltage can be defined as the electric potential between two points in a circuit. Typically, one of those points is earth ground, that is, zero volts. Two types of voltage measurements—absolute and amplitude—comprise the majority of voltage measurements you will be making with your DSO.

A DC voltage measurement between ground and a second point in the circuit is called an *absolute voltage measurement*. An *amplitude measurement*, conversely, is a peak-to-peak AC voltage measurement on a signal found at the second test point. Both absolute voltage and voltage amplitude measurements use the vertical axis on your oscilloscope display. The instrument's vertical scale control sets the range for voltage measurements.

Voltage amplitude includes both amplitude and peak-to-peak (often abbreviated as "Pk-Pk" or P-P) measurements. Both of these are taken from the waveform top to its bottom. Peak-to-peak measurements include any noise, spikes, or overshoot on the waveform. A scope can be set to ignore those factors if it has a Histogram High-Low setup function. The reference is always the low point on the waveform.

## Voltage measurement applications

You are making *amplitude* measurements if you measure the peak-to-peak ripple on a power supply or the peak-to-peak voltage on an AC motor. If you need to determine the total peak-to-peak voltage at a test point in a logic circuit, or the peak-to-peak voltage developed by a pressure transducer, you also will be making amplitude measurements.

*Absolute* voltage measurements include the maximum (Max), minimum (Min), mean, high, and low measurement of a voltage. Max is

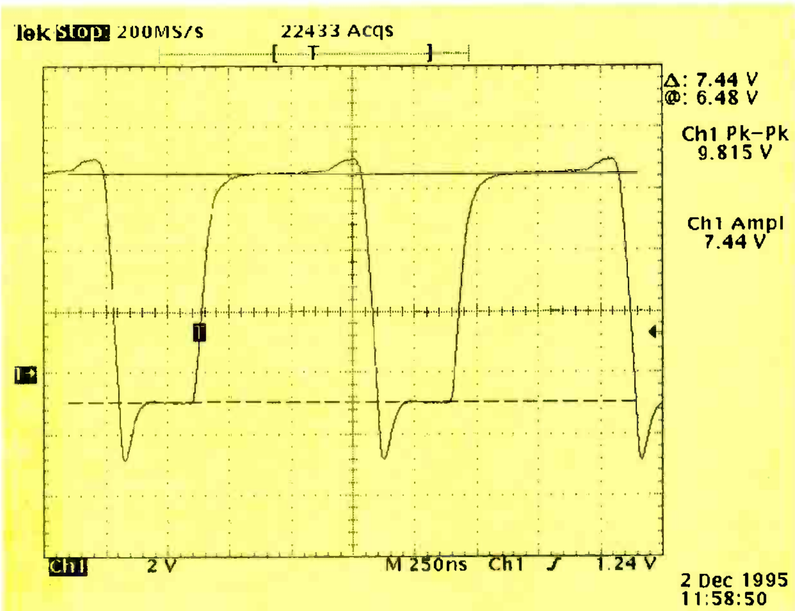



**Fig. 1**—THREE AMPLITUDE AND TWO ABSOLUTE voltage measurements are shown above. The oscilloscope's measurement system has made both a peak-to-peak and an amplitude measurement. For the absolute measurements, the active (@) cursor is making one absolute measurement at the waveform top. Secondly, the peak absolute value can be read from the graticule at about 7 volts (3.5 divisions at 2 volts/division). Earth ground is one division below graticule center, as marked by the 1→ symbol.

*Ed Caryl is an Application Engineer/Product Support Specialist at Tektronix, Inc.

the positive peak voltage, while Min is the negative peak voltage. These measurements are referenced to earth ground.

You would make absolute voltage measurements if you needed to determine, for example, the mean value for a power supply output or the peak start-up current required by an AC motor. You would also use absolute voltage measurements to verify battery voltage or the logic levels in digital logic circuits.

## Three ways to make voltage measurements

There are three ways to measure voltage. First, most DSOs have menu-selectable, *automatic measurement functions* that will make the measurements for you (Figure 1). These measurements are derived directly from waveform data and are the most accurate voltage measurements you can make—if the oscilloscope is set up properly.

To ensure proper setup, you must configure the oscilloscope to provide the highest vertical resolution possible. Select the highest sensitivity, spreading the waveform over the greatest vertical amplitude. The tradeoff, however, is that you lose the ability to know exactly where your measurement is derived from on the waveform.

*Voltage cursors* provide the second measurement method (Figure 1). These measurements are derived from wavefrom data, but are subject to operator error. To achieve accuracy, you must align the cursors with the exact waveform points intended. If your DSO has a zoom function, you can magnify the waveform features to make it easier to place the cursors correctly. Voltage cursors provide the benefit of indicating where your measurement is being made on the waveform.

The third measurement method is aligning the waveform with the displayed graticule markings, then counting divisions, and multiplying the answer by the vertical readout sensitivity. This is the casual *eyeball method* you probably are accustomed to using (Figure 1) when you operate an oscilloscope.

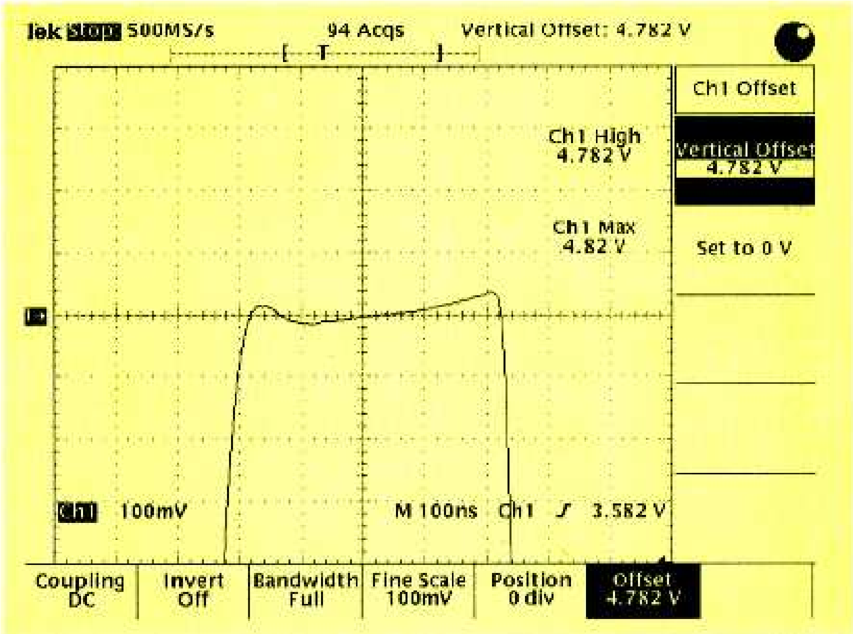



**FIG. 2—** AN ABSOLUTE VOLTAGE MEASUREMENT USING OFFSET is shown above. The offset voltage is the vertical difference between earth ground and graticule center. This has been set to coincide with the High value measured by the oscilloscope measurement system. The Max measurement is reading the peak value. The instrument has a ±2% AC gain error, but using offset, the error specification on these measurements is reduced to ±1.23%.

## Specifications that affect measurement accuracy

There are four oscilloscope specifications that impact voltage measurement accuracy: vertical-gain accuracy, DC-balance accuracy, offset-voltage accuracy, and vertical resolution.

*Vertical-gain accuracy* is typically measured using DC voltages, and thus is usually called "DC-gain accuracy." This is confusing because gain accuracy most affects AC, peak-to-peak, and amplitude measurements. Vertical-gain errors typically come from vertical attenuators, amplifiers, and, in DSOs, from analog-to-digital converters (ADCs).

There are two ways to specify DC gain accuracy: as a full-scale display amplitude percentage, or as a measured value percentage. Most amplitude measurements are made at less than full scale, usually from four to six divisions. If full scale is eight divisions, two percent of full scale equals four percent of four divisions. If the gain accuracy is a measurement error percentage — in other words, a percent of reading— then two percent remains two percent for all measurements.

*DC-balance accuracy* is a factor in all push-pull amplifiers such as those used in oscilloscopes. A push-pull amplifier amplifies a signal that moves both above and below ground or zero potential. DC-balance accuracy is the difference between earth ground and the level that the instrument interprets as earth ground. This specification affects all measurements where ground is the reference, e.g., absolute voltage measurements.

DC balance is quite dependent on temperature, but all oscilloscopes have some way to adjust it. In Tektronix DSOs, for example, DC balance is performed during Signal Path Compensation (SPC). This routine is found in the Utility menu, under Cal (Calibration). It will typically restore DC balance to less than one-tenth division error. If necessary, the remaining error can be quantified by simply grounding the input and examining where the baseline trace falls. If you are routinely making high precision DC measurements, you should run SPC at least once a week.

*Offset* is a precision internal voltage source used to offset a signal level. It can be used to position a small DC signal (such as ripple signals found on power supplies) on-screen to enable amplification and a more accurate measurement of the signal. Offset also can be used as a nulling voltmeter by placing the measured level at the center horizontal graticule line.

*Vertical resolution* is set by the ADC and the acquisition mode. Eight-bit ADCs are the most common. This means there are two-to-eighth-power ($2^8$) voltage levels in the vertical resolution, 256 levels available to represent signal amplitudes. These levels are distributed over either 8 or 10.24 vertical divisions, the total vertical "dynamic range." If signal averaging, HiRes (high resolution), or other signal processing features are used, the vertical memory is extended to 16 bits. The practical limit using these higher resolution techniques is 12 to 13 bits, as set by internal instrument noise.

## Measurement type vs. specification

Some DSO manufacturers lump all of the previously mentioned accuracy components into one specification, usually called "DC accuracy." This practice makes it difficult to design the method of your measurements in order to improve accuracy with special techniques or to determine the real errors.

Vertical gain error and resolution are the only error factors to consider when making amplitude or peak-to-peak measurements. You need not consider offset and DC balance accuracy. If the waveform is repetitive (a requirement of peak-to-peak measurements), use signal averaging to reduce noise. Or, if noise is to be included in the measurement, use peak detect acquisition mode (if available) to detect the noise. If signal averaging is used, only the vertical gain error affects your measurements.

When the signal is single-shot, or if you employ Peak Detect, add the gain error and resolution. The resolution will be plus or minus one digitizing level (DL). An instrument with an eight-bit ADC and 8 divisions dynamic range has 32 DLs per division. The 10.24 divisions of dynamic range in Tektronix DSOs result in 25 DLs per division. The display resolution in Tektronix DSOs is 50 levels-per-division, or 9 bits. Signal-averaged or HiRes waveforms will be displayed at this 9-bit resolution. If your oscilloscope has a zoom feature, you can employ it to see up to 13-bit resolution.

Resolution is the key to precise amplitude measurements. Use all of the DSO's dynamic range possible without clipping the waveform. Then use signal averaging or HiRes mode if your instrument provides this capability.

Absolute voltage measurement accuracy is a combination of gain, DC balance, and offset accuracy. On many DSOs, the accuracy calculation is complex if the measured voltage level is not located at center screen. The accuracy calculation is much simpler if you use the offset control voltage to bring the measured level to the center horizontal graticule line. At this point, only DC balance and offset accuracy are important. The offset control voltage is very precise—plus or minus 0.2 or 0.4 percent in Tektronix instruments. Don't be afraid to overdrive the oscilloscope by running the unmeasured waveform parts off screen (Figure 2).

## Summary

The oscilloscope has more than earned its reputation as an essential tool in the electronics toolbox. As we've seen, the DSO in particular brings many advantages to making voltage measurements, including zoom and automatic measurements. Just remember, for the most accurate amplitude voltage measurements, be sure to use the maximum resolution your DSO provides. Also, take advantage of your oscilloscope's full dynamic range, and, when noise is present, employ the signal averaging or HiRes mode. For absolute voltage measurements, the offset feature will help ensure a higher degree of accuracy. Finally, whenever possible, let the oscilloscope make the measurement with the automatic measurements capability that most DSOs now provide.

*Readers can contact Tektronix by calling 1-800-479-4490, Action Code 300. Additionally, Tektronix maintains a home page at:*

*http://www.tek.com/Measurement.* EN

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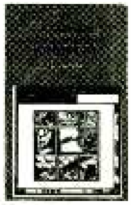

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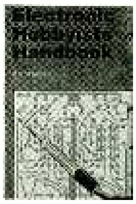

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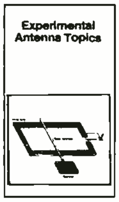


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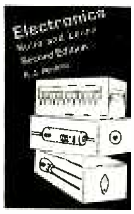


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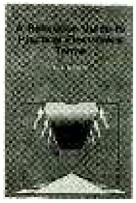

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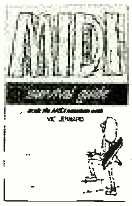


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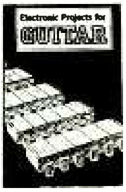


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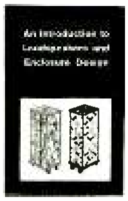

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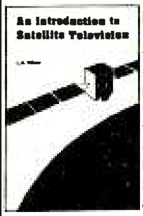

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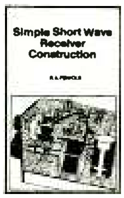


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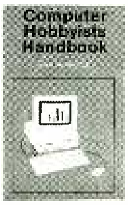


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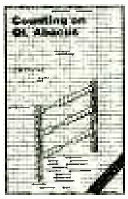

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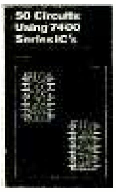

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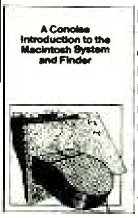


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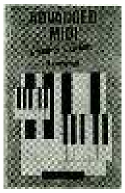

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## L/C METER

*continued from page 32*

It can be seen that the impedance increases with increasing L or Q and decreases with increasing C. Higher impedances develop higher voltages across the tank in the oscillator circuit described above, while lower impedance's develop lower voltages. The maximum value of L is determined by the upper limit of 2.5 volts peak-to-peak while the maximum value of C is determined by the lower limit of 2 to 10 millivolts. For the oscillator described above, these limits are approximately 200 millihenrys and 2.0 microfarads, but they are also a function of the Q of the inductors or capacitors. The L/C meter's top range is specified at 100 millihenrys and 1 microfarad, but values up to the maximum limits mentioned above can usually be measured depending upon their Q. Capacitors must be non-polarized.

### The microcontroller

If the oscillator is the heart of the L/C meter, then IC2, a PIC16C61 microcontroller, is its brain. The PIC16C61 is an advanced version of the familiar PIC16C54 18-pin microcontroller from Microchip Technology. The 16C61 has a 14 bit instruction that allows CALLs and GOTOs to anywhere in its 1024-instruction program memory without the page management overhead of the 16C54. It has 36 bytes of RAM and an eight level deep stack rather than the two level stack of the 16C54. The outputs can sink or source up to 20 milliamperes, allowing it to drive LEDs or, in the case here, a reed relay. It also has interrupts which are not used in L/C meter. Another useful feature is built-in pull-up resistor on the inputs which helps reduce the parts count.

The output of the oscillator is applied to the RTCC REAL-TIME CLOCK COUNTER pin. This increments an 8-bit counter inside the microcontroller. The microcontroller accumulates the count for a period of 0.2 seconds. Discrete signals from the $L_X$, $C_X$, and ZERO switches are input to the microcontroller so it knows what the operator wishes it to do. Seven outputs are used to drive the intelligent LCD display which is operated in its 4-bit (nibble) mode. Four of the outputs are data bits (D4–D7), one is REGISTER SELECT (RS), one is READ/WRITE (R/W) and the last is ENABLE (ENB). One input pin is a jumper which provides two ways to display capacitance values as shown in Table 1.

The jumper-shorted option is for those more inclined toward metric units who want capacitances specified in nanofarads, when appropriate. The jumper-open is for old timers like me, who prefer only picofarads and microfarads. That option has one less digit of resolution in the .0100 to 0.999 range.

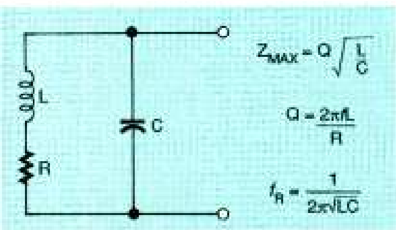
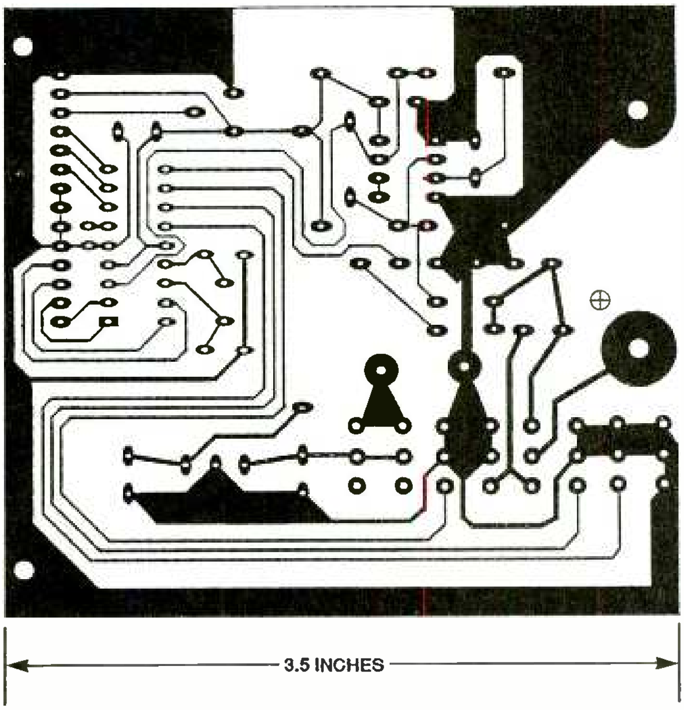



**FIG. 2—THE OSCILLATOR'S OPERATION can be best understood by examining this simplified equivalent circuit of a parallel-resonant tank.**

**TABLE 1—DISPLAY OPTIONS**

| Inductance | Capacitance (jumper shorted) | Capacitance (jumper open) |
|---|---|---|
| 0.000 - 0.999 μH | 0.00 - 0.99 pF | 0.00 -0.99 pF |
| 1.000 - 9.999 μH | 1.00 - 9.99 pF | 1.00 - 9.99 pF |
| 10.00 - 99.99 μH | 10.00 -99.99 pF | 10.00 - 99.99 pF |
| 100.0 - 999.9 μH | 100.0 - 999.9 pF | 100.0 - 999.9 pF |
| 1.000 - 1.999 mH | 1.000 - 9.999 nF | 1000 - 9999 pF |
| 10.00 - 99.99 mH | 10.00 - 99.99 nF | .0100 - .0999 μF |
| 100.0 - 999.9 mH * | 100.0 - 999.9 nF | .1000 - .9999 μF |
| 1.000 - 9.999 H ** | 1.000 - 9.999 μF * | 1.000 - 9.999 μF * |

* Programmed into the computer but some values may be out of range.
** Programmed into the computer but out of range.




**FULL-SIZE L/C METER foil pattern.**

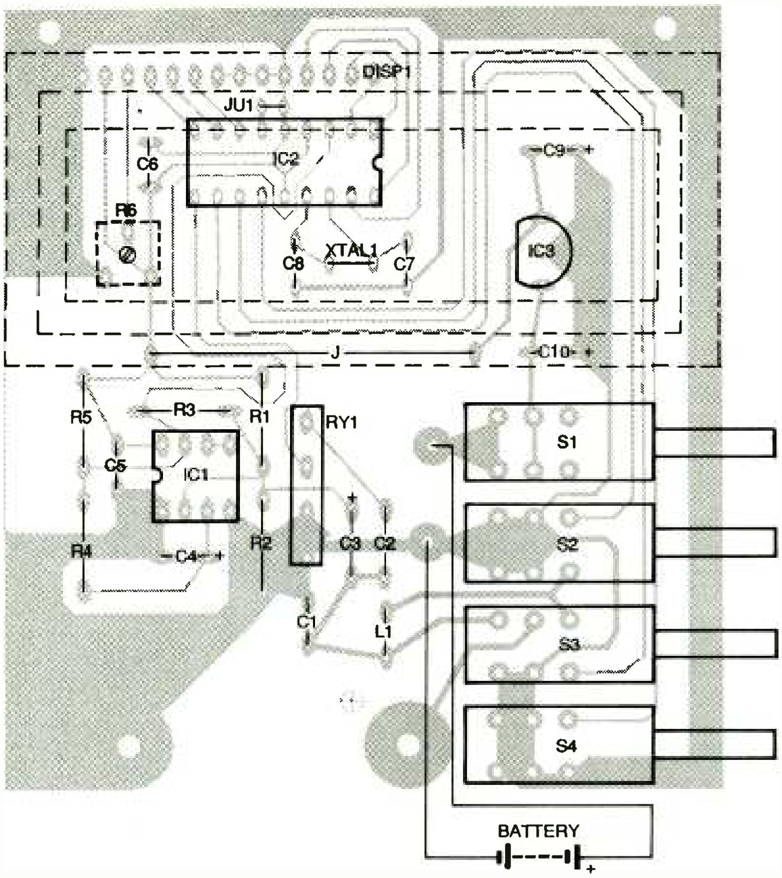



**FIG. 3—PARTS PLACEMENT DIAGRAM. Be sure to mount R6 on the rear of the board so you can adjust the display's contrast after the display is installed.**

## Self-calibrating

One of the truly unique attributes of the L/C meter is that it is self-calibrating. It's really a "put it together and it works" project. That is, if all the parts are in the right place and you do a good job of soldering, then it will work.

During the calibrate cycle the microcontroller first measures $f_1$, the frequency when only L1 and C1 are in the tank circuit. The frequency will be:

$$f_1 = \frac{1}{2\pi\sqrt{L1C1}}$$

This is one equation with two unknowns and therefore cannot be solved for L1 and C1. To obtain another equation, a known capacitor is switched into the tank circuit. The microcontroller raises the CALIB line to a logic high level. This energizes relay RY1, which switches capacitor C2 (a 1000-pF, 1% polystyrene capacitor) into the tank circuit. That causes the frequency to become:

$$f_1 = \frac{1}{2\pi\sqrt{L1(C1+C2)}}$$

The two equations can be solved simultaneously to give:

$$C1 = \frac{f_2^2}{f_1^2 + f_2^2} C2$$

and finally:

$$L1 = \frac{1}{4\pi^2 \quad f_1^2 \quad C1}$$

Because of this self-calibration capability, the exact values of L1 and C1 are not critical and components with tolerance ratings of 10% are used. The accuracy of the device is dependent upon C2 which is a capacitor with a tolerance rating of 1%..

### PARTS LIST

**All fixed resistors are ¼ watt, 5%**
R1, R2, R3—100,000 ohms
R4—47,000 ohms
R5—1000 ohms
R6—10,000 ohms, potentiometer
**Capacitors**
C1—680 pF ceramic disc
C2—1000 pF, 2% (Mouser 140-PF2A102F or equiv.)
C5,C6—0.1 µF, ceramic disc
C3—10 µF, 10 volts, Tantalum
C4,C9,C10—10 µF, 10 volts, electrolytic
C7,C8—20 pF, ceramic disc
**Semiconductors**
IC1—LM311N voltage comparator
IC2—PIC16C61 microcontroller (Microchip Technology)
IC3—78L05 voltage regulator
**Other Components**
XTAL1—4.0 MHz crystal (Digi-Key X006 or equiv.)
L1—68 mH (Mouser 434-1120-680L or equiv.)
RY1—SPST N.O. reed relay (Hamlin HE3621A0500 or equiv.)
DISP—LM-16151 (Digi-Key OP116 or equiv.)
J1—14 pin square post socket (Digi-Key 929974-01-36 or equiv.)
P1—14 pin square post plug (Digi-Key S1022-36 or equiv.)
S1, S2, S3—DPDT alternate action switch (Digi-Key EG1001 or equiv.)
S4—DPDT momentary switch (Digi-Key EG1002 or equiv.)
**Miscellaneous:** case (PacTec HP9VB), 5-way binding posts, hardware.

**Note: The following are available from: Almost All Digital Electronics, 1412 Elm St. S.E., Auburn, WA 98092 (206-351-9316):**
- **Disk containing source and object code: $19.95 (includes free copy of MPASM, PIC assembler, and MPSIM, PIC simulator)**
- **Programmed IC2: $29.95**
- **Hard-to-find parts kit: $49.95 (includes printed-circuit board, all switches with buttons, L1, C1, C2, RLY1 and U2)**
- **Complete kit: $79.95 (includes machined case with panel decal)**
- **Assembled unit: $99.95**

**Include $4.00 shipping and handling per order. Add and additional $4.50 on C.O.D. orders. Washington State residents add 8% sales tax**

## LISTING 1

```
INITIALIZE THE CPU AND I/O PORTS
INITIALIZE THE LCD DISPLAY
WHILE Lx OR Cx are ON
      DISPLAY "SWITCH ERROR"
WEND
(The computer cannot calibrate itself if Lx or Cx are on.  The unit
waits for the operator to clear the switches.)
DISPLAY "WAIT" (wait 10 seconds  for the oscillator to stabilize.)
CALIBRATE:
      DISPLAY "CALIBRATING"
      MEASURE F1
      SWITCH IN THE CALIBRATION CAPACITOR
      MEASURE F2
      SWITCH OUT THE CALIBRATION CAPACITOR
      COMPUTE C1=F2^2 / (F1^2 - F2^2) C2
      COMPUTE L1=1 / (4 p^2 F1^2 C1)
DO (loop continuously)
      IF Lx and Cx are OFF
            IF ZERO
                  GOTO CALIBRATE (re-calibrate the unit)
            ELSE
                  DISPLAY "READY" (ready to measure Lx,Cx,or be ZEROed)
                  MEASURE and STORE F1
            END IF
      ELSEIF Lx ON AND Cx OFF
            MEASURE F2
            IF ZERO ON
                  MEASURE and STORE F1
                  DISPLAY "0.000"
            ELSE (ZERO OFF)
                  COMPUTE Lx=(F1^2 / F2^2 -1) L1
                  DISPLAY "Lx="
                  DISPLAY VALUE in engineering units
            END IF
      ELSEIF Cx ON AND Lx OFF
            MEASURE F2
            IF ZERO ON
                  MEASURE and STORE F1
                  DISPLAY "0.000"
            ELSE (ZERO OFF)
                  COMPUTE Cx=(F1^2 / F2^2 -1) C1
                  DISPLAY "Cx="
                  DISPLAY VALUE in engineering units
            END IF
      ELSE (Lx and Cx both ON)
            DISPLAY "SWITCH ERROR"
      END IF
LOOP
```

The unit can be re-calibrated by pressing ZERO when $L_x$ and $C_x$ are both off. This may be desirable when measuring very small values. In such cases, the unit should be allowed to warm up for about 5 minutes to allow the oscillator to thermally stabilize.

### Making measurements

When the $L_x$ and $C_x$ switches are off, the microcontroller continuously measures $f_1$ to track any drift in frequency. When the $L_x$ switch is depressed, the unknown inductor is placed in series with L1. The total inductance is then $L1 + L_x$. This causes the frequency to change to:

$$f_2 = \frac{1}{2\pi\sqrt{(L1 + L_x)\ C1}}$$

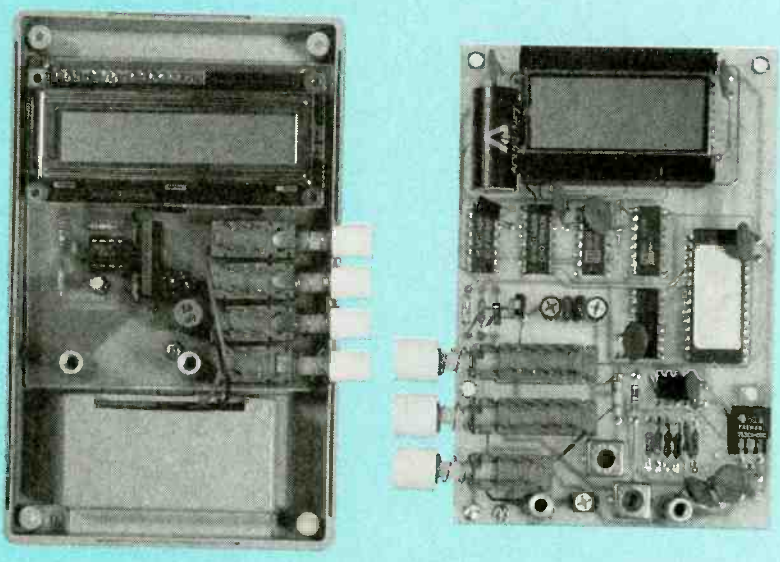
This equation can be solved, simultaneously with the equation for $f_1$ to produce:

$$L_x = \left[\frac{f_1^2}{f_2^2} - 1\right] L1$$

Similarly when the $C_x$ switch is depressed the unknown capacitor is placed in parallel with C1. The total capacitance is then C1 + Cx.

$$f_2 = \frac{1}{2\pi\sqrt{L1\ (C1 + C_x)}}$$

## A DESIGN THAT IMPROVES WITH AGE



**THE NEW L/C METER is shown on the left, mounted in its case. The original version's PC board is shown on the right. Note how the PC board size and complexity have been reduced greatly.**

In July of 1988, *Radio-Electronics* magazine (*Electronics Now's* predecessor) presented the L/C Meter I. It measured inductance and capacitance by detecting the shift in frequency of a oscillator when an unknown is inserted into its tank circuit. At that time it was postulated that a microcontroller would be the best solution to the computation and display of the result. However, there were no inexpensive microcontrollers available back in 1988. Instead a ROM look-up table approach was used.

That was 1988, this is 1996 and the Micochip Technology's series of PIC microcontrollers allows the use of a microcontroller in this version of the L/C Meter. The result is increased resolution and range as well as intelligent display of the result in engineering units. The technique and the oscillator circuit are essentially the same as original L/C Meter, which had 12 ICs and an LCD display. This updated version uses only 3 ICs and features an intelligent LCD display. The original L/C Meter had to be manually calibrated, while the new unit is self-calibrating. Best of all, the new L/C Meter is significantly less expensive than the original. Ω

Which is solved for Cx, with the equation for $f_1$, to produce:

$$C_x = \left[\frac{f_1^2}{f_2^2} - 1\right] C1$$

### Stray inductance and capacitance

The circuit traces on the printed-circuit board, the switches , and the test leads all contribute a small amount of stray inductance ($L_s$) and capacitance ($C_s$). These stray values add to the values of L1 or C1 when the $L_x$ or $C_x$ switches are pressed, slightly affecting the frequency of $f_1$. The unit is zeroed by pressing the ZERO switch, which causes the unit to re-measure $f_1$ with the stray values in the circuit.

To zero $L_s$ the operator must short circuit the test leads, press $L_x$ and then press the ZERO button. Similarly, for capacitors, the operator open circuits the test leads, presses $C_x$ and then presses ZERO.

This zero operation is good until the $L_x$ or $C_x$ switch is turned off. If the $L_x$ or $C_x$ switch is again turned on the unit must be re-zeroed.

### Floating-point math

From all of the above equations it would seem that there is some relatively high-powered math involved and there is. The lower half of program memory in the microcontroller contains a complete 32-bit floating-point math package. The math package includes ADD, SUBTRACT, MULTIPLY and DIVIDE instructions. It also contains conversions from integer to floating-point, floating-point to integer and integer to binary-coded decimal (BCD).

The computer measures frequency by counting the number of oscillator cycles for a period of 0.2 seconds. The result is an integer. This number is converted to floating-point and all calculations are done in floating-point. When the values of $L_x$ or $C_x$ are finally computed, the answer is converted to an integer and then to BCD for display.

The upper half of the microcontroller's program memory contains the functional software which is described in Listing 1 by a pseudo BASIC-like, high-level language.

### Construction

The L/C meter is indeed simple and there is no particular order of assembly. Refer to Fig. 3, the parts-placement diagram. Note that there is only a ⅜-inch space under the display when it's mounted. Leave enough lead length on the taller parts so you can tip them at an angle to reduce their height. Figure 4 is a photograph of the board under the display. Note how the crystal and voltage regulator are installed at an angle.

Start assembly with the resistors. Then solder in the sockets for the IC's, the capacitors, and then the switches. The switch terminals should just barely stick through the printed-circuit board in order for the shafts to line up with the holes in the case. Be careful not to install the switches upside-down. Remove the little tin rivet from under the brass leaf of the ZERO switch only. This converts it from an alternate-action switch to a momentary-contact switch (see Fig. 5.).

Solder P1, the male, square-post header, at the top of the PC board. Install the contrast control, R6, on the back of the printed-circuit board otherwise you will not be able to adjust it with the display installed. Install the two ¾-inch spacers for the test jacks as shown in Fig. 5. This should complete printed-circuit board assembly. Solder J1 to the display unit. A single-sided printed-circuit board is used so don't forget the one jumper wire needed as indicated on the parts layout. Decide which type of capacitor display you prefer. If you prefer to indicate nanofarads, solder jumper wire JU1 as indicated on the parts layout.

Pass the leads from the battery clip through one of the slots in the battery box of the case and solder them to the appropriate pads of the printed-circuit board. Plug in the display and turn on the unit. If you don't see anything on the display, don't panic, try adjusting R6, the contrast control. The unit will display WAIT for 10 seconds followed by CALIBRATING for two seconds followed by READY. If it does, you're up and running. Adjust the contrast control so the background is just barely visible. Install the printed-circuit board in the bottom of the case using three No. 4 sheet metal screws. Install the top cover of the case and install the binding posts as shown in Fig 5. Test leads should not exceed 4 inches in length with a banana plug at one end and alligator clip at the other.

If your finished unit doesn't work, remove the printed-circuit board and carefully inspect to see you have soldered everything that should be soldered, and that you have not created any inadvertent solder bridges. It is very unlikely you will have any problems; however, if you purchased your kit from the source in the parts list they will try to fix it free except for a

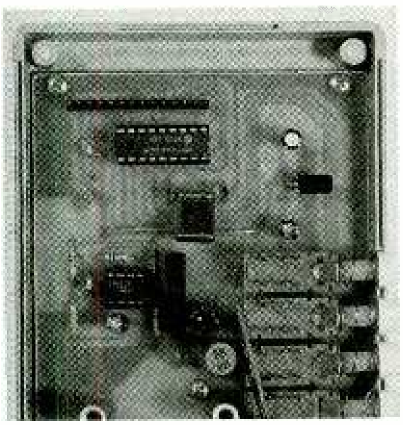


FIG. 4—THE AREA UNDER THE DISPLAY has a maximum clearance of ⅜ inch. Note how the crystal and voltage regulator are tilted to decrease their heights.

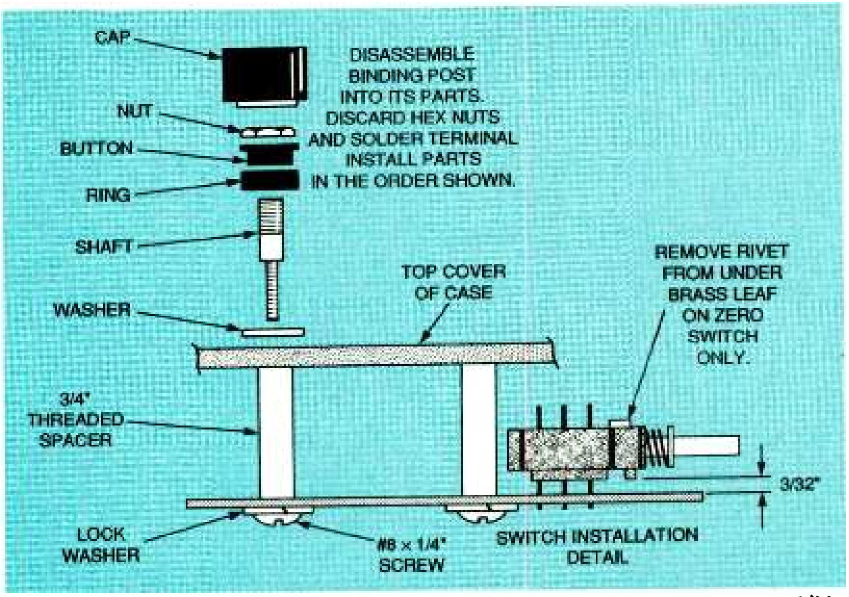



**FIG. 5—MECHANICAL DETAILS. Remove the rivet from the Zero switch to convert it to a momentary-contact switch.**

$4.00 return postage and handling fee.

For those who wish to make their own printed-circuit board a full size PC-board foil pattern is provided. The switches called out in the parts list should fit without problem. When the original L/C Meter was designed, a large volume of surplus switches was obtained. These are supplied with the new L/C meter kits from the source listed at the end of the Parts List. For those with the capability to program their own PIC16C61 the code can be downloaded from the Electronics Now BBS (516-293-2283 N81). Look for LCM.ZIP. The code can also be purchased from the source listed in the parts list and includes a free copy of MPASM, the PIC assembler, and MPSIM, the PIC simulator.

## Operation

The typical stray inductance is .04 to .06 μH and the typical stray capacitance is 5 to 7 pF. When measuring inductors less than 5 μH or capacitances less than 50 pF, it is advisable to zero the unit first. For larger values, the strays are insignificant to the result. It is difficult to retain a reading of 0.000 pF because of the extreme sensitivity of the meter. Your body capacitance influences the reading. Try zeroing the capacitance and then move your hands around the test leads without touching them. You will find you can adjust the reading a few hundredths of a picofarad.

To measure inductance, place the unknown across the test leads and depress $L_X$. The inductor must have DC continuity, or the unit will display NOT AN L. To measure capacitance place the unknown across the test leads and press $C_X$. If the unknown is out of range the unit may break into spurious oscillation and display random or rapidly changing values.

The oscillator tends to drift a few hertz during the first few minutes of operation. When measuring very small values the unit should be allowed to warm up for about five minutes and then re-calibrated and zeroed.

## Accuracy and resolution

The L/C meter accuracy is specified at 3% of reading. This is vastly superior to units specified as percent of full scale. For example a unit on a 1-mH range, specified at 1% of full scale, would have a maximum error of 10 μH which could be as much as a 100% error when measuring a 10 μH inductor. Our L/C meter would have a maximum error of 3% for the 10 μH inductor.

The author measured about

*Continued on page 88*

## WHAT'S NEWS

*continued from page 12*

and Science within the European Strategic Program for Research in Information Technology (ESPRIT) of the European Union.

## 4× digital multilevel storage demonstrated

Information Storage Devices, Inc. (ISD), of San Jose, California, has successfully demonstrated 4× nonvolatile digital storage using a proprietary and patented multilevel storage technology. While traditional digital memory can store only one bit per transistor cell, with ISD's technology it is possible to store four bits of digital data per single memory cell. Such an advancement could lead to substantial cost savings, because 75% fewer memory cells would be required to store a given amount of information. The multilevel technology could play a major role in products for which size, power consumption, and cost are important– for instance, cellular phones, PDAs, fax machines, printers, solid-state film, pagers, and PCMCIA cards.

"The efficiency and cost implications of this technology are significant," said David Angel, ISD's president and CEO. "This development potentially opens up new markets and lower cost points than we previously thought possible."

ISD is contemplating the manufacture of a stand-alone family of 4× nonvolatile digital data storage chips, and is also discussing joint technology and product development with potential partners. The new technology would require no changes to ISD's current manufacturing processes.

## TTL-compatible LMOS logic

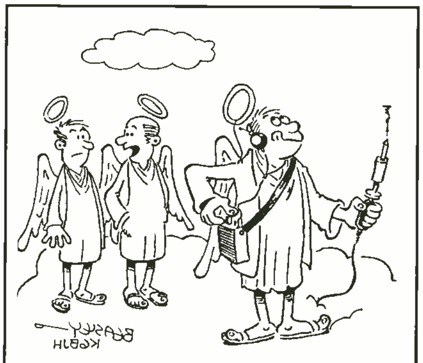
Toshiba America Electronic Components, Inc. (TAEC) has introduced a series of LMOS logic devices that is fully compatible with TTL logic output signals and can be used as a direct interface between a 3-volt to a 5-volt system for mixed power supply logic.

The new devices are offered in small packaging for ease of placement and flexibility of design with PC-board layouts. The super mini 5-pin (SMV), which, at 2.8×2.9mm, occupies 75% less mounting area than an SSOP package. The ultra mini 5-pin (USV), which measures 2.0×2.1 mm, occupies 87% less area.

THE MOVEMENTS OF THE STM TIP are defined by simple mouse clicks on the screen displaying the STM image of the playground. The ring (lower left) marks the starting point of the STM tip; the destination of the pushing process is marked by the cursor arrow.

"The new devices address the needs for a high-speed, low-power-dissipation chip in a small surface-mount package required by portable applications such as notebook computers," said David Lanthier, senior product marketing manager for Toshiba. "TTL LMOS has a typical propagation delay time of 10 nanoseconds and an input leakage current of 1.0 microamperes at 25(C. These features give designers the ability to save on component board space."

Other applications include hand-held, portable, and consumer electronics such as cellular phones, PCs, pagers, LAN networks, disk drives, PC peripherals, and PCN systems. EN



*He's trying to make a D.F. loop out of his.*

## ATV DOWNCONVERTER

*continued from page 38*

The gain for the overall circuit can be adjusted by changing the resistive value for R11 (see Table 1).

The IF amplifier directly feeds a 50 to 75-ohm load. Maximum downconverter IF output is around -2 dBm for 1 dB compression. This is 150 to 200 millivolts into a load of 50 to 75 ohms. Capacitor C18 and R13 provide decoupling of the IF circuits from the regulated 8-volt bus.

The local oscillator output signal is generated by Q5 in a typical Colpitts oscillator circuit. Bias for Q5 is provided by R17 through R21. Resistor R21 and surface-mount bypass capacitors C24 and C25 decouple the local oscillator frequency from the regulated 8-volt DC bus. The resonant circuit for the local oscillator is formed by C21, the internal base- emitter capacitance of Q5, and emitter-to-ground capacitance, stripline Z6, trimmer capacitor C22, and varactor diode D1 in parallel with C23. (Capacitor C23 is *not used* in 1300 MHz version.) The capacitance of varactor D1 is varied by a voltage applied to it via R22 that ranges from 1 to 8-volts DC.

The varactor D1 provides fine tuning of the local oscillator frequency because the setting of trimmer C22 has the major effect on oscillator frequency. Trimmer C22 will change the oscillator frequency by several hundred MHz. When set correctly, C22 sets the local oscillator frequency so that D1 can tune the circuit over the desired range. This will be a bandwidth of about 30 MHz for the 900 MHz downconverter, and 60 MHz for the 1300-MHz version.

Voltage for D1 is fed through isolating resistor R22 from either of two sources. The first source is the on-board tuning potentiometer R24, whose wiper provides 1 to 8 volts DC. Resistor R25, connected to the ground side of potentiometer R24, sets the low-voltage limit to about 1 volt. Diode D2 acts as half of a logical OR gate, and R23 and C26 provide a pull- down to ground and RF bypassing for the varactor tuning voltage. The second source is a tuning voltage derived from a remote-tuning setup.

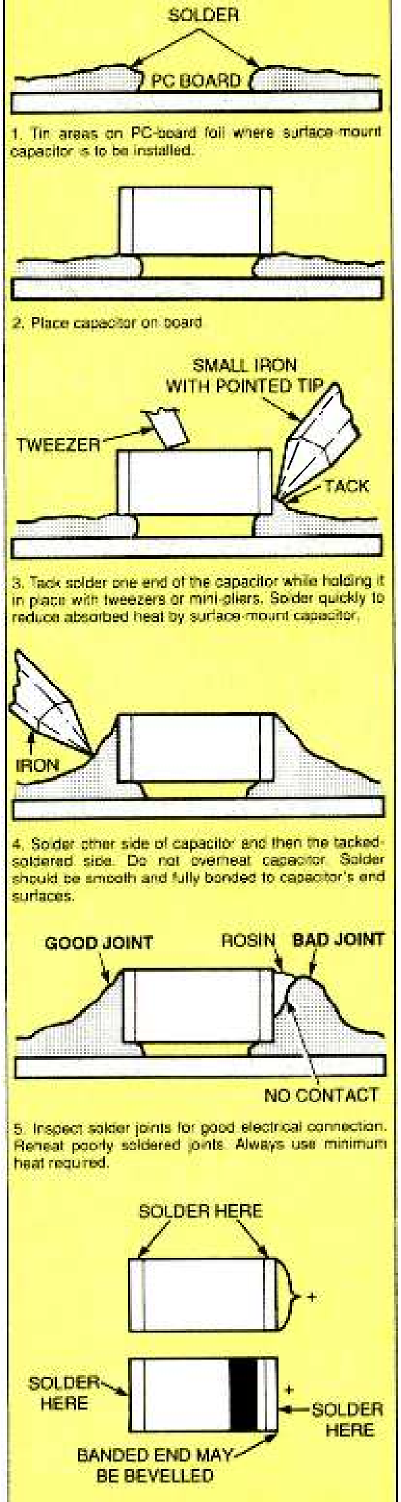
### Remote tuning

Remote tuning is an important feature of the downconverter because it allows the unit to be mounted directly at the antenna feed point, thus eliminating a coaxial feedline for 900-MHz signals. Feedlines have high losses at this frequency unless they are special, expensive types. Even then, losses are still high for long cable runs. For example, a good quality, expensive ($60 to $80 per 100 feet) coax feed-line such as 9913 has a loss of 5-dB per 100 feet of cable at 1000 MHz. The output of the downconverter can be fed via an inexpensive coaxial cable (such as the RG59 or RG66), which has an attenuation of about 2 dB per 100 feet at the output frequency and costs about $15 per 100 feet.

A DC Block Unit (see Fig. 3) allows a variable tuning voltage to be added into the IF coaxial feed-line to power and tune the downconverter. This voltage should vary from 10 to 20 volts DC to properly remote tune the downconverter. Capacitor C19 (Fig. 2) blocks this DC but passes the IF signal from Q4. Inductor L3 passes DC (only 10-ohms DC resistance) but blocks the IF signal because it has a very high impedance at 60 MHz. The input of 10 to 20-volts DC is passed to voltage regulator IC1 via blocking diode D7 (Fig. 2). Voltage regulator IC1 supplies +8-volts DC to the downconverter circuitry, insensitive to the 10 to 20-volt variation of the input DC voltage.

The 10 to 20-volts DC input is also supplied to Zener diode D6 and diode D5, dropping 9 volts across these diodes, resulting in 1 to 11-volts DC across pull-down resistor R27. Resistor R6 and clamp diode D4 limit the voltage at the input of D3 to 1 to 9 volts. This results in about 0.3 to 8.3 volts DC across R23 and C26. This voltage is fed to varactor D1 via R22 for tuning. As the DC voltage on the IF cable varies from 10 to 20 volts, the converter is both powered and tuned over its frequency range. If oper-

HOW TO INSTALL SURFACE-MOUNT CAPACITORS




1. Tin areas on PC-board foil where surface-mount capacitor is to be installed.

2. Place capacitor on board.

3. Tack solder one end of the capacitor while holding it in place with tweezers or mini-pliers. Solder quickly to reduce absorbed heat by surface-mount capacitor.

4. Solder other side of capacitor and then the tacked-soldered side. Do not overheat capacitor. Solder should be smooth and fully bonded to capacitor's end surfaces.

5. Inspect solder joints for good electrical connection. Reheat poorly soldered joints. Always use minimum heat required.

NOTE: Observe that polarized surface-mount capacitors are marked in one of two ways.

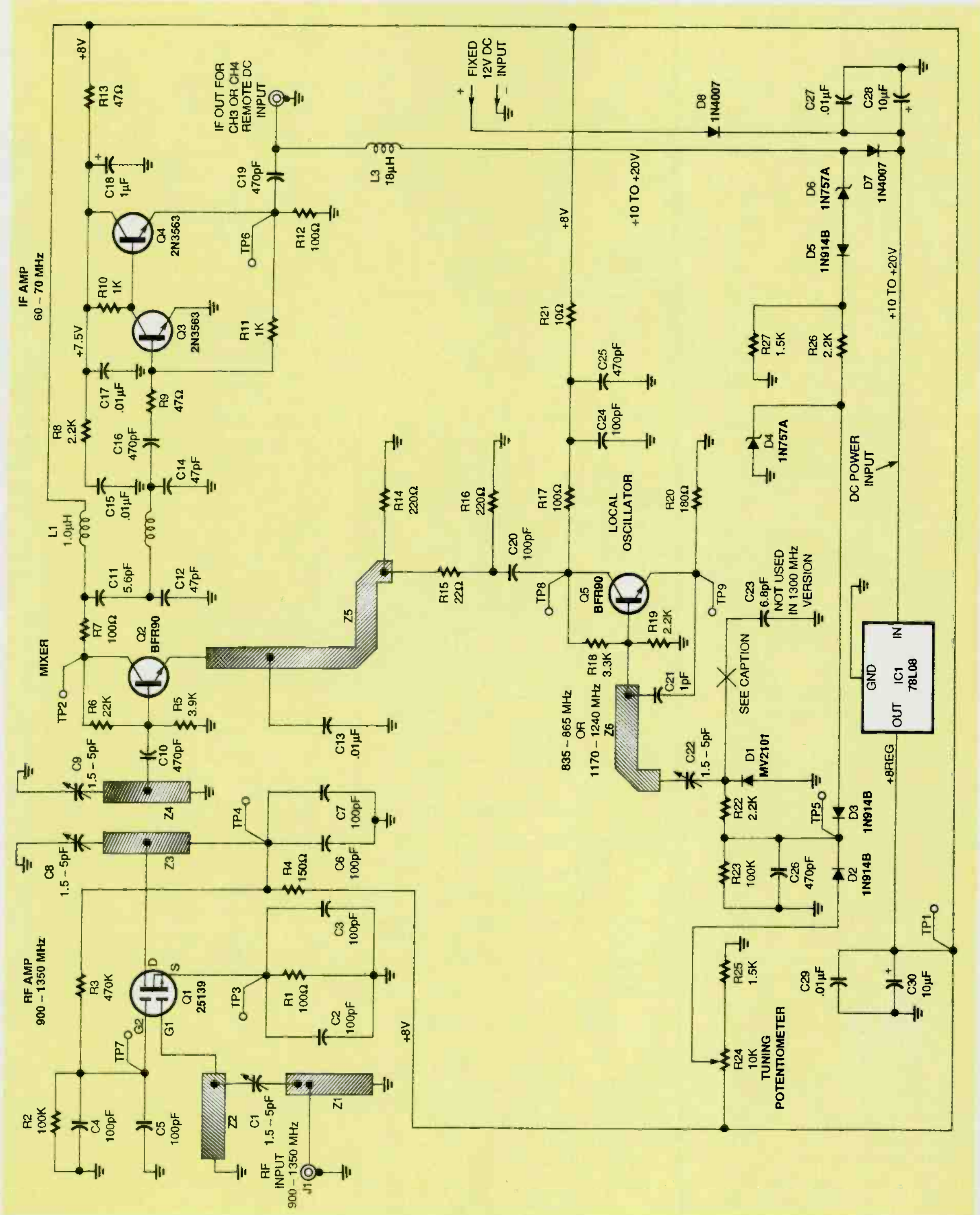



FIG. 2—SCHEMATIC DIAGRAM for the downconverter covers both the 900-MHz and 1300-MHz versions. Aside from slight foil modifications, the only difference is the elimination of C23 in the 1300-MHz version.

ation from a fixed DC power supply (11 to 15 V) is desired, the converter is powered with 12-volts DC via the DC input and blocking diode D8. In this case, tuning is done with the on-board tuning potentiometer, R24, and the DC Block unit is not needed.

When remote tuning is used, tuning potentiometer R24 must be set at its extreme counterclockwise position to set the voltage at the wiper to its lowest DC potential. All or part of the downconverter tuning range won't be obtained with R24 in any other position.

### Clean power supply

Any hum or noise on the tuning voltage from an external power supply will modulate the local-oscillator frequency, thereby frequency modulating the IF signal. This effect is most degrading for the 1300-MHz model, where the tuning sen-

TABLE 1—TROUBLESHOOTING VOLTAGES AT TEST POINTS

| Test Point Location | Volts DC | Localized Trouble Area |
|---|---|---|
| Junction of D8, IC2 | +11.4 | D8 |
| Junction of IC1, C30 (TP1) | +7.6 to 8.4 | IC1 |
| Junction of R4, C6, C7, Z2 (TP4) | +6.2 to +7.2 | Q1, R4, C6, C7 |
| Junction of R1, C2, C3 | (TP3) | +0.5 to +1.2 Q1, R1, C2, C3 |
| Junction of R2, R3, C3, C4 (TP7) | +1.0 to +1.4 | Q1, R2, R3, C4, C5 |
| Collector Q2 (TP2) | +5.5 to 7.2 | Q2, R5, R6, R7, R8, R13, R14, R15, R16, L1, C11, C15, C17, C18 |
| Junction of D2, D3, C26 (TP5) | 0.5 to >+7.0 as R24 is rotated | D1, R24, R25, D2, D3, R23, R22 |
| Collector Q5 (TP8) | +6.5 to +7.2 | R21,M C24, C25, Q5, C20, R18, R19, R20 |
| Emitter Q4 | +0.8 to +1.0 | Q3, R10, R11, R12, C16, C19 |
| Base Q4 | 0.7 volts more than base of Q3 | Q3, R10, R11, R12, C16, C19 |

*Check all transistors and IC's for correct installation. Check diodes and electrolytic capacitors for correct polarized installation.

sitivity of the local oscillator is 10 MHz per volt of tuning voltage. Just 1 mV of hum will result in 10 kHz of frequency deviation. For FMTV use, this will be noticeable as video hum bars in the received picture. AM signals will be less susceptible to hum and noise from the power supply.

This power supply defect should not be tolerated because it is easy to build a *clean* external power supply from inexpensive readily available voltage regulator ICs.

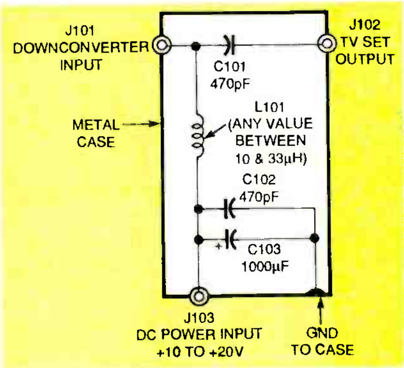



FIG. 3—DC BLOCK UNIT is required at the TV receiver or monitor site when remote tuning the downconverter.

## Pre-construction details

Do not substitute parts specified in the Parts List or change the PC-board layout should you etch a PC board from the patterns shown.

Use good lighting while assembling parts on both sides of the 2.5 × 4-inch PC board. A magnifier lens is necessary because the parts are too small to check for markings and solder joints are too minuscule to inspect with the naked eye.

All trimmer capacitors and grounded leads of resistors

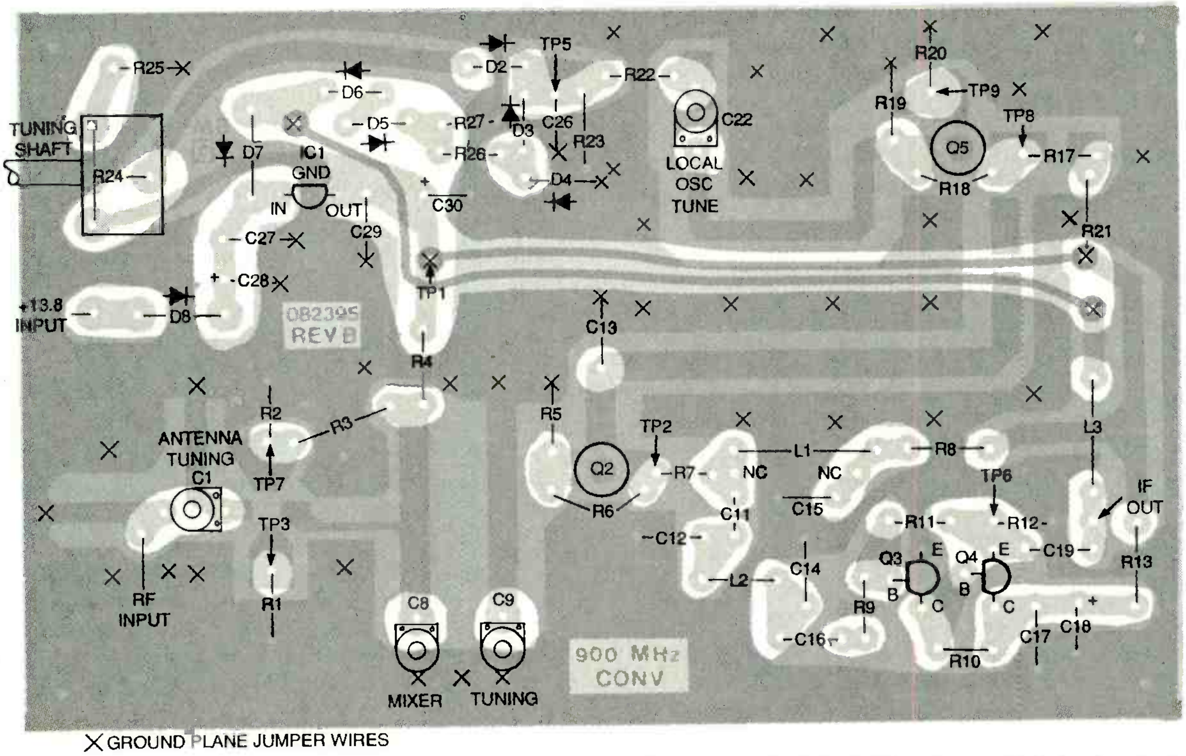
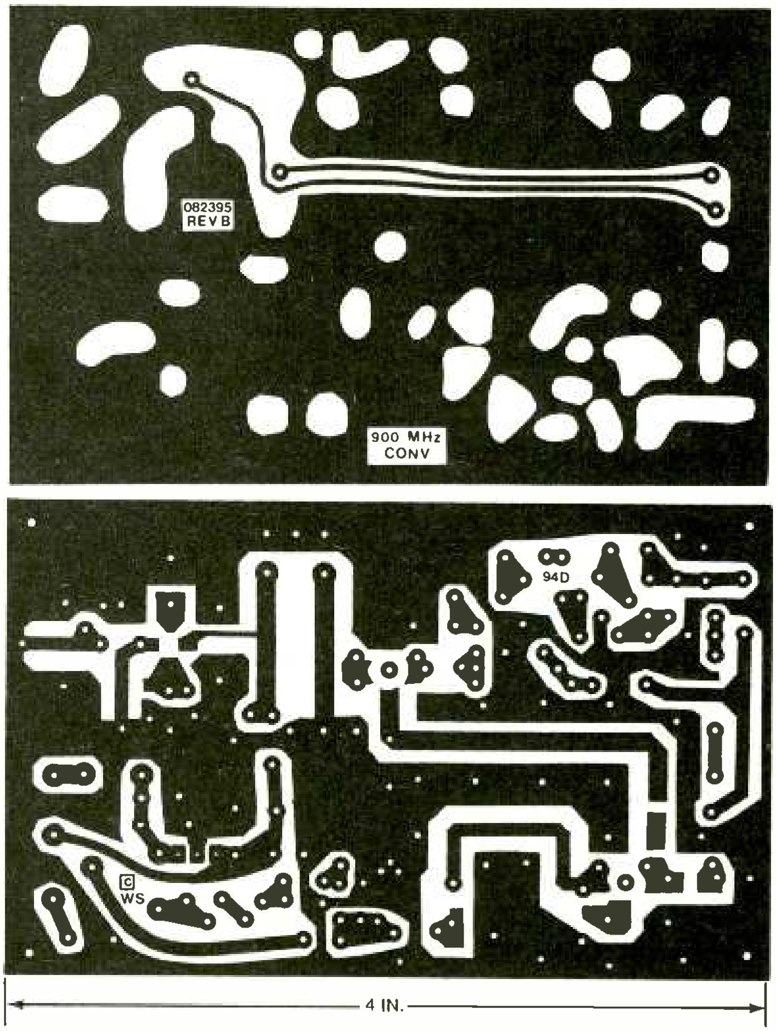



FIG. 4—TOP SIDE OF PC BOARD for the 900-MHz downconverter is shown with parts locations identified. Be sure to install all ground jumpers where indicated and solder to both sides of the PC board.

## FOIL DIAGRAMS FOR THE DOWNCONVERTER 900-MHz AND 1300-MHz MODELS

While it is possible to design the same printed-circuit board foil pattern for both Downconverter models (since the frequencies differ by 350 MHz), compromises are necessary in the RF microstrip elements which would result in performance sacrifice in RF gain and tuning rate. Therefore, individual foil patterns were designed for each model. The 900-MHz model can be re-tuned to cover up to about 1100 MHz, and the 1300-MHz model will cover about 1150 to 1450-MHz (in 60-MHz segments) for other applications, with almost the same performance. The IF output frequency can be changed to anywhere between 40 and 100 MHz by changing one component and shifting the local oscillator frequency as required. The foil patterns provided are actual size and can be copied.

Starting in the upper-left corner and proceeding clockwise, the foil patters are: 900-MHz top, 1300-MHz top, 1300-MHz bottom, and 900-MHz bottom. The PC boards are all the same size—4 X 2.5 inches.




must be soldered on both sides of the foils on the PC board. This is good RF grounding practice. Also, there are many ground-plane jumpers (approximately 3 dozen) that must be soldered in place, because the commercially available PC boards are not plated through, and plated-through PC boards cannot be made at home.

Do not solder any parts to the PC board until as many components as possible are inserted. Coils L1 through L3 are installed after all other components are inserted. Mount all parts tight and close to the board. Projects in the microwave frequency region require *zero-lead lengths* for parts in the RF circuit sections.

### Start construction

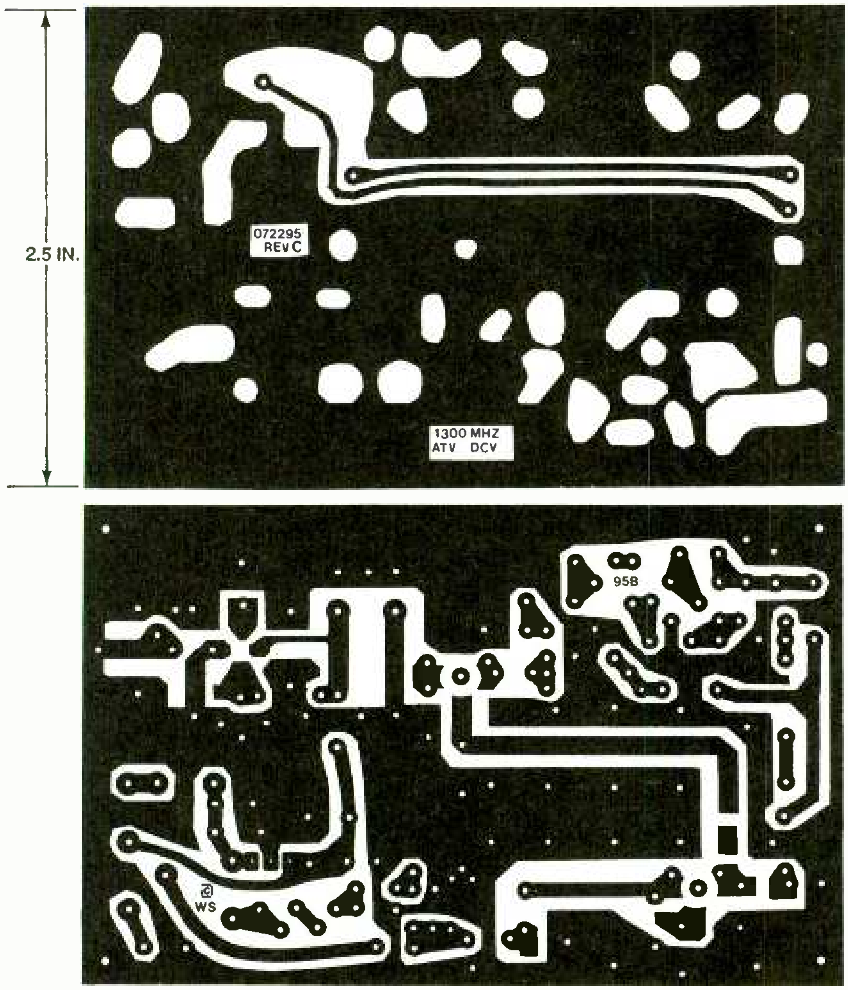
Begin construction by inserting all trimmer capacitors in

### PARTS LIST

**All resistors are ⅛-watt, 5% unless otherwise specified**
R1, R7, R12, R17—100 ohms
R2, R23—100,000 ohms
R3—470,000 ohms
R4—150 ohms
R5—3,900 ohms
R6—22,000 ohms
R8, R19, R22, R26—2,200 ohms
R9, R13—47 ohms
R10, R11—1000 ohms
R14, R16—220 ohms, surface-mount
R15—2 ohms, surface-mount
R18—3,300 ohms
R20—180 ohms
R21—10 ohms
R24—10,000-ohms potentiometer
R25, R27—1,500 ohms

**Capacitors**
C1, C8, C9, C22–1.5-5 pF trimmer, PC mount
C2–C7, C20, C24—100 pF, surface-mount
C10, C25—470 pF, surface-mount
C11—5.6 pF, NPO
C12, C14—47 pF, NPO
C13, C15, C17, C27, C29—0.01 µF, GMV disk, 50-volt
C16, C19, C26—470 pF, GMV disk, 50-volts
C18—1.0 µF, 35-volt electrolytic
C21—1 pF, surface-mount
*C23–6.8 pF, surface-mount
C28, C30—10 µF, 25-volt, electrolytic
*Used in 900 MHz downconverter only

**Semiconductors**
D1—MMBV2101T1 (Motorola) varactor, 6.8 pF at 4 volts, surface-mount
D2, D3, D5—1N914B, fast-switching diode




the PC board. See Fig. 4. Solder trimmer rotor terminals to the top side of the PC board. Be careful not to melt the plastic. Do not solder the bottom foil at this time.

Mount all ⅛-watt resistors. Only solder the top of the PC board where resistor lead passes through the ground foil. Solder as many as you can. Do not solder the bottom foil yet. Surface-mount resistors will be installed later. Install tuning potentiometer R24. Leave the thumbwheel of R24 in the center-rotation position.

Install the fixed capacitors. If any come with pre-formed leads, straighten the leads with pliers so the capacitor can fit as close to PC board as possible. Pull the leads through board so capacitor bodies are tight to PC board. Watch polarity of all electrolytic capacitors. Confirm that the capacitor values are correct prior to soldering them in place.

Do not install any of the surface-mount components yet. Install all transistors and diodes, except Q1 (25139) which will be installed later. See Figs. 4 and 5. Check polarized parts for correct orientation. All TO-92 transistors should be ⅛ inch from

D4, D6—1N757A, 9.1-V, 0.5-watt, Zener diode
D7, D8—1N4007, 1000-V, 2.5 A, rectifier,
Q1—NE25139 (California Eastern Labs.) low-noise, dual-gate RF-amplifier
Q2, Q5—BFR90, npn, low-noise, UHF amplifier, MESFET
Q3, Q4—2N3563, npn, RF/IF/Video bipolar
IC1—78L08, positive voltage regulator

**Coils and Chokes**

L1—RF choke, 1 µH, ±5%
L2—Fabricated coil (see text)
L3—RF choke, 18 µH with less than 10-ohms resistance

**Miscellaneous**

J1, J2—See text
1—Plastic shaft extension for R24
1—Length of #22 enameled, solid copper wire
1—Machine screw, #8-32, binding head
1—PC board for 900-MHz or 1300-MHz downconverter

**DC BLOCK UNIT (OPTIONAL)**

C101, C102—470 pF, disc ceramic, 50-volts
C103—1000 µF, 25-volts, electrolytic
J101, J102—Type F connectors, female, chassis mount
J103—DC power connector that can be shielded, 2.5 mm or RCA phono, female chassis mount
L101—Any value from 10 to 33 µH, less than 10-ohms DC resistance
1—Metal enclosure, RF tight

A complete parts kit for the 900-MHz or 1300-MHz downconverter, consisting of the PC board and all parts that mount on it, is available from: North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804. The 900- MHz model sells for $39.00, 1300-MHz sells for $41.00. Both models: $76.50 (must be ordered at same time). Please add $4.50 for postage and handling for one unit or $5.50 for both units. New York residents must include local NY sales tax. Be sure to specify which model (900 or 1300 MHz) you are ordering. Parts for optional DC Block Unit are not included in this kit.

A catalog containing information on transmitters, downconverters, video cameras and lenses, and a number of other kits and electronic projects is available from the above address. Please send SASE (75-cents postage) and $1.00 to cover handling and mailing (refundable with order).

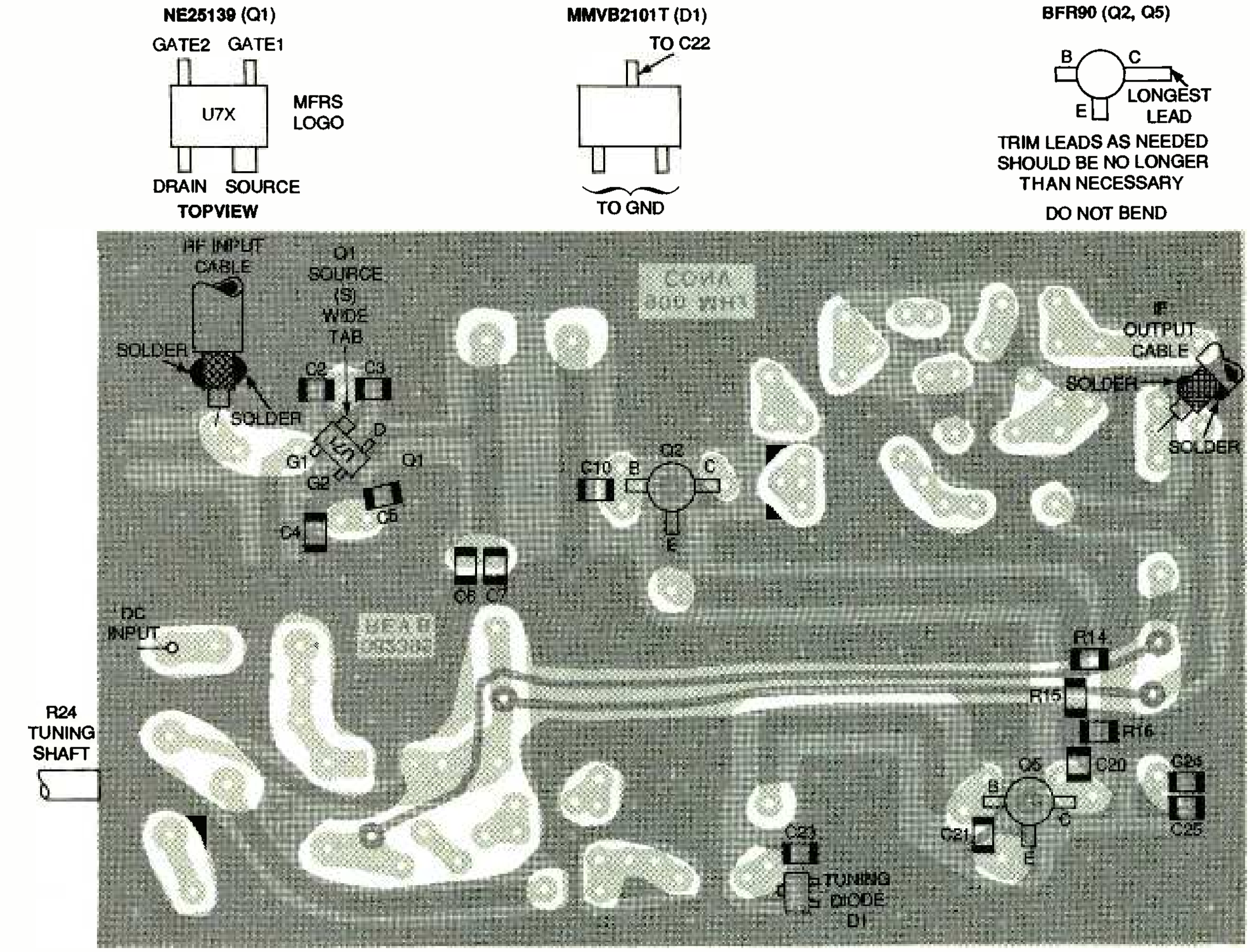



FIG. 5—BOTTOM SIDE OF PC BOARD for the 900-MHz downconverter is shown with parts locations identified. Cable lengths should be just long enough to provide suitable length when PC board is installed in a metal case.

the surface of board. Solder the emitter lead of Q3 to the top of the PC board where it passes through ground foil. Install voltage regulator IC1 and check its lead orientation. The flat end should face the edge of the PC board.

Check all work done so far for accuracy and orientation of components. Trim all component leads close to the PC board. Solder all bottom foil connections. (Do not plug any unused holes with solder.) Carefully fabricate L2 (see Fig. 6) and install in the PC board. Use an 8-32 screw as a tool to hold L2 during installation. After installing L2, remove screw by unthreading it from the coil. Coat L2 with clear lacquer, Duco cement, or clear nail polish.

Use left-over lead clippings or bare, solid, tinned wire to install ground plane jumpers in *all* open positions (see Fig. 4)—*this is very important*. Install a 1-inch length of bare tinned wire in +12v connecting hole near D8 to serve as a terminal. Place a piece of sleeving over it to avoid short circuits and make a small hook at the wire's end.

Install all surface-mount capacitors, as shown in Fig. 5, on the *bottom* foil of the PC board. Refer to detailed surface-mount instructions in sidebar *How to Install Surface-Mount Capacitors*. After installing all surface-mount capacitors, avoid flexing the PC board, which might crack the surface-mount capacitors.

Install the surface-mount resistors R14, 15, and 16 the same way as surface-mount capacitors (see Fig. 5). Resistors R14 and R16 are marked 221 (220 ohms) and R15 is marked 220 (22 ohms). Install the resistors with the marked side facing up from PC board so the markings are seen. Check the resistive values with an ohmmeter or DVM before installation.

Install Q1 as shown in Fig. 5. The thicker lead is the source (S) lead. Handle Q1 carefully; it is sensitive to electrostatic discharge (ESD). Check the orientation of Q1's leads before soldering in place. Then, install D1. The side of D1 with two leads is the ground side.

### Tune-up and checkout procedures

The downconverter is aligned by peaking for maximum received signal. There is no tricky alignment procedure or specialized RF test gear necessary for good results and performance from the downconverter.

The successful tune-up of the downconverter requires either a known signal in the 900 or 1300 MHz band to act as a reference and tune-up aid, or access to a frequency counter and a signal generator covering this range. A sweep generator is excellent if you can obtain the use of one. If you have an ATV transmitter, it can be used as a signal source—but remember to use a dummy antenna and keep the transmitter at some distance to prevent overloading the downconverter. You will need a suitable TV receiver or monitor tuned to either VHF channel 3 or 4, (an old B/W portable TV will do), a variable power supply supplying 10 to 20-volts DC at 40 milliamperes or more (preferably one with a built-in voltage and current metering), a DMM, and clip leads and cables as needed. If you cannot obtain these items, find someone to help you. A frequency counter that is reliable to at least 100 MHz higher than the downconverter receiving frequency is a great help in setting up the local oscillator and finding out where you are during tune-up.

First, carefully check your work for accuracy, component placement, and correct orientation, and poor solder connections. Make sure that surface-mount capacitors are correctly installed—a malfunction can destroy the gain of a stage. Also check for inadvertent solder bridges. When you are sure everything is OK, connect a DC source to the 12-volt input (D8 and ground). Ground is negative. No damage will occur should the power supply be accidentally reversed. Note the current drawn from the power supply. It should be around 35±5 milliamperes. If higher than 40 milliamperes, check for possible short circuits. If lower than 30 mA, something may be open or missing.

**Voltages checks**

Refer to schematic diagram (Fig. 2) and parts layout diagrams (Figs. 4 and 5) so that you fully understand the circuit portions that will be tested. Unless specifically stated, the negative meter lead shall be grounded to negative terminal of power supply when making voltage measurements. If voltage discrepancies are noted, check the components indicated in Table 1 (page 69) for faults. Slight variations outside specified voltage limits specified may be ignored if component checks do not reveal anything wrong. If you experienced some deviation from the voltages measured but were not too far off, the downconverter may be OK, but remember and record these slight voltage deviations should any further problems be encountered. If trouble is experienced at a later step with that particular circuit, further investigation may be needed. Remember that the 8-volt on-board regulator has a 5% tolerance and this will affect all other readings. Also, your DMM could be a few percent in error as well.

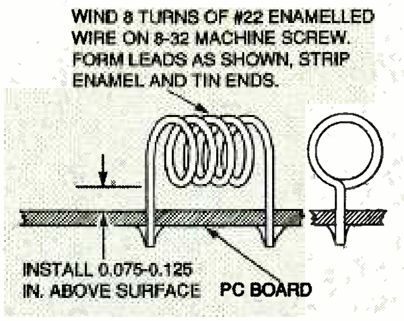



FIG. 6—COIL L2 FORMING and installation details. Wind 8 turns on 8-32 machine screw to form coil L2. Do not remove screw until after installation on PC board.

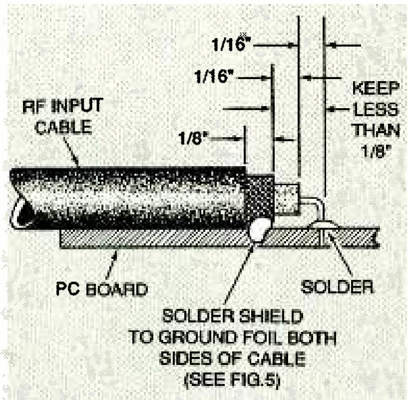



FIG. 7—INSTALLATION of RF input cable is critical. Keep recommended dimentions equal to or less than given in diagram, otherwise excessive losses will occur.

1. Set the thumbwheel of R24 at its approximate center position, and set C22 so its plates are about ¼ meshed. Now measure the voltage at the base of Q2. Using a non metallic tool, slowly rotate trimmer C22. There should be some perceptible voltage change at base of Q2 as C22 is rotated from minimum to maximum and back. Touching a metallic screwdriver blade to the stripline Z6 should also produce some change in this reading if Q5 is oscillating. A change of 0.01 volt or more is about what you will see if all is OK. This confirms that the local oscillator circuit is oscillating and that the mixer is getting a RF signal from the local oscillator.

2. Check that no part is getting hot.

3. If steps 1 and 2 are successful, connect the positive lead from a variable-voltage supply to junction C19 and L3, and connect the negative lead to ground. Set the wiper of R24 at ground (extreme counterclockwise rotation as viewed from shaft side). Set the power supply to +11 volts. Check for following voltages:

- At TP1 a voltmeter should indicate +7.6 to +8.4-volts DC as measured before in step 1. If not OK, check L3, D7, C27, and C28.
- At TP5 a voltmeter should indicate less than +1.2-volts DC. If not OK, check D6, D5, R27, R26, D4, and D3.

4. Increase the power supply voltage to 19 or 20-volts DC. Repeat step 3. The reading at TP1 should still read the same, however TP5 should be about +9-volts DC. If not, check all components mentioned in step 3. Steps 3 and 4 check out the remote tuning circuitry. If OK, proceed with the alignment in next step.

5. Connect the center conductor of a 75-ohm coaxial cable to the junction of C19 and L3 and the shield braid to ground as shown in Fig. 5. Terminate the end of the cable to J2, a connector suitable for your TV or monitor. (This is generally a type F connector.) Tune the TV to channel 3 or 4— whichever is unused in your area—and set its controls for normal reception. If you have a sensitive RF millivoltmeter, use it as an output indicator instead of a TV

set. The meter is easier to interpret.

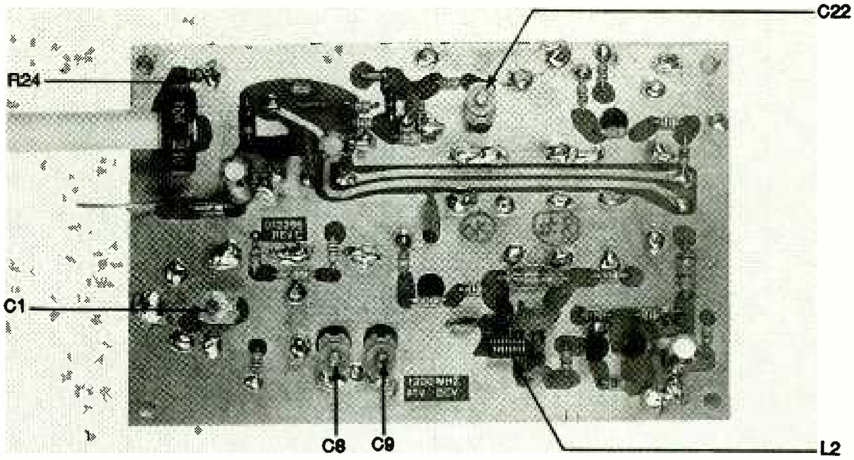
Connect a suitable signal source to J1, the downconverter input. Use 50- ohm low-loss cable and keep connections *short*. Refer to Figs. 5 and 7 for cable installation dimensions that are critical. The signal source can be either a generator or antenna. Preset all trimmer capacitors (there are four) to settings given in Table 2. Make sure to use the correct presets as the presets for 900 and 1300 MHz versions differ. Set the thumbwheel of R24 to its center position.

6. Connect +12 to +14-volts DC from the power supply to D8, the negative lead connects to foil ground. Keep the bottom of the PC board at least ½ inch above any kind of material which may detune the microstrip elements on the bottom of the PC board. Because both conductors and insulators can cause detuning, a set of four 1/2 or 3/4-inch plastic or brass standoffs installed in the four corner holes of the PC board should be used. Use only a nonmetallic tuning tool for all adjustments in the following steps.

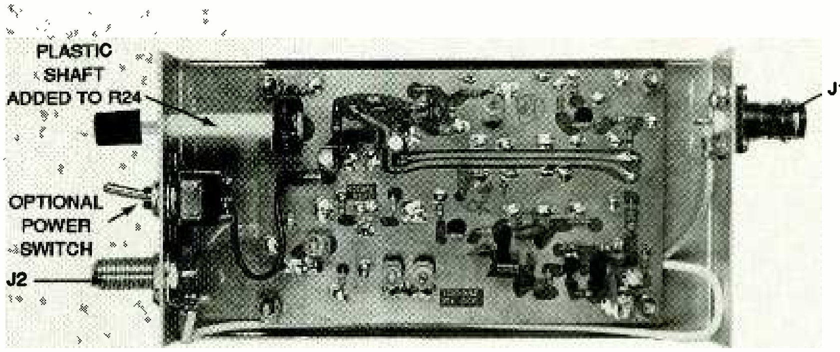
7. Activate the signal source and *slowly* rotate C22 until some indication of reception is seen on the monitor or RF voltmeter. Use a fairly strong signal at first. On confirmation of reception, decrease signal until it is just high enough for a reliable indication. As you remove the tuning tool from C22, undoubtedly some detuning will occur. You will have to compensate a little to get the tuning correct when the tool is removed. A frequency counter rated up to 1000 to 1500 MHz can indicate frequency shifts.

8. Next, couple the frequency counter to Q3. Stay at least ½ inch away from C22 and Q3. Set C22 for 850 ± 3 MHz with R24 at its center position (900 MHz model) or 1210 ± 3 MHz (1300 MHz model). You must have a steady reading, not a wildly jumping one. You may have to experiment with the coupling method, depending on your counter. We found loop coupling a little easier than the factory supplied whip antenna that came with our counter. *Do not* connect any probes, cables, or wires directly to the oscillator circuit or any of its components. A cable can be connected to the emitter of Q2 through a 220-ohm ⅛ or ¼-watt resistor for the frequency counter, if desired, but this may detune the oscillator 10 or 20 MHz. However, with certain counters that are low in sensitivity above 800 MHz this may be the only way to get a steady reliable reading. You can later compensate for this by touching up C22 once you are in the ballpark.

9. Once you obtain a steady reading and you are reasonably sure it is valid, proceed to check the local-oscillator tuning range. Rotate R24 through its entire range. For the 900 MHz model, the local oscillator should cover 840 to 867 MHz (assuming a channel 3 IF) and 1180 to 1240 MHz for the 1300 MHz model. Note that most ATV activity on 900 MHz is between 910 and 923 MHz, and in the case of the 1300 MHz, between 1240 and 1290 MHz (with gaps) so if you cannot quite achieve a 27 MHz range on 900 MHz, this should not be a problem. You can extend the range by replacing C23 on the 900-MHz model with a 5 pF chip NPO and retuning C22. The 1300 MHz model has somewhat wider tuning range (typically greater than 70 MHz). It is desirable to keep the tuning range as narrow as possible to improve the tuning



**CLOSE-UP VIEW OF 1300-MHz downconverter board. Short lead lengths and neat construction techniques are a must!**



**MOUNT THE DOWNCONVERTER in a metal case for proper shielding. Use connectors to match your equipment.**

**TABLE 2**
**TRIMMER CAPACITOR PRESETS**

| Trimmer Capacitor | Percent of Mesh |
|---|---|
| Presets for 900-MHz model | |
| C1, C8, C9 | 25% |
| C22 | 80% |
| Presets for 1300-MHz model | |
| C1, C8, C9 | 10% |
| C22 | 20% |

rate and ease of tuning a station. Adjust C22 as necessary to ensure desired coverage. For other IF frequencies, the local oscillator tuning range can be shifted lower (higher IF) or higher (lower IF). Note that the local oscillator must be *below* the signal frequency or else the IF signal will have its spectrum inverted with respect to the input signal spectrum. This will cause difficulties in TV reception in AMTV, and video and sync inversion in FMTV reception, unless the IF is designed for this.

If no frequency counter is available, you will have to depend on the reception of a known signal, or use a calibrated receiver covering the local oscillator range to pick up the local oscillator's signal.

If you dont have a frequency counter, receiver, or analyzer, dont worry. Use a known signal as follows. First set C1, C8, C9 and C22 to the presets shown in Table 2 if you have not yet done so. Set R24 at center of range. *Slowly* rotate C22 until some indication is seen on the TV or monitor, or other output indicator connected to junction of C19 and L3. Next, confirm that this is due to the signal source by shutting it off. If the indication disappears, this is the signal you want. Keep the signal level as low as possible for best results. If you get no results, make sure the signal has not gone off the air, and that trimmers are preset to correct settings, and the monitor, TV receiver, or indicating device is correctly set up and functioning. The presets are close enough to enable a strong signal to pass through the downconverter and give an indication.

10. Once you have an indication on the screen, peak C1, C8, and C9 for maximum signal as seen on the monitor. You should repeat this step as needed until no further improvement is obtained. Recheck setting of C22 to ensure correct tuning range is obtained. Check your final settings against presets. They should not be very different, as the tuning elements are printed on the PC board and therefore tuning should be close to presets shown. However, if you are setting up the downconverter for other than the specified frequency ranges, the presets will vary.

11. Your downconverter is now working. Now you can go over the adjustments again to further improve performance. If you can get access to a sweep generator, align the downconverter for a flat response within $\pm 2$ dB over the selected amateur band. The alignment is simple and straightforward so do not hesitate to experiment. You should be getting about 37 to 43 dB gain out of the downconverter and around 2 to 3 dB noise figure if everything is working properly.

12. The downconverter can be mounted in a shielded box with connectors of your choice. We recommend type N, TNC, SMA, or BNC for the input and an F connector for the output. Be sure to waterproof all connections for mast mountings. It is suggested that the alignment be checked after mounting the PC board in any enclosure since some slight detuning may result.

13. For remote tuning, make sure your variable supply is *clean*. Any noise or hum will cause FM on the local oscillator signal and a noisy received picture. Be sure also to set R24 fully CCW when remote tuning is used, or else the converter tuning range will be restricted or nil.

**Variable gain**

Both models of the downconverters develop 37 to 43-dB power gain from the antenna input to the RF output. This gain may be too much when strong TV signals are received, resulting in overload of the TV set. The unit's gain may be modified by changing R11 from the default value of 1000 ohms to other values as specified in Table 3.

A 1000-ohm potentiometer in place of R11 can be used for providing continuous variable gain. This portion of the circuit operates at the IF frequency, so a potentiometer and wiring techniques suitable at 70 MHz should be used. The IF output should be maintained below 150 millivolts rms in order to prevent overload of the converter. This is a very strong signal to feed into a TV receiver or video monitor.

**TABLE 3—PRESET GAIN**

| Desired Gain (dB) | R11 Value (Ohms) |
|---|---|
| 43 | 2,200 |
| 34 | 470 |
| 28 | 220 |
| 25 | 100 |

Resistor R11 values assume a nominal gain of 40 dB. Increasing the gain beyond an extra 3 dB is not recommended. To reduce RF gain for very strong signals, it is recommended that a negative bias voltage supply of 0 to -10 volts be applied to TP7 through a 220,000-ohm resistor. This can be obtained from a potentiometer that is connected across a -10 V DC supply.

The potentiometer functions as an RF gain control in this case. Reverse AGC from the TV receiver used as a monitor could be arranged so as to bias TP7 from +1.5 volts DC at zero signal to -3.0 VOLTS DC on strong signals. Typically 35 to 40 dB RF gain reduction may be obtained using either of these approaches. As TV receivers vary, the individual circuit arrangements for doing this are left to the ingenuity of the builder.

Another gain reduction method is the use of a manually operated switch to ground TP7. This will reduce RF gain approximately 10 dB. This switch can be a simple SPST switch. For greater reduction of gain the switch may be connected to a negative voltage of -1 to -3 V as needed.

The matching ATV transmitter for the downconverter appeared in the May, 1996 issue of *Electronics Now* and corner reflector antenna construction will be covered in a future issue of *Electronics Now*. Refer to the May, 1996 issue for details of the system's overall performance in field trials. Ω

## HARDWARE HACKER

*continued from page 50*

*Synergetics* and not to *Electronics Now* editorial. Snailmail only please.

### New tech lit

From *Fujitsu* a fat new data book about *Wireless Communications and Power Management*. From *Micrel*, a *Designing PCMCIA Power Control* ap manual and data book.

From *Analog Devices*, free design software on the TMP01 *Temperature Controller*. An *Electronic Designer's Guide* is available from *Littelfuse*.

Two economical alternate sources for oscilloscope test probes are *Probe Master* and *Test Probes Inc.*

Low cost bearings are available in the *Nyliner Plus Evaluation Kit* from *Thomson*. Details on a fresh *Gelcast* approach to low cost ceramics (both magnetic and otherwise) are offered from *Oak Ridge National Labs*. Used Santa Claus machines are in stock at *Commonwealth Trading*.

Several freebie samples of useful self-stick *Velcro* products are offered by *Levitt Industrial Textile*.

Power electronic modules suitable for large motor controls and such are offered at bargain prices by *Beyond Electronics*. Free catalogs.

*Talking Electronics* is a brand new international hobby magazine. This one appears to have lots of hands-on and low cost projects.

For all the fundamentals of digital integrated circuits, be sure to check out my *TTL Cookbook* and *CMOS Cookbook*. These are also available as a portion of my *Lancaster Classics Library*. From *Synergetics*. I'm in the process of building up a web page at *http://www.tinaja.com* I am calling it *The Guru's Lair*. It is still under construction, but you are certainly welcome to visit. Eventually, it should hold rich text and fast globally searchable reprints for all of my columns and stories, a technical helpline area, links to other sites, a *Synergetics Consultant's Net* access, plus third party support for the Basic Stamp and similar goodies. My site works best when you have both *Netscape Navigator Gold* and an *Adobe Acrobat Amber* reader. EN

## FLY CONTROLLER

*continued from page 40*

### PARTS LIST

**All resistors are 1/4-watt, 5% units.**
R1—560 ohms
R2—100 ohms
R3—120 ohms
R4, R5—100,000 ohms
R6, R7—330 ohms
**Capacitors**
C1—470 µF, 25 volts, electrolytic
C2—0.004 µF, 25 volts, electrolytic
C3—0.01 µF
C4—40 µF, 25 volts, electrolytic
C5—0.2 µF
C6—0.007 µF, 100 volts
**Semiconductors**
D1—1N4002 diode
IC1—LM317T voltage regulator
IC2—LM3909 LED flasher
IC3—NE7555 or NE555 timer
LED1—Red LED
Q1—2N2222A switching transistor, NPN
Q2—2N3055 power amplifier, NPN
Q3—KTN2222 infrared phototransistor, NPN (Radio Shack 276-145 or equiv.)
**Additional Parts And Materials**
B1—12-volt deep-cycle battery
RY1—5-volt relay, single-pole, double-throw (Radio Shack 275-240 or equiv.)
1—12 volt type "T" or "CD" automobile ignition coil
1—13.8-volt, 1-watt photo-voltaic panel
1—6-inch modular solderless breadboard (Radio Shack 276-174 or equiv.)
1—6-inch modular PC board (matches solderless breadboard, Radio Shack 276-170 or equiv.)
Weather-tight automobile battery storage case, TO-3 heat sink, conductive-foil tape, wire, glossy- white boards or plastic panels, lumber for trap construction
**Sources of some materials**
Automobile ignition coil obtainable from J. C. Whitney Co., 2233 S Throop St., Chicago, IL, 60608 or most automotive parts store.
Solar panels obtainable from Edmund Scientific Co., 101 Gloster Pike, Barrington, NJ 08007-1380; from H & R Co., 18 Canal St., P.O. Box 122, Bristol, PA 19007-0122; and Integral Energy Systems, 109 Argail Way, Nevada City, CA 95959.

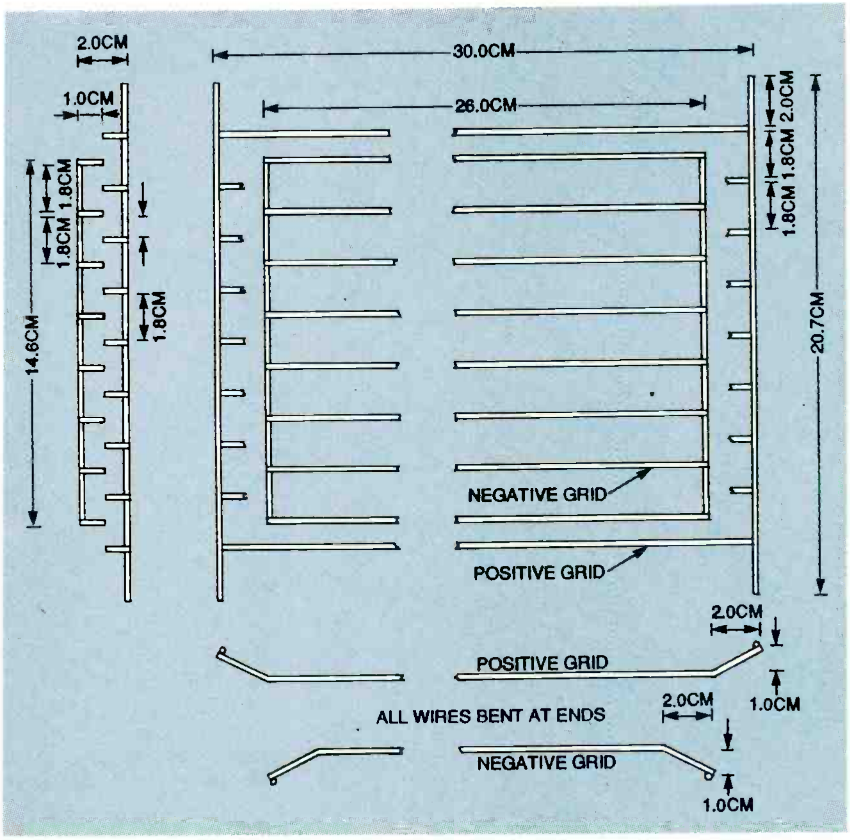



**FIG. 3—THE GRID for the solar-powered fly controller is fabricated from stiff wire that can be assembled with solder, braising material, or by welding. No. 12 solid copper wire without insulation is a good choice. It forms easily and solders well with a 100-watt iron. (Note: 2.54 cm equals 1.0 inch.)**

high-voltage spikes produced by the switching voltage across the relay's coil. The switching circuit is turned off at night or during periods of heavy cloud cover by phototransistor Q3 whose internal resistance increases as the ambient light diminishes. This reduces the positive bias on Q1's base, causing the transistor to cut off. LED1 serves as a voltage dropping device.

Single-pole, single-throw relay RY1 provides brief pulses of the 12-volt battery voltage to IC3, an NE755 timer that is wired as a free-running audio-frequency pulse generator. The pulses are amplified by a 2N3055 power amplifier transistor, Q2. The output of Q2 drives an automobile ignition coil, T1, to generate the high-voltage pulses for the external grid. The output voltage at the secondary winding of T1 is approximately 12,000-volts peak-to-peak.

The circuit is powered by a 12-volt rechargeable lead-acid or nickel-cadmium battery. A 1-watt or better solar panel of the type used to keep automobile batteries charged should be used to eliminate the need to recharge the battery frequently. Many different solar panels are available on the surplus market where the price is considerablly less than buying new for catalog suppliers.

### Building the controller

The parts for the controller first are assembled on a solderless breadboard with the 12-volt battery, solar panel and ignition coil off the board. Install C6 as close to the T1 primary winding as possible. Power the unit up and be sure the circuit is functioning. Check for a spark at the center terminal of the ignition coil.

Remove the parts one at a time and mount them on a matching PC board. Figure 2 shows the author's layout on a solderless board. Put the wired

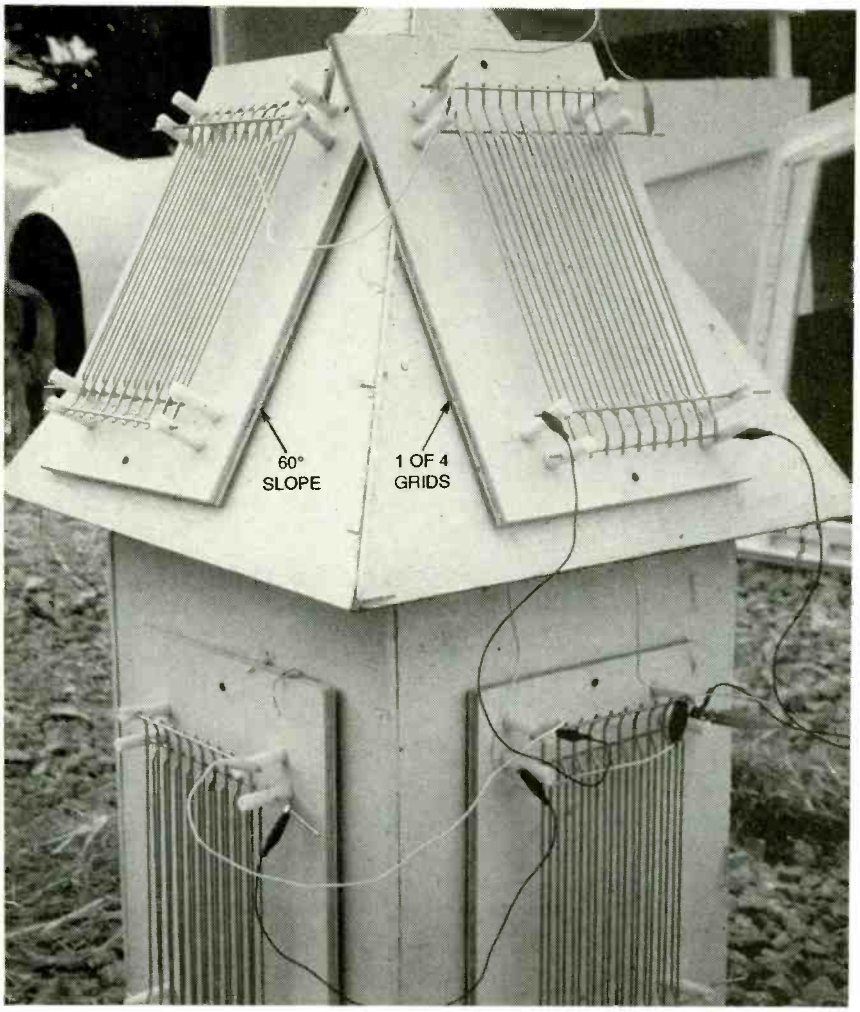



FIG. 4—THE GRIDS ARE MOUNTED on a box form, called a trap, (each controller can support up to four grids), that houses the controller and rechargeable battery. The solar cells may be mounted on a short mast and sloped to catch the maximum sunshine available.


FIG. 5—VIRTUALLY ANY automobile ignition coil can be used for T1.

PC board aside until it is needed.

### The high-voltage grid

The grid is made up of two comb-like elements (Fig. 3) which are spaced 5 mm apart from edge to edge. (Note: 25.4 mm equals 1.0 inch.) The grid elements can be constructed from 16 gauge wire (i.e. a coat hanger), from conductive foil, or from a combination of foil and wire. A good alternative is #12 bare, solid, copper wire used by electricians to wire houses.

The grid should be mounted on high-gloss white wooden or plastic panels and the panels should be mounted either vertically or with a sixty degree slope from the horizontal (see Fig. 4). Porcelain standoffs electrically isolate the grid from the panels that could become conductive when wet. The terminal for the case of the transformer T1 (if it has one) is grounded to earth as is the negative input of the primary and secondary windings. One terminal of the grid is connected to the same common ground. The high voltage line from the secondary winding is attached to the other grid terminal. One controller circuit can easily power four grids.

### Operation of the trap

To eliminate flies, place four grids on a specially constructed stand as shown in Fig. 4. This configuration is called a trap. The slope of the grids mounted at the top of the trap is sixty degrees from the horizontal. The grids are mounted on adjacent surfaces of the trap. Place one trap to the north, and one to the east of places where flies gather. Good spots are at the eastern ends of buildings which house animals, near dog kennels, and near garbage cans or dumpsters. For best results, check the traps once a day and remove any insects or debris which have become lodged in the grids and are shorting the grid.

### Safety concerns

Although the current available at the controller's grids is very small, the voltage is high enough to jolt a person. Therefore, power to the controller should always be turned off before handling any part of the circuit or grids. Also, the device should not be used where children can reach it. A high-voltage warning sign will keep curious adults away.

The solar-powered fly controller shown in the photographs has been in use for five years to control flies around kennels, garbage cans and in animal pastures. Several controller circuits and traps have been assembled and put to use at indoor and outdoor locations. None had any down time because of malfunction. If sufficient sunlight and an adequately sized solar panel are present, the batteries will remain charged for the life of the trap. Ω

continued from page 42

gate an excessive current draw; check for worn-through insulation, a seized or tight engine, and a faulty starter. If the starter turns the engine slowly, the current draw is not high, and the battery is in good condition, check the resistance in the starter circuit. Its brushes may be defective, making poor contact or the commutator of the armature may be dirty.

Added resistance in the starter circuit causes the starter to turn slowly. For example: In a starter system drawing 200 amps, 0.01 ohms of added resistance in the starter cable will cause a 2 volt drop in voltage at the starter's armature. A 0.01 ohm resistance is too small for all but the most expensive and sophisticated ohmmeters to measure. However, you can measure a voltage drop indicating where there is excessive resistance (Fig. 3). Determine if there is resistance in the circuit by measuring the voltage drop across each connection and component in the starter circuit. Do this while cranking the engine. Measure the voltage drop between the battery post and the connecting cable, the solenoid posts and the wires that attach to them, and across the solenoid itself. Also, check the connection on the starter, alternator (feed and ground side) and the ground strap connection to the engine block. A logical test sequence would be to start by first measuring the battery voltage between the + and − terminals when the starter is cranking. Then measure the voltage between the starter terminal and engine block when cranking. If the starter voltage is significantly less, use our just completed procedure to isolate the voltage drop. The corrective action is usually indicated by the fault's location: clean and tighten poor connections, replace defective cables, etc.

**Ignition systems**

If your engine has breaker points in the distributor, use your multimeter to measure the resistance across the contacts when the points are closed. The reading should be very low, typically 0.1 to 0.3 ohms.

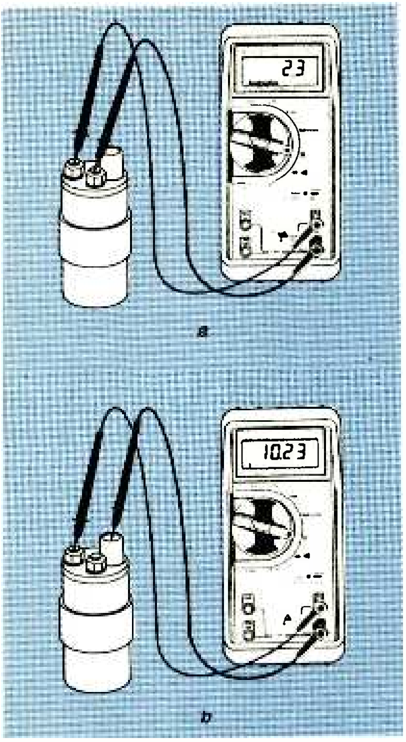



FIG. 4—USING A DIGITAL MULTIMETER to check the continuity of the primary (a) and secondary (b) windings of an ignition coil. Resistive values shown are typical for these coils.

The primary and secondary windings in the ignition coil can also be measured for resistance (see Fig. 4). If your digital multimeter has an automatic ranging feature, use the manual ranging feature on the multimeter to avoid any oscillations between ranges that can sometimes be caused by the inductance of the coil.

Ballast resistors in series with the coils primary winding can be measured. Look for low values in the range of 0.5 ohm. A word of caution: Connecting and disconnecting the battery source in the digital multimeter across the primary winding of the ignition coil will cause a high-voltage surge in the secondary winding. The shock experienced is usually minor. However, an involuntary sudden movement by you might cause a bruising injury or worse.

If you suspect a malfunctioning ignition coil, check the resistance of primary and secondary windings. Do this when the coil is hot, and again when it is cold. Expansion and contraction may open a coil winding. Also measure from the case to each connector. The primary windings should have a very low resistance, typically from a few tenths of an ohm to a few ohms. The secondary windings have a higher resistance, typically in the 10-kilohms to 13-kilohms range. To get the actual figures for a specific coil, check the manufacturer's specifications.

**Condensers (capacitors)**

Shorted condensers are a common problem. Many experienced boaters replace them at the beginning of every season (or once a year where the boating season is year round) and keep a spare condenser onboard for emergency replacement when away from the dock. Your multimeter is a valuable tool that can check the capacitor's usability. Set the multimeter to the ohms range and observe the meter reading or bar graph indication. The battery in the multimeter will charge the capacitor from zero volt to the battery potential causing the ohms reading to increase from zero to infinity for a good condenser. A leaking condenser will have a finite resistance, indicating that you should replace it.

Be sure to reverse the leads to the meter and check current flow both ways. Also make sure to check condensers, both hot and cold. Leaking condensers do not give an infinity-ohms reading.

**Spark plug wires**

Most modern gasoline engines have resistance wire for the high-voltage connections from the distributor cap to the spark plugs. The internal resistance within the wire reduces radio interference and produces a cleaner spark. Plug wires should be checked for open circuits if they are more than two years old. A common sense approach is to replace plug wires biannually. Keep a few of the longer old plug wires aboard for emergency replacements when not at dockside. Due to the heat of the spark plug insulator, a spark plug boot may bond to the spark plug. Pulling a spark plug boot straight off the spark plug can damage the delicate conductor inside the insulated wire. Rotate the boot to free it before pulling it off.

If you suspect bad wires, test the resistance of the wire while gently twisting and bending it. Resistance values should be about 10 kilohms per foot depending on the type of wire being tested; some may be considerably less. You should compare readings to other spark plug wires on the engine to provide a relative reference for a typical good reading.

### Outboard motors

The ignition troubleshooting procedure for outboard motors given here can be used for any small one- or two-cylinder gasoline engine using a breaker-point magneto ignition. This type of ignition is commonly found in lawn mowers, chainsaws, emergency-power generators, snow throwers, etc.

In order to start, the engine requires three things:

a. The proper amount of fuel/air mixture,

b. A properly timed spark,

c. Some piston compression.

If the engine won't start, chances are that one or more of these items is missing. The troubleshooting logic is straightforward: Find out which critical items are missing, why and repair.

Before getting into the actual procedure, verify that the fuel tank has a sufficient quantity of fresh fuel mixture and if your engine has an electric starter, use the DC volts function on your digital multimeter to check the battery voltage. Use the ohms function to check the cables for loose or corroded connections. The battery system may be smaller that a multi-horsepower marine engine, but the troubleshooting techniques previously discussed apply here.

With reference to the ignition system, here is a list of the critical components listed in the order of their likelihood of failing: spark plug, breaker points, coil, high-voltage wire, condenser and flywheel magnet.

### Spark plug check

We will assume you have already tried the normal starting procedure, i.e., turned the engine over a number of times, first with the choke closed and then open. Remove the cowling (if necessary) to gain access to the spark plugs. For a twin cylinder engine, label the spark plug wires so that they can be replaced in the correct order. Pop the wires off and unscrew the spark plug(s). Keep track of which plug came out of which cylinder.

Examine each plug carefully. This is like palm reading; the condition of the plug tip can tell a story about what is going on in each cylinder. If the plugs are wet with gasoline, fuel is undoubtedly reaching the cylinders. If the plugs are dry, the opposite is true. Look for a blockage in the fuel system or a bad fuel pump in a remote tank.

If the plug(s) are fouled with carbon and/or oil, several things could be wrong. The spark to the plug(s) is weak or non-existent. The spark plug heat- range is too cold. (Check the engine's manual to determine the recommended plug type.) Another possibility is the engine has been run for long periods of time at low speeds, maybe with an incorrect fuel or fuel/oil mixture. In the case of multi-cylinder engines, if only one plug shows difficulties, the problem is likely to be a weak spark from the ignition system or a defective plug.

The next step is to check actual spark plug operation. If new plugs are available, use them. If not, clean the old ones as follows: Using a sharp object such as the point of a safety pin or a straightened fish hook, scrape off the deposits on the insulator surrounding the center electrode. Dig down between the insulation and sidewall and remove as much deposited carbon as possible. Now, wash out any remaining oil or carbon particles with a non-conductive solvent such as paint thinner or unmixed gasoline. Allow the plug to air dry; blow on it if necessary.

Next, gap each plug by tapping or bending the outer electrode. If you don't know what the recommended gap is, use 0.025" (a bank credit card is typically .030"). Test each plug and high-voltage wire combination by connecting the wire to the plug and laying the plug on the engine block where the gap can be seen. The plug's outer body needs to make electrical contact to the engine's metallic block, just as it does when it is screwed in place. Now, turn the engine over at normal cranking speed and watch for a spark. If you are in bright sun, you may have to shade the plug to see the spark. If this test shows no spark, or a weak spark, the trouble is with the breaker points or the coil

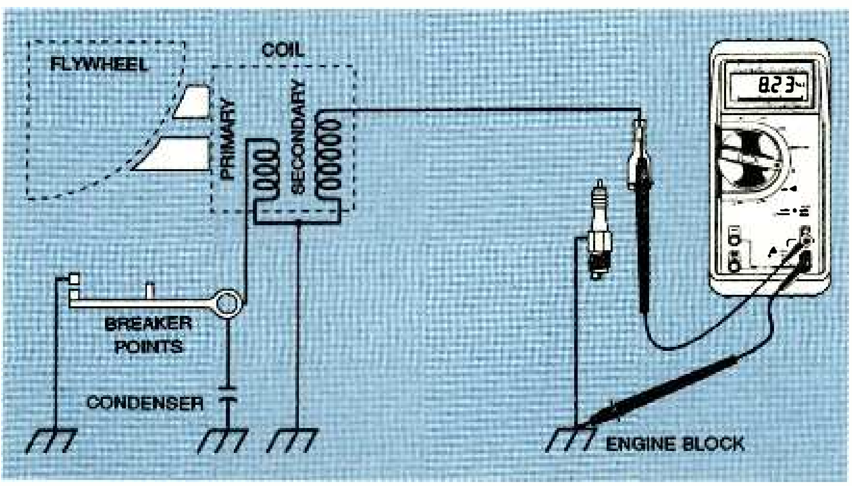



**FIG. 5—CONTINUITY TESTS for the high-voltage wire.**

inside the magneto. A strong spark indicates that the plugs were fouled and you corrected the problem.

The next test checks for a continuous path for the spark through the high-voltage wire and the ignition coil (see Fig. 5). For a one-cylinder engine, there is a direct electrical path from the plug cap through the high-voltage wire and ignition coil to the engine block. This can be checked without taking the magneto apart as follows: Set the multimeter to the ohms function. Use the range button to manually select the 40 kilohm range.

Now, touch one probe tip to the engine block and the other to the metal connector inside the plug wire cap. The meter should read the resistance of the coil and high-voltage wire in series. Good readings will range from 3 kilohms to 15 kilohms. Higher readings mean a poor connection or cable. A poor connection typically occurs either where the high-voltage wire connects to the coil or at the other end where the high-voltage wire connects to the spark plug clip inside the cap. An infinite resistance reading means that there is an open circuit or break in the electrical path. If you get a bad reading, check again and make sure you are making a good connection with both test leads.

**Continuity test**

If you are testing a 2-cylinder, 2-cycle engine (mixed fuel), perform this test for each cylinder individually. Look for a correlation between a bad reading and a fouled spark plug on the same cylinder.

If the engine is a 4-cycle model (unmixed fuel), such as a Honda or Onan, the test is performed slightly differently, as shown in Fig. 6. You should expect continuity from one spark plug clip to the next since there is only one secondary winding. The secondary winding is not connected to the engine block. However, an open spark path will kill the spark to both cylinders.

A break in the high-voltage circuit can occur in several places as shown in Fig. 7. If the poor connection or open circuit occurs at the spark plug clip, you may be able to repair it without taking anything else apart. If the problem is located inside the magneto, it will probably be necessary to remove the flywheel.

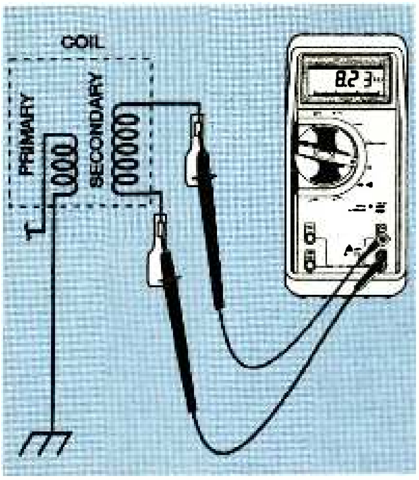



**FIG. 6—RESISTANCE/CONTINUITY TEST for 2-cylinder, 4-cycle engines. Note that there is no distributor and that both plugs fire at the same time.**

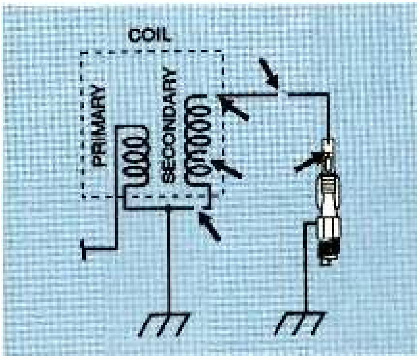



**FIG. 7—LOCATION OF possible circuit interruptions in the secondary winding, high-voltage circuit.**

**Breaker point test**

The breaker points on a magneto ignition are often located under the flywheel. Remove any parts obstructing the flywheel's removal. Hold the flywheel in a stationary position with a strap wrench and remove the large nut that holds the flywheel to the crankshaft. Use a puller to loosen the flywheel and lift it off the crankshaft. Locate the breaker points and examine the contact surfaces. Caution here: when rotating the crankshaft, turn it in the forward direction only to prevent damage to the water-pump impeller.

For proper operation, the breaker-point contact surfaces should be clean and shinning. Make an electrical resistance test with your digital multimeter before attempting to clean the contact surfaces. This provides a before and after indication. Refer to the diagram in Fig. 8. Note the points are in parallel with the primary winding of the ignition coil and condenser. When the points are open, the resistance across the coil will be about 1 ohm (the winding's wire resistance). When the points (with clean contacts) are closed, the resistance falls to 0.1 to 0.2 ohms. Any oil or corrosion on the point contact surfaces increases the resistance and reduces the primary winding current. This subsequently weakens or kills the spark.

Measure the contact resistance as follows: Place the multimeter in the ohms function. Hold the probe tips tightly together to obtain a reference reading with the tips shorted. The reading should show zero (0.0) ohms. If not, note the value. This is the reference reading.

Now place the probe tips on opposite sides of the point contacts when the points are in the closed position. The meter should now read no more than 0.1 ohm greater than the reference reading. Higher readings indicate contamination on the contact surfaces. If the contact surfaces are pitted, the best choice would be to replace the points. If you can't install new ones, then carefully clean the ones you've got. The object here is to remove all contamination without damaging the underlying metal.

A small plastic block on the breaker points rides a rotating cam that opens and closes the points. If this block shows signs of wear, or is shortened by wear, replace the breaker points to avoid future problems.

The preferred cleaning method is to remove the contaminants from the points'

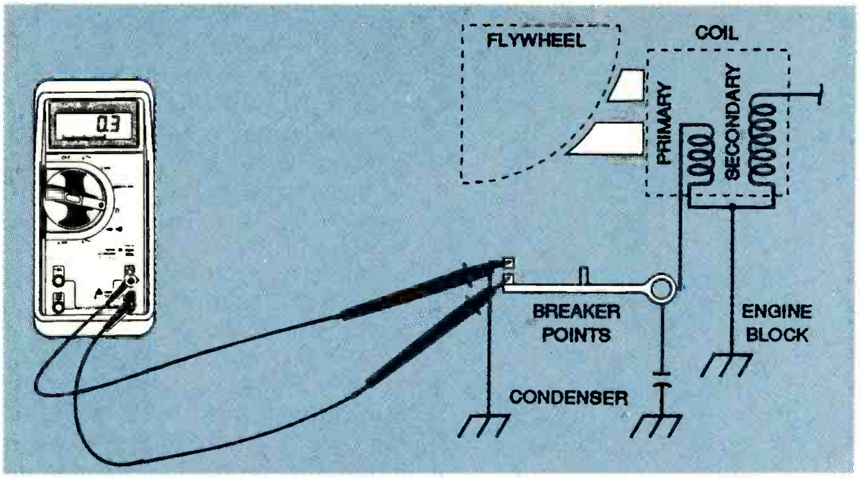



FIG. 8—TEST METHOD for determining breaker point contact resistance.

surfaces as well as metallic oxides that build up. A fine burnisher (a very fine, paper-thin file) is slid over the points' surfaces as the points are gently held closed.

Emergency cleaning methods must be used at times. Scrape the contact surfaces with a sharp carpet-layer's knife. You could file the surfaces with the abrasive surface of a matchbook striking surface—it functions like a fine file. Next, wipe the contacts with solvent on a clean cloth. Away from the dock use ordinary gin or vodka. Filing sometimes work, but there is a risk of damaging the underlying metal. This shortens the life of the contacts. Never use course sandpaper! The grit imbeds itself in the contact metal, rendering the points useless. If you have any doubt about the perfect condition of the points, replace them!

If you want a quick fix to get the engine running in an emergency situation, try the following: With the crank shaft positioned so that the points are closed, gently pry the breaker arm open. Next, insert a clean business card between the contact surfaces. Release the breaker arm so that the points grip the card through its width. This wipes the contacts in the process. The card has two beneficial properties. It is absorbent enough to remove oil and is just gently abrasive enough to remove surface contamination.

When you think the cleaning is complete, verify the results by repeating the electrical resistance test. Before leaving the points, make a visual inspection of the gap in the open position. A typical specification would be 0.020 inches.

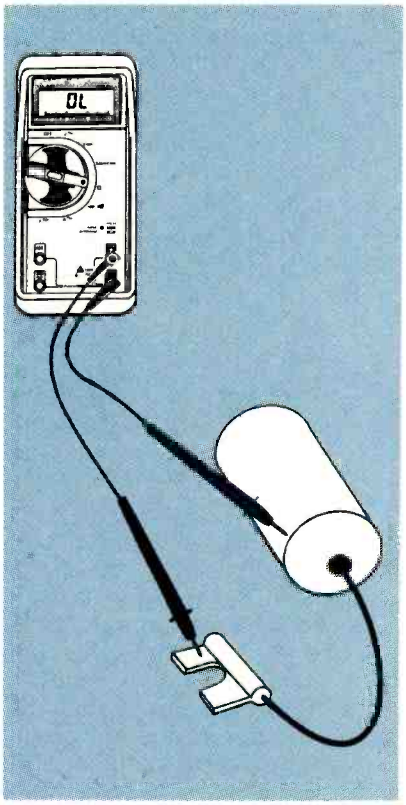



FIG. 9—CHECKING THE IGNITION condenser for leakage.

### Condenser test

As before, check the condenser as follows: Disconnect the condenser lead, then place the multimeter in the capacitance function and hold one test lead to the capacitor case and the other to the terminal. (See Fig. 9).

Do not touch both leads with your fingers simultaneously because it causes reading errors. A typical range of good readings would be .015 µF to .030 µF. If the DMM indicates an overload in the capacitance function, the condenser is shorted. A very low capacitance reading probably means the condenser is open. Condensers are not repairable so a bad reading will likely mean a trip to the parts store.

If your multimeter does not have a capacitance function, use ohms instead. This test is best performed with the ignition condenser removed from the engine. Start by shorting the condenser by touching the lead to the case. Now, touch one probe to the lead and one to the case. Don't touch the probe tips or exposed condenser parts with your fingers. Watch the meter reading as the condenser is charging for indications that it is leaking or shorted. Now reverse the test leads and repeat the test. The results should be the same. If the results are negative (no bad indication), the condenser is good.

### Flywheel magnet test

Flywheel magnet failures are rare but sometimes do occur. You can verify the strength of the magnet with a simple test. Locate the inside surface of the flywheel that travels near the pole pieces of the coil. You will find some magnetic material (typically laminated steel) in two places. It's separated by a gap of non-magnetic material (typically aluminum). Lay a hacksaw blade on the laminations near the gap. If the magnet is good, it provides a strong pull on the hacksaw blade. If not, refer to the engine's manual for replacement parts.

### Reassembly and final check

Once you've checked out and repaired the ignition system, reassemble the engine and repeat the spark plug test. If the spark looks good, install the plug(s) and try again to start the engine. If troubles persist, inspect the fuel system. Carburetor

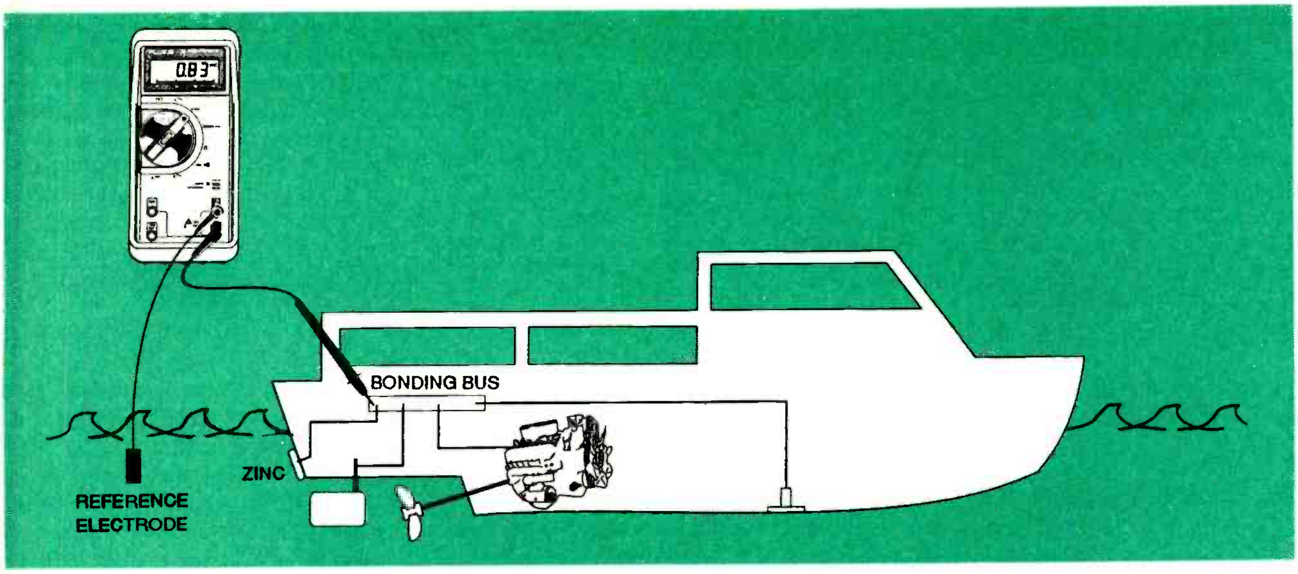



**FIG. 10—TESTING THE CORROSION protection on your boat using a reference electrode.**

cleaning may be required. Remember, most engine manufacturers recommend the addition of fuel stabilizer for long periods of storage.

## Corrosion control

The corrosion protection system on your boat should be checked at regular intervals. Neglect leads to costly and time-consuming repairs. In order to perform the checks detailed here, your digital multimeter should be accurate, rugged and reliable; and, most important, it should have a 10-megohm input impedance in the DC-volts function. The high-input impedance allows you to test your boat in either fresh water or salt water, with repeatable results.

In general, the term corrosion refers to the unwanted loss of metal from the hull and/or underwater metal fittings of the vessel. There are two main types of corrosion—mechanical and electrical. Mechanical rust is common everywhere; a piece of metal rusts because it oxidizes. Under the electrical category, there are three common subcategories: galvanic corrosion, stray current corrosion, and crevice corrosion.

*Galvanic corrosion* occurs when two dissimilar metals are connected together electrically in the presence of a conductive electrolyte. The water about the hull, either fresh or saline, is the electrolyte. Atoms in the less noble metal give up their electrons to the more noble metal and the atoms with one or more electrons missing are released to flow (corrode) into the electrolyte in the form of positively charged ions.

*Stray current corrosion* occurs when a voltage source *pulls* electrons out of the metal. The voltage source might be the boat's lighting system, charging system or even elements of the communications system. In fact, some or all of the electrical system provides the stray current through ground loops commonly associated with audio systems. This corrosion allows the positively charged ions to flow into the electrolyte as previously described.

*Crevice corrosion* is actually a form of galvanic corrosion. However, it involves only one metal. A portion of the metal (in the crevice) becomes active (less noble) due to a loss of oxygen while the remainder stays passive. If an electrolyte is present, a galvanic couple is formed and the active metal is converted to ions and enters the electrolyte solution.

Materials used in the construction of marine vessels are chosen using various criteria. These include cost, mechanical strength, workability and corrosion resistance. When you want to compare metals according to their corrosion resistance, you refer to a ranking list called the Galvanic Series of Metals first learned in high school chemistry. This is often referred to as the "noble scale." This scale indicates the relative boundlessness each metal has for its electrons, i.e., it ranks the metals according to their electron bonding strength.

Metals at the active (less noble) end of the scale yield electrons and corrode more easily than metals on the passive (more noble) end of the scale (see Table 1).

Underwater metals can be protected if they are supplied with sufficient extra electrons. Active metals like zinc protect the more noble metal, iron. If the two metals are immersed in

### TABLE 1—GALVANIC SERIES OF METALS

| | |
|---|---|
| **Active** (least noble) | Magnesium |
| | Zinc |
| | Aluminum |
| | Cadmium |
| | Steel |
| | Iron |
| | Brass |
| | Tin |
| | Copper |
| | Bronze |
| | Lead |
| | Titanium |
| | Silver |
| | Platinum |
| **Passive** (most noble) | Gold |

Alloys may vary according to composition the same electrolyte, and deliberately connected by an electrical bonding system, the zinc liberates its electrons and, in time, the zinc is dissipated. This chemical action protects the iron from corroding and the loss of the zinc is relatively inexpensive compared to the damage caused by corrosion. In this configuration, the zinc is called an *anode* and the protected iron is called the *cathode*. This setup is the familiar principle of an operating battery.

### Reference electrode

When a metal is in contact with an electrolyte such as sea water, the metal establishes a natural potential or voltage with respect to the electrolyte. This natural potential (or "freely existing" potential) exists when no extra electrons are being supplied or removed by an outside voltage source. You can measure this potential with a digital multimeter and a reference electrode. The reference electrode allows you to make an electrical connection to the sea water with a known, repeatable value, i.e., a reference value.

Reference electrodes are often called half cells because they contain a metal and a metal compound. Popular types are copper-copper sulfate and silver-silver chloride. Marine system tests are often conducted with a silver- silver chloride electrode (see description in Reference 1).

**TABLE 2—SAMPLE READINGS**

| Metal | Free Unprotected* | Protected* | Over Protected* |
|---|---|---|---|
| Steel | 0.05V | 0.75V | 1.00V |
| Bronze | 0.30V | 0.55V | 0.80V |
| Aluminum | 0.65V | 0.90V | 1.05V |

* Voltages given in this table are typical values obtained using a silver/silver-chloride reference electrode. Values may vary according to alloy and type of coating.

The principle of the test is straightforward: You want to establish the corrosion protection system by supplying electrons. The trick is to supply exactly enough electrons to raise the potential of the protected metal 250 millivolt (1/4 volt) above the freely existing value. The test procedure is as follows (Refer to Fig. 10):

**1.** Set a multimeter to DC volts.

**2.** Connect the reference electrode to the volts input jack. Place the reference electrode in the water. Best results are obtained when the electrode is located away from the anode.

**3.** Connect the multimeter common jack to a probe that will be used to contact each piece of underwater metal.

**4.** Touch the common probe to each underwater metal fitting and record the millivolt value as displayed on the meter. If all underwater metal fittings are connected together with a bonding system, as shown in Fig. 10, then all readings should be identical. Some typical values for several metals are listed in Table 2.

Over-protection causes paint to peel from a metal hull, or chemical damage to a wooden hull. References 1 and 2 explain the dangers of over protection and details about bonding systems. In all probability you might be able to borrow a reference electrode from your marina's electrical shop.

Boating is a pleasure sport that can have serious consequences should preventative maintenance be avoided and minor problems ignored. Your boat is the only thing between you and Davy Jones locker. Keep it in excellent condition with a power plant that delivers every time you crank the motor over. Ω


**References for Additional Information**

1. *Boat and Yacht Corrosion Control*; by Yacht Corrosion Consultants, 2970 Seaborg Avenue, Ventura, CA 93003.
2. *Boatowner's Illustrated Handbook of Wiring*; by Charlie Wing, International Marine, Camden, Maine.
3. *Your Boat's Electrical System*; by C. Miller and E.S. Maloney, Hearst Marine Books.

## SCOPE ADAPTER

*continued from page 44*

standard universal component board with power buses that measures 1⅞ × 2¾ inches. A larger board will fit in the case, but it is important that the signal leads be kept as short and direct as possible. They must also be electrically isolated from each other. If the circuit board does not have mounting holes in the corners, drill them at this time.

Refer to the parts placement diagram, Fig. 2. It is recommended that you lay out the components on the board first, following the general locations shown in Fig. 2, to be sure that you have an appreciation for the size of the components before you begin to insert and solder them. Avoid running DC signal lines parallel to AC lines when you wire the board.

Cut off pins 1, 2, 13, and 14 on the 14-pin DIP socket (these pins are not connected within IC1). Install the socket flush with the edge of the circuit board. (This saves solder pads on the circuit board.) Install and solder the three 8-pin DIP sockets, leaving space for resistor R2, transistor Q3, and capacitors C4, C6, and C7. Install and solder R15, R26, Q1, Q2, and Q3. Then install the remaining passive components, leaving long leads where necessary for interconnections to the board and front and rear panel controls and jacks.

Make the power connections on the under side of the board to the power bus strips. Power lines from J3 go to IC1. NOTE: The ±5 volts required by resistor R6 is taken directly from J3. Double and triple check the wiring, looking particularly for inadvertent solder bridges or cold solder joints. Make any corrections necessary at this time.

### Mechanical work

Refer to the assembly diagram Fig. 3. Begin the mechanical part of the project by locating, center-punching, and drilling or forming all of the holes on the front and back vertical panels on the lower half of the case, using Fig. 3 as a guide. Drill or form the holes on the front panel for LED1, S2, S4, and precision potentiometer R18. Drill the hole for LED1 just large enough to permit a press fit of the top of the lens. Then drill the holes in the back panel for S1 and S3, R6, and J1, J2, and J3.

Using the circuit board as a template, locate, center punch

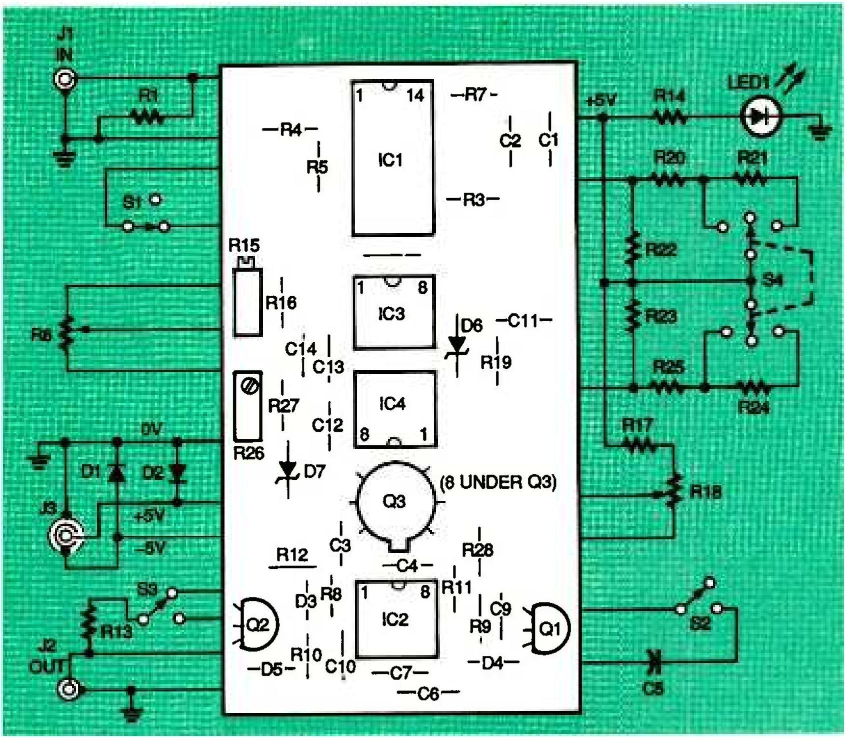



FIG. 2—PARTS PLACEMENT DIAGRAM for the adapter showing approximate locations of components on the circuit board. Many other components are chassis mounted and wired to the circuit board.

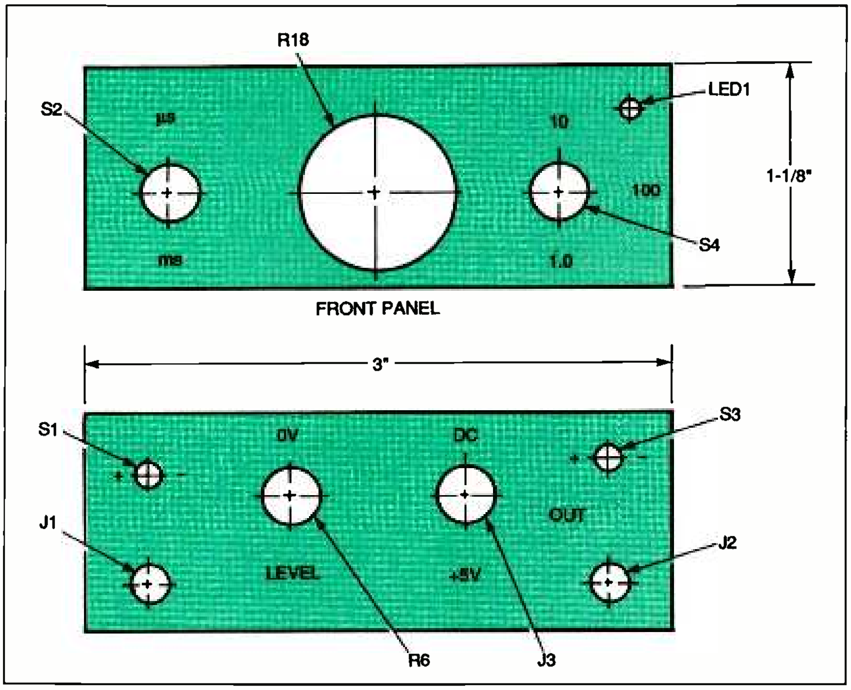



FIG. 3—DRILL PATTERN AND LABELS for the end panels of the lower half of the project case.

## PARTS LIST—DUAL OSCILLOSCOPE ADAPTER

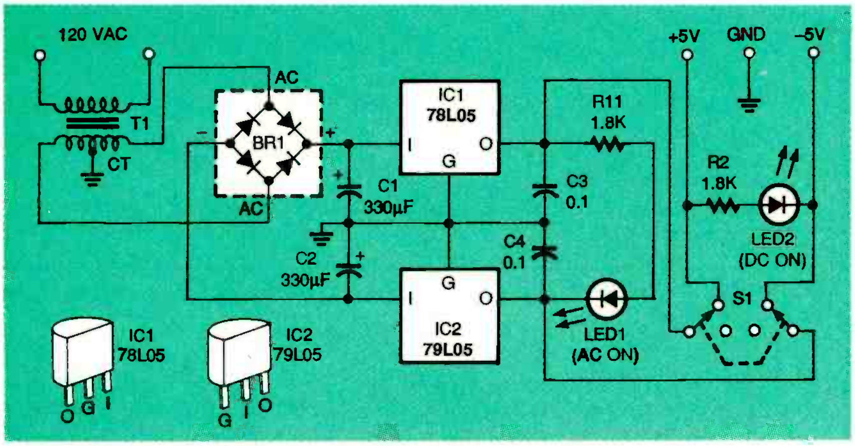
**All resistors are ¼-watt, 5%, unless otherwise specified.**
R1—51 ohms
R2, R5, R7—470 ohms
R3—120,000 ohms
R4—15,000 ohms
R6—10,000 ohms potentiometer, ⅛-inch dia. shaft
R8—10,000 ohms
R9, R10—5600 ohms
R11, R12, R14—680 ohms
R13, R28—1000 ohms
R15—100 ohms, cermet trimmer poitentiometer, multiturn
R16—4020 ohms, 1%, metal film
R17, R20, R25—100 ohms, 1%, metal film
R18—1000 ohms, 10-turn, precision potentiometer, Bourns 3540S or equiv.
R19—150 ohms
R21, R24—1000 ohms, 1%, metal film
R22, R23—10,000 ohms, 1% metal film
R26—25,000 ohms cermet trimmer potentiometer, multiturn
R27—100 ohms

**Capacitors**
C1, C7, C13—0.1µF monolithic ceramic
C2—47µF, 16 V, solid tantalum
C3—100 pF, 10% ceramic disc
C4—0.001µF, 5% polyester
C5—1.0µF, 5% polyester
C6—0.01µF, monolithic ceramic
C8, C14—1.0µF, 35V, solid tantalum
C9, C10—56 pF monolithic ceramic
C11, C12—100 pF monolithic ceramic

**Semiconductors**
IC1—LM319, dual comparator, National or equiv. IC2—TLC555 CMOS timer Texas Instruments or equiv.
IC3, IC4—LF356 JFET operational; amplifier, National or equiv.
Q1—2N3906, PNP transistor
Q2—2N3904, NPN transistor
Q3—2N5117 or 2N3810, matched dual PNP transistors (2N5117, Semiconductor Technologies, or 2N3810, NTE 82), T0-78 package
D1, D2—1N4001, 1-A silicon rectifier, 50 PIV
D3, D4, D5—1N4148 silicon diodes
D6—1N751A/1N5231B, 5.1 V Zener diode, 5%, 500mW
D7—1N749A/1N5229B, 4.3 V Zener diode, 5%, 500mW
LED1—Light-emitting diode, T1 case, red

**Other components**
S1, S3—toggle switch, SPDT, subminiature, 1 A, panel mount
S2—toggle switch, SPDT miniature, 1 A panel mount
S4—toggle switch, DPDT miniature, center off, 1 A, panel mount
J1, J2—jack, BNC female, panel mount
J3—phone jack, ⅛ (3.5 mm) 3 conductor w/matching plug

**Miscellaneous:** circuit board (see text), Radio Shack 276-150 or equivalent; two-part aluminum project case (see text); precision potentiometer counter dial, 15-turn, Clarostat Clarodial or equiv.); 8-pin DIP sockets, three; 14-pin DIP socket; plastic standoffs, ⅜-inch; screws and nuts, solder.




SCHEMATIC FOR A ±5-VOLT, REGULATED dual power supply.

and drill the four mounting holes approximately in the center of the base of the lower half of the case. Then drill a hole for the solder terminal strip between S4 and the circuit board ,as shown in Fig. 4. This might be the right time to label the control positions for jacks, switches and potentiometers to be mounted on the front and rear panels by some convenient method, as shown in Fig. 3.

### Assembling the adapter

Insert and fasten all of the panel-mounted components on the front and back panels, as shown in Fig. 4. Install the terminal strip with a screw and nut. Refer to the off-board component schematics on parts placement diagram Fig. 2. Position and solder a length of No. 22 AWG bare bus wire from the ground lug on J1 to the ground lug on J3 and on to the ground lug on J2. Insert and solder resistor R1 on J1, resistor R13 from J2 to S3, and diodes D1 and D2 from J3 to the ground bus.

## PARTS LIST—POWER SUPPLY

**Resistors are ¼ watts, 5% unless otherwise specified**
**R1, R2—1800 ohms**

**Capacitors**
C1, C2—330µF, 16 V, aluminum alectrolytic
C3, C4—0.1 µF, 25 V, monolithic ceramic

**Semiconductors**
IC1—78L05 voltage regulator, +5V, 100 mA, National or equiv.
IC2—79L05 voltage regulator, −5V, 100 mA, National or equiv.
BR1—full-wave bridge rectifier, 1 A, 50 PIV
LED1—light-emitting diode, red, T1 case
LED2—light-emitting diode, yellow, T1 case

**Other components** T1—transformer 120 VAC primary, 12.6 VAC center-tapped, 0.2 A
S1—toggle or slide switch, miniature, DPDT, 1 A

**Miscellaneous:**project case, (see text), circuit board, ⅛ jack, panel-mounted AC line plug, insulated hookup wire, solder, screws, and nuts.

**Note: One source for Q3, the 2N5117 matched dual PNP transistor, is Johnson Shop Products, P.O. Box 2843, Cupertino, CA 95015, 408-257-8614**

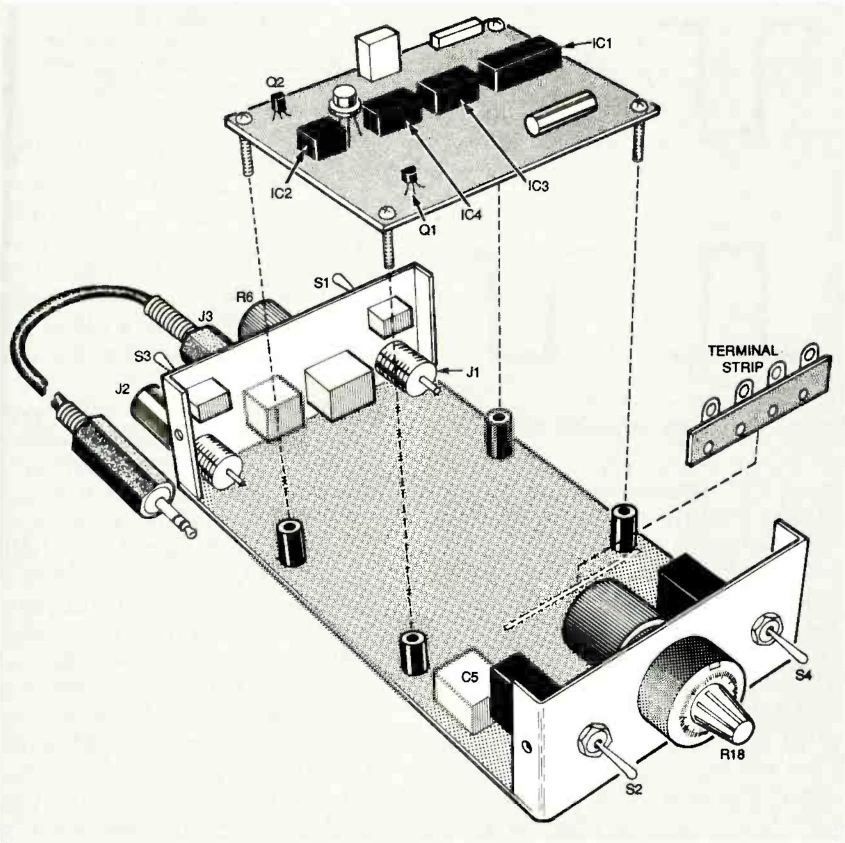
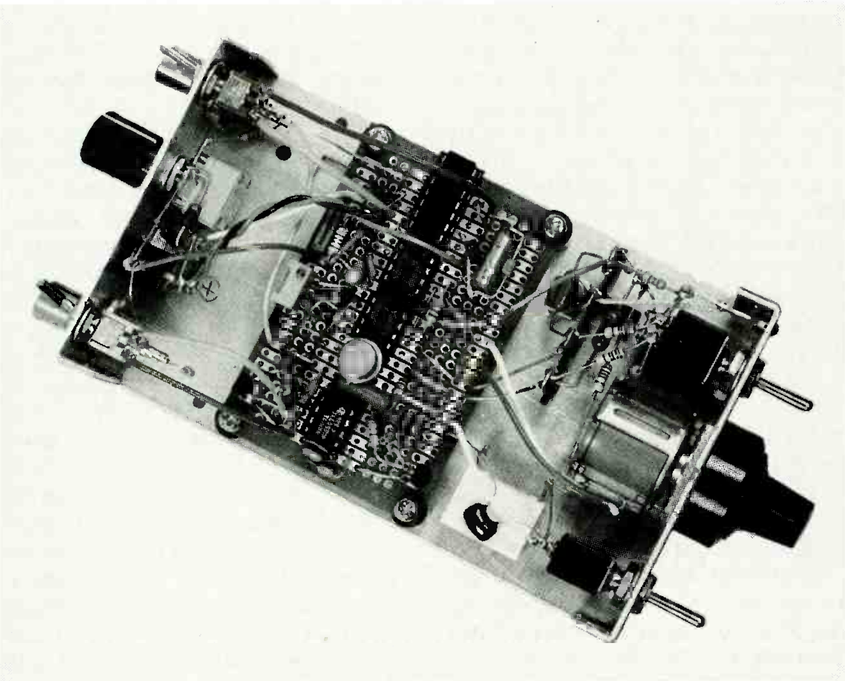



**FIG. 4—ASSEMBLY DIAGRAM showing the locations of the circuit board and panel-mounted components.**



**INSIDE VIEW of the completed Dual Scope Adapter reveals a neat and professional-type assembly. Check that the cover causes no shorts when the box is closed.**

Select one lug on the terminal strip for the +5-volt lead, one for ground (mounting lug), and one for each emitter of transistor Q3. Install and solder R22 and R23 on the terminal strip, R21 and R24 on switch S4, R20 and R25 from switch S4 to the terminal strip. Install and solder resistor R14 from LED1 to the terminal strip along with a ground lead from the cathode of LED1. Install and solder resistor R17 from R18 to the terminal strip. Install and solder capacitor C5 on switch S2 with a free lead ready for connection to the circuit board.

Fasten four ⅜-inch standoffs to the bottom side of the circuit-board mounting holes, position it on the base plate holes and fasten it with four screws. Connect and solder all wires from the off-board components. Again check all soldered connections for cold or inadequately soldered joints, and make any corrections necessary. Install the four ICs in their sockets.

Set multiplier potentiometer R18 as follows: Turn the shaft full counter-clockwise and install the counter so that it reads 1.00. Thus, when it is rotated ten turns fully clockwise, it will read 11.00, a range of ×1.00 to ×11.00. To obtain the highest accuracy, measure the actual resistance of R18 and select or trim R17 (100 ohms nominal) so that: R17 = (R18/10) +2 ohms. For example, if R18 = 990 ohms, R17 will equal 99 +2 = 101 ohms. The extra 2 ohms compensates for the finite gain of Q3, which causes nonlinear multiplier performance.

### Calibration and test

Plug the power supply into jack J3, connect jack J1 to your oscilloscope's CHANNEL 1 output jack, and connect J2 to the Z axis jack. Set the trigger for a positive slope, and set S1 and S3 to (+) on your adapter. Set R6 (TRIGGER LEVEL) to mid position (zero volts) and select the 10 millisecond range as follows: Set S2 to "ms", S4 to "10", and the turns-counter on R18 to full counterclockwise.

Turn on the power supply and, with a digital multimeter, adjust potentiometer R15 on the circuit board so that about 60 millivolts is present from the +5-volt bus to pin 3 of IC3. Then set R26, also on the cir-

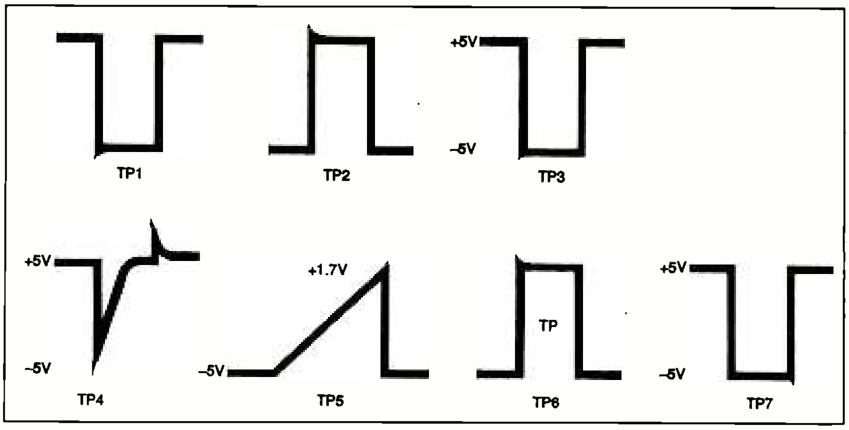



**FIG. 5—OSCILLOSCOPE WAVEFORMS at selected test points, as shown on Fig. 1**

cuit board so that there is a reading of 0.0 millivolts between pins 2 and 3 of IC4.

If you should encounter any problems with the circuit at this time, you might want to observe the waveforms at the test points identified in the schematic, Fig. 1. Figure 5 illustrates the wavforms to be expected at those test points.

Introduce a 60-Hz signal from a separate, low-voltage filament-style transformer to CHANNEL 1 of your oscilloscope, and display two or three cycles at about six divisions of vertical height. With the adapter set at 10 milliseconds, you should see a waveform with about 50% or more of each cycle in bold relief (intensified) with the remainder dimmed.

Adjust your oscilloscope's intensity control for the best contrast of the two parts of the trace. The positive half of each cycle should be bold. If it is not, set rear panel switch S3 (OUTPUT SLOPE) to (−), to allow the bold section to lengthen as the multiplier (R18) is advanced clockwise. Rotate the knob of panel potentiometer R6 (TRIGGER LEVEL) back and forth and observe how the cursor can be triggered at any point on the positive-going slope. (Reverse S1's position to trigger on the negative-going slope.)

Advance the turns counterclockwise, and observe the bold section lengthening towards the next cycle so that it eventually forms a complete bold trace. At this setting, the adapter output pulse is equal to the time period of the 60-Hz signal (16.7 milliseconds). A very small advance of the turns counter will cause each alternate cycle to dim. Adjust your oscilloscope's sweep speed to see this clearly, and then set the turns counter to ×1.67. Now adjust calibration trimmer R15 to locate the trace exactly at the point where it changes from full bold on each cycle, to bold on each alternate cycle.

This completes the calibration and operating instructions for the time period mode. As expected, any type of waveform can be measured by simply manipulating the slope, range, and multiplier controls of the unit.

To use the delayed sweep mode, connect output jack J2 to the TRIGGER INPUT jack on your oscilloscope (instead of the Z axis jack). Introduce the signal to CHANNEL 1, set switches S1 and S3 to match the oscilloscope waveform's slope, and adjust the range controls to the approximate signal time period. Switch the oscilloscope to EXT. TRIGGER), and rotate the turns counter to keep that part of the signal-to-be-viewed on screen as you increase sweep speed to expand the signal.

**Regulated power supply**

A schematic for a wall outlet mounted ± 5-volt power supply for this oscilloscope accessory is included because commercial versions are not widely available. The author built the supply into a two-part aluminum project case measuring 3¼ ×1½ ×2 inches. These cases are standard, off-the-shelf items. Ω

## L/C METER

*continued from page 65*

60 components on a HP4275A L/C meter. Measuring these components on the L/C meter prototype found an average error of just 0.60% for inductors and 0.13% for capacitors. These values ranged from .1 μH to 6.8 μH for the inductors and 2.7pF to .068 μF for the capacitors.

The prototype was also used to measure the values of a series of 5% tolerance inductors up to 150 mH, and a series of 10% mylar capacitors up to 1.6 μF. All of these parts measured well within the specified tolerance of their marked values indicating the accuracy of the L/C meter extends at least up to 150 mH and 1.5 μF. These measurement were made on a single unit. The measured values could vary, from unit to unit, by 1% to 2% as a function of the exact value of C2, 1% tolerance polystyrene capacitor.

The L/C meter has a four-digit resolution, which for small values of L and C are 1 nH and .01 pF. You cannot accurately measure values this small. The resolution greatly exceeds the accuracy.

You can measure values as small as .01 μH and .1 pF with about 15% accuracy. However, you generally won't find components this small. For example a piece of wire less than one inch long has an inductance of 0.01 μH.

The resolution of the meter is, however, relative, and can be used for sorting a batch of similar components as it truly does indicate which are slightly larger of smaller than others. Also, for small values of inductance, the leads will contribute quite a bit to the value. Measuring from the ends of the leads instead of next to the body of the component can add up to 0.025 μH.

For small values the frequency of operation (test frequency) is about 750 kHz decreasing to about 60 kHz at .1 μF or 10 mH and about 20 kHz at 1 μF or 100 mH. Ω

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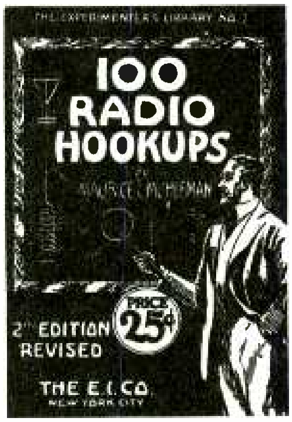


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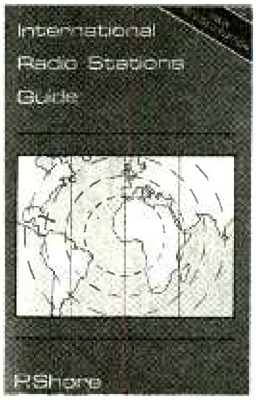


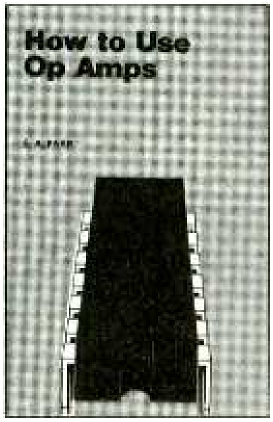


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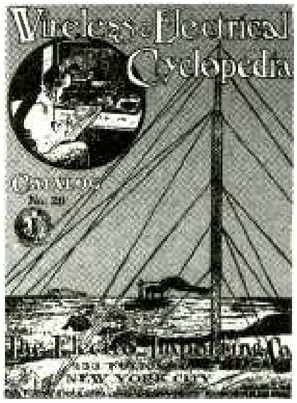


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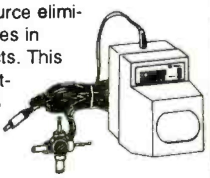

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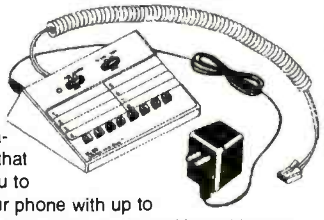

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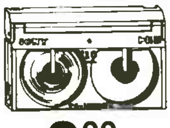

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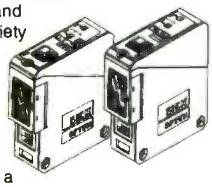

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| size | Mfr. | price | size | Mfr. | price |
|---|---|---|---|---|---|
| 640x480 (backlit) | Epson | $35.00 | 480x128 | Hitachi | $15.00 |
| 640x400 (backlit) | Panasonic | $25.00 | 256x128 | Epson | $20.00 |
| 640x200 | Toshiba | $15.00 | 240x128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

## 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.

**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 )**

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**Proteon ProNet-4 Model p1347 Token Ring Board $79.00**
16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

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**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.
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**ADAPTEC 4070A (RLL) OR 4000A (MFM) SCSI Controller, your choice $25.00**
**IBM 370 option XT and AT emulation boards $35.00**

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**Non-Enclosed TTL**
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| | |
|---|---|
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**5" COLOR MONITOR $49.00**


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## CHARGE COUPLED DEVICES

**"The Spy In The Sky" $29.00** — **MATRIX TYPE**

**Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V)**
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 $29.00**
**1024 element CCD $15.00**
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## HACKER CORNER

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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.

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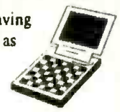
**Portable Micro Terminal $99.00 or 2 for $149.00**

Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal • Use by itself as electronic notebook • Onboard microprocessor, data RAM (32K) and Video RAM (64K) • Complex built in diagnostics and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dimensions: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1")

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|---|---|---|---|
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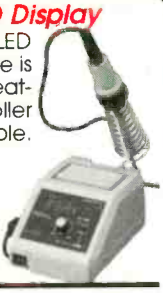

| CAT NO | DESCRIPTION | PRICE EACH 1 | 5 |
|---|---|---|---|
| SL30 | Deluxe Soldering System w/LED | $86.00 | $75.00 |
| SL24V | Spare 24V Soldering Iron for SL10 or SL30 | 10.50 | 7.50 |

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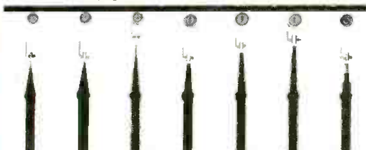

821 822 823 824 825 826 827

## *Replacement Tips for SL10/SL30*

We now offer a variety of replacement tips for the SL10/SL30 soldering stations.

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| 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 |
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|---|---|---|---|
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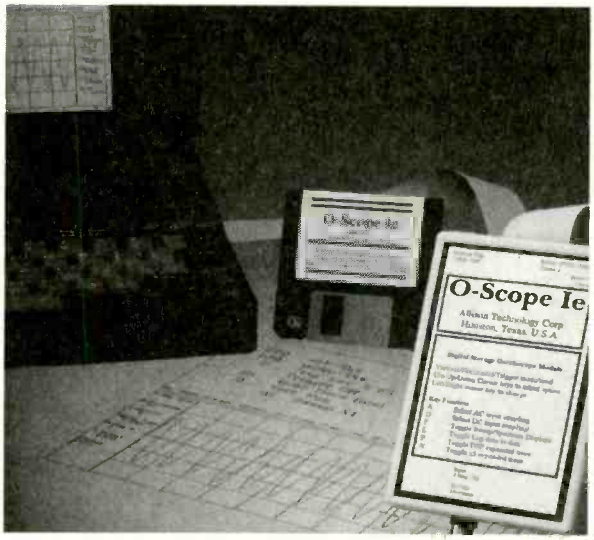


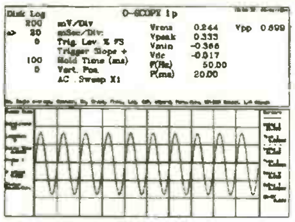

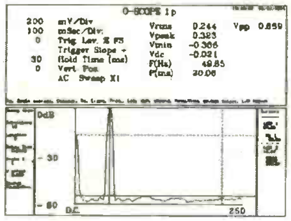

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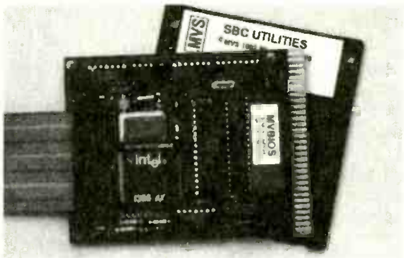


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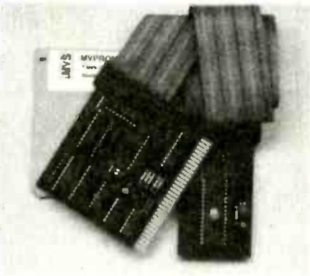


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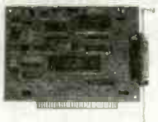

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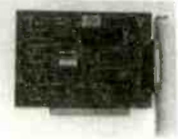

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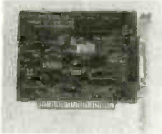

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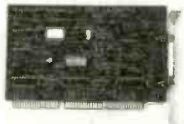

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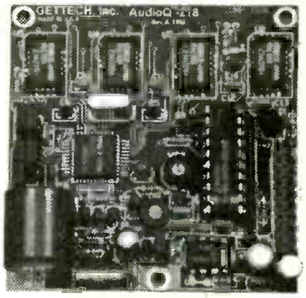

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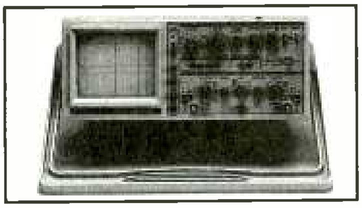

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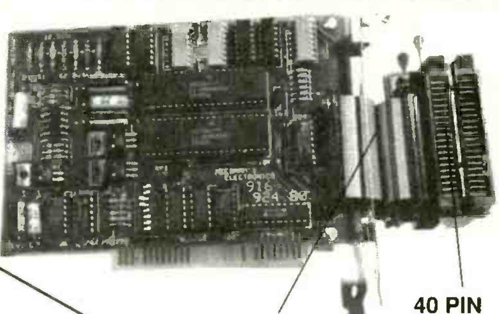

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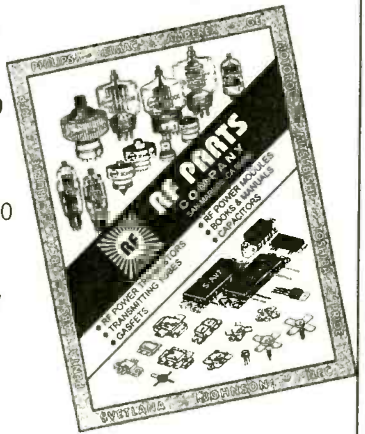


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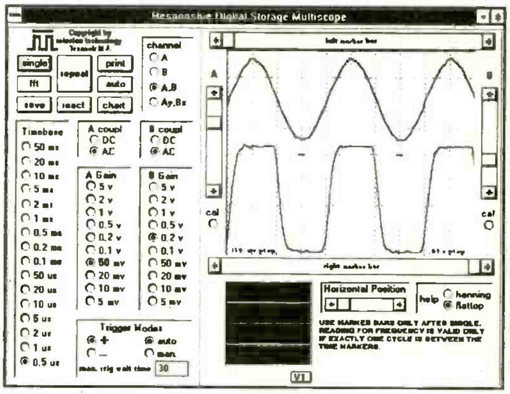

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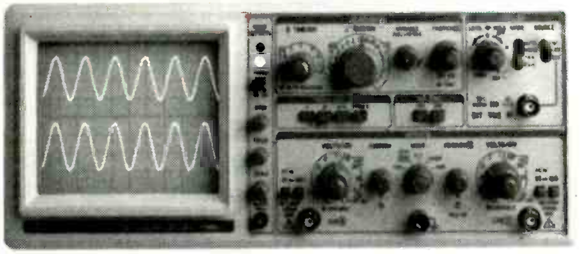

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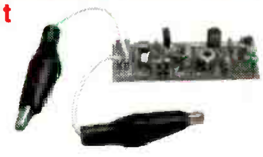

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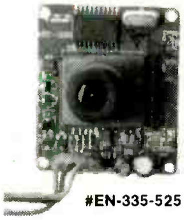

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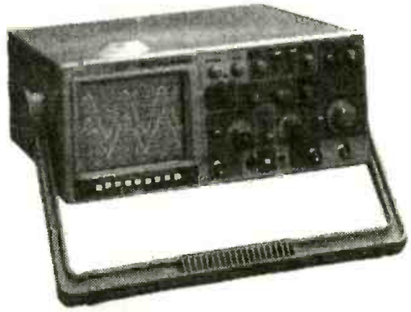

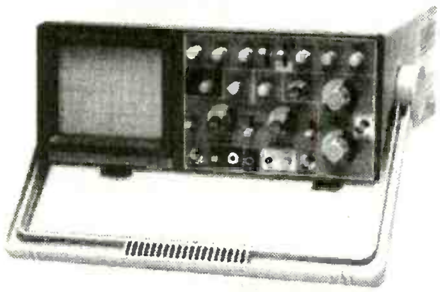

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### 25/30MHz

**DS-303 $1095**
- Analog / Digital Storage

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

**S-1325 $335**
- 25MHz Analog

**OSCILLOSCOPE SELECTION CHART**

ANALOG

| Model | Bandwidth MHz | Sensitivity (max) | No. of Channels | Sweep Rate Max ns/div | Delayed Sweep | Video Sync | Component Tester | Beam Find | Time Base |
|---|---|---|---|---|---|---|---|---|---|
| S-1365 | 60 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1360 | 60 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1345 | 40 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1340 | 40 | 1mV/div | 2 | 10ns/div | No | Yes | No | No | 1 |
| S-1330 | 25 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1325 | 25 | 1mV/div | 2 | 10ns/div | No | Yes | No | No | 1 |

DIGITAL STORAGE

| Model | Bandwidth MHz | Analog Sen (max) | No. of Channels | Sampling Rate | Memory Channel | Internally Backed Up | Pretrigger % | Output |
|---|---|---|---|---|---|---|---|---|
| DS-303 | 30 | 1mV/div | 2 | 20MS/S | 2K | Yes | 0, 25, 50, 75 | RS232 |
| DS-603 | 60 | 1mV/div | 2 | 20MS/S | 2K | Yes | 0, 25, 50, 75 | RS232 |

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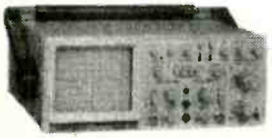

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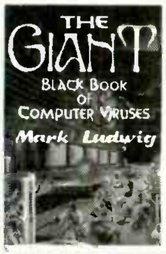


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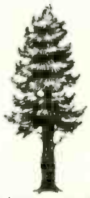

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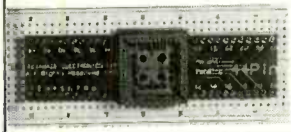

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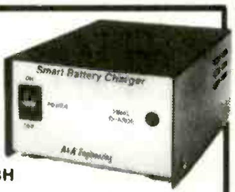

**JUN 87 QST**

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**FOR GEL-CELLS or LEAD ACID BATTERIES.** **Features:** Precision temperature tracking voltage reference & three mode charging sequence. Standard kit is for 12V @ 1/2 or 1 Amp, user selectable. Can be connected to the battery indefinately, will not overcharge. Weighs 2 pounds and measures 4"W x 5½"D x 2½"H. Finished enclosure included in kit.

**Complete Kit Only ............ $59.95**
**Assembled & Tested .......... $79.95**

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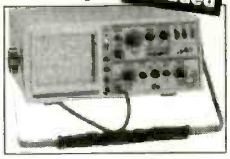
## B&K 20MHz Dual Trace Oscilloscope

**Probes Included**

- 1 mV/div sensitivity
- AUTO/NORM triggered sweep operation
- AC, TVH, TVV and line coupling
- Calibrated 19 step time base with x-10 magnifier



**model #2120** 2 Year Warranty ......... **385.00**
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**model #2190A** 100MHz 3 Ch ........ **1339.95**

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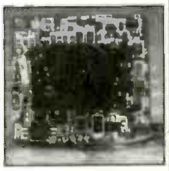
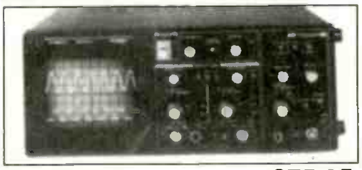


**model #CVC50PH** ............. **139.95**

## Protek Test Equipment

**20 MHz Oscilloscope**
**Dual Trace w/ Component Checker**



**#P3502C** Dual Trace ........................... **375.95**
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**Cutting Edge** The model 506 meter has a RS-232C serial interface. Measured values are transmitted to the computer via an interface cable and supplied software WINDOWS and MS-DOS.
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**Special**
model #MD1
**145.95**

**Sale!**

## Elenco Digital Capacitance Meter

- 1 UF to 20,000 UF
- Banana jack and special insertion jack Included

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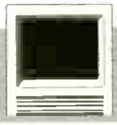

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**CIRCLE 232 ON FREE INFORMATION CARD**

# USE ELECTRONICS NOW CLASSIFIEDS

READ BY ELECTRONIC BUYERS AND SELLERS AND TRADERS

## INSTRUCTIONS FOR PLACING YOUR AD!

### HOW TO WRITE YOUR AD

**TYPE or PRINT** your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

### WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

### RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

**If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.**

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues.**Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface**, add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $4.00 per word.

**General Information:** A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue ( i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

### DEADLINES

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.**

**AD RATES:** $2.50 per word, Minimum $37.50

Send you ad payments to:
**ELECTRONICS NOW 500 Bi-County Blvd, Farmingdale, NY 11735-3931**

## CATEGORIES

| | | | |
|---|---|---|---|
| 100 – Antique Electronics | 270 – Computer Equipment Wanted | 450 – Ham Gear Wanted | 630 – Repairs-Services |
| 130 – Audio-Video Lasers | 300 – Computer Hardware | 480 – Miscellaneous Electronics For Sale | 660 – Satellite Equipment |
| 160 – Business Opportunities | 330 – Computer Software | 510 – Miscellaneous Electronics Wanted | 690 – Security |
| 190 – Cable TV | 360 – Education | 540 – Music & Accessories | 710 – Telephone |
| 210 – CB-Scanners | 390 – FAX | 570 – Plans-Kits-Schematics | 720 – Test Equipment |
| 240 – Components | 420 – Ham Gear For Sale | 600 – Publications | 730 – Wanted |

## CLASSIFIED AD COPY ORDER FORM

**Place this ad in Category #**________ **Special Category $30.00 Additional** __________________

| | | | |
|---|---|---|---|
| 1 - $37.50 | 2 - $37.50 | 3 - $37.50 | 4 - $37.50 |
| 5 - $37.50 | 6 - $37.50 | 7 - $37.50 | 8 - $37.50 |
| 9 - $37.50 | 10 - $37.50 | 11 - $37.50 | 12 - $37.50 |
| 13 - $37.50 | 14 - $37.50 | 15 - $37.50 | 16 - $40.00 |
| 17 - $42.50 | 18 - $45.00 | 19 - $ 47.50 | 20 - $50.00 |
| 21 - $52.50 | 22 - $55.00 | 23 - $57.50 | 24 - $60.00 |
| 25 - $ 62.50 | 26 - $65.00 | 27 - $67.50 | 28 - $70.00 |

| | | | |
|---|---|---|---|
| 29 - $72.50 | 30 - $75.00 | 31 - $77.50 | 32 - $80.00 |
| 33 - $82.50 | 34 - $85.00 | 35 - $87.50 | 36 - $90.00 |
| 37 - $92.50 | 38 - $95.00 | 39 - $97.50 | 40- $100.00 |

Total words ______ $2.50 per word = $______

Bold Face ______ $0.40 per word = $______

Special Heading ______ $30.00 = $______

Other ______ = $______

**Total classified ad payment $**______ **enclosed**

**TOTAL COST OF AD $** ______

[ ] Check [ ] Mastercard [ ] Visa [ ] Discover

Card # _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Expiration Date _ _/_ _

Signature________________________

Name ______________________ Phone ______________________

Address______________________City State Zip ______________________

CIRCLE 231 ON FREE INFORMATION CARD

# CLASSIFIED

## MISCELLANEOUS ELECTRONICS FOR SALE

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**FIBER-Optic Projects** — Swing into the new technology by assembling tried and true projects recently published. "Practical Fiber-Optic Projects" - BP374 is only $9.95. (price includes shipping) **ELECTRONIC TECHNOLOGY TODAY INC.,** PO Box 240, Massapequa Park, NY 11762-0240.

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**TUBES,** New, up to 90% off, S.A.S.E., **KIRBY,** 298 West Carmel Drive, Carmel, IN 46032.

**CBers** Order new CB Trick III CB book. Shows CB tune ups, amplifiers, and expert CB info! Send $19.95 to **MEDICINE MAN** CB, PO Box 37, Clarksville, AR 72830.

**RESISTORS** 20 for $1.00. LEDs 4 for $1.00. Catalog $1.00. **ZIPFAST,** Box 12236, Lexington, KY 40581-2238.

**POOR** reception on your A.M. radio? Our Signal Booster will help. Guaranteed! Send $2.00 for details (refundable with order). **FALA ELECTRONICS,** PO Box 1376, Dept. 4, Milwaukee, WI 53201.

**HAVE** a beeping or chirping sound with scrambled video on channels. We can help. Professional quality positive notch filters. Discounts on 5 or more. Fast courteous service. All credit cards. We now carry 1-piece cable units w/volume control and parental lockout for all systems. Call 1 (800) 684-0539.

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**PROTECT** yourself with the Security Plus 100,000 volt Stun Gun. It's safe, effective and strong enough to stop any attacker. Send $99.95 (shipping is included) to: **F.M.C.,** PO Box 1174, Forest Hills, NY 11375.

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**TECHNICIANS:** Electronic component tester for use with oscilloscope. Satisfaction guaranteed. $29.95 plus S&H. Info.: **ELECTROHM,** 529 Brentwood, Lawrence, KS 66049.

**QUALITY** used test equipment for sale. Call, fax or write for list. **RIDGE EQUIPMENT,** PO Box 84, Mt. Airy, MD 21771. (301) 831-7671.

**SURPLUS** electronic test equipment for sale for pennies on the dollar. Request list. Phone: (908) 722-6157. Fax: (908) 722-6391.

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**BECOME** a professional locksmith. Home study. Free career literature. **P.C.D.I.,** Atlanta, GA. 1 (800) 362-7070. Dept. LKG342.

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# CLASSIFIED

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CIRCLE 331 ON FREE INFORMATION CARD

# ADVERTISING INDEX

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**Fax 1-(516) 293-3115**

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**Adria Coren**
credit manager (ext. 208)

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1-909-659-9743
Fax 1-909-659-2469

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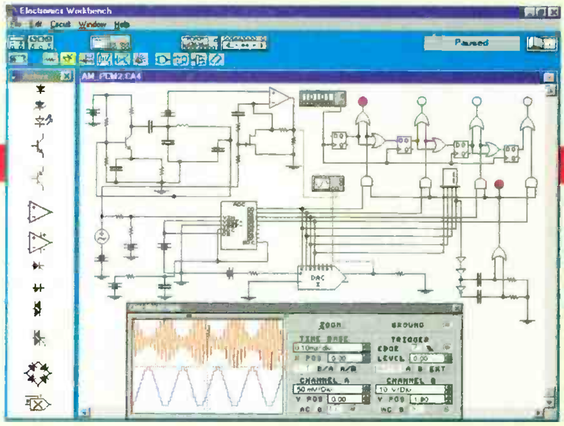


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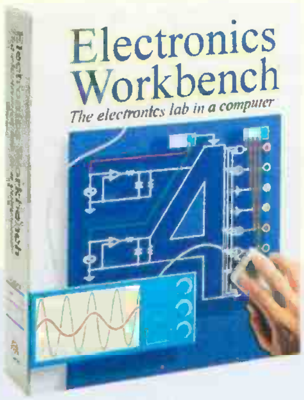


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