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- **ENERGY AUDITOR REVEALS APPLIANCE POWER COST**
- **HOW A POWER SUPPLY REALLY WORKS!**

Plus a Computer Design Program

Quadram QuadEGA + Enhanced Graphics Adapter (p. 76)

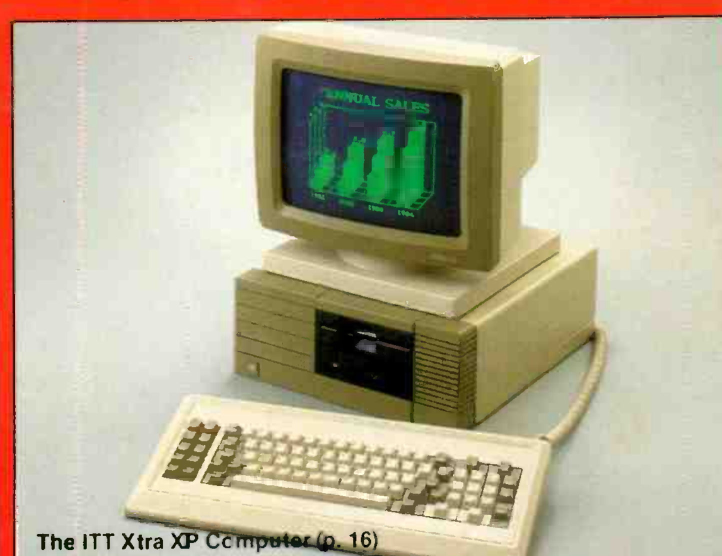
How to Build a:

- "Hands-Free" Talk/Listen Telephone Accessory
- Smoke Alarm Inhibitor that Shuts Off "Safely"
- Rem... ed Doorbell
- Low-... lectronic Enhancements

Test Report:

- ITT's Xtra XP Computer— A Supercharged IBM PC XT Compatible

Build the Energy Auditor (p. 20)



The ITT Xtra XP Computer (p. 16)

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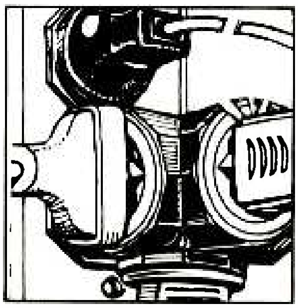

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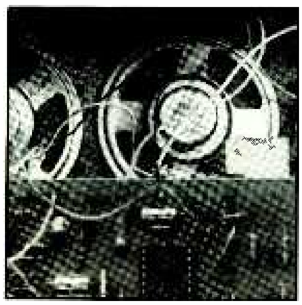

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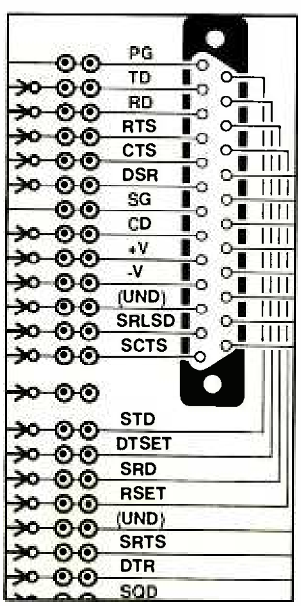

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EDITORIAL

Changing Times

In a short period of time, we've witnessed important changes caused by developments in electronics. It's nothing short of amazing! For example, the traditional manual typewriter has almost gone the way of the Dodo, while the plain vanilla electric typewriter appears to be on the way toward extinction, too, being displaced by *electronic* typewriters.

In 1978, electric typewriters were bought to the tune of 950,000 units, while the new kid on the block, electronic models, moved only 36,000 into the hands of users. By 1983, however, the types were in a dead heat with sales of 525,000 each. Only three years later, 1986 projections indicate that only 150,000 electric models would be purchased vs. 1.7-*million* electronic models.

Interestingly, IBM, which not long ago had about 80% of the office typewriter market to itself, took only a 29% slice last year. Moreover, IBM now sells more electronic models than electric (Selectric) ones. Competitors like Xerox have moved briskly into the electronic field. The big X just announced a solid-state addition to its 600 series of Memorywriter electronic typewriters that proofreads spelling with a 100,000-word vocabulary in ROM.

What else will the future bring in terms of change through electronics? One interesting possibility posed is that television will turn out to be the vehicle that's used first to premiere new motion pictures on a pay-per-view basis, usurping the role that movie theatres have held all these years.

Another likely scenerio, an old one, is working at home with computers. Future Computing, a Dallas-based market research company, says that more and more consumers are citing this as a reason for buying personal computers. According to them, increasing one's personal and business productivity were the main reasons given for buying a computer last year by 60% of respondents compared to 20% two years earlier.

There are new electronics on the horizon that will certainly have an enormous impact on us, of course. One especially intriguing one is contained in the FCC's Docket PR-86-38, which concerns a new consumer hand-held two-way radio that would contain individual addresses so that selective contact would be made. Retail prices such as $50 to $80 have been bandied about for this system. For more info about it, you can write to the FCC (1919 M Street N.W., Washington, DC 20554). Wouldn't this make a nice change?

Art Salsberg

LETTERS

It's Celsius Time

•Your article in the February, 1986 issue on temperature sensors used the name Centigrade for degrees C. The name for the C symbol is now Celsius.

Larry Stempnik
Warren, MI

Working for Peanuts

•Our company newspaper, the *Bell Labs News,* seldom prints anything worth reading. There were no raises for many at Bell Labs this year due to AT&T cost-cutting and staff reduction efforts (a lot of fairwell pizza parties). So I thought it would be interesting to send its "Industry Watch" column's copy of the item on electronic engineers' salaries that appeared in the News section of the September 1985 issue of *Modern Electronics.* They printed it, and it was undoubtedly the most interesting piece in the whole paper. Most of our salaries are nowhere near the "averages" reported by the IEEE. On well, Charlie Brown is Chairman of the Board for AT&T as we work for peanuts!

Name Withheld
Naperville, IL

"Siliconnections" Connects

•I enjoyed the book, "Siliconnections" [by Forrest Mims] and just had to finish it even though I really have less than zero time for reading these days. Your books make me want to reach for my soldering iron. I am particularly tempted by diode laser communications. I have the December issue of *Modern Electronics* and am looking forward to the January issue for the rest of the article on that subject.

Prof. Arthur L. Schawlow
Stanford University
Stanford, CA

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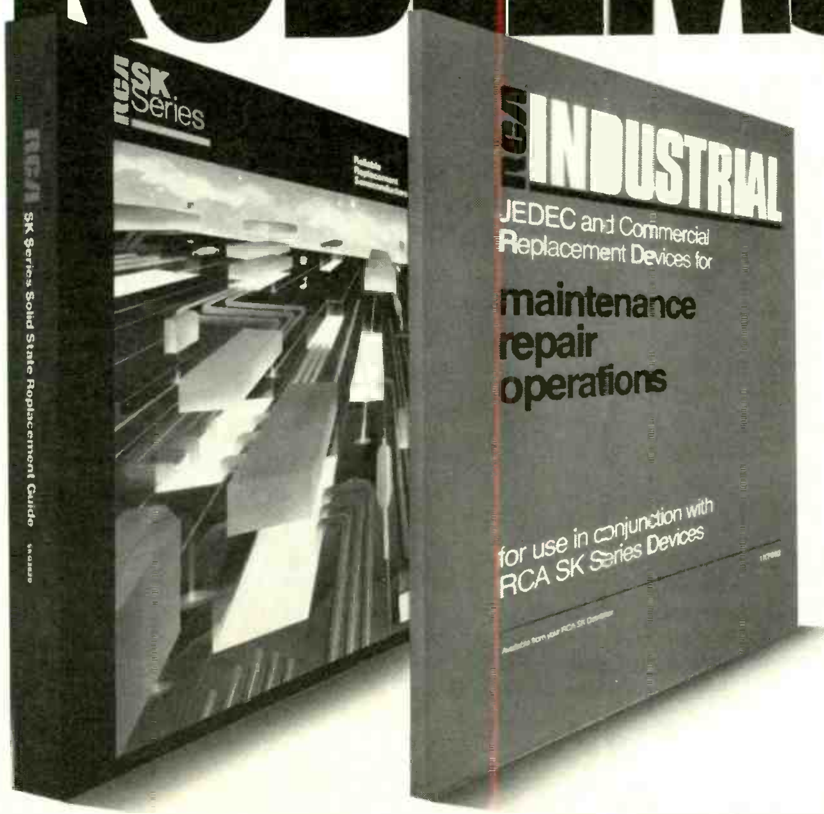

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*Joint Electron Device Engineering Council

RCA SK Replacement Solid State

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MODERN ELECTRONICS NEWS

SATELLITE TV SCENE. Announced as the nation's first commercial satellite distribution network for business computer users, Computer Distribution Network (CDN) reports that unscrambled satellite signals began March 3 on Galaxy II and Transponder 5. It begins with 6¼ hours of weekly programming, with plans for expansion to 5 hours daily by summer. Programs will cover information about computers related to product information, hands-on training, seminars, panel discussions, etc. . . .Earthside, the Stolle Corporation, Sidney, OH, is offerring dealers a 30-day trial period for its six-ft. SpaceMate antenna or eight-ft. SpaceMate Plus dish with polar mount. No-charge return is an option.

NEW PROTECTION SCHEME. MECA's popular "Managing Your Money" software package has a new protection scheme that enables it to be booted directly from a hard disk instead of with an "ignition key" floppy. However, it is said to randomly require the user to insert his original disk to continue on his way. Otherwise, the program hangs up. It all sounds just as annoying as before; more so, in fact.

ENGINEERS' SALARIES SECOND TO LAWYERS. That's what a recent statistical release from the U.S. Department of Labor reports. The electrical/ electronic engineers' 1985 median salary was $33,920 compared to lawyers' $35,115. Physicians hit only $30,750 annually. Oh, yes, in the fine print it noted that the median earnings do not include self-employed professionals, which most physicians and lawyers are. This is called sleight-of-hand statistics, we think. . . .On another front, the hottest jobs in America are programmer analyst, computer sales representative, plant manager, design enginner and controller/accounting officer, according to a survey by Dunhill Personnel System of its 300 franchise operations. Design engineers are reported to be hottest in the Southeast region.

TI TO SAMS. Those fine books on electronics by Texas Instruments, which includes its "Understanding..." series, went to Howard W. Sams & Co. in a recent acquisition that followed Macmillan's acquisition of Sams. Gobble, gobble, gobble.

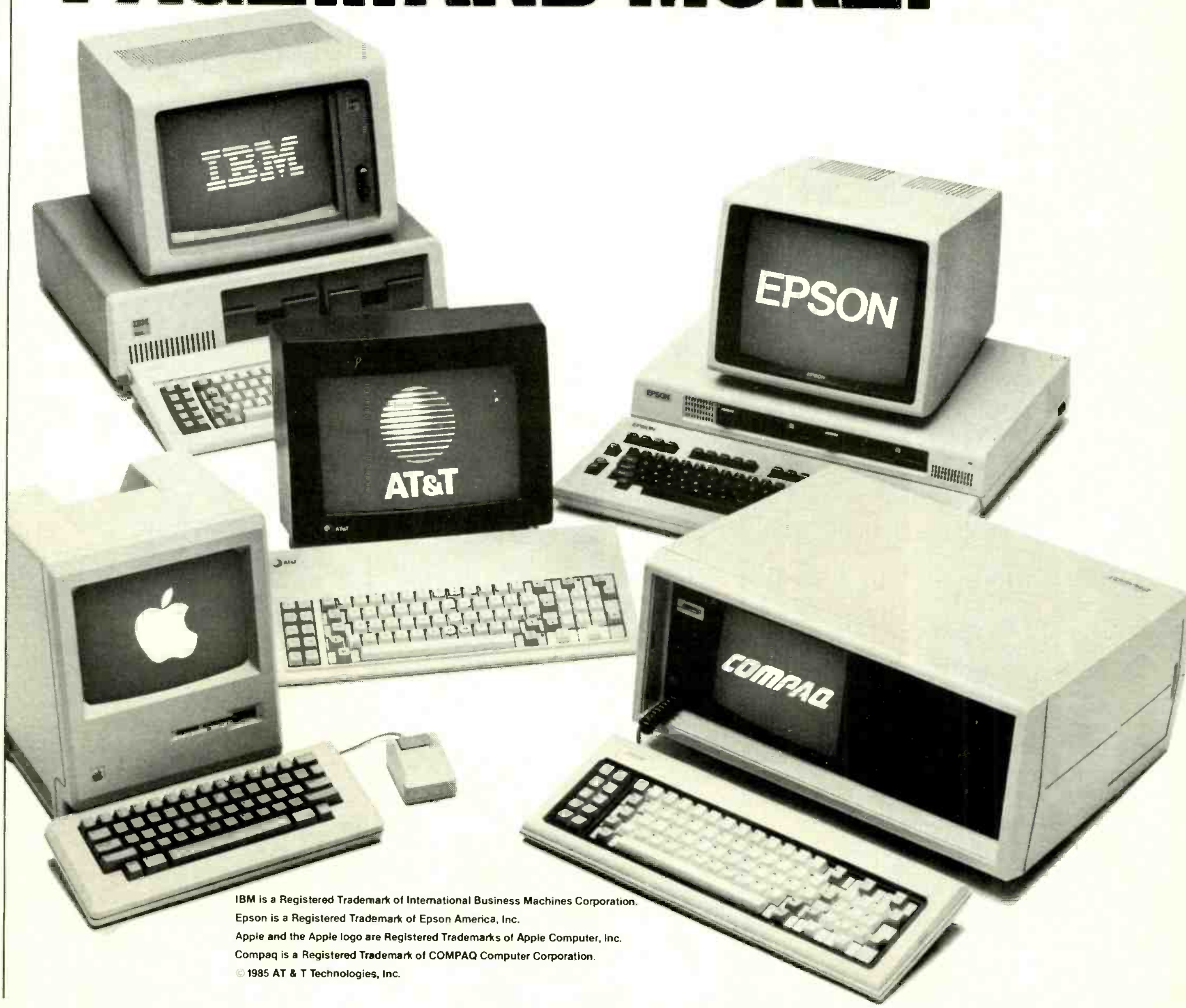
DISPOSABLE TELEPHONES. Small disposable telephones will play a major role in reducing deaths that are said to occur as a result of infections contracted while in hospitals, says Mini-Phone Inc. (Midland, TX) president Gary Johnson. The company's "Mini-Phone" comes pre-sanitized and packaged so that the only person using it is the patient, who may throw it away or take it home when the hospital stay is over. The $15 phone will likely be the lowest charge on the hospital bill. What will Blue Cross say to this one?

UNDERWATER VIDEO. Sony Corp. is marketing its 8-mm "Handycam" camcorder with a "Marine Pack" model that can operate safely to almost 140-ft. water depth. It includes a piezoelectric underwater microphone. Look for it in the summer.

SEARS TRIES APPLE-COMPATIBLE. Sears and Franklin Computer have agreed on test-marketing Franklin's Apple-compatible models in New York, New Orleans and Pacific Northwest markets.

NRI Trains You At Home—As You Build

GET THE KNOW-HOW TO SERVICE EVERY COMPUTER ON THIS PAGE...AND MORE.



Your Own IBM-Compatible Computer

Learn the Basics the NRI Way—and Earn Good Money Troubleshooting Any Brand of Computer

The biggest growth in jobs between now and 1995, according to Department of Labor estimates, will occur in the computer service and repair business, where demand for trained technicians will actually *double*.

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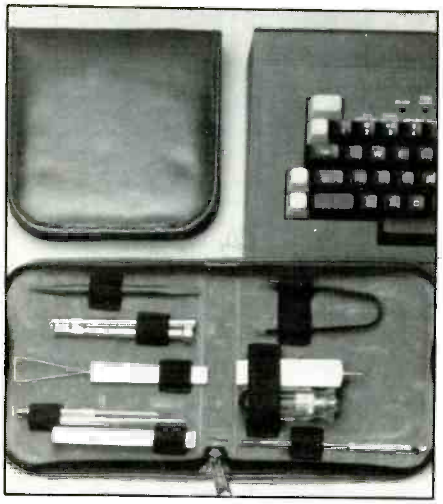
NEW PRODUCTS

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.

Computer Service Tool Kit

Jensen Tools' new Model JTK-9 is a tool kit especially designed for owners of personal computers and related peripherals. It is said to enable the nontechnical user of most personal computers to remove and install unit covers, circuit boards, memory chips, cables and connectors, and to perform routine maintenance tasks with ease.



Included in the kit are: a screwdriver handle with 1/8" slotted screwdriver, No. 1 Phillips screwdriver and 3/16" and 1/4" nutdriver blades: CMOS-safe insertion/extraction tool with built-in pin straightener; screw starter; and disposable penlight. The tools are contained in a compact 7" × 7" × 1" zippered vinyl case.

CIRCLE 7 ON FREE INFORMATION CARD

Clamp-On Digital Meter

A low-cost hand-held digital clamp-on meter that measures dc and ac current right on a conductor is available from Extech Instruments (Waltham, MA). The Model L380901 meter also offers a full range of multimeter functions, including measurements of ac and dc voltage, current, resistance and diode check, using standard

probe-type test leads. Ac voltage and current ranges are calibrated in rms. The clamp-on arrangement provides a 400-ampere ac and dc range.

A peak-hold function permits recall of a current surge. A plug-in type K thermocouple adapter that works on the meter's 200-mV dc range allows the DMM to measure temperatures from −50.0 to +199.9 degrees F or C.

A large 3½-digit LCD window displays values being measured and includes low-battery and overload indicators. The meter comes with an impact-resistance case. $99.

CIRCLE 9 ON FREE INFORMATION CARD

Programmable Hand-Held Scanning Monitor Radio

Regency's Model HX1200 keyboard programmable hand-held scanner can receive more than 15,000 frequencies from eight different bands. Band coverage includes: vhf-low (30 to 50 MHz), vhf-aircraft (118 to 136 MHz), vhf-Amateur (144 to 148 MHz), vhf-high (148 to 174 MHz), Federal and Government Land Mobile (406 to 420 MHz), uhf-Amateur (440 to 450 MHz), uhf (450 to 470 MHz) and uhf-T (470 to 512 MHz). The scanner comes programmed with 45 popular frequencies, but frequencies are easily changed via the keypad. An LCD display shows the frequency entered and flashes messages to aid in programming.

Additionally, the scanner can search an entire band to find active new frequencies. When a call is received, searching can continue or the user can store the new frequency in memory.

Features include a priority channel, channel lockout, scan delay and direct channel access. A drop-on charger and vehicle cigarette lighter dc adapter are available as options. Dimensions are 1 9/10"H × 3¾"W × 7¾"D, and it comes with a carrying case.

CIRCLE 8 ON FREE INFORMATION CARD

AT Lookalike Computer

The Gemini Advantage Processor (GAP) from Gemini Electronics (Longwood, FL) is an IBM PC AT

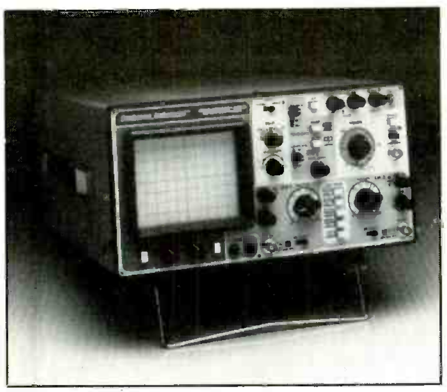
lookalike computer built around an 80286 microprocessor that runs at a selectable 6 or 8 MHz and has the capability of running at 10 MHz. The GAP comes with 1M byte of user RAM on its main board with two selectable memory maps and an 80287 interface.

Featured are 12 expansion slots, six with 16-bit buses. There are five half-height drive positions, with four accessible through the front of the system unit's case. Data can be secured with a key lock that locks the main unit's case and the keyboard's data line. Power for the system is supplied by a 230-watt power supply that features an external fuse and a 110/220-volt switch. $1,995.

CIRCLE 11 ON FREE INFORMATION CARD

Compact Oscilloscope

New from Beckman Industrial is the Model 9020 compact dual-trace,



20-MHz oscilloscope with built-in sweep delay and component tester. Its maximum sweep speed is 50 ns/division, and sensitivity is rated at 1 mV/division. The scope's 6″ CRT provides a variety of displays, including: channel 1 only (normal or inverted), channel 2 only, alternate, chop or channel 1 plus channel 2. An XY feature is also standard.

The 9020 permits either mono or dual display and comes equipped with a "hold off" feature that maintains an easy-to-read stable display. $495 includes two ×1/×10 probes and operating manual.

CIRCLE 10 ON FREE INFORMATION CARD

Boat & RV TV/FM Antenna

The "Omni-Ceptor" omnidirectional vhf/uhf/FM antenna from Winegard (Burlington, IA) is designed specifically for boats and recreational vehicles. A built-in amplifier allows the Model MR-30 antenna to pick up signals from any direction without having to rotate it while moving.

A vhf/uhf band separator, 30 ft. of coaxial cable, connectors and a weather boot are included with the antenna. All mounting hardware is stainless steel to resist the elements.

A clamp assembly allows the antenna to be mounted to a horizontal or vertical pipe up to 1¼″ in diameter for marine users; a separately available mount for RVs sets up the antenna in a fixed position just 12″ above the roof, eliminating the need to crank the antenna up and down. The antenna's power supply is 12-volt dc/117-volt ac switchable.

The antenna measures 22″ in diameter and 6½″ deep and is completely sealed in a tough ABS plastic housing for protection against the elements. $139.95.

CIRCLE 13 ON FREE INFORMATION CARD

Variable Power Supply

An economical 0-to-30-volt, 3-ampere regulated dc power supply with low ripple characteristics has

been introduced by B&K-Precision. The Model 1630 supply features regulated outputs for both voltage and current; built-in metering; a preregulator that limits internal dissipation; an isolated output so that either polarity can be floated or grounded; and reverse polarity protection.

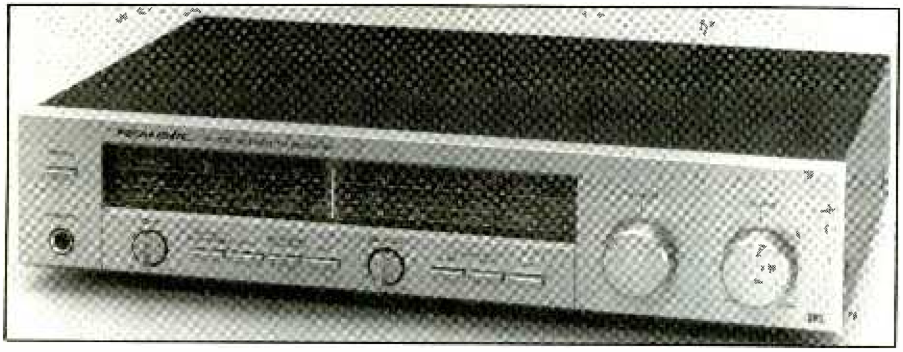
Full current limiting from 5 to 100 percent of maximum output current protects both the power supply and any circuit test. Two Model 1630 supplies can be connected in parallel to provide a 0-to-30-volt output at up to 6 amps or in series to provide a 0-to-60-volt output at up to 3 amps.

Supplied with the Model 1630 are test leads, schematic and parts list, and instruction manual. $225.

CIRCLE 12 ON FREE INFORMATION CARD

Stereo TV Sound Receiver

Radio Shack's Realistic Model TV-100 stereo TV sound receiver needs only a pair of speakers to give you the full effect of true stereo broadcasts. Completely stand-alone,



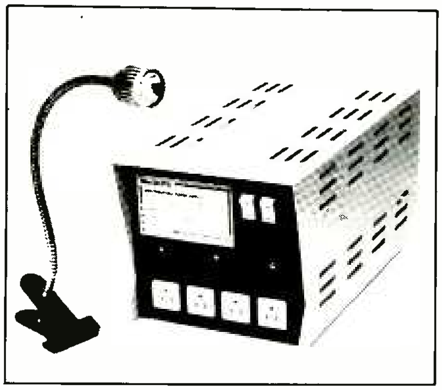
it does not require connection to your TV receiver to provide two-channel sound. You simply connect it to your antenna (or cable) lead-in, connect a pair of speakers, turn on the power and tune in the desired channel's frequency. Tuning is via a rotary control and readout is on a slide-rule dial. Switches are provided for selecting the low-vhf, high-vhf and uhf bands.

In addition to a true stereo function, the Model TV-100 offers stereo synthesizer, mono and special-audio-program (SAP) modes. An auxiliary input can be selected by pressing a front-panel switch. Other controls include: a power switch and tone, balance and volume controls. LEDs automatically light when a station is broadcasting in stereo or SAP. $139.95; $149.95 with two Minimus 2.5″ speakers.

CIRCLE 14 ON FREE INFORMATION CARD

Uninterruptible Power Supply

Electronic Specialists is now marketing an uninterruptible power supply that is capable of supplying up to 20 minutes of power during extended



power outages. The on-line unit is said to operate without distruptive switching transients. It contains wideband emi/rfi filtering and high-speed, high-current spike suppression for extended protection, with additional protection provided by an integral overload/short-circuit-proof design.

Automatic internal battery recharging is incorporated into the system. A front-panel TEST switch permits convenient power removal to check panel monitors and complete system operation. Line phase lock, automatic Blackout illumination, Battery-Saver automatic shut-down option and external battery option are also featured. The uniterruptible power supply is available in 250- and 500-watt versions.

CIRCLE 18 ON FREE INFORMATION CARD

TVRO Installer's Filter Kit

A filter kit that is designed to help satellite TV system installers cure more than 80 percent of terrestrial interference (TI) at TVRO earth stations is available from Microwave Filter Co. (E. Syracuse, NY). Included in the No. 4957 kit is a microwave bandpass filter than passes all 24 transponders but suppresses microwave interference at frequencies be-

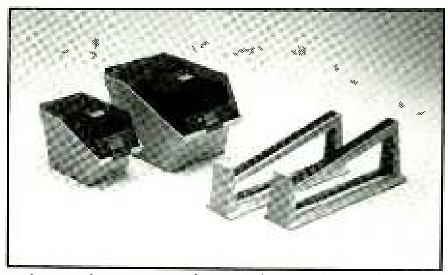
low or above the entire TVRO band. A switchable i-f test trap for 60 and 80 MHz can be used to diagnose TI. It can be left in place to suppress TI, but three lower-cost fixed traps included in the kit for 60, 80 or both 60 and 80 MHz combined provide a more economical solution.

A narrow-band i-f filter solves problems due to environmental conditions other than TI. This filter can be switched in and out as needed. Also included in the kit is a practical field manual of solutions to a full range of TI problems and two 36″ type F cables. The kit comes in a key-locked carrying case with interior cushioning. $525.

CIRCLE 15 ON FREE INFORMATION CARD

Space-Saving Computer Accessories

Allsop Computer Products' new Universal Printer Stand and diskette storage boxes are designed to save workspace. The two-piece printer stand uses no more space than the printer itself. It adjusts to fit all pop-



ular printers and positions the printer at the optimum angle for viewing while seated. It has vibration/noise-absorbing foam pads and recessed rubber feet that prevent sliding.

The plastic Disk File/60 and Disk File/30 Micro storage boxes accommodate 60 and 30 diskettes, respectively, and have see-through lids. They are said to occupy less space than other boxes with the same disk capacities, whether open or closed. Both have built-in handles and spring-loaded lid latches; an advanced hinge design that keeps the lids in the up position; and adjustable dividers that support the disks at an easy-view 20-degree angle.

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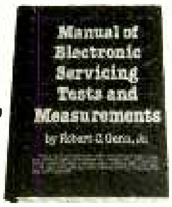

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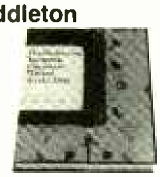

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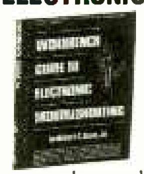

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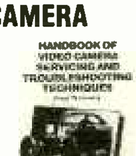

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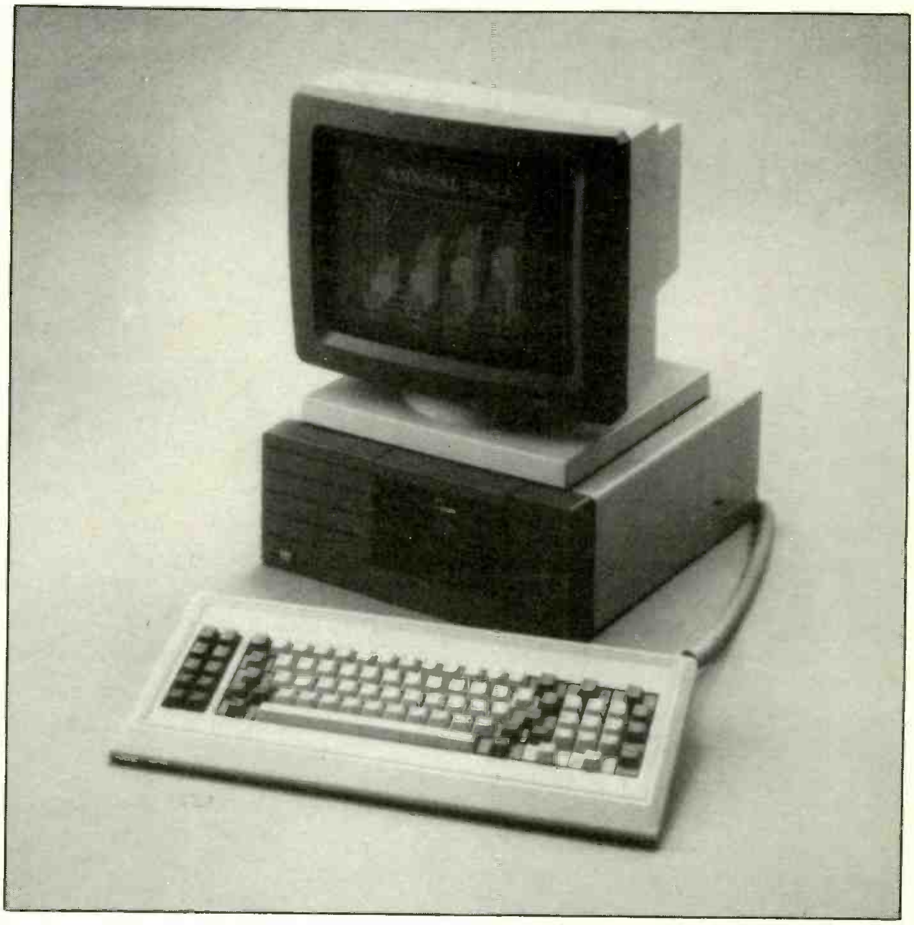
Computers

ITT's Xtra XP Computer: A Supercharged IBM PC XT Compatible

IBM sets the *defacto* standards in the computer world, but some followers come up with more exciting, higher performing machines with competitive prices. One such desk-top microcomputer is ITT's Xtra XP model.



A major contributor to its improved performance is the Xtra XP's true 16-bit 80286 microprocessor that operates at a speedy 6 MHz (as contrasted to the PC XT's 8/16-bit 8088 processor's 4.77-MHz operating speed). Proprietary software routines helps, too, as does a zero-wait-state RAM system.

ITT's Xtra XP (extra power) is available in two basic versions. For this report, we examined the Mod V with a 20M-type hard-disk system, 360K-byte floppy disk drive, 1.6M bytes of RAM and an RGB color video monitor. This configuration has a suggested retail price of $6,020.

The basic Mod V computer with 512K of RAM, 20Mb hard-disk system and one floppy-disk drive is priced at $4,595. The lower-cost Mod III version is configured the same as the basic Mod V, but has 10Mb of hard-disk capacity instead of the Mod V's 20Mb and is priced at $3,995. Add $370 for a monochrome display (amber or green) and adaptor for $685 for the color display/adaptor. Serial and parallel parts are standard. A speaker output jack, RCA pin type, is provided, too.

System Overview

Following IBM's lead, ITT supplies the Xtra XP in three pieces: a system unit, detached keyboard and video display monitor. The two-tone beige system unit is 5.6"H and has a footprint of only 15.6"D × 14"W, which is about 30% smaller than that of the IBM PC XT. Removing two screws allows the system unit's cover to be removed for full access to the interior of the computer.

Up front are a half-height 360K floppy-disk drive and immediately below it is a half-height 20M hard-disk system. There are no internal space provisions for adding a second floppy disk drive, however, which contributes to its relatively compact dimensions, as does three expansion slots less than the IBM PC XT's eight. (However, the built-in RS-232 port and having the diskette controller and memory expansion provisions on the motherboard makes up for the fewer slots.) On the rear panel are a male DB-25 connector for the RS-232 serial port, a female DB-25 connector for the Centronics parallel port (both come standard in the basic computer), the keyboard connector and the POWER switch.

Inside the system unit is a motherboard with five IBM PC XT-compatible expansion slots. Only the outermost slot can be used to expand user RAM to its maximum of 1.64M bytes, however, because of the expansion board's need for the usual 64-pin connector plus a 40-pin connector. The motherboard can accommodate 640K of RAM, as compared to only 256K on the PC XT's motherboard.

A socket is provided for an 80287 math coprocessor. The instruction set of the main 80286 processor expands upon and uses the 8088's instruction set as a subset. The 80287 coprocessor provides fast number crunching capability when used with software to support the coprocessor.

The ITT Xtra XP uses the same graphics modes used in the IBM PC XT—320 × 200 in medium and 640 × 200 in high resolution. ITT offers a monochrome and two color boards; however, the computer can use any monochrome or color board available for the PC XT.

Some features of the ITT color video monitor used with the Xtra XP computer for this review are particularly attractive. First is a built-in tilt-and-swivel base that makes it easy to adjust screen orientation for comfortable viewing wherever the monitor is located. The second is a 14" diagonal measurement for the screen, along with its 0.31-mm dot pitch and nonglare etched faceplate that give clean, sharp and easy-to-read text.

A splendid user's guide that discusses the basics of the computer and its advanced features, as well as use of the built-in ROM-based diagnostics monitor, is supplied with the computer.

Upon power-up, the machine performs a self-test and parity check. Built-in diagnostics provide detailed analysis of CPU, interrupts, DMA, video and memory through keyboard control. (Happily, the memory test is internal-switch defeatable.)

The Keyboard: Improving on the Standard?

Almost identical to that of the IBM PC XT's keyboard, the one supplied with the ITT Xtra XP computers has positions of the SHIFT and backslash keys transposed. The ITT's is in the preferred position.

Among other improvements noted for the Xtra XP's keyboard that the IBM PC XT doesn't feature are the use of legends (rather than symbols) on such keys as TAB, SHIFT and RETURN; LEDS in the NUM LOCK and CAPS LOCK keys; wider RETURN key; and a convenient ENTER key on the numeric keypad.

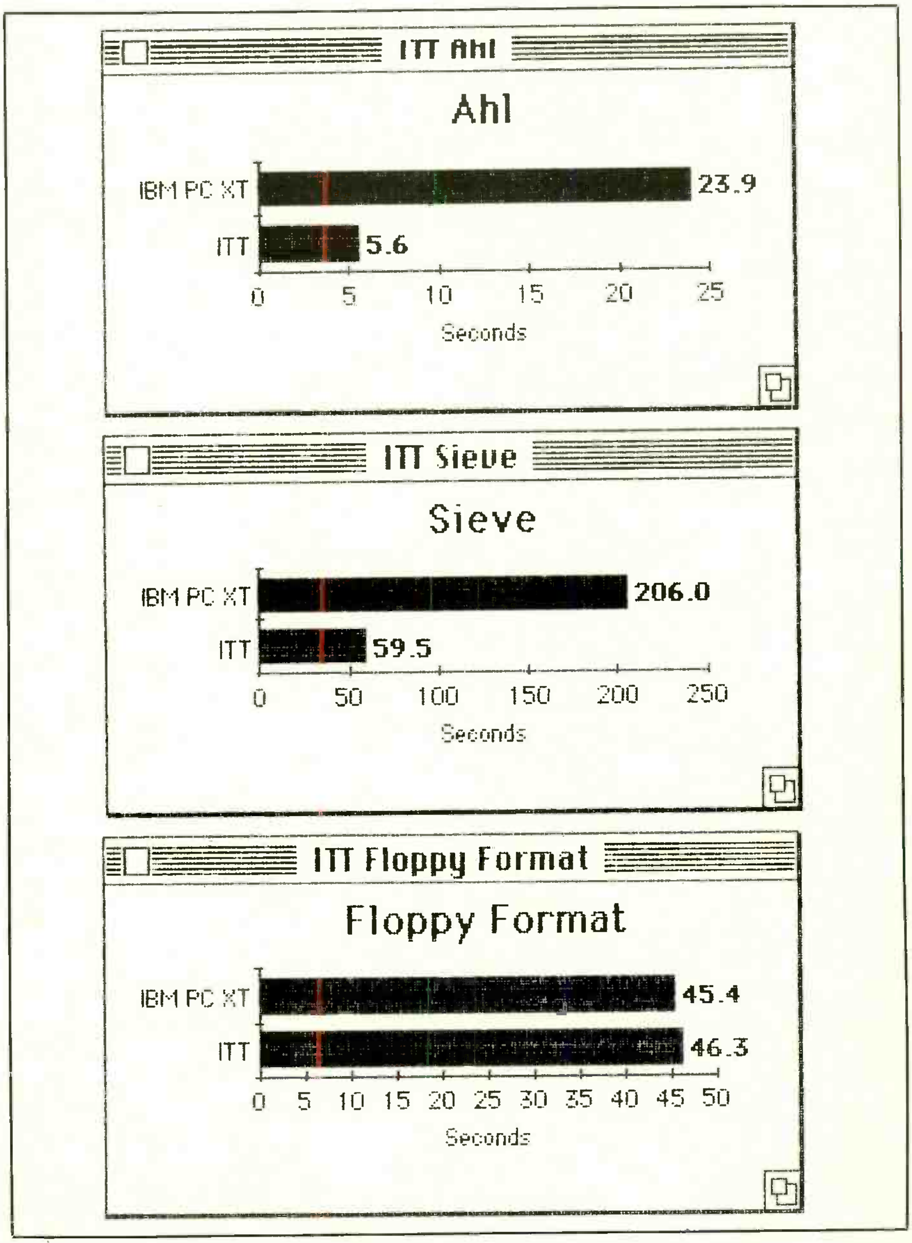
Mass Storage: Panacea or Pain?

ITT Xtra XP computers come with either 10 or 20 megabytes of hard-disk mass storage and one 360K-byte double-sided, double-density floppy-disk drive. The standard-performance hard-disk system has an average access time of 85 ms and is similar to the hard-disk drive used in the IBM PC XT.

In light of ITT's intention to make the Xtra XP into a high-performance PC XT-compatible computer, one might wonder why the company chose to use a standard-performance hard-disk system when high-performance systems with only 40-ms access times are available. According to ITT, two factors favored the standard-performance system. First was reliability. Even a year after introduction of IBM's more costly PC AT computer, its high-performance hard-disk system (drive and controller) is still plagued with system failures.

A second factor was price. High-performance systems cost about twice what standard systems cost. Balancing the speed improvement of the high-performance system against its poor reliability record, to date, ITT appears to have made a wise choice in going for the standard hard-disk system.

Although the Xtra XP computers are



Run times of three performance benchmark programs are plotted for ITT's Xtra XP and IBM's PC XT computers. Note the much faster execution times for the ITT computer in the first two plots.

touted to be much better versions of the PC XT, I'm surprised that ITT did not include an *automatic* head-parking function in the hard drive on power-down. (Though this feature isn't standard for standard-performance systems, it can be and has been available in other products.)

Even though head parking is a simple matter (while in the operating system, you simply type "Spindown," followed by a carriage return to accomplish it), the danger is that a user might forget to do this before powering down. If this happens, accidentally bumping the computer or moving it to another location can damage the head and or media. Spindown parks the head in a safe area or the disk.

The Software

Although the disk operating system is very similar to IBM PC DOS 2.1, ITT DOS 2.11 adds some enhancements that are available only in the later PC DOS 3.1. Foremost of these is VDISK, which sets up a RAM disk. Another is ATTRIB, which sets the read-only attribute of a file. Yet another is LABEL, which is used to create, change or delete a volume label.

By far the most important software improvement ITT brings to the Xtra XP is a utility called FXP. This program sets up a specified block of RAM as a disk cache that's used to enhance disk access times.

When FXP is in operation, all disk drive activity is monitored by the computer. Whenever a program requests data from disk, FXP first checks to see if it's in the cache. It it isn't, FXP loads the entire disk track that contains the data into cache RAM. Data that the program needs is then passed to it. If requested information is in the cache, the disk is bypassed and the data is sent directly to the program with blazing electron speed.

To further enhance operating speed, FXP uses "elevator" writes. If no writes are made during a 1-second or so period, FXP begins writing modified tracks to disk. Instead of writing to disk randomly, the track nearest the current position of the disk head is written first, followed by the next nearest, and so on, until all modified tracks have been updated. This procedure is similar to the manner in which an elevator operates. Passengers may request different floors in a random order, but the elevator stops at each floor nearest its current location in the direction it is moving, in an orderly, efficient manner.

As more and more data is requested from disk, cache RAM eventually fills up. When further data is requested from disk, the least frequently used track in cache is replaced with new tracks from the disk.

In use, the FXP disk cache is transparent to the user. Once placed in the autoexec file, no further reference need be made to it! All buffers are *automatically* written to floppy and hard disks so there's no need for manual transfer of files from RAM to disk before powering down the computer. Moreover, data is also placed in a print RAM buffer partition. Memory space not used for this purpose is automatically employed in speeding up disk operation.

As you can see, the cache system is vastly superior to a "RAM disk" system, which requires a different operating method to get it going and to ensure that data isn't lost by forgetting to save it.

ITT's DOS disk also contains BASIC Version 2 and ASYCOM, which is a communications program.

Compatibility Picture

Fundamentally, the Xtra XP is a fine IBM PC XT clone. It emulates virtually 100 percent of the PC XT's functions. Though the Xtra XP comes up in the 6-MHz mode, the slower speed required by some PC XT software can be selected simply by pressing CTRL-ALT-/ to achieve a very high degree of software compatibility. Even so, one soon discovers that the Xtra XP isn't *totally* compatible with the IBM PC XT.

In actual tests, we were able to load and run a wide range of "standard" compatibility-test software in an Xtra XP. However, we did have a problem trying to install Ashton-Tate's Framework II, even though it's claimed to support the ITT computer. (We had no such problem installing the original version of Framework.) The problem is apparently due to Framework II's new copy-protection scheme.

We didn't try a great many software packages written for the PC XT in the Xtra XP, but those we did try (Lotus 1-2-3, WordStar and other major packages) all worked as expected. In most cases, they ran with blinding speed, when compared to the more leisurely pace we've experienced with the PC XT. Furthermore, it far surpasses the much costlier IBM PC AT's operating speed when working with complex spreadsheets, among other applications, when used in its FXP mode.

There are some unusual circumstances where software designed for an 8088 CPU executes differently than an 80286 does and, therefore, the ITT machine won't run it properly; neither will the IBM AT, for that matter.

In the hardware area, we see no reason why virtually any board designed to operate in the PC XT won't work equally well or better in the Xtra XP. Again, we didn't try a great many plug-in boards, but those we did try (all popular standards) worked without a hitch.

How it Performed

The proof of the ITT Xtra XP's "extra power" can be seen in two benchmarks we ran: The Sieve of Eratosthenes and Ahl's Simple Benchmark. As is evident from the charts, the Xtra XP completed the tests three to four times faster than the PC XT.

In another series of tests, a 467K database with 585 records (PFS Test 1) and a 57K database with 146 records (PFS Test 2) were searched using PFS File on both machines. In the first test, a search was conducted for the 200th record in the file. The Xtra XP found the record four times faster than did the PC XT. The test was rerun to determine the effect of ITT's disk cache. Notice that due to the large size of the file relative to the size of the 512K cache, there was no increase in performance the first two times any record was searched. Subsequent use, however, illustrated the advantageous automatic changes made by the disk-cache system. Operations were speeded up with each successive use, setting in at 5.8 seconds in

(Continued on page 82)

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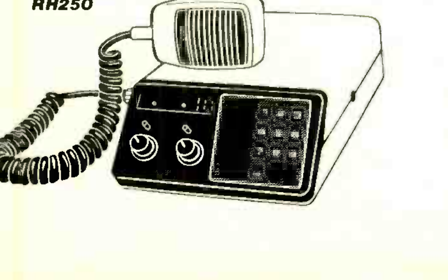

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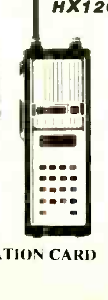

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By Bill Owen

The Energy Auditor to be described here will shed light on the amount of electrical energy an applicance uses so that you can take appropriate action to cut back on its use or budget properly for anticipated utility bills.

The device is a digital electronic meter that, when connected to an air conditioner, furnace or other electrical load will display the accumulated cost of electricity in dollars and cents. Continuous monitoring of electrical consumption makes it possible to set up realistic budgets in just a few days, rather than making you wait the usual 30 days in a billing cycle. It will also enable you to quickly verify the claimed energy savings with a new appliance, allowing enough time for you to return it if it does not meet "specs."

General Comments

The Energy Auditor totalizes and displays pulses generated at a rate that is proportional to the cost in dollars in electrical power consumed while the appliance being monitored is operating. Pulses are generated within the project by a precise voltage-controlled oscillator (vco). Current to the load is sensed and enables the vco's output. (In the case of direct thermostat connection, closure of the heating or cooling contactor is sensed.)

Cost per hour to operate the load can be measured, calculated or estimated. In any case, the value used must be averaged for a given period of time. Fortunately, the unit cost per

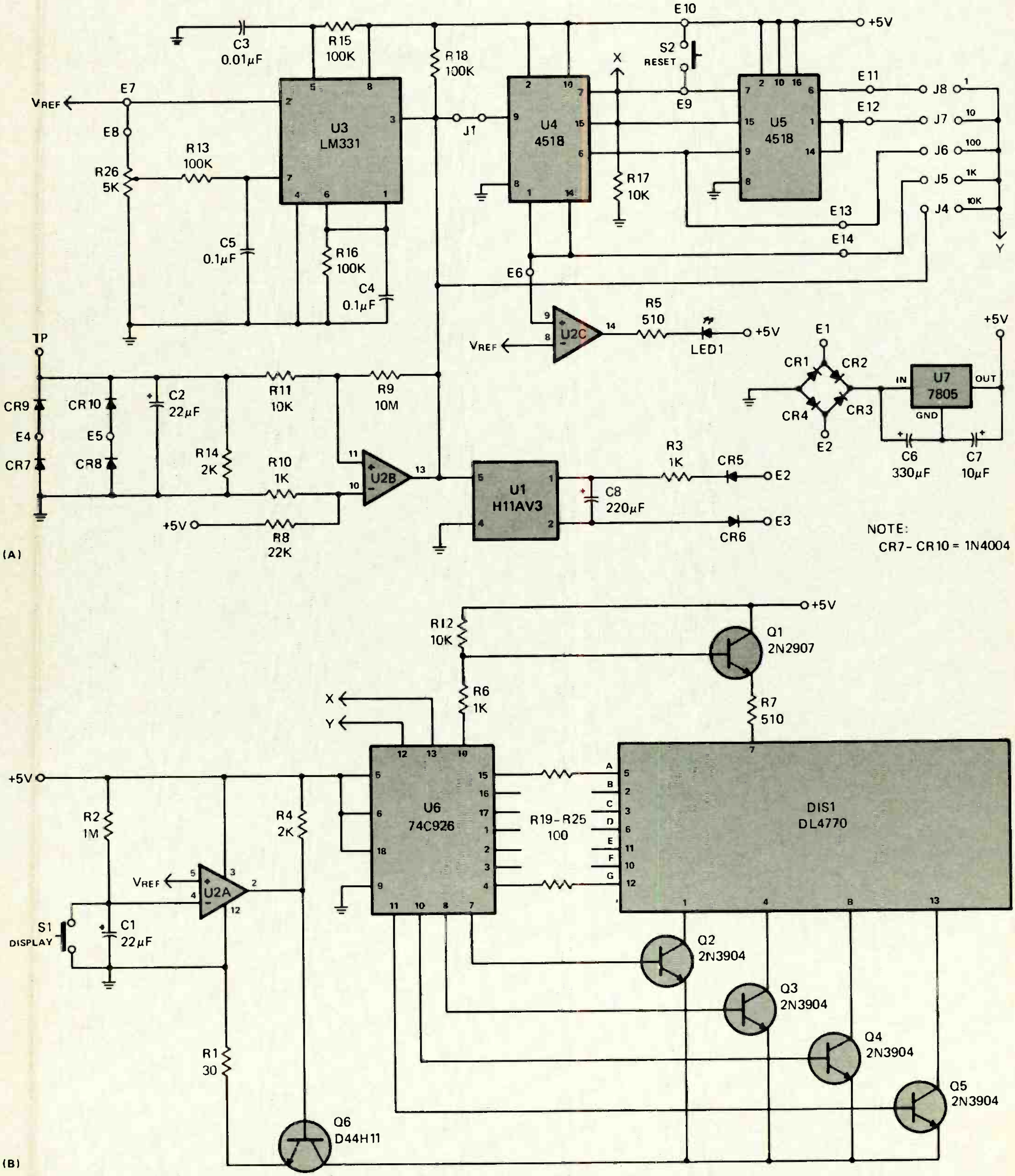


Fig. 1. Note in this overall schematic diagram of the Energy Auditor that its circuit uses a combination of analog and digital ICs to provide a direct readout in dollars of energy consumed by an electrical appliance.

PARTS LIST

Semiconductors
CR1 thru CR10—1N4004 or equivalent rectifier diode
DIS1—DL4770 4-digit common-cathode LED numeric display
LED1—Red light-emitting diode
Q1—2N2907 pnp transistor
Q2 thru Q5—2N3904 npn transistor
Q6—D44H11 npn transistor
U1—H11AV3—Optocoupler
U2—LM339 comparator
U3—LM331 voltage-controlled oscillator
U4,U5—4518 dual up-converter
U6—74C926 counter/display driver
U7—7805 5-volt regulator

Capacitors
C1,C2—22-μF, 35-volt electrolytic
C3—0.01-μF polystyrene
C4,C5—0.1-μF monolithic
C6—330-μF, 35-volt electrolytic
C7—10-μF, 35-volt electrolytic
C8—220-μF, 25-volt electrolytic

Resistors (¼-watt, 1% tolerance)
R1—30 ohms (2 watts)
R2—1 megohm
R3,R6,R10—1000 ohms
R4,R14—2000 ohms
R5,R7—510 ohms (5%)
R8—22,000 ohms
R9—10 megohms (5%)
R11,R12,R15,R17—10,000 ohms
R13,R16,R18—10,000
R19 thru R25—100 ohms (5%)
R26—5000-ohm, 22-turn Trimpot

Miscellaneous
S1,S2—Normally open momentary-action pushbutton switch
Printed-circuit board; suitable cabinet; current-sensing transformer (see text); conductive foam switch (see text); ac adapter; zip cord; hookup wire; solder; etc.

Note: The following are available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307: complete kit of parts (not including ac adapter) for $39.95 plus $1.75 P&H; optional AC-2 adapter for $6.95; individual parts (send query). Florida residents, please add sales tax.

hour is fairly consistent for most household loads. You can calculate the cost per hour for a given appliance by multiplying the wattage of the load by the current cost per kilowatt hour (kWhr). The electric rate is the total amount for electricity on your utility bill, divided by 1000 to give you the kWhr rate. Most utility companies also indicate separately on your bill the cost per kWhr for the billing period.

Using the formula Cost per hour = Load in watts × (Cost per kWhr/1000), I calculated the hourly cost of a 42-gallon hot-water heater that uses a 4500-watt heating element as follows, using a 10-cent per kWhr electric rate. The cost per hour = 4500 × ($0.10/1000) = $0.45 (or 45 cents) per hour. This is how much it would cost every hour the heater is on.

However, hot-water heater elements switch off and on according to the temperature of the water inside the tank. The Energy Auditor totals the running time and displays total cost for actual usage. Using a meter, I discovered that the water heater actually consumes 3850 watts (16.25 amperes × 236 volts). Plugging these measured values into the equation, the cost became 39 cents per hour.

If you do not have an ac voltmeter and ammeter to make actual readings, the calculated value will be adequaate and, more importantly, will give you an accurate indication of your savings. For example, if the heater element thermostat is turned down, running time will decrease and the Energy Auditor will indicate the change.

A central air-conditioning system pulls 17.5 amperes at 236 volts, which translates to 4130 watts. Full-load compressor power is listed on the name plate as 18 amperes. Either the calculated or the actual measured value can be used in this example. When plugged into the above equation, cost becomes 42 cents per kWhr.

In the case of the hot-water heater, the Energy Auditor must be calibrated for 39 pulses per hour, the air conditioner for 42 pulses per hour. In either case, power consumption of the load can be measured or determined from the electrical data plate found on the appliance.

About the Circuit

In the schematic diagram shown in Fig. 1, precision voltage-controlled oscillator (vco) *U3* generates a series of pulses, the exact frequency of which is adjusted by trimmer control

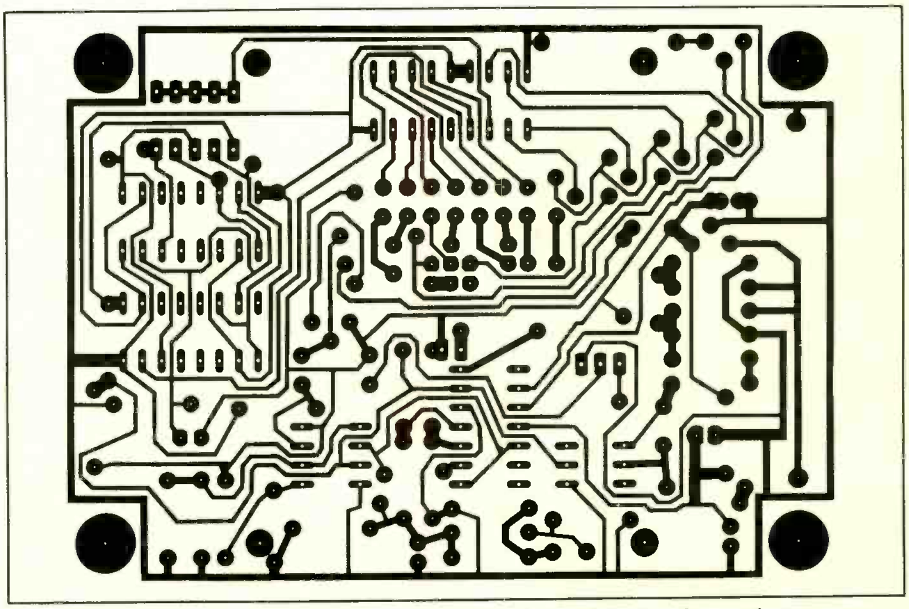
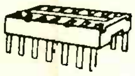


Fig. 2. Actual-size etching-and-drilling guide for the project.

214-234-8116 ELECTRONIC SURPLUS SPECIALS 214-234-8105

MACHINE PIN SOCKET



22 PIN GOLD PLATED SOCKET
5 pcs $1.00
Stk. #ICS-22M

CIRCUIT BOARD BONANZA

Soung generator boards removed from electronic pin-ball games. Contains oscillators, control circuits & 2 watt audio amp. Experimenters dream!!!
$2 ea — 10/$12.50 w/schematics

5V & 12V REGULATOR BOARD
Regulator board containing 5V & 12v TO-220 regulators, fuses, bridges, caps & I/O connectors. Size 2"x4" w/heatsinks.
REG-512 .... $3.50

RECTIFIER BOARD
Contains (4) 10 Amp bridges, (3) large filter caps, & I/O conn. Size 4.5"&8"
BRDG-4 .... $2.50ea or 10/$12.50

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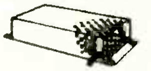
Circuit board removed from SINGER electronic calculators. Has 20 linear & cmos IC's & a wealth of other parts.
BD-20 ..... $2.50 ea or 10/$12.50

POWER SUPPLY
MFG. BY GENERAL INSTR.



INPUT: 110VAC
OUTPUT: +5VDC @ 5AMPS
+12VDC @ 2.5AMPS
-12VDC @ 3AMPS
PS-120 .... $24.50
Used is some Commodore comp.

LOW PROFILE SOCKETS (TIN)

# OF PINS	PRICE
8	$.08
14	$.10
16	$.12
18	$.15
20	$.18
22	$.18
24	$.20
28	$.25
40	$.30

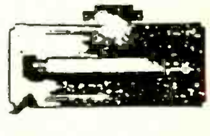
ELECTRONIC PIEZO BEEP BUZZER
Special — 2/$1.00
7/8" Diameter element on plastic mounting. Originally used in Radio Shack telephone as the ringer.
Stk. #PZO-78 .... $.75

ULTRAVIOLET TUBES GOOD FOR EPROM ERASERS
110 VAC
$2.25 ea. — 10/$15.00

8" DRIVE POWER SUPPLIES
$24.50

8" DISK DRIVE POWER SUPPLY
Heavy duty supply can run up to 4 drives. Enclosed frame. Input 117VAC. Output: 5VDC @ 7 Amps; +24VDC @ 6 Amps; -24VDC @ 6 Amps.
Stk #PS-8 .... $24.50

BUILD YOUR OWN EPROM ERASER



115VAC BLACK LIGHT (ULTRA VIOLET)
115 volt ultra violet light, with lamp, ballast and in-line cord switch. Just build enclosure to finish.
Stk. #EPB-125 .... $12.50

$.75 ROCKER SWITCH
16 Amp On/Off
Used in Xerox 820 Computers

Full Wave Bridge
6AMP-300V
2/$1.00

MINI-TOGGLE SWITCH
5AMP DPDT
$.65 EA
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SNAP ACTION SWITCH
MICRO-SWITCH ASS'T OF 10
$2.50
STK #500-10M

DISK DRIVE MOUNTING SCREWS
20 for 50¢

COMPUTER POWER CORDS
$1.25 EA — 10/$10

12 VDC TOY MOTOR
Stk. #MO-12 .. 2/$1.00

COMPUTER GRADE CAPACITORS
Ass't of 10
Stk#CCG-10 .... $2.50

CPM DISKETTE FOR USE WITH NEC V-20 PROCESSORS
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WALL PLUG ADAPTERS
6VDC @ 300ma
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ISOLATION TRANSFORMER
117VAC
117VAC @ 125VAC
MFG BY SIGNAL TRANS
$3.00 Each 10/$20.00

RIGHT ANGLE HEADERS

40 Pin	$.40
34 Pin	$.50
10 Pin	$.25

TRANSFORMERS

STK.#	PRI (VAC)	Secondary (VAC)	Price
TN-6.3	117	6.3 @ 300ma	$1.25
TN-12	117	12 @ 400ma	$1.35
TN-24A	117	24 @ 200ma	$1.25
TN-24B	117	24ct. @ 3.6 Amp	$3.50

HEAT SINK
TO-3
$.25

LOAR RESISTOR FOR IBM POWER SUP.
5 Ohm @ 25 watts
$1.79
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General purpose compact power supply. 3 outputs: +5V @ 1 Amp, +12V @ 1 Amp & +24V @ 1 Amp. Power Transistors mounted on a heat sink 2"x4" w/transformer. Stk #PS-3P $4.49

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Model No. TC-1M converter. Both Mid-Band & VHF frequencies. Has built in power supply. Units are new & in working cond.
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RIBBON CABLE

9 conductor Spectrastrip with red market stripe. 250' per roll. 28ga. stranded wire.
WRIB-9 .... $10/Roll
20 conductor spectrastrip with red market stripe. 100' per roll. 28ga. stranded wire.
WRIB-20 $.30/ft. or $25/roll
34 conductor spectrastrip with red marker stripe. 100' per roll 28 ga. stranded wire.
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ALL SIZES & VALUES
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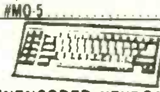
for robotics, precision movement applica-tion etc.
STEPPER MOTOR
(Unifilar Wound)
5 VDC 3½ Watts 7.5°X
48 Step/Rev. 28 RPM
Stk. #MO-5 .... $3.50

UNENCODED KEYBOARD



Full size kybd. w/number pad. 70 keys w/LED power indicator. Orig. from dumb terminals. New!!! Mfg by Hi-Tek
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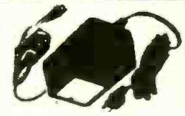
VINYL DISKETTE HOLDER
Holds 2 5¼" diskettes. Has 3 hole punch to mount in standard loose leaf folder. Stk #- VIN-5 .... 10/$2.50
For standard 8½x11

ATARI GAMES
ATARI GAME ROMS
An assortment of 10 Atari game ROMs. Simply open any Atari cartridge & replace the existing ROM with a new one. Play another 10 games instantly.
Stk. #ROM-10 .... 10/$2.50

$6.95
Stk. # WTN-1810



XEROX 1810 Power Transf.
Extremely Hard To Find!!!

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Stk #WTN-4860 .... $16.95

ATARI REPLACEMENT POWER SUPPLIES

11.5 VDC @ 1.95 AMP
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Delta Design Table Top Temp. Chamber	$100
Altos Computer	$250
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Box of 50 pcs waveguide & antenuators	$100

CALL FOR OUR NEW FLYERS

APPLE III MEMORY EXPANSION BDS
$15.00
w/OK memory

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12 POS KEY PAD
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2" Bar Magnet with Tape On One Side
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COMPUTER SPEAKERS
2.25" 8 ohm .25 watts
This is the same speaker that IBM uses. Excellent for computer builders.
Stk. #SPK-8 .... $.65

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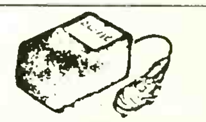
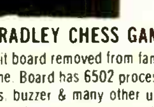


For TV game & computer peripheral equipment. Rated 110VAC input. Ouput +5VDC @ 860MA, +12VDC @ 300MA & -12VDC @ 300MA. Model #WM-113
Stk. #WTN-113 .... $6.75

COMPUTER CHESS GAME



MILTON BRADLEY CHESS GAME
Electronic circuit board removed from famous toy maker's game. Board has 6502 processor, 74LS series ic's, buzzer & many other useful components. Boards are complete and undamaged. MB part #7924243001
BD-792 $3.95 ea. .... 10/$24

Components Ass't
Your Choice $2.75

Stk#	Description
CD-180	Ceramic Disk Capacitors 10 pcs of 18 different values. 180 pcs total
CE-180	Electrolytic Capacitors 10 pcs of 18 different values. 180 pcs total
CM-180	Mylar Bypass Capacitors 10 pcs. of 18 different values. 180pcs total
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TANTALUM CAP ASS'T
10 pcs
$2.00

COILED CORD BONANZA
4 Conductor coiled cord. Black vinyl jacket. Extends to 6 ft. No connectors on either end.
Stk. #CC-000 .... 3/$1.00
4 Conductor coiled cord. Black vinyl jacket. Extends to 6 ft. Phone connector on one end and no connector on the other.
Stk. #CC-020 .... 2/$1.00
4 Conductor coiled cord. Grey vinyl jacket. Extends to 6 ft. Used as keyboard cable. Phone jack to 5 pin din connector.
Stk. #CC-100 .... $4.00

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18 Guage rubber coated. Red, black, white or blue .... 100'/$13
HOOK-UP WIRE
24 Guage stranded cond. 22 guage solid conductor, your choice .... 100'/$2
WIRE WRAP WIRE
30 Guage solid cond. Choice of colors.
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3 VOLT LITHIUM BATTERY
Used as battery back-up on most multi-function cards.
Mallory BR 2325
$1.00 EACH — 10/$5.00

CERAMIC DISC CAPACITOR ASS'T
200 pcs
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TV-GAME SWITCH
$.65 EACH
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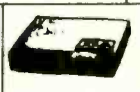
ULTRA-SONIC TRANSDUCER
Don't know what these came out of but this is a doozey of a device. Unit is an aluminum cylinder containing a piezo ceramic with an adjustable coil in parallel. Frequency is 24 khz. Can be used in many ultrasonic circuits.
Stk. #ULT-58 .... $2.25

TOCOM 55 PLUS CABLE TV CONVERTER
55 CHANNEL CONVERTER



Complete Unit — $24.50
Mainboard — $7.50
Power Supp. — $4.50
We Received A Large Shipment Of These Cable Converters. Good Savings!

COLECO JOYSTICKS
$2.50 EACH
10/$17.00

CRYSTALS

Frequency	Case	Price
4.0MHZ	HC18	$1.25
6.0MHZ	HC18	$1.25
8.0MHZ	HC 18	$1.25
10.7MHZ	HC 18	$0.75
14.318MHZ	HC 18	$1.25
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VOLTAGE REGULATORS

7805	5v	1.5 amp
7812	12v	1.5 amp
7824	24v	1.5 amp
7905	-5v	1.5 amp
7905	-5v	1.5 amp
7912	-12v	1.5 amp

$.43 Each

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CIRCLE NO. 138 ON FREE INFORMATION CARD

R28. Dual decade counters *U4* and *U5* divide the output of the vco by 10, 100, 1000 and 10,000, respectively. The four divided outputs and the direct vco output are available for counting by 4-digit counter/LED digit driver *U6*. The appropriate count input is selected by jumpers J4 through J8. By selecting a jumper and adjusting *R28*, counts per hour from 10 to more than 1-million are obtainable, even though maximum display is limited to 9999. (Note that J4 through J8 can be either jumpers or via separate positions in a DIP switch.)

Counter/driver *U6* multiplex drives common-cathode display *DISI* through segment limiter resistors *R19* through *R25* and digit drivers *Q2* through *Q5*. Transistor *Q1* drives the decimal point, while *Q6* enables the entire display by providing a path to ground when pin 2 of *U2* is high.

Pressing *S1* discharges *C1* to ground, unclamping pin 2 of *U2*. The display is on for 3 to 4 seconds, until *C1* recharges to a level greater than the 1.8-volt Vref. The Energy Auditor is not required to maintain a continuous display—only when you want to take a consumption reading.

A second comparator in *U2* drives activity indicator *LED1*. Jumper wire J2 connects the comparator's pin 9 input to one of the pulse outputs identified as E11 through E14. This causes *LED1* to flash when the load under test is on. Switch *S2* provides a reset function; pressing it forces *DIS1* to display all 0s.

Operation from a wall thermostat allows the Energy Auditor to be powered by the latter's 24-volt ac control voltage. The screw terminal connections on the thermostat mounting plate are color-coded red (R) for return, white (W) for heat, yellow (Y) for cool and green (G) for fan. In Fig. 1, E2 connects to R and for air conditioning E1 goes to W and E3 goes to Y. For heat, the connections from E1 and E3 are reversed.

When the cool or heat contactor is open, there is 24 volts ac across E2 and E3, which turns on the LED inside *U1*. In turn, this activates *U1*'s internal phototranistor and pulls pin 3 of *U1* low, stopping *U3* from outputting pulses. Energizing the contactor by starting the compressor or heating coil releases pin 3 of *U1* to enable output pulses from *U3* counting.

Other loads are sensed by passing one leg of the power wiring through a current-sensing transformer. This transformer is a powdered-iron toroid on which are wound 30 or so turns of insulated magnet wire. This transformer connects into the circuit at points E4 and E5 in Fig. 1. The distance between the Energy Auditor and sensing transformer is not critical; so the cable connecting the two can be as long as needed.

Current flowing to the load produces an ac voltage in the sensing transformer. This voltage is rectified by the full-wave bridge consisting of *CR7* through *CR10* and is then filtered by *C7*. The resulting dc voltage forces pin 11 of *U2* to a potential greater than that at pin 10, switching comparator output pin 13 high and enabling the output pulses at pin 3 of *U3*. Power from a 12-volt ac, 200-mA plug-in wall transformer, enters the Energy Auditor at points E1 and E2. This voltage is rectified by *CR1* through *CR4* and filtered by *C6*. The dc output from this portion of the circuit is regulated at +5 volts by *U7* and is subsequently distributed to the rest of the circuitry in the project.

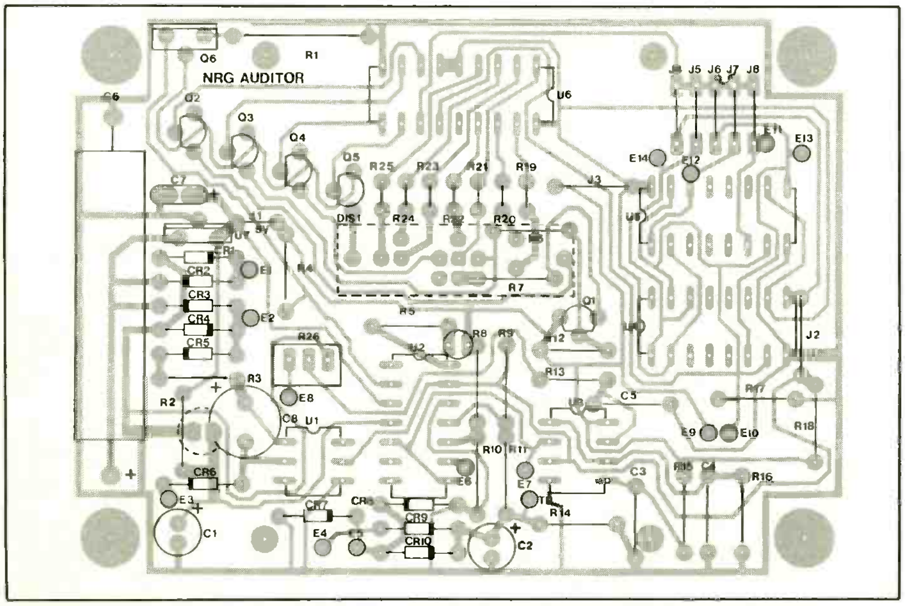


Fig. 3. The component location and orientation guide for the pc board.

Construction

To make the Energy Auditor as compact as possible and to facilitate easy assembly, printed-circuit wiring is recommended. You can fabricate your own pc board, using the actual-size etching-and-drilling guide shown in Fig. 2, or purchase one ready for component installation from the source given in the Parts List.

Wire the board exactly as shown in Fig. 3, referring back to Fig. 1 and the above text for details on interconnections between the board and off-board components. It is a good idea to use sockets for all ICs except *IC7*. Also, if you prefer, you can replace jumpers J4 through J8 with a 5-position DIP switch.

Make sure when you install the diodes and electrolytic capacitors that they are properly polarized and that the ICs and transistors are properly oriented. Note also that *DIS1* and pushbutton switch *S1* mount on the

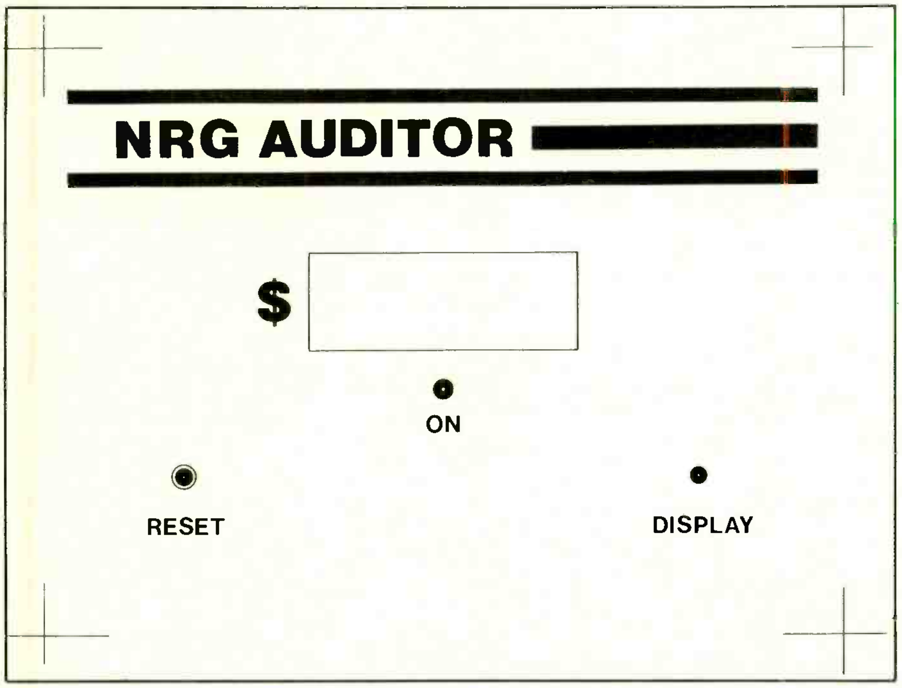


Fig. 4. A suggested panel layout for the Energy Auditor's case.

foil or solder side of the board. To accomplish this, you must mount the display panel and switch high enough above the board's surface to provide access for soldering.

Fabricate RESET switch *S2* by making a sandwich with a 0.5" square of copper-clad pc material on the bottom (copper side facing up), double-stick foam tape in the middle and conductive antistatic foam material on top. Solder one end of a 1" solid wire to the copper on the pc material. Cut a 0.25" hole in the center of the double-stick foam tape and place it on the copper side of the pc material.

Form a hook in one end of a 1¼" solid wire, hook the wire through one corner of the conductive foam, and crimp the hook. Then place the conductive foam on the exposed surface of the double-stick foam tape with the corner with the attached wire adjacent to the corner with the wire soldered to the pc material and press firmly into place. Place another layer or two of double-stick foam tape on the blank side of the pc material.

Push the wire leads into holes E9 and E10 on the pc board assembly from the *foil* side. Bend the leads to allow the *S2* assembly to lie flat on the pc board, held in place by the double-stick tape. Solder the wire leads to the pc board pads.

Actuation of *S2* occurs when the conductive foam shorts against the pc board or when a sharp metal object or paper clip pierces the foam and touches the board. Resetting the Energy Auditor is done infrequently; so fabricating *S2* in this manner is a good way to go. Besides, this approach eliminates the possibility of an accidental reset that can wipe out data. Of course, you can substitute a normally-open pushbutton switch, but make sure that you locate it where it cannot be accidentally actuated.

As mentioned above, you will have to wind your own sensing transformer if you plan to use the Energy Auditor for applications other than to sense the closure of thermostat contacts. You do this by winding 30 or so turns of No. 30 magnet wire on a 0.5" ferrite toroid form. When you finish winding the turns, carefully scrape away ¼" of enamel down to bare wire at both ends of the winding and connect and solder to them as long zip cord as you need. Cover the connections with electrical tape. Then connect and solder the other end of the zip cord to points E4 and E5 on the pc board assembly.

You can mount the Energy Auditor inside any enclosure that will accommodate it, although a plastic box will make the task of cutting the slot for the display easier to perform. The prototype of this product was housed inside a 4⅜" × 3¼" × 1½" plastic box. If you use such a box, you can use the layout shown in Fig. 4 as a guide to dressing up the "front panel." Finally, cut a slot in the box to provide a means for the power and sensing transformer's cables to exit.

Checkout and Use

After thoroughly inspecting your wiring and soldering, you can test the circuit as follows. First temporarily connect the red (positive) and black (negative) leads of a 9-volt battery connector to points E1 and E2 (polarity is not important, since the *CR1* through *CR4* bridge circuit will apply the proper polarity to the rest of the circuit). Snap on a 9-volt battery. Then use a clip lead to connect *TP* to + 5 volts at J1 to start counting.

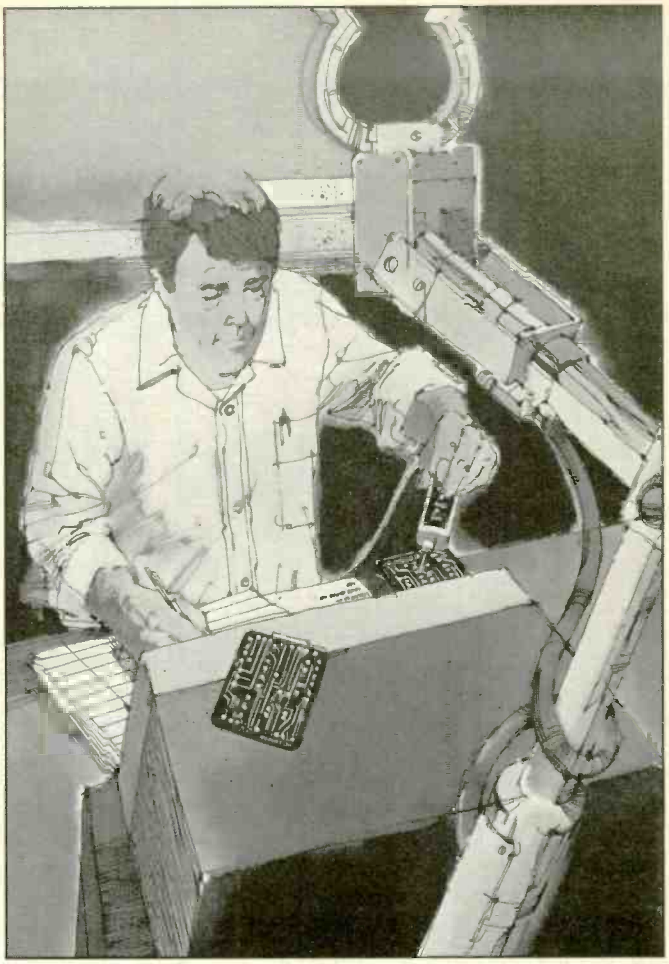
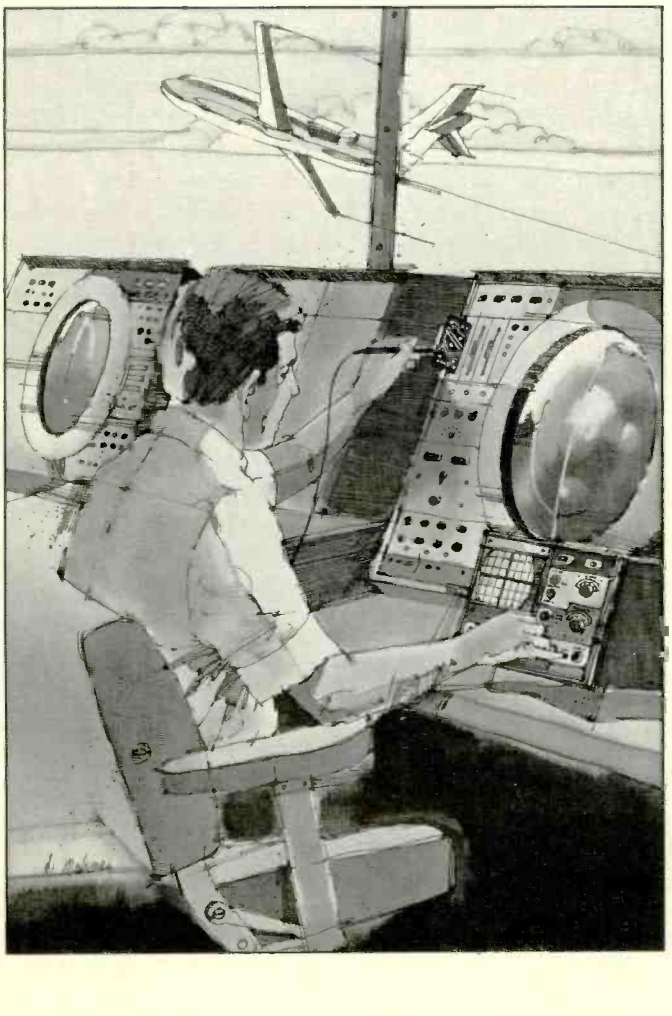
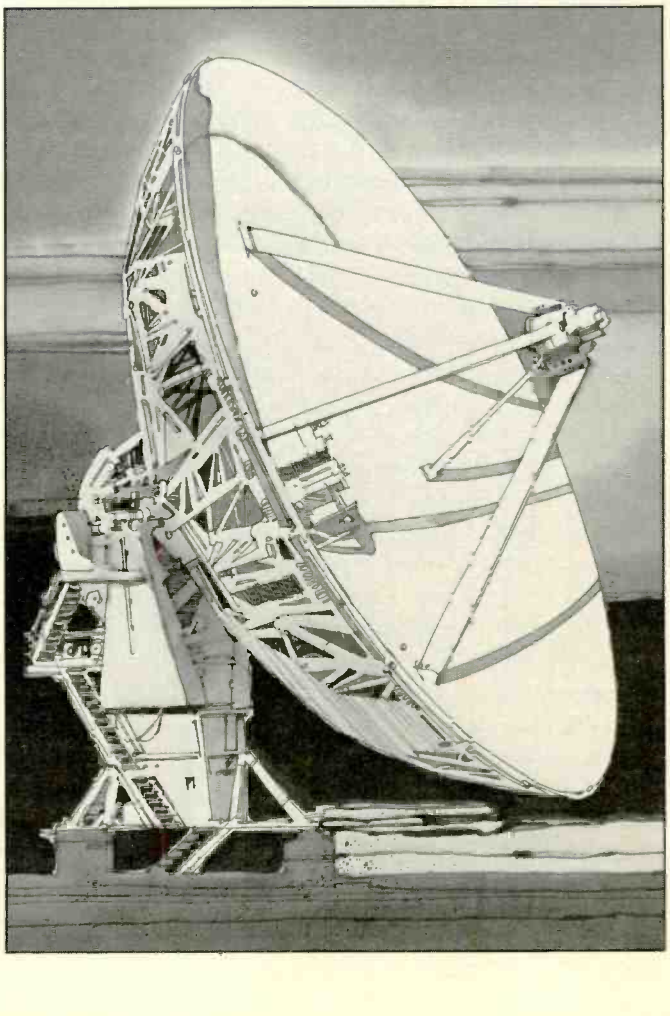
Adjust 22-turn trimmer potentiometer *R28* and install J5 to observe the pulses being totaled when DISPLAY switch *S1* is pressed. Check out the reset action and make any adjustments needed to switch *S2*.

Assume you are planning to use the Energy Auditor with a 42-gallon hot-water heater. You must adjust *R28* for 39 pulses per hour for a 39-cents-per-hour operating cost base.

It would be inconvenient to have to wait an hour just to find out that at its lowest setting *R28* causes the vco to output more than 30,000 pulses per hour. To obivate this, we use *U4* and *U5* to divide the vco's output by, say, 1000 by installing J5. You can then set the vco for a more convenient 39,000.

Consider that 39,000 pulses per hour works out to 650 pulses per minute, and watching a 60-second

(Continued on page 80)

AC-to-DC Conversion

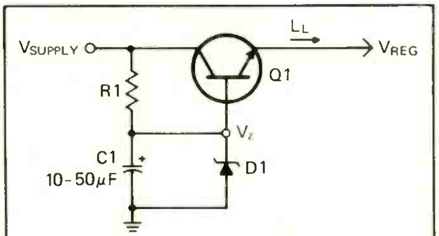
How a power supply really works, regulators you can build, and a computer program to aid design

By Duane M. Perkins

A power supply invariably contains an ac-to-dc converter consisting of a power transformer, a rectifier and a filter. Most often, the filter is simply a capacitor connected across the output of the rectifier. There has probably been more written regarding the design of power supplies than any other type of electronic circuit, but little is said about how the ac-to-dc converter actually works. While design guidance is given in the form of rules of thumb, as in the excellent article by Joseph Carr (*Modern Electronics,* March 1985), some misconceptions about the transformer/rectifier/filter section can lead to poor performance unless the rating of the transformer is very generous as compared to the load.

Thanks to ready availability of inexpensive voltage-regulator ICs, there is usually little need to know the precise voltage of the unregulated supply. The question is, is it high enough to assure good regulation at the maximum load current? A regulator can function only if there is a voltage drop across it. The drop required depends on the regulator. The supply voltage must never drop below the regulated voltage plus the minimum voltage the regulator requires

A voltage regulator not only delivers a fixed, known voltage; it does two other important things as well. It practically eliminates ripple even if there is a high percentage on the unregulated supply. It also provides a very low impedance power source to the load and minimizes coupling of the various stages or sections of the load circuit through the power supply. For these reasons, it is advisable to use a regulator even if a precisely known voltage is not required. A smaller transformer can be used because the regulation doesn't depend on low winding resistance.



$$V_{reg} = V_Z - V_{BE}$$

$$V_{supply} > V_{reg} + 1.4$$

$$R1 = (V_{supply} - V_Z)/[I_L/\beta) + 0.001]$$

Fig. 1. Simple series-pass regulator.

A Simple Regulator

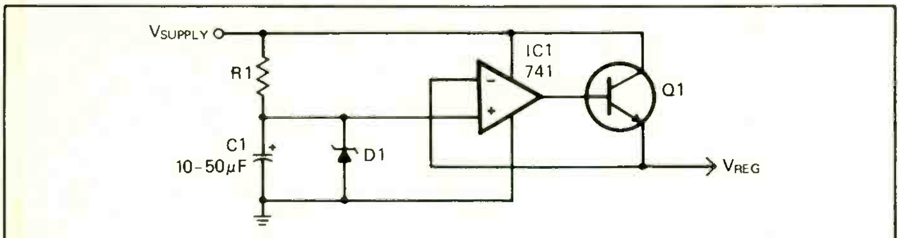
A voltage regulator can be built with a transistor, a zener diode, a resistor and a capacitor, as shown in Fig. 1. Using a 2N2222 transistor, total cost would be less than $1.10. While this simple circuit does not provide the tight regulation required for some applications, it is adequate for many purposes and requires little voltage drop (about 1.4 volts, depending on the saturation point of the transistor).

Select a transistor with a minimum beta of 50 and a current rating that exceeds the maximum current the load will draw. Dissipation will be the voltage drop multiplied by the load current. Because the current through the zener diode will decrease as the load current, and thus the base current, increases, the zener voltage is not exactly constant. A high beta will minimize this variation. You can use a darlington, but the regulated voltage will be two diode-drops below the zener voltage. The drop across the base-emitter junction will increase with load current, by as much as .25 volts. Still, it is possible to achieve a regulation of ± 0.2 volt or better.

A Better Regulator

A much better regulator is shown in Fig. 2, where an op-amp is used to monitor the output voltage and force it to equal a reference voltage provided by the zener diode. Since *R1* must supply only enough current for the zener diode, the zener voltage is not affected nearly as much by changes in load current. The minimal effect results from a drop in the supply voltage as the load current increases. The supply must be at least 1.7 volts greater than the regulated voltage.

Although it would not make sense to build a regulator if you can use an IC, you may have requirements not readily matched. The circuit in Fig. 3 can be used for any voltage and current you might require and provides overload protection for both the regulator and the supply. The value of *R4* should be selected so that even a short-circuited output will draw no more current than both can safely handle. Diodes *D2* and *D3* will not conduct until the output current causes about a 0.6-volt drop across *R4*. When the drop reaches about 0.8 volt, no addi-



$V_{reg} = V_Z$ $\quad V_{supply} > V_{reg} + 1.7$ $\quad R1 = (V_{supply} - V_Z)/0.0005$

Fig. 2. Op amp forces output to equal reference provided by zener diode.

tional current will flow into the base of *Q1*, limiting the current to that value.

The 741 *IC1* op amp has internal overload protection. Transistor *Q2* provides a nearly constant current for the zener diode, which keeps the reference voltage very constant. Regulation is extremely tight, as long as supply voltage stays above the output voltage plus the load current multiplied by *R4* plus about 1.7 volts. In the Fig. 3 circuit, *R2* + *R3* should be about 50,000 to 100,000 ohms, and the reference potential should be at least 2 volts. If you wish, you can use a potentiometer for *R2*. Select a transistor with a current rating greater than the current limit (0.8/*R4*) and a dissipation rating greater than the current limit multiplied by the supply voltage. Use a heat sink if necessary.

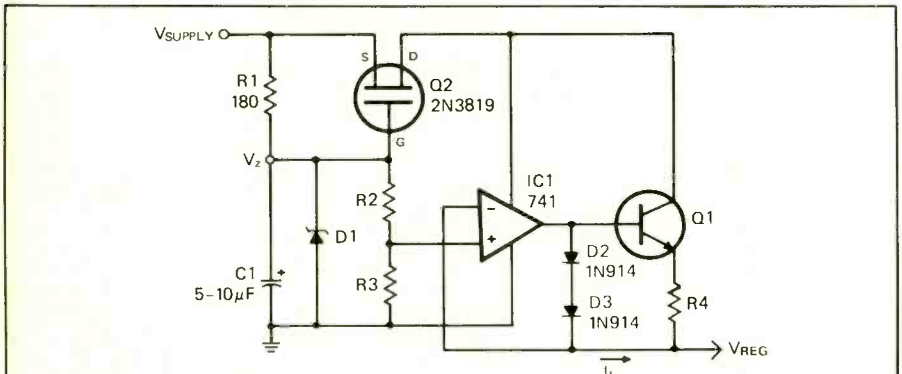
Whether you are using an IC or building your own, a capacitor should be connected across the output to hold the voltage steady until the regulator has time to respond to a change in the load current. Determine the capacitance from the maximum *change* in load current. The regulator should be allowed at least 100 microseconds to respond, so the capacitor should be selected to hold the voltage within the required limits during that interval, using the formula: $C = 10^{-4}(\Delta I/\Delta V)$. For a change of 0.1 volt, 1000 μF per ampere is required.

Design Stage

We have discussed voltage regulators at some length because the ac-to-dc converter must be designed to supply a voltage that never drops below that required by the regulator. Let us assume we will use the circuit in Fig. 3 for an output of 5 volts at 0.25 ampere. We will use a transistor with current and dissipation ratings of 3 amperes and 20 watts, so there will be no concern with regard to exceeding safe operating parameters. Further assume for *R1* a value of 2 ohms to limit the current to 0.4 ampere, and a transformer rated at 6.3 volts and 0.45 ampere. We built the supply and measured 6.7 volts to the regulator. An oscilloscope showed that the supply peaked at a little above 7 volts. This is woefully inadequate. We need a minimum of more than 7.2 volts for a regulator output of 5 volts (5 + 0.25 *R4* + 1.7). Adding more capacitance cannot help because the maximum is too low. Evidently we need a larger transformer, but do we want a higher voltage or more current? Before we decide what to try next, let us see what is happening.

Simultaneous scope traces of the secondary ac and unregulated dc voltages look like Fig. 4. The peak occurs at about 118 degrees, not at 90 degrees as would be expected if the load on the transformer were purely resistive. The load is partly reactive during the charging interval, which accounts for the phase lag. Peak secondary voltage is lower than it would be with no load, because the load current causes voltage drops across the resistance of the windings. If we are to predict the results, we must take these facts into account.

A power transformer is shown in Fig. 5A. A resistive load that draws the rated secondary current will cause a measurable voltage drop. The turns ratio is selected to provide at least the rated secondary voltage at the rated secondary current. Therefore, the no-load secondary voltage is always



$V_{reg} = V_Z[(R3/(R2 + R3)]$ $\quad V_{supply} > V_{reg} + I_L R4 + 1.7$ $\quad I_{limit} = 0.8/R4$

Fig. 3. Regulator with overload protection.

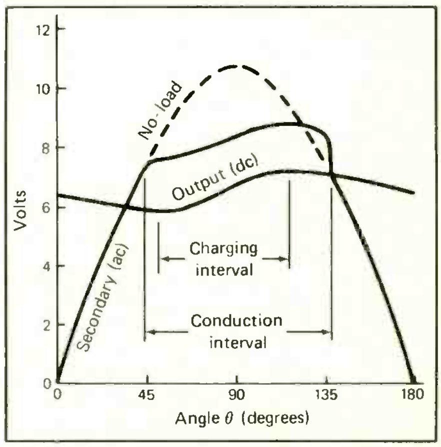


Fig. 4. Typical voltage curves.

greater than the rating. Figure 5B shows the equivalent ac power source with an internal resistance equal to the voltage drop under load divided by load current.

The transformer used for the circuit described above measured 7.5 volts rms with no load, and peaked at 10.6 volts on the scope. A 13.3-ohm load caused a drop to 6.4 volts rms, which indicates an internal resistance of 2.3 ohms (1.1 volts drop divided by 0.48 and amperes drawn by 13.3 ohms at 6.4 volts).

In Fig. 6 is shown the supply circuit with the transformer viewed as in Fig. 5B. At every instant in time, the sum of the voltage drops must equal the source voltage, according to Kirchoff's law. The source voltage can be calculated as $V = \sin \theta\sqrt{2}\,(V_p/T)$, where V is the instantaneous voltage induced in the secondary winding with no load, θ is the angle relative to the beginning of a cycle, V_P is the rms voltage on the primary and T is the turns ratio. The term (V_P/T) is, of course, the no-load secondary rms voltage.

In this circuit, the diodes function as a switch that is open when the secondary voltage is less than the sum of the dc output voltage plus the diode drops. As long as we recognize that the capacitor will be recharged during each half-cycle, we can ignore *D3* and *D4*. The capacitor will charge only when the secondary current exceeds the load current. Accordingly, the transformer voltage drop equals the load current multiplied by the internal resistance at the instants of minimum and maximum dc output voltage, when only the load current is being supplied by the transformer. Once the angles corresponding to these instants are known, it is a simple matter to calculate the voltages.

During the charging interval, the load on the transformer is capacitive, and voltage lags current. Peak voltage occurs later than at the 90-degree mark. How much later depends on how much charge remains on the capacitor at the beginning of the charging interval; and this depends on the load current. The charging interval begins when the rising secondary voltage goes far enough above the instantaneous dc voltage to produce a current in excess of the load current. As load current increases, this occurs earlier in the cycle. Thus the charging interval is lengthened as load current increases, starting earlier and ending later, with correspondingly lower minimum and maximum voltages.

Painless Computations

Finding the angles of the cycle where minimum and maximum voltages occur is a difficult task. Because of the complex interaction of a number of variables, a mathematical analysis is daunting. However, the computer program shown elsewhere in this article is a reasonably good model of an ac-to-dc converter of the type discussed here. It accepts the following parameters:

(1.) Load resistance or current (R or I)

(2.) Filter capacitance (C)

(3.) Peak no-load secondary voltage ($V = \sqrt{2} \times$ rms no-load secondary voltage)

(4.) Equivalent internal transformer resistance (S)

(5.) Diode drop (D) (sum of both for bridge rectifier)

(6.) Rectifier pulses per cycle (N = 1 for half-wave, 2 for fullwave)

(7.) Ac line frequency (F = 60 in U.S.A.)

If you want accurate results, measure the diode drop at maximum load current. Some diodes may have as much as a 1.6-volt drop at maximum rated current (the 1N4000 series). The diodes in the rectifier used in the circuits described here had a measured 0.85-volt drop at 0.25 ampere for a total of 1.7 volts across the bridge. (See "Diode Voltage vs. Current box.)

Accurate measurement of the loaded and no-load secondary voltages is also important if you want accurate results. You can use rated voltage and current, rather than using a known load, if you simply want to be assured of adequate performance; actual output will very likely be a bit higher.

The program will print the following results:

V(MIN) and angle

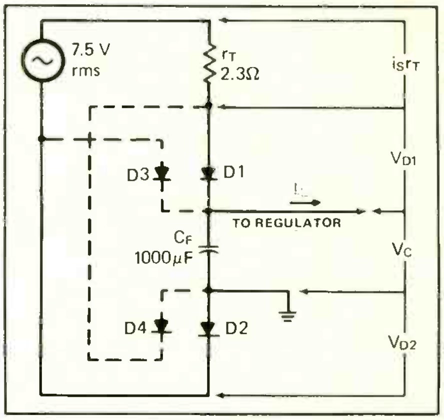
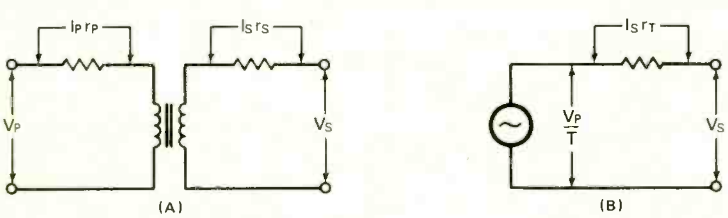


Fig. 6. At 6.3 V and 0.45 A output.



$$R4 < 0.6/I_{L(max)} \qquad r_T = [(V_p/T) - V_S]/I_S$$
$$T = N_P/N_S = (V_P - I_P r_P)/(V_S + I_S + I_S r_S)$$

Fig. 5. Winding resistance in (A) can be viewed as being in series with the windings. Looking into secondary (B), transformer appears to be an alternator with winding resistance of r_T and no-load voltage of V_P/T.

```
*********************************
*****  AC-TO-DC CONVERSION  *****
*****  By Duane M. Perkins  *****
*********************************

0 GOTO 9;REM AC-TO-DC MODEL
1 I=.26:REM FILTER CAPACITOR
2 C=1000E-6:REM FILTER CAPACITOR
3 V=10.6:REM PEAK NO-LOAD SEC. V
4 S=2.3:REM XFMR RESISTANCE
5 D=2*.85:REM BRIDGE DIODE DROPS
6 N=2:REM FULL-WAVE RECTIFIER
7 F=60:REM LINE FREQUENCY
8 RETURN
9 A$="AC-TO-DC"
10 GOTO 100:REM INITIALIZE
20 GOTO 200:REM GET RUN PARAM.
30 GOTO 300:REM FIND V(MIN)
    AND ANGLE ON NEXT CYCLE
40 GOTO 400:REM FIND V(MAX)
    AND ANGLE ON NEXT CYCLE
50 GOTO 500:REM TEST IF STABLE
60 IF Z9$="N" THEN 30:REM REPEAT
    IF STILL NOT STABLE
65 IF Z9$="A" THEN 90:REM FILTER
    CAP CANNOT SUSTAIN CURRENT
70 GOTO 600:REM SIMULATE ONE
    CYCLE TO COLLECT DATA
80 GOTO 800:REM CALCULATE AND
    PRINT FINAL RESULTS
90 GOTO 980:REM END RUN
99 END
100 REM*** INITIALIZE ***
110 CLS:PRINT"RUN "A$
120 GOSUB 1000:REM INITIALIZE
    CONSTANTS AND VARIABLES
130 B=1/K
160 PRINT@256,"PRESS enter ";
    "WHEN PRINTER READY"
170 Z9$=INKEY$:IF Z9$<>CHR$(13)
    THEN 170
180 LPRINT:CLS:PRINT A$;"RUNNING"
190 GOTO 20
200 REM*** SET RUN PARAMETERS ***
210 GOSUB 1:REM GET RUN PARAM.
220 G=360*F*C:I1=I:Q=2*P/N:
    T=R*C:W=2*P*F:IF R>0 THEN
    U=E^(-1/(360*F*T))
230 IF R>0 THEN LPRINT"R =";R,:
    GOTO 250
240 LPRINT"I =";I,
250 LPRINT"C =";C
260 LPRINT"V =";V,"S =";S
270 LPRINT"D =";D,"N =":N
280 LPRINT"F =";F
290 GOTO 30
300 REM***FIND V(MIN) & ANGLE***
310 T1=(Q+A0-A1)/W:IF R = 0
    THEN 330
320 V0=V1*E^(-T1/T):I1=V0/R:
    GOTO 340
330 V0=V1-T1*I/C:IF V0<0
    THEN V0=0
340 V2=V0+I1*S+D:V3=SIN(A0)*V:
    IF V2>.999*V3 AND V2<1.001*V3
    THEN 370
350 S0=V2/V:IF S0>1 THEN S0=1
360 GOSUB 2000:GOTO 310:REM FIND
    ARC SIN AND REPEAT
370 IF R>0 THEN V0=(V3-D)/(1+S/R):
    GOTO 390
380 V0=V3-I*S-D
390 GOTO 40
400 REM***FIND V(MAX) & ANGLE***
410 V1=V0:A1=A0:IF R>0 THEN
    I1=V1/R
420 A1=A1+B:V3=SIN(A1)*V:V2=V1+D
430 I2=(V3-V2)/S:V1=V1+(I2-I1)/G
440 IF R1>0 THEN I1=V1/R
450 IF V1+I1*S+D<V3 THEN 420
460 IF R>0 THEN 480
470 V1=V3-I*S-D:GOTO 490
480 V1=(V3-D)/(1+S/R)
490 GOTO 50
500 REM*** TEST IF STABLE ***
510 PRINT"V(MIN) =";V0:PRINT
    "        AT";K*A0:PRINT"V(MAX)
    ="V1: PRINT"        AT";K*A1
520 IF V1=V4 AND V0=0 THEN 570
530 T1=(Q+A0-A1)/W:IF R=0 THEN
    V2=V1-T1*I/C:GOTO 550
540 V2=V1*E^(-T1/T)
550 IF V2>.995*V0 AND V2<1.005
    *V0 THEN Z9$="Y":GOTO 590
560 Z9$="N":V4=V1:GOTO 590
570 LPRINT C;"FARAD CANNOT":
    LPRINT " SUSTAIN";I:"AMP."
580 LPRINT"INCREASE CAPACITANCE":
    Z9$="A"
590 GOTO 60
600 REM***SIMULATE ONE CYCLE***
    ******TO COLLECT DATA******
610 PRINT"COLLECTING DATA":S3=0:
    T1=(Q-A1)/W:V5=V0+(V1-V0)/2
620 IF R>0 THEN 640
630 V2=V1-T1*I/C:GOTO 650
640 V2=V1*E^(-T1/T)
650 S1=V2:S2=(V2-V5)^2
660 FOR A2=B TO Q STEP B
670 IF R>0 THEN I1=V2/R
680 V4=SIN(A2)*V:V3=V4:IF
    V4>V2+D THEN V3=V2+D
690 I2=(V4-V3)/S
700 IF R=0 OR I2>0 THEN 720
710 V2=V2*U:GOTO 730
720 V2=V2+(I2-I1)/G
730 S1=S1+V2:S2=S2+(V2-V5)^2:
    S3=S3+I2^2
740 NEXT A2
790 GOTO 80
800 REM***CALCULATE AND PRINT***
810 A2=INT(10*K*A0+.5)/10
820 V2=INT(100*V0+.5)/100
830 A3=INT(10*K*A1+.5)/10
840 V3=INT(100*V1+.5)/100
850 V4=INT(100*N*S1/360+.5)/100
860 V5=SQR(N*S2/360):
    V5=INT(100*V5+.5)/100
870 I2=SQR(N*S3/360)
880 I2=INT(1000*I2+.5)/1000
900 REM***PRINT RESULTS***
920 LPRINT"V(MIN) =";V2;"AT";A2
930 LPRINT"V(MAX) =";V3;"AT";A3
940 LPRINT"V(AVG) =";V4
950 LPRINT"RIPPLE =";V5;"V(RMS)"
960 LPRINT"SEC. CURRENT =";I2;
    "AMP. (RMS)"
970 GOTO 90
980 PRINT A$;" DONE"
990 GOTO 99
1000 REM**INITIALIZE CONSTANTS**
     ********AND VARIABLES******
1010 REM CONSTANTS
1020 A=0:B=0:C=0:D=0
1030 E=2.71828183
1040 F=0:G=0:I=0
1050 K=57.2957795
1060 N=0:P=3.14159265
1070 Q=0:R=0:S=0:T=0:U=0
1080 V=0:W=0:Z=0
1090 REM VARIABLES
1100 A0=0:A1=0:A2=0:A3=0
1110 I1=0:I2=0:S0=0
1120 S1=0:S2=0:S3=0:T1=0:V0=0
1130 V1=0:V2=0:V3=0:V4=0:V5=0
1140 ZY$="":ZN=0:ZX=0:ZY=0
1150 RETURN
2000 REM***FIND ARC SIN****
     *******IN RADIANS*****
2010 REM LOCAL Z
2020 IF ABS(S0)<1 THEN 2050
2030 IF ABS(S0)=1 THEN A0=
     1.5707963:GOTO 2080
2040 PRINT"S0 =";S0;"ABORT AT
     2040":STOP
2050 ZX=1-SQR(1-S0^2):ZY=2*S0:
     ZN=-1
2060 ZY=SQR(.25*ZY^2+ZX^2):ZX=
     1-SQR(1-.25*ZY^2):ZN=ZN+1:
     IF ZX=0 THEN 2060
2070 A0=2^ZN*ZY
2080 RETURN
63999 REM END PROGRAM
```

```
Use these parameters and results
to test the program with a resis-
tive load.

R = 30              C = 4.7E-03
V = 10.4651804      S = .736434109
D = 1.7             N = 2
V(MIN) = 7.45 AT 63.1
V(MAX) = 7.81 AT 112.1
V(AVG) = 7.71
RIPPLE = .13 V(RMS)
SEC. CURRENT = .58 AMP.(RMS)
```

V(MAX) and angle

V(AVG) as measured by DC voltmeter

RIPPLE in RMS volts as measured by AC voltmeter

RMS secondary current (should not exceed rating)

For the circuit we have built, allowing 10 mA for the regulator for a total of 0.26 ampere, the program gives V(MIN) = 5.84 AT 50.2 and V(MAX) = 7.22 AT 116.2.

As determined experimentally, the voltage is much too low for the regulator operation. Using the computer, we can experiment with other possibilities without building the circuit. However, each of the circuits described was actually constructed, and the voltages were measured, to verify the computer results.

Let us first try using two transformers that are identical to the one just described, with their secondaries in series to obtain 12.6 volts at 0.45 ampere. Internal resistance was 3.3 ohms (not 4.6 ohms because the primaries are in parallel). Using these figures, the computer gave the following results.

V(MIN) = 15.07 AT 56.3

V(MAX) = 16.46 AT 116.3

V(AVG) = 15.91

> **Diode Voltage Vs. Current**
>
> The voltage dropped across a diode increases about 0.06 volt for each ten-fold increase in current. The current required to produce a drop of less than 0.06 volt across a silicon diode is negligible. Therefore, we assume that conduction begins at that voltage (about half as much for a germanium diode). The current required to produce a 0.84-volt drop is 10,000 times that required to produce a drop of 0.6 volt. The drop increases as the logarithm of the increase in current:
>
> $$V_1 = V_0 + 0.06 \log (I_1/I_0)$$
>
> Here, I_1 is the current that produces a drop of V_1 and I_0 is the current that produces a drop of V_0.

SEC. CURRENT = .492 AMP. (RMS)

The voltage is much greater than necessary, with the result that about 2.75 watts will be dissipated by the regulator. Secondary current exceeds the rating. This is not a good solution. Therefore, let us see what happens when the secondaries of the transformers are connected in parallel instead of in series for 6.3 volts at 0.9 ampere. This gives an internal resistance of 1.15 ohms, V(MIN) = 6.53 AT 53.5, and V(MAX) = 8.05 AT 108.5.

Without going any further, it is obvious that a larger capacitor is needed to bring the minimum up to the required level. Trying 4700 μF, we get:

V(MIN) = 7.22 AT 60.4
V(MAX) = 7.57 AT 115.4
V(AVG) = 7.48
RIPPLE = .12 V(RMS)
SEC.CURRENT = .536 AMP. (RMS)

This is right at the critical point where regulation would be lost if the voltage drops any lower because of low line voltage. When this circuit was built, the regulator output stayed constant at 5 volts most of the time, but the scope did show a very slight dip at other times. These results would be satisfactory using the regulator in Fig. 1 or Fig. 2, which requires less voltage drop, but there would be no overload protection.

Other Possibilities

Using a center-tapped transformer and a two-diode rectifier might do the trick because there is only one diode drop. We tried a transformer rated for 12 volts (6 volts each side) at 0.45 ampere. Since only one side of the secondary supplies current on a given half-cycle, internal resistance should be calculated on the basis of a load placed across half the secondary. At no-load, the voltage across half the secondary measured 7.25 volts and dropped to 6.45 volts with a 13.3-ohm load. This indicates a resistance of 1.65 ohms, which is significantly better than the rating would indicate. With a 2200-μF capacitor, the following results were obtained:

V(MIN) = 7.22 AT 56
V(MAX) = 7.86 at 117
V(AVG) = 7.62
RIPPLE = .23 V(RMS)
SEC.CURRENT = .494 AMP. (RMS).

Again, for an application not requiring overload protection, this would be satisfactory, and better than the previous circuit because it uses only one transformer with a rating just a bit less than the maximum load. If the load reaches the maximum only occasionally, no harm will be done, but a continuous overload is not advisable. Using a larger capacitor would in-

```
ACTUAL COMPUTER PRINTOUTS

Parameters and results for all
circuits described in text. Use
these to verify that the pro-
gram has been correctly entered.

I = .26             C = 1E-03
V = 10.6            S = 2.3
D = 1.7             N = 2
F = 60
V(MIN) = 5.84 AT 50.2
V(MAX) = 7.22 AT 116.2
V(AVG) = 6.63
RIPPLE = .46 V(RMS)
SEC. CURRENT = .456 AMP.(RMS)

I = .26             C = 1E-03
V = 21.2            S = 3.3
D = 1.7             N = 2
F = 60
V(MIN) = 15.07 AT 56.3
V(MAX) = 16.46 AT 116.3
V(AVG) = 15.91
RIPPLE = .5 V(RMS)
SEC. CURRENT = .492 AMP.(RMS)

I = .26             C = 1E-03
V = 10.6            S = 1.15
D = 1.7             N = 2
F = 60
V(MIN) = 6.53 AT 53.5
V(MAX) = 8.05 AT 108.5
V(AVG) = 7.4
RIPPLE = .49 V(RMS)
SEC. CURRENT = .506 AMP.(RMS)

I = .26             C = 4.7E-03
V = 10.6            S = 1.15
D = 1.7             N = 2
F = 60
V(MIN) = 7.22 AT 60.4
V(MAX) = 7.57 AT 115.4
V(AVG) = 7.48
RIPPLE = .12 V(RMS)
SEC. CURRENT = .536 AMP.(RMS)

I = .26             C = 2.2E-03
V = 10.2530483      S = 1.64961241
D = .85             N = 2
F = 60
V(MIN) = 7.22 AT 56
V(MAX) = 7.86 AT 117
V(AVG) = 7.62
RIPPLE = .23 V(RMS)
SEC. CURRENT = .494 AMP.(RMS)

I = .26             C = 2.2E-03
V = 10.4651804      S = .736434109
D = 1.7             N = 2
F = 60
V(MIN) = 7.29 AT 61.4
V(MAX) = 8.04 AT 108.4
V(AVG) = 7.74
RIPPLE = .23 V(RMS)
SEC. CURRENT = .543 AMP.(RMS)

I = .26             C = 4.7E-03
V = 10.4651804      S = .736434109
D = 1.7             N = 2
F = 60
V(MIN) = 7.49 AT 63.7
V(MAX) = 7.83 AT 111.7
V(AVG) = 7.73
RIPPLE = .12 V(RMS)
SEC. CURRENT = .571 AMP.(RMS)

I = .304117647      C = 4.7E-03
V = 10.4651804      S = .736434109
D = 1.7             N = 2
F = 60
V(MIN) = 7.33 AT 62.1
V(MAX) = 7.7 AT 113.1
V(AVG) = 7.59
RIPPLE = .15 V(RMS)
SEC. CURRENT = .667 AMP.(RMS)

I = .65             C = 4.7E-03
V = 10.4651804      S = .736434109
D = 1.7             N = 2
F = 60
V(MIN) = 6.37 AT 54.8
V(MAX) = 7.16 AT 116.8
V(AVG) = 6.85
RIPPLE = .26 V(RMS)
SEC. CURRENT = 1.189 AMP.(RMS)
```

crease the secondary current and is also not advisable. If you use a circuit with these parameters, be sure the regulator requires no more than a 2.2-volt drop.

Since we are aiming at a supply that can deliver 0.25 ampere at 5 volts and sustain a current of 0.4 ampere without harm, it looks like we need a transformer rated in excess of 1 ampere. Radio Shack's Cat. No. 273-1351 is rated for 6.3 volts at 1.2 amperes and has a no-load secondary voltage of 7.4 volts rms. With a 5-ohm load, the secondary measured 6.45 volts, indicating an internal resistance of 0.7364 ohm. We tried this with 2200 μF and got these results:

V(MIN) = 7.29 AT 61.4
V(MAX) = 8.04 AT 108.4
V(AVG) = 7.74
RIPPLE = .23 V(RMS)
SEC.CURRENT = .543 AMP. (RMS)

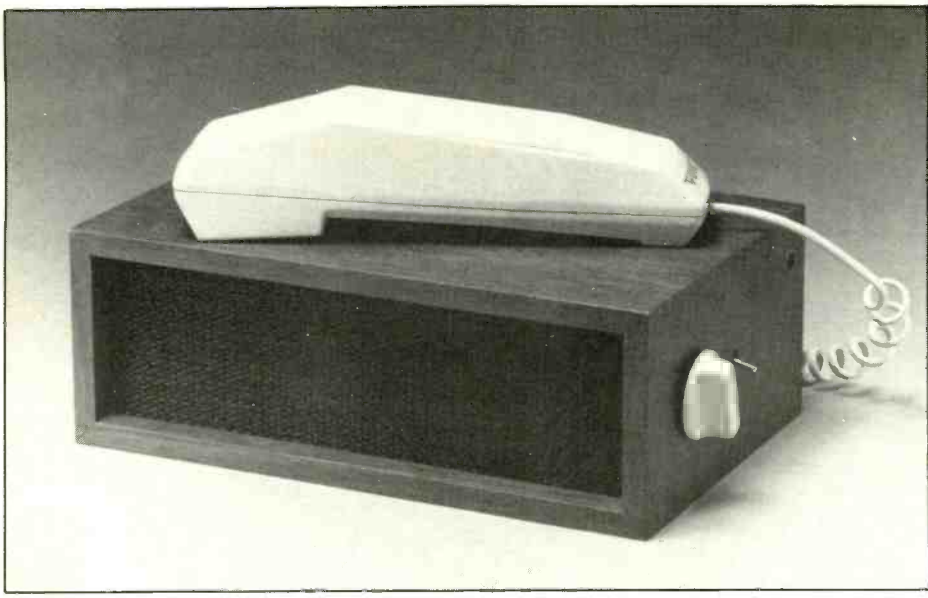
Though this looks good, secondary current is well below the rating. Therefore, we can add capacitance and improve the margin. Using 4700 μF gives the following results:

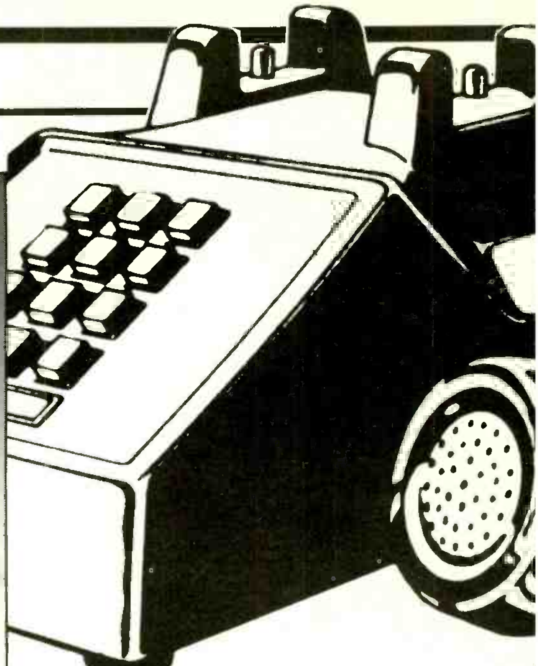
V(MIN) = 7.49 AT 63.7
V(MAX) = 7.83 AT 11.7
V(AVG) = 7.73
RIPPLE = .12 V(RMS)
SEC. CURRENT = .571 AMP. (RMS)

This assures good performance with the rated load. In fact, with a bigger transformer giving still more current before loss of regulation, the current limit can be raised. Using 1.25 ohms for *R4*, the current limit will be 0.64 ampere, and the drop required by the regulator is down to 2.1 volts at 0.294 ampere (a 17-ohm load on the regulator). Allowing 10 mA for the regulator for a total of 0.304 ampere, we get these results:

V(MIN) = 7.33 AT 62.1
V(MAX) = 7.7 AT 113.1
V(AVG) = 7.59
RIPPLE = .15 V(RMS)
SEC.CURRENT = .667 AMP. (RMS).

(Continued on page 81)





Add a Speakerphone to Your Telephone

Project gives talk/listen "hands-free" telephone communications with upgrade capability for dial-out operation

By Anthony J. Caristi

Telephone amplifier/speaker units give you hands-free conversations. Also, they provide conference conversations since other people in the room can hear the voice(s) at the other phone end and join in if they wish to.

If you don't have one, the Speakerphone presented here will make a nice addition to any room, whether or not it contains a telephone since it is phone-line powered. Thus, it can be operated wherever you care to run a pair of telephone-line wires since it needs no batteries or ac line power. The device is voice switched so it automatically switches back and forth, depending on which end is talking. Furthermore, a convenient volume control lets the user adjust sound level to his liking.

To answer an incoming call, you simply flip a switch and commence talking. The only drawback is that you cannot initiate a call, but this will be overcome in an article next month that will show you how to add a Touch Tone dialer and electronic ringer to your Speakerphone, making it a complete telephone.

How It Works

A single MC34018 integrated-circuit chip in the Speakerphone contains all amplifier, attenuator, level detector and regulator circuitry required to provide a complete voice-switched telephone circuit. A simplified block diagram of the MC34018 chip is shown inside the dashed-line box in Fig. 1, along with the external driver circuitry that make up this project. The full schematic is shown in Fig. 2.

Two attenuators are used in this circuit—one for the receive and one for the transmit sides. the circuit's half-duplex operation permits voice signals to travel in two directions (transmit and receive) but not simultaneously, thus avoiding acoustical feedback that could occur as a result of the close proximity of the microphone to the speakers.

When one attenuator is at minimum attenuation the other is at max-

imum attenuation. Thus, both are never on or off simultaneously. When no voice signal is present, each attenuator operates at about half gain, in an "idle" condition. A signal received from the microphone or the telephone line causes the attenuators to assume proper gain status according to the source of the received signal. Information from transmit and receive level detectors goes to the transmit/receive comparator, which controls the attenuators to amplify the desired signal and attenuate the reverse signal path.

Logarithmic-response amplifier level detectors provide a wide dynamic range for overload protection to accommodate a wide range of input signal levels. The level detectors respond quickly to any increase in signal level and slowly decay when the input signal is no longer present. This assures fast switching response when the transmit/receive mode must be changed, without causing false switching during short periods of silence, like natural pauses in speaking. The outputs of the transmit and receive level detectors are fed to the transmit/receive comparator that controls the attenuators.

Since some amount of background noise always reaches the microphone, an on-chip signal/noise detector is used to detect the change in audio signal level arriving at the microphone when a person speaks. To accomplish this, a voltage on capacitor *C27* in Fig. 2 is used as a "reference" that represents the average noise level picked up by the microphone. The time constant of this "memory" circuit is about 5 seconds, as determined by the values of *C27* and *R33*.

As long as background noise remains fairly constant, with no sudden increase in sound energy, the signal/noise detector will hold the transmit and receive attenuators at idle. When someone nearby speaks, the increase in voltage generated by the voice signal causes the signal/noise detector to switch state before the voltage on *C27* can increase. This causes the automatic attenuator to go into the transmit mode, coupling the voice signal to the telephone line.

An electret microphone is used to pick up voice signals. Because the output signal from the microphone is relatively low, an amplifier inside *IC1* provides 34 dB of gain so that what is being said can be heard by the party at the other end of the tele-

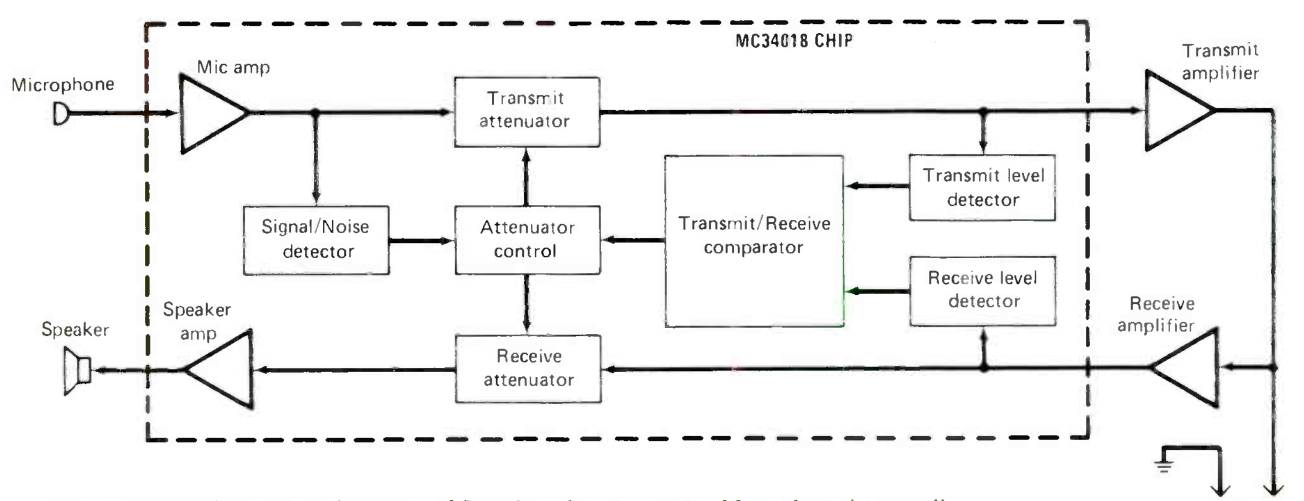
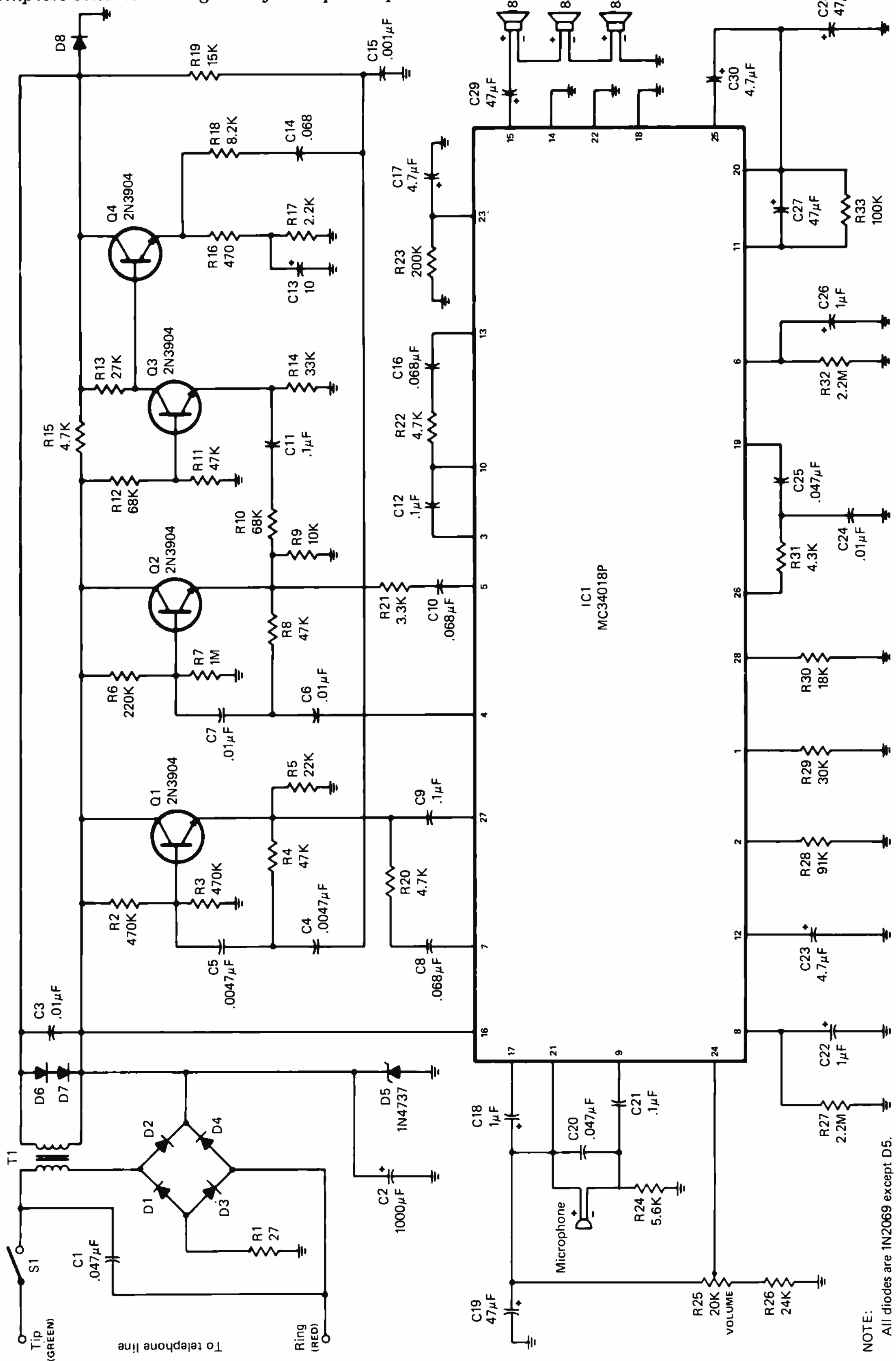


Fig. 1. Simplified block diagram of Speakerphone system. Note that almost all of it is contained inside the MC34018 chip inside the box.

Fig. 2. Complete schematic diagram of the Speakerphone.



PARTS LIST

Semiconductors
D1 thru D4,D6 thru D8—1N2069 or equivalent silicon diode
D5—1N4737 or equivalent 7.5-volt zener diode
Q1 thru Q4—2N3904 or equivalent npn silicon transistor

Capacitors (10 volts)
C1,C20,C25—0.047-μF disc
C2—1000-μF electrolytic
C3,C6,C7,C24—0.01-μF disc
C4,C5—0.0047-μF disc
C8,C10,C14,C16—0.068-μF disc
C9,C11,C12,C21—0.1-μF disc
C13—10-μF electrolytic
C15—0.001-μF disc
C17,C23,C30—4.7-μF electrolytic
C18,C22,C26—1-μF electrolytic
C19,C27 thru C29—47-μF electrolytic

Resistors (¼-watt, 10% tolerance)
R1—27 ohms
R2,R3—470,000 ohms
R4,R8,R11—47,000 ohms
R5—22,000 ohms
R6—220,000 ohms
R7—1 megohm
R9—10,000 ohms
R10—6800 ohms
R12—68,000 ohms
R13—27,000 ohms
R14—33,000 ohms
R15,R20,R22—4700 ohms
R16—470 ohms
R17—2200 ohms
R18—8200 ohms
R19—15,000 ohms
R21—3300 ohms
R24—5600 ohms
R27,R32—2.2 megohms
R28—91,000 ohms
R30—18,000 ohms
R33—100,000 ohms
R23—200,000 ohms, 5%
R26—24,000 ohms, 5%
R29—30,000 ohms, 5%
R31—4300 ohms, 5%
R25—20,000-ohm, linear-taper potentiometer

Miscellaneous
S1—Spst switch
T1—Microtran No. T2106 transformer
Printed-circuit board or perforated board and soldering hardware (see text); electret microphone (Radio Shack Cat. No. 270-090 or similar); miniature 8-ohm speakers (three in series to make 24-ohm impedance; see text); socket for IC1 (see text); suitable enclosure; stranded hookup wire; machine hardware; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Etched and drilled pc board for $8.75 and MC34018P integrated circuit for $10.00. Add $1.00 for S&H. New Jersey residents, add sales tax.

phone line. There's no on-chip provision for adjusting microphone gain for different microphone sensitivities. However, this can be accomplished externally by selecting the appropriate value for *R24*. The 5600 ohms shown is a good choice for the specific microphone called for in the Parts List.

Also built into *IC1* is an amplifier that can drive a 24-ohm speaker at 100 milliwatts of power. This is sufficient for normal listening volume and can be adjusted as desired with VOLUME control *R25*. To minimize distortion when very large signal excursions are received from the telephone line, the speaker amplifier incorporates a peak limiter that operates as an automatic gain control.

Because 24-ohm speakers aren't commonplace, Speakerphone uses three ordinary 8-ohm speakers connected in series to provide the impedance to match *IC1*'s output circuit. Use of three speakers instead of just one gives the added benefit of providing a more pleasing sound.

Voltages at the outputs of the signal/noise detector and transmit/receive comparator are monitored by *IC1*'s attenuator control section. When no signal is on the telephone line and the microphone is picking up just background noise, the attenuator control causes each attenuator inside *IC1* to run at idle. The circuit is thus ready to swing either way, depending on the source of the first valid signal detected from the telephone line or microphone.

As soon as a signal is detected at either input, the transmit/receive comparator switches state to indicate the presence of one of the signals. The signal/noise detector then permits the attenuator control to set the attenuators to the required state. As a conversation on the telephone line alternates between the parties at either end of the line, the attenuator control quickly switches back and forth to provide proper amplification of the voice signals present on the line.

Construction

Except for the microphone, speakers, VOLUME control and switch, the entire circuit of the Speakerphone can be contained on a printed-circuit board measuring 4″ square or a slightly larger perforated board using appropriate soldering hardware. You can fabricate your own pc board, using the actual-size etching-and-drilling guide given in Fig. 3. Alternatively, you can buy a pc board ready for wiring from the source given in the Note in the Parts List. Whichever construction method you decide to use, parts placement isn't critical.

The layout for the pc board (which can also be followed for perf-board construction) is shown in Fig. 4. Use a socket for *IC1*. If you can't find a 28-pin socket, use two sockets with fewer pins and, after cutting off the excess pins, mate them to make up a 28-pin socket. Solder the socket to the pc board now, but do *not* install the IC in it until instructed to do so.

Make sure all diodes and electrolytic capacitors are properly polarized (see in Fig. 4) before soldering their leads to the pc board's copper pads. Similarly, make certain that the transistor leads are plugged into the correct holes before soldering.

Wire the board as shown. Off-the-

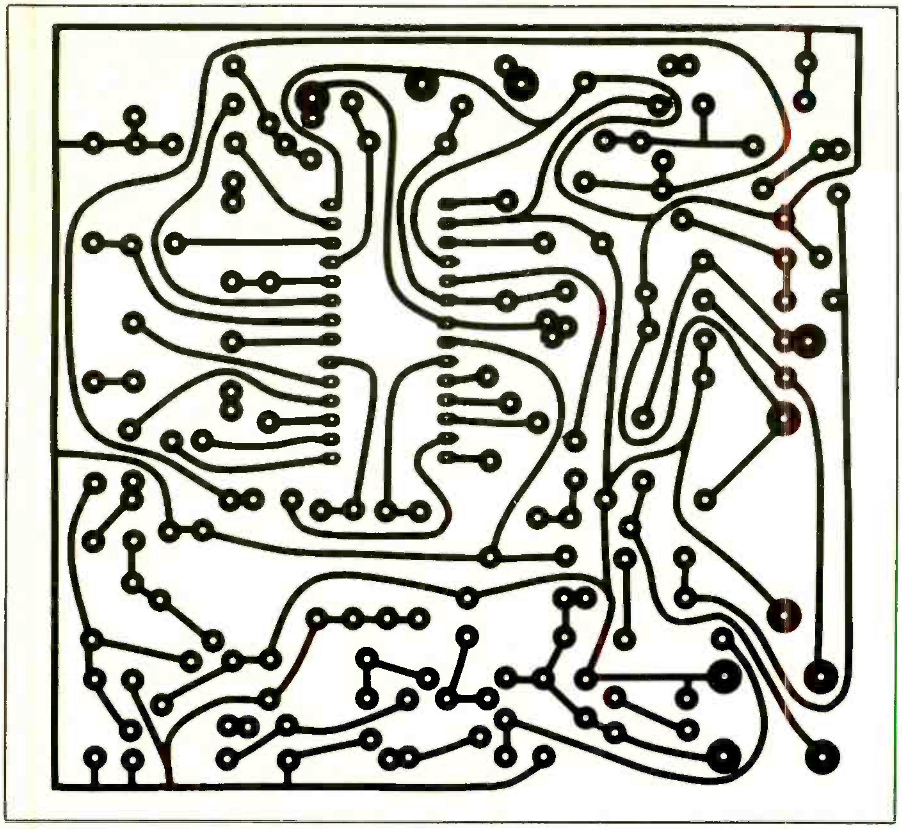


Fig. 3. Actual-size etching-and-drilling guide to use when making your own printed-circuit board.

board components *R25, S1,* the speakers and the microphone connect to the board via stranded hookup wire soldered to the indicated pads. Make these wires as short as practical for final assembly.

Use a cabinet that's large enough to accommodate the circuit board, speakers and microphone. Locate the microphone as far as possible from the speakers to avoid interaction (acoustical feedback) between them if you plan on operating the Speakerphone at or near the maximum volume setting.

The three speakers must be wired in-phase with each other. So before you wire them in series with each other (see Fig. 2), check the polarities of each, even if all three appear to be identical or have their "hot" lugs identified with a + sign or paint dot.

The simplest way to check speaker phasing is with an AA or C cell in a battery holder, with clipleads connected to the holder's lugs. Clip the lead connected to the negative (−) lug to one lug of one of the speaker's lugs and touch the cliplead connected to the holder's positive (+) lug to the other speaker lug while observing the direction in which the cone moves. Outward cone movement, tells you that the lead connected to the holder's + lug is the hot lug on the speaker. Inward movement tells you that the lead connected to the holder's − lug identifies the hot lug. After determining which is the speaker's hot lug, put a + sign or a dot of paint near the lug.

Test each speaker in the same manner. Then wire the speakers in series as shown in Fig. 2. Connect and solder the speaker wires coming from the circuit board to the appropriate lugs.

Connections to the telephone line are made at the points identified as "tip" and "ring" in Fig. 2. Telephone company wire coding for these are greed and red, respectively. (The yellow and black telephone wires aren't used in the Speakerphone.) Note that *S1* is in series with the green telephone wire and the "tip" connection on the board.

The Speakerphone's full-wave diode bridge at the telephone-line input, automatically applies the correct polarity signal at this input. Be sure to use a modular connector, as required by FCC regulations, to connect the Speakerphone to the telephone line.

Checkout and Use

Make sure *IC1* is *not* in its socket. Connect a dc voltmeter, set to a 10-to-20-volt full-scale range, across *C2* (observe proper polarity). Plug Speakerphone's modular connector into a telephone receptacle and close *S1*. The meter should read approximately 7.5 volts.

Remove the positive voltmeter lead from the positive lead of *C2* and use is to measure the voltage at pin 16 of the IC socket. The reading should once again be about 7.5 volts. Then use the same lead to check the voltage at pins 14, 18 and 22 of the IC socket; the meter should indicate 0 volt at all three points. Disconnect the Speakerphone from the telephone line. If you don't obtain the proper reading at any or all points, rectify the problem before proceeding to installation.

Set *S1* to OFF and use a 10- to 100-ohm resistor to completely discharge *C2*. Then install *IC1* in its socket. Make sure the IC is properly oriented and that no pins bend under its case as you push it home.

With *S1* set to OFF and VOLUME control *R25* set to center of rotation, connect Speakerphone to the telephone line. If you have a true Touch-Tone telephone, dial or call out after you set *S1* to ON. If you have a rotary-dial or "pulse" phone, dial a number and then set *S1* to ON. Once *S1* has been set to ON, hang up your telephone. You should now hear the ring signal through Speakerphone's speakers. Adjust the VOLUME control for a comfortable listening level. When your call is answered, you can carry on a conversation just as you would normally hold one with someone in the same room with you.

Coming Next Month

As mentioned, Speakerphone is not a complete telephone instrument. It merely adds hands-free talk/listen capability to an existing telephone. However, next month, in the conclusion of this article, we'll tell you how to add a Touch Tone pushbutton dialer and an electronic ringer that *will* make Speakerphone into a complete instrument. **ME**

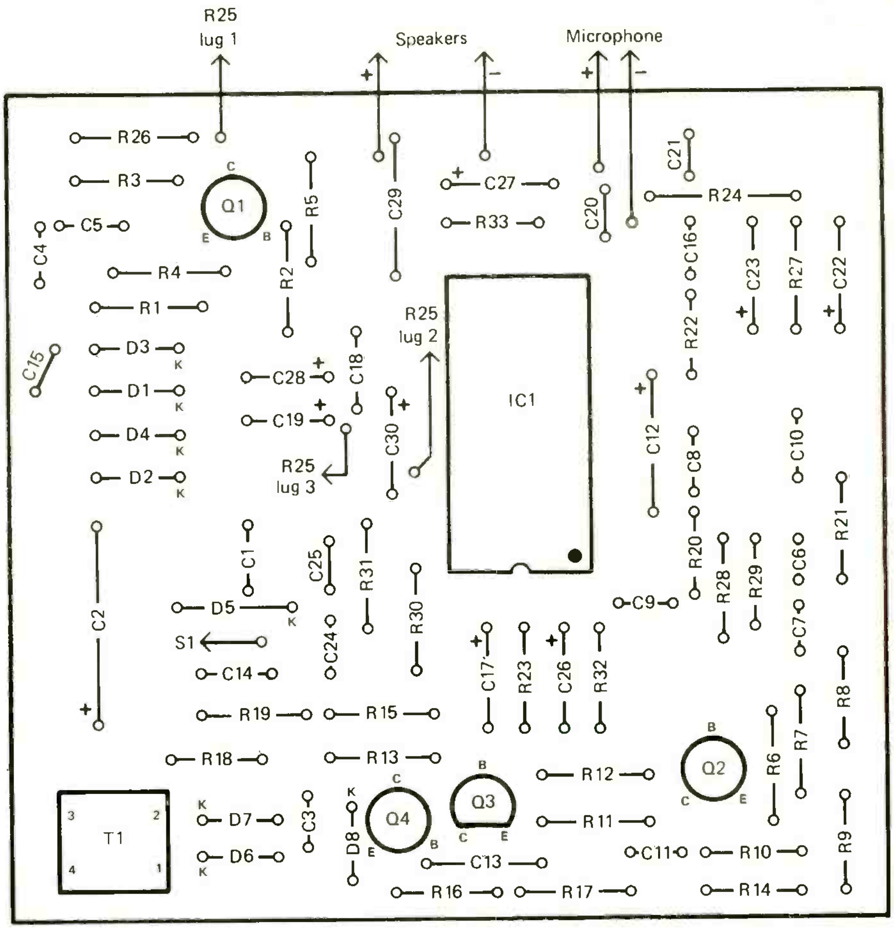
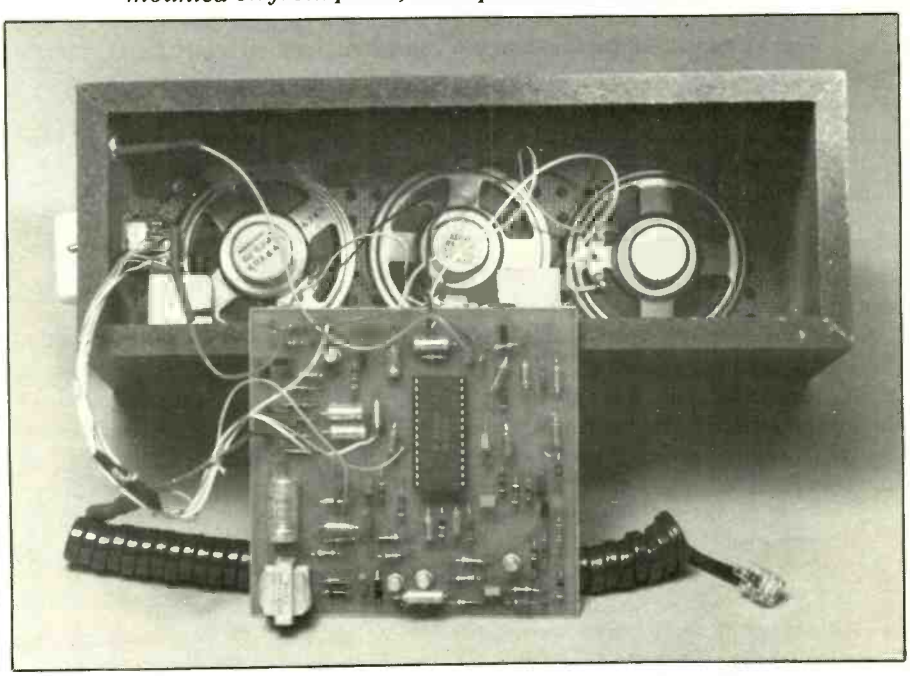


Fig. 4. Components-placement and orientation diagram.

Completed project just prior to mounting circuit board. Note that speakers are mounted on front panel, microphone and switch on side.



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5¼" Same as above, but bulk pack w/o envelope	**6497-FA**	0.49
5¼" DSQD Soft Sector (96 TPI)	**6501-FA**	1.09
5¼" Same as above, but bulk pack w/o envelope	**6507-FA**	0.84
5¼" DSHD for IBM PC/AT - bulk pack	**6667-FA**	2.07
3½" SSDD (135 TPI) - bulk pack	**6317-FA**	1.67
3½" DSDD (135 TPI) - bulk pack	**6327-FA**	1.99

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; DSHD = Double Sided High Density; TPI = Tracks per inch.

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Atari XL/XE Power Supplies: A Hardware Mystery Solved

Exploring similarities and differences of the four major types of XL/XE supplies and how you can repair them

By Benjamin Poehland

If you're a serious Atari XL hardware enthusiast, you probably keep a copy of the 800XL Field Service Manual close by your machine. Perhaps you've even purchased a copy of the recently released Sams *Computerfacts* for the 800XL. As good as these references are for troubleshooting and repairing a malfunctioning 800XL, neither contains information concerning the power supply, which is very prone to failure. Replacement of a defective power supply will cost you 30% or more of the price of a new 800XL at today's discount prices. Of course, you can return an out-of-warranty power supply to Atari directly for repair. However, you'll pay for this and you won't have the use of your computer during the turnaround. Given that the power supply is a major component of the computer and is absolutely essential to its operation, it's doubly mysterious that the available hardware manuals virtually ignore it. The reason may be that there are at least four different types of power supplies shipped with the 800XL! This being the case, let's examine each and determine what, if anything, can be done if it fails.

Fig. 1. Pictured here are the four major configurations of power supplies supplied with Atari XL computers arranged from Type I through Type IV left to right.

A Plethora of Supplies

Figure 1 shows the four major types of power supplies that have been shipped with 800XLs. (Considering the many changes Atari has undergone since the introduction of the XL machines, there may be still others not covered in article.) The units are arranged and numbered roughly in the order of their appearance. Type I on the left was shipped with early production 800XLs until about the winter of 1984. It is the prettiest of the power supply boxes and is the only one made in Hong Kong (all the others are made in Taiwan). Type II supply appeared in 1984 prior to the Tramiel takeover. It seems to be the most frequently encountered. It's also the heaviest, hottest and ugliest. Type III was encountered by chance in a shipment of 800XLs containing the most recent (Type IV) power supplies. Although black in color like the Type II it has the stylish appearance of the Type I and is the only one of the group specified for use with both the 600XL and 800XL. The newest

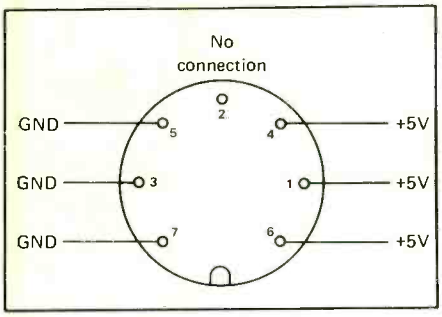


Fig. 2. Pinout descriptions for XL/XE connector on cable that goes to the computer.

Type IV supply has been shipping with some 800XLs since the spring of 1985. It's the smallest, lightest, coolest and most sophisticated (electronically) of the XL supplies. The Type IV is also the standard supply that has been shipping with the new 130XE since the appearance of that machine in mid-1985. The design of the Type IV represents a radical departure from all the previous designs, as we shall see.

Despite the multiplicity of differences, all four of these power supplies perform the same function. They convert the 117 volts from the ac line to the +5 volts required by the computer. All have the same type of power connection for an XL or XE machine (see connector pinout in Fig. 2). Any of the four power supplies described in this article (and *only* these four!) should provide sufficient current to operate a 600XL, 800XL or 130XE computer and associated peripherals without difficulty.

Type I: The Beauty Queen

If your computer was furnished with this type of supply, count yourself lucky. Not only is it the most powerful and aesthetically pleasing, it is also *repairable*. Access to the circuitry is accomplished by first removing the four rubber feet from the bottom (they may be held in place by soft glue, so pull hard). Under each foot is a screw that can be removed with a Phillips screwdriver. You can then remove the top cover.

Figure 3 is an interior view of this supply, while Fig. 4 is its schematic diagram. The component most likely to fail in this circuit is the miniature 3-amp fuse. (You can get it inexpensively from Radio Shack as an "in-

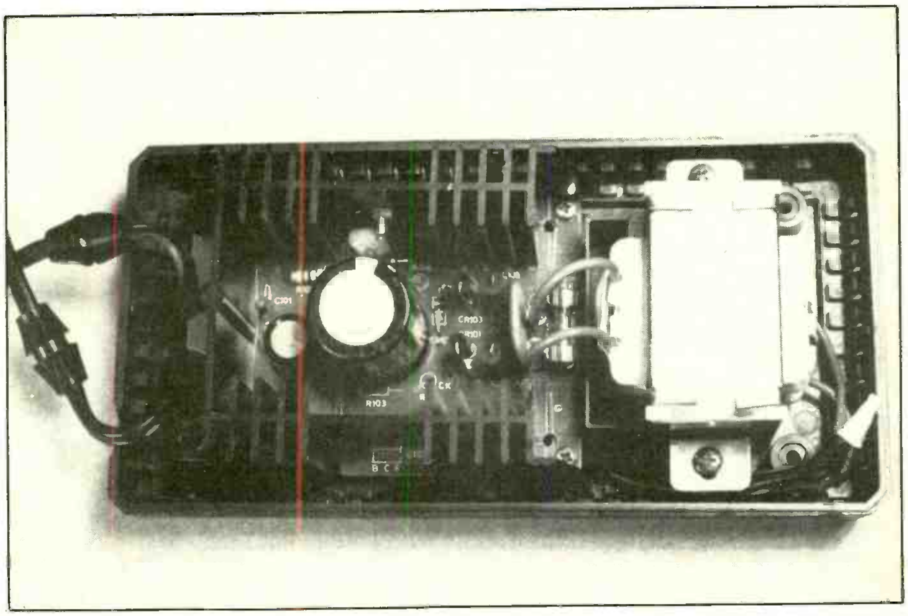
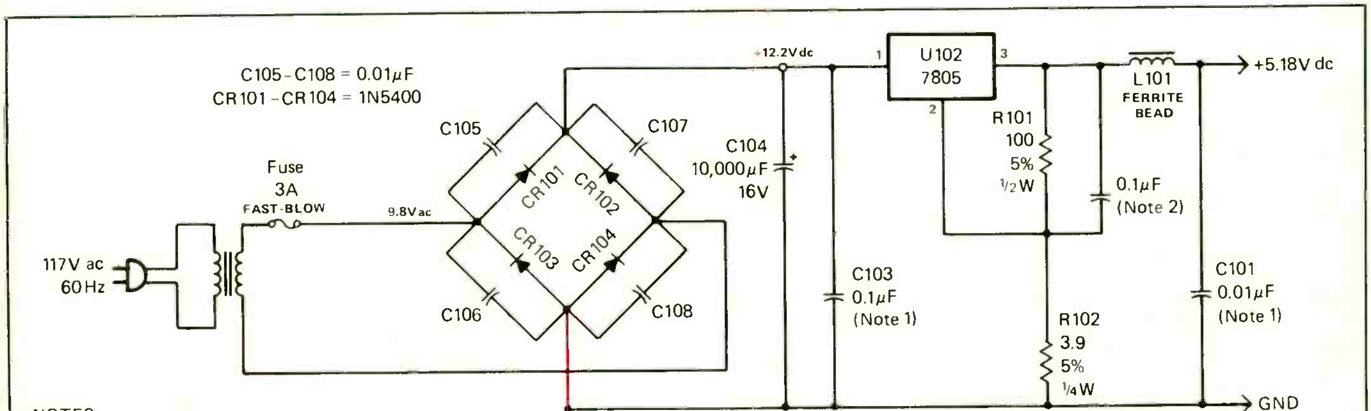


Fig. 3. This is the interior view of the Type I power supply, slightly modified.



NOTES:
1. May not be in all units or may be a different value.
2. Tack soldered to foil side of PC board. May not be in all units.
3. Voltage measurements made under no-load conditions.

Fig. 4. This is the schematic diagram of the Type I power supply. Component designations in all schematics correspond to locations screened on pc boards.

strument fuse.") The critical component in this supply is the *U102* 7805 voltage-regulator chip with built-in thermal overload protection. If the chip gets too hot, it shuts down until it cools off, then pops back on again. The large heat sink visible in Fig. 3 cools the chip and prevents the thermal protection from activating prematurely.

The large power transformer reduces the 117 volts from the ac line to about 10 volts ac, which is then converted to pulsating dc by rectifier diodes *CR101* through *CR104*. The dc pulses are smoothed by filter capacitor *C104* (visible in the center of the circuit board in Fig. 3). The smoothed unregulated dc is regulated down to a constant +5 volts by 7805 regulator *U102*. The output voltage to the computer is boosted slightly by the *R101/R102* resistor network to help counteract delivery of a lower voltage under heavy load. Capacitors *C101*, *C103* and *C105* through *C108*, and ferrite bead *L101* filter out high-frequency noise that could interfere with computer operation.

In addition to the usual Atari part number, the Type I's printed-circuit board also has markings and spaces for additional parts that may or may not be present in your unit (several different versions are probably in existence). Those empty spaces give the appearance that someone at the old Atari tried to save money by shaving the number of parts.

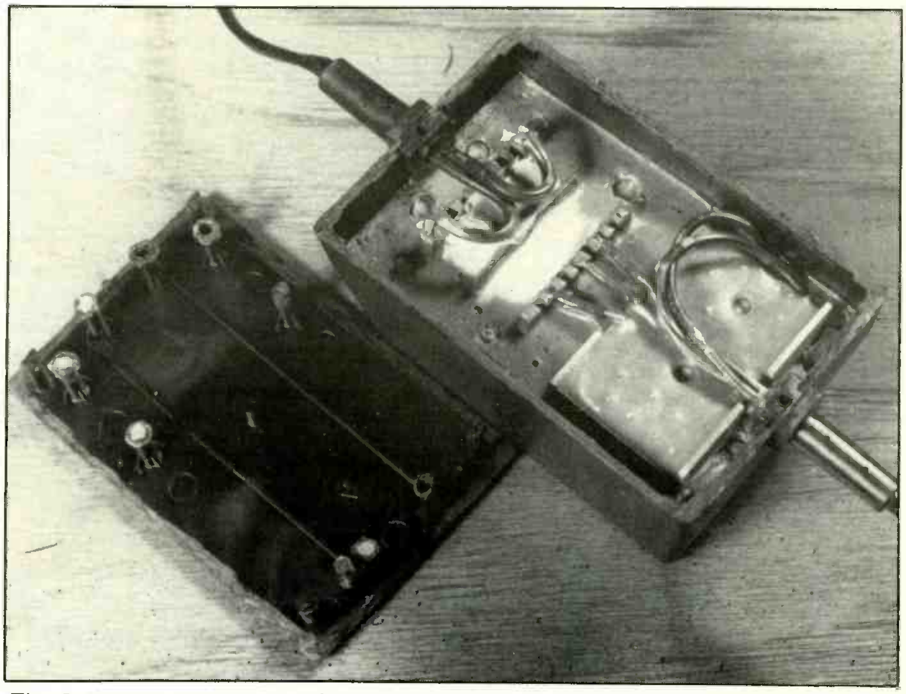


Fig. 5. Note in this photo of the Type II power supply that the entire unit is permanently sealed in plastic potting compound, eliminating repairability.

Type II: The Ugly Klunker

If you're using this type of power supply and it poops out, you can't fix it. Atari can't fix it, either! Figure 5 shows why. The entire circuit, transformer and all, is permanently sealed in potting compund. The outer plastic case is permanently sealed, too. I had to use special tools to cut open the one shown to get this photo. After several hours of operation, the Type II supply gets uncomfortably warm, which probably means that its circuitry is similar to the Types I and III circuits. It's very discouraging to

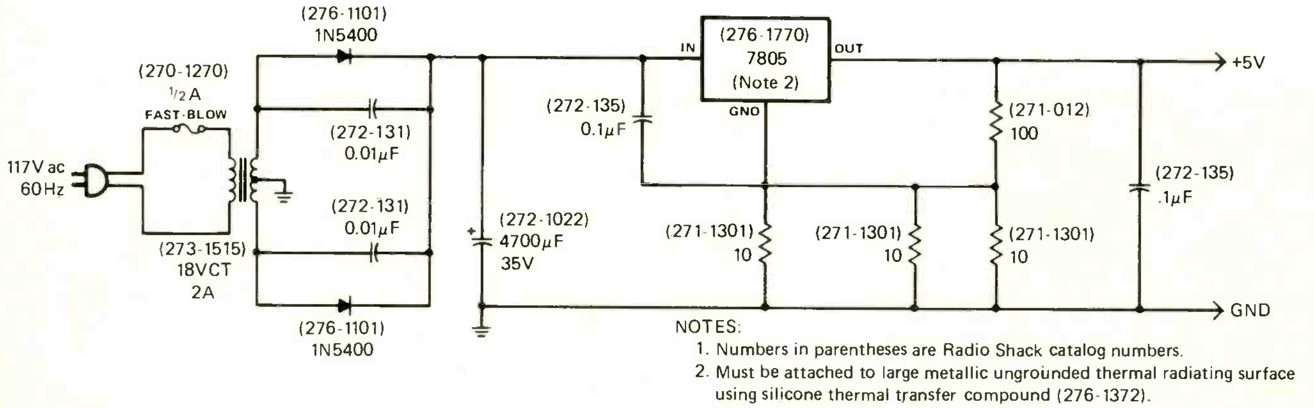


Fig. 6. Shown in this schematic diagram is all the circuitry needed to build a replacement for the Type II power supply. All components are readily available.

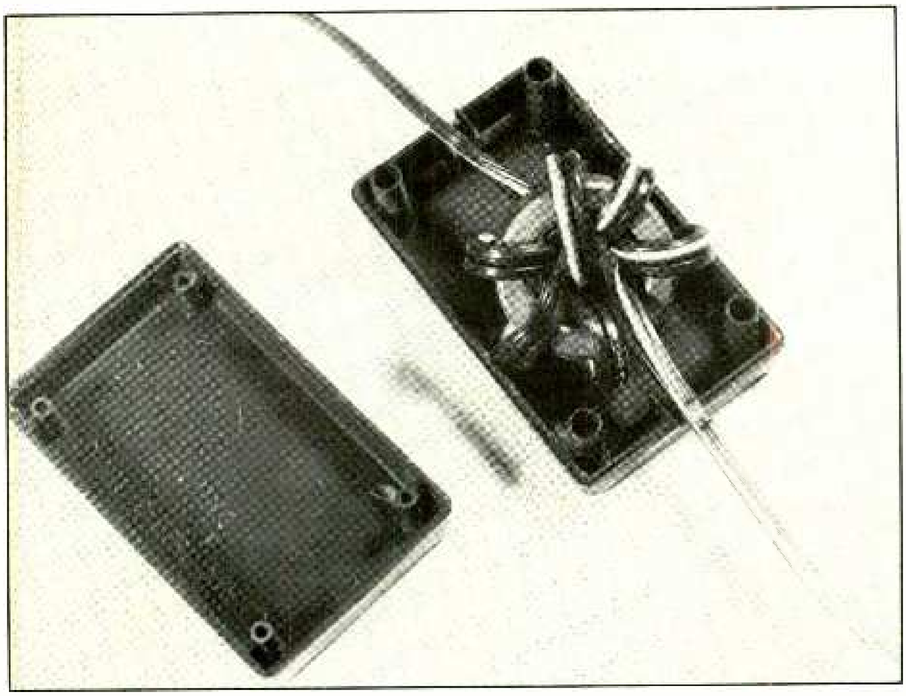


Fig. 7. A radio-frequency interference suppressor for the Type II power cord is inside a plastic box near the end of the cable that goes to the computer.

consider that inaccessibly bured in that chunk of plastic may be a 25-cent fuse whose failure will require replacement of the *entire* unit.

If this supply goes dead and your computer is out of warranty, you have only three options. You can return your defective Klunker to Atari accompanied by a suitable payment ($24.95 including the handling fee), which is costly if you live on the East Coast and wait up to four weeks for a replacement to arrive. You can purchase a new power supply outright from any of several mailorder houses for $25 to $35 plus shipping. Your best alternative, however, may be to build a new supply from the schematic in Fig. 6.

Building your own power supply should cost you about $20 in commonly available parts, providing a supply for adequate power for an XL or XE machine. The ac line cord and power cable/connector assembly can be salvaged from your defective Type II for reuse. A pc board isn't required, since the parts can be mounted in a suitable enclosure using 5-lug terminal strips. Be *very* careful if you go this route, because the power supply connects directly to the ac line and a potential electrocution hazard exists if things are not wired properly. When you finish wiring it, measure the supply's output voltage at each pin of the connector *before* connecting it to your computer.

This is the only power supply that comes with an externally mounted device to suppress radio frequency (r-f) interference. This is the little black plastic box attached to the power cord that goes to the computer. Figure 7 is a photo of the innards of this mysterious little box. Note that it is nothing more than ferrite core around which the power cord has been wound three times in one direction and three more times in the opposite direction. This same device is also used on the video cable that connects the computer to a TV.

Type III: The Black Beauty

This is the simplest and easiest to repair of the XL power supplies. The neat, streamlined appearance of the interior of this unit is shown in Fig. 8. Its schematic diagram (Fig. 9) is very similar to that of the suggested replacement for the Type II supply (Fig. 6). Access to the interior of this unit is obtained in the same manner as for the Type I supply.

Because the power transformer in the Fig. 9 circuit uses a center-tapped secondary, only two rectifiers are required to provide "full-wave" rectification of the ac voltage. With its

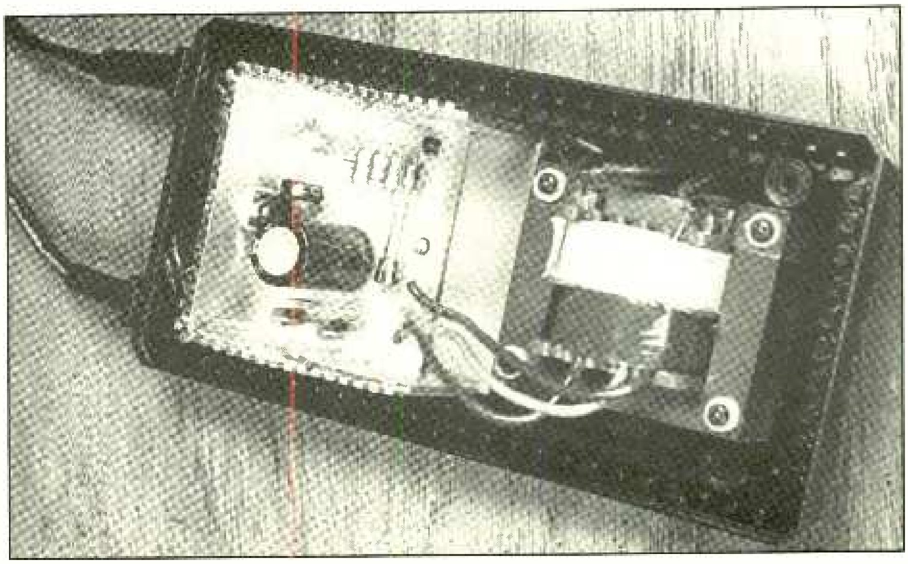


Fig. 8. This is an interior view of the Type III supply.

Power Your Next Project With an ac Adapter

External wall-transformer type ac adapters are now powering home computers and peripherals. The reason for this is that electrical equipment that connects directly to the ac line must be "certified" before it can be approved for consumer use. But certification is costly and time-consuming, which can cut profit margins. To minimize losses, many manufacturers are now obviating the need for certification by eliminating direct connection of their products to the ac line. Using *external* power supplies, puts the responsibility for certification on the manufacturer of the supply. Everyone benefits—even *you*!

Depending on the power needs of your project, you can use any of a number of plug-in ac adapters instead of building in a transformer. The table lists a number of heavy-duty adapters used with home computers and peripherals and includes input and output specifications. Note that output power ranges from 7.5 to 56 volt-amperes (VA) with these adapters. This should be sufficient for the modest needs of most home-built electronic projects.

All adapters listed are UL or/and CSA approved and are designed to be operated from a 117-to-120-volt, 60-Hz ac line. If you decide you need any of these adapters for a current or your next project, look through the mailorder ads—many are now available at reasonably low cost.

If your project's power demands aren't in the "heavy-duty" category, you might want to use a less-bulky, general-purpose ac adapter like those sold by Radio Shack, some local parts stores and many mail-order houses.

Low cost and safety make ac adapters the ideal alternative to home-built projects with built-in transformer power supplies.—*R.L.L. Hu*

AC Adapters Used With Popular Home Computers & Peripherals

Model	Input	Output
Apple IIc	25 W	15 V dc, 1.2 A, 18 W
Atari 130XE	25 W	5 V dc, 1.5 A (7.5 VA)
Atari 400/800 and 1050 disk drive	50 W	9 V ac, 31 VA
Atari 520ST	49 VA	5 V dc, 3 A +12 V dc, 30 mA −12 V dc, 30 mA
Atari 600XL/800XL	40 W	5 V dc, 1.5 A
Atari 1027 printer	60 W	9.5 V ac, 40 VA
Colecovision Video Game	250 mA	+5 V dc, 900 mA −5 V dc, 100 mA +12 V dc, 300 mA
Commodore 16	16 W	9.5 V dc, 1 A
Commodore 64 and VIC-20 (new)	40 VA	5 V dc, 7.5 W 9 V ac, 6.7 VA
Commodore 128	70 VA	5 V dc, 4.3 A 9 V ac, 1 A
Commodore VIC-20 (old)	400 mA	10 V ac, 30 VA
IBM PC*jr*	70 mA	16.7 V ac, 56 VA
Texas Instruments 99/4A	300 mA	18 V ac, 22 VA 7.5 V ac, 1 VA
Timex/Sinclair TS1000/ZX-81	15 W	9 V dc, 1 A
Timex/Sinclair TS2068	26 W	15 V dc, 1 A

Note: Input is manufacturer's rating at 117 V ac; "dc" Output is pulsating dc; all ratings are nominal.

low parts count and simple layout, this looks like the power supply Atari should have furnished with all XL machines from the beginning. Why they didn't is anybody's guess.

An interesting voltage trimming feature in this supply compensates for slight differences in the output of individual 7805 regulators. The combined value of *R2, R3* and *R4* is 1.8 ohms. Together with *R1,* they provide a 1.8% boost in output voltage. It is possible that in some Type III supplies, one or more of these resistors will be missing. This circuit has been cleverly designed so that if the output voltage is a little low, it can be raised merely by snipping out one or two resistors such that the remaining combination yields the desired voltage within a range of seven values from 1.8% to 8.2%.

Type IV: The Peanut

If the Type III supply caused Atari's power supply designer to sweat a little, the Type IV must have given him a whopping headache! In the Type IV, the elegant simplicity of the Type III has been completely abandoned. As you can see in Fig. 10, the small circuit board is densely packed with many components. The relative complexity of the circuit is fully revealed in the Fig. 11 schematic.

The "brain" of this supply is the 14-pin 723 low-power voltage regulator. This chip regulates the output voltage very precisely but by itself is not husky enough to deliver the current demanded by a 130XE computer. To overcome this problem the 2SD613 external power transistor is used to pass the heavy current that provides the "muscle." This is really two power supplies in one. Hefty rectifier diodes *D3* and *D4* provide the

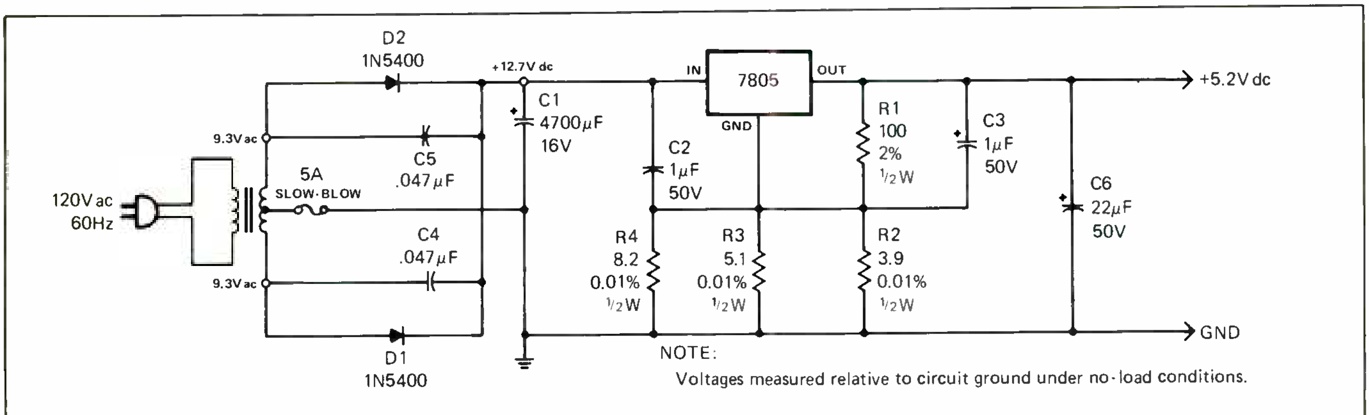


Fig. 9. Schematic diagram of the Type III power supply.

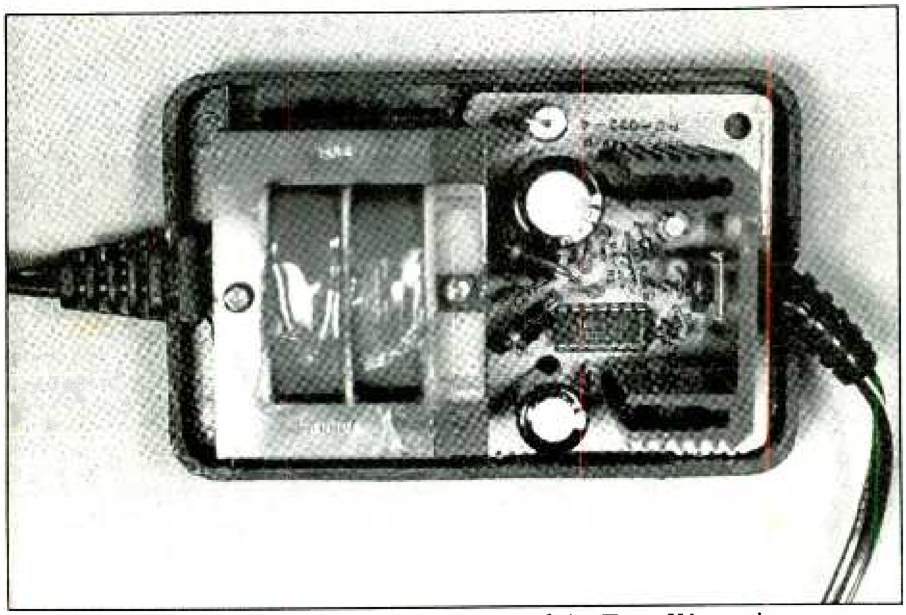


Fig. 10. This is an interior view of the Type IV supply.

primary dc voltage that feeds the pass transistor and powers the computer. The smaller *D1* and *D2* rectifiers provide a secondary supply that's used solely to power the 723 regulator.

Various reference and bias voltages required for proper operation of the regulator are provided by the complicated-looking *R2* through *R7* network. Surge protection for the regulator is provided by *R1*, while *R8* serves a similar function for the pass transistor. Resistor *R9* is a sensing element used by the regulator to limit output current to a safe level.

A Type IV power supply is repairable, but Atari has done a good job of discouraging anyone from attempting repairs by packaging it in a permanently sealed plastic box similar to that used for the Type II supply. It would be very difficult for most Atari owners to open this case without irreparably damaging it. I had to work very carefully with a Moto-Tool fitted with an abrasive wheel to get the photo of the innards shown in Fig. 10. If you get this far and have completed whatever repairs are required, you must then figure out how to reseal the case. If your incision is relatively clean all around the base, a thin bead of "Super Glue" placed around the exposed cut edge of one case half will suffice to stick everything back together again. then apply heavy pressure to both halves for at least 15 minutes to ensure a good bond.

Once you have gotten to the inside of a Type IV unit you could look at the fuse, any of the diodes, the regular chip, and/or the pass transistor as the most likely source of trouble. If you discover a bad transistor, you can replace it with a commonly available TIP 3055 device. If the 723 IC is defective, you'll have to desolder and remove it—without damaging the printed circuit board—before it can be replaced.

Of all the supplies discussed here, the Type IV performs most poorly with regard to meeting its output specifications. The other types all produce in excess of one ampere at their rated voltage under conditions simulating actual use. But the Type IV doesn't produce even one full ampere. While this apparently doesn't hamper operation of the computer, it does suggest a slimmer reliability margin in locations where ac line voltage is subject to fluctuation.

A second point of concern is related to the pass transistor used in the Type IV supply. Any transistor can fail in such a way that it places a short circuit between the collector and emitter terminals. If this should occur and the full 10 volts dc at the collector of the 2SD613 is passed to the

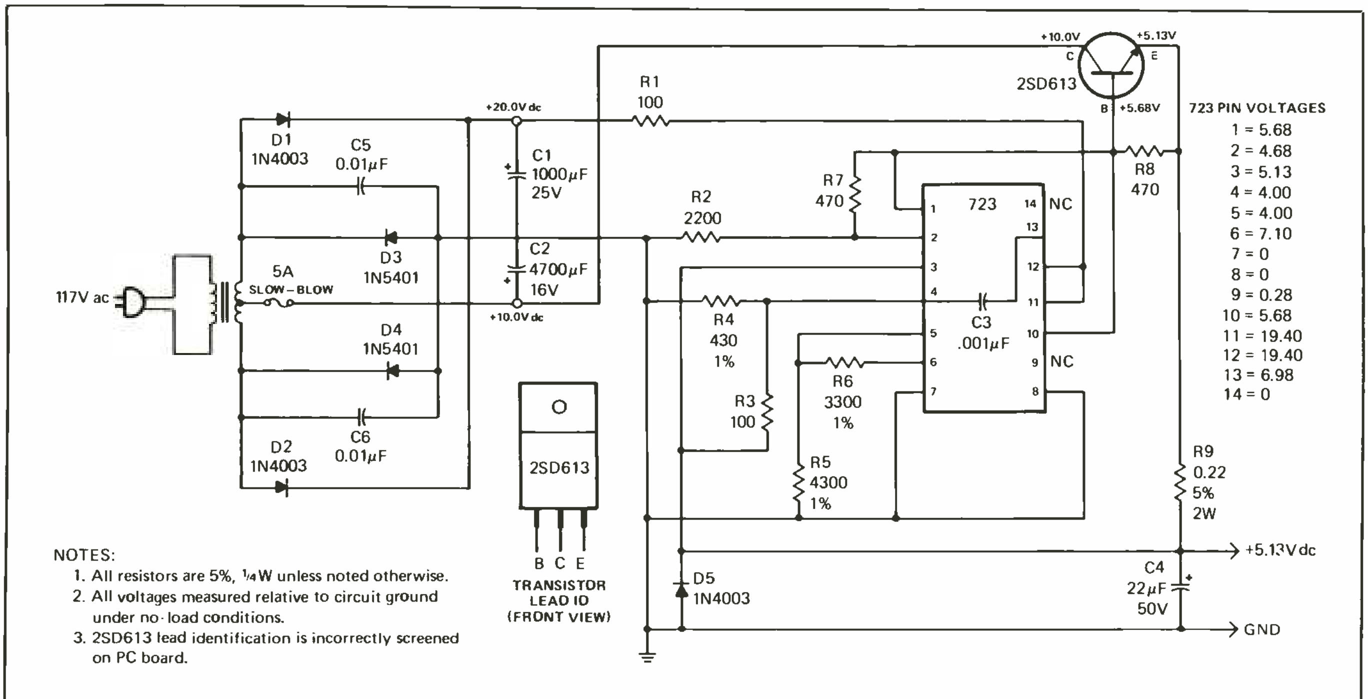


Fig. 11. Schematic diagram of the Type IV power supply.

Atari XL/XE Power Supply Characteristics

Characteristic	I	II	III	IV
Aesthetic appeal	superb	rotten	nice	so-so
Interior accessibility	easy	impossible	easy	difficult
Ease of repair	easy	impossible	easy	tedious
Output Rated Amperes	1.5	1.5	1.5	1.5
Volts	5.0	5.0	5.0	5.0
Measured Amperes	1.44	1.15	1.29	0.93
Volts	4.90	4.90	4.90	4.90

computer, it will "fry" your computer. Though such a disastrous condition is unlikely to occur, the possibility *does* exist.

In Conclusion

By now, you should know what type of power supply your Atari XL or XE computer has, what its circuitry looks like, whether or not it's repairable, and the supply's advantages and disadvantages. In the Table is a summary of the major features of the different power supplies we've discussed and a comparison of output specifications versus actually measured test conditions. Despite the wide variation in ability to meet their full output specifications, all four types of supplies do a good job of delivering the "juice" to your computer. They also appear to be fairly rugged and reliable in normal use. Hopefully, you'll never have occasion to put the material contained in this article to use. **ME**

A Smoke Alarm Inhibitor

Silences a smoke detector for a predetermined period of time when a false alarm occurs and then automatically rearms the detector thereafter

By Sally Benevento
& John Benevento

For a smoke alarm to sound an early alert, it must be located near potential fire hazards, such as in a kitchen or near a fireplace. But it's just such locations that are prone to causing the detector to sound false alarms. Disconnecting the battery from the detector when conditions are ripe for activating a false alarm to be sounded is risky because you might not remember to reconnect it later. However, there's a much safer way to handle the false-alarm annoyance. The Smoke Alarm Inhibitor described here is it!

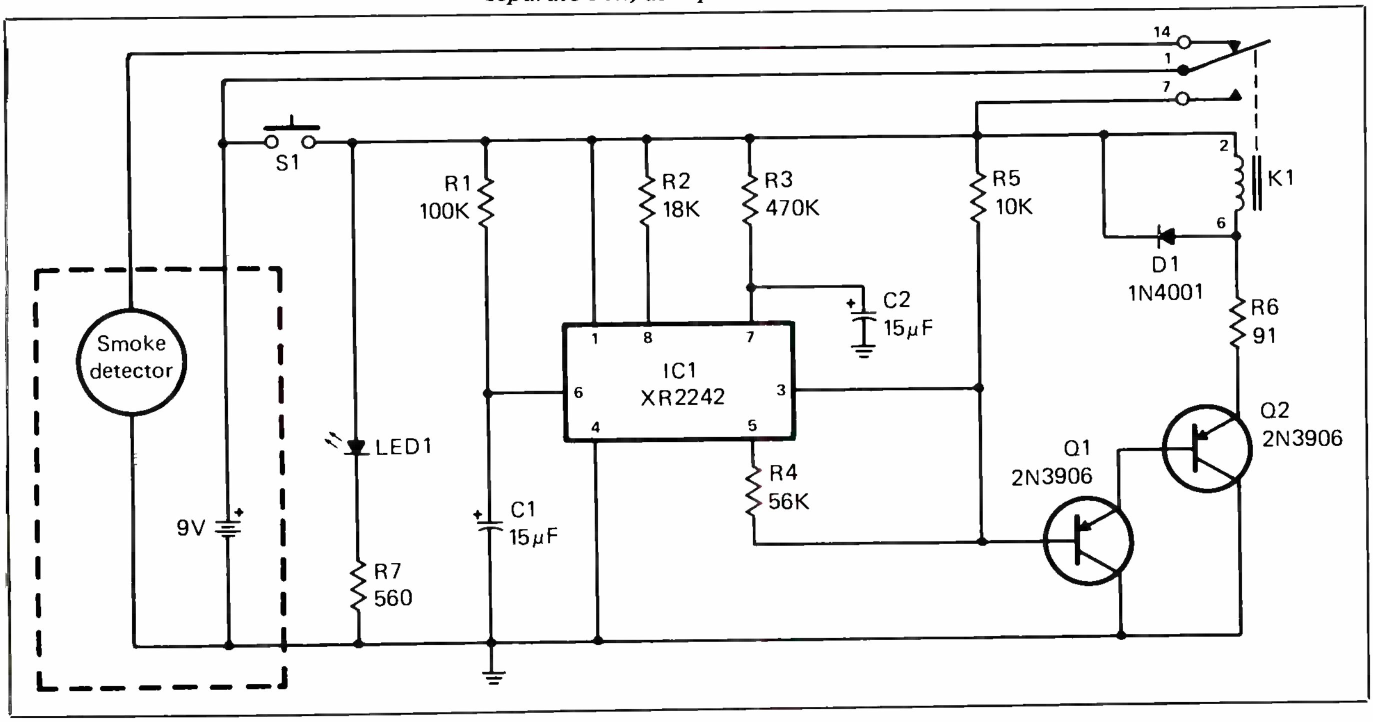
The Inhibitor lets you push a button to silence the alarm when false triggering occurs. The alarm will remain silenced for a predetermined period of time, usually in minutes for practical applications. (A much shorter or longer time can be selected.) The Inhibitor circuits gets its power from the smoke detector's internal battery but draws no power until it is activated, so battery life remains about the same as it would be without the Inhibitor.

You can install the Inhibitor circuit inside a smoke detector's case or externally. In either case, it's activated via a remote pushbutton switch within easy reach. The switch is housed in a box along with a light-emitting diode that comes on to inform you that the Inhibitor has been activated and that the alarm won't sound, even in the presence of dense smoke, until the countdown cycle has been completed.

About the Circuit

Three important design considerations are met with the Inhibitor circuit. First and most important, all the functions of the original smoke detector are unmodified. Therefore, the smoke detector defaults to its original operating condition. Next, the Inhibitor circuit in standby draws no power from the smoke detector's battery. Finally, the circuit is small enough to nestle inside the average

Fig. 1. Complete schematic diagram of the project. The circuit can mount either inside the smoke detector or in a separate box, as explained in text.



PARTS LIST

Semiconductors

D1—1N4001 rectifier diode

IC1—XR2242CP (Exar)

LED1—Panel-mount light-emitting diode or standard light-emitting diode with panel holder

Q1,Q2—2N3906 transistor

Capacitors

C1,C2—15-μF, 35-volt tantalum capacitor (see text for selecting C2 value)

Resistors (¼-watt, 10% tolerance)

R1—100,000 ohms

R2—18,000 ohms

R3—470,000 ohms (see text)

R4—56,000 ohms

R5—10,000 ohms

R6—91 ohms

R7—560 ohms

Miscellaneous

K1—Miniature DIP relay (Magnecraft No. W172DIP-2 or equivalent)

S1—Spst normally-open pushbutton switch.

Printed-curcit board or perforated board with soldering hardware; suitable enclosure (see text); sockets for IC1 and K1 (optional); hot-melt glue, silicon adhesive or foam mounting tape (see text); 3-conductor cable (preferably color-coded); hookup wire; machine hardware; solder; etc.

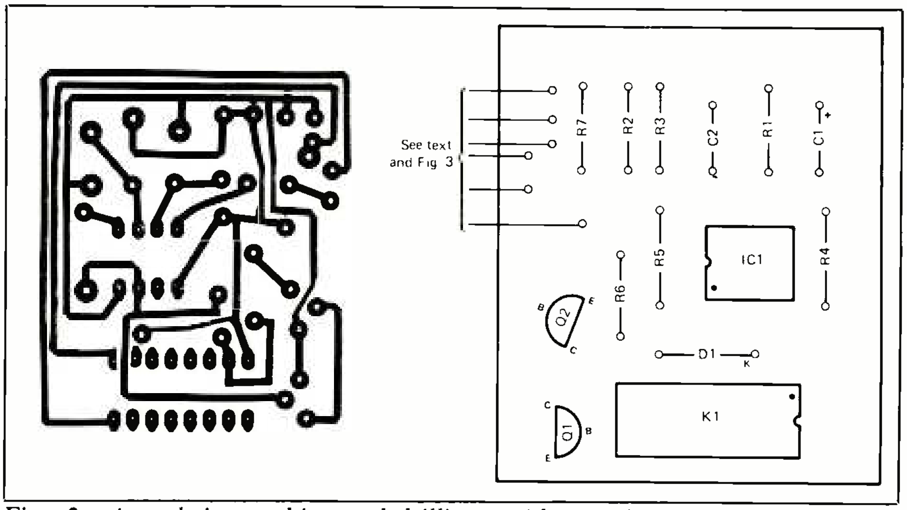


Fig. 2. Actual-size etching-and-drilling guide (at left) and components-placement/orientation diagram (at right).

smoke detector or in a remote switchbox.

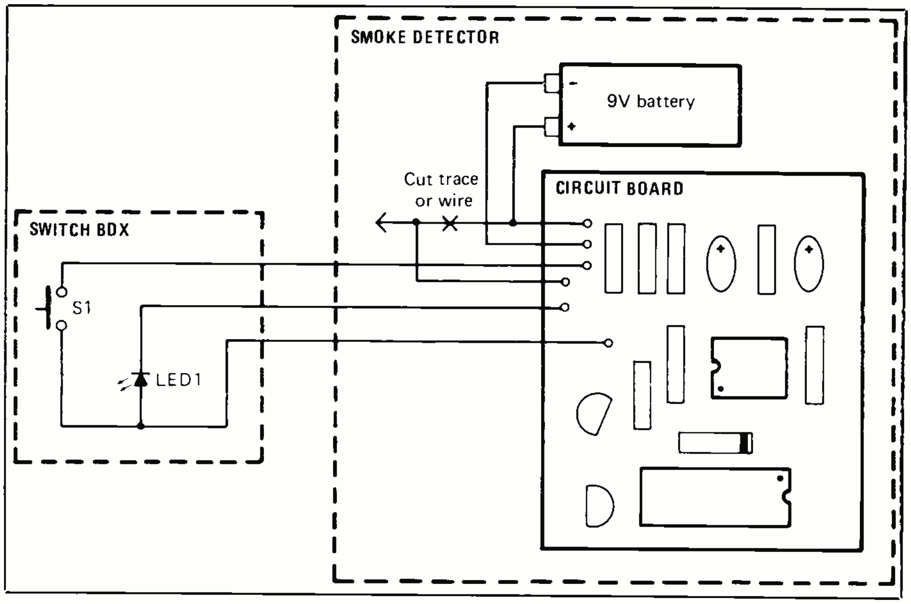
At the heart of the Inhibitor circuit is Exar's XR2242 long-range timer, identified as *IC1* in Fig. 1. This device is a modified 555 timer IC with an internal divide-by-128 divider. This combination timer/divider chain allows you to select from a wide range of timing cycles. A period of 15 minutes is obtained with the values shown for frequency determining elements *R3* and *C2*. The period formula is: Period = 128RC, where *R* is in ohms and *C* is in farads. Using the values shown for *R3* and and *C2* in the formula, we obtain Period = 128 × 470, 000 ohms × 0.000015 farads = 902.4 seconds. Dividing by 60 seconds, we obtain a 15.04-minute figure for period.

With the XR2242 chip, you can use resistor and capacitor values ranging from 1000 ohms to 10 megohms and 0.001 to 1000 microfarads, respectively, to obtain periods ranging from a fractions of a second to many hours. However, you will be safest with values that yield a timing period in the range from 10 to 30 minutes in a critical application like smoke detection.

Applying a positive-going trigger pulse through *S1* and the *R1/C1* network to pin 6 of *IC1* initiates a timing cycle. In appproximately 100 milliseconds, the voltage on pin 6 of *IC1* rises to trigger the timer. At the same time, *K1* energizes through the Darlington arrangement of *Q1* and *Q2* and remains energized for the entire timing cycle. The contacts of *K1* at pins 1 and 7 of the miniature relay apply V_{cc} to the Inhibitor circuit when *S1* is released, while the normally-closed circuit between pins 1 and 14 of *IC1* interrupt power to the smoke detector.

At the end of the timing cycle, pin 3 of *IC1* goes high. This shuts off *Q1* and resets the timer. With *K1* now de-

Fig. 3. Details for mounting the circuit board inside the smoke detector.



energized, the detector is returned to normal operation through pins 1 and 14 of the relay.

Power for the Inhibitor circuit can be from any 4.5-to-15-volt dc source. If your detector uses a battery rated at other than 9 volts, you must use a different value for current-limiting resistor *R6* for 6-volt dc relay *K1*. Select a value that limits current through *K1*'s coil to no more than the maximum specified by the manufacturer.

Light-emitting diode *LED1* is optional. It is included here to inform you that, when lit, the Inhibitor has been activated. Current through *LED1* is limited to a safe level by dropping resistor *R7*, whose value has been selected for a 9-volt battery source. If you power the Inhibitor from a source with a lower or higher voltage, you must change the value of *R7* to keep the current within safe limits.

Diode *D1* across the relay's coil provides a discharge path when *K1* deenergizes. It is mandatory to prevent high-voltage spikes induced by the collapsing field generated by *K1*'s coil from damaging the circuit.

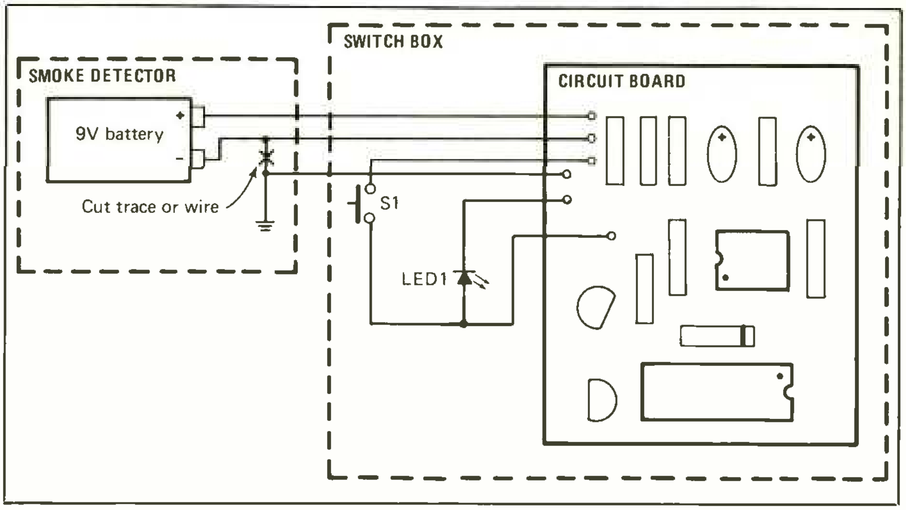


Fig. 4. Details for mounting the circuit board in an external box.

Construction

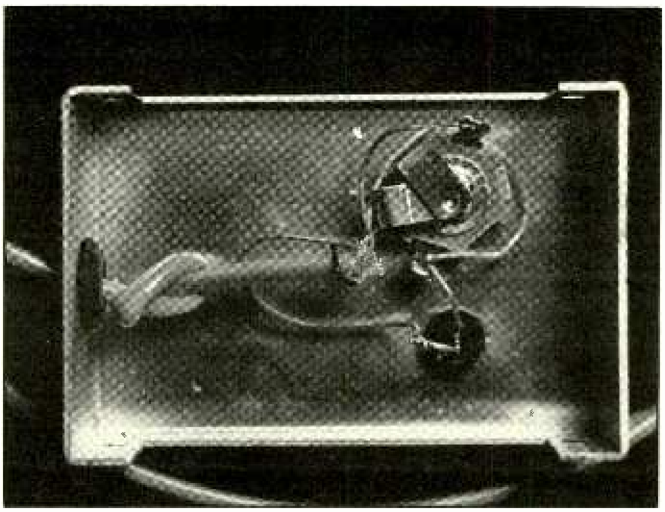
Before you begin construction, remove the battery from the smoke detector and break the battery's positive (+) line by cutting the wire or circuit-board trace near the power input connection (see Figs. 3 and 4). Then determine where to install the Inhibitor's circuit assembly—inside the case that houses your smoke detector or externally in a separate box that connects to the detector via a cable. In either case, *S1* and *LED1* (if used) must mount in a remote box of their own. Internal installation is recommended if at all possible because it obviates any remote chance of a break in the external wiring from defeating the purpose of the smoke detector.

Interior mounting of the circuit board requires as compact a circuit board assembly as possible. This means you'll have to fabricate a printed-circuit board, using the actual-size etching-and-drilling guide shown at the left in Fig. 2. External mounting in a separate remote box doesn't put size restraints on the circuit-board assembly and lets you choose perforated-board (with appropriate soldering hardware) wiring.

Use the diagram shown to the right in Fig. 2 as a wiring guide for the pc board and as a general layout guide for perf-board construction. As you

Fig. 5. Circuit-board assembly mounted inside smoke detector (at lower-left, just above battery). Cable at left goes to external remote LED/switch box.

Fig. 6. A 3-conductor cable connects the pushbutton switch (left) and LED (right) to the circuit-board assembly mounted inside the smoke detector.



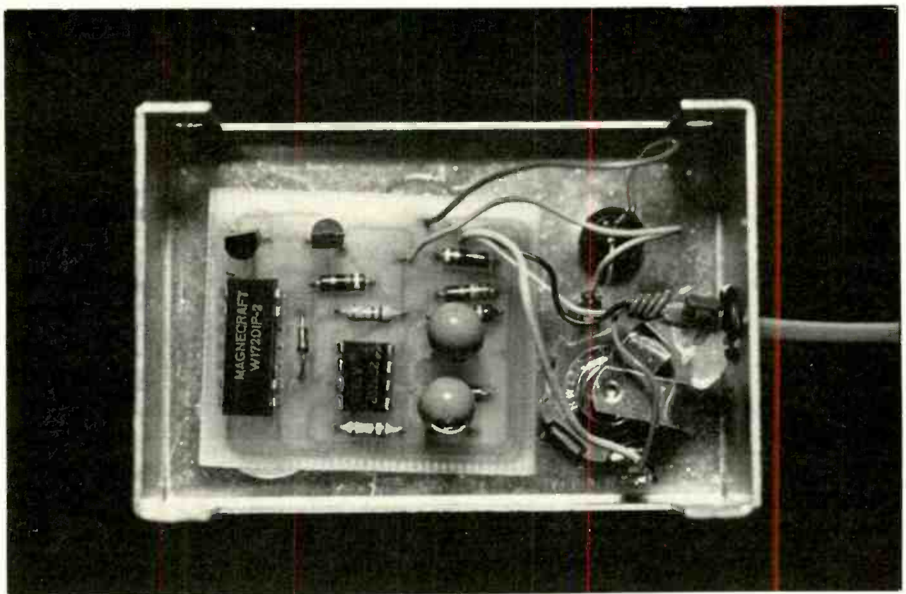


Fig. 7. Circuit-board assembly, pushbutton switch and LED mounted inside separate box, with 3-conductor cable connecting them to smoke detector.

install each component on either board, make sure its value is correct and that polarization and orientation, where applicable, match the illustration in Fig. 2 before soldering it into place. Use of sockets for *IC1* and *K1* is optional but recommended, except where circuit height might prevent internal mounting.

If you've decided to install the circuit-board assembly inside the smoke detector's housing, choose a location where it won't interfere with either the detector's own circuitry or the case. After checkout, the board will be anchored in place with silicone adhesive, hot-melt glue or another suitable cement. Figure 5 shows a typical installation.

Prepare the remote switch box by drilling mounting holes for *S1, LED1* and entry of the 3-conductor cable that will be used to interconnect the box and smoke detector. No extra holes for mounting the board inside the box (if you choose this approach) are required, since you'll mount the board with foam mounting tape with adhesive on both sides or a liberal daub of hot-melt glue or silicone adhesive after checkout.

Drill and deburr the holes and then mount the switch and LED in their respective holes and line the remaining hole with a rubber grommet. Wire whatever circuitry is inside the box according to Fig. 3 or Fig. 4, whichever applies to your installation. Then pass the 3-conductor cable through the rubber grommet, tie a knot in it 3″ from the end inside the box, and connect and solder its leads to the appropriate points. Figure 5 shows details of a switch/LED arrangement.

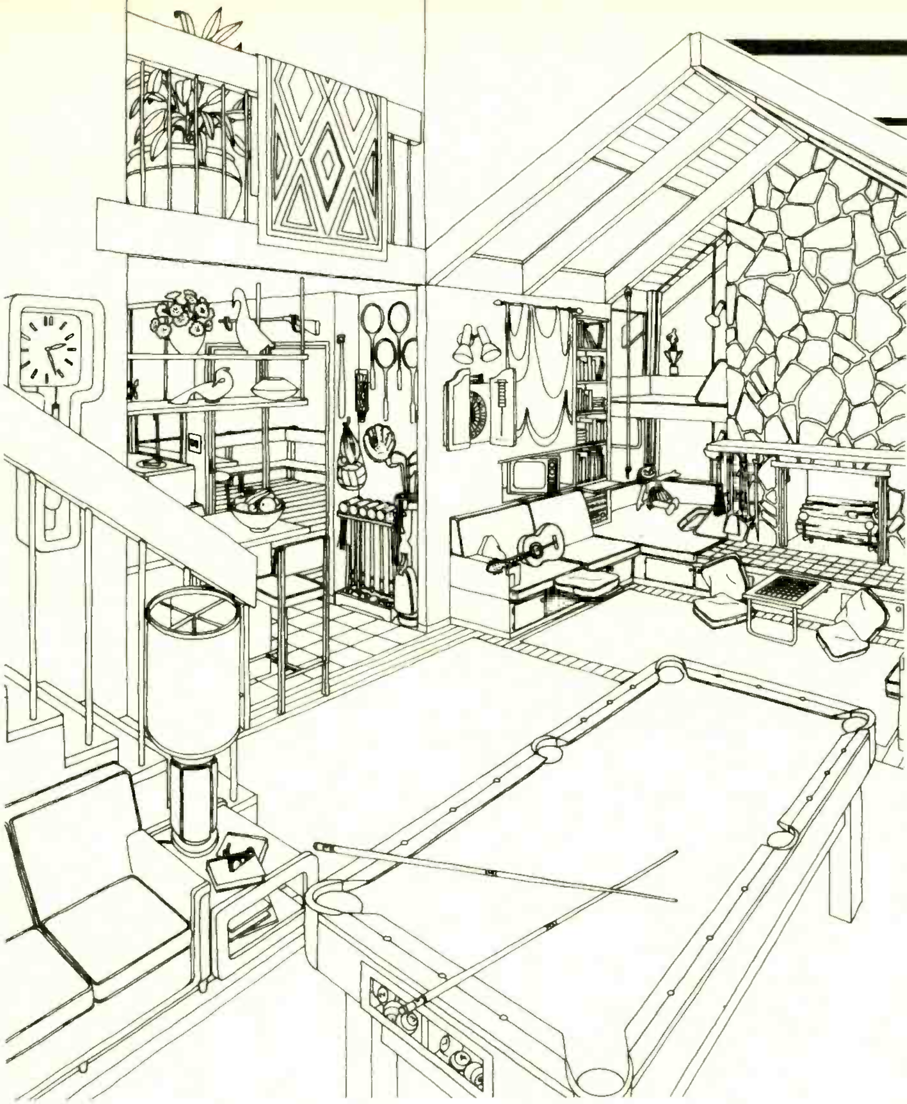
If you've decided to mount the circuit-board assembly inside the box, sandwich the foam tape between the foil side and the inside surface of the box (or use a liberal daub of hot-melt glue or silicon adhesive) after soldering the cable and other wiring to the appropriate pads. Figure 7 shows details of the circuit-board/switch/ LED arrangement.

Select a convenient mounting location for the switch box in your kitchen, near your fireplace or wherever false alarms are a problem. Mount the box and then determine how long the 3-conductor cable must be, including all routing, and cut it to length. Connect and solder all conductors to the appropriate points in the circuit. Recheck all wiring against Figs. 1 through 4. Once you're satisfied everything is okay, reinstall the battery in the smoke detector.

Checkout and Use

Replace the battery and check out the smoke detector according to the manufacturer's instructions. If you obtain proper operation, push and release the Inhibitor's delay switch. The LED, if used, should immediately come on to indicate that the Inhibitor has been activated and the alarm should silence. Now wait until the Inhibitor has timed out and recheck for proper operation of the smoke detector one more time.

Once the Inhibitor has passed all tests, you can proceed to final assembly and installation. Secure the circuit board in place as detailed above and close up the detector's case. A good final step to take is to protect the 3-conductor cable with moulding wherever it might be prone to damage.



An Electronic Remote Doorbell

How to add a second doorbell in your basement, yard, at poolside or wherever you need it

By Brad Thompson

If you're like most of us, you probably can't hear your doorbell when you're in the basement, attic, garage or yard. After having missed the postman once too often while in my basement workshop, I decided to do something about this. Here's how I solved the problem.

About Doorbells

Most modern doorbell circuits are made up of a step-down transformer, a pushbutton switch and a bell, chimes or a buzzer. The transformer is permanently wired into the ac line and delivers about an ampere of current at 10 to 20 volts ac. The pushbutton is a simple normally-open switch made from springy brass; the bell, chime or buzzer is nothing more than an electromagnet to which is attached a clapper.

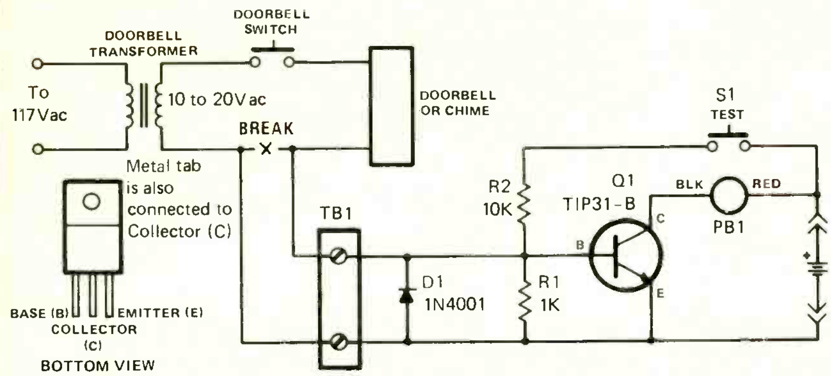
Though the doorbell circuit is simple, attaching a remote bell can be difficult because of the way the system is wired. Connecting a second bell in series with the first doesn't work very well, causing the bells to buzz rather than ring and/or work intermittently. Connecting a second bell in parallel with the first is an improvement in terms of operation, but pulling the additional wires through walls to where you want the remote bell to be is a lot of extra work. It would be much simpler to sample the current in the bell circuit at the transformer.

The current in the circuit must be sampled with as little voltage as possible. One circuit that does the job simply and effectively is shown in the schematic diagram. You can build and install this circuit in just a few hours, at a cost of $12 or less.

How it Works

Transistor *Q1* switches on during positive-going half-cycles of the ac-line voltage when the doorbell is pushed. When *Q1* is conducting, its collector current flows through piezoelectric buzzer *PB1*. The 3-kHz tone generated by the buzzer is modulated by the 60-Hz line frequency to produce a cricket-like sound that can easily be heard over background noises.

Diode *D1* prevents *Q1*'s emitter-base junction from reverse voltage stress when the ac goes negative. Resistor *R1* prevents the transistor from turning on because of leakage current flowing through the doorbell circuit resulting from dirt or corrosion in the doorbell switch. Effects on doorbell performance are mini-



PARTS LIST

B1—9-volt battery
D1—1N4000 series rectifier diode
PB1—Piezoelectric buzzer (Radio Shack No. 273-060 or similar)
Q1—TIP31-B (Texas Instruments), Radio Shack No. 276-2107 or similar power transistor
R1—1000-ohm, ¼-watt, 5% tolerance carbon-film resistor
R2—10,000-ohm, ¼-watt, 5% tolerance carbon-film resistor
S1—Spst normally-open pushbutton switch
TB1—2-contact screw-type terminal board
Misc.—Suitable enclosure; 4-lug terminal strip (no lugs grounded); holder and clip for B1; machine hardware; hookup wire; solder; etc.

The schematic diagram of the remote-doorbell circuit. It includes details for connection into an existing doorbell circuit.

mized because *Q1*'s emitter-base voltage drop induced by *D1* subtract less than 1 volt from normal circuit potential.

Press-to-test switch *S1* and resistor *R2* bypass the bell circuit and provide an easy way to check battery *B1*. Current drain from *B1* is a few microamperes, due to leakage through *Q1*'s collector-emitter circuit. Hence, battery life approaches shelf life. A 9-volt battery is recommended for maximum life.

Construction

There's nothing critical about packaging or circuit layout. You can make substitutions for the components specified in the Parts List, but make sure you use a *power* transistor for *Q1*, because its base-emitter junction must be able to handle up to 1 ampere of current.

When assembling the circuit, make sure the collector and metal mounting tab to which it is electrically connected are not short-circuited to the other components.

If you plan to use a two-piece chassis box to house the doorbell repeater circuit, mount all components on the front half. Fasten the rear half of the box to a wall near the doorbell transformer. After wiring the circuit on the front half of the box, carefully check your wiring. Make certain that *PB1*'s red and black leads go to *B1*+ and *Q1*'s collector, respectively, and that *D1*'s cathode lead (nearest the banded end of the diode's body) goes to *Q1*'s base.

When you're satisfied with your wiring, press TEST switch *S1*. This should cause *PB1* to sound. When you release *S1*, *PB1* should immediately silence. If you have a milliammeter, place it in series with the battery. Releasing *S1* should cause the meter's indication to drop to 20 microamperes, unless *Q1* has excessive collector-base leakage.

If everything checks out okay, assemble the two halves of the chassis box. Break one wire of the doorbell circuit as shown in the schematic diagram. Attach the wires to the terminal strip. *Caution:* Before making any connections to the doorbell transformer, measure the voltages at its terminals. It's the low-voltage side that goes to the bell circuit that you must use. Be careful to avoid touching the ac-line side.

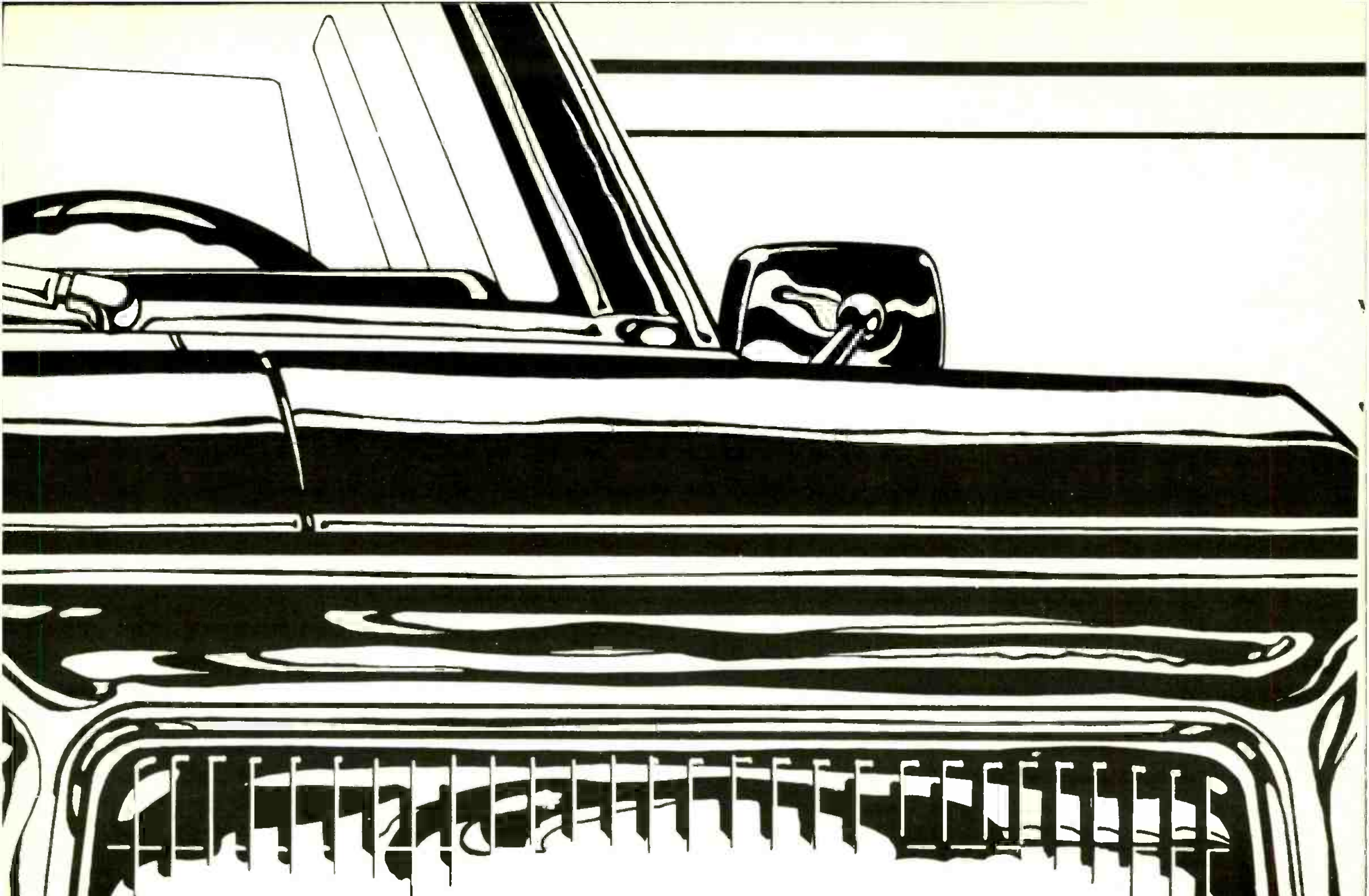
If you can't get an assistant to push the doorbell while you check the basement repeater, use a piece of tape to hold the button in. If you hear no sound from the repeater, check the external connections.

If you live near a radio or TV station or a neighbor with a high-powered amateur radio transmitter, connect a 0.01-microfarad capacitor across the external terminals on the repeater box. This will bypass any r-f energy picked up on the doorbell wires and will help prevent premature exhaustion of the battery.

Those people who live in older homes whose doorbells are battery powered can also use the remote doorbell described here. All you need do is identify the wire that goes to the positive terminal of the doorbell battery and attach it to the terminal on the repeater that goes to the transistor's emitter. Install a jumper wire from the base terminal to the doorbell battery's positive terminal to finish the job. Finally, if you don't already have a doorbell, you can rewire *S1* to *TB1* and use the repeater as a doorbell by itself.

In Conclusion

Once you install a remote doorbell where you can't hear the main bell, you'll soon wonder how you ever got along without it. Never again will you miss the postman, a visiting relative or your neighbor just because you didn't hear them "ring." **ME**



$0 to $10 Car Modifications

Inexpensive ideas to enhance car stereo, trailer signal lights and ignition switching

By Tom Bavis

Few, if any cars come with all the things we would like them to have. Three common deficiencies are addressed here by solutions that are so simple you'll probably be asking yourself, "Why didn't I think of that?" All of them are inexpensive (the first one is free) and simple to incorporate into any vehicle.

Add an "Accessory" Switch

Most foreign-car makers do not provide an "accessory" position on the ignition switch as U.S. car makers do. This can lead to problems. For example, if the car's radio, generally wired directly to the battery, is left on overnight, the battery can be run down. Also, if the radio isn't switched on and off with the ignition, its power switch/volume control gets a lot of extra wear.

There is a way to add that missing accessory switch for just the cost of a length of tape. I wired my car radio as shown in Fig. 1 to switch on whenever the key is in the ignition switch. To find out if your foreign car's the same as shown, unplug the key warning buzzer and check its socket with a 12-volt bulb or a voltmeter. The bulb should light or the meter should reg-

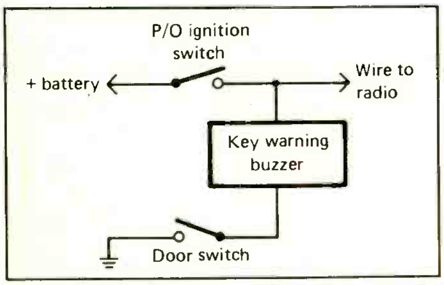


Fig. 1. An "accessory" switch circuit for the price of a piece of tape.

ister 12 volts only when the key is in the ignition switch.

If you obtain the proper indication, simply splice the red ("hot") wire from your radio to the wire between the ignition switch and buzzer, as shown. Completely insulate the connection with electrical tape, and you're done. One final thought: if your radio doesn't have an in-line fuse, it's a good idea to add one. A melted wiring harness isn't pretty.

You should be able to perform this modification in an hour or less.

Center-Channel Stereo

Although many people buy new cars with factory sound systems, there are still plenty of people who prefer to install their own. In doing so, the speaker mounted in the dashboard normally isn't used in stereo setups and is usually left unconnected. However, it can be used as a center-channel driver, as shown in Fig. 2, to give better sound.

Ideally, the center-channel speaker should be 4 ohms if your other speakers are 8 ohms, or 2 ohms when used with 4-ohm speakers. Since you aren't likely to have this combination, Fig. 2 shows a resistor for volume balancing purposes. The value of this resistor is about 3.3 ohms for 4-ohm speakers and 6.8 ohms for 8-ohm speakers. If you want to get fancy, a power-type potentiometer can be used (a "fader" control is ideal for this purpose).

One side effect of this modification is increased perceptible separation between the left and right channels, since some of signal from each channel is dropped across the center speaker and is applied to the opposite channel out-of-phase. If this bothers you, install a capacitor across the center-channel speaker, as shown. A 50-microfarad capacitor is about right. This limits the center channel to only the less-directional low frequencies and gives the left and right channels a slight emphasis on the more directional middle and higher frequencies. Since you're unlikely to find a nonpolarized 50-microfarad capacitor, you can use two electrolytic capacitors connected back to back, as illustrated.

Phasing of the speakers is critical in this arrangement. If the speakers don't have polarity markings (usually a "+" or red dot identifying the "hot" terminal), you can determine polarity with the help of a flashlight cell. Connect the cell across each speaker's terminals and observe the direction of cone movement with respect to battery hookup. The "hot" terminal is the one to which the cell's + contact is attached when the cone moves out.

(Continued on page 87)

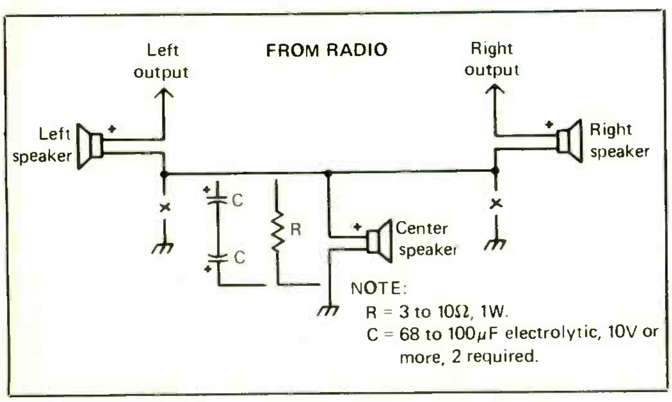


Fig. 2. Use this schematic to add a center-channel speaker when a nonfactory stereo radio is installed.

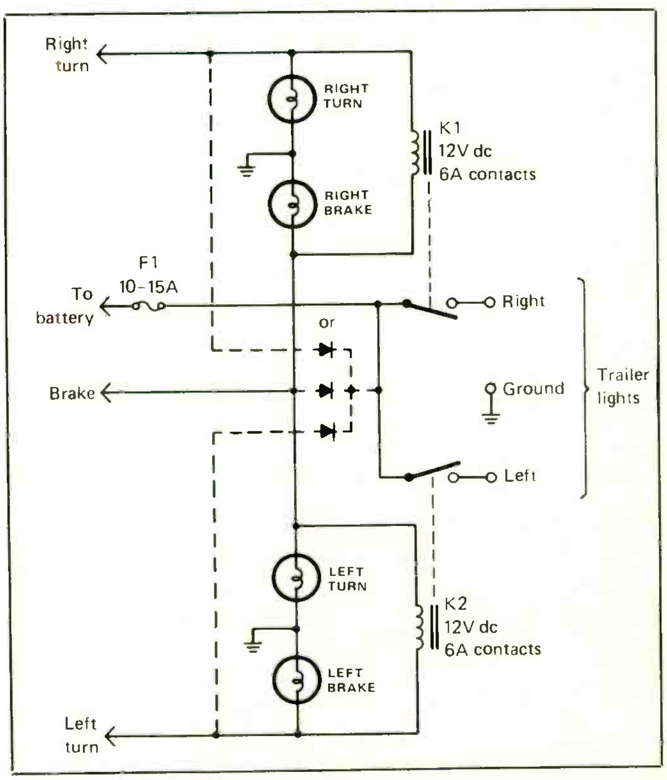


Fig. 3. This circuit provides satisfactory brake/turn lights when you tow older trailers with newer cars.

How to See Near-Infrared Radiation

By Forrest M. Mims II

Experimenters who are not equipped with the apparatus necessary to visualize the invisible radiation emitted by near-infrared-emitting diodes and lasers have, nevertheless, been quite successful at using such diodes for communications, remote control, intrusion alarms and object detection. Of course, as radio so aptly illustrates, the inability to visualize electromagnetic radiation does not preclude its use. Still, the application of invisible radiation is greatly enhanced by the ability to visualize the radiation pattern produced by such radiation.

Several means are available for visualizing invisible infrared beams. They include electronic image converters, liquid-crystal screens, and infrared-sensitive phosphors. Each will be explained here. First, it's important to discuss the nature of near-infrared radiation.

Near-Infrared Radiation

Near-infrared radiation falls just beyond the visible red portion of the optical spectrum. Because of the amazing sensitivity of the human eye, the border between visible red light and invisible near-infrared is fuzzy. Figure 1 shows the spectral response of the rod and cone cells in the human eye. Peak sensitivity of the cone occurs in the green at 550 nanometers. According to an intentional standard, 1 watt of green light at 550 nm is equivalent to 680 lumens.

Specifying the minimum and maximum wavelength sensitivity of the eye is considerably less precise. For instance, though most textbooks simply give the maximum wavelength sensitivity as 720 or so nanometers, the sensitivity of the eye cannot be defined with such sharpness. Instead of decreasing abruptly, the eye's sensitivity falls gradually. Thus, at 700 nm, the normal eye has a sensitivity only about one-thousandth of that at 550 nm. At 750 nm, sensitivity is 0.0001 of that at 550 nm.

When compared to the eye's response to green light, these sensitivity levels are certainly very low. Nevertheless, a person with normal red vision can easily see a source emitting at 750 nm. What's more, if the source is sufficiently intense, it is even possible to see sources that emit in the vicinity of 900 nm. This is fascinating, since sources at this wavelength have almost always been considered totally invisible to the naked eye.

You can test the response of your eyes to near-infrared radiation by looking at an 880-nm AlGaAs infrared-emitting diode driven at or near its maximum current level (usually 50 or 100 mA). If you have normal red vision and if the background light is subdued, you should see a dull-red glow emerging from the LED's lens. Since this LED, like all such devices, does not emit radiation having a narrow spectral peak, the eye responds more readily to the shorter wavelengths within the beam. Nevertheless, since the emission from 880-nm AlGaAs emitters is negligible at 800 nm, it is obvious that the eye can respond to radiation beyond this point.

It is highly unlikely that you can see the emission from a 940-nm GaAs:Si emitter operating at the same power as an 880-nm emitter. That's because the sensitivity of the eye at 940 nm is at least two decades less than that at 880 nm.

Figure 2 is an extension of the standard

Fig. 1. Spectral sensitivity of the normal human eye.

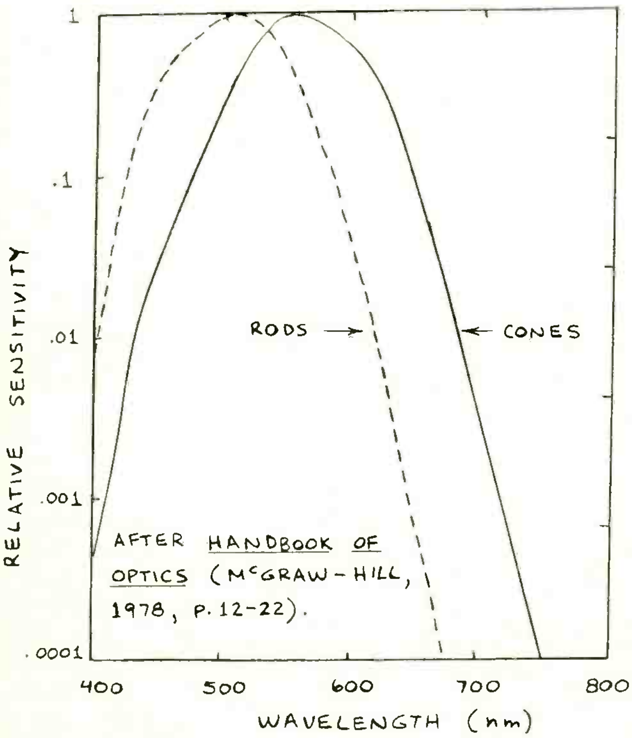
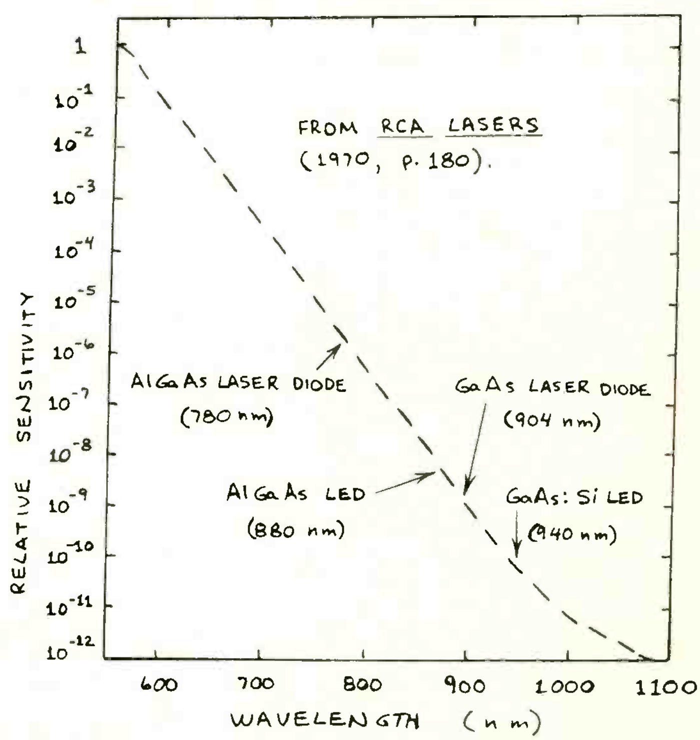


Fig. 2. The near-infrared sensitivity of the human eye.



human eye spectral response curve that shows the normal eye's response to near-infrared. Though this curve shows that the eye can respond to wavelengths beyond 1,000 nm, it is important to keep in mind that the power level of light at this wavelength that is necessary to elicit a visual response is very likely high enough to damage the retina! Therefore, it is important to avoid staring into the beam of, for instance, a 1,060-nm laser (such as neodymium-doped YAG or glass) in hopes of "seeing" the beam. Such lasers can easily produce permanent retinal damage and even bloody lesions within the eye.

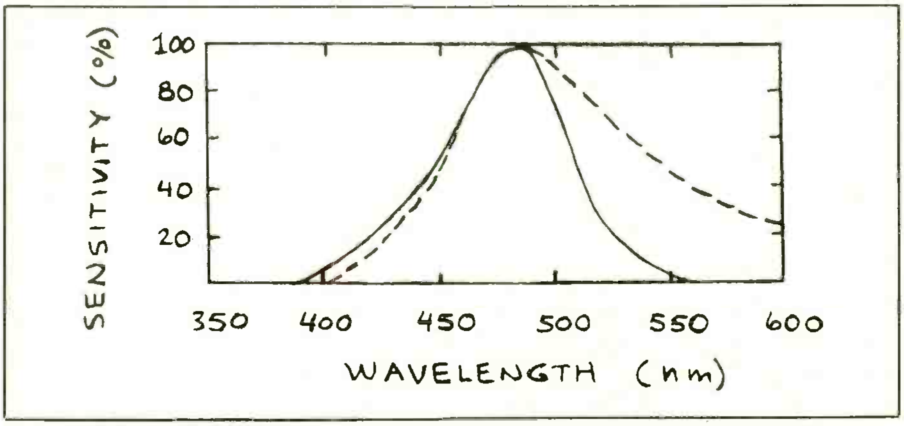


Fig. 3. Excitation sensitivity of Kodak (solid) and Quantex (dashed) phosphors.

Liquid Crystals

Cholesteric liquid crystals are greasy substances in which the constituent molecules are in the form of helixes. As the temperature of the material is altered, the helix expands or contracts accordingly. The distance between adjacent twists of the molecules generally matches the wavelength range of visible light. Therefore, the crystal will selectively reflect specific wavelengths. As the temperature of the material changes, the reflected wavelengths change. Thus a crystal can be prepared that will reflect blue light when its temperature is cool and red light when its temperature is warm.

Liquid crystals are available as encapsulated spheres affixed to sheets of plastic. The plastic is generally given a black background to improve contrast, causing the colors reflected by the crystal to appear more vivid.

A beam of visible or near-infrared radiation of sufficient power will cause the portion of a liquid crystal screen it illuminates to become slightly warmer than the surrounding areas. Therefore, the beam pattern will be indicated by a region having a different color than the remainder of the screen. Since the liquid crystal will readily respond to ambient temperature changes, it is usually necessary to stabilize the temperature of the material to visualize an infrared beam.

I have used this method to observe the infrared beams emitted by various lasers, LEDs, and flashlights. You can salvage small pieces of liquid-crystal material from novelties and skin thermometers. Sheets of liquid-crystal material having various temperature-sensitivity ranges are available from Edmund Scientific. (See the company's catalog for details about prices and temperature ranges.)

Infrared-Sensititive Phosphors

Certain rare-earth compounds emit a visible glow when exposed to near-infrared radiation. Some such phosphors respond directly, while others must first be "charged" by visible light before being illuminated by near-infrared. Infrared-sensitive phosphors can be used to visualize infrared beam patterns if the material is first applied to a flat card.

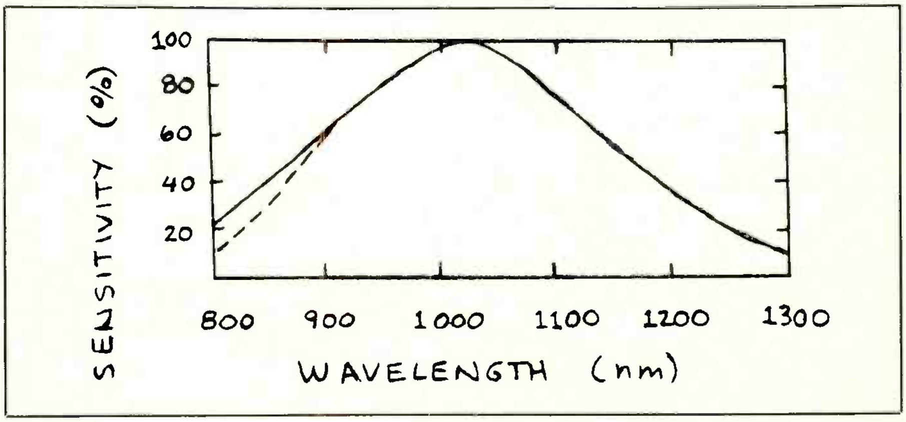
Two suppliers of near-infrared-sensitive phosphor cards are Kodak and Quantex Corp. After being charged by visible light for a few seconds, these cards emit an orange glow where they are illuminated by a near-infrared beam. Eventually, the phosphor will stop glowing, and the card will have to be recharged by another exposure to visible light.

Kodak's phosphor appears off-white when viewed in ordinary room light, while Quantex's appears tan. Nevertheless, from the data sheets supplied by both companies, the properties of the phosphor cards made by both companies are very similar. Figure 3 shows the excitation sensitivity of the phosphor cards available from both companies. From these curves it is apparent that blue or green light is required to charge these phosphors.

Figure 4 shows the sensitivity of these phosphors to near-infrared radiation. The response of the material peaks at slightly beyond 1,000 nm, and the relative response at 880 nm, the wavelength of high-power ALGaAs LEDs, is nearly 60 percent. Overall sensitivity ranges from 700 nm to 1,300 nm.

Figure 5 shows the spectral emission of the two phosphors. Note that the emission

Fig. 4. Infrared sensitivity of Kodak (solid) and Quantex (dashed) phosphors.



of both cards peaks in the orange region of the spectrum. Incidentally, it is important to note that the vertical scales of the two curves compare relative, not absolute, sensitivity. The Quantex phosphor appears considerably brighter than the Kodak phosphor when both are illuminated by the same level of near-infrared radiation.

Two kinds of infrared-sensitive cards are available from Quantex and Kodak. The standard card is formed by sandwiching between two sheets of clear plastic a white paper card coated on one side with phosphor. A transmission card is also available. This card consists of phosphor sealed between two layers of clear plastic to permit the cross-section of an infrared beam to be viewed or photographed by observing the orange pattern on the back side of the card.

Kodak sells phosphor cards ranging in size from 2″×2″ ($24) to 20″×24″ ($1,220). Both standard and transmissive cards are available. Kodak also sells an IR Phosphor Stick ($8) that has a ¾″ square of phosphor at one end; minimum order, however, is $35. For more information, request Publication U-70 from Eastman Kodak's Special Product Sales Division.

Quantex sells a standard card with an active region 2″ square ($19.95). Other sizes and transmission cards are also available. These cards use a phosphor that glows much brighter than that used in the Kodak products. Under development is a card that glows blue, rather than orange, in response to near infrared. The company has a minimum order of $30.

To avoid the minimum order requirements imposed by Kodak and Quantex, you can purchase a single high-brightness Quantex card with a 2″ square active area from Edmund Scientific Company (Cat. No. F35,887) for $19.95 plus $3.95 postage and handling.

Standard phosphor cards are very handy for making a quick check of the operation of infrared remote-control transmitters, optical-fiber systems, and other applications in which infrared-emitting diodes or lasers are used. Transmission cards are especially useful for observing and photographing beam patterns from infrared-emitting diodes.

I always keep an infrared-sensitive phosphor card handy to check the operation and the beam pattern of various infrared-emitting devices. It's even possible to focus the lens of an infrared voice or tone transmitter while watching the orange pattern on a phosphor card.

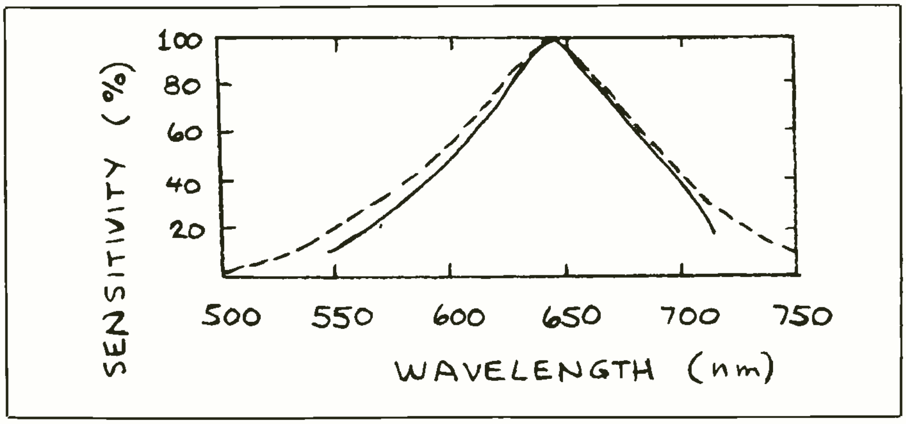


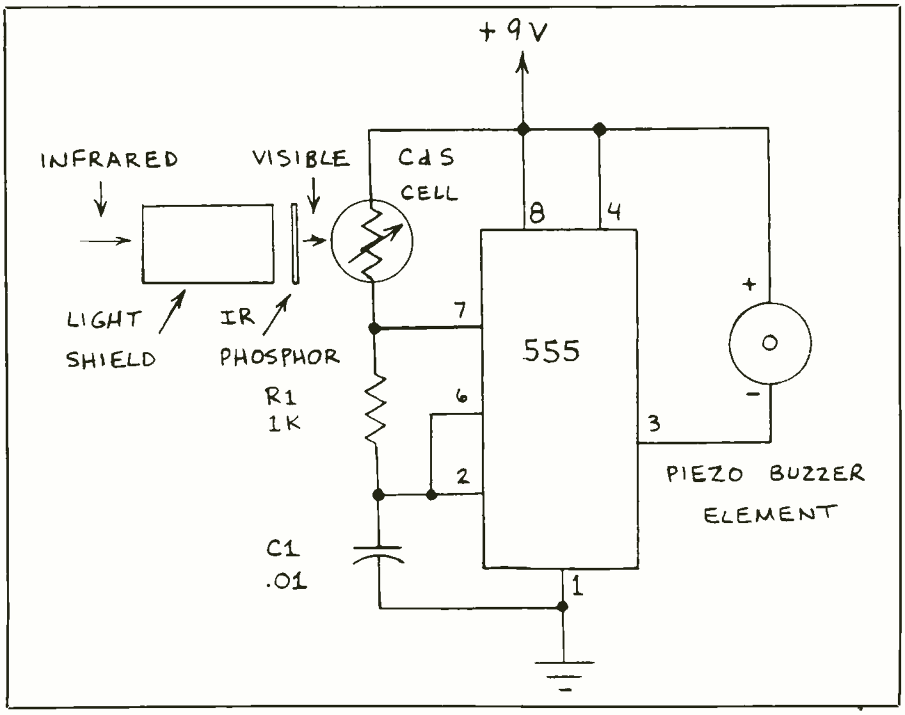
Fig. 5. Spectral emission of Kodak (solid) and Quantex (dashed) phosphors.

Infrared-phosphor cards have other applications as well. For instance, a small infrared-sensitive card will permit a cadmium-sulfide photoresistive cell, which has a peak spectral response in the green portion of the spectrum, to respond to near-infrared radiation.

Figure 6 shows a simple arrangement I used a verify this application. In operation, the 555 functions as an oscillator whose frequency is determined by the resistance of a CdS cell and *C1*. Near-infrared striking a charged phosphor card stimulates the emission of orange light which, in turn, reduces the resistance of the CdS cell and increases the frequency of the tone generated by the oscillator. Since the CdS cell is very sensitive to visible light for this application to work, the detector must be shielded from ambient light by a near-infrared filter or must be operated in darkness.

A test version of the circuit in Fig. 6 produced very noticeable changes in the fre-

Fig. 6. A simple near-infrared-sensitive audio oscillator.



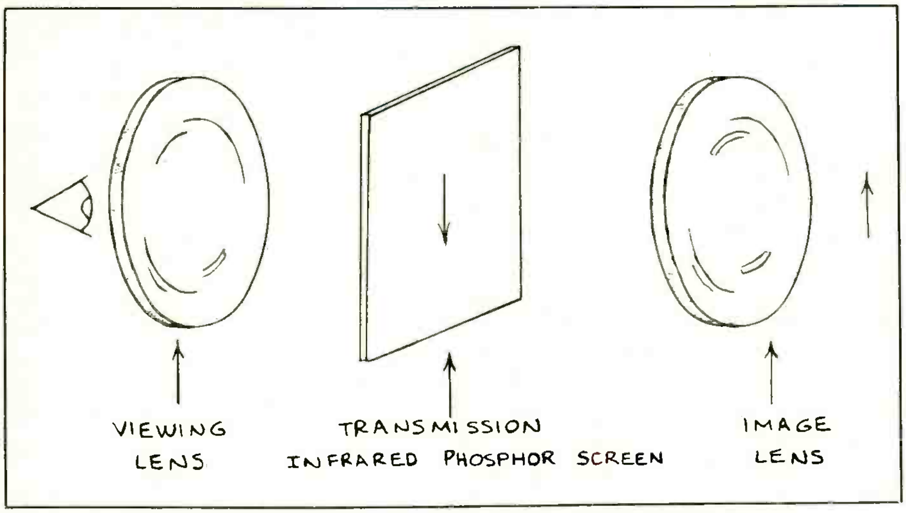


Fig. 7. An ultra-simple phosphor-card near-infrared viewer.

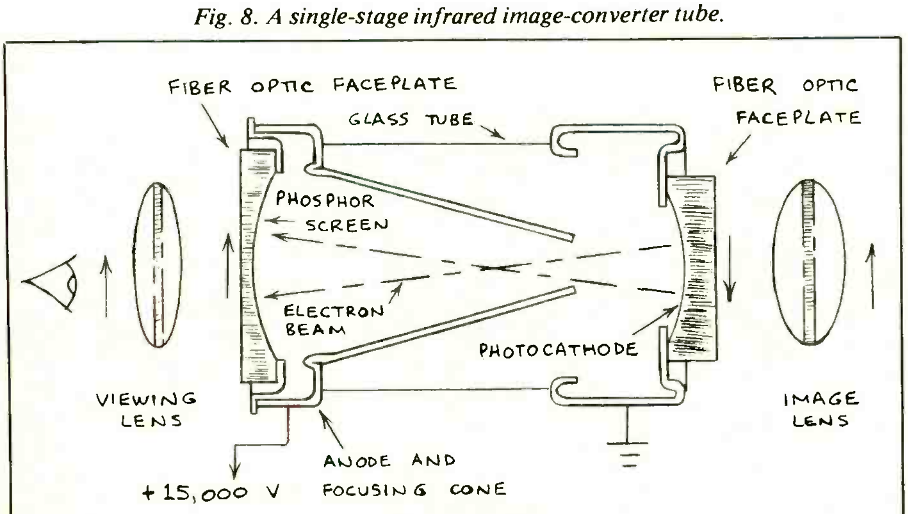
quency of the output tone when the phosphor card was exposed to near-infrared. The circuit even responded to the near-infrared from a pulsed-LED tone transmitter. These results indicate that many other standard photoresistor circuits can now be modified to detect near-infrared radiation. Of course, a means will be required for recharging the phosphor card after it is discharged.

It has been proposed that infrared-sensitive phosphors might form the basis for an optical memory. A fully-charged phosphor will retain the ability to respond to near-infrared for several months or more. Information could be saved on a phosphor substrate by either of two means. In one, an entire phosphor substrate would be charged with blue light and then data would be stored by selectively illuminating small regions of the phosphor with near-infrared until the optical charge in those regions was removed. The data would be read out by briefly bathing the substrate with near-infrared, thereby revealing patterns of dark regions denoting data.

In a second method, the entire phosphor substrate would be "erased" by exposing it to near-infrared. Data would then be stored by illuminating the phosphor with patterns of blue light. As in the first method, the data would be read out by bathing the substrate with near-infrared, thereby revealing data as patterns of glowing orange dots.

The emission form Quantex's card is so sensitive it is possible to assemble a crude image converter from a transmission card and some lenses. Figure 7 is an outline view of the setup I used to verify this application. With this arrangement, it was possible to view bright infrared sources in a dark room. However, it was not possible to see objects illuminated by a near-infrared source. For that application, an electronic image-conversion system is required.

Fig. 8. A single-stage infrared image-converter tube.



Electronic Image Converters

Electronic image converters include image-conversion tubes and various kinds of electron-tube and solid-state television cameras. The earliest and still one of the most important such devices is the handheld image converter. Figure 8 is an outline view of a single-stage electrostatic tube used in advanced viewers of this type. This tube is considered advanced because it uses fiber-optic faceplates to improve the resolution at the infrared-sensitive photocathode and the phosphor viewing screen.

In operation, near-infrared radiation is imaged by a lens onto the face of a photoemissive cathode at ground potential. Electrons driven from the cathode by the impinging infrared are attracted to a circular anode electrode at the opposite end of the tube having a positive potential of from 12,000 to 20,000 volts. A centrally located ring eletrode through which the electron beam passes is charged at an intermediate potential. This focuses the electrons into a beam that forms an electron replica of the infrared image on the cathode. A phosphor screen inside the anode transforms this pattern into a visible image.

Several companies sell handheld image-conversion systems complete with an image tube and a self-contained high-voltage power supply. One of the cheapest is the SPL-338-20 Infra Red Viewer available for $220 from John J. Meshna Jr., Inc. (19 Allerton Street, Lynn, MA 01904). A sturdier model with built-in battery receptacle is the Cat. No. F31,074 FJW Find-R-Scope for $945.95 from Edmund Scientific. Handheld image converters are also made by Electrophysics Corp.

ELECTRONICS NOTEBOOK . . .

The fiber-optic faceplate version of the basic image tube described above can be cascaded into two or three stages to provide a high degree of light amplification. Cascaded image tubes are called image intensifiers. Depending on the type of photoemissive material they employ, they can be used to amplify either visible or near-infrared. When used to amplify visible light, they are sometimes call "starlight scopes." No matter what they are called, they are very expensive, generally selling for at least several thousand dollars.

A new generation of image intensifiers requires only a single stage in which the active component is a disk containing thousands of microscopic, parallel capillaries, each having a diameter of only 10 micrometers. The disk is called a microchannel plate. The capillaries, which emerge through both faces of the plate, are lined with a photoemissive film. An incoming photon will release a single electron which will travel down the capillary toward a positively charged anode. Along the way, the electron will bounce against the sides of the capillary, thereby triggering release of additional electrons. The result is that a single photon entering one end of a capillary stimulates a shower of photons at the other end. These electrons strike a phosphor screen and produce an image representative of the infrared pattern imaged on the surface of the plate.

If you cannot afford an infrared-image converter like those described thus far, you may already have a suitable substitute if you have a video camera and monitor. Silicon photodetectors respond well to near-infrared radiation. Therefore, it should come as no surprise that silicon vidicons and silicon-array cameras can be used in conjunction with a conventional television monitor to transform invisible infrared into a visible image. Conventional vidicons and TV tubes having an extended-red response can also respond to near-infrared radiation.

Lasers and Infrared-Viewers

If you plan to use any of the devices described in this column to view the near-infrared emission from a laser, to avoid the possibility of serious eye damage you *must* follow these precautions:

(1.) Because plastic surface of phosphor cards and liquid-crystal screens can reflect laser radiation into your eyes, always attenuate the beam or use protective eyewear.

(2.) Never view a laser beam straight on through a transmissive infrared-sensitive phosphor card.

(3.) Never view a laser beam straight on through an image converter tube. Instead, use the tube to observe the pattern the beam forms on the non-glossy paper.

Be sure to follow these and any additional safety precautions provided by manufacturers of near-infrared viewing devices. For additional information about laser safety, see "Performance Standards for Laser Products" bulletin No. 21 CFR 1040 from the National Center for Devices and Radiological Health. Also see "ANSI Standard for the Safe Use of Lasers" published by and available from the American National Standards Institute. **ME**

Names and Addresses

American National Standards Institute
1430 Broadway
New York, NY 10018
Eastman Kodak Co.
Special Product Sales
121 Lincoln Ave.
Rochester, NY 14605
Edmund Scientific Co.
101 E. Glouster Pike
Barrington, NJ 08007
John J. Meshna Jr., Inc.
19 Allerton St.
Lynn, MA 01904
National Center for Devices and Radiological Health
8757 Georgia Ave.
Silver Spring, MD 20910

HARDWARE HACKER

Sources of information on wire, the SCSI Standard, testing and interfacing of RS-232C serial data

By Don Lancaster

The main feature of this month's column discusses what anyone interested in computers and digital interfacing should know about the so-called RS-232C serial interface standards. But first a timely word about where you can get information on wire.

Where can I get tech details on wire and cable?

Check out the new *Master Catalog 885* by *Belden.* This beauty has a technical information section that gives you lots of details on solid and stranded magnet wire, details on all the major coaxial cable types, and charts of cable current capacities. Best of all is a list of some 54 ap notes and tech bulletins available free.

Of particular interest to *Modern Electronics* hardware hackers should be its bulletins on soldering (T/8-13), coax selection (T/8-24), and hi-fi cables (T/8-31). As always, you should make letterhead requests or direct telephone inquiries.

Speaking of wire in general, one of the best sources I have found for breadboarding jumpers is the *Squires Electronics* BK-1 wire kit. It's a steal at $9.95. Squires also sells such things as shrink tubing and precut wirewrap wire.

What is an SCSI interface?

SCSI stands for "Small Computer Standard Interface." This is an emerging standard way of connecting hard disks and streaming tape backup systems to personal computers. Since the SCSI or "scuzzy," interface is very good at rapidly transferring large amounts of data, you'll shortly see its use for such things as laser printers, image processing, document scanners, CD disks, and graphics workstations.

Much of the new interest in this standard centers on the new SCSI interface in the Macintosh Plus by *Apple Computer.* SCSI interfaces for the Apple IIe and IIc should also be available shortly.

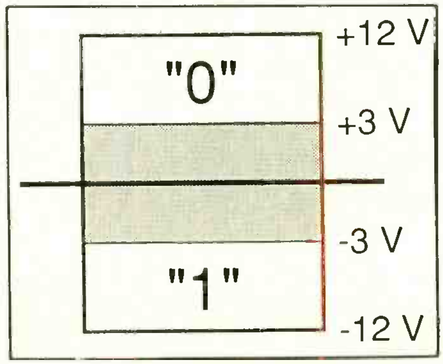


Fig. 1. The RS-232C signal levels.

The SCSI interface is fully documented in ANSC X3T9.2 SCSI Specification, available for $20 from *CBEMA*.

For magic chips that make SCSI go, check into the WD33C92/3 from *Western Digital.* WD also has lots of data sheets, ap notes, and listings available.

What is an RS-232C interface?

Who in their right mind would ever interconnect computers and peripherals with an interface that (a) uses weird supply voltages; (b) requires cumbersome and expensive connectors of too many pins; (c) is error prone; (d) works only over limited distances, (e) provides zero safety or current loop isolation; (f) is lousy at networking; and (g) is both very difficult to use and complex to debug? The answer, unfortunately, is just about everybody who uses a computer.

RS-232C is far and away the most common way of connecting a personal computer to a printer, plotter or modem. The DB-25 connectors used are now seen everywhere. Even older dot-matrix printers are pretty much being forced into serial RS-232C communications.

The "lets go serial" mania began when personal computer manufacturers discovered they could get FCC certification far easier with a stock and slow serial interface than with a fast parallel one.

At any rate, RS-232C is a standard, and incredibly awful, way of connecting computers and peripherals together. As many as 25 lines may be needed for a single serial interface.

Let's look at the key concepts of RS-232C. The data communication is asynchronous, meaning that any amount of time can go by between character or data transmissions. Each character or data word sent consists of a start bit, seven or eight data bits, an optional and seldom-used parity bit, and finally one or two stop bits.

Only seven data bits are needed to send a character, while eight are needed for an 8-bit data byte. Alternately, an 8-bit data byte can be broken up into a hex ASCII *pair* of characters that can be sent as two successive 7-bit characters. The Laserwriter uses this latter route, nicely letting you shove pictures and images through any old word processor. And nastily taking twice as long to send the characters over the interface.

Check back into last month's "Hardware Hacker" to see how these bits are generated and received using hardware or software UARTs.

Character transmission rate is set by the baud rate, which in turn sets the speed at which the bits go flying over the interface. Standard baud rates are 300 or 1200 for modems, 300 or 9600 for printers.

Note that many personal computers cannot scroll their screens faster than 1200 baud. The number of characters per second is roughly equal to one-tenth the baud rate. Thus, 300 baud translates to approximately 30 characters per second.

Figure 1 shows the transmitted voltage levels. A logic zero is anything from +3 to +12 volts. A logic one is anything from −3 to −12 volts. Note that this negative logic is "upside down" from what you might expect. From −3 to +3 volts is usually assumed to be noise.

Figure 2 shows the most important and most-often-used RS-232C pins and what they do.

There are two ground lines, the signal ground on pin 7, and the separate safety ground on pin 1. While the signal ground is always used, it is very important to prevent any ground loop currents or system noise from going over this line.

Pin 2 is the data-out line, while pin 3 is the data-in line, referenced to the host computer.

Now the fun begins. If you are driving a modem, then pin 2 at the host connects

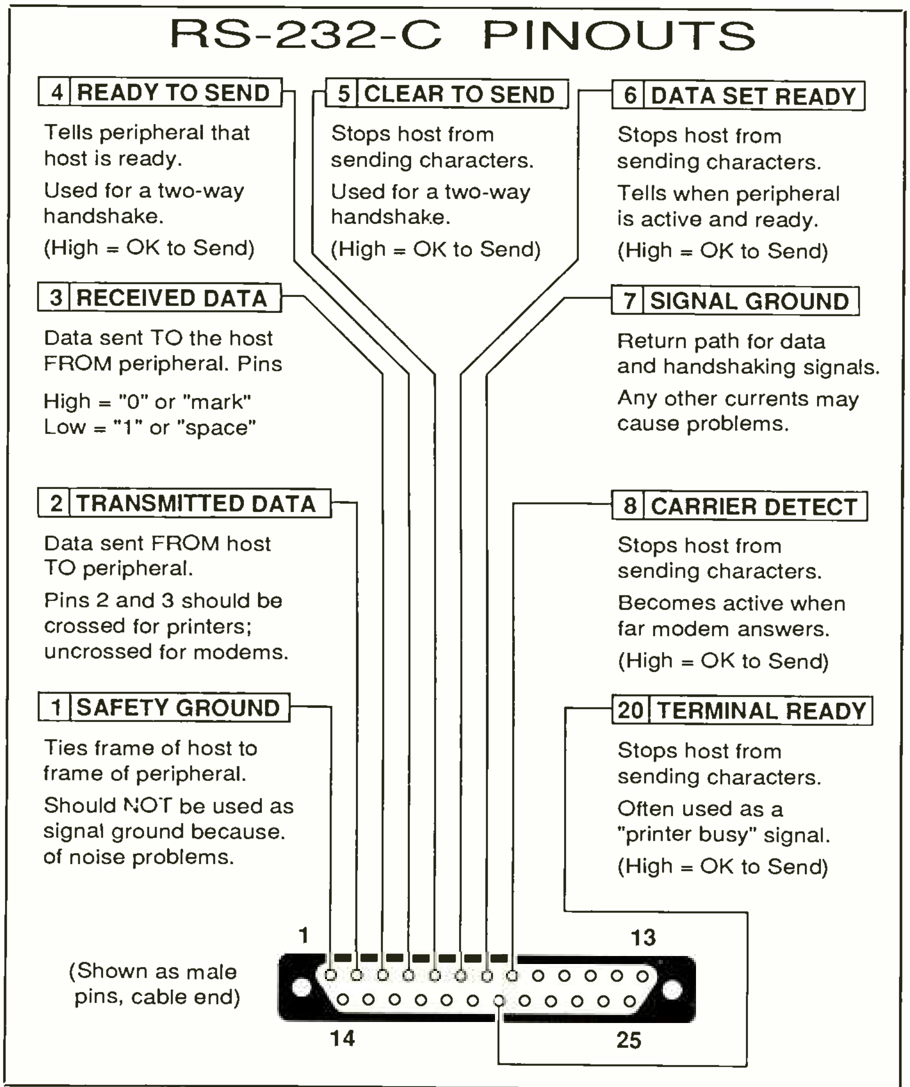


Fig. 2. These are the most-often-used RS-232C connector pinouts.

to pin 2 at the modem. Pin 3 at the host connects to pin 3 at the modem. On the other hand, if you are connecting to a printer or peripheral with some smarts, then pin 2 at the host must connect to pin 3 at the peripheral, and vice versa.

So, sometimes you have to cross the data path to get both ends speaking to each other. Data path crossing can be done inside the cable (watch this detail *very* carefully!) by DIP switches or with port configuration blocks. The rule is: modems do not cross; printers cross once and only once.

Pins 4 (Ready To Send) and 5 (Clear to Send) are not used too often, but they give you a secondary way of handshaking. As before, these pins do not cross with modems and do cross with printers that use these lines.

Pin 6 is an output signal from the host called I/O Ready. This one tells the printer or whatever that the computer is running and ready to either send or receive data. Pin 8 is called the Carrier Detect. It is intended mostly for modem use, whenever the modem wants to tell the computer that it found the necessary tones on the phone line to start communication.

Finally, pin 20 is the very important Data Terminal Ready line, otherwise known as the printer busy line. The printer uses this line to stop characters or data being sent whenever it already has more data than it can use. It is this line that is supposed to stop transmission whenever a printer's buffer is full.

Unfortunately, there is no standard rule of how many pins are used which way. Some printers can live with only four wires, namely signal ground, transmitted data, received data, and printer busy. Other times, all 25 of the pins end up in use doing exotic things.

One baseline rule for printers is to: cross 2 and 3; cross 4 and 5; and jumper 6, 8, and 20 together. But there are many other variations and possibilities.

There's a gadget called a modem eliminator that can plug between two RS-232 cables to let two personal computers directly talk to each other. A null modem often crosses 2 and 3 and jumpers 6, 8, and 20. If the null modem has no handshake, pin 20 on each end goes to its own pin 6 and 8. If the null modem has full handshaking, then pin 20 on each end goes to pins 6 and 8 on the opposite end.

Another gadget is the sniffer. A sniffer may be used to monitor whatever data is passing over the RS-232C interface, without interfering in any way with that data transmission and without any handshaking of any sort. This ties a pair of connectors together with all lines straight through. A separate male connector has only pin 7 tied to the others. Pin 3 of this connector is switchable to either the main pin 2 line or pin 3 line. Often a series resistor, say 3000 ohms, is placed in the sniffer lead to minimize any loading.

What is handshaking?

Handshaking is any technique that makes sure a character or a data value gets used once only. The simplest form of handshaking is to send out characters or data so slowly that they can never be missed. While simple and cheap, this is often very wasteful of both your time and that of your personal computer.

For "real" handshaking, you have the choice of a direct, or hardwire connection, or by sending text control commands over the serial interface.

Personal computers have long favored a direct-wire handshake, often coming from peripheral to the computer by way of RS-232C line 20, which is often used as a "printer busy" signal.

Dino computers and minicomputers have traditionally used text character commands. Note that a hardwire connection is simple and cheap and can immediately stop character transmission. On the other hand, the hardwire busy signal cannot be routed through a modem or a satellite link.

One fairly uncommon text control command handshaking is called ETX/ACK. Whenever an ETX or hex $03 is found in a printer's buffer, an ACK or hex $06 is sent back to the host computer. In effect, the computer says "let me know when you have gotten so far." The peripheral answers later with "I just got there." The computer is "boss" in this transaction.

The most-used text control commands are called XON/XOFF, otherwise known as DC1/DC3. Whenever a printer buffer gets fairly full, an XOFF command, or a hex $11 is sent to the computer. The computer stops sending any characters for a while. Meanwhile, the printer is using up the characters in its internal buffer. When the printer or other peripheral has used up most of the characters left, it sends an XON command, or a hex $14. The character stream begins anew.

With XON/XOFF, the printer says to the computer "Hey, hold up sending me stuff for a while." Later on, the printer says "OK, I can now use more data." The printer is temporarily the "boss" with this type of handshaking.

Note that the printer or whatever never runs out of characters and never has to stop. On the other hand, a fairly large buffer is needed for the "slop" at both ends for continuous character usage.

More and more personal computers are switching to the XON/XOFF route. The Laserwriter laser printer demands this type of handshaking, as do most modems. XON/XOFF is directly available by the Super Serial Card used in an Apple IIe. Older Apple IIc computers lacked a ready-to-go XON/XOFF ability, but this has been cured in the brand new "3.5 ROM" monitor release. See your dealer for the upgrade details.

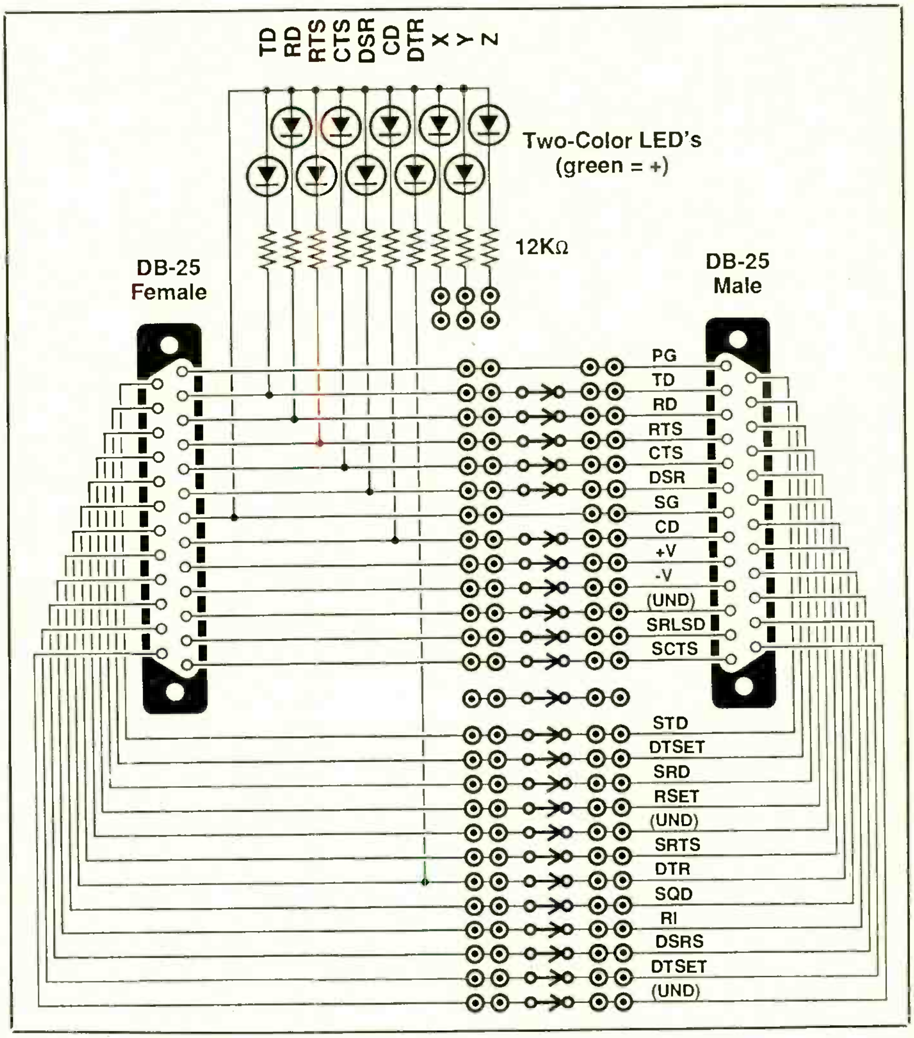


Fig. 3. Schematic diagram of a typical RS-232C breakout box.

How do I service an RS-232 serial data system?

As with most troubleshooting techniques, "divide and conquer" works well here. The best rule is to attack the big lumps first!

First, make sure the cables are in fact connected and routed between the systems in the way they are intended. Then check to be sure that pins 2 and 3 are *not* crossed for modem use, and *are* crossed *once and only once* for printer use. This crossing can be done with programming blocks, slide switches, or physical interchanging of cable pins.

Second, make sure that the data rates and formats are the same at both ends. Very often, a low initial baud rate of 110 or 150 bits per second is a good starting point, for it eliminates subtle handshaking problems from your initial setup. Seven or eight data bits, one or two stop bits, and no parity are often chosen. These are sometimes settable with slide switches, sometimes with system software. Repeating, it is *extremely important* that both ends of the system are running at the same baud rate, have the same parity, and have the same number of data and stop bits.

HARDWARE HACKER...

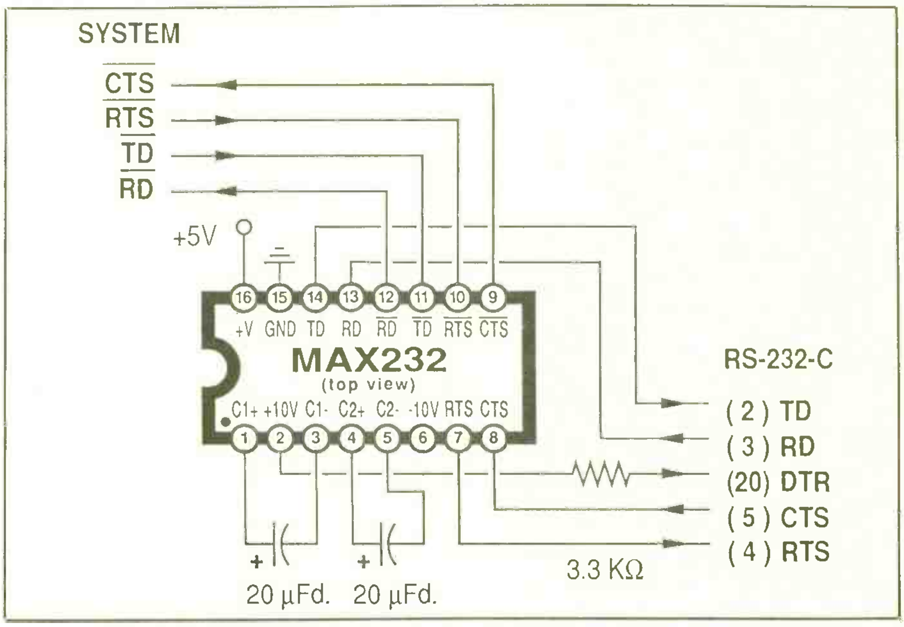


Fig. 4. An RS-232C interface that needs only a single 5-volt supply.

Do not go beyond step two until such time as the printer or whatever is trying to do something. If you get incorrect characters, very often a study of an ASCII character table can tell you what is really happening. Pay attention to any pins that could hold up sending of the characters.

Third, get something sent over the interface so you can handle the more subtle problems. If the printer is running over the same line or is double spacing, then a "CR after LF" switch or two is set wrong. If the printer insists on only printing, say 80 columns, when it is a wider printer, chances are an interface card or serial interface circuit is throwing in its own carriage returns where it thinks the line should end. In the Apple world, a "[I] 80 N" command will often set the interface to an 80-column line, while a "[I] 255 N" will often set the interface so wide that only the output text or the printer will force its own carriage returns.

At this point, you should get at least a paragraph or so of correct text or data on each try.

Fourth, attack the handshaking. Speed up the baud rate to whatever you really want, remembering that modems often have maximum limits of 300 or

NAMES AND NUMBERS

Apple Computer
20525 Mariani Avenue
Cupertino, CA 95014
(408) 966-1010

Black Box Inc.
Box 12800
Pittsburgh, PA 15241
(412) 746-5530

Belden Wire and Cable
Box 1890
Richmond, IN 47375
(317) 983-5200

CBEMA
311 First Street NW S500
Washington, DC 20001
(202) 737-8888

Maxim
510 Pastoria Avenue
Sunnyvale, CA 94086
(408) 737-7600

Motorola Semiconductor
Box 20912
Phoenix, AZ 85036
(602) 244-6900

Squires Electronics
503 North 13th Avenue
Cornelius, OR 97113
(503) 357-7132

Western Digital
2445 McCabe Way
Irvine, CA 92714
(714) 851-1221

1200 baud, and that few computer screens can scroll even at a 1200 baud rate. Very often, 9600 baud is a good choice for a one-way printer trip, if the printer is set up to handle this rate.

One sure sign of handshake problems is when printing is normal for half a page or more and then gets violently ill. What has happened is the printer buffer or whatever overflowed, plowing the works.

Handshaking problems often consist of a jumper or slide switch not connecting the "busy" line from the printer or other peripheral to the "stop sending" line of the interface.

An oscilloscope can be used to solve any RS-232C problem, but it is both expensive and usually not capable of monitoring all interface lines at the same time. Instead, a device called a breakout box is used that can tell you an awful lot in a hurry. The breakout box goes between an RS-232C connector and a cable.

Figure 3 shows the typical features of a breakout box. Two-color light-emitting diodes will tell you if any line is high or low. It is important to limit the LED current to one milliamp or less so it does not swamp and overload any signal line. The extra test points let you connect an oscilloscope or voltmeter onto suspect leads. The jumper blocks let you break the "straight through" connections and cross leads, or do whatever to force a working interface.

One source of breakout boxes, RS-232C cables, and stuff like this is *Black Box Inc.* Their Black Box Catalog also has lots of useful technical information in it.

Show me an RS-232C circuit

You need a line driver to get from regular logic levels to RS-232C. Similarly, you need a line receiver to get from the RS-232C levels back into logic levels compatible with your usual computer circuits.

The usual way to do this was with a pair of old warhorse chips, the *Motorola* MC1488 and MC1489. The 1488 has four drivers, while the 1489 is a quad receiver. Motorola has recently upgraded and improved this product into the MC145406, a single package solution that provides three drivers and three receivers.

Both the old and new versions suffer from a serious flaw. Besides the usual +5 volts, you also need a +12-volt and a −12-volt supply. In today's modern computer circuits, it may turn out that the RS-232C drivers are the *only* thing that needs these oddball supply voltages. Thus, using these chips can add power supply cost and complexity.

Its *Maxim* to the rescue. This company's stunning new MAX232 chip is a pair of RS-232C drivers and a pair of receivers that—get this—works entirely off a single +5-volt supply. To do this neat trick, there is a pair of voltage converter circuits built into the chip. The first converter doubles the +5 to +10 volts; the second one changes the +10 into −10 volts. Figure 4 shows how to connect this exciting new circuit. The cost is under $5 in singles, and you save even more by not having to mess around with oddball power supply voltages.

In Parting

I have just freshly reprinted both my *Micro Cookbook,* Volume 1 and *Enhancing Your Apple II and IIe,* Volume 1, so be sure to write or call if you are interested in picking up either of these.

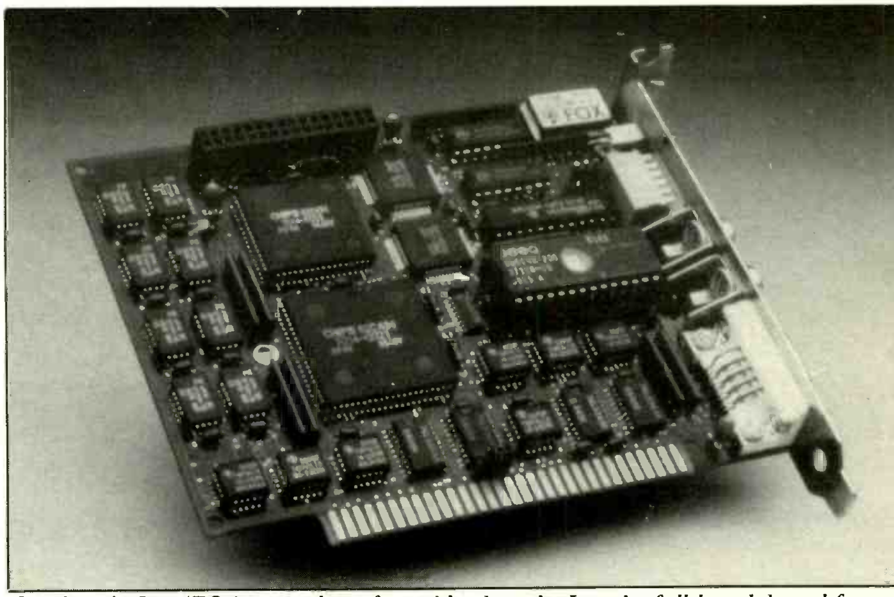
Remember that this is your column and you can get free technical assistance by writing or calling per the box at the end of this column. At present, I am several hundred letters behind, so you will get the fastest results by calling, rather than writing. **ME**

NEED HELP?
Phone or write your **Hardware Hacker** questions directly to:

Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

First Impressions: Microsoft's "Windows" Operating Environment and Quadram's QuadEGA + Enhanced Graphics Adapter Card

By Eric Grevstad


Quadram's QuadEGA + emulates four video boards. I used a full-length board for my January tests, but Quadram said this half card would be shipping by February.

If this column has a bias, it's a conservative one based on economy. I've praised old-fashioned 8088 machines as low-cost workhorses, declared that monochrome graphics cards eliminate the need for expensive color monitors, and questioned the necessity for memory-hogging graphics interfaces, at least with this generation of hardware.

Every so often, though, I let the gee-whiz side of me take over. This month's products are the most advanced operating system software you can buy and the most advanced graphics board to go with it: Microsoft's long-awaited Windows and Quadram's versatile QuadEGA +. Not only are they state-of-the-art innovations, they're bargains. Even when I have a fling, I don't lose track of the fundamental values.

Beyond the Limits

With Windows ($99), I have to revise the trite phrase above: Microsoft's operating environment is *past* the state of the art, a step toward the day we all have DOS 5.0 and 10 megabytes of memory. It's software for tomorrow's hardware and applications, in that it fully supports only a few of today's systems and programs. Even so, it's already the best Macintosh imitation for MS-DOS micros. Digital Research's GEM Desktop, never too healthy, is dead.

Of the three types of video cards Windows works with, the Color/Graphics Adapter produces a dull black, white, and gray display on a color monitor, but an Enhanced Graphics Adapter or monochrome Hercules Graphics Card will put you in bit-mapped heaven, adjusting default hues and playing with the supplied Windows Write and Paint programs' typestyles, sizes, and patterns like the MacWrite and MacPaint imitations they are. You'll also want a mouse; Windows works from the keyboard, but requires breezy sequences like Alt, tab, tab, space, M, release Alt, right arrow, right arrow, enter.

Windows' centerpiece is the MS-DOS Executive, which replaces the A or C prompt with a list of programs and files available for point-and-shoot selection like Mac or GEM icons. In the Executive and Windows applications, pull-down menus control file handling or choices such as changing fonts or directories or clearing an entry.

Besides Write and Paint, the free applications include a bunch of smaller, surprisingly likable tools designed for pop-up or memory-resident use like those of Borland's SideKick. There's a showy analog clock and a calculator whose totals can be pasted into an application. The Calendar program offers a daily or monthly view of appointments and alarms. Notepad, sort of a tiny version of Microsoft Word, has simple editing functions and word wrap for creating ASCII files.

Terminal is a communications program with click-to-change protocol settings for phone or null modem text transfers, though no Xmodem protocol for binary files. Cardfile is a cute, self-sorting mini-database. A spooler prints Windows files as a background task. And, unlike GEM, there's a Mac-style clipboard that swaps copies or deleted material between programs.

Hitting the Wall

These Microsoft tools use Windows' standard graphics drivers, which, as Windows attracts other software companies, will cut today's confusion of different drivers for different video hardware. Unfortunately, until firms get on the bandwagon with "well-behaved" programs using generic DOS and video channels, the supplied applications and a handful of others such as dBase II, R:base 5000, and IBM's DisplayWrite and Assistant series are the only ones that really work in Windows. Others, when activated, seize the whole screen and vanish when you return to the Executive, freezing instead of running in the background.

This deprives you of multi-tasking, and of Windows' best feature—the fun of tiling, watching the non-overlapping, automatically sized and swapped windows created as you shuffle programs between the active display and the row of icons at the bottom of the screen. When RAM runs out, less recently used programs are bumped to (in declining order of efficiency) Above Board or other expanded memory, a RAM disk, or a physical disk drive.

Windows does, as one reviewer raved, let you turn programs like WordStar into memory-resident utilities like SideKick. But so do 16K memory partition or switcher utilities, which give more precise cut-and-paste control (Windows' clipboard can take only full-screen snapshots of applications that don't fit windows).

These limitations are sad because Windows really should do more for the over-180K RAM and 1.2 MB of hard-disk space it takes. As is, even with an XT and 640K, for the 8088 chip it's cruel and unusual punishment.

Pull-down menus become trickle-down menus; when a program does fit in a window, it slows down like the PgDn command in my Norton Utilities display—which took 1.4 seconds in old DOS and 5.5 seconds when sharing the display with two quarter-screens. Using the Executive, Notepad, clock, and calculator with the minimum 256K and two floppy disks, Windows ran between constant crashes, inactive windows turning to garbage and half a minute to redraw the screen after closing a menu.

If you have an AT or faster compatible with 640K, a megabyte of expanded memory, a hard disk, Enhanced Graphics Adapter, and mouse, Windows is brilliant. For the rest of us, it ranges from sheer hell to an intriguing toolbox—maybe worth $99 just to play with until you get your next hardware upgrade, by which time there'll be more software that works with it. It's definitely where DOS is going, but I think there's no hurry to get there.

An Adaptable Adapter

It's a tradition that's made this country great: Whenever IBM creates a good product, someone follows its standard in six months with something that costs less and has more features. The latest example is Big Blue's Enhanced Graphics Adapter (EGA), rapidly supplanting the old Color/Graphics Adapter (CGA) as software companies exploit its more colorful palette and sharper resolution. But the EGA costs $982 in its desirable 256K configuration.

This sets the stage for the most audacious IBM knockoff yet: a video board that works like the 256K EGA, the CGA, the text-only Monochrome Display Adapter (MDA), and the Hercules Graphics Card, all in one slot for $595. It's the QuadEGA+, Quadram's version of the VEGA card from Video-7 of Milpitas, CA (whose neighbor, Chips and Technologies Inc., developed the board's chameleon graphics chips and licenses them to several manufacturers).

Clone owners should ask for a test drive; my highly compatible Tandy 1200 HD refused to start with the QuadEGA+ in place, and the Quadram tech support staffer I called said the company hadn't yet compiled a list of machines that accept the new board. With a borrowed PC, however, the QuadEGA+ worked nicely. DIP switches and a toggle switch, resettable without opening the computer's case, configure its 9-pin connector for your monitor—TTL monochrome, RGB color, or enchanced color. (Two RCA composite jacks are for EGA-style options to be announced.)

With a monochrome monitor, the adapter shows the MDA's familiar 80 × 25 display, with sharp text, boldface, and underlining. An RGB monitor shows the CGA's equally familiar (and fuzzier) 40- or 80-column text and four-color graphics, while using the QuadEGA+ as an EGA brings that board's improved text and 16-color graphics—at 640 × 350 resolution with an enhanced display, or 640 × 200 with a standard color monitor like the one I used. (Windows looked wonderful, but two diagnostic screens, showing the high resolution, were confetti.)

Besides the DIP switches, Quadram supplies a software driver with CGA and HGC emulation modes, plus a screen saver that blanks the display after a specified interval without keyboard input. I never needed the CGA command; a program that both directly addresses the color card's graphics controller and boots itself instead of loading through DOS (such as Microsoft's Flight Simulator) will stymie the QuadEGA+, but all my CGA software, including a self-booting Ms. Pac-Man game, worked without the patch. The Hercules emulator produced that board's fine TTL text and 720 × 348 graphics for Windows and fancy Microsoft Word italics and subscripts, though I couldn't get Word's condensed 90-column, 43-line display.

The QuadEGA+ is the last video adapter you'll need for almost any software or monitor under the sun; if you want the ultimate in color, its savings over IBM's EGA help ease the $845 bite of the Enhanced Color Display. I still think a monochrome monitor and graphics card are a thrifty solution for all except heavy presentation graphics work, but I don't know of a monochrome card with a coupon offering Windows for $20. **ME**

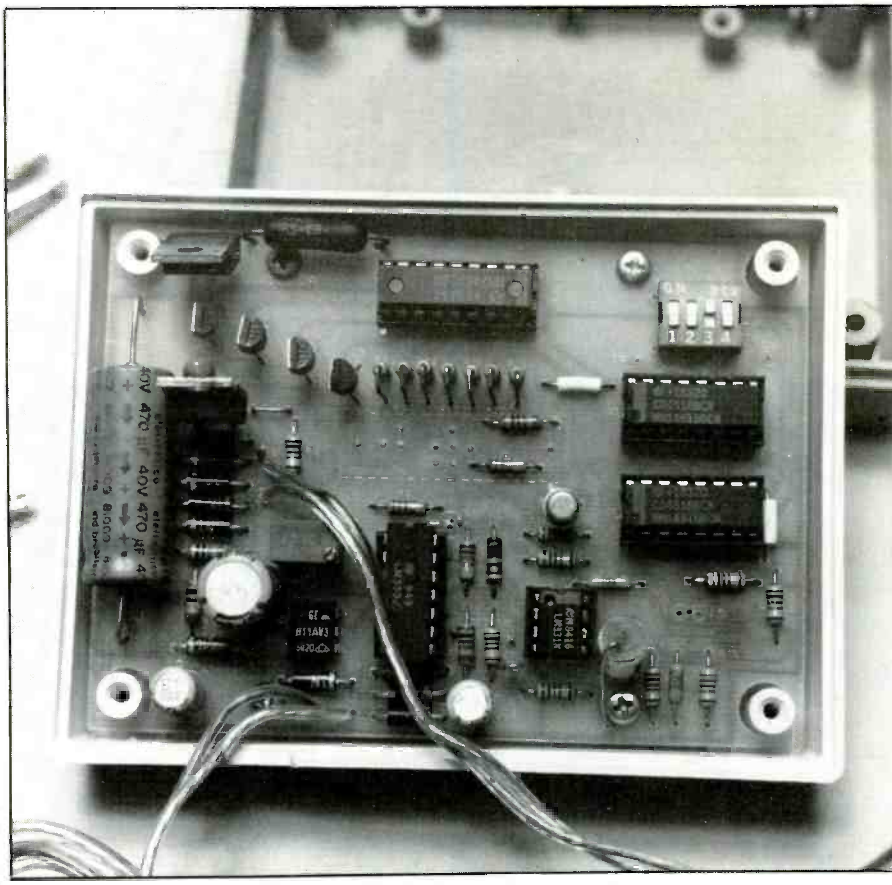
Names and Addresses

Microsoft Corp.
10700 Northup Way
Box 97200
Bellevue, WA 98009
206-828-8088

Quadram Corp.
One Quad Way
Norcross, GA 30093
404-923-6666

countdown is a lot more convenient than having to wait a whole hour. So you remove J5 (open position 5 if you are using the DIP switch) and solder down J4 (or close position 4) to allow the counter to count the direct vco output before it is divided down. Now adjust *R28* for a consistent 650-count-per-minute display. For more accuracy, wait 5 minutes to get a 3250-count display and then 15 minutes to obtain a 9750-count display. When calibration is as close as possible to ideal, remove J4 (open position 4 of the DIP switch) and install J5 (close position 5). The Energy Auditor is now ready for installation.

Before finalizing installation, however, check that the Energy Auditor operates reliably with the 12-volt ac wall transformer. If there is an ac outlet near the hot-water heater, mount the project directly on the heater with a couple of strips of foam mounting tape.



Interior view of completed project.

Kill power to the circuit breaker and remove the access panel to your heater's wiring. Remove the wire nut from one of the wires and separate the wires at the twisted-together joint. Slip the sensing transformer over the loose wire, reconnect the heater's wires and reinstall the wire nut. Position the sensing transformer out of the way. Restore power to the heater's breaker circuit and plug in the project.

Run the hot water until ON indicator *LED1* comes on to tell you that the heating element is energized. The LED should flash when the project senses that the load is energized, the flash rate of the LED depending on the setting of *R28*. This can be changed by moving jumper J2 from E14 to E13, E12 or E11 to achieve lower flash rates.

For alternative installation near the wall thermostat, you must first calibrate *R28* for 42,000 counts per hour (700 counts per minute) and install J5 (or close position 2 of the DIP switch). Remove the thermostat's cover and use a screwdriver to expose the base plate. Then make the three-wire connections to the R, W and Y terminals. You can then fasten the project to the wall with a couple of strips of foam mounting tape. Reassemble the thermostat and route the wires so that they will not show. This operating mode can be had with a minimum of wiring, while the previously described one offers the most flexibility for a variety of applications.

In Conclusion

From the foregoing, you can no doubt see other uses for one or more Energy Auditors. Someday, all appliances may come with direct-read cost-to-operate displays like the Energy Auditor's. Until then, this project will give you a headstart on saving money. **ME**

AC-to-DC Conversion Design *(from page 35)*

We could consider this the absolute maximum load (allowing for low line voltage) and rate the supply conservatively for 0.25 ampere. Now we must be sure the transformer will not be overloaded in the event of a shorted output. With a current of 0.65 ampere, we get these results:

V(MIN) = 6.37 AT 54.8
V(MAX) = 7.16 AT 116.8
V(AVG) = 6.85
RIPPLE = .26 V(RMS)
SEC. CURRENT = 1.189 AMP. (RMS)

Right on target! After continuously operating at this current for some time, the transformer was nicely warm to the hand, suggesting that it was running at rated capacity. (Transistor *Q1* required a heat sink.)

Note that 4.23 watts of raw ac power is being consumed to deliver a mere 1.25 watts of clean dc to the load. That 3-watt difference will generate low heat in this low-power supply. It is a good idea to make sure that the heat will be rapidly transferred to the environment.

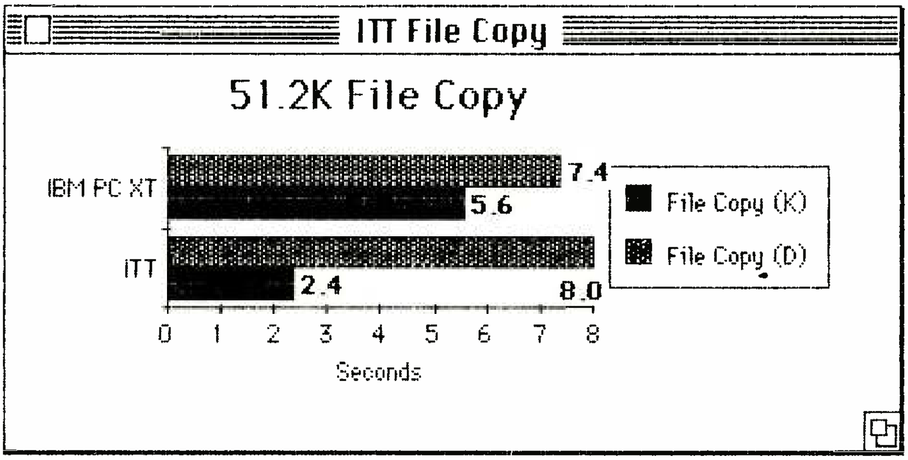
Using the Program

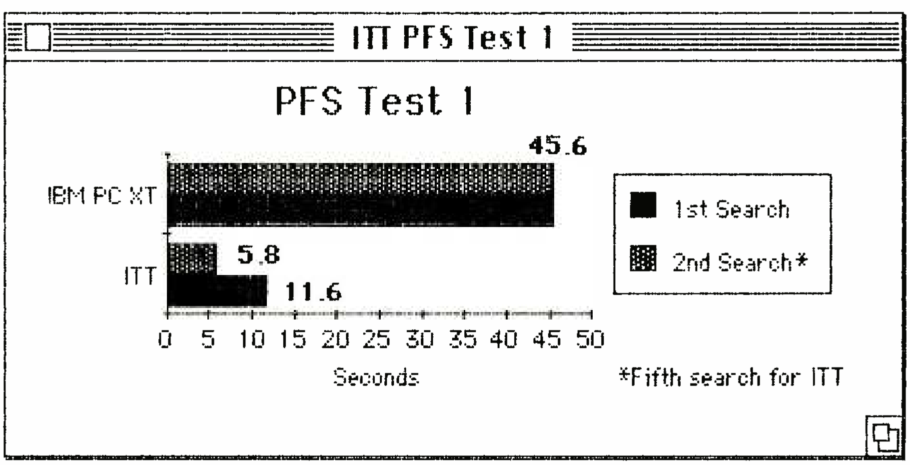
If you plan to use the computer program, here is some advice. Do not expect the results to be exactly as predicted. Although they were very close in all the circuits described, you should allow some margin for error due to measurement inaccuracies and parts tolerances. All angles used in the computations are in radians. If your computer has trigonometry functions based on angles in degrees, multiply by K before entering the function and divide by K after the result is returned (K is set to 57.2957795 at line 1050). If your computer has the ARC SIN function, you can use it in place of the subroutine starting at line 2000, but be sure to convert the result to radians if it is in degrees. The program has been organized to make it easy to follow. You should have no difficulty adapting it to your computer if you have some knowledge of the BASIC language.

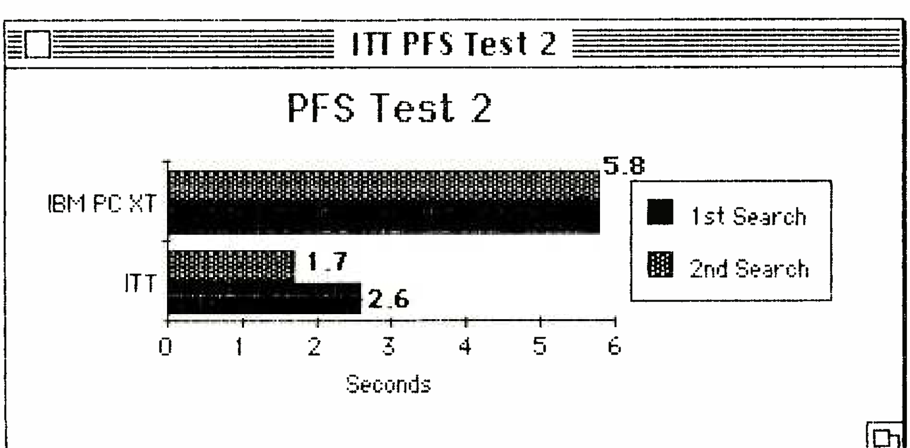
Circuit parameters are entered in lines 1 through 7 as program statements. The actual value can be coded in the line, or a formula that evaluates to that value can be entered. For example, peak secondary voltage can be entered by either of these statements: V = 10.6 or V = SQR(2)*7.5. If it is not convenient to enter the parameters as program lines, you can use INPUT statements instead.

CLS is the clear screen command. PRINT@256 displays at position 256, which is the beginning of line 8 for 32-column display. CHR$(13) is the ASCII character received when the ENTER key (or whatever key you use to enter data or program lines) is pressed. Any line containing one of these can be modified to suit your computer since these statements do not affect the actual computation. **ME**

ITT's Xtra XP Computer continued







Search times for three records in a database. Once again, the ITT Xtra XP computer's speed eclipses the IBM PC XT's.

contrast to the earlier 11.9 seconds by the fifth use. Clearly, the cache's algorithm is super!

In PFS Test 2, the same type of test was done with a smaller file. In this test, the effect of the disk cache is equally dramatic. Note that the first search on the Xtra XP took 1.5 times longer than the second search did.

In another test, a 51.2K text file was copied from the hard disk to a floppy disk. Here the time for the DOS prompt to appear on-screen was contrasted to the time for the floppy drive's activity LED to go off. As the chart shows, keyboard control was returned more than twice as fast with the Xtra XP, as compared to the PC XT, yet the time for the floppy drive's activity LED to go off is slower with the Xtra XP than with the PC XT.

In only one test were the times for the two computers comparable—for formatting of a floppy disk. In both cases, the time was about 46 seconds.

An additional performance-enhancing factor in the Xtra XP is its zero-wait-state RAM. Wait states are extra cycles a processor inserts when accessing memory. For example, when simulating 8088 memory access, the 80286 inserts three wait stages for each byte and eight wait states for each word.

Hard-copy printing speed demonstrates still another area in which the Xtra XP's performance is better than the PC XT's. In addition to providing a disk cache, the FXP program allows a user to set up a print buffer. Whenever text or graphics is to be printed, data is sent to the buffer, which then feeds it to the printer. With a large enough buffer, an entire document can be loaded, immediately restoring full computing capabilities to the user. You don't have to wait for the printer to finish printing to continue computing.

Using the print buffer feature temporarily reduces the amount of memory reserved for caching. When print buffering is no longer needed, FXP automatically restores the memory set aside for caching. Of course, if a printing job is bigger than the amount of memory set aside for buffering, you do have to wait until the

ITT Xtra XP Versus IBM PC/XT Comparison Chart

	ITT Xtra XP	IBM PC XT
Microprocessor (CPU)	80286	8088
Clock speed	6 MHz	4.7 MHz
Math coprocessor (optional)	80287	8087
Operating system	ITT DOS 2.11	PC-DOS 2.1
RS-232 serial port	Standard	Optional
Centronics parallel port	Standard	Optional
Floppy-disk controller on system board	Yes	No
Maximum RAM on system board	640K	256K
Standard/maximum RAM	512K/1.64M	256K/640K
Expansion slots	5**	8
Floppy-disk capacity	360K	360K
Hard-disk capacity	10M/20M	10M
Dimensions (WXDXH)	14″×15.6″×5.6″	19.5″×16″×5.5″
Price*	$4,365	$4,420

*Monochrome display, 10M hard disk, 512K RAM
**In typical configurations, the ITT has the equivalent of eight slots through built-in expansion provisions that don't require extra slots. See text.

buffer takes in the last bit of data before you can resume using the computer.

Comments/Conclusions

With the Xtra XP series, ITT has pulled off an interesting design switch to deliver machines that are especially close in software compatibility to th IBM PC XT and on the mark it seems in hardware compatibility, while providing much more computing power. All this was done while maintaining prices in the same IBM XT ballpark.

It did this by using Intel's faster 80286 CPU, the same one employed in IBM's AT computer, but runs its I/O bus as an 8-bit system as in the XT instead of as an 8/16-bit one as in the AT. Complementing the foregoing is a wonderfully efficient cache system and no-wait-state RAM operation. Furthermore, the ITT Xtra XP model's user RAM can be expanded internally to almost three times that of the PC XT.

What we have in performance, then, is a computer that rivals and sometimes significantly exceeds the more costly AT in operating speed, not to mention totally ripping the XT in performance and power capability.

ITT's Xtra XP takes up much less space on a desk than the larger XT, but in doing so gives up the capability of adding a second diskette drive or tape backup system internally. The model's construction quality is excellent and the machine's appearance is fit for any professional or business office. The Xtra XP's character set is good, though not great, much as the XT's with a standard color graphics card. Color on the ITT video display is excellent with nice, deep saturation. In the color display's monochrome mode, however, it could use a little more maximum brightness control range in anticipation of some brightness loss over the years.

The ITT keyboard has an excellent feel to it and the "bumps" on the F and J home keys are a definite plus for touch-typing. The keyboard itself is a nice, solid weight and size, though I wish it had a longer coiled connector cord.

Totalling up everything, the ITT XP offers superb value and performance. It's a computer that is intelligently and conservatively engineered to give real benefits to users from a company that is likely to stand behind its product. If one wishes to, he could upgrade the IBM PC XT to provide most of the benefits of the ITT XP, of course. There are turbo boards and dozens of other performance-enhancing boards around for this purpose. But this would add considerably to the cost of an XT. In sum, I would unhesitatingly recommend the ITT Xtra XP to a prospective purchaser as a desktop computer to seriously consider when cost is not a primary consideration and cost/performance value is. ME

—*Joseph Desposito.*

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Only three components are needed to make the adapter. This is the simplest arrangement I know. It works by using the difference between the two circuits to power relays that switch power to the trailer's brake/turn lights.

When I tried the three-diode circuit shown in dashed lines, I experienced some problems. Since the car wiring carries more current, there's more of a voltage drop. Also, the diodes themselves have a drop of nearly 1 volt. These drops add up to significantly dimmer trailer lights. Finally, most cars will require a variable-load flasher. (These problems are common with commercial 3-to-2 circuit adapters.)

I eliminated the problems by adding a new wire with an in-line fuse for trailer light power. For this installation, I recommend that you use a 10- to 15-ampere fuse and at least 16-gauge wiring.

This is the most ambitious of the modifications in terms of cost. However, it shouldn't cost you more than $10. Timewise, you can figure about two to three hours of work. **ME**

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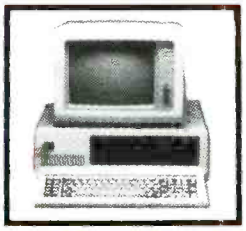

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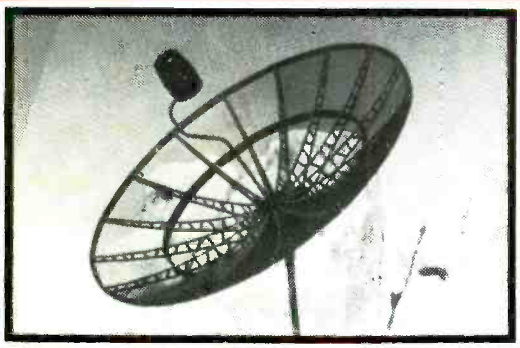

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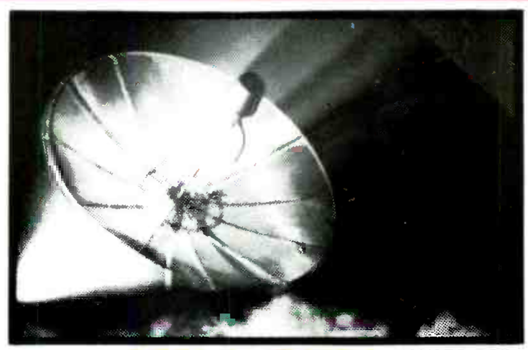

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