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THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

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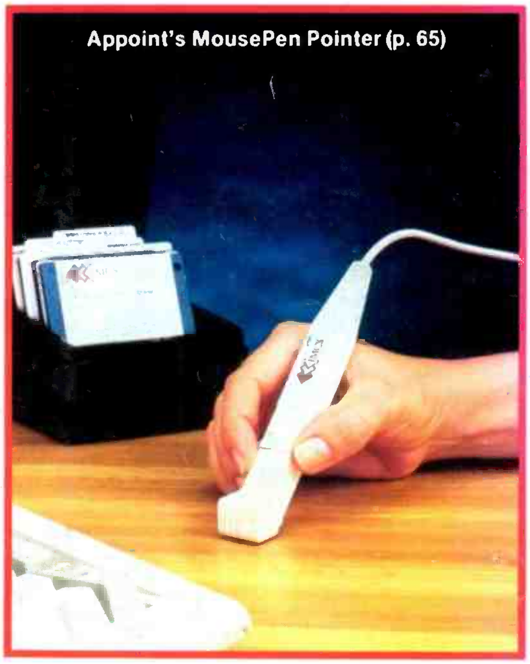
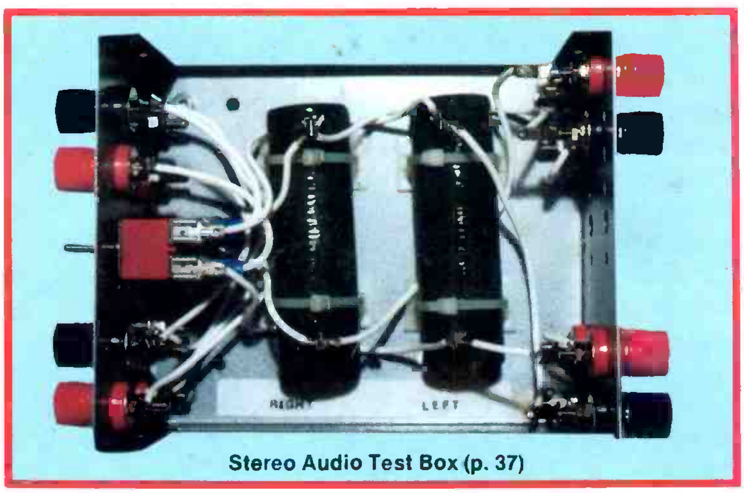

Appoint's MousePen Pointer (p. 65)


No-Contact Infrared Thermometer Accessory (p. 24)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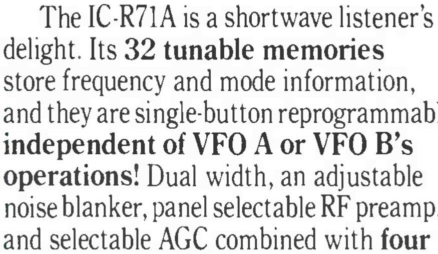

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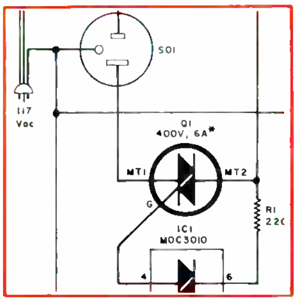

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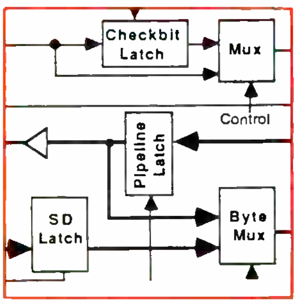

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FEATURES

COLUMNS

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Offices: 76 North Broadway, Hicksville, NY 11801. Telephone: (516) 681-2922. FAX (516) 681-2926. Modern Electronics (ISSN 0748-9889) is published monthly by CQ Communications, Inc. Subscription prices (payable in US Dollars only): Domestic—one year $18.97, two years $36.00, three years $53.00; Canada/Mexico—one year $21.00, two years $40.00, three years $59.00; Foreign—one year $23.00, two years $44.00, three years $65.00. Foreign Air Mail—one year $76.00, two years $150.00, three years $224.00.

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CQ Communications, Inc. is publisher of CQ The Radio Amateurs Journal, Popular Communications, Modern Electronics, CQ Radio Amateur (Spanish CQ), and the CQ Amateur Radio Buyer's Guides.

PERSONAL DIGITAL CELLULAR PHONES. Next year NYNEX Mobile will introduce wireless personal telephone service (PTS) in New York City. It'll use a new digital transmission standard and expand the breadth of cellular telephone services. It will buy switching equipment from AT&T Network and digital phone handsets from Qualcomm, Inc. for resale to consumers. It's reported that the new phones will be significantly smaller and lighter than present cellular models, and also less expensive. The phones will have a "sleep" mode when not in use to minimize battery drain

Among services to be offered are traditional two-way communications, a less-expensive one-way outgoing service that responds to a built-in pager for incoming calls, and an economical one-way outgoing-only service

UNFAIR BANNING. Starting January 1, 1991, the Government Ethics Reform Act of 1989 (Section 601 of P.L. 102-194) prohibits civil servants from accepting payment for writing or giving speeches about any subject whether or not it's related to their job. Apparently directed against congressmen and government officials from accepting honoraria, the legislation is written so that it blankets all federal workers. As a result, it will be illegal for a clerk working for the government to write a poem and be paid for it; or a short story or a technical article for a magazine. Or writing for a religious newsletter on a part-time basis, and so on. Clearly, the law has to be refined--and quickly--since it affects people whose part-time efforts have nothing to do with influence peddling. WRITE TO YOUR CONGRESSMEN AND SENATORS to demand a change in the law.!

There's Senate legislation afoot to ban the use of lead solder for connecting components (Bill S.2637). The Environmental Protection Agency can make an exception for certain products, but there's no assurance that the electronics industry will be among them. As you know, the commonly used tin/lead ratio for solder is 60/40, and industry spokespeople say that there's no lead-free substitute for it when considering corrosion, resistance and thermal stress. Among alternative alloys is indium-based material. Again, write to your legislators about this. Babies don't suck on soldered interconnects. Moreover, the lead in solder is contained within the compound.

TRACKING SATELLITE INTERFERENCE. Engineers at Georgia Institute of Technology say they've developed a system for pin-pointing the location of ground stations that interfere with satellites. Called the Satellite Interference Locations System, it uses a variation of techniques long used for radio navigation. The system employs a Time Difference of Arrival technique to infer longitude and latitude, and could theoretically provide accuracy to within a fraction of a mile. Most satellite interference is not caused by a "Captain Midnight," which interfered with Home Box Office (HBO) four years ago, but due to accidental turn-on of a legal transmitter at the wrong time, sloppy operation by TV news crews and commercial FM radio station signal leaks into satellite uplinks.

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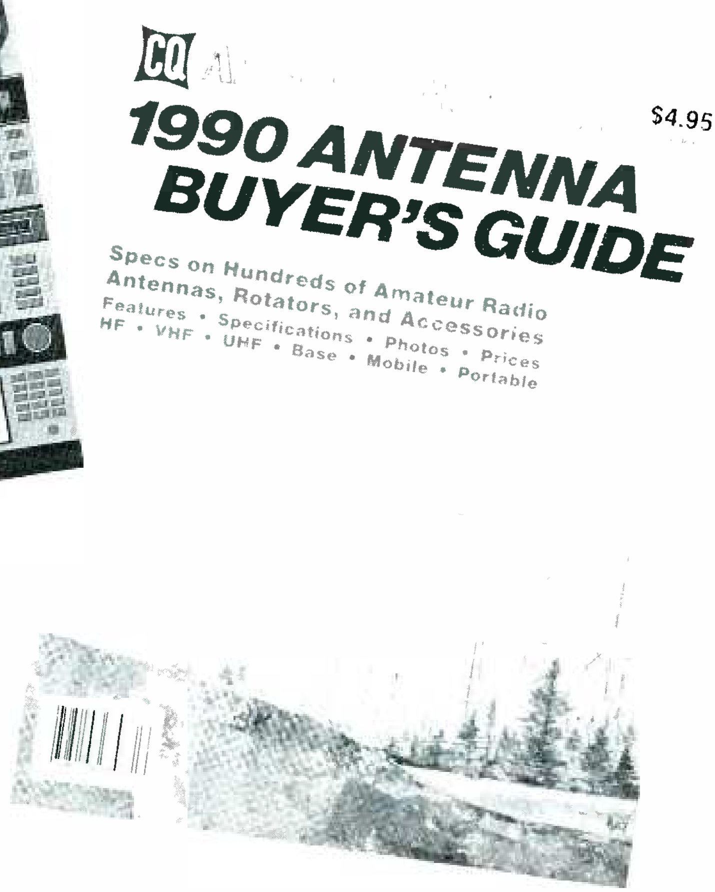
You can **buy with confidence** when you have all the facts. The **1991 Equipment Buyer's Guide** gives you in-depth coverage of HF/VHF/UHF rigs and accessories. All the information is here in **one handy, concise directory** with descriptions, technical specifications, model numbers, retail prices and photographs. How do you get a ham license? **What's the latest on the code-free license?** What equipment do you really need to work the satellites? **Should you buy a computer** for your shack? How do you add computer control to your rig? You can buy with confidence when you have all the facts. **Order the 1991 Equipment Buyer's Guide today!**



You'll need the **Antenna Buyer's Guide** to squeeze every last dB out of your antenna dollars. Make sure you get the best possible antenna system for the best price! HF and VHF, UHF, directional and omnidirectional, vertical and horizontal, mobile and portable—they are all covered in depth. Tuners, cables, wattmeters and more! You'll find detailed charts, specification, photos and retail prices. Advice on getting the proper tower and antenna permits from a leading authority on PRB-1. Step-by-step guide to putting up your first beam! The bands are hotter then ever right now. **You can't afford to wait.**

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EDITORIAL

Modern Electronic Drafting

Computer graphic systems have changed the way many people draw electronic schematic diagrams and create artwork for making printed-circuit boards. Marrying mechanical drawing to computers is nothing new—it began in the early 1960s. From a hardware viewpoint, it started with mainframes, extending to minicomputers and then to graphics workstations. In recent years personal computers have been used for this purpose, too.

The more powerful a PC is, the more sophisticated accompanying software can be. Even today's top-model PCs, however, exhibit severe limitations in what they can accomplish in the CAD area. For certain applications, such as design work that requires solving analysis problems, they're still too slow. For some solid modeling uses, they don't have enough memory for precise work.

Nevertheless, for many CAD purposes, they're very satisfactory. Furthermore, their relatively modest price makes them exceptionally attractive since more engineers can have access to the machines for a host of CAD applications where they work very well. In electronics, they're especially effective for drafting and for printed-circuit-board layouts. Moreover, they serve well to train users for work on much larger CAD/CAM (computer-aided drafting/computer-aided manufacturing) computers.

A particular boost for PCs in the electronics area has been the great increase in symbol libraries. Consequently, a user can quickly pluck a variety of electronic device drawings from a library and place them anywhere in a work area. It becomes easy to create interconnects, enter text, edit drawings, etc. Sophisticated software programs allow PCs to simulate circuit operation, design chips, and even do limited modeling and analysis.

With PC schematic programs now selling for under $100, wedding electronics and computers is not even costly today for anyone who wants to become CAD trained, or draw schematics for personal or educational reasons. Costlier programs open new vistas, which include professionally created schematics and pc-board layouts. Moreover, one can add symbol libraries for non-electronic drawing applications, such as landscape architecture, bathroom design, etc.

For high-quality work, you need good-performance equipment, of course. You won't get it with an old 4.7-MHz computer with 256K user memory, a CGA video monitor and a nine-pin dot-matrix printer. Also, you will definitely need a mouse pointing device.

Some indications of how professionals use CAD/CAM/CAE is revealed in a recent study by CAD/CAM Publishing (841 Turquoise St., Suite D, San Diego, CA 92109), which publishes a monthly newsletter, *Computer Aided Design Report*. It indicated that 47 percent of system owners plan to add work stations for producing schematics, while 51 percent plan such an expansion for PCB layout. The most popular electronic engineering applications for CAD are, according to the study, drawing schematics (40%), PC boards (34%), logic simulation (13%), analog simulation (10%), IC layout (10%), timing analysis (10%), and fault simulation (8%).

To get a better feel for what's available in schematic drawing and printed-circuit-board layout programs in the personal computer world, we examined a batch of them from ones at low price points to more costly packages. Additionally, we worked with an educational software package that simulates circuit activity through output readings of software-generated "instruments" of all kinds. And we varied the type of computers and peripheral equipment used.

The results of these efforts will be detailed here, starting next month. I think you will find it to be both interesting and inspirational since it's a field of endeavor that weds electronics and computers, and offers growing job opportunities.

Art Salsberg

LETTERS

Equivalency

• Would you please supply me with equivalent numbers for CMOS op amp *IC1* and 3914 dot/bargraph display driver *IC2* for the "Biofeedback Monitor & Lie Detector" featured in the August 1990 issue of *Modern Electronics.*

In the same issue appeared the "Darkroom Exposure Meter" for which I would like to know the equivalent for the Vactec VT200 photocell recommended for *PC1*. The text mentions that this device is available from Allied Electronics and Newark Electronics. While this may be so, both sources have a minimum requirement of $25 per order, which puts building such projects beyond the reach of reasonable price.

May I suggest that if *Modern Electronics* wishes to sell magazines in Canada, full information about ICs and other devices should be given so that equivalents can be purchased here without having readers suffer the cost of postage, customs, etc.

John E. Sandon-Humphries
Logan Lake, B.C., Canada

The CMOS op amp you refer to is a specialized device that is available in only 1,000-piece quantities. The Note at the end of the Parts List gives a source from which this chip can be obtained in single-unit quantity. The 3914 is available from Digi-Key (1-800-344-4539), among other suppliers. The VT200 series was cited as a typical example of the photocell to use. You can use any other photocell that has the characteristics given in the article.—Ed.

Perspective, Please

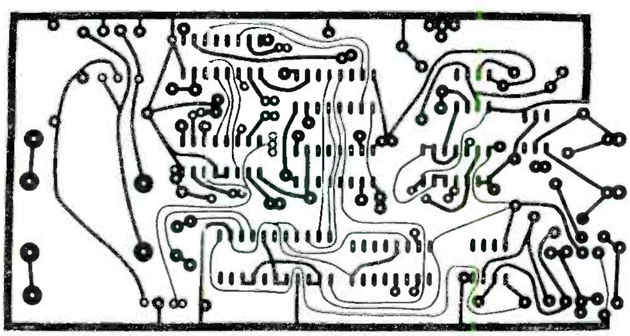
• What is the view of the Dinsmore magnetic sensor in Fig. 2 of the "Digital Compass" project featured in the August 1990 issue of *Modern Electronics*?

J.B. Craig
Marysville, CA

The view is from the bottom of the device.—Ed.

Cleaner Copy

• The etching-and-drilling guide for the main pc board in Part 2 of the "Dual-Application Telephone Security System" that ap-



peared in the July 1990 issue of *Modern Electronics* appears to have a few short circuits between closely-spaced traces. Any chance of getting a "clean" copy?

J.A. Furstman
Brooklyn, NY

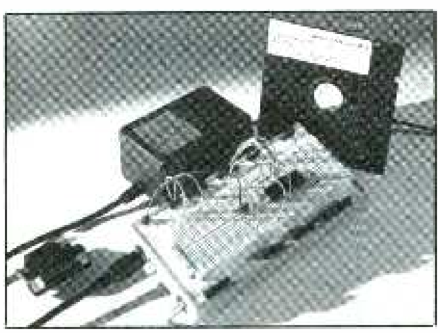
The original pc guide appears to have suffered from "ink bleed" during printing. Here it is cleaned up but shown at 75% actual size. You can easily clean up the original by working from this copy. Alternatively, you can have this blown up to actual size for direct use. Also note that the trace that originates at the pin 12 pad for IC7 *and passes between the pads for pins 11 and 12 for* IC6 *and terminates at the pin 21 pad of* IC2 *should also be connected to the pin-12 pad for* IC6.*—Ed.*

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

Universal Interface Design Aid

The micro-LAB computer peripheral from Fisher Instruments (Bothell, WA) is designed to be a universal computer interface. It is intended to be a design aid for use by engineers, designers and students. Reported to function with virtually any computer that has an RS-232 serial port operating at 300 to 19,200 baud with no handshaking required, micro-LAB can be controlled via almost any computer language.

Included in the micro-LAB package are a solderless breadboarding socket, function generator, D/A and A/D converters, fixed and program-



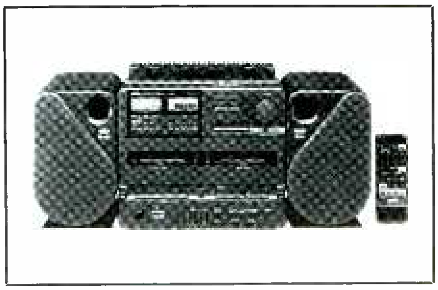
mable clocks, counter, audio amplifier and speaker, two eight-bit input and two eight-bit output-only ports. Sample applications and graphics are also provided. All inputs and outputs are TTL-compatible. Clock/counters include three crystal-controlled clock sources, three 16-bit timer/counter control channels and one eight-bit event counter.

Three eight-bit ± 10-volt dc channels are provided, as are one eight-bit 10-volt ac channel and one eight-bit 0-to-10-volt dc D/A converter. The function generator provides sine, square and triangular waveforms with sweep input. A separately available power pack provides +12 and −12 volts, both at 250 mA, and +5 volts at 500 mA. The device measures 7.6″ × 3.5″ × 1.3″. $349.95; $34.95 power pack; $3 demo disk.

CIRCLE NO. 51 ON FREE INFORMATION CARD

Shelf-Size Stereo System

Yamaha Electronics Corp. has a compact stereo system that utilizes Active Servo Technology to achieve low and accurate bass response from



small speakers. The Model YST-C11 consists of an Active Servo Technology amplifier, AM/FM-stereo tuner, CD player, dual cassette decks, four-band graphic equalizer and detachable stereo speakers. The amplifier employs various types of matching and feedback circuitry to produce extremely low and accurate bass response from speakers with a footprint of only 5⅞ by 9½ inches.

The CD player at the top of the console unit offers direct, random and programmed access. It features a 20-track calendar; track-selection keypad; intro scan; auto replay synchronized to the cassette deck for recording; and built-in timer for wake-up purposes.

An EQ record on/off cassette-deck function permits adjustment of the tonal qualities of the signal being recorded and endless playback of both sides of a tape. Dolby B noise reduction is provided for both decks. Timer record/play permits the programming for later operation.

PLL synthesized tuning with direct entry and 10 presets is featured in the AM/FM-stereo tuner. A low-noise AM loop antenna and a timer are included.

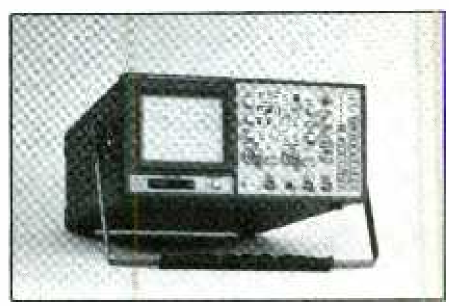
The speakers feature a 4¾-inch midrange driver, 1-inch tweeter and Yamaha's YST air woofer. The cloth speaker grilles are in an offset pear shape to leave visible the open throats of the air woofer ports.

Other system features include a balance control and LEDs that show volume level. Except for the rotary Volume and slide-type equalizer and balance controls, all functions are operated via pushbuttons. An included 34-button infrared remote controller duplicates virtually all control functions on the console unit. $999.

CIRCLE NO. 52 ON FREE INFORMATION CARD

High-Speed DSOs

Hitachi now has two new lines of high-speed digital storage oscilloscopes. Its 65 and 75 series DSOs share such common features as: 100-MHz analog/digital bandwidth; two-channel simultaneous sampling; 2-mV/div. sensitivity; eight-bit vertical resolution; 4K record length; 100-ns glitch capture, averaging and roll modes; cursors, readout and save memory; sweep time autoranging; and built-in IEEE-488 GPIB inter-



face. All models also include pre/post triggering, trigger lock, digital processing and four-color HPGL plotter output.

Acquisition modes provided include normal, average, envelope and roll. Triggering can be set for peak-to-peak, normal, TV-V, TV-H or single. Frequency is measured automatically by all models, while P-P

(Continued on page 14)

How to build a high-paying career, even a business of your own, in computer programming.

RICK BRUSH,
NRI PROGRAMMER/ANALYST

Start with training that gives you hands-on programming experience—at home and at your own pace. Training that begins with BASIC, then continues with Pascal, C, and COBOL—today's hottest computer languages. Training that even includes a powerful IBM-compatible computer, modem, and programming software you keep.

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No matter what your background, NRI gives you everything you need to succeed in programming, today's top-growth computer career field.

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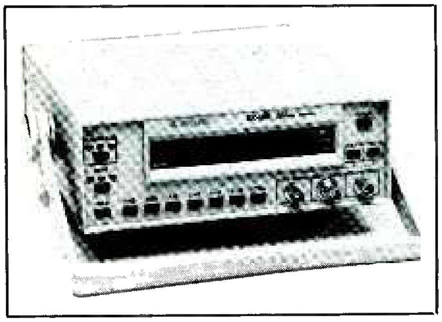
Accredited by the National Home Study Council 5414-110 voltage is also automatically measured by the 75 series only. Accessories provided with these DSOs include two probes (1×/10× switchable) and, for the 75 series only, a 64K IC memory card and an IC dummy card.

The Models VC-6075 ($4,195) and VC-6065 ($3,995) feature 12.5 MHz single-shot bandwidth and 50 MS/s sample rate. The Models VC-6175 ($4,695) and VC-6165 ($4,495) up the ante to a 25-MHz single-shot bandwidth and boost sample rate to 100 MS/s. Finally, the models VC-6275 ($4,995) and VC-5265 ($4,750) boost the sample rate to 200 MS/s. Available options include: an IEEE-488 interface card and GPIB cable, DADisp V. 1.05B and V. 2.0 signal-processing software for use in IBM PCs and compatibles; IC card reader/writer; high-speed PC-transfer interface; color plotters; IC memory card; etc.

CIRCLE NO. 53 ON FREE INFORMATION CARD

Frequency Counter/Timer

ZTEST Electronics Inc. (Mississauga, ON, Canada) is now marketing the Myoung Model RUC-1300 reciprocal universal frequency counter/timer. The eight-decade instrument



offers three input channels: two with 100-MHz range and a third with a 1.3-GHz range. The RUC-1300 measures frequency, period, period averaging, time-interval, ratio and sum/difference of two channels and totalizes. Reciprocal techniques are said to accurately measure low frequencies by measuring the period and displaying the result as a high-resolution frequency. Basic sensitivity is rated at 50 mV into 1 megohm for the 100-MHz channels and 25 mV into 50 ohms for the 1.3-GHz channel. Self-test and the ability to hold a reading are standard features. $485.

CIRCLE NO. 54 ON FREE INFORMATION CARD

Video Imaging Software

MFJ Enterprises' (Mississippi State, MS) MFJ-1289 MultiCom IBM-compatible software lets users of the MFJ-1278 transmit and receive multiple gray-level weather fax maps, SSTV pictures and AP news photos. With it, you can also transmit and receive full-color packet pictures. The package gives 80 One-Key Macros and Call-Alert that sounds an alarm when a preselected character sequence is received by the MFJ-1278.

Auto-Set lets you instantly switch modes without having to retype command parameters. Auto-Router lets you store digipeater node routes for instant digipeating. Packet MultiPlex lets you send and receive a packet message during a binary file transfer so that you can exchange programs without your QSO being completely cut off. Also included is Multi-Word, a word processor specifically designed for multi-mode communications. With it, you can bring up a text file from within MultiCom and transmit any portion directly from that file. Multi-Word can also be used for everyday word processing.

MultiCom lets you integrate an optional MFJ-1292 Picture Perfect Video Digitizer so you can shoot and transmit a video picture via SSTV, fax or packet.

With this program, you also get menu control of your entire disk, disk utilities for graphics screen capture and conversion to packet picture format, disk of sample pictures, effective packet throughput readout, screen colors set, sound on/off switch, RS-232 cable and instructions. The program requires an IBM PC XT/AT or compatible with 512K of RAM and CGA, EGA or VGA graphics and an MFJ-1278 multi-gray level modem. The copy-protected program is distributed on three 5¼" disks (3¼" disks are available). $59.95.

CIRCLE NO. 55 ON FREE INFORMATION CARD

Updated Desktop Computer

Atari's new MC68000-based 32-bit internal/16-bit external 1040STE desktop computer comes with a full megabyte of memory for eight times as many colors—4,096 in all—than were possible with the predecessor 1040ST. It also features hardware-based smooth scrolling and a coprocessor BLiTTER chip for accelerated graphics speed. Upgraded sound architecture in the computer provides digitized pulse-code-modulation stereo sound.

Other features of this upgraded computer include: internal 3.5" floppy-disk drive; 8-MHz operating speed; built-in MIDI ports; built-in TOS operating system with GEM desktop; industry-standard modem and printer ports; two analog joystick, DMA hard-disk and ROM ports; and two-button mouse. A software package included with the computer provides spreadsheet, word-processing, educational and enter-

tainment programs that utilize the computer's upgraded sound and scrolling capabilities. The computer measures 18¾" ×W × 11½"D × 2¾"H and weighs 9.5 lbs. $699.95.

CIRCLE NO. 56 ON FREE INFORMATION CARD

Scanner Antenna

Antenna Specialists' Model MON-53 all-band scanner antenna is available for either roof or deck mounting. The antenna utilizes an exclusive Micro-Choke™ to achieve enhanced performance in the 800-MHz band

without affecting performance at other monitoring frequencies.

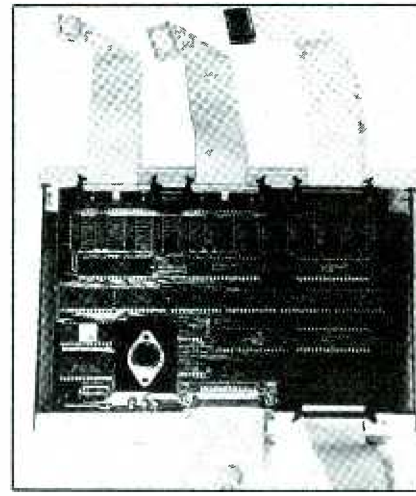
Included with the MON-53 is a 17-foot coaxial cable with an installed pin plug ready for immediate mounting in a ⅜'' hole. All-band Micro-Choke performance is also available with the Antenna Specialists Model MON-52 mobile trunk-lid-mount and Model MON-58 base-station antennas.

CIRCLE NO. 57 ON FREE INFORMATION CARD

Multi-Pod EPROM Emulator

With Total Power International's (Lowell, MA) Logimer 3-Pod Emulator, you can emulate up to three EPROMs simultaneously. EPROMs that can be emulated include the 2764, 27128, 27256 and 27512. A second emulator can be interfaced with the first to expand the total system to six pods. With the 3-Pod Emulator, all you need do is connect the pods instead of the EPROMs and inject your program. Should modification be necessary, you simply press a switch to modify your program. Having completed the emulation, you copy the program into EPROM.

Using the Emulator, one can execute a split, join, update and checksum. The unit is compatible for binary, ASCII, Intel and Motorola systems. It is also possible to select addresses. Features include: multiple-window software with mouse; command line or batch file execution; split and merge of even/odd files; calculation and file checksum; large files split on three pods; pod contents full page edition; data transfer check; and copy of single file on working file.

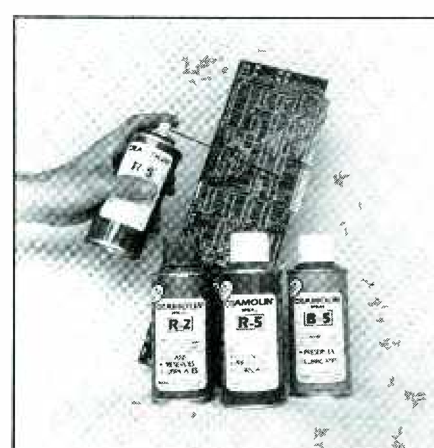


The Logimer 3-Pod Emulator is designed to run on IBM PC and compatible computers equipped with 384K of RAM. It features a power switch, input to printer connector, parallel input/output connector. The hardware measures 10¾" × 7½" × 1¾". The accompanying program supports both monochrome and color monitors. The system supports 512K devices and is fully windowed with pull-down menus. The pods terminate in 28-pin connectors that plug into standard IC sockets. A 9-volt power supply is included. $1,499.

CIRCLE NO. 59 ON FREE INFORMATION CARD

Deoxidizing Agent

Caig Laboratories' (Escondido, CA) Cramolin® DeOxidizer is said to be a fast-acting solution that cleans, preserves, lubricates and improves conductivity of all metal surfaces, including gold. In use, DeOxidizer is sprayed onto metal contacts, connectors and other metal surfaces to quickly remove resistive oxides and form a protective molecular layer that adheres to the metal surfaces and maintains maximum electrical conductivity, reduces wear and protects the surface from future oxidation. It is for use on switches, potentiometers, relay contacts, plugs, sockets, printed-circuit edge connec-

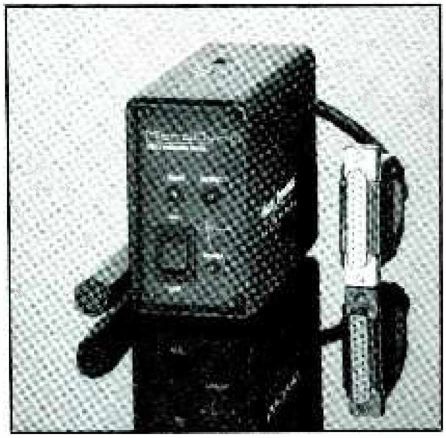


tors and more. The product comes in an aerosol can and uses an ozone-safe propellant.

CIRCLE NO. 58 ON FREE INFORMATION CARD

NEW PRODUCTS • • •

Speech Processing System



The MicroDyn II from Voice Dynamics Corp. (Irvine, CA) voice input/output system is reported to provide voice recognition of 1,000 words of up to 1,000 characters per word with an accuracy of better than 98% and unlimited text-to-speech synthesis. It listens to command or data input and then responds by sending keystrokes via its serial port and text to an on-board synthesizer for audio prompting and verification. Creation, editing, voice training testing and maintenance are accomplished from a standard MS/PC-DOS computer with supplied software. The software includes sample vocabularies and allows the system to be used with OS/2, UNIX, DEC, dumb terminals, emulators and custom OEM applications.

The system features concurrent operation of voice recognition, keyboard or barcode under the MS/PC-DOS operating system. It transparently operates with standard application software. A word boundary indicator provides status of existing noise levels and proper classification of spoken words. The system is fully compatible with IntroVoice VI vocabularies. It uses an 8086/8088-compatible NEC V-25 microprocessor operating at 8 MHz and comes with 128K of battery-backed RAM and 32K of on-board EPROM and supports up to 128K of EPROM. It operates asynchronously with an IBM PC/AT/386 and PS/2 or compatible computer via a 25-pin DB-25 connector/cable arrangement operating at 9,600 baud.

Word groups can be isolated in separate sub-vocabularies within the same master vocabulary. By spoken command, up to 15 independent sub-vocabularies can be accessed at any time from a total of up to 100 sub-vocabularies. Miniature phone jacks are provided for a microphone and speaker. The system supports a wide range of dynamic, electret and cardioid microphones (available as options). Power required is 5 volts dc at 185 milliamperes and is obtained from the host computer over the serial cable. MicroDyn II measures 4″ × 3″ × 1¾″ and weighs 1 lb.

CIRCLE NO. 50 ON FREE INFORMATION CARD

Hyperflanger/Chorus Unit

PAIA Electronics (Edmond, OK) has reintroduced its Hyperflanger and Chorus Unit analog sound-processing unit. An extremely quiet device, it is useful both in a studio and for live processing. A hyper triangular control oscillator permits both linear time sweeps and exponential time sweeps that human ears prefer, both adjustable over a range of 71:1. An exclusive resonance lock circuit allows a user to hang regeneration "on the edge" without having to worry about breaking into feedback howls.

Designed to mount in a single 1.75″ standard rack space, the Hyperflanger and Chorus Unit requires a power supply rated to deliver between ±12 to ±15 volts at 200 mA.

The kit includes pc board, all components, controls, hardware and assembly/users manual. $139.95; a black anodized front panel with printed control designations, $15.95.

CIRCLE NO. 61 ON FREE INFORMATION CARD

PC Overcoat Pen

Planned Products' (Santa Cruz, CA) Circuit Works 3300 overcoat pen insulates, protects and repairs pc boards, components and delicate electronics. It is used in the same manner as a writing pen. The 3300 applies a conformal coating that in-

sulates against short circuiting, arcing and static discharge as it protects against moisture, abrasion, chemicals and other environmental hazards. When used to repair solder masks, the pen is reported to improve the reliability and safety of pc modifications and repairs.

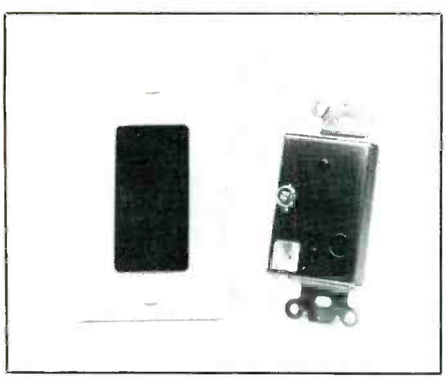
The conformal polymer overcoat material is available in several colors, including green and clear. The material is designed to match the durability and color of solder masking materials to assure nearly invisible repairs. It dries in 5 to 10 minutes at room temperature and can be cured at 50° to 100° C to enhance overall performance. It is claimed to have excellent adhesion to pc materials and to be safe to use on gold, silver, copper and solder alloys.

When not in use, the pen's spring-loaded tip closes to prevent drying and clogging. The tip is self-cleaning, and enough coating material is included to insulate and protect 60 feet of exposed 1/16″-wide trace on a pc board. $9.95

CIRCLE NO. 62 ON FREE INFORMATION CARD

Infrared Repeater

Sonance's (San Clemente, CA) new ROAR (Remote Optical Amplified Repeater) system provides remote control of multiple-room audio systems or use in situations where a direct line of sight for infrared remote control is not practical. It consists of



infrared emitter, splitter, sensor and remote power-supply modules. The system utilizes standard four-conductor telephone cabling and connectors to reduce cost and simplify installation.

The sensor and emitter mount in standard light-switch junction boxes. They utilize a specially formulated Lexan lens that passes only IR signals while rejecting all other wavelengths to prevent false triggering from ambient sunlight or a lighted fireplace. The sensor and emitter are available in standard, Decora and Decora Lens styles, the last using a larger lens for better off-axis transmission and reception.

Agc circuitry increases the sensor's sensitivity in proportion to the increase in distance between it and hand-held remote transmitter. An ultra-bright LED, visible through the sensor lens, gives visual indication that the module is receiving data from the remote transmitter.

The splitter and power supply can be mounted in an out-of-the-way location. The splitter can accommodate up to four connections, and splitters can be ganged so that up to 10 units can be operated from one power supply and one sensor.

CIRCLE NO. 63 ON FREE INFORMATION CARD

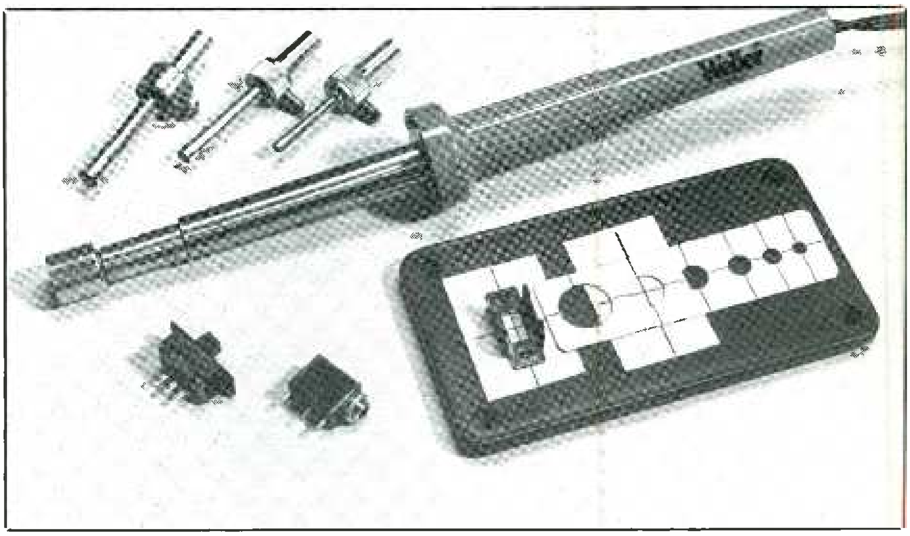
(Continued on page 81)

CIRCLE NO. 79 ON FREE INFORMATION CARD

How To Thermally Machine Project Boxes

Give a professional-looking finish to the plastic enclosures in which electronic projects are popularly housed

By Adolph A. Mangieri



Machining the popular polyvinyl plastic project enclosures that have largely replaced costlier phenolic project boxes can be an exercise in frustration. Though shatterproof, these boxes are made from a soft plastic that has a relatively low melting point. As a result, the bit of a hand drill can tear or melt its way through the plastic and "walk" excessively from the exact point you want to drill a hole. Grabbing action often turns larger size holes into ragged and oval shapes. Also, making the square and rectangular holes required for mounting some components is done by tediously drilling many small holes and filing the slippery plastic. You can simplify machining of polyvinyl project boxes with a few thermal punching tools that you make yourself. In this article, we will describe how to make these tools from readily available materials.

The materials you need are brass tubing from TV rabbit-ears antennas for thermal punches and ¼-inch aluminum or brass shafts, couplers and hubs. You can easily make and adapt these tools to a small soldering iron, which provides the heat source. Hole sizes vary from under ⅛ to ½ inch in diameter for use on thermoplastics up to 3/16 inch thick. Rounding out the assortment of cutters, you can make chisel knives and square and rectangular cutting tips. You will discover that, combined with conventional machining methods, thermal machining can simplify installation of components in thermoplastic project boxes.

Plastics & Machining

Common plastics fall into two general categories. Most of the plastics you will encounter are members of a wide variety of thermoplastic resins, such as ABS, polyvinyl, acrylic and styrene. Thermoplastic resins are injection-molded under heat and pressure to form the enclosures used for consumer electronic products, various small electrical appliances and houseware items, to name a few.

Thermoplastics may include fillers such as waxes to add flexibility and fibers to impart strength or better machinability. When heated, this type of plastic gradually softens at first and eventually melts and finally burns, with increasing temperature emitting acrid and toxic fumes. Thermoplastics machine reasonably well, provided you have a drill press and operate it very slow using an assortment of brad- or spur-point bits.

Thermosetting plastics, such as the phenolics, make up the second category of plastics. Thermosetting plastic is formed by chemical reaction between phenol and formaldehyde. it does not soften when heated but does eventually char at sufficiently high temperatures. Thermosetting plas-

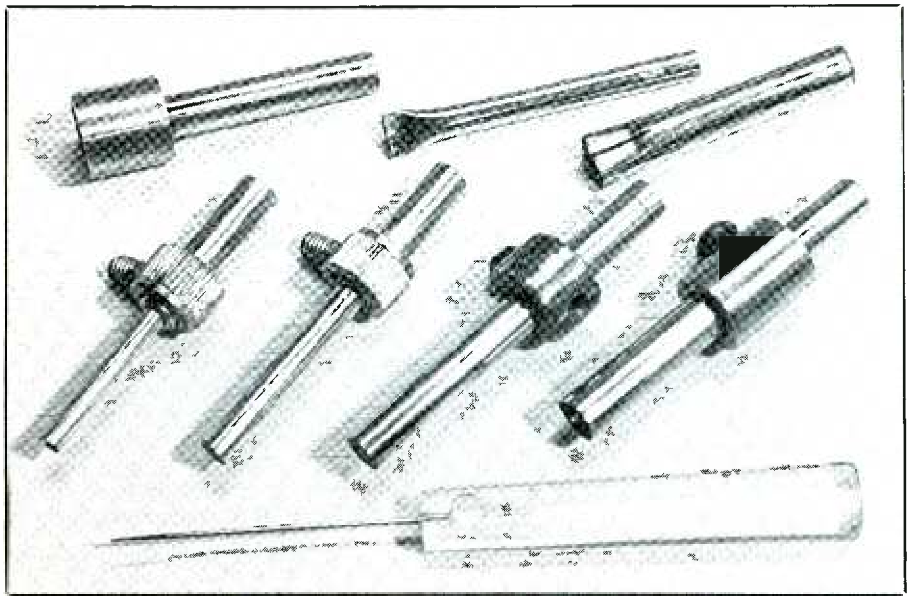


Fig. 1. Small hole cutters include thermal punches made from TV rabbit-ears antenna sections and round, rectangular and knife shapes. Clean-out tool is shown at bottom.

tics are used where high strength, dimensional stability and resistance to high temperature are required. With excellent electrical properties, the plastic is widely used for switch board panels, relay frames, motor switch parts, and the plastic parts of cooking utensils, toasters and steam irons. Non-reinforced types are very brittle. Products reinforced with fiberglass cloth or fibers are nearly unbreakable. Plastics including glass and silica fillers quickly dull drill bits. The relatively hard plastic is easily drilled but may tend to chip when the drill breaks through, and large holes are usually a bit difficult to machine.

Recommended for thermal punching is a 40- to 50-watt soldering iron that accepts ¼-inch-diameter slide-in tips. A typical example of such an iron is the Weller Model SP40 40 watt unit shown in the lead photo. You can easily make any needed adapters and tools using ¼-inch brass or aluminum shafts, shaft collars, spacers and hubs salvaged from TV tuners, radios and the like. Multi-deck wafer switches yield assorted spacers, and metal inserts of knobs yield ¼-inch collars. The metal hubs of wheels and gears of tuning mechanisms yield collars and ¼-inch shaft couplers.

Shaft couplers, shaft extenders and collars are usually available from companies that cater to amateur radio needs. The thin-wall hard brass tubing of TV rabbit-ears antennas provides durable high-strength cutting tips. A single "ear" of such an antenna usually consists of four sections of tubing measuring about 9/32, 15/64, 3/16 and 1/8 inch in diameter, all of which can be put to good use as thermal hole punches.

Shown in Fig. 1 are four thermal punches of assorted sizes installed on adapters that have a ¼-inch-diameter upper portion. The adapters fit into and are retained by a ¼-inch brass shaft extender, shown at top left in Fig. 1. The shaft extender replaces the the original soldering tip and butts firmly against the barrel of the iron. It transfers axial punching force to the barrel of the iron—not to the inner end of the heating element. You may need to cut the shaft of the extender so that it does not bottom out against the inner end of the heating element.

In lieu of a shaft extender, you can make one by installing a 1½-inch length of brass shaft on a ¼-inch shaft coupler. Drill a small spot on the shaft to firmly seat the setscrew. Lacking a shaft coupler, make one from a ¾-inch-long by ½-inch-diameter brass hub with a ¼-inch hole. You may have to install one or two 6-32 setscrews in a shaft hub salvaged from a pulley or gear., Figure 1 also shows a chisel knife tip at top-center, a rectangular tip at top-right and a clean-out tool at bottom.

When making the adapters shown in Fig. 1, avoid high precision tight fits because metal oxidation and thermal expansion may create problems with "freezing" or binding. Be aware, though, that a very loose fit impairs heat transfer. Dimensions specified are nominal and should be altered as needed to match the sizes of brass tubing you are using. Use only brass or aluminum for the adapters, but feel free to modify the adapters to suit your own particular needs.

Adapters for 1/8- and 3/16-inch tips shown at left in Fig. 1 are two-sided collets. For the 1/8-inch tip adapter, use a 1-inch-long by ¼-inch-diameter seamless spacer with 1/8-inch through hole. Grip the spacer vertically in a vise. Then use a fine-toothed hacksaw to cut a ½-inch-long slot lengthwise to form a two-sided 1/8-inch collet. Slip a ¼-inch shaft collar over the slit portion, with setscrew positioned 90 degrees from the slot. Use the same size spacer to make a 3/16-inch collet for the 3/16-inch tip. Using a 3/16-inch drill bit, enlarge the 1/8-inch hole in the spacer to a depth of ½-inch. Slot the drilled portion to form a two-sided 3/16-inch collet. Then install a ¼-inch shaft collar on the collet.

Adapters for the larger 15/64- and 9/32-inch tips shown at the right in Fig. 1 utilize ¼-inch solid shafts. Make the adapter for the 15/64-inch tip from a 1 3/8-inch length of shaft. Chuck 9/16 inch of the shaft into a 1/4-inch drill. Slip a washer with 1/4-inch hole on the protruding end of the shaft to protect the drill chuck. At low to medium drill speed and using a flat file, reduce shaft diameter until the 15/64-inch tubing slides onto the shaft. Check frequently as you file, using the tubing as a gage. When the diameter is about right, use a finer file and finish up with No. 240 sandpaper.

Install a 1/4-inch shaft collar to grip the tubing to this adapter. For the 9/32-inch tip, cut off a 1 1/2 inch length of 4/4-inch shaft, which slides freely into the 9/32-inch tubing. Slightly enlarge the hole of a 1/4-inch shaft collar to slide fit on the 9/32-inch tubing.

Use a small tubing cutter to cut rabbit ears tubing to length. Cut off a 2-inch length of 1/8-inch tubing, and square off both ends and remove burrs. With a small tapered reamer, turn the working end of the tip to a knife edge. Then use a high-speed hand grinder, such as a Mototool, and a thin and abrasive cutoff wheel to cut a 5/16-inch-long axial slot on one side of the tip to form a clean-out slot. Wear a face guard when working with the grinder!

Push the tip fully into the 1/8-inch collet with clean-out slot lined up with the setscrew of the collet collar. The setscrew tells you where to find the clean-out slot. Cut off and prepare a 1 1/2-inch length of 3/16-inch tubing and install in the 3/16-inch collet.

Cut off and similarly prepare a 1 1/2-inch length of 15/64-inch tubing. Then make a 1/2-inch-long axial slot at the upper end of the tip 180-degrees removed from the clean-out slot. Install the tip on the adapter with setscrew aligned with the clean-out slot. Prepare a 1 1/2-inch length of 9/32-inch tubing and install on its adapter.

Figure 2 shows 3/8- and 1/2-inch round "cookie cutters" and two square cutters made from 1/2-inch lengths of deep-drawn thin-wall brass or stainless steel cups. For round cutters, use the bottom portion of stainless-steel cases from AAA and AA alkaline or nickel-cadmium cells. Use caution when cutting these cells because the contents are caustic. Thoroughly clean the cutters and square up the open ends.

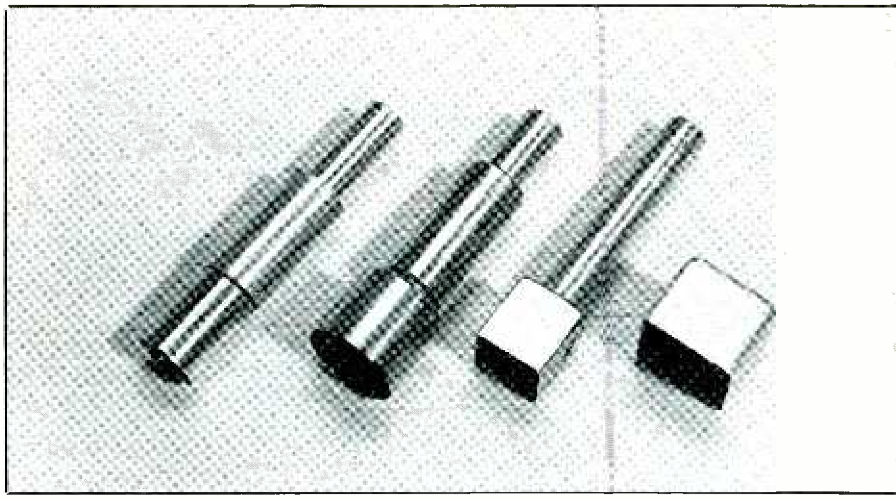


Fig. 2. Cookie cutters include large round and square hole makers made from shells of battery cases and miniature r-f transformer shields.

Bevel-sharpen round cutters inside to a knife edge using a cone-shaped mounted stone by hand. Drill a central hole in the bottom of the cutters to pass a 6-32 machine screw. For the Weller Model SP40 iron, cut a 1 1/4-inch-long by 1/4-inch-diameter shaft. For other irons, slide the shaft stock fully inside the iron; then withdraw it 1/8-inch and mark and cut it to length. Square up one end and drill and tap axially for a 6-32 machine screw. Secure the cutter to the shaft with a 6-32 × 1/4-inch screw and lockwasher.

In use, the cookie cutters replace the soldering iron tip, with cutter butted against the barrel of the iron to take up punching forces. These cutters can also be retained by the shaft extender to permit ready interchangability of all cutters. In this case, and especially for the larger cookie cutters, install slide-on spacer bushings, as shown on the round cutters in Fig. 2. The bushings increase heat flow and impart rigidity.

You can use the brass or aluminum outer fine tuning shaft of rotary-type TV tuner switches to make the spacers. Make the spacers long enough to butt firmly between the top surface of the cutter and the front edge of the shaft extender. Carefully square up both ends of the spacer to assure good thermal contact.

Use the brass shield of a subminature r-f transformer to make the 3/8-inch square cutter. Use the shield of a miniature r-f transformer to make a 1/2-inch square cutter shown unmounted at the right in Fig. 2. Bevel the inside edge of the tips to a knife edge with a small fine flat file. Clean-out slots are optional on these cutters because you can easily pry out the waste slug with a clean-out tool made from the plastic handle of a toothbrush and a medium-size sewing needle. Drill a small hole in the end of the handle and secure the the needle in place epoxy cement.

The tip shown at the top-right in Fig. 1 has a rectangular cutting edge for roughing in the slots of slide switches. To make square and rectangular tips, prepare and sharpen the end of the tip but defer slotting of the clean-out slot. Use the square and rectangular tapered tangs of files as a forming mandrel. If needed, true up

MATERIALS LIST

- ¼ " diameter brass or aluminum shafts
- ¼ " brass shaft extender
- ¼ " brass shaft coupler
- ¼ " shaft collars (4)
- ¼ " diameter spacers (1 " long with ⅛ " hole)
- TV rabbit-ears antenna (four sections)
- AA and AAA alkaline or Ni-Cd cell shells
- Brass or aluminum spacer or hub (¾ " long, ¼ " hole)
- Miniature and subminiature r-f transformer shield cases
- Medium sewing needle
- Plastic handle (see text)
- Light-gauge sheet aluminum
- 40-watt soldering iron with ¼ " tip (Weller Model SP40 or equivalent)
- Solid-state incandescent lamp dimmer
- Ac line cord with plug
- Small enclosure
- Chassis-mount ac receptacle
- 5-ampere 3AG fast-blow fuse and holder

the file tang on the grinding wheel.

Slide the tip firmly onto the tang and pinch, peen and shape it until a rectangle is formed. Because the hard brass tubing is not highly malleable, the rectangle may end up being slightly barrelled. Lastly, cut a clean-out slot in the tip as shown.

The beveled chisel knife cutter shown at top-center in Fig. 1 handily forms large cutouts. As an example in making chisel knives, cut off a 1½ inch length of 15/64-inch tubing. Pinch one end flat for ¼-inch in a vise to obtain a double-thickness flat blade.

One or both vertical edges of the flattened portion will probably split. Select the best side of the flat blade for the knife, and remove the other side, leaving a single thickness blade. Do this by scoring the blade 3/16 inch from the end with a fine triangular file and pry off the waste portion. Use a file to true up the blade and bevel it on one side to a knife edge.

Assorted tool guides or templates and a panel machined with these tools is shown in Fig. 3. Use light-gauge aluminum sheet to make templates. Lay out and drill the holes slightly undersize and ream to final size to clear the tip. Scribe cross-hair lines. Make the DB9 connector template shown at top-left in Fig. 3 by drilling a number of small holes and filing the hole to final size. Metal frames of miniature and standard slide switches and other components serve well as tooling templates.

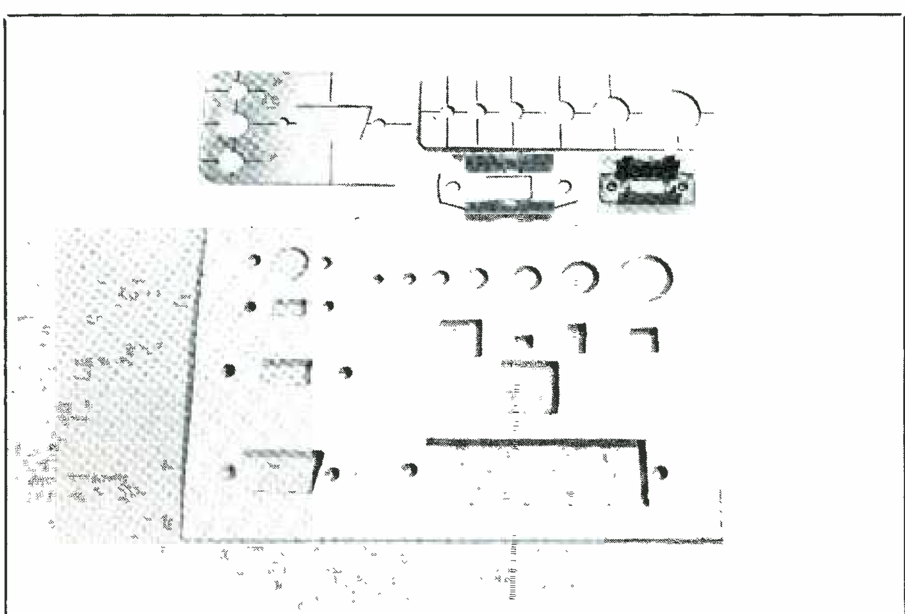


Fig. 3. Hole templates and switch bodies aid machining of panels.

You need a means to adjust the voltage applied to the soldering iron used with your home-fabricated tools. I use a bench powerstat (variable-voltage transformer) with calibrated dial. It has two ac receptacles, which permit operation of two hot-punch irons at the same time. You can use a full-range solid-state traic motor speed controller instead. An inexpensive wall-mount solid-state rotary incandescent light dimmer that handles loads up to 600 watts performs just as well.

Wire together the dimmer and iron as shown in Fig. 4. Install the dimmer in a small enclosure and calibrate its dial in 10-volt steps from 60 volts to maximum. To calibrate, connect a 60-watt incandescent lamp and an ac voltmeter (preferably true-rms—*not* peak—type) to the "load" side of the dimmer.

Using the Tools

Like in soldering, the technique used to machine thermoplastics with thermal tools requires some practice at first to master it. For hot punching with little or no melting of the plastic, the rate of heat flow and tip temperature is just sufficient to allow the tip to be forced through the plastic with moderate downward pressure on the tool. The tip softens the plastic and you push the tip through the plastic.

At appreciably higher temperature, the plastic melts rapidly and very little force, if any, is needed as the tip penetrates the plastic. However, high heat often produces acrid toxic fumes and fouling of the tip with sticky plastic. Therefore, the objective is to use the tools at lower temperature to avoid fumes and fouled tips.

Practice on scrap pieces of vinyl siding, ABS plastic taken from TV cabinets and plastic housewares until you perfect your technique. Initially, operate the soldering iron at 117 volts. Then, after a 3-to-8-minute warm-up period, position the iron vertically and push down on the plastic while moving the top of the iron in a small circle. Place a piece of tablet back or chipboard under the plastic.

At 117 volts, the tip is likely to be too hot, penetration will be rapid and some sticking of plastic to the tip will occur. If so, lift the iron after penetration and quickly remove the waste slug. Wipe the tip with fine steel wool or a heavy cloth to remove the adhering plastic. If the plastic melts inside the the tip, twirl a small drill bit inside the hot tip to remove it.

Perform trials with the powerstat or light dimmer set to 40, 60, 80, and 100 volts in turn. At insufficient input power, heat flow down the thin walls of the tip will fail to soften the plastic. At about 80 to 100 volts, the tip will heat sufficiently to soften the plastic and permit you to push the tip through in 2 to 4 seconds without creating fumes, melting the plastic or fouling of the tip. The holes will have little or no burrs, and the waste slug will be barely deformed, if at all. This is the desired operating condition. Usually, the powerstat is set for 70 to 100 volts after initial warmup at 117 volts. If you are using a solid-state controller with arbitrary dial calibration, take note of the dial indications as you determine the correct setting.

Figure 3 illustrates a plastic panel machined with the thermal punches. At left from top to bottom, the cutouts accept a phono jack, miniature slide switch, standard slide switch and DB9 connector. At lower-right, the large cutout accepts a Centronics parallel printer connector. The series of graduated holes at top-right accept screws and a wide variety of jacks, switches and potentiometers. (Use a reamer to increase hole size as required.) Below are several holes punched with the squared cutters.

To make the hole pattern for slide switches, position the template at the desired location with clear double-sided tape. Use a square or oblong-shaped cutter to remove the waste material in the oblong hole in several penetrations. Punch the mounting holes and remove the template. Touch up the oblong hole with a small file. If necessary, slightly ream the two mounting holes.

When making cutouts for DB-style connectors, proceed in a similar manner. When using the beveled knife for DB-connector cutouts, place the flat surface of the cutter against the edge of the template and make a series of overlapping penetrations. If necessary, use an X-acto or other hobby knife to break out the large waste slug. Finish the edges of the hole with a small file. For large oblong cutouts, lay out the hole pattern in pencil. Place a thin metal strip along the edge of the pattern and use it a a guide as you cut the hole with the chisel knife.

With close observation and slight twist of the tool, you can usually feel and determine full penetration of the tip through the plastic. Tip penetration is easily felt by allowing the tip to fall through the plastic by about 1/16-inch. Place a 1/16-inch thick chipboard shim under the workpiece but clear of the hole. Alternatively, use a sheet of dense foam plastic as a backup to readily feel and limit penetration of tip through the plastic.

Holes for miniature and subminiature phone jacks are preferably hot-punched with the aid of the centering template. The hole can be punched slightly undersize and enlarged with a tapered reamer. A piece of wood held in a vise provides backup on the inner walls of a project box.

When making medium to large round holes, the waste slug can be made to remain in the plastic, eliminating the need to remove the waste from the tip. Push the tip through the plastic without axial rotation. The plastic in the clean-out slot retains the waste in the panel. Use a pencil to push out the slug. To lift the waste

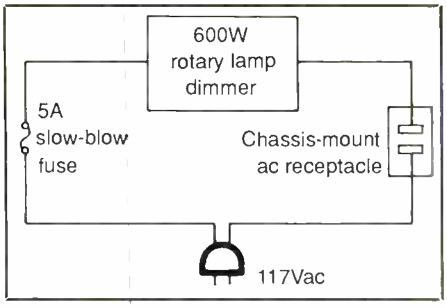


Fig. 4. Wiring details for light dimmer and soldering iron circuit.

with the tip, rotate the tool slightly after it penetrates the plastic to cut the material in the clean-out slot.

When machining the panel of a plastic project box, cover the entire outer surface of the box with masking tape to avoid scratches as you work. Mark hole locations on the tape and punch from the outer surface. At correct tip temperature (not critical), the holes produced are remarkably clean. At higher heat and with thicker panels, a small annular ring may form on the entrance and a small burr on the exit sides of the hole. Remove burrs using the countersink bit or knife.

These thermal punches are intended to be used on plastics up to 3/16 inch thick. Holes were punched in plastics up to 1/4 inch thick, but such a thickness requires more heat and time to penetrate the plastic. Filled plastics, such as ABS TV cabinets, punched satisfactorily. Acrylic and styrene plastics tended to foul tips.

After several hours of use, remove the shaft extender from the iron and clean both to prevent buildup of oxides and seizing. From time to time, remove the shaft collars from the tips, and the tips from the adapters and clean them with fine steel wool.

Variations

The following may prove to be helpful if you experiment with larger- or smaller-wattage soldering irons or cutter tips that are different sizes and lengths. For a given power input to the soldering iron, the heat available to soften the plastic is primarily limited by the effective thermal conductivity of the relatively thin walls of the cutters. Halving tip length doubles the heat flow. Stainless-steel cutters are relatively short because this material is a poor conductor of heat.

The tips shown in Fig. 1 can be adapted to a soldering iron that accommodates ⅛-inch screw-in tips. After you identify the threads on the original soldering tip (probably metric), you will need a screw tap that matches the threads of the soldering tip and corresponding machine screws. Drill and tap the upper end of the collets or adapters to accept the machine screw. Install the screw in the collet, driving it in until it binds firmly. Cut of excess screw length. Tips so constructed tend to work loose but otherwise perform well. Limit tip size to smaller diameters.

Thermal shaping and cutting tools are frequently used in plastic arts and crafts projects. You may have need for larger cutters and chisel knives best adapted to higher-wattage soldering irons. Relatively compact, Weller's Models WP80 80-watt iron with ⅜-inch slide-in tip and WP100 100-watt iron with ½-inch slide-in tip are recommended for heavy-duty use in punching larger holes. Cutters made from C- and D-size cells were adapted to the larger iron and performed well.

"The teacher wants us to bring a pencil to school tomorrow . . . what's a pencil?"

An Infrared Thermometer Accessory

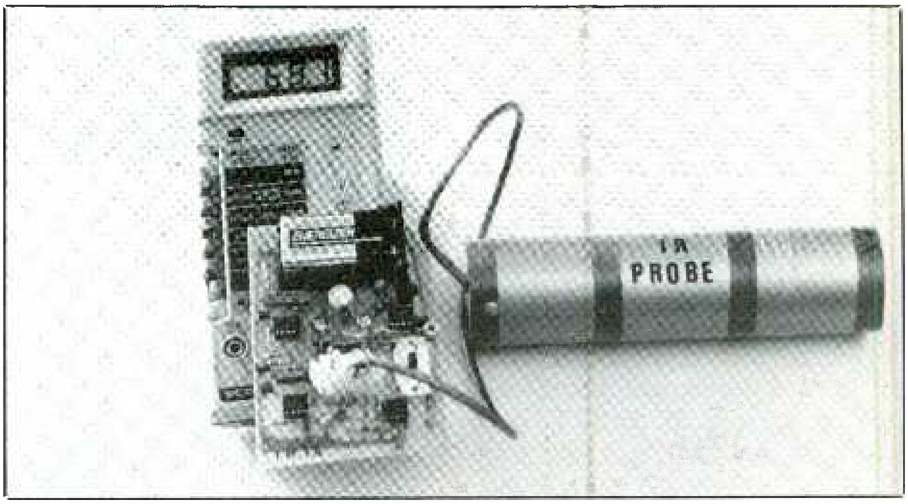
Lets any DMM measure temperatures fast—without requiring physical contact!

Thomas R. Fox

An infrared thermometer can do seemingly amazing things—measure the temperature of a cloud layer from the ground and, with a special rig, the surface temperature of the moon and Mars. More mundane uses include temperature measurement of moving objects and non-contact measurements of hazardous objects like high-voltage and radioactive equipment. The response of an IR thermometer is also fast!

An infrared thermometer is also useful in applications in which contact thermometers are traditionally used. For example, it can be used for making quick checks of building insulation and weather-stripping for estimating heating/cooling loss. Too, a non-contact infrared thermometer that accurately measures temperature in the 85° to 115°F range has obvious utility in medicine. Good as it is, though, the infrared thermometer cannot fully replace the mercury thermometer, whose advantages include greater accuracy and lower cost. But for specialized non-contact measurements, the infrared thermometer cannot be beat.

The IRTA Thermometer accessory plugs into the inputs of a hand-held DVM or DMM set to dc volts; so no enclosure is required. Except for the probe assembly, all components, including switches and battery, mount on a printed-circuit board.



About the Circuit

The complete schematic diagram of the IRTA Accessory is shown in Fig. 1. The output of thermopile detector *IRS1* is connected to the noninverting (+) input of *IC1*. With a 1,000-ohm value for *R1* and 150,000-ohm value for *R2*, *IC1* amplifies the output of *IRS1* by 151 (1 + 150). This amplified output is connected to *R3*, which forms one leg of the summing amplifier. The other input to this summing amplifier comes from *IC2*, which provides the temperature-compensation voltage for the circuit.

Actual design of the temperature-compensation circuit is a bit involved mathematically and will not be presented here. The goal here is to have the thermopile detector respond only to temperature differences. Therefore, either the reference junction must be maintained at a constant temperature or the reference junction temperature must be measured and used to compensate the circuit. This instrument uses automatic temperature compensation.

Temperature measurement of the reference junction of the sensor is accomplished with LM335 temperature transducer *IC10*. This transducer attaches with a thermally-conductive cement to the TO-5 header leads of *IRS1*. According to Dexter Application Brief-2, the leads of the detector is the best place to monitor the temperature of the reference junction.

The value of *R10* is chosen to be as large as practical to minimize self-heating of *IC5*. The temperature-compensating circuit is made up of *IC2*, *R6*, *R8*, *R9* and *IC5*.

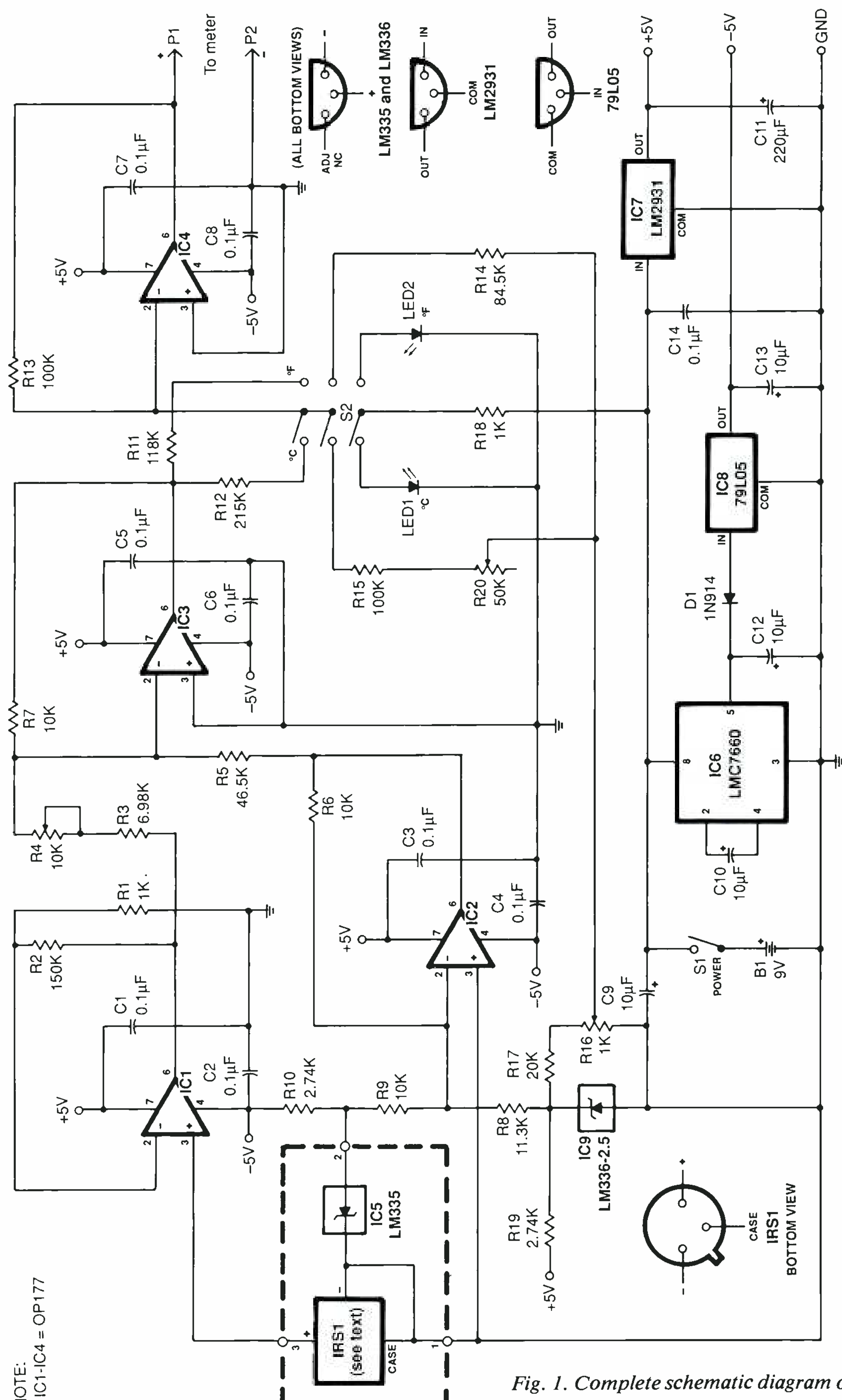


Fig. 1. Complete schematic diagram of Infrared Thermometer Accessory.

PARTS LIST

Semiconductors

D1—1N914 or similar silicon diode
IC1 thru IC4—OP-177 precision operational amplifier (see text)
IC5—LM335Z temperature transducer
IC6—LMC7660 voltage converter
IC7—LM2931 fixed +5-volt regulator
IC8—79L05 low-power fixed −5-volt regulator
IC9—LM336-2.5 2.5-volt precision voltage reference
LED1—Low-power, high-efficiency red light-emitting diode
LED2—Low-power, high-efficiency green or yellow light-emitting diode

Capacitors

C1 thru C8,C14—0.1-µF, 50-volt ceramic monolithic
C9,C10,C12,C13—10-µF, 25-volt electrolytic
C11—220-µF, 25-volt electrolytic

Resistors (¼-watt, 1% tolerance)

R1—1,000 ohms
R2—150,000 ohms
R3—6,980 ohms
R5—46,400 ohms
R6,R7,R9—10,000 ohms
R8—11,300 ohms
R10,R19—2,740 ohms
R11—118,000 ohms
R12—215,000 ohms
R13,R15—100,000 ohms
R14—84,500 ohms
R17—20,000 ohms
R18—1,000 ohms (5% tolerance, ¼-watt)
R4—10,000-ohm, 15-turn pc-mount trimmer potentiometer
R16—1,000-ohm, 15-turn pc-mount trimmer potentiometer
R20—50-ohm, pc-mount trimmer potentiometer

Miscellaneous

B1—9-volt alkaline battery
P1,P2—Banana plug
IRS1—1M thermopile detector with argon gas and 6.5-to-15.5-micron LWP filter (specify argon gas and LWP filter; $50 + $2 P&H from Dexter Research Center, Inc., 7300 Huron River Dr., Dexter, MI 48103; 313-426-3291)
S1—Spst pc-mount slide switch (Digi-Key Cat. No. SW100-ND)
S2—3pdt miniature pc-mount slide switch (Digi-Key Cat. No. SW121-ND)
Main printed-circuit board or perforated board with holes on 0.1″ centers and suitable Wire Wrap or soldering hardware and enclosure (see text); detector pc board; sockets for all DIP ICs; 3-contact plug/socket pair (Digi-Key Cat. No. A1493/A1436; optional —see text); 9-volt battery snap connector and holder; three-conductor cable with red-, green- and black-insulated conductors; 1½″L × ½″ID yellow CPVC pipe; 1⅝″L × 1½″ID white PVC pipe; 5″L × 1½″ID white PVC pipe; epoxy cement; cable tie; insulation; duct tape; aluminum paint; solder; etc.

Note: The following items are available from Magicland, 4380 S. Gordon, Fremont, MI 49412: Complete kit of parts, including all ICs, main and probe pc boards and all other components (pipes, cables, etc.) but *not* including IRS1, battery and optional items, Kit. No. IRTA-MAG1, $49.50; OP-177 op amps, each $2.50.
Digi-Key is located at 701 Brooks Ave. S., P.O. Box 677, Thief River Falls, MN 56701-0677; tel. 1-800-344-4539.

The output of the temperature-compensating circuit is applied via *R5* to summing amplifier *IC3*, which sums this voltage with the amplified thermopile voltage. The output of *IC3* goes to a degree circuit made up of *S2*, *IC4* and related components. The primary purpose of this degree circuit is to modify the voltage to make it (in millivolts) correspond to either Celsius or Fahrenheit degrees, depending upon the setting of *S2*.

With *S2* set to °F, 50 millivolts yields a meter reading of 50 °F. Similarly, in the °C position, 50 millivolts yields a reading of 50 °C. Switch *S2* also controls two light-emitting diodes: red °F *LED2* and green °C *LED1*.

Calibration for this circuit is accomplished with *R16* and *R4*. Potentiometer *R4* is used to adjust the gain of the amplified thermopile voltage and *R16* provides a small offset voltage to the degree calibration circuit. Potentiometer *R20* is used to adjust the Celsius circuit.

Since the IRTA Thermometer accessory uses a single 9-volt battery (*B1*) and the circuitry requires both +5 and −5 volts for proper operation, some type of voltage conversion is required. This is accomplished with LMC7660 voltage converter *IC6*, which converts the +9 volts from *B1* to the −9 volts required by the summing amplifiers.

The −9 volts that exits at pin 5 of *IC6* is unregulated. It is passed through *IC8*, which outputs a tightly regulated −5 volts. The +9-volt source from *B1* also goes to *IC7*, which outputs a tightly regulated +5 volts. Thus, all voltage requirements of the circuitry are satisfied by the relatively simple *IC6*/*IC7*/*IC8* power supply arrangement.

Bear in mind that the values of several resistors used in this accessory depend on the geometry and material of the thermopile probe. For instance, the value of *R2* depends upon the internal diameter and length of the pipe in the probe assembly. So keep in mind that the values given in Fig. 1 and specified in the Parts List were selected for the prototype probe described later.

Ultra-precision OP-177 devices are recommended for all operational (summing) amplifiers. Specifications of the new OP-177 are significantly better than those for the famed OP-07—at about the same price. For optimum operation, *IC1* requires the tightest possible specifications, which means that an OP-177 or its equal should be used here. For *IC2*, *IC3* and *IC4*, the specifications are not as critical; so you can use less-expensive op amps—even a 741—to economize.

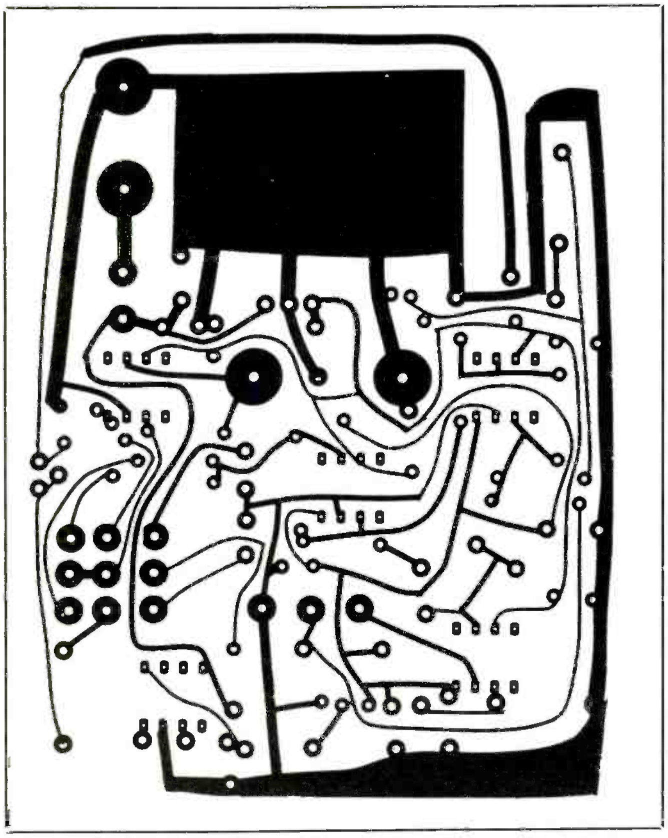


Fig. 2. Actual-size etching-and-drilling guide for main printed-circuit board.

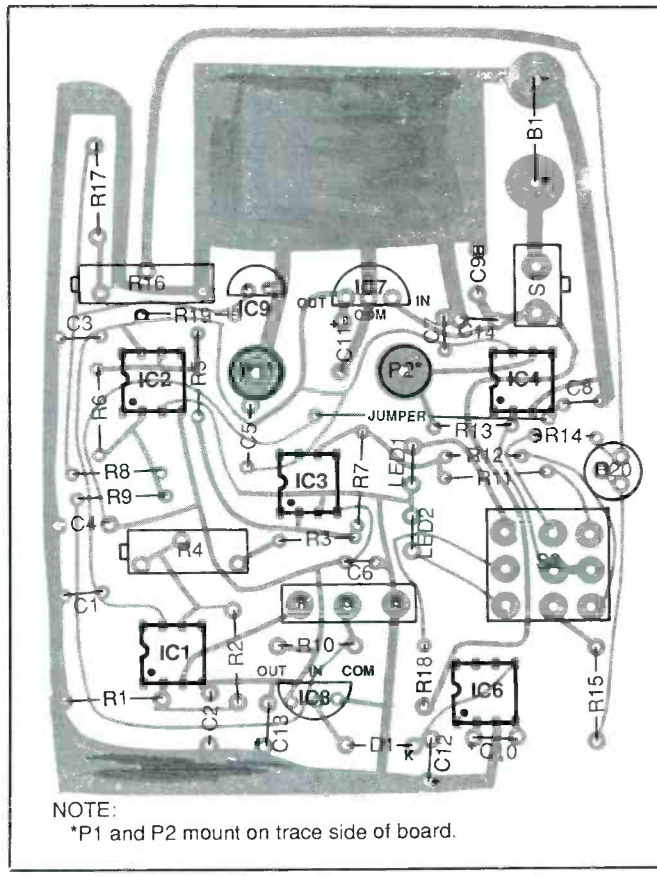


Fig. 3. Wiring guide for main pc board.

Construction

If you prefer not to fabricate a pc board, you can assemble the circuitry on perforated board that has holes on 0.1-inch centers, using suitable Wire Wrap or soldering hardware. If you go this route, make the connections to the meter via short cables terminated in banana plugs and house the assembly in a small enclosure.)

Fabricate the pc board using the actual-size etching-and-drilling guide shown in Fig. 2. If you do use this guide, be sure to use the recommended battery holder and switches. Begin populating the board by installing and soldering into place sockets in all DIP IC locations. Do not plug the ICs into their respective sockets until after you have conducted initial voltage checks and are satisfied that the circuit is properly wired. Next, mount the banana plugs in their respective locations on the copper-trace side of the board. After they are physically mounted, spot solder the banana plugs to the copper pads surrounding them to assure good electrical connections.

Now install and solder into place the resistors, trimmer controls, capacitors, diode and LEDs in their respective locations. Make sure the electrolytic capacitors, diode and LEDs are properly oriented before soldering their leads into place.

Continue populating the board by installing and soldering into place *IC7*, *IC8* and *IC9*, making sure you follow the basing diagrams given in Fig. 1. Trim the leads of a 9-volt battery snap connector to a convenient length and strip ¼ inch of insulation from each. Tightly twist together the exposed fine wires and sparingly tin them with solder. Plug the black-insulated lead into the hole labeled B1 − and solder it into place. Similarly, plug the red-insulated lead into the hole labeled B1 + and solder it into place. Mount a 9-volt battery clip holder in the space reserved for it at the top of the circuit-board assembly with 4-40 machine hardware. Finally, mount the switches in their respective locations. If you wish, you can mount a cable connector in the area just above *R10* (see Parts List).

Carefully examine the circuit-board assembly to make certain that all components are installed in the proper locations and that those that require polarization and special basing are properly installed. Turn over the circuit-board assembly and carefully check your soldering. Solder any connections you may have missed, reflow the solder on any suspicious connections and remove solder bridges, especially around the closely spaced IC socket pads, with a va-

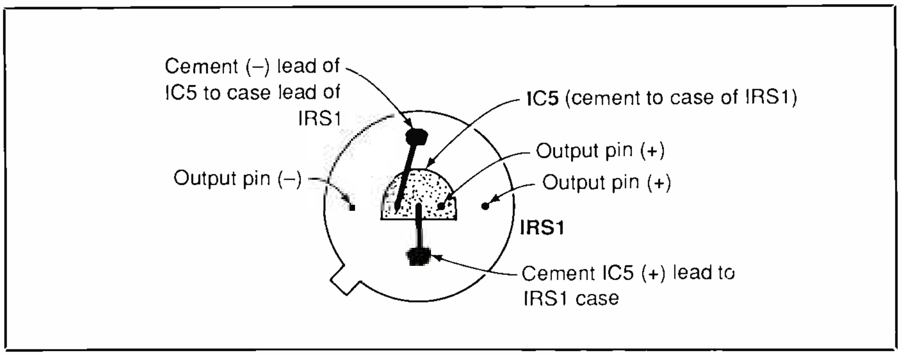


*Fig. 4. Epoxy cement top of LM335 (*IC5*) to bottom of thermopile detector (*IRS1*) case and connect together leads as illustrated.*

cuum-type desoldering tool or desoldering braid. Then temporarily set aside the circuit-board assembly.

Though the design of the basic circuitry is fairly straightforward, if you use an ultra-precision op amp like the OP-177 for *IC1*, probe design is simple but not trivial. As shown in Fig. 4, begin fabrication of the probe by cementing, with fast-setting epoxy cement, the top of the case of *IC5* to the bottom of the case of *IRS1*. Position the two devices as shown.

When the cement has fully set, loosely twist together the positive (+) lead of *IC5* and the case lead of *IRS1* and solder the connection. This assures that *IC5* measures the reference-junction temperature of *IRS1*.

You should use a printed-circuit board on which to mount the *IRS1/IC5* combination and wire to it the cable that connects the probe assembly to the main circuit. Fabricate this board with the aid of the actual-size etching-and-drilling guide shown in Fig. 5(A). Once the board is ready, mount the *IRS1/IC5* assembly on it, as shown in Fig. 5(B).

Now remove 1 inch of outer plastic jacket from both ends of a 24- to 36-inch length of three conductor cable, preferably with insulation color coded red, green and black. Twist together the exposed fine wires in all conductors at both ends of the cable and sparingly tin with solder. Plug the conductors at one end into the holes specified in Fig. 5(B) and solder them into place. Note that the cable conductors plug into the *copper-trace* side of the board.

The internal structure of the probe assembly consists of a 1½-inch length of a ½-inch inner-diameter CPVC plastic pipe and the small pc board used to mount the detector/transducer assembly, as shown in Fig. 6. Common CPVC plastic water pipe is a good choice for the housing of the probe assembly. The ideal material is a tube that absorbs infrared energy in the 6.5-to-15.5-micron wavelength region but does not emit infrared in this wavelength band. CPVC may have at least a slight tendency to this ideal characteristic.

The excellent directional characteristics of the probe assembly indicates that CPVC absorbs most infrared energy in the 6.5-to-15.5-micron region. The main circuit compensates somewhat for the potential error caused by the IR emissions from the tube striking the thermopile detector. The primary error here arises if the tube is at a significantly greater or lesser temperature than the transducer. This can occur if one holds onto the sensing end of the probe assembly or if the probe is used in an environment where the temperature is rapidly changing.

In addition to being the electrical heart of the probe, the ½-inch inner-

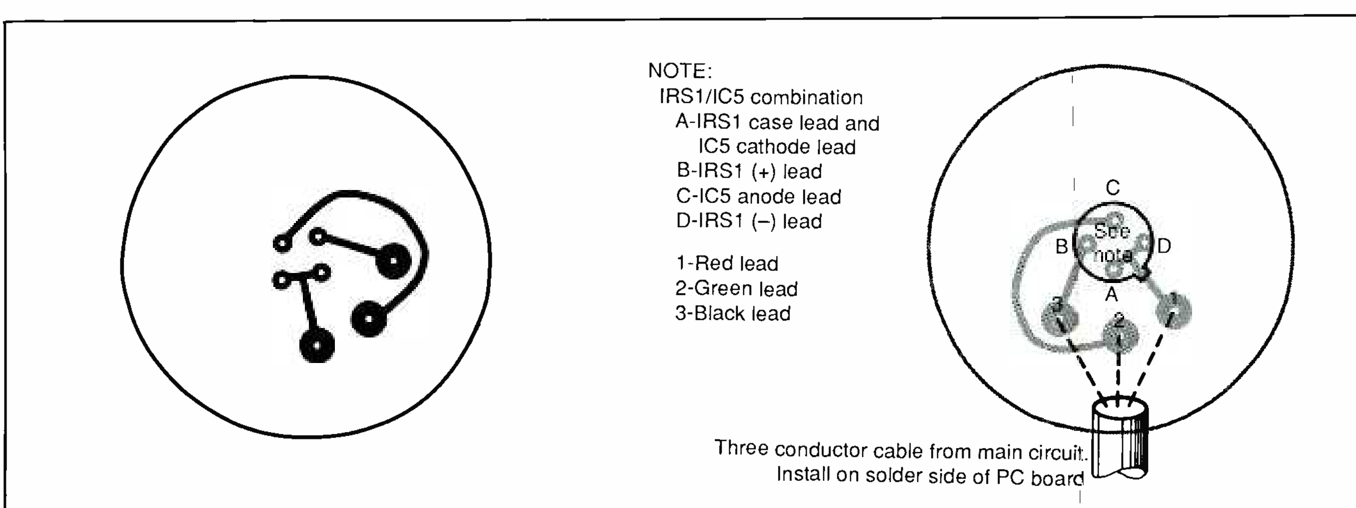


Fig. 5. Actual-size etching-and-drilling guide (A) for probe pc board and wiring guide (B) for same.

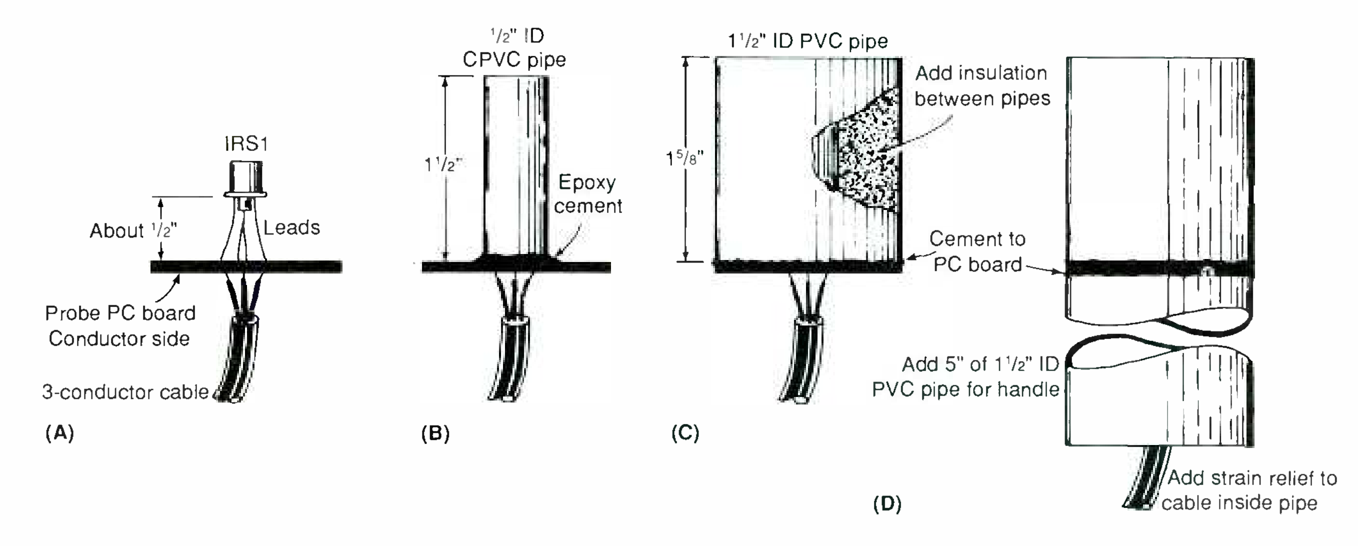


Fig. 6. Fabrication details for probe-assembly housing.

diameter main detector tube and accessory 1½-inch inner-diameter pipe cement to this pc board. Use a good-quality epoxy cement to secure the tube and pipes to the board. While not essential, you should place an insulating material between the detector tube and outside pipe.

As shown in Fig. 6(D), cement a 5-inch length of 1½-inch inner-diameter PVC pipe to the copper-trace side of the circuit-board assembly to use as a handle for the probe. Pass the cable out the open end of the pipe. Attach a strain relief to this cable inside the pipe. This can be a plastic cable tie secured in place to the wall of the pipe with hardware.

Terminate the free end of the cable in a connector compatible with the one you used on the main circuit-board assembly. Wrap the outside of the 1½-inch pipe with gray duct tape or coat the pipe with a good aluminum paint, such as Dow's XP-310.

Checkout & Calibration

Connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to a convenient circuit-ground point. Snap a fresh 9-volt alkaline battery into its holder and set *S1* to "on." Touch the "hot" probe of the meter to the OUT pins of *IC7* and *IC8* in turn. You should obtain readings of +5 and −5 volts, respectively. If not, touch the "hot" probe to pin 8 of *IC6* and note if you obtain a reading of +9 volts.

Assuming the outputs of *IC7* and *IC8* are correct, touch the "hot" probe of the meter to pin 7 of the *IC1*, *IC2* and *IC3* sockets. In all three cases, you should obtain a reading of +5 volts. You should also obtain a reading of −5 volts at pin 4 of all three sockets. If you fail to obtain the proper reading at any point, power down the circuit and rectify the problem before proceeding.

Once you obtain the proper readings at all points mentioned, power down the circuit and plug the DIP ICs into their respective sockets. Make sure each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

On power-up, one of the LEDs should light, the specific one that does depending upon the position to which *S2* is set. Set your meter to its 200-millivolt full-scale range. Connect the common lead of the meter to circuit ground and the "hot" probe to the wiper contact of *R16* and adjust this trimmer control for a meter reading of 65 millivolts. This done, turn off the adapter and set *R4* and *R20* to about center of rotation.

Plug the adapter into the banana jacks on your meter and set the meter to its 200-millivolt full-scale range. Plug the cable from the probe assembly into its connector on the main circuit-board assembly, and switch on project and meter. Setting *S2* to °F should cause the red °F LED to light.

For preliminary calibration, use a thermometer to determine ambient room temperature. Assuming the room is at 72° F, point the probe at an inside wall (for optimum accuracy, tape the sensing area of a good-quality contact thermometer to the wall). Adjust *R16* so that 72 millivolts is displayed by the meter. For many purposes, this is the only calibration required.

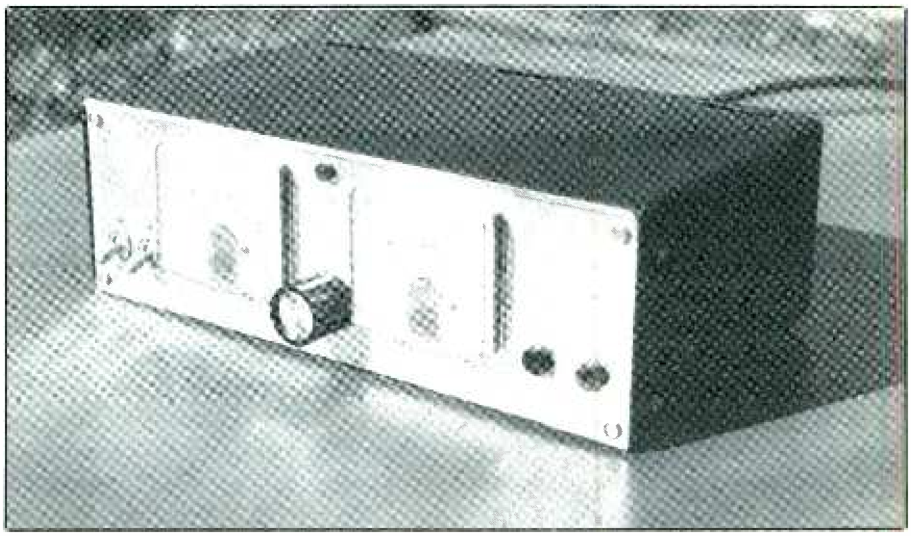
Now close your fist for a minute and then point the tip of the probe at your opened hand, positioning it within an inch of but not touching your skin. The meter should indicate a temperature between 89° and 96° F, with 93° F being typical. If the temperature is outside this range, additional calibration is warranted.

(Continued on page 77)

A Precision Low-Voltage DC Power Supply

This laboratory-grade power supply offers two user-selectable output voltage ranges, is short-circuit protected and can go all the way down to 0 volt

By Dennis Eichenberg



Circuit designers, service technicians and serious electronics experimenters can benefit from use of a laboratory-grade low-voltage power supply. "Laboratory-grade" usually means when one is considering a very expensive commercial product. Fortunately, you can build a laboratory-grade power supply, such as the Low-Voltage Precision DC Power Supply described here, for only moderate cost.

This Power Supply provides a clean, precise output that is adjustable from 0 to 9 volts dc, which can be used in instrument calibration and circuit testing, as well as for general bench tasks. Two user-selectable ranges are available: a low range that gives very fine resolution control for 0-to-150-millivolt outputs, and a high range that starts at 0 and goes up to 9 volts. Both deliver up to 2 amperes of current, and both feature current limiting for short-circuit protection. With the components specified, maximum ripple is a low 2 millivolts peak-to-peak.

Separate voltmeter and ammeter movements are built into the Power Supply to provide simultaneous indication of output voltage and current. The voltmeter automatically switches range when the output voltage range selector is operated.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry used in the Low-Voltage Precision DC Power Supply. Power from the 117-volt ac line enters through the ac line cord shown at the upper-left. The incoming 117 volts ac is stepped down to 25.2 volts dc by power transformer *T1*. The center tap on the secondary side of *T1* is grounded so that full-wave bridge rectifier *RECT1* can provide both positive and negative voltages referred to ground for the remaining circuitry.

Capacitors *C1* and *C4* provide low-frequency filtering of the pulsating dc emerging from *RECT1* for the positive and negative voltage-regulator circuits made up of *IC1* and *IC2*, respectively. High-frequency noise filtering is taken care of by *C2* for *IC1* and *C5* for *IC2*.

Relay *K1* has its coil wired in parallel across the primary of *T1* after POWER switch *S1*. This relay has two sets of normally-closed contacts that connect separately to bleed resistors *R1* and *R2* across *C1* and *C4*, respectively. The purpose of these resistors is to discharge the capacitors when the power supply is shut down to prevent an output spike from occurring.

Positive dc power from the + output of *RECT1* is delivered directly to POWER indicator *LED1* through current-limiting resistor *R15*. Any time the supply is powered up, this LED will be on.

The pure positive dc voltage that results from the filtering action of electrolytic capacitor *C1* is passed through voltage regulator *IC1* and emerges as a tightly regulated +15 volts. Capacitor *C3* at this point provides additional high-frequency noise filtering for this line.

In a similar manner, the pure negative dc voltage that results from the filtering action of *C4* is transformed into a tightly regulated −5 volts by *IC2*. As above, *C6* at this points provides additional high-frequency noise filtering for this line.

Operational amplifier *IC3* and its associated components make up a voltage-reference source for the Power Supply. Zener diode *D1*—a 9-volt, 7.5-milliampere device with a temperature coefficient rated at 0.01/%°C—serves as a very stable and accurate voltage reference, which is required for the Power Supply to be precise under all operating conditions. Op amp *IC3* functions here as a buffer for the zener diode.

With RANGE switch *S2* set to its HI position, the Supply's high range is selected. OUTPUT LEVEL control *R7* provides the means for adjusting this range from 0 to 9 volts. Setting *S2* to its LO position places potentiometer *R7* in series with fixed resistor *R6* for precision adjustment of the Supply's low range from 0 to 150 millivolts.

The reference voltage from pin 6 of *IC3* is delivered to noninverting (+) input pin 3 of operational ampli-

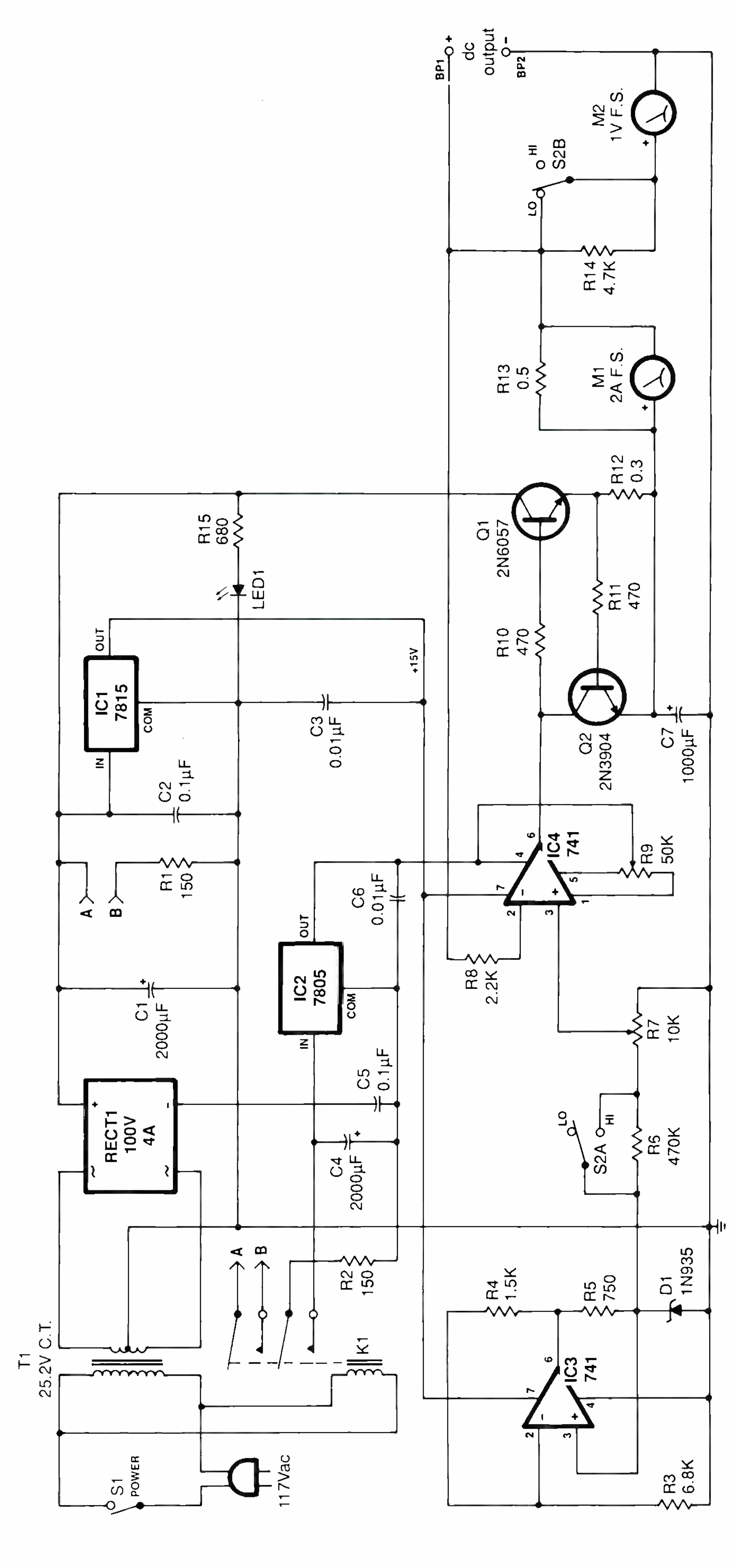


Fig. 1. The complete schematic diagram of the Precision Low-Voltage DC Power Supply circuitry.

PARTS LIST

Semiconductors

D1—1N935 precision zener diode (see text)
IC1—7815 +15-volt regulator
IC2—7805 −5-volt regulator
IC3,IC4—741 operational amplifier
LED1—Jumbo red light-emitting diode
Q1—2N6057 silicon npn Darlington transistor
Q2—2N3904 or similar general-purpose silicon npn transistor
RECT1—100-volt, 4-ampere full-wave bridge-rectifier assembly

Capacitors

C1,C4—2,000-µF, 25-volt electrolytic
C2,C5—0.1-µF ceramic disc
C3,C6—0.01-µF ceramic disc
C7—1,0000-µF, 25-volt electrolytic

Resistors (¼-watt)

R1,R2—150 ohms, 1-watt, 10% tolerance
R3—6,800 ohms, 1% tolerance
R4—1,500 ohms, 1% tolerance
R5—750 ohms, 1% tolerance
R6—470,000 ohms, 10% tolerance
R8—2,200 ohms, 10% tolerance
R10,R11—470 ohms, 10% tolerance
R12—0.3 ohm, 3-watt, 5% tolerance
R13—0.5 ohm, 3-watt, 5% tolerance
R14—4,700 ohms, 5% tolerance
R15—680 ohms, 10% tolerance
R7—10,000-ohm panel-mount 10-turn potentiometer
R9—50,000-ohm pc-mount trimmer potentiometer

Miscellaneous

BP1,BP2—Five-way binding post or banana jack (one red, one black)
K1—117-volt ac relay with 3-ampere dpst contacts
M1—2-ampere dc full-scale ammeter movement (see text)
M2—1-volt dc full-scale dc meter movement (see text)
S1—Spst toggle or slide switch with 3-ampere or more contacts
S2—Dpst toggle or slide switch with 0.5-ampere or more contacts
T1—25.2-volt, 2.8-ampere center-tapped power transformer
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for IC3 and IC4; TO-3 mounting kit for Q1; suitable enclosure (see text); ac line cord with plug; rubber grommets; control knob for R7; six- and two-lug terminal strips; thermal transfer compound; small-diameter heat-shrinkable or plastic tubing (see text); lettering kit and clear acrylic spray (see text); ½-inch spacers; machine hardware; hookup wire; solder; etc.

fier *IC4*, which buffers the signal. Potentiometer *R9* permits nulling (zeroing) the output signal from *IC4* when potentiometer *R7* is set to its minimum position.

The output at pin 6 of *IC4* goes to the base of series-pass transistor *Q1* via bias resistor *R10*. Over-current protection is provided by *Q2*. This transistor senses the output current of the power supply flowing through *R12*. Capacitor *C7* provides circuit output filtering, and resistor *R8* protects *IC4* from shut-down transients.

Output current of the power supply into an external load is indicated by ammeter *M1*, and output voltage is indicated by voltmeter *M2*. Both meter movements are identical 1-volt dc units that have a dc resistance of 47,000 ohms. Resistor *R13* serves as a shunt for *M1*. A current of 2 amperes flowing through this 0.5-ohm resistor develops 1 volt across the resistor. This provides a full-scale indication for *M1*.

The 1-volt range of *M2* is sufficient for the LO setting of *S2*. For the HI setting of the switch, however, *R14* is switched in series with the meter movement to make up a voltage divider that changes the range of *M1* to 10 volts full-scale.

Construction

There is nothing critical about component placement and wire runs in this Low-Voltage Precision DC Power Supply. Therefore, you can assemble the project using any traditional wiring method. If you wish, you can design and fabricate a printed-circuit board on which to mount and wire together the active circuitry. Alternatively, you can use perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, however, be sure to use sockets for *IC3* and *IC4*.

Not all components mount on the circuit board. Those that do not include the POWER and RANGE switches, relay, power transformer, LED, meter movements, OUTPUT LEVEL control, bridge rectifier, some resistors (*R1*, *R2*, *R6* and *R12* through *R15*) and capacitors (*C1*, *C2*, *C4*, *C5* and *C7*), and transistor *Q1*.

Once you have decided upon which type of circuit board you will use, install and solder into place the IC sockets. Follow up with the voltage regulators, zener diode and transistor *Q2*. Take care to properly orient these devices before soldering any leads or pins into place. Then install and solder into place the fixed resistors, capacitors and trimmer potentiometer.

Prepare 10 8-inch lengths of stranded hookup wire by stripping ¼ inch of insulation from each end. Tightly twist together the fine wires at all ends and sparingly tin with solder. Solder one end of each wire into place on the circuit board for connection later to off-the-board components. The completed circuit-board assembly wired on perforated board is shown in Fig. 2.

Select an enclosure that is large enough to accommodate the circuit-board assembly and all other components and has suitable front-panel space on which to mount the meter movements, POWER and RANGE switches and POWER LED, and the two OUTPUT five-way binding posts or banana jacks. A suitable enclosure is shown in the lead photo.

Machine the enclosure as needed. This includes cutting suitable-size/shape holes for the meter movements in the front panel and an entry hole for the ac line cord through the rear panel. When you are done with the machining operation, deburr all holes and cutouts made in metal panels to remove sharp edges. Place a rubber grommet in the hole for the ac line cord.

If you wish, paint the prepared front panel with one or two coats of white or light-gray spray enamel. Allow each coat to thoroughly dry before applying the next and proceeding to lettering the legends. Use a dry-transfer lettering kit to label the switch positions, the OUTPUT LEVEL control and both meter movements. Protect the legends with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next.

Fabricate a heat sink for *Q1* from a 2 × 3-inch sheet of aluminum stock. Power transistor *Q1* comes in a TO-9 package. It must be installed on its heat sink with the aid of a TO-3 mounting kit so that it is electrically insulated from but thermally coupled to the heat sink. Machine the heat sink to accommodate the socket. Deburr all drilled holes. Then mount *Q1* to the heat sink, using thermal compound to assure good heat transfer from the transistor to the heat sink.

Plan the layout in and on the enclosure so that the circuit-board assembly is as far as possible from the power transformer to minimize electrical noise in this circuitry. Mount the transformer in place with 6-32 × ½-inch machine screws, nuts and lockwashers, sandwiching the mounting lug of a two-lug terminal strip under the nut of one mounting screw.

Mount *C1* and *C4* with wire ties and self-adhering wire-tie saddles. Use a 6-32 × ½-inch machine screw and lockwasher to mount the relay in place. Then mount a six-lug terminal strip near these capacitors.

Use ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers to mount the circuit-board assembly in the chosen location. Mount the heat sink/*Q1* assembly near the circuit-board assembly and a two-lug terminal strip near this for the wires that will connect to the OUTPUT binding posts or jacks.

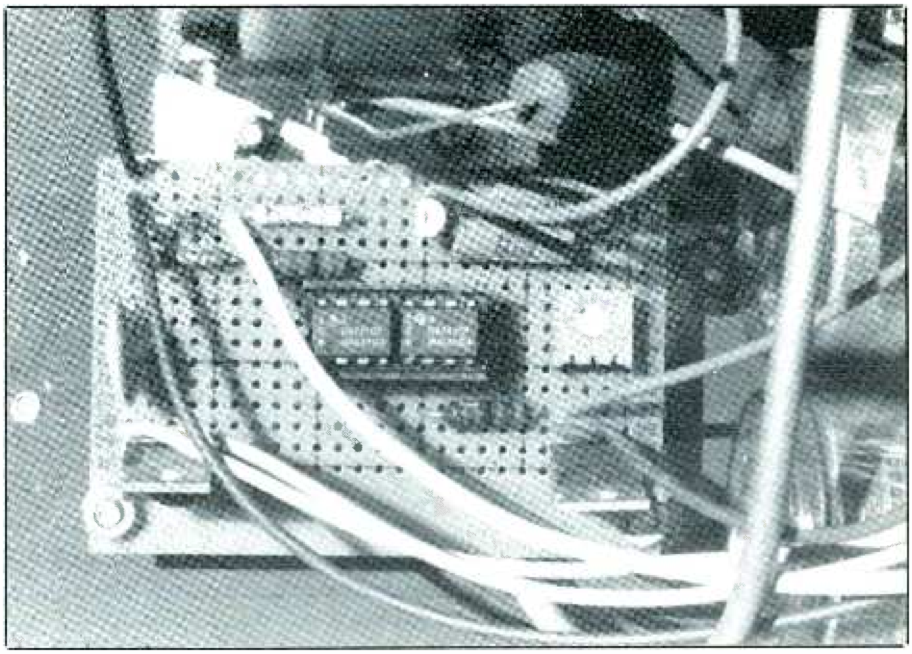


Fig. 2. A close-up view of the small circuit-board assembly on which the active circuitry is mounted and wired.

Use the hardware provided with them to mount the meter movements in their respective locations on the front panel of the enclosure. Then mount the two switches, panel-mount potentiometer and binding posts or banana jacks in their respective holes.

The LED mounts on the front panel. Line the hole you drilled for it with a small rubber grommet to serve as the mounting medium. Alternatively, you can use a standard LED panel clip to aid in mounting this POWER "on" indicator. If you use neither mounting device and the LED does not hold in place by friction, use a small daub of fast-setting clear epoxy cement to secure it in place.

When wiring the circuit, take particular care with the sections in which potentially lethal 117-volt ac line power is present. Make sure everything in these sections is fully insulated and that all connections are electrically and mechanically secure before soldering them. Use No. 18 or larger gauge stranded hookup wire for the connection between *S1*, the coil of the relay and the power transformer.

Also use No. 18 or larger stranded wire to make the connections from the power transformer to the bridge rectifier assembly, which should be mounted on the six-lug terminal strip. Use wire of the same gauge to interconnect the bridge rectifier, relay contacts, *C1* and *C4*.

Mount resistors *R1* and *R2* on the six-lug terminal strip. Then use No. 22 or larger-gauge stranded hookup wire for wiring to the LED. Crimp and solder one lead of *R15* to the lead of the LED. Clip the other lead of the LED to a length of ½ inch and form a small hook in the remaining stub.

Slide a 1-inch length of heat-shrinkable or other plastic tubing over the free ends of the wires that are to connect to the LED network. Crimp and solder these wires to the other lead of the resistor and lead stub of the LED (observe polarity). When the connections cool, slide the tubing over them to completely insulate them and shrink into place. Then make the connections between the circuit-board assembly, *Q1* on the heat sink and potentiometer *R7* and mount *R12* on the socket for *Q1*.

Make the connections between the circuit-board assembly and two-lug terminal strip for the output binding posts or banana jacks. Mount *C7* on the terminal strip. Then use No. 18 or larger-gauge stranded wire for the interconnections between the two-lug terminal strip, meter movements, switches and OUTPUT binding posts or banana jacks.

Install *R6* and *R14* on *S2*. Install *R13* on *M1*. The meter movements connect into the circuit via No. 18 hookup wire terminated in No. 6 terminals.

Tightly twist together the fine wires in each conductor of the ac line cord and sparingly tin with solder. Route the free end of the line cord through its rubber-grommet-lined hole and tie a strain-relieving knot in it a suitable distance from the unprepared end inside the enclosure. Crimp and solder the two conductors to the two-lug terminal strip mounted in place via the hardware that secures the power transformer to the enclosure. Finally, wire together the primary circuit of the power transformer. An interior view of the finished prototype of the project is shown in the photo in Fig. 3.

Calibration & Use

You need a dc voltmeter or a multimeter set to the dc-volts function to calibrate the Power Supply. Set the meter to safely accommodate at least 15 volts of input. Connect the common lead of the meter to the negative (black) OUTPUT binding post or banana jack. Then connect the "hot" meter lead to the + (red) binding post or banana jack. Set the POWER switch to "off" and the RANGE to its LO position. Rotate the knob on the OUTPUT LEVEL control fully counterclockwise.

Plug the Power Supply's line cord into an ac outlet and set its POWER switch to "on." Monitor the meter display as you adjust the setting of trimmer potentiometer *R9* until the output reading from the Power Supply is as close as possible to 0 volt. This done, set the RANGE switch to HI and verify, via the voltmeter or multimeter, that the output of the Power Supply is still 0 volt.

Slowly rotate the knob on the OUTPUT LEVEL control clockwise while monitoring the reading indicated on the external meter. The output potential from the power supply should reach +9 volts when this control's knob is fully clockwise and the RANGE switch is set to HI. The voltmeter on the Power Supply should now verify this reading. If so, set the RANGE switch to the LO position and verify via both meters that the output is 150 millivolts.

If all checks out well to this point, connect a 10-ohm, 10-watt resistor across the OUTPUT binding posts or banana jacks. Set the RANGE switch to HI and the OUTPUT LEVEL panel control to fully counterclockwise. Turn on the Power Supply and slowly adjust the knob on the OUTPUT LEVEL control clockwise while observing the panel meters.

You should observe both pointers steadily rise from minimum toward maximum until the control reaches full clockwise rotation. At this point, the output potential from the Power Supply should be approximately 9 volts and output current should register approximately 0.9 ampere. The load resistor will get warm rather quickly; so do not maintain this test for an extended period.

When you are finished testing the Precision Low-Voltage DC Power Supply, finish assembling it. You now have a Power Supply that will provide the precise power required for your most demanding low-voltage testing and experimenting. ME

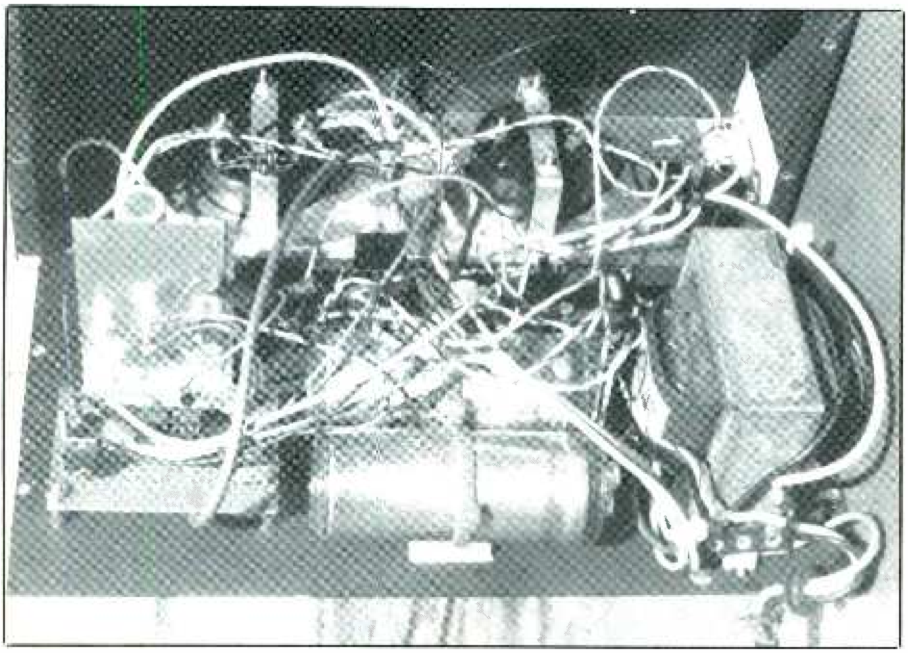


Fig. 3. Interior view of completed Power Supply. Note that the circuit-board assembly at the lower-left is positioned as far as possible from the power supply at the lower-right.

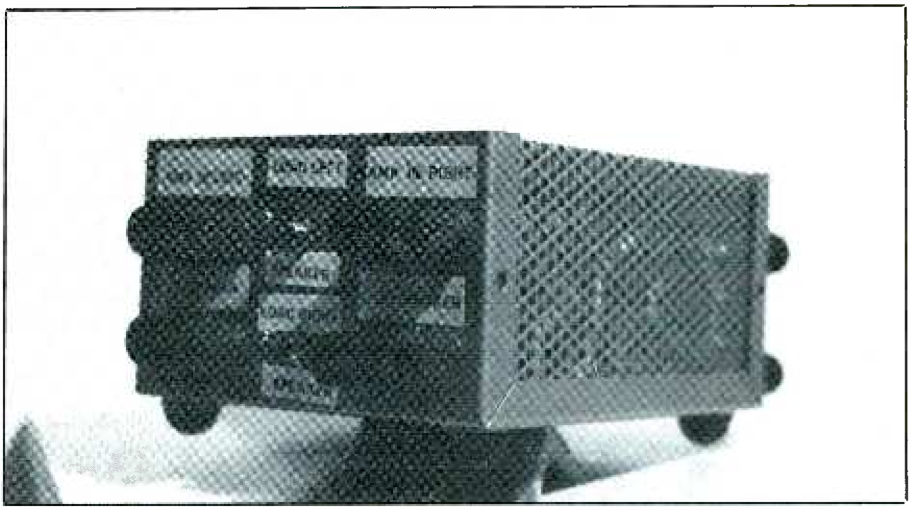
Stereo Audio Test Box

Simplifies connection of test equipment to audio gear for troubleshooting and repair

By Irving E. Farnham

Making connections for testing audio equipment can be a real hassle. Ordinarily, you end up with a tangle of cables that often have to be transposed during tests. Moreover, noninductive loading resistors are often used that yield less than reliable measurement readings. Our Stereo Audio Test Box provides an elegantly simple solution to all this.

The Box has separate left- and right-channel switches for loading and unloading resistors and individual stereo channel amplifier inputs and speaker outputs. Multiple outputs accommodate a variety of test instruments, including a multimeter and oscilloscope. All input and output connections are made through five-way binding posts to accommodate any possible type of cable termination.



About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry for *one* channel of the Stereo Audio Test Box. Two identical but independent such circuits are required for full stereo testing.

As you can see, the circuitry is very simple. It consists of a variety of binding posts for connection of the audio and test equipment, a dpdt switch and a high-power loading resistor for each channel. Setting *S1* to its LOAD position places the 8-ohm, 100-watt inductive load of resistor *R1* across the output circuit of the amplifier channel under test, via *BP3* and *BP4*. If you are testing both channels of a stereo amplifier simultaneously, you would set the switch for both channels to the LOAD position. Because the two tester channels are completely independent of each other, you can also test an amplifier with only one channel loaded.

Setting the switch to the UNLOADED position routes the signal from the output of the audio amplifier directly to binding posts *BP1* and *BP2* for driving a speaker. This gives you the ability to use your ears as a "test instrument" during troubleshooting.

Note that the Stereo Audio Test Box does not require power to operate. It is completely passive. Thus, you can use this instrument in the field as well as on a shop testbench.

Construction

Because the circuit is so simple in configuration, building the project is almost as simple. The first thing you must do is get together all the components that make up the Stereo Audio Test Box circuitry. Next, select an enclosure that will comfortably house the two large high-power resistors and has adequate front and rear panel space on which to mount the binding posts and switches.

The enclosure you choose must have one perforated panel to permit the heat from the resistors during tests to escape. If you cannot find such an enclosure, use a standard metal project box, but replace a solid metal panel with a perforated panel like those used for radiator covers, which you can purchase from most hardware and housewares stores.

Having obtained a suitable enclosure, plan its panel and interior layout in a logical manner. The best place to mount the two resistors is on the floor of the enclosure, as shown in Fig. 2. All binding posts that permit connection to test instruments

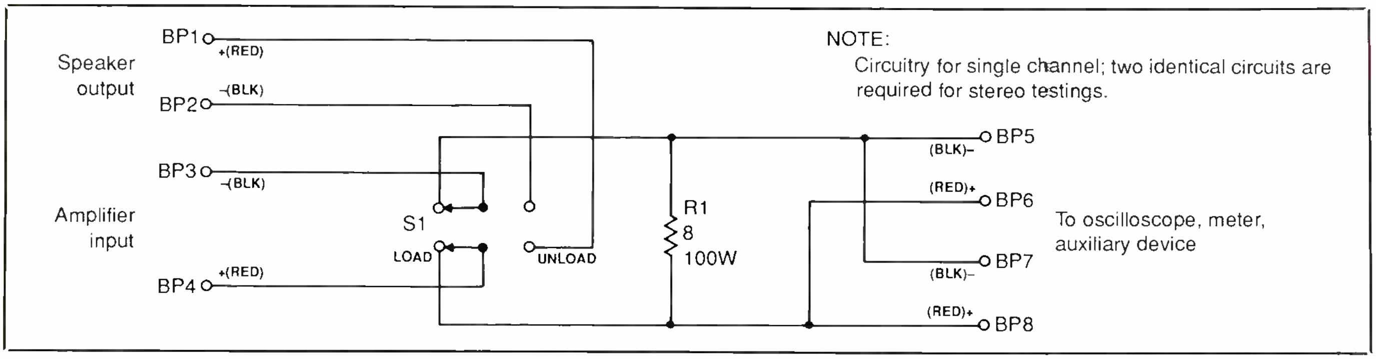


Fig. 1. Schematic diagram of one channel (two identical channels are required for stereo) of the circuitry used in the Stereo Audio Test box.)

should be grouped together, preferably on the rear panel of the enclosure, as shown in Fig. 3(A). The remaining binding posts and switches should also be grouped together, in separate left- and right-channel groupings, on the front panel, as shown in Fig. 3(B).

Once you know how you want the switches, binding posts and resistors to lay out, drill mounting holes for all but the resistors. Deburr all holes to remove sharp edges. Then label each banana jack hole position according to its function and each switch position. Use a dry-transfer lettering kit for a professional appearance, protecting the legends with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next. Alternatively, you can use a plastic tape labeler or even masking-tape labels.

Mount the binding posts in their respective locations; use red colored ones for *BP1*, *BP4*, *BP6* and *BP8* and red colored ones for the remaining binding posts so that you know the polarities of the hookups to make to the project. When you mount the binding posts into place, be sure to use insulating hardware so that none comes into electrical contact with the metal enclosure. Also, place a solder lug on each mounting post.

Next, mount the switches in their respective locations. Then refer back to Fig. 1 and wire together the switches and binding posts for each channel. Use heavy-duty insulated 14-gauge wire for all wiring. Strip ¼ inch of insulation from both ends of each wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. Terminate the wire ends that go to the switch lugs in suitable insulated quick-disconnect crimp terminals. Then crimp and solder the wires to the appropriate solder lugs on the binding posts and slip the connectors onto the switch lugs.

Mount two adhesive-backed tie mounts to the floor of the enclosure for each resistor. Space these far enough apart to assure that the two resistors will not touch each other when mounted into place. Figure 2 shows how each resistor secures to the floor of the enclosure via two tie mounts and plastic cable ties.

Again using 14-gauge stranded wire, connect the resistors into the circuit. Refer to Fig. 1 for details on how to do this. When you are done, make sure that neither resistor physically touches the floor of the enclosure. Each should be spaced slightly above the floor to permit air to circulate around it.

PARTS LIST

- BP1,BP4,BP6,BP8*—Red five-way binding post
- BP2,BP3,BP5,BP7*—Black five-way binding post
- R1*—8-ohm, 100-watt noninductive power resistor (MCM Electronics Cat. No. J-28-048 or similar)
- S1*—10-ampere dpdt toggle switch (All Electronics Cat. No. MTS-8HD or similar)
- Misc.—Suitable enclosure (6″ × 5″ × 3″ aluminum or steel with perforated cover—see text); 4 adhesive-backed tie mounts; plastic cable ties; quick-disconnect insulated terminals; lettering kit (see text); 14-gauge stranded wire; solder; etc.

*Double up on these components for stereo version of project.

Parts Supplier Addresses

All Electronics Corp.
P.O. Box 567
Van Nuys, CA 91408
1-800-826-5432

MCM Electronics
650 Congress Park Dr.
Centerville, OH 45459-4072
1-800-543-4330

Checkout & Use

Set both switches on the Stereo Audio Test Box to LOAD. Connect a multimeter set to the ohms function across Left Channel AMPLIFIER INPUT binding posts *BP3* and *BP4* for the Left Channel and note the reading obtained. It should be approximately 8 ohms. Repeat for the same-numbered AMPLIFIER INPUT binding posts in the Right Channel. Then make sure that there is complete isolation (infinity reading) between the Left and Right Channel Inputs.

With the switches still in the LOAD position, you should obtain an ohmmeter reading of infinity across SPEAKER OUTPUT binding posts *BP1* and *BP2* in both channels. Set the switches to the UNLOAD position and use your ohmmeter to check for continuity between the AMPLIFIER INPUTS and SPEAKER OUTPUTS. You should obtain an infinity reading at all instrument binding posts (*BP5* through *BP8*) with the switches set to UNLOAD.

Connect the common lead of the multimeter (still set to the ohms function) to the metal enclosure. Then touch the "hot" probe to each binding post in turn while observing the display. In *all* cases, you should obtain an infinity reading (overrange reading if you are using a digital multimeter set to the highest range) at all binding posts.

If you fail to obtain the proper reading at any point in the above procedure, double-check all your wiring against Fig. 1. Do *not* proceed until you have corrected the problem.

When using the Stereo Audio Test Box, connect the speaker outputs of the amplifier under test to AMPLIFIER INPUT binding posts *BP3* and *BP4* in each channel, making sure you observe the same polarity for each channel. Then feed the output from a signal generator into the AUX inputs of the amplifier.

Connect the input cables of a dual-trace oscilloscope to any pair of outputs in each channel and a multimeter set to the ac-volts function or any other monitoring instrument to the other pair of outputs in each channel. Finally, connect speaker systems to the project via the Speaker Output binding posts in each channel.

Turn on your test instruments and the amplifier. Conduct whatever tests you plan on making. One word of caution: *Never* set the switches to UNLOAD without first connecting the speakers to the Stereo Audio Test Box. If you do, the amplifier can overload and either shut down or the output transistors will be damaged.

Other audio components that do not require a load can be connected to the AMPLIFIER INPUT binding posts for testing purposes. In this case, always leave the switches in the UNLOAD position, and connect any instruments used to make tests via the SPEAKER OUTPUT binding posts.

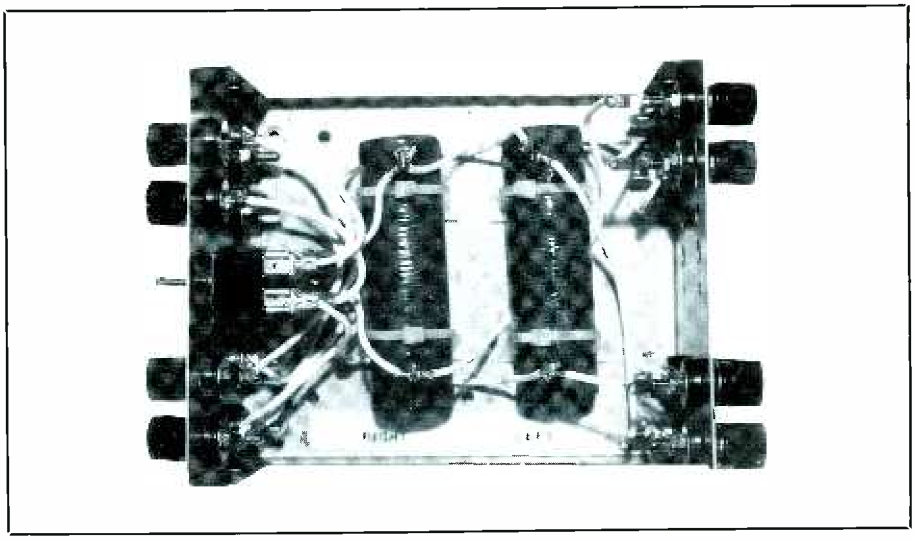


Fig. 2. Interior view shows amplifier and speaker connectors mounted on rear enclosure panel (right), test-equipment connectors and switches mounted on front panel (left) and high-power loading resistors mounted on floor (center).

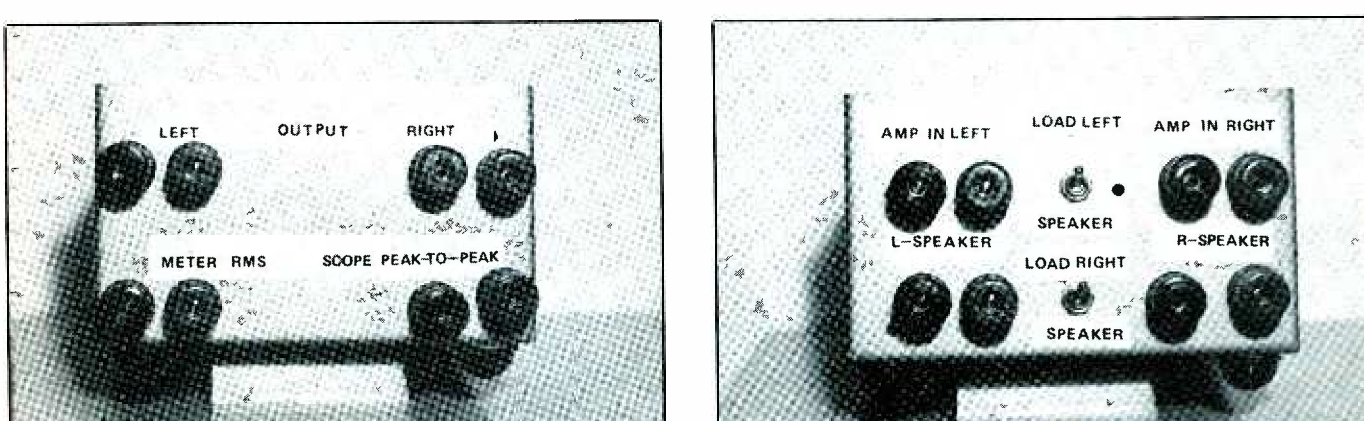
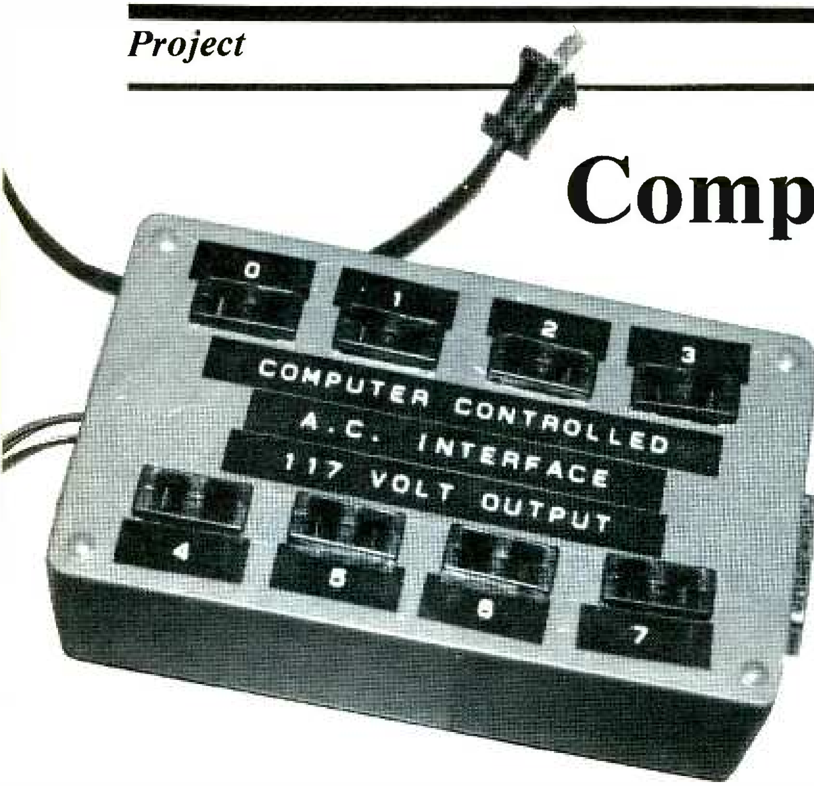


Fig. 3. Binding posts for test instruments mount on rear panel (A), Amplifier and Speaker binding posts and switches on front panel (B) of enclosure.



Computer-Controlled AC Interface

Simple interface circuit and BASIC program let you control lights and other appliances from the keyboard of your IBM PC or compatible computer

By George F. Stockman IV

Use of a desktop computer in non-traditional applications offers a fascinating area for experimenting. If this interests you, our AC Interface circuit is just the ticket for getting you started. It provides an interesting twist to your workstation by allowing you to load a BASIC program to on/off control different electrically-operated devices directly from your keyboard.

Connecting the Interface to the parallel port on an IBM PC or compatible computer permits up to eight ac-powered receptacles to be switched on and off individually or simultaneously with the touch of a few keys. This can be convenient for operating lights, fans, small motors, and other ac-operated devices. The power drawn by the controlled devices to be operated is limited only by the ratings of the components being used. Some practical applications for this project include operation of ventilation fans, solenoid-controlled water valves, outdoor house lighting and keyless door locks, space heaters, radios, night lights and table lamps, etc.

About the Circuit

Most resistive devices powered from the 117-volt ac line can be controlled using the AC Interface circuit shown schematically in Fig. 1. This circuit is operated by a menu-driven PSWITCH.BAS computer software program written in BASIC and shown elsewhere in this article. The source code may be compiled to permit self-execution and eliminate the need for the BASIC program. The program tells the computer to raise or lower the logic levels of its eight parallel data lines.

For the following explanation, we will use Channel 1 of the circuit. Any other channel can just as easily be used for this purpose, since all eight channels are identical in design and operation, except that each is accessible by a different code from the keyboard of the computer being used.

Instructing the computer's parallel port to raise a data line to logic level 1 (+5 volts dc) forward-biases the gallium-arsenide infrared-emitting diode inside optical isolator *IC1*. The infrared energy emitted at this point triggers on the bidirectional DIAC, also inside *IC1*.

When the DIAC switches on, it triggers triac *Q1* into conduction. In turn, *Q1* completes the 117-volt ac line circuit to any load plugged into receptacle *SO1*, which now turns on.

Resistor *R1* limits current flow through the LED inside *IC1*, while resistor *R2* limits gate current to *Q1*. If you substitute a different triac for *Q1* check maximum forward current and gate current ratings to ensure a safe forward current flow. Use Ohm's Law to determine the value of gate resistor in such a case.

As shown in Fig. 1, the project is expandable to include up to eight control channels. Select for each channel a triac that will safely accommodate the expected load.

Note that the project connects to your computer via the latter's parallel port. If you are using a parallel printer with your computer, you must install a second parallel port and configure the operating system to recognize it. Alternatively, you can use an external AB switch to select between printer and AC Interface or use a duplex connector into which both printer and project can be plugged to use the single port. If you go the last route, turn off your printer when operating the AC Interface. Otherwise, signals from the printer can upset operation of the project.

Construction

This is a very simple project to build, thanks to the small component/channel count. Therefore, you can use any traditional technique to mount and wire together the components. If you wish, you can design and fabricate a printed-circuit board for the components selected. Alternatively, you can mount the components on perforated board that has holes on 0.1-inch centers using Wire Wrap or soldering hardware and point-to-point wire them together.

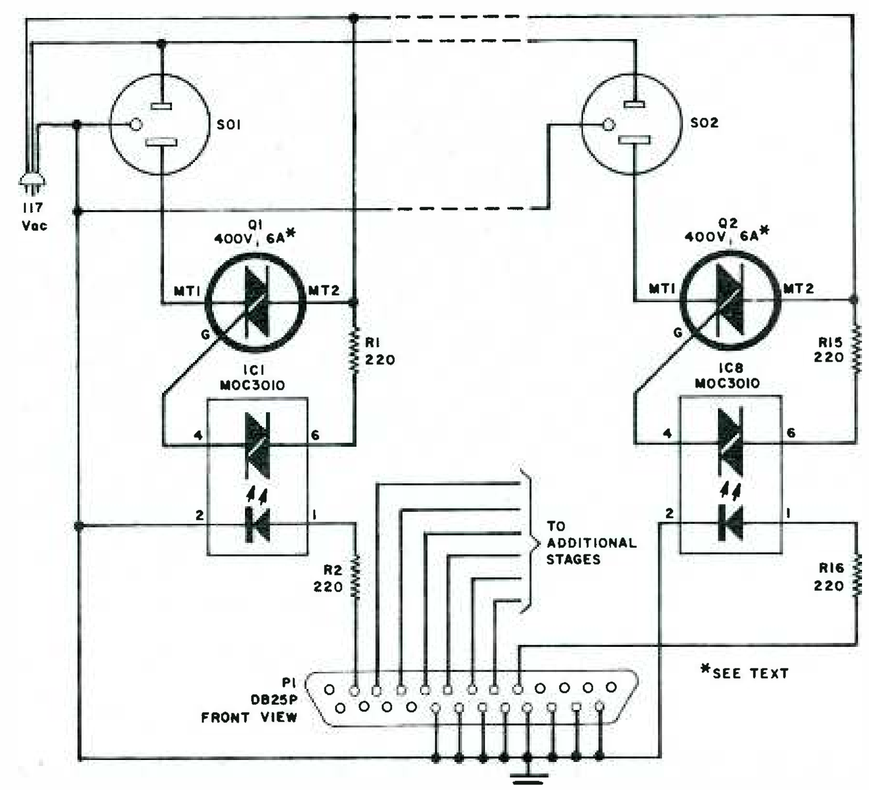
When laying out your circuit, leave plenty of room for the components and future expansion, the latter assuming that you are assembling less than the maximum of eight channels. It is a good idea that, whatever the wiring technique, you use sockets for the optical isolators.

Wire together the components according to Fig. 1. When you are finished wiring the circuit-board assembly, strip ⅜ inch of insulation from both ends of as many heavy-duty stranded hookup wires as are needed to connect from the triacs to the ac receptacles. (If you wish, you can substitute medium-duty zip cord in place of individual wires.) Tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder. Then connect and solder one end of each wire to the appropriate points on the circuit board.

Next, use 10-conductor ribbon cable to wire to the free ends of the resistors that go to the anodes of the LEDs inside the optical isolators. After cutting the cable to length, remove and discard one conductor. Then separate the conductors at one end of the cable a distance of 1 inch and as needed at the other end. Strip ¼ inch of insulation from all conductors at both ends of the cable.

Tightly twist together the fine wires at both ends of each conductor and sparingly tin with solder. Use heat judiciously as you do this to minimize fusing and charring the insulation. Crimp and solder the end of the cable opposite that which the conductors have been separated only 1 inch to the appropriate points on the circuit-board assembly.

With the circuit-board assembly fully wired, carefully check it over to make certain that it is accurately wired. Remember that full 117-volt



PARTS LIST

Semiconductors
IC1 thru IC—MOC3010 optical-isolator (Radio Shack Cat. No 276-134 or equivalent)
Q1 thru Q8—400-volt, 6-ampere or greater triac (Radio Shack Cat. No. 276-1000 or similar; see text)

Resistors
R1 thru R16—220 ohms, ½ watt

Miscellaneous
P1—Solder-type DB-25P male connector (Radio Shack Cat. No. 276-1547 or similar)
SO1 thru SO8—Chassis-mount, three conductor snap-in ac receptacle (All Electronics)
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; ac line cord with plug; enclosure (Radio Shack Cat. No. 270-224 or similar; see text); spacers; rubber grommet; machine hardware; hookup wire; solder; etc.

Fig. 1. Complete schematic diagram of the Computer-Controlled AC Interface circuit.

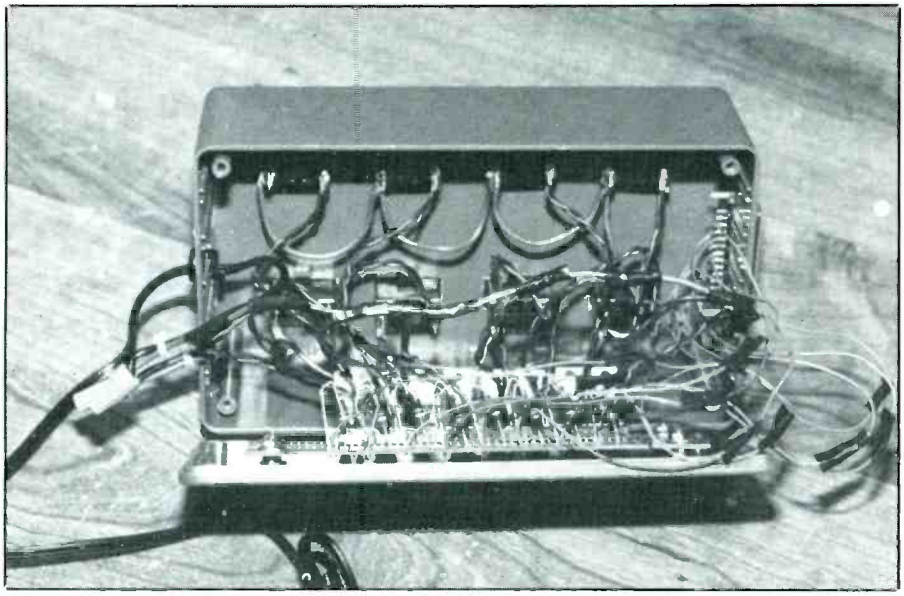


Fig. 2. Interior view of completed project housed inside plastic project box.

BASIC Program For Operating Computer-Controlled AC Interface

```
10 CLEAR: CLOSE: KEY OFF: CLS: DEC = 0: OUT 888, DEC
20 BYTE$ = " 0   0   0   0   0   0   0   0"
30 LOCATE 1, 21: PRINT "ZDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD?"
40 LOCATE 2, 21: PRINT "3  PARALLEL INTERFACE PROGRAM  3"
50 LOCATE 3, 21: PRINT "@DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDY"
60 LOCATE 10, 15: PRINT "BIT NUMBER    7   6   5   4   3   2   1   0 "
70 LOCATE 11, 15: PRINT "DDDDDDDDDDDDDEDDDEDDDEDDDEDDDEDDDEDDDEDDD4 "
80 LOCATE 12, 29: PRINT "3   3   3   3   3   3   3   3 "
90 LOCATE 13, 29: PRINT "A   A   A   A   A   A   A   A "
100 LOCATE 14, 15: PRINT "   VALUE      "; BYTE$
110 LOCATE 21, 16: PRINT "COPYRIGHT,  GEORGE F. STOCKMAN, IV,  1989"
120 DELAY = TIMER + 5: WHILE DELAY > TIMER: WEND
130 LOCATE 21, 16: PRINT STRING$(41, 32)
140 LOCATE 21, 11: PRINT "BIT NUMBER TO TOGGLE / [CR] TO RESET / [ESC] T
150 A$ = INKEY$: IF A$ = "" THEN 150
160 IF A$ = "0" THEN 240 ELSE IF A$ = "1" THEN 260 ELSE IF A$ = "2" THEN
170 IF A$ = "3" THEN 300 ELSE IF A$ = "4" THEN 320 ELSE IF A$ = "5" THEN
180 IF A$ = "6" THEN 360 ELSE IF A$ = "7" THEN 380
190 IF A$ <> CHR$(13) THEN 230
200 BYTE$ = " 0   0   0   0   0   0   0   0"
210 DEC = 0: BIT0 = 0: BIT1 = 0: BIT2 = 0: BIT3 = 0
220 BIT4 = 0: BIT5 = 0: BIT6 = 0: BIT7 = 0: GOTO 430
230 IF A$ = CHR$(27) THEN CLS: SYSTEM ELSE BEEP: GOTO 150
240 IF BIT0 = 0 THEN BIT0 = 1: DEC = DEC + 1 ELSE BIT0 = 0: DEC = DEC -
250 GOTO 390
260 IF BIT1 = 0 THEN BIT1 = 1: DEC = DEC + 2 ELSE BIT1 = 0: DEC = DEC -
270 GOTO 390
280 IF BIT2 = 0 THEN BIT2 = 1: DEC = DEC + 4 ELSE BIT2 = 0: DEC = DEC -
290 GOTO 390
300 IF BIT3 = 0 THEN BIT3 = 1: DEC = DEC + 8 ELSE BIT3 = 0: DEC = DEC -
310 GOTO 390
320 IF BIT4 = 0 THEN BIT4 = 1: DEC = DEC + 16 ELSE BIT4 = 0: DEC = DEC -
330 GOTO 390
340 IF BIT5 = 0 THEN BIT5 = 1: DEC = DEC + 32 ELSE BIT5 = 0: DEC = DEC -
350 GOTO 390
360 IF BIT6 = 0 THEN BIT6 = 1: DEC = DEC + 64 ELSE BIT6 = 0: DEC = DEC -
370 GOTO 390
380 IF BIT7 = 0 THEN BIT7 = 1: DEC = DEC + 128 ELSE BIT7 = 0: DEC = DEC
390 BYTE$ = "": BYTE$ = BYTE$ + STR$(BIT7) + "  " + STR$(BIT6) + "  "
400 BYTE$ = BYTE$ + STR$(BIT5) + "  " + STR$(BIT4) + "  "
410 BYTE$ = BYTE$ + STR$(BIT3) + "  " + STR$(BIT2) + "  "
420 BYTE$ = BYTE$ + STR$(BIT1) + "  " + STR$(BIT0) + "  "
430 OUT 888, DEC: LOCATE 14, 28: PRINT BYTE$;: GOTO 150
```

ac line potential appears in parts of the circuit. Incorrect wiring can prove disastrous to delicate components. So make certain that your wiring is correct.

Once you are satisfied with your wiring, temporarily set aside the circuit-board assembly and proceed to machining the enclosure that will house he project.

You can use any type of enclosure in which to house the project that is large enough to accommodate the full-size circuit-board assembly and has room on its top panel for mounting the ac receptacles and at one end to accommodate DB-25 connector *P1*. This can be all-metal, all-plastic (as shown in the photos) or a mixture of the two.

Machine the enclosure as needed. That is, drill mounting holes in the floor for the circuit-board assembly, cut a suitable size and shape slot through one end wall in which to mount the DB-25 connector, and drill a hole through the opposite end wall for entry of the line cord. Finally, cut as many slots in the top panel into which to mount the number of ac receptacles being used. If you drilled any holes or cut any slots through a metal panel, deburr the edges to remove sharp projections and line the ac cord's hole with a rubber grommet.

Now mount the receptacles in their slots and the circuit-board assembly in place using ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers. If the line-cord entry hole is through metal, line the hole with a rubber grommet. Pass the free end of the line cord through its hole and tie a strain-relieving knot in it about 6 inches from the free end inside the enclosure. Tightly twist together the fine wires in each conductor and sparingly tin with solder.

Draw the free end of the ribbon cable coming from the circuit-board assembly out through the slot for the DB-25 connector. Referring to the schematic diagram, carefully solder a suitable length of solid bare hookup wire across the sides of pins 18 through 25 of the connector. These are the pins shown connected at the lower-right of the connector in the schematic. Then carefully solder the ground wire coming from pin 2 of both optical isolators to any one of these pins.

Solder the free ends of the remaining conductors in the ribbon cable to pins 2 through 9 of the connector, as shown in the schematic. When soldering any of the ribbon cable conductors into place, use heat judiciously to minimize heat damage to the insulation.

When you are finished wiring the connector, carefully check it over. Reflow the solder on any pin that appears suspicious. Check particularly for solder bridges between the closely spaced pins of the connector. If you locate any, clear it with desoldering braid or a vacuum-type desoldering tool. Then mount the connector in its slot in the end wall of the enclosure with suitable machine hardware.

Wire the receptacles into the circuit by crimping and soldering the free ends of the heavy-duty leads coming from the circuit-board assembly to the lugs on the receptacles. Finally, wire into the circuit the ac line cord as shown. A photo of the completed project housed inside a plastic project box is shown in Fig. 2.

When you are done, check all wiring, especially in the portions of the circuit where ac line voltage is to be present (triacs *Q1* through *Q8* and receptacles *SO1* through *SO8*).

Using the Interface

Plug a suitable parallel connector cable between the parallel output port of your computer and the DB-25 connector on the project. Then plug a table lamp into receptacle *SO1* on the project and plug the Interface's line cord into an ac outlet. Make sure the lamp switch is "on".

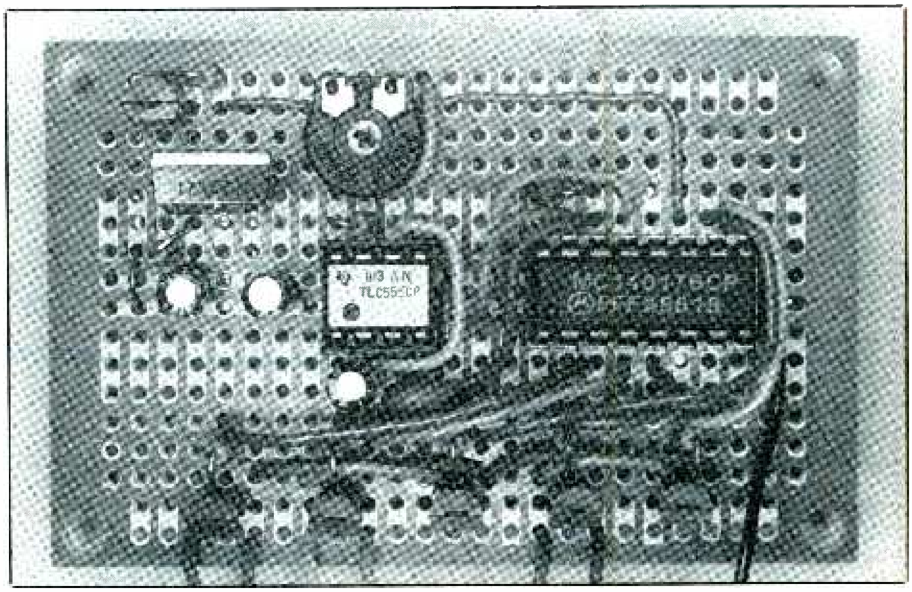
Turn on your computer and key in the BASIC program given in the listing. Save the program to disk under a filename PSWITCH.BAS. Now RUN the program, and follow the instructions given on-screen. You should be able to toggle on and off the lamp plugged into the receptacle. If so, unplug the lamp from *SO1* and plug it into *SO2*, and toggle it on and off from the keyboard of your computer. Repeat this procedure until you have checked out operation of all channels you have wired into the system.

If you fail to obtain toggle action in any channel, power down the computer. Unplug the project from both the ac line and computer. Then rectify the problem. Do not proceed to use the project until you are sure that it is operating properly. **ME**

Area-Code Speed Dialer

Automatically dials any area code, including the "1" that may be required, and any digit needed in an office telephone system to access an outside line

By Dave Wysock



If you're like me, you spend a considerable portion of your workday making telephone calls—often to numbers that require you to dial an area code first. At the very least, this entails dialing three extra digits before you even get to the exchange and number for the party to be called. If you live in a metropolitan area where the number of telephone instruments are stretching Ma Bell's capacity to the limit, you also have to dial 1 before dialing the area code. And to further complicate matters, if your company requires you to dial 9 just to get an outside line, you have to dial yet another digit. So you may have to dial as many as five extra digits for each call you make outside your calling district.

Our Area-Code Speed Dialer, allows you to simply press one button to initiate an automatic sequence that dials the "extra" digits required in a toll call to one specific area code. It can handle up to 10 digits. The Speed Dialer is "programmed" for a specific area-code sequence. If you frequently call several different area codes, you can build a separate Speed Dialer with its own button and program it for one-touch dialing of each.

About the Circuit

This project requires a telephone instrument that uses a TCM-5087 or TP-5087 chip for generating the Touch Tone® signals required for DTMF (dual-tone multi-frequency) dialing. This chip is popularly used in most standard tone-dialing telephones. It is wired to a keypad in a matrix format made up of vertical columns and horizontal rows. The dialing chip and keypad hookups are shown in the boxed section in Fig. 1.

When no key on the dialing keypad is pressed, pull-up resistors are active on column inputs and pull-down resistors are active on row inputs. Column latches are on and ready to store column key closures. After a key is pressed, the row pull-down resistors cause a negative-true condition to exist on the column inputs, which starts an oscillator and initiates tone generation. In this project, transistors sequenced by a decade counter close the appropriate keyboard switches by electronic means.

CMOS 555 timer *IC1* in Fig. 1 is configured as an astable multivibrator. Its square-wave output at pin 3 goes to INPUT pin 14 of 4017 decade counter *IC2*. Each time pin 14 "sees" a pulse, *IC2* decodes it and delivers a high on one of its 10 output pins. Only one output pin is high at any given time; all other pins remain low.

When activated, the outputs at pins 3, 4, 10, 5 and 9 of *IC2* are forward-bias *Q3* through *Q7*, respectively. The transistor emitters and collectors connect to the row and column inputs of the keypad in the proper sequence for the particular area code for which the project is built. The other outputs shown for

IC2 can be used if you need extra digits. Use a separate transistor for each extra digit and observe the proper connection sequence during programming.

Activation of the Speed Dialer is accomplished by pressing and releasing momentary-contact switch *S1*. This causes *C1* to charge and sends *Q1* into conduction. In turn, *Q1* supplies power from the +9-volt bus to the rest of the circuit.

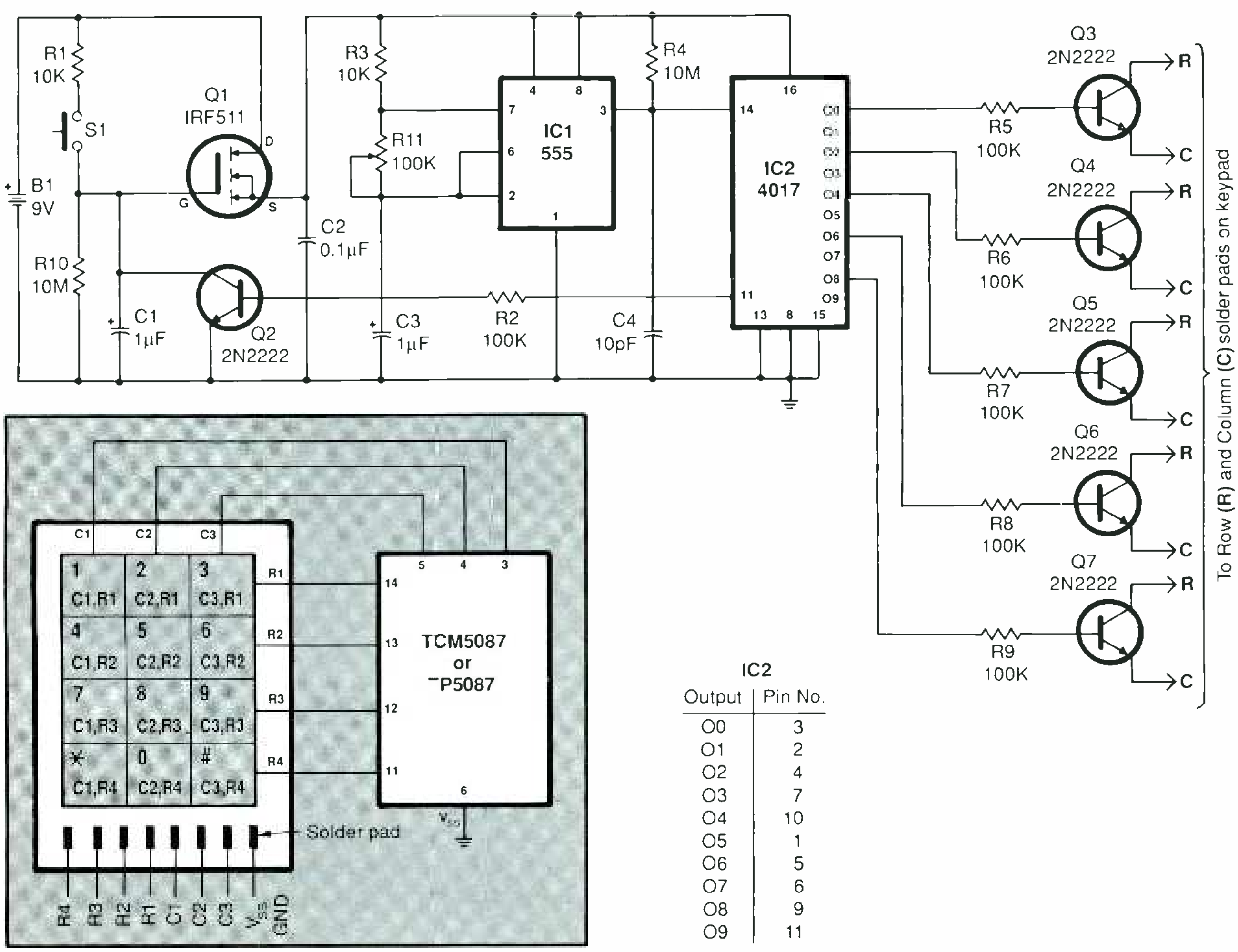
With power applied, *IC1* generates square waves that are delivered to the CLOCK input of *IC2* at pin 14. As the pulses are processed by *IC2*, *Q3* through *Q7* turn on and off sequentially, closing the row and column switches and generating the tones required to dial the area-code (and any other) digits. At the tenth pulse, *IC2* biases on *Q2*, causing *C1* to discharge and automatically shut off the Dialer.

Because only low-power CMOS chips are used in this project, the current drain on the power source is on the order of only 0.5 milliampere. Therefore, it is practical to use an ordinary 9-volt alkaline battery as the power source for this project.

Construction

Before you build your Area-Code Speed Dialer, open the telephone instrument with which you plan to use it and verify that it uses a TCM5087 or TP5087 chip. If it does, you are in business. If not, replace the instrument with one that does use either of these particular chips.

Next, find a way to access the row and column inputs to the chip. In many desk-type phones, this can easily be accomplished via solder pads located just under the keypad (see Fig. 2) that connect the chip to the key switches. Incidentally, a desk-style telephone instrument has enough room inside it to easily accommodate the circuit-board assembly of the project and battery inside



IC2 Output	Pin No.
O0	3
O1	2
O2	4
O3	7
O4	10
O5	1
O6	5
O7	6
O8	9
O9	11

Fig. 1. Complete schematic diagram of the circuitry used in the Area-Code Speed Dialer.

PARTS LIST

Semiconductors

IC1—TLC555 timer

IC2—4017 decade counter/divider

Q1—IRF-511 or any general-purpose power-type MOSFET (Radio Shack Cat. No. 276-1718 or similar—see text)

Q2 thru Q7—2N2222 or similar general-purpose npn silicon transistor (see text)

Capacitors

C1,C3—1-μF, 16-volt electrolytic

C2—0.1-μ, 16-volt disc

C4—10-pF

Resistors (¼-watt, 10% tolerance)

R1,R3—10,000 ohms

R2,R5 thru R9—100,000 ohms (see text for quantity)

R4,R10—1 megohm

R11—100,000-ohm, ⅛-watt pc-mount trimmer potentiometer

Miscellaneous

B1—9-volt alkaline battery (see text)

S1—Spst normally-open, momentary-action pushbutton switch

Printed-circuit board or perforated board with holes on 0.1″ centers and suitable Wire Wrap or soldering hardware; DIP IC sockets; 1N914 isolation diodes (see text); 9-volt dc plug-in wall-type power supply (optional—see text); suitable enclosure (optional—see text); light-emitting diode and 470-ohm, ¼-watt resistor for test purposes (see text); terminal strip (optional—see text); machine hardware; hookup wire; solder; etc.

the instrument. If you are planning to build more than one Speed Dialer for different area codes, consider housing them in a separate enclosure and powering them from the ac line via a plug-in wall-type 9-volt dc power supply.

As can be seen in Fig. 2, the components that make up the project easily fit on a small (4.5 × 7-cm) IC-type prototyping board, such as the Radio Shack Cat. No. 276-150. Alternatively, you can design and fabricate a printed-circuit board on which to mount the components. Whichever way you go, though, be sure to use sockets for the two ICs.

You can use any power MOSFET for *Q1*. The IRF-511 specified in the Parts List is overkill, but it is readily available from your local Radio Shack store. To save space, the heat-sink tab can be carefully snipped off the IRF-511.

Any general-purpose npn switching-type device can be used for the remaining transistors. Fig. 1 shows six such transistors. You may or may not require this many, depending on the number of extra area-code and other digits you must dial.

If you do not have to dial a 9 or a 1, you can get by with just four transistors (an "extra" transistor, shown as *Q2* in Fig. 1, is always required for shutting down the Dialer after the area-code digits have been dialed). If you must dial either a 9 or a 1 or both, you need five or six transistors.

If you have to dial any number combination that has repeated digits in it (such as 1-815), a separate transistor is not needed for each digit that is repeated. Simply bring the appropriate *IC2* counter outputs to a single transistor. Make sure to use separate 1N914 diodes to isolate the common outputs, though.

Before actually mounting the components in place and wiring them together, plan your layout on grid paper (preferably with 10 boxes to the inch to obtain an actual-size layout). Once this is done, mount the two DIP transistor sockets in place, followed by the resistors, capacitors, trimmer control and transistors. Do *not* plug the ICs into the sockets until after you have conducted voltage checks and are certain that the circuit is properly wired.

Referring back to Fig. 1, carefully wire together the components using insulated hookup wire. Make certain that the connections for the electrolytic capacitors are properly polarized, and follow the basing configurations shown for the transistors.

Strip ¼ inch of insulation from both ends of as many 6-inch lengths of stranded hookup wire as are needed for the connections to the transistors that serve as electronic switches for the keypad. (The number of wires needed is determined by the number of transistors used, as detailed above.) Tightly twist together the conductors at both ends of each wire and tin with solder.

Connect and solder one end of these wires to the emitters and collectors of the transistors. Do not terminate the other ends at the keypad of the telephone instrument just yet. Connect and solder the red- and black-insulated leads of a 9-volt battery snap connector to the positive (+) and negative (−) rails, respectively, on the circuit-board assembly.

Prepare three 10-inch-long stranded hookup wires as above. Crimp and solder one end of each of two of these wires to the lugs of *S1*. Terminate the other ends of these wires at the appropriate points on the circuit-board assembly. Connect and solder one end of the remaining wire to a point in the circuit that is at ground potential.

Double check all wiring. Make sure each component is in its correct location and is properly oriented, where applicable. Check your soldering, too. Solder any connection you missed and reflow the solder on any suspicious connection. If you locate any solder bridges, especially around the pins of the IC sockets, clear them away with desoldering braid or a vacuum-type desoldering tool.

Checkout & Use

Connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to any point in the circuit that is supposed to be at ground potential. Snap a fresh 9-volt battery into the connector. Press and hold *S1* closed. Touch the "hot" lead of the meter to pins 4 and 8 of the *IC1* socket and pin 16 of the *IC2* socket. The meter should indicate approximately

+5 volts at all three IC socket pins. Release *S1*.

If you do not obtain the correct reading at any socket pin. disconnect the battery from the circuit and correct the problem before proceeding. Once you are certain that the circuit is properly wired, plug the 555 timer chip into the *IC1* socket. Make sure the timer is properly oriented and that no pins overhang the socket or fold under between IC and socket.

Crimp and solder one lead of a 470-ohm, ¼-watt resistor to the cathode lead of a light-emitting diode. Then solder one end of a 5-inch-long stranded hookup wire to the anode lead of the LED. Tack solder the free lead of the resistor to any convenient point in the circuit that is at ground potential.

Snap the battery back into its connector. Holding *S1* closed, plug the free end of the wire connected to the anode lead of the LED (make sure the two LED leads do not touch each other) into pin 14 of the *IC2* socket. Press and release *S1*. If all is okay, the LED should blink rapidly. If it does, jumpering from the +5-volt rail to pin 11 of the *IC2* socket should cause the LED to extinguish.

With the battery removed from the circuit, plug the 4017 counter chip into the *IC2* socket. Again, make sure the IC is properly oriented and that no pins overhang the socket or fold under between IC and socket. Plug the battery back into its connector.

Touching the free end of the wire connected to the anode of the LED, press and release *S1*. The LED should eventually flash on and then extinguish. Do this for all counter outputs used to ascertain that all are working properly.

If you experience any difficulties during the checkout procedure, disconnect the battery from the project and troubleshoot as needed. Do not proceed to final installation until you have corrected any problems.

Once you are certain that the circuit has been correctly wired, disconnect the test LED and wires. Then disconnect your telephone instrument from the wall jack and open it up to get at the internal circuitry. Drill a hole in the housing of the telephone instrument to permit mounting *S1* in a location where it will be easily accessible but will not interfere with either the circuit-board assembly or the internal workings of the telephone instrument. If you are building two or more Speed Dialers, prepare an enclosure in which to house them by drilling mounting holes for the individual switches and an entry hole for the power cord from the external dc power supply.

Following Fig. 1, carefully solder the free ends of the wires coming from the transistors connected to the outputs of *IC2* to the appropriate row and column pads on the keypad of the telephone instrument, as shown in Fig. 2. Again, if you are building more than one Speed Dialer, mount a multiple-lug terminal strip inside the separate enclosure and run wires from the keypad solder pads to

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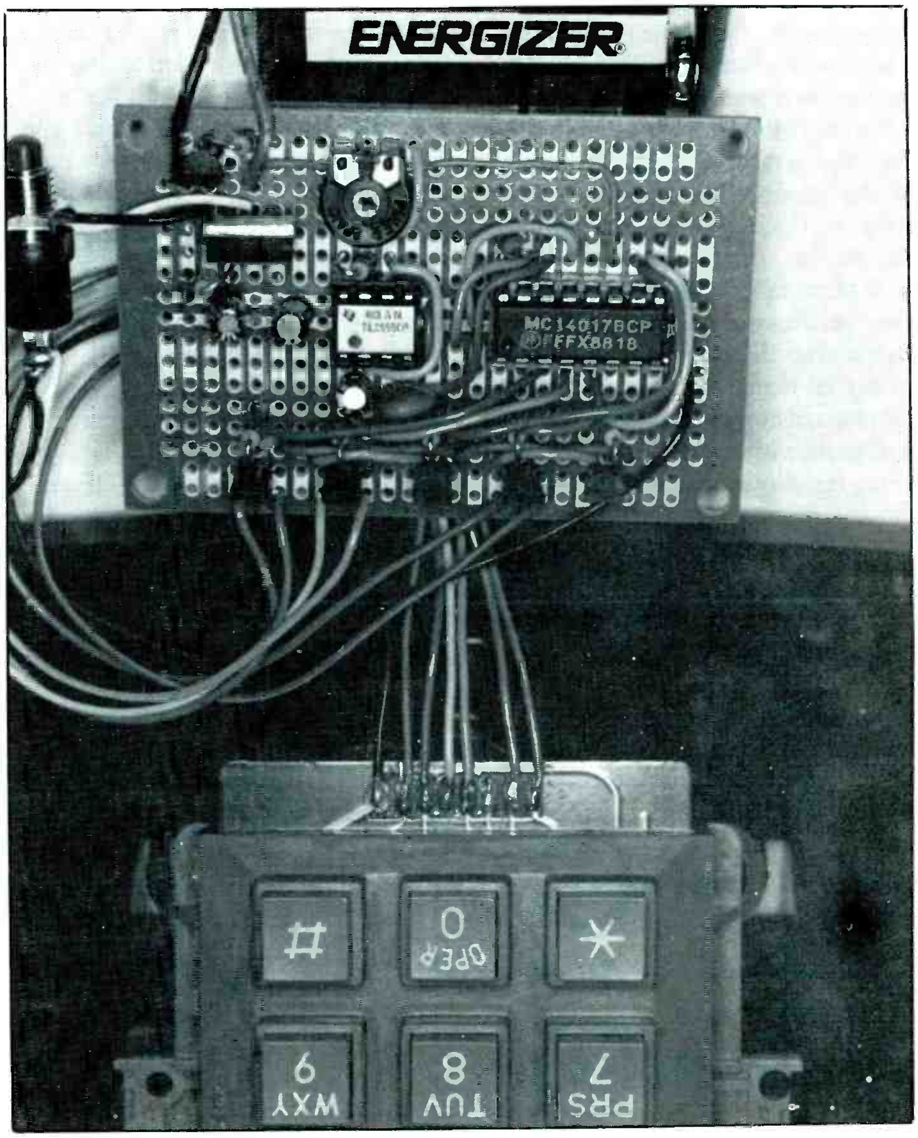


Fig. 2. Connections between Speed Dialer circuit-board assembly and telephone instrument keypad are made with insulated stranded hookup wire.

Dc-to-Dc Converters

A simplified approach to designing and building circuits to convert one dc voltage to another

By Anthony J. Caristi

Recent advances in electromagnetics have created revolutionary new powering schemes that are now used in many electronic instruments and devices. Ac-powered electronic equipment have heretofore required bulky, heavy power transformers to provide isolation from the ac line and to step up or down the line voltage as needed. Modern gear still uses power transformers, of course, but with the new technology, the transformers are now far smaller and less costly than their predecessors, thanks to driving frequencies that are many times that of the 60-Hz ac line. Smaller transformer and higher driving frequency, combined with a a sophisticated switching technique, result in less bulky, lighter-weight, more-efficient and less-expensive equipment.

Much of the credit for the advances in electromagnetics is owed to the development of new magnetic materials, particularly ferrites. A direct result of this progress is the dc-to-dc converter, a circuit that enables a dc source of one voltage to be changed or converted to another lower or higher voltage. Small size, high efficiency and low cost have made these a valuable part of any designer's "toolbox." In this article, our focus is on the theory, design and fabrication of dc-to-dc converters. Emphasis here is on practicality and on hands-on experimenting.

Ferrite Pot Cores

As shown in Fig. 1, the dc-to-dc converter is a very simple circuit that contains relatively few components. The heart of the converter circuit is power transformer *T1*, which provides the required step-up (or step-down) of the supply voltage. A benefit of a transformer-operated circuit like this is the isolation it provides between the input and output circuits, which is a very valuable asset, for example, when using the ac line as the source of power. The transformer in this type of circuit is usually made using ferrite magnetic material.

Ferrites are dense, homogenous ceramic materials that typically contain iron oxide and such other metals as manganese, zinc, nickel or magnesium. They are processed by compressing and firing at temperatures of 2,000 degrees F into various shapes to produce a hard, brittle, magnetic

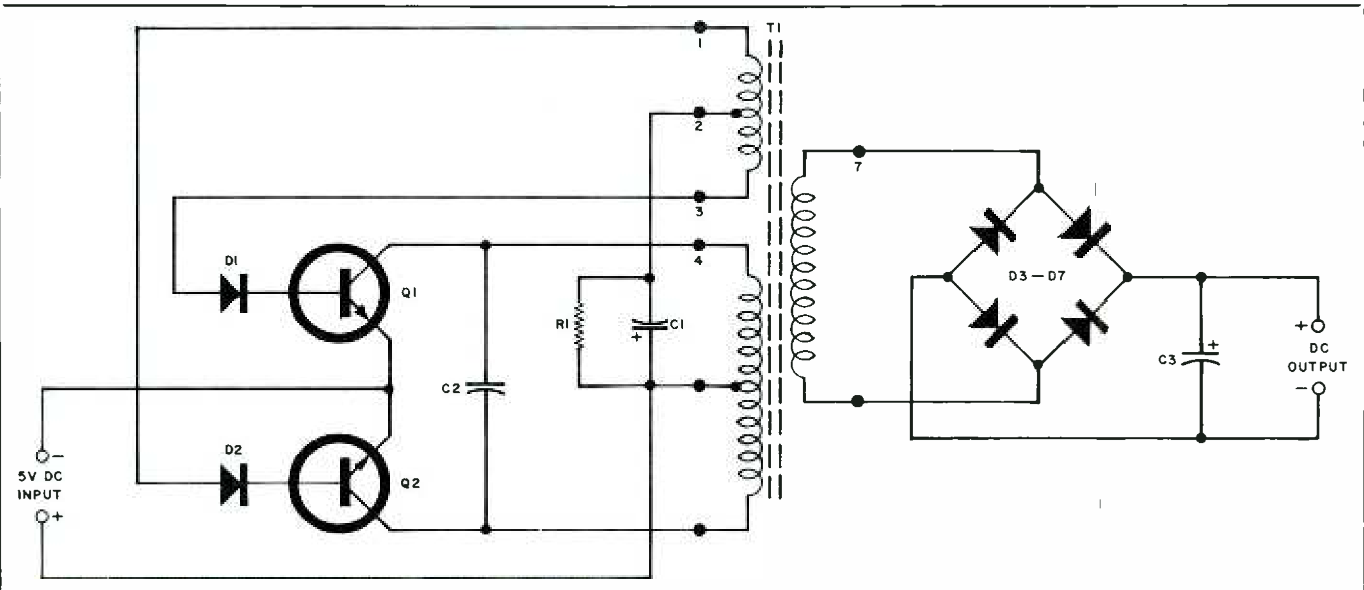


Fig. 1. Schematic diagram of a typical dc-to-dc converter circuit.

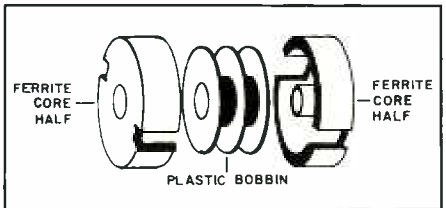


Fig. 2. A ferrite pot core is composed of two precision-machined ferrite halves and a plastic bobbin on which the turns of an inductor or transformer are wound.

material that can be machined to the desired dimensions and finish.

Ferrite as a magnetic material has some very real benefits when compared to the iron-based materials more commonly used. Ferrites exhibit high electrical resistivity and significantly lower eddy-current losses. They can be used at frequencies ranging from less than 5 kHz to beyond 50 MHz. Furthermore, ferrites provide high permeability and high Q, and they are very cost competitive with other magnetic materials. The ability to manufacture ferrite materials into almost any shape or configuration offers unmatched flexibility to the circuit designer.

Ferrite magnetic materials are available in many shapes including various configurations of pot cores, laminations that resemble those used in conventional iron-core transformers, and toroids. Because the simple pot core is one of the easiest types of ferrite forms to wind and assemble, this particular configuration is the one recommended in this article for making power transformers for dc-to-dc converter circuits. Even so, the design information presented here can also be used for other types of magnetic cores as well.

A pot core is depicted in the Fig. 2 drawing. It is simply a cylindrical assembly composed of two identical halves. It is designed so that a plastic bobbin can be installed between the halves. When the pot-core halves are meshed together, the assembly becomes a self-shielding, closed-loop magnetic component.

An inductor can be fabricated by winding a continuous series of turns on the plastic bobbin. To fabricate a transformer, you simply wind two or more inductors on the bobbin.

Pot cores are specified by nominal size in millimeters (mm), which is usually part of the catalog number of the product. For example, a core with a diameter of 22 mm and an assembled height of 13 mm will usually be identified by the number 2213. Cores as small as 5 mm in diameter and 5 mm in height are commonly available, as are many other sizes up to 42 millimeters or more in diameter.

Theory of Operation

To properly design the transformer for use in a dc-to-dc converter, you must first understand how such a circuit works. We will use the Fig. 1 schematic for this explanation. This circuit is simply a push-pull oscillator that uses a transformer that has a feedback winding at terminals 1, 2 and 3; a primary winding at terminals 4, 5 and 6; and a secondary or output winding at terminals 7 and 8.

When power is first applied to the circuit, both transistors forward-biased through *R1*. This causes collector current to flow in *Q1* and *Q2*. However, since the two halves of the circuit do not perform identically, the increased current in one transistor will be greater than the other. This difference in current in the primary winding of *T1* is reflected as an induced voltage in the feedback winding, which causes the current flow in one transistor to increase rapidly to saturation and diminishes the current flowing through the other transistor, with the result that the latter transistor is biased into cutoff.

When the current in the conducting transistor has reached its saturation level and can increase no further, the magnetic field in *T1* ceases to change. The voltage induced in the feedback winding now suddenly reverses, causing current to flow in the initially cutoff transistor. This current increase, which is in the opposite phase as the previous current, induces a voltage in the feedback winding, which cuts off the current in the initially conducting transistor. This cycle of events repeats at a very rapid rate, which might be 5 kHz or 10 kHz.

Diodes *D1* and *D2* in series with the bases of *Q1* and *Q2*, respectively, prevent reverse polarity voltages from the feedback winding from being applied to the transistors. This is a safety measure that ensures that the reverse emitter-to-base voltage of the transistors does not exceed safe limits.

In operation, each transistor in the circuit acts as a switch that causes the voltage from the power source to be alternately impressed on each half of the primary winding of *T1*. The result is that a square wave with a peak-to-peak potential that is equal to four times the supply voltage (measured from collector to collector) provides excitation to the primary winding of the transformer.

A third winding of *T1* provides step-up or step-down action. The shape of the output waveform at this winding is also a square wave,which is fed to the conventional full-wave bridge-rectifier circuit made up of *D3* through *D6* to provide the desired pulsating-dc output voltage. Finally, filter capacitor *C3* smoothes the pulsating dc from the bridge circuit to provide pure dc.

A great advantage of the Fig. 1 circuit is that the value of filter capacitor *C3* can be many times smaller than is required by a conventional power supply driven from a 60-Hz source. This is because higher frequencies are more readily smoothed with smaller values of filtering capacitance. A smaller-value capacitance results in a physically smaller capacitor. Thus, size, weight and cost are all reduced.

It is important to note that in a circuit of the configuration shown in

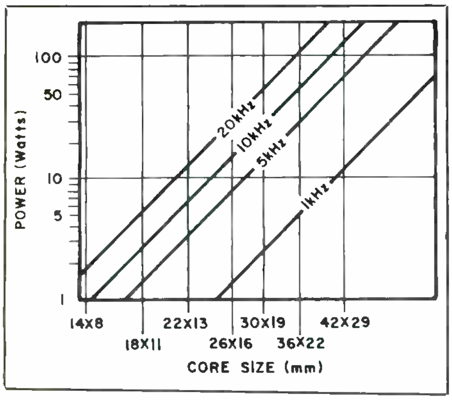


Fig. 3. Pot-core-selection nomograph.

Fig. 1, using an ungapped core, full-wave rectification of the output waveform should always be used. This is because the net value of dc current in the windings of the transformer must be zero, to prevent saturation of the core due to direct current. Half-wave rectification would not satisfy this requirement and, thus, should not be used.

Transformer Design Considerations

Although the dc-to-dc converter circuit operates with square waves, the transformer design technique is very much similar to that used for sine-wave excitation. It is important that the following be fully understood if you expect to design and make a useful transformer.

Ferrite products manufactured today are available in many different compositions. Selection of the best type of material depends on such factors as operating frequency, core loss, operating temperature and permeability. For the Fig. 1 dc-to-dc converter transformer design, the Type G ferrite material supplied by Magnetics provides very low core loss and high saturation flux density properties, both of which are beneficial to the final result.

• *Selecting a Core.* As would be expected, the size of the core is a function of the amount of power that can be safely handled by the transformer. To calculate power, you must know the dc output voltage and load current. Taking into consideration the efficiency of the circuit, input power can then be calculated. Because it is difficult to accurately predict the efficiency of the final circuit design, an approximation is used. As a conservative estimate, assume a 70-percent efficiency. Transformer power input is then calculated as $P = (E \times I)/0.7$, where P is input power, E is output dc voltage and I is output dc current.

Manufacturers of magnetic cores supply charts or graphs that make it possible to select a suitable core in accordance with the power requirements of the design. A graph that illustrates the power handling capacity of pot cores as a function of operating frequency and core size under typical operating conditions is shown in Fig. 3.

Using Fig. 3, the appropriate core for a given application is selected by locating the point where the input power level of the converter and the oscillation frequency meet. Following this point down to the horizontal axis, the core size is determined. Bear in mind that a larger core size than recommended can be used, but not a smaller one. In some cases, you may want to reduce the turns required for your inductor or transformer or provide sufficient winding space for one that requires many turns.

• *Selecting Wire Size.* For many applications, the choice of wire size for the windings will be determined by physical considerations and not by the actual primary or secondary transformer current. (Very fine wire is difficult to handle.) However, it is important that a tabulation like that shown in Table 1 be consulted to verify that the minimum wire size requirement is met. The current-carrying capacity indicated in Table 1 is based on the acceptable standard of 500 circular mils/ampere of current.

It is important to note that the design of the circuit is such that only half of the primary winding carries current at any given time. Thus, the current-carrying capacity of the wire selected for the primary winding need be only half the calculated input current of the circuit.

The resistance of the wire selected for the windings should be taken into consideration when selecting wire size. When many turns of fine wire are used, the total resistance of the winding can become an appreciable part of the circuit and will affect the voltage regulation and efficiency of the transformer. Figure 4 is a simplified diagram that illustrates the effect of the winding resistance.

Consider the transformer in Fig. 4 to be a perfect component with zero primary and zero secondary resistance. External resistances R_p and R_s can be considered to be equal to the measured resistance of the windings of the actual transformer.

One can easily see that voltages will be dropped across both resistances (E_p and E_s), in accordance with Ohm's law, when the transformer is delivering current. Thus, the voltage seen by the primary of the transformer is equal to the power source voltage minus E_p. Similarly, the voltage seen by the load is equal

Table 1
Wire Current Capacity & Resistance

Wire Size (AWG)	Capacity (mA)	Resistance (Ohms/ft.)
18	3,250	0.006
20	2,050	0.010
22	1,280	0.016
24	808	0.026
26	506	0.041
28	318	0.065
30	200	0.104
32	128	0.162
34	79	0.261
36	50	0.415
38	32	0.648
40	19	1.080
42	13	1.660

to the transformer secondary induced voltage minus (E_s).

When designing transformers that have appreciable winding resistances, these voltage drops must be taken into consideration. Should an initial transformer design exhibit winding resistance that would result in excessive voltage drop, the design should be repeated using larger-size wire. In some cases, this may necessitate use of a larger core.

• *Core Geometry.* After a pot core has been tentatively selected for the transformer design and the total number of turns has been calculated, Fig. 5 can be consulted to determine the capacity of the bobbin (in number of turns of wire) for various wire sizes. This graph helps in selecting the wire size to be used, as long as you remember that the minimum wire-size restriction shown in Fig. 4 is taken into account. Bobbin winding area, tabulated in square inches, is found in Table 2.

Figure 5 is based on just one winding on the bobbin. Since the transformer will contain three windings, the insulating tape that is to be placed between each winding will reduce the total number of possible turns you can wind on the bobbin; so take this into consideration as well when selecting core and wire sizes.

• *Calculating Turns.* The number of turns of wire you must wind on the bobbin is determined by such factors as operating frequency in Hz; effective magnetic area of the core in square centimeters; potential impressed on the primary winding in volts; and flux density in Gauss.

To simplify the procedure for determining the required number of turns, some assumptions must be made. These are flux density and operating frequency. Since neither of these parameters need be precise, the assumed values will work very nicely in the design of the transformer.

Operating frequency is assumed to be 10 kHz. Since the actual operating frequency of the final design is a function of the inductance of the primary winding and the load, it may be more or less than 10 kHz. If the actual frequency is too far out of the desired range, the number of primary turns can be increased to reduce frequency or decreased to raise frequency. If the number of turns is reduced, the flux density of the core should be recalculated, using the expression below for N_p, to verify that it does not exceed 4,000 Gauss.

Since you are dealing with square-wave operation in your dc-to-dc converter, there is no need to preserve linearity of the transformer. This being the case, the desired flux density can be selected over a fairly wide range. A large flux density permits fewer turns on the winding. Of course, the trade-off is that as flux density increases, so do core losses, and excessive core loss can result in overheating of the transformer core.

For the Type G magnetic material used in this design, the saturation flux density specified by Magnetics is 4,000 Gauss. For a dc-to-dc converter transformer design, you can assume an operating flux density of half that value, or 2,000 Gauss.

Effective magnetic area is determined by the physical size and design of the pot core and is specified in square centimeters. Use Table 2 to determine the effective magnetic area for various pot-core standard sizes. The Winding Area listed in the Table is specified in square inches and will be used later when determining the capacity of the core in terms of number of turns of wire.

The formula to use to calculate the number of turns is: $N_p = [(25 \times 10^6)(E)]/[(A)(B)(F)]$, where N_p is the number of turns of one section of the primary, *E* is dc supply voltage, *A* is effective magnetic area in square centimeters, *B* is flux density in Gauss and *F* is frequency in Hz. Only half the primary winding is considered in this equation because each half is subjected to the total power source voltage, as previously discussed.

Once the number of turns of the primary (N_p) is known, the number of turns for the secondary winding (N_s) can be easily calculated by the simple relationship: $N_s = [(N_p)(\text{output voltage})]/(\text{input voltage})$

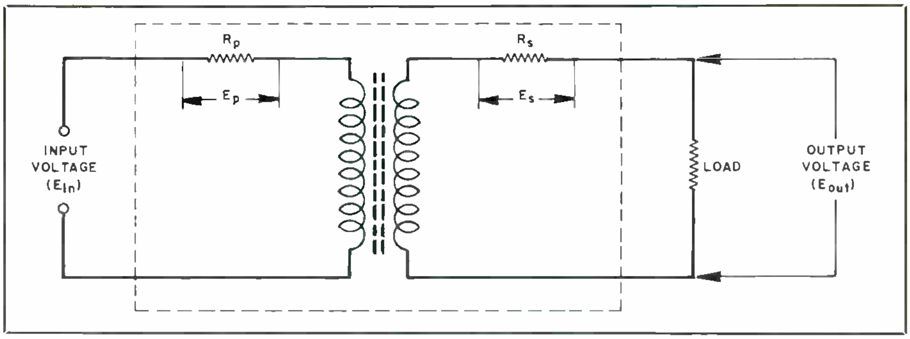


Fig. 4. Detail illustrates primary and secondary winding resistance of transformer with its IR voltage losses (E_p *and* E_s).

**Table 2
Core Magnetic & Winding Areas**

Core (mm)	Magnetic Area (sq. cm)	Winding Area (sq. in.)
7 × 4	0.041	0.0038
9 × 5	0.11	0.0047
11 × 7	0.16	0.0079
14 × 8	0.25	0.0153
18 × 11	0.43	0.0265
22 × 13	0.63	0.0453
26 × 16	0.94	0.0653
30 × 19	1.36	0.0840
36 × 22	2.01	0.1170
42 × 29	2.66	0.2150

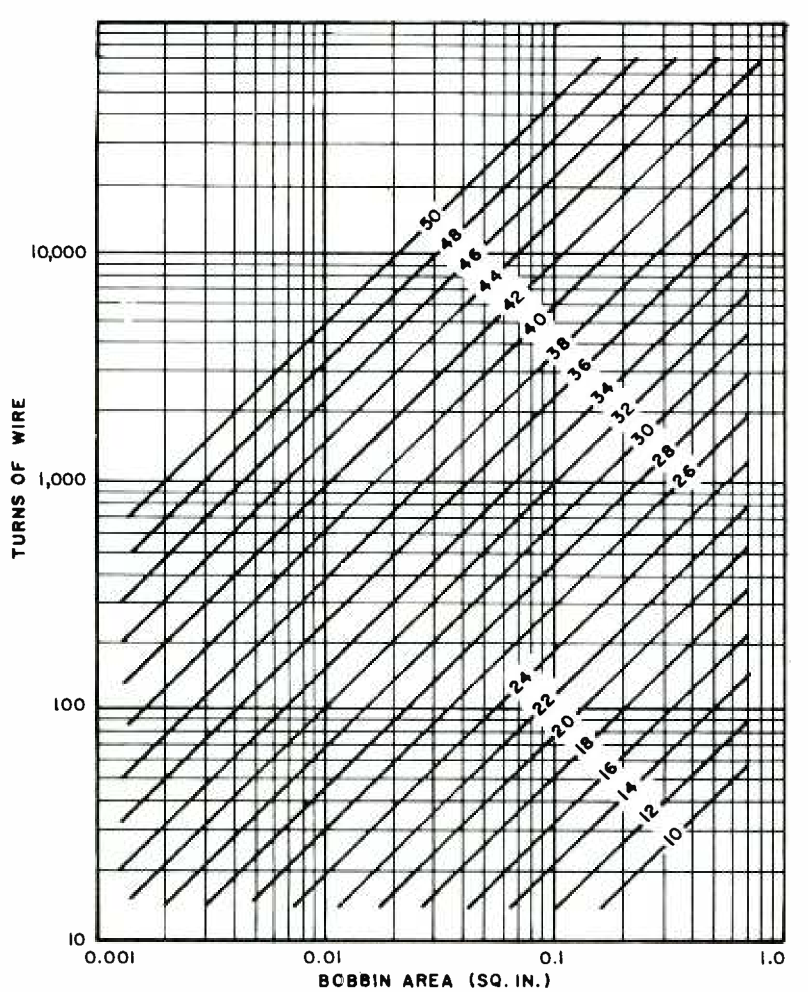


Fig. 5. Bobbin capacity in number of turns and various wire sizes nomograph.

This expression simply reflects the step-up or step-down voltage ratio of the transformer. For circuits that operate at low output voltages, the diode drop of the bridge rectifiers (1.4 volts for a full-wave bridge) must be considered when calculating transformer turns ratio, necessitating a greater number of secondary turns.

The feedback winding of the transformer must provide sufficient positive feedback to the transistor oscillator circuit to sustain oscillation. Since the base circuit of each transistor can be forward-biased with a source potential of about 1.4 volts, the number of turns for this winding will be relatively few. For most designs, a 10-turn center-tapped feedback winding will work very well. Wire size for this winding is not critical; and can be any convenient size.

• *Winding the Primary.* The dc-to-dc converter transformer operates with square waveforms that have fairly rapid rise and fall times. When current in an inductive winding is suddenly cut off, the circuit will "ring," causing relatively large voltage spikes to appear at the collectors of the transistors. This condition can be further aggravated in poorly constructed transformers that do not have tight magnetic coupling between the two halves of the primary.

In the design example we will step through later, a "bifilar" winding technique is used for the primary. This type of winding produces a transformer primary with the tightest possible coupling and minimizes the amplitude of the ringing voltage.

• *Circuit Constants.* The value of *R1* in the circuit must be calculated for each converter design, since its value is determined by the voltage of the power source and full-load transistor collector current. The purpose of *R1* is to forward-bias the transistors to ensure proper startup of the circuit when power is first applied. Too large a value will result in a circuit that will not start under load, while too small a value will result in excessive input current to the circuit and lower conversion efficiency.

A simple way to arrive at a value for *R1* is to assume a required base current of about 10 percent of the input current to the circuit and then using Ohm's law to calculate the required value. Include in the calculation the 0.7-volt emitter-to-base drop, especially in circuits driven by very low voltages. For example, if the input current is 100 milliamperes and the power source is 12 volts, *R1* = (12 volts − 0.7 volt)/0.01 ampere = 1,130 ohms.

Be sure to calculate the required power in watts for *R1*. Circuits driven by high input voltages require ½-watt or greater power ratings for the resistor. Choice of npn power transistors for the circuit is not complicated. Collector breakdown voltage should be at least four times the supply voltage because the circuit can generate very large voltage spikes at the collectors. A small value capacitor, *C2*, wired across the primary winding of the transformer as shown can sometimes tame voltage spikes and help protect the transistors from damage due to large voltage transients.

The collector current rating of the transistors is determined by the input current of the circuit, which is easily calculated once you know the input power and voltage. Use transistors

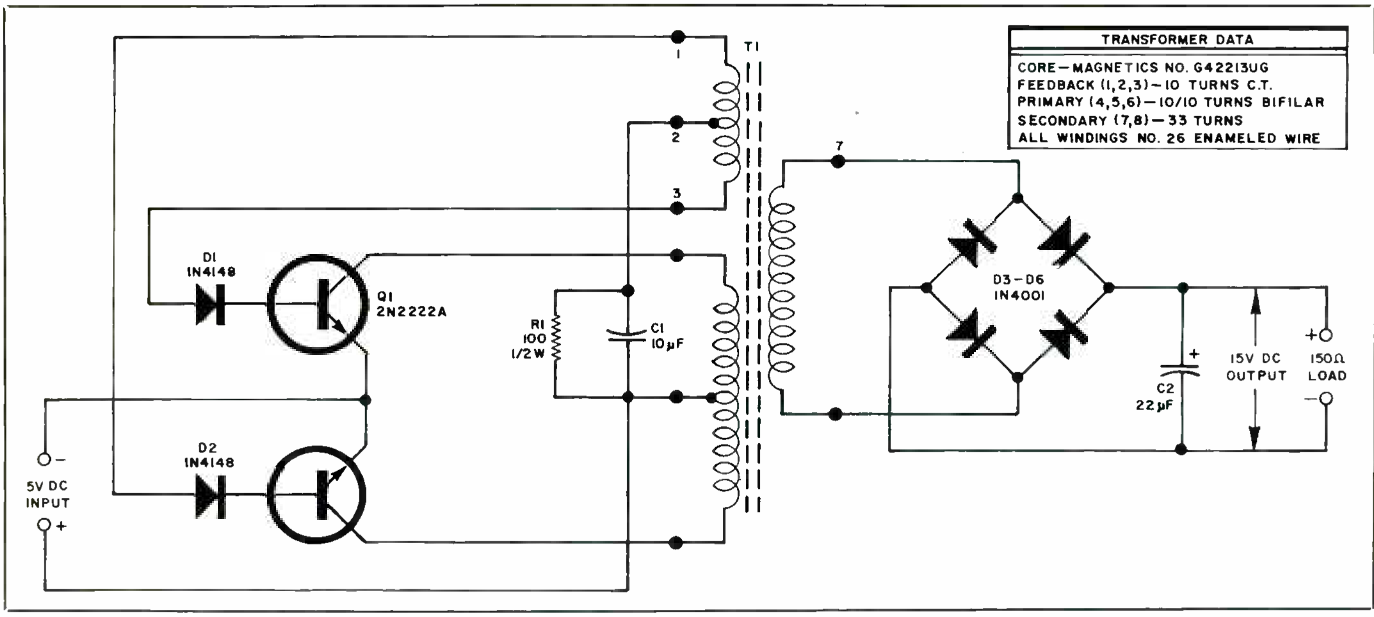


Fig. 6. A practical design example of a dc-to-dc converter circuit that can be used for experimental purposes or incorporated into an actual project.

that have a continuous collector current rating of at least twice the expected input current.

Designing the Circuit

You now have sufficient information to design your own dc-to-dc converter circuit. Let us do so now, using the practical design example shown in Fig. 6. The circuit to be discussed is a dc-to-dc converter powered by a 5 volt source to produce a 15-volt dc output. This is a common application for digital logic systems that operate with a power source of 5 volts dc that also include analog circuitry that requires a higher voltage.

For our design example, assume the output of the dc-to-dc converter is 15 volts dc and delivers a load current of 100 milliamperes into a 150-ohm load. The design sequence would be as follows:

(1) Calculate the input power of the circuit assuming 70-percent efficiency: $P = (15)(0.1)/0.7$ which calculates out to 2.14 watts

(2) Select a pot core size from Fig. 3 at a 10-kHz operating frequency: from the data given, a 22 × 13-mm core is suitable, but an 18 × 11-mm could also be selected.

(3) Calculate the number of turns for each half of the primary winding of the transformer, using 2,000-Gauss flux density and an effective core area of 0.63 sq. cm for the 22 × 13-mm core: $N_p = (25 \times 10^6)(5)/(0.63)(2{,}000)(10{,}000) = 9.9$ turns. Thus, each half of the primary will have 10 turns.

(4) Calculate the number of secondary turns for a 15-volt output, taking into consideration a 1.4-volt loss for the bridge rectifier diodes: $N_s = (15 \text{ volts} + 1.4 \text{ volts})(10 \text{ turns})/(5 \text{ volts}) = 32.8$ turns, which rounded out becomes 33 turns.

(5) Select primary wire size by calculating the input current and referring to Table 1: Input current = 2.14 watts/5 volts = 428 mA. Each half of the primary will carry 428/2 or 214 mA average current, which means that No. 28 wire can be used.

(6) Select secondary wire size for a load current of 100 mA, which means that No. 32 wire can be used.

(7) Check Table 2 to determine if the calculated number of turns (63 total) will fit on the bobbin with space to spare for the insulating layer between windings. Since Table 2 indicates that up to 200 turns of No. 28 wire will fit, the bobbin has sufficient space for the windings. Additionally, best transformer design is with the bobbin as full as possible. Larger-gauge wire can be used if desired to fill the bobbin and reduce voltage drops in the windings.

(8) Select the transistors, using four times the supply potential, or 20-volt minimum collector-to-emitter breakdown, and 428-mA collector current. The npn 2N2222A silicon transistor meets this criteria.

(9) Calculate the resistance and power dissipation of *R1* using Ohm's law, using 10 percent of the expected input current and allowing for a 0.7-volt base-to-emitter drop: $R1 = (5 \text{ volts} - 0.7 \text{ volt})/0.0428$ ampere = 100.4 ohms, and Power = $(5 \text{ volts} - 0.7 \text{ volt})(0.0428 \text{ ampere}) = 0.18$ watt. For this application a 100-ohm, ½-watt resistor would be used.

(10) When winding the transformer, best construction, is obtained by winding the primary using the bifilar technique to achieve maximum coupling between the primary halves. It is mandatory that the winding procedure be followed exactly to ensure proper phasing of the primary and feedback windings.

Start with the feedback winding that is identified by terminals 1, 2, and 3, using a length of No. 28 magnet wire. Place a tag with the numeral 1 on one end of the wire, allow about 2 inches of lead length, and wind five turns around the bobbin, starting with the labeled end. At the fifth turn, bring the wire out of the bobbin for a length of about 2 inches. Fold the wire back toward the bobbin to form a loop and wind 5 more turns onto the bobbin in the *same* direction as before. Leaving about 2 inches of lead length, cut the wire at the terminal end. Secure the winding with one layer of thin insulating tape (Mylar tape is good). Label the looped center tap with the numeral 2 and the remaining wire with the numeral 3.

Now wind onto the bobbin the bifilar primary. Start with two No. 28 wires of sufficient length to wind 10 turns for each wire. Label the end of one wire with the numeral 4 and the end of the other wire with the numeral 5. Take the pair of wires with the labeled ends together, allow for 2 inches of lead length, and wind 10 turns of this double wire around the bobbin, in the *same* direction used for the feedback winding. Secure this winding to the bobbin with Mylar tape and cut the two unmarked ends, leaving about a 2-inch lead length.

Carefully scrape about ¼ inch of the enameled insulation from the ends of the primary-lead wires (leave the labels in place). Use an ohmmeter or audible continuity checker to locate the unidentified end of the wire connected with the one labeled 4 and label it with the numeral 5. Then label the remaining wire with the numeral 6. Twist together the two wires labeled 5 to identify the center tap.

The phasing of the secondary winding is not important. Hence, you do not have to concern yourself with the direction used to wind it onto the bobbin. Simply wind 33 turns of No. 32 wire onto the bobbin, again allowing about 2 inches of lead length. Secure this final winding with Mylar tape and mark its leads with the numerals 7 and 8.

Now inspect the shiny surfaces of the two halves of the ferrite pot core to ascertain that it is free of dirt and foreign particles that would interfere with the mating of the pieces. Place the bobbin between the two cores like a sandwich, and carefully secure the two halves of the transformer together with tape.

Use a small machine screw with a fiber washer between screw head and core and nut and core and nut to hold together the core. Do not over-tighten the screw; too much pressure will crack the ferrite and render it useless.

You can now install the transformer in the circuit for which it was designed to check out operation. Should the output voltage of the transformer under load conditions prove to be greater or less than desired, you can reduce or increase the number of turns on the secondary as needed to bring the voltage in line with the needs of the circuit.

Once you wire the circuit shown in Fig. 6, using your newly made transformer, you should obtain the results given in Table 3.

From the foregoing, it should be obvious that designing with and using dc-to-dc converters in power-supply designs is both practical and easy to do. By implementing such circuits in many applications, you reap all the benefits these systems have to offer and will be employing the most modern approach to power-supply design.

Table 3. Operating Parameters for Design Example

Input	Output
5.0 volts	14.1 volts
390 mA	94 mA (150-ohm load)
1.9 watts	1.3 watts
Efficiency	68 percent
Operating frequency	6,450 Hz

Three sets (minimum order) of size 2213 pot-core/bobbin assemblies are available for $25 from: A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463. Add $2.50 to cover postage and handling. New Jersey residents, add state sales tax.

Analog Arithmetic

By Forrest M. Mims, III

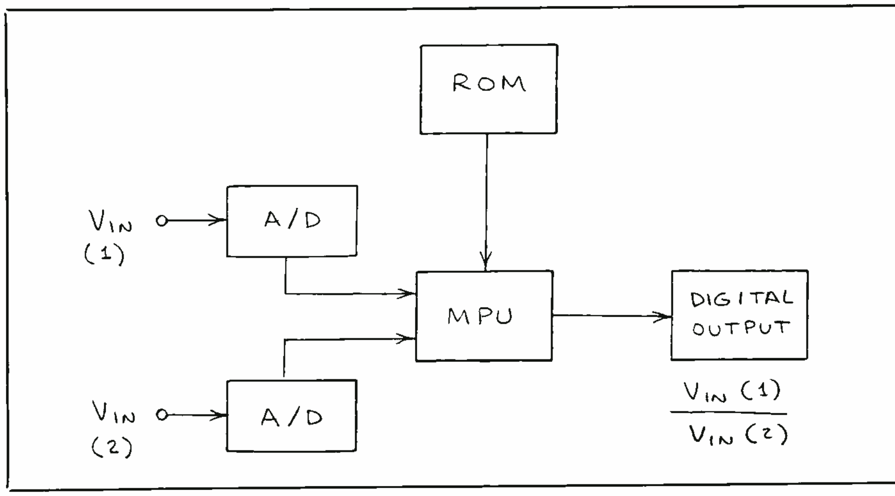


Fig. 1. How to divide two voltages with a microprocessor.

Thanks to digital calculators and computers, manipulating numbers has become exceedingly easy to do. Even though these operations are most often accomplished by means of digital circuits, there is still a very important role for analog circuits that process numbers.

Consider division. It's easy to divide one number by another with the help of a calculator or computer. But how do you divide one voltage by another? And why would you even want to perform this operation in the first place?

The quotient of one quantity divided by another is the same as the ratio of the two quantities. There are many applications in which it is very important to know the ratio of two values. For example, in the chemical industry, ratiometric calculators are used to control the ratio of chemicals being transported to a mixing chamber. The same technique can be used to control the ratio of ingredients in the production of everything from dog food and cake mix to cement and paint. Ratio calculation can also be used to determine differences in the signals from transducers that measure strain, force, acceleration, efficiency, distortion, light level and so forth.

One of my principal interests in ratiometric measurements is comparison of the intensities of two adjacent wavelengths of sunlight. Various gases in the atmosphere selectively absorb different wavelengths of visible light and ultraviolet and infrared radiation. By measuring the ratio of the intensity of the radiation at one of these absorption bands and a nearby non-absorbing or reference band, it is possible to determine the quantity of the absorbing gas in a column through the atmosphere.

Another use for the ratiometric measurement technique is remote determination of temperature. This method relies on the fact that everything in the universe emits a broad band of infrared radiation. The peak wavelength of this radiation and the slope of its curve are determined by the temperature of the emitter. Therefore, by monitoring the intensity of the infrared radiation at two different wavelengths, it is possible to determine the slope of the curve and temperature of the object being detected.

Digital vs. Analog Arithmetic

If an electronics engineer with a digital background is asked to design a circuit to divide two voltages, chances are the block diagram of the resulting circuit would resemble the one shown in Fig. 1. Here each voltage is first converted into its digital equivalent by means of an analog-to-digital (A/D) converter. The two digital numbers are then presented to a microprocessor that has been programmed to divide one number by the other. Finally, the quotient is converted back into its analog equivalent with a digital-to-analog (D/A) converter.

There is a simpler way to accomplish this task. Indeed, all analog and digital functions and operations described above can be replaced by a single integrated circuit known as an analog divider. A digital designer might point out that

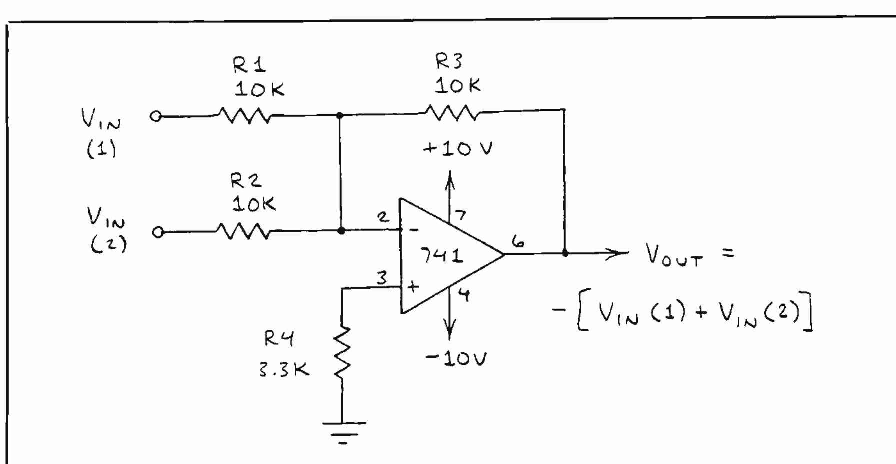


Fig. 2. Example of an operational-amplifier summing (adding) circuit.

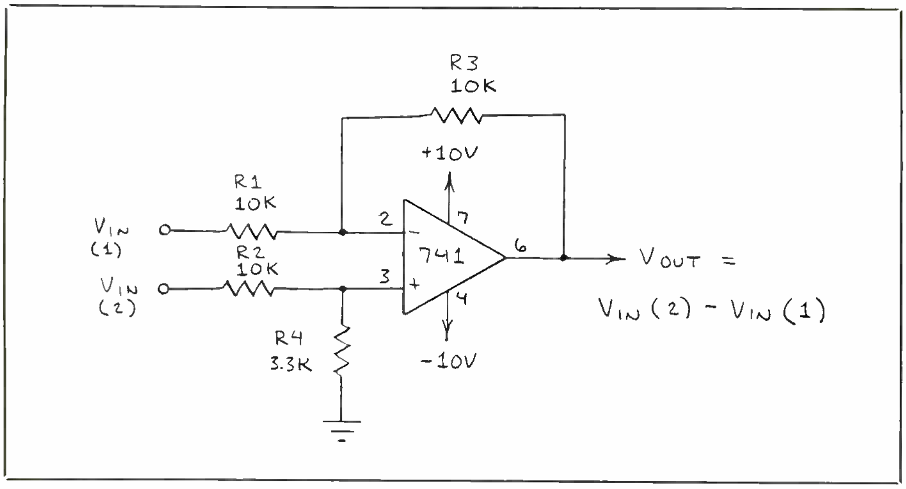


Fig. 3. Example of an operational-amplifier differencing (subtracting) circuit.

the digital circuit provides a considerably more accurate quotient when it divides two numbers. True, but in this case the numbers come from a pair of A/D conversion circuits. Therefore, overall accuracy of both circuits is controlled by analog circuitry.

Shortly we'll experiment with the DIV100, a sophisticated analog divider chip. First, however, let's look at the basic principles of analog arithmetic.

Using Op Amps To Add and Subtract

The schematic of a simple circuit that adds two voltages is shown in Fig. 2. This circuit, commonly called a summer or adder, is often used to mix two or more signals. When the resistance of the feedback resistor matches that of input resistors *R1* and *R2*, the voltage gain of the circuit is unity. Increasing the resistance of feedback resistor R_f causes the circuit to both add and multiply.

The schematic of a simple circuit that subtracts the voltage at Input 2 from the voltage at Input 1 is shown in Fig. 3. This circuit is commonly known as a difference amplifier or subtracter. As in the Fig. 2 circuit, if the resistance of the feedback resistor matches that of the input resistors, the circuit has unity gain.

Besides performing addition and subtraction, simple operational-amplifier circuits can convert a voltage into its logarithm. As we'll see shortly, these basic circuit functions provide the essential ingredients required for analog multiplication and division.

The logarithm of a number is the exponent of the number when it is expressed as a power of the base 10. For instance, 10,000 is 10^5, or 10 raised to the fifth

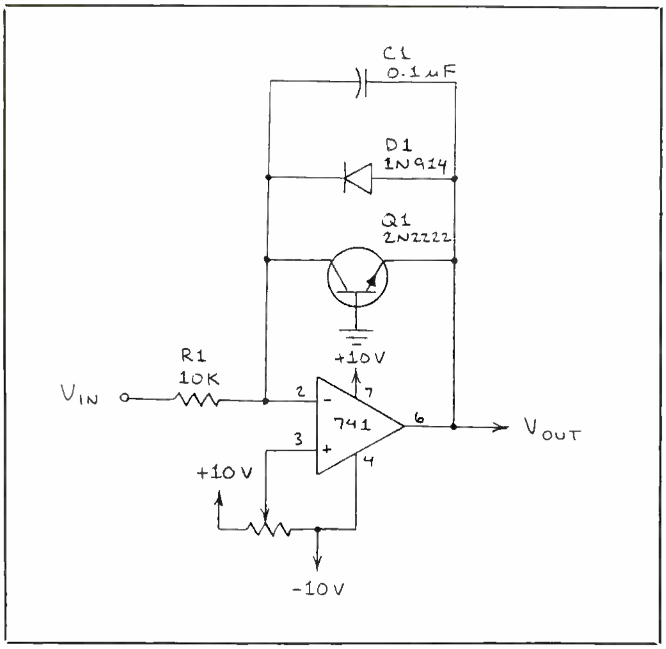


Fig. 4. Schematic of a simple logarithmic amplifier.

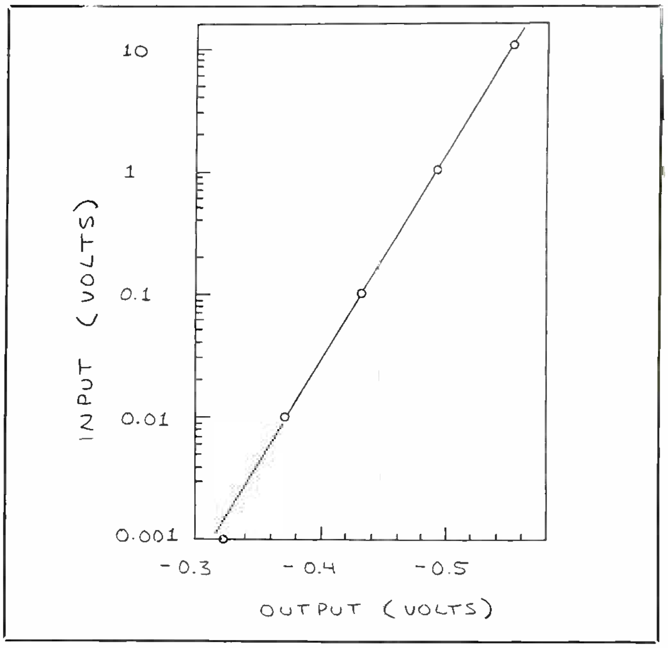


Fig. 5. Plotted operation of log amplifier circuit shown in Fig. 4.

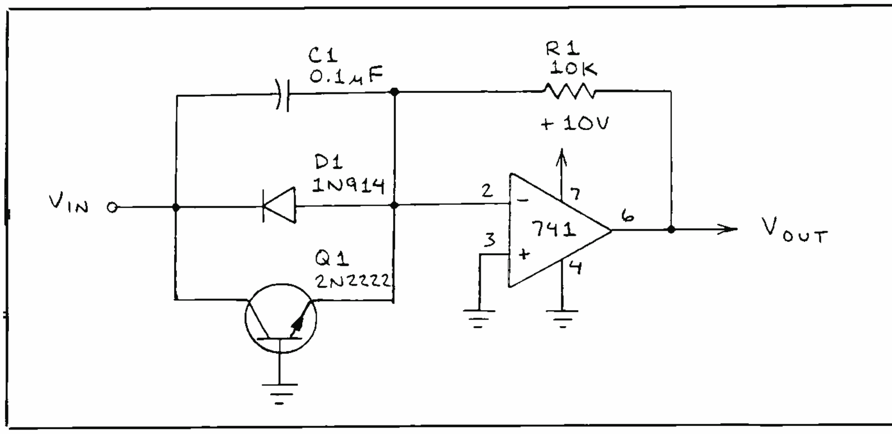


Fig. 6. Schematic of a simple antilogarithmic amplifier.

power. Therefore, the logarithm of 10,000 is 5, and 437 is $10^{2.8669}$, which yields a log of 2.8669.

Two analog voltages can be multiplied or divided if they are first converted into their respective logarithms. Multiplication is accomplished by using a summing amplifier to add the logarithms of the two numbers. The antilog of the sum is the product of the two voltages. Division is accomplished by using a difference amplifier to subtract the log of the divisor from the log of the dividend. The antilog of the difference is the quotient of the two voltages.

Inserting a non-linear element, such as a diode or transistor, into the feedback of an op amp transforms the circuit from a linear to a logarithmic amplifier. Figure 4 shows one commonly implemented version of the basic op-amp logarithmic amplifier. A breadboard version of this circuit gave the following outputs for a range of input voltages:

Input (volts)	Output (volts)
0.001	−0.322
0.010	−0.371
0.100	−0.432
1.000	−0.494
10.000	−0.557

The output voltage is inverted (negative) because the op amp is connected in its inverting mode. Polarity can be ignored or changed to positive by adding an inverting buffer stage.

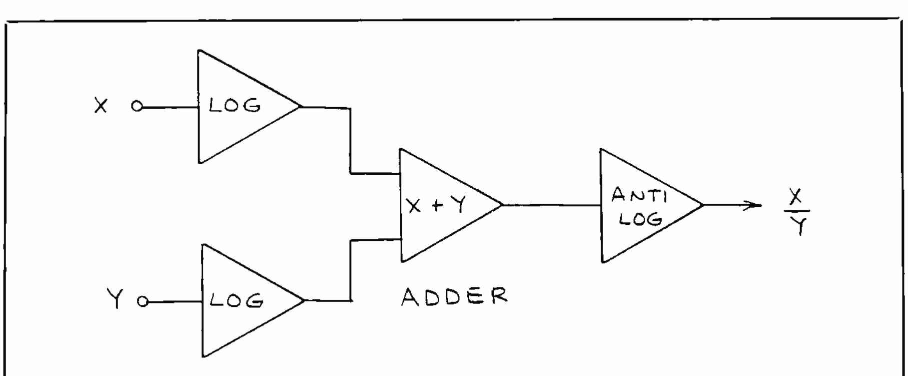


Fig. 7. Diagram of function blocks of a logarithmic multiplier.

Figure 5 is a plot on a semi-log graph of the values listed above. Since the graph is a straight line, the log amplifier prototype is reasonably accurate, at least for the range of values over which I tested it.

The output of this log amplifier is not exactly the log of the input voltage. Instead, the output is approximately −0.06 log V_{in} + K, where K is a constant. For the circuit I tried, K is 0.495. Different amplifiers will give slightly different values of K. You can compute the exact value with a scientific calculator.

The output from a log amplifier can be transformed back into linear form by means of an antilogarithmic amplifier. Antilog amplifiers can also be used to expand a very narrow range of input voltages into a much wider and, therefore, more easily resolved voltage range.

Shown in Fig. 6 is the schematic for a basic antilog amplifier you can easily assemble. The components are essentially the same as those of the log amplifier in Fig. 4. The chief difference is that the feedback circuit in Fig. 4 has become the input portion of the circuit in Fig. 6.

If the input of an ideal antilog amplifier is connected to the output of an ideal log amplifier, the resulting transfer function is $V_{out} = V_{in}$. In practice, of course, both amplifiers contribute various errors, and the output does not exactly follow the input. In the case of the prototype log and antilog amplifiers I tried, the error was rather substantial, as you can see from the following data:

Input (volts)	Output (volts)
0.001	− 0.001
0.010	− 0.006
0.100	− 0.111
1.000	− 1.205
10.000	− 11.490

As this table quickly reveals, log and antilog amplifiers are subject to serious errors. The most important error source is temperature changes in the 2N2222 transistor that serves as the nonlinear feedback element. Another is the offset voltage of the op amp itself. When the input voltage to the op amp is very small, the offset voltage can cause substantial but predictable errors. Some op amps are equipped with offset adjustment pins that permit the offset voltage to be trimmed to zero when the input is connected to ground.

Still another source of error is the op amp's bias current. 741 op amps, like those I used to assemble the circuits shown in Fig. 4 and Fig. 6 have a bias current that ranges from 80 to 500 nanoamperes. This error can be reduced significantly by means of bias-current potentiometer *R2*. A better way is to use one of the newer high-performance op amps that have very low bias current.

One way to significantly reduce these and other errors is to mount all components of the log amplifier on a common substrate (for temperature control) and use laser trimmed resistors (for high accuracy). Several manufacturers make log amps in just this fashion.

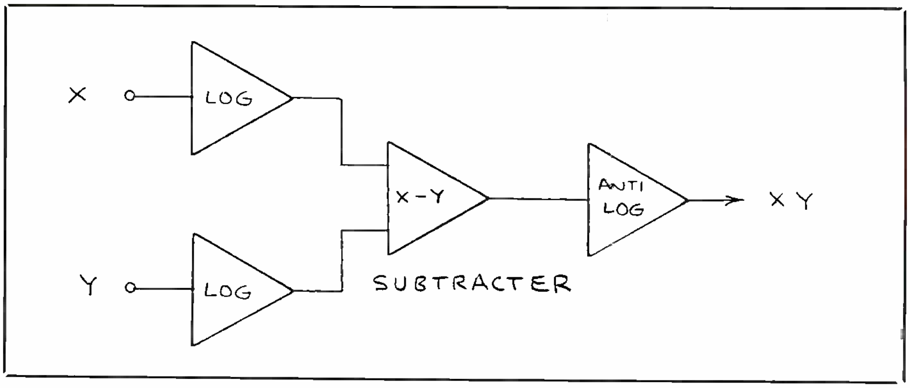


Fig. 8. Diagram of function blocks of a logarithmic divider.

Multipliers & Dividers

As was demonstrated earlier, two numbers or voltages can be multiplied by adding their logs. Figure 7 shows how this can be accomplished electronically. The two voltages are first converted into their respective logarithms. Then the two logs are added by a summing amplifier. Finally, the output of the summing amplifier is converted back to linear form by an antilog amplifier.

Division can be accomplished by subtracting the log of the divisor from the log of the dividend. Figure 8 shows how this is done electronically. The circuit is essentially identical to the multiplier circuit in Fig. 7, except that the summer has been replaced by a difference amplifier.

The AD534 is a hybrid microcircuit that includes 12 laser-trimmed resistors for high accuracy. This remarkable circuit, which has been accurately designated a single-chip analog computer, includes log and antilog amplifiers that can be connected in various ways to multiply, divide, square and extract square roots. Figure 9 shows how the chip is connected to implement each of these functions.

The accuracy of the AD534 is considerably better than that of any logarithmic circuits I have fashioned from separate components. The following table shows the operation of an AD534 connected as a multiplier and square rooter:

X	X^2	AD534	$\sqrt{10X}$	AD534
1	1	0.95	3.16	3.09
2	4	4.08	4.47	4.51
3	9	9.20	5.48	5.52
4	16	16.24	6.32	6.36
5	25	24.40	7.07	7.11
6	36	35.20	7.75	7.72
7	49	48.20	8.37	8.42
8	64	63.20	8.94	8.90
9	81	79.80	9.49	9.50
10	100	98.70	10.00	10.05

Comparing these results with those given earlier, you can see that the AD534 is exceptionally accurate. If you have ever attempted to calibrate a log multiplier using a 10-turn potentiometer, you will be happy to pay the $29.95 that Analog Devices (P.O. Box 9106, Norwood, MA 02062) charges for the hermetically sealed metal-can version of the AD534.

Single chip multipliers can be used to perform division. The DIV100 divider, however, provides superior performance because it is designed specifically to perform division operations. It can also be used to extract square roots.

Shown in Fig. 10 is the schematic of a circuit that uses a DIV100 to determine the ratio of the intensity of two light sources. The first time I assembled this circuit, its accuracy was very poor. I discovered that, for best results, the DIV100 inputs should be connected to sources with a very low output resistance. This requirement was met by inserting a pair of unity gain op-amp buffers between the op amps for the two detectors and the DIV100 inputs. If you use a quad op amp, these two buffers will already be available without having to add an additional chip.

You can power the DIV100 from any source that delivers ±12 to ±20 volts. For best accuracy, however, power-supply potential should be at or very near a regulated ±15 volts. Moreover, each side of the power supply should be bypassed by connecting 10-microfarad and 1,000-picofarad capacitors from the + and − supply points and circuit ground. (This may not be necessary if you use very short leads between the power supply and the circuit.)

Figure 10 is the schematic of a circuit that provides a ratiometric measurement of the relative light falling on two photodetectors. The DIV100 can also be used to compute the percentage difference between a reference voltage and an unknown voltage. It can be also used in various kinds of automatic-gain-control and voltage-controlled filter applications. See the DIV100 data sheet for additional information.

The DIV100 is made by Burr-Brown Corp. (P.O. Box 11400, Tucson, AZ 85734). Single-quantity price is $36.60.

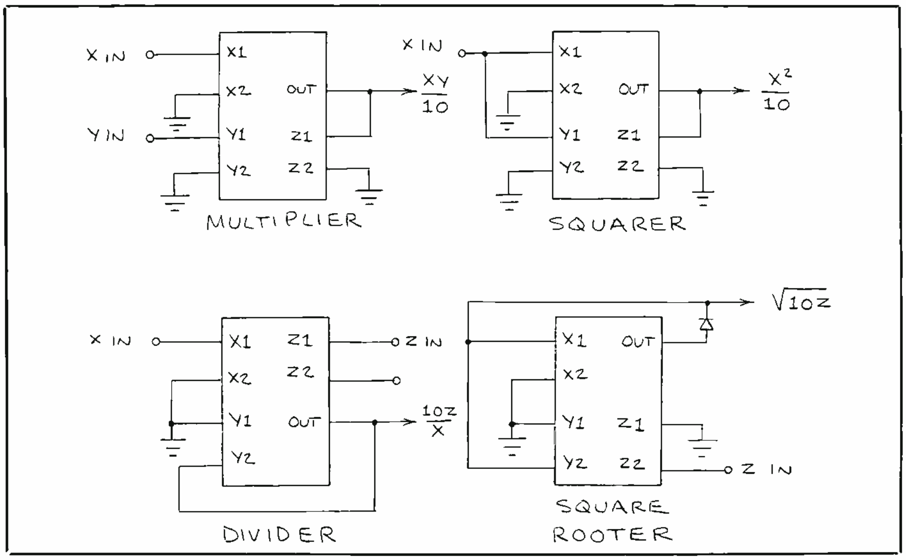


Fig. 9. Details of how arithmetic operations are performed by configuring an AD534 multiplier chip in different ways.

Higher-accuracy versions are available at greater price. Burr-Brown has a $75 minimum-purchase requirement. Therefore, try to find a Burr-Brown representative that is willing to accept single-unit orders. Alternatively, you may want to purchase three or more chips from the ample Burr-Brown catalog of analog ICs.

Going Further

While digital computational circuits provide much greater accuracy than analog circuits, analog computational circuits sometimes provide a much simpler way to solve a problem when absolute accuracy is not required. In any event, even digital circuits are only as accurate as the A/D converters that supply their inputs.

If you would like to learn more about analog computational circuits, one of the classic references in the field is *Nonlinear Circuits Handbook*. This 540-page book describes multiplication, division, squaring, rooting, log and antilog circuits, rms-to-dc conversion, and much more. Though first published in 1976, the basic principles it describes have not changed. *Nonlinear Circuits Handbook* is available for $5.95 from Analog Devices. With the knowledge you gain from this book and a handful of precision multiplier and divider chips, you can design a very sophisticated analog computer that can perform wonderfully complicated calculations in real time. **ME**

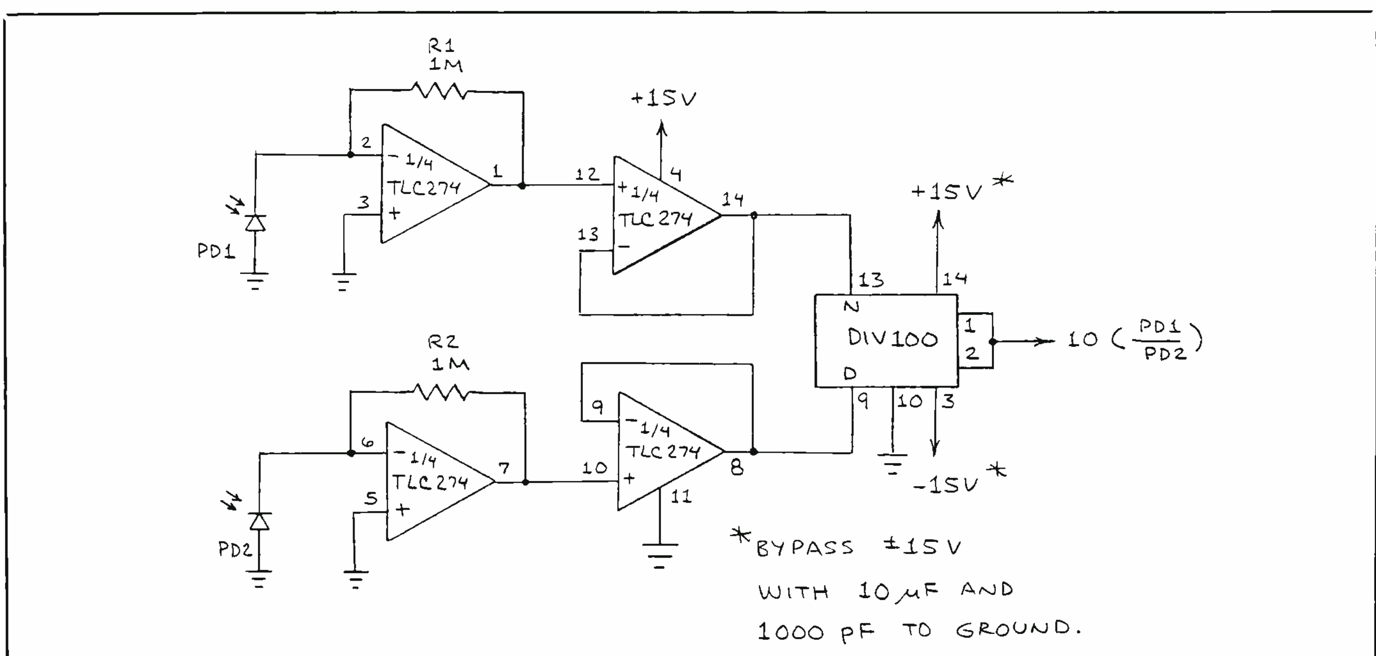


Fig. 10. This ratiometric light-detector circuit is built around a DIV100 divider chip.

Error Detection & Correction, Lithium "Kickstarter," and Improved PROM and SPROM Chips

By Joseph Desposito

In this month's column, we highlight three new error-correction-and-detection chips for high-performance memory systems. Following that is a tutorial on parity-checking versus Hamming code error detection and correction. We then cover a lithium "kickstarter" chip for personal computers. Finally, we examine two upgraded PROMs.

32-Bit Flow-Thru EDC

Integrated Device Technology (3236 Scott Blvd., P.O. Box 58015, Santa Clara, CA 95052) has introduced a 32-bit flow-through error-detection-and-correction (EDC) unit, the IDT49C465, that achieves fast speeds by using a flow-through two-bus architecture. The two-bus architecture eliminates several external memory drivers, allowing a simultaneous data error detection and correction process to occur between the processor and memory. Operating at 20-ns error-correct time, the IDT49C465 provides designers with speed and reliability for high-performance memory systems.

The parity-check-and-generate features on the IDT49C465 can be used with any 32-bit RISC high-performance microprocessor to maintain parity on the system bus and eliminate five external components. In addition, sophisticated diagnostics on the component can log up to 16 errors and capture the most recent erroneous data word, giving designers greater flexibility in handling data errors.

As microprocessor speeds reach beyond 25 and 33 MHz, 64-bit-wide memory buses will become increasingly more common. In 64-bit system buses, alternative parity-type error checking requires eight bits to implement. The IDT49C465 also requires eight bits to implement. However, it also allows errors to be corrected, not just flagged.

Using modified Hamming code developed at AT&T Bell Labs, the IDT49C465 can detect all single-bit hard and soft errors and correct them within a single cycle. Double-bit errors can be detected 100 percent of the time, while triple-bit errors can be detected more than 50 percent of the time. The IDT49C465 also features a built-in system data latch (see Fig. 1) for pipelined memory system designs that allow pipelined reads from memory.

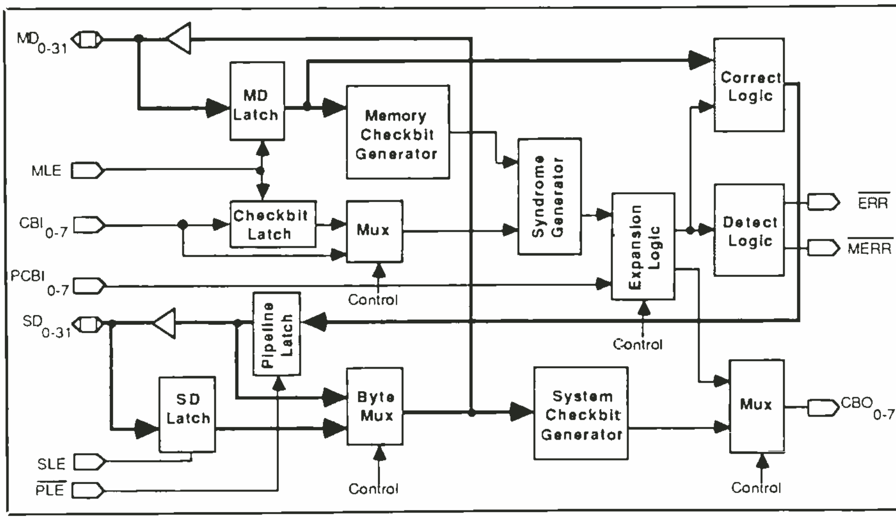


Fig. 1. Integrated Device Technology's IDT49C465 32-bit flow-through error detection and correction chip features a system data latch for pipelined reads from memory.

The IDT49C465 is available in a 144-pin grid array (PGA). In large OEM quantities, the 20-ns (correct time) IDT49C465 sells for $92.40.

Integrated Device Technology also announced speed-up of two other EDC circuits, the IDT49C460 and IDT39C60, which are single-bus units. The IDT49-C460 32-bit EDC has decreased error-correction time from 30 ns to 18 ns, a speed improvement of 40 percent, while the IDT39C60 16-bit EDC has decreased error-correction time to 25 ns, which is 17 percent faster than before.

Again using modified Hamming code, the IDT39C60 and IDT49C460 can detect all single-bit hard and soft errors and correct them within a single cycle. Double-bit errors can be detected more than 50 percent of the time.

In the early 1980s, EDC circuits were found almost exclusively in commercial mainframe and minicomputers and avionics flight computers. With constant price decreases and availability of faster speeds, EDC circuits will be accessible to new markets, such as single-user workstations and personal computers.

Available now at 18 ns (correct time), the IDT49C460 is offered in 68-pin plastic leaded chip carrier (PLCC) packages. In a PLCC package, the 18-ns version of the IDT49C460 sells for $98.50 in 100 and up quantities. The IDT39C60 is offered in 48-pin plastic and ceramic DIP and 52-pin PLCC and LCC packages. The 25-ns (correct time) version sells for $41.25, packaged in a plastic DIP in 100 and up quantities.

Error Correction Vs. Parity Checking

Computer system builders have always faced the decision of how to handle memory data errors. In memory systems, two types of error can occur: "hard" and "soft." A hard error is a permanent error in the hardware that causes the data bit to be stuck-at-one or stuck-at-zero. Soft data errors, on the other hand, are random and unpredictable. Sources of soft data errors are transmission line effects, power surges, pattern-sensitive memory cells and alpha-particle radiation.

As systems operate at clock speeds in excess of 25 MHz, system noise and power surges become increasing concerns to the system designer. Also, as state-of-the-art memory technology gives us submicron features, susceptibility to alpha particles flipping a memory bit is almost certain to increase.

Historically, parity checking has been the preferred method for detecting errors in data, due to its simplicity of implementation. Parity is generated by counting the number of data bits that are high and assigning a parity bit to make the total either an even or odd number of high bits.

There are two parity conventions used: "even" and "odd." Even parity designates a low on the parity output bit if there are already an even number of data bits that are high. If an odd number of data bits are high, then a high is designated on the parity bit. On the other hand, odd parity designates a low on the parity bit if there are already an odd number of data bits that are high. The parity bit is high if there is an even number of data bits high.

Parity has the advantage of detecting errors very quickly—in 12 ns for a chip like the AS280. Implementing parity does not require a large number of external components: a parity checker/generator, like the AS280, and the additional memory used to store the parity bits. Systems generally implement byte parity with a separate parity bit for each eight bits.

There are two significant down sides to parity checking. Firstly, there may be cases when more than one bit gets flipped from high to low or low to high. If two bits get flipped (two-bit error), the sense of the parity remains the same even though the data is in error. So, parity is not a fail-safe error-detection mechanism. Secondly, when a parity error gets flagged, the system must intervene and decide what to do with the erroneous data. Should it ignore the error? Should it try to receive the data again? In either case, a decision must be made by an arbitrator, ultimately slowing down system throughput.

Hamming Code To the Rescue

Developed by Bell Labs in the 1950s, a Hamming code is capable of not only detecting all single-bit errors, but also of correcting those bits to their original sense. In addition, the Hamming code detects all double-bit errors and most triple-bit errors.

The EDC circuits from IDT implement the Hamming code generation and checking for correcting memory errors. During a write to memory cycle, a check bit word is generated for each data word by the EDC circuit. For 16-bit data, six bits are needed for a check bit word. Seven bits are needed for 32-bit data, and eight bits are needed for 64-bit data words.

On a read from memory cycle, the EDC circuit reads both the data word and the check bit word. A new check bit word is then generated and compared (ORed) with the original check bit word.

Syndrome bits generated by the comparison of the two check bit words indicate whether the data is error-free or if there is an error. Additional circuitry on the EDC can determine from the syndrome bits which single bit is in error and correct that data bit. The corrected data then becomes available in the data output. All double-bit errors and most triple-bit errors can be detected with the syndrome bits and an error flag generated.

If a parity error-checking scheme is used, single-bit errors can be flagged, but not corrected. Therefore, the error must be handled with an interrupt to the main processor for arbitration. Using EDC, single-bit errors can be corrected on the fly, and the processor can continue to process data without interruption. Another consideration is component overhead. In a byte-parity scheme, 32-bit data requires four parity bits and 64-bit data requires eight parity bits. With EDC, 32-bit data requires seven check bits, a slight premium over the parity scheme.

With 64-bit data, only eight check bits are needed for the Hamming code, the same overhead as implementing parity, but with the added benefit of performing error correction. As memory systems go to wider memory buses (from 32 to 64 bits and beyond) for increased bandwidth, EDC will supersede parity as the preferred method of memory checking.

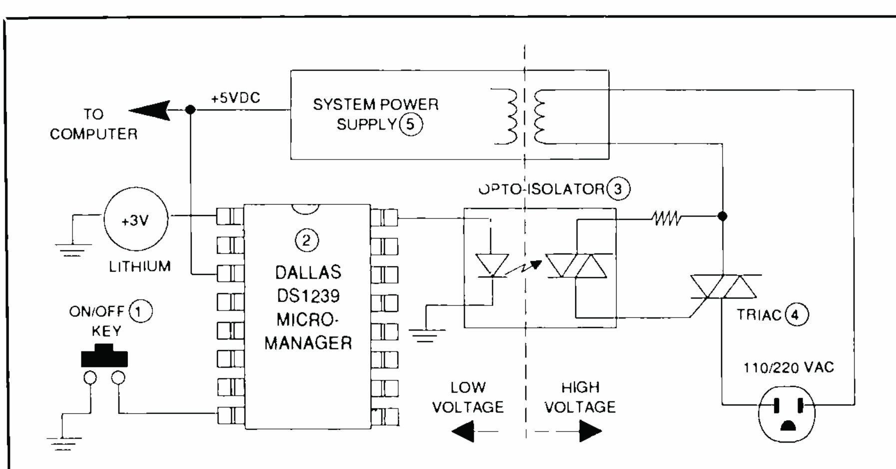


Fig. 2. Dallas Semiconductor's DS1239 MicroManager chip cold starts a computer from the keyboard, rather than from a rear- or under-table-mounted power switch.

Lithium "Kickstarter" Chip

Dallas Semiconductor (4350 Beltwood Pkwy. S., Dallas, TX 75244) has introduced the DS1239 MicroManager, a chip with special circuitry that cold starts a computer from the keyboard, instead of a circuit-breaker switch.

Cold starting a computer with a kick from a lithium energy source moves the point of control to the keyboard so that users need not reach to the back of the system or under the table to turn it on. In addition to convenience, the DS1239 enhances safety by keeping 110/220-volt ac power cabling distant from the person activating the switch.

UL and CSA/VDE approvals for equipment are simplified because isolation and confinement of the ac voltage reduces shock and fire hazards. When equipment power is off, a pushbutton closure is detected by the chip (see Fig. 2), which then sources a minute amount of lithium energy. This energy lights an optical isolator to kick on a triac that, in turn, powers up the system.

Alternatively, the pushbutton can be wire ORed to a signal from a real-time clock or a telephone ringer; the equipment can then be automatically turned on. The chip monitors a second pushbutton to reset a processor when the operator wants to intervene. This interface allows for easy hookup of an external switch for a hardware reset-function.

Along with lithium kickstarting, the MicroManager chip supervises the processor in a computer system. If the processor does not check in within the prescribed amount of time, it is assumed to be out of control. A watchdog timer stops the processor automatically, then resets and starts it.

The D51239 has provisions to monitor power. If the 5-volt dc power supply dips out of tolerance, a warning signal interrupts the processor, permitting storage of vital information in nonvolatile RAM for an orderly shutdown and graceful restart. The chip's circuitry also converts SRAM into nonvolatile memory that is lithium-backed.

The D51239 MicroManager Chip Plus Kickstarter is list priced at $3.50 in 1,000-piece quantities.

Enhanced PROM & SPROM

Raytheon Co., Semiconductor Div. (350 Ellis St., P.O. Box 7016, Mountain View, CA 94039) has announced the R29771 and R29773 4,096 × 8 (32K) standard bipolar PROM and power-switched SPROM. These two devices are improved replacements for the R29671 and R29673 PROM and SPROM.

The R29771 has a maximum access time of 55 ns (compared to 70 ns with the previous device) and an enable access time of 35 ns over the full commercial temperature range.

The R29773 is the SPROM equivalent to the R29771 PROM. In the power-down mode, there is a 75-percent power savings with an access time of 55 ns maximum and an enable access time of 85 ns. The built-in power switching capability is accomplished by on-chip power switches that turn off most of the internal circuitry for devices that are not selected.

Both devices are manufactured with nichrome fuses and low-power Schottky technology and are ideally suited for special-environment applications required in space and aircraft systems.

The R29771 and R29773 are available over the commercial and military temperature range in 24-pin 0.3" and 0.6" DIPs. In 100-piece quantities, pricing for these devices starts at $9. **ME**

Life & Death and The MousePen

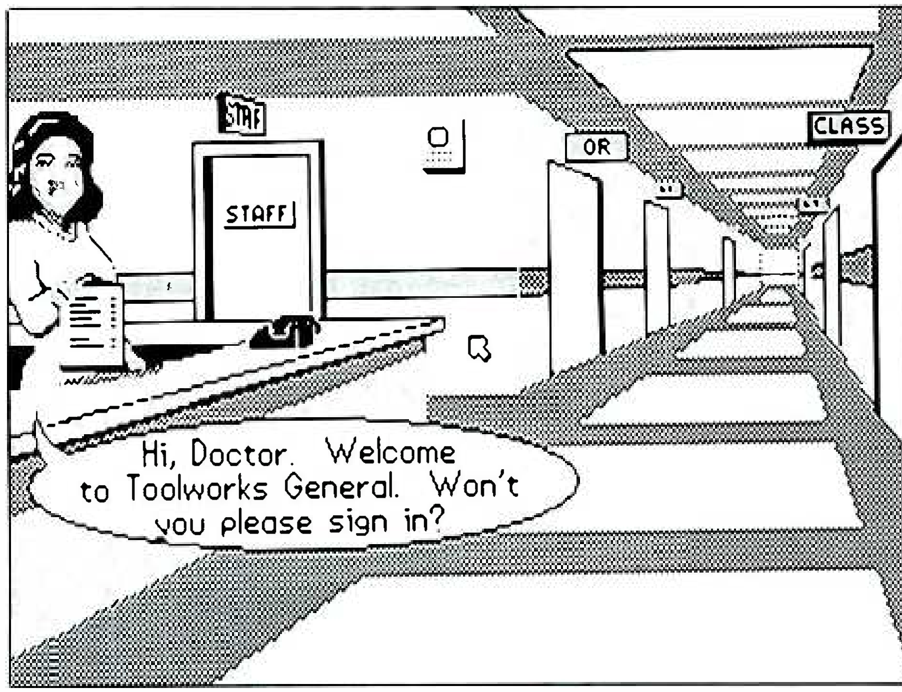
By Ted Needleman

With the holidays on the way, I thought it might be fun this month to look at a few things that you can hope for (or buy for yourself).

Life & Death

My mother always wanted a doctor in the family. She somehow never got over the fact that her children chose less glamorous careers. Well, mom, I may not have gone to medical school, but now, with Life & Death from The Software Toolworks, your first-born is examining patients, ordering tests and performing an occasional operation.

Life & Death is an interesting package. It's not quite a game, though it is both fascinating and absorbing. It is, within limits, a stimulating and educational medical simulation. You become a surgical resident at Toolworks General Hospital, where you're responsible for examining, diagnosing and treating a variety of abdominal ailments.



At the start of The Software Toolworks' "Life & Death" game program, the opening screen has a nurse greet you as you step into Toolworks General Hospital. Your patients, the medical school and operating room are in rooms off the corridor.

Booting up the program, you find yourself greeted by the floor nurse, and asked to sign in. Once you have, you're directed to various ill patients in several rooms up and down the corridor. You go to the room by using a mouse to move an arrow-shaped cursor to the door you wish to enter, then clicking the left hand button. The clipboard at the foot of the the patient's bed is examined by clicking on it. It then describes their symptoms (all of which are remarkably similar—"flu-like," with weakness and abdominal pain). The clipboard also has a variety of actions you can take.

You can observe the patient, medicate him, run an UltraSound or take an X-Ray, refer him to a specialist, or perform surgery. By moving the cursor to a box next to the action you wish to take, clicking the mouse button, initialing the order by clicking the initial box, and then clicking off to the side of the clipboard, you cause the requested action to be initiated.

If you rush ahead and perform any of the clipboard options right away (except for observe), you will be asked to attend a lecture in the medical school (which is the first door on the right of the corridor). You must first perform a physical examination of the patient. When you click on the bed cover, the patient's undraped abdomen is presented. Palpating the abdomen is accomplished by using the mouse to position the cursor arrow over the area you wish to examine and clicking the mouse button. The patient responds with either an expression of pain or a comment about how it doesn't hurt there.

Results of your examination will dictate whether further tests should be run, medication administered, or the patient put under observation.

You gain the judgment to make these calls from your medical education (reading the 22-page "excerpt" from a fictitious "Anatomy and the Surgical Technique" textbook, or like me, by watching hundreds of reruns of "Medical Center" and "Marcus Welby"). If you choose the wrong course of action, it's off to class for a lecture on why you where wrong and what you should have done. Having a few patients die on you because of carelessness also tends to hone diagnostic skills.

In your highly condensed stint as a resident, you get to treat a variety of illnesses (most based in the abdominal area), such as infection, gas, gallstones and kidney stones (which are referred to a specialist) and appendicitis, where you get to operate.

Performing an operation is quite an experience. First you visit the Doctor's Lounge to pick out your assistants. The nurse there hands you dossiers with the person's picture, qualifications, strengths and weaknesses, and which of the other available assistants they do and don't get along with. Then it's off to the operating room. The operation is performed by using the mouse to grab the desired instrument or medication and then using it.

Performing the operation is realistic enough that if you're really squeamish, like I am, it's difficult to make a cut with the scalpel. And, unfortunately, while the procedure is described in the accompanying "textbook," there are no pictures in the "abridged version." I lost quite a few patients before I figured out what some of the parts were. You can also lose your patient by forgetting to clamp off bleeders (those arteries and veins you cut through).

As the body count piles up, you eventually even get to save a patient or two. But it is distracting to hunt around on the little table for what you need while your patient is bleeding to death on the operating table. Now I know why doctors in medical shows are always yelling things like "retractor!," "clamp!," and "spanner wrench!" Once you take your eyes off the patient, it's easy to forget just where you were in the operation.

You can, however, put the operation on "hold" by pressing the "P" key on the computer keyboard while you go back to the book to figure out what that little squirmy thing is that you just nicked with the scalpel. You also have to pay attention to the patient's vital signs. While printing the screen dump that accompanies this article, the keyboard was locked, so I could only watch while my patient went into Bradycardia (slowing and missed heartbeats). If I could have just gotten to the medicine cabinet, I might have saved him. Oh well, there my malpractice insurance rates go through the roof! (I'll just have to raise my fees!)

As if having patients die on you wasn't realistic enough, The Software Toolworks also provides some doctors accouterments, such as a surgical mask, rubber gloves, and even a cardboard beeper so you can return your wireless phone pages.

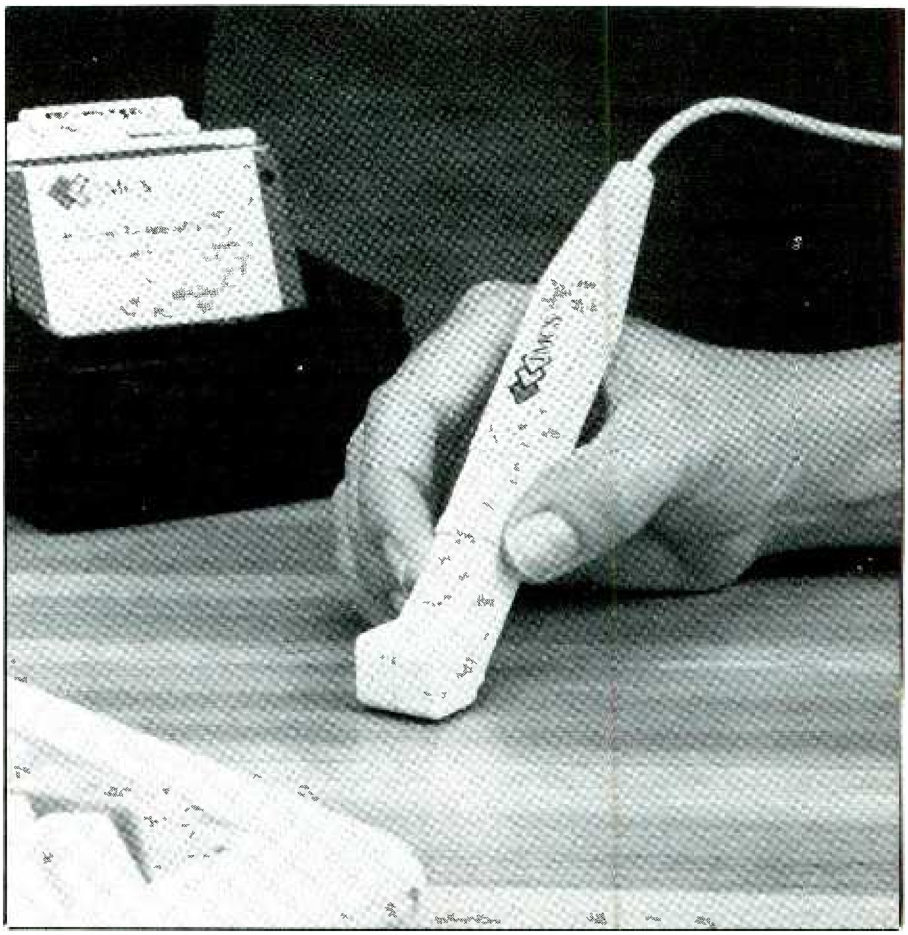
Life & Death can run on most MS-DOS PCs. It requires only 256K of RAM and can run in either graphics or text mode. Graphics mode, especially color graphics, is much more fun. As you can tell from the accompanying screen dump, the displays are not amazingly lifelike. And the patients all tend to start looking the same after a little while. No, it's not that you stop thinking about them as individuals, but to save disk space, The Software Toolworks has programmed in only three or four patients and re-uses them with different symptoms and ailments.

I don't usually spend a lot of time playing games on my computers. I use them much too extensively in my work to enjoy them very much in my spare time. But I find myself booting up Life & Death pretty often. It's challenging, entertaining and educational at the same time. (I just wonder if there's any way I could get a set of MD plates for my car now.)

The MousePen

Many of today's applications, such as the game reviewed here, require some sort of pointing device. The mouse has become the most popular of them, with millions having been sold. In previous columns, we've taken a look at some of the available alternatives, including trackballs, FELIX the friendly pointer, and CalComp's WIZ mouse/digitizer. All were interesting, but none have quite taken the place of my trusty old "soap-bar" Microsoft mouse.

I've been using something the last few months that might actually displace my mouse from its desk space—the Appoint MousePen. True to its name, the MousePen looks like a ball-point pen with a very thick barrel and a snout. The snout is



Appoint's MousePen, as its name implies, is a mouse pointing device housed in a pen-like enclosure. Handled in much the same manner as you would a pen marker, this device requires very little desk space to operate and hardly any learning time at all.

bent at about 135 degrees to the body of the pen and contains a small plastic roller ball. The barrel has two square buttons, one above the other, with a raised bump on the bottom button so that it can be located by feel. This bottom button, by the way, corresponds to the left button on a standard mouse, while the top MousePen button acts as the right mouse button. When holding the MousePen like a writing instrument, your finger naturally falls on top of the bottom button—you don't have to hunt around for it.

Weight of the MousePen is just an ounce or two. A thin cable coming out of the top of the body is terminated in a small PS/2-type DIN connector (for the standard model), a DB-9 connector (for the model meant to be used with laptops), or a connector for Apple's DeskTop Buss (on the Macintosh model). Appoint supplies an adapter with the standard model that lets you use the MousePen with DB-9 and DB-25 serial ports, as well as the PS/2's DIN port.

As with most pointing devices, the MousePen comes with two pieces of software: a set of menu utilities and a paint program called TelePaint. I didn't bother examining the menu utilities. I've looked at other similar utilities in the past and have been uniformly unimpressed with software that tries to add pull-down menus to programs that really weren't designed for them. When using Wordstar or 1-2-3, I've gotten so used to the way the command keys work, that trying to use pull-down menus just slows me down. These menus work best when they have been designed into a product from the start. PageMaker, Word for Windows and Excel are all examples of products whose pull-down menu structure compliments, rather than detracts from, the operation of the program. And even these packages offer command key "shortcuts" for those of us who have become used to this approach.

I did, however, install and examine TelePaint. This is a fairly standard color paint program, similar in function and features to Spinnaker's Splash and Z-Soft's PC Paintbrush. If you don't already have a paint program, you'll appreciate TelePaint, but there's nothing in it that would cause you to switch from a paint program you already have and are used to.

The MousePen has two big advantages over "soap-bar" mice that have caused me to really like it. First is its Microsoft mouse compatibility. Appoint includes a mouse driver on the supplied utility disk. However, if you already have an MS mouse installed, you won't need it. I just unplugged the Microsoft mouse from my PC, plugged in the MousePen, and everything that used a mouse accepted the MousePen without question.

The second benefit the MousePen offers is that it doesn't use much of your desk's real estate. Using a standard mouse generally requires that you dedicate about a square foot of empty desk space in which to move the mouse. The MousePen makes do in an area about 2 or 3 inches square. In fact, the "MousePen Pad" now included with the device is a 2-inch-square pad of paper. The MousePen, like many other recent mouse introductions, is ballistic in nature. If you move it fast, the cursor on the screen moves farther for a given mouse distance. When moved slowly, however, the distance you cover moving the MousePen and that covered by the moving screen cursor more evenly correspond.

Best of all, the MousePen just feels good in use. Holding it feels the same as holding a large pen or marker, and using it feels the same as writing. There's very little learning curve until you feel comfortable with the MousePen—you already know how to use it. Appoint states that its research indicates that the MousePen may be particularly useful for those who suffer from carpel tunnel syndrome (a pinched nerve in the wrist). The company doesn't, however, say if day-long users of the MousePen tend to suffer from writer's cramp.

I'm still not sure that there's any such thing as the perfect pointing device, but having used the MousePen for the last couple of months, I think Appoint has come the closest to it yet. If you're in the market for a new (or your first) mouse, do take a look at the MousePen. ME

PRODUCTS MENTIONED

Life & Death
$49.95
The Software Toolworks
4470 Redwood Hwy.
San Rafael, CA 94903
415-883-3000

MousePen
$149.95 (IBM models); $129.95 (Apple DTB model)
Appoint
1332 Vendels Circle
Paso Robles, CA 93446
805-239-8976

Bridging the Gap Between Dot-Matrix and Laser Printers

By Joseph Desposito

If owning a dot-matrix or ink-jet printer in the 1990s makes you feel like a second-class citizen, there's something you can do about it. LaserTwin from Metro Software (1870 W. Prince Rd., Suite 70, Tucson, AZ 85705) will let most dot-matrix and ink-jet printers emulate a Hewlett-Packard LaserJet Series II printer.

LaserTwin is a terminate-and-stay-ready (TSR) utility that translates LaserJet commands into a language your printer can understand. This lets you configure applications programs for the HP Series II LaserJet, rather than for your dot-matrix or ink-jet printer. And since the HP Series II LaserJet enjoys wide support among applications that use a variety of typefaces and sizes, such as PageMaker 3.0, Microsoft Word, and WordPerfect 5.1, LaserTwin lets you tap into that support.

In essence, your non-laser printer's capabilities are extended to increase the number of typefaces it ordinarily is limited to, permit printing larger sizes and printing in landscape (sideways) orientation. Consequently, the program can open up desktop publishing opportunities for people who do not own or plan to buy a laser printer.

LaserTwin is for the IBM PC and compatible computers. It requires at least 2MB of free hard-disk space. The product, which includes three 5.25-inch disks and a user manual, has a suggested retail price of $179.

Installation & Use

To install LaserTwin, you simply put a disk labeled "Master Disk -1" into your floppy drive and type: FIRSTIME. The installation program then prompts you through the necessary procedures to get LaserTwin up and running.

Unfortunately, when you first run the program by typing LT at the DOS prompt, you get a message informing you that you have a copy of the product that is not registered. The message isn't so bad, but if you don't register right away and get your secret code number from the company, a two-line trademark message is printed across every page you print with the program!

During the installation process, you select a printer from a long list of popular models. If you don't see your printer on the list, you can use a compatible printer or call the company to find out the latest additions to the list. We used LaserTwin with a Juki Model 5510 dot-matrix printer, which is not on the list. However, the Model 5510 is compatible with the Epson Model FX-80, which listed.

During installation, you also choose "boot up" conditions. This is done to emulate the front-panel settings on the HP Series II laser printer, which allows you to change such things as the symbol set, the type style, and the orientation of the boot-up font.

LaserTwin includes a print spooler, which you set up during installation. Settings for this and other features can be changed by running the install program again (typing LTINSTAL instead of FIRSTIME).

When residing in memory, LaserTwin takes up 26K of RAM. There is no provision for moving the program into LIM 4.0 expanded memory.

Once you load the program into memory, you can forget about it. It runs in the background and is completely transparent. However, if you want to change certain program settings, you must issue commands from the DOS prompt. For example, the command "LT K" reduces the size of the printout.

We ran a test pattern included with the program. Three things were obvious from the test printout. First, the Juki dot-matrix printer could indeed function just like an HP Series II printer; second, the printer was printing very slowly; and third, the quality of print from the nine-pin printer was nothing like that obtained from a laserjet printer.

We then set up Microsoft Windows 3.0 to work with an HP Series II printer with 4 MB of memory. (LaserTwin lets you do this if you have an extra 4 MB of free space on your hard disk.) There is one other step you have to perform with Windows: you have to edit the WIN.INI file

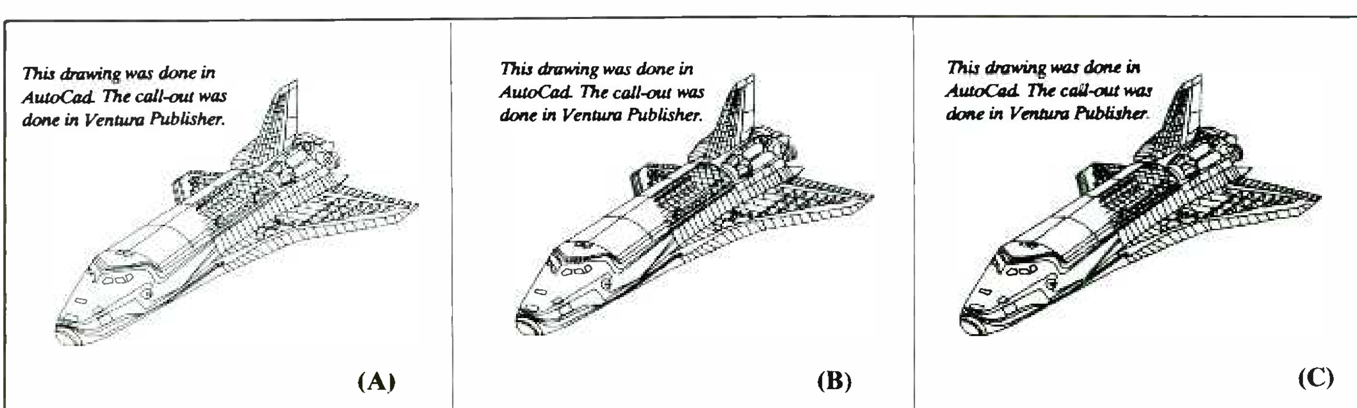


Fig. 1. Samples of printouts using LaserTwin: (A) HP DeskJet, (B) 24-pin dot-matrix and (C) 9-pin dot-matrix printers.

and turn the print spooler off—a simple task. However, when we tried to print a simple document with Windows Write, we could not do it.

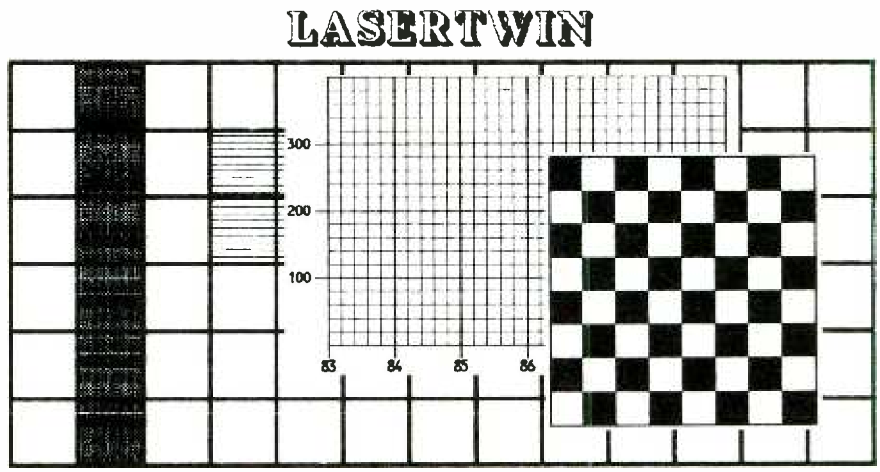
When we called the technical support line at Metro, we found out that versions of Windows prior to 3.0 work just fine with LaserTwin, since earlier versions use the BIOS. Windows 3.0 doesn't. Thus, you must do one of the following: configure you printer port as LPT1.OS2, using the Windows Control Panel, or edit the Windows WIN.INI file by adding the line "LPT1.PRN: =" to the Ports section of the file. Once we made the change, the printer worked fine.

When we tried to do some fancy printing with Aldus PageMaker 3.0, we quickly realized that LaserTwin includes just Courier and line-printer fonts. The only way you can use other fonts is if you have additional soft fonts. Luckily, Metro Software also sent us its SuperFonts 25/1 program (see below)—we didn't have any other soft fonts available.

For anyone who desires more control of the printer, LaserTwin includes a text-formatting and printer-control language. The language includes commands for font control, special effects, and box graphics, among other things. To use the commands, you place them in text destined for the printer. The text can come from a word processor, spreadsheet, database or language program. For example, to print a spreadsheet sideways, you just add the command "[LAN" to the file. These commands can also be sent from the DOS prompt by preceding them with the command SENDLT.

If you have never used an HP laser printer, you might find some of its quirks disconcerting. For example, if you configure Lotus 1-2-3 for the HP Series II, you'll find it works differently than it does with most dot-matrix printers. To cite one, if the spreadsheet you try to print is less than a page in length, nothing happens when you press GO. The HP Series II won't start printing until you hit Page (a formfeed in 1-2-3). Also, you don't get condensed type with the familiar /015 string. You'll have to use HP laser commands instead, which are in-

SOFTWARE FOCUS...



Part of a printout that gives proof that LaserTwin is properly installed and is operating correctly. Heading was produced by downloading an HP software font to printer. Various boxes and grids, shown superimposed on each other here, give user an idea of what can be done with LaserTwin.

cluded in the manual. The 106-page manual is well-written, but includes just three illustrations.

SuperFonts 25/1

A companion program to LaserTwin, and priced the same, is SuperFonts 25/1. This program gives you all Hewlett-Packard cartridges from A to Z. It includes over 139 fonts, all of HP's symbol sets, over 14 type families and 11 type sizes that range from 6 to 18 points. Fonts are selected from a pull-down menu.

Comments

We used LaserTwin with a 9-pin dot-matrix printer and the results were okay but not spectacular enough to warrant a $179 expenditure. However, Metro Software provided us with print samples from 9-pin, 24-pin and ink-jet printers. The ink-jet sample, taken from an HP DeskJet, is truly impressive, as can be seen in the top illustration in Fig. 1.

The capabilities of LaserTwin are stifled since it includes only two common fonts. If you really want to produce nice-looking printouts you'll have to purchase additional soft fonts. Keep in mind, however, that one of the benefits of LaserTwin is that it allows you to use the wide assortment of commercial soft fonts, such as Bitstream Fontware, designed for use with the HP Series II laser printer. Another benefit of LaserTwin is that it lets you print sideways without purchasing a special program.

Conclusion

At $179 for LaserTwin and another $179 for SuperFonts 25/1, these aren't programs you purchase on a whim. Having access to HP Series II capabilities is certainly a big plus, but best output comes from an ink-jet printer like the HP DeskJet. And if you purchase a DeskJet and the two Metro packages, you'll probably pay more than you would for one of Hewlett-Packard's low-cost laser printers or an HP compatible.

If you already have a DeskJet or a 24-pin dot-matrix printer, you might well consider investing in LaserTwin, especially if you find yourself frustrated by the limitations of your printer in terms of font support. If you have a 9-pin printer, however, you may not be satisfied with the print quality in relation to the price you have to pay for it.

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BOOKS

Troubleshooting and Repairing Camcorders. *By Homer L. Davidson. (Published by Tab Books. Soft cover. 533 pages. $22.95.)*

The electrical and mechanical complexity of the camcorder demands an authoritative reference one can turn to when troubleshooting and repairing these sophisticated video devices is required. In a general sense, this book fits the bill. The stated aim of this book is to provide practical and technical data to help make camcorder repairs much easier. Examining the contents, this aim appears to be admirably achieved.

Beginning from square one, the book's opening chapter is devoted to the camcorder in general and videocassette formats. Here it discusses Beta, VHS and VHS-C and 8-millimeter formats and goes on the discuss camcorder features in general, hookups, etc. A second chapter, titled Tips and Techniques, introduces service precautions, service data, voltage measurements, signal paths, test equipment, and more.

Following chapters dissect the camcorder, dividing it into the Camera Section, Video Circuits, System Control, Trouble Detection and Servo Circuits, Motor Circuits and Audio Circuits. Each chapter deals with the title topic in some detail to help familiarize the reader with the various elements that make up the typical camcorder and how they form the whole.

Still later chapters deal with mechanical tape operations, mechanical and electrical adjustments and power supplies. Interspersed among these is a chapter titled Remove and Replace, which gives hints on how to go about sensibly disassembling the camcorder to remove and replace items that have gone bad. Near the end of the book is an extensive Troubleshooting chapter that deals with this topic in a symptom-and-solution approach. Though many of the solutions presented here are specific to certain brands/models of camcorders, it is applicable to other brands/models. The book closes with three appendices: commonly used abbreviations, camcorder manufacturers with addresses and a glossary of technical terms.

This well-written and easy-to-understand book is exceptionally well-illustrated. Throughout the text are excellent photos, schematic and block diagrams, tables and drawings that help explain the text material so that the reader can readily navigate among the various elements that make up the camcorder. If you do camcorder repairs, you need this book.

CMOS/TTL Digital System Design. *By James Buchanan. (Published by McGraw-Hill Publishing Co. Hard cover. 258 pages. $44.95.)*

This book is about electrical design of high-speed TTL and CMOS systems. It is not about logic design and should not be considered as a course in logic-circuit design theory. Its main thrust is showing how TTL and CMOS devices must be implemented to behave properly and how to optimize the environment in which they are used to assure reliable, cost-effective digital hardware. Tested shortcuts and techniques and a toolkit of solutions to common problems associated with advanced Schottky and CMOS systems are presented. Every aspect of high-speed digital systems is covered. Throughout the book, practical engineering approximations are used in place of rigorous mathematical analyses.

Two parts make up the book. Part 1 deals with device characteristics, while Part 2 deals with design and techniques for dealing with the special concerns of high-speed logic.

Following a brief introduction, Part 1 goes on to discuss TTL and CMOS logic family characteristics, interface requirements, and other related matters. It then explains what TTL and CMOS logic circuits are and discusses, in separate chapters, noise margin for the two families of devices, sources of transient currents and inductance and transient-current effects. In Part 2, topics covered include power distribution, synchronous design, clock distribution, signal interconnections, signal quality, system timing, reset signals and unused reset signals.

Three appendices follow Part 2. These are devoted to conversion factors, definitions of symbols and acronyms and trademarks. A glossary of technical terms closes the book.

Television and Video Systems. *By Charles G. Buscombe. (Published by Prentice Hall. Hard cover. 377 pages. $45.80.)*

This large-format (8½" × 11") book was written to help train future technicians and make life easier for technicians whose specialty is consumer TV receivers ▶

and monitors, projection sets and VCRs. It presupposes that the reader has some familiarity with the fundamentals of electronics and hands-on experience working with circuits and test equipment.

To adequately cover the range of circuitry used in modern consumer video equipment, the book is divided into 22 chapters. Most discuss circuitry from the TV receiver point of view. However, since VCRs use identical or similar circuitry, plus specialized recording and playback circuitry, what one learns from the TV receiver section is applicable to the VCR.

Because it is meant to serve as a training aid as well as a reference for experienced personnel, the book begins with five general chapters on the basics of the TV system, TV receivers, electronic components, test equipment and servicing aids, and basic troubleshooting and repair techniques. The remainder of the book is largely a blow-by-blow description of the various circuits that make up the TV receiver, with each circuit type assigned its own chapter (a separate chapter deals with digital TV, monitors and picture enhancement, and another chapter at the end of the book is devoted to projection TV). Within each chapter, one simply looks up a given symptom, which is followed by a paragraph on the probable cause and one or more paragraphs that detail how to localize the trouble.

Only two chapters are specific to the VCR. One discusses the various VCR components, magnetic recording fundamentals, microprocessor and system control, etc. The other covers troubleshooting, maintenance and repair of both electronic and mechanical problems.

All in all, this well-presented, well-rounded book lives up to its title and subtitle. The text is terse without being dry. It is excellently illustrated with schematics, drawings, block diagrams and photos. Every chapter closes with a battery of questions, numbering as few as 10 up to almost 40, to test the reader's grasp of the topic discussed. No formalized answer key is provided, though. This is an excellent first troubleshooting book that is likely to be frequently used even by old hands who are experienced in troubleshooting, maintaining and repairing consumer video equipment.

NEW LITERATURE

Test Equipment Catalog. The "Tek Direct Catalog" allows buyers to order test and measurement equipment directly from Tektronix. Among the items listed and fully described are hand-held and low-end portable oscilloscopes, printers, accessories, software and training aids. These products cover a price range from $150 to $5,000. Special product offerings in the form of discounts and free products are included in this latest issue of the Catalog. Additionally, some featured products are available to the public only through the new Catalog. For a free copy of the fall Tek Direct Catalog, write to: Tektronix, Inc., P.O. Box 19638, Dept. ME, Portland, OR 97219-9881.

Power Supply Testing Literature. Two new application notes on automatic power supply testing from Intepro Systems detail advances made in areas of general interest to people engaged in design, testing and repair of power supplies. One covers techniques for measuring a supply's response to transient conditions. The other looks at a new type of electronic load design that provides a much higher quality of test than conventional loads. For free copies, write to: Intepro Systems Inc., Attn. Mike O'Connor, Six Fortune Dr., Billerica, MA 01821.

Scientific Software Catalog. MicroMath Scientific Software's 1990-91 Software for Complex Scientific Problem Solving catalog highlights five of the company's scientific software products and lists nine other such products from other companies. The 32-page color catalog gives overviews of: a GRAPH package that incorporates the most important features for research data presentation; MINSQ for nonlinear curve fitting and model development; EQUIL for solution of aqueous chemical equilibrium problems; LAPLACE that employs the numerical inversions of Laplace transforms; and RSTRIP compartmental modeling and pharmacokinetic analysis. Other products mentioned include MathCAD, CSS, PrintAPlot, MathEdit, PROQube, GAUSS, PC Tools, DERIVE and FracTools. For a copy, write to: MicroMath Scientific Software, P.O. Box 21348, Salt Lake City, UT 84121-0348.

Area Code Speed Dialer *(from page 47)*

separate lugs. Then wire the switch-closure transistors to separate lugs on the terminal strips.

Do not forget to also terminate the ground wire from the circuit-board assembly at V_{SS} of the tone circuit. If any output shares the same destination, jumper these connections on the circuit-board assembly or assemblies. Do *not* attempt to terminate more than one wire at any solder pad on the keypad. If you are building more than one Speed Dialer, solder the wires to the appropriate lugs of the terminal strip, using a 1N914 diode in each line to isolate the IC outputs and transistors from each other and each assembly from all others.

Wire the transistors in the proper sequence. For example, if you are building the Speed Dialer to automatically key in the number 9-1-725, connect the wires from *Q3* to the C3 and R3 pads, the wires from *Q4* to the C1 and R1 pads, the wires from *Q5* to the C1 and R3 pads, the wires from *Q6* to the C2 and R1 pads and the wires from *Q7* to the C2 and R2 pads on the keypad assembly.

When you are finished wiring from the circuit-board assembly to the keypad or terminal strip, mount the switch(es) in the hole(s) you drilled for it (them). Then use double-sided foam tape to mount the battery to the housing of the telephone instrument with which the Speed Dialer is being used. You can also use double-sided foam tape to mount the circuit-board assembly inside the instrument in any location where it will not interfere with the phone.

If you built more than one Speed Dialer and housed them inside a separate enclosure, you can also use double-sided foam tape to mount them in place. Alternatively, use ½-inch spacers and suitable machine hardware for mounting purposes. Wire the power lines to the various circuit-board assemblies, taking care to observe proper polarity in all cases. Then mount the switches in their various holes and label each with the appropriate area code.

Set any potentiometers to their center of rotation. Plug the telephone instrument back into its wall jack (make sure the handset is on-hook). Lift the handset off-hook and press the button on the Speed Dialer while listening through the handset. You should hear the digits of the area code being automatically dialed. At the end of the dialing sequence, you should hear an open line, which now allows you to complete dialing a number to that area code.

The potentiometers are used to set dialing speed. If the dialing speed is too fast for your telephone company to handle, adjust the settings of the pots. Check each Speed Dialer in turn for proper operation. **ME**

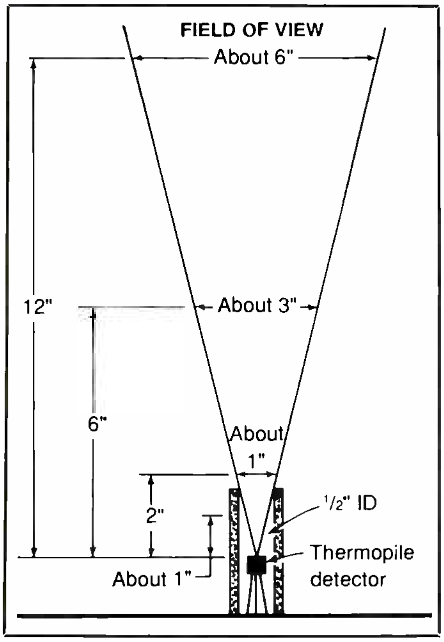

Fig. 7. For accurate temperature measurement, object must fill field-of-view of sensor in probe. The smaller the object, the closer the probe must be held to it.

Potentiometer *R4* is provided for setting circuit gain. Decreasing its resistance increases the gain of the circuit and, thus, increases the thermometer's sensitivity. As an alternate, adjust *R4* and *R16* so the meter indicates the correct hand and inside wall temperatures. Several adjustments will likely be necessary to get calibration to be near-perfect.

Assuming you have performed preliminary calibration of the adapter, fill a small plastic bucket to about one-quarter full with small ice cubes and add enough cold water to fill the bucket to the half-way mark.

Keeping the end of the probe about two inches from the water, take the temperature of the water. It should register between 32° and 34° F. If not, adjust *R16* so it does. (Caution: Do *not* point the probe at an ice cube. Its temperature may be much lower than freezing!) For optimum accuracy, use the ice water and an inside wall as temperature standards, and adjust *R4* and *R16* so that the thermometer adapter/meter arrangement shows the correct temperatures.

Calibration for the Celsius mode is done by adjusting *R20*. After final calibration in Fahrenheit mode, set *S2* to °C. The green LED should now light. When it does, adjust *R20* for a correct reading in degrees Celsius in the meter display. To convert degrees Fahrenheit to degrees Celsius subtract 32 and divide the result by 1.8. For example, 77° F = (77 − 32)/1.8 = 25° C.

Using the Project

The Infrared Thermometer Accessory has two main advantages over standard contact thermometers: nearly instant response and the ability to take temperature measurements without physical contact. Useable measurement distance varies from ⅛ inch (just far enough from an object to avoid contact) to theoretically infinity (assuming the temperature of an infinite-size object is being measured). However, for accurate measurement the field-of-view of the detector must be filled, as in Fig. 7.

Note in Fig. 7 that the maximum measurement distance depends upon the size of the object. With the geometry shown, the minimum size of the object that can be accurately measured is about ⅝ inch in diameter. For an object the size of a hand, maximum measurement range extends to about three inches, the temperature of a car can be taken at six feet and the average surface temperature of an ocean can be taken from space 100 miles away.

A quick non-analytical way of determining maximum measurement range of an object is to first place the end of the probe as close as possible to the object and note the reading obtained. As you pull back the probe from the object, the reading should remain fairly steady until maximum distance is obtained. Beyond this distance, the reading starts to change significantly. Of course, if the temperature of the surroundings is the same as the object, the reading remains the same regardless of how far the object is from the probe.

For optimum sensitivity, set a 3½-digit DVM or DMM in its 200-millivolt full-scale range to display degrees directly without the confusion of a decimal point. Set to the 200-millivolt full-scale range, the meter provides the measuring system with an accuracy of a tenth of a degree. Nevertheless, accuracy is not increased and at this high sensitivity setting, the 0.1-millivolt digit in the display will appear to fluctuate, due to noise from various sources.

If you set your meter to the 2-volt full-scale range, only full degrees will be displayed, and the decimal point may cause confusion, but the display will be steady, with no loss in accuracy.

A primary inherent source of error in infrared thermometers has to do with guessing the object's emissivity. Emissivity has to do with the ratio of infrared radiation that an object emits to the infrared radiation a perfect black-body radiates. In calibrating this adapter, it is assumed that a person's hand, the walls of the building and water have the same emissivity of about 0.9. This is a good assumption and is precise enough for general use.

This Infrared Thermometer Accessory does not have a specific adjustment for emissivity. However, it can be used for low-emissivity materials, like steel, if you calibrate the accessory using the same type of material at a known temperature. This procedure is more troublesome but vastly more accurate than guessing at the emissivity of the material.

Due to its nature, an infrared thermometer cannot be designed to measure temperatures as accurately as a contact thermometer can. However, this Infrared Thermometer Accessor is extremely sensitive, has super-fast response and can be calibrated to have an accuracy within ±3° F. **ME**

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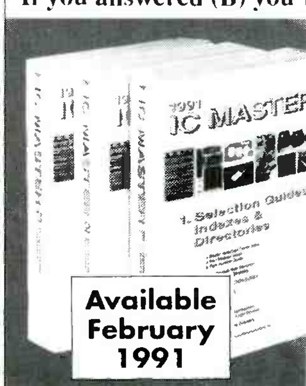

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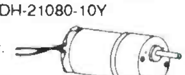

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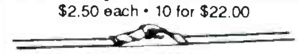

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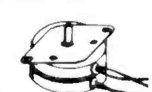

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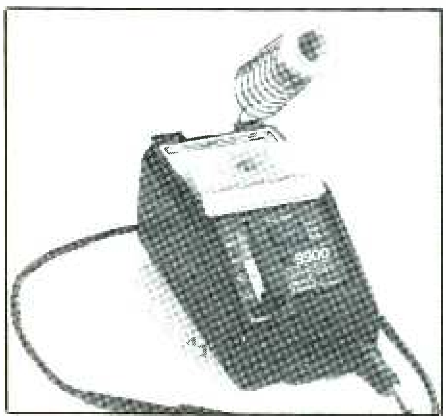
Among other performance features, the new iron provides a closed-



loop circuit that assures temperature stability at idle. Combined with zero switching and grounding from tip to plug, the Model 9910HC is claimed to be ideal for working on voltage-sensitive components. Additionally, the 24-volt iron features a long-life break-resistant ceramic heating element and a cool ergonomically designed grip for operator comfort.

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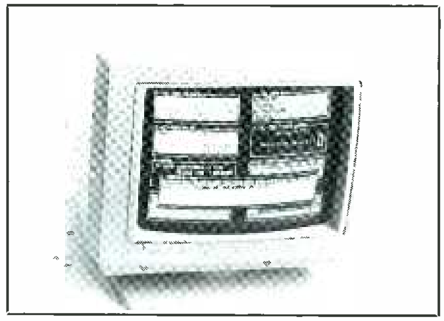

munication applications into one platform, via a multitasking windowing environment running on an 80386 DOS-based platform.

FECOS consolidates control of eight different pieces of equipment into one platform and permits screens to be adjusted to suit the requirements of each application. It collects and processes alarms and events from different communication equipment. Alarms and events are logged in a SERMON (Status ERror MONitor) window, with corrective action taken through FECOS. The system also provides local and remote dateline monitoring and protocol analysis for wide-area networks.

FECOS supports DOS applications that are DESQview compatible. It communicates with the applications via a standard PC/AT COM port. Information received or transmitted by DOS applications can be routed to FEALARM/SERMON using one or two channels of the FECOS multi-port card. The easy-to-use software is menu-driven and includes pop-down windows. It lets you control position, size and color of all applications windows.

Platform requirements: 80386 processor running at 20 MHz or greater; 1M of conventional memory plus a minimum of 3M of extended memory for the four-application version of FECOS (7M of extended memory for eight-application version); EGA or VGA with EGA emulation capability graphics; Microsoft or compatible mouse; MS-DOS 3.3x; and a parallel port configured as LPT1: or LPT2:.

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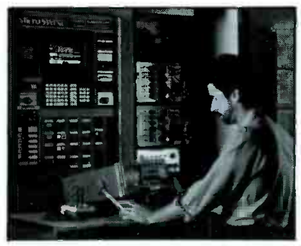

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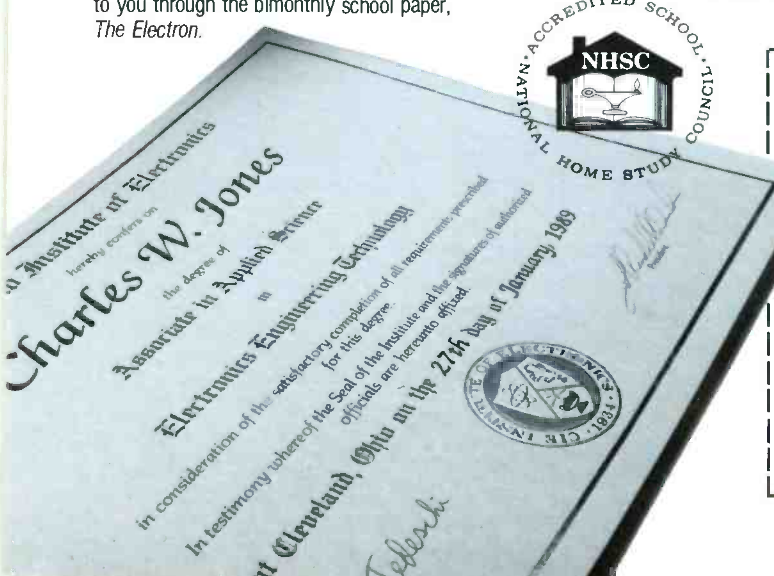

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- **DCK-1** DC cable kit for 12 volt DC use.

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