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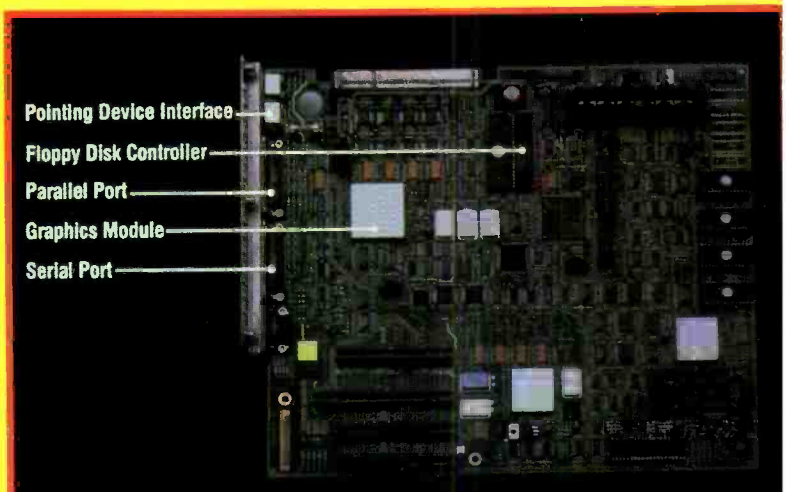
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

Light-Activation Projects:

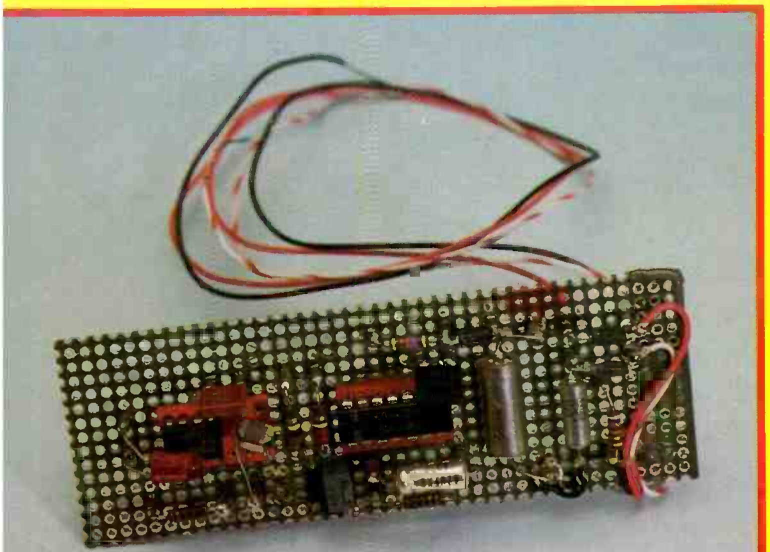
- Twilight Car-Headlight Alert
- Phone-Activated Lamp Timer

Plus:

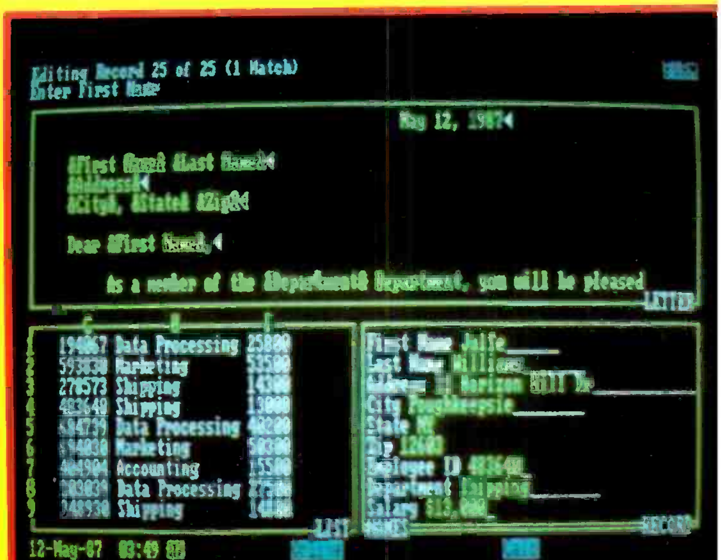
- Scope Test Applications Guide
- IBM's New Personal Computers
- A Variable-Pulse Generator for Digital Troubleshooting
- English-Language Shortwave Schedules



IBM's New Personal Computers (p. 16)



Twilight Sentry Car Accessory (p. 42)



Lotus Symphony 1.2 Reviewed (p. 76)

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Also: Forrest Mims Discusses Magnetic Field Sensors ● Don Lancaster on the Newman Motor; Linear Stepper Motors & Drivers; Robotic Bearings ● Integrated-Software Reviews: Lotus Symphony 1.2 & PFS:First Choice ● Electronic & Computer News . . . and more.

BSR's Endangered Colossus

Prepare for bone jarring bass and dramatically clear highs from these newly developed 15" 3-way 5 speaker systems that nearly missed their chance to charm an audiophile's ear. BSR moved its dbx and ADC divisions into one facility and these speakers almost became orphans. So now, they're yours at a close-out price.

By Drew Kaplan

It's a shame. But, it's also a great opportunity to get a pair of 15" audiophile loudspeakers with the newest in stereo imaging at a market-breaking price.

Imagine a precisely matched mirror image pair of top-of-the-line BSR speakers that can effortlessly recreate the cataclysmic impact of a full orchestral crescendo at full volume and yet offer flawlessly subtle sound detail to 21,500hz.

You'll thrill to thunderous bass all the way down to 26hz. Incredibly rich, full, vibrant sound at low volume will explode with life as you increase the volume.

But before we examine the front speaker complement, the twin overlapping crossovers and **the top mounted sonic placement and ambiance speakers**, let's see why they were almost orphaned.

You see, BSR, the half billion dollar electronics giant, is the parent company of two of the best names in up-scale audio, dbx and ADC.

Last year dbx developed a new multi-thousand dollar speaker system called the Soundfield One which lets you sit virtually anywhere in your room and have full stereo imaging and terrific sound.

BSR decided to consolidate ADC and dbx into one building (still 2 companies) and put all its speaker efforts into dbx.

POOR JACK

Well, while dbx's engineers were off designing their multi-thousand dollar masterpieces, BSR's Senior Acoustical Engineer (he had been Fisher's Chief Engineer for 10 years during its top end component stereo days), was designing BSR's radically new speaker line.

The revolutionary top of the line 15" stereo imaging pair pictured above will let you enjoy superb stereo imaging without sitting directly in front of your speakers.

But unfortunately, in the consolidation move, BSR's speakers went by the wayside, and so did Jack.

Enter DAK. After a few fearful negotiations and considering the engineering costs BSR had already expended, they agreed to make the speakers just for DAK.

Because there's virtually no BSR overhead left on these speakers, and the R&D was all but complete, we've gotten these speakers for virtually the component costs plus a little BSR labor.

And don't worry about Jack. BSR had him finish the engineering (they really are great people) and they'll pay him a royalty on each speaker we sell. Besides, by the time you read this, Jack is sure to be snapped up as the Chief Engineer at another esoteric audio company.

WHAT'S STEREO IMAGING?

Stereo imagery is the logical separation and interaction between channels. It's the successful creation of a panoramic wall or stage of music rather than the confined, easily located 2 speaker sound.

IT'S WHAT'S INSIDE THAT COUNTS

Imagine the full thunder of a kettle drum, or the pluck of a string bass being explosively recreated in your living room. BSR's 15" sub-bass acoustic suspension driver will revolutionize your concept of low clean bass.

Its magnetic structure weighs a thundering 48 ounces. But that's not all. The magnetic field is developed by the rare earth metal Strontium for state of the art massive but flawlessly controlled bass.

A 38mm voice coil with a 200° centigrade temperature capacity, will handle the most demanding digital or analog recordings. And, a new super rigid cabinet design virtually eliminates coloration due to uncontrolled cabinet resonance.

At low volume, the bass will fill in and envelop you. At high volume, your room, your walls and your neighbors will shake. (Not for apartment dwellers please.)

MATCHED PAIRS

The mid-range and high end of BSR's speakers are truly unique. Front mounted 8" polypropylene mid-range drivers provide rich sound while top mounted 5" polypropylene mid-range drivers provide an open, lifelike ambiance.

Front mounted exponential horn tweeters provide awesome brilliance to 21,500 hz, while top mounted tweeters enhance separation because they are mounted to the outside edge of each speaker.

So, this system has a specific left and a specific right speaker. You'll find wide, but interactive separation that will vastly widen your ideal listening area.

The imagery will give the illusion of musicians actually playing in front of you. Your music will take on a three dimensional quality. You'll enjoy superb stereo imagery regardless of each speaker's specific placement in your room.

MORE SPECIFICS

The exponential horn tweeters, both in front and on the top of these systems, employ 25mm rigid phenol diaphragms for stability and accurate response.

Polyamid-imid binders and ferro-fluid coolant allow for a 300% increase in heat dissipation so you can drive the voice coils up to 200° centigrade.

Now, the mid-range. Both the 8" front firing and the 5" top firing polypropylene drivers reproduce the mid-range frequencies like no ordinary speakers.

It's amazing that so many speaker manufacturers simply slap in 5" paper mid-ranges to reproduce what's really the major portion of the sound spectrum.

BSR's 8" and 5" polypropylene mid-ranges are rigid, exacting drivers that deliver incredibly pure uncolored sound. They have matched 25mm voice coils, also protected by ferro-fluid and polyamid-imid to 200° centigrade. They are driven by powerful barium ferrite magnetic fields.

NOT QUITE FINISHED YET

To prevent phase shift and cancellation, two totally separate crossover networks are employed in these speakers.

All frequencies below 800 hz are directed to the 15" woofer. The front system routes frequencies above 800hz to the 8" mid-range to take full advantage of its superb reproduction capabilities. Frequencies above 3400hz are routed to the horn tweeter.

The top mounted system routes only frequencies above 1200hz to the 5" polypropylene ambiance mid-range driver, and frequencies above 3400hz are routed to the top sonic placement tweeter.

There are level controls for both the top and front mounted speakers so that you can voice the speakers to match your musical taste and environment.

Note: Only the top tweeters are mounted at the the edges. The front mounted tweeters are conventionally mounted for acoustical symmetry.

Each speaker is fuse protected for up to 200 watts peak, 150 watts continuous power. You can operate these super efficient speakers with as little as 20 watts.

AND OH WHAT A PRETTY FACE

The speaker systems are 30" tall, 19¼" wide and 10½" deep. Their lovely oak wood-grain appearance is enhanced by the dark removable grill cloths that beautifully contrast with the rich wood-grain tones. They're a statement of audio elegance when placed in any room. They're backed by BSR's 2 year limited warranty.

A COLOSSAL DREAM COMES TRUE RISK FREE

You'll hear depth of sound at low levels that was previously unobtainable. And yes, when you crank up the volume, your music will explode with realism and drama.

Try these speakers in your own system. Then compare them at any Hi-Fi Store with any pair of speakers up to $1000. If they don't beat all the competition hands down, simply return them to DAK in their original boxes within 30 days for a courteous refund.

To order your matched pair of BSR top-of-the-line 15" 3-way 5 speaker systems with unique stereo imaging risk free with your credit card, call toll free or send your check for DAK's market-breaking price of just **$299** for the **MATCHED PAIR** plus **$34** for Postage and Handling. Order No. 4868. CA res add tax.

It's a dream system for an audiophile. Sonically pure, thunderously powerful, these BSR speakers will make your future listening years an on-going fabulous, if not earthshaking experience.

DAK INDUSTRIES INC.

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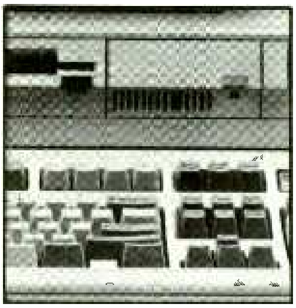

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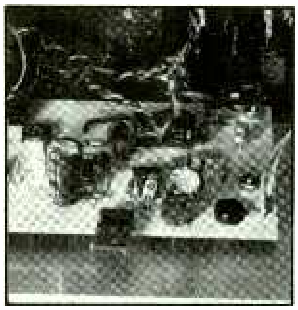

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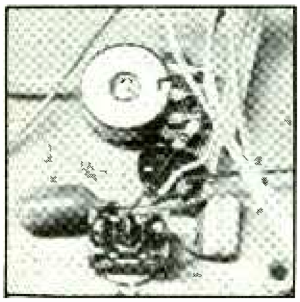

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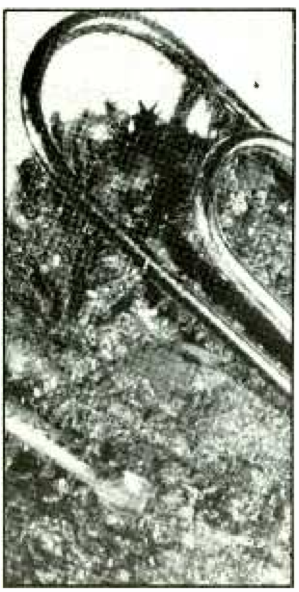

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EDITORIAL

Killing the Golden Goose

You can stretch a thing only so far . . . before it breaks. As an example, in a quest for more state income, congressional legislation was introduced to force mail-order outlets to charge out-of-state buyers sales tax. What gall!

Congressman Byron Dorgan (D-North Dakota) introduced this bill, limiting imposition of this repulsive tax to companies with $5-million or more sales. His cohort, Representative Jack Brooks (D-Texas), is a bit kinder, suggesting a $12.5-million exemption ceiling.

It's claimed that state governments lose $1.5-billion every year in sales tax to out-of-town sales of merchandise. Even if this figure is accepted, the amount is easily made up by keeping local delivery service businesses healthy. Additional workers needed to deliver merchandise all pay local and state income tax; tax is paid on vehicles needed for transportation; tax is paid on gasoline; bridge and tunnel fares are collected, etc.

Mail-order buyers pay merchandise shipping charges, of course, which balances out a sales tax. With sales tax on top of this, the onerous added cost burden would deter many prospective buyers from going this purchasing route.

If this were to happen, everyone would lose, I think. Mail-order buying opportunities represent a convenient way to obtain merchandise for people who live in most parts of our country because local retail stores generally don't carry all the desirable products that one might want. Even stores in the largest cities cannot supply the needs of its inhabitants in many product areas. Like electronic parts.

Aside from additional consumer costs that a sales tax would impose, can you imagine the bookkeeping hardship inflicted on the mail-order company in distributing sales tax money to 50 states instead of the one state it's located in? Furthermore, how in the world would this ever be enforced by 50 states? Imagine each state expanding its work force to just handle these taxes, let alone face the challenge of enforcement. It would be a bureaucratic nightmare . . . and a very costly one at that.

Many states do have laws allowing collection of sales tax on merchandise bought from out-of-state companies, but they aren't implemented. The U.S. Supreme Court, in fact, ruled 20 years ago that these laws were not enforceable. Nevertheless, Congress can topple this ruling.

Rep. Dorgan says that passage of his bill would remove unfair competition waged by mail-order outlets since local stores impose sales taxes. I don't agree. Shipping charges balance it. Local stores offer an opportunity for one to buy and receive a product immediately as well as return it and get a replacement or refund the same day. Mail-order companies, in turn, offer lower product prices and a wider choice of goods. So the competition is very well balanced in my view.

As ridiculous as this sales-tax bill might seem to be, with its high implementation costs and prospects of one state not being able to enforce the whole thing in another state, I wouldn't blithely toss this proposal out as one that Congress will not favor. I've seen wilder decisions made. As an example, in my Long Island, New York area, it was recently learned that students in a low-income area were being given after-school tutoring for which they were paid $3.35 per hour as an inducement wage to attend! Proponents of the program say that the program would be dead if this were not done, even though teacher and maintenance personnel payments would be continued for this purpose, and that this is equivalent to rewards that rich people give to their children for this purpose. (Really?) With this boondoggle in mind, you would do well to write your congressman and register an objection to this oppressive proposal. That is, if you want to ensure the existence of plentiful mail-order outlets and lower prices.

Art Salsberg

Correcting the Correction

• In your April 1987 issue, you printed my correction of the "EPROM Programmer For the Commodore 64" (November 1986). You made a few mistakes, though. In Fig. 2, pin 18 of IC2 is actually pin 16, not pin 15. There are two chips which have pins 16 going to +5 volts. You did not note the fact that IC3 is the one to change pin 16 to pin 20.

Brian L. Miller
Johnson City, TN

WordStar 4.0

• I read with interest your review of WordStar 4.0 in the June 1987 issue, along with a few others. I honestly can't tell you how amused I am at the reactions of old die-hard WordStar troops to the news that their ancient wheezer of a word processor has finally been patched into something resembling a modern program. Congratulations to all of them: they can pay more for a reasonably powerful word processor that—Halleluja!—retains the clunky old WordStar user interface than they would for a truly powerful, modern program like WordPerfect or Word. Both of these are easier to use and cheaper than the new WordStar. They both also have all of the features you listed in your future wish-list for WordStar, as well as many more.

C'mon, let's face it: it's time for WordStar to die and go to CP/M heaven. The microcomputer world has had revolution after revolution in the time since WordStar—admittedly powerful for its period—first appeared. Stretching the program all out of shape to fit it to MS-DOS machines, and stretching it grotesquely to accommodate modern features while retaining the same hoary interface, is silly. WordStar 4.0 is an overpriced attempt to combine old WordStar's familiarity with an ill-thought-out array of modern features, and it works about as well as you'd expect under those handicaps.

If you're truly in love with WordStar, stay with your patched-up version 3.31. If you want a truly powerful, full-featured, modern and easy-to-use word processor, get WordPerfect or Microsoft Word. They are the true "word stars."

J. Daniel Gifford
Citrus Heights, CA

It's true that the word processors you cite are leaders among the high-power ones available. The review did observe that the new WordStar has a way to go and that enhancements in the next end-of-the-year version will likely cure some weaknesses. Nevertheless, the learning curve being what it is, WordStar 4.0 is still a natural selection for old WordStar troops. Cost for users of earlier versions is extremely low, too, making it a truly great buy in this case. It runs rings around a patched-up version 3.31, so why should one stick with it at this time? In defense of WordStar, note, too, that Sidekick's notepad, among others, uses WordStar's control-key conventions, not others, so familiarity spreads across many programs. Ignoring all the forgoing positive attributes of WordStar, which one shouldn't do, WordPerfect and Word are indeed superior at this time.—Ed.

DIGITAL AUDIO TAPE RECORDERS. Technics, among others, has introduced a digital audio tape recorder (DAT), though its availability and price have not been announced yet. The recorders use the same recording/playback system as the compact disc on a cassette about half as large as a standard audio cassette. When analog input signals are received, a digital-analog converter records them as digital signals on tape and an analog-digital converter changes the signals for playback. The system uses a rotating head. A host of convenience features such as random access programming and high-speed search are incorporated.

TEMPEST COMPUTER SHIELDING. Specially shielded computer and communications equipment that's qualified under a DOD program will reportedly pass the $1.5-billion sales mark this year, according to market researcher International Resource Development (Norwalk, CT). Though there's talk about adapting the principles to commercial computers, it's not cheap given the high cost of fiber optics, which has a high immunity to leakage, and coating of CRT glass with thin metal film that doesn't let radio waves pass through, etc.

WIRELESS HAND-HELD TERMINALS FOR WAITERS. ESP, which stands for Electronic Service Pad, was introduced by Remanco Inc. recently. It's a hand-held computer terminal that uses FM radio to transmit food or beverage orders to the kitchen, bar or check printer. Up to 1,500 menu choices can be programmed into ESP. The company, which had merged with California-based Validec Inc., is setting up house along Boston, MA's famous hi-tech Route 128.

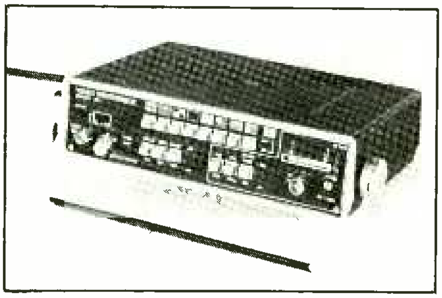
EDUCATION. A new educational VCR tape from Automatic Connector, Inc. (Commack, NY) is designed for viewers interested in buying, specifying or working with electrical connectors. The 27-minute, $35 tape covers applications and specifications relating to insertion loss, VSWR, in-line connection, panel-mounting and more, as well as details on coaxial cable, strip and microstrip lines.... Student engineers at the University of Rhode Island and Cherry Semiconductor established a joint program to produce graduates with experience in designing integrated circuits. Seniors in electrical engineering do the design work, while Cherry Semiconductor handles fabrication, which is then tested by students.

INFORMATION SERVICES. "National Business Telephone Directory" lists 8,700 electronics and electrical companies with names, addresses and phone numbers. IBM has 191 listings for its offices in the U.S.; General Electric, 483. Total businesses bound into the 1,903 pp. directory number more than 350,000. Produced by Gale Research Co. (1-800-223-Gale), it's priced at $95.... A new on-line information service, JAPAN TECHNOLOGY, offers English-language abstracts and indexes of articles from nearly 600 Japanese technical and business journals. The service is from UMI (University Microfilms Int'l.) and is offered through Dialog Information Services with an initial database of 75,000 English-language abstracts and article citations. The service builds on UMI's 1986 introduction of the printed "Japanese Technical Abstracts," and promises to change technical information exchange between the countries from a one-way road to two-way. More info on Japan Technology is available by calling Tom Satoh (202-785-160·), Linda Stott (313-761-4700); for Dialog information, call Paula Dowell (415-858-3742).

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.

Comprehensive Pattern Generator

A portable audio/video pattern generator built around custom ICs that is claimed to have four times the number of patterns and only one-third the volume of any comparable unit has been announced by NCM Electronics. Called the Video Wonderbox, it features 42 standard black-and-white and color patterns, including NTSC color bars. Video Wonderbox is designed for testing, troubleshooting and aligning VCRs, computer video monitors, and monochrome, color and cable-ready TV receivers. It features what is claimed to be the industry's first 1-kHz internally modulated frequency—the same standard test sound used by large broadcast companies. It also features one of the widest ranges of r-f channels (from channel 2 to 40) currently available in any portable audio/video tester.



Video Wonderbox's controls include a 0.5/1/1.5-volt video output selector switch, pushbutton switches for pattern and function selection, a rotary r-f level control and a thumbwheel r-f tuning control. All inputs and outputs are made through BNC connectors. The instrument measures 8″L × 5⅝″D × 2″H, weighs 2.6 lbs. and comes with a swivel tilt bail/carrying handle. $519 NTSC version; $699 PAL/SECAM version.

CIRCLE 14 ON FREE INFORMATION CARD

Bar-Code-Programmable VCRs

With the stroke of an electronic light pen, programming has become easier than ever before with two new VCRs from Panasonic. A pencil-like scanner allows users to program their VCRs directly from a bar-code function sheet included with the VCRs. The scanner eliminates the pushing of buttons. The Model PV-4722 VCR offers Panasonic's HI-Tech 4 double-azimuth four-head system that helps improve special effects in the SP and SLP modes through a new sampling method coupled with a direct-drive cylinder and direct-drive capstan motors guided by digital servo control. The HI-Tech sampling method reads twice as much information as Panasonic's previous four-head systems. Now every field of information is read, as opposed to every other field, eliminating the stepping effect from slow motion.

Features include: on-screen display; Omnisearch playback at 7× speed in SP and 21× in SLP; Search Lock for extra-quick search to locate a particular scene; Double-Fine Slow that enables the bar-code unit to present finer, more detailed slow motion at SP and SLP speeds; and 155-channel tuning range.

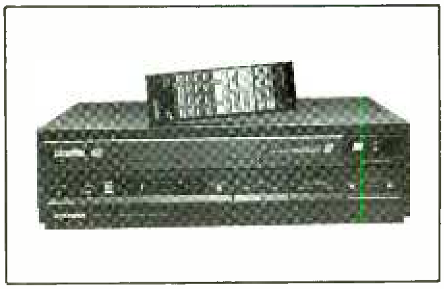
In addition to bar-code programming capability, on-screen display and 155-channel tuning, the Model PV-4761 offers VHS Hi-Fi stereo sound with a dynamic range in excess of 90, dB and frequency range of 20 to 20k Hz. It also features MTS stereo record/playback circuitry for true stereo and SAP.

CIRCLE 15 ON FREE INFORMATION CARD

LD/CD/CDV Player

Pioneer Electronics announced its Model CLD1010 player that is capable of playing the new 5-inch CD videodiscs (CDVs), compact discs (CDs) and 8- and 12-inch LaserVision discs (CDVs). In addition to adding the CDV capability, a number of audio and video enhancements have been incorporated into this third-generation combination player. Video enhancements include: 400-line horizontal resolution, improved S/N ratio of 46 dB (luminance), on-screen display that provides several informative indications on a blue background. Audio enhancements include two-times oversampling digital filtering with a S/N of 96 dB and dynamic range of 95 dB on CDs and LaserDiscs without digital sound tracks. In addition, the new remote-control functions include CX on/off for noise reduction, a digital/analog switch and a TV/LVP button for switching between TV and LaserDisc player.

Compact discs and LaserDiscs can be programmed to play back a sequence of up to 10 tracks or chapters. Editing features include programming "pause" and "autopause" between chapters or tracks and the ability to change a program once it is in play.

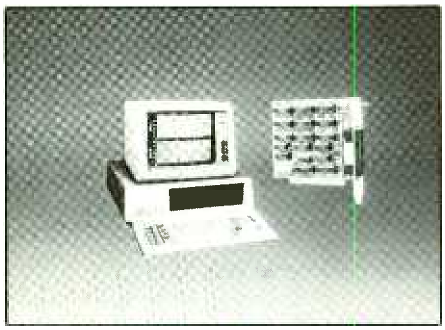


Other features include automatic front loading, automatic disc size detection, forward and reverse chapter skip and track search, time search accurate to minute and second, full random access and special effects. Five-mode repeat (side, track, memory, program and segment) is also included. Front-panel controls include open/close, play/pause, scan forward/reverse and chapter skip/track. $800.

CIRCLE 17 ON FREE INFORMATION CARD

Digital I/O Board

MetraByte's (Taunton, MA) new PIO-24 is a high-current parallel digital input/output card that allows 24 TTL/DTL-compatible digital I/O lines to be monitored or controlled by an IBM PC, XT, AT, PS/2 or compatible computer. The 24 digital I/O lines are divided into three 8-bit ports, each of which can be configured as an input or an output. Port C



can also be divided into two 4-bit ports that can be independently set up as inputs or outputs. Typical applications for the PIO-24 include contact closure monitoring, digital I/O control, plotter interfaces, etc.

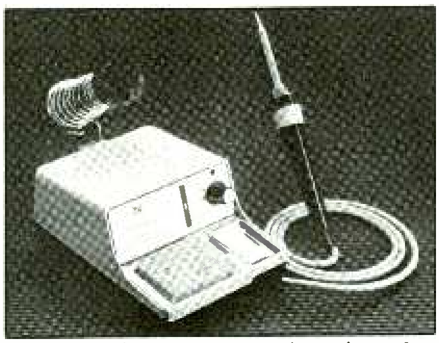
Programming the PIO-24 is said to be very easy. The board uses four addresses in the computer's I/O address space. These addresses represent one control word that simply tells the board which ports are to be inputs and which are to be outputs. The remaining three ports directly write to or read from the three 8-bit I/O ports.

Power from the computer's bus is brought out through the PIO-24's connector to allow external circuitry to be developed without the need for any external power supplies. The PIO-24 provides full access to the computer's interrupt control lines. This allows the board to be used in a wide variety of high-speed I/O interface applications. $165.

CIRCLE 18 ON FREE INFORMATION CARD

Temperature-Selectable Soldering Station

The Supertemp XY7 soldering station from Davle Tech (Fair Lawn, NJ) is claimed to offer the ultimate in controlled-temperature soldering. A



rotary switch on the station gives the user a choice of 608, 662, 716, 770, and 824 degrees Fahrenheit fixed temperatures to suit just about any soldering task encountered in electronics. Its specially insulated nichrome-wire heating element is compressed between two layers of stainless steel for ruggedness and is located at the end of the barrel to insure instant heat-up and recovery.

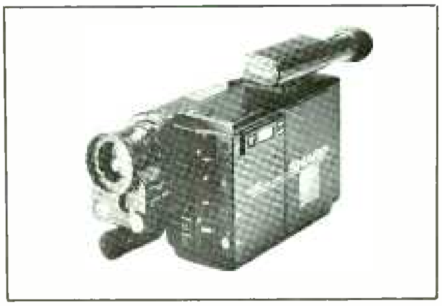
A unique electronic control circuit maintains tip temperature to within ±6 degrees, the result of embedding the thermocouple sensing unit in the bevel of the heating element's barrel so that the tip seats against it. This allows closest possible monitoring of tip working surface temperature.

Electronic "zero voltage" switching protects voltage- and current-sensitive devices (CMOS and the like) against transient voltage spikes caused in the soldering station. The soldering tip is grounded through the power unit to ensure that tip leakage is less than 0.4 millivolt and 0.03 microampere.

CIRCLE 19 ON FREE INFORMATION CARD

Lightweight VHS-C Camcorder

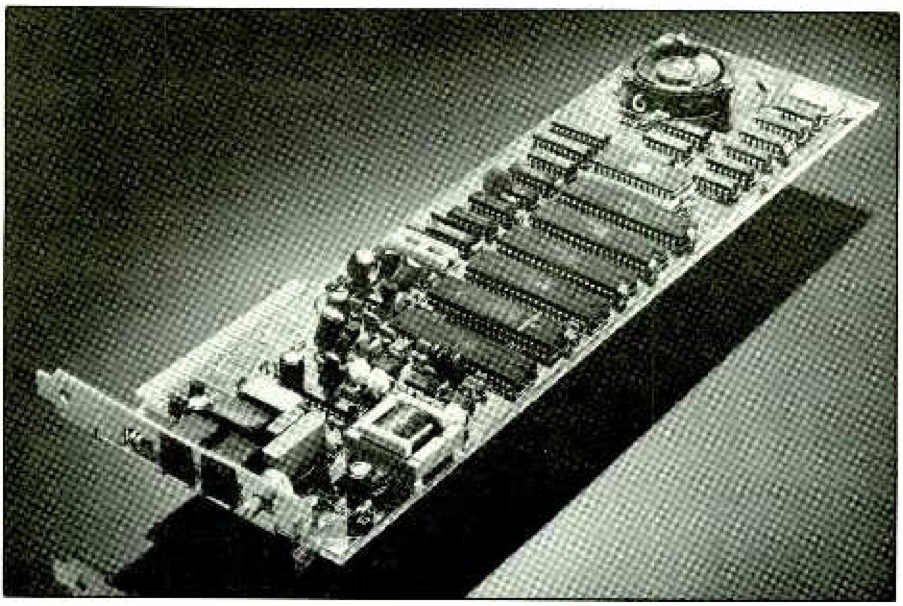
Sharp Electronics has added a new 2.9-lb. VHS-C camcorder with 1-hour recording capabilities and HQ (High



Quality) recording to its line of video products. The compact Model VC-C50UA camcorder records on an audio-cassette-sized video tape, which fits into a special full-size VHS adapter for playback on a standard table-top VHS videocassette recorder. In the extended-play (EP) mode, the camcorder can record up to one hour with the HQ system assuring crisp, distortion-free pictures.

Features include: a vibration-resistant, high-accuracy ½" CCD image sensor; F/1.6 6× power zoom lens with macro focus; automatic focus, white balance, iris control and white fader; rotating ½" electronic viewfinder; large easy-to-use control buttons; and 4-digit tape counter with memory function. The camcorder can be powered from the ac line, a battery pack or an automotive battery. $1,599.95.

CIRCLE 20 ON FREE INFORMATION CARD



1200-BPS Internal Modem

Okidata's Okitel™ 1200b full-card internal 300/1200-bps modem is designed to be used with IBM PC series and compatible computers. It comes with an offer of free connect time and discounts worth up to $150 on CompuServe Information Service or NewsNet or substantial discounts on the Dow Jones News/Retrieval Service. Bundled with the new modem is the Okitel II communications software, a custom version of Lindberg Systems' Omniterm® that provides all the features needed for error-free communications, including terminal emulation, host mode, macro compatibility and host-to-disk file capture.

Automatic Adaptive Equalization enhances the 1200b's ability to communicate over noisy phone lines. The modem looks at line characteristics and adjusts its filters automatically to bypass line interference to allow distortion-free data to reach the computer. Other features include autodial and auto-answer, tone/rotary dial compatibility, built-in speaker for call monitoring, two modular telephone plugs, in-use indicator, analog local loopback test feature, self-test function (on power-up, initialization and RAM/ROM) and Hayes compatibility.

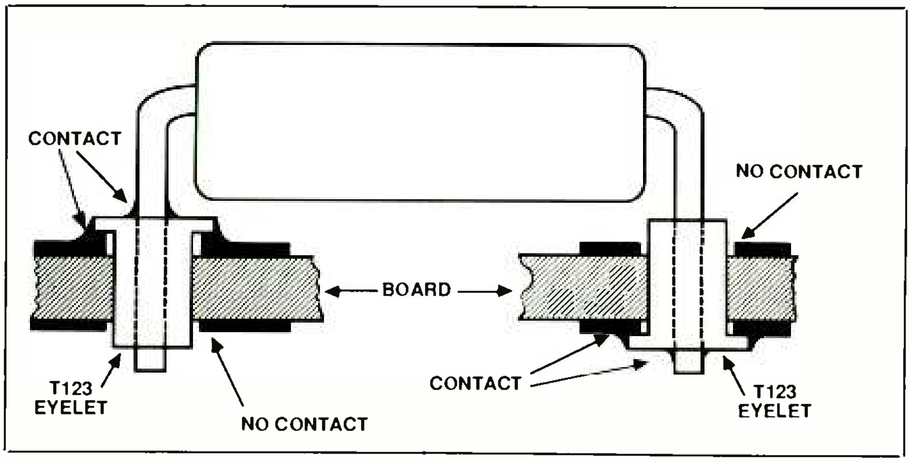
The Okitel 1200b automatically configures itself to the transmission speed of incoming calls and disconnects the phone line when a call is completed. Users can program a delay that bypasses spurious line interruptions, including call-waiting signals, to maintain the phone connection. Default settings for the modem's basic operating parameters are factory set for quick installation, but telephone and computer interface can easily be customized through simple commands entered at the computer. $389.

CIRCLE 21 ON FREE INFORMATION CARD

Computer Prototyping Boards

Vector Electronic Co. (Sylmar, CA) has a line of low-cost prototyping cards with a new circuit pattern for achieving higher performance when building circuits that employ 8- and 16-bit microcomputer chips. The boards have a matrix of 0.055"-diameter holes on 0.1" centers drilled in 1/16" FR4 epoxy-glass circuit cards. Full-size boards measure 13.25" wide for the IBM PC, XT and AT and compatible computer versions; 4.2" high for PC and XT versions; and 4.8" high for the AT version.

Holes in the copper planes on both sides of the boards are isolated by 0.085" copper-free rings. Two approaches are available to connect to the copper planes. In one, No. T123 eyelets are placed in the appropriate board holes, followed by the leads of the components. The flanges of the eyelets then make contact with the circuit plane. Solder completes the lead-to-eyelet and eyelet-to-copper plane connections. Since the eyelet is flanged on only one side, connection is made to only one side of the board. The other method is installation of socket pins with solder washers that connect the pins to one board plane. Due to the clearance area around all holes in the component mounting areas, installed leads or terminals are isolated from the circuit until intentionally connected. $42.30.



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MINICODE (N-12) VARISYNC	119.95	62.00 ea.
MINICODE VARISYNC W/AUTO ON-OFF	179.95	115.00 ea.
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MLD-1200-3 (CALL IF CH. 2 OUTPUT)	109.95	58.00 ea.
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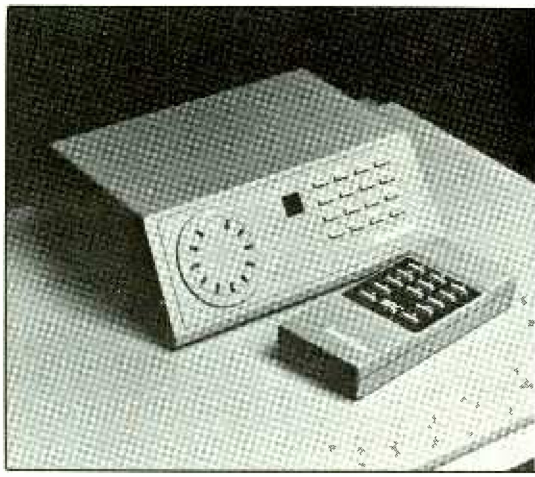
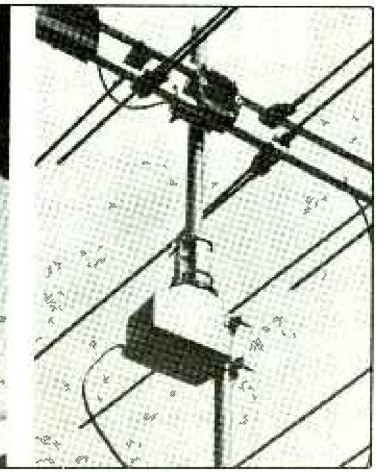




Programmable Antenna Rotator

A new programmable antenna from Channel Master is claimed to be the first of its type to feature a microprocessor-controlled memory and infrared remote control. The Model 9520's controller console is capable of storing up to 11 station directions in memory for vhf/uhf TV and FM stereo reception. A 14-function, soft-touch remote-control keypad conveniently recalls automatic antenna positioning information. A manual positioning key also permits the user to fine-tune reception on channels not stored in memory.

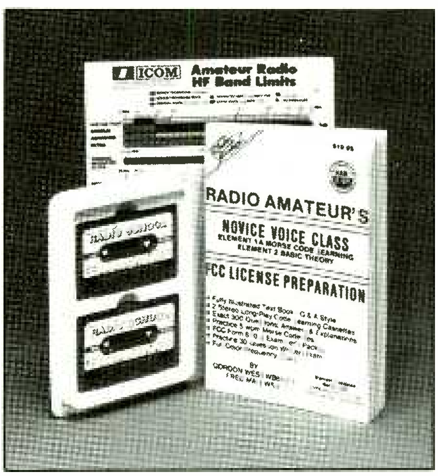
A 9-volt battery provides backup power to protect the memory against power-failure erasures, and a LED compass dial on the controller console indicates antenna positioning during operation. The system is UL and CSA approved and features three-conductor wire installation. $130 for complete rotator package; $90 for Model 9535 programmable controller and remote controller without motor drive.

CIRCLE 23 ON FREE INFORMATION CARD

Code Course for Novice Hams

Gordon West Radio School (Costa Mesa, CA) has a low-cost Morse code and theory course for people who would like to become amateur radio operators. Two long-play stereo audio cassettes cover learning Morse code and are designed for users who have absolutely no background in copying code. A Novice voice-class license preparation manual that accompanies the cassettes discusses Novice class questions and the correct and incorrect answers that can be found on the FCC test. Several chapters cover a detailed introduction to the amateur radio service, and there is an illustrated chapter on learning the International Morse Code with the cassettes.

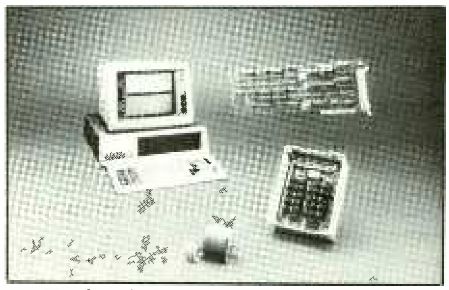
The tapes and books contain sections specifically for two ham radio operators to review the latest procedures in giving the Novice test. An FCC Form 610 and a sample Novice exam are also part of the "quick course" packet. Also included is a full-color ICOM frequency-band chart. $19.95 plus $2.00 P&H.



CIRCLE 24 ON FREE INFORMATION CARD

Stepper-Motor Control Board

New from MetraByte (Taunton, MA) is the MSTEP-5 two-axis stepper motor control board for IBM PC, XT, AT and compatible computers. It comes with software that permits user control of motors (or monitoring of encoders) with high-level, simple-to-understand commands. It allows the user to set acceleration, deceleration and maximum step rates, etc. Once initialized, the user need only provide the number of steps to move for clockwise or counterclockwise rotation. The system then controls the motor as it accelerates, reaches terminal speed, decelerates and stops after the desired number of steps. Other functions are also implemented in the software.



Each of the two stepper channels consists of an intelligent controller chip that can execute a variety of motion control commands. Once a command has been loaded, the computer is no longer burdened by controlling the desired motion, but it can monitor its status. A stepper motor can be moved any number of steps up to 24 bits of resolution (16,777,216 steps) with controlled acceleration/deceleration or at a constant step rate. Associated with each motor are five limit switch inputs and a motor-enable output. The limit switches provide normal and emergency stop limits at both ends of travel and a home or reference point at any intermediate point.

Options include a high-current stepper-motor driver board ($325); a 200-step/rev., 35-oz.-in. stepper motor ($190); and a 1,000-pulse/rev. incremental shaft encoder ($275). $595.

CIRCLE 25 ON FREE INFORMATION CARD

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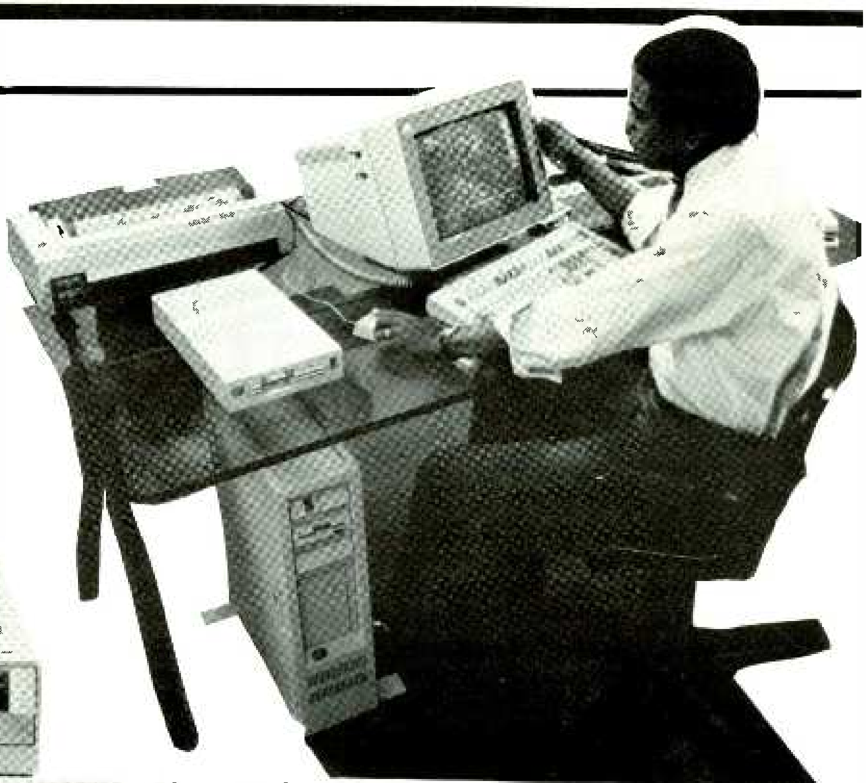
We'll Give You Tomorrow.

PS/2's Model 30, the lowest-priced new IBM computer, uses an 8086 CPU, is about 25 percent smaller than an IBM XT and operates up to twice as fast.



Floor-standing Model 80, using Intel's powerful 80386 microprocessor, is the most powerful computer in the IBM Personal System/2 family.

The New IBM Personal Computers

Big Blue drops the gauntlet with a new family of personal computers

By John McCormick

IBM's new family of computers, the Personal System/2™, represents a major change in the giant corporation's small-computer market thrust. Three of the four new models are brimming with new hardware technology and two new disk operating systems, promising to challenge the ingenuity of clone makers.

I had the opportunity to work with some of these new IBMs almost as soon as they were announced, helping a local MicroAge dealer set up the computers. I also own one of the first Model 60s sold in the country, which is a model that's right under the top one, Model 80, which is not yet available. Based on this exposure, here's an overview of the new models, starting with the lowest-priced one and working up to the top of the line, and detailing some of my experiences with them.

Model 30

The Model 30, which is available with two 3.5-inch floppy-disk drives or one floppy drive and a 20MB hard disk and integrated controller, comes with 640KB of system RAM; parallel, serial and mouse ports; and floppy controller and clock—all on the motherboard. Its color graphics subsystem, called MultiColor Graphics Array (MCGA), features 300 × 200 × 256 and 640 × 480 × 2 color graphics, with an 8 × 16 character box. So the potential of getting dazzling color graphics beyond that of EGA is there once appropriate software comes on the scene.

An 8086 microprocessor is used instead of the familiar 8088 found in many PC and XT compatibles. Its 8086 microprocessor, which is not a new chip, is fully compatible with the commonplace 8088 but runs at 8 MHz with no wait states as compared to the 8088's 4.7 MHz. It's no surprise, then, that the Model 30 runs much faster than a standard PC or XT. It's not in the AT class, though, since a relatively slow (80-millisecond) hard disk compromises its performance.

Three 8-bit expansion slots are available for optional cards. The 8-bit expansion slots are the standard PC/XT ones and will work with most older expansion boards, though they're not compatible with the new IBM bus structure used on the 80286 and 80386 microprocessor-based computers.

The Model 30's power supply has a surprisingly low 70-watt design, but its extensive use of VLSI chips and surface-mount technology apparently reduces power requirements. All the new models employ IBM's enhanced keyboard, featuring function keys aligned across the top.

Much less desk space is taken up by the Model 30 than predecessor models. It measures only 16″W × 16.6″D × 4″H, which is about 25 percent less space than used by a PC-XT.

At $1,695 for the dual-diskette version and $2,295 for the single drive and 20MB hard disk, the machine is not outrageously priced. When you consider that all you need to add are a monitor and DOS to have a complete system, this is certainly a model worth looking at if you are interested in a high-end XT-class desktop machine.

Model 50

Like the Model 30, this is a very compact desktop unit. But the Model 50 uses the more powerful Intel 80286 processor chip operating at 10 MHz. As with all of IBM's new models, a math coprocessor is optional and runs at the CPU's rate. The standard computer comes with 1MB of memory on a motherboard that's expandable to 7MB, a 20MB hard disk and a 3.5-inch diskette drive. The last works either in the 720K format, which is common to the Model 30 and many portable computers, or in the new 1.44MB high-density mode; it's also used by the Models 60 and 80. There's also provision for an optional second diskette drive that's utterly simple to install: just pull off a front cover and slide in the second floppy-disk drive.

Model 50, too, has three expansion slots. However, they are all incompatible with older PC, XT, and AT models because this model is the one that begins a departure in design from all other IBM personal computers. It uses an entirely new 16-bit Micro Channel architecture; the motherboard comes with all the ports and controllers built in, just like the Model 30. It supports up to 15 Direct Memory Access (DMA) devices, twice that of the PC bus. Together with its 10-MHz microprocessor, the Model 50 is said to move data up to two times as fast as an IBM AT, though it would seem that its relatively slow 20MB hard disk drive cuts into this gain.

A 128KB ROM (Model 30 has a 64KB ROM) adds a BASIC language interpreter and security features. Graphics support differences start here, too. The Model 50 and following new models use a Video Graphics Array (VGA) rather than the Model 30's also-new MCGA, providing 640 × 480 × 16 and 320 × 200 × 256 color graphics, as well as 720 × 400 × 16 color text mode with a finer 9 × 16 character box. The 50's power supply is rated at 94 watts.

Dimensions of this model are 14.1″W × 16.5″D × 5.5″H, which is a footprint that's also smaller than a PC or XT. The Model 50, at $3,595, is the lowest-priced machine that will also run on IBM's advanced Operating System/2 (slated to be available the first quarter of 1988) as well as the new DOS 3.3 that all four models can use.

Model 60

The Model 60 I bought, which is designed to stand on end on the floor like a small tower, came with the standard 1MB user memory, one 3.5-inch 1.44MB diskette drive with a controller that supports another one, parallel and serial ports, mouse port, time/date clock/calendar, and a 44MB hard disk. IBM's new architecture continues here as in the Model 50, with the same improved speed and color graphics capabilities. It is also plug-ready to accept another floppy drive and hard drive without buying additional controllers. Moreover, installation is so simple that many owners would want to do the job themselves.

This is the basic Model 60 unit and lists for $5,295. It's certainly not cheap, but actually not much different than a comparably equipped (and slower) Tandy 3000 (an AT clone). There are options for a second hard disk, expanding with 44MB, 70MB or 115MB drives, which are all speedy 30-ms access-time types compared to the 80-ms drives in Models 30 and 50. Also, memory can be extended to 15MB.

If you are serious about computing, need lots of room for expansion, and want a solid gateway to the future direction that IBM is taking, this is the model for you, featuring 7 open expansion slots (Micro Channel), a hefty 207-watt power supply, a high-speed hard disk in the PC-AT class (about 40 ms access time for the 44MB drive; faster for larger-capacity ones), and room for two more disk drives.

Model 80

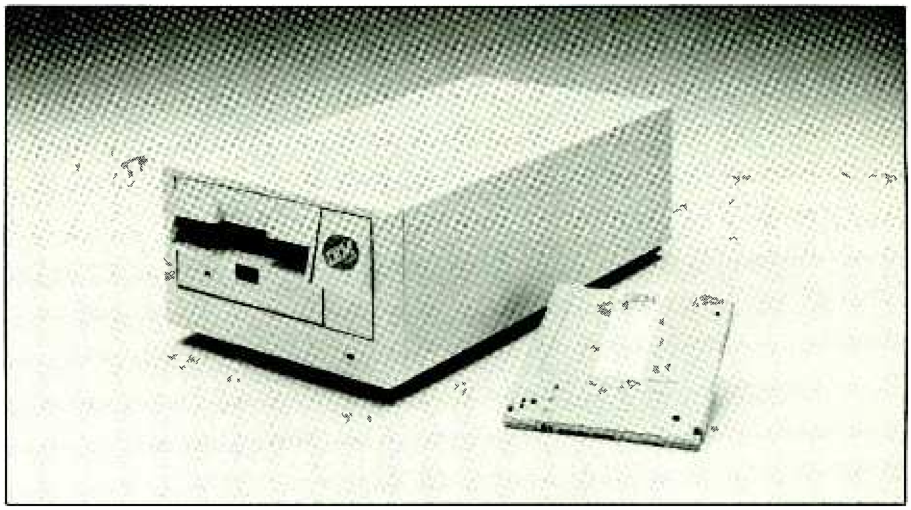
The Model 80, which should be available this fall, is the long-awaited IBM 80386 32-bit microprocessor computer. It will have a base price of $6,995 and come in both 16- and 20-MHz versions. Its speed is said to be up to 3.5 times that of the AT as compared to the 2-times speed increase maximum posted by Models 50 and 60, aided by fast 1MB RAM chips. Most other specifications are the same as the Model 60, except for a bigger power supply (225 watts), greater maximum motherboard RAM capacity (2MB), and three 32-bit and four 16-bit expansion slots for plug-ins. Memory can be expanded up to 16MB.

Model 80 is obviously the most powerful member of the new IBM family of microcomputers. It's designed to stand on the floor rather than on a desk and measures 19"D × 6.5"W × 23.5"H. A 1MB RAM/44MB fixed-disk model is priced at $6,995. IBM is pointing this model toward users who have to solve complex math and engineering problems, are involved in image processing or in handling of very demanding business applications.

High Technology

High tech pays off big in these new computers, all of which make extensive use of SMT packages and VLSI (Very Large Scale Integration) custom gate arrays to pack everything onto the motherboard. The Video Graphics Array, for example, has 12,750 gates; CMOS circuitry is as small as 1.5 microns or about 6/10,000ths of an inch. IBM developed a substantial number of the parts that go into the new computers. Up to 80 percent of what goes into the top-model Model 80, for instance, was developed by IBM. Compared to the older models' boards, these look as if IBM shortchanged you with fewer components. This impression is due, of course, to the reduced parts count made possible with custom VLSI chips. The clusters of very tiny parts include 640K (Model 30) or 1MB (Models 50 and 60) of RAM, floppy controller, serial, parallel and pointer ports, real-time clock/calendar, and graphics adapter, among other circuits. Although this means lowered manufacturing costs that can be passed on to the buyer, it could also mean very expensive repairs.

For example, my Model 60 went back to the dealer the day after I got it because it wouldn't power up reliably, and the entire motherboard was replaced. When the new motherboard arrived it showed many signs of modification, with a number of jumper wires added to the SMT board. It also arrived without the adapter needed to fit this new board into my computer. This is the sort of teething problem to be expected with spanking new computers and will probably be cleared up soon, but high tech doesn't necessarily mean clear sailing unless you're dealing with throw-away products. Cost was no problem since the Model 60 was new and under warranty.



The IBM 3363 Optical Disk Drive uses a removable disk storage device that enables PS/2 users to store 200MB of data on each one.

Compatibility

Software compatibility is easy to explain. Quite simply, these computers are essentially IBM compatible. They'll work with earlier versions of DOS (PC-DOS) and, according to IBM, most of today's applications programs will run on the new systems. Notable exceptions are some games that failed to switch VGA graphics to the correct mode (EGA), I discovered. A patch is already available for the superb Starflight program and others are expected. So if you can transfer software or get it on 3.5-inch disks there will likely be few problems. Hardware compatibility is also simple to cover. Except for the low-end Model 30, the other new Personal System/2 models aren't hardware compatible, other than for devices normally connected to RS-232 or printer parallel ports.

The Model 30, with three 8-bit expansion slots, will physically accept the old PC-compatible boards. However, they will not necessarily be able to work properly. I tested a Hayes 1200-baud modem board which appeared to work fine, but some other boards I tried did not work in the Model 30. Consequently, for the time being, the only way to be certain about hardware compatibility is to try your favorite board in the new machine.

The 16-bit data bus (Model 50 and Model 60) and 32-bit bus (Model 80) are totally new, so older PC-compatible boards won't work; the video port is only directly compatible with four new IBM analog displays, although the monitors will work with older PCs using an adapter); the 50's and 60's 1.44MB 3.5-inch floppy format is new (the 30's 720K 3.5-inch is the standard format used by other computers, as is the low-density capability of the 1.44MB drive).

Data Migration

IBM offers something called a Data Migration Facility (under $35), consisting of software and a hardware adapter that lets you transfer data and non-copy-protected programs from a PC-XT-AT compatible to the new machines using the older machine's parallel printer cable. The software is on a 5.25-inch disk to run on the older machine, and the hardware adapter is a sort of "null modem" for parallel ports.

Data and non-copy-protected programs are transferred from your older system to the new PS/2 computers using your printer cable.

The New Operating Systems

Although the new computers will run with any DOS above 2.0, they require DOS 3.0 and above to support the 3.5-inch 720K floppy format. The new DOS 3.30, in turn, is needed to format and use the 1.44MB high-density floppies and hard disks larger than 32MB. Also, it contains some files designed to make networking faster and easier to use and supports more communications ports.

You will also need the new 3.30 ($120; $75 for an upgrade) for its FILES35 receiving file so that you can use the $35 Data Migration Facility. A FASTOPEN command in 3.30 will speed access to regularly used hard-disk files, which becomes more important as hard-disk capacities increase. This file keeps track of the location on your hard disk(s) of up to 999 files, greatly reducing the time needed to locate files.

Hard-disk users can rejoice when they use DOS 3.30's BACKUP command. It finally works the way it should have in the first place! For years, DOS users have complained about it, mostly because you could back up a lot of information on floppy disks only to run out of formatted disks before you're though—and have to start all over. BACKUP now lets you pause to format more disks if needed. It also logs files and identifies the disk they're on. The new APPEND command extends capabilities of the PATH command, letting you specify non-executable files in the same way you currently specify executable files using the path command.

DOS 3.3, which can also enhance the capabilities of all other IBM personal computers, is actually an interim single-tasking disk operating system for the new models. The real impact of these new machines, excluding the lowest-priced unit, Model 30, will be felt when IBM's new Operating System/2, with a base price of $325, is available. This operating system will run DOS programs in a shell, enabling the machines to remain IBM-DOS compatible, while being able to work with IBMs right up through mainframe computers. An enhanced version will support the IBM SQL (Structured Query Language) for relational databases.

With OS/2 and the Model 50, 60, or 80, desktop database work will be an order of magnitude better, assuming new software comes along to complement it. OS/2 will be the IBM operating system designed to make full use of the vast memory addressing capabilities of the 80286 and 80386 processor chips in "protected mode" operation.

It's basically a multitasking system that lets you run many programs at the same time and features a variety of operating enhancement prospects, including concurrent communications, wide-ranging interfacing, database management with multiple-user provisions, a Window Manager, and so on. However, even Standard Edition Version 1.0, which is essentially a stripped Operating System/2, won't be available until the first quarter of 1988. Version 1.1, which adds a graphics-based Presentation Manager and windowing, won't have its availability date announced until the end of 1988, at the same time as the Extended Edition that adds communications support and database management.

Graphics

The new PS/2 computers' graphics capabilities differ from earlier models' video modes. As noted previously, Model 30's MCGA (MultiColor Graphics Array) emulates the standard CGA while adding 640 × 400 2-color and 320 × 200 256-color graphics. The other, costlier models use VGA (Video Graphics Array), which features many operating modes that go beyond EGA, although EGA standards (as well as CGA) are emulated too.

The best VGA mode with 50, 60 and 80 models produces a resolution of 720 by 400 16-colors from a pallet of 262,144 colors. With a display adapter and a memory expansion kit, one can get 256 colors on screen in a 640 × 480 graphics mode. As a comparison, in EGA mode the maximum resolution is 640 by 350 with 16 colors out of a possible 64. Model 30 owners can add the VGA mode with a $595 graphics board and one of IBM's new monitors, which will automatically sense the board's capabilities. At the top of the line, an 8514 16-inch color monitor, memory expansion kit, and display adapter board will give you 1,024 by 768 resolution for about $3,100. Here you can view up to 51 lines of text with 146 characters per line if you wish. At the other end, the 12-inch Personal System/2 monochrome monitor only costs $250 and my 14-inch color monitor sells for $595.

Numbers are just numbers, but one glance at the demo program running on any of these computers will knock your eyes out; these monitors are just spectacular (at least compared to older PC graphics).

The WORM

One almost unnoticed expansion accessory for the new systems is a 200MB optical disk selling for about $3,000. This device is a Write Once/Read Many (times) mass-storage device with an access time about half that of the Model 30 or 50 80-ms hard disks, but with easily removable media, just like a floppy drive.

This optical disk uses a laser beam to mark the disk, but you can't erase and use the disk again. Consequently, once it is full, you need to insert another cartridge. Why is this so great? Well, just for backup this is a tremendous device, providing reliable backup along with relatively fast access to the data. For businesses with accounting, correspondence, or database files which are constantly being updated, the WORM not only provides massive amounts of relatively fast storage, it also gives you complete, secure copies of all previous data.

The Model 60 can handle up to six of the 200MB WORM drives, providing over 1 gigabyte of on-line storage and an unlimited number of removable cartridges.

Conclusions

These are fast, exceptionally quiet computers that are already starting to generate 3rd-party support. I know of manufacturers who are already working on products to make use of the new bus structure, and Princeton has already announced new monitors that will work with both older computers and the new Personal System/2s.

A $495 IBM Music Feature adapter card enables the new PS/2 line to use a MIDI keyboard to compose, record and play back music from the 8086-CPU-based Model 30 computers.

Software companies have announced that they will supply their copy-protected programs on 3.5-inch disks for registered owners at nominal cost, and companies like Ashton-Tate have already started marketing their software with both 5.25- and 3.5-inch disks at a slightly higher price/package.

Will the new family of computers have a major impact on the market? It's difficult to conceive that it won't in time. The capabilities of Models 50, 60 and 80 combined with IBM's market clout are just too great for business and industry to ignore in the long run. Clearly, though, it will require a long period before the full capacity of the new systems is realized.

It's interesting to note that Model 30, which does not offer a gateway to future IBM advances, is already selling at a considerable discount in some areas. Here in central PA, however, all models are selling faster than the dealer can get them—and at full retail. Other models are reportedly being discounted, too. At the same time, IBM has substantially lowered its suggested selling prices for XT and AT models, which should give clone makers some fits.

I'm pleased with my Model 60 and have already ordered a Model 80 in anticipation of advances that the future will bring, which includes all manner of software, including CAD/CAM and personal publishing, connectivity to other equipment, etc. Immediately, though, I already have better color graphics, higher resolution and greater operating speed. Welcome, too, are the extras such as the absence of DIP switch setting requirements since the systems poll the hardware and automatically adjust settings when, say, a board is added, such as IBM's Music Feature adapter card for the Model 30 that can be used for studio recording or live performances. I look forward, too, to the common interface that coming additions from developers will bring. ME

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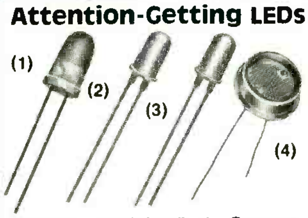

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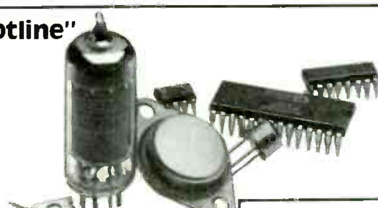

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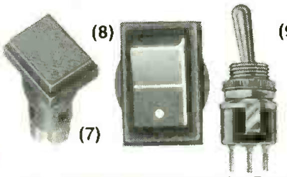

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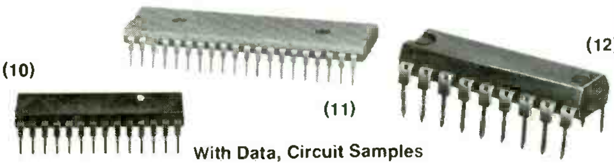

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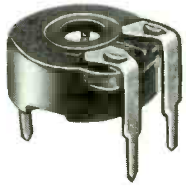

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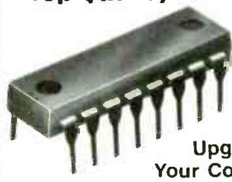

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Oscilloscope Measurements Guide

Part 2 (Conclusion)

Test procedures for sine waves, phase, Lissajous, pulses, frequency response, square waves, and dc-linearity and curve-tracer measurements

By Robert Witte

Last month, in the first installment of this article, we discussed the typical elements that make up the typical analog oscilloscope, the differences between analog and digital scopes, and the types of probes commonly used. This month, we get into actual testing procedures.

An oscilloscope produces a picture of the voltage waveform that is being measured. This allows the instrument user to think in terms of the actual waveform when making measurements. Therefore, determining zero-to-peak voltages, rms voltages and the like simply means interpreting the scope display. The displayed waveform's accuracy is subject to the instrument's finite bandwidth, internal errors and the loading effect.

Sine-Wave Measurements

Figure 9 shows a typical display of a sine wave on an oscilloscope CRT screen. The usual parameters can be determined with just a small amount of care. Peak-to-peak voltages can be first found in terms of display divisions and then be converted to volts. The peak-to-peak value of the sine wave in Fig. 1 is four divisions. If vertical sensitivity is set to 0.5 volt/div., the peak-to-peak voltage is 4 × 0.5 = 2 volts. (This value might need to be adjusted if a divider probe is used.) Zero-to-peak voltage is just two divisions, so 2 × 0.5 = 1 volt.

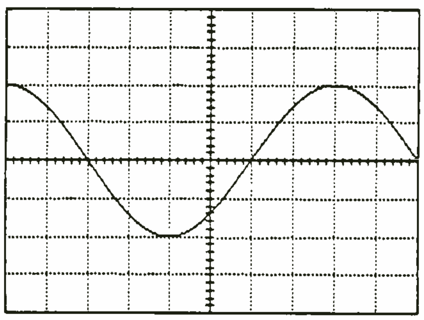


Fig. 9. Sine wave voltage measured using an oscilloscope. If vertical sensitivity is 0.5 volt/div., $V_{p\text{-}p}$ is 2 volts and $V_{0\text{-}p}$ is 1 volt.

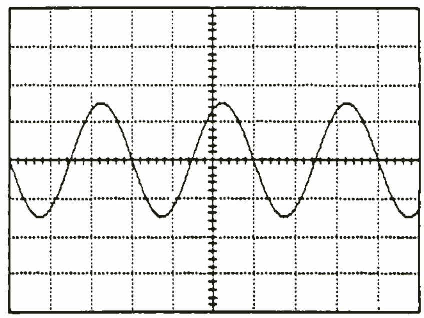


Fig. 10. Oscilloscope waveform when vertical sensitivity is 0.2 volt/div. and time base is 500 microseconds.

Root-mean-square (rms) voltage is not as easy to determine, at least not directly from many oscilloscopes. But the relationship between zero-to-peak and rms values for a sine wave is known: $V_{rms} = 0.707 \times V_{0\text{-}p} = 0.707 \times 1$ volt = 0.707 volt rms. This calculation is valid for only a sine wave, but there are conversion factors for other waveforms.

The foregoing uses the vertical scale to determine voltage information. The horizontal (or time) scale can be used to determine the waveform's period. The waveform's period in Fig. 9 is eight divisions. With the horizontal axis set at 0.2 ms/div., the signal's period is 8 × 0.2 ms = 1.6 ms. Although the frequency cannot be read from the scope directly, it can be calculated by using the period waveform

$$f = 1/T$$

The waveform's frequency in the illustration equals 1/1.6 ms, or 625 Hz. Frequency is another value that cannot be determined directly from

(Continued on page 26)

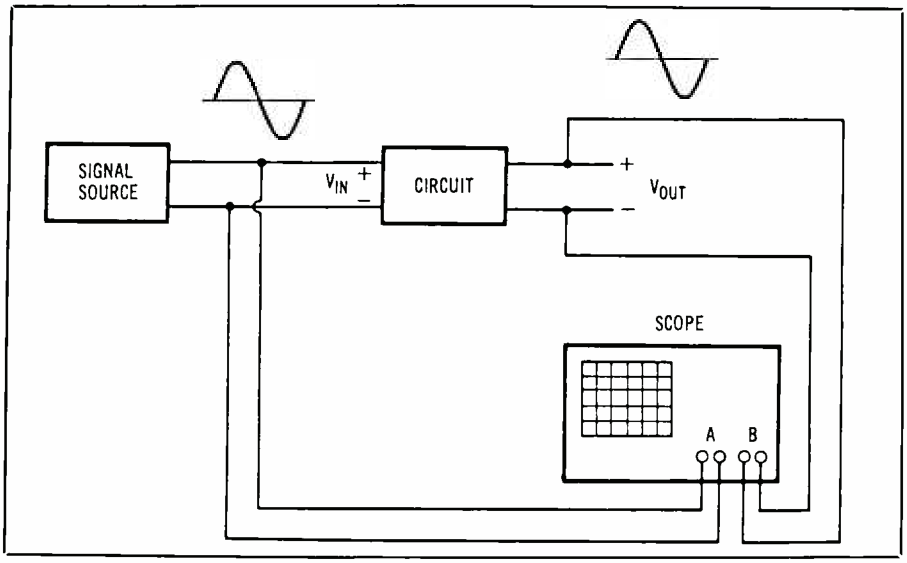


Fig. 11. Arrangement for measuring ac voltage gain of a circuit.

the oscilloscope, but the scope gives us the information needed to calculate the value.

As an example, one can determine zero-to-peak voltage, peak-to-peak voltage, period and frequency of the waveform shown in Fig. 10 with a few simple calculations, as follows:

The waveform shown here is 1.5 divisions zero-to-peak and three divisions peak-to-peak.

$$V_{0\text{-}p} = 1.5 \text{ div.} \times 0.2 \text{ V/div.} = 0.3 \text{ volt}$$
$$V_{p\text{-}p} = 3 \text{ div.} \times 0.2 \text{ V/div.} = 0.6 \text{ volt}$$

The period of the waveform is three divisions.

$$T = 3 \text{ div.} \times 500\ \mu\text{s/div.} = 1.5 \text{ ms}$$
$$f = 1/T = 666.67 \text{ Hz}$$

If a voltmeter and an oscilloscope are connected to the output of a function generator, a comparison of the two measurements will highlight the advantages of each. The scope provides a complete representation of the waveform out of the function generator. Its peak-to-peak and zero-to-peak ac values are easily read and, for most waveforms, the rms value can be calculated. If there is some dc present along with the waveform, this, too, will be evident in the voltage-vs.-time display (assuming that the scope is dc coupled). The period and frequency of the waveform can also be measured.

On the other hand, the voltmeter will supply only voltage information about the waveform. Many voltmeters will read rms, but accuracy of the reading may be dependent on the type of waveform (if the meter is an average-responding type). Also, no indication is given of the actual shape of the waveform. The user may assume a given shape, but distortion due to improper circuit operation may cause the waveform to be much different.

A voltmeter is easier to use than a scope, of course. It requires less interpretation of its display, has fewer controls to adjust, and its physical size is usually much smaller and more convenient. Voltmeters are also generally more accurate for amplitude measurements than oscilloscopes. A typical oscilloscope amplitude accuracy is around 3 percent, while voltmeter accuracies are typically better than 1 percent. However, the voltmeter provides no time or frequency information at all.

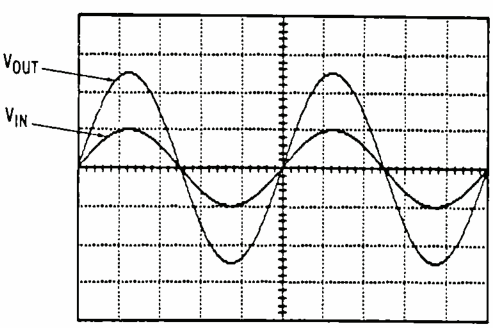


Fig. 12. Oscilloscope display for measuring gain of a circuit.

Voltage-Gain Measurement

It is often desirable to measure gain (or loss) of a circuit such as amplifiers, filters and attenuators. The voltage gain is defined as

$$\text{Voltage Gain} = G = V_{in}/V_{out}$$

where V_{in} and V_{out} are voltages at the input and output of a circuit, respectively. In other words, gain describes how big the output is compared to the input. V_{in} and V_{out} can be any type of voltage: dc, ac zero-to-peak, ac rms, etc., as long as both voltages are measured consistently. If output is larger than input, gain is greater than one; if output equals input, gain is exactly one; and if output is less than input, gain is less than one.

Voltage cain can be expressed in decibels (dB):

$$\text{Voltage Gain (dB)} = G\text{ (dB)} = 20 \log (V_{in}/V_{out})$$

If output is greater than input, gain (in dB) is a positive number. If output equals input, gain is 0 dB. If output is less than input, gain in dB is a negative number. Gain and loss are opposite terms. A gain of −10 dB (output is actually smaller than input) corresponds to a 10-dB loss.

Figure 11 shows the simplest method for measuring ac voltage gain. A source is used to supply input voltage and a two-channel oscilloscope is used to measure input and output voltages. The source can be any type capable of producing a sine wave at the frequency of interest. The resulting oscilloscope display is shown in Fig. 12. Values of the two voltages are determined from the display and the gain is calculated. If the input signal into the circuit is not critical, then it is desirable to set the sine-wave source so that the value of V_{in} is at a convenient level (such as 1 volt) to calculate gain. Again, the ac voltage can be determined in a variety of ways, but zero-to-peak and peak-to-peak will usually be the most convenient to use.

As an example, let us determine the voltage gain for V_{in} and V_{out} shown in Fig. 12, expressing the value in dB. It shows the zero-to-peak value of V_{in} = 1 div. × 1 volt/div. = 1 volt zero-to-peak and V_{out} = 2.5 div. × 2 volts/div. = 2.5 volts zero-to-peak. The voltage gain, $G = V_{out}/V_{in} = 2.5/1 = 2.5$.

Notice how easy the gain calculation was with V_{in} equal to 1 volt. Gain in dB, G (dB) = 20 log 2.5 = 7.96 dB.

Phase Measurement

The waveforms shown in Fig. 12 have no phase difference between them, but this is not always the case. Many circuits introduce a phase shift between input and output. In some electronic systems, phase shift is unimportant, but many times it is a critical parameter to measure.

The setup shown in Fig. 11 can be used to measure phase shift through a circuit. If there is a non-zero phase shift through a circuit, the resulting oscilloscope display will look something like Fig. 13. (Circuit gain is 1 for simplicity.) The scope display gives the user a direct, side-by-side comparison of the two signals to determine phase difference.

First, the sine-wave period is found in terms of graticule divisions. (Recall that one complete cycle corresponds to 360 degrees.) Next, determine the phase difference in terms of graticule divisions. This can best be done by choosing a convenient spot on one waveform and counting the divisions to the same spot on the other waveform. The starting edge

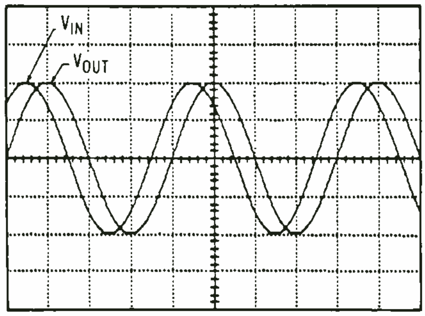


Fig. 13. Phase difference between two sine waves can be measured using time-base method.

of the sine wave (where it crosses zero) is usually a good reference point since most scope graticules have the middle of the display marked with the finest resolution. The resulting phase difference, in degrees, is:

$$\text{Phase Shift } \theta = 360 \times \text{Shift (in div.)/Period (in div.)}$$

Since interpreting the oscilloscope display is somewhat tedious, it is recommended that the user double check the measured value. This simply means taking another look at the display, roughly estimating the phase shift (knowing that one cycle is 360 degrees), and comparing this to the calculated answer. The two should be roughly the same.

The only problem remaining is to determine the phase shift (positive or negative). V_{out} is normally measured with respect to V_{in}, so V_{in} is the phase reference. If V_{out} is shifted to the left of V_{in} (V_{out} leads V_{in}), then V_{out} will have a positive phase relative to V_{in}. If V_{out} is shifted to the right of V_{in} (V_{out} lags V_{in}), then V_{out} will have a negative phase relative to V_{in}. Use of the terms "lead" and "lag" are less likely to be confusing than calling the phase positive or negative.

Since phase repeats on every cycle (360 degrees), the same phase relationship can be described in numerous ways. For example, if V_{out} leads V_{in} by 270 degrees, this will be the same as V_{out} lagging V_{in} by 90 degrees. Although both of these expressions are technically correct, it is recommended that phase differences be limited to ±180 degrees. Therefore, the appropriate expression would be V_{out} lags V_{in} by 90 degrees.

Here is how to determine phase difference between V_{out} and V_{in} in Fig. 13. The period of both waveforms is four divisions, while phase shift is 0.5 division. Thus

$$\theta = 360 \times 0.5/4 = 45 \text{ degrees}$$

Since V_{out} is shifted to the right of V_{in}, V_{out} lags V_{in} by 45 degrees

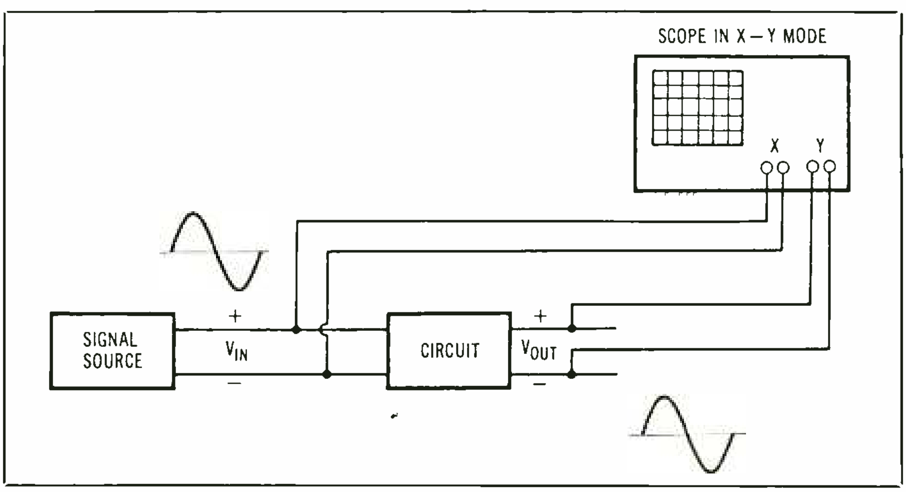


Fig. 14. The proper connection for measuring the phase difference between the input and output of a circuit.

or, equivalently, V_{in} leads V_{out} by 45 degrees.

Lissajous Method

Another method of measuring phase between two signals is called the "Lissajous method" (or Lissajous pattern). Although somewhat more complicated, this method will usually result in more accurate phase measurement. Figure 14 shows a scope connected so that phase between output and input of a circuit can be measured. The oscilloscope is configured in the X-Y mode, with one signal connected to the horizontal input and the other signal connected to the vertical input.

Figure 15 shows the elliptical shape that results from this measurement. Two values, A and B, can be read off the display and can be used to calculate the phase angle. Value A is the distance from the X axis to the point where the ellipse crosses the Y axis, and value B is the height of the ellipse, also measured from the X axis. It is important that the scope be set up with both the X and Y axes set at the 0-volt level. On most scopes, this would be accomplished by grounding both inputs and adjusting the dot on the display to be at the center of the screen. Both volts/div. controls can be adjusted to allow convenient, accurate reading of the values. The two controls do not have to be set the same, since A and B are measured along the same axis.

Two general cases must be considered. If the ellipse runs from lower-left to upper-right, the phase angle is between 0 and 90 degrees (Fig. 16). If the ellipse runs from lower-right to upper left, the angle is between 90 and 180 degrees. The angle can be calculated from the A and B values using the appropriate equation shown in Fig. 8.

Unfortunately, the sign of the angle cannot be determined using this method. If the calculated angle is 45 degrees, for example, the phase difference may be +45 or −45 degrees.

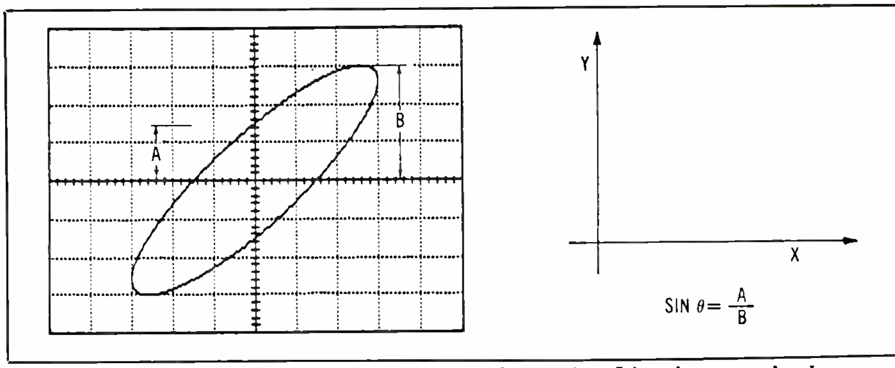


Fig. 15. Scope is in X-Y mode when using Lissajous method.

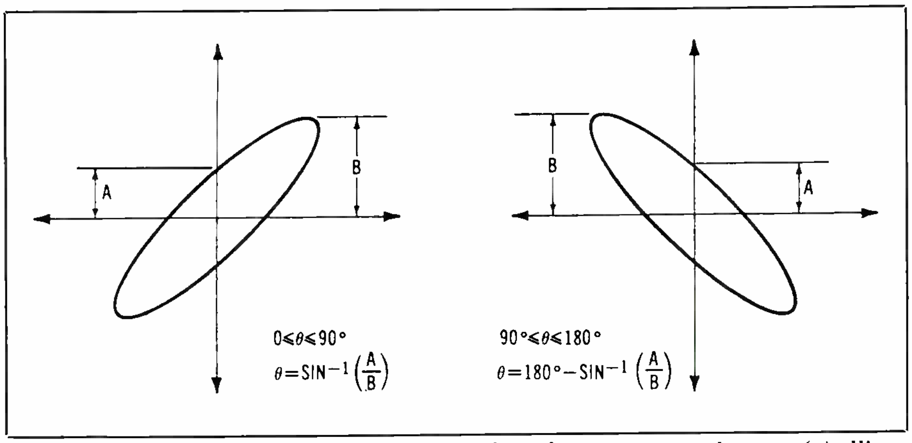


Fig. 16. Lissajous method for measuring phase has two general cases: (a) ellipse from lower-left to upper-right; (b) ellipse from upper-left to lower-right.

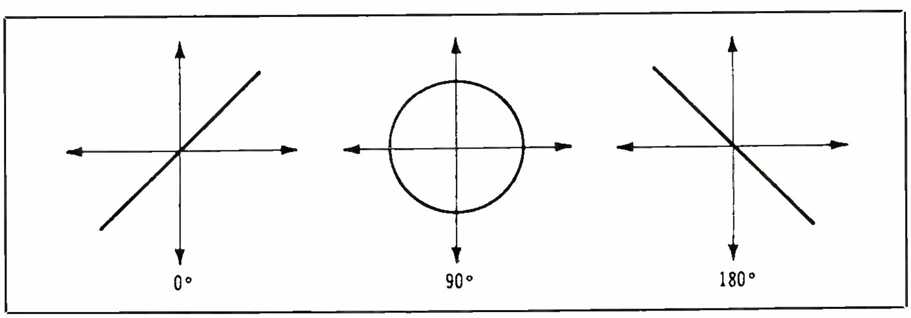


Fig. 17. Some special cases of Lissajous phase measurement.

That is, the signal on the vertical axis may be leading or lagging the signal on the horizontal axis by 45 degrees. However, the time-base method can be used to determine the sign, while using the Lissajous method for greater accuracy. A quick look using the time-base method is also a good check on the results from the Lissajous method.

Some special cases of the Lissajous display are shown in Fig. 17. Here, when the ellipse collapses into a straight line, the two waveforms are in-phase. This can also be used as a very precise indication when adjusting for zero phase between two signals. If the ellipse is a perfect circle (with both volts/div. controls set the same), the waveforms are exactly

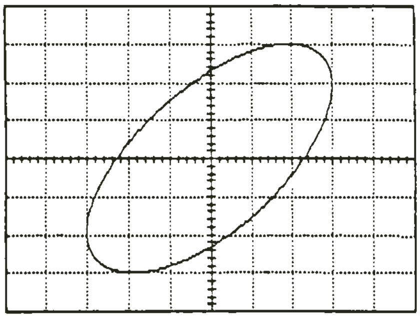


Fig. 18. Lissajous pattern for example used in text.

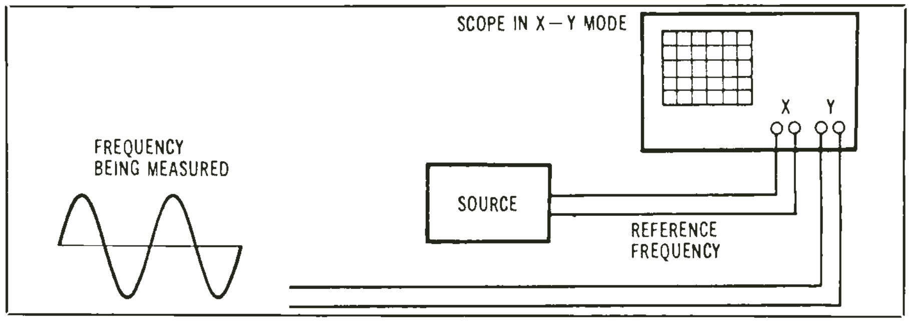


Fig. 19. Lissajous method can be used to compare frequency being measured with a known reference frequency, with oscilloscope operated in X-Y mode.

90 degrees apart. Again, this could be +90 or −90 degrees. If the display becomes a straight line, but in the lower-right/upper-left orientation, the two signals are exactly out-of-phase (180 degrees apart).

Here is how to determine phase difference between two signals with the Lissajous pattern shown in Fig. 18.

The ellipse is lower-left to upper-right. First find the values of A and B, which are A = 2.3 divisions and B = 3 divisions. Then calculate degrees as follows:

$$\theta = \sin^{-1}(A/B) = \sin^{-1}(2.3/3)$$
$$= 50 \text{ degrees}$$

The Lissajous method can also be used to compare frequency of two sine waves. The oscilloscope, operating in X-Y mode, is connected as shown in Fig. 19. Frequency being measured is connected to the vertical axis, while reference frequency (hopefully precisely known) is connected to the horizontal axis. If the two frequencies are the same (1:1 ratio), the situation is exactly the same as the phase measurement case.

In Fig. 20a, the oscilloscope display is shown for a 1:1 frequency ratio and a 90-degree phase shift. If the phase is other than 90 degrees, the display will not be a perfect circle, but an ellipse. Again, this case was covered under phase measurement. If the two frequencies are not exactly the same, the display will not be stable and the ellipse will contort and rotate on the display.

Other frequency ratios are also shown in Fig. 20. They may also appear warped or slanted in different ways just like the ellipse is a slanted version of a circle (for the 1:1 case). In general, the ratio of the two frequencies is determined by the number of cusps (or humps) on the top and side of the display. Consider Fig.

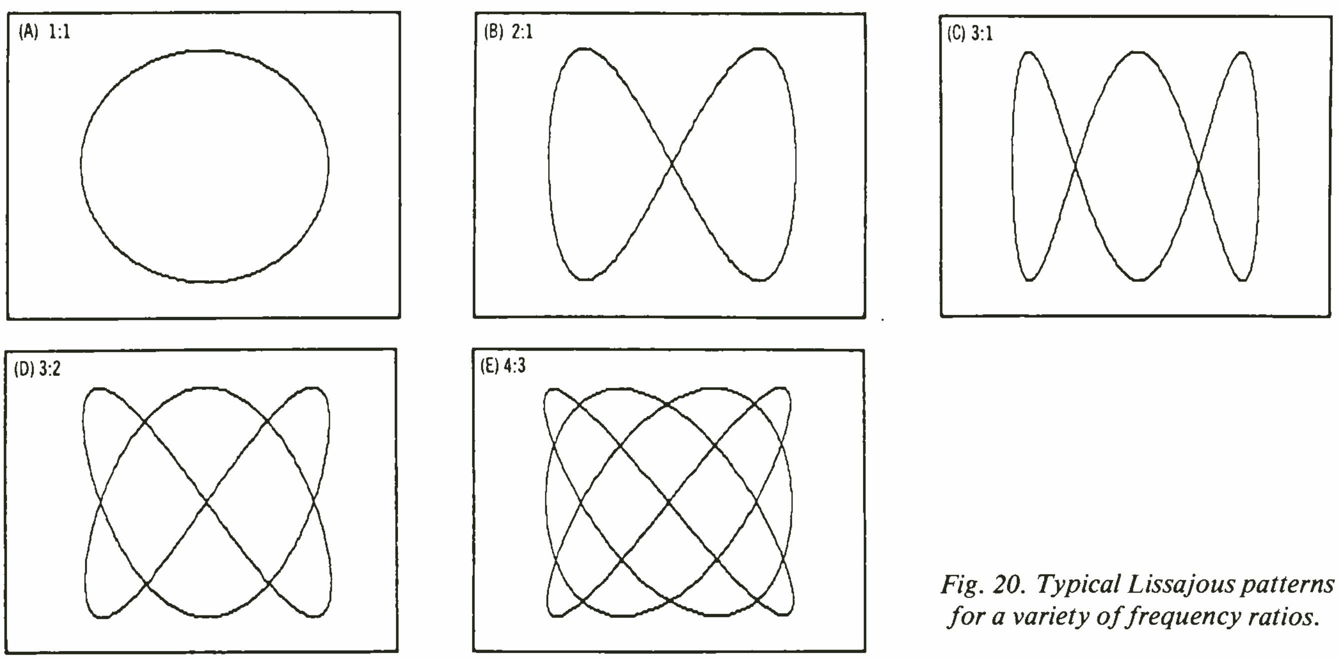


Fig. 20. Typical Lissajous patterns for a variety of frequency ratios.

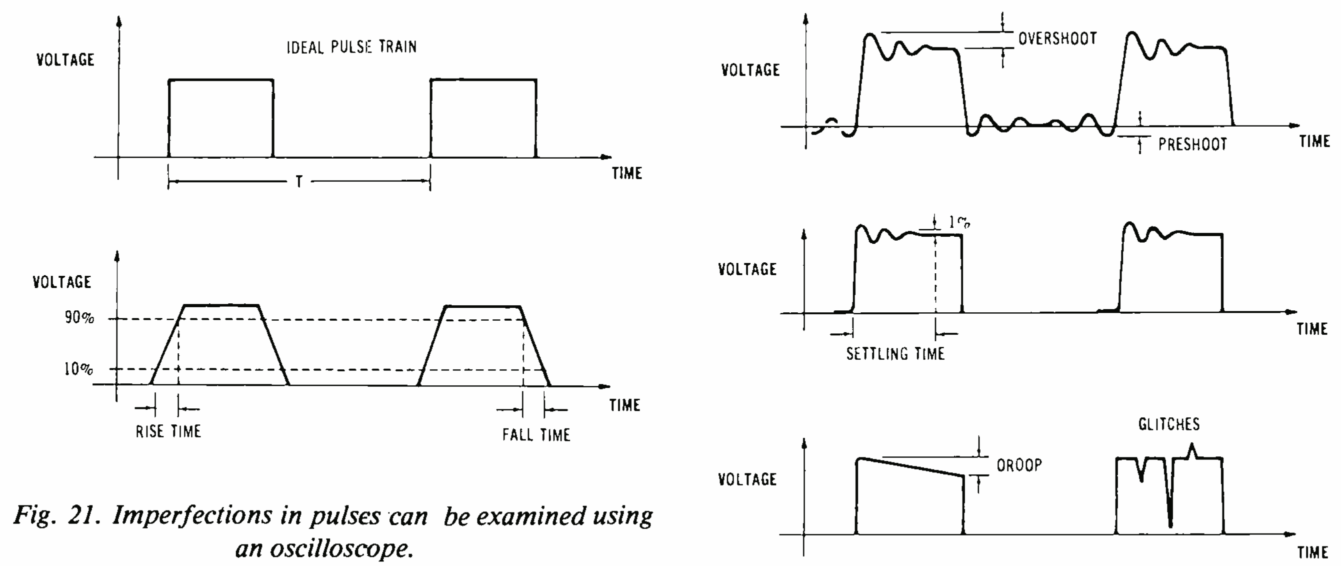


Fig. 21. Imperfections in pulses can be examined using an oscilloscope.

20b. There are two cusps across the top and only one down the side. Therefore, the frequency ratio is 2:1. In Fig. 20d, there are three cusps across the top and two down the side, resulting in a frequency ratio of 3:2.

This technique can be applied to any similar frequency ratio. The display will be stable only when the frequency ratio is exact. In general, if the frequency sources are not phase-locked together, there will be some residual phase drift between the two frequencies with a corresponding movement on the display.

This method of frequency measurement is somewhat limited since it only deals with distinct frequency ratios. It does help if a sine-wave source with variable frequency is available for use as the reference. Then the source can be adjusted so that the measured signal's frequency results in a convenient ratio.

Since this method operates on the basics of frequency ratios, the limiting factor in measurement accuracy is the reference source's frequency accuracy and stability. If the source used as the frequency reference is not more accurate than the oscilloscope's time base, there is no advantage in using this method. Instead, the frequency should be calculated from the period of the waveform measured in the time-base mode.

Pulse Measurement

Pulse trains (and square waves) can be measured and characterized using an oscilloscope. The measurement involves basically connecting the scope to the waveform of interest, obtaining a voltage-versus-time display of the waveform and extracting

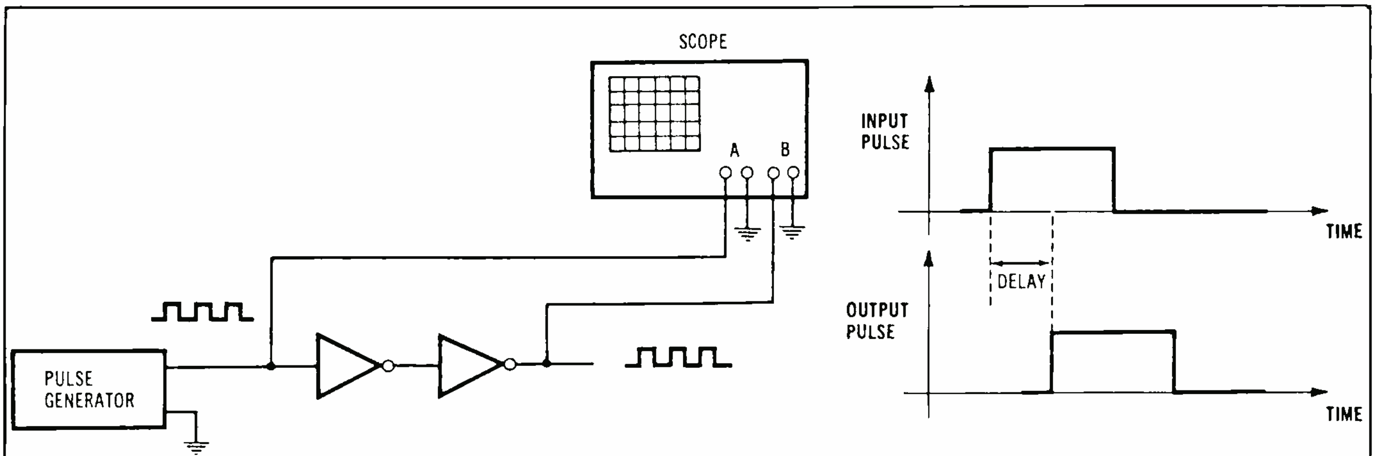


Fig. 22. An oscilloscope can be used to measure time delay between two pulses, as in input and output of a digital circuit.

the parameter of interest from the display. Oscilloscope bandwidth and rise time must be adequate so that the pulse being measured is not corrupted.

Various imperfections may exist in the pulse train (Fig. 21). Because of similarities of the pulse train and square wave, these terms for describing imperfections may also be applied to a square wave. Ideally, the pulse goes from 0 volt to $V_{0\text{-}p}$ in zero time. However, due to circuits that cannot respond infinitely fast, rise time is finite. Rise time is usually specified to be the time it takes a waveform to go from 10 to 90 percent of $V_{0\text{-}p}$. Similarly, fall time is the time it takes for the waveform to go from 90 to 10 percent of $V_{0\text{-}p}$. Rise and fall times may or may not be the same.

The pulse may actually exceed $V_{0\text{-}p}$ after the rising edge and then settle out. The amount that the voltage exceeds $V_{0\text{-}p}$ is called "overshoot," and the time it takes to settle out is called "settling time." Settling time is specified when the waveform has settled to within some small percentage of $V_{0\text{-}p}$ (often 1 percent). "Preshoot" is similar to overshoot, except that it occurs before the edge of the pulse.

The top of the pulse may not be perfectly flat, but have some small slope to it. The amount that the top of the pulse slopes downward is called "droop." Abrupt voltage changes in the waveform, called "glitches," are particularly common in digital circuits. Glitches can be large enough to cause a digital signal to enter the undefined region or, in more extreme cases, to change a logic state. Some circuits will tolerate a certain amount of glitching, but glitches are generally undesirable as they can cause a circuit to malfunction.

The time delay between two pulses (for example, in a digital circuit) can be measured using a two-channel scope. Figure 22 shows two logic gates (inverters) connected end-to-end and driven by a pulsed logic signal. In all digital technologies, it takes a small but non-zero amount of time for the input pulse to reach the output. The oscilloscope is set up to display both input and output of the two-gate circuit. The resulting time delay between the two waveforms is found by counting the number of divisions between the rising edge of the input pulse and the rising edge of the output pulse. This is then multiplied by the time/div. setting on the scope to obtain the time difference between the pulses.

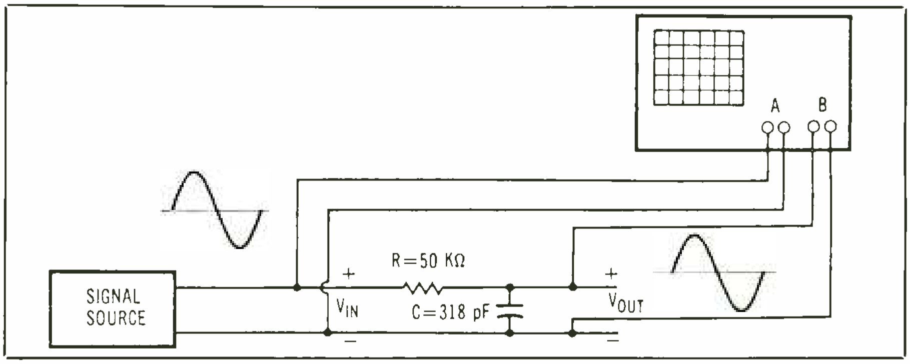


Fig. 23. Example of a frequency-response measurement.

Frequency-Response Testing

Earlier, gain and phase measurements were discussed as applied to a single frequency. A single-frequency sine wave was connected to the input of a circuit and the gain through the circuit as well as the phase of the output signal (relative to the input) were measured. This describes the behavior of that circuit at that particular frequency. But it is often desirable to characterize circuit performance over a wide range of frequencies. The gain and, to a lesser extent, phase measured at a range of frequencies is called the circuit's "frequency response."

The most obvious way to measure

Measured Values for RC Circuit

Frequency (Hz)	V_{in}	V_{out}	Gain	Gain (dB)
2,000	0.2	0.20	0.98	−0.17
4,000	0.2	0.19	0.93	−0.64
6,000	0.2	0.17	0.86	−1.33
8,000	0.2	0.16	0.78	−2.15
10,000	0.2	0.14	0.71	−3.01
12,000	0.2	0.13	0.64	−3.87
14,000	0.2	0.12	0.58	−4.71
16,000	0.2	0.11	0.53	−5.51
18,000	0.2	0.10	0.49	−6.27
20,000	0.2	0.09	0.45	−6.98
30,000	0.2	0.06	0.32	−9.99
40,000	0.2	0.05	0.24	−12.30
50,000	0.2	0.04	0.20	−14.14
60,000	0.2	0.03	0.16	−15.67
70,000	0.2	0.03	0.14	−16.98
80,000	0.2	0.02	0.12	−18.12
90,000	0.2	0.02	0.11	−19.13
100,000	0.2	0.02	0.10	−20.03

a circuit's frequency response is to perform multiple single-frequency gain (and phase) measurements and plot them as gain vs. frequency and phase vs. frequency. For example, Fig. 23 shows a simple low-pass RC filter being driven by a sine-wave source. The oscilloscope is connected so that it measures input and output voltages. The resulting voltage measurements at the input and output for a variety of frequencies are tabulated as shown in the Measured Values for RC Circuit table. (Note that if only gain is required, other instruments, such as a voltmeter, could be used to measure V_{in} and V_{out}.)

Gain for each frequency is calculated by dividing output voltage by input voltage at that frequency. The frequency response can then be plotted as in Fig. 24. Alternatively, frequency response can be plotted in decibels on the vertical axis and logarithmic frequency on the horizontal axis. Since the dB scale is inherently logarithmic, this results in a log-versus-log type of display.

The logarithmic scale has the effect of showing widely varying gain values on a compact plot. Notice that the frequency scale of Fig. 25 easily accommodates several decades of frequency, while the linear scale used in Fig. 17 does not.

Although the previously described point-to-point method is valid and produces accurate results, it is somewhat time consuming. To speed up the measurement process, another way to measure frequency response involves using a sweep generator. The swept sine wave of the sweep generator is connected to the input of the circuit under test. The output of the circuit is then connected to the oscilloscope's vertical (Y) channel, with the scope operated in the X-Y mode. In turn, the voltage of the sweep generator drives the horizontal (X) axis of the scope. (The generator's marker output should be connected to the scope's Z-axis input.)

As the generator sweeps in frequency, the sweep voltage of the generator ramps upward (in proportion to frequency), causing the output of the circuit under test to be plotted across the scope display. In this manner, the entire frequency response of the circuit is quickly displayed.

This method relies on the output of the sweep generator being constant with frequency. Any deviation from flatness of the generator will cause error in the frequency response. Also, drive capability of the generator is important. The load that the circuit places on the generator will usually vary over frequency. Therefore, the generator must be relatively insensitive to these changes or an-

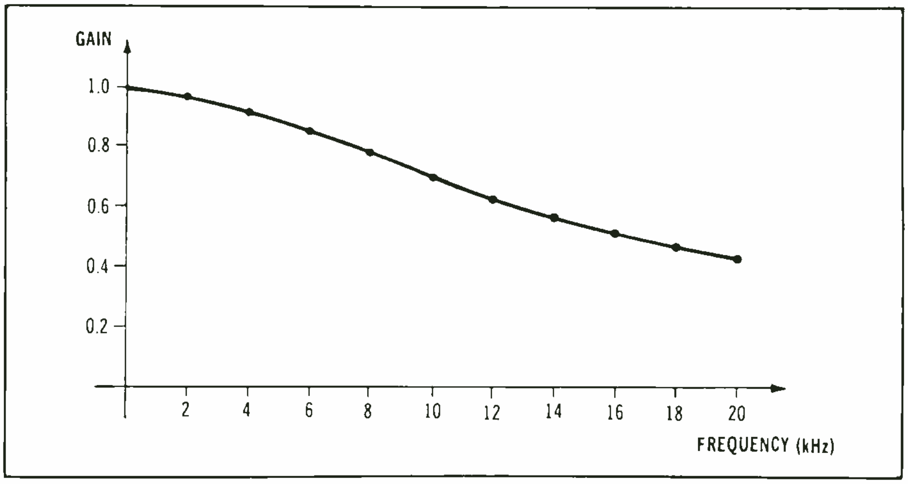


Fig. 24. The frequency response of an RC filter plotted as linear gain versus linear frequency.

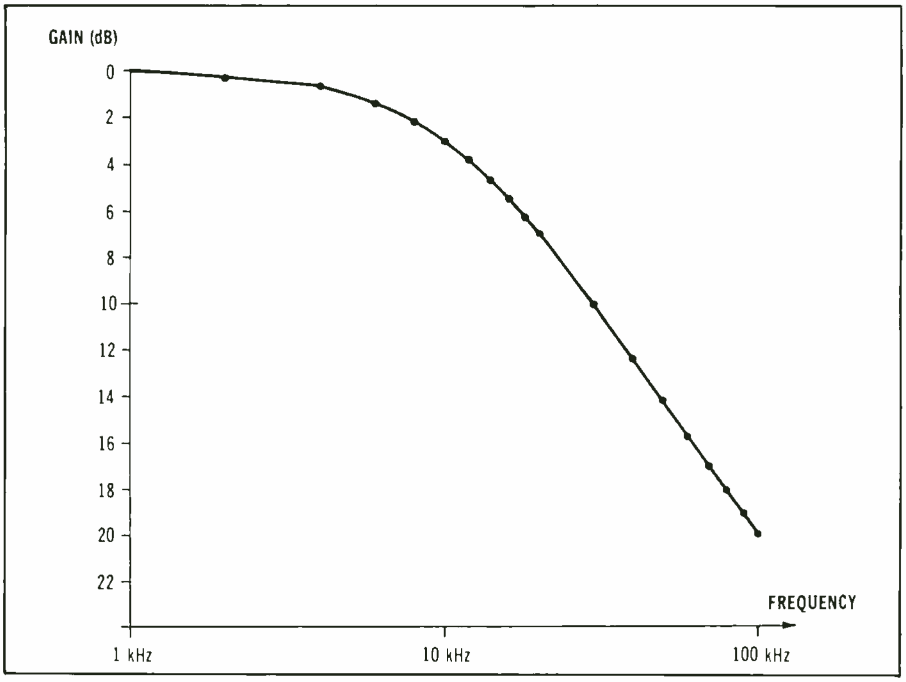


Fig. 25. Frequency response of RC filter plotted as gain in decibels (dB) versus log frequency.

other error will be introduced. For both of these reasons, it is a good idea to check (with the scope) to make sure that V_{in} is constant as the generator sweeps.

The sweep generator should not be swept too fast, since the circuit under test needs time to respond. This is particularly important in circuits with abrupt changes in gain as the frequency varies. Consequently, the sweep rate is usually set experimentally by reducing it until the frequency response no longer changes with each change in the generator's sweep rate.

The sweep generator may be swept in a linear or logarithmic manner, depending on the desired type of frequency axis. The scope's vertical axis is, of course, always linear.

It is sometimes desirable to locate a particular point on the frequency-response curve precisely with respect to frequency. Thus, many sweep generators supply a "marker" output signal that pulses when a particular frequency (or frequencies) is present at the generator output. The sweep generator will pulse the marker output, causing a change in intensity on the oscilloscope display at precisely the marker frequency. Exactly how intensity changes (whether it gets brighter or dimmer) will depend on the polarities of the marker signal and of the Z-axis input.

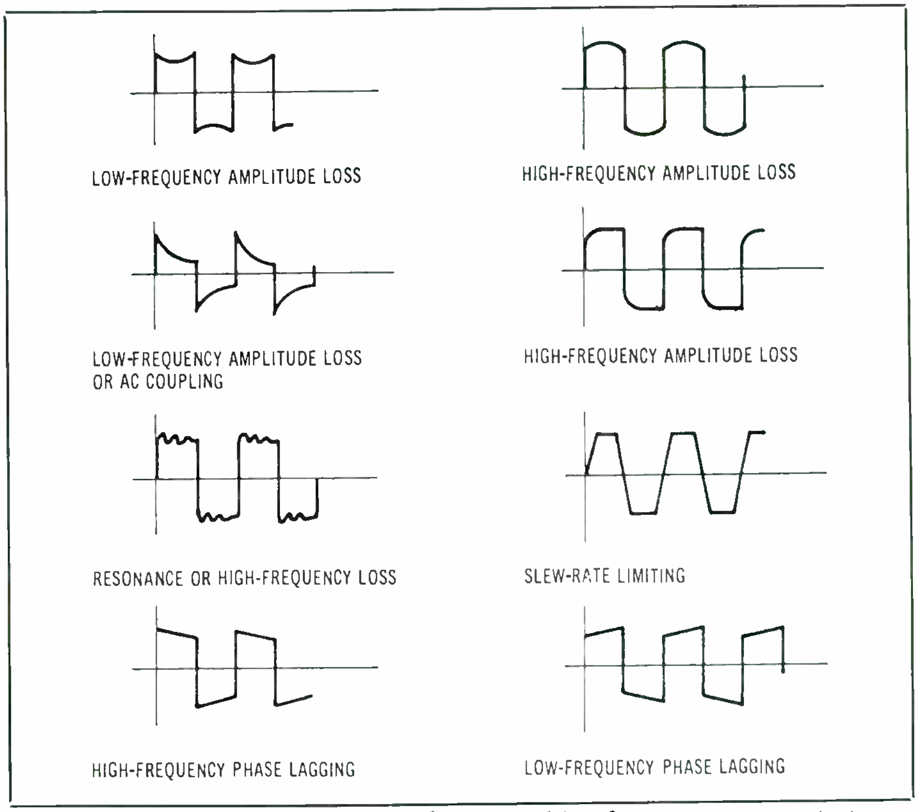


Fig. 26. Some examples of waveforms resulting from square-wave test.

Square-Wave Testing

The square wave is also used to characterize frequency response of circuits. This technique is valid only for devices with flat frequency responses, such as audio amplifiers. (A fairly standard test for audio equipment is a 1-kHz square-wave test.) In addition, the circuit under test must be dc coupled.

One special case of square-wave testing is the compensation of attenuating probes. Here, a square wave is applied from a function or pulse generator to the input of the circuit being tested, while the circuit's output is monitored on an oscilloscope. The square wave is very rich in harmonics, which extend out to may times its fundamental frequency, so the relative amplitude of each of these harmonics must remain unchanged in order for the output to be a square wave. If the circuit under test is an amplifier, the amplitude of each harmonic will be increased by the amplifier's gain, but their amplitude relative to each other will remain the same. In addition, each harmonic has a particular phase relationship with the fundamental frequency that must be maintained. Otherwise, the output will not be a true square wave.

The circuit could even have a perfectly flat amplitude response but not pass a square wave correctly due to phase distortion. This type of test

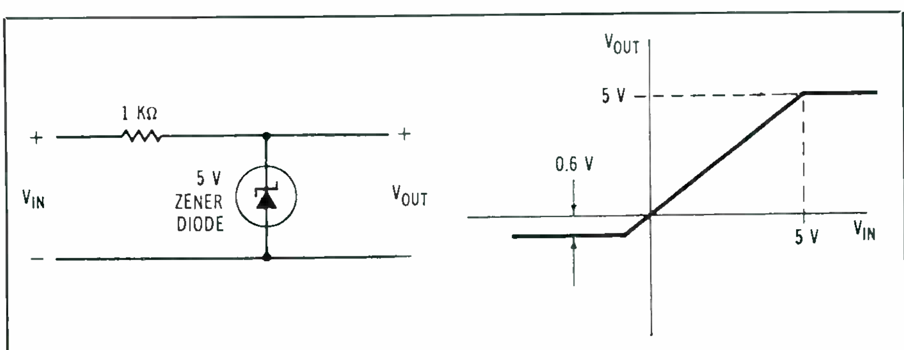
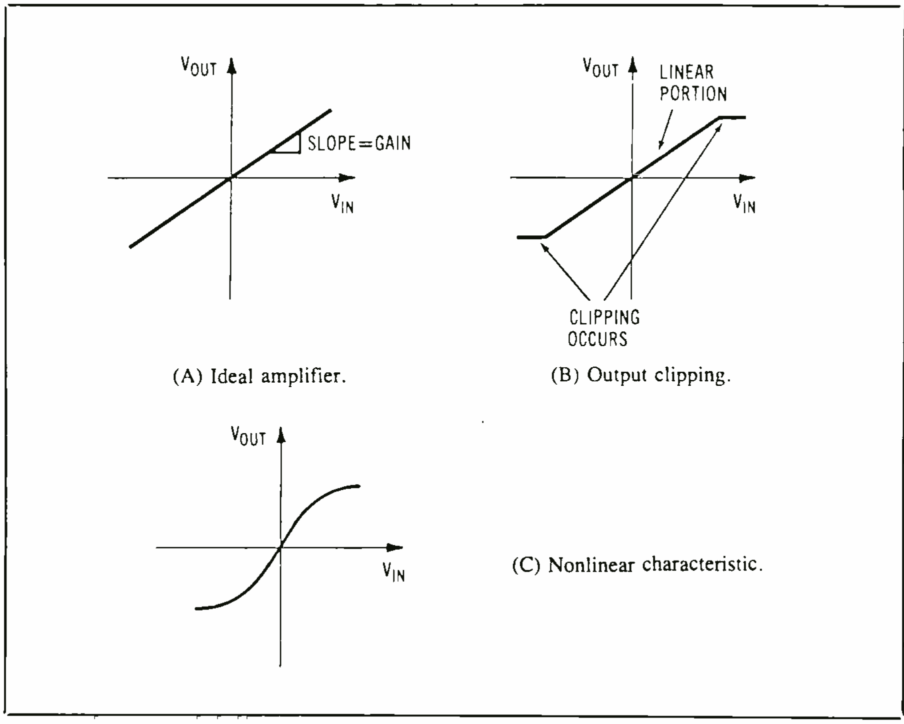


Fig. 27. Clipping circuit in (a) limits output voltage to between 0 and 5 volts. The V_{out} versus V_{in} linearity display for clipping circuit is shown in (b).

requires a high-quality waveform at the input, otherwise the output square wave will also be degraded.

Depending on the output characteristics of the generator, the circuit under test may even load the generator enough to cause distortion. It is usually a good idea, therefore, to monitor the input waveform with the second channel of the oscilloscope.

Although the square-wave test does not result in a frequency-response plot, it does test a circuit quickly, with good qualitative results. Some typical output waveforms encountered in square-wave testing and their causes are shown in Fig. 26. Phase shift at low or high frequencies can cause a tilt to one side or the other of the square wave. It is difficult to predict the effects of attenuation at either high or low frequencies as it depends greatly on the exact shape of the frequency response. However, a few typical examples are illustrated. Some circuits will exhibit noticeable degradation in the rise time of the output square wave. This is referred to as "slew-rate limiting."



(A) Ideal amplifier.

(B) Output clipping.

(C) Nonlinear characteristic.

Fig. 28. The V_{out} versus V_{in} plot for an ideal amplifier is a straight line (a). In a real amplifier, imperfections like output clipping and other nonlinearities can occur, as in (b) and (c).

Dc Linearity Measurement

It is often desirable to compare dc voltage out of a circuit with dc voltage in. This can be done using the X-Y mode of the oscilloscope. A slowly rising dc voltage is applied to the input of the circuit as well as the X axis of the scope. A convenient method of obtaining the varying dc voltage is to use a function generator's triangle wave with a very low frequency, say, 100 Hz. The output of the circuit is connected to the Y axis of the scope, resulting in the output voltage being plotted vs. the input voltage. The generator's frequency is made fast enough so that the display does not flicker too much but is made slow enough so that operation of the circuit is not affected. (Remember, a dc voltage is being simulated.)

Consider the clipping circuit shown in Fig. 27a. For a V_{in} of less than 5 volts and greater than 0 volt, the zener diode acts like an open circuit and V_{out} is equal to V_{in}. When V_{in} becomes greater than 5 volts (the zener voltage), the diode turns on and V_{out} is limited to 5 volts, no matter how large V_{in} gets! If V_{in} becomes less than 0 volt, the diode turns on in the other direction and limits V_{out} to 0 volt. (Actually, it would limit the voltage to a slightly negative value, typically −0.6 volt, depending on the diode.) At any rate, the effect of the circuit is to limit the output voltage to between about 0 and 5 volts.

If a dc linearity measurement is made on the circuit using the technique described, the display would appear as shown in Fig. 27b. The sloped portion of the trace corresponds to the region where V_{out} equals V_{in}. The two flat parts of the trace are where V_{out} is limited by the clipping action of the circuit.

With an amplifier, it is usually desirable to have the output always equal the input, but amplified by some amount. Thus, the output waveform is the same as the input waveform, except that the former has a larger amplitude than the latter. For increasingly larger input voltages, the amplifier will at some point stop producing a proportionally larger output voltage. At this point, the output waveform will be clipped. Waveform peaks are flattened out at this output level.

The V_{out}-versus-V_{in} linearity plot of the amplifier can also be used to measure this phenomenon (Fig. 28a). The display is a straight line whose slope is the amplifier's gain. Ideally, the straight line would extend indefinitely. That is, the amplifier would be capable of amplifying an input voltage, no matter how large. In reality, though, the amplifier will clip at some point, usually as the peak voltage approaches the amplifier's power-supply voltage, as shown in Fig. 28b. The straight line is still present, but it flattens out at the point of limiting. Typically, the trace does not break sharply, but instead is rounded off.

Since the V_{out}-versus-V_{in} characteristic is a straight line, this type of circuit operation is called "linear." If the plot is not a straight line, the characteristic is termed "nonlinear" (Fig. 28c). Nonlinear amplifier operation causes distortion of the output signal (usually harmonics).

Curve-Tracer Measurement

Another useful oscilloscope measurement technique is the curve-tracer circuit. This method uses the oscilloscope in the X-Y mode to display the current flowing through a component (such as a resistor or diode) versus the voltage across the component. This display is referred to as the I-V (current-voltage) characteristic of the component.

There are several ways to make this measurement. Figure 29a shows a function generator driving the curve-tracer circuit. Here, V_2 is the voltage across the device being measured and V_1 is the voltage across the resistor. By Ohm's law, V_1 will be proportional to the current through the resistor, which is also the current through the component being tested. So if V_1 could be displayed versus V_2, the I-V characteristic of the component would be shown. If the scope has floating inputs, this can be done with no problem.

Unfortunately, most scopes have grounded inputs, which results in the situation shown in Fig. 29b. Both sides of the component under test are grounded, resulting in a short circuit across it. The situation is further compounded if the source has a grounded output. If the source is floating, the circuit in Fig. 29c can be used. Note that the circuit ends up being grounded at only one point.

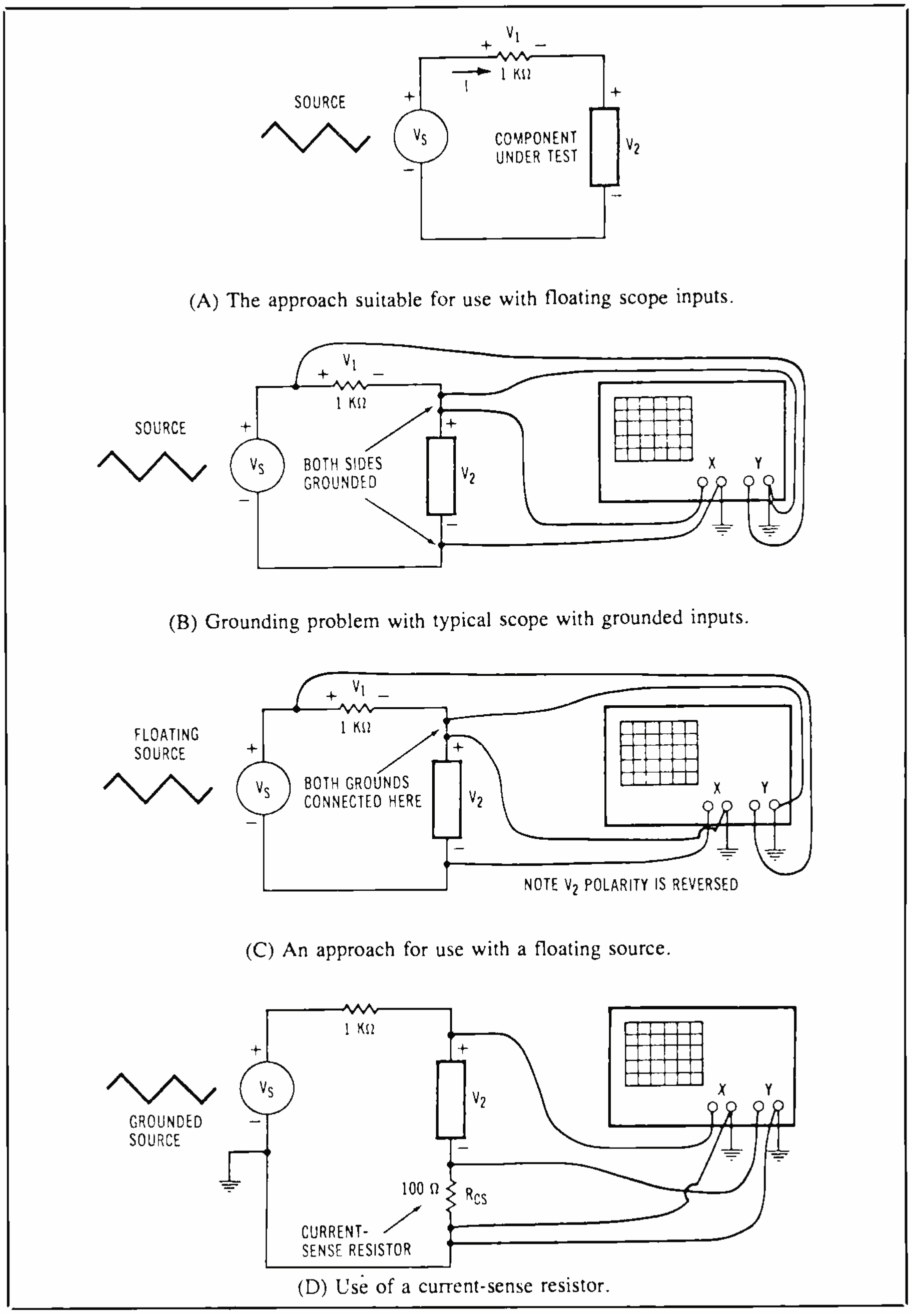


Fig. 29. Methods for displaying component I-V characteristics.

Something has changed, though! The horizontal axis of the scope will be $-V_2$ (instead of $+V_2$) due to reversal of the horizontal input leads. This can be compensated for if the scope has an "Invert Channel B" switch. Otherwise, the I-V curve will appear backwards on the display (left half of the display swapped with the right half). This may be acceptable if you are willing to mentally make the conversion.

If both scope and source are grounded, another technique must be used. A current-sense resistor is placed in series with the component under test. The vertical input of the scope then uses the voltage across this resistor to measure current. The voltage across the current-sense re-

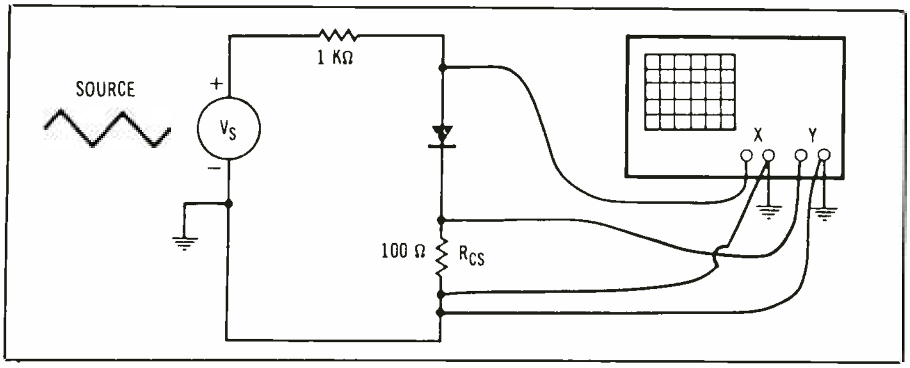


Fig. 30. Diode's I-V characteristic can be measured using curve-tracer circuit with current-sensing resistor.

sistor will introduce a small error in the measurement of V_2, but as long as the resistor's value is kept small, the error will be acceptable. The resistor's value cannot be made too small since, for a given current being measured, voltage will increase with smaller resistance. Scope sensitivity will ultimately determine how small a current-sense resistor value can be used.

As a practical example, Fig. 30 is set up to measure the I-V characteristics of a diode, using the current-sense method. The source (usually a function generator) is set to produce a low-frequency triangle wave, although a sine wave will also work. The triangle wave acts as an automatically varying dc voltage, causing the voltage across the diode to also change. At the same time, the voltage across and current through the diode are measured. Amplitude and

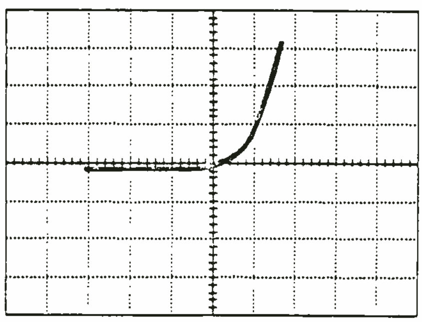


Fig. 31. The characteristic I-V curve of a solid-state diode junction.

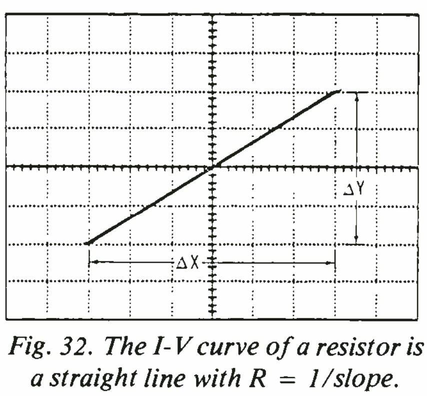


Fig. 32. The I-V curve of a resistor is a straight line with R = 1/slope.

frequency of the function generator can be set experimentally, but a zero-to-peak potential of 5 volts and a frequency of 30 Hz is a good starting point.

The resulting I-V characteristic of a diode is shown in Fig. 31. The horizontal scale can be determined directly from the volts/div. setting. However, the vertical scale must take into account the value of the current-sense resistor, as follows:

$$\text{Amps/div.} = (\text{V/div.})/R$$

where R is the value of the current-sense resistor.

The resulting curve is the classic behavior of the solid-state diode. For voltages greater than zero (right half of the display), current quickly increases. For voltages less than zero (left half of the display), current is essentially zero. So the diode conducts in the forward direction, but it acts like an open circuit in the reverse direction.

The scope display may actually show two separate traces instead of the single curve. One trace is drawn as the voltage increases and the other is drawn on the decreasing portion of the triangle wave. They may be slightly different due to either capacitive effects or heating of the component being tested. Reducing either the frequency or the amplitude of the triangle wave will cause the two traces to converge into a single trace.

To conclude, it is worth noting that the curve-tracer circuit can also be used to measure unknown resistors. The resulting I-V curve is shown in Fig. 32. Resistance value is determined by calculating 1/slope of the line, taking into account the oscilloscope's settings, as well as the value of the current-sense resistor. The current-sense resistor's value should be chosen to be at least a factor of ten smaller than the unknown resistor. **ME**

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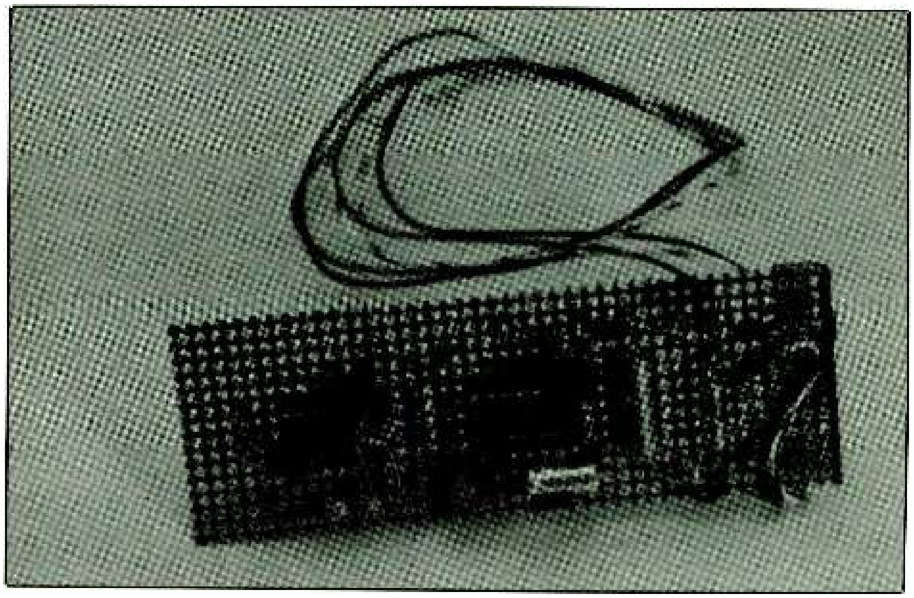
Twilight Sentry

This device visually warns a driver if his vehicle's headlights are off as night approaches

By Anthony J. Caristi



Today, many cars have all-electronic displays that light up in a brilliant display of color the instant the ignition is turned on, regardless of whether it is daylight or dark outside. Consequently, there is no visual feedback to alert drivers of these cars that their headlights have not been turned on at dusk or even after full dark. For this reason, many vehicle operators can be seen driving with their headlights off, making it more difficult for other drivers to be immediately aware of the car's presence. (Older cars, in contrast, had incandescent dashboard lighting that provided a driver with an intuitive sense of dusk's approach—if you could not read the dashboard indicators, it was time to turn on the headlights.)

Installing the Twilight Sentry in your car restores the telltale needed to alert you to turn on your headlights when twilight approaches. Completely automatic in operation, you do not even have to remember to arm the Twilight Sentry. Once installed, Twilight Sentry senses ambient light and, when the light gets to a predetermined level, starts flashing an attention-getting light-emitting diode that tells you to turn on your headlights. Turning on your headlights extinguishes the LED, eliminating any possible distraction from your driving from that quarter. The project works in both new and older cars, even those with incandescent dashboard lighting.

About the Circuit

The heart of the Twilight Sentry circuit shown in Fig. 1 is cadmium-sulfide photoresistive cell *PC1* whose resistance is inversely proportional to the intensity of the light striking its active surface. That is, when the light is bright, the cell's resistance is low, and vice-versa. By connecting *PC1* in series with *R1* and powering the circuit from an automotive 12-volt dc electrical system, the voltage across the photocell is nearly zero under bright-light conditions. As the intensity of the light diminishes, the resistance of *PC1* gradually rises.

The output of the *PC1/R1* circuit is wired in parallel with SENSITIVITY control *R2*. The output from this arrangement is used to drive the pin 1 input of NOR gate A in *IC1* (see Fig. 2 for pinouts and internal details of the integrated circuits used in this project).

Gates A and B of *IC1* make up a flip-flop or latch circuit that has two stable states that depend on the logic levels fed to the inputs at pins 1 and 6. A logic 1 pulse or voltage fed to either input causes the corresponding output (pin 3 for gate A and pin 4 for gate B) to assume a logic 0 condition and remain in this state until the circuit is toggled to its alternate state by applying a positive voltage to the opposite latch input. This latch circuit is used to "remember" that the vehicle has been started and that its headlights are still off.

Turning on the ignition generates a positive-voltage pulse that is delivered to pin 6 of gate B in *IC1* through capacitor *C2*. This pulse

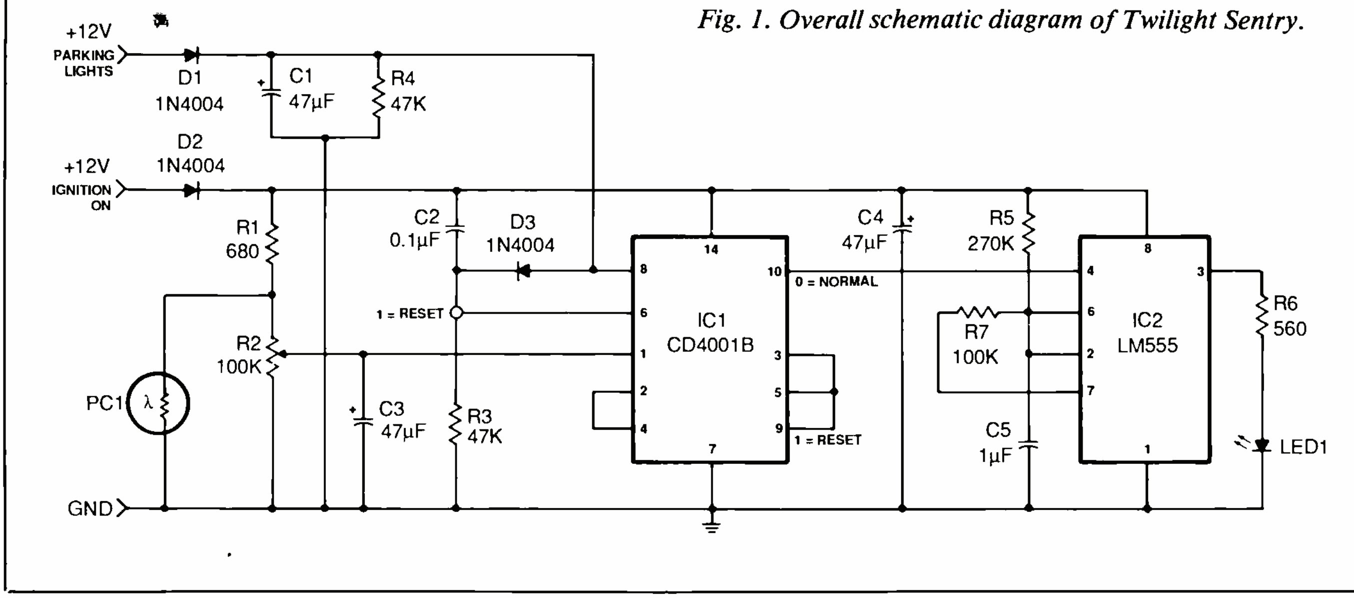


Fig. 1. Overall schematic diagram of Twilight Sentry.

puts the latch circuit into the reset mode as long as sufficient light strikes the photocell.

As dusk approaches, the voltage at pin 1 of *IC1* rises. When this potential reaches approximately 8 volts, the latch circuit toggles into its alternate state if the vehicle's headlights are still off. As the circuit switches to its alternate state, the output of gate C at pin 10 of *IC1* rises to a logic 1 because both outputs of this NOR gate are now at a zero logic level.

The positive voltage fed to pin 4 of timer *IC2* triggers this circuit into oscillation. Operation of the timer circuit is in the free-running (astable) mode. The frequency of oscillation is approximately 2 Hz. Driven by the output of *IC2* at pin 3, light-emitting diode *LED1* now flashes on and off to provide a visible indication that the vehicle's headlights are off and should now be turned on.

Turning on the headlights causes the logic 1 fed to the pin 8 input of gate C in *IC1* to generate a logic low at the pin 10 output to timer *IC2*. This shuts down the oscillator and extinguishes the LED. In addition, the latch circuit is triggered into its reset mode by means of diode *D3* so that *LED1* will not turn on if you are driving at dawn and shut off the headlights after sunrise.

Construction

Assembly of the entire project can be accomplished by wiring the components that make up the circuit on a printed-circuit board or on perforated board with the aid of suitable soldering or Wire Wrap hardware. In either case, it is a good idea to use sockets for the ICs.

You can fabricate your own pc board with the aid of the actual-size etching-and-drilling guide shown in Fig. 3. Alternatively, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List.

As you install rectifier diodes and electrolytic capacitors *(C1, C3* and *C4)*, be sure to properly orient these components before soldering their leads to the copper pads on the bottom of the board. Note that though *C5* has a 1-microfarad value, which is ordinarily in the electrolytic range, this is not a polarized capacitor. It should, in fact, be a 1-microfarad ceramic capacitor. However, if you have any difficulty obtaining a non-polarized 1-microfarad capacitor, you can substitute an ordinary electrolytic of this value.

Prepare three 5″ lengths of insulated stranded hookup wire (use stranded wire throughout this project) by stripping ¼″ of insulation from both ends of each. Twist together the fine wires at all ends and sparingly tin with solder. Plug one end of these wires into the holes labeled GND, +12V IGNITION ON and +12V PARKING LAMP and solder into place. The other ends of these wires will be connected later.

Note in Fig. 4 that though SENSITIVITY control *R2* mounts directly on the circuit board, photocell *PC1* and light-emitting diode *LED1* mount off the board in separate holes drilled in the enclosure that houses the project. You have two options for mounting the LED. You can mount it directly on the panel of the project's enclosure and run short hookup-wire leads from it to the appropriate holes in the circuit board. Alternatively, you can mount the LED remote from the project box (on or under the dashboard of your vehicle, where it will readily be seen) and run a cable from it through a hole in the enclosure and back to the circuit board. You have the same options for mounting the photocell.

If you plan on having both the LED and photocell on the enclosure, with no parts in remote locations, mount the LED on the panel facing the driver's seat and the photocell facing out through the windshield with the project sitting on the dashboard. (Before making this decision, however, see Installation below.) This way, the photocell can detect ambient light levels and the LED can perform its function as a visible alerting device.

Should you decide to mount the LED on a panel of the enclosure, trim both leads to ½" in length and form a small hook at the end of each stub. Strip ¼" of insulation from both ends of 3" lengths of red- and black-insulated wires. Twist together the fine wires at both ends of the wires and sparingly tin with solder. Connect and solder one end of the red-insulated wire to the anode lead and the black-insulated wire to the cathode lead of the LED. Then slip a 1" length of small-diameter heat-shrinkable tubing over each wire and lead, pushing them snug up against the bottom of the LED's case so that they completely cover the soldered connections and all exposed LED lead. Shrink the tubing solidly into place.

For a remotely mounted LED, follow the above procedure, except make the wires long enough to bridge the project's and LED's installation locations.

The same arrangement used for mounting the LED applies to mounting the photocell except that if the latter is to be mounted on an enclosure wall simply trim its leads to appropriate length (if needed). Since the photocell is not polarity-sensitive, there is no need to color code the wires used for its cable in remote installation. Additionally, you need use only ½" lengths of small-diameter heat-shrinkable tubing, enough to completely insulate the soldered connections when the remote cable is used.

You can use any type of enclosure for housing the Twilight Sentry as long as it can accommodate the circuit-board assembly and a three- or four-contact screw-type terminal strip (plus the photocell and LED if they are to be mounted on the box's panels). A metal enclosure is preferable to assure a good solid electrical ground between the project and your

PARTS LIST

Semiconductors
D1,D2,D3—1N4004 silicon rectifier diode
IC1—CD4001B quad 2-input NOR gate
IC2—LM555 timer
LED1—Red light-emitting diode

Capacitors (25 working volts)
C1,C3,C4—47-μF electrolytic
C2—0.1-μF ceramic disc
C5—1-μF ceramic or electrolytic (non-polarized; see text)

Resistors (¼-watt, 10% tolerance)
R1—680 ohms
R3,R4—47,000 ohms
R5—270,000 ohms
R6—560 ohms
R7—100,000 ohms
R2—100,000 trimmer potentiometer (Bourns No. 3329 or similar)

Miscellaneous
PC1—Cadmium-sulfide photoresistive cell (Radio Shack Cat. No.176-1567 or similar)
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); sockets for ICs; suitable enclosure (see text); small-diameter heat-shrinkable tubing; small rubber grommets (see text); 3- or 4-contact screw-type terminal strip; ½" spacers; 4-40 × ¾" machine screws, nuts and lockwashers; stranded hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: etched and drilled pc board for $7.75; CD4001B for $2.00; LM555 timer for $2.50. Add $1.00 P&H. New Jersey residents, please add state sales tax.

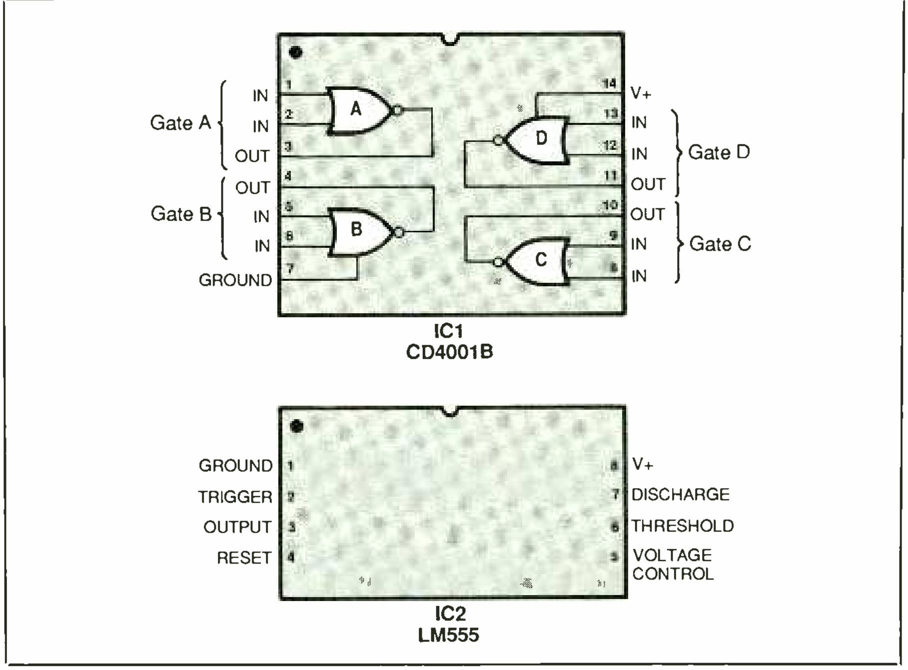


Fig. 2. Pinouts and internal details of integrated circuits used in project.

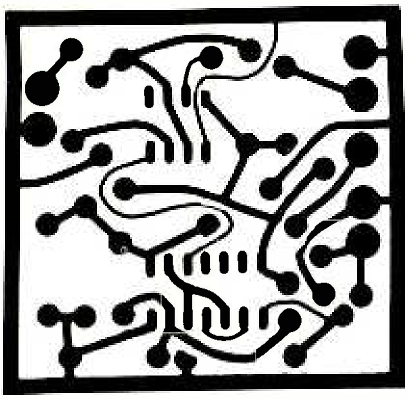


Fig. 3. Actual-size etching-and-drilling guide for printed-circuit board fabrication.

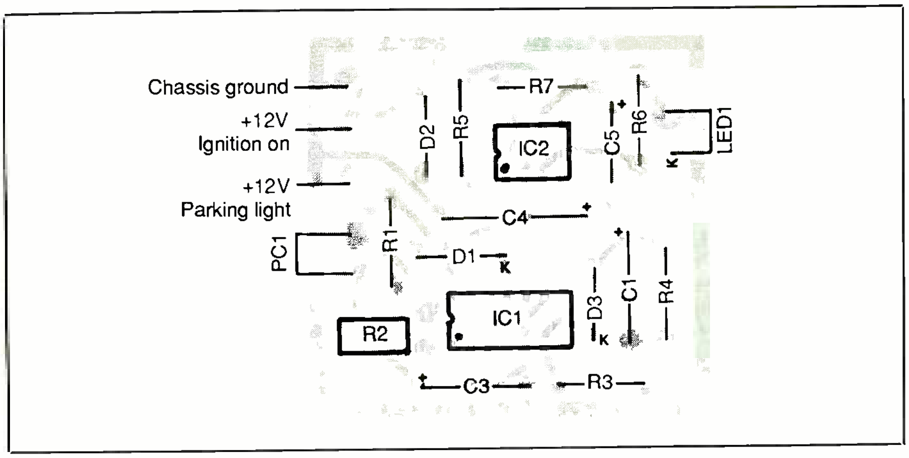


Fig. 4. Wiring guide for pc board. Use this layout as a guide to component placement and orientation if you use perforated board and soldering or Wire Wrap hardware.

vehicle's ground, but a plastic box is easier to machine.

Machine the enclosure as follows. First, drill holes for the photocell and LED, sizing each according to whether it will be used as a mounting hole for the device or as an entry hole for the device's cable. If you are mounting the LED or/and photocell on an enclosure wall, size the hole to provide a snug but not force fit. Then cut a slot and drill the mounting holes for the terminal strip.

Drill ⅛"-diameter holes in the board as near as possible to the upper-left and lower-right corners with the board viewed as shown in Fig. 3. Make sure these holes are far enough away from all circuit-board conductor traces so that mounting hardware will not touch any but the ground trace around the perimeter of the board.

Set the board inside the enclosure and position it so that it will not interfere with the terminal strip, LED or photocell. Mark the locations of the mounting holes and drill the holes in the marked locations. Temporarily mount the board in place on ½" spacers and determine exactly where to drill the access hole for the adjustment slot for the SENSITIVITY control. Then remove the board and drill this hole.

If the enclosure is a metal box, deburr all holes with a file. Then line the holes through which the cable(s) to the LED or/and photocell will pass with small rubber grommets. If you are using a plastic enclosure, no rubber grommets are needed.

Mount the screw-type terminal strip in its cutout and the LED and photocell in their respective holes. Then connect and solder the LED (observe polarity) and photocell leads (or cables) to the appropriate holes in the circuit board and the free ends of the hookup wires you installed earlier on the board to the lugs of the terminal strip. Refer to Fig. 4 for wiring details.

If the LED or/and photocell are to be remotely located, loosely twist together the wires that make up each cable along its entire length. Then pass the free ends of these cables through the holes drilled for them and tie a knot in each 4" from the free end inside the box before soldering the wires to the circuit-board assembly.

Mount the circuit-board assembly. Use ½" spacers and 4-40 × ¾" machine screws, nuts and lockwashers. If there is any possibility of the spacers touching any but the perimeter trace on the bottom of the board, sandwich insulating fiber washers between them and the board. Then label the screw-type terminal strip contacts as detailed in Fig. 4.

Checkout and Adjustment

Before plugging the integrated circuits into their sockets and installing the project in your vehicle, it is a good idea to check it out to make sure all components are installed in their proper locations and that they are properly oriented. Then recheck all soldered connections.

Once you are satisfied that your wiring is okay, use a meter set to measure 12 volts dc or more to check for the proper voltages. To be able to do this, you need a 12-volt dc source, which can be a bench power supply or your vehicle's battery. Connect the power supply or battery to the project via the +12V IGNITION ON and GND contacts of the terminal strip (observe polarity).

Now connect your meter's common lead to circuit ground. Touch the positive lead of the meter to pin 14 of *IC1* and then pin 8 of *IC2*; in both cases, you should obtain a reading of approximately +12 volts. If you do not obtain the proper readings, power down the circuit and recheck your work. Do not proceed until the problem has been corrected.

(Continued on page 88)

Telephone-Activated Lamp Timer

Device automatically turns on lamp when it is dark and a phone call is received

By Steve Lympany

Anyone who has ever stumbled around in the dark trying to find his telephone to answer its ring will appreciate our Telephone-Activated Lamp Timer. The Telephone-Activated Lamp Timer turns on a lamp when your phone rings and keeps it on while you are conversing and for a period of time after you hang up. The last feature is adjustable to allow you to get back to bed before the project extinguishes the lamp. The time-out period is adjustable over a range of from about 2 to 75 seconds, which should be more than sufficient to suit just about any situation. Additionally, if you want to turn off the lamp before the time-out cycle has completed, simply push a button on the Lamp Timer. If you are not around to answer the telephone when it rings, the lamp will remain on for the time-out period after the last ring burst from the incoming call.

Two ac receptacles are provided on the Lamp Timer to allow you to connect a lamp and any other ac-powered device you might find appropriate in this application. One receptacle is manually switchable to allow you to set the lamp to constant-on so that you can use it for reading or other purposes before you retire. But do not forget to switch the Lamp Timer back to its automatic mode before lights out.

About the Circuit

As shown in the block diagram in Fig. 1, required functions of the Telephone-Activated Lamp Timer are ring detection, off-hook detection, variable timing and relay drive. The circuit that provides these functions is shown schematically in Fig. 2.

When a ring signal is detected by the Timer on the green and red conductors of the telephone line, the "tip" and "ring" lines, respectively, of RJ11 jack *J1*, it is divided down by *R1*, *R2* and *R3*. It is then coupled through *C1* to pins 1 and 2 of optical coupler *IC2*. (Note: The pinouts and internal details of the ICs used in this project are shown in Fig. 3.) The presence of this signal causes pin 5 of *IC2* to be pulled low. This high-to-low transition is ac coupled through *C2* to pin 3 of *IC2*. The resulting negative-going edge causes timer *IC3* to begin its timing cycle.

The output signal at pin 3 of *IC3* is used with *IC4* to switch on relay driver *Q1*. The timing period is reinitiated each time the telephone rings.

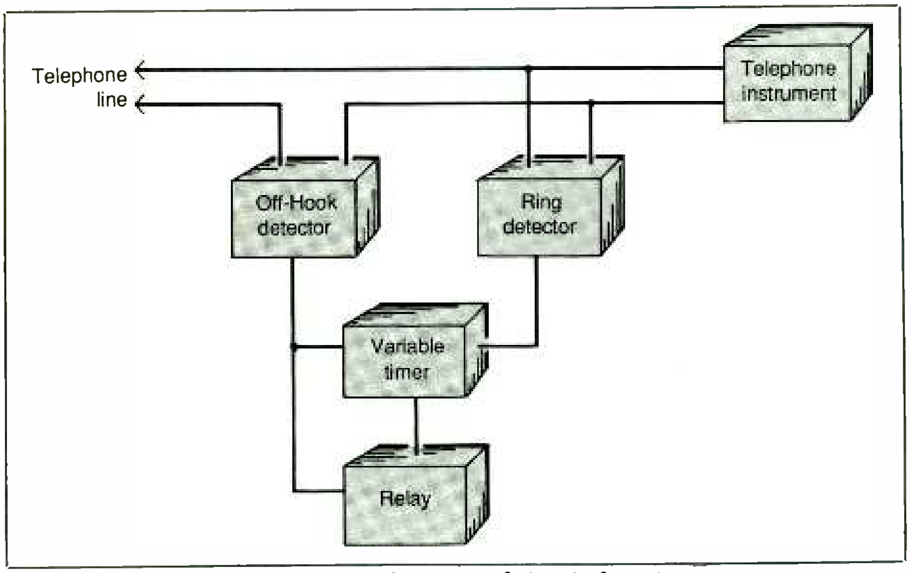
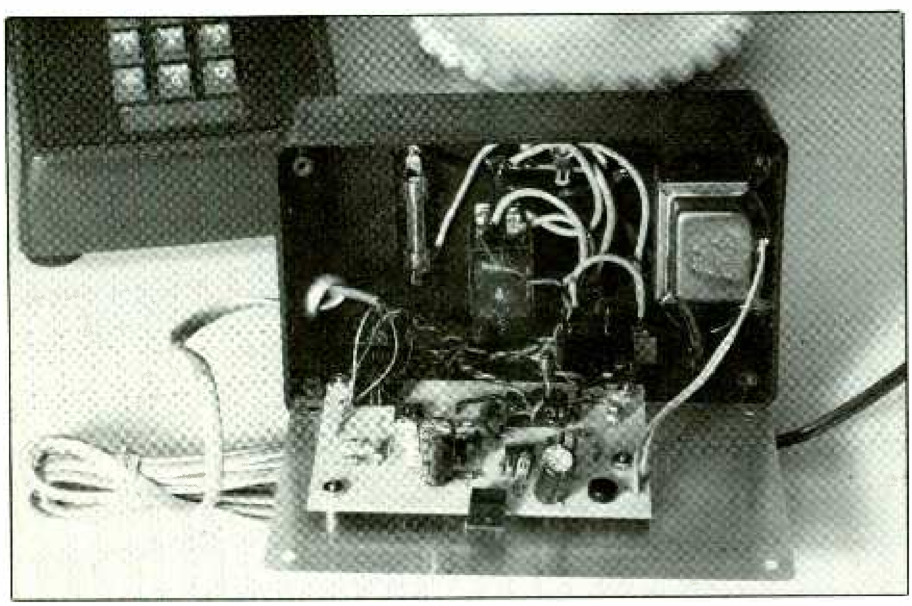


Fig. 1. Block diagram of circuit functions.

Therefore, relay *K1* remains energized during the ring bursts and for the time-out period following the occurrence of the last ring signal.

Lifting the receiver of the telephone instrument creates an off-hook condition so that the current flowing through the instrument is sensed by optoisolator *IC1*. (This allows for bidirectional line-current sensing so that off-hook detection occurs independently of line polarity.) This causes pin 5 of *IC1* to be pulled low. When this condition is passed through *IC4*, *Q1* conducts and energizes the relay and holds it that way during the period of time the telephone instrument is off-hook. Hanging up the telephone (putting it back on-hook) causes pin 5 of *IC1* to go high. This signal is inverted at pin 4 of *IC4*, and the resulting negative-going edge is coupled through *C2* and *D2* to trigger *IC3* into operation. Timer *IC2*'s output then drives *K1* for the time-out period. Hence, *K1* will remain energized for the time-out period after you hang up.



Interior view of finished project.

Potentiometer *R8* provides the means for adjusting the time-out period as desired. The time-out period of the 555 timer used for *IC3* is calculated from the formula: $T_O = 1.1(RC)$, where T_O is the time-out period in seconds, *C* is the value of *C3* and *R* is the sum of the values of *R7* and *R8*. Therefore, with the value of *C8* being 68 microfarads and *R* being adjustable between 20,000 and 20M ohms, the resulting time-out period adjustment range is from about 1.5 to 76 seconds. Of course, you can substitute other values of *R* and *C* to increase or decrease the time-out period as desired.

If you would like to extinguish the lamp before the timer completes its time-out cycle, you can press and release momentary pushbutton switch *S2* to reset the Timer and arm the circuit so that it is ready for the next incoming call.

A double-pole, double-throw (dpdt) relay was used for *K1* in this project basically because it was readily available. However, if a second ac outlet is not needed, a single-pole, double-throw (spdt) relay can be substituted, making the project's cost a bit lower.

Also shown in Fig. 2 is the schematic diagram of the ac power supply used to power the Telephone-Activated Lamp Timer. This is a simple full-wave dc supply that delivers regulated 12 volts dc to the Timer circuits. After stepping down the incoming 117 volts ac to 12.6 volts ac, the supply rectifies it to pulsating dc with bridge rectifier *RECT1* and then filters it to dc with *C8*, after which it electronically regulates it at 12 volts dc with *IC5*.

TIMER/BYPASS switch *S1* is a convenience feature. With this switch in the circuit, you can bypass the Tim-

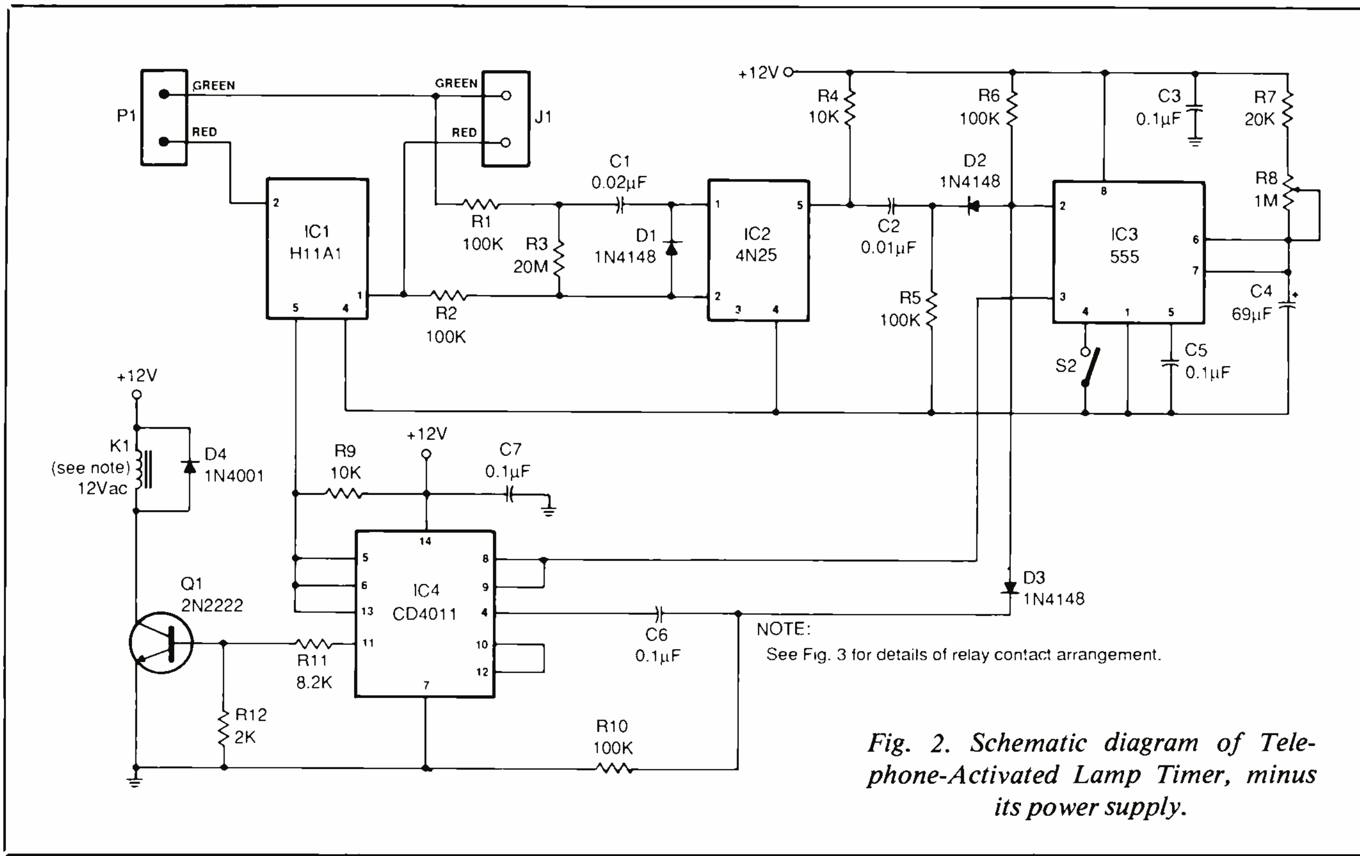


Fig. 2. Schematic diagram of Telephone-Activated Lamp Timer, minus its power supply.

er's relay so that ac receptacle *SO1* can be manually switched on and off. This allows you to use the lamp the project controls as a reading lamp when the switch is set to the BYPASS position.

Construction

This is a very simple project to build. A printed-circuit board is recommended for wiring the circuit, through you can use perforated board and suitable soldering or Wire Wrap hardware if you wish. In either case, it is a good idea to use sockets for *IC3* and *IC4*. You can also use sockets for *IC1* and *IC2*, though you will have to use standard 8-pin DIP sockets for these 6-pin ICs and make arrangements on the board for the extra pins (or remove the pins from the sockets altogether). Also, plug up the holes for the unused socket

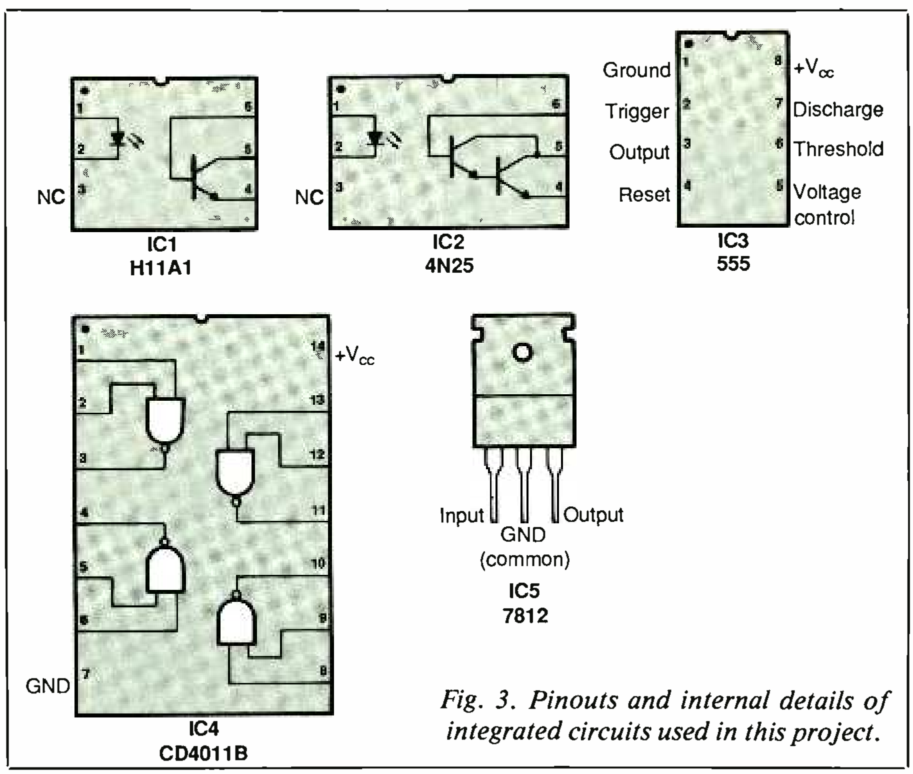


Fig. 3. Pinouts and internal details of integrated circuits used in this project.

PARTS LIST

Semiconductors
D1,D2,D3—1N4148 switching diode
D4—1N4004 rectifier diode
IC1—H11A1 ac optical isolator
IC2—2N45 optical isolator
IC3—555 timer
IC4—CD4011 CMOS quad NAND gate
IC5—7812 + 12-volt regulator
Q1—2N2222A npn transistor
RECT1—100-PIV bridge rectifier (Radio Shack Cat. No. 276-1152 or similar)
Capacitors
C1—0.02-µF, 250-volt electrolytic
C2,C6—0.01-µF, 50-volt disc
C3,C5,C7—0.1-µF, 50-volt disc
C4—68-µF, 35-volt electrolytic
C8,C9—150-µF, 35-volt electrolytic
Resistors (1/4-watt, 10% tolerance)
R1,R2,R5,R10—100,000 ohms
R3—20 megohms
R4,R6,R9—10,000 ohms
R7—20,000 ohms
R11—2,000 ohms
R8—1-megohm potentiometer
Miscellaneous
F1—0.5-ampere slow-blow fuse
J1—RJ11 (6-position) modular telephone jack
K1—12-volt dc, 3-ampere dpdt relay (Radio Shack Cat. No. 275-206 or similar; see text)
P1—Telephone line cord with modular plug
S1—3-ampere spst slide or toggle switch
S2—Spst momentary action pushbutton switch
SO1,SO2—Chassis-mount ac receptacle
T1—12.6-volt, 250-mA power transformer
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware; ac line cord with plug; fuse holder; control knob for potentiometer; suitable enclosure (see text); small rubber grommet or plastic strain relief for line cord; ½" spacers; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Steve Lympany, P.O. Box 51281, Raleigh, NC 27609: 4N24 optoisolator for $1.50; H11A1 optical isolator for $4.00; bridge rectifier for $1.50; telephone line cord with connector for $1.50; and RJ11 modular telephone jack for $2.25. Add $1.50 for P&H. North Carolina residents, please add state sales tax.

pins to prevent the optoisolators from being plugged in wrong.

You can fabricate a printed-circuit board with the aid of the actual-size etching-and-drilling guide shown in Fig. 4. Once the board is ready, wire it exactly as shown in Fig. 5, taking care to properly orient all electrolytic capacitors, diodes, integrated circuits, bridge rectifier and the transistor. (If you are point-to-point wiring the circuit on perforated board, follow the layout shown in Fig. 5 for component placement.)

Start wiring the board by installing and soldering into place first the IC sockets. Follow with the resistors, capacitors, rectifier assembly, diodes and transistor. Do not install the ICs in their sockets until after you have performed the voltage checks upon completion of wiring.

Note in Fig. 5 that power transformer *T1*, switches *S1* and *S2*, ac receptacles *SO1* and *SO2*, relay *K1* and fuse *F1* and its holder mount off the circuit board. This being the case, prepare 14 5" lengths of hookup wire by stripping ¼" of insulation from each end of all of them. Plug one end of these wires into all vacant board holes, except those for *T1*, and solder them into place.

You can use any size metal or plastic enclosure that will accommodate the circuit-board assembly and all off-the-board components without crowding. Machine the selected enclosure to provide mounting holes for the circuit-board assembly, power transformer, relay, switches, fuse holder and potentiometer and for entry of the ac line and telephone cords. Then cut slots and drill mounting holes for the chassis-mount ac receptacles.

If you are using a metal enclosure, deburr all holes and line the entry

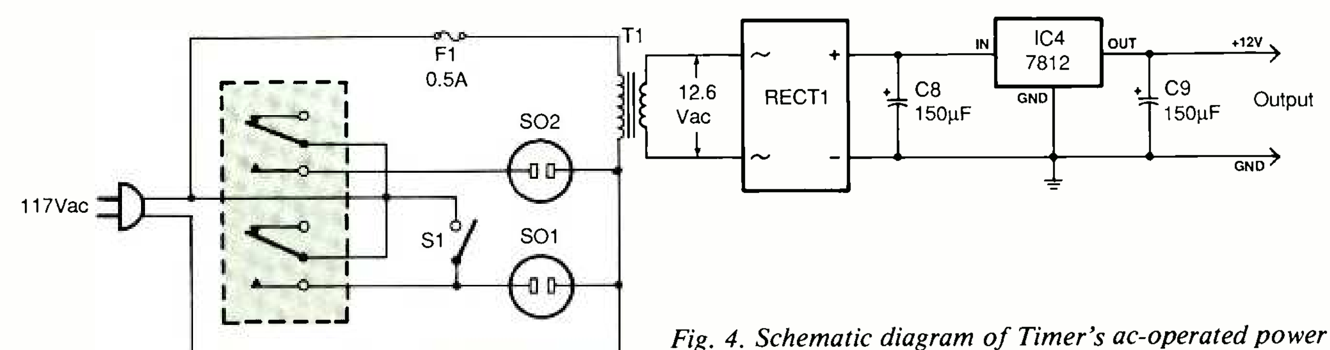


Fig. 4. Schematic diagram of Timer's ac-operated power supply shows details of relay K1's contact arrangement.

holes for the ac line cord and telephone cord with rubber grommets.

Mount the circuit-board assembly on the floor of the enclosure with ½" spacers and 4-40 × ¾" machine screws, nuts and lockwashers. Then mount all off-the-board components in their respective holes and cutouts. Pass the ac line cord and the telephone cord through their rubber grommets and tie a knot in each about 5" from the free ends inside the enclosure to serve as strain reliefs. Twist together the fine wires in each cord's conductors and sparingly tin with solder. Interconnect all components and wiring, referring to Figs. 2 and 5 for details.

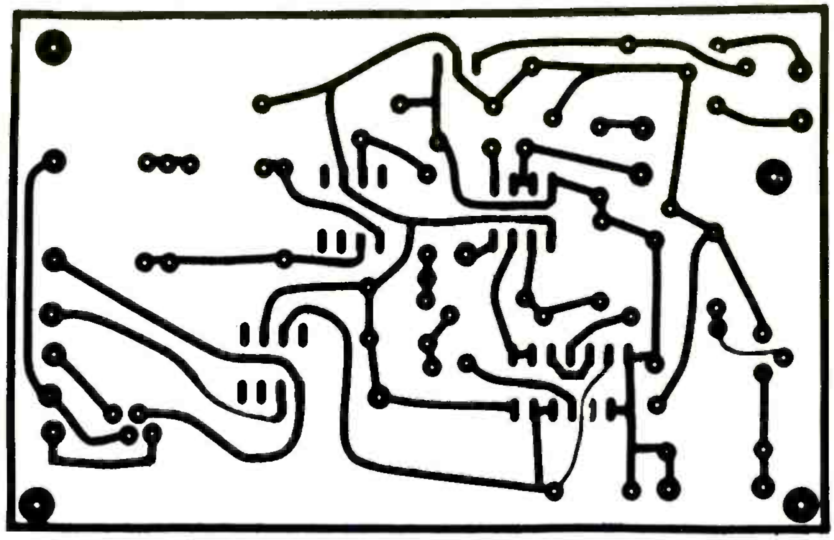


Fig. 5. Actual-size etching-and-drilling guide for fabricating a printed-circuit board for the project.

Checkout & Final Assembly

Once the project has been fully wired (the only IC that should be installed at this time is voltage regulator *IC5*), plug its line cord into an ac receptacle. Connect the common lead of a dc voltmeter set to read 12 volts or greater to circuit ground. (*Warning:* Dangerous ac line voltage appears at various portions of the circuit. Therefore, exercise caution when making the voltage checks to avoid touching these portions of the circuit.) Measure the voltages at pin 3 of *IC5*, pin 8 of *IC3*, pin 14 of *IC4* and the cathode of *D4*. In all cases, you should obtain a reading of + 12 volts. If not, power down the circuit and double check all wiring and components orientations and locations. Do not proceed until you have cleared up the problem.

Once the voltages check out, power down the project and allow the charge on *C4, C8* and *C9* to bleed off. Then install the ICs in their respective sockets. Make certain that the ICs go into the correct sockets, in the proper orientations (see Fig. 5) and that no pins overhang their socket or fold under between IC and socket as you seat the ICs.

Plug the Timer's line cord into an ac receptacle and momentarily short together pins 2 and 5 of *IC2* with a short length of hookup wire while listening for the relay to energize (you should hear a click as the relay's contacts snap closed). After the Timer has timed out, the relay should deenergize, again with a click. Repeat this test with *R8* adjusted to different settings throughout its range. You should hear the relay energizing and deenergizing in each case, but the time-out period (time between on and off clicks) should be different at each setting.

Once the tests show that the circuit is operating properly, you can put your Telephone-Activated Lamp Timer into service. To do this, plug *P1* into the telephone wall jack and the telephone instrument into *J1*. Then plug a switched-on lamp into *SO1*. Your Telephone-Activated Lamp Timer is now ready to light your way to your telephone when it rings after lights out. **ME**

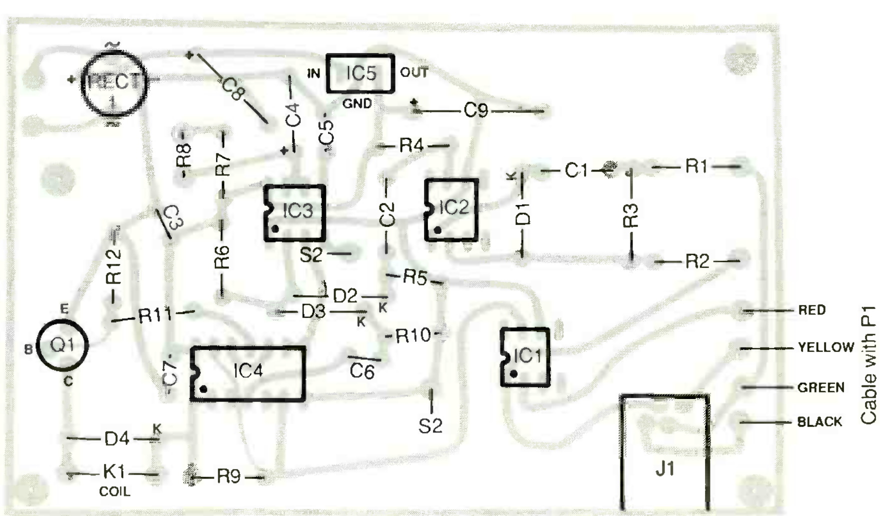


Fig. 6. Wiring guide for pc board. Use this layout if you wire the project on perforated board.

Build a Better Music Synthesizer by Thomas Henry. (Tab Books. Soft cover. 167 pages. $11.95.)

Though commercial synthesizers abound, the author believes that anyone with enough technical knowledge can always build a better electronic instrument on his own. This is the premise of this book, which guides the reader through building the music synthesizer that best suits his needs. The book is divided into three main parts, the first of which covers the basics of sound, general descriptions of the various modules used in synthesizers, the electrical standards involved and, finally, planning the synthesizer itself.

Part II contains the circuits of the modules, along with full explanations of how they work. Included here are the schematics for such modules as a deluxe vco, a four-pole low-pass vcf, vcas, a one-chip ADSR, a supercontroller, a digital keyboard and more. All of the various modules required to build a flexible, sophisticated music synthesizer are covered in detail, including a quadrature function generator, a balanced modulator and the all-important power supply.

Part III shows how to put it all together. An assembly chapter covers power-supply connections, completing the synthesizer, testing and troubleshooting procedures and using the synthesizer. The concluding chapter, titled Inventing New Modules, gives suggestions for more analog circuits and talks about moving toward digital synthesis, with details on using computers for generating electronic music. It ends with a look toward the future.

Appendixes list sources of supplies and books, manuals and periodicals to which the reader can refer for more details. This is a well-written and fully illustrated book. It should appeal to every electronics enthusiast who is a musician at heart.

Installing Your Own Telephones, Second Edition. (Reston Books. Soft cover. 176 pages. $14.95.)

Installing your own telephones and wiring can save you hundreds of dollars. This book shows how anyone can install phones and run whatever wiring is needed, even through walls and floors. It does so with easy-to-understand, step-by-step instructions and fully detailed drawings that provide expert guidance from start to finish. It even tells you what tools and materials are needed for each job.

Lots of useful information is given in the book. Among them is how the telephone operates, which paves the way for proper installation. It also gives tips on how to evaluate an existing phone system to determine if it fills your requirements and how to modify it so that it does. Installation instructions include replacement of modular and old-style telephones, running interconnecting cables and adding phones to modular and old-style systems. The book tells you what to do during construction to build in the wiring, instead of adding it after a home or small business structure is completed.

It also shows how to physically and electrically install the dozens of popular accessories routinely used in the home and business. The concluding chapter deals with very helpful installation checks and troubleshooting and contains a handy table that lists the most common problems, their likely causes and what to do to cure them. In sum, this book can save most anyone a lot of money by showing the reader how to do it himself.

NEW LITERATURE

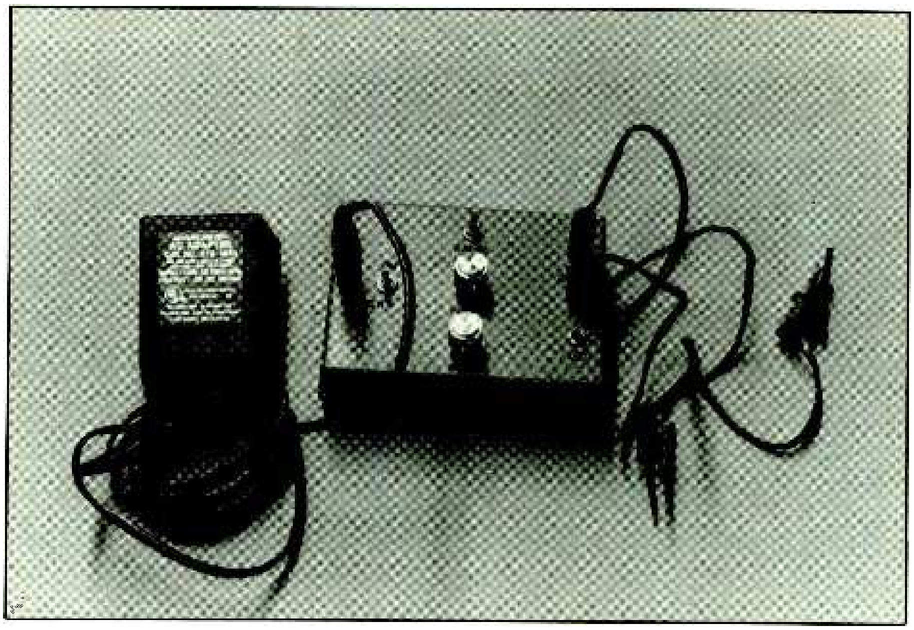
Shortwave Products Catalog. Universal Shortwave Radio's new catalog lists and fully describes a broad range of products for the shortwave radio listener. Product categories include radio receivers, converters, filters, tuners, active antennas, headphones, switches, cables converters, decoders and more. It even includes listings for code tapes, a large propagation wall map and books. Product brand names represented include ICOM, Kenwood, MFJ, Palomar Engineers, Panasonic, Sangean, Ten-Tec, Yaesu, etc. For a free copy of Universal Shortwave Catalog No. 87-03, write to: Universal Shortwave Radio, 1280 Aida Dr., Dept. M, Reynoldsburg, OH 43068.

Power-Conversion Products Catalog. Semtech Corp.'s new 36-page 1987 Short Form Catalog lists more than 300 discrete devices and more than 300 standard power-conversion assemblies in both commercial and JAN, JANTX and JANTXV versions. The catalog describes the company's broad line of off-the-shelf products and custom and semi-custom capabilities. For a copy, write to: John Pennant-Jones, VP Sales & Mktg., Semtech Corp., 652 Mitchell Rd., Newbury Park, CA 91320.

A Varipulse Generator

A wide-range pulse generator for use in digital electronic circuit testing and troubleshooting

By Ralph Tenny



If you work or experiment with digital electronic circuitry, a pulse generator can be just as important a piece of test equipment to you as are an oscilloscope and a logic probe. Like most test instruments, however, different pulse generators give different levels of performance, depending on design and cost. Though the "Varipulse" Generator about to be described is a simple digital project, it offers performance that's close to that of low-cost laboratory pulse generators. Not only will it become a handy tool for your digital work, it also gives you hands-on experience with one of the newest types of digital logic—HCMOS (high-speed CMOS).

Varipulse is an adjustable-frequency pulse generator that has three TTL-compatible outputs. Three switch-selectable ranges, coupled with a 100:1 vernier control, permit the output frequency to range from about 1 Hz on the low end to more than 1.5 MHz on the high end. Pulse width of the simultaneous positive and negative outputs can be varied from 180 nanoseconds (0.18 microsecond) to 75 microseconds. Pulse frequency is twice that of the main output in three overlapping ranges. Range 1 covers 3 MHz to 27 kHz, range 2 from 40 kHz to 250 Hz and range 3 from 400 Hz to 2 Hz.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Varipulse Generator, including its low-voltage dc power supply. The basic clock generator is built around *IC1A*, with *R1*, *R2* and *C1* setting a basic frequency of between 3 MHz and 27 kHz to make up range 1. This 100:1 range is a result of the resistance ratio between *R1* (where *R2* = 0 ohm) and *R1* + *R2* (where *R2* is at maximum resistance).

Switch *S1* connects either *C2* or *C3* in parallel with *C1* to establish ranges 2 and 3, respectively. This is a three-position switch with a center-off position to allow for range 1's conditions. Alternatively, it can be a 3-position, nonshorting rotary switch with no connection made to the position-2 contact lug.

Connected as a divide-by-2 flip-flop, *IC2A* is continuously toggled by *IC1A* for as long as power is applied to the Varipulse's circuit. Four sections of *IC1* are connected in parallel with each other to increase the available output drive for the external load connected to the MAIN output. The MAIN output at *J1* delivers a continuous train of square pulses whose amplitude excursion is almost 5 volts peak-to-peak.

Positive and negative pulses are generated by *IC1B* and *IC2B*, respectively. The only difference between the *IC1A* and *IC1B* oscillators is *D1* in the latter. This diode holds the *IC1B* oscillator off as long as pin 6 of *IC2B* is at logic 0. (For details on how the oscillator circuit works, see "The Schmitt-Trigger Oscillator" box elsewhere in this article.) When pin 6 of *IC2B* is high, *D1* is reverse-biased, which allows *IC1B* to oscillate. When *D1* is conducting, *IC1B*'s output is high.

When *D1* releases pin 3 of *IC1B*, *C4* charges up until pin 3 reaches its upper threshold, at which point, *IC1B*'s output switches low and resets *IC2B*.

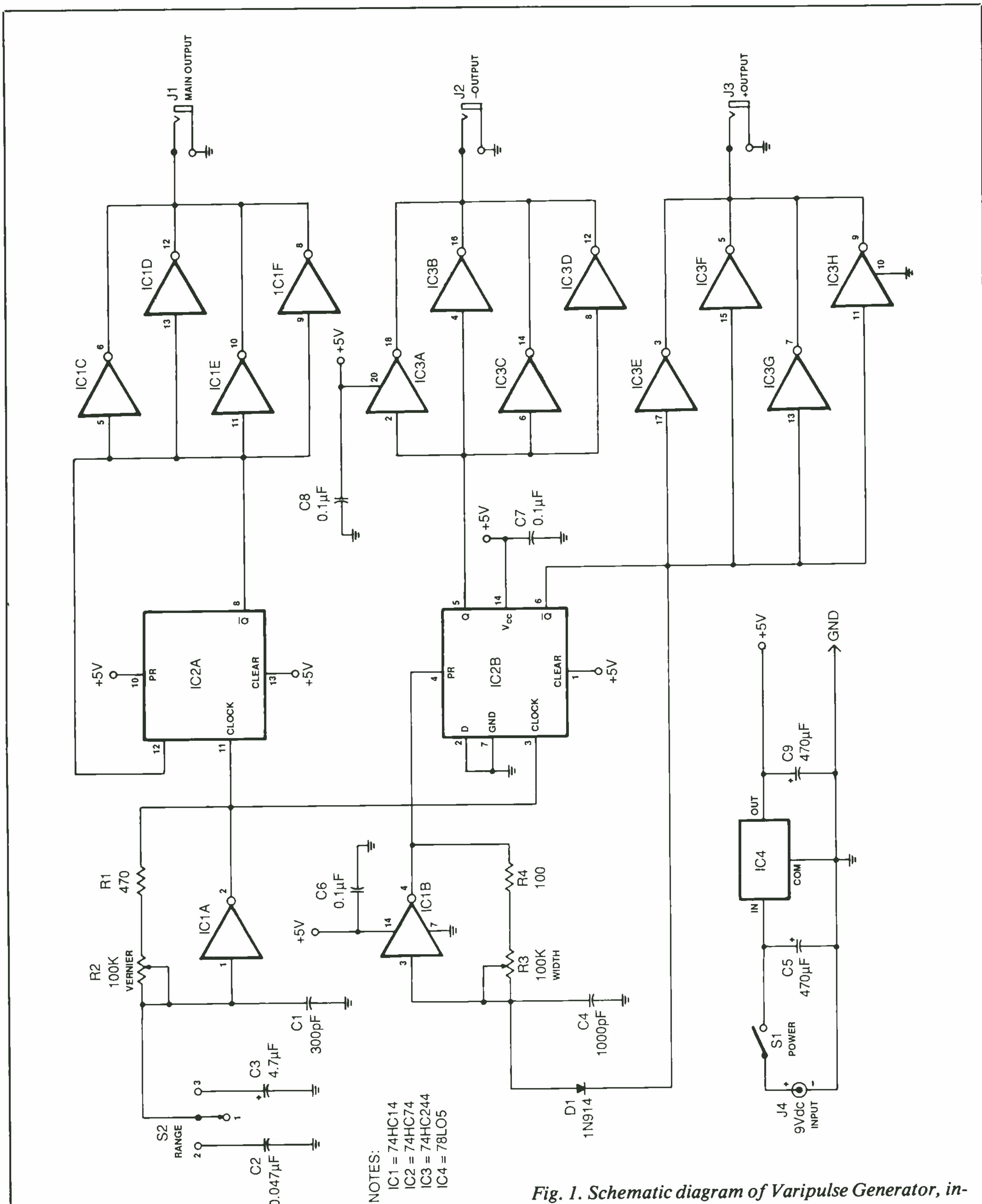


Fig. 1. Schematic diagram of Varipulse Generator, including its low-voltage power supply.

PARTS LIST

Semiconductors

D1—1N914 or 1N4148 switching diode

IC1—74HC14 Schmitt-trigger hex inverter

IC2—74HC74 dual-D flip-flop

IC3—74HC244 octal tri-state buffer

IC4—78L05 +5-volt regulator (DIP or TO-92 version; see text)

Capacitors

C1—330-pF film or dipped mica

C2—0.047-µF film

C3—4.7-µF, 10-volt minimum aluminum or tantalum electrolytic

C4—1 000-pF film

C5,C9—470-µF, 25-volt aluminum electrolytic

C6,C7 C8—0.1-µF ceramic

Resistors (¼-watt, 5% tolerance)

R1—470 ohms

R4—100 ohms

R2,R3—100,000-ohm linear-taper potentiometer

Miscellaneous

J1,J2,J3—Miniature phone jack

J2—Power jack (to match connector on cable of selected wall transformer)

S1—Spst slide or toggle switch

S2—Spdt switch with center-off position or 3-position, nonshorting rotary switch (see text)

9-volt dc, 100-mA or more plug-in wall transformer (Radio Shack Cat. No. 273-1651 or similar; see text); suitable enclosure (Unibox No. 130 or similar); printed-circuit board or perforated board (Uniboard No. 302 or similar) and suitable soldering or Wire Wrap hardware; sockets for ICs; miniature phone plugs (3); "micro-grabber" connectors (3); 9 ft. flexible-lead cable or coaxial cable (see text); knobs for R2 and R3; lettering kit (see text); hookup wire; solder; etc.

The Schmitt-Trigger Oscillator

The Schmitt-trigger logic block is available as high-speed CMOS logic in two forms: a hex inverter 74HC14, and a quad NAND gate 74HC132. Normal logic inverters and gates will oscillate unpredictably if a slow rising signal or a dc level between 0.8 and 2.0 volts is applied to the input. The Schmitt-trigger logic block has been modified internally to prevent oscillation.

In a Schmitt logic block, input voltages must rise higher than an upper threshold of about 3.5 volts before the output changes. After the output changes, the input must then drop to lower than 1.0 volt before the output changes again. This assures that slowly changing voltages won't cause undesirable oscillations.

Figure A shows the response of a logic Schmitt element to a varying voltage. Note that the output of the element changes only when the input crosses a threshold-voltage level.

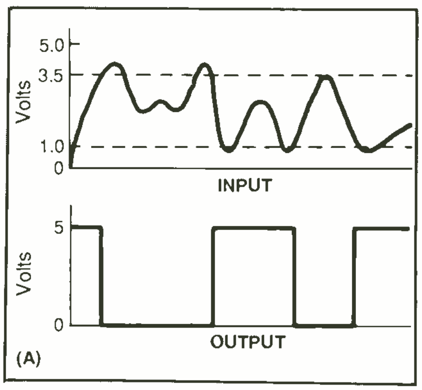


Fig. A. Schmitt-trigger response to varying input.

Figure B shows the logic Schmitt used as an oscillator. Here, *R1* provides feedback to the input but is forced to charge or discharge *C1* before the input voltage can change. Figure C shows the input and output waveforms of the Fig. A oscillator.

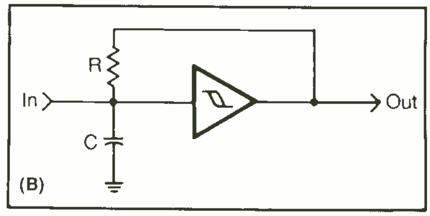


Fig. B. Schmitt-trigger oscillator.

When power if first applied to the oscillator, *C1* is totally discharged and the output is high. As *C1* charges through *R1*, the input voltage rises to the upper Schmitt threshold. This causes the output to switch to low and, in turn, causes *R1* to start discharging *C1*.

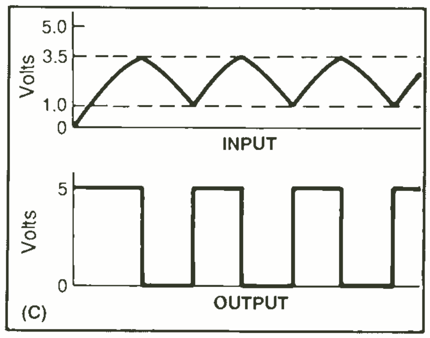


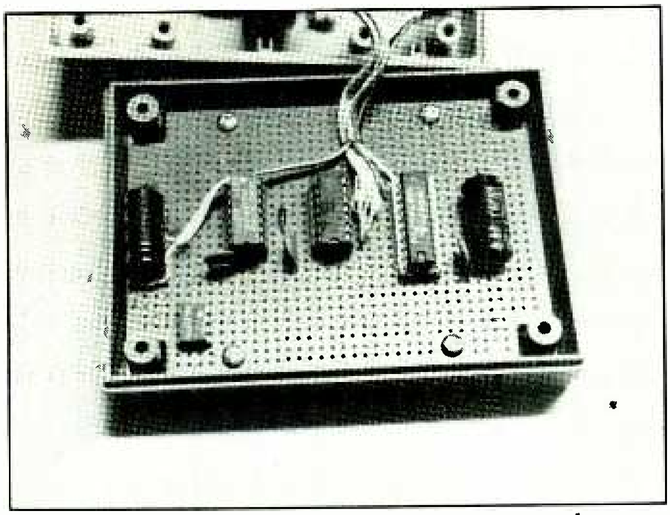
Fig. C. Schmitt-trigger oscillator output waveforms.

When *C1* discharges to the lower Schmitt threshold, the output switches high once again. This completes one cycle. Immediately following this, *C1* begins to charge toward the upper threshold again. Hence, *C1* charges and discharges between the two Schmitt threshold voltages as long as oscillations continue. The circuit continues to oscillate until power is removed or *C1* is held below the lower threshold.

This causes pin 6 of *IC2B* to go low and lock out of oscillation. The result is that pin 5 of *IC2B* goes low each time *IC1A* switches high and goes high when *IC2B* switches low.

As long as pin 4 of *IC2B* is held low by *IC1B*, *IC2B* will not respond to clock pulses from *IC1A*. With *R3* set to maximum resistance, the pulse rate is twice as fast as the MAIN output. This is because the MAIN output is divided by two from the basic frequency developed by *IC1A*, but *IC2B* can be triggered only once during each cycle of *IC1A*. The +OUT and −OUT outputs available at *J3* and *J2*, respectively, are identical to each other except for the inversion between the complementary outputs of *IC2B*.

Octal bus driver *IC3* has two sets of four sections connected in parallel to provide high-current drive for the pulse outputs. Because these outputs



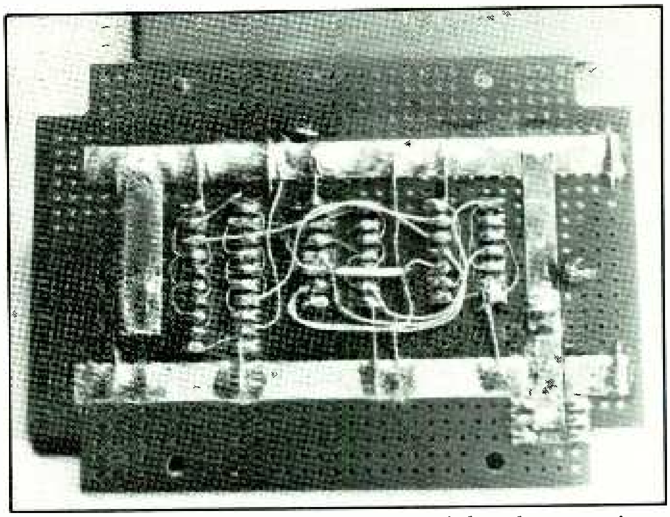


Fig. 2. Top view (left) of assembled project shows suggested component layout. Bottom view (right) shows typical wiring with self-stick IC pads and conductors.

are capable of ringing almost any kind of output cables, the output leads must be terminated properly.

The period of *IC1B*'s single pulse is set by the values of *R2*, *R3* and *C4*. The apparent 1,000:1 ratio of *R3/R2* is actually slightly less than 400:1 (75/0.18). There are two reasons for this apparent error. Firstly, variable resistors seldom are adjustable all the way down to exactly 0 ohm and may have an "end resistance" of as much as 0.1% of the resistor's rated maximum resistance. Secondly, low-cost potentiometers may have less than rated resistance, due to normal manufacturing tolerances.

Varipulse's somewhat unusual pulse-generating circuitry gives a capability that's unique for this type of instrument. The adjustment range of *R3* produces pulses that are greater in width than the period developed by *IC1A* on range 1 and part of range 2. Recall that when pin 4 is low, *IC2B* cannot respond to clock signals. Therefore, it's possible to set pulse WIDTH control *R3* for longer than one *IC1A* period. This allows you to divide the main output frequency by 2, 2.5, 3, 3.5, etc., with a maximum of about a 10:1 ratio. Consequently, test projects can have two fixed-relationship input triggers.

The recommended power supply

The Output Pulses

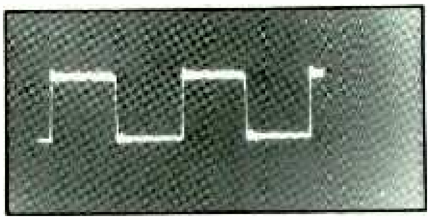
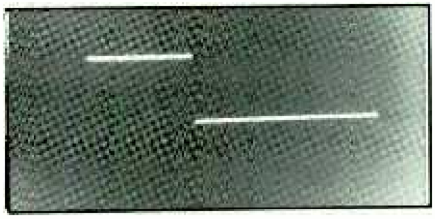
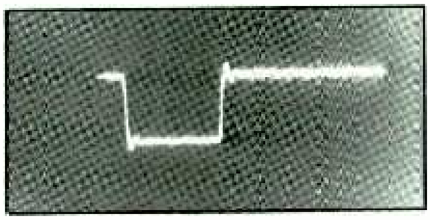


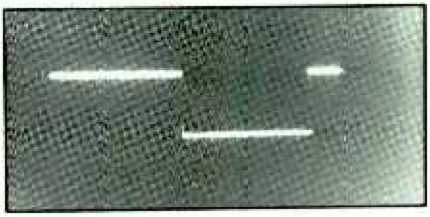
Photo of Varipulse's 1.5-MHz output into 100 ohms.



A 75-microsecond (maximum-width) output pulse.



A 180-nanosecond negative pulse.



A 22-kHz square-wave pulse.

These photos show the Varipulse Generator's output signals as displayed on a 100-MHz oscilloscope. The output was terminated with 100 ohms to match the impedance of the test leads. Failure to match test-lead impedance will cause overshoot and ringing in the output signal.

Different output test leads will require different terminating resistances. Try to avoid using leads that require 93- or 100-ohm terminating resistors to obviate overloading of output drivers in the Varipulse Generator.

Shown in the upper- and lower-left photos is the high-frequency ringing typical of most high-speed pulses. The upper-left photo shows the Main output at 1.5 MHz, while the lower-left photo shows a 180-nanosecond-wide negative pulse.

In the upper- and lower-right photos is shown the 75-microsecond maximum-width positive pulse. These outputs are typical of low-cost pulse generators.

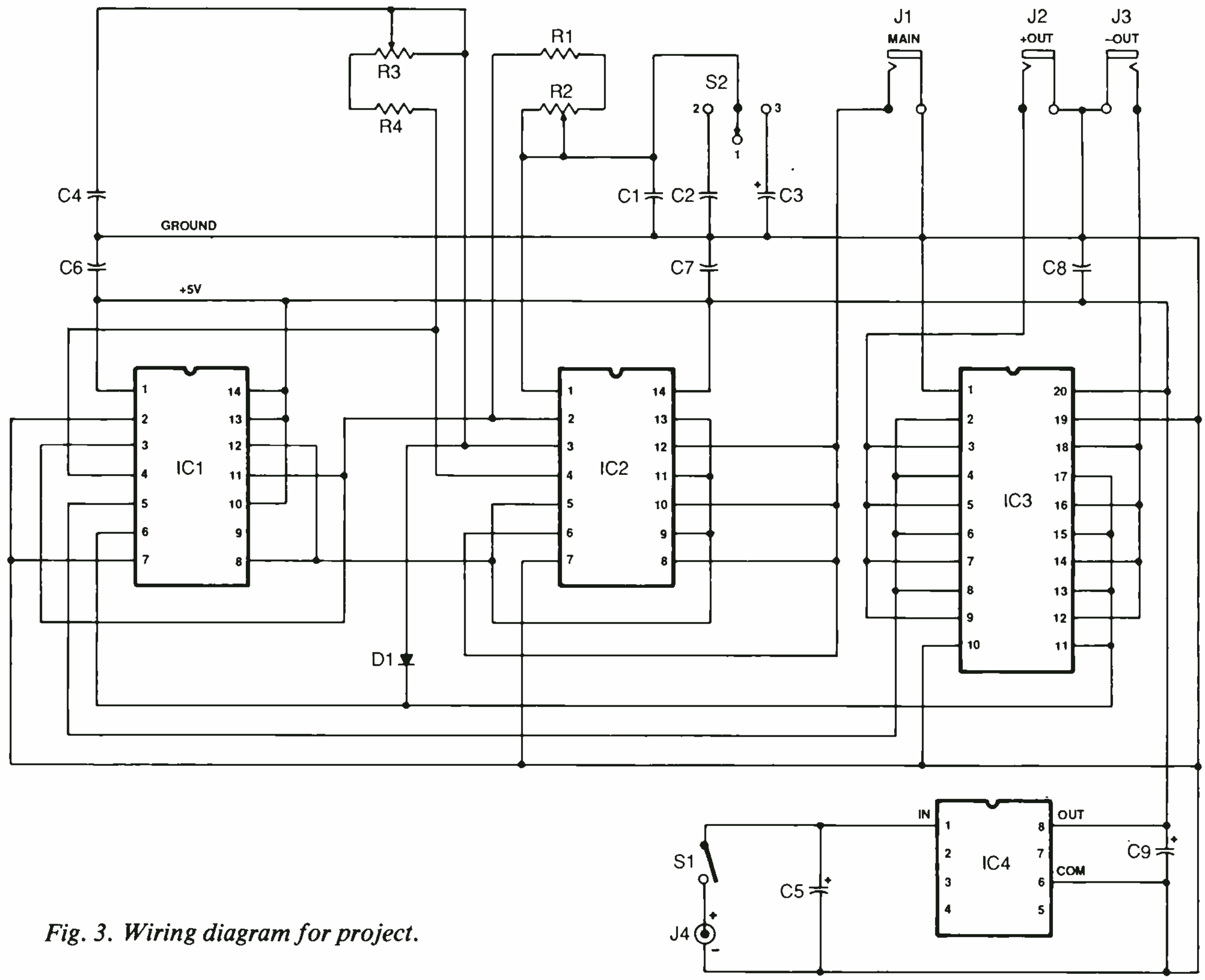


Fig. 3. Wiring diagram for project.

for the Varipulse Generator is a small plug-in wall transformer with separate filtering and regulation as shown. The transformer should be rated to deliver 9 volts dc at about 100 milliamperes, though the one specified in the Parts List delivers a considerably higher current than this. Hence, more than one small instrument can be simultaneously powered from the same wall transformer. Power from the transformer is filtered by *C5* and regulated to the required 5 volts dc by *IC4*.

Construction

By using an external power supply, the finished project can be made very compact, as illustrated in the lead photo. Assembly of the circuitry itself can be accomplished via any of the traditional wiring methods, including on a printed-circuit board of your own design. Alternatively, you might want to use perforated board (with holes on 0.1″ centers) and suitable Wire Wrap or soldering sockets and post terminals.

The prototype of the project was wired on perforated board. A suggested component layout for this arrangement is shown in the top-view photo in Fig. 2, while the bottom-view photo shows how the circuit was wired together on perforated board. (The wiring diagram for the circuit is shown in Fig. 3.) Note in the bottom-view photo the use of EZ Circuit IC patterns and self-stick copper foil conductors that simplified construction of the prototype. Interconnections were made with Wire Wrap-type No. 30 Kynar wire. Whatever wiring method you decide to use, it's a good idea to use sockets for *IC1*, *IC2* and *IC3*. Use a socket for *IC4*, too, if you decide to use an 8-pin DIP voltage regulator. If you use a TO-92-packaged regulator, you don't need a socket.

Figure 4 illustrates special layouts

(Continued on page 86)

Magnetic Field Sensors

By Forrest M. Mims III

Electronic sensors that detect magnetic fields have countless applications in electronics and other technologies. Many such sensors are available, including various kinds of inductors and solid-state devices. Among the most important solid-state sensors of magnetic fields are Hall-effect devices, the principal subject of what follows. Before taking a detailed look at Hall-effect devices, let's review some basics of magnetism and the simplest detector of magnetic fields.

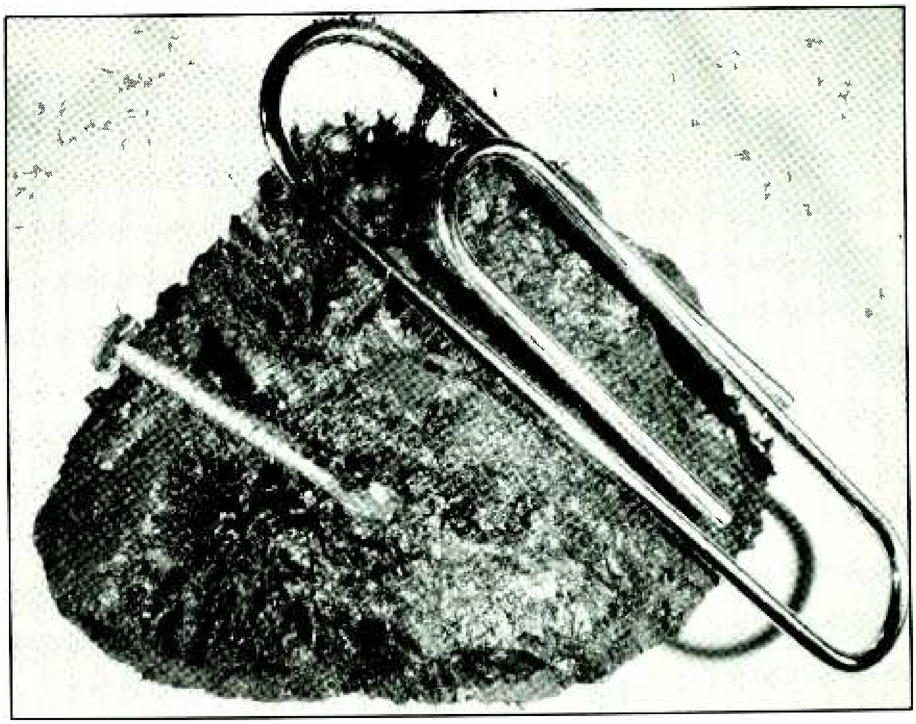


Fig. 1. A lodestone in the author's shop.

Magnetism & Magnets

In ancient times, pieces of iron oxide found near the city of Magnesia in Asia Minor were found to possess the remarkable ability to attract and repel one another. Samples of this mineral were known as "leading stones" and, later, "lodestones" or "loadstones." The phenomena displayed by lodestones came to be known as "magnetism."

Observations about magnetism were recorded by the Greeks as early as 800 B.C. In 1269, Petrus Peregrinus de Maricourt studied the magnetic field of a spherical lodestone and found that its magnetic lines of force intersected at two points on opposite sides of the stone. He called these points the "poles" of the stone. Around 1600, William Gilbert found that a lodestone lost its magnetic properties when heated but regained them when cooled.

The interrelationship between electricity and magnetism was discovered in 1819 when Hans Christian Oersted found that the current flowing through a wire attracted a nearby compass needle. Oersted's discovery laid the foundation for the development of electromagnetic technology, along with its attendant electromechanical devices, such as meters, relays, solenoids and motors.

In 1838, Johann Karl Friedrich Gauss, a German mathematician and physicist, published a classic paper about the Earth's magnetic field. Because of Gauss's contributions to the field, the measure of strength of the magnetic field is named after him. A magnetic field of 1 gauss (G) is produced at a point 1 centimeter away from a straight wire through which a current of 5 amperes is flowing. Another unit of magnetic field of intensity is named in honor of Nikola Tesla, the famous American engineer. One tesla (T) equals 10,000 G.

The strength of the field near a magnetized needle is only a small fraction of a gauss. A pair of lodestones from Utah in my electronics shop each have a strength of several tens of gauss. A small speaker magnet may have a field strength of hundreds of gauss. The field strength of larger magnets can exceed thousands of gauss. The Earth's magnetic field has a strength of about 0.3 G at the equator and about 0.7 G at either pole.

Incidentally, the Earth's magnetic field may vary from 0.0002 to 0.0005 G during a single day. A "gamma" is 0.000001 G. Therefore, the range of daily variation is 20 to 50 gamma.

Since the lodestone was for centuries the only available magnet, it seems fitting to include Fig. 1, which is a photo of the lodestone in my electronics shop. This lodestone from Utah weighs just under an ounce and measures 1 inch along its longest dimension. Its maximum magnetic flux, as measured with a calibrated Hall device, is 140 gauss. The iron filings, paper clip and small nail clinging to the lodestone clearly reveal its magnetic properties.

Manufactured magnets are available in countless sizes and configurations. They are made from ferromagnetic materials like steel, cobalt and alloys such as aluminum-nickel-cobalt (Alnico) and neodymium-iron-boron. Flexible magnets are made by fixing a ferromagnet in a binder. They are available in sheets that can easily be cut with scissors.

Low-cost magnets are available from many suppliers, including department stores and Radio Shack. A wide range of magnets, some quite powerful, is available from Edmund Scientific Co.

Most low-cost magnets have a flux density of a few hundred gauss. For ex-

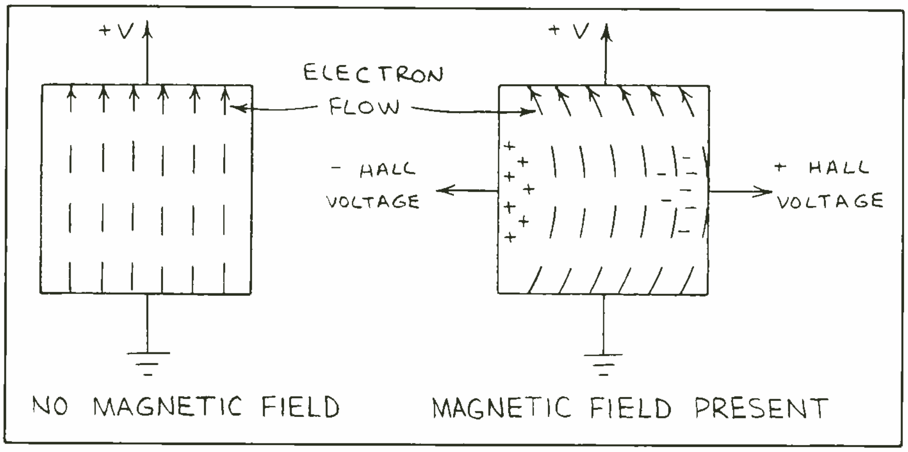


Fig. 2. The Hall effect.

ample, here are the flux densities of several common magnets found in my shop:

Magnet Type	Flux in Gauss
Speaker	290
Flexible disc	400
Electromagnet	220

Much more powerful magnets are available. For example, a small Alnico VIII magnet only 0.25 inch in diameter and 0.25 inch long has a flux density greater than 1,000 G. Edmund Scientific sells both electro- and permanent magnets that can lift up to 200 pounds.

The Compass

There is controversy among historians over whether the Chinese or Europeans first invented the compass. However, many historians agree that the first compass was probably a piece of lodestone suspended from a string. After the lodestone settled down, the same side always pointed in a northerly direction. A needle can be magnetized by stroking it across a lodestone. This explains the early development of compasses made by attaching a needle to a small piece of wood floating in a dish of water.

Why include the venerable compass in a discussion devoted primarily to solid-state magnetic field sensors? As note above, the Earth's magnetic field has a strength of only from about 0.3 to 0.7 G. While the direction of the Earth's magnetic field is readily indicated by the simplest compass, the solid-state magnetic-field sensors described below are not nearly as sensitive. Their sensitivity can be increased to rival that of a compass by means of a piece of metal called a "flux concentrator." I'll have more to say about this later.

The Hall Effect

In 1897, the physicist Edward H. Hall

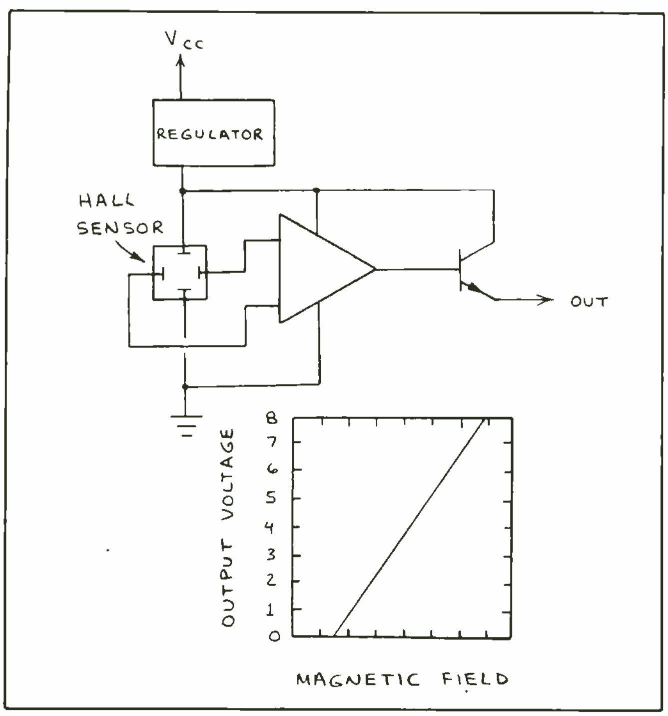


Fig. 3. Linear-output Hall sensor.

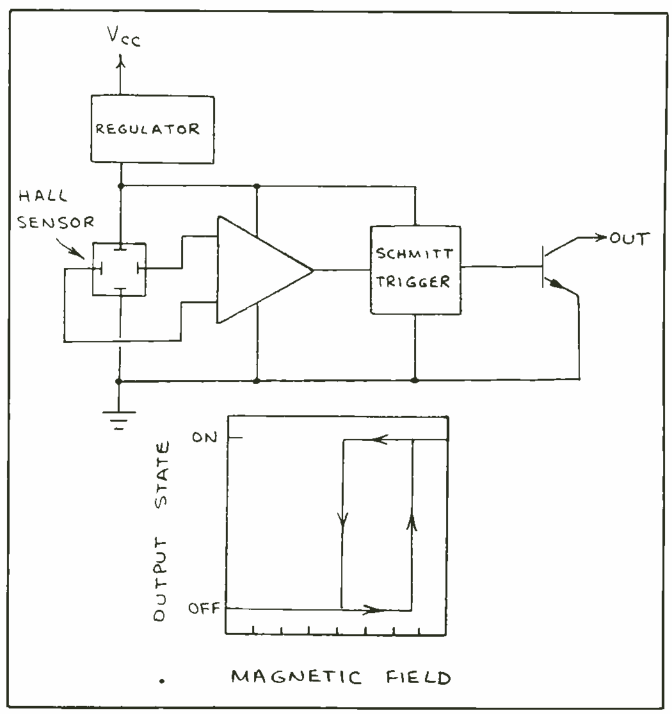


Fig. 4. Digital-output Hall sensor.

found that a current flowing through a film of gold was influenced by a magnetic field. As shown in Fig. 2, when no magnetic field is present, the current flowed directly between terminals on opposite sides of the gold film. When a magnetic field was applied, the path of the current was deflected as shown at the right in Fig. 2. The altered current path caused more electrons to appear on one side of the gold film. Therefore, a potential difference existed between the two sides of the film. The voltage represented by this difference in potential is now called the "Hall voltage."

It was eventually discovered that certain materials exhibit much higher sensitivities to magnetic fields than does gold. Particularly important are compound semiconductors, such as indium antimonide, indium arsenide and indium arsenide phosphide.

Early Hall-effect sensors were discrete devices. Most of today's Hall-effect sensors are integrated devices that include an amplifier and voltage regulator. Figure 3, for example is the internal circuitry for a typical integrated Hall-effect sensor having a linear output. A typical such sensor has a sensitivity of around 1 millivolt per gauss.

Hall-effect devices are well-suited for switching applications. Figure 4 shows the internal circuitry for a typical integrated Hall sensor having a digital output. The Schmitt trigger is included both to provide on/off switching and a degree of hysteresis. The hysteresis provides a more stable switching action by preventing oscillation that might occur if the on/off threshold points were equal.

F.W. Bell Co. is a major manufacturer of discrete Hall sensors. The two major manufacturers of integrated linear and digital Hall devices are Micro Switch and Sprague.

Figure 5 shows an early discrete Hall sensor that has resided in my bench stock since around 1970. Figure 6 shows various kinds of linear and digital Hall sensors made by Sprague and Micro Switch that include integrated amplifiers and voltage regulators. The small chips are surface-mountable Hall digital-output devices made by Sprague.

Applications

The number of applications for Hall sensors rivals that for optoelectronic sensors. Indeed, in many applications, either a Hall or an optoelectronic sensor can be used. On the other hand, there are many applications for which a Hall or an optoelectronic sensor is suited. For example, an optoelectronic sensor can detect smoke, paper, plastic and nonferrous metals. A hall sensor can detect magnetic fields and discriminate between ferrous and nonferrous materials.

Figure 7 illustrates several typical applications for Hall sensors. The vane, notch and rotating magnet sensors are used to monitor a rotating assembly. The output from the Hall sensor can provide a direct indication of rotation rate (tachometer) or speed. Or it can be fed back to the electronics that control the assembly's drive motor or brake. These or similar methods can be used to detect the flow of a liquid or gas through a sealed nonferrous pipe. The flow of gas or liquid will cause a ferrous or magnetic rotor in the pipe to spin. A Hall device adjacent to a pipe can detect the spinning impeller.

Figure 7 also shows a level or tilt detector that consists of a magnet attached to a pendulum suspended over a Hall device. This principle can be used to make vibration detectors, accelerometers and seismometers.

There are literally dozens of other applications for Hall sensors. Here are just a few:

- Brushless motor

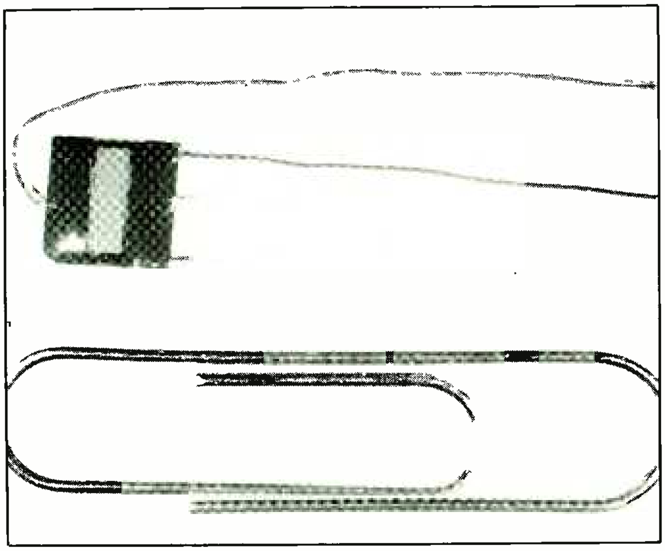


Fig. 5. An early discrete Hall-effect device.

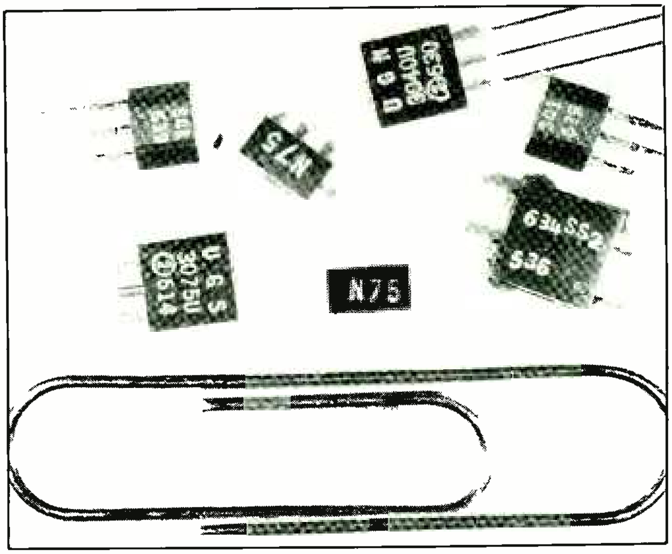


Fig. 6. Assorted linear and digital Hall devices.

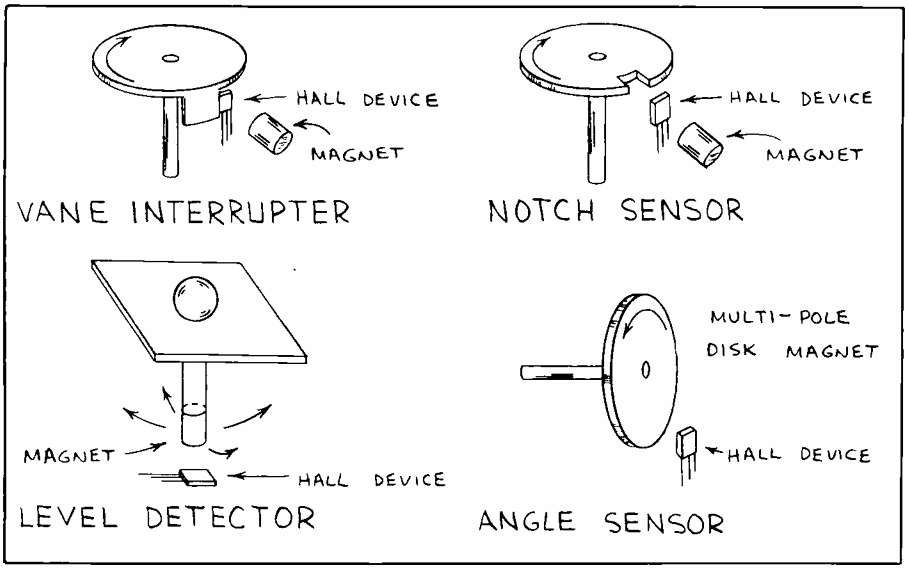


Fig. 7. Typical Hall sensor applications.

- Piston detector
- Solid-state compass
- Nonwear pushbutton switch
- Joystick sensor
- Proximity sensor
- Shaft encoder sensor
- Door-interlock sensor
- Pressure sensor
- Current sensor

The last application, current sensing, is accomplished by passing a current through through a coil of wire placed near a Hall sensor. The electromagnetic field produced by the current will be detected by the Hall sensor. This principle can even be used to sense the current flowing through a straight wire. In either case, no electrical contact to the coil or wire is required.

Adjustable-Threshold Hall Sensor

Most digital-output Hall sensors do not include a means for altering the device's sensitivity. Figure 8 is a simple circuit that transforms a linear-output Hall sensor into a digital-output device having an adjustable threshold. Though Fig. 8 specifies a Sprague UGN-3503 Hall device, this circuit is ideal for experimenting with various Hall sensors. For example, it works with Micro Switch 9SS series linear Hall sensors. It can be used to compare the relative sensitivity of various sensors. And it can be used to explore new applications.

In operation, a 741 or other operational amplifier is operated as a comparator. Potentiometer *R1* serves as a voltage divider that sets the reference voltage of the comparator. When the voltage from the Hall sensor exceeds the reference voltage, the output of the 741 switches from low to high. Therefore, the LED does not glow. When the voltage from the Hall sensor falls below the reference voltage, the output from the 741 switches from high to low and the LED glows.

The circuit in Fig. 8 was tested with an Alnico VIII magnet with a diameter of 0.25 inch and a length of 0.25 inch. This magnet, which is available from Micro Switch in a threaded adapter, has a flux density of at least ±1,000 G adjacent to either pole. Flux density decreases with increasing distance according to the inverse square law. In this case, the flux density is only about ±100 G at 0.3 inch from either pole.

With a Sprague UGN-3503 Hall device connected into the circuit as shown and *R1* set for maximum sensitivity, the magnet could be repeatedly detected at a distance of 0.5 inch. Detection distance was increased to 2.5 inches when a Micro Switch 9SS series linear Hall device was used. The 9SS device, which is assembled on a ceramic substrate along with laser-trimmed resistors, has a sensitivity of around 2.5 mV/G.

Bias Magnets & Flux Concentrators

Operation of a Hall sensor alone can be enhanced significantly by means of very simple, completely passive devices, such as bias magnets and flux concentrators. As will soon be seen, the role of these passive devices is in some ways interchangeable.

A "bias magnet" is simply a small magnet placed behind a Hall sensor, as shown in Fig. 9. With a small bias magnet cemented to the back of a Hall sensor, the device will sense the absence or presence of a ferrous metal. When the north pole of the magnet is placed against the back of the Hall sensor, the sensor will detect the presence of a ferrous metal near the sensor's front face. When the south pole of the magnet is placed against the back of the Hall sensor, the sensor will detect the absence of ferrous metal.

There are numerous applications for Hall sensors equipped with bias magnets. Those that detect the presence of ferrous metal can indicate the presence of a gear tooth or cam in a rotating assembly. They can also be used in limit switch applications. For example, a Hall sensor limit switch can switch off or reverse a motor after an assembly moving along a track reaches the end of its travel. They can also be used to find nails hidden by wallpaper or plaster.

Hall sensors that detect the absence of ferrous metal can be used to detect a notch or the absence of a gear tooth or cam in a rotating assembly. They can also function as a security device by indicating when a metal object like a tool box or office machine has been moved.

A "flux concentrator" is a piece of ferrous metal that attracts magnetic lines of

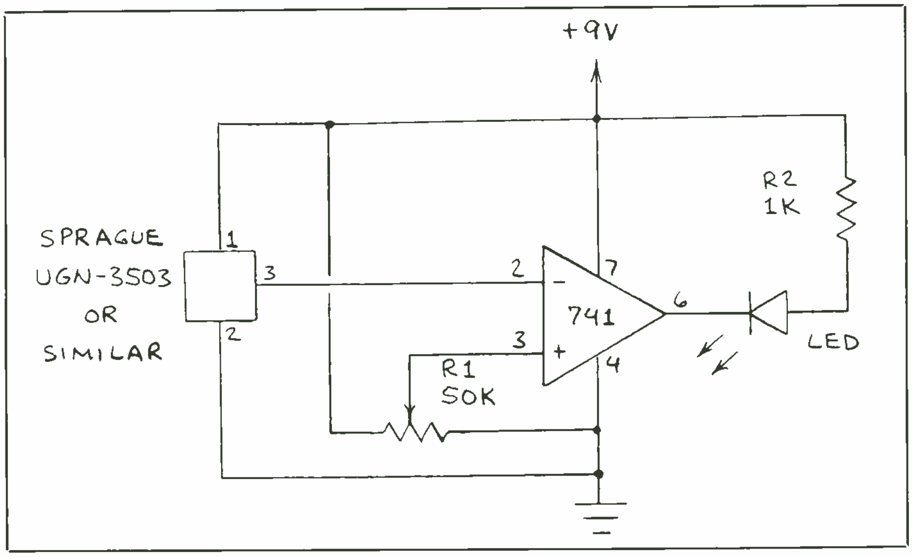


Fig. 8. Adjustable-threshold digital-output Hall sensor.

force. A flux concentrator placed adjacent to a Hall sensor, as shown in Fig. 10, can direct more magnetic lines of force toward the Hall sensor than might otherwise be collected by the sensor alone. The resultant increase in flux density is analogous to the increase in optical power density that occurs when light is collected and focused by a lens.

An excellent discussion of flux concentrators is given in "Hall Effect Applications" (Sprague, 1986). According to this publication, a flux concentrator can increase the flux density at a Hall device by as much as 100 percent. In a demonstration experiment, a samarium-cobalt magnet 0.25 inch square by 0.125 inch long produced a flux density of 187 G at a

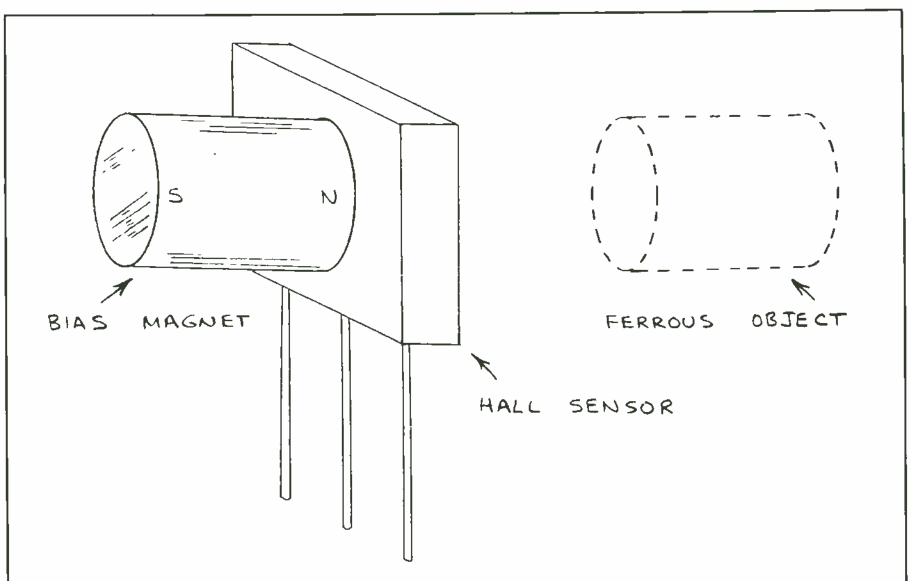


Fig. 9. Ferrous metal detector using bias magnet.

ELECTRONICS NOTEBOOK...

Hall device 0.25 inch away. A flux concentrator 0.125 inch in diameter and 0.5 long placed behind the Hall sensor increased flux density to 291 G.

Incidentally, the flux concentrator in Fig. 10 has a tapered end facing away from the Hall device. This configuration is useful when the Hall sensor is backed by a bias magnet and intended to detect the presence of small ferrous objects, such as gear teeth. In most applications, best results are obtained by placing the tapered end of the concentrator adjacent to the Hall device.

A typical Sprague Hall device has an active area that is 0.1 inch square. Therefore, it would appear that the end of the flux concentrator should have a similar area. However, since the encapsulated Hall device is 0.044 inch from the rear surface of the Hall device, the tapered end of the concentrator should be made somewhat larger than the active area of the Hall sensor. Though Fig. 10 depicts a cylindrical flux concentrator, other shapes can be used. In the case of a cylinder, the length of the concentrator affects in a nonlinear fashion the magnitude of flux concentration. For example, according to a graph published by Sprague, increasing the length of a particular concentrator from 0.1 to 0.5 inch increases the flux by perhaps 50 percent. Increasing the length of the concentrator to 1 inch made only an insignificant contribution to flux density.

Commercial flux concentrators are generally made from low-carbon, cold-rolled steel. Other ferrous materials can also be used. For example, using the circuit shown in Fig. 8, I employed an ordinary steel nail as an effective flux concentrator. When the head of the nail was placed behind the Hall sensor, the circuit's LED came on when a small magnet was brought to within 1.1 inches of the sensor. When the nail was removed, the magnet had to be moved to within 0.6 inch of the sensor before the LED would turn on. Even a paper clip flux concentrator increased detection range by a few tenths of an inch.

Bias magnets and flux concentrators have overlapping effects. For example, I repeated the above experiment with a slightly magnetized 2.5-inch long nail, placing the pointed end of the nail adjacent to the back of the Hall device. When the bias voltage was set so that the LED was just extinguished, the LED would switch on when a small magnet was placed as far as 5 inches from the front of the

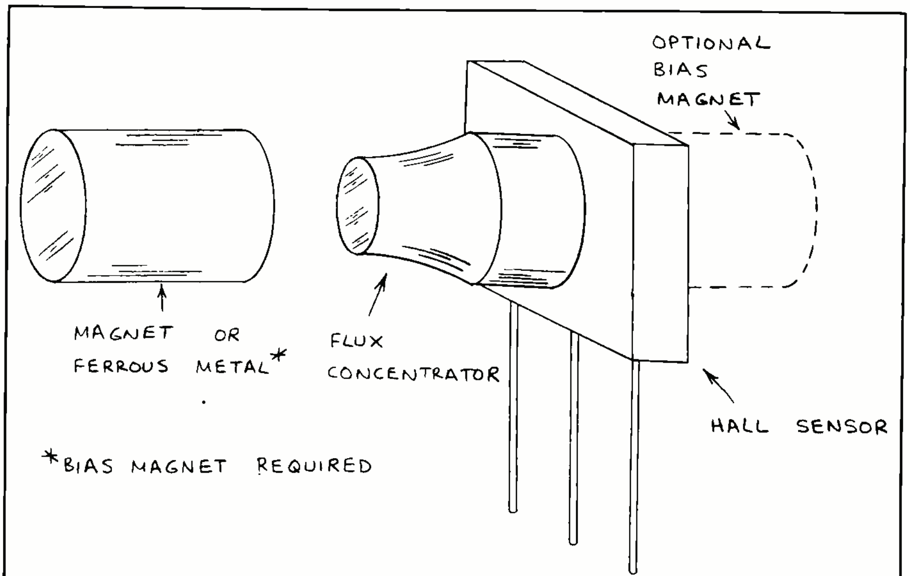


Fig. 10. Using a flux concentrator with a Hall sensor.

Hall device. This result seems quite remarkable—and repeatable.

Other Solid-State Magnetic Field Detectors

Though Hall-effect sensors are apparently the dominant solid-state means for sensing magnetic fields, other kinds of solid-state sensors of magnetic fields have been developed. Some 20 years ago, Edward C. Hudson Jr. invented the "Magnistor," a magneto-sensitive twin-collector transistor. Soon afterward, Sony introduced a magneto-diode, a device whose resistance is altered by an external magnetic field.

The magneto-resistor has also been around for some time. Recently, Nippondenso Co., Ltd., introduced a new magneto-resistor, the MRE-104 ferromagnetic magneto-resistance element. This thin-film device is two series-connected magneto-resistors with a center tap. Two resistors are included because the device has a nonlinear response, particularly at low flux intensities. The two resistors permit the device to be used in a bridge circuit to help compensate for its nonlinear response.

The MRE-104 can be used in many of the same applications for which Hall devices are used. It's particularly well suited for applications in which a variable-resistance output is desired. For example, the MRE-104 can be connected as the feedback resistor to make an amplifier whose gain is controlled by a magnetic field. It can also be used in a circuit that indicates changes in a magnetic field by means of a variable-frequency tone. Finally, it might be possible to connect the MRE-104 directly to the joystick input of a personal computer that interfaces with a joystick that has internal potentiometers.

Going Further

Next month, I'll conclude this discussion of solid-state magnetic field sensors with some practical and experimental circuits. Included will be a calibrated gaussmeter, a simple stud finder that will locate nails hidden behind paint and wallpaper and a magnetic alarm to attach to your floppy-disk storage cabinet. I'll also show how a low-cost Hall device can be used to detect the Earth's magnetic field.

In the meantime, you can learn much more about Hall and other magnetic field sensors by visiting a good technical library. Numerous technical papers and books include references to solid-state magnetic field sensors. Another good source of additional information is the literature published by manufacturers of such devices. In addition to Sprague's "Hall Effect Applications," mentioned earlier, an excellent reference is *Hall Effect Transducers*, a 280-page book published in 1982 by Micro Switch. **ME**

NAMES AND ADDRESSES

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007

Micro Switch
A Honeywell Division
Freeport, IL 61032

Nippondenso Co., Ltd.
Okura & Co., Inc.
1630 Oakland Rd.
Suite A101
San Jose, CA 95131

Sprague Electric Co.
70 Pembroke Rd.
Concord, NH 03301

A Sampling of Summer 1987 English-Language International Shortwave Broadcasts

By Gerry L. Dexter

Time	Country/Station	Frequencies
0000	REE, Spain	6125, 9630
	BBC, England	9515
	R. Sofia, Bulgaria	6070, 11720
	R. Beijing, China	9550
	R. Havana, Cuba	6090, 9740
	R. Berlin Int'l, E. Germany	6080, 9730
	R. Portugal (30)	9680
	R. Discovery, Dominican Rep.	6245
	Radio Vatican (50)	6030, 9605, 11845
	R. Austria Int'l (30)	6155
	BRT, Belgium (30)	5910
	R. Canada Int'l	5960, 9755
	V. of Israel	5885, 7465, 9435
	R. Moscow	5915, 5940, 6000, 7115, 7185, 7215, 7310, 13665
	R. Korea, S. Korea	15575
0100	V. of Greece (30)	7430, 9430
	RAE, Argentina	9690, 11710
	RAI, Italy	6010, 9575
	SRI, Switzerland (15)	6135, 9625, 9725, 9885
	RCI, Canada	5960, 9755
	HCJB, Ecuador	9870
	DW, West Germany	6040, 6085, 6145, 9545, 9565, 11785
	R. Budapest, Hungary	6025, 6110, 9520, 9835
	R. Belize	3285
	R. Baghdad, Iraq	11750
	AFRTS, USA	6030, 11790, 15355
	R. Prague, Czechoslavakia	5930, 7345, 9740, 11990
	VOA	5995, 6130, 9455, 9650, 9775, 9815, 11580
0200	R. Bras, Brazil	11745
	R. Havana, Cuba	6120, 6140
	R. Berlin Int'l., E. Germany	6125, 6165
	R. Polonia, Poland	7145, 7270, 11815, 15120
	WCSN, USA	9465
	R. Tirana, Albania (30)	7065, 9745
	HCJB, Ecuador	6230, 9870
	R. Cairo, Egypt	9475, 9675
	V. of Israel	5885, 7465, 9435
	R. Netherlands (30)	6020, 6165, 9590, 9895
	R. Bucharest, Romania	6155, 9510, 9570, 11810, 11940
	R. RSA, So. Africa	6010, 6185, 9615
	VOFC, Taiwan	5985, 9555, 11740
	R. Japan	5960
	R. Korea, So. Korea	15575
	R. Kiev, Ukraine	7165, 11790, 11860, 13645
0300	V. of Greece (40)	7430, 9430
	R. New Zealand (45)	15150
	R. Beijing, China	9645, 11970, 11980, 15445
	R. Berlin Int'l, E. Germany	6010, 9560
	R. Polonia, Poland	6095, 6135, 7145, 7270, 9525, 11815
	SRI, Switzerland (15)	6135, 9625, 9725, 9885
	R. Vatican (10)	6150
	RFI, France (15, 45)	6055, 9800
	R. Prague, Czechoslovakia	5930, 7345
	DW, West Germany	6045, 6185, 9545, 9565, 9640
	R. Portugal	9705
	HRVC, Honduras	4820
	TGNA, Guatemala	3300
	R. Budapest, Hungary	6025, 6110, 9520, 9835
	TIFC, Costa Rica	5055
	TWR, Netherlands Antilles	9535
	R. Earth (WHRI), USA	7400
0400	BBC, England (30)	5975, 9510
	R. Sofia, Bulgaria	7115
	R. Havana, Cuba	6035
	R. Berlin Int'l, E. Germany	6010, 9560
	WCSN, USA	9840
	V. of Turkey	9560
	R. Tirana, Albania (30)	9480, 11835
	RFI, France (15, 45)	6055, 9800
	R. Botswana	4820, 7255
	R. Bucharest, Romania	5990, 6155, 9510, 11810, 11940
	TWR, Netherlands Antilles	9535
	R. Uganda	4975
0500	HCJB	6230, 9870, 11910
	V. of Israel	7465, 9435
	R. Netherlands (30)	6165, 9715
	R. Moscow	5915, 5945, 6000, 7115, 7150, 7440
	BBC	5975, 6005, 7160, 9410, 9510, 9600
	AFRTS, USA	6030, 11790, 15330
	REE, Spain	9630
	V. of Nigeria	7255
0600	R. Cook Islands	11760
	ELWA, Liberia	4760
	BBC	9640
	R. Havana, Cuba	9525
	WCSN, USA	7365
	R. Tirana, Albania (30)	7065, 9500
	R. Korea, So. Korea	6060, 9570
	R. RSA, So. Africa (30)	7270, 11900, 15245, 17780
	GBC, Ghana	4915
	VOFC, Taiwan	5985
0700	R. Sofia, Bulgaria (30)	9700, 11720
	R. Moscow	7165, 7290
	SIBC, Solomon Is.	5020, 9545
	VOA	5995, 6035, 6080, 6125, 9530, 9540

Times are in UTC. Numbers in parentheses indicate starting time for English that many minutes past the hour.

Time	Country/Station	Frequencies
	BBC	9510, 9600, 9640
0800	WCSN, USA	7365
	R. Australia	5995, 9655
	BRT, Belgium	9880
	R. Netherlands (30)	9630, 9715
	R. Pyongyang, No. Korea	9530
	HCJB, Ecuador	6130, 6205, 9745, 9860
	KNLS, Alaska	5960
0900	AWR, Sri Lanka	6005, 7270, 15425
	R. Kuwait	15505
	HCJB, Ecuador	6130
	DW, West Germany	6160
	NBC, Papua New Guinea	4890
	R. Australia	5995, 6080, 9580, 9710, 11720
	FEBC, Philippines	11890
	BBC	9700, 9750, 11750
1000	R. New Zealand (30)	11780
	R. Australia	5995, 6080, 9580, 9710, 11720
	R. Netherlands (30)	6020, 9650
	R. Moscow	9600, 9795, 13645, 13665, 13680
	R. Norway (Sun)	9590, 15175, 15185, 15230
	SRI, Switzerland	9560, 9885, 11905, 15570
	V. of Vietnam	9755, 9765, 12035
	BSKSA, Saudi Arabia	11855
1100	R. Pyongyang, No. Korea	9750
	BBC	5965, 6195, 11775
	R. Beijing, China	9535
	R. Tirana (30)	9480, 11855
	R. Japan	6120
	R. Pakistan	9825, 11820, 11835
	RFI, Finland	11945, 15400
	V. of Vietnam	9755, 9765, 12035
	TWR, Netherlands Antilles	11815
1200	R. Singapore	11940
	R. Bangladesh (30)	15525
	R. Beijing, China	9535, 9645, 11980
	R. Ulan Bator, Mongolia	9615, 12015
	RFI, Finland	11945, 15400
	VOPK, Kampuchea	9695, 11938
	SLBC, Sri Lanka	6075, 9720, 15425
	R. Tashkent, Uzbek SSR	7325, 9600, 9715, 15460
	AIR, India	11620, 15245
	R. Australia	6060, 7215, 9580, 9770
	RAE, Argentina	15345
1300	FEBC, Philippines	11850
	BBC	6195, 9410, 9510, 9740, 11705, 11775, 15070, 15105
	R. Beijing, China	9550, 9730
	R. Australia	6080, 7205, 9580
	V. of Vietnam	9840, 15010
	RFI, Finland	11945, 15400
	BRT, Belgium	15580
	R. Norway Int'l (Sun.)	15185, 15310
	R. Pyongyang, No. Korea	9345, 11665
	KTWR, Guam	9870
	UAE Radio (30)	11940, 17775, 17865
1400	R. Sweden Int'l	9695, 15345
	HCJB, Ecuador	15115, 17890
	RFI, Finland	11945, 15400
	R. Korea, So. Korea	9750, 15575
	Radio Norway Int'l (Sun.)	9530, 15315
	AFRTS, USA	9700, 11805, 15330, 15430
	AIR, India	11810, 15335
1500	DW, West Germany	15135
	Africa #1, Gabon (30)	11940, 15200, 15475
	HCJB	11740, 15115, 17890
	R. Veritas, Philippines	9565, 15120
	RCI, Canada	11955, 15440, 17820
	R. Moscow	9895, 11705, 11840, 13790, 15425
	TWR, Guam	9870
	R. Australia	9580
1600	BBC	9410, 9515, 15070, 15260, 15390, 17885
	RFI, France	6175, 11705, 11805, 11930, 15315
	WCSN, USA	15270
	R. Pakistan	11615, 15595, 17660
	AWR, Guam	11910
	V. of Indonesia	11790, 15150
	EAE Radio	9640, 11955, 15230
	V. of Vietnam	9840, 15010
1700	R. Norway Int'l	9590, 9655, 11850
	AFRTS, USA	9700, 11805, 15330, 15430
	R. Moscow	9470, 9490, 11840
	BSKSA, Saudi Arabia	9720
	V. of Nigeria	11770
	RBI, East Germany (45)	9730
1800	R. Kuwait	11675
	R. Sofia, Bulgaria (30)	9740, 11735, 11835
	WCSN, USA	21640
	R. Bras, Brazil	15265
	R. Netherlands (30)	17605
	Africa #1, Gabon (30)	11940, 15200, 15475
	SRI, Switzerland	9535
	AIR, India	11620
	BBC	9410, 11820, 12095, 15070, 15400
	RCI, Canada	15260, 17820
	V. of Nigeria	11770, 15120
1900	R. Afghanistan	9635

COMMUNICATIONS

Time	Country/Station	Frequencies
	HCJB	11740, 15220, 15270, 17790
	R. Algeria	9509, 9640, 15215, 17745
	ZBC, Zambia	9581
	AIR, India	7412, 11620
	AFRTS, USA	15330, 15430, 17765
	BBC	9410, 11820, 15070, 15400
	R. Havana, Cuba	11795
	R. Kuwait	11675
2000	R. Havana, Cuba (50)	11725, 15300
	WCSN, USA	9465
	R. Cairo, Egypt (30)	9655
	R. Netherlands (30)	9540, 9715, 11740
	R. Damascus, Syria	9550, 12085
	BRT, Belgium	5900, 5910
	AIR, India	9910
	V. of Israel	7465, 9435, 11610, 12080
	RCI, Canada	11945, 15325, 17820, 17875
2100	RBI, East Germany (45)	6125
	R. Finland Int'l (30)	11945, 15400
	HCJB (30)	11740, 15270, 17790
	R. Jamahiria, Libya	7425, 11815
	R. RSA, So. Africa	9585, 11900
	R. Vatican	7250, 9645
	SRI, Switzerland	9635, 9885, 11955, 12035
	WRNO, USA	15420
	V. of Nigeria	15120
	R. Cairo, Egypt	15375
2200	BBC	5975, 6175, 9410, 9590, 9915, 11750, 15260
	R. Polonia (30)	7125
	V. of Turkey	9560
	WCSN, USA	7365
	V. of Israel (30)	5885, 7465, 9435
	VOFC, Taiwan	7355, 6155, 9955
	RCI, Canada	5960, 9755
	BRT, Belgium	5900, 5910
	VOA	6045, 11775, 15185, 15290, 15445, 15580, 17740
	WRNO, USA (30)	9852.5
2300	R. New Zealand (45)	15150
	BBC	6120, 9590
	R. Sweden Int'l	6045, 9695
	RCI, Canada	9755
	R. Japan	9645, 9675, 15235
	V. of Nicaragua (50)	6015
	RBI, East Germany	6070, 6125, 6165
	R. Sofia, Bulgaria	11720
	R. Vilnius, Lithuanian SSR	6200, 7165, 9765, 11790, 13645, 15180
	R. Moscow	5915, 5940, 6070, 7115, 7150, 7190, 7310, 7440
	R. Korea, So. Korea	15575

ME

HARDWARE HACKER

Thoughts on the Newman motor; continuous battery rejuvenation; linear stepper motors and drivers; robotic bearings; new literature

By Don Lancaster

Several readers have asked me where to go to obtain good prices for larger-than-hacker quantities of electronic parts. Say you need a few thousand light-emitting diodes right now and at the lowest cost. Where do you go? One quantity parts source that shouldn't be ignored is the classified section of *Electronic News*, a trade weekly. Here you will find all sorts of surplus, distress and odd-lot quantities of mainstream components at literally unbeatable prices. There are only two minor catches: there's usually a $50 line minimum or $100 order minimum, so these great sources are not for onesie-twosie users; and stock exists only on a "here today, gone tomorrow" basis.

Turning to some other news, the Postscript page-description language has now in fact become an industry standard, as the last and most obvious holdout—Hewlett-Packard—finally caved in to user demands. H-P now joins Adobe, Allied-Linotron, Apple, IBM, QMS, Qume and hundreds more already in the club.

Note that the Postscript language is in the public domain and anyone can use it for any purpose. There are all sorts of hacker opportunities here. Of all the computer languages I have ever seen anywhere, Postscript is far and away the most fun and most addictive, both physiologically and psychologically.

Write or call per the "Need Help?" box if you need any more information on getting started with Postscript.

What are your views on the Newman motor?

The story so far goes something like this: A few years ago, a backwoods Mississippi inventor by the name of Joseph Newman created a new motor which, under some circumstances, appeared to create more energy than it consumed. Some other supposedly competent engineers looked at the motor and, surprisingly, agreed. A major battery company even offered some development funding.

Newman attempted to patent his invention and was treated extremely shabbily by the patent office bureaucrats. The device was tested by the National Bureau of Standards, and the results ended up at best controversial. Newman went to the media and became first a media event and then a part of a media circus.

For three wildly different backgrounds on all this, check out the more or less middle-of-the-road story in the May 1987 issue of *Discovery* magazine (page 48), the NBS report on the motor's testing, and Newman's own book on the subject.

The motor itself is relatively conventional. It does have an unusually high amount of winding inductance and is also an unusually high voltage device.

Under the most credible circumstances, the usual demo of the motor goes something like this: Ordinary dry batteries are connected to a load and completely flattened. The motor is run, apparently increasing speed and performance as it goes along.

The batteries are then reconnected to the original load and are then used to drive the original load for a much longer time than they did when fresh.

As a microcomputer pioneer, I have had more than my fair share of arrows in

rce

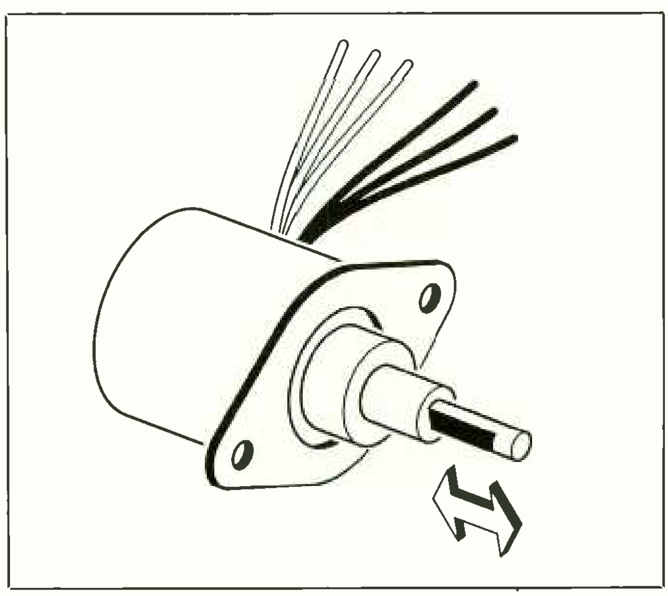


Fig. 2. The Airpax 92100 is a smaller linear stepper than the Hurst SLS.

my back, and I will always champion the maverick individual who is doing things on his own. I even wrote a classic book on this matter titled *The Incredible Secret Money Machine*. On the other hand, I do have a traditional engineering education and industry background and am pretty much a fan of the second law of thermodynamics.

My personal views on perpetual motion, UFOs, psychic phenomena, *et al* is simply this: Give me a simple, duplicable and verifiable way of showing the effect and I will believe. Until then, I will remain a skeptic, albeit one who seeks out any controversy and loves to rattle any establishment cages—or at the very least, run a stick over the bars.

What I cannot fathom is why *any* inventor or hacker would ever attempt to patent *anything*. If a Las Vegas casino owner had the gross effrontery to offer the same odds as the patent office does, he would be tarred and feathered and run out of town on a rail.

Not one patent in 300 will ever generate any positive cash flow. Not one patent in 3,000 exists that can't be thrown out or severely minimized through a diligent enough search for prior art in obscure places. For most individual hackers and inventors most of the time, attempting to patent something results only in outright theft of their precious time, money and sanity. [*There are enough success stories emanating from patents to continue to encourage inventors to go this route. Odds don't seem worse than those offered by lotteries. Nevertheless, there's a lot of wisdom in what is said if the inventor doesn't have the money (personal or corporate) to challenge a patent violator—Editor.*]

So what is really going on?

Okay, here's my theory on what's happening here. It may be all wet, but it does fit the facts more closely than anything else I have seen. It leaves the inventor and laws of thermodynamics more or less intact. It also gives hardware hackers an opportunity to experiment with something that just may turn out to be worthwhile, and in a research area that has not been thoroughly plowed over.

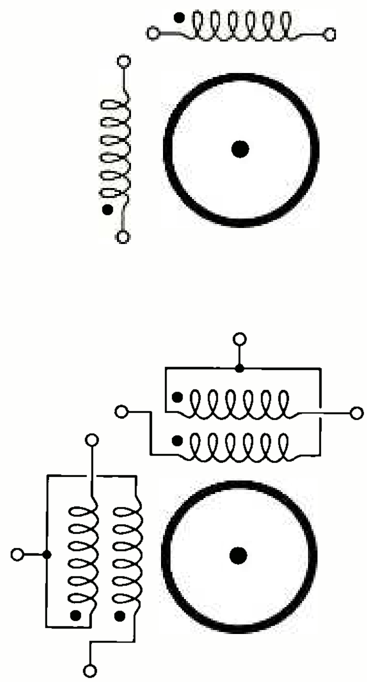


Fig. 3. The two main types of stepper-motor windings.

The motors tested always seem to involve lots of high voltage, r-f energy, transients and pulses, and lots of sparking. As we've seen, batteries are normally involved in the excess-energy demonstrations. What we really have here is a simple battery rejuvenator.

Total energy in a carbon-zinc flashlight cell is vastly in excess of the amount of light you can get running a flashlight. As long as even a tiny scrap of the zinc case remains, there is still energy to be gotten. People have known for quite a while that you can "recharge" flashlight cells a number of times. But note that this is not really a true recharging. Rather than increasing the chemical potential energy as is done with a lead-acid battery, you are really removing or minimizing processes (particularly polarization) that interfere with getting the already-there chemical energy out. So any recharging is really "rejuvenation."

An example: Say you fish out the old chemistry book and build yourself a wet cell by placing two dissimilar metal electrodes in an electrolyte. Sure enough, you get an output current and may even light a lamp with it. But after a while, the lamp gets dim.

You look closely at your cell and find that there are all sorts of bubbles on one electrode. These bubbles act as an insulator that reduces the cell's current density. So you whap the beaker a good one, all the bubbles float upward, and the current goes back up near its original value. Being a Rube Goldberg type, you build a solenoid "whapper" that clunks the beaker every now and then. By "feeding back" some of the cell's energy in a rejuvenation process, the total useful energy you get out is much higher.

Question: Might there be some continuous rejuvenation process that can be

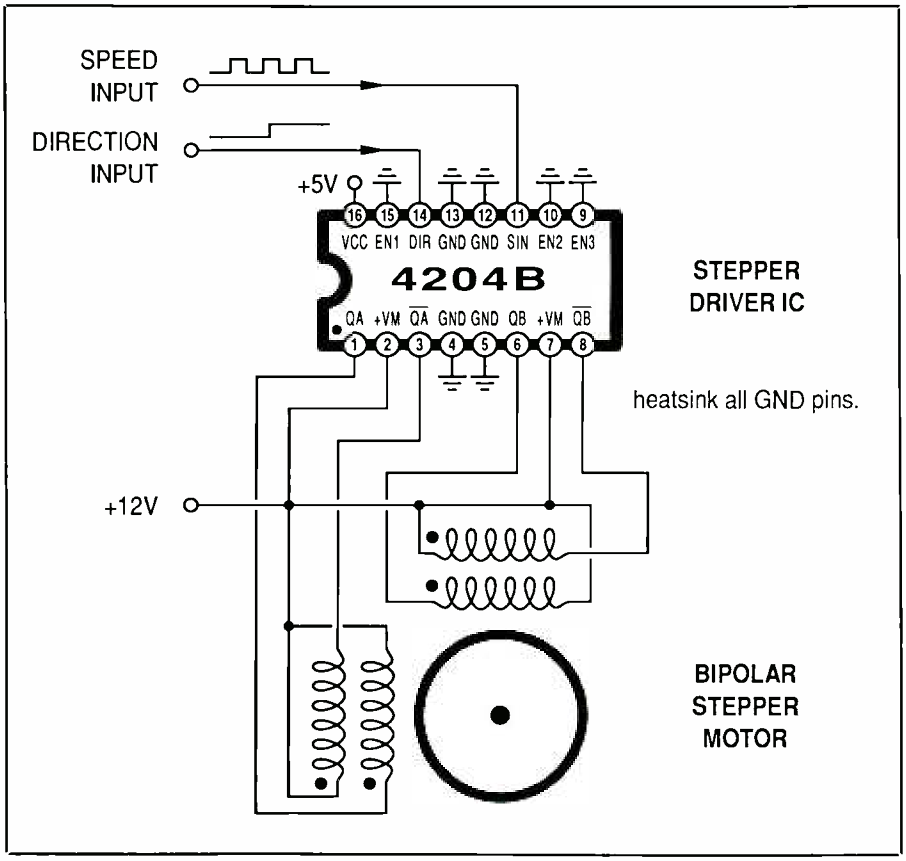


Fig. 4. A typical small stepper-motor driver circuit.

done by feeding back pulses, ac or r-f energy into a dry battery? The answer to this is almost certainly yes. Can the process be made very efficient, worthwhile and workable with many popular types of cells? That remains to be seen.

Note that the electroplating people do this sort of thing all the time. They first plate for a fairly long time and then purposely reverse the current to unplate for a short time. The reversals end up giving a far smoother finish with fewer sharp edges or imperfections.

Ferinstance, what if you did discharge a battery for 5 seconds into a 100-milliampere load and then sent a 10-ampere pulse back into it for 5 milliseconds? You would then be returning one-tenth the energy to the battery, but it might very dramatically lengthen overall battery life.

While you are experimenting on this, there's a related project that could easily become commercially successful. What if you had an efficient inverter that worked down to, say, 0.5 volt? You could now really flatten a flashlight battery while at the same time maintaining a constant bulb brightness. Similarly, portable radios and cassette players could be run much longer on "dead" batteries without distortion.

For maximum efficiency, you could even run the inverter on a pulse basis that always tries to match the load impedance to the cell's present source resistance. In theory, this can increase the life of the cell by an additional 30 to 50 percent.

A law called the "maximum power transfer theorem" explains why a car battery's impedance is carefully matched to the impedance of the starter. This is the only way maximum possible power can be delivered during cranking. The same idea could substantially increase flashlight cell life.

A safety tip: Do not try to feed back excess pulse, ac or r-f energy into a lithium or nickel-cadmium cell! Even with plain old flashlight cells, you might consider using a "bomb shelter" consisting of a paint bucket filled with sand and having a plastic cup inside.

Let me know what you come up with on this. It seems there are plenty of possibilities here.

What is a linear stepper?

Take an ordinary stepper motor, but make it hollow at its center. Then feed a threaded shaft through the center and drive it with a nutplate on the stepper's armature. As the stepper is stepped, the nutplate turns, which, in turn, advances or retards the threaded shaft. This would give you a way to push or pull things in tiny and accurate increments under computer control with lots of force over fairly long strokes.

Uses? They're multitudinous, including: animation tables; printed-circuit drills; numeric controlled milling machines; plotters; robotics; valve actuators; electronic engine controls; production equipment; research projects; point-of-purchase displays; and dozens of applications that haven't been mentioned or possibly even imagined.

Figure 1 shows the Hurst model SLS linear actuator. It is a 12-watt unit that delivers 25 pounds of force in 2-mil (0.002-inch) increments over an 8-inch length. Single evaluation units cost just under $50, though the price drops to less than $20 when these are purchased in quantity. The onesie price seems rather steep, until you take into account the "compared to what?" factor.

We are using this dude locally to model a new type of solar pump that is simpler

NAMES AND ADDRESSES

Airpax Corp.
Cheshire Industrial Park
Cheshire, CT 06410
(203) 272-0301

Eastern Air Devices
1 Progress Dr.
Dover, NH 03820
(603) 742-3330

Electronic News
7 East 12 St.
New York, NY 10003
(212) 630-0951

Hurst Mfg.
Box 326
Princeton, IN 47670
(812) 385-2564

Motion Magazine
2030 Hillman Circle
Orange, CA 92667
(714) 974-0200

Motorola
P.O. Box 20912
Phoenix, AZ 85036
(602) 244-6900

Powerconversion
2472 Eastman Ave.
Bldg. 34
Ventura, CA 93003
(805) 658-0933

Reticon
245 Potrero Ave.
Sunnyvale, CA 94086
(408) 738-4266

SGS-Ates
1000 E. Bell Rd.
Phoenix, AZ 85022
(602) 867-6100

Sprague
115 NE Cutoff
Worcester, MA 01606
(617) 853-5000

Texas Instruments
P.O. Box 225012
Dallas, TX 75265
(214) 995-2011

Thomson Industries
Shore & Channel Dr.
Port Washington, NY 11050
(800) 645-9357

Xilinx
2069 Hamilton Ave.
San Jose, CA 95125
(408) 559-7114

and far more versatile than traditional pumping methods. Using computerized stepping, the stroke and speed can be independently adjusted. This can eliminate any need for inverters or storage batteries, while at the same time simplify the pump mechanism to a single moving part.

On custom order, lead screws up to several feet long can be obtained. Note that there is no theoretical limit to the stroke you could get out of one of these, so long as a lead screw of the required length is available. Maintaining precision and avoiding any binding would, of course, get worse with increasing length.

You would have to keep the lead screw itself from rotating any on its own, usually with an external restraint. Details on this depend on your intended use.

Figure 2 shows a smaller *Airpax* Series 92100 unit. This is much smaller than the SLS linear actuator and gives only a 0.5-inch maximum stroke in 2- or 4-mil steps and with a force slightly greater than 1 pound. Price is around $20 each, but you might be able to find an Airpax Series 92100 unit for free (or nearly so) at your local junkyard, as some automobiles use these devices for their computerized carburetor idle adjustments. Unfortunately, I don't know which specific models to send you after. Be advised, though, that there are also some plain old throttle solenoids that look about the same as these; so make sure you are getting a "real" stepper when you make your visit to the junkyard.

You can step these up to 400 steps per second, which means they can travel the 0.5-inch stop-to-stop distance in something like 0.6 second. But you lose force at higher stepping rates.

On other models, you can get other pitches on the lead screws, which lets you trade off resolution per step against speed of travel.

We are using this one locally to adjust the teeth on a cotton picking machine. The stepper acts as a sort of micrometer, advancing until it touches each tooth. The number of steps needed then tells the mechanic how much shim to add.

Whether or not you care about cotton picking, what we have here is an easy and precise way to eliminate a tedious and time-consuming job. If the teeth are too close, you destroy the machine; if they're too far away, your yield and grade go down.

Another source of linear actuators is *Eastern Air Devices*, but their military look and their refusal to include pricing in their mailings doesn't bode well for hackers.

Tell ya what. Let's have us another contest. A free book to the best ten entries and a free tinaja quest for two (FOB Thatcher, AZ) for the best overall entry. Just dream up a new or interesting use for one or two linear steppers, or tell me a specific automobile make or model that uses a linear stepper.

Fair enough?

How does a stepper motor work?

A stepper motor consists of a toothed magnetic rotor and a toothed iron stator. The number of teeth sets the step angle and number of steps per revolution. In the absence of any electrical input, the rotor will "lock" to the stator by seeking out paths of minimum magnetic reluctance.

Two sets of windings are provided. The "A" winding is active one-third the distance between teeth, while the "B" winding is active two-thirds the distance between teeth.

A four-step process is used to advance to the next tooth position. The A winding is first activated, attracting the toothed rotor one-third of the distance to the next tooth. Then the B winding is activated, attracting to the two-thirds point. Next, the A winding has its current reversed to repel toward the two-thirds point. In the final step, the current in the B winding is reversed, repelling the rotor to its new and final position.

Speed is determined by the number of steps applied per second. Direction is determined by the roles of the A and B windings.

As Fig. 3 shows, there are two different ways that stepper motors can be wound. In a "unipolar" stepper, there is only a single A winding and only a single B winding. This is cheaper and has more power, but it requires you to electronically reverse the high-current feed through each winding. Thus, what you gain is stepper economy, you lose in driver cost and complexity.

In a "bipolar" or "bifilar" stepper, there are two separate A windings and two separate B windings. Each winding is in the opposite sense of the other; so a current in one winding will attract the rotor, while the same current in the other winding will repel the rotor. These bipolar windings are much easier to drive, but they cost more and offer less power than the unipolar stepper's winding scheme.

You can usually tell which type of stepper you have by counting the number of leads that are on it. Assuming that all leads are brought out separately, a unipolar stepper will have four wires, while a bipolar stepper will have six. For most hacker uses, bipolar windings are the overwhelmingly favorite choice.

How do I drive a stepper motor?

Most stepper manufacturers have available driver circuits for their devices, though they tend to be older hybrid designs that are overpriced. Instead, there are several suppliers of single- and double-chip stepper-motor drivers. These include *Sprague, SGS-Ates* and *Motorola.*

Figure 4 shows a circuit for the Sprague UCN-42-4B single-chip stepper driver. While I haven't yet been able to check out this chip (stay tuned), it looks like a typical modern circuit with 1.5 amperes of drive capability and internal thermal and overload protection.

To use the Fig. 4 circuit, you provide two inputs. The first is the direction input that decides whether the stepper will go forward or backward. The second is a train of square-wave pulses that set the speed to be traveled in the chosen direction.

By the way, the best two places to find out all about steppers and stepper motors are *Motion* and *Powerconversion* industry magazines.

What's in the goodies barrel this month?

There sure has been a lot of interest in the CCD and photodiode imaging products we looked at two months back. In fact, it is the number-one Helpline topic. Just in the nick of time, Reticon has come up with a brand new and free "Image Sensing Products" handbook, while Texas Instruments has a new literature package and applications note titled "CCD Output Signal Processing."

Xilinx has a "Programmable Gate Array Design Handbook" out on the next step beyond EPROMs and EPALs—entire gate arrays that you can electrically program yourself. Prices are still quite high, but these arrays are bound to become great future hacker components.

Any of you hackers who are into robotics will be interested in the $9.95 Nyliner bearing evaluation kits from the Thomson Industries folks.

I've got my usual goodies in stock, including the classic *TTL Cookbook, CMOS Cookbook* and *The Incredible Secret Money Machine.* Write or call for a complete list that includes some neat stuff. Let's hear from you. **ME**

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:

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

Lotus Symphony: Power With a Price

Examining the latest release of this popular software package that boasts five applications

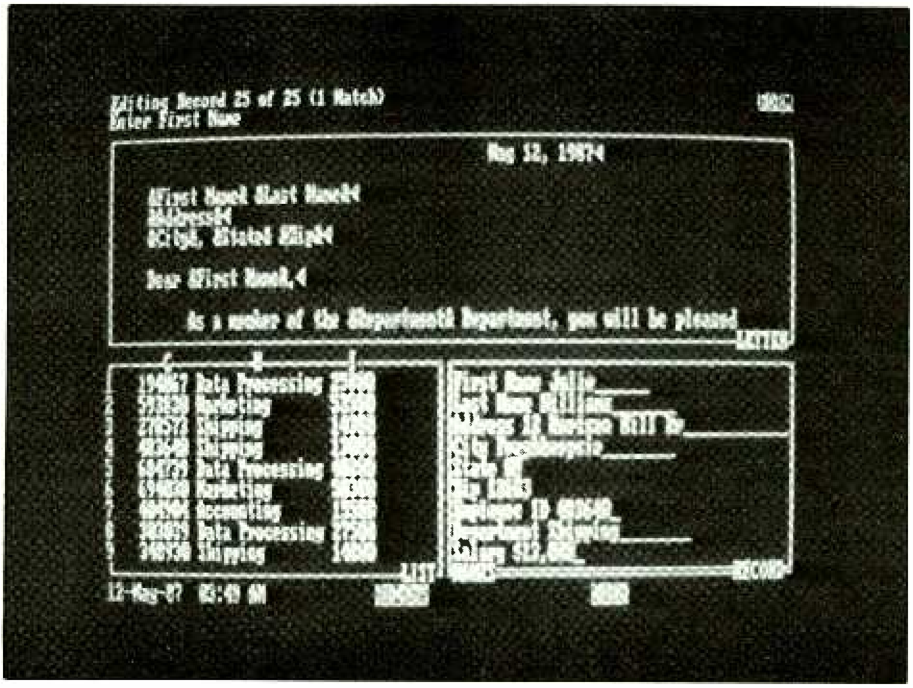
By Joe Desposito

Symphony, an integrated software product from Lotus Development Corp., has been on the market a few years now. Recently, however, Lotus released version 1.2 of this product, its second upgrade. We'll look at the entire program here and point out where it differs significantly from the older versions.

Integrated software on a microcomputer is an attempt to realize a dream, of course. The dream is to be able to have a bevy of applications available at the flick of a key, such as a spreadsheet, word processor and database. Separate applications, in contrast, force you to end one and load another.

Integrated software, therefore, allows you to switch from application to application, and move data from, for example, a spreadsheet to a word processor. In most cases, though, you can't have your spreadsheet doing calculations at the same time that you're composing a letter.

Symphony 1.2 comes with six disks, three manuals, reference cards and keyboard overlays in a hard cardboard case. The "list" price is $695, but this is usually discounted to about $450. The program runs on the IBM PC family of computers and compatibles with DOS 2.1 or later and at least 384K of RAM.



Symphony windows let you view several parts of a worksheet at the same time. Shown is a form letter (top), typical record and part of the database (bottom-right and -left).

Symphony Overview

Symphony includes five business applications programs: spreadsheet, word processor, database, business graphics and communications. Since Lotus has built its reputation on a spreadsheet product, namely Lotus 1-2-3, it isn't surprising that all of Symphony's applications are spreadsheet based. What this means is that all of the applications reside in different areas of a common worksheet, making it easy for a user to interface with any one. Thus, if you were creating a report that used spreadsheet results and business graphics, each of these parts would lie in different areas of a common worksheet.

This worksheet thread has some drawbacks. For example, suppose you had constructed rows and columns of numbers in one area of the worksheet and then switched to the word processor to write a letter. While you're writing the letter, let's say you realize that you left out a row of numbers. So you switch back to the spreadsheet and insert a row. Depending on where you placed your document in the worksheet, you might be surprised to find a blank line in the middle of your letter. Of course, there are ways to prevent this from happening, but it brings home the point that everything you do is seen by Symphony as being part of one big worksheet.

There are also good points related to this approach. For example, if you're typing a report and decide to change from typing normal paragraph-oriented text to typing numbers in columns, you can switch environments from DOC (word processing) to SHEET (spreadsheet) to facilitate columnar typing.

In Symphony, the different application areas are called SHEET, DOC, GRAPH, FORM and COMM. To select the appropriate work environment, you press two keys, ALT and F10. Symphony makes extensive use of function keys and ALT key combinations. A function key template included with the program lets you select 20 different operations. Additionally, there's a Keyboard Guide that details the functions of 32 more keys and key combinations.

To use Symphony, you type either Access or Symphony at the DOS prompt. If you type Access, the program presents a menu of choices on a horizontal bar at the top of the screen that is the Lotus trademark. The choices are Symphony, Tutorial, PrintGraph, Install, File Translate, and Exit. Choosing Symphony here or typing it from the DOS prompt brings you into Symphony's SHEET environment. The blank spreadsheet screen looks very much like a Lotus

1-2-3 screen. If you type "/," you'll even bring up a horizontal menu bar. But a quick inspection shows that the menu is not identical to the one you would find in 1-2-3, although it is similar.

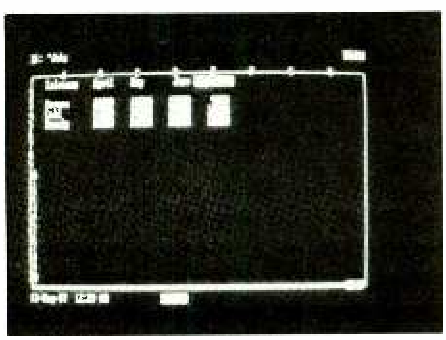
In Symphony, there are two types of menus, the Services menu (function key F9), which are the general commands that are useful in every work environment, and the Menu menu (F10), which has commands specific to the work environment you are in. The familiar "/" key brings in the specific SHEET Menu, but it does nothing but display a "/" in the word processor.

The Spreadsheet

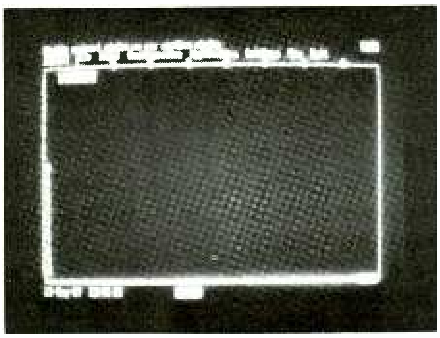
When Symphony is loaded, it automatically places you in the spreadsheet environment. You must press ALT-F10 to select a different environment. Though the menus aren't identical to the ones in Lotus 1-2-3, all the functions are basically the same. A seasoned 1-2-3 user switching to Symphony might find it disconcerting, however, to not being able to leverage off his keystroke knowledge.

The Symphony spreadsheet is as large as the one in Lotus 1-2-3 version 2.0 (8,192 rows by 256 columns) and appears to be just as fast. Files created by Symphony 1.2 have a WK1 extension, as are those created by 1-2-3 version 2.0.

Macros can be created only while in the SHEET environment. Although a major feature of Symphony, creating a macro isn't obvious since there is no selection on



Symphony's SHEET environment is very similar to that in Lotus 1-2-3.



Symphony starts in the SHEET environment; pressing function key F9 beings up the Services Menu.

the menu called macro. Macros can be created in two ways: by having Symphony record your keystrokes or by typing in the macro. To create a macro by the former method, you must go to a blank portion of the spreadsheet, press F9 for the Services menu, select Settings, Learn and Range. You then specify a single column range large enough to accommodate the entire macro, and press Return and Quit twice. This simply prepares you to enter the macro.

The next step is to turn on the Learn mode by pressing ALT-F5. Once this is done, Symphony will record all keystrokes that you make. After you're finished, you type ALT-F5 to leave the Learn mode. Now all that's left is to leave the macro. To do this, you need to bring up Menu with F10, select Range, Name and Create. Then you type the macro name and specify the first cell in the Learn range. Pressing Return ends the chore.

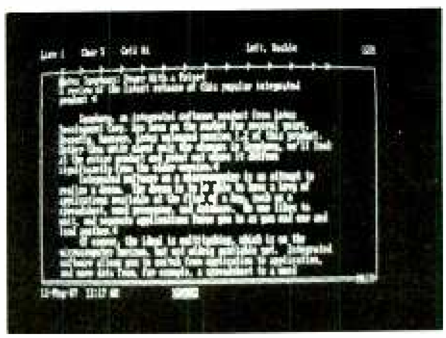
One way to recall the macro is to type F7 (the USER key) and then type the macro name and press Return. If all this sounds confusing, it's probably because it is. But there are many people who have learned this procedure and benefited greatly from it. If you don't feel up to the task, you can always seek out ready-made macros for Symphony. A macro is normally saved by Symphony in the worksheet in which it was generated. However, if you want to use a macro in different worksheets, Lotus provides a Macro Library Manager that lets you do this.

New spreadsheet features of version 1.2 are Matrix and Regression, which are for statistical calculations. Additionally, a Range Input command (also in 1-2-3 Ver. 2) gives added control over data input during macro execution.

To sum up, the spreadsheet portion of Symphony is as powerful as that of Lotus 1-2-3 Ver. 2 and as confusing to learn in some areas. Although the menus for the Symphony spreadsheet aren't identical to those of 1-2-3, the same functions are available.

Symphony's Word Processor

At the start, let me note that the Symphony word processor doesn't automatically reformat a paragraph that has been edited, sharing this shortcoming with very few programs today. Therefore, if you decide to change (add or delete) a few words, the paragraph must be reformatted by pressing F10, Justify and Return. This doesn't have to be done immediately, but it is an annoyance.



In the DOC or word-processing environment, there are margin and tab symbols along the top line of the screen.

Otherwise, the word processor offers enough ease of use and special features to make it useful. It's easy to use since most word-processing functions are readily available at the touch of a key (F10). Once this key is pressed, you can select Copy, Move, Erase, Search, Replace, Justify, Format, Page, Line Marker or Quit. And all functions are fairly easy to implement.

One of the nicest features of the word processor is the way it lets you navigate around a document. Besides the normal navigational aids, Symphony has a speed-search feature that lets you go straight to the next occurrence of a character by pressing the End key followed by the character.

The Symphony word processor doesn't do any on-screen formatting except for margins, tabs and justification. If you double-space a document, you won't see it on the screen, nor will you see any underlining, bold or other print attributes. To do this, you must insert special codes to mark the beginning and end of text you want to print in these styles. These are done from the menu bar, but instead by pressing a control-key combination before and after the text as well as a letter to indicate the type of style you want (for instance, *b* for bold, *u* for underline).

Another knock against the word processor is the time it spends doing routine tasks. For example, reformatting a 200-line document took almost 25 seconds, and moving a paragraph from the bottom to the top of the same document took almost 5 seconds.

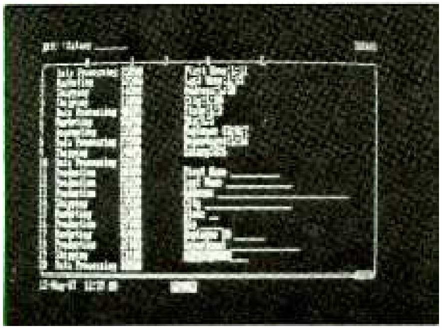
In summary, the word processor is fairly easy to learn and use and contains a few nice features, but it has some drawbacks, too, as cited. Thus, it's great to have it as an application that works with a handful of other applications without the fuss of leaving the program altogether, but it's not a first-drawer word processor as compared to some separate word processors.

The Symphony database manager should more properly be called a file manager since it has no relational features. However, the features that it does have are comparable to some of the better file managers on the market.

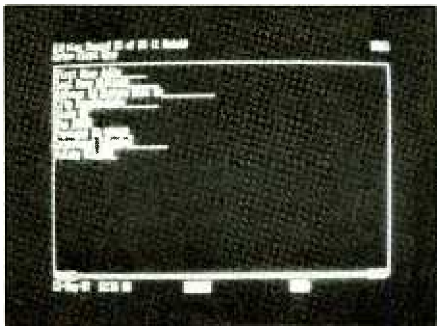
For example, there are five different field types: label, number, date, time and computed. You can format fields in different ways, such as currency. You can have a default entry in a field, create custom prompts, and even have Symphony automatically check data against preselected criteria as the data is being entered.

Records can be sorted and searched. Selection criteria for searches can use formulas or functions, and several criteria can be combined using the logical operators AND, OR and NOT. Once you've entered data into Symphony, you can extract it with printed reports and mailing labels.

I tried entering 25 name and address records that were on a disk in ASCII comma-delimited format into the Symphony database (FORM) environment. This should have been a simple task, yet it degenerated into an exercise in patience as I weaved through the manuals trying to figure out the correct procedure to use.



This screen shows a database file as it appears in the SHEET environment. Notice the field specs and form layout as well as the data.



In the FORM environment, forms can be constructed for data entry. Fields can be in a vertical column or placed anywhere on the screen to mimic paper forms.

Normally, you would expect to set up a typical form for the data report, import it, and be finished. In Symphony, however, you import data into the SHEET environment first. Then you adjust the widths of the columns as necessary to fit your data. When this is done, the usual procedure for creating a database can begin. In the SHEET environment, you list the field names, types and fields (separated by colons) in a vertical column. Then you switch to the FORM environment to create an input form. This is done by selecting Generate from the Menu and choosing a few more options.

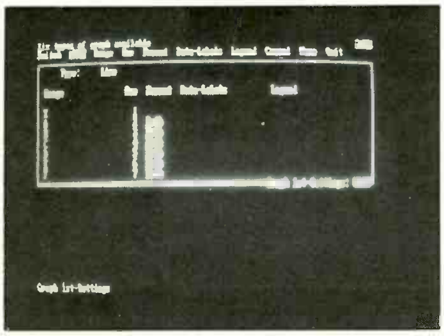
Once this is completed, the fun begins. (Although this may not be the only way to import a file, it was the only method I could find.) You bring up the SHEET menu, select Query and the Parse, specify the Parse range, and press Return. If all your data matches your database field specifications, the job is done. If not, you just have to try again. The real problem with this method is that it's described in the manual in the "Advanced Tasks" chapter under "Capturing Data During a Communications Session."

Once I finally discovered how to get our data into the FORM environment, Symphony manipulated it impressively. It took less than a second to sort the data, and also less than a second to find a record based on two criteria. Both operations were performed without difficulty from the FORM menu.

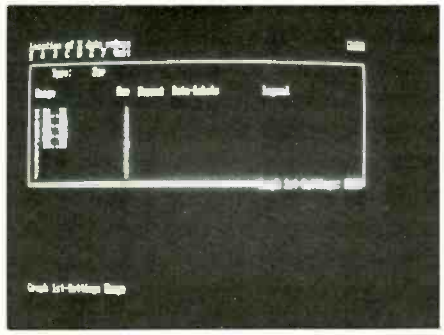
Overall, the database portion of Symphony compares favorably to some of the better flat file managers currently on the market.

Symphony's Graphics

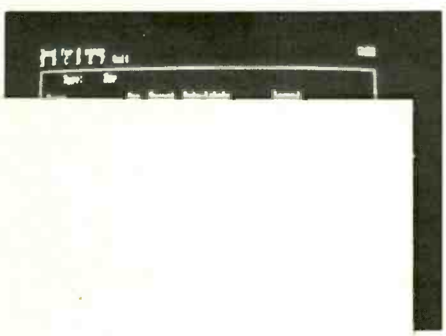
Like the database portion of Symphony, the Business Graphics part is closely tied to the SHEET environment. All numbers must be entered into a worksheet before a graph can be produced. Symphony graphics are not startling. If you're looking for jazzy three-dimensional plots, Symphony won't produce them. But it



When constructing a graph, you select options in a settings window.



This graph settings window shows the ranges selected from the worksheet.



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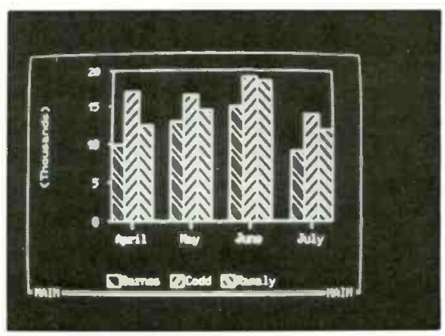

The bar graph corresponds to a Symphony worksheet.

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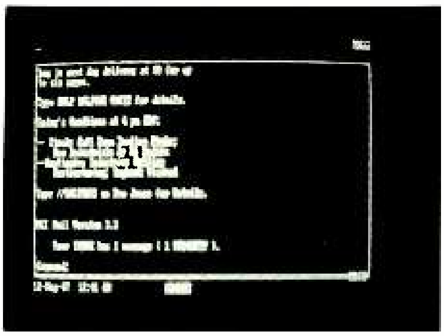
time. To print a graph, you [illegible] leave Symphony and select PrintGraph from the Access Menu. The graph produced by an Epson FX printer could only be deemed fair. One shortcoming of the Graph portion of Symphony is that it isn't tightly integrated into the rest of the program. Since you have to leave Symphony to print a graph, it's difficult to insert graphs into the body of a report.

A nice feature (for your viewing pleasure) is that you can "attach" a graph to data in a worksheet. As data in the worksheet changes, the graph is automatically redrawn, which can be viewed in a separate window.

Communicating With Symphony

As a communications product, Symphony gets good ratings. It has most of the features the average user of on-line services might want. For example, this latest version offers three protocols: XMODEM for binary file transfers; B protocol, which is used by CompuServe; and BLAST (Blocked ASynchronous Transmission). It also has automatic log-on for easy entry into information networks and parsing of captured data for trans-



You link to other computers (in this case, MCI Mail) through Symphony's COMM environment.

forming the data into a form useful for spreadsheet analysis. I used the COMM environment to "pick up" my MCI mail. Before attempting to make a connection, however, it was necessary to select Settings from the COMM Menu and enter such items as baud rate, parity, length and phone number. These settings can be saved in a file for any future transmissions with MCI.

Everything on MCI went well until I attempted to send a letter. Apparently, using the File-transfer selection on the menu doesn't do the trick. Unfortunately, that's the suggested way to send a file, according to the manual. Searching through the reference manual, however, I learned that I had to use the Transmit Range function for this purpose, which the tutorial omitted.

Symphony Integration

An integrated product like Symphony is usually purchased for the purpose of making one's job easier. One of the typical jobs that Symphony can do very well is form letters. This task depends on the union of the database and word-processor portions of the product. To print form letters in Symphony, you write the letter in the DOC environment, and include field names from your database with ampersands. For example, you might include &Customer Name& in the heading of your letter instead of typing the actual name. When the letter is finished, you must specify the worksheet range of the letter before you can begin printing the letter.

Another example of integration in Symphony is its ability to include spreadsheet cells in a document. This is helpful when typing letters that include numbers calculated in the spreadsheet. If a number in a worksheet changes, the number in the letter automatically does, too.

Integration with other products is also an important issue. Through the Translate command of Access, it's possible to import and export files to and from dBase III Plus (a new feature of this version) as well as 1-2-3 versions 1A and 2, Jazz, Symphony versions 1.0 and 1.1, and VisiCalc. You can also import and export DIF files.

Symphony Documentation & Tutorial

Symphony documentation is plentiful; there's a 410-page *How-To Manual* and a 595-page *Reference Manual.* Although well-illustrated and nicely presented from a printing point of view, the manuals fail in many respects. Foremost, they don't anticipate what users will likely do with Symphony. For example, is it so unlikely that users will transfer database files from another product (in ASCII format), that this task isn't even mentioned in the manuals? The manuals also fail by presenting too much information on a topic at times, rather than getting directly to the point. There's nothing more frustrating than knowing what you want to do but not being able to nail down the correct sequence of events to do it for this particular product.

The Symphony disk-based tutorial is comprehensive and well done. Although it takes a while to get through, it does provide good insight into the product.

Conclusions

As an extension of Lotus 1-2-3, Symphony is a product for people who have a strong need for a superior spreadsheet. Since 1-2-3 itself has business graphics and some database capability, you would need the word-processing and communications capabilities of Symphony to tip you over to this product rather than to 1-2-3. As Lotus, the company, encourages more and more developers to hook into 1-2-3 with add-in products (for example, a word processor), you have to wonder about the ultimate future of Symphony, though.

At present, Lotus itself advertises add-in products for Symphony. An example is an outliner program. Programs such as this and a spelling checker, for instance, are absolutely necessary for Symphony to compete with stand-alone as well as other integrated products. Another consideration for both Lotus products is that they use a copy-protection scheme. Although Lotus has dispensed with key-disk protection, the product is still protected on the hard disk, a problem with which you may or may not want to deal.

Overall, Symphony packs plenty of power, integrating all the key applications used in a business environment. The latest release extends this further by adding compatibility with Lotus' 1-2-3 Release 2.01, as well as more statistical tools and other refinements previously noted.

It certainly packs plenty of power and versatility, probably more than any user could employ. But it's there for the asking, assuming that there's a Symphony guru around to come up with appropriate programs.

If you already use 1-2-3 and are contemplating a step up to Symphony, you should really be sure that you have a strong need for word processing and communications for use with a spreadsheet. If you do, and intended users are already into 1-2-3, the transition would be a worthwhile one. If you're starting from scratch, though, Symphony can be a frustrating program to master and make it perform up to your expectations. Moreover, it has some weak spots that dilute the effectiveness of such an extended integrated applications package. **ME**

Beginners and Background: PFS:First Choice, Teamwork

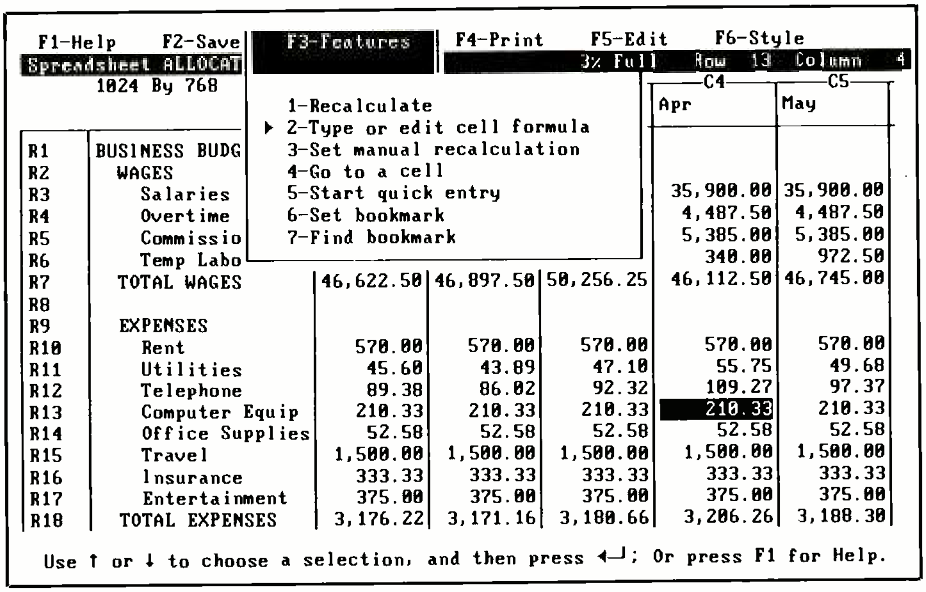
By Eric Grevstad

It's been a while since IBM unveiled its Personal System/2 line, and readers are probably clamoring to know whether I'll drop my anti-IBM bias and endorse the new machines. (Well, not actually clamoring, but my dad asked me what I thought about them.) I can sum up my feelings in two sentences: Personal Sysem/2 models are the best micros from Big Blue since the original PC. Don't rush out and buy one.

Why not? Well, some of the specs don't light my fire: the 8086-based Model 30 is an orphan, announced as part of PS/2 but based on older, incompatible technology, nothing you can't get from many high-speed XT or low-cost AT clones. Among the 80286 machines, the affordable Model 50 has few slots and a PC*jr*-level power supply; the Model 60 is expensive; and the forthcoming 80386 Model 80 is wickedly expensive.

Besides, right now the best thing about the PS/2 units is their snap-together, no-switch design. Real computers have had built-in parallel and serial ports for years, and there should be add-on cards for the new Video Graphics Array standard before there's much software for it. Other manufacturers have already adopted the current "enhanced" keyboard, though I still think it came from IBM Day Care where kids randomly arrange Colorforms to design keyboard layouts.

Most important, the Personal System/2 machines are built around two things that aren't here yet and whose absence gives compatibles makers time to maneuver: boards using the promising new Micro Channel Architecture expansion bus and Microsoft's long-awaited OS/2, the operating system that makes IBM's notoriously delayed token-ring network seem rushed to market. Both are essential; and, yes, both will become standards. But we've got a solid two years to play with our existing hardware and software. When someone asks me to recommend a good system for a beginner these days, I suggest a solid brand-name clone like the Epson Equity and the program reviewed below.



PFS:First Choice merges five proven programs and adds spiffy pull-down menus.

First-Class Introduction

I've had this job long enough to use terms like "subdirectory," "clipboard," and "Lotus-style menu" without blinking. But it's sometimes good to remember novices who don't know a sort field from a spreadsheet. Recently, an Apple user I know spent his first weekend with MS-DOS and came back raving about an integrated productivity package. I was intrigued enough to try it myself, and I agree. PFS:First Choice is the best beginners' software ever.

It's no surprise that First Choice is easy and yet flexible enough for anyone who doesn't need fancy word-processing formats or relational database power. It's basically a merger of Software Publishing Corp.'s five classic PFS programs, joined with copious, consistent prompts, help screens, and pull-down menus of numbered commands (you can move the cursor and press Enter or just type a number). The centerpiece is the program that, years ago, was my own first date with DOS after leaving my TRS-80—PFS:Write, the word processor that still tickles me with its automatic reformatting and on-screen show of page breaks, headers, and footers.

The communications module has two neat features. First, it replaces confusing log-on strings or macros by simply looking over your shoulder while you call a service and type your passwords; after that first time, just pick the service from the menu and sit back. Second, once you're on-line, you're actually in the word processor—you can receive text, edit it, save it, and send it back, or use the PgUp or Ctrl-Home (top of file) commands to review material that's scrolled off the screen. None of the "capture on/off" folderol of other programs here. Customizing the menu of phone numbers and parameters is easy, as is answering a call or handling Xmodem as well as ASCII file transfers.

The database and report modules need no introduction. Among flat-file databases, no one's yet topped PFS:File and PFS:Report, the duo that let you sketch a database form on the screen without fussing over field lengths or data types, then either fill in the blanks for retrieval matches or specify ordered and calculated fields for sorted reports.

The fifth wheel in First Choice is the spreadsheet, which is one of the world's easiest to learn but one of the least helpful in preparing you for more powerful, conventional programs. It's full of conveniences like automatic column width adjustment, the ability to use cell names instead of addresses in formulas, and a "quick entry" mode that, given "January" in one cell, automatically types "February," "March," and so on for the next.

Entering formulas, though, is an awkward process of calling and exiting a pop-up box that can obscure cells you want to see, and there's no way to quickly put one cell's formula into a range short of copying one cell at a time. Also, all the modules, except possibly the painless communication program, take the same leisurely pace that made me outgrow PFS:Write—there are a few shortcut keys, such as Alt-D to delete a word, but experienced users can grow impatient with menus, prompts, and confirmations.

Still, PFS:First Choice is a remarkable package that makes child's play of integrated chores like mail merge or copying spreadsheet rows into a letter (handy "bookmarks" let you jump back to your place in a file after leaving it to fetch part of another for your clipboard). At its street price (about half its $199 list), it's almost worth buying just for the excellent, easy instruction manual.

Pop-Up Lists

Interface Technologies Corp. seems bent on running into big guns. The firm took on Lotus 1-2-3 with Farsight, a slow but nicely integrated spreadsheet and word processor that I reviewed here in June 1986; it's now challenging SideKick and Metro with a pop-up utility called Teamwork. The latter's a decent accessory if you need to manage long lists of names and phone numbers, but is otherwise nothing special for $65.

Teamwork has the same "load me last" foibles as many memory-resident programs, and it's clumsier than some in other respects: it takes a separate program instead of a keystroke sequence to clear Teamwork from memory, and you can't change its command key from Alt-T to something else (press Alt-T twice if your application program requires it). It's moderately bulky, taking 115K with room for 660 lines of data (other versions take 140K and 81K with larger and smaller data space).

Like its rivals, Teamwork can show the ever-popular ASCII code table (plus the even less popular function-key scan code table), along with a simple calendar running through 2099 (no appointments, no alarms, nothing before 1980, so you can't find the day of the week on which you were born). Its calculator shows a running tape with four-point and scientific notation, but no memory, business, or scientific functions.

Teamwork's heart, though, is its ASCII text editor. Compared to other pop-up notepads, it has adequate editing power, no print formatting, and three notable features. One is the ability to sort a file on the first or a specified column, screwing up titles or headlines by serving to maintain a phone list or other database that'll fit on a 77-character line. A search function finds a name or entry, while a phone dialer places voice (not data) calls to a listed number.

The program also keeps two lists in memory at once, cutting and pasting between full- or half-screen views of, say, a phone directory and an appointment list. Finally, Teamwork lets you mark and capture text from an underlying application screen, in case you want to make an ASCII file of some spreadsheet rows or merge a dBase record into your phone list. All in all, this program is mediocre compared to more general desk accessories, but it does a good job as a mini-database or list manager.

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CN Hotels and Tower          1-800-268-8136      in Canada
Campaign Discount Clearance  1-202-555-1988     300,000 Gary Hart buttons
Coiffures by Maurelle        555-0932           Jane's hair stylist
Deluxe Caterers II           555-8761           Take-out & bachelor parties
Fiscal Fitness Inc.          1-212-555-0930     Tax dodge consultants
Marriott Hotels              1-800-228-9200     Steal the soap
Modern Electronics           1-516-681-2922     Ask about "PC Papers"
Phaenon Corporation          1-603-555-1919     Publication consultants
Thomas, Richard, & Harold    1-312-555-7600     British Trade reps

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If you've got a little list, Teamwork keeps it and other accessories on call.

Forgotten Copy Department

It appears that most of the hardware description of the NEC MultiSpeed laptop computer I reviewed here in May was accidentally left out. The following is the copy that was left out. It should immediately precede "The Software" breakhead in the column.

Lift the NEC's screen, and your complaints about its extra couple of pounds disappear. Its keyboard is the best of any laptop to date, an XT-style layout complete with two columns of function keys, a real keypad for numeric entry and cursor control, lighted Caps Lock and Num Lock keys, and (sigh) the backslash between Shift and Z. The smallish Enter and Shift keys and relocated keypad take an hour's getting used to, but after that typing is a pleasure, with a snappy feel and no "shifted down arrow equals PgDn" nonsense.

The super-twisted LCD screen shows a full 25 lines and 80 columns of crisp blue characters, but lacks a backlight like the Zenith Z-181's—giving the MultiSpeed a respectable four to six hours on its Ni-Cd battery (recharged in eight hours on the supplied ac adapter), but making it a headache in dim rooms.

In decent light, however, it's quite readable, with ample angle and contrast adjustment and the ability to run Color/Graphics Adapter software in eight successively paler shades of blue. Built-in boldface and palette customization software lets you set most programs to your liking, though less easily than the Toshiba's color-switching utility, or disable the LCD (removing it altogether if you wish) in favor of a color monitor.

Since I didn't have the desktop disk hookup (my Tandy doesn't have an IBM-style external floppy interface anyway), I sat through some old-fashioned null modem downloads to get my software onto the MultiSpeed. Once there, however, everything I tried (including a memory partition that crashed IBM's Convertible) ran like sixty. The portable's name comes from its ability to switch its NEC V30 processor to the old 4.77-MHz clockspeed, but its usual 9.54-MHz performance is terrific.

The MultiSpeed runs with near-perfect compatibility at about 2.8 times the speed of a standard PC (doing a Lotus 1-2-3 recalculation in 9.6 instead of 26.5 seconds, for example). To beat that, you'll need an AT or clone with an 8-MHz 80286 chip (about four times PC speed). The 3.5-inch disk drives don't match that pace. While quicker than 5.25-inch floppies, they're about one-fourth as fast as a mediocre hard disk—but they're spacious and reasonably quiet. Besides having separate access lights, drive A even sounds slightly different from drive B. ME

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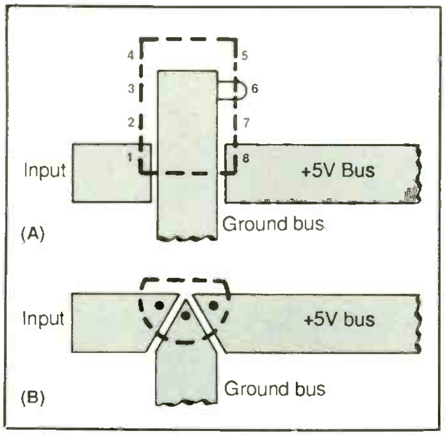

Fig. 4. Conductor details for DIP (A) and TO-92 versions of IC4 regulator.

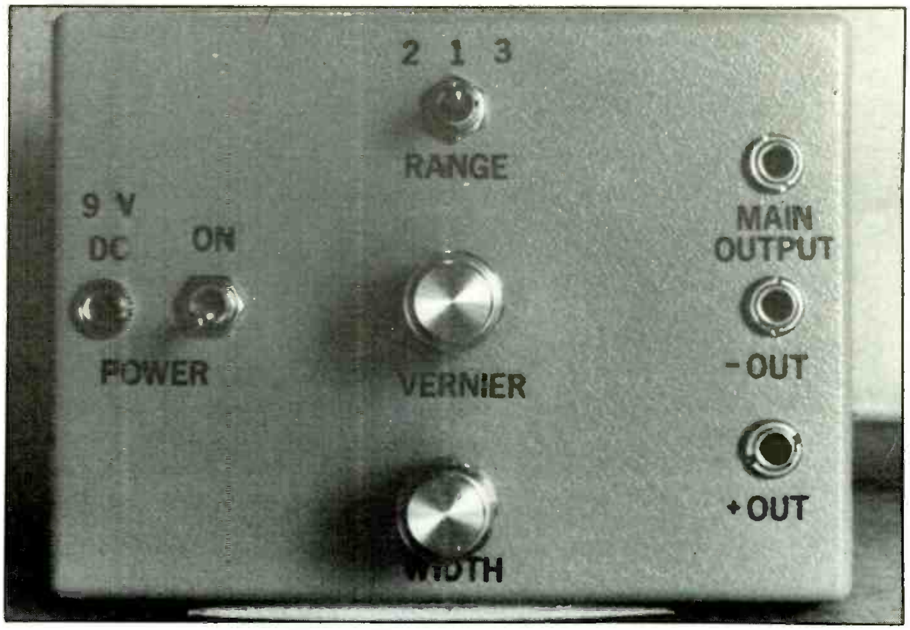

Fig. 5. Project's front panel.

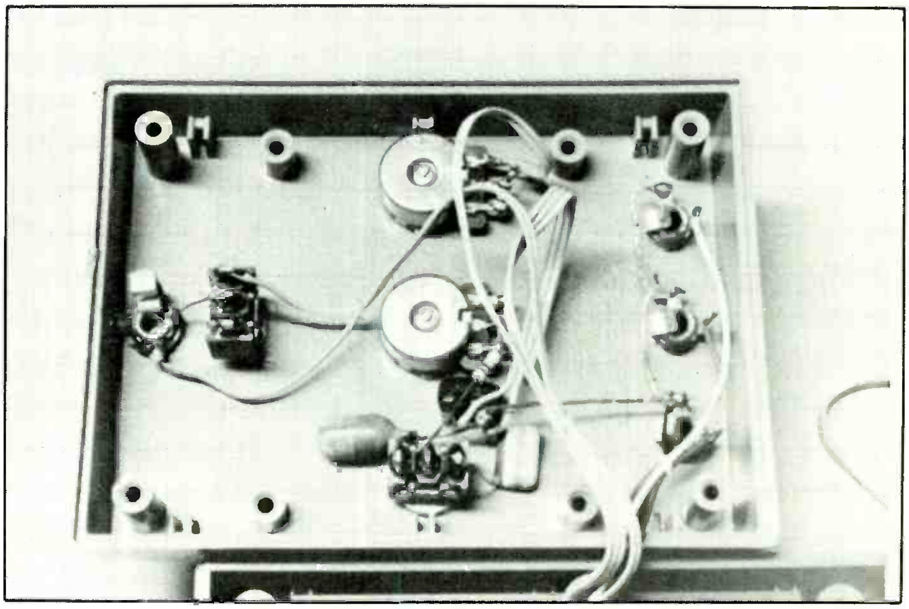

Fig. 6. Interior view of enclosure's front panel with controls, switches and jacks mounted in place.

for low-resistance connections to *IC4*. In (A), which applies to the 8-pin DIP version of the regulator, pins 1 and 8 of *IC4* should be soldered directly to the input and + 5-volt bus strips, and the ground bus connects to pin 6 via a wide bus strip that passes between the input and output bus strips. This ground bus then crosses the board and wraps back to near the far end of the + 5-volt bus to permit short connections to be made for *C8*. Note, too, that *C6* should also have short leads, while *C7*'s leads can stretch between the power bus strips between *IC1* and *IC2*.

Figure 4(B) illustrates the special bus arrangement for *IC4* if you should decide to use the small TO-92 78L05 regulator. Again, emphasis is on short leads and wide power and ground bus strips.

Because the ICs in the Varipulse Generator generate about 3 MHz on range 1, ceramic bypass capacitors *C6*, *C7* and *C8* must be located directly at the IC sockets. Capacitors *C5* and *C9* are aluminum electrolytics that have poor frequency response at high frequencies. Ceramic capacitors have low impedance at high frequencies and are used here because HCMOS ICs require the same bypass precautions as TTL ICs do.

Once you have the circuit-board assembly fully wired, you can proceed to machining the small enclosure in which the bulk of the project is to be housed. Choose an enclosure that will comfortably accommodate the circuit-board assembly and has sufficient depth to allow you to mount the various controls, jacks and switches on the front panel (see Fig. 5 for a suggested layout) with ample clearance between them and the circuitry.

Test fit the components in their respective locations and then remove them. Label the panel according to position and/or function. If you use dry-transfer lettering, spray two or three light coats of clear acrylic over the entire panel and wait for each

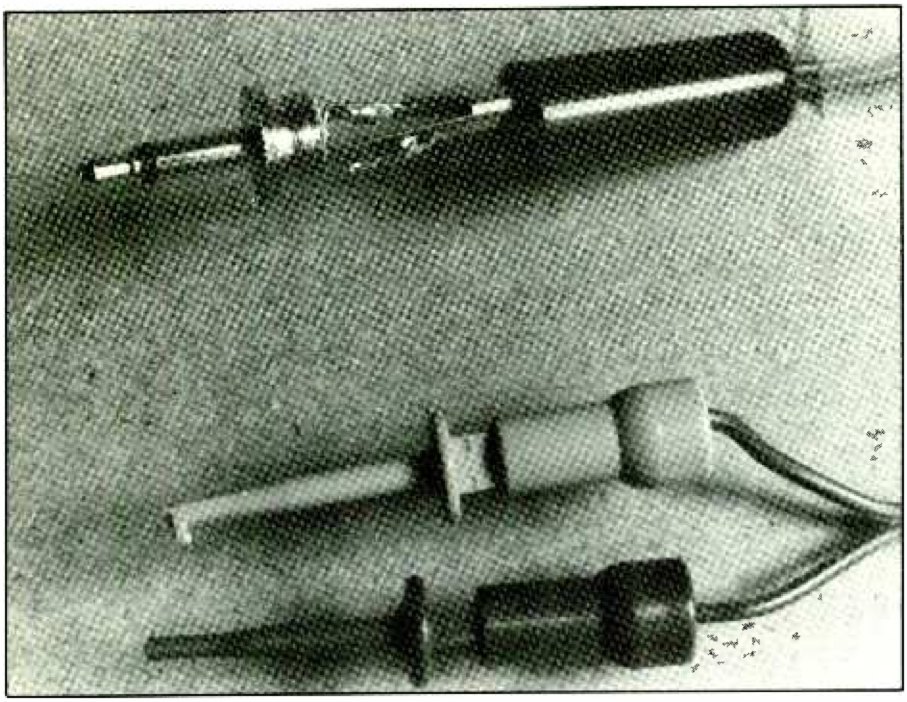

Fig. 7. Output cable construction details show miniature phone plug (upper) and "micro-grabber" connectors (lower).

coat to dry before spraying on the next. This will protect the lettering from scratching and wearing off as you use the project. If you use a tape labeler, there's no need to protectively coat the front panel.

Referring back to Fig. 3, wire the remainder of the circuit. Figure 6 shows the control, jack and switch arrangement from inside the enclosure. Note that some components mount off the circuit-board assembly, directly to the lugs of the switches and controls. Note particularly the ground strap that interconnects the output jacks and timing capacitors.

Finally, make up three sets of test leads. For these, you will need miniature phone plugs, two-conductor flexible lead (or miniature coaxial cable) and "micro-grabber" connectors. Use 36″ cables for each test lead you prepare. Figure 7 shows details of test-lead construction. **ME**

Twilight Sentry *(from page 45)*

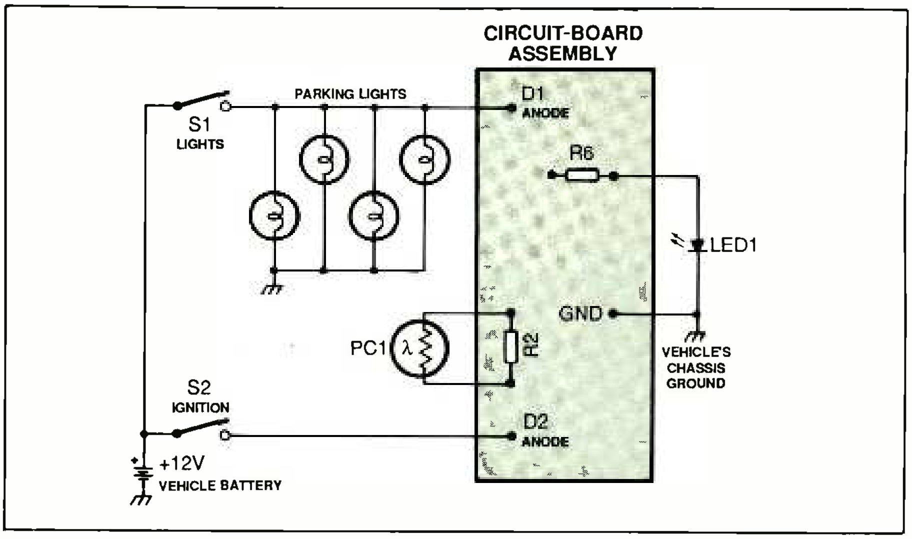

Fig. 5. Wiring diagram shows details for typical installation of Twilight Sentry in a vehicle. Photocell and/or LED can be mounted remote from main circuit.

When you do obtain the proper readings, power down the project and plug the ICs into their respective sockets, taking care to observe proper orientations. Handle *IC1* as you would any other CMOS-type static-sensitive device. As you plug each IC into its socket, make sure that none of its pins overhang the socket or fold under between IC and socket as you push it home.

Now check actual circuit operation, once again using the power supply or vehicle battery as a power source. Do this in a location where the ambient lighting is subdued. First set SENSITIVITY CONTROL *R2* fully counterclockwise. Then with some light striking the photocell, connect the power supply's or battery's ground or negative lead to the GND contact and the positive lead to the +12V IGNITION ON contact of the screw-type terminal strip on the project. The LED should be off.

Simulate a dusk condition by shielding most of the light from the photocell. In bright light, you will have to exclude almost 100 percent of the light. Adjust *R2* clockwise until the LED begins to flash. Then use a short wire or a paper clip to jumper from the anode of *D1* to the anode of *D2*. The LED should now turn off.

If you fail to obtain the proper results during your tests, you must troubleshoot the circuit and rectify the problem. You can check the latch circuit by measuring the potential at pin 13 of *IC1*, which should be about 12 volts when you first apply power to the circuit with *R2* set fully counterclockwise. Setting *R2* to its fully clockwise position and with no light falling on the photocell, the potential at pin 3 of *IC1* should drop to zero and remain there.

Measure the voltage across the photocell to be sure that it is near zero under bright-light conditions. It should rise to no more than about 8 volts as the photocell is darkened.

You can check operation of the *IC2* oscillator by measuring the voltage at pin 4. When power is first applied to the anode of *D2* and with light striking the photocell, you should measure 0 volt. With *R2* set fully clockwise and the photocell in darkness, the measurement should rise to about +12 volts and the LED should flash.

If the logic levels at pin 4 of *IC2* are correct but the LED fails to flash, carefully check your wiring, the component values of the *IC2* oscillator circuit and the polarity of the LED. If necessary, try a new LED.

Installation

Figure 5 shows a simplified installation diagram to use to wire the Twilight Sentry into your vehicle's electrical system. Since the photocell is extremely sensitive, you may want to mount it in a location that is somewhat sheltered from direct light. Whatever location you choose, however, make sure that the photocell is protected from the elements and that there is no possibility that the connections can be accidentally shorted to any metal part of your vehicle.

Voltage to drive the anode of *D2*, via the +12V IGNITION ON contact of the terminal strip, must be obtained from a point in your vehicle's electrical system that is at +12 volts with the ignition on and at 0 volt with the ignition off. Use a voltmeter to locate such a point. Since the circuit draws very little current, you can use the power lead of any ignition-on accessory, including your car radio or a windshield-wiper motor.

The anode of *D1* must be driven, via the +12V PARKING LAMPS terminal-strip contact, from one of the running lights of your vehicle. You can tap off the parking or tail lights. Do not use the headlight circuit, since the high-low beam switch may cause the LED to flash when it should not. Use the dc voltmeter to make certain that you have selected the correct wire in your vehicle to which to make this connection. You should obtain a reading of +12 volts when the lights are on and 0 volt when the lights are switched off.

Be sure to connect circuit-board common to the chassis of your vehicle, via the GND contact of the terminal strip, to assure a good ground.

After installing the Twilight Sentry in your vehicle, make a final adjustment of the SENSITIVITY control. This must be done under actual twilight conditions, at the level of light you want the warning LED to flash. Set *R2* fully counterclockwise (least-sensitive position). Start your vehicle's engine and make sure all lights are off. Now very slowly adjust *R2* clockwise until the LED begins to flash. This will be the ambient light level at which the project will provide a visible warning. After making this adjustment, turn on your vehicle's headlights and note that the LED should now extinguish.

After installing the Twilight Sentry in your vehicle, inform all other drivers who use your car of its function. You will now have peace of mind knowing that you and other drivers who use your vehicle will never inadvertently drive without lights at dusk. **ME**

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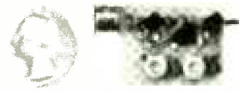

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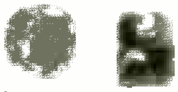

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