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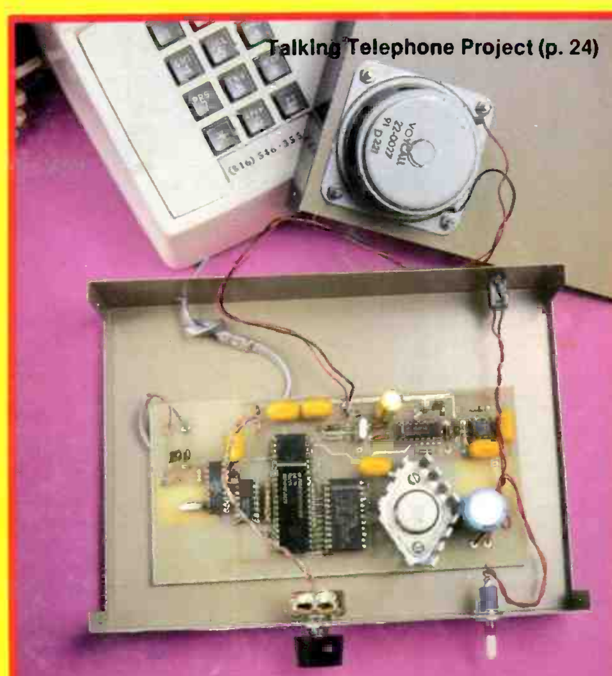

Talking Telephone Project (p. 24)

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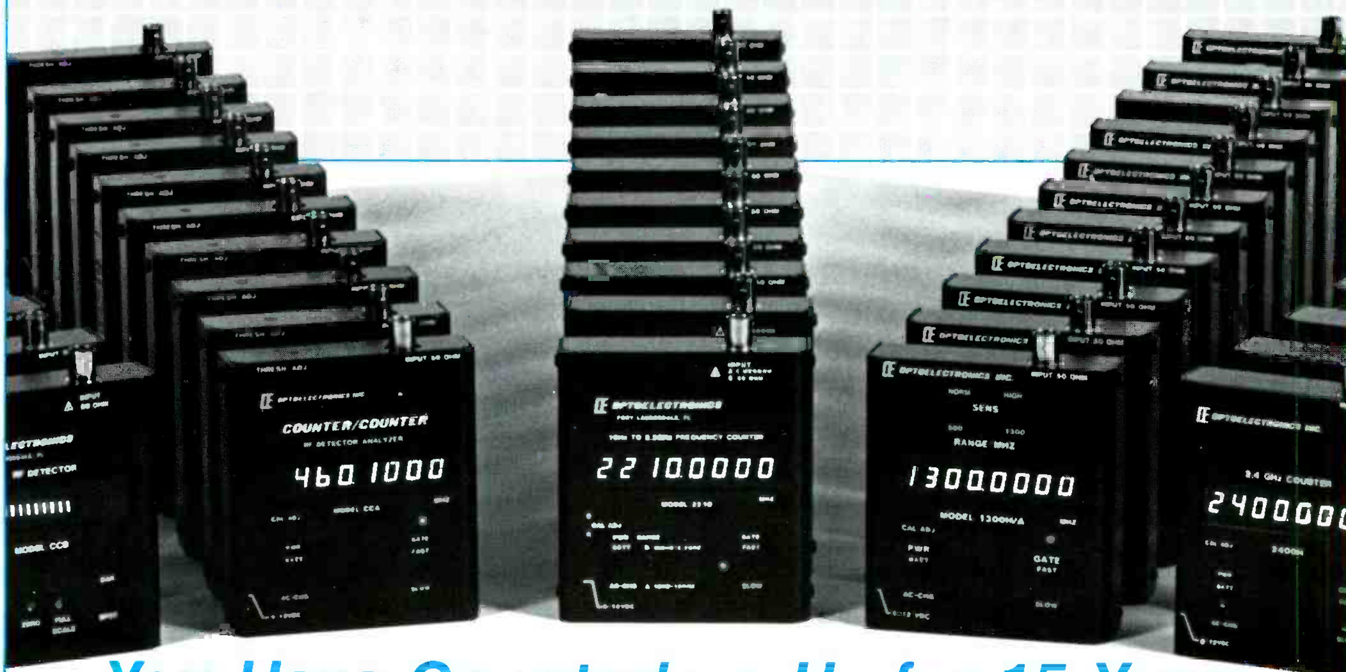

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450 MHz	< 3 mv	< 5 mv	< 3 mv	< 1 mv	< 5 mv
850 MHz	< 3 mv	< 20 mv	< 5 mv	NA	< 5 mv
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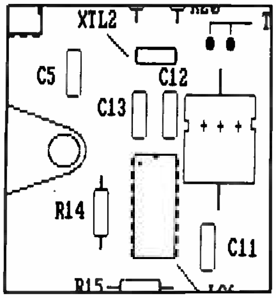

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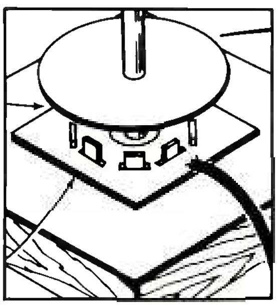

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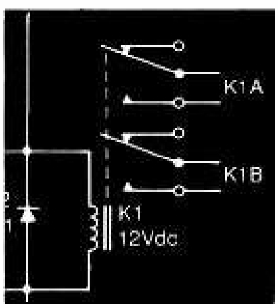

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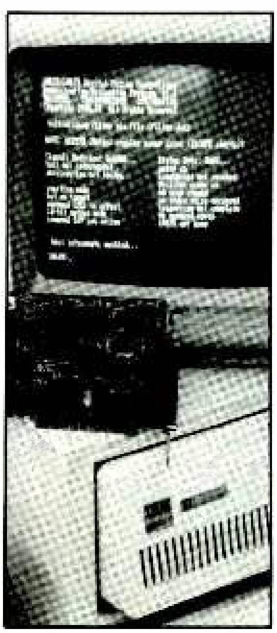

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FEATURES

COLUMNS

DEPARTMENTS

On the Cover. A selection of detector elements. (Photo courtesy of Infrared Industries, Inc.)

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FAX: (516) 681-2926

Jonathan Kummer
Advertising Manager

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EDITORIAL

Computer Power

Personal computers have become working tools for electronics-oriented people much as test instruments are. It's no surprise, then, that most *Modern Electronics* readers own computers. Many, however, are planning to replace them with more powerful ones. Zeroing in on which computer(s) to buy, which 69.8% of our readers say they'll be doing this year, is not an easy chore. The first decision to make is what type machine you want among incompatible ones: IBM, Apple or Apple Macintosh, Commodore Amiga or Atari ST, among others. Once this choice is made, the next one to determine is how much computer power you want for now and the foreseeable future.

The foregoing choices are what our article on "Choosing the Right Computer Power" is all about. Many such decisions will be made on the basis of retaining the use of software and hardware already owned. So if you've got an old IBM or MS-DOS compatible, you'll likely want to continue with this breed of machine. For those who own non-compatible, limited-power computers, such as a Commodore 64, and want to upgrade, the decision is pretty much wide open.

This month, we're examining the IBM/compatible personal computer field, dividing choices among the microprocessors each model category uses. Essentially, this breaks down to 8088, 8086, 80286 and 80386 processors. In essence, this means selecting between an IBM-equivalent of the old PC, XT or AT models, or a system using the newer 80386SX and 80386 microprocessors that are incorporated into the better models of IBM's Personal System/2 series or other makers' compatibles.

We'll follow this in another issue with a close look at other computer types. We led off with IBM-type machines because 74.6% of prospective buyers in our 1989 Study indicated they plan to buy this type.

The IBM computer world has certainly been a volatile one the past year, with pickings among the stan-

LETTERS

Credit Where Credit Due

• We were pleased to see your review of our DynaBook in the July 1989 issue of *Modern Electronics*. I just wanted to give proper credit to one of our suppliers, Elographics Inc., for the software tools that were presented in the Evaluation. The clarification concerns the screen shots of the bottling plant and fire control. While these software demonstrations are components of the Scenario software product line, they were developed and trademarked by Elographics, which manufactures the DynaBook touchscreen. The Elographics software tools effectively demonstrate the powerful capabilities of touchscreen technology

Judith Bolger
VP Marketing
Scenario Inc.

Author Update

• In my "Practical Printed-Circuit Boards" (August 1989), the following information did not appear but is germane to the subject:

The method detailed in Step 1 can also be used with negative (photographic) artwork. Flip over the photocopied artwork, backlight it and trace the conductor and pad outlines to make a positive. All holes and edges in the copper cladding must be smoothed with sandpaper, even on single-sided boards; otherwise, there may be "donut" shaped defects around several holes due to the undercutting effect of the etchant. Your fingertips will reveal the difference.

In Step 4, spacing between conductor traces can be as little as 1/32-inch. Unwanted adhesive should be removed with the dard bus, IBM's Micro Channel Architecture (MCA), and upcoming Compaq-led EISA bus complicating matters. The former requires expansion boards specifically made for the MCA , while the latter will accept existing standard-bus 8-bit and 16-bit boards. I'd guess that MCA and EISA will live as side by side competitors down the road. Without any EISA computers available at this time, and the promise of higher initial cost anyway when they do appear, the choice between them for present buyers is moot.

See what author Joe Desposito has to say about each type of computer. His counsel will serve as a fine guideline to making key computer-buying decisions. The final decision you make will be heavily dependent on how you'll be using a computer now and in the near future, of course. Price, too, will be an early consideration.

(continued on page 63)

starting fluid. Finally, the rubber-cement block mentioned could easily remove short resist traces like the one touched by the larger circle in Fig. 4.

Wayne Richardson

Humidity Sensor Source

• Some readers have had difficulty locating the Mepco/Centralab No. 2322 691 90001 humidity sensor specified in my "Relative-Humidity Meter" article (August 1989). This item is available from Hamilton-Avnet electronics distributors (201-575-3390 in New Jersey, or consult your white pages for a distributor closer to you). Readers who do not wish to place the $50 minimum order Hamilton-Avnet requires can obtain the sensor from me for $15 plus $2 shipping and handling.

Anthony J. Caristi
69 White Pond Rd.
Waldwick, NJ 07463

VIDEO WORLD ADVANCES. Sony demonstrated a coat-pocket-size HandyCam camcorder, the CCD-TR5, at a summer electronics dealer trade show. The full-featured model weighs just 1-3/4 lbs.

On another video front, electronic still cameras, which store photographic images as electronic signals instead of on chemically sensitive film, and are viewed on standard TV sets, continue to advance. They typically use a standard of 2-inch floppy discs as the storage medium. Now along comes Toshiba with a prototype of a new electronic still camera design that uses IC memory instead of floppies.

According to Toshiba, the new system can provide picture resolution with over 400 horizontal lines, excelling S-VHS images. This compares to a 300-line average for floppy-based electronic still cameras. Using digital storage, it's easier to modify image data. Moreover, since the IC-card camera doesn't use a disk drive, it can be made smaller and more reliable. The IC card has a 20 MB memory capacity. Using compression technology, it quadruples the number of storable photo images to 13.

A portable player has also been developed for use with the IC-Card Camera. It's an electronic album that's based on a DAT recorder, and can hold up to 1,600 pictures on a single 120-minute Digital Audio Tape cassette. The machine has a random-access function to retrieve any photo image by keying in its number. Furthermore, audio messages can play concurrently with photo images. Sales projections per year are expected to reach 10-million units worldwide by the year 2000.

MUSIC, MUSIC. Atari introduced a MIDI-compatible laptop computer with real-time capabilities. It can be used on the road or in the home to create dynamic music. $1,500....At the same time, the company debuted its Hotz MIDI keyboard controller that it claims will revolutionize the way music is composed and performed. The computerized keyboard can be programmed to play chords or individual notes in any key.

MusicWriter, Inc. (Los Angeles-Los Gatos, CA) plans to make available a high-tech sheet music distribution system in the spring of 1990. It consists of CD-ROM terminals in sheet music stores that will store up to 20,000 titles. Customers can immediately access the sheet music database from the system's menu-driven personal computer, having it printed on a laser printer. MusicWriter says it will download new releases of sheet music to each station. The MusicWriter plays the first eight bars of any song for the customer, too, who can choose what key it should be in. Furthermore, the music chosen can be produced on a MIDI disk that's compatible with one's computer or synthesizer. Price for a customized sheet? About three dollars!!

VEHICLE LOCATION MONITOR. A satellite identification system for monitoring truck location has been developed by Secura Corp. of Philadelphia, PA. Called "Trailstar," is establishes a communications link through a radio determination satellite service, Geostar, so that a dispatcher will always know the location of tractors and trailers. It's expected to reduce theft as well as answer the question, "Where is the truck?"

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.

Wrist Watch Pager

Said to be the industry's first, Motorola's new land mobile pager is small enough to be worn on a wrist like a watch. Developed jointly with Timex, the less-than-one-ounce user-friendly Wrist Watch Pager has separate controls for timekeeping and pager functions and is rated to provide more than 40 days of continuous operation on one battery.

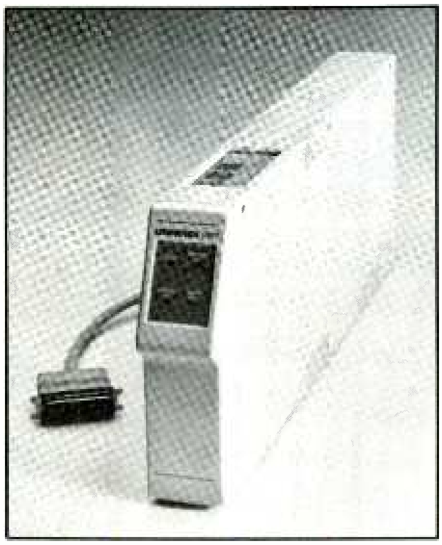
Functions include a non-volatile memory that stores messages, even

when the unit is turned off. A message erasure feature allows the user to delete all read messages without affecting unread and protected ones. A message time-stamping feature displays the time a message is received on a built-in LCD screen following the actual message. The screen displays 12/24-hour time of day, day of week and date on two lines. These are replaced with the message received while reading the message.

CIRCLE NO. 151 ON FREE INFORMATION CARD

Plain-Paper FAX Printing

The OMNIFAX PPI from Telautograph (Los Angeles, CA) is an interface module that receives facsimile transmissions and prints them on plain paper through Hewlett-Packard LaserJet II and compatible laser printers. It connects directly to a telephone line and the printer's parallel port to allow the user to print FAXes without the need for a FAX machine. The unit has 1 megabyte of RAM and requires that the printer have the same for optimum performance. Internal memory allows the PPI to buf-



fer and hold up to 60 pages of incoming FAX transmissions. Average print speed with the LaserJet II is rated at two pages per minute.

The compact OMNIFAX PPI is designed to operate in tandem with an existing FAX machine. It will receive transmissions and print them on non-thermal paper, with the FAX system operating as the sending device. If the laser printer is in use when a FAX is coming in, the PPI stores the transmission until the printer is free again or until its buffer reaches capacity. If the latter occurs, transmissions reverts to the existing FAX system and messages are printed on thermal paper. The unit receives CCITT Group 3 facsimile transmissions at 9,600 bps in either standard or fine-print modes. $1,395.

CIRCLE NO. 152 ON FREE INFORMATION CARD

Static-Control Workstation Kits

Kits for controlling static electricity at workstations in virtually any envi-

ronment are available from Charleswater Products, Inc. (W. Newton, MA). Statfree® Static Control Work Station Kits are said to eliminate the dangers of static electricity by dissipating charges built up on people and objects, draining away a 5,000-volt static charge to zero in less than 50 milliseconds. The kits feature electrically conductive floor mats, table mats, elastic wrist straps and grounding cords. Available as Basic, Standard and Vinyl Kits with various combinations of floor and table mats to suit user requirements, these kits are designed in accordance with DOD HDBK 263. From $130.

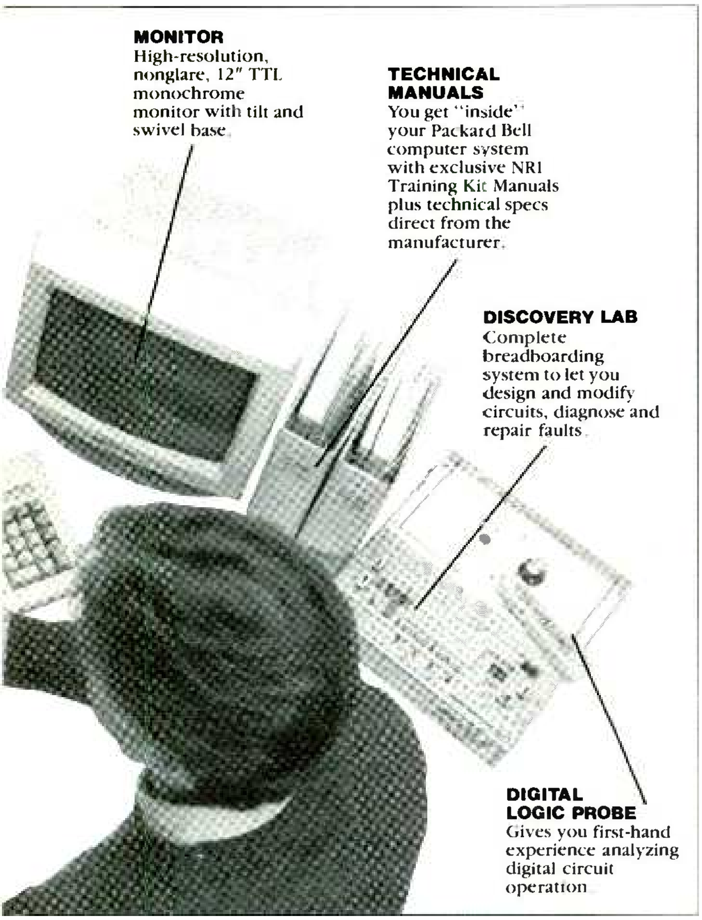
CIRCLE NO. 153 ON FREE INFORMATION CARD

Scanning Receiver

A new 100-channel base/mobile receiver that offers complete public-service-band coverage has been announced by Ace Communications

(indianapolis, IN). The Model AR 950 receiver tunes the 27-to-54-, 108-to-174-, 406-to-512 and 830-to-950-MHz bands, covering all of the police, fire and emergency bands,

in school, on the job, how to troubleshoot and like NRI



Using your D/A converter along with the exclusive text-to-speech software also included, you explore the fascinating technology behind both digitized and synthesized computer speech.

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NEW PRODUCTS . . .

plus the new services above 800 MHz in 12.5-, 25- and 30-kHz increments.

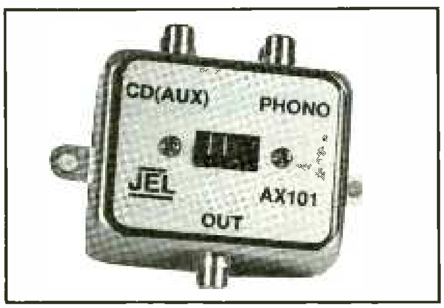
In a mobile environment, the new radio can be mounted under the dashboard, using a supplied mounting bracket. As a base station, the radio can sit atop a desk and be powered from the ac line via a supplied adapter. Supplied with the Model AR 950 are a standard telescopic whip antenna and a flexible rubber antenna optimized for reception at 800 MHz, both with appropriate hardware.

On the front panel are 25 keys that permit programming of five banks of 20 channels each. Pairs of upper and lower limits for bands to be searched can be stored in five separate search memory locations. All information is stored in three non-volatile memories that do not lose data even if power is removed from the unit. Other features include: first-channel priority; keyboard lockout; BNC antenna connector; and blue back-lit LCD display window that offers 22 separate prompting annunciators to aid in operating the unit. $299.

CIRCLE NO. 154 ON FREE INFORMATION CARD

Retro-Fit CD Input

Johnson Electronic Labs (Warner Robins, GA) has introduced the Model AX101 CD-to-phono input adapter that allows amplifiers that



do not have a CD or auxiliary input to accept a CD player (or other auxiliary device) through the magnetic phono input. Features include a passive circuit design that minimizes noise and distortion; a selector switch for CD or phono operation; an RIAA response accuracy that is rated to be within 1 dB; and a chrome-plated housing with removable tabs for convenient mounting. $89.95.

CIRCLE NO. 155 ON FREE INFORMATION CARD

Microwave Leakage Tester

Microcheck is a new non-contact microwave leakage detector from A.W. Sperry Instruments, Inc. The Model SMW-1 device "reads" microwave

radiation as low as 0.1 mW/cm^2. The lightweight, ruggedly built detector has no leads that have to be hooked up, no switches to set, not buttons to press, no control settings to monitor and no battery to replace. $17.95.

CIRCLE NO. 156 ON FREE INFORMATION CARD

Security Monitor/Dialer

With the House Sitter security monitor/dialer from Heath Zenith, keeping tabs on your home is as simple as making a telephone call. Designed to interface with the company's security and most other systems or as a stand-alone unit, the Model DS-6230 House Sitter lets a user monitor various conditions in his home with a single telephone call. When the unit is called, it provides a report on house temperature, sounds in the house, whether power has failed and a

choice of one other condition. In addition, the unit can also dial up to four telephone numbers to report on any alarm that might occur when no one is home.

House Sitter features a keyboard that "talks to you" in English as you program the device. Programmable functions include setting up to four telephone numbers for emergencies, high and low temperature limits, entering a secret code that locks out programming, and others. Installation takes only a few minutes and consists of simply plugging in the power cube and connecting the monitor/dialer to a standard telephone jack. $129.95.

CIRCLE NO. 157 ON FREE INFORMATION CARD

Wireless Control Panel

York Controls (Richardson, TX) has announced availability of a new compact 72-channel wireless (radio-frequency) controller with 16-character LCD display. The Model TD-72 is

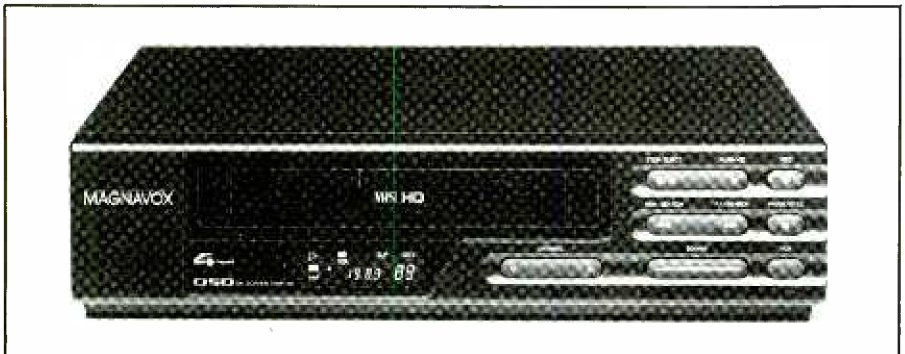
capable of controlling up to 72 functions of a York Controline System, commanding any combination of home-entertainment or/and environment equipment. Up to eight different pieces of equipment can be selected using a slide switch mounted on the faceplate. Up to nine pushbuttons can also be mounted on the faceplate to give the TD-72 a maximum 72-function capability.

The LCD window displays a legend for the particular device chosen for control by the slide switch; this function is transmitted when a button is pressed on the panel. Each button on the control panel of the device can serve more than one function; so each key cap can be engraved with multiple legends or symbols (color coding is also available).

CIRCLE NO. 158 ON FREE INFORMATION CARD

Easy-To-Use VCRs

Philips Consumer Electronics Co. has released a new series of VCRs designed to allay the fears of consumers who are intimidated by the technical operating aspects of the videocassette recorder. The Smart 'N Easy series consists of three models under the Magnavox brand name. The line is characterized by an easy-to-read function indicator, on-screen programming, a user-friendly reference card and larger operating buttons, all designed to make the user more comfortable with the VCR.

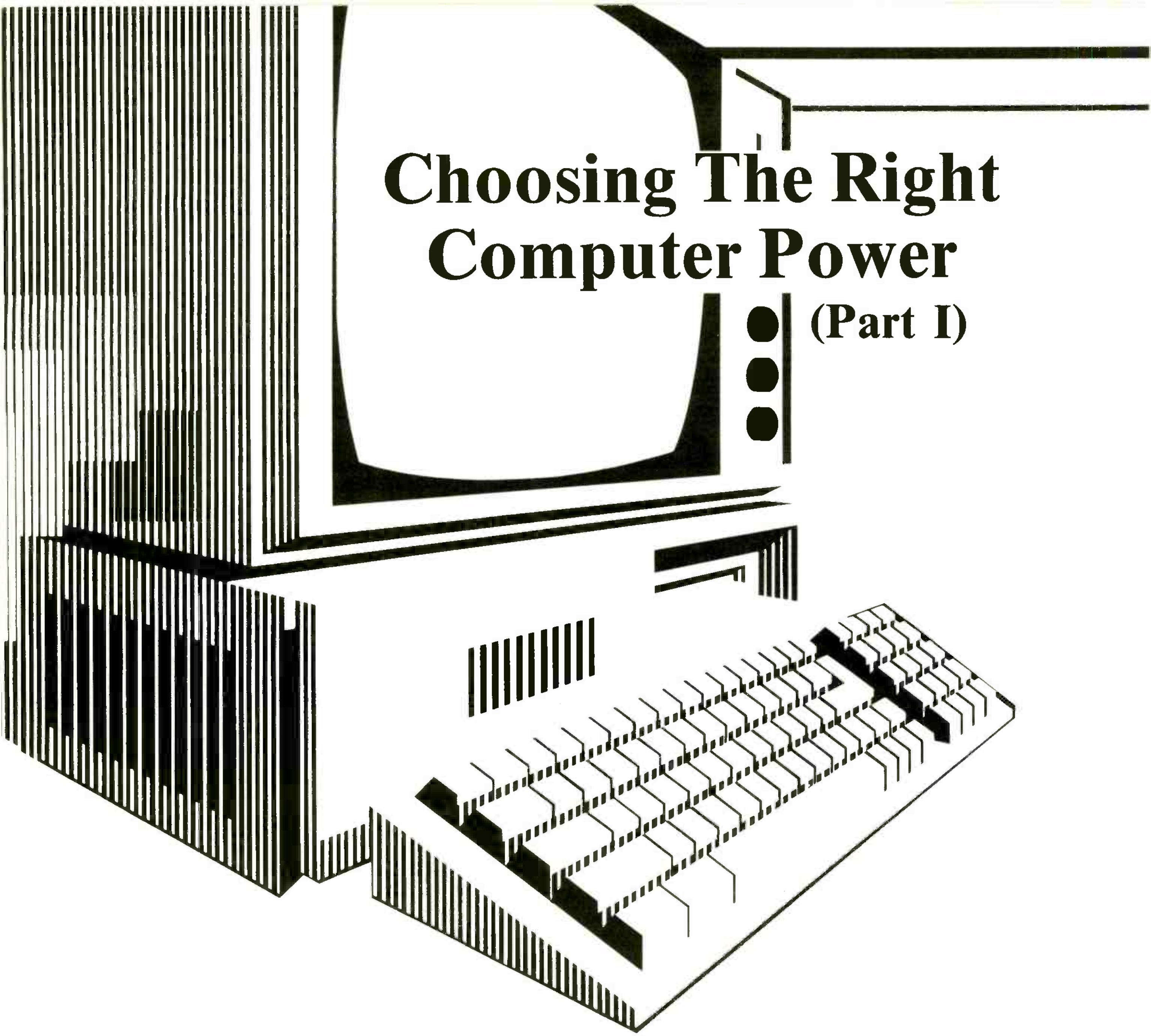


The Model VR1820AT ($449.95) offers a 45-function unified remote controller that operates both the VCR and six Magnavox TV functions. Its easy-to-read multi-function on-screen display continuously alerts the user to all important recording nd playback conditions, including time, counter position, tape speed and channel number. When the VCR is turned off, the time display dims. On-screen indicators are also provided for recording/playback functions, channel number, clock setting, date, counter, programming, one-touch record and one-touch record standby. Other features include automatic tracking; automatic scan tuning; four-event/one-month on-screen programming; repeat play; ×21 forward/reverse latching search; frame advance, still frame, slow motion and variable slow motion in SLP; transition editing; and automatic VCR/TV switching.

The Model VR1830AT ($469.95) has the same features as the VR1820AT, except that it has three heads and adds forward/reverse ×21 in SLP/×7 in SP latching search, still frame in SP/SLP, frame advance in SP/SLP, slow motion in SP/SLP and variable slow motion in SLP. The top of the line is the four-head Model VR1840AT ($499.95) that has an audio/video "Learn" remote with five A/V functions. It has all the features and functions of the above two models plus a jitter-free field still, noiseless double fine slow and variable fine slow motion.

CIRCLE NO. 159 ON FREE INFORMATION CARD

(Continued on page 72)



Choosing The Right Computer Power (Part I)

Guidelines to buying personal computers

By Joseph Desposito

As we head into the final months of the 1980's, marking about 15 years since the first personal computer was marketed, a substantial number of *Modern Electronics* readers are expected to buy one or more of these wondrous machines—69.8 percent of you, according to a 1989 study. In light of this, there are many questions that need to be asked and answered concerning these purchases.

Foremost on the list of questions should be: Which personal computer is right for me? Should I purchase one that ascribes to the IBM standard or should I consider one of the many varieties of Apple computers? Or is one of the Commodore or Atari models best for my particular needs? The answers to these questions might well fill a book. We, however, have chosen to shed light on the subject in a two-part article. The first part will view personal computing through a blue-filtered lens—in other words IBM and compatible computers. The second part will examine the world of Apple, Atari and Commodore computers.

IBM & Compatible Computers

When you begin to discuss IBM and compatible computers, a company name that likely pops into mind is Intel. This is because Intel manufactures the bulk of the microprocessors that are in these machines. And there is no better starting point when talking about personal computers than to focus on the microprocessor that the computer uses.

Most IBM and compatible computers use an 8088, 8086, 80286, 80386SX or 80386 microprocessor. Now if money were no object, my suggestion to all readers would be to buy a computer with an Intel 80386 microprocessor. This chip is currently the most powerful of the Intel line that is used in personal computers. (Intel does have a more powerful 80486 microprocessor, but personal computers that use the chip are not yet on the market.)

However, since the cost of a computer is always a factor, the next question to ask is: What are the tradeoffs you have to make based on price? A major tradeoff is speed. If you were to succumb to an advertisement for a true blue IBM PC compatible for a bargain basement price of just $799, for example, you would be buying a personal computer with an 8088 microprocessor that has a clock speed of just 4.77 MHz. Since clock speed is one of the factors in how fast programming instructions are executed inside the computer, you would be saddled with the slowest speed available in an IBM computer. However, this doesn't mean that this computer is a terrible purchase. After all, the IBM PC was the American business standard for two or three years. This computer still does certain tasks like word processing relatively well.

Most 8088-based compatibles today, however, use an 8088-2 or a NEC V-20 microprocessor. These are dual-speed processors that run at 4.77 MHz and 8 or 10 MHz. The higher speed is usually selectable with a keystroke command such as CTRL/ALT/+. This effectively doubles the speed of the computer.

Why Buy an 8088 Computer?

If you were to consider buying an 8088-based computer, you would probably do so mainly for word processing and light spreadsheet or database work. It's best to buy a monochrome system for three reasons—it keeps the cost down, the monochrome display is much faster than a CGA (color graphics adapter) display, and text is sharper. A monochrome system consists of a monochrome adapter and monochrome monitor, of course.

Most monochrome adapters advertise Hercules compatibility, which means they are compatible with the standard established by the Hercules Graphics Card that allows you to display graphics as well as text on your monitor, a matter that the originally introduced IBM PC ignored. Keep in mind, however, that the IBM PC is also a pretty nice game machine. If you're into games, therefore, this means buying at least a CGA adapter and CGA monitor, both relatively low-cost items, instead of monochrome ones. Much costlier, but much better from the standpoint of picture sharpness and number of colors that can be displayed, would be the EGA adapter and color monitor.

Most plain IBM PC compatibles come with one or two 5.25" low-density disk drives. A low-density disk holds 360 KB of data. If you can afford a 20-MB hard disk, you should purchase one for your computer right away. A Seagate 20-MB hard disk with 65-ms access time sells for about $250 now.

Though the 5.25" low-density floppy disk was the IBM standard for quite a number of years, this type of disk and drive are now more the lowest-common denominator than a true standard. The 5.25" low-density standard is being challenged on several fronts: 5.25" high-density and 3.5" low- and high-density formats. When IBM began using the 3.5" format in its newest personal computers, it legitimized the format. Both of IBM's low-end PS/2 computers, the Models 25 and 30, have 3.5" low-density disk drives. Other computers in the PS/2 line feature a 3.5" high-density disk. A 3.5" high-density disk has a storage capacity of 1.44 MB.

One feature that some 8088-based computers lack is a real-time clock. This can be a nuisance if you would like a time and date stamp on your files (which DOS does automatically) without having to manually set time and date each time you boot up your computer. If your computer does not come with a clock, you can easily get one by purchasing a clock chip or a multifunction card that typically includes this feature.

A more advanced microprocessor, the 16-bit 8086, which maintains full compatibility with the eight-bit 8088, is employed in computers to derive greater speed and some more power. Nevertheless, it is bunched here with the 8088 as an older micro (more than 10 years) that doesn't come near the speed and power of microprocessors currently in use.

Interestingly, IBM's PS/2 Models 25 and 30, and compatibles from other companies, use the 8086 microprocessor running at 10 MHz. With these computers, you don't have to worry about which video display to buy. They have the display circuitry built into the main computer board (motherboard). The display is MCGA, which stands for multicolor

" . . . never be able to run some newer operating systems."

graphics array. It is essentially the same as CGA, but with twice as many scan lines. This produces a sharper image, but also necessitates a more costly video display monitor. You must purchase either an MCGA monitor or one of the many multi-scan monitors on the market.

The reason you can't use a CGA monitor with MCGA video is that a CGA monitor is designed for a horizontal scan rate of 15.75 kHz. The MCGA scan rate is double that or 31.50 kHz. Multiscan monitors, such as the popular NEC MultiSync (NEC Home Electronics, Wood Dale, IL) color monitor, can automatically adjust to horizontal scan rates that vary from about 15 kHz to about 35 kHz.

While we're on the subject of 8088- and 8086-based personal computers, let's not forget about laptop portables. Most low- cost portables compatible with the IBM PC use some variation of these chips (usually a low-power CMOS version). And most use 3.5" low-density disk drives and have a CGA output besides the built-in LCD (liquid-crystal display).

8088 Pros & Cons

If you're contemplating an 8088- or 8086-based personal computer, you should know what you will *not* be getting. You will not be getting enough speed or power to run graphics-based programs such as the Excel (Microsoft, Bellevue, WA) spreadsheet program or the Pagemaker (Aldus, Seattle, WA) desktop publishing program or serious computer-aided design programs. You will not be getting enough speed or power to run large databases or large spreadsheets in a reasonable amount of time. Also, you will never be able to run some of the newer operating systems such as Microsoft's OS/2. (However, you should always be able to run the latest version of MS-DOS.)

On the positive side, an 8088-based computer can be expanded relatively inexpensively, since speed is not an issue. Memory chips need only be rated at 150 ns, thus making both conventional and expanded memory cheaper to buy. And hard disk drives need only be rated at 65 ms or so, the least expensive drives on the market. Expansion is accomplished for the most part through expansion slots on the computer's motherboard. The original IBM PC had five slots, while the IBM XT had seven regular-sized slots and one short slot. The original XT also came standard with a 10-MB hard disk drive, considered paltry storage nowadays.

A suggested 8088-based system would be one with dual speeds of 4.77 and 8 or 10 MHz, 640 KB of RAM, at least five expansion slots, a real-time system clock, a monochrome-graphics (Hercules compatible) adapter and monochrome monitor, a disk drive controller for both a floppy and hard disk drive, a 360-KB floppy drive, a 20-MB hard disk drive, and parallel and serial ports.

If the system is for home use and you intend to play games on it in addition to your other computing tasks, then you could substitute a CGA adapter and CGA monitor for the monochrome adapter and monitor, and purchase a joystick and an add-in board with a game port. Do bear in mind, though, that the quality of text or numbers will not be even nearly as good as with a monochrome system. So if word processing weighs heavily in your plans, you may want to rethink color-game capability—or buy a multifunction adapter that handles mono, CGA and EGA, and get both a mono and a color monitor.

You can purchase 8088- or 8086-based computers in computer stores or through mail order.

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286 Computers—Speed At Last!

When IBM announced its AT model in 1984, many so-called power users, who had been frustrated by the limitations of the IBM PC and XT, were ecstatic. Not only was there a clock speed increase from 4.77 MHz to 6 MHz, but there was also a power increase. The 8088 has an eight-bit data bus, which means it can send and receive program instructions and data only 8-bits at a time. Also, the 8088 can address only 1 MB or 1,024,000 memory locations (although DOS limits use for programs to 640K). The 80286, on the other hand, has a 16-bit data bus (as does the 8086), so it can send and receive program instructions and data 16-bits at a time, and it has a 16 MB physical address space.

What Price Speed?

The most significant asset of 80286-based computers compared to 8088- and 8086-based machines is the speed difference. Since you'll pay more money for this speed you should have a real need for it.

The increased speed of 80286 computers is accomplished by faster processor speeds (some chips can run as fast as 20 MHz) and faster disk drives. Hard-disk drives of IBM AT-type computers should have an average access time of 40 ms or less (28-ms ones are popularly used).

Let's spend a little time examining 80286 processor speeds. As mentioned earlier, the original IBM AT had a clock speed of 6 MHz. After a while, faster 8-MHz ATs came along. In some AT compatibles, the processor speed increased to 10 MHz. At this point many companies tried to squeeze more speed out of the system by running it at zero wait states. When a computer is operated at zero wait states, the system RAM has to be fast enough so that the microprocessor never has to add a wait state or extra clock cycle to the signals that it sends to memory.

Remember that RAM is made up of millions of physical transistors or electronic switches that take a fraction of a second to switch states from on to off or vice-versa. As the speed of the processor increases, the RAM chips must have a faster response time or else the processor will have to wait until the RAM is ready, thus slowing down the overall operation of the system.

Whereas in a 4.77-MHz IBM PC you could use RAM chips rated as high as 200 ms, in a 10-MHz 80286 computer you would need costlier RAM chips rated at 85 ms in order to operate at zero wait states reliably (in effect equivalent to 12-MHz, one wait state operation).

You can figure out how fast your RAM must be to operate at zero wait states by calculating the inverse of the clock speed. For example, a clock speed of 4.77 MHz translates into about 209 ns per cycle (1 divided by 4,770,000). A clock speed of 10 MHz translates into 100 ns per cycle (1 divided by 10,000,000). The response time of RAM should be comparable to the clock cycle time to ensure reliable operation. And since RAM chips are rated in discrete categories (for example, 85 ns, 100 ns, 120 ns, 150 ns), you should choose a value that is equal to or less than the calculated value. (You can get away with response time ratings higher than the calculated values simply because the rating on the chip represents a worst case value.)

Although IBM does not manufacture an 80286-based computer with clock speeds faster than 10 MHz, others make AT-compatible computers that can be found with clock speeds of 12 MHz, 14 MHz, 16 MHz and 20 MHz. You should be aware that chip maker Intel doesn’t produce 80286 chips rated faster than 12.5 MHz. However, there are two companies that manufacture faster versions of the 80286: Harris Semiconductor (Melbourne, FL) and Advanced Micro Devices (Sunnyvale, CA). One limitation here is the coprocessor. If you intend to use the 80287 coprocessor in your computer, keep in mind that the fastest one that Intel makes runs at 10 MHz. And no other company makes a faster version.

One of the problems that crops up in these faster-speed computers is the speed of the bus. Some manufacturers increase the speed on the bus to match the speed of the processor. This causes problems with some input/output devices such as mouses (mice?) and network cards. If you’re using a mouse on a computer with a 14-MHz bus speed, for example, the mouse will sometimes die (fails to move the cursor), and the computer must be rebooted. The IBM AT bus speed is 8 MHz, which is a speed you should look for when purchasing a compatible. For example, you can purchase a 12-MHz AT-compatible with a bus speed of 8 MHz.

Earlier, it was mentioned that an AT or compatible should use a hard disk drive with an average access time of less than 40 ms. You should also consider purchasing a drive with a minimum storage capacity of 40 MB. Whereas some years ago, 5- or 10-MB hard-disk drives were sufficient and rather costly peripherals, nowadays even 20- or 30-MB drives become filled up with application and utility programs, and normal everyday use. Since most 40-MB drives have an average access time of about 28 ms, you will also have the advantage of adding more speed to your system. Generally, the larger the storage capacity of the drive, the faster its average access time.

The 640K Barrier

The amount of memory that generally comes standard on the motherboard of AT-compatible computers is 1 MB. This does not mean that your programs and data can use 1 MB—you are still limited to 640K due to the restrictions of MS-DOS. The extra 384K that you get is called extended memory. This memory can be used for such things as RAM disks, disk caching, and print spooling. DOS provides a utility called VDISK to create a RAM disk, but you would have to purchase separate software to implement such features as disk caching and print spooling.

The only way to run programs or store data outside of conventional 640K RAM on an AT computer is by purchasing an expanded memory card that supports the LIM (Lotus-Intel-Microsoft) 4.0 standard. Programs such as Lotus 1-2-3 Version 2.0 and higher can use expanded memory for very large spreadsheets. To run programs in expanded memory, however, the program itself must support this feature of the LIM 4.0 standard. Right now, some TSR (terminate and stay resident) programs support it.

Once you begin to think about purchasing an 80286-based computer, another variable might enter the picture. Are you interested in the classic bus or the Micro Channel Architecture (MCA) bus? The classic bus is the bus that was introduced in the IBM PC and extended in the IBM AT. In the IBM PC, the expansion slots, where you plug in your choice of printed-circuit boards, have 64 pins. The electronic signals on these pins essentially define the eight-bit classic bus.

The IBM AT, in turn, has two of these 64-pin expansion slots, and six longer slots made up of two pieces—

the 64-pin slot and a 36-pin slot butted up against it to form a longer 100-pin expansion slot. The electronic signals on this longer expansion slot define the 16-bit classic bus. All of the IBM AT-compatible computers (IBM no longer produces a Model AT) use the classic bus, as does the IBM Model 30-286. The 80286-based computers that use the Micro Channel bus are limited to IBM's Model 50 series and Model 60 series.

According to Chet Heath of IBM, "The Micro Channel interface is designed to support the configuration, extendibility, reliability, and serviceability needs of multitasking and multiuser and networked systems." The MCA bus introduced the program option select function (POS), which automatically resolves conflicts between devices attached to the personal computer system. This function also eliminates all configuration switches in the system, which means the user no longer has to set DIP switches on the motherboard of the computer.

The MCA bus is also designed to support multi-master capability, which means that an add-in card, such as a coprocessor adapter card, can act as the bus master. The bus supports up to 15 bus masters in addition to the microprocessor. Bus master cards can communicate directly with input/output devices and memory without depending on the system's microprocessor. Thus, bus masters distribute processing responsibility efficiently throughout the system, freeing the main processor resources for other tasks.

Answering the question of whether to go classic or Micro Channel depends on several factors. First is cost. An 80286-based Micro Channel computer costs more than one with a classic bus. Second is functionality. Although the MCA bus promises to add more functionality to your personal computer as described above, in reality, the bus-master cards have been slow coming to market. Moreover, the benefits of the new IBM bus have been challenged by many manufacturers of classic bus computers. However, the Micro Channel does seem to be the bus of the future. Therefore, it's your decision to make as to when to buy into what's ahead, as compared to what's more useful at a lower cost right now.

Final 286 Considerations

The standard floppy-disk drive on an IBM AT or compatible is the 1.2-MB drive. Of course, you can add any other type of floppy drive to the system if your disk drive controller, system BIOS, and version of DOS (3.3 or higher) support it.

One of the features of an 80286-based computer versus an 8088-based one is a setup disk. On 8088 computers, you must set DIP switches to tell the computer what the configuration is in terms of disk drives, display, memory, etc. On an 80286 computer you set the configuration through software. Some manufacturers include a setup disk, while other manufacturers include the setup in ROM memory. The latter is much more convenient.

When you choose an 80286 computer you are more likely to want a color system, too. The choice you make for your color adapter will also determine your choice of monitor. On an AT-compatible system, you should not settle for anything less than EGA (enhanced graphics adapter) and probably should choose VGA (video graphics array).

If you were to choose an IBM 80286 Micro Channel computer, such as the Model 50Z, VGA would be a standard feature built into the system board. On most AT compatibles, though, you must purchase a separate video adapter card. The main difference between EGA and VGA is that the former is a digital design and the latter is an analog design. What this translates into in the real world is the number of colors that can be simultaneously displayed on-screen. While most EGA cards offer 16 colors from a palette of 64, VGA cards offer 256 colors from a palette of 256K (262,144).

Standard EGA resolution is 640 by 480 with 16 colors or 640 by 350 pixels, while standard VGA is 320 by 200 with 256 colors. You can also purchase enhanced EGA cards and super VGA cards to extend the resolution. A typical resolution for a super VGA card is 600 by 800 pixels and, depending on the card, either 16 or 256 colors can be displayed.

Once you have settled on the type of graphics display adapter, the next step is to purchase a monitor that matches the adapter. For EGA you could purchase a digital EGA monitor, and for VGA you could purchase an analog VGA monitor. Or you could simply purchase a multiscan monitor that displays both digital EGA and analog VGA.

All multiscan monitors can display standard EGA and VGA, but some don't have a high enough horizontal frequency to display super VGA. To display super VGA, you can probably get by with a monitor that has a horizontal frequency range of about 15 to 35 MHz. You would be better off, however, with a monitor such as the NEC MultiSync Plus; it has a horizontal frequency range of 21.8 to 45 kHz (note that this monitor does not have a low enough frequency to display CGA).

A choice you need to make with an AT-type computer is the kind of keyboard you want. There are basically two varieties, the 84-key standard AT keyboard and the 101-key enhanced AT keyboard. The basic differences between the two are these: the function keys (10) on the standard keyboard are on the left side in two vertical rows, while the function keys (12) on the enhanced model are along the top; the enhanced keyboard has a separate cursor keypad and separate named keys (Home, Pg Up, etc.).

". . . you can run Windows 286."

Besides the type, you should be concerned with the feel of the keyboard. Some keyboards that come with compatible computers are very light in weight. Others have a mushy feel when you press the keys. Although this might be to your liking, you should realize that some manufacturers, such as IBM, include keyboards that are heavy and have an excellent tactile response. IBM's keyboard has firm spring tension and a sharp breakover point early in its travel that can be distinctly felt and heard. If you buy a computer and don't like the keyboard, you can purchase a replacement model from such companies as Northgate (Plymouth, MN) and KeyTronic (Spokane, WA).

One last point to make about AT-style computers is the enclosure. The IBM AT has a significantly larger case than the IBM PC or XT. And most compatibles are the same size as the IBM AT. If this is too big for your taste, you might consider one of the small-footprint ATs. In general, these computers are smaller because they don't offer the same number of expansion slots as a standard AT. In some systems, like the Dell System 220 (Dell Computer Corp., Austin, TX), a 20-MHz 286, the three expansion slots are such that cards must be mounted horizontally, rather than vertically. Although this doesn't affect the function of the add-in card, you should be aware of this kind of change from the norm.

Pros & Cons of an 80286 Computer

What are the drawbacks of purchasing an 80286-based computer rather than a higher priced 80386 model? Since the 80386 chip is the microprocessor for today and for the foreseeable future for IBM and compatible computers, you won't be able to run some new programs that take specific advantage of the chip's features, especially its ability to do multitasking. On the other hand, purchasing an 80286 computer will save you money compared to an 80386, but not that much anymore compared to an 80386SX, a sort of hybrid type.

For the most part right now, this means you cannot use any of a number of 386 operating systems such as Microsoft Windows 386, PC MOS/386 (The Software Link, Atlanta, GA), VM/386 (IGC, Santa Clara, CA), DESQview/386 (Quarterdeck, Santa Monica, CA), Concurrent DOS 386 (Digital Research, Monterey, CA). Also, applications are coming out that are meant to run only on 80386-based computers. One that is already here is Paradox 386 (Borland, Scotts Valley, CA).

On the bright side, you can run graphics-based programs such as Windows 286 on your 80286, and any programs that run under Windows, such as Microsoft Excel and Aldus PageMaker. Keep in mind for graphics programs that the faster your computer, the better these programs work. Microsoft's OS/2 operating system and Presentation Manager will also run on an 80286 computer (though only for single-user use).

If you choose to use Windows on your computer, you should certainly invest in a mouse. A serial mouse connects to the serial port of your computer, while a bus mouse connects to a port on an add-in mouse card. IBM PS/2 computers have a mouse port as a standard feature.

A suggested 80286-based system would be one with a clock rate anywhere from 10 to 20 MHz running at zero or one wait state, 1 MB of RAM, eight expansion slots (two 8-bit and six 16-bit), a VGA graphics adapter and multiscan monitor, a 1.2-MB floppy drive, a 40-MB hard disk drive with 28-ms average access time, and parallel and serial ports.

You can purchase AT-compatible computers in computer stores or through mail order.

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386 Computers—Speed And Power!

Earlier, I stated that if money were no object, my suggestion to all readers would be to buy a computer with an Intel 80386 microprocessor. These personal computers are the fastest and most powerful IBM/compatible computers on the market. Software companies are just beginning to tap the power of this processor, which means that many new software products will be coming out that take specific advantage of its architecture. Therefore, it seems that the best computer to buy for now and the foreseeable future is one built around an 80386 microprocessor.

You still have a host of choices to make if you decide to go for the money. First you have 80386 and the new less-powerful (but also less costly) 80386SX computers with the *classic* bus, and then you have IBM and others with *Micro Channel* 80386 computers. One other bus architecture that looms on the horizon is EISA, which is backed by a number of computer manufacturers headed by Compaq. However, this bus has not appeared in a personal computer at this writing. We'll discuss the merits of these types later.

Full 80386 Speed Ahead

Since one of the main features of the 80386 chip is its speed, computer manufacturers have had to come up with ways to improve the speed of the whole system. For what good is a 20-, 25- or now 33-MHz processor if the rest of the system can't keep up? Some of the ways that manufacturers have tried to improve the speed of the whole system is with very fast memory chips, memory caches, fast disk drives and controllers, and proprietary bus schemes.

When contemplating the purchase of an 80386 computer, the first question to ask is about RAM. How much RAM is on the motherboard, what kind of chips are used, how fast are the chips, and how can RAM be expanded?

Microprocessor Comparisons

IBM Equiv.:	PC 8088	XT 8086	AT 80286	PS/2 Series 80386SX	PS/2 Series 80386
Speed Ranges (MHz)	4.77/ 8/10	4.77/ 8/10	6/8/10/ 12/20	16/20	16/20/ 25/33
Data Bus (bits)	8	16	16	16	32
Data Bus (bits)	8	16	16	16	32
RAM Type	DRAM	DRAM	DRAM	DRAM	DRAM, SRAM Cache
Extra Memory Use	Expanded	Expanded	Expanded, Extended	Expanded, Extended	Expanded, Extended
Expansion Boards (bits)	8	8	8/16	8/16	8/16/32
Operating System	DOS	DOS	DOS,OS/2	DOS,OS/2	DOS/OS2
Runs New '386 Software	No	No	No	Yes	Yes

To receive the full benefit of the 80386's 32-bit data path, a computer needs 32-bit RAM. Since the classic bus provides for only 16-bit operation, the manufacturer needs to have a proprietary 32-bit memory slot in the computer. Of course, some 32-bit RAM will be on the system board—the more capacity the better. But if you want to expand beyond that, you will in most cases have to depend on the manufacturer to provide a 32-bit memory expansion board. This is much different than with 80286 computers that can use any of a number of 16-bit memory expansion boards.

The RAM in most 80386 computers is either all dynamic RAM, or dynamic RAM and a small amount (up to 64 KB) of static RAM. The fastest and most expensive RAM is static RAM, which has a typical response time of 35 ns or less. Dynamic RAM is slower, but is also less expensive. Still, the dynamic RAM used in an 80386 computer needs to be the fastest dynamic RAM available, with response times of 70 or 80 ns.

Some companies have chosen to tackle the speed problems of dynamic RAM by designing into the system a cache controller chip such as the Intel 82385. The chip usually works together with a small amount of static RAM (32 or 64 KB). This greatly increases the speed of the system, while still gaining the cost advantage of dynamic RAM.

A caching system increases the speed of main (dynamic) memory by interposing fast static RAM between the processor and slower dynamic RAM. A copy of the most frequently used data is kept in the static RAM. In fact, if the static RAM cache accepts more data than has actually been requested by the processor, in effect guessing what comes next, speed can be improved even further.

Both addresses and data can be kept in the static cache RAM. The addresses are those accessed by the processor on previous cycles, while the data is the data associated with the addresses. A cache "hit" occurs whenever the processor requests a previously requested address. The processor can then bypass the dynamic RAM and retrieve the data from the static RAM.

Since most program code consists of looping routines that repeatedly access the same memory locations, it becomes highly probable that valid data will reside in the cache RAM. And since programs typically operate in a sequential manner, the hit rate can be increased by pre-fetching data in sequential addresses and putting it into the cache.

The Intel 82385 cache controller uses a caching scheme called two-way set associative mapping. Another type of caching scheme is called direct mapping. 80386 computers that use the latter scheme need more static RAM to implement it. Computers such as the Compaq 386/25, Dell System 310, and IBM PS/2 Model 70 use the Intel cache controller. One computer that uses direct mapping is the Everex Step 386/25.

Having some type of cache memory in the computer allows the system to run at zero wait states for a good part of its operation even though the bulk of the RAM in the machine would normally require one wait state. Since an 80386 normally accesses and loads from main memory in two clock cycles, and each wait state adds one clock cycle, machines without static RAM caches pay a performance penalty that somewhat negates the effect of the faster speed of the microprocessor.

There are other solutions to the fast RAM problem. Some 80386 computer manufacturers use interleaved RAM. With this scheme, two banks of dynamic RAM are accessed alternately by the processor. This method is useful for 20-MHz machines, but not fast enough for 25 MHz and above. However, interleaved RAM, which effectively reduces the number of wait states to about 0.7 for a computer running at 20 MHz, is not as good a solution as a static RAM cache, which can reduce the effective number of wait states to less than 0.2.

Another memory scheme is called static-column or page-mode RAM. Each memory location in the computer has a unique row and column address. In a page memory scheme, sequential information is assumed to have the same row address, so the processor only looks for the column address to find the data. This increases speed enough to reduce the effective number of wait states to 0.7. Static column RAM is actually dynamic RAM combined with special circuitry.

Main memory is not the only part of an 80386 computer's memory that is relatively slow compared to the speed of the processor. There is also read only memory (ROM) for computer designers to worry about. The solution that some computer manufacturers have come up with is a concept called shadow RAM. Shadow RAM refers to the practice of copying the video BIOS and system BIOS programs from their respective ROM chips into faster 32-bit dynamic RAM, thus creating a shadow of these programs in RAM.

New Architectures For New Problems

In their quest to keep up with the speed of the 80386 processor, some manufacturers have elected to design proprietary architectures that take into account the fact that some parts of the computer can operate faster than other parts. For example, the Compaq 386/20 and 386/25 computers use a system called the Flex Architecture. This architecture combines a memory caching scheme with a concurrent memory and input/output bus to optimize overall system throughput while maintaining compatibility of the classic bus.

The Flex Architecture uses the Intel 82385 cache memory controller to provide fast retrieval of frequently accessed data. The controller manages the microprocessor's read and write requests and directs the request to either 32 KB of high-speed static memory or to main memory. This improves performance by reducing the need for bus accesses to main memory and therefore provides zero-wait-state operation approximately 95% of the time.

The Flex Architecture also provides a practical solution to the bottleneck of data traffic created in personal computers that use high-performance components such as 80386 processors and high-speed disk drives and memory. Some personal computer architectures eliminate this bottleneck by increasing the speed of the bus, but sacrifice compatibility with peripheral devices. Other architectures maintain compatibility but do not relieve the bottleneck.

The Compaq Flex architecture alleviates bottlenecks by providing separate data paths for memory and peripheral input/output. Thus, the bus architecture does not limit total system throughput. An additional performance benefit is the system's ability to accommodate concurrent operation of the input/output and memory buses. Concurrent operation is achieved when the 80386 microprocessor is executing out of its cache memory and, at the same time, a peripheral is accessing main memory through the unit's direct memory access (DMA) controller.

Another proprietary, though also classic-bus-compatible, architecture is AST's SMARTslot architecture. It purports to give users the multitasking benefit's of IBM's Micro Channel while maintaining compatibility with existing IBM AT-class hardware and software. The SMARTslot Architecture includes an AT bus extension that allows multiple bus masters to reside on the bus. AST's Premium/386 includes three expansion slots that have the multimaster extension. To add the multimaster capability, AST increased by eight the number of signal pins on a 16-bit AT expansion slot. However, standard PC/AT expansion cards still operate in the multimaster slots.

The SMARTslot Architecture enables four bus masters to co-exist (the host CPU and three bus-resident masters). Control logic arbitrates the multimaster operation. The arbitration logic accepts bus requests and then grants bus accesses to refresh and DMA control circuits, just as all AT-compatible systems do. The bus extension pins add three Master Request, one Master Busy, and three Master Grant signals to the arbitration scheme. The arbitration logic implements a "fair" arbitration scheme to grant bus access to any master on the bus.

Arbitration logic gives priority to refresh and DMA requests. If a refresh request interrupts a bus master's access to the bus, however, the same bus master regains access when the refresh operation ends. A Lock input to the arbitration logic allows system software to lock out other bus masters. This Lock feature can be useful for time-critical applications.

SMARTslot Architecture also provides the zero-wait-state 32-bit memory access capability required in high-performance applications. A single slot in the Premium/386 is dedicated to memory. AST includes a board that provides up to 13 MB of RAM. The board uses static-column RAM to improve access speed when reading consecutive addresses.

Speed All Around

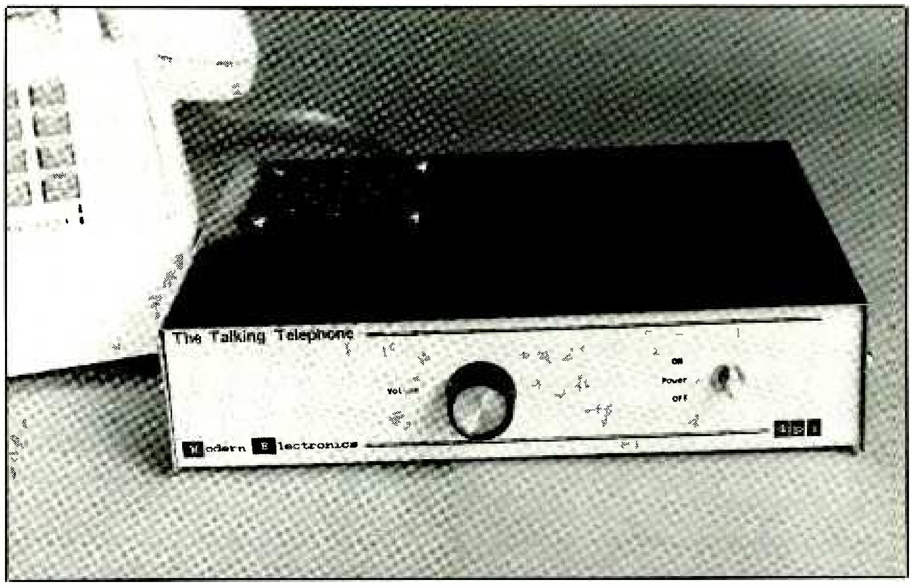
Memory is not the only part of the computer that needs to be fast enough to keep up with the processor. Hard disk drives and controllers need to be as fast as possible, too. As cited above, the larger the capacity of a hard disk drive, the faster its average access time. This means that you should seriously consider purchasing

(Continued on page 68)

A Talking Telephone

Vocalizes each number digit as you "dial" it on a Touch Tone-type keypad

By Steve Sokolowski



The circuit presented here will actually "speak" the number you dial as you key it in on a telephone Touch Tone-type keypad. It accomplishes this with the aid of the Digitalk Speech Synthesizer made by National Semiconductor.

Aside from its novelty, this project has its practical side. It is an excellent means for eliminating mis-dialed telephone numbers because it serves as a form of "error correction" as you "dial" the digits of a telephone number. As you listen, you can tell if you touched a wrong key and, if so, terminate the operation before the misdialed number gets through your telephone office and you are charged for a wrong number. This feature is particularly handy for the visually handicapped, who can also vocally verify that they have dialed correctly.

About the Circuit

Before getting into how the Talking Telephone works, it is important that you know something of how a standard telephone instrument works. Though there are two main types of telephone instruments—rotary-dial (or pulse) and Touch Tone-types—the latter are far more commonly found in the modern home and office. Because of its widespread use, the Talking Telephone was designed around the Touch Tone system.

Touch Tone dialing was developed by Bell Telephone some 20 years ago. It uses pairs of eight specially selected audio tones that are further divided into groups of four low and four high tones. Because tone pairs are used for each digit in the telephone number, the system of dialing used is technically known as "Dual Tone Multi Frequency" (DTMF) dialing. A genuine DTMF tone is the algebraic sum of one tone from each of the low- and high-frequency groups.

How these tones are used can be visualized by referring to Fig. 1. In (A) is shown the waveform of an 825-Hz sinusoid that is generated by simultaneously pressing Row 3 buttons 7, 8 and 9 on the Touch Tone-compatible keypad. The 1,336-Hz sinusoid waveform generated by the tone dialer if Column 2 buttons 2, 5, 8 and 0 are pressed simultaneously is illustrated in (B). Now, if only button 8 on the keypad is pressed, internal circuitry sums these two tones to produce the waveform illustrated in (D).

The conventional tone-type keypad has only 12 buttons for the numerals 0 through, * and #. However a complete DTMF keypad can have 16 buttons in all—the usual 12 plus four more labeled A through D (see Fig. 2). These last four buttons are used for communication with special equipment and, as a result, are rarely included on standard home and office telephone instruments.

By using a special DTMF receiver integrated circuit, the dialing tones of the telephone instrument can be converted into binary codes that can subsequently be fed into the Data input of the Digitalker IC. These binary codes are converted by the Digitalker chip into words that are vocalized through a speaker.

The specialty integrated circuit that accomplishes the above is the G8870 DTMF Receiver chip manufactured by California Micro Devices. It is quite sophisticated, as demonstrated by the block diagram of its internal circuitry shown in Fig.

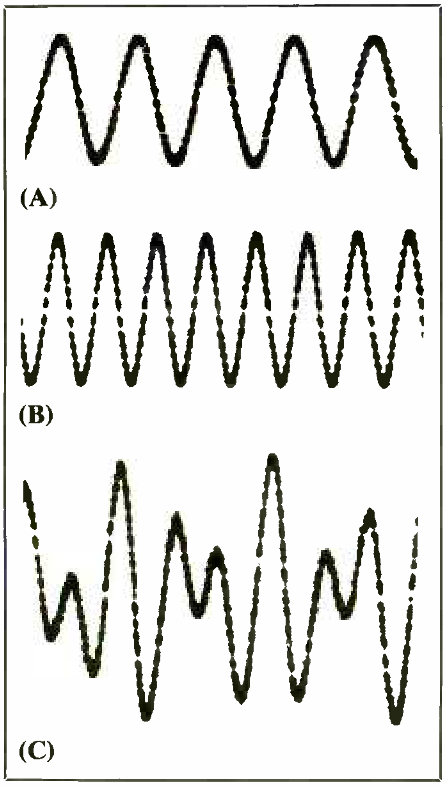


Fig. 1. Examples of DTMF tones generated when (A) a Row 3 button is pressed on the dialing keypad (582 Hz); (B) a Column 2 button is pressed (1,336 Hz); and (C) the "8" button is pressed (algebraic sum of Row 3 and Column 2 signals).

3 (its case configuration and pin assignments are shown in Fig. 4). Considering the internal complexity of this chip, its retail price of about $10 provides a very cost-effective way to go for designing and building inexpensive telephone-related projects.

A tone-dial telephone instrument produces a dual-tone (two-tone) output whose unique frequencies are rigidly determined by the Row and Column of the switching matrix for each particular button in the keypad. When it was first introduced in the 1960s, the Touch Tone dialer was made from a comparatively large number of inductors and capacitors that produced pure sine-wave output signals. In contrast, modern DTMF keypads use crystal-controlled integrated circuits that generate the synthesized stair-step waveform illustrated in Fig. 5.

Though the step waveform produced by modern tone-type keypads may only crudely approximate the sine waveform, DTMF receiving equipment like the G8870 can receive and decode every tone into its corresponding binary output (see Table 1). It is this output code that is converted by another integrated circuit—a preprogrammed 74188 PROM that has been programmed with the appropriate data)—into the required digital code that is then delivered to the input of the Digitalker.

Refer now to the schematic diagram of the of the basic Talking Telephone circuitry shown in parts (A) and (B) of Fig. 6. The G8870 DTMF Receiver chip and programmed 74188 PROM are shown as *IC1* and *IC2*, respectively, in part (A). It is the eight-bit output of *IC2* at pins 1 through 7 that is fed to the inputs at pins 15 through 9, respectively, of MM54104 Digitalker chip *IC3* in part (B). Each eight-bit input that is delivered to *IC3* (burnt into *IC2*) selects the word—or in the case of our Talking Telephone the number—*IC3* is to vocalize when a key on the telephone instrument's keypad is pressed.

Actual vocalization of any given digit is the responsibility of the Digi-

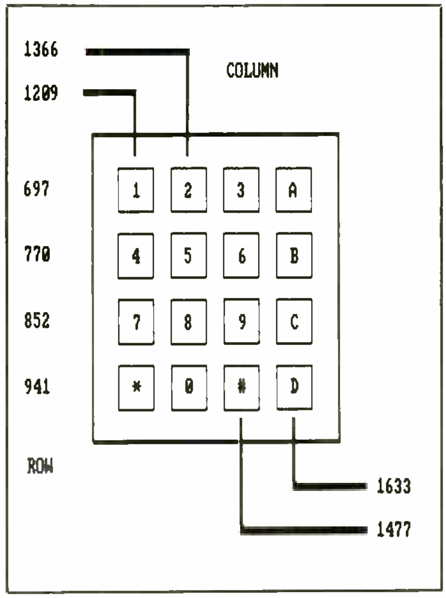


Fig. 2. A tone-type DTMF dialing keypad can have a total of 16 keys, though all but the ones labeled "A" through "D" are normally found on current home and business telephone instruments.

talker chip. This chip, *IC3* in Fig. 6(B), stores complete words in its two support SSR1 and SSR2 chips. (The three-chip set is available for about $25 from Jameco Electronics.) The MM54104 specified for *IC3* is the heart of the Digitalker set. This 40-pin DIP device has eight data lines on which the binary code of the word (or

Table 1. Tone Keypad Frequencies and Binary Codes

Button	Low Frequency Component (Hz.)	High Frequency Component (Hz.)	HEX Output Format 3	2	1	0
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0
A	697	1633	1	1	0	1
B	770	1633	1	1	1	0
C	852	1633	1	1	1	1
D	941	1633	0	0	0	0

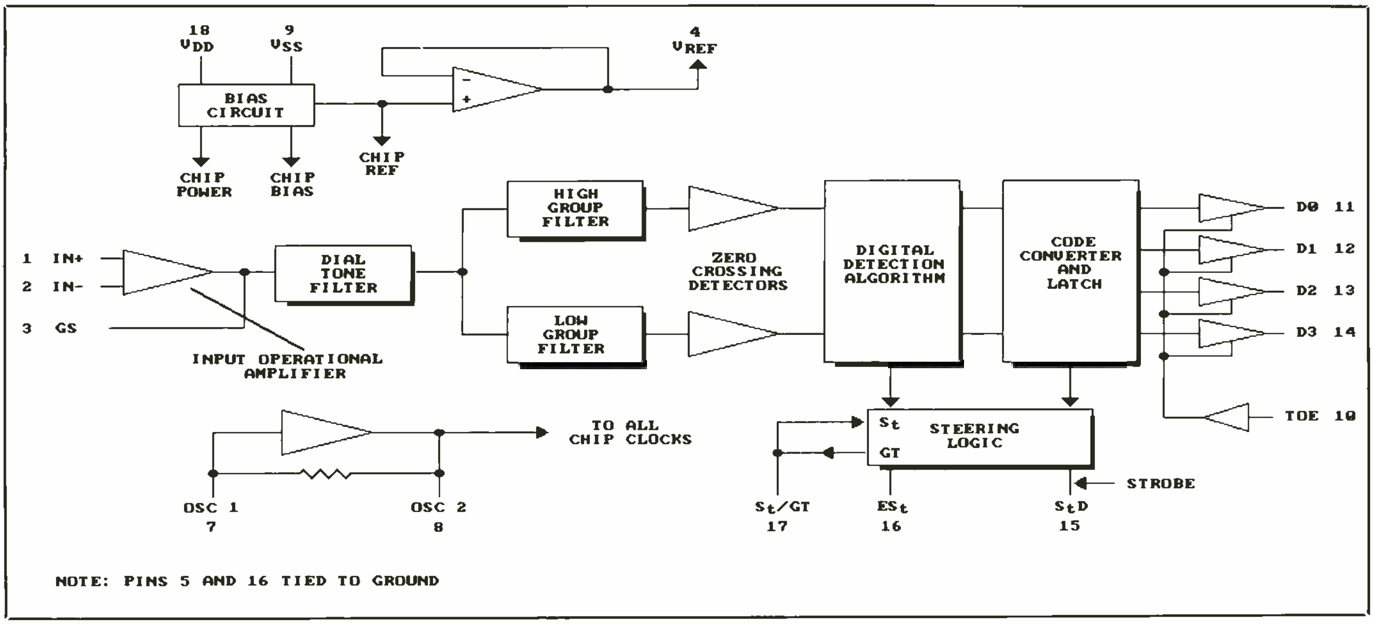


Fig. 3. Block diagram of circuitry inside the G8870 DTMF Receiver chip.

number) you wish to be vocalized through a speaker is placed.

Table 2 lists the 11 binary codes you need for this project. These are all contained inside the SSR1 RAM that comes as a basic element in the Digitalker kit. Since the SSR2 RAM is not needed in this project, store it away in a safe place. You may want to use it at some future time for another talking circuit.

So far, we have discussed the device that converts the DTMF signal of a tone dialer into a binary code and the Digitalker that accepts this code as input and transforms it into the word that is to be vocalized. How this is accomplished is as follows.

Pins 1 and 2 of *IC1* in Fig. 6(A) connect directly across the telephone line through the *C1/R1* and *C2/R2* networks, respectively. This input allows the DTMF signal that is generated by pressing one of the keys on the tone dialer to be passed to the complex filtering and switching electronics inside *IC1*. The binary code that corresponds to the key pressed, listed in Table 1, is made available at pins 11 through 14 of *IC1*.

Compare Tables 1 and 2 for a moment. The whole idea of this project

Table 2. Digitalker Vocabulary List

Word	Address SW8	SW1	Word	Address SW8	SW1	Word	Address SW8	SW1
This is Digitalker	0000	0000	Q	0011	0000	IS	0110	0000
ONE	0000	0001	R	0011	0001	IT	0110	0001
TWO	0000	0010	S	0011	0010	KILO	0110	0010
THREE	0000	0011	T	0011	0011	LEFT	0110	0011
FOUR	0000	0100	U	0011	0100	LESS	0110	0100
FIVE	0000	0101	V	0011	0101	LESSER	0110	0101
SIX	0000	0110	W	0011	0110	LIMIT	0110	0110
SEVEN	0000	0111	X	0011	0111	LOW	0110	0111
EIGHT	0000	1000	Y	0011	1000	LOWER	0110	1000
NINE	0000	1001	Z	0011	1001	MARK	0110	1001
TEN	0000	1010	AGAIN	0011	1010	METER	0110	1010
ELEVEN	0000	1011	AMPERE	0011	1011	MILE	0110	1011
TWELVE	0000	1100	AND	0011	1100	MILLI	0110	1100
THIRTEEN	0000	1101	AT	0011	1101	MINUS	0110	1101
FOURTEEN	0000	1110	CANCEL	0011	1110	MINUTE	0110	1110
FIFTEEN	0000	1111	CASE	0011	1111	NEAR	0110	1111
SIXTEEN	0001	0000	CENT	0100	0000	NUMBER	0111	0000
SEVENTEEN	0001	0001	400HZ TONE	0100	0001	OF	0111	0001
EIGHTEEN	0001	0010	80HZ TONE	0100	0010	OFF	0111	0010
NINETEEN	0001	0011	20MS SILENCE	0100	0011	ON	0111	0011
TWENTY	0001	0100	40MS SILENCE	0100	0100	OUT	0111	0100
THIRTY	0001	0101	80MS SILENCE	0100	0101	OVER	0111	0101
FORTY	0001	0110	160MS SILENCE	0100	0110	PARENTHESIS	0111	0110
FIFTY	0001	0111	320MS SILENCE	0100	0111	PRECENT	0111	0111
SIXTY	0001	1000	CENTI	0100	1000	PLEASE	0111	1000
SEVENTY	0001	1001	CHECK	0100	1001	PLUS	0111	1001
EIGHTY	0001	1010	COMMA	0100	1010	POINT	0111	1010
NINETY	0001	1011	CONTROL	0100	1011	POUND	0111	1011
HUNDRED	0001	1100	DANGER	0100	1100	PULSES	0111	1100
THOUSAND	0001	1101	DEGREE	0100	1101	RATE	0111	1101
MILLION	0001	1110	DOLLAR	0100	1110	RE	0111	1110
ZERO	0001	1111	DOWN	0100	1111	READY	0111	1111
A	0010	0000	EQUAL	0101	0000	RIGHT	1000	0000
B	0010	0001	ERROR	0101	0001	SS (Note 1)	1000	0001
C	0010	0010	FEET	0101	0010	SECOND	1000	0010
D	0010	0011	FLOW	0101	0011	SET	1000	0011
E	0010	0100	FUEL	0101	0100	SPACE	1000	0100
F	0010	0101	GALLON	0101	0101	SPEED	1000	0101
G	0010	0110	GO	0101	0110	STAR	1000	0110
H	0010	0111	GRAM	0101	0111	START	1000	0111
I	0010	1000	GREAT	0101	1000	STOP	1000	1000
J	0010	1001	GREATER	0101	1001	THAN	1000	1001
K	0010	1010	HAVE	0101	1010	THE	1000	1010
L	0010	1011	HIGH	0101	1011	TIME	1000	1011
M	0010	1100	HIGHER	0101	1100	TRY	1000	1100
N	0010	1101	HOUR	0101	1101	UP	1000	1101
O	0010	1110	IN	0101	1110	VOLT	1000	1110
P	00101	111	INCHES	0101	1111	WEIGHT	1000	1111

NOTE 1: "SS" makes any single word plural
NOTE 2: Address 143 (WEIGHT) is the last legal address in this particular word list.
Exceeding address 143 will produce pieces of unintelligible invalid speech data.

is to have the Digitalker vocalize a predefined word when a specific binary code is placed on its Data Input bus, shown as SW8 through SW1 at pins 8 through 15 in Fig. 6(B). For illustrative purposes, let us assume that the "1" button on the dialer keypad is pressed. Table 1 indicates that this would generate a binary code of 0001. Table 2 indicates that a binary code of 00000001 is placed on the Data Bus of *IC3*, causing the Digitalker to vocalize the word "one."

Now let us assume that the "5" button on the dialer keypad is pressed, which causes *IC1* in Fig. 6(A) to output the binary code 0101, as indicated in Table 1. Table 2 shows that this code will cause the Digitalker to vocalize the word "five." Let us take this a bit further by assuming that the "0" key is pressed, causing the binary code 1010 to be generated, according to Table 1. Referring to Table 2, the binary code 1010 will cause the word "ten" to be vocalized. Obviously, this is not what is wanted. One of the tasks assigned to *IC2* is to correct for this situation for our particular application.

ROM *IC2* can be programmed to deliver the 0001 1111 binary output of the word "zero" every time its input code is the 1010 binary code for decimal 10. This programming can also be taken a step further. Suppose you press the "*" or "#" key on the dialer keypad. Table 2 indicates that if you press either key, the Talking Telephone would ordinarily vocalize the words "eleven" and "twelve," respectively. By programming *IC2* to deliver the binary code for a 400-Hz tone burst (0100 0001) every time either of these keys is pressed, you eliminate mis-spoken words.

The second task of *IC2* is to correct a problem associated with the G8870 chip used for *IC1*. If you compare the pinouts of the G8870 given in Fig. 4(A) with those of the 74188 or 8223 used for *IC2* in Fig. 4(B), you will see that the Data Output lines of the former are in reverse of those of the latter. Normally, pin 10 of the 74188 or 8223 is reserved for a Data 0 input. At this physical location, *IC1* delivers a Data 3 output. This dilemma can be corrected by programming *IC2* to output a binary code that is the reverse of the original.

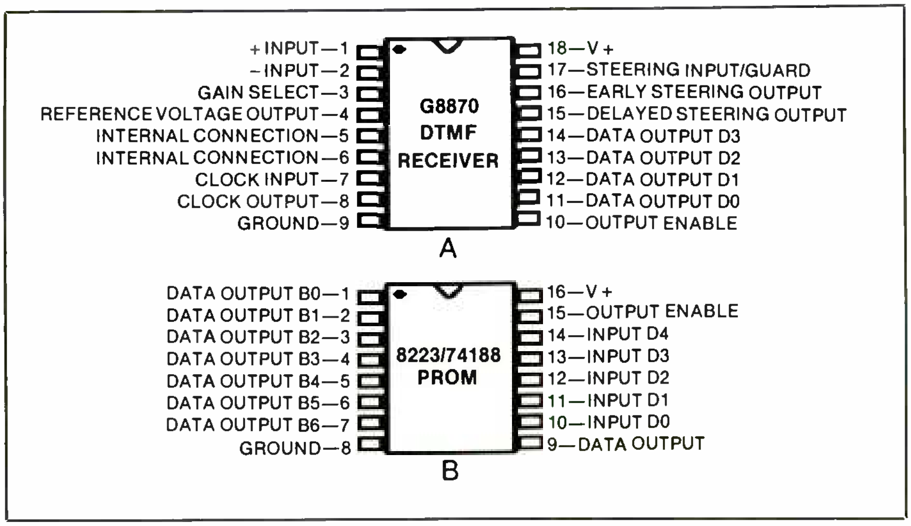


Fig. 4. Package configurations and pinouts for (A) G8870 DTMF Receiver and (B) 8223 or 74188 PROM.

To resume our explanation where we left off, pins 1 and 7 of *IC2* deliver the appropriate binary code to the Data Input bus of *IC3* at pins 8 through 15. To allow the Digitalker to output a signal that will vocalize the selected word, a logic-1 pulse must be applied to the pin 4 Write Strobe input of *IC3* in Fig. 6(B). Returning to Fig. 6(A), the pin 10 Strobe Output of *IC1* produces the

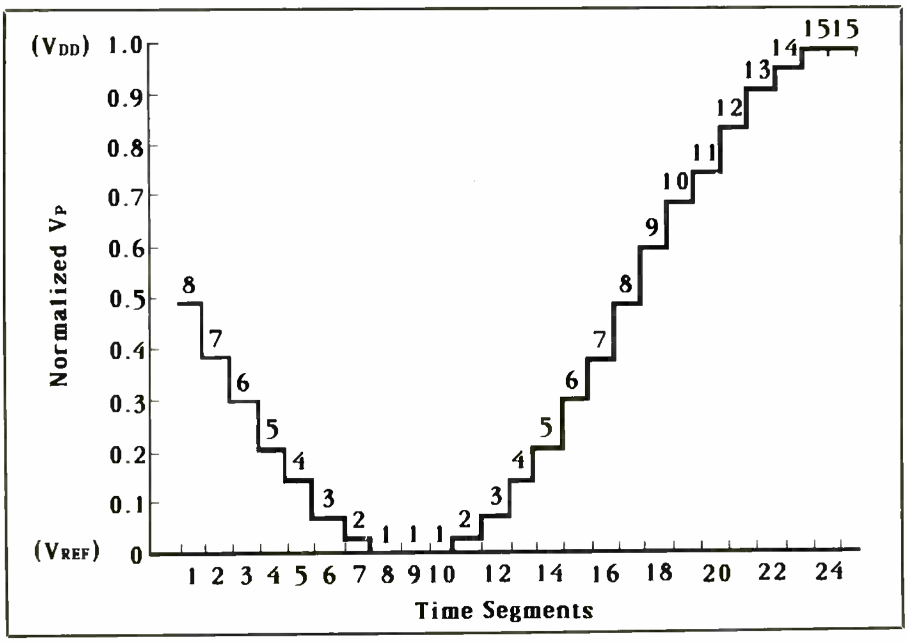


Fig. 5. Modern DTMF keypads use crystal-controlled ICs that generate a synthesized stair step wave that is a crude approximation of the pure sinusoid wave produced by original DTMF dialers.

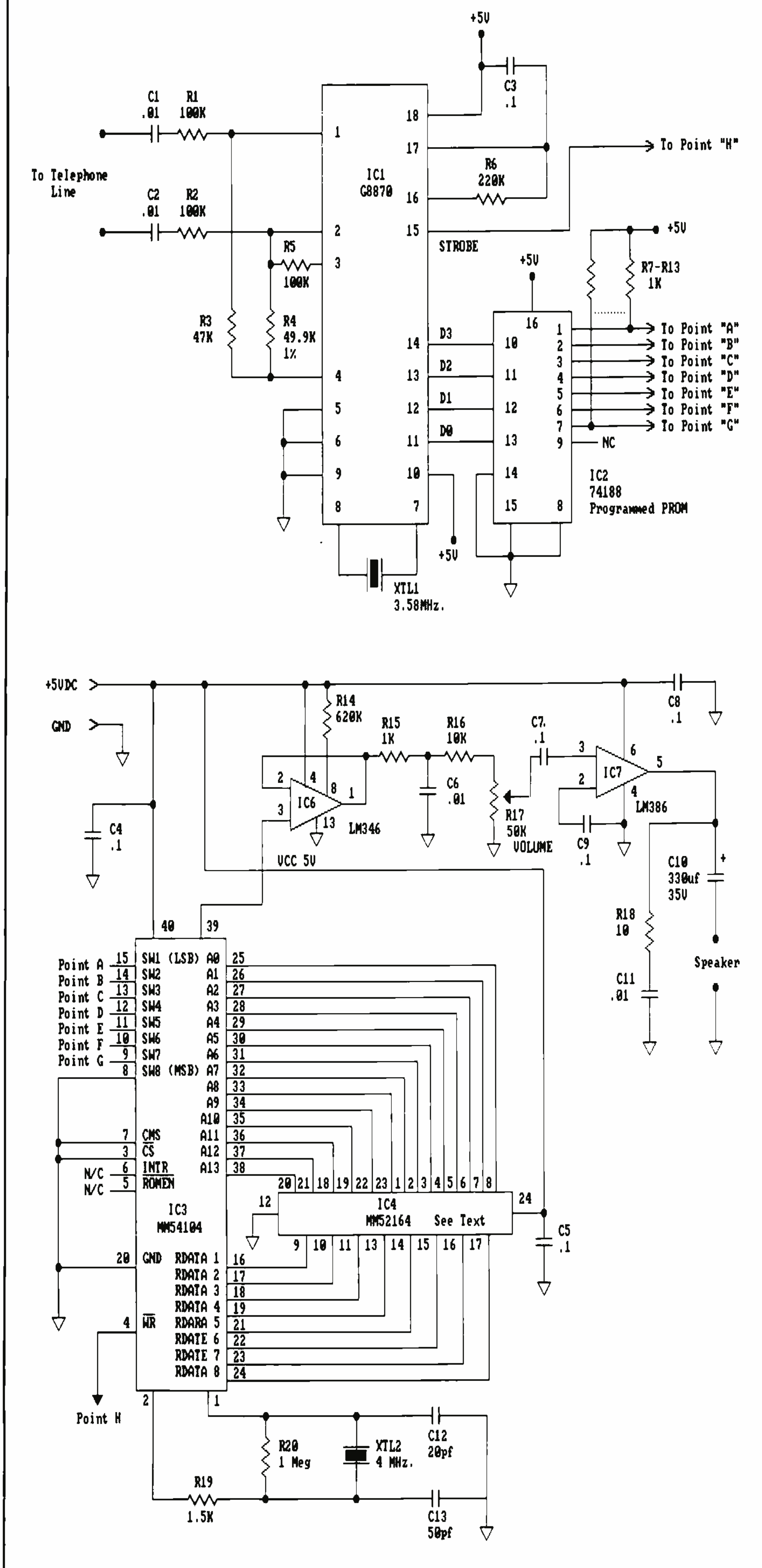


Fig. 6. Schematic diagram of basic Talking Telephone circuitry shown in two parts.

required positive-going pulse every time a valid tone is detected at the input of this IC.

The positive-going pulse is coupled directly to pin 4 of *IC3* in Fig. 6(B). When any key on the dialer keypad is pressed, two actions occur. The first is placement of the appropriate binary code on the Data Input lines of *IC3*. The second is that the needed positive-going pulse is generated by the DTMF Receiver and is available at pin 10 of *IC1* in Fig. 6(B).

The MM52164 shown in Fig. 6(B) as *IC4* is the SSR1 ROM that is programmed with the vocabulary data listed in Table 2.

Resistors *R15* and *R16* and capacitor *C6* in the *IC6* circuit make up a filter, while *IC7* is a low-voltage power amplifier whose output level is adjustable by VOLUME control *R17*. Vocalization is accomplished by capacitively coupling the output at pin 5 of *IC7* through *C10* to a small speaker as shown.

Power for the Talking Telephone is provided by a common 9-volt, 500-milliampere dc plug-in wall power supply, as shown in Fig. 7. The raw dc output from this power supply is filtered by *C4* and regulated to 5 volts by regulator chip *IC5*. It is then delivered to the circuitry shown in Fig. 6.

Construction

There is nothing critical about component layout or conductor routing when assembling this project. Therefore, you can use either printed-circuit wiring or point-to-point wiring on perforated board that has holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware. Whichever approach you choose, it is a good idea to use sockets for all DIP integrated circuits.

If you wish, you can fabricate your

PARTS LIST

Semiconductors
IC1—G8870 DTMF receiver (see text)
IC2—74188 or 8223 programmed PROM (see text)
IC3—MM54104 Digitalker (see text)
IC4—MM52164 SSR1 RAM (part of Digitalker IC kit; SSR2 chip is not used—see text. Available from Jameco—see text)
IC5—7805K fixed +5-volt regulator in TO-3 case
IC6—LM346 operational amplifier
IC6—LM386 audio power amplifier

Capacitors
C1,C2,C6,C11—0.01-μF ceramic disc
C3,C5,C7,C8,C9—0.1-μF ceramic disc
C4—220-μF, 35-volt radial-lead electrolytic
C10—330-μF, 35-volt axial-lead electrolytic
C12—20-pF ceramic disc
C13—50-pF ceramic disc

Resistors (¼-watt, 5% tolerance)
R1,R2,R5—100,000 ohms
R3—49,000 ohms
R4—49,900 ohms (1% tolerance)
R6—220,000 ohms
R7 thru R13,R15—1,000 ohms
R14—620,000 ohms
R16—10,000 ohms
R18—10 ohms
R19—1,500 ohms
R20—1 megohm
R17—50,000-ohm, audio-taper panel-mount potentiometer

Miscellaneous
T1—9-volt, 500-mA dc plug-in power supply
XTL1—3.58-MHz colorburst crystal
XTL2—4-MHz crystal
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for all DIP ICs; suitable enclosure; telephone line cord; small rubber grommets (see text); heat sink and insulator kit for voltage regulator (see text); spacers; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Steve Sokolowski, P.O. Box 8535, Spring Hill, FL 34606: Ready-to-wire double-sided pc board with plated-through holes, \$21.50; G8870 DTMF Receiver chip, \$10.50; programmed 74188 PROM, \$5.75; 3.58-MHz crystal, \$1.75; telephone T adapter, \$2.25. Include \$2.75 P&H per order. Florida residents, please add state sales tax.

own printed-circuit board for the project using the actual-size etching-and-drilling guides shown in Fig. 8. Note here that this is a double-sided board. You can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List. This board has plated-through holes, which allows you to complete all soldering on the solder side of the board.

If you home fabricate your pc board, bear in mind that it will *not* have plated-through holes. Thus, you *must* solder all component leads and pins to the copper pads on *both* sides of the board. Also, without plated-through holes, you cannot use conventional IC sockets that do not provide soldering access on the top side of the board. Therefore, use Molex Soldercon® socket strips in place of conventional sockets.

Orient the pc board on your work surface as shown in Fig. 9 (make certain that its component side is facing up) and begin wiring it by installing and soldering into place the IC sockets. Do *not* install the ICs in the sockets until after you have conducted voltage checks and are certain that your wiring is correct. (Note: Use Fig. 9 as a rough guide to component layout if you wire the project on perforated board, but refer back to Fig. 6 and Fig. 7 for wiring details.)

With the sockets in place, install and solder into place the resistors, noting that all but one of them above *IC3* mount on-end. Note also that one lead of *R7* through *R13* just above *IC3* pass through holes in the board and solder into place. The remaining resistor leads tie together to form a single-conductor "bus" that

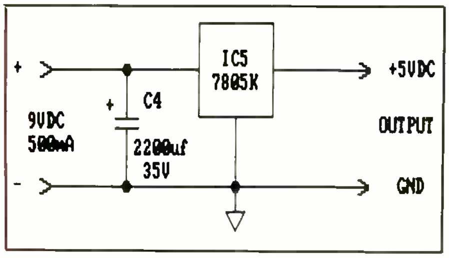


Fig. 7. Schematic diagram of power-supply circuitry for Talking Telephone.

plugs into the hole to left of the resistor network and solders into place. The method of accomplishing this is shown in the detail drawing at the lower-right in Fig. 9.

Next, install voltage regulator *IC5* in the location shown. This IC is in a TO-3 case and must mount on a heat sink using an insulator and heat-transfer compound. If you are using a pc board that has plated-through holes, mount the regulator on its heat sink to the board using 4-40 × ¼-inch machine screws, nuts and lockwashers.

If you are using a board that does not have plated-through holes, loosely mount the regulator to the heat sink using 4-40 × ½-inch machine screws, lockwashers and nuts. Crimp and solder a 1-inch length of bare solid hookup wire or cut-off resistor lead to each pin of the regulator. Mount the regulator in place, using ¼-inch metal spacers and the machine hardware already loosely securing the it to the heat sink. Feed the screws through the holes in the "corners" of the regulator and then into holes in the board.

Make sure that the wires on the regulator pins go into the two holes in the board provided for the regulator pins and that a lockwasher is placed between the trace on the bottom of the board and nuts that fasten down the screws. Then solder the pins of the regulator to the pads on the bottom of the board that has plated-through holes or the wires to the pads on both sides of the board if you are

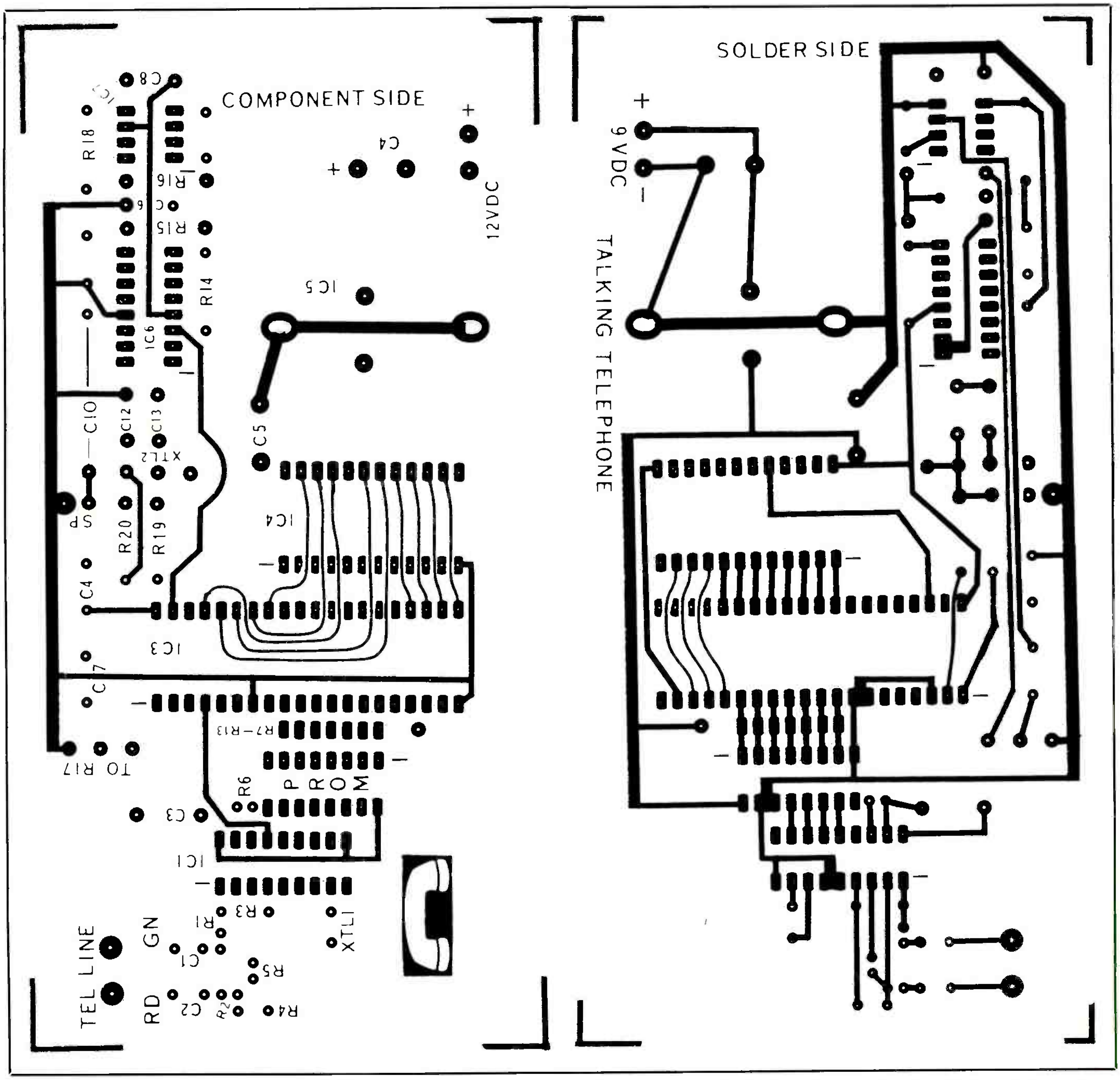


Fig. 8. Actual-size etching-and-drilling guides for top (left) and bottom (right) of double-sided printed-circuit board required for wiring together the project.

using a board that does not have plated-through holes.

Continue wiring the circuit-board assembly by installing and soldering into place the capacitors. Make sure the electrolytics are properly oriented before soldering their leads to the pads on the bottom of the board. Then install the crystals.

Strip ¼ inch of insulation from both ends of five 5-inch-long hookup wires. If you are using stranded hookup wire, tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder. Plug one end of the wires into the holes for the speaker and VOLUME control and solder into place. Temporarily set aside the circuit board.

Now prepare the enclosure that will house the project. You can use any type of enclosure that will accommodate the circuit-board assembly and provides mounting space for the speaker and VOLUME control. Machine the enclosure as needed. That is, drill four mounting holes for

(Continued on page 70)

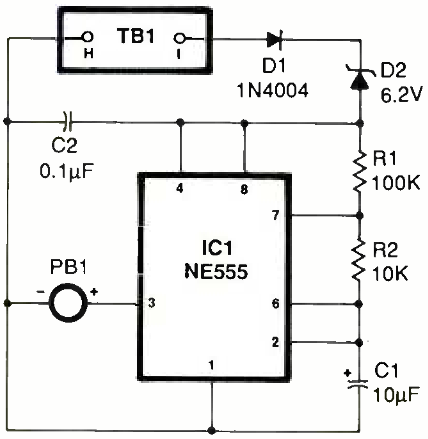
Car Back-Up Alarm

Sounds an audible alert to warn pedestrians and other drivers when you move your car in reverse gear

By Charles R. Ball, Jr. & W.K. Ball

Over the years, a number of safety features have been introduced by the automotive industry. One of the most practical among these is the device that audibly alerts pedestrians and other drivers that a vehicle is backing up. Every motor vehicle should have such a device in it—not just certain commercial vehicles. If you wish to have your family car sound an alert when you place the transmission in reverse gear, you can do so by installing our Car Back-Up Alarm.

This Back-Up Alarm automatically sounds an intermittent, piercing tone when you put your vehicle in reverse. The Alarm immediately silences when the shift lever is taken out of reverse position. The circuit that accomplishes this is very simple and can be built for less than $20 in readily available components.



PARTS LIST

Semiconductors
D1—1N4004 or equivalent rectifier diode
D2—1N4735A or equivalent 6.2-volt, 1-watt zener diode
IC1—NE555 timer

Capacitors
C1—10-µF, 16-volt electrolytic
C2—0.1-µF, 25-volt ceramic

Resistors (¼-watt, 5% tolerance)
R1—100,000 ohms
R2—10,000 ohms

Miscellaneous
PB1—Piezoelectric buzzer (Murata Erie PKB8-4A0)
Printed-circuit board or perforated board with holes on 0.1″ centers and suitable Wire Wrap or soldering hardware (see text); terminal board (Mouser Cat. No. ME153-2102); suitable enclosure (see text); splice connectors; hookup wire; solder; etc.

Note: The following items are available from BALLco, Inc., P.O. Box 1078, Snellville, GA 30278-1078 (Tel. 404-979-5900): Printed-circuit board No. 881101-B,$9.95; complete kit of parts not including enclosure, $19.95. When ordered with the kit, price of the enclosure is $3.95. Printed-circuit board is postpaid in U.S.; for other items, add $2.50 P&H postage and handling. Georgia and Florida residents, please add sales tax.

Fig. 1. Complete schematic diagram of the Back-Up Alarm circuit.

About the Circuit

The Back-Up Alarm's circuit, shown schematically in Fig. 1, is built around the 555 timer integrated circuit. In this circuit, *IC1* is connected in the astable configuration.

When you move the shift lever of your vehicle to the reverse-gear position, the circuit to the back-up lights becomes active and, hence, is at +12 volts. This potential is fed through rectifier diode *D1* and zener diode *D2* to timer *IC1* and actuates the timer.

Diode *D1* provides protection in the event of reversal of polarity when power is connected to the circuit. Zener diode *D2* reduces the +12 volts delivered by the electrical system in the vehicle in which the project is installed to a safe operating level for audible piezoelectric buzzer *PB1*.

The output of the timer chip is fed to *PB1*, which has internal electronics to provide a warning tone whenever sufficient voltage appears across the terminals of the piezo buzzer. The duty cycle, or alarm on/alarm off time, can be tailored by changing the values of resistors *R1* and *R2* and capacitor *C1*. Capacitor *C2* filters out any electrical noise that might appear on the back-up light circuit line.

Assembly & Checkout

Because of its simplicity, the Back-Up Alarm circuit can be built using just about any traditional assembly technique. If you wish, you can assemble the circuit on perforated board that has holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware. Alternatively, you can assemble it on a printed-circuit board that can be purchased from the source given in the Note at the end of the Parts List or by fabricating your own using the actual-size etching-and-drilling guide given in Fig. 2.

Assuming printed-circuit assembly of the project, wiring diagram Fig. 3 shows component placement and orientation. If you are assembling your Back-Up Alarm project on perforated board, use Fig. 3 as a

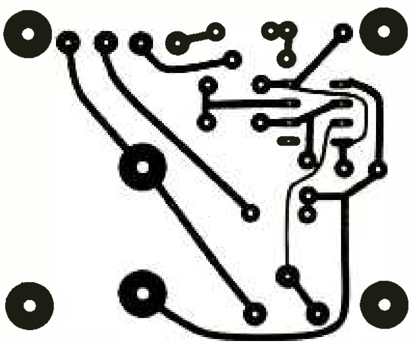


Fig. 2. Actual-size etching-and-drilling guide to use for fabricating the project's printed-circuit board.

rough guide to component placement and orientation.

Due to the typically rough mechanical environment of a motor vehicle, a socket is *not* recommended for *IC1*. If a socket is used, mechanical vibration is likely to cause the IC to work loose from it. Therefore, begin project assembly by installing and soldering into place the resistors. This done, install the capacitors and diodes. Make certain that electrolytic capacitor *C1* and both diodes are properly oriented before soldering their leads to the copper pads on the bottom of the board.

Next, install the piezo buzzer on the board. Actually, you can mount this buzzer either on the board, as illustrated in the Fig. 3 wiring diagram, or off the board and wire it to the appropriate pads on the board via stranded hookup wires. (Note: In this project use only *stranded* hookup wire.) Once the buzzer has been installed, plug the pins of the timer chip into the holes in the *IC1* location and solder each into place. Make certain that the IC is properly oriented and that each pin goes into the appropriate hole in the board before soldering any pins into place. Then install and solder into place terminal board *TB1*.

At this point, it is a good idea to check operation of the circuit. To do so, connect the terminals H and I of *TB1* to the positive (+) and negative (−) terminals, respectively, of a 12-volt dc power source. If all is okay, the alarm should alternately sound and silence for about 2 and 3 seconds, respectively, and repeat this cycle for as long as power is applied to the circuit. (If you used different values than those specified for *R1*, *R2* and/or *C1*, the on/off periods will, of course, be different.)

If your circuit fails to operate as described, power it down and rectify the problem before proceeding. Check particularly for components installed in the wrong locations and in improper orientation. Flip over the board and check all soldered connections. If you see a connection you missed, solder it now. Also, if any connection appears suspicious, reflow the solder on it, and use desoldering braid or a vacuum-type desoldering tool to remove any solder bridges you find.

Once you are certain that the circuit is operating properly (and *after* attaching to it appropriate-length power leads, spray several coats of clear acrylic over the entire circuit-board assembly (but *not* the piezo buzzer and *TB1*) to protect against moisture.

Once weather sealed, the Back-Up Alarm assembly can be installed in your vehicle in a protected location as-is or in an enclosure. If you plan

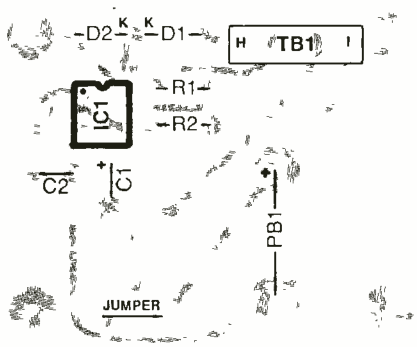


Fig. 3. Wiring guide for pc board. Use the layout shown here as a rough guide to component placement if you assemble the circuit on perforated board.

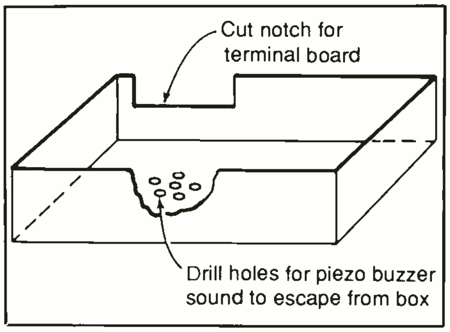


Fig. 4. Machining details for the project's enclosure.

on using an enclosure, prepare it as shown in Fig. 4. The cutout required for the terminal board can be made with a nibbling tool. Make sure you check the orientation of the circuit-board assembly *before* making the cutout (the enclosure has only two posts for mounting the board). Position the assembly with the component side down and the two mounting holes lining up with the mounting posts to determine which part of the enclosure to cut!

If you mounted the piezo buzzer directly on the circuit-board assembly, drill five $^3/_{16}$-inch-diameter holes to permit the sound to escape. On the other hand, if you have decided to mount the buzzer outside the enclosure, drill only one $^3/_{16}$-inch-diameter hole for the wires that are to go to the buzzer to exit the enclosure.

Caution: Plastic is a tricky material to drill, and some plastics are easier to drill than others. The plastic used to make the box specified in the Parts List will chip, crack, grab or self destruct if large-size bits are used. Drill speed is important, slower speeds being generally better.

Once you have prepared the enclosure for the project, route the back-up lights and vehicle ground wires and the cable for the piezo buzzer (if you mounted this externally) through the appropriate holes. Position the circuit-board assembly inside the enclosure, with the components facing down and *TB1* lined up with the cutout. Secure the assembly in place

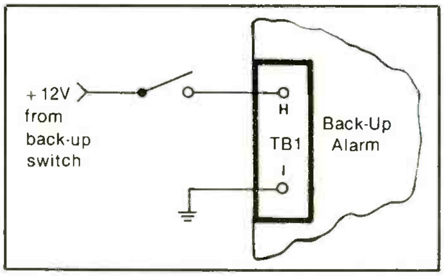


Fig. 5. Details for installing Back-Up Alarm in a vehicle.

with two screws and then mount the cover on the enclosure, using the remaining four screws.

Installation

Refer to Fig. 5 for details on installing the Back-Up Alarm in a motor vehicle. Note here that terminal H on *TB* connects to the back-up light conductor located at the back-up switch in your vehicle. If your vehicle has a column shift lever, this switch is normally located on the steering column. For other shifting arrangements, refer to the owners or shop manual or check with your dealer to determine where the back-up switch is located.

The wire coming from terminal H on *TB1* is easy to connect to the back-up switch conductor without having to make any cuts in the existing vehicle wiring with the aid of parallel splice connectors. These connectors are available at your local Radio Shack store and most hardware stores.

Connect terminal I to any convenient chassis ground point in your vehicle, using a suitable length wire.

You can mount the project in any convenient location inside your vehicle near the rear bumper. The location selected should place the project out of the way of direct water spray. Use double-sided foam tape or Velcro strips to fasten the enclosure in place in the selected location.

Since the sound from the piezoelectric buzzer is fairly directional, you may want to mount the electronics package of the Back-Up Alarm in the trunk and fabricate a bracket to mount the buzzer on the bumper. **ME**

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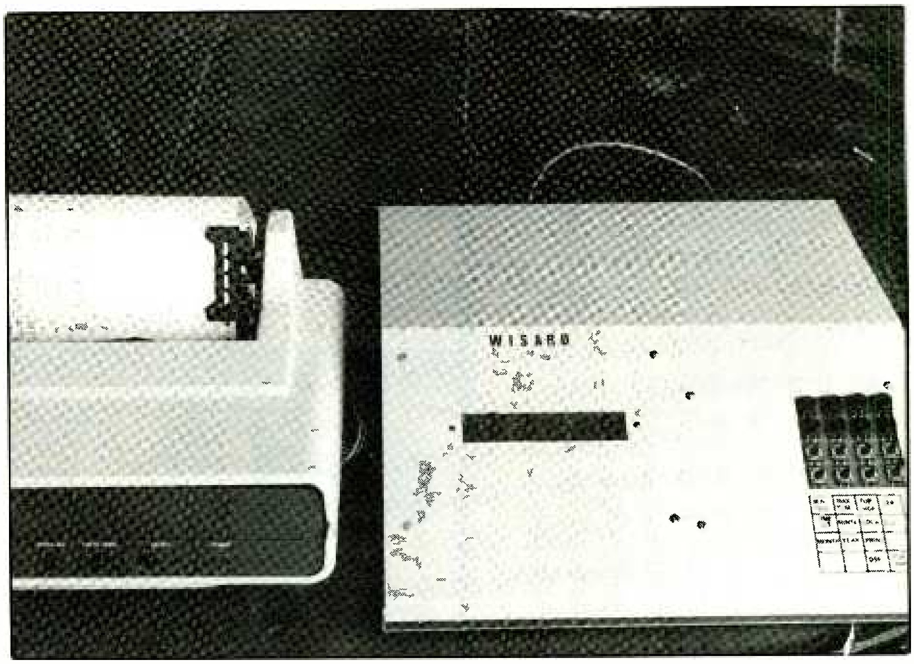
A Smart Weather Monitor

(Conclusion)

How to use and variations on the basic project

By Thomas R. Fox



In the first four installments of this article, we described construction and initial testing of the WISARD, a stand-alone expandable multi-function "smart" thermometer and temperature predictor. In this final installment, we discuss instrument operation and give hints on modifications you can make to expand it. We will conclude with a brief look at a down-to-earth variation on the basic WISARD project.

Sensor Placement

As has previously been stated, the basic WISARD has five sensors, one each to detect rain/dew, daylight and sunshine and two to track temperature variations.

For the project to accurately sense the presence of moisture, the rain/dew sensor must be mounted in a location where rain will strike it directly. An area of the roof of your house that has no tree branches or other structures that obstruct a clear line of sight overhead is one suitable location for the rain/dew sensor.

Sunshine and daylight sensors *Q1* and *Q2* in the schematic diagram in Part 1 are simple phototransistors. One method of protecting these sensors from the weather was described in Part 4. Daylight sensor *Q2* must be mounted outside, such as on a roof. A nearly perfect location for sunshine sensor *Q1* is on a 1,000-foot tower, well above surrounding trees and buildings. This is obviously impractical in real-world situations. Hence, the site that gives perhaps the largest accuracy/cost ratio is the highest point of the roof of the structure in which the WISARD project is located.

The firmware for the project treats temperature sensor *TS1* as the "inside" monitoring device and temperature sensor *TS2* "outside" monitoring device. Most of the records and temperature analysis pertain to outside sensor *TS2*.

Assuming you are using standard ME1 firmware, *TS1* should be located inside the structure, close to where the WISARD is located. It may be of interest to you to monitor the internal temperature of the project. If so, you can mount *TS1* directly to the A/D Memory-Expansion module in the holes assigned for this sensor.

The purpose of *TS2* is to measure outside air temperature. Therefore, locate this sensor in a suitable thermometer shelter, such as illustrated in Fig. 18. Mount this shelter a minimum of 6 feet from any building or other structure that is heated during the winter and cooled during the summer.

Operating WISARD

Once the project has passed its initial tests and you have mounted the various sensors in suitable locations, it is time to put WISARD on-line. Unlike most electronic devices, WISARD should be allowed to undergo a full

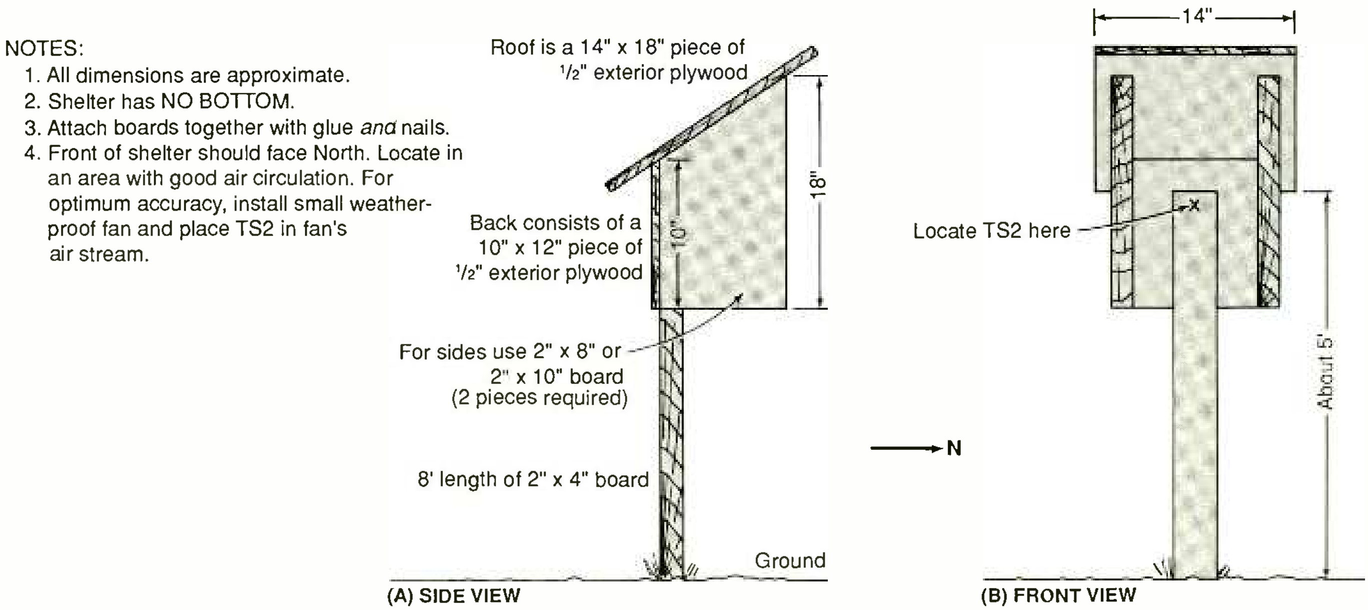


Fig. 18. Details for building a shelter for the outside-temperature sensor.

24-hour period of initialization. Self-taught tutoring is required inasmuch as the firmware that predicts minimum temperature requires the full 24-hour period that comprises a day, as well as sunrise and sunset times. Other reasons for the required "schooling time" are that WISARD requires mean and hourly temperature data before it can "intelligently" predict temperatures.

After setting the project in its permanent location, it is best to start it up in the morning, after dawn. A nighttime start-up may cause the project to act erratically at first. However, if you do start the project operating at night, do not be concerned by the various error messages and/or sluggish operation that result.

If you have a printer connected to it when WISARD is first turned on, a warning message will be printed that informs you that power has been off, the clock/calendar requires setting and data may be in error. This warning message is printed every time power is interrupted and then restored *and* whenever the battery has discharged.

In Part 4, we described how to set the clock. The DISPLAY key on the keypad is used to flash up the various data in the LED display. Pressing this switch once causes a "d" to flash intermittently in position 5 of the display. This "d" indicates that the minimum and maximum temperatures, day, month and year can be accessed by pressing the appropriate keypad keys.

Pressing the DISPLAY key on the keypad once again causes the "d" to disappear from the display. Now if one of the keys previously mentioned is pressed, the display will show "ErrOr.'

WISARD has built-in pagination that assumes a 66-line page. At the top of each new page, the project prints out the date and time it started printing that page. This information permits simple organization of data. At the beginning of the first page, press the TOP PAGE, key. Thereafter, WISARD will automatically keep track of the other pages for you.

Pressing the FORECAST key causes WISARD to print out the high temperature forecast for the day and the low temperature for the night. Notice that if this key is pressed while daylight conditions exist, the forecast minimum temperature will be "???." This simply means that WISARD does not have enough data to forecast a temperature yet. It waits until the daylight sensor is clothed in darkness. Also, WISARD waits until 6:00 AM before it estimates how warm the temperature will be for any given day.

Pressing the PRINT key forces a printout of various information, including the hourly temperature readings for the day. The purpose of the VERSION key is to provide a printout of the version of the firmware in use.

As has previously been mentioned, if a printer is connected to WISARD and is on at 9:00 AM, the project automatically prints out temperature

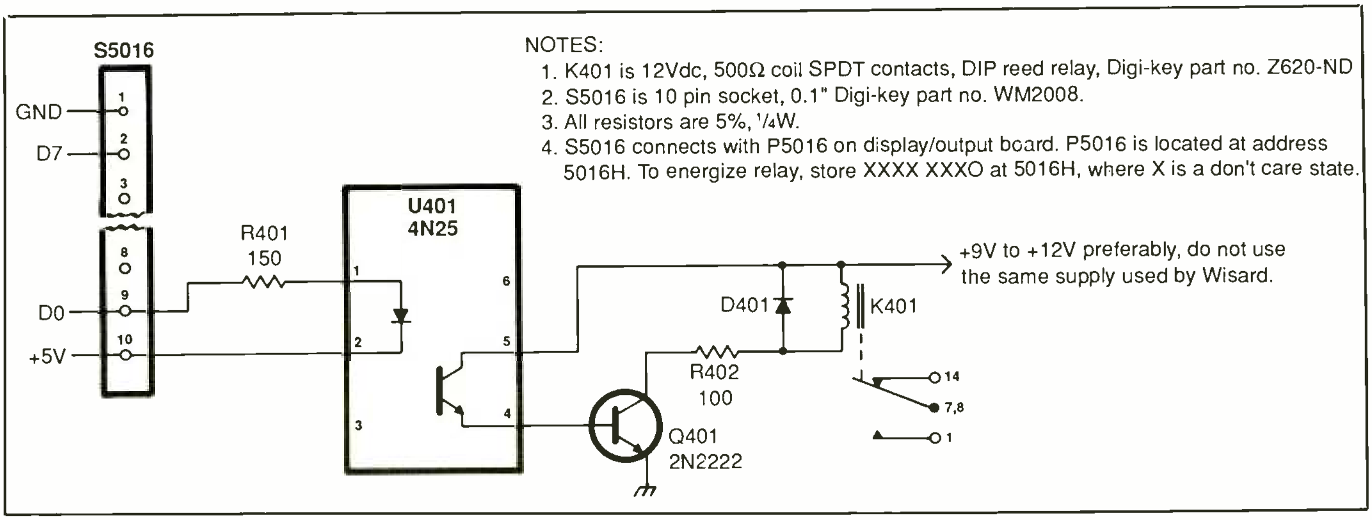


Fig. 19. Schematic diagram of a tested control circuit for loads that require more than 25 milliamperes of current.

and other information from the previous day. If for some reason the power or printer is off at 9:00 AM, printout will occur at 10:00 AM. If you do not desire a printout, you can either turn off the printer or disconnect it from the project.

ME1 firmware instructs WISARD to printout a rain/dew message when rain first hits the moisture sensor and a "dried-off" message when moisture has evaporated from the sensor. Normally, this does not cause a problem. However, on a day in which scattered sprinkles occur, printouts may become an annoyance because of the deluge of messages that will be printed out. If the annoyance is too great, you can simply turn off the printer. Alternatively, you can install a switch in series with the moisture sensor to allow you to disable it under such conditions.

Adding Versatility

A simple circuit connected to The Display/Output module of the project will allow WISARD to control just about anything imaginable, such as an alarm at a certain temperature or a pump upon detection of rain. Another possibility is to have WISARD turn on its own printer before it prints out a message and shut off the printer after printout is complete. This "printer controller" saves on the cost of electricity and reduces the possibility of the printer overheating.

A somewhat more sophisticated chore would be for WISARD to use two temperature sensors in a differential temperature controller for a solar heating system. Another use for a sophisticated differential temperature controller is in a cooling system that uses a large exhaust fan to keep a whole house cool at a fraction of the cost of air conditioning.

On the Display/Output module are 16 outputs that can be used to control 16 separate devices. These outputs are tied to connectors *P5016* and *P5017* in the project. Pin 1 of these connectors is tied to circuit ground, pin 10 to the +5-volt rail (see Fig. 19). Pins 2 through 9 are associated with data lines D7 through D0, respectively.

The "cleanest" way to access the pins of these connectors is with a socket like Digi-Key's Part No. WM2008 (crimp terminals Part No. WM2200 are also needed). This type of socket can also be used for the PM210 connector on the A/D Memory-Expansion module and *P301* on the Keyboard module.

The "output" pins of *P5016* and *P5017* are connected to 74LS373 octal D-type transparent latches whose outputs can sink about 25 milliamperes of current and can be used to control a solid-state buzzer or LED directly. You can hook this output to a low-power sensitive relay that has high-current contacts to control loads that require more current. Bear in mind, though, that direct connection to a relay has the potential of being problematical. When MCUs and MPUs are used, it is good design policy to isolate the logic supply from the power supply with an optical isolator or similar device.

Shown in Fig. 19 is the schematic diagram of one control circuit that works. Relay *K1* can be a Digi-Key Part No. Z620-ND, which has a 12-volt dc coil resistance of 500 ohms and has contacts rated at 0.25 ampere at 28 volts dc. Just about any similar 12-volt dc relay with a coil resistance greater than 400 ohms will probably work in this circuit. The optical isolator shown is the popular 4N25. Clamping diode *D1* eliminates negative spikes on the power line.

The Fig. 19 circuit works okay with power supplies that can deliver between 9 and 12 volts dc. Ideally, the power supply used should be

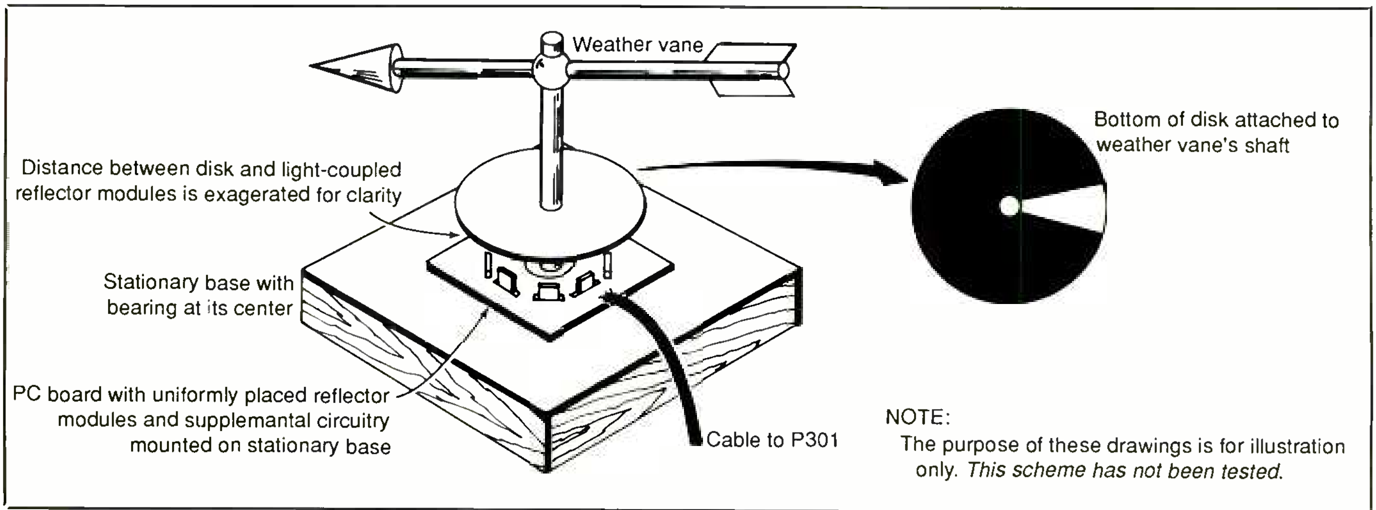


Fig. 20. Typical example of a weather vane arrangement using eight reflector modules to indicate wind direction.

completely isolated from the supply that powers the WISARD project.

Most real-world applications require far more than 0.25 ampere of current. This should present no problems because all you have to do is simply connect a power relay and suitable power source to the contacts of *K1* in the Fig. 19 circuit. In this case, *K1* should be able to control a relay that can handle more than 20 amperes at 240 or more volts ac.

Other Modifications

If you are familiar with the previous four parts of this article, you are probably aware that about 25 percent of WISARD's circuitry is not used by the "standard" configuration of the project. The purpose of the surplus circuitry is to provide a simplified means of expanding the project. In previous installments, we have only touched upon wiring WISARD to control power devices. Now let us look briefly at what you can do with the optional inputs for the project.

Five sensors have been described so far for the basic project, but 14 more can easily be added. Six sensor inputs connect to the A/D converter, which transforms analog voltages into eight-bit digital "words." The remainder of the inputs must be connected to sensors that have one-bit (i.e. high/low) resolution—typically a switch.

As an example of an addition you can make to WISARD, assume you want the project to monitor barometric pressure. Obviously, the project cannot actually read barometric pressure. However, barometric pressure, converted into an electrical signal, can be processed into a form that WISARD does understand—in this case, a varying voltage.

To implement a barometer function, you begin with a solid-state pressure transducer. Then you add a circuit that has an output of 0 volt at a barometric pressure of 28.44 inches of mercury and 5.0 volts at 31.00 inches of mercury and connect it to pin 1 of the *PM210* connector on the A/D Memory-Expansion module. Then you enable this input with the following short routine:

```
EXPRESS PSHB
        CLRB
        STAB 5002H
WAIT3   DECB
        NOP
        NOP
        NOP
        BNE  WAIT3
        PULB
        RTS
```

To actually load the barometric pressure information into WISARD, simply call up the "LOADA" subroutine in the firmware. After it is called, Accumulator A of the 6803 processor will contain the barometric pressure information. Assuming linearity, one LSB (least-significant bit) will correspond to 0.01 inch of mercury. Inputs to pins 2 through 6 of the PM210 connector are treated similarly. However, change the address in the enable subroutine from 5002H to 5003H, 5004H, 5005H, 5006H or 5007H, respectively.

Now let us look at a rather unique example of the use of the logic inputs connected to *P301* of the Keyboard module—a wind-direction indicator.

You implement the wind-direction indicator starting with a weather vane, to the bottom of which has been fastened a disk that has a single white radial strip on the bottom. Under the disk, on a stationary circuit-board assembly, you have eight light-coupled reflector modules arranged in a circular pattern with equal angular spacing with reference to the center of the disk. (See Fig. 20)

Coupling each reflector module to a special circuit allows the system to develop a voltage that can be fed to a pin of *P301*. By providing (via firmware) some basic data concerning the disk, WISARD can infer which way the wind is blowing. This simple arrangement may not be the best for a wind-direction sensor, but it does demonstrate that *P301* can be used as more than just a means for connection of option switches to the project. (Note: *P301* is located at address 5011H, as is *LED2*, but no conflict exists. Thanks to the R/W line and decoding circuitry, *LED2* can only be written to and *P301* can only be read.)

Predicting Temperatures

Firmware for the temperature-forecasting capability of WISARD is contained in the 2732A EPROM in the A/D Memory-Expansion module. Two separate routines are supplied for minimum and maximum temperature forecasts.

The algorithm for minimum temperature forecast is primarily algebraic. The project uses the length of the day, times at sunrise and sunset and four preceding temperature measurements to formulate a quadratic equation that is solved for one hour after sunrise, which is assumed to be the low point of the temperature-versus-time curve. This algorithm results in extreme accuracy if sky or wind conditions are unchanged during the night. If these conditions do change, the predicted low temperature will be revised at the next hour. The algorithm is not "location-sensitive" and, thus, is accurate in all geographic locations on Earth.

The algorithm for the maximum temperature forecast routine modifies average measured data for specific conditions. The particular routine used in the project has been optimized for Grand Rapids, MI but is accurate in similar climates. However, it may be somewhat inaccurate —especially in winter—south of 30 degrees north latitude.

The basic data in the maximum temperature forecast routine consists of the average temperature spread (which is maximum to minimum) for each month. This program can easily be customized for a particular geographical location, as long as the average temperature spread is known for each month.

The program modifies the "average" temperature spread to take into account such variables as sunshine, cloudiness, rain, mean temperatures, time of day, time of year, and so on. This modified spread is added to the minimum temperature to obtain a forecast maximum, which itself may be modified, under certain conditions, before being printed out.

If you plan to modify—but not totally rewrite—WISARD's firmware, you need the source code. This and the Intel hex and object files are available on a 5.25-inch PC-compatible disk from the source in the Materials Availability box. The source code is written in 6801/6803 assembly language that, except for a few additional instructions, is identical to 6800/02/08 assembly language. Several built-in subroutines can help you in writing modified code. A few are enumerated below:

• **PRINT.** Used to simplify printing of messages. Before this subroutine can be called, the Index Register must be loaded with the starting address of the message. Generally, labels are used to indicate this starting address. For example, the following program segment will print out, "Long live WISARD!":

```
        LDX #MES
        JSR  PRINT
        .... .......
        .... .......
MES DB  'Long live WISARD!',0
```

Notice that the message is terminated in a 0.

• **ENASEN1, ENASEN2.** These subroutines "enable" temperature sensors *TS1* and *TS2*, respectively. To load the data into accumulator A, call the "LOADA" subroutine.

• **DELAY1S.** Creates a delay of about 1 second.

• **DIGITAL.** Converts the data in Accumulator A into digital format. An error results if the data exceeds 99.

• **DISPLF.** This subroutine assumes Accumulator A holds temperature data. When it is called, the display shows the temperature in degrees Fahrenheit. (**DISPLC** is virtually identical except that the display shows degrees Celsius.)

• **PRNTIME, PRNDATE.** When called, these subroutines print the time and date, respectively.

• **PRNTTMP.** This subroutine assumes temperature data is in Accumulator A and prints temperature in degrees Fahrenheit. (If OPTION switch 3 in the project is set to "off," this routine also prints out temperature in degrees Celsius.)

• **DIVIDE.** This subroutine stores the most-significant bit (MSB) of the dividend at DIVIDNM and least-significant bit (LSB) at DIVIDNL. The MSB of the divisor must be stored at

Materials Availability

A number of items that can save you time and effort in locating components and other materials for the WISARD and assembling the project are available from Magicland, 4380 S. Gordon, Fremont, MI 49412. They include: Kit of components for the A/D Memory-Expansion module (does not include programmed 2732A programmed EPROM), No. ADME1, $65; double-sided A/D Memory-Expansion module pc board, No. 680X-ADM-2, $22; complete set of precision resistors for A/D module, No. PRAD89, $5; LM335, $2 each; ADC0809, $4; 6116LP, $7; 74LS541, $1.45; 6803, $3.75; LM1830, $2.25. Available separately from same source: 27128 EPROM programmed with firmware ME1, V1.9 or later, $18; 2732A programmed EPROM, $12; both EPROMs, $25. Firmware assembly-language source code and Intel hex file on PC-compatible 5.25-inch floppy disk, $2.75. Michigan residents, please add 4% sales tax.

DIVISRM and LSB at DIVISRL. The quotient resides at QUOTINT.

If you are new to 680X assembly language, the A/D Memory-Expansion module has a "polite" optional 2716 EPROM on it that can contain software "bugs" that will not completely throw off WISARD. When OPTION, switch 1 is "on," the MCU does not know this EPROM exists because the program bypasses the "JSR EPR2716" instruction. Setting the switch to "off" causes the program to jump to starting address 400H of the 2716. To make use of this feature, start the "2716 program" with "ORG 0." Be sure to end the program with an RTS instruction that returns from the subroutine.

If you want to modify the firmware, you need a translator program called an "assembler." One reason for this is that the source code for WISARD's firmware is written in assembly language. Since few personal computers use the 6801/03 series MPU/MCUs, you must use a cross-assembler to assemble source code written for an MPU that is distinctly different from the MPU used by your computer. Use a text editor or word processor to write the source code and cross-assembler to translate this into a form the MCU/MPU understands. A "linker" is usually used to link the object file produced by the cross assembler into a format that is understood by most PC-based EPROM programmers. Linker programs are usually supplied with cross-assemblers.

After assembling the source code, "burn" it into an EPROM with an EPROM programmer like the stand-alone model featured in the February and March 1987 issues of *Modern Electronics*. Alternatively, you can obtain programmed EPROMs from the source given in the Materials Availability box.

A Note About Printers

WISARD has a strictly serial printer interface and will not work with a printer that has a parallel interface. This is no hardship if you own a printer that has both serial and parallel interfaces. If you plan on dedicating a printer exclusively for use with WISARD, low-cost RS-232-compatible surplus printers are available.

You do not need an actual printer for the WISARD. If you wish, a terminal or computer, the latter with terminal-emulation software, can be used in place of a printer. The only requirement for whatever print-out device you decide upon is that it can communicate at 600 or 4,800 baud.

This concludes our series on the sophisticated WISARD weather monitor and temperature predictor. With this project, you will never be without current weather-condition reports. Additionally, you will also be able to follow weather trends simply by reading earlier printed reports, and you get predictions on what the high and low temperatures will be for the day based upon those trends. In effect, you have your own abbreviated version of the weather monitoring and forecasting equipment used by professional weather-watch services. And as we have pointed out, you can also use WISARD's optional expansion capabilities to monitor for flooding in your basement, loss of refrigeration in your freezer, etc. and to initiate remedial action. ME

One-Button Digital Timer

Accurately controls the time-on interval for rechargeable cells and batteries to prevent damage due to overcharging

By Dennis Eichenberg

For many electrical and electronic devices, rechargeable cells and batteries have eliminated the inconvenient umbilical line that draws power from the ac line. Unfortunately, many recharging systems provide no automatic monitoring facilities. If you do not constantly monitor the charger, you run the risk of overcharging and destroying a battery power source. This is especially true of lead-acid cells and batteries but is also an important factor with popular nickel-cadmium and other rechargeable devices. One way to eliminate this risk is to use the "One-Button Digital Timer" described here.

Our Timer is fully automatic in operation. It applies ac line power to your battery charger for a preselected period of time, after which it disconnects power from the charger. Thus, it prevents overcharging any battery or cell in the charger it controls. The Timer is also useful for controlling power to a lamp, coffee maker and any other electrically-operated device that must be powered for a single interval of time.

Designed for simplicity and fail-safe operation, our Timer connects between the ac power line and the charging system. To operate it, you simply set a for an 8-, 10- or 12-hour charge cycle and press à single button to begin the countdown. At the end of the timed cycle, the Timer automatically disconnects line power from the charger. The Timer is built around readily available and inexpensive components and is the ideal accompaniment to any charger.

About the Circuit

The complete schematic diagram of the circuitry used in the One-Button Digital Timer is shown in Fig. 1. As you can see, this circuit was designed to use a minimum number of components and as little power as possible from the ac line. The latter is achieved through use of low-power CMOS integrated circuits that have mininal current requirements and operate over a wide range of power-supply voltages.

One side of the ac line is tied directly to one side of ac receptacle *SO1* (into which the battery charger or other device to be controlled plugs) and one end of the primary winding of power transformer *T1*. The other side of the ac line connects to one side of normally open START pushbutton switch *S1* and the armature lug of contacts K1A and K1B of relay *K1*.

The remaining contact of *S1* and the other normally-closed K1A contact connect to the remaining end of the primary winding of *T1*. With this arrangement, false starts are eliminated and no ac power is applied to the primary side of the transformer until *S1* is momentarily closed to complete the circuit from the ac line.

Timer current requirements are quite small. Hence, the contact rating of *S1* can be 1 ampere. The contact rating of *K1*, on the other hand, must be hefty enough to handle any load that may be plugged into *SO1*.

The secondary winding of *T1* provides 12.6 volts ac to bridge rectifier *RECT1*. The bridge rectifier should have a rating of not less than 50 volts.

The negative (−) terminal of *RECT1* serves as ground reference for the circuit, while the pulsating dc at the positive (+) terminal is coupled through isolating diode *D1* to filter capacitor *C1*, which converts the pulsating dc to pure dc. Use of *D1*

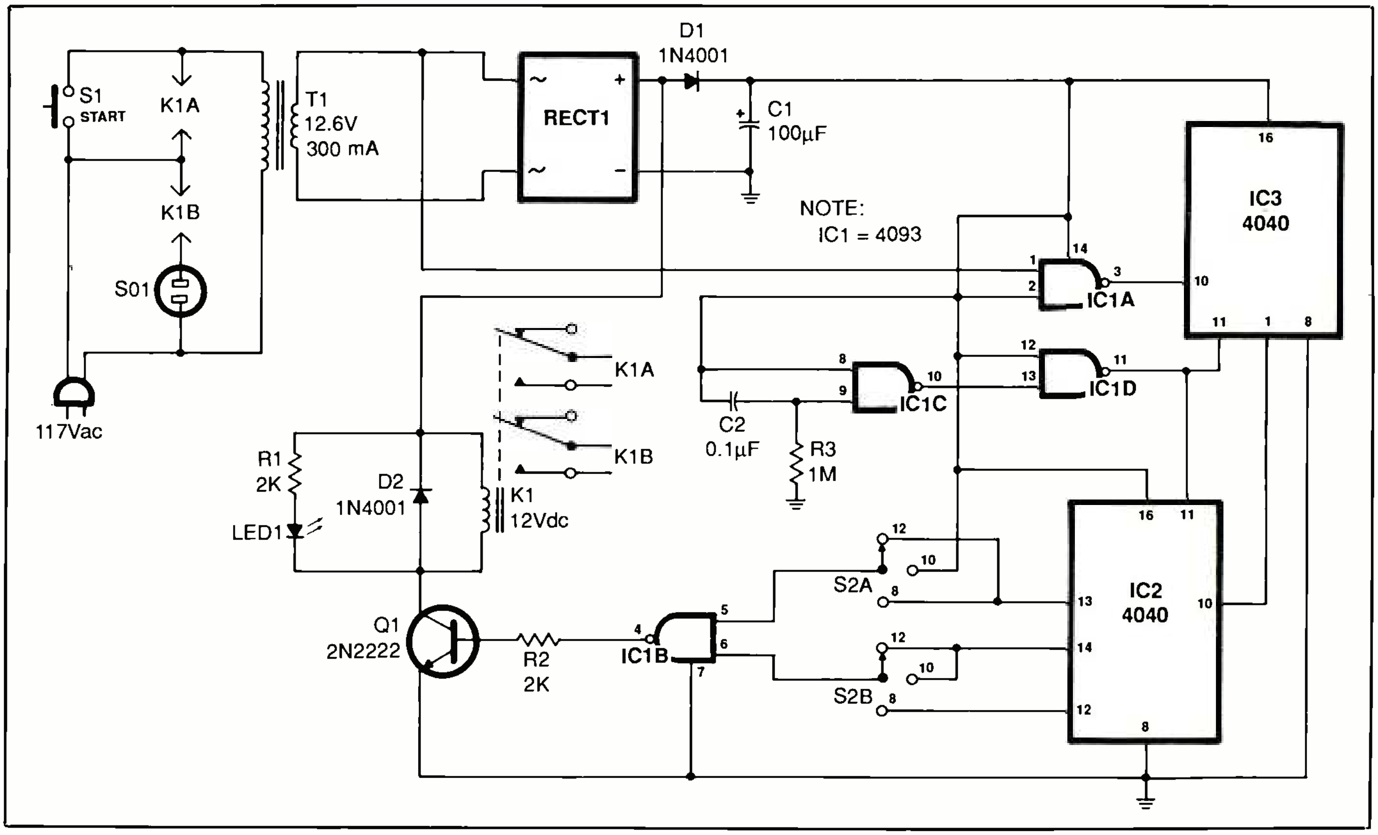


Fig. 1. Complete schematic diagram of the circuitry used in the Timer.

provides isolated unfiltered dc (at the anode) and filtered dc (at the cathode). The unfiltered dc is used to drive the circuitry that does not required filtering and minimizes the physical size of *C1*.

Note that the unfiltered dc voltage is applied to pin 1 of NAND gate *IC1A* and is shown in Fig. 2(A). The output waveform at pin 3 of *IC1A* is a train of square-wave pulses with a period of 1/60 of a second, as shown in Fig. 2(B). This output serves as the system "clock." The period developed by this circuit arrangement is extremely stable because it is synchronized with the frequency of the ac power line.

Cascaded 12-stage binary ripple counters *IC2* and *IC3* permit the clock signal to be divided over a range from 21 to 224. The 220, 221 and 222 outputs are delivered to input pins 5 and 6 of NAND gate *IC1B* by switch sections *S2A* and *S2B*, respectively. This switch is wired to provide periods of 7.28, 9.71 and 12.13 hours, which are rounded out to 8, 10 and 12 hours, respectively, at output pin 2 of *IC1B*.

A buffered power-up one-shot multivibrator circuit consisting of *IC1C* and *IC1D* provide an initial reset signal for *IC2* and *IC3*. The one-shot circuit is triggered by V+. Its period of approximately 0.1 microsecond is determined by the values of *C2* and *R3*.

Transistor *Q1* is driven by the output signal at pin 4 of AND gate *IC1B* through current-limiting resistor *R2*. Starting the timer by pressing START switch *S1* sends *Q1* into saturation to energize *K1* and turn on light-emitting diode *LED1*. Resistor *R1* serves as a current limiter for the LED, which turns on when the Timer is started and continues to glow during the entire countdown period. It extinguishes when the countdown period times out and *K1* deenergizes.

Diode *D2* across the coil of *K1* is a protective device. It prevents *Q1* from being damaged by the inductive current spike that is generated when power is removed from the coil and its energy field collapses.

Construction

There is nothing critical about component layout or/and conductor routing. Consequently, you can use any method of construction that suits you to build the One-Button Digital Timer. For example, you can design and fabricate a printed-circuit board on which to mount and wire together the components. Alternatively, you can use perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, though, it is important that you use sockets for the ICs. These are static-electricity-sensitive devices that can easily be damages by some soldering irons.

Begin construction by installing the IC sockets on your pc or other board. Then install the resistors, bridge rectifier assembly, transistor, diodes and capacitors. Before soldering their leads into place, make certain that the rectifier, diodes and *C1* are properly polarized.

Strip ¼ inch of insulation from both ends of 19 6-inch lengths of stranded hookup wire. Use fairly large gauge wires for the lines that are to go both lugs of relay contacts K1B and the chassis-mounted ac receptacle. These should be of a gauge that will safely handle the current drawn by the load to be controlled. Tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder.

PARTS LIST

Semiconductors

D1,D2—1N4001 or similar 50-PIV, 1-ampere silicon power diode
IC1—CD4093 CMOS quad Schmitt-trigger NAND gate
IC2,IC3—CD4040 12-stage ripple counter
LED1—Red light-emitting diode
Q1—2N2222 or similar general-purpose silicon npn transistor
RECT1—MDA100A or similar 50-PIV, 1-ampere full-wave bridge rectifier

Capacitors

C1—100-μF, 15-volt electrolytic
C2—0.1-μF, 35-volt ceramic disc

Resistors (¼-watt, 10% tolerance)

R1,R2—2,000 ohms
R3—1 megohm

Miscellaneous

K1—12-volt dc relay with dpdt contacts rated to safely handle current that will be drawn by the device being controlled
S1—Spst momentary-contact normally-open pushbutton switch
S2—2-pole, 3-position rotary switch
SO1—Chassis-mount ac receptacle (see text)
T1—12.6-volt, 300-mA power transformer
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for ICs; pointer-type control knob for S2; suitable enclosure (see text); ac line cord with plug; panel clip or rubber grommet for LED1; rubber grommet for ac line cord; ½-inch spacers; machine hardware; stranded hookup wire (including heavy-gauge wire for load circuit); solder; etc.

Connect and solder one end of each of 12 these wires to the following points on the circuit-board assembly: one wire at each end of *R1*, one at the toggle of *S2A*, one at the toggle of *S2B*, one to the point to which pin 16 of the *IC3* socket connects, one to the point where pin 12 of the *IC3* socket connects, two to the point to which pin 13 of the *IC3* socket connects, two to the point where pin 14 of the *IC3* socket connects and two to the junction formed by the collector of *Q1* and the anode of *D2*.

Crimp and solder one end of the heavy-gauge wires to the lugs for the normally-open K1B contacts of *K1*. Then crimp and solder two of the lighter-gauge wires to the K1A normally-open contacts of *K1*. Crimp and solder the free end of the wire coming from the *R1/D2* junction to one coil lug of *K1* and the wire coming from the *D2/Q1* junction to the other coil lug. Mount the relay on the circuit-board assembly.

Crimp and solder a wire to each primary lead of *T1* and insulate both connections with heat-shrinkable tubing. Connect and solder the secondary leads of *T1* into the circuit at the appropriate points. Then mount the transformer on the circuit-board assembly.

Do not wire the ac line cord, switches or chassis-mounted ac receptacle into the circuit until after you have machined the enclosure.

Locate one of the wires coming from the junction formed by the collector of *Q1* and the anode of *D2*. Slip over the free end of this wire a 1-inch length of small-diameter heat-shrinkable tubing. Clip the cathode lead of *LED1* to ½ inch in length. Inline solder the free end of the identified wire to the cathode lead of the LED. Make this connection electrically and mechanically secure.

Repeat the entire operation for the anode lead of the LED and the wire coming from *R1*. When both connections have cooled, slide the lengths of heat-shrinkable tubing over the connections and flush against the bottom of the case of the LED. Shrink the tubing solidly into place.

Do not wire the ac line cord, chassis-mounted ac receptacle or switches into the circuit until after you have machined the enclosure.

You can use any type of enclosure that will accommodate the circuit-board assembly, chassis-mounted ac receptacle, switches and LED without crowding. The lead photo shows the author's prototype built into a defunct commercial appliance timer module, which eliminated the need for cutting an opening for the ac receptacle. If you have one of these, by all means use it, especially since it obviates the need for making the receptacle opening and eliminates the need for an ac line cord.

Machine the enclosure as needed. That is, cut the opening for the chassis-mounted ac receptacle and drill

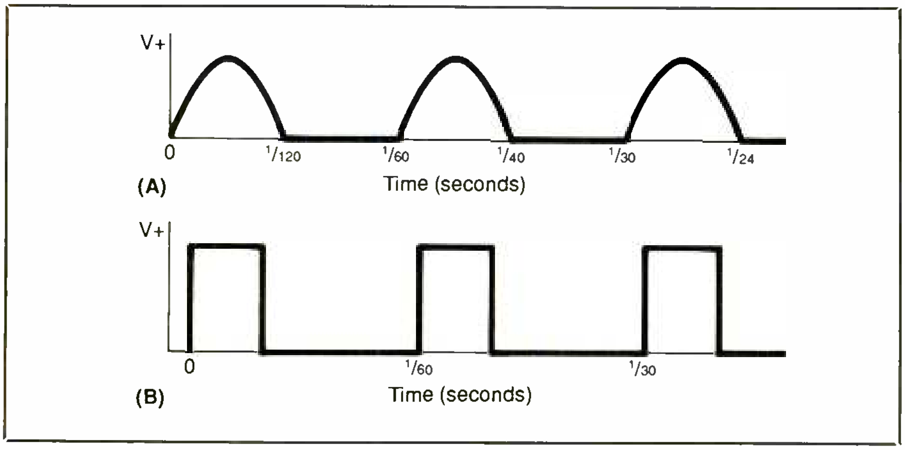


Fig. 2. Half-wave rectified voltage waveform (A) that appears at the + terminal of RECT1 when the project is timing out and the square-wave clock pulses (B) it generates at output pin 3 of IC1A.

mounting holes for the circuit-board assembly, LED and two switches. Also drill a hole for entry of the ac line cord. Make the hole for the LED large enough to accommodate a panel clip or small rubber grommet. If you are using a metal enclosure or have drilled any holes through or cut the slot for the receptacle in a metal panel, deburr all cut edges and line the hole for the ac line cord with a rubber grommet.

Route the line cord into the enclosure and tie a strain-relieving knot in it about 5 inches from the free end inside the enclosure. Tightly twist together the fine wires at the ends of both conductors and sparingly tin with solder. Crimp but do not solder one conductor to one lug of the pushbutton switch and the other conductor to one lug of the receptacle. Locate one of the leads of the primary of *T1* and crimp and solder the free end of it to the same receptacle lug as the line cord is crimped.

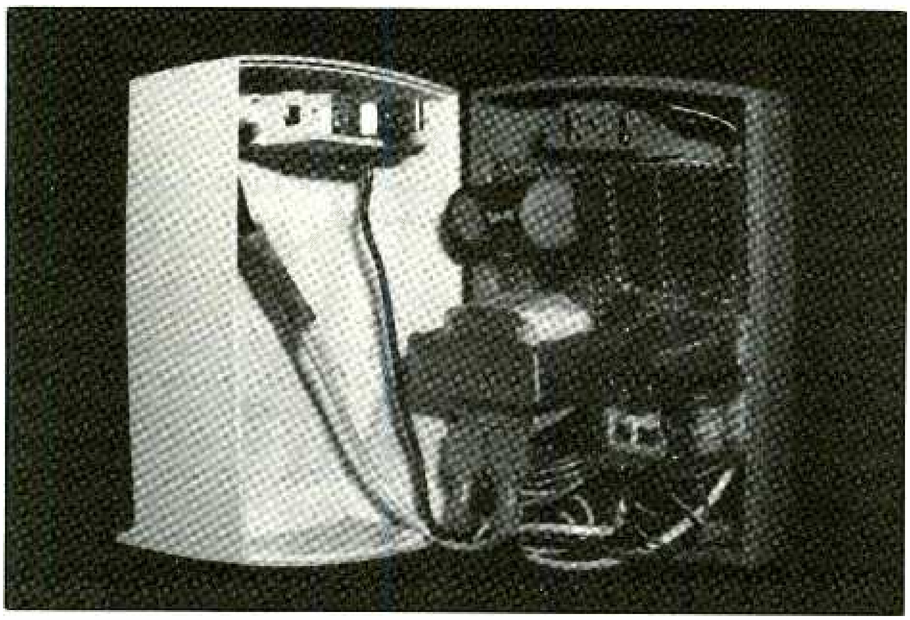


Fig. 3. Interior view of author's prototype showing perforated-board construction inside a commercial appliance timer.

Crimp the free ends of one wire coming from the K1A and K1B lugs of *K1* to the same lug of *S1* to which the ac line cord is crimped. Solder the connection. Next, crimp and solder the free end of the other K1B wire to the unoccupied lug of *SO1*. Then crimp and solder the free ends of the remaining *T1* primary and K1A wires to the unoccupied lug of *S1*.

Carefully examine the switch you will be using for *S2* to identify its toggle lugs and its position-lug sequence. Crimp and solder the free ends of the wires coming from pins 5 and 6 of the *IC1* socket to the *S2A* and *S2B* toggle lugs, respectively. Then crimp and solder the free ends of the wires coming from pins 12, 13, 14 and 16 of the *IC3* socket to the position lugs of the switch as illustrated in Fig. 1.

Before proceeding to final assembly, use a dry-transfer lettering kit or tape labeler to label the switches and LED (see lead photo). If you use the former, protect the lettering with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next.

Before proceeding to final assembly, check all component installations for proper value or type and orientation. Carefully check all wiring, especially wherever ac line power will appear in the circuit. Then carefully examine all soldered connections. If you missed any connection, solder it. If you find a connection that appears to be suspicious, reflow the solder on it and add solder if needed. If you locate any solder bridges, use desoldering braid or a vacuum-type desoldering tool to remove them. Do not proceed to final

(Continued on page 82)

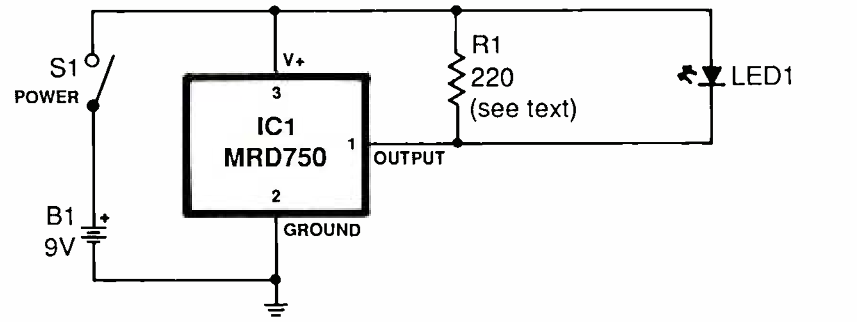
An Infrared Detector

Simple tester gives visible indication of whether or not invisible infrared energy from, say, a hand-held remote controller is being generated

By Jeff Orthober

Have you ever had to check out the hand-held infrared remote-control transmitter for your TV/VCR/audio system to determine if it was working? Or have you been experimenting with infrared and need a device that will let you know if your IR emitter is actually emitting? As you know, you can't exactly look into a powered infrared emitter to see the radiation it's emitting because it's invisible to the human eye.

Here's a "tool" you can put together in about 10 minutes that will let you check out the invisible signal. It's a simple five-component Infrared Detector that "sees" infrared energy. When it does detect infrared energy, it turns on a light-emitting diode to let you know that the device being tested is operating.



PARTS LIST

B1—9-volt battery
IC1—MRD750 infrared detector with logic output
LED1—Jumbo light-emitting diode
R1—220-ohm, ¼-watt resistor (value not critical—see text)
S1—Spst slide or toggle switch
Misc.—perforated board and suitable hardware or solderless breadboarding socket (see text); suitable enclosure (see text); battery snap connector for B1; hookup wire; solder; etc.

Note: The following items are available from JL Electronics, 43 White Plains Dr., Nashua, NH 03062: MDR750 detector, $3 or two for $5; complete kit of parts (does not include power switch or enclosure), $10.

Complete schematic diagram of the simple circuitry that makes up the Infrared Detector.

Circuit Operation & Construction

Refer to the schematic diagram of this simple project's circuit during the following explanation. The project is built around Motorola's MRD-750 infrared detector chip, shown here as *IC1*. This device has a built-in detector element and Schmitt-trigger logic output that lights *LED1* whenever it detects the presence of infrared energy.

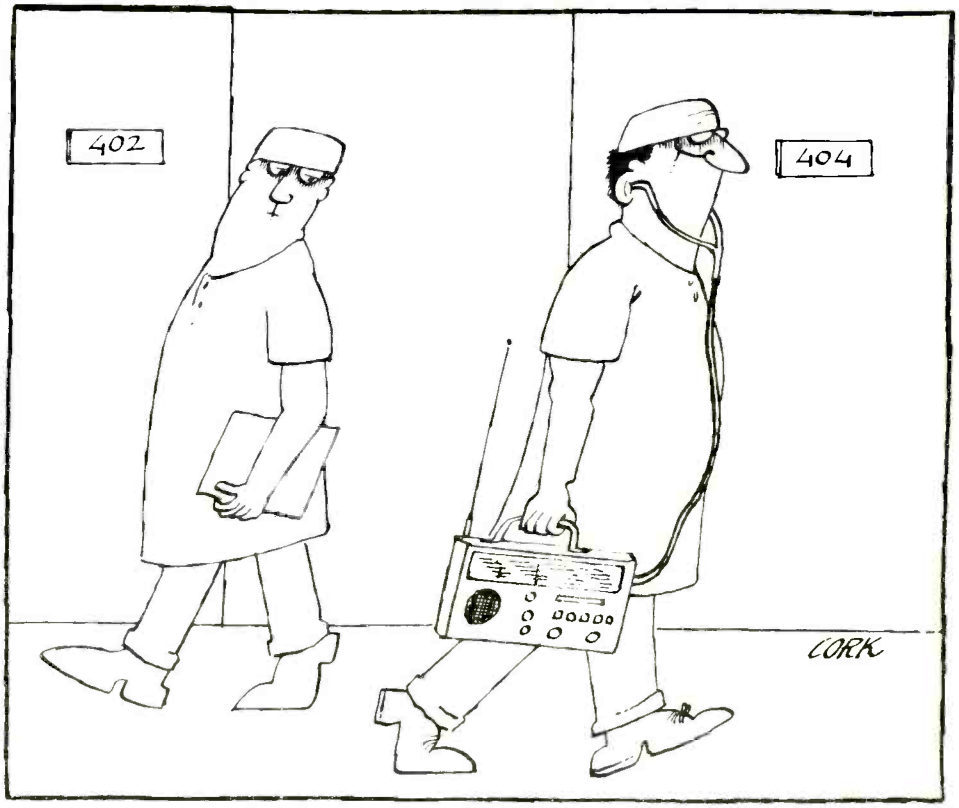
As you can see, the MRD750 has only three pins, one each for power, ground reference and output. When *IC1* does not detect IR energy, its OUTPUT pin is in the tri-state condition and *R1* serves as a pull-up resistor. Now when *IC1* does detect the presence of IR radiation, its output goes to a logic low. This allows *LED1* to turn on, providing you with an invisible indication of the presence of the IR energy.

The value of *R1* is really not important. Though 220 ohms is specified on the schematic and in the Parts List as a commonly available value that can be used for *R1*, the value of this resistor can be anywhere within the range from 50 to 1,000 ohms.

Power for the circuit is supplied by *B1*, a 9-volt battery. It is switched in and out of the circuit via *S1*.

This circuit is so simple that it can easily be assembled and wired together in just a few minutes on perforated board with suitable hardware or even on a small solderless breadboarding socket. You may wish to house it in an enclosure. If you do, make sure to use an enclosure that will accommodate the circuitry and battery without crowding. Also, make sure that the IC has a clear, unobstructed view to the outside and that you mount the LED in a location where it will easily be seen by you.

To use the Infrared Detector, place the sensor window on *IC1* so that is directly in line with and 2 inches or less from the source of the IR radiation. Flip on power to the project and device being tested, and observe whether or not the LED on the Infrared Detector comes on. If it does, the device under test is emitting IR radiation; if not, something is wrong with the device under test. That's all there is to it. **ME**



How to Detect Ultraviolet, Visible Light and Infrared Radiation

By Forrest M. Mims III

Even though many different kinds of light detectors are available, most of us routinely use only phototransistors and photoresistors for the majority of our light-detection applications. This leaves out many kinds of light detectors that may work much better.

This is the first of several columns in which I plan to introduce each of the most-important classes of light detectors and describe how they are used. I'll also present some circuits you can try with various detectors. First, however, let's devote some time to defining light and to looking at the first light detector and some of the many applications that light detectors have since made possible.

Light Defined

There isn't enough space here to include a full discussion about the physics of the nature of light. But it is important to define which wavelengths of the electromagnetic spectrum are generally considered to be light.

Light is usually considered to be those wavelengths of the electromagnetic spectrum that are visible to the human eye. By this definition, light is restricted to the wavelengths that form the colors of the rainbow. These wavelengths are usually said to range from about 380, nanometers on the blue end to about 780 nanometers on the red end of the spectrum.

Actually, the boundaries that separate visible and invisible light are rather fuzzy. Depending on the intensity of the light and its contrast with the background, many people can see beyond 380 nanometers on the blue end of the spectrum and beyond 780 nanometers on the red end. For example, most people can easily see the 780-nanometer radiation emitted by the diode laser in a compact-disc player. People who have had the lens of an eye removed during cataract surgery can see down to 320 nanometers.

Invisible electromagnetic radiation between 200 nanometers and the lower limit of visible blue light is called the ultraviolet spectrum. Sometimes, ultraviolet radiation is called "black light."

Invisible electromagnetic radiation beyond visible red light and out to 1,000 micrometers is known as the infrared spectrum. Since the infrared spectrum is so wide, it's usually subdivided into three regions. Wavelengths out to 1.5 micrometers make up the near-infrared spectrum. Wavelengths between 1.51 and 6 micrometers make up the middle-infrared region. Finally, wavelengths between 6 and 1,000 micrometers are perceived as heat by the human body. (*All* electromagnetic radiation causes at least some increase in the temperature of objects it strikes. More about this later.)

Shown in Fig. 1 are the relationships of ultraviolet, visible and infrared radiation to the remainder of the electromagnetic spectrum. Often, the definition of light is extended to include some or all of the ultraviolet and infrared wavelengths. Many kinds of light detectors can detect wavelengths across the ultraviolet/visible or visible/infrared regions of the spectrum. Therefore, for the purpose of this column, the broader definition of light will be used.

Blackbody Radiation

Electromagnetic radiation is emitted by any object whose temperature is greater than that of absolute zero (0 degree Kelvin or −273.18 degrees Celsius). This is known as "blackbody radiation." Since

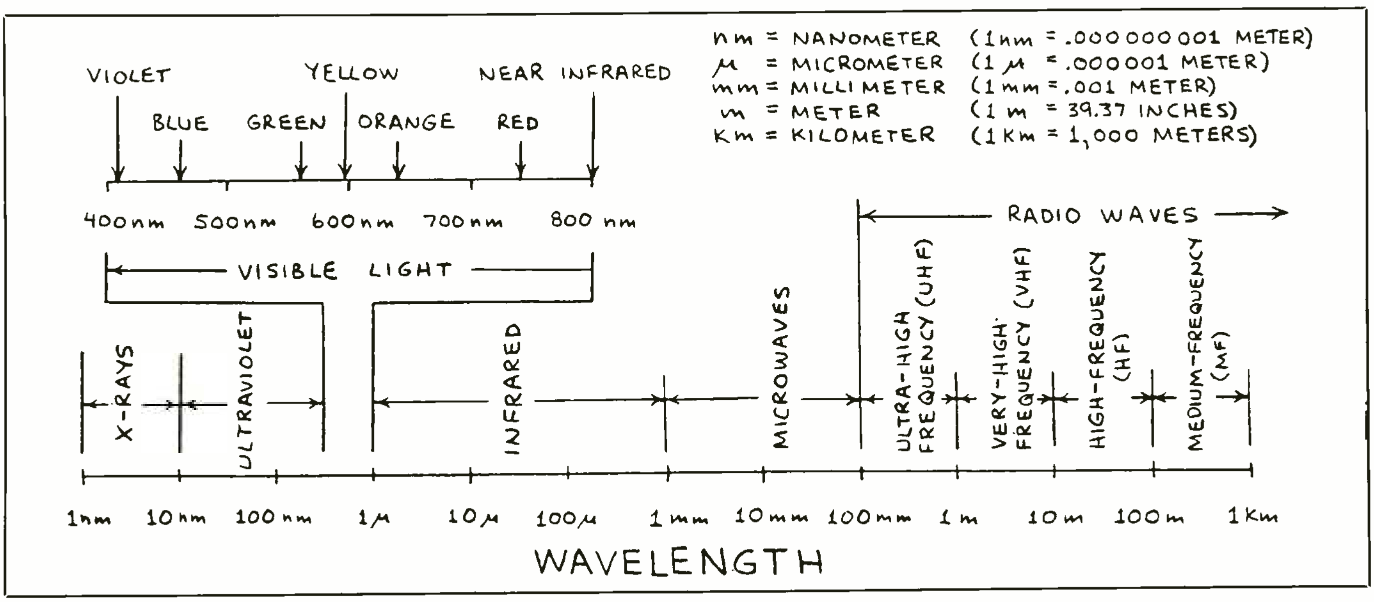


Fig. 1. The electromagnetic spectrum.

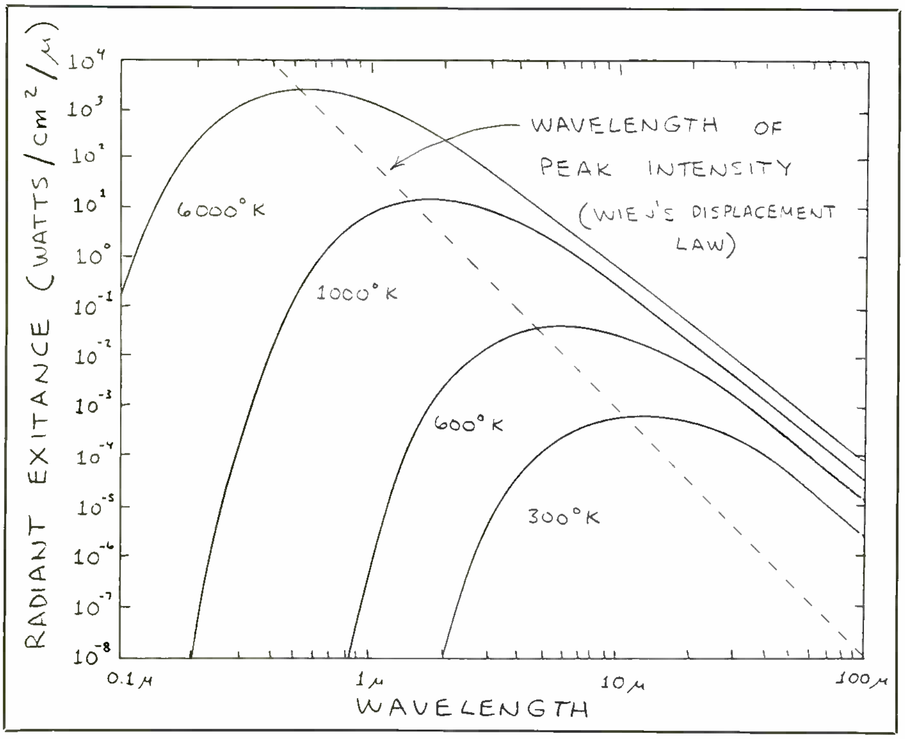


Fig. 2. Peak spectral existence of a blackbody at various temperatures.

nothing is known to be at a temperature of absolute zero, everything is a blackbody radiator.

The peak wavelength of the blackbody radiation emitted by an object is directly related to the temperature of that object. The blackbody radiation of an object whose temperature is less than about 1,725 degrees Celsius falls predominantly in the infrared portion of the spectrum. While the page you are reading is an excellent reflector of visible light, it is much too cool to emit visible blackbody radiation. If this page is at room temperature (300 degrees Kelvin), it's emitting blackbody radiation that has a peak wavelength of around 9.66 micrometers.

The peak spectral wavelength emitted by a blackbody at a given temperature is given by Wien's displacement law, which states that Wavelength = 2,898/temperature in degrees Kelvin. For example, if your body temperature is 310 degrees Kelvin, the peak blackbody radiation emitted by it has a wavelength of 2,898/310 degrees, or 9.35 micrometers. Since the temperature at the surface of your skin is is actually less than 310 degrees Kelvin, your blackbody radiation is somewhat greater than 9.35 micrometers.

Graphed in Fig. 2 is the radiation emitted by a blackbody at a range of temperatures. The curve for a blackbody at 6,000 degrees Kelvin approximates the radiation from the sun outside the Earth's atmosphere. The straight line that connects the peak emission wavelengths follows Wien's displacement law.

Wien's displacement law works both ways. For example, if the peak spectral wavelength of a glowing ladle of molten metal can be measured, the temperature of the metal can be calculated using Wien's displacement law. The same procedure can be used to determine the temperature of the filament in an incandescent lamp when current is flowing through it. The *color temperature* of the light source is the temperature at which a hot blackbody must be maintained to produce a spectrum of light that matches that of the light source.

First Light Detector

According to Genesis, God invented both light and the first light detectors. Biological light detectors remained the only ones available until 1873. In that year, Willoughby Smith was working with multiple-megohm resistors made from crystalline selenium that he had designed to test a submerged transoceanic cable. His assistant, a Mr. May, discovered that the resistance of the selenium resistors was greatly reduced when the devices were exposed to sunlight.

Smith performed some experiments with selenium light detectors and his results created great interest in scientific circles. Soon, other scientists confirmed what May and Smith had discovered. Within a few years, it was learned that selenium was most sensitive to greenish-yellow light and that a selenium detector could function as a sun-powered battery.

Early experiments with selenium light detectors were performed by connecting the detector in series with a battery and a galvanometer. In 1878, Alexander Graham Bell proposed substituting a telephone receiver for the galvanometer so that changes in light intensity could be converted into audible sound. The eventual result was his invention of the photophone, the first lightwave communication system.

Applications

Circuits that detect light have become increasingly important in electronics. Most cameras include built-in light sensors. At the receiving end of every infrared remote-control unit is a detector. Night lights and security lights are switched on and off by a light sensor. Many telephone conversations are transformed into flashes of light that are sent though optical fibers and received by sensitive light detectors. Sensitive detectors connected to fiber-optic sensors detect liquid level, particles displacement and vibration.

Light detectors are used to detect fire, match colors and measure ultraviolet radiation. They are used to receive the beams of lasers and LEDs in break-beam intrusion-detection systems. Light detectors read the bar codes on labels, and they detect the laser beam deflected from the surfaces of compact discs.

Many new applications are made possible by placing two light detectors side by side in the same case or package. This forms what is known as a dual detector. In a typical application, each half of the detector is connected to one input of a difference amplifier and the dual detector package is placed at the focal point of a lens or parabolic reflector.

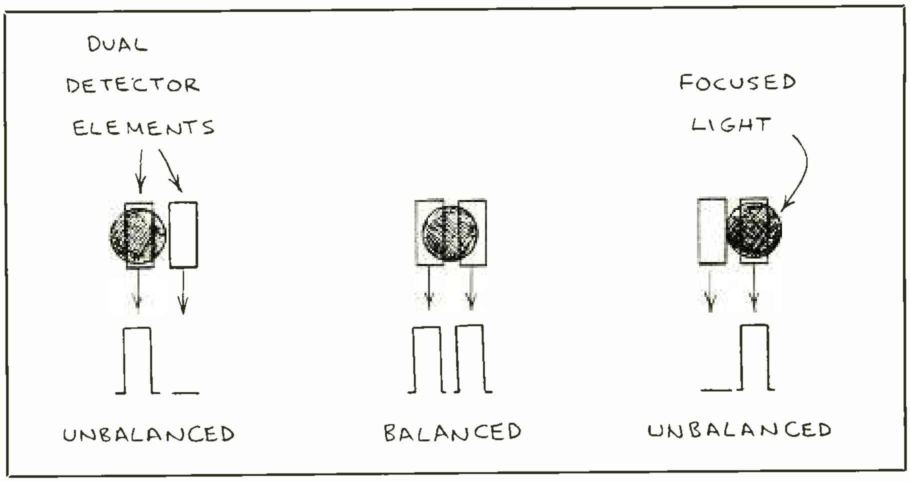


Fig. 3. These drawings show how a dual detector detects a moving radiation source.

Normally, as shown in Fig. 3, both detectors receive the same amount of illumination; hence, the output of the two detectors is balanced. If something that alters the amount of light being received by one half of the dual detector moves across the field of view of the detector, one detector will generate a greater output than the other. When this occurs, a voltage appears at the output of the difference amplifier.

Dual detectors are especially useful for detecting the flickering flames of a fire. They're also widely used to detect moving objects and even people and animals. All these applications are possible by using detectors that respond primarily to either visible light or to infrared radiation.

The above are only some of the many —almost limitless number of—applications for light detectors. I haven't even listed applications for position-sensitive detectors, detector arrays and image detectors used in television cameras.

Detector Specifications

Light detectors can be characterized by many different specifications. The most important of these are response time, sensitivity and noise.

Many applications can tolerate very-slow response times. Who cares, for example, if a night light switches on in a few milliseconds or a few nanoseconds? Photoresistors are very slow to respond, but their excellent sensitivity makes them an ideal choice for this application.

Other applications require very-fast response times. Optical-fiber communication systems are a good example, since most such systems transform voice signals into pulses of light. Semiconductor junction photodiodes have a very-fast response time, making them ideally suited to this application.

Generally speaking, junction detectors with a small active surface are faster than those with a large active surface. This is because smaller detectors have less junction capacitance than do larger detectors.

The sensitivity of a detector is a measure of how well it responds to light at a particular wavelength. For example, a typical silicon photodiode has a sensitivity of about 0.5 ampere per watt to light that has a wavelength of about 900 nanometers. In other words, a photodiode that has this sensitivity will generate a current of about 0.5 milliampere when it is illuminated by 1.0 milliwatt of radiation at a wavelength of 900 nanometers.

Sensitivity of some detectors varies with previous exposures to light. For example, the resistance of a photoresistor varies with the light striking the active surface. After the light source is removed, the photoresistor's resistance may not return completely to its normal or dark value for some time. This is called the "light-history" or "memory" effect.

Like diodes and resistors, light detectors generate internal noise. The noise of a light detector is often specified in terms of *noise equivalent power* or *NEP*. The NEP of a detector is the level of light that matches the detector's inherent noise level. In terms of signal-to-noise ratio, a detector's NEP is that level of light that gives an SNR (S/N ratio) of 1.

Keep in mind that detector specifications apply to the detector as it is purchased. For example, so-called blue-enhanced silicon photodiodes can be used to detect ultraviolet radiation. But ultraviolet radiation is highly attenuated by most kinds of glass and plastic. Therefore, the detector will not meet its specifications if it is placed behind a window or lens that does not transmit the ultraviolet.

The dozens of different types of light detectors can be divided into two broad categories: thermal detectors and photodetectors. Thermal detectors indirectly detect the presence of light by measuring either the temperature increase or some effect of the temperature increase that occurs when light strikes a temperature-sensitive element. Photodetectors detect light directly by the photoelectric effect.

There are many differences between thermal and photoelectric detectors, but the most important is spectral response. Thermal detectors have a spectral response that is virtually flat from the deep ultraviolet to the far infrared. Photoelectric detectors, on the other hand, have a much narrower spectral response.

Thermal Detectors

Since thermal detectors respond to a temperature increase, a common misconception it that they detect only infrared radiation. Actually, as noted above, thermal detectors can detect ultraviolet and visible wavelengths as well, because all wavelengths of light can cause a temperature increase. That's why the blue-green beam from an argon laser I was once using virtually instantly ignited a black cloth that shielded some equipment from ambient light.

The temperature-sensitive resistor or bolometer was among the first thermal detectors. The thermistor is a semiconductor bolometer.

A thermopneumatic or Golay cell is a small gas-filled chamber. A thin film on one wall of the chamber bulges outward when the internal gas expands on being warmed by optical or IR radiation. Displacement of the film is detected by a simple interferometric technique in which Newton's rings are formed.

In 1938, an array of 61 thermopneumatic cells was used to detect aircraft more than 20 kilometers away. The cells were mounted at the focal point of a 1.5-meter military searchlight mirror. A single cell could detect an aircraft. Movement of the aircraft could be detected while observing changes in the Newton's rings on the individual detectors.

Another early kind of thermal detector is the thermocouple, which is the junction of two dissimilar metals that produce a voltage when heated. The thermopile is an array of thermocouples that provides more output voltage than is possible with a single thermocouple.

Finally, there is the pyroelectric thermal detector. One such detector is made from lithium tantalate, an asymmetrical, non-conducting crystal. Electrodes are applied to both sides of the crystal to form a capacitor. The internal electrical field of the crystal appears across the electrodes of the capacitor. When the crystal is illuminated, the charge on the capacitor is almost instantly altered.

Besides lithium tantalate, pyroelectric detectors are made from ceramics like lead zirconate titanate. They are also made from piezoelectric film.

Comparisons

Thermopiles and pyroelectric detectors are by far the most important kinds of thermal detectors. Miniature thermopiles, which can be purchased for as little as $50, are several times more expensive than some inexpensive pyroelectric detectors. On the other hand, thermopiles are much easier to use. Since they generate a voltage, they can be used with simple high-gain op-amp circuitry.

Since pyroelectric detectors are electrically equivalent to tiny capacitors, they must be connected to FET-input amplifiers that have a very-high input impedance. Otherwise, the minuscule charge on the detector will be drained away before it can be measured.

Pyroelectric detectors are very sensitive and have a much faster response time than thermopiles. But it's important that you realize that pyroelectric detectors respond only to *changes* in incident radiation. Thermopiles, on the other hand, generate a continuous output current when illuminated by a light source.

What does the foregoing mean in practice? Shine a flashlight on a pyroelectric detector, and it will generate an output pulse. Remove the light, and it will generate a second pulse. Repeat this experiment with a thermopile, and it will generate a continuous current for the entire time it is illuminated.

Pyroelectric detectors can easily detect moving sources of ultraviolet, visible-light or infrared radiation if the detector is placed at the focal point of a lens or reflector. For steady sources that do not move, a chopper wheel can interrupt the radiation that strikes the detector.

As noted above, the spectral response of thermal detectors is virtually flat. That's because their spectral response is dependent solely on the absorption properties of the black soot or paint used to

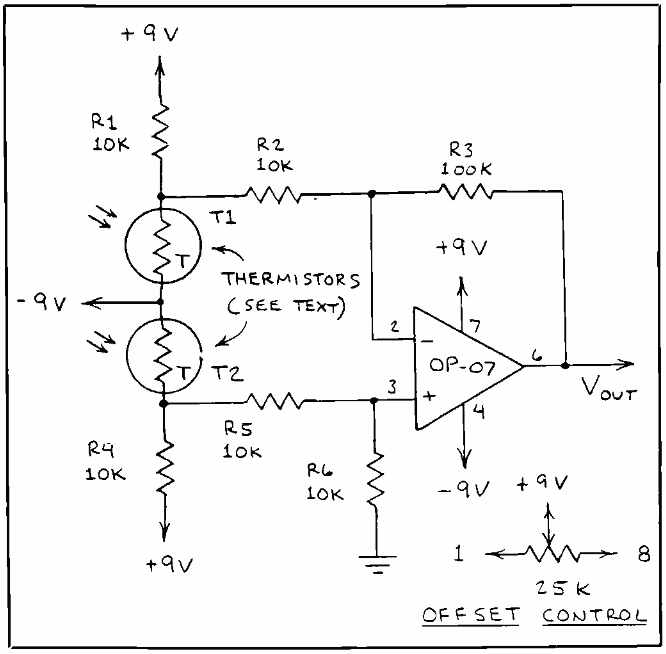


Fig. 4. A sensitive thermal detector made with thermistors.

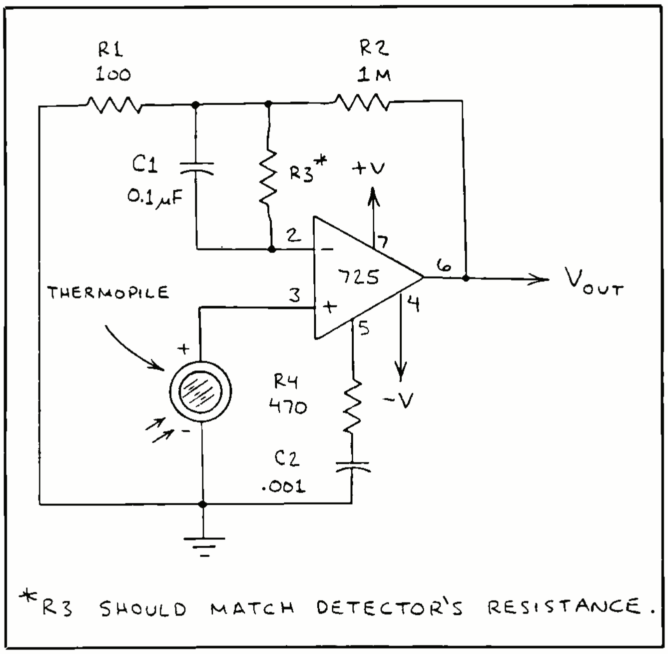


Fig. 5. A precision amplifier for a miniature thermopile.

coat the detector's active surface. The spectral response can be changed by using filters or different kinds of window materials that double as filters.

Potassium bromide (KBr), a common window material for thermal detectors, has excellent transmission properties from the ultraviolet out to beyond 35 micrometers. Quartz or silica is used when ultraviolet and visible wavelengths are being detected. Germanium is used to block these wavelengths in favor of a band between 2 and around 20 micrometers. The infrared energy emitted by you and me peaks at around 10 micrometers, thereby making germanium a suitable window material when human beings are being detected.

Both pyroelectric and thermopile detectors are available with either single or dual elements for detection of flickering flames or moving objects, as above.

Briefly reviewing, the two outputs from the dual detector are connected to the inputs of a difference amplifier, and the detector is placed at the focal point of a lens or mirror. When both elements are equally illuminated, the output of the amplifier is zero. When one element receives more radiation than the other does, the output of the amplifier swings positive or negative. The direction of output swing is determined by which element is warmer than the other.

Experimenting With Thermistor Detectors

I described thermistors in some detail in my May 1989 "Electronics Notebook" column. The main emphasis of that column was the use of thermistors as indicators of temperature change. Several application circuits were provided.

You can make a simple thermistor detector from a blackened thermistor by attaching a thermistor to a small piece of metal that is coated with soot or black paint. While this arrangement will detect light, it will also respond to changes in the temperature of the surrounding air. Therefore, it must be used when the temperature of the surrounding air is very stable. Alternatively, or it must be shielded from air currents.

You can greatly increase the sensitivity of a thermistor by mounting it at the focal point of a flashlight reflector. You can prevent air currents from producing false signals by covering the reflector with a polyethylene film, which is a good transmitter of infrared radiation.

Temperature effects can be canceled out by using two thermistors, one of which is shielded from the light being measured. The outputs from the sensors then go to a difference amplifier.

Figure 4, for example, shows one way to connect two thermistors to a difference amplifier. The thermistors are Radio Shack Cat. No. 271-110 devices. This readily available thermistor has a resistance that ranges from 329.2 kilohms at −50 degrees Celsius to 758 ohms at +110 degrees Celsius. Many other thermistors will also work in this circuit.

I used an OP-07 precision operational amplifier for the Fig. 4 circuit, but other high-quality op amps will work equally well. Connect the amplifier's output to an analog multimeter set for a full-scale indication of a few volts or so. Feedback resistor *R3* should have a resistance of about 20,000 to 30,000 ohms for initial tests. Adjust the OFFSET CONTROL so that the meter's pointer is near the middle of the scale. The pointer will move toward the positive end of the scale when you touch thermistor *T1* and to the negative end when you touch thermistor *T2*.

You can increase the sensitivity of the Fig. 4 circuit by increasing the value of *R3*. First, place a short piece of clear plastic tubing over the two thermistors to keep away stray air currents. Then adjust the value of *R3*. The meter's pointer will tend to swing wildly when you adjust the OFFSET CONTROL. Therefore, use a high meter range setting at first to avoid damaging the analog movement.

When you finally balance the circuit, it will be extremely sensitive. Pointing the 1-milliwatt beam from a helium-neon laser at one thermistor will cause a pointer deflection of tens of millivolts. A flashlight will cause a much greater deflection.

Experimenting With Thermopile Detectors

You can perform many interesting experiments in ultraviolet, visible-light and infrared detection with a thermopile detector. If your budget is limited, you can attempt to make your own thermocouple from two dissimilar metal wires. Thermocouple wire is available from many sources. The Electronic Goldmine (P.O. Box 5408, Scottsdale, AZ 85261) sells a 2-inch length of thermocouple wire for 49 cents (specify Cat. No. S2009). Omega Engineering, Inc. (P.O. Box 2669, Stamford, CT 06906) stocks every imaginable kind of thermocouple and raw thermocouple wire.

If you can spare around \$50, your best bet is to purchase a miniature thermopile detector. Dexter Research Center, Inc. (7300 Huron River Dr., Dexter, MI 48130) is a major manufacturer of thermopile detectors. The company makes a dozen or so single- and dual-element multi-junction detectors, most of which are priced at \$50 or \$60 each. Optional window materials and filters are available for an additional \$4 to \$10.

While I have not yet experimented with a miniature thermopile detector made by Dexter Research, I have worked with a Model C1 miniature thermopile made by Sensors, Inc. Unfortunately, this company no longer makes miniature thermopile detectors, but the Model C1's design and specifications are similar to those of some of the thermopiles made by Dexter Research.

The Model C1 thermopile features 12 miniature thermocouples deposited on a substrate and connected together to form a thermopile. The active region of the thermopile is coated with black paint or soot and is installed in a TO-5 transistor case. The case is fitted with a potassium bromide window that transmits optical wavelengths ranging from 250 nanometers in the ultraviolet to more than 35 micrometers in the infrared.

Thermopiles made by Dexter Research that have specifications similar to those of the Model C1 include the Model M5 with 10 junctions and the Model 1M with 15 junctions.

Figure 5 is adapted from a circuit recommended by Dexter Research for amplifying the signal from its thermopile detectors. You can use a common 741 op amp in this circuit, but you'll obtain substantially better results with the recommended 725 instrumentation-grade operational amplifier.

Figure 6 is a simpler circuit I've used with the Model C1 thermopile. This circuit gives an output of a few tenths of a volt when a hand is moved within 6 inches or so of the thermopile. Much greater output signals are given when the detector is illuminated by a small penlight or powered light-emitting diode.

Since the spectral response of this detector is almost flat, it's interesting to compare the output voltage given by various sources of ultraviolet, visible-light and infrared radiation. Try a candle flame, sunlight, a hot soldering iron, a xenon strobe light and various LEDs.

When using the Fig. 6 circuit, keep in

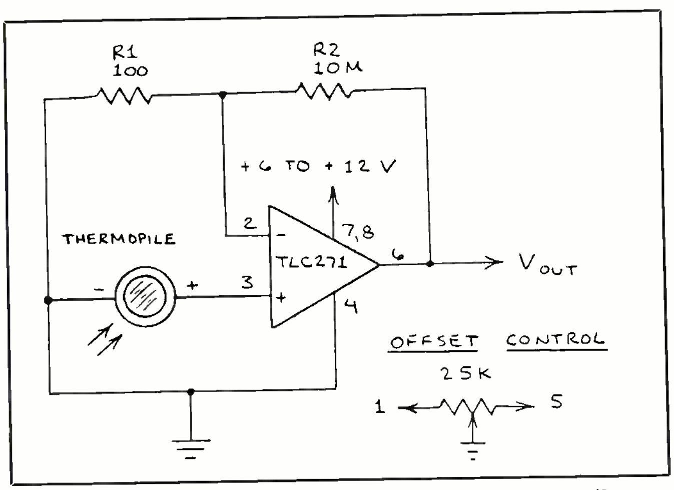


Fig. 6. A low-power amplifier for a miniature thermopile.

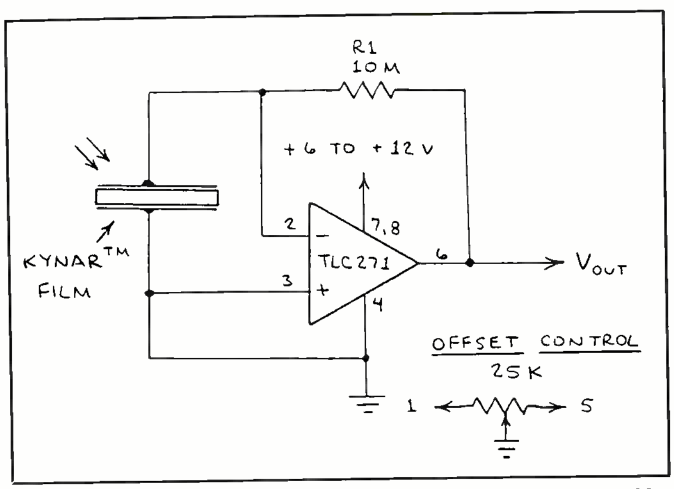


Fig. 7. A high-impedance amplifier for Kynar™ pyroelectric film.

ELECTRONICS NOTEBOOK...

mind that it is powered by a single-polarity supply. This means that the OFFSET CONTROL should be adjusted to give a small output from the amplifier when the thermopile isn't being irradiated. Otherwise, temperature changes that cause the output of the detector and the op amp to drift may force the output to zero even when the detector is receiving a signal. You'll have much better results observing the detector's response if you connect the output of the op amp to a multimeter with an analog meter movement than to one that has a digital numeric display.

The TLC271 op amp in the Fig. 6 circuit will also work with a dual-polarity power supply. For full details, see the Texas Instruments TLC271 data sheet.

Incidentally, the TLC721 is a CMOS op amp with a very high input impedance. Therefore, be sure to use safe MOS handling procedures when using it. You can use other kinds of CMOS op amps in this circuit as long as you revise the pin connections as necessary.

Experimenting With Pyroelectric Detectors

I described pyroelectric detectors in detail in the July 1987 "Electronics Notebook." That column included several tested circuits for lithium tantalate detectors made by Eltec Instruments, Inc. (P.O. Box 9610, Daytona Beach, FL 32020-9610). The circuits described in that column can also be used with ceramic pyroelectric detectors like those made by Amperex Electronic Corp. (George Washington Hwy., Smithfield, RI 02917).

I didn't cover plastic-film pyroelectric detectors in the July 1987 column. Kynar™ plastic piezoelectric film is the best-known pyroelectric plastic film. It's manufactured by Pennwalt Corp. (Kynar Piezo Film Dept., P.O. Box 799, Valley Forge, PA 19482). You can purchase a Kynar film kit from Edmund Scientific Co. (101 E. Gloucester Pike, Barrington, NJ 08007-1380).

You can easily make a large-area pyroelectric detector by connecting piece of metalized Kynar film to a high-input-impedance amplifier, such as shown in Fig. 7. Though I used a TLC721 CMOS op amp in this circuit, any high-input-impedance CMOS-type op amp should work.

For test purposes, connect the output of the amplifier to an analog-type multimeter that is set for a full-scale reading of 1 volt or less. As with the Fig. 6 circuit, be sure to adjust the OFFSET CONTROL to give a small output voltage at all times.

The Kynar film element I used measures approximately $\frac{5}{8} \times 1\frac{1}{2}$ inches. Therefore, its capacitance is considerably greater than that of miniature lithium tantalate and ceramic pyroelectric detectors. This greater capacitance slows down the detector's response time to as much as 1 second or so. If you place your hand near the detector, the output voltage will slowly increase by 20 or 30 millivolts, pause and then slowly begin to decline. The detector will also respond to the light from a flashlight or LED.

Going Further

Application circuits given here are only a hint of what can be done to process the signals from the various kinds of thermal detectors. For example, you can make a threshold alarm by connecting a comparator to the output of a detector amplifier. For monitoring the output of a detector in the dark, you can connect a LED bargraph display to the output of a detector amplifier. You can greatly increase the output of the thermal detectors by using them in conjunction with various kinds of lenses and reflectors.

Be sure to tune in next month to "Electronics Notebook," when I'll continue this discussion of detectors with a detailed look at phototubes, photodiodes, phototransistors and other photoelectric detectors. **ME**

An ISDN Communications Controller, a Dedicated Motion Controller, a Micro-Power Comparator, and a Ground Fault Interrupter

By Joseph Desposito

National Semiconductor (2900 Semiconductor Dr., Santa Clara, CA 95052), a company committed to establishing a leadership position in the Integrated Services Digital Network (ISDN) marketplace, has announced a chip optimized for communications control. The company's new 16-bit HPC16400 Communications Controller implements all Layer-2 and Layer-3 functions of the ISDN specification in a highly integrated, flexible system.

Though optimized for ISDN applications, the HPC16400 is capable of addressing a wide range of additional information control applications, including data storage, document imaging, and data communications.

A member of National's 16-bit HPC (High-Performance microController) family, the HPC16400 shares a common core CPU, with unique memory and I/O configurations suitable for specific applications (see Fig. 1). The HPC16400 contains two High-level Data Link Control (HDLC) channels that serve as transceivers for the communications channels defined in the ISDN Basic Rate Interface (BRI). The HDLC circuitry implements proper frame sequencing and control, error detection and retransmission, and address recognition. The channels can sustain continuous HDLC data rates as high as 4.6 Mb/s, making them suitable for proprietary high-speed networks, as well as ISDN applications.

A 4-channel DMA controller acts as an interface to external data RAM, enabling the HPC16400 to exploit the speed of the HDLC channels. Bus requests are initiated automatically and completed by the controller without further intervention after initial CPU acknowledgment.

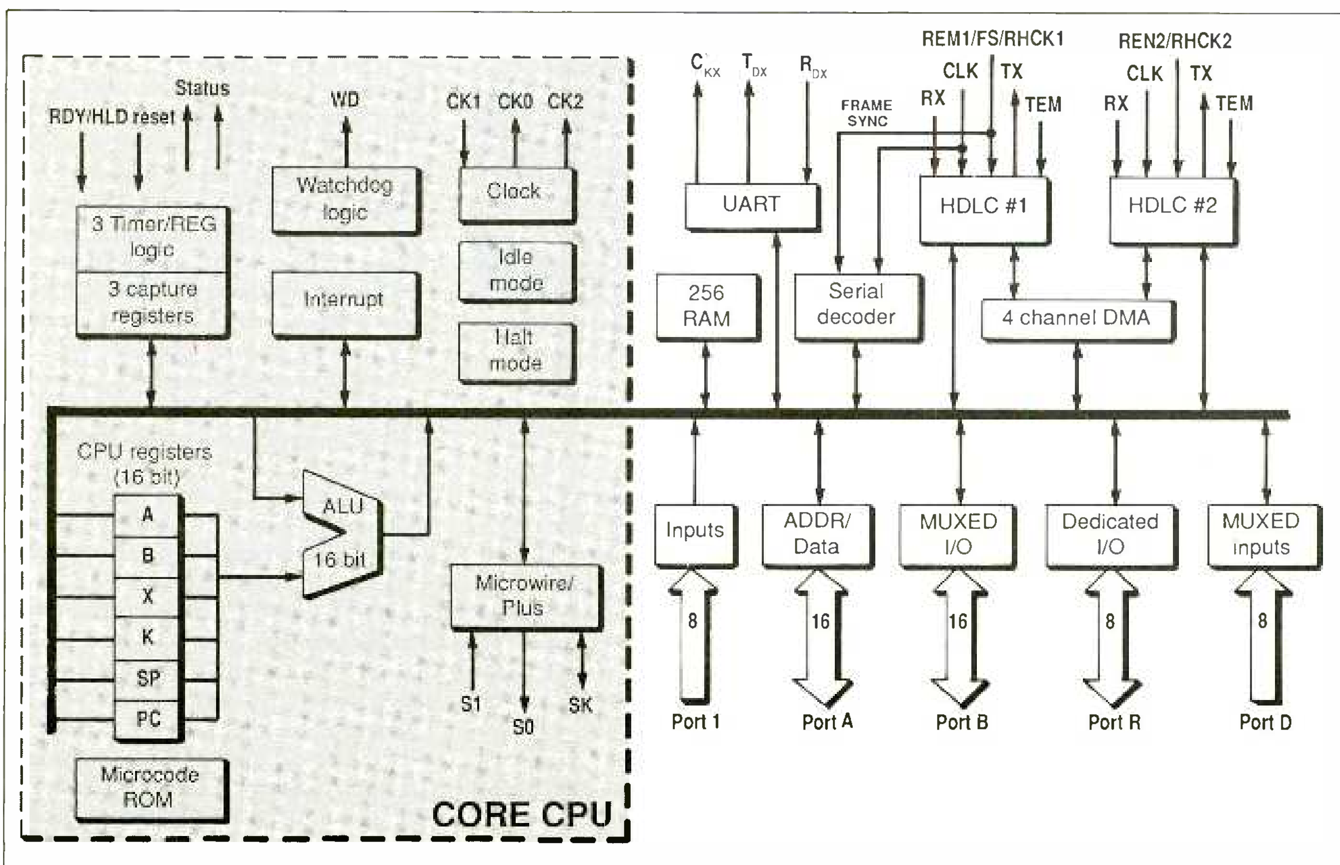


Fig. 1. National Semiconductor's 16-bit HPC16400 High-Performance microController has a common core CPU and unique memory and I/O configurations suitable for specific applications.

SOLID-STATE DEVICES...

Fig. 2. The LM628 motion-control processor governs the position, velocity and acceleration, rates of servo mechanisms. The LM628 evaluation board is shown in front of the video monitor in this photo.

A programmable serial interface decoder allows the two HDLC channels to be used with devices employing inter-chip serial links for point-to-point and multipoint data exchanges. The decoder generates Enable signals for the HDLC channels, allowing multiplexed D- and B-channel data to be accessed.

A full-duplex programmable UART facilitates communications between the HPC16400 and other on-board controllers. The UART includes a programmable baud-rate generator, allowing designers to select industry-standard baud rates regardless of crystal frequency. This ensures that the system can be operated from a single crystal.

The HPC16400 uses several register sets to simplify packet management, thus increasing the efficiency of data transmission and storage. The device's 256 bytes of RAM store user-variable data packets. A multiplexed bus to external memory provides direct addressing for up to 64 kilobytes of memory, while additional control outputs are available for up to 544 kilobytes of memory.

A number of extra pins and National's MICROWIRE/PLUS serial data expansion interface help to implement peripheral functions. And four user-configurable 16-bit timer counters can be used to implement timeouts, including default timers outlined in various specifications.

The HPC16400 can be purchased in 68-pin PLCC, LCC, TapePak, and PGA packages. In PLCC packaging, the device is priced at $30 each in 1,000-unit quantities.

National Semiconductor further supports the efforts of ISDN systems designers by offering an ISDN chip set (which includes the HPC16400) and a number of development tools and services. One of its key development tools is the TP3500 ISDN Evaluation System, a development board that simplifies hardware and software design and debugging. The TP3500 evaluation system is priced at $995.

Dedicated Motion Controller

Also from National Semiconductor is the LM628 dedicated motion-control processor, which lets designers develop high-performance, computer-controlled, motion-control systems.

Intended for use with a variety of dc and brushless dc servo motors, the LM628 provides precise control for many kinds of industrial motors. Typical applications include factory automation robots, material handling machines, computer plotters, medical imaging equipment, and elevator controls.

The motion controller uses incremental shaft-encoder feedback to control the position, velocity, and acceleration and deceleration rates of servo mechanisms. It takes pulses from an incremental encoder and commands from an 8-bit parallel bus that is connected to a host microprocessor. Based on the commands and programmable PID (proportional integral differential) filter parameters, the LM628 writes to a DAC (digital-to-analog converter) to control a motor.

Because an LM628 is used to control each motor in a system, the host processor is free to attend to other system tasks, such as coordination, data manipulation, and other supervisory functions. The use of the LM628 also reduces the number of parts required for complete control of a single axis. All that is needed is the dc mo-

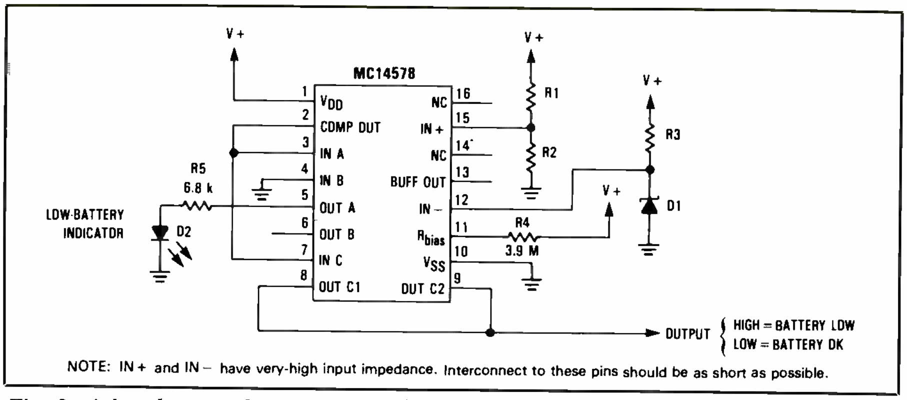


Fig. 3. A low-battery detector circuit built around Motorola's MC14578 micro-power comparator.

tor/actuator, an incremental encoder, a DAC, a power amplifier, and the LM628. The LM628's output port can drive either an 8-bit or 12-bit DAC.

The LM628 can be programmed in real time during motion activity with a wide range of control parameters, and can control motors of any size. Additional features include 32-bit internal computation capability, a 750-kHz encoder capture rate, an internal trapezoidal velocity profile generator, and a fixed proportional and integral sampling frequency of 3 kHz. Also featured is a position interrupt that is activated when the motor crosses a user-specified position.

The LM628 operates at a clock frequency of 6 MHz. It is available in 28-pin DIPs for $30 each in quantities of 100 and up. IBM PC, XT, and AT-compatible servo motor controller boards featuring the LM628 are available from Technology 80 Corp. (Minneapolis, MN). Each board intelligently controls one dc servo motor and is delivered with software to help you evaluate the LM628 in a motion control system. The boards have ±10-volt analog outputs for connection to a servo power amplifier.

Micro-Power Comparator

The MC14578 from Motorola (MOS Digital-Analog Integrated Circuits Division, Austin, TX 78762) is an analog building block consisting of a very high input impedance comparator and a voltage follower used to monitor the noninverting input of the comparator without causing circuit loading.

The MC14578 can function with voltage inputs ranging from 3.4 to 14 volts. The quiescent current is rated at 10 microamperes at room temperature, which allows an extended battery life for applications using batteries as either the main source or as back-up power.

Included on the chip are four enhancement-mode MOS field-effect transistors (MOSFETs). These FETs can be externally configured as either open-drain or totem-pole outputs. For safety, the drains have static-protecting diodes on the chip. Another feature is the electrostatic discharge (ESD) protection circuitry present on all input pins.

In a system design application, only one additional component is required for proper comparator operation. A 3.9-megohm resistor rated at ±10% must be installed between the reference bias pin and V+.

Typical applications for the MC14578 are: signal pulse shaper, threshold detector, low-battery detector, line-powered smoke detector, and liquid/moisture sensor. A low-battery detector circuit is shown in Fig. 3.

The MC14578 is priced at $1.34 when purchased in quantities of 500 to 999.

Ground Fault Interrupter

The LM1851 from Raytheon Semiconductor (350 Ellis St., Mountain View, CA 94043) is a controller for ac outlet ground fault interrupters. The device detects hazardous grounding conditions (for example, a pool of water and electrical equipment connected to opposite phases of the ac line) in consumer and industrial environments. The output of the LM1851 triggers an external SCR, which, in turn, opens a relay circuit breaker to prevent a harmful or lethal shock.

The LM1851, by complying with U.S. UL943 timing standards, ensures maximum immunity to false triggering due to line noise. Additionally, there is circuitry to reset a timing capacitor in the event that noise pulses introduce unwanted charging currents. A flip-flop is included to ensure firing of even a slow circuit breaker relay on either half-cycle of the line voltage when external full wave rectification is used.

The LM1851 can be configured to detect both normal faults (an unintentional electrical path, between the load terminal of the hot line and the ground, as shown by the dashed lines in Fig. 4A) and grounded neutral faults (an unintentional electrical path between the load terminal of the neutral line and ground, as shown by the dashed lines in Fig. 4B).

A typical ground fault interrupter circuit is shown in Fig. 5. It is designed to operate on 120 V ac line voltage with 5 mA normal fault sensitivity. A full-wave rectifier bridge and a 15,000-ohm/2-watt resistor are used to supply the dc power required by the LM1851. A 1-microfarad capacitor at pin 8 used to filter the ripple of the supply voltage is also connected across the SCR to allow firing of the SCR on either half cycle.

When a fault causes the SCR to trigger, the circuit breaker is energized and the line voltage is removed from the load. At this time, no fault current flows and the timing capacitor (C_t) discharge current increases from threshold current I_{th} (the value of current set by the external resistor R_{set}) to 3 times I_{th}. This quickly resets both the timing capacitor and an output latch on the chip. The circuit breaker can be reset and the line voltage supplied to the load, assuming the fault has been removed.

A 1000:1 sense transformer is used to detect the normal fault. The fault current, which is basically the difference current between the hot and neutral lines, is stepped down by 1,000 and fed into the input pins of the operational amplifier through a 10-microfarad capacitor. The 0.0033-microfarad capacitor between pin 2 and pin 3 and the 200 picofarads between pins 3 and 4 are added to obtain better noise immunity. Normal fault sensitivity is determined by timing capacitor discharging current I_{th} (set by R_{set}).

Grounded neutral detection is accomplished by feeding the neutral coil with 120-Hz energy continuously and allowing some of the energy to couple into the sense transformer during neutral fault conditions.

The LM1851 is available in an 8-lead plastic DIP and an eight-lead small-outline package. Pricing is $1.19 in 100-piece quantities. Transformers can be obtained from Magnetic Metals (21 St. and Hayes St., Camden, NJ 08101). ME

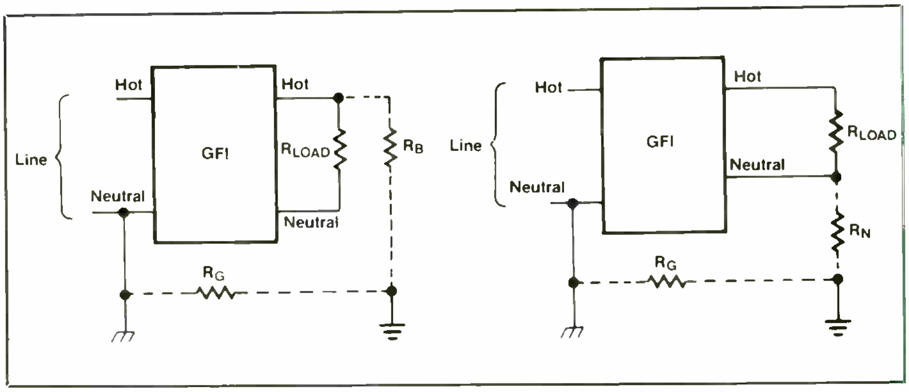


Fig. 4. Raytheon's LM1851 ground fault interrupter chip can be configured to detect (A) normal unintentional electrical-path faults between the load terminal of the hot line and ground and (B) grounded neutral faults where an unintentional electrical path exists between the load terminal of the neutral line and ground (dashed line.).

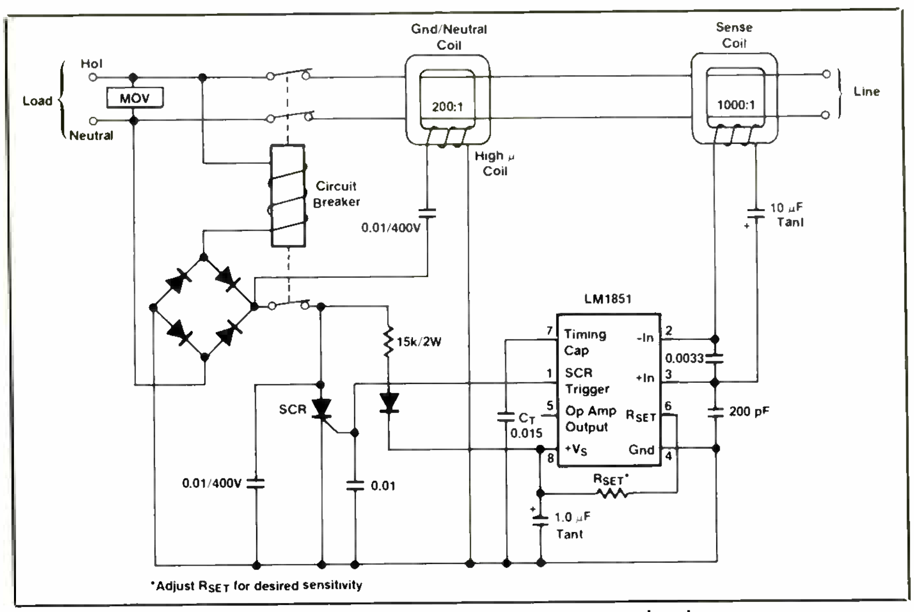


Fig. 5. A typical ground fault interrupter circuit.

And the Winner Is . . .

By Ted Needleman

I have to admit that I really like laser printers. In the various professional endeavors I'm involved in, the speed and quality that these printers provide really make a difference. In the last year or so I've come across several software packages that make the laser printers I use even more useful or fun. And while none of the three packages I'll discuss are of earthshaking importance, they all meet a specific need.

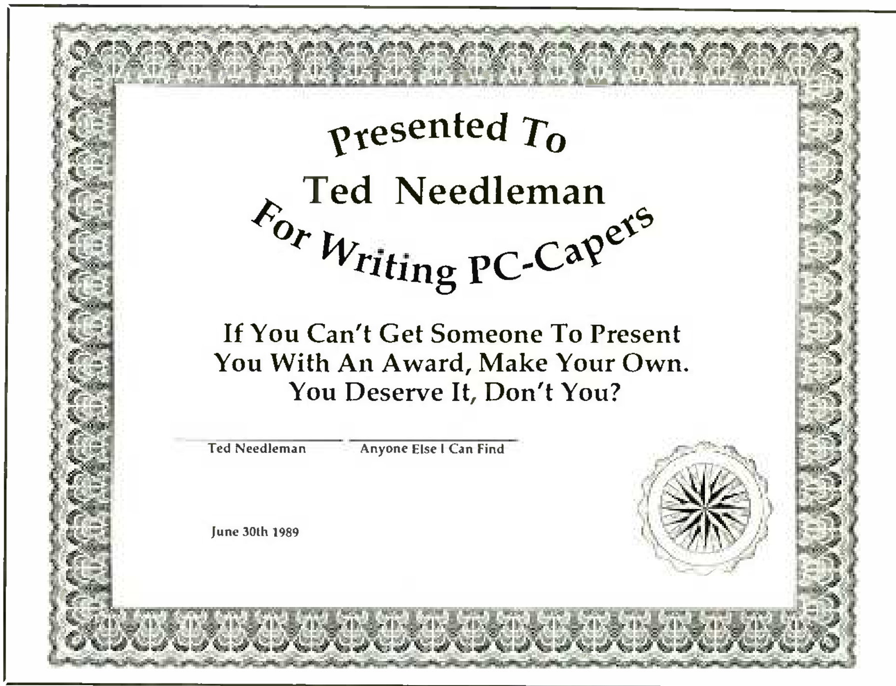
Top Honors

Producing award certificates, whether they are serious or humorous, is a big business in the printing industry. Just go into your local card shop and chances are that you'll find a display offering "Mother of The Year," "Best Golfer" and a number of other awards available for purchase. The prices for these seem to vary greatly. I've seen them for as little as $2 and as much as $7 or $8.

In the past, I've used Certificate Maker, from Springboard Software, to make a variety of certificates and awards. The package is inexpensive (about $40), available for different computers, easy to use, and produces its certificates on a dot-matrix printer. The only problem with it is that the output looks like it was produced on a dot-matrix printer. When I set my laser printer into its Epson emulation mode, with the hope that my certificates would look more like laser-printed documents, I wound up with awards that still had a dot-matrix look (though the dots themselves were very sharp!).

When my oldest boy turned four recently, I thought it would be fun to make up "Certificates of Appreciation" for his friends who attended his birthday party. I had just received Springboard's newest product, Top Honors, and decided to give it a try.

Top Honors is a Macintosh-based package. It requires a Mac Plus, SE, or Mac II with at least 1MB of RAM, a PostScript printer, and Apple's System V4.2 or above and Finder V6.0 or above. The System and Finder are not supplied on the program disks, so if your Mac has an earlier version of these, you'll need to upgrade before you can use Top Honors.



A typical example of an award certificate printed on a laser printer using "Top Honors" from Springboard Software, Inc.

The software is specifically designed to enable you to create custom awards and certificates, and doing so is extremely easy. After you've installed the software on your hard disk, or made working copies if you're going to be using floppies, you may also want to install several fonts. Springboard provides a bonus font, "Old German," which can be installed with the Font/DA Mover system utility. If a PostScript laser printer is installed and turned on when Top Honors is started, you can use any of the fonts the printer offers in laying out your certificate; the software interrogates the printer as to what fonts are available.

If a laser printer is not immediately available, or is turned off, you will have to design your certificate with whatever fonts are installed on your Mac. Later, when you go to print the certificate, you can substitute a laser font for those used in the layout.

Using Top Honors is a snap. Choose which orientation (horizontal or vertical) you want for your certificate, then start assembling it. The first step is to choose a border. Top Honors provides 24 patterns for you to choose from, and if you feel ambitious, you could even create your own with many of the available illustration or drawing programs and add them to the Borders file. Then use the mouse to double-click on the areas of the certificate you want to work on. There is the Award wording itself on the top of the certificate (for example, In Appreciation, Certificate of Merit, Diploma, etc.), an area to fill in the particulars, a signature area, and places for a seal. You can have up to four signature lines, with a date line.

You can use up to three graphics on a certificate; one seal (Springboard provides seven different ones), one EPS (Encapsulated PostScript) that can be resized and grayed to provided a tinted background image, and one MacPaint

PC CAPERS...

graphic. If you have clip art available to you, or if you've created your own graphics with another package, these can easily be used in your awards.

One outstanding feature of Top Honors is the ability to input a list of names and print a series of certificates using one, several, or all of these names on individual certificates. To accomplish this, use the phrase *name* on the certificate where a person's name would ordinarily go. Then go into the FILE menu and choose "Create Name List" and enter your list of names. When you go to print the certificate, a window opens that lets you select the names you wish to have appear on each of the certificates. Top Honors then prints a certificate using each of the names you've selected.

I do have one criticism about Top Honors: it can't be used without an expensive PostScript laser printer. You can create awards and certificates on a Mac not so equipped, but you won't be able to print even a draft copy of your certificate. I'd love to see a version of Top Honors that could produce laser-quality output on the less expensive LaserJet and compatible printers. At the very least, Springboard should add the ability to print a draft-quality proof on an ImageWriter dot-matrix printer. Other than this, I think Top Honors deserves an award as an easy-to-use fun package.

3-2-1 LiftOff

As versatile as laser printers are, there are still a few things that you can't easily do with them. For example, I often submit reports in a custom binding cover set. These are report covers with the papers sandwiched between them and fastened with a set of plastic strips using a machine made by Velobind. The report covers I use are made out of vinyl, grained to look like leather and with a suede finish on the surface. While the front is gold-stamped with my company's name on it, there have been times when I wanted to put a title, or some other wording such as "Prepared For:" on the front cover.

Not only are these cover sets simply too thick to feed trough a laser printer, but even if they weren't, I'd be afraid that the heat of the process would melt the vinyl. For these types of problems I've had to resort to a friend's Kroy lettering machine. This machine essentially prints letters onto a transparent adhesive film, which is then burnished onto the object on which you want the print to appear.

It's a little annoying to have to use last generation's technology with all of the technologically advanced equipment I usually have available, but it's been the best way to solve the problem. At least it was until I received DP-Tek's 3-2-1 LiftOff. The 3-2-1 LiftOff is a combination of software and supplies that produces adhesive lift-off labels using your PC and laser printer. These labels, when produced, are then burnished onto whatever you need to label. In essence, this package turns your PC into the equivalent of a Kroy lettering system.

I found the software easy to install and just as simple to use. The program disk has an install routine that asks for a drive and directory path where you wish the software to be located. Then it transfers the files over to this directory, creating it in the process if necessary. In total, the software and included fonts require about 1.3MB of hard-disk space. These files are stored on the supplied floppy disk in a compressed format, and are unpacked during installation. This takes just a few minutes to accomplish.

When you're finished, just type LIFTOFF, and you're in the program. The software itself is very simple, and consists of two windows. The editing window, at the bottom of the screen, shows what you are typing in, while the "TAPE" window displays what will be printed in WYSIWYG (What You See Is What You Get) format. The software offers two type faces (Serif and Sans Serif) in two weights (bold and normal). You can also print each character in a point size ranging from 6 points (very small) to 60 points (almost an inch high (72 points equals 1 inch). You can also control spacing (called kerning) and the orientation (horizontal or vertical) on each character.

When you're finished editing the tape, which can be up to 11 inches long, you print it out on a special sheet of paper (a dozen of these LiftOff sheets are supplied) fed through your laser printer. Then you take the tape supplied, lay a piece of it over the characters just printed, and go over it with a burnishing tool supplied in the package. This transfers the toner onto the tape, which can then be placed on any object you could normally stick a piece of mending tape onto. This process takes longer to describe than do; I had my first transfer tape within four minutes of installing the software.

3-2-1 LiftOff does exactly what it advertises, and its $90 cost is not at all unreasonable. At the same time, I'm a little hesitant to recommend it unconditionally. The reason for this is that you probably have 97% of this package already on hand. The tasks the software performs, letting you input and edit text and then flipping it 90 degrees for printing, can easily be accomplished with any "paint" type program such as PC-Paint or Publisher's Paintbrush.

These programs give you a wider selection of fonts to choose from (though DP-Tek offers an optional font pack for $49 that adds three more fonts and 93 symbols). The plastic burnishing tool supplied with the package can be substituted for by a popsicle stick and the liftoff tape looks suspiciously like ordinary Scotch™ tape, down to the Spartan plaid on start of the roll. The only component that isn't easily substituted is the special paper (called LiftOff sheets) that you run through the laser printer.

This paper has a smooth, almost non-stick finish, and looks to me to be very similar to the freezer paper you can buy at any supermarket. But to be honest, there's no way I'm going to experiment with putting freezer paper through my $3,000 laser printer to see if this is the case. DP-Tek charges $49 for a supplies kit containing 50 sheets of LiftOff paper, an extra burnishing tool, and six assorted rolls of tape.

I have a suspicion that if someone wanted to experiment, they could put together the equivalent of 3-2-1 LiftOff's materials kit for about $4 or so. Given the large multi-thousand dollar investment a laser printer represents, and the cost of getting it repaired if you feed the wrong material through it, few people (including myself) will be that adventurous. If you have a need for it, the $90 price of 3-2-1 LiftOff isn't unreasonable, and it sure beats the current price of a Kroy lettering machine. **ME**

Products Mentioned

Top Honors
Price: $ 99.95
Springboard Software, Inc.
7808 Creekridge Circle
Minneapolis, MN 55435
(612) 944-3912

3-2-1 LiftOff
Price: $ 89.00
DP-Tek, Inc.
3031 W. Pawnee
Wichita, KS 67213
(316) 945-8600

EDITORIAL

(from page 6)

After you come to a computer-type conclusion, there are other factors to weigh, such as whose brand, how much memory, hard disk's access speed, and so on. Joe doesn't go into such details here. Answers to these are more easily made than the major ones discussed herein.

One last thought. If you're in the market for a computer now, don't wait for the next design advance. The upcoming 80486 microprocessor will be even faster than an 80386, but the latter will not be at all made obsolete. So why wait; there's *always* something better (and likely more expensive) coming up over the horizon. Enjoy and profit by jumping to a new level of computer productivity and flexibility now. Good shopping!

Art Salsberg

The New Chessmaster 2100: Successor to Chessmaster 2000 Displays Increased Power

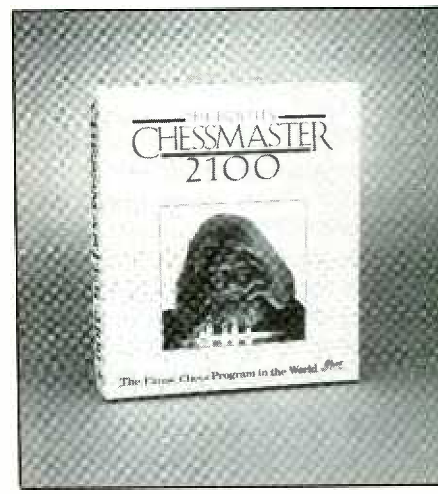
By Art Salsberg

The Fidelity Chessmaster 2100 is The Software Toolworks (Chatsworth, CA) latest chess program, superseding its winning predecessor, Chessmaster 2000 while maintaining the same low price of $44.95 for IBM PC and compatible, Apple II Series and Apple IIGS computers and $39.95 for Commodore 64/128. (Expected soon are Apple Macintosh and Commodore Amiga versions at $49.95.)

The latest program is available on either 5¼" or 3½" disks in the IBM version, which we examined. It can be used with PC/XT/AT and PS/2 systems. At least 512K of user memory is required, as is a graphics adapter, whether Hercules, CGA, EGA, VGA or MCGA, using a keyboard, a mouse or a joystick. The program is not copy-protected.

Installation is simple. Moreover, if you've used the earlier CM 2000, you'll be completely at home with the CM 2100. Whereas the new CM has unlimited levels of play from newcomer to grandmaster, the older one was limited to 12 levels. Playing hints and the teaching mode are expanded, too, as is the classic games library which adds 10 games for 110 total.

Among the most important changes is its opening move increase to 150,000 from 71,000. Some frills include a "Rate My Play" feature and voice sound that can announce your opening play line and moves.



Chessmaster display in 3-D mode.

There's a "War Room" mode that enables the player to get an overall view of lots of things, such as a move list, captured pieces, clocks and a "Show Thinking" window. You can now print games with full graphics, rather than only text, select time per move or per game or moves per minute.

A host of other advances include replaying a whole game with the program analyzing it, playing in "Two People" mode, and add your own piece sets if you have one of the popular paint programs.

The Chessmaster 2100 is a better chess player than the older 2000 by a fair degree. Furthermore, it's easier to handle for newcomers and has some glitzy things such as voice to titillate people. (The voice is on the hoarse side, though.) There's enough here to justify a new model number, though some might say a new version number would have sufficed. In any event, we liked the first model, 2000, very much as we wrote in a review about two years ago (see *Modern Electronics*, December 1987). This one's even better . . . and the price has been held. **ME**

CIRCLE NO. 101 ON FREE INFORMATION CARD

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BOOKS

Master Handbook of 1001 Practical Electronic Projects (Solid-State Edition). *Edited by Kendall Webster Sessions. (Tab Books Inc. Soft cover. 391 pages. $19.95.)*

Books like this one are very popular for the time they save by providing a host of time-saving schematics from which one can build useful devices. This book is a cut above the average for its range of topics and its focus entirely on solid-state circuitry. Every circuit schematic is accompanied by a short caption that contains information needed to get it working. For example, if a coil must be hand wound, you get complete information on how to do this. Adding to the value of this book is the claim that every circuit has been breadboarded and tested to assure the reader that it actually works. The result is a level of confidence not usually found in similar books.

Looking up a circuit is easy because the book is divided into 18 sections, each of which deals with a specific topic or several interrelated applications. One section focuses on alarms, sensors and triggering circuits; another deals with just audio amplifiers; and yet another deals with receivers, r-f preamps, converters, etc. There are specialty topics as well, like automotive circuits, power supplies, logic circuits, signal-generation circuits, test equipment, and so on. Just about any circuit one may need, short of the very exotic, is almost certain to be found in the pages of this book.

Two appendices and two indexes are provided. One appendix is an IC substitution guide, the other a listing of the electronic symbols used in the schematics. The first of the two indexes lists solid-state components by number and gives the page(s) for the schematics in which they are used appears. The other index is an alphabetical listing of the circuits contained in this book, making it very easy to find a particular circuit.

If you are an avid hobbyist or experimenter or design custom equipment, this book will be an important asset in your technical library.

Laboratory Automation Using the IBM PC. *By Stephen C. Gates & Jordan Becker. (Prentice-Hall, Inc. 322 pages + Disk. $36 hard cover; $18 soft cover.)*

Interfacing a scientific or industrial instrument to a computer to obtain automated operation is the subject of this book, which integrates the software and hardware aspects of laboratory automation. Its 15 chapters are divided into three parts. Part 1, consisting of nine chapters, starts with a definition of automation and then goes on to discuss the hardware and software aspects of laboratory data collection and instrument control. In doing so, it discusses A/D and D/A converters, noise detection and reduction, digital I/O, the IEEE-488 bus, serial communications, counters and timers, and coordinated data collection and control.

In three chapters, Part 2 discusses techniques for analyzing laboratory data. It introduces user- and programmer-friendly software and discusses peak detection and digital image processing. Part 3, also comprising three chapters, describes how to increase the power and efficiency of laboratory computer usage with a more sophisticated application of hardware and software. This part brings local-area networks into the laboratory, speeds up processes using assembly language, and discusses interrupts and direct memory access.

A wide range of BASIC program listings that perform different functions appear throughout the unusually well-written text. The authors, both of whom are associated with IBM, recommend converting the BASICA programs to QuickBASIC, C, Pascal, Fortran or Forth. All programs printed in the book are also available for direct loading on an IBM PC-compatible 5¼" floppy disk affixed to the inside rear cover of the book. The Scientific Routines diskette also includes a host of programs not printed. In addition to the listings, many tables, schematics and drawings are provided where their inclusion help explain text material.

This is an especially useful book for anyone planning to automate a laboratory. It is chock full of valuable information.

NEW LITERATURE

Test-Equipment Catalog. Now available is the complete Modular Systems catalog for 1989 from Hameg Instruments. Listed and fully described (including photos and technical specifications) are digital multimeters, milliohmmeter and LC meter; dc-to-1-GHz frequency counters; distortion meter; spectrum analyzer; tracking generator; function, sine-wave and pulse generators; and triple power supply. Each instrument listed is accompanied by listings of accessories (cables, probes, adapters, etc.) that go with them. A separate price sheet is also included. For a free copy, write to: Hameg, Inc., 88-90 Harbor Rd., Dept. ME, Port Washington, NY 11050.

Tools Catalog Supplement. Contact East's 48-page supplement to its 1989 General Catalog lists hundreds of products for testing, repairing and assembling electronic equipment. New items listed include analog/digital oscilloscopes, static-protection products, soldering stations and supplies, test equipment, and precision hand tools. Other listed items include voice/data communications test devices, tool kits, wire and cable aids, adhesives for electronics, and inspection equipment. All products are fully described, including full specifications and color photo. For a copy, write to: Contact East, 335 Willow St. S., N. Andover, MA 01845.

Full-Line Equipment Catalog. A new catalog that lists and describes the 1989 test and measurement product line from John Fluke Mfg. Co. and N.V. Philips has just been published. The 520-page catalog integrates the product lines of the two companies into 16 major categories and features 19 new products and 19 new service programs. New products issued since the last edition of the catalog are highlighted in a full-color introduction section. The full index of all products and services that follows is arranged both according to function and numerically. For a copy, write to: John Fluke Mfg., Co., Inc., P.O. Box C9090, Dept. ME, Everett, WA 98206.

Test Instruments Catalog. A 12-page catalog from RAG Electronics lists and describes new and used brand-name electronic test instrumentation for sale and lease. Listed are spectrum analyzers, ac and dc power sources, environmental chambers, signal sources and oscilloscopes. Among the brand names represented are Fluke, Hewlett-Packard, Hameg, Hitachi, Power Designs and Tektronix, among others. For a copy, write to: Keith Gertzman, RAG Electronics, Inc., 21418 Parthenia St., Canoga Park, CA 91304.

System Configuration Planner. Heath/Zenith is offering a "System Configuration Planner" for its new data acquisition and control product line. It is designed to make it easier for manufacturing and processing personnel to computerize manual data acquisition and process-control applications by walking them through digital or analog input, output and I/O systems. The illustrated chart proceeds step-by-step through logical choices in planning individualized systems and highlights the main features of modular instrument products so that users are able to quickly identify the correct components for their operations and to make adjustments when operations change. For a free copy, write to: Jim Lytle, Heath/Zenith Computer Based Instruments, P.O. Box 21, Dept. ME, St. Joseph, MI 49085.

DMM Selection Guide. The Instrumentation Products Division of Beckman Industrial has a new full-color, illustrated selector guide that describes the company's newest line of digital multimeters. The guide presents Beckman's HD150 series line of 3½-digit heavy-duty autoranging DMMs. For a free copy, write to: Beckman Industrial Corp., 3883 Ruffin Rd., Dept. ME, San Diego, CA 92123-1898.

Clock Source Ap Note. Linear Technology's "AN12: Circuit Techniques for Clock Sources" applications note contains schematics of a number of clock oscillator circuits that can replace gate oscillators and achieve better performance, greater accuracy and lower drift with time and temperature. Among the circuits presented are an oven-controlled crystal oscillator with less than 1 part per billion (ppb) drift over a 0°to 70°C range with a time drift of less than 1 ppb/week; 10- and 25-MHz crystal oscillators; temperature-compensated crystal oscillator; voltage-controlled crystal oscillator; reset-stabilized oscillator; and a stable RC oscillator. For a copy, write to: Gary Evans, Adv. Mgr., Linear Technology Corp., 1630 McCarthy Blvd., Milpitas, CA 95035-7487.

(from page 23)

Typical Base Computer Prices*				
Processor & MHz Speed	Hard-Disk Capacity	Video Monitor	RAM Included	Typical Price (Mail Order)
(Old XT Type)				
8088/4.7-8	20 MB	Mono	640K	$ 975
8086/8-10	20 MB	Mono	640K	1,150
(Old AT Type)				
80286/12	30 MB	Mono	1 MB	$1,650
80286/20	40 MB	VGA Color	1 MB	2,625
(New Generation)				
80386SX/16	30 MB	Mono	1 MB	$1,950
80386SX/20	80 MB	VGA Color	1 MB	3,050
80386/16	30 MB	VGA Color	1 MB	$3,300
80386/33	110 MB	VGA Color	1 MB	4,200

*All With Monitor, 1 Floppy & Additions Noted

the highest capacity drive you can reasonably afford.

Purchasing a 28-ms 40-MB hard disk instead of an 18-ms 90-MB drive will compromise the performance of your system. The hard-disk controller is a factor here, too. For the most part, IBM AT and compatible computers use an ST-506 MFM (modified frequency modulation) controller, which has a data transfer rate of 5 megabits per second. Many 80386 computers use an ESDI (enhanced small device interface) to double the transfer rate to 10 megabits per second. Even higher transfer rates are possible with an SCSI (small computer systems interface).

One other component of speed in an 80386 computer is the coprocessor. Whereas the fastest Intel 80287 coprocessor runs at 10 MHz, the fastest Intel 80387 coprocessor runs at 25 MHz. Another company, Weitek, manufactures coprocessors for the 80386 that outperform Intel's 80387. But while most 80386 computers include a socket for an 80387 coprocessor, relatively few include a socket for the Weitek coprocessors.

Some Words About 80386 Power

Now that we've covered the speed issues associated with 80386 computers, let's discuss power. Power comes from the 32-bit architecture of the chip and from its ability to operate in protected mode.

The 80386 has a 32-bit data bus, can address 4 gigabytes of physical memory, and supports virtual memory. The virtual address space of the 80386 is 64 terabytes. The 80386 can operate in either real or protected mode. In real mode, the processor has a real address space of just 1 MB, the same as the 8088 and 80286 processors. In protected mode, however, the 80386 has an address space equal to its virtual address space.

The benefit to the user of the 80386's protected mode is the ability to multitask or do more than one task simultaneously, like run a database program while you are typing a letter. Protected mode is what keeps the instructions and data from one task from interfering with the data and instructions from another task.

Although the 80286 processor has the ability run in protected mode, it has compatibility problems with software written for the 8088 and 8086 processors when in that mode. The 80386, however, has no compatibility problems. Instead it provides an 8086 virtual machine mode that many software designers have taken advantage of.

For example, with Windows 386, you can run two or more tasks simultaneously in different windows, each with a full 640 KB of memory available to it. The effect is like having two or more computers on your desk instead of one. Keep in mind though, that performance degrades according to the number of virtual machines that are running at the same time.

The 80386SX

The final aspect of 80386 machines to consider is the relatively new 80386SX chip. This chip was designed by Intel so that manufacturers could make a low-cost version of an 80386 computer. The basic difference between the 80386 and the 80386SX is that the SX version has a 16-bit data bus path while itself processing instructions at a 32-bit clip. This eliminates any need for 32-bit memory in the system, while still maintaining the ability to run 386 software. Although SX machines run at clock speeds of 16 MHz and higher, the need for total system speed is not as pronounced as the need for compatibility. The microprocesor's cost has come down recently, making an 80386SX machine more competitively priced against an 80286 computer.

Pros & Cons of 80386 Computers

For heavy computing needs such as desktop publishing and CAD/CAM, it's imperative to have an 80386 computer. In fact, any graphics-based programs cry out for the power of the 80386. An 80386 computer will make any computerist's life a joy, however, no matter what the task at hand. Tasks that take minutes to finish on an 8088 computer are finished in seconds on an 80386. And, of course, the 80386 is best suited for multitasking operations.

Are there any drawbacks associated with an 80386 computer? Well first there is price. Although a bare-

"… less clear on which bust to take into the 1990s."

bones 80386 system may be offered at a relatively low cost by some manufacturers, this can be deceiving because the components needed to make it reach its full potential are costly. Also, for people who desire speed and multitasking, there may be an initial level of disappointment since the high speeds cannot be maintained for multiple 8086 virtual machines in use simultaneously.

A suggested 80386-based system would be one with a clock rate anywhere from 20 to 33 MHz running at zero or less than one wait state, 2 MB of RAM, eight expansion slots (two 8-bit and six 16-bit), one proprietary 32-bit memory slot, cache controller and 32K static RAM, shadow RAM capability, a VGA graphics adapter and multiscan monitor, a 5.25" 1.2-MB floppy drive, a 90-MB hard disk drive with 18-ms average access time and ESDI controller, and parallel and serial ports.

A suggested 80386SX system would be one with a clock rate of 16 to 25 MHz running at zero or less than one wait state, 2 MB RAM, five expansion slots, a 3.5" 1.44-MB floppy drive, and the same video and hard disk drives as above.

You can purchase 80386 or 80386-SX computers in computer stores or through mail order.

In Conclusion

IBM-compatible computers break down into several groups, depending on the microprocessor used and the computer's bus structure. The microprocessors are the 8088, 8086, 80286, 80386, and 80386SX. The bus structure choices for now are the classic bus and the Micro Channel bus.

An 8088 computer is best suited to do character-based word processing and other light tasks. It's by far the least-expensive machine choice. Anyone who needs speedier performance should consider either an 80286 or 80386 computer. If you want to work with a graphics interface such as Windows, an 80286 computer can do the job, but an 80386 can do it much better, with its ability to do true multitasking. An 80386SX has capabilities similar to the 80386, but a computer system with this chip sacrifices optimum speed.

As far as buses go, the classic bus has been the bus of the 1980s, but the Micro Channel may well be the bus of the 1990s, with its bus-master capability.

It seems clear that the chip and therefore the computer for today and the foreseeable future is an 80386. (There will be an 80486, we know, and advanced versions beyond it. But right now, they're not here in any volume.) However, it seems less clear as to which bus is the right one to take into the 1990s though MCA leads.

There are a lot of other factors that have to be mixed in before coming up with a sensible buying decision, price and supplier support aside. Weighing in heavily will be whether or not the computer(s) is for personal or business (profit-making) reasons. For the latter, it almost always makes sense to buy with an eye to the future, whether it's for reasons of speed, advanced software, data storage expansion, and so on. Accordingly, a computer system with an 80386SX will likely be the starting point, whether classic or MCA bus. No less than a 40-MB drive will do here, with 80 MB or so really really more desirable from a long-term investment view.

For personal use, much depends, on how personal it is and the spare money that's available. Will part of the computer's use be for business reasons? Are you studying engineering and plan to use it for CAD/CAM purposes?

In addition to the foregoing considerations, which only observe a few things to weigh, do you intend to go the IBM-format route? Perhaps an Apple Macintosh would be more appropriate . . . or a Commodore Amiga . . . or an Atari ST? Should this be the case, look for coverage of non-IBM types in a following issue.

the circuit-board assembly in the floor of the enclosure. Then drill a mounting hole for the control and entry holes for the plug-in wall power supply's cord and the incoming telephone line cord in the back panel. Finally, drill a series of small holes in the top panel to permit the sound from the speaker to escape. If you are using a metal enclosure or drilled holes through a metal panel, deburr them to remove sharp edges.

Secure the speaker in place, centered over the small holes you drilled for the sound to escape, with a thick bead of silicone adhesive. Allow the adhesive to set undisturbed for several hours and preferably overnight before proceeding.

Meanwhile, mount the VOLUME control in its hole and route the free ends of the plug-in power supply and telephone line cords through their entry holes. If there is a connector on the end of the either or both cords, clip it off and discard it before routing the free ends into the enclosure. Also, if you drilled the entry holes through a metal panel, line them with small rubber grommets. Tie a strain-relieving knot in each cord.

Prepare the free end of the power-supply cable by separating the two conductors a distance of about 1½ inch. Strip ¼ inch of insulation from the ends of both conductors, tightly twist together the fine wires exposed in each conductor and sparingly tin with solder. Use a dc voltmeter or a multimeter set to the dc-volts function to ascertain the polarity of the conductors with the power supply plugged into an ac outlet.

Making certain to observe correct polarity, plug the conductors of the unpowered power supply into the holes provided for them in the circuit-board assembly and solder into place. Then mount the circuit-board assembly into place with ½-inch metal spacers, 4-40 × ¾-inch machine screws, lockwashers and nuts. Locate the three wires for the VOLUME control and crimp and solder them to the lugs of the panel-mounted control as shown.

Carefully remove 1½-inch of outer plastic jacket from the free end of the telephone line cable. You need only the red- and green-insulated conductors of this cable. Strip ¼ inch of insulation from the ends of the red- and green-insulated conductors (clip away any other conductors you might have exposed when you removed the outer plastic jacket).

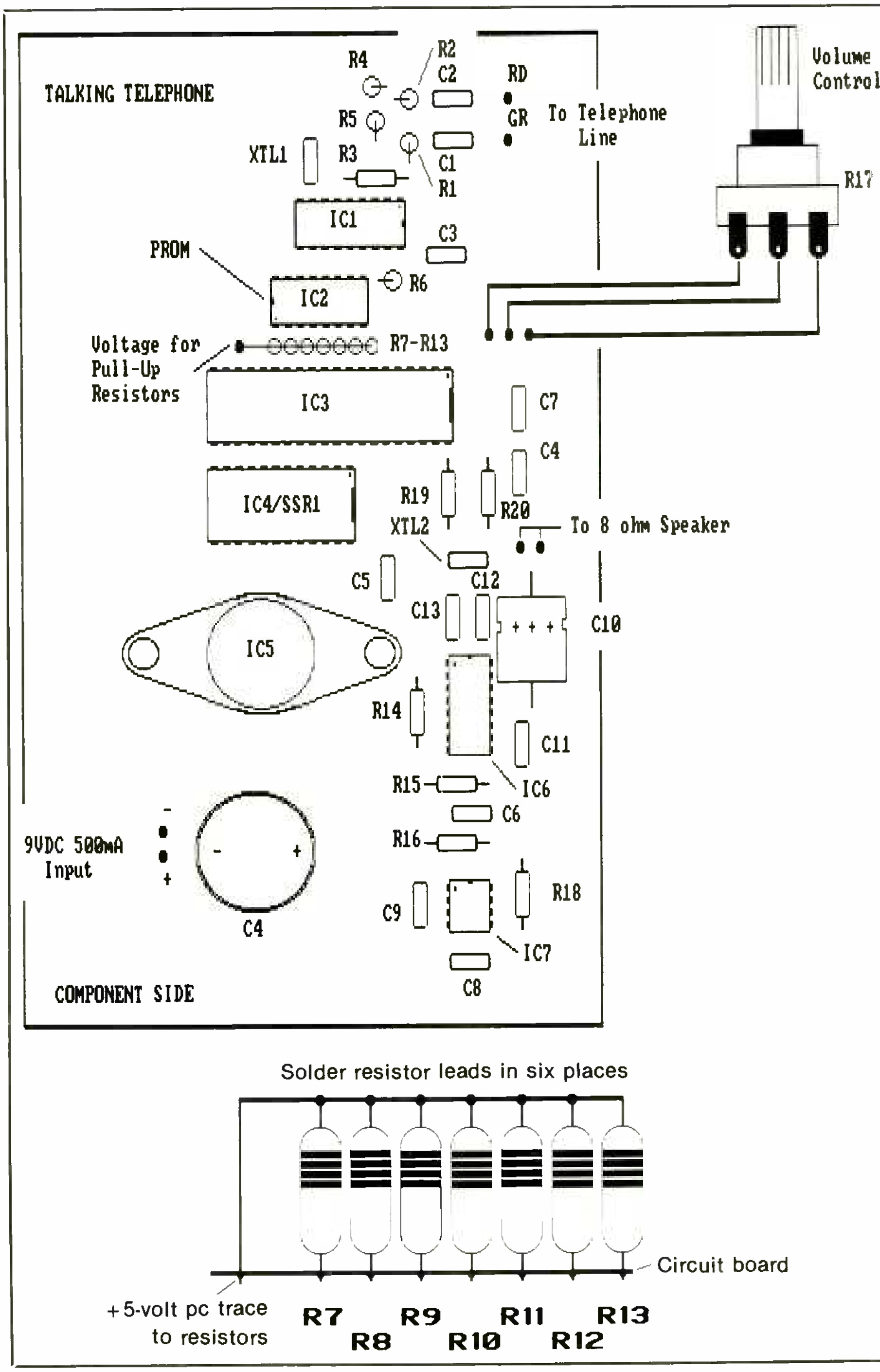


Fig. 9. Wiring diagram for printed-circuit board, with detail for mounting resistors on-end.

Tightly twist together the fine wires in each conductor and sparingly tin with solder.

As you did for the power-supply cord, plug the ends of the conductors in the telephone line cable into the holes provided for them in the board. Observe proper color coding before soldering these conductors into place.

Checkout & Installation

With only voltage regulator *IC5* installed on the circuit-board assembly, clip the common lead of a dc voltmeter (or multimeter set to the dc-volts function) to a convenient circuit-ground point in the project. Plug the power supply into a convenient ac outlet. Then touch the "hot" probe of the meter to pin 18 of the *IC1* socket, pin 16 of the *IC2* socket, pin 40 of the *IC3* socket, pin 24 of the *IC4* socket, pin 4 of the *IC6* socket and pin 6 of the *IC7* socket. In all cases, you should obtain a reading of +5 volts.

If you do not obtain the correct reading at all points, touch the "hot" probe to the OUTPUT pin of regulator *IC5*. Once again, the reading obtained should be +5 volts. If not, touch the "hot" probe to the INPUT pin of the regulator and note if you obtain a reading of approximately +9 volts. If not (or if a negative reading is obtained), power down the project and double check the polarity of the input voltage from the plug-in power supply. Correct the problem before proceeding.

Once you are certain that you have properly wired your Talking Telephone, unplug it from the ac line. Allow a minute or so for the charges to bleed off the electrolytic capacitors. Install the ICs in their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

At least two of the ICs in this project—*IC3* and *IC4*—are delicate MOS devices that require special anti-static handling procedures. Make sure you ground the project and yourself before attempting to remove these devices from their carriers and installing them in their sockets.

When the silicone adhesive has set enough to prevent the speaker from moving around, place the top half of the enclosure alongside the bottom half. Crimp and solder the free ends of the remaining two wires to the lugs of the speaker.

Without connecting the Talking Telephone to a phone line, just plugging its power supply into an ac outlet will cause the Digitalker to automatically announce: "This is Digitalker" in a female voice. This indicates that a majority of the circuitry is operational.

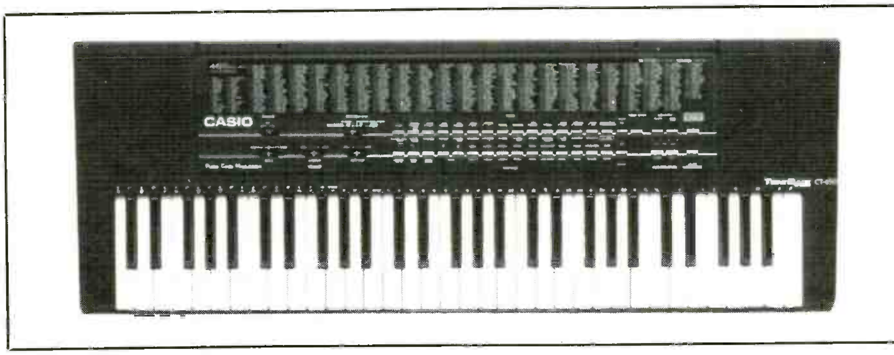
To further test the circuit, plug the telephone line cord into a standard telephone jack and set the VOLUME control to about halfway. If you do not have a free telephone jack into which to plug the project, use an adapter that will let you plug two devices into a single jack.

Lift the receiver of a nearby tone-dial telephone instrument that is connected to the same line to which the project is connected. Press each button and listen for the appropriate vocalization of the corresponding word from the Talking Telephone. Test all 10 buttons on the dialing keypad. Be sure to hang up between groups of three numbers so that you do not complete an unwanted call.

When you have ascertained that the project is operating properly for all 10 numeral buttons on the keypad, press the "*" and "#" buttons. You should hear a tone burst from the speaker as you press each of these two buttons.

When the project is not in use, the Talking Telephone should be turned off. You can accomplish this in either of two ways—unplugging the power supply from the ac outlet or installing a toggle or slide switch in series with the +9-volt line from the power supply to the project. **ME**

NEW PRODUCTS • • • *(from page 15)*



Electronic Keyboard

Casio's Model CT-650 standard-size electronic keyboard offers "Tone-Bank" capability that makes possible up to 465 combinations. It is ten-note polyphonic and has dual speakers with stereo delay and panning. It also has 12-bit PCM instrument sounds with "ToneBank" layering capability. Other features include: 20 background rhythms using 46 PCM sound sources; the Casio Chord auto-accompaniment system; and "real-time" and "operation" memory.

The keyboard is MIDI-compatible for personal-computer use, and it operates on D-size cells, which are included, or from ac line power via an optional adapter. $399.

CIRCLE NO. 160 ON FREE INFORMATION CARD

Talking Translators

Seiko Instruments USA, Inc. has announced two new hand-held electronic audio translators. Called the Voice Station Talking Translator for Travelers, the pocket-size device is available in French and Spanish versions (Models TR-7200 and TR-7100, respectively). Each contains more than 300 useful phrases that cover virtually everything from finding a hotel to ordering from a menu.

To operate either Translator, the user simply finds the required phrase in an accompanying Phrase Guide, which is organized by category. Next to the printed phrase is a number, which can be found on the Translator by pressing either the Fast-Forward or Reverse button until it appears in the display. Once the Play button is pressed, the user can listen to the phrase in the foreign language for which the Translator is designed through an earphone. A Replay button permits the phrase to be repeated as many times as necessary for the user to master pronunciation of the phrase. Among the categories listed in the Phrase Guide are: customs and immigration, shopping, touring, health problems and meeting people. $129.95.

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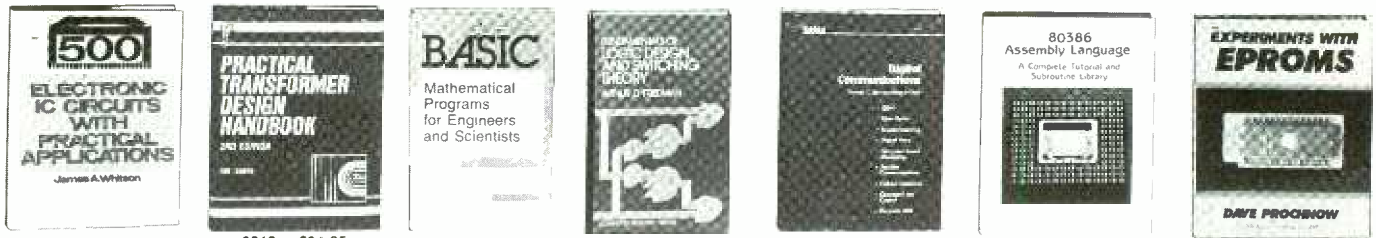

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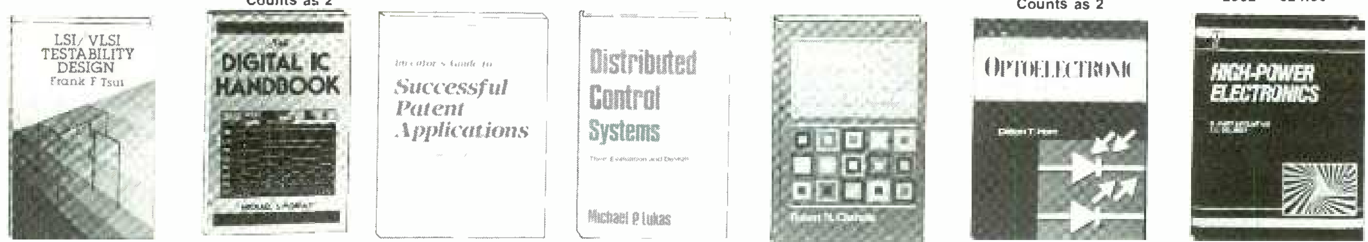

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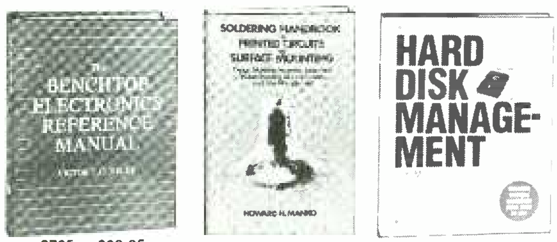

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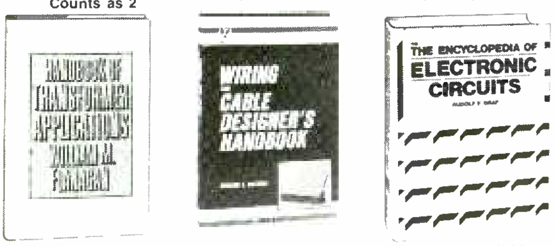

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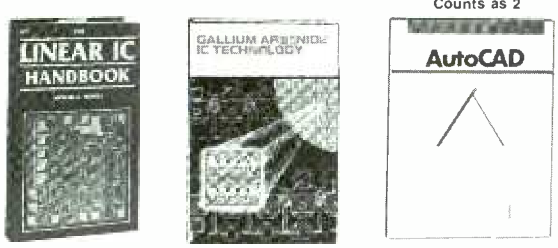

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Last month I reviewed improved hard disk performance from proper interleaving. This month's topic is memory interleaving.

Although as important to memory design as access time, CYCLE time is seldom discussed beyond the board designers lab. ACCESS time is the time it takes a memory chip to either make its contents available to the processor (read), or store the data that the processor wants saved (write). CYCLE time is equal to access time plus precharge time. PRECHARGE time is the time it takes the memory chip to restore its internal charge after a read or write cycle. In many processor designs, the critical timing factor that prevents back to back memory accesses is the precharge delay, because without it, the processor could run full speed ahead with no WAIT states.

Interleaved memory is used to nullify that delay. First the memory is divided into left and right banks. The processor then accesses the memory by alternating from one bank to another. While the left bank is recovering from an access (precharging), the right bank is ready to go; on the next access from the left bank the right bank recovers.

While not all accesses are sequential, and sometimes the memory request will be to the same bank that was last accessed, the vast majority will be interleaved and the machine will run at NEAR ZERO wait states because of interleaving.

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27128	16384x8	250ns	12.5V	28	4.25
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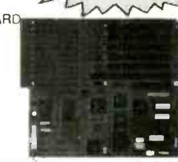

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(from page 45)

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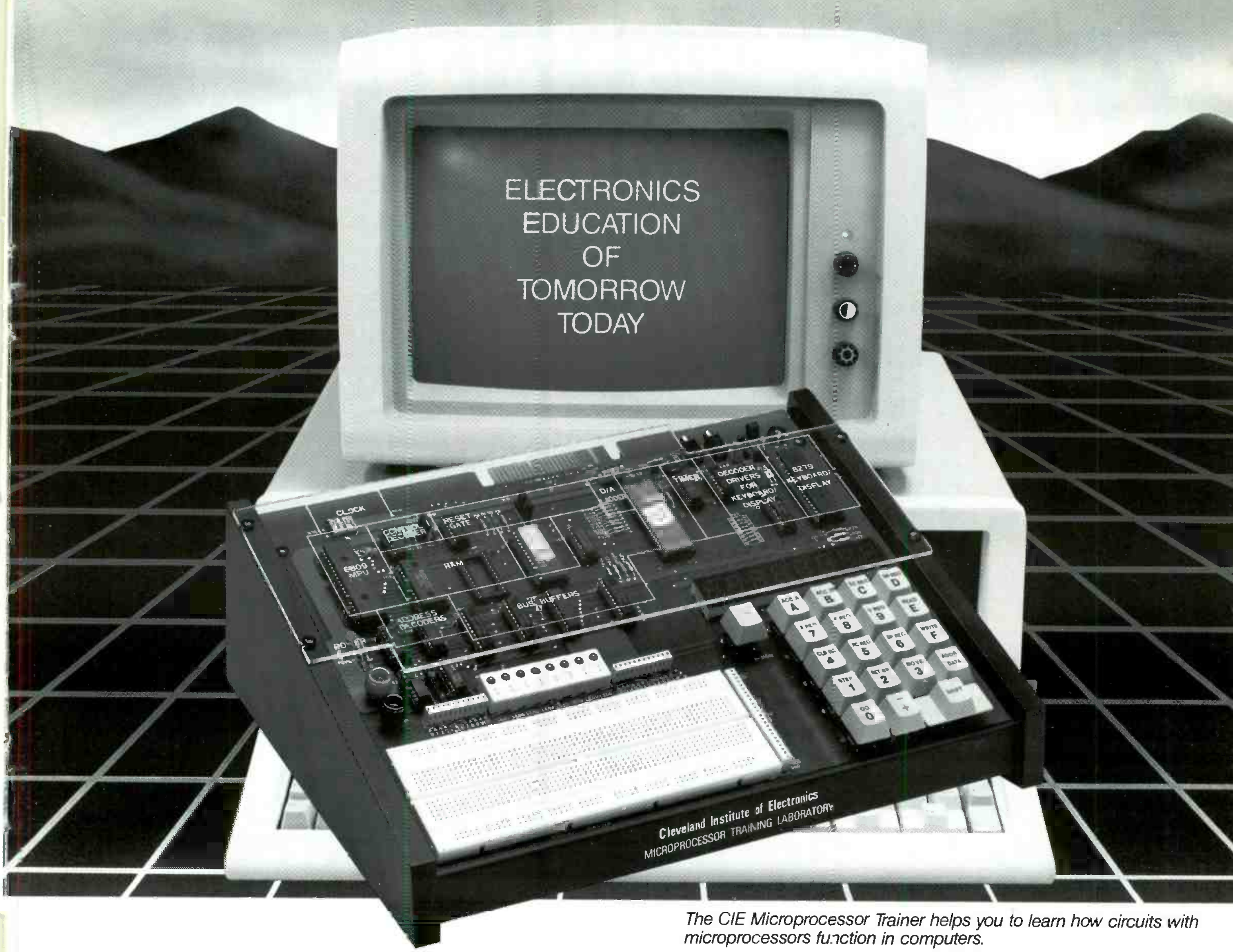

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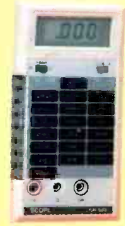

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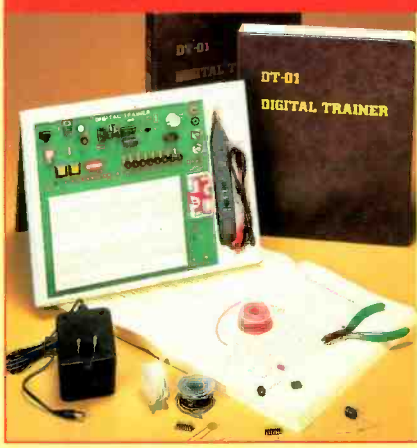

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