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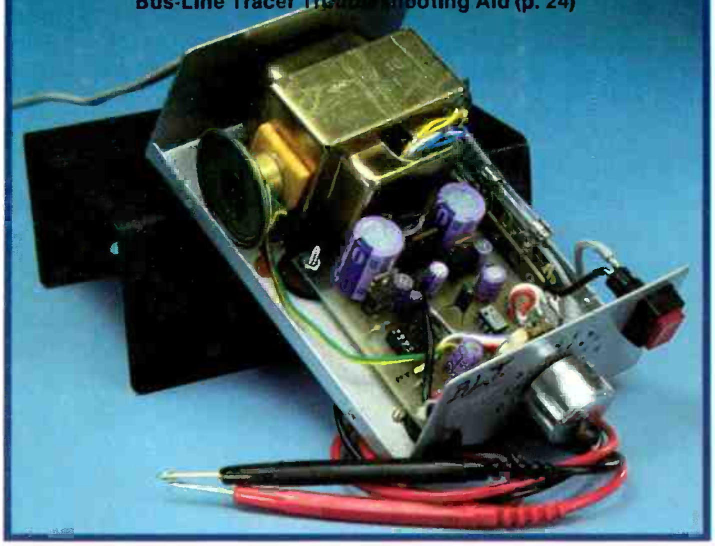
- **Extending a Multimeter's DC Amp Range Beyond 10A**

Reports from Comdex Atlanta (p. 62 & p. 70)

Bus-Line Tracer Troubleshooting Aid (p. 24)



Wireless Remote Telephone Ringer (p. 30)

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Plus: New Active-Filter Chips ● Reports from Comdex Computer Show ● SABA's Handheld Optical Scanner ● Latest Tech Books & Literature ● Electronics & Computer News ● Xerox Ventura Publisher Review ● Forrest Mims' Xenon Flashtube Circuits

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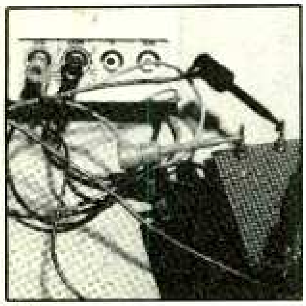

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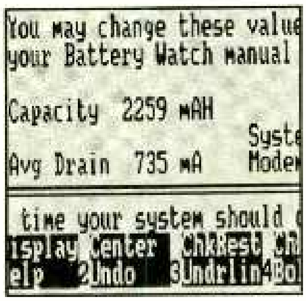

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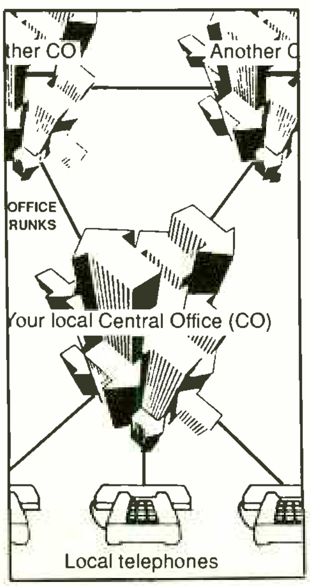

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Offices: 76 North Broadway, Hicksville, NY 11801. Telephone: (516) 681-2922. FAX (516) 681-2926. Modern Electronics (ISSN 0748-9889) is published monthly by CQ Communications, Inc. Application to mail at second class rates pending at Hicksville, NY and other points. Subscription prices (payable in US Dollars only): Domestic—one year $17.97, two years $33.00, three years $48.00; Canada/Mexico—one year $20.00, two years $37.00, three years $54.00; Foreign—one year $22.00, two years $41.00, three years $60.00. Foreign Air Mail—one year $75.00, two years $147.00, three years $219.00.

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EDITORIAL

Little Things Count

Troubleshooting electronic and computer equipment calls for using a variety of test instruments, accessories and supplies. These may range from a sponge to wipe the tip of a solder iron to automatic test equipment (ATE) systems.

Probably the most neglected "tool" in the servicing business relates to maintenance, which is often just plain cleaning of sorts. This might be likened to an automotive grease-and-oil job, except that electronic and computer equipment are not generally "maintained" in this manner. In most cases, a technical service person doesn't see a piece of equipment unless it has broken down. Since this is common, it makes sense for servicemen to provide maintenance at the time they repair equipment—and charge for this service, of course.

In the early days of television, this meant cleaning a bevy of contacts on a turret tuner using a cleaning inset that was substituted for an unused-channel contact strip. The substitute strip was saturated with a liquid cleaning agent so that stationary contacts unreachable by hand would be cleaned while rotating the movable tuner section. Contact cleaner was also sprayed into all controls and on switches. And dirt was blown away with a small vacuum cleaner.

Nowadays, the use of chemicals and "wipes" have expanded. They include switch and contact cleaners of yore for a wide variety of electrical devices, as well as newly developed agents to combat chronic problems with modern equipment. Among these are static-reducing sprays to prevent high-voltage zapping of sensitive electronic components, special non-abrasive, pre-saturated pads to clean, lubricate and protect metal contacts, dry air dusters to remove microscopic dust that could effect magnetic media, micro dusters to blow dust and dirt away from tight areas, pre-moistened pads to clean optical surfaces, solder-flux removers, and so on.

Beyond the foregoing, there are check-out tests that could be performed (for a price, of course) that would reveal up-coming problems or even deficiencies that might not be apparent. For example, a computer hard disk might have some defective spots that go unnoticed because data has not yet been saved there. There are programs available that give advanced warning and lock out these sections. There are test discs for CD players and test tapes for tape recorders that check the "health" of equipment, as well as video test gear that can pinpoint alignment deficiencies, among others, that have caused deteriorated color pictures.

If professional service people would

LETTERS

Super Connection

• I greatly enjoyed Forrest Mims' article on superconductors ("Electronics Notebook," March 1988). When attempting to measure resistance of superconductor material with an ohmmeter, I also got the strange result reported in the article, namely that the resistance seemed to *increase* as the material cooled. As Forrest Mims points out, the problem is in the contact resistance between the ohmmeter probes and the material. I devised the following method to avoid this problem.

First, I connected a low-voltage power supply to the material using brass clips. I then used separate voltmeter probes, each touching the material near one of the brass clips, to measure the voltage drop in the material resulting from the power-supply current.

To achieve a reasonable voltage drop at room temperature (about 10 mV), I adjusted the power supply current to 3 amperes. When I added liquid nitrogen to cool the material, I kept adjusting the power supply to keep the current constant (to correct for the changing contact resistance) and noted the voltmeter reading. As the material cooled, the voltage slowly dropped for a while and then suddenly decreased to zero. Since current was passing through the superconductor, it could show zero volt only if it has zero resistance.

Eva Garland
Los Altos Hills, CA

sell this maintenance program, both customer and service company would benefit, the former through better-performing equipment and less equipment down time and the latter through higher profits.

Service/maintenance companies might offer a flat-rate charge based on equipment value for this procedure. It would certainly be more beneficial to the end user than the practices of some of the large law firms in New York City, which really sock it to you for rather minor services. The latest I heard is a flat $550 charge for breakfast, lunch and dinner, depending on the hours you spend there on business, in the firm's sumptuous private dining room—whether or not you actually dine! Without any forewarning (you find out about it when you get the bill, which could be as high as $1,650 per person if you're there a whole day).

Observing charges made by lawyers, physicians, and even automobile mechanics, electronic and computer services might be one of the last true service values in town.

Art Salsberg

• Thank you for Forrest Mims' educational and entertaining "Experimenting With a Superconductor" (March 1988). I recently purchased some liquid nitrogen (for experimenting with laser diodes) and found Mr. Mims' comments on buying and storing the stuff accurate. For anyone interested in using liquid nitrogen in their experiments, the following may help.

Drill a small hole in the cap of the thermos bottle to permit the vaporizing gas to escape. Keeping the cap on the bottle minimizes spillage and waste, and the hole prevents explosion. (New caps can be purchased separately.)

I found that welding supply outfits are the best source for liquid nitrogen, but

(Continued on page 65)

NEW PHONE APPLICATIONS. A new hot-line software service has been introduced for IBM and compatible computers by PC Problem Solvers, Sunnyvale, CA. The service provides answers to user problems with the most-widely-used applications programs for spreadsheets, word processing and database management, such as Lotus 1-2-3, WordPerfect, dBase III Plus, and others. There's a $25 charge for this service on a per-call, per problem solution basis, which may be charged to a major credit card. If a software specialist is not able to talk to a caller immediately and fails to call back within 17 minutes, there's no charge for assistance, which is offered over a nationwide toll-free number (800-727-4911) on Monday through Friday, 6 a.m. to 6 p.m. (Pacific Time)....A bill before the U.S. House of Representatives would, if passed, provide the FCC with the power to mandate that all new residential and business telephones in the U.S. be hearing-aid compatible. GTE Consumer Communications Products Corp. already has a policy of only supply hearing-aid compatible phones. It costs GTE in the range of 20 to 50 cents per unit to include this feature. There are exceptions to such compatibility, noted GTE's Freeman Robinson, who testified before a House Subcommittee on the subject. "Secure" phones, for example, are designed to avoid generating any fields that could be monitored by the enemy, and should therefore be exempt from hearing-aid compatibility. Also, within commercial airplanes, hearing aids cannot couple to air-to-ground telephone equipment.

VIDEOTAPE WATCHING. We're spending almost twice as much time watching recorded videocassettes as we are doing any recording, according to a study by AGB Television Research, reports the American Home Satellite Association. Moreover, half the recorded material is never watched! In a three-week study of 2,000 VCR homes, which excluded satellite-dish owners, the VCRs were used an average of seven hours per week, with 49% of the time spent playing back commercially recorded cassettes, 23% on unattended (time shift) recording, 11% recording a program being watched, and only 17% playing back homemade recordings.

Interestingly, the AGB report noted that households with premium cable taped 45% more than nonsubscribers, but play back 26% less. Most prerecorded videotape watching is done, not surprisingly, on Saturday nights (23%), followed by Friday nights (19%) and Sundays (16%). Sunday evening led all for video recording with 26%. Anchorage, Alaska is the leading city in VCR household ownership with 76.8% penetration.

HIGH-TECH JOB MARKET. Electronics and computing-industry jobs are still in the midst of good times, with healthy forecasts. The Bureau of Labor Statistics, for example, projects that jobs in the semiconductor industry will increase from 268,000 in 1986 to 289,000 in the year 2000, while electronic computing employment is expected to rise from 418,000 to 503,000 in the same time frame. The computer service market looks rosy, too, since it generated about $14.8-billion in revenue last year, and is growing by leaps and bounds judging by a reported 14% annual growth in worldwide field servicing revenues.

THE COMPUTER WORLD. Mechanical drafting is the most popular computer-aided design application, according to a survey of CAD-system users by CAD/CAM Publishing, Inc., San Diego, CA. Most companies use ECAD for schematics and printed-circuit layout, while less than a third use simulation programs. The market for CAD systems is highly fragmented, with lots of brands out there. AutoCAD is the leading single application for mechanical drafting, the survey found, though less than 5% who use CAD for three-dimensional design and modeling employ it.

Apple Computer and Quantum Computer Services announced a new online communication and information service for Apple computer owners, called "AppleLink--Personal Edition." It will allow Apple users to "talk" with each other and access Apple-specific and general online information and resources. The new service will include user participation in online forms with guest speakers such as Apple co-founder Steve Wozniak, the exchange of electronic mail, stock quote information, free software, hardware/software Q&A multi-player games, computer enhancements, electronic encyclopedia reference, transactions such as making airline reservations, ordering products, etc. The Apple II AppleLink--Personal Edition works on Apple IIGS, IIc and IIe systems, while a Macintosh version that will be available later this year will operate on Mac 512K, Plus, SE and II computers. The retail price for the software, user guide, first year's subscription to a monthly AppleLink Update magazine, and two hours of non-prime-time use is $35, with $6/hour charged for non-prime-time use and $15/hour for prime-time use, with no difference for baud rates of 300, 1200 and 2400.

AUDIO & VIDEO REPAIRS. According to New York-headquartered ComponentGuard Inc., a name-brand extended warranty company, servicing entertainment audio and video components (excluding TV sets) cost the populace $345-million last year. More than 40% of VCRs require servicing within five years, with the consumer cost ranging from $40 to $250, according to the company. One-third of all audio turntables need service in their lifetimes at an average cost of $70, the company reports, with compact-disc players having the highest service rate.

METAL DETECTORS. Electronic metal detectors are a familiar sight at beaches, where they're used to search for buried coins. The recipient of the first metal-detector patent (1937) and founder of Fisher Research Lab, Dr. Gerhard Fisher, who recently passed away at the age of 89, had worked for Lee DeForest, inventor of the vacuum-tube triode, for a few years. Among his score of patents was a direction finder for airplanes, which he designed in 1929. An outgrowth of this development, which used locp antennas, was his metal detector, called a "Metallascope." The research staff at Federal Telegraph, for whom he developed the direction finder, believed it was not marketable. His persistence paid off, as such electronic detection instruments are widely used today by treasure hunters, utility companies searching for buried pipes, geologists scouting for ore, law-enforcement agencies detecting hidden weapons, and so on.

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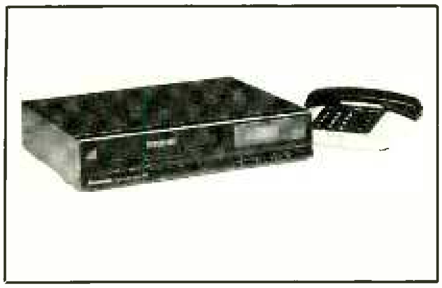
Phone-Programmed VCR

Panasonic's new Model PV-4826 VHS videocassette recorder can be remotely programmed by telephone, as well as the conventional local method with on-screen display. With the VCR connected directly to the telephone line, the user simply calls home to direct it to record in his absence. A two-digit access code brings the VCR "on-line." Programming is then accomplished by keying in specific letters on the controller's keypad.



A Hi-Tech4 video head system based on a double-azimuth design is said to produce superior special effects in the SP and SLP modes. It uses a sampling method that couples with a direct-drive cylinder and direct-drive capstan motors guided by digital servo control. This system reads twice as much information as previous Panasonic four-head systems so that every field (instead of every other field) is read, which eliminates the "step-action" effect common in slow-motion playback.

Using local programming, commands are verified in bold graphics on the TV receiver's screen as they are transmitted from the remote controller. Auto Prompting provides on-screen instructions for each phase of programming. The system can also be used to verify a variety of functions.

Other features include: 155-channel digital tuning with Auto Set (enables a recently activated channel to be added in proper numerical sequence by pressing a single button); audio/video noise muting system that replaces noise from blank segments of tape and unused channels with a quiet blue screen; high-speed Omnisearch; one-touch record; and 43-button wireless remote controller. $550.

CIRCLE 3 ON FREE INFORMATION CARD

PC-Based Multiple Test-Instrument System

Rapid Systems' (Seattle, WA) Model R15 multiple-instrument system is said to turn PC, XT, AT and compatible personal computers into a variety of electronic test equipment with only a change of applications software. The dc-to-250-kHz system includes an 8-bit, 500-kHz digitizer and five different applications software packages. The software allows a user to use his computer to do digital oscilloscope displays, FFT spectrum analysis, data logging, data transfer and data acquisition directly into his own BASIC, turbo Pascal and C programs.

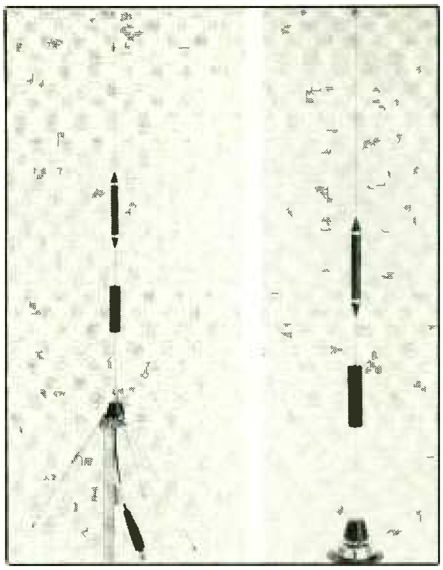
Hardware features include a full 8-bit A/D converter, 2,048-point data memory and four input channels. Other features include: external or internal analog triggering; software-selectable gain from 10 mV/division to 20 volts/division;

turnkey, menu-driven operation of all software; data-logging software for direct storage to disk or plotter; digital oscilloscope software with zoom, cursor readout, etc.; spectrum-analysis software; and file-transfer software to Lotus 1-2-3, dBASE, ILS, DADiSP and more. Users manuals are provided for all hardware and software. $995.

CIRCLE 29 ON FREE INFORMATION CARD

Scanner Antennas

Antenna Specialists' new all-band scanner antennas for capturing Public Service transmissions such as police, fire and emergency communica-



tions are claimed to provide enhanced performance up to 1,000 MHz. They include the Models MON-52 mobile and MON-58 base-station versions. Featuring Micro-Choke™, they are said to provide pinpoint resonance at 800-MHz scanning frequencies and concentrated beam focus at low radiation angles for maximum-range monitoring. The antennas cover from 25 MHz to 1 GHz.

The mobile version has a no-holes "Quick-Grip" trunk-lid mount for easy installation and includes coaxial cable with installed pin plug. The base-station version feature easy one-clamp installation.

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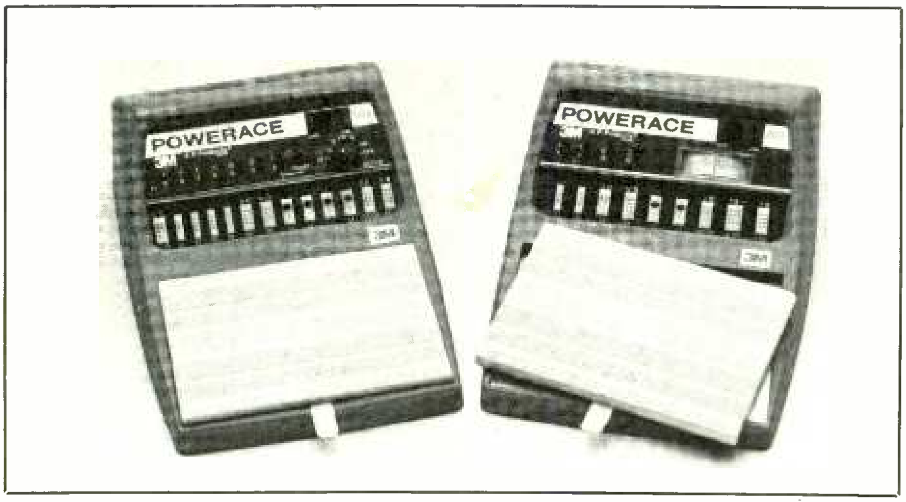


Breadboarding Labs

New Powerace solderless breadboarding labs from 3M Electronic Products accommodate removable breadboarding assemblies, called Powerace Plus-Boards, that permit multiple-circuit projects to be built using a single Powerace unit. Each Powerace lab comes with one removable Plus-Board assembly, and additional Plus-Boards are available separately. With the new labs, one can design a variety of different circuits, each on its own Plus-Board, and run them simultaneously from the Powerace's internal power supply.

Powerace Plus-Board assemblies consist of two solderless breadboarding sockets with tie points on 0.1″ centers to accommodate all DIP IC sizes and a wide variety of discrete components with lead diameters of up to 0.032″. Containing 1,680 tie points, each Plus-Board can accommodate up to 18 14-pin DIPs. The sockets are mounted on an aluminum ground plane, making the boards suitable for high-frequency and high-speed/low-noise circuits. Contained within the basic Powerace unit is a short-circuit-protected ac-operated power supply.

Two models are available. The Model 202 is designed strictly for TTL circuits and includes a built-in fixed +5-volt power supply and a six-range clock oscillator. The Model 203 is designed for CMOS and other circuits that require multiple supply voltages and has built-in +15- and +5-volt supplies and an analog meter movement. Both models appear to also have some basic logic blocks built in, as well as selector switches and LED status indicators.

CIRCLE NO. 101 ON FREE INFORMATION CARD

Car CD/Tuner/Amplifier

Pioneer Electronics' Model DEH-66 can be installed as a front- or rear-mount DIN-size head unit that houses a multi-function CD player, AM/FM tuner with electronic audio control and a 20-watt/channel amplifier. The amplifier features electronic volume, balance, bass and treble controls; a gold-plated line-level output to an external amplifier and rear speakers; multi-function numeric display; and numeric display of volume, bass, treble, balance and fader control settings.

The CD player features a variety of playback modes, including track search, track scan, music repeat and random play; fast forward and reverse with sound; two-times oversampling digital filter; three-beam laser pickup; power disc-load mechanism; and power eject and automatic play.

According to Pioneer, the Supertuner III's PLL-quartz electronic tuner has very high sensitivity with strong three-signal IM rejection. Up to 18 FM and 6 AM stations can be preset, and a preset scan function simplifies locating a desired local station. Best stations memory automatically tunes the six strongest stations in an unfamiliar area. Automatic up- or down-channel seek and selectable local seek tuning enables the tuner to search for static-free strong local stations. A built-in pulse noise suppressor eliminates ignition and static noise picked up by the antenna.

An amber-illuminated LCD panel displays time of day when the unit is off and information suitable to the function selected when it is on. For security, a "secret code" system disables the unit when electrical power is disconnected until a preset numeric code is correctly entered. $800.

CIRCLE NO. 102 ON FREE INFORMATION CARD

Desoldering Braid

Chem-Wik SD from Chemtronics (Hauppauge, NY) is a new desoldering braid designed specifically for use in circuits containing static-sensi-

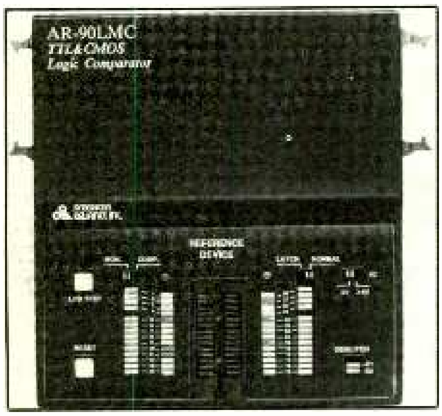
tive components. Packaged on special static-dissipative bobbins, the braid is said to protect microcircuits from potentially damaging electrostatic discharge during the desoldering process. The product consists of a finely woven flat copper braid that has been impregnated with a pure rosin flux. It conforms with DOD Standard 1686 and DOD Handbook 263 and meets the decay-rate provision of MIL-B-81705B.

Chem-Wik SD is supplied on 5- and 10-foot spools in widths ranging from 0.025 to 0.190 inch.

CIRCLE 27 ON FREE INFORMATION CARD

Logic Comparison Tester

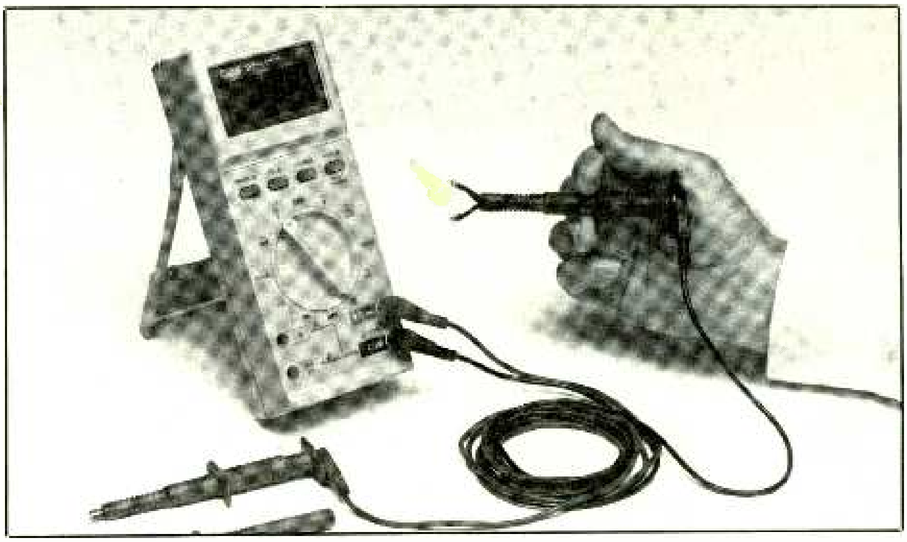
A new logic comparison tester from American Reliance (Rosemead, CA), the Model AR-90LMC is based on a proprietary custom IC that permits use of a single unit with both TTL and CMOS logic. It operates at 20 MHz and can detect a single timing error as short as 50 nanoseconds in



duration, which is claimed to be two to three times faster than the AR-90LMC's nearest competitor. Additionally, the tester can accommodate ICs with up to 28 pins, versus the typical 20 pins. It features two modes of operation—normal and latch—and permits direct viewing of logic states by using a built-in monitor mode.

Supplied with the tester are both 16- and 28-pin test clips, an interconnect cable, carrying case and operator's manual. $379.

CIRCLE 26 ON FREE INFORMATION CARD



Test Lead Set

John Fluke's TL20 industrial test lead set offers long heat-resistant test leads and interchangeable safety-designed alligator clips with retractable jaws and stainless-steel needle-point test probes. Both ends of the red- and black-insulated test leads are terminated in right-angle connectors. The alligator clips and needle-point probes that plug into one end of the cables are also color coded. The jaws of the alligator clips are opened by a mechanism similar to that used in squeeze-hook assemblies, which minimizes the chance of contact with live circuits. The test probe tips are 19 mm long and have sharp, insulation-piercing points.

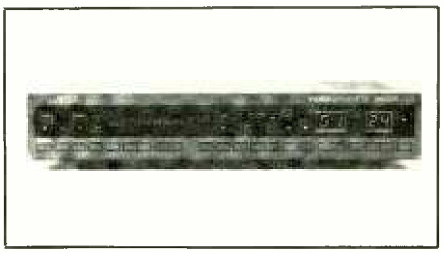
Very fine wire strands in the 1.6-meter-long test leads improve flexibility and resistance to breakage from repeated vibration and bending. Test lead insulation is a kink-resistant silicone rubber material that is usable from −100 to +300 degrees C. Shrouded banana plugs at the meter ends of the cables feature twice the number of contacts to ensure long connector life and low contact resistance. $35.

CIRCLE 25 ON FREE INFORMATION CARD

Satellite TV Receiver

General Instrument Corp.'s VideoCipher II 2650R satellite TV integrated receiver/descrambler (IRD) displays virtually every aspect of the home satellite system's operation. It provides on-screen messages that show exactly how the satellite system is functioning and to guide the user in changing antenna positions and storing channel and parental-supervision settings.

The 2650R combines a VideoCipher II descrambler with a full-featured receiver in a single integrated chassis. It has expanded memory capabilities that allow the user to store fine tuning for video and audio chan-

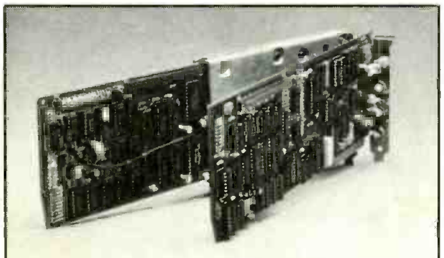


nels, parental-supervision settings, and internal TI filter operation. The unit connects to a home stereo system to provide digital stereo sound. Mono, discrete and matrix stereo subcarrier signals can also be received with two integrated bandwidth filters that provide optimum clarity. $1,248 (includes optional antenna positioner).

CIRCLE 24 ON FREE INFORMATION CARD

PC-Based Digital Storage Oscilloscope

Heath/Zenith Computer Based Products Group's Model SDS-5000 digital storage oscilloscope features analytical capabilities and performance characteristics that are claimed to normally be available only in much more expensive instruments. The SD-5000 board system can plug directly into the expansion bus of an IBM PC/XT/AT or compatible computer or in a Heath/Zenith instrument chassis. Simple plug-in installation and software provided with the product can have the SDS-5000 up and running in just a few minutes.



Heath/Zenith
Digital Storage Oscilloscope

Dual on-board analog-to-digital (A/D) converters capture two channels simultaneously, without reducing the digitizing rate. A real-time mode samples data at speeds up to 20 MHz with 4K memory depth (16K with an optional SDS-5000-16 memory upgrade). Software-controlled 10-step attenuators scale the input voltage from 40 mV to 40 volts full-scale.

The SDS-5000 can be used to examine pre- and post-trigger events; zoom in on trouble spots; make cursor measurements; and perform signal averaging, delayed-sweep, infinite-persistence, signal addition and subtraction and file saving and retrieval operations.

Compatible with other Heath/Zenith computer-based test instruments, the SDS-5000 can also be used as the centerpiece of an automated test system. $1,995.

CIRCLE 23 ON FREE INFORMATION CARD

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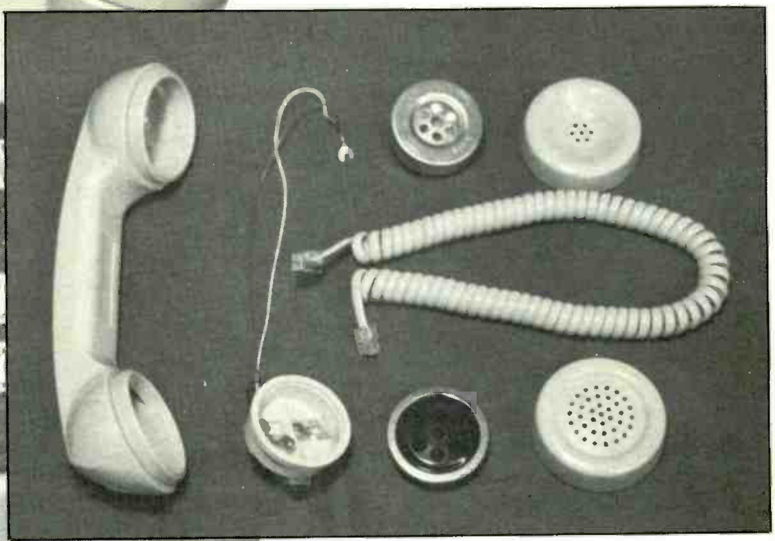


Telephone Technology

(Part I)

A look at elements that make up the telephone instrument and how they work together

By Stephen J. Bigelow

The ordinary telephone has become a vital part of our everyday personal and business lives. Consequently, when a problem arises with the instrument, the interface for a device that depends on it (a computer modem, facsimile machine, etc.) or the phone system itself, it is an extremely disruptive event.

As a technological force that we deal with regularly, you should have a basic understanding of how this marvel works so that you will be able to remedy many phone problems yourself, properly interconnect devices to it, and have the underpinning knowledge to follow rapid technical changes occurring today in telephone electronics.

In this first article of a two-part series, emphasis is on the telephone instrument's component parts and how they work together to form our telephone communications system.

Component Parts

Standard telephone instruments are manufactured in a great variety of shapes and convenience features. Nevertheless, every instrument has only five basic elements in it, as illustrated in Fig. 1.

(1) HOOKSWITCH. This is nothing more than a mechanical-activated device that connects (or disconnects) the transmitter, receiver and dial units into the voice circuit. A hookswitch is always activated by the weight of the handset resting on a plunger as it sits in the cradle. It can be as simple as a set of on/off contacts in an electronic telephone instrument or a much more sophisticated device with multiple sets of contacts.

(2) DIAL UNIT. This is the device used in the instrument to signal the local exchange as to who—or more correctly, what number—is being called. Three technologies are currently used to signal the Central Office (CO) as follows:

Rotary Dial. This is a mechanical device that merely interrupts the flow of current entering the instrument by means of a *rotary* dial, shown in Fig. 2(A). Thus, it is called pulse dialing. The number of interruptions in line current corresponds to the digit being dialed. When the dial plate is rotated from its rest position, the off/normal contact set of the dial closes to mute the audio at the receiver so that annoying clicks and noises are not heard. When the dial plate is released from the digit position to which is was rotated, the pulse contact set, shown schematically in Fig. 2(D), opens and closes to send the desired number of pulses.

Each pulse transmitted back to the Central Office must be within specific time limits for the CO to correctly interpret it. Typically, a pulse is 0.1 second in duration. It will break contact for 0.06 second and make contact for 0.04 second (referred to in telephone company parlance as a 60/40 pulse ratio), as shown in Fig. 2(E). If you could make and break the hookswitch connections with just the correct timing, it would be possible to dial out in rotary fashion without rotating the dial plate. Rotary dials pulse out at 10 pulses per second (pps) and will be interpreted by *any* Central Office.

Dual Tone Multi Frequency (DTMF). This method uses a predetermined set of tones, called Touch Tone, to signal to the Central Office the digits of the number being dialed. Although the technology to implement DTMF dialing is as common today as is traditional rotary technology, DTMF tones can be used only by Central Offices that are equipped to handle them.

Two assemblies make up a DTMF dialing unit: the pushbutton keypad or mechanical assembly and the tone-generating printed-circuit assembly. A pair of frequencies, unique to each button, is generated whenever a button is pressed on the "dial" keypad. These frequency pairs are detailed in Fig. 3. Pressing any given button causes the frequencies listed both horizontally and vertically to be generated simultaneously. For example, pressing the *5* button generates 1,336-Hz horizontal and 770-Hz vertical tones; pressing *9*, 1,477- and 852-Hz tones; etc.

Frequencies generated by a DTMF keypad must be accurate to within 2 percent of their specified values for the entire life of the keypad. Also, the minimum time a tone must be present for the Central Office to interpret and respond to it is 0.05 second.

Pulse Dialing. Also called Tele-Pulse dialer, this mechanism is commonly used in many newer electronic telephone instruments. It has a 12-button keypad, the same as the DTMF keypad, but its internal electronic circuitry sends pulses to the Central Office instead of tones. This hybrid dialer combines the convenience and speed of DTMF and the universality of rotary dialing.

With pulse dialing, you can dial much faster than the time it takes for the instrument to pulse out each digit dialed because Tele-Pulse circuits have built-in memory modules that store the digits keyed in, in the proper sequence. It is this memory capability that makes possible the memory and redial features found in newer electronic telephone instruments. Though many Tele-Pulse circuits are switchable to 20 pulses per second, the Central Office must be capable

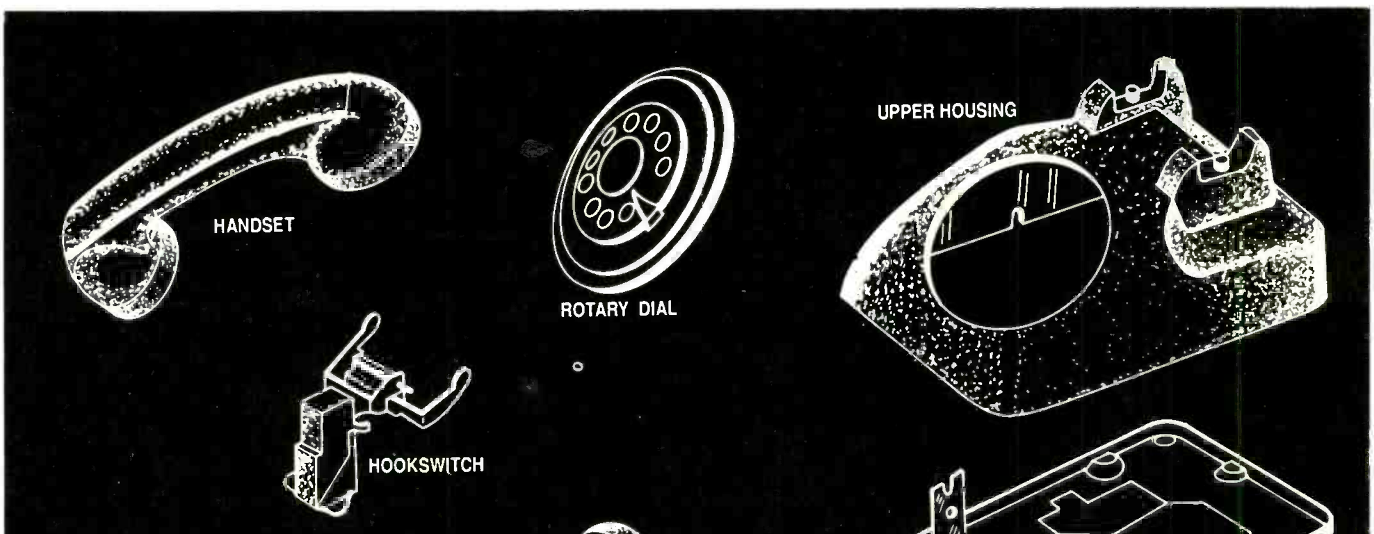
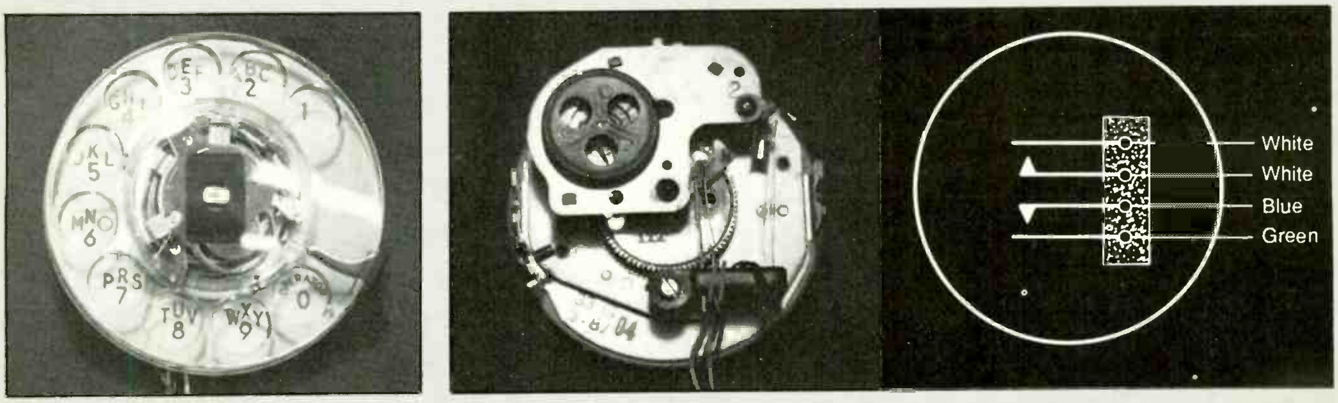


Fig. 1. Drawings show variety of elements that make up a conventional rotary-dial telephone instrument.



(A) (B)

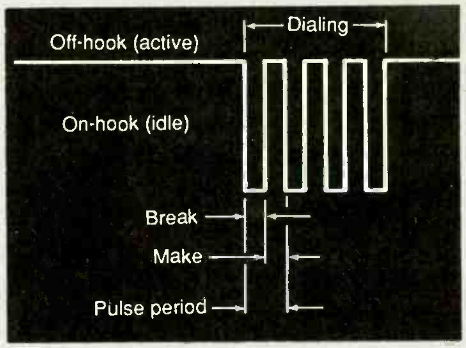


Fig. 2. In (A) a typical rotary dial is depicted; (B) is a rear-view photo of the dial mechanism and a schematic diagram of its contacts; and (C) is a graphical depiction of the rotary dial pulses.

(C)

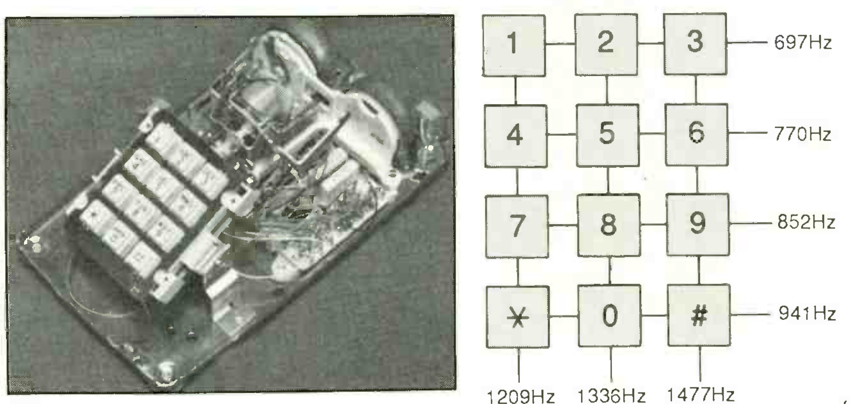
of accommodating pulses at this faster rate.

(3) NETWORK. Tie points for all elements in the telephone instrument are provided by the network. This element filters and amplifies voice signals, houses a capacitor that is used in the ringer circuit, filters out noise and voltage spikes and provides loss compensation and line balance between the "tip" and "ring" sides of the incoming telephone line. Line balance provides a ground reference to the phone line.

(4) RINGER. This element informs the user that a caller is waiting on the line. Ringers can be electronic devices in which an integrated circuit is used to detect the ring-signal bursts delivered by the Central Office and a buzzer that generates the audio sound that alerts the recipient to an incoming call. Texas Instruments' TCM1506 is ideally suited as a telephone ringer device.

A conventional telephone instrument may use electromechanical bells, but modern phones generally use an all-electronic ringer assembly like the one shown in Fig. 4.

A conventional electromechanical ringer consists of little more than a coil of wire wound around an iron core to create an electromagnet. A capacitor with a value of about 0.1 microfarad in series with the coil dc isolates the ringer from the telephone line so that the coil will not draw loop



(A) (B)

Fig. 3. The DTMF Touch Tone keypad mounted in a standard telephone instrument in (A) shows network, dual ringer and hookswitch assemblies, while (B) illustrates the frequency pairs generated by each key closure.

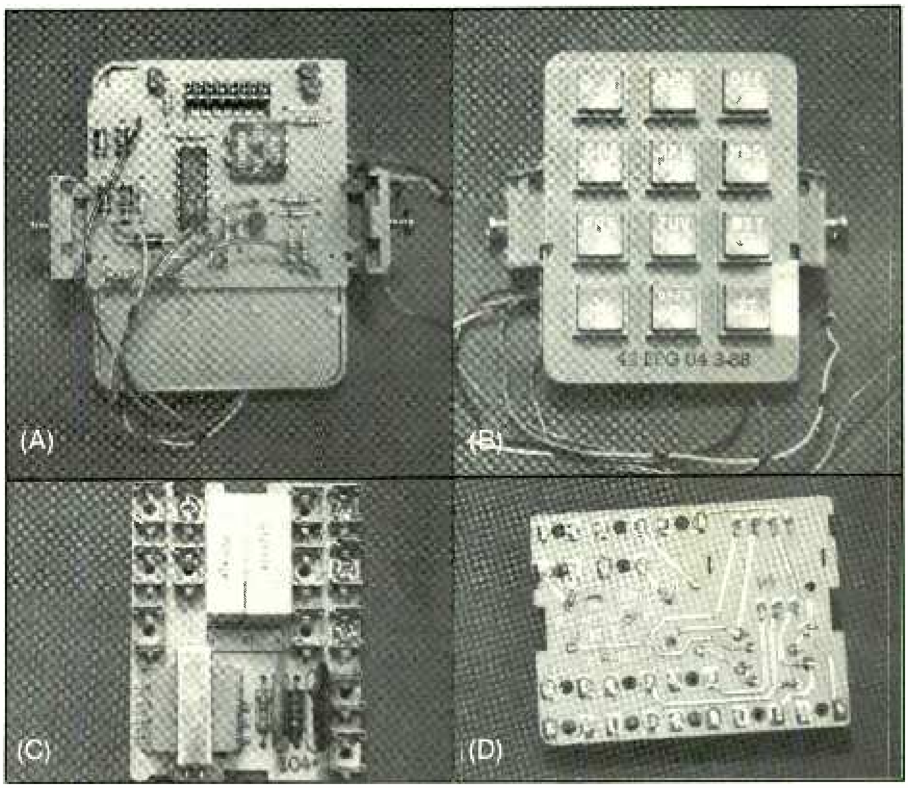
current when the phone is on-hook. The capacitor passes only the ac ring signal when it appears on the line.

Central Offices in the United States signal telephones by means of an ac voltage whose magnitude can range from 90 to 120 volts rms. For most telephone instruments, the frequency of the ring signal is 20 Hz. The on/off intervals of this signal are called the "ringing cadence." In the U.S. this cadence is broken up into 2-second on and 4-second off intervals, as in Fig. 5(A). In other countries, like the United Kingdom, the cadence is a bit more complicated and consists of dual bursts of 0.4 second separated by a 0.2-second delay, as shown in Fig. 5(B). Each dual burst is separated by a 2-second pause.

The most common type of ringer used in conventional telephone instruments is the straight-line, or non-frequency-selective type that rings at *any* ring-signal frequency. On a party line, where several customers share the same telephone line, a different ring frequency is used to alert each customer to their incoming calls. A frequency-selective ringer in each subscriber's instrument on a party line assures that only one instrument rings when a specific number is dialed. Party lines are of only passing interest here because they are not very popular in the U.S. today.

(5) HANDSET. In the handset assembly are located the transmitter and receiver units for the telephone instrument.

The receiver is an electromechanical device that recreates the transmitted audio-frequency sounds the originating instrument sends over the telephone network. It consists of a rigid metal diaphragm placed over a permanent magnet and a coil of wire wrapped around the magnet. As voice-signal current flows through the coil, the resulting magnetic field interacts with the permanent magnet's field and causes the diaphragm to vibrate. Sound energy created by this vibration is a fairly faithful reproduction of the original voice.



Shown in (A) and (B) are front and rear views of a 4200 EPG DTMF-type dial pad assembly, while in (C) and (D) are shown front and rear views of standard 2500-type network assembly.

The transmitter converts sound vibrations into an electrical current that varies in amplitude and frequency in step with the sound energy impinging on the microphone element. Like the receiver, the transmitter is essentially a rigid metal diaphragm mounted over a capsule containing carbon granules. As sound energy strikes the diaphragm, the capsule is expanded and compressed to cause resistance changes in the carbon granules. These changes in resistance cause voice-signal current to vary, thus creating an electrical signal that is transmitted through telephone network equipment to the phone at the other end of the line.

Electronic telephones may use new electrodynamic and electret microphones in place of the traditional carbon-granule element. Such microphones are rugged and low in cost, making them ideal for telephone applications.

Modern telephones that have built-in speakers and microphones provide the convenience of "hands-free" operation and come with a "mute" feature. In its simplest form, the MUTE button, when pressed, turns off the external microphone in the instrument so that no sound at all is transmitted to the party at the other end of the line.

These, then, are the five major elements that make up any telephone instrument. They are summarized in Fig. 6.

Central Office

Your local Central Office is the common point to which all telephones in your local exchange are wired and which provides the means by which you can connect through to parties located outside your local CO, as il-

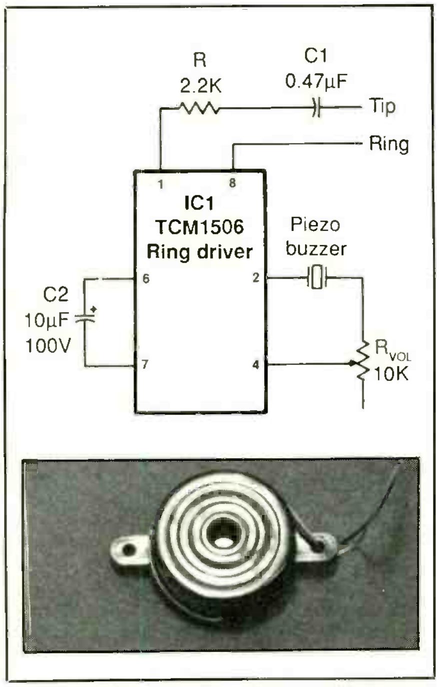


Fig. 4. A typical all-electronic ringer circuit built around a Texas Instruments TCM1506 ring-driver IC. Also shown is a photo of a piezoelectric buzzer typically used in telephone ringer applications.

lustrated in Fig. 7. It is the Central Office that generates the ring signal, dialtone and −48 volts dc required to power and operate your telephone instrument and all others connected to it. The Central Office also interprets the signals from your telephone's dial pad and performs all switching functions that connect your instrument to the instruments of other parties being called.

Your Central Office has a unique number that identifies it to the telephone network. It is the so-called "exchange" and consists of the first three digits of your telephone number, exclusive of any prefixes and area code. For example, if your number is 555-1234, your telephone instrument is connected to Central Office number 555. With four digits remaining in the seven-digit number, your local Central Office can handle up to 10,000 instruments with unique numbers (555-0000 to 555-9999).

Voice signals travel between the telephone instrument and Central Office over a single pair of wires that are traditionally identified as the "tip" and "ring" conductors. These names originated in early telephone installations wherein all "switching" was done by operators who manually plugged and unplugged cables terminated in phone jacks to make the instrument-to-instrument connections. The jacks into which these plugs were plugged had two contacts: the "tip" which made contact with the ball-like tip on the phone plug and the "ring" that made contact with the barrel-shaped common portion of the plug. In modern usage, the tip conductor is always color-coded green, the ring conductor always red.

With the telephone instrument's handset on-hook, −48 volts dc appears across the tip and ring conductors connected back at the Central Office, as shown in Fig. 8(A). With the phone on-hook, the instrument is in its "idle" state and no current is drawn by it. The weight of the handset resting on the hookswitch keeps the dial unit, transmitter, receiver and network disconnected, leaving only the ringer connected across the telephone line.

Lifting the handset from the cradle closes the hookswitch and places the remainder of the instrument's elements across the line. The loop voltage on the line now drops to about −6.5 volts dc and a loop current begins to flow. (Loop current can range from 15 to 30 milliamperes.) When the Central Office detects this current, it knows that your phone is off the hook and sends down the line a continuous dialtone, as depicted in Fig. 8(B). The standard dialtone is a mixture of 350- and 440-Hz frequency tones. When you hear the dialtone, you can begin dialing. As you dial, your instrument sends back to the Central Office pulses that correspond to the digits of the number being dialed, as shown in Fig. 8(C).

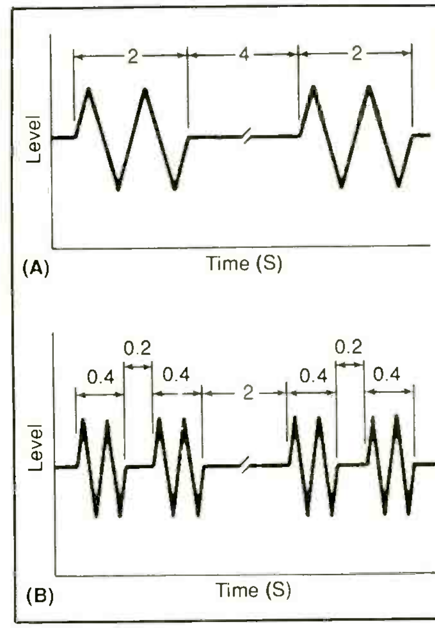


Fig. 5. Ringing cadence used in U.S. and Europe (A) and in United Kingdom (B).

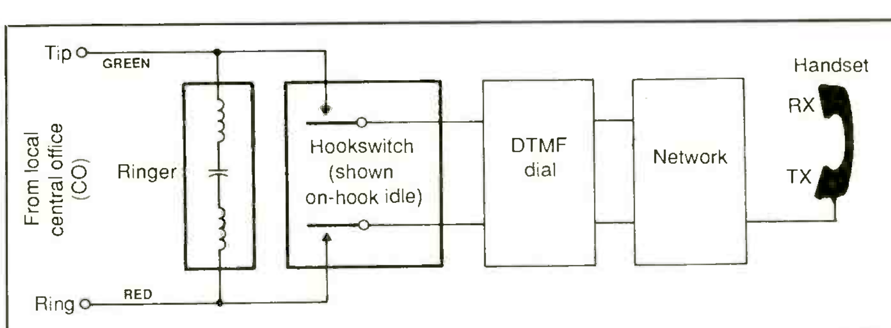


Fig. 6. Simplified diagram of a conventional single-line telephone.

The destination phone (the party you are calling) is specified by the sequence of the digits dialed. When the Central Office receives the first digit or pulse, it removes the dialtone from the line. Then, after all digits have been dialed, the Central Office checks to see if that station is active or not.

If the instrument you dialed is busy (off-hook), the Central Office sends a busy signal back to your phone, as in Fig. 9(A). A typical busy signal is made up of 480- and 620-Hz tones that are generated for 0.5 second, with 0.5-second pauses between each pulse.

If you dial a phone that is on-hook, the Central Office sends to it a ring signal and to your phone a ringback signal. The ringback signal is a mixture of 440- and 480-Hz tones that are generated at a rate of 2 seconds on and 4 seconds off, as shown in Fig. 9(B). When the party being called lifts his instrument's handset, the Central Office connects together the two stations and stops all signaling. Conversation can now take place, as in Fig. 9(C).

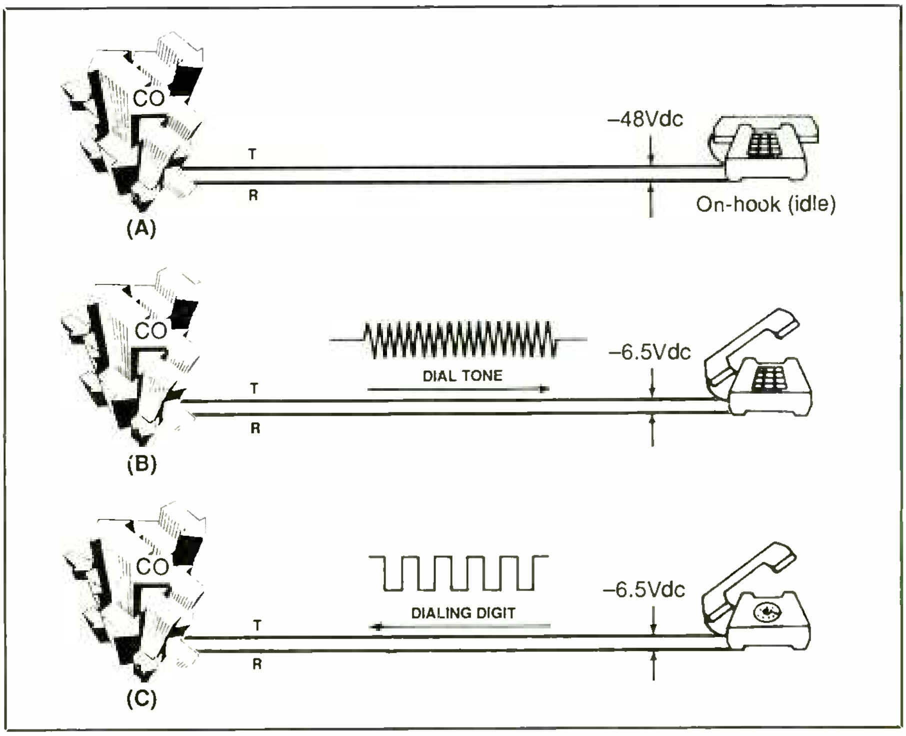


Fig. 8. These drawings show originating station conditions: (A) on-hook; (B) off-hook and drawing a dialtone; and (C) off-hook and dialing out digits.

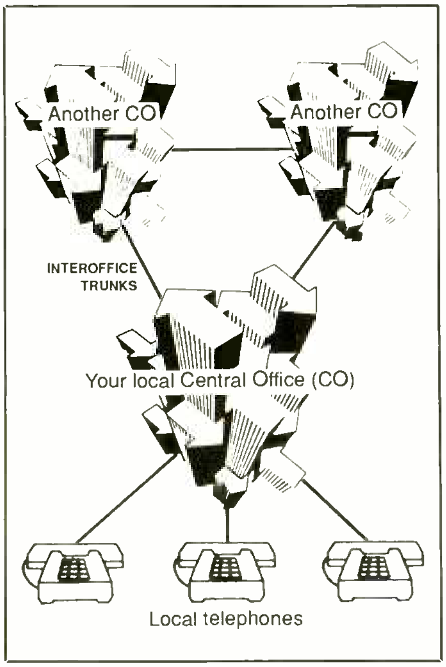


Fig. 7. All local phones connect to a Central Office, which is responsible for interconnecting instruments within its exchange area and connecting its local phones to other Central Offices for out-of-area calls.

Many modern multi-line telephone instruments now feature a "hold" function that makes it possible to have more than one line ring at the instrument. There will be additional keys on the instrument that permit selection of each individual line. Alongside or nearby will be the HOLD button.

The hold function is essentially a device that draws loop current to keep a line open but disconnects the network, dial, transmitter and receiver if you hang up. When a line is on hold, you can actually hang up or access another line to hold a conversation with another party.

When a HOLD button is pressed, a resistor is connected across the telephone line to draw current. At the same time, mechanical linkages cause the line in use to disconnect from the circuit. As long as the resistor is across the line, drawing current, the line from the Central Office will remain open and the instrument at the distant end will remain connected (assuming, of course, that it remains off-hook).

Installation

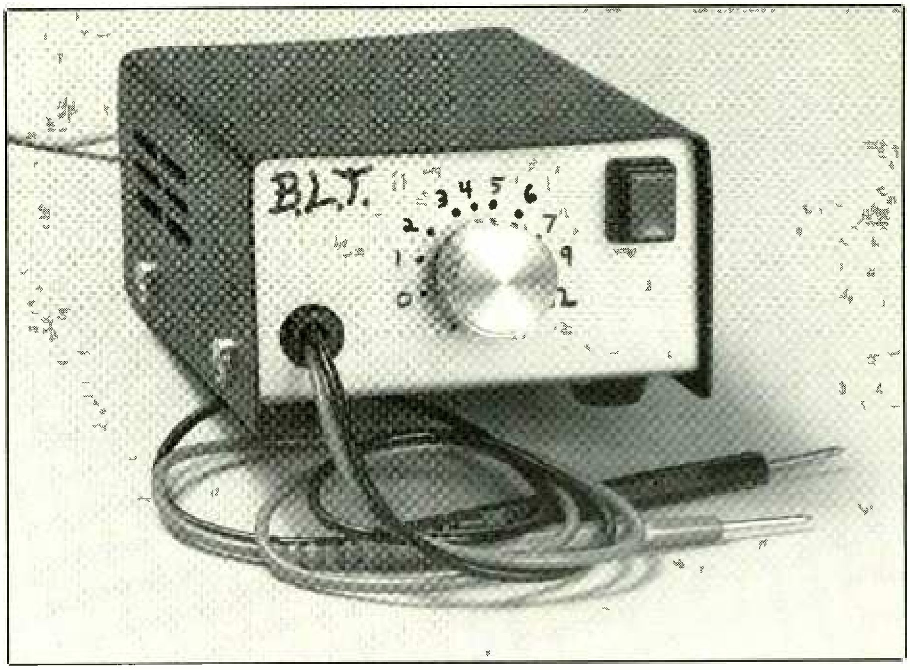
Installing a telephone instrument in a location where a jack does not exist is a fairly simple, straightforward procedure. To begin, you need an RJ11 or RJ14 modular-type jack. Many retailers, such as department, hardware and Radio Shack stores carry an assortment of jacks to suit just about any given installation requirement, as well as cables, connectors and tools for telephone installation work. Tools needed to do the job include a slotted-blade screwdriver, diagonal cutters, a staple gun to secure exposed cable, and a drill with a long bit if you need to run cables through walls or/and floors. You may also want to have handy a multimeter to

(Continued on page 78)

Bus-Line Tracer

Novel instrument speeds circuit troubleshooting by audibly indicating defective components along a bus line without disconnecting them

By David Miga, CET



Picture a scenario where you're working on a defective TV receiver that has only 6 volts on its 30-volt supply line and the supply is okay. Since the line reads only 8 ohms to ground when the set is turned off, some part is obviously partially shorted. No problem, you might think—until you realize that the line runs to more than 60 components!

There are a lot of ways to approach this troubleshooting problem. Most methods are very time consuming. Using a special instrument, the Bus-Line Tracer described here, however, allows you to locate the defect with amazing speed while the power is turned off. It does not require unsoldering a single device or even looking at a meter's indication. Instead, it beeps in increasingly higher sound pitches as you move a test probe to each successive component on the line. When the defective component is reached, whether it's the second one or the thirty-second one, the pitch suddenly increases, indicating that you've found the culprit.

The foregoing represents an actual experience I had while using the Tracer. The 32nd component turned out to be a leaky 47-microfarad capacitor. Double-checking by moving the probe to the next device, the beep was lower, while moving it back to the 47-μF capacitor caused the Tracer to beep at a significantly higher pitch. To verify that the capacitor was defective, I sprayed the component with a freeze spray while the Tracer beeped away. The pitch changed drastically and I knew that I had found the leaky "8-ohm" device—in about five minutes.

Think of the Tracer as an ohmmeter with a 15-ohm maximum scale, but with a resolution of just 5 milliohms, and a beeper instead of a meter scale and you'll understand what we've got here: a substitute for a very costly 5½ digit micro-ohmmeter. Whether the problem is caused by a shorted or leaky component or a solder bridge on a pc board's copper trace, the Tracer will pinpoint it for you.

Its parts, including case and test leads, all on a pc board measuring only 2½ × 3 inches, at a total cost of less than $80 plus your assembling efforts, is a welcome alternative to buying an instrument for a few thousand dollars or unsoldering components one by one along the bus line.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Bus Line Tracer, including its ac-operated power supply. In the power-supply circuit, the 117-volt ac line potential is transformed to 30 volts ac by power transformer *T1*. This lower voltage is converted to pulsating dc by bridge rectifier *RECT1*, after which it is smoothed to pure dc by filter capacitors *C1* and *C2*, respectively. Regulators *IC1*, *IC2* and *IC3* then convert the unregulated dc to +8, −8 ,and +5 volts (all referenced to the grounded center tap of *T1*) for distribution to the remainder of the circuitry as needed. Capacitors *C3*, *C4* and *C5* add stability to the regulator outputs.

Integrated circuit *IC4* is a dual operational amplifier in a single package. The first op amp in *IC4* is wired as a unity-gain precision adjustable voltage reference that supplies the negative input of the second on-chip op amp at pin 6 of *IC4*. This second op amp is wired to provide a voltage gain of 4,700 with the values specified for resistors *R1* and *R2*.

In operation, a precise +5 volts is delivered from *IC3* through *R3* to the red test probe and, hence, to the component under test. Depending on the resistance of the component under test, a potential of between 0 and +5 volts is placed across *R3*, This voltage is monitored by the second op amp in *IC4* through *R4*. A test potential of +5 volts was decided upon because it is great enough to force a stubborn solid-state junction into conduction and drive intermittent components but is still low enough to permit testing in digital equipment without inflicting damage.

The output from the second op amp in *IC4*, at pin 7, can be anywhere between −8 and +8 volts. This output voltage is passed through stabilizing resistor *R5* to the delta-voltage input at pin 5 of 555 timer *IC5*. The timer is configured as an astable multivibrator. The pin 5 output from *IC5* is also applied to the circuit made up of *D1*, *R6*, *Q1*, *R7* and *R8*. This circuit holds reset pin 4 of *IC5* low when the red test probe is not touching a cir-

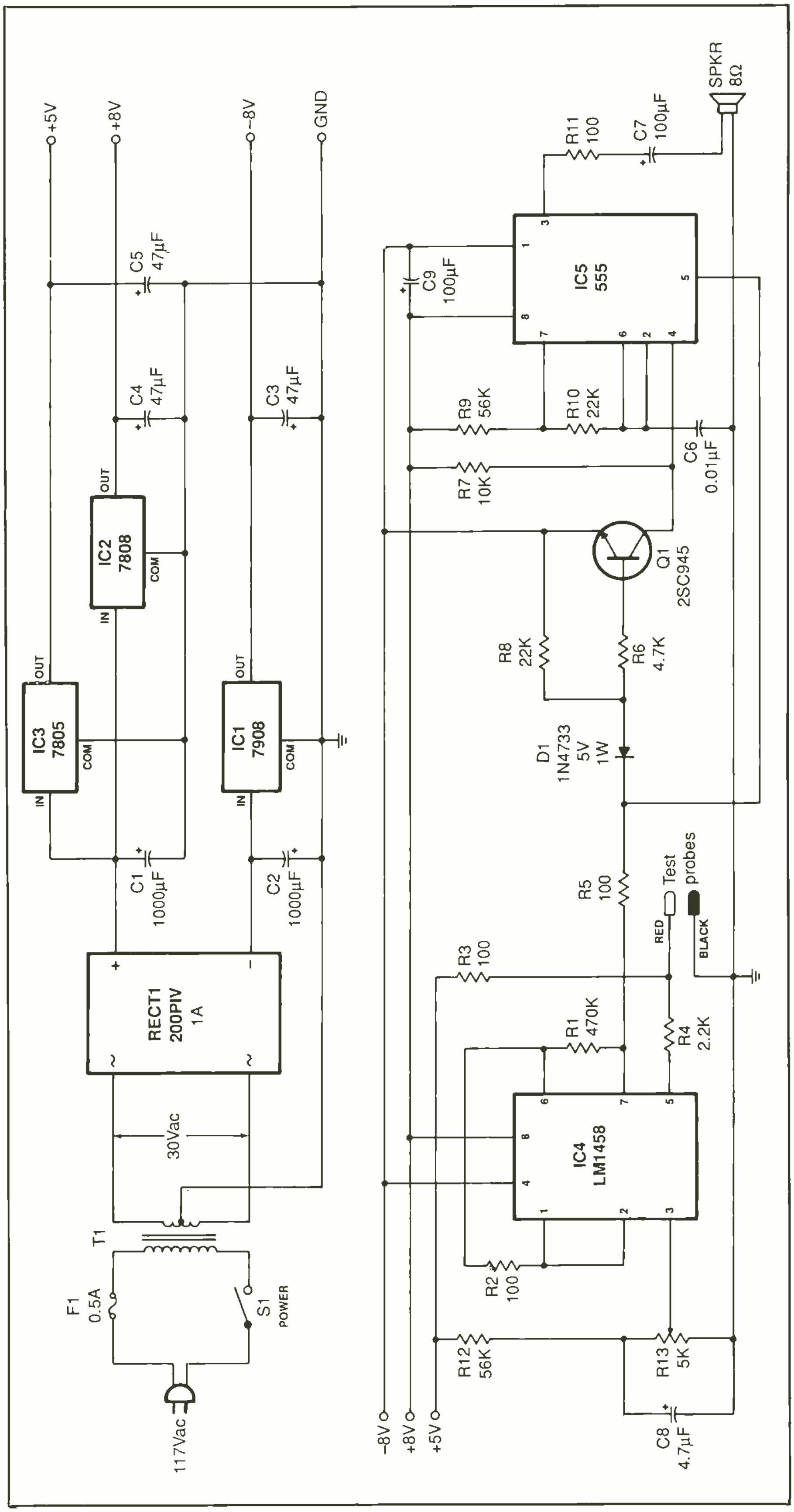


Fig. 1. Complete schematic diagram of the Bus Line Tracer, including its ac-operated power supply.

cuit or component under test. Hence, it serves as a muting system that prevents the project from sounding between measurements.

Oscillating frequency range of *IC5* depends on the values used for *C6*, *R9* and *R10*. With the values specified for these components, the project outputs a tone that is in the audible range between 1 kHz and 5 kHz. The specific frequency of the audio tone depends on the voltage applied to pin 5 of *IC5*. This audio tone, which is passed through limiting resistor *R11* and dc isolation capacitor *C7* to the speaker, is the only "indicator" this project uses.

PARTS LIST

Semiconductors
D1—1N4733 or similar 5-volt, 1-watt zener diode
IC1—7908 − 8-volt, 1-ampere voltage regulator
IC2—7808 + 8-volt, 1-ampere voltage regulator
IC3—7805 + 5-volt, 1-ampere voltage regulator
IC4—LM1458 or RC4558 dual operational amplifier
IC5—NE555N timer
Q1—2SC945 or ECG123A npn silicon transistor
RECT1—Philips ECG5304 or Mouser No. 33SC020 200-PIV, 1-ampere bridge rectifier

Capacitors
C1,C2—1,000-µF, 25-volt electrolytic
C3,C4,C5—47-µF, 16-volt electrolytic
C6—0.01-µF, 50-volt Mylar
C7,C9—100-µF, 25-volt electrolytic
C8—4.7-µF, 50-volt electrolytic

Resistors (¼-watt, 5% tolerance)
R1—470,000 ohms
R2,R5,R11—100 ohms
R4—2,200 ohms
R6—4,700 ohms
R7—10,000 ohms
R8,R10—22,000 ohms
R9,R12—56,000 ohms
R3—100 ohms, 3-watt metal-film
R13—5,000-ohm, linear-taper, panel-mount potentiometer

Miscellaneous
F1—500-milliampere pigtail fuse
S1—Spst slide or toggle switch
SPKR—8-ohm, 0.1-watt, 1.5″-diameter speaker (Panasonic No. 4P15SA or similar)
T1—30-volt, center-tapped, 1-ampere power transformer
Printed-circuit board; 3-lug terminal strip; suitable enclosure (Radio Shack Cat. No. 270-252A or similar; see text); ac line cord with plug; red- and black-coded test leads (Vanco TL-1 or similar; see text); large pointer-type control knob for R13; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Electronic Design Specialists, Inc., 951 SW 82 Ave., N. Lauderdale, Fl 33068: Kit of all components, test leads and pc board but not including enclosure and rubber grommets, No. EDS-68KIT, $59; No. EDS-68PCB single-sided printed-circuit board with layout, $15; No. 256861 30-volt, center-tapped power transformer, $12; Vanco TL-1 modified test-lead set, $5. Add $6 postage & insurance for kit, $4 for any individual component. Florida residents, please include 6% sales tax.

Construction

Since only low frequencies are used in this project, component layout is not overly critical, though use of a printed-circuit board on which to wire the circuit is highly recommended. What is important is the length and thickness of the wire used for the 5-volt run to *R3* and the red test probe. Wiring in this portion of the circuit should be selected to provide the least amount of resistance to assure maximum instrument accuracy.

If you wish, you can fabricate your own printed-circuit board, using the actual-size etching-and-drilling guide shown in Fig. 2. Alternatively, you can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List.

As shown in the Fig. 3 wiring diagram, all components except POWER switch *S1*, power transformer *T1*, fuse *F1*, potentiometer *R13* and miniature 8-ohm speaker *SPKR* mount directly on the pc board. As you wire the board, make certain that you properly orient the electrolytic capacitors, diodes, transistor and ICs before soldering any leads or pins to the copper pads on the bottom of the board.

After all on-board components have been mounted, install the two wire jumpers in the indicated locations. You can use bare solid hookup wire or cut-off resistor or capacitor leads for these jumpers. Now strip ¼ inch of insulation from both ends of five 4-inch lengths of hookup wire. If you use stranded hookup wire, tightly twist together the fine conductors at all wire ends and sparingly tin with solder. Then plug one end of these wires into the holes for POT, POT WIPER, +SPKR and two to GND. The other ends of these wires will be connected later, after the circuit-board assembly has been mounted inside its enclosure.

Extensive testing, using many kinds of test leads, has led this author to conclude that the best type to use has thick probes, like those on the Vanco TLB-1 test-lead set. The probes on these *must* have the tip filed flat for maximum surface contact area. The most important thing to remember for this project is that the lower the resistance of the test leads and probes, the more accurate will be your test results. Therefore, cut the test-lead cables to as short a length as you can manage, but do not leave them longer than 18 inches or so.

Snip off as much test lead length from the banana-plug ends of the cables. (Use of the usual banana plug/jack arrangement is *not* recommended in this project because the small amount of resistance they normally introduce in the test lines will result in large inaccuracies in test re-

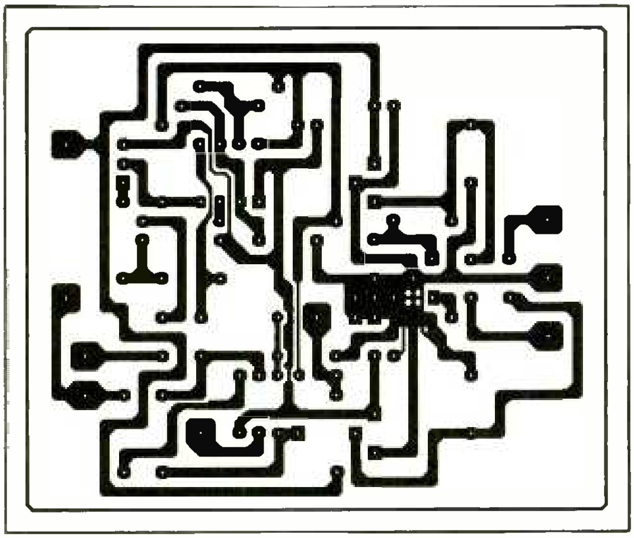


Fig. 2. Actual-size etching-and-drilling guide to use when fabricating your own printed-circuit board.

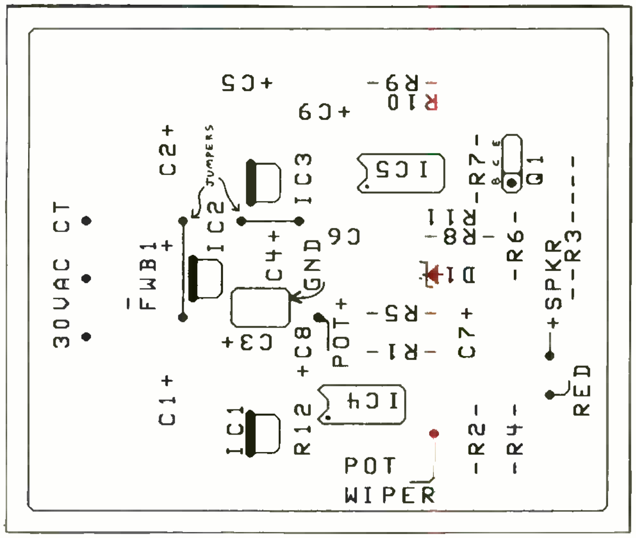


Fig. 3. Wiring diagram for printed-circuit board. Note the two wire jumpers that must be installed.

sults.) After removing the banana plugs, strip ¼ inch of insulation from both test-lead cable ends, tightly twist together the fine conductors and tin with solder. Do the same for the raw end of the line-cord cable.

You can house the project in any type of enclosure that will comfortably accommodate the circuit-board assembly and all off-the-board components and has adequate front-panel space for mounting the switch and potentiometer and rear-panel space for mounting a three-lug terminal strip (no lugs grounded) on it where they will not physically or electrically interfere with the rest of the circuitry.

Use of the Radio Shack project box specified in the Parts List will minimize your machining task because it comes with adequate slots in it to permit the sound from the speaker to escape. If you use a different enclosure, cut slots or drill extra holes for the speaker's sound to escape, in addition to drilling the mounting holes for the circuit-board assembly, off-the-board components and terminal strip, and to permit the test leads and ac line cord to enter it.

After machining is done, deburr all holes and line the ones through which the line cord and test lead cables are to pass with small rubber grommets. Tie a strain-relieving knot in the line cord and test-lead cable pair about 4 inches from the prepared ends inside the enclosure.

Plug the secondary wires of *T1* into the holes labeled 30VAC and CT and solder into place. Also, solder the free end of the red test lead into the hole labeled RED and the free end of the black test lead into one of the holes labeled GND. Then use ¼-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers to mount the circuit-board assembly into place inside the enclosure. Then mount the power transformer, switch, fuse block, potentiometer and speaker in their respective locations.

Locate the wire coming from the hole labeled R13 WIPER and crimp and solder its free end to the center lug on the potentiometer. Then crimp and solder the free end of one GND wire to the right lug, viewed from the rear, of the pot and the R13 wire to the left lug. Next, crimp and solder the ends of the wires coming from the +SPKR and GND holes to the appropriate lugs on the speaker.

Wire the primary side of the power transformer as follows. First, bend the leads of the pigtail fuse as needed and crimp them to the end lugs on the terminal strip. Crimp one line-cord lead to the nearer-end lug and solder the double connection. Crimp one transformer primary lead to the other end lug and solder the double connection. Next, cut a length of stranded hookup wire to as long as needed to bridge from the center lug on the terminal strip and the other lug on the switch. Strip ¼ inch of insulation from both ends of this wire, tightly twist together the fine wires and tin with solder. Crimp and solder one end of this wire to the unoccupied switch lug and the other end of this wire and the remaining power transformer primary lead to the center lug of the terminal strip.

Calibration & Use

When the project is fully assembled, slide onto the potentiometer's shaft a large pointer-type control knob. Plug its line cord into an ac receptacle. Set the POWER switch to on and the potentiometer to mid-rotation. Firmly press the black and red test probes against a pc-board's copper trace with about 1 inch of separation between the two probe points and hold for about 5 seconds. Remove the probes from the copper trace and use a finger to touch each of the regulators in turn and note if any is operating hot. If any is, this is a sign that something is wrong with your wiring.

None of the voltage regulators in this project is heat-sinked for the simple reason that the circuit draws very little current until the test probes are applied to a component under test. Even then, current flow through the test probes into the circuit under test is limited to 50 milliamperes. So if any regulator operates hot, power down the project and carefully check it over for incorrectly installed components, poor soldering or an inadvertent solder bridge between copper pads and traces on the pc board. Reflow the solder on any suspicious connection and use solder wick or a vacuum-type solder sucker to remove shorting bridges. Do not use the Bus Line Tracer until you have corrected any problem. When the project is ready to use, assemble its enclosure.

To calibrate the potentiometer with legends that indicate resistance on a leaky bus, you need resistors in 1-ohm increments starting with 1 ohm and ending with 10 ohms. With power applied to the project, simply measure each resistor with the test probes and make a mark on the front panel at the position for each at which you hear a "beep" in the middle of the project's audio-frequency range.

When you are finished measuring resistances, power down the project and remove the knob from the potentiometer's shaft. Use a dry-transfer lettering kit to label each marked location with the resistance value measured. Seal the potentiometer's shaft and the switch with masking tape. Then spray two or three *light* coats of clear acrylic over the lettering to protect it from scratching when you use the project. Allow each coat to dry before spraying on the next.

When the acrylic spray has completely dried, remove the masking tape from the pot's shaft and switch. Then replace the knob on the potentiometer's shaft.

To use the Bus Line Tracer to make actual measurements, connect the black test probe firmly to the main circuit ground of the equipment under test. The best way to do this is to actually solder the probe tip to circuit ground to assure a perfect ground connection. (This will also allow you to free one hand to adjust the potentiometer on the project.)

Firmly press the red probe tip to any copper trace on the printed-circuit board to which any component under suspicion is soldered. Then adjust the potentiometer's setting for an audio-tone pitch midway in the project's audio-frequency range to calibrate the project to whatever reference bus-line resistance to ground.

Instead of being limited to finding only full short circuits, the Bus Line Tracer can be adjusted to any resistance in the range from 0 to 15 ohms. By doing this, the only difference between readings can only be the copper trace on the pc board under test. The resistance of a ⅛-inch-wide copper trace being about 10 milliohms per inch, the Bus Line Tracer can find a leaky component that is only ½ inch away from a good component soldered to the same trace bus run. If a copper trace is much narrower than ⅛ inch, as is the case with many computer pc assemblies, accuracy of the project is increased because the trace has more resistance per unit of length.

The range of reference potentiometer *R13* in Fig. 1 is limited to 15 ohms by the 47,000-ohm value chosen for *R12*. You can change the value of *R12* if you prefer a different range. For example, a 56,000-ohm value limits the range to only 10 ohms. Be advised that the circuit becomes increasingly more sensitive and, thus, more difficult to adjust as the resistance of the component under test increases as it heats up. Actually, though, this heat-up effect can be used to advantage. If the red test probe is soldered to the bus line and the reference is adjusted accordingly, a can of freeze spray can be used to cool each suspected component. The one that causes a dramatic change in the pitch of the Tracer's audio tone is the defective one in this case.

The Bus Line Tracer is not the kind of test instrument you reach for as often as you would your DMM. However, when you do need it, you will discover that no other instrument will suffice. With this project, you can zip through dozens of component tests along a bus line in a small fraction of the time it would take you to accomplish the same with traditional test equipment. **ME**

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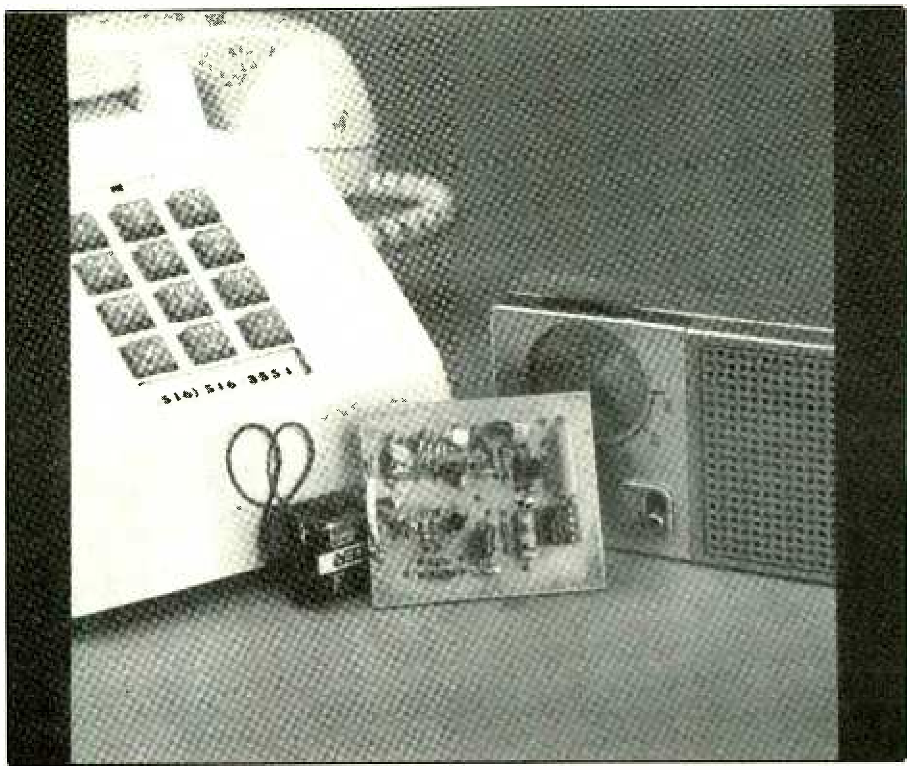
A Wireless Remote Telephone Ringer

This "poor man's cordless telephone" works with an FM radio to remotely signal when your wired telephone rings

By Anthony J. Caristi



A cordless telephone is a useful consumer-electronic de-device. Though it lets you originate calls, its major benefit is in alerting you to incoming calls when you are not near enough to a wired phone to hear it ring. If the alert feature is all you really need, the Wireless Remote Telephone Ringer presented will do the job inexpensively, though you will have to get to a wired telephone to answer the call.

This Wireless Ringer is easy to build because the "receiver" section already exists. It is an ordinary portable FM radio that can be picked up for $10 or less. Only one radio is needed in any given installation, but because this is an r-f transmitter project, any number of radios can be used if more than one person wants to listen for an incoming-call signal from different remote locations. Transmitter power from the Ringer is low enough so that the project will not interfere with your neighbors' FM reception.

Totally automatic in operation, this project does not even require a power switch, though you can include one to permit you to turn it off when it will not be used for weeks or months at a time.

About the Circuit

Referring to the schematic diagram in Fig. 1, the cordless telephone transmitter consists of telephone ring-signal detector *IC1*, which is followed by a two-stage transmitter consisting of *Q2* and *Q3* that operates on the 88-to-108-MHz FM broadcast band. The transmitter's carrier frequency is modulated by unijunction-transistor oscillator *Q1*, whose operating frequency is set at about 2 kHz.

Power for the transmitter and audio oscillator is provided by 9-volt transistor battery *B1*. This battery is automatically switched through to the project's circuits to deliver current only in the presence of the ring signal that announces an incoming call. Current demand from the battery is very modest. Because of the automatic power-up feature, useful battery life should therefore be extremely long.

Transistor *Q2* and its associated components make up a traditional grounded-base Colpitts oscillator whose frequency of oscillation is de-

PARTS LIST

Semiconductors

D1,D2—1N4148 or similar silicon switching diode
IC1—TCM1520AP ring-signal detector (Texas Instruments)
Q1—2N2646 unijunction transistor
Q2,Q3—2N5179 npn r-f silicon transistor
Q4—2N6659 n-channel enhancement-mode field-effect transistor
Q5—2N2907 pnp silicon switching transistor

Capacitors (50 WV or greater)

C1—6,800-pF ceramic or Mylar
C2,C10—0.1-μF ceramic disc
C3,C11—0.001-μF ceramic disc
C4—22-pF NPO ceramic disc
C5—47-pF NPO ceramic disc
C6—0.33-μF, 250-volt Mylar
C7—10-μF electrolytic
C8—0.47-μF ceramic disc
C9—10-pF NPO ceramic disc

Resistors (¼-watt, 10% tolerance)

R1—68,000 ohms
R2—150 ohms
R3,R5—47,000 ohms
R4,R6—1,000 ohms
R7—10,000 ohms
R8—2,200 ohms
R9—100,000 ohms
R10—4,700 ohms
R11—1 megohm

Miscellaneous

B1—9-volt transistor battery
L1—Inductor (hand-wound—see text)
S1—Spst normally-open, momentary-action pushbutton switch
S2—Spst slide or toggle switch (optional—see text)
Printed-circuit board (see text); suitable metal enclosure (see text); 12" to 18" telescoping portable-radio antenna; socket for IC1; snap connector and holder clip for 9-volt battery; small rubber grommet; heavy-gauge magnet wire for L1; ¼" or ½" metal spacers; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Ready-to-wire pc board, $9.95; 2N2646 UJT, $2.95; 2N5179 r-f transistor, $3.75 each; 2N6659 FET, $2.95; 2N2907 switching transistor, $1.50; TCM1520AP ring detector IC, $4.95; 0.33-$\mu$F Mylar capacitor, $1.00; and set of three NPO ceramic capacitors, $2.00. Add $1.50 P&H per order. New Jersey residents, please add state sales tax.

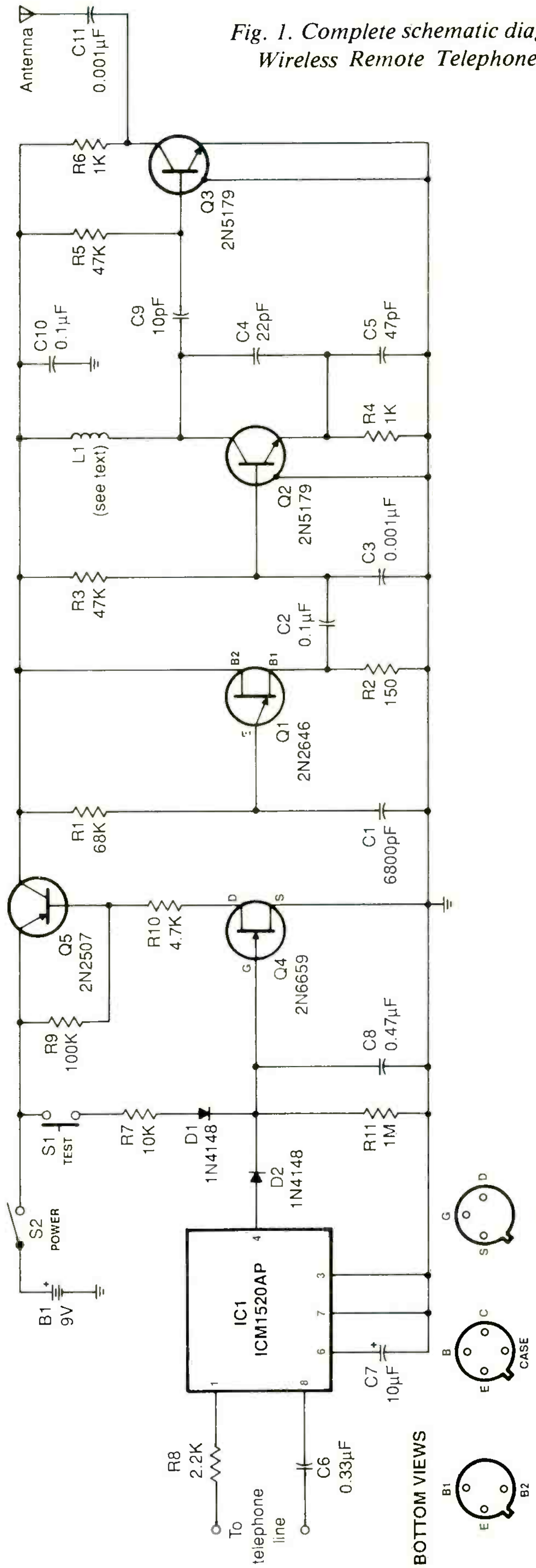


Fig. 1. Complete schematic diagram of the Wireless Remote Telephone Ringer.

termined by the values of *L1*, *C4* and *C5*. To meet the criteria to sustain oscillation, it is necessary that the base and collector of the transistor be connected to opposite ends of an LC tank circuit, with the transistor's emitter connected somewhere between these two points. In the Fig. 1 circuit, this is accomplished by placing the base of *Q2* at r-f ground potential by means of *C3* and the emitter about one-third the way up from ground, which is accomplished through the voltage-divider action of *C4* and *C5*.

A traditional Colpitts oscillator has two capacitors connected in series with each other to form the voltage divider needed in an oscillator circuit of this type. Contrast this to the Hartley oscillator, which is similar in design to the Colpitts oscillator except that a tapped inductor is used to provide voltage division. Transistor *Q2* is forward-biased by *R3* to sustain oscillation when power is applied to the circuit.

Unijunction transistor *Q1* is connected into the circuit to form a free-running relaxation oscillator. When 9-volt dc power is applied to the circuit, *C1* charges up at a rate determined by the RC time constant of *R1* and *C1*. When the potential across *C1* reaches about 50 percent of the supply voltage, *Q1* suddenly conducts and dumps most of the charge on *C1* into *R2*.

Now partially discharged, *C1* once again begins to charge, as it did initially, until *Q1* breaks into conduction and dumps the charge into *R2*. This charge/discharge action repeats at a rate of about 2,000 times per second for as long as power is applied to the circuit.

When *Q1* conducts, a voltage spike appears across *R2* as a result of the discharge action of *C1*. This voltage is capacitively coupled, via *C2*, to the base of *Q2* and causes a very slight variation in this transistor's operating current at the 2-kHz audio-frequency rate at which *Q1*

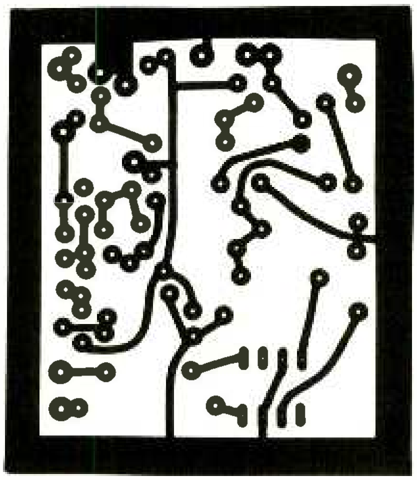


Fig. 2. Actual-size etching-and-drilling guide for bottom of printed-circuit board needed for this project.

is operating. As a result, the frequency of operation of *Q2* is modulated so that its output signal, amplified by *Q3* and radiated by the antenna, can be detected by the discriminator circuit in any FM radio or receiver that is within range and is tuned to the project's carrier frequency. When this signal is detected, the FM radio will produce a pulsed 2-kHz tone to

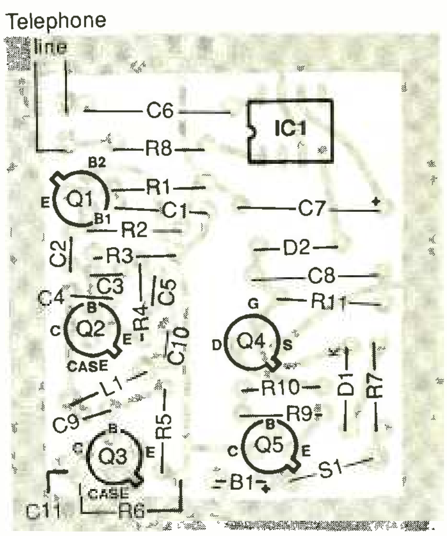


Fig. 3. Copper on top surface of board serves as r-f ground plane for circuit board. Holes indicated by solid black dots are to be cleared of copper as described in text.

inform you that your telephone is ringing.

Integrated circuit *IC1* is a special device that has been specifically designed as a telephone ring-signal detector to respond to the pulses on the telephone line to which it is connected. Contained inside this chip are a bridge rectifier, 5-volt regulator and transient suppression circuits that prevent damage to the IC and false operation in the event of a random voltage spike on the telephone line.

During standby, *IC1* presents a high impedance to the telephone line and does not affect either outgoing or incoming calls. However, when the 90-volt, 20-Hz ring signal appears across the line to announce an incoming call, the energy of the incoming signal is stored in *C7* and the on-chip voltage-regulator circuit produces + 5 volts dc at output pin 4. This regulated voltage is then fed to the gate of enhancement-mode n-channel field-effect transistor *Q4*.

Transistors *Q4* and *Q5* and their associated circuitry make up an automatic electronic switch that permits current from *B1* to flow to the rest of the project's circuitry only in the presence of the telephone ring signal. At all other times, the switch is "open" and disconnects the battery from the circuit.

Battery voltage is fed to the emitter of *Q5*, which cannot conduct current until its base if forward-biased. During standby, *Q4*'s gate-to-source voltage is zero because *IC1* is idle and, thus, is delivering no voltage to the circuit. The drain-to-source resistance of *Q4* is essentially infinite under this condition, so no base or collector current flows through *Q5*.

When *Q4* is switched on by the voltage that appears at its gate in response to the ring signal, this transistor's drain-to-source resistance becomes almost zero, allowing base current to flow out of *Q5* and causing this transistor to saturate. This places almost the full battery voltage on the collector of Q5 and allows the transmitter to operate.

Since the time constant of C8 and R11 is relatively short, Q4 operates only during each 2-second burst of ring-signal energy produced by telephone company equipment. This produces a sound in the portable FM radio that is similar in cadence to the normal telephone ring signal.

To verify that the circuit is operating, normally-open TEST pushbutton switch S1 has been included in the transmitter. When closed, this switch applies forward-bias to Q4 without the need for the ring signal to be present. Pressing S1 verifies the operating condition of the transmitter by allowing you to listen for the 2-kHz tone (this time continuous as long as S1 is closed) in the FM radio being used as the system's receiver.

Construction

Since this project operates in the vhf radio range, it is important that you adhere to certain construction techniques to obtain proper operation. Printed-circuit-board wiring, therefore, is mandatory. Furthermore, this pc board must be copper clad on *both* sides. One side has no copper removed from it during the etching process (except for small areas, which will be discussed presently), while the other is etched to remove all copper from it except as needed for interconnecting conductors. The solid-copper side of the board serves as both an r-f ground plane and circuit common to which all grounded component leads are to be soldered.

You can fabricate your own printed-circuit board using the actual-size etching-and-drilling guide given in Fig. 2. Alternatively, you can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List.

If you fabricate your own board, be sure to first coat one entire side with etch resist or mask it with tape to prevent the etchant from eating away any copper. After etching the board to bring out the required copper-trace pattern, remove the etch resist (or tape) from both sides of it. Then, referring to Fig. 2, drill *all* component-lead holes, as indicated by the solder pad centers.

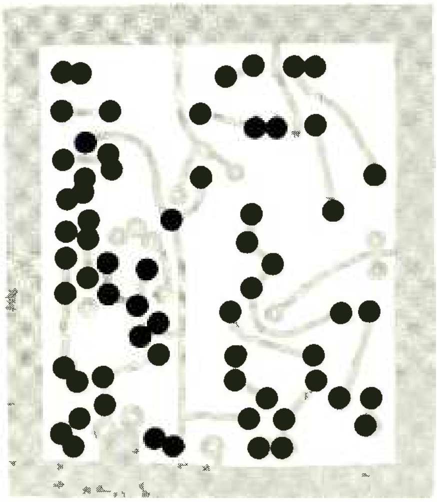


Fig. 4. Wiring diagram for pc board.

Though you do not etch the top (ground-plane) side of the board, you must still clear copper from around all holes through which component leads must pass and are *not* to connect to the ground plane. These holes are indicated by the heavy solid-black dots in Fig. 3.

Use about a 3/16-inch drill bit to remove about a 1/8-inch-diameter circle of copper around each indicated hole. After placing the bit in the hole, gently rotate it *by hand* to clear away the copper. Do *not* use a power or pin drill for this operation; the danger of accidentally drilling clear through and ruining the board is too great. Instead, use a very sharp, preferably new, bit. The sharper the bit, the faster and easier will be the manual drilling task.

Bear in mind that the holes into which component leads that are to be grounded must *not* be cleared of copper. Otherwise, it will be difficult, if not impossible, to solder these leads to the copper on the top of the board.

When the board is ready to be populated, refer to Fig. 4. Start populating it by plugging the leads of the resistors into the indicated holes and soldering them into place. (Note: All components mount on the ground-plane side of the board.) Next, install and solder into place the capacitors and diodes, taking care to properly orient the latter. Then install the transistors in their respective locations, referring to Fig. 1 for lead identifications. Remember that just one orientation-sensitive component incorrectly installed on the board will render the circuit inoperative and may even result in damage to itself or/and nearby components.

It is important that you use the specified components for C4, C5, C6, Q2 and Q3. The transistors are rated for high-frequency amplifier applications, as in this project, and the capacitors are temperature-stable to maintain stable operating frequency.

Note that Q2 and Q3 have four leads: one each for emitter, base, collector and case. The case lead must be soldered to the ground plane on the board to provide an r-f shield for the transistor in both cases. All transistor grounded leads and grounded leads of the other components shown in Fig. 1, except for IC1 as noted below, must be soldered to the copper on *both* sides of the board.

Use a socket for IC1. It will not be necessary to solder grounded pins 3 and 7 to the top-of-the-board ground plane. These two pins will automatically be grounded through the copper paths on the bottom of the board after soldering the socket into place. Be sure, however, that all holes for the socket, except those for pins 3 and 7, are cleared of copper on the top surface.

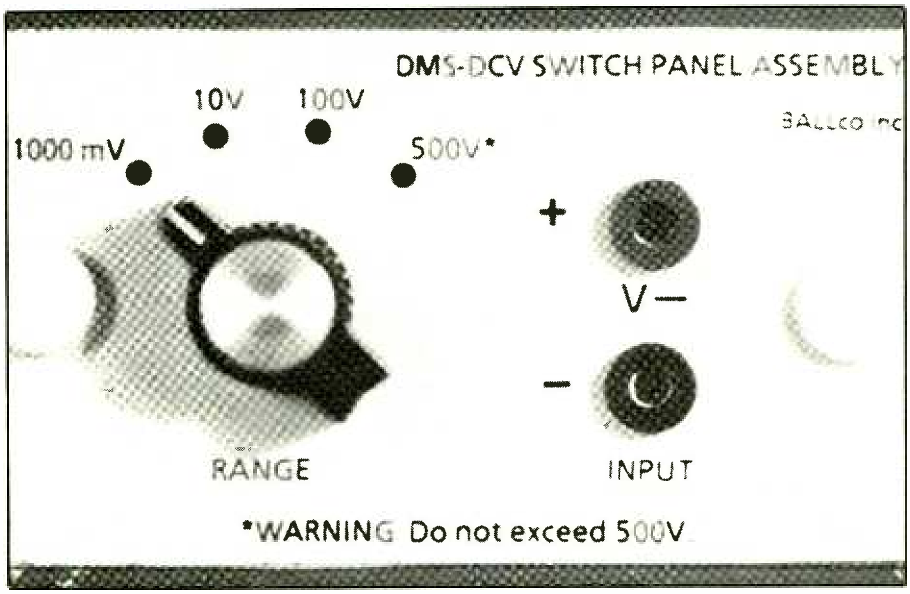
Though you must hand-wind inductor L1, the procedure for doing so is very simple. Start with a length of solid bare hookup wire or enamel-coated magnet wire. If the latter, use fairly heavy wire so that it readily holds its shape without having to use a coilform and scrape away the ena-

(Continued on page 80)

DigiVolt DC Accessory

This accessory module adds multi-range dc-voltage measuring capability to the Digital Measuring System

By C.R. Ball Jr.



The Digital Measuring System (DMS) whose basic module was introduced in the August 1986 issue of *Modern Electronics* is basically a single fixed-range dc voltmeter. So far, we've adapted the basic module for use as a tachometer (September 1986) and an ohmmeter (February 1988). Now we'll get back to basics by showing you how to use the DMS to measure dc voltages with the DigiVolt-DC module that provides a choice among four ranges. With this module, the DMS can measure up to 999 millivolts, 9.99 volts, 99.9 volts and 999 volts full-scale.

Our DigiVolt-DC offers the option of using the DMS as a single-range (your choice among the four possibilities) panel meter or, with an optional switching module, a four-range digital voltmeter (DVM). Before getting into the theory of operation and construction of the DigiVolt-dc, however, let's briefly compare analog and digital panel meters, their make-up and the way they are specified to gain a perspective on dc-voltage measuring in general.

Analog & Digital Panel Meters

Analog voltmeters are actually *current-measuring* ammeters that have been set up and calibrated to indicate voltages, with series resistors used to permit higher voltages to be displayed. A pictorial representation of a typical analog dc voltmeter is shown in Fig. 1(a).

Because the meter presents a parallel path across whatever circuit or component is being measured, it thus affects the value of the reading taken. Therefore, the more sensitive the milliammeter used as the voltmeter's indicator, the greater the allowable value of series resistance and, consequently, the less the loading on the circuit being measured.

Typical high-quality multimeters use movements rated at 10 or 1 microampere full-scale (FS), providing 100,000- or 1M-ohm/volt sensitivity. Analog panel meters may have sensitivities as low as 100 ohms/volt, but these are usually permanently connected into circuits where loading is nulled out in calibration.

A digital panel meter (DPM), shown pictorially in Fig. 1(b), is not handicapped by being a current-measuring device and, thus, presents a negligible load to the measured circuit, which is typically 10 to 100 megohms. The higher input resistance of a digital meter, however, makes DVMs inherently more sensitive to noise. The higher the input resistance, the more susceptible to noise the DVM, particularly when measuring low-level voltages.

Amplified dc voltmeters, as shown in Fig. 1(c), such as VTVMs, FET-VOMs, etc., behave much as digital meters with respect to noise and circuit loading, although they're not quite as susceptible to noise. These meters, though, have a less accurate analog display.

Whether analog or digital, all meters present some loading on the circuit under test. This loading is specified in different ways for analog and digital meters. Because they are really current-measuring devices, the loading of analog meters is specified

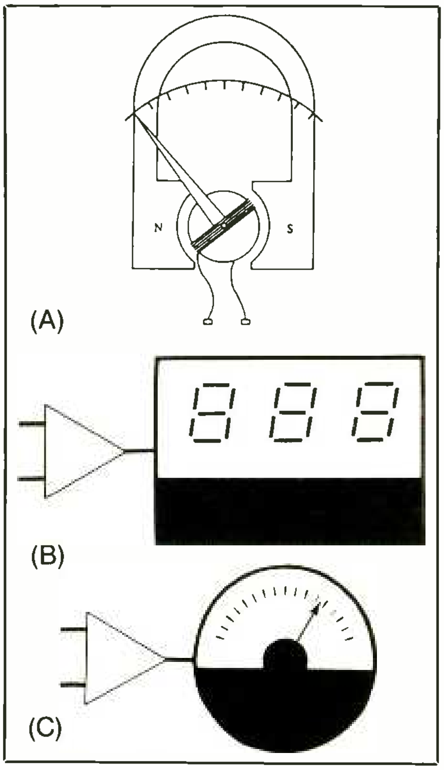


Fig. 1. Representations of a basic analog meter movement (a); basic digital meter (b); and basic amplified analog meter (c).

in terms of ohms/volt. That is, input sensitivity changes according to the magnitude of the applied voltage. For example, a VOM rated at 10,000 ohms/volt on the 10-volt range would present a 100,000-ohm shunt resistance (10,000 ohms × 10 volts) across the measured circuit. Digital and amplified analog meters, on the other hand, specify loading in terms of a specific input resistance, such as 10 megohms, regardless of the range being used.

All meters have a basic sensitivity, or the lowest value that the movement or A/D converter can accurately convert to a usable indication. Analog meters that are not amplified have sensitivity specified in full-scale volts, although they are actually current-measuring devices.

Digital and amplified analog meter sensitivity is also specified in volts (or millivolts) full-scale. The basic sensitivity of the original DMS module is 999 millivolts (roughly 1 volt) full-scale. Therefore, it can measure from −99 to +999 millivolts directly, without the need for scaling. Measurement of other voltages, however, requires either amplification or attenuation of the input voltage to fit within the basic −99- to +999-millivolt basic range.

Because the DMS has a 1-millivolt resolution, which is adequate for the great majority of applications, amplification will not be discussed here.

Another important factor is resolution, which is the smallest increment of the measured parameter that can be accurately discerned. On analog meters not equipped with an anti-parallax mirrored scale, one scale division is generally the closest that can be accurately read. On DPMs, such as the DMS, a 1-millivolt resolution is possible because the display reads out directly on an unambiguous numeric display that needs no interpolation.

Input Scaling Circuit Considerations

For the DMS to display potentials greater than +999 millivolts, some sort of attenuation is required. The easiest way to achieve this is with resistive input scaling, using the common voltage-divider network. Typical single- and multiple-range scaling networks are detailed in Fig. 2.

The important considerations to take into account when designing a scaling network are: loading on the circuit in which a measurement is made, accuracy of the reading and the instrument's susceptibility to noise.

Circuit loading is caused by a shunt current flowing through the measuring device. For most applications, loading is usually not a problem because the input resistance of the measuring instrument generally exceeds 80 megohms. Because this higher input resistance is very sensitive to static charges and electrical noise, scaling networks are usually used to make the input more manageable and to provide the required measurement range, though at a penalty of added circuit loading.

To better understand the effect of loading on the circuit under test and on measuring accuracy, consider the simple divider network shown in (a) in Fig. 3. Here, the voltage from point X to ground can be calculated using Kirchoff's Law to be 10 volts. Measuring the voltage between point X and ground in (b) results in a parallel shunt path of 10,000 ohms (1,000 ohms/volt). Using the parallel-resistance formula $R_{eff} = (R1 \times R2)/(R1 + R2)$, we find that the effective resistance from point X to ground is 5,000 ohms, resulting in an actual and displayed potential of 5.26 volts, or an error of approximately 50 percent. This would be true even if the meter is accurate to within 0.1 percent.

Now let's measure the voltage be-

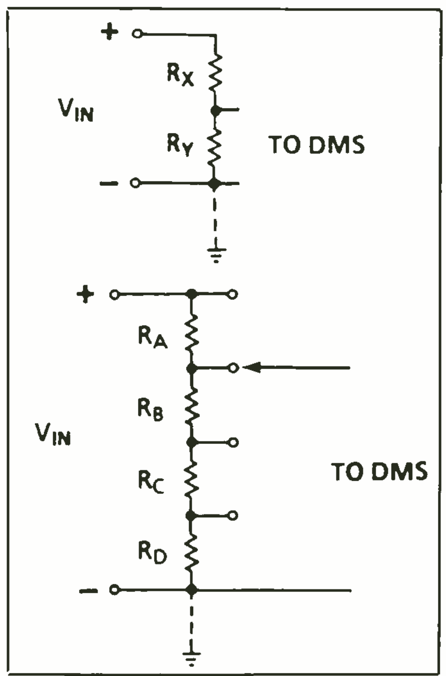


Fig. 2. Single multi-range resistive divider networks for input scaling.

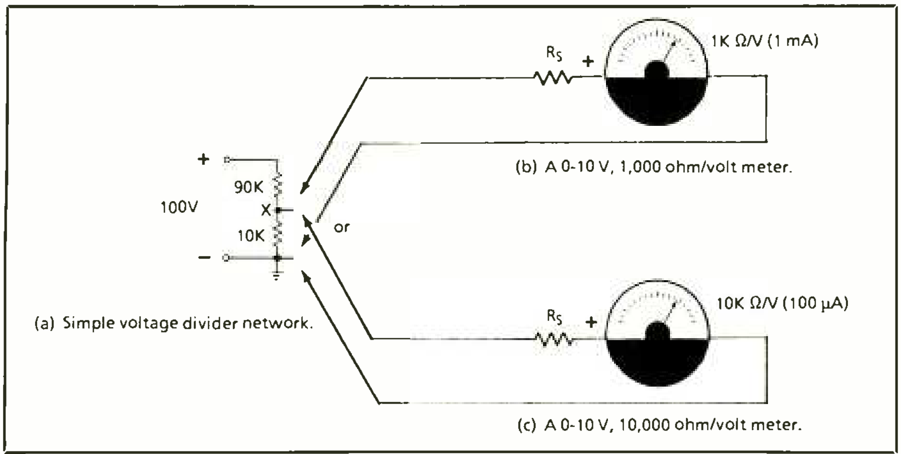


Fig. 3. Simple divider network and meter circuit illustrate circuit loading effects.

tween the same points using a meter with a more sensitive movement, this time 10,000 ohms/volt, as in (c) in Fig. 3. Using the parallel-resistance formula, the effective resistance is now 9,090 ohms, which results in an actual and displayed potential of 9.17 volts, for an error of about 10 percent. This 10-percent error might be acceptable as long as the loading does not adversely affect circuit performance and you are aware that you are not measuring the actual voltage.

If you measured the voltage from point X to ground with the DMS, using a 10-megohm scaling network, the reading would be 9.99 volts, for a loading error of 0.1 percent. As you can see, then, the lower the input resistance of the meter, the greater the circuit-loading effect on both reading and circuit parameters. You might think the effects of loading are exaggerated, but in a MOSFET circuit, *any* loading whatsoever is usually too much!

Since loading is such an important factor in circuit performance, as well as in measurement accuracy, it would appear that the higher the input resistance of the measuring instrument the better. High input resistances, however, are susceptible to noise. So for electrically noisy locations, the tendency is toward lower input resistance to obtain greater signal-to-noise ratios (S/Ns). The tradeoff is that input resistance should be high enough to provide the desired accuracy and still reject "ambient" noise.

Small values of capacitance placed directly across the input of the meter often reduce noise, particularly at radio frequencies. A good rule of thumb is to have an input resistance that is 10 times the highest circuit resistance across which the meter will be connected. This is usually 10 megohms. Input resistances much greater than 10 megohms are usually impractical in general-purpose meters, though they can be found in laboratory instruments.

The 10-megohm scaling network represents a good tradeoff between noise immunity and circuit loading. For very noisy locations, consider a 1M-, 100K, or even 10K-ohm scaling network and an appropriate capacitor. Tables I and II detail scaling resistor values for various input resistances for both fixed and selectable ranges. Suggested values of capacitance are also included for situations where noise might be a problem.

Final accuracy of a scaling circuit depends on several factors, such as the accuracy of the resistance values in the scaling network and the basic accuracy of the DMS itself. Since the latter is 0.1 percent ± 1 count, use of 1-percent resistors (available from Digi-Key among others) will usually provide an instrument with an overall accuracy that's better than 3 percent. However, to fully utilize the inherent accuracy of the DMS, 0.1-

Table 1. Input Impedance vs. Scaling Resistors for Fixed Range

Z_{IN} / V_{FS}		1K	10K	100K	1M	10M
1 V	R_X = R_Y =	0 1K	0 10K	0 100K	0 1M	0 10M
10 V	R_X = R_Y =	900Ω 100Ω	9K 1K	90K 10K	900K 100K	9M 1M
100 V	R_X = R_Y =	990Ω† 10Ω	9.9K† 100Ω	99K 1K	990K 10K	9.9M 100K
1000 V*	R_X = R_Y =	††	††	99.9K† 100Ω	999K† 1K	9.99M 1M
C **		0.2 μF	0.2 μF	0.1 μF	0.1 μF	0.01 μF

* For measurements above 500 volts, divider resistors should be mounted external to the DMS because of circuit board clearance.
** Filter values for use in noisy locations.
† Power resistors must be used.
†† Not recommended due to excessive power dissipation.

PARTS LIST

Semiconductors
CR1,CR2—1N4735 zener diode
CR3—1N4148 or 1N914 switching diode
Q1—2N2222 npn silicon transistor

Capacitors (25 WV)
C1—0.1-µF ceramic disc
C2—220-µF electrolytic

Resistors ¼-watt)
R1—90 megohms, 1% metal-film (see text)
R2—900,000 ohms, 1% metal-film (see text)
R3—90,000 ohms, 1% metal-film (see text)
R4—10,000 ohms, 1% metal film (see text)
R5—10 ohms, 5%
R6—4,700 ohms, 5%
R7,R8—56 ohms, 5%

Miscellaneous
S1 thru S4—Screw switch (see text)
S5—8-position DIP switch (optional; see text)
S21—Dual 4-position nonshorting rotary switch (optional—see text)
Printed-circuit boards; male headers (AP Products No. 929834-04); 8-, 14- or 16-pin IC socket and matching ribbon cable with plug (optional; see text); 7805 +5-volt regulator and 0.1-µF disc capacitor (optional; see text); suitable enclosure (see text); sheet Plexiglas or Lexan and red filter for front panels (see text); machine hardware; hookup wire; solder; etc.

Note: The following are available from BALLco, Inc., P.O. Box 1022, Snellville, GA 30278-1022: Etched, drilled, plated and silk-screened main pc board, No. 861-005, $10.95; complete kit of parts for DigiVolt-DC subassembly, including headers, terminal boards and DIP switch but not enclosure front panel, voltage regulator and components for switching subassembly, No. DMS-DCV-K, $19.95 plus $2.50 P&H; LED board kit, including boards, LEDs and ribbon cables No. 651-032, $7.95; front-panel kit, including Lexan, inlay, filter and hardware, No. 651-001, $8.85; switch panel assembly, including Lexan, inlay and hardware, No. 651-033, $8.85. Georgia residents, please add state sales tax.

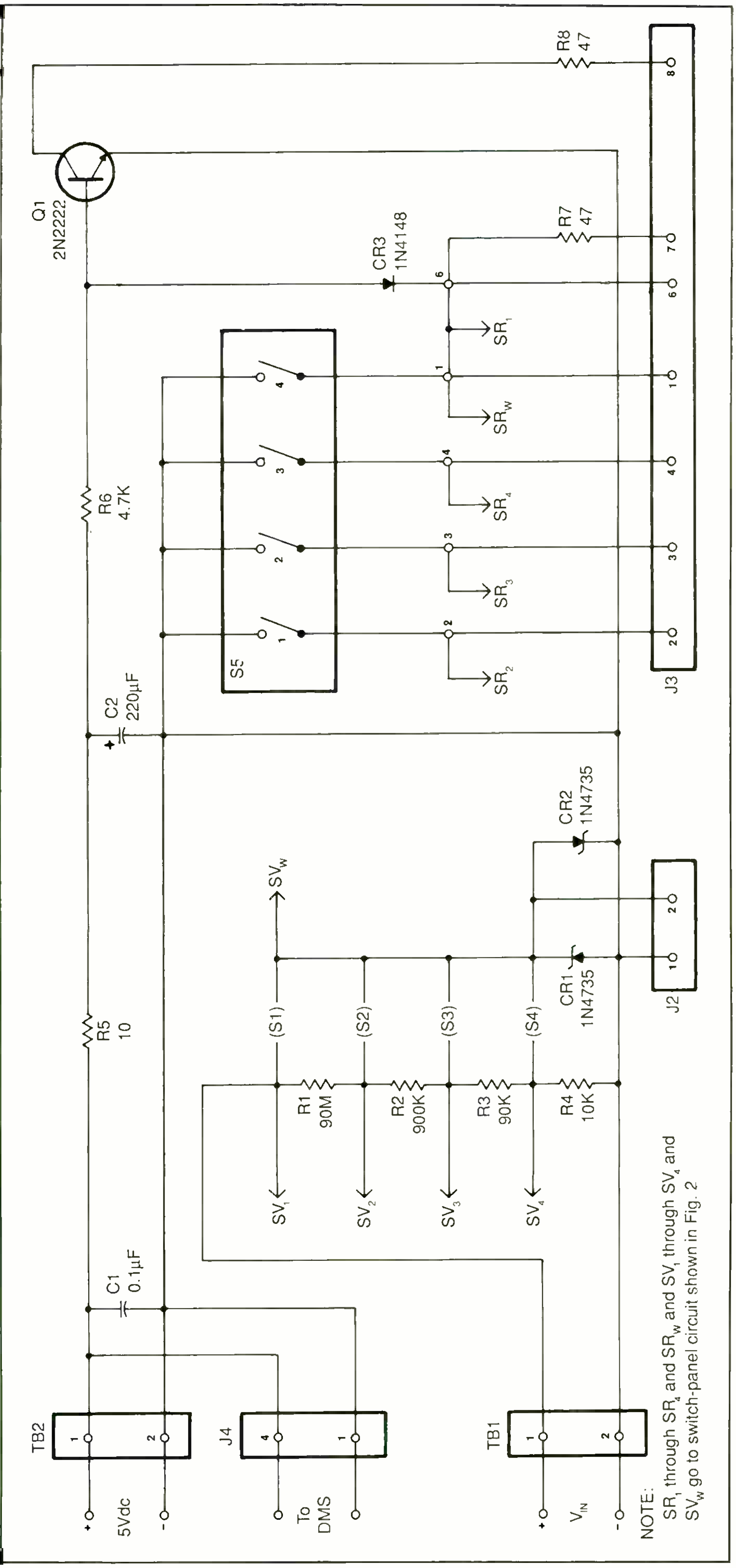


Fig. 4. Schematic diagram of DigiVolt-DC accessory.

Table 2. Input Impedance vs. Scaling Resistors for Four-Range (1, 10, 100 & 1000V*) Divider

Z_{IN} / Scaling R	1K	10K	100K	1M	10M
R_A	900	9K	90K	900K	9M
R_B	90	900	9K	90K	900K
R_C	9	90	900	9K	90K
R_D	1	10	100	1K	10K
C**	0.2 µF	0.2 µF	0.1 µF	0.1 µF	0.01 µF

* For measurements above 500 volts, divider resistors should be mounted external to the DMS because of circuit board clearance.
** Filter values for use in noisy locations.

percent-tolerance resistors are preferable, though they are expensive and sometimes difficult to locate.

About the Circuit

You have a choice of a single fixed-range DigiVolt-DC accessory for using the DMS as a DPM or a four-range accessory that makes the DMS into a general-purpose voltmeter.

• *Fixed-Range DPM.* The DMS can be made into a fixed-range panel meter simply by inserting the proper scaling resistors into the basic instrument's printed-circuit-board locations identified as R_X and R_Y. You must decide what voltage range you want the DPM to respond to and then determine what level of circuit loading is permissible. Choice of total divider resistance should be based upon allowable circuit loading and noise considerations, as discussed above.

Table I lists several voltage ranges and input resistances with appropriate values for resistors R_X and R_Y on the DMS board. Suggested values for noise filter capacitor *C2* are also given in this Table. Unless the DMS is to be used to measure a voltage where the input common and DMS's power-supply common are not at the same potential, R_Z should be zero ohm. That is, a jumper wire should be installed in the R_Z location on the board. If circuit and meter commons (grounds) are not at the same potential, install a 100,000-ohm resistor in the R_Z location to provide the proper bias for the A/D converter and the voltage to be measured should be connected to pin 2 (common) and 4 (+) of *J2*.

If you do not find the values you need in Table I, you can calculate them using the formulas: $R_X = R_T(V_T - V_M)/V_T$ and $R_Y = R_T - R_X$. In these formulas, R_X is the value of the unknown input scaling resistor; R_Y is the value of the common scaling resistor; R_T is the total scaling network resistance; V_T is the maximum input voltage to the DMS; and V_M is the full-scale input voltage to the DMS, which is approximately 1 volt.

• *Selectable-Range Meter.* The DMS can be made into a selectable-range meter by adding to it a module containing a resistive divider network and a variety of switching options. This is the DigiVolt-DC add-on module, which is shown schematically in Fig. 4. With the optional four-position switch in Fig. 5, you have ranges that allow you to set the DMS for any range from 0 to between 0.999 to 999 volts full-scale.

The ranges and divider resistances for several different input impedances are detailed in Table II. The 10-megohm scaling network, which represents a good compromise between circuit loading and noise immunity, was chosen for the DigiVolt-DC module. If necessary, you can use another Table II scaling network as your needs dictate.

The proper divider ratio for the desired range is selected by screw switches *S1* through *S4* in Fig. 4. The signal from the selected division point is fed to the DMS for display.

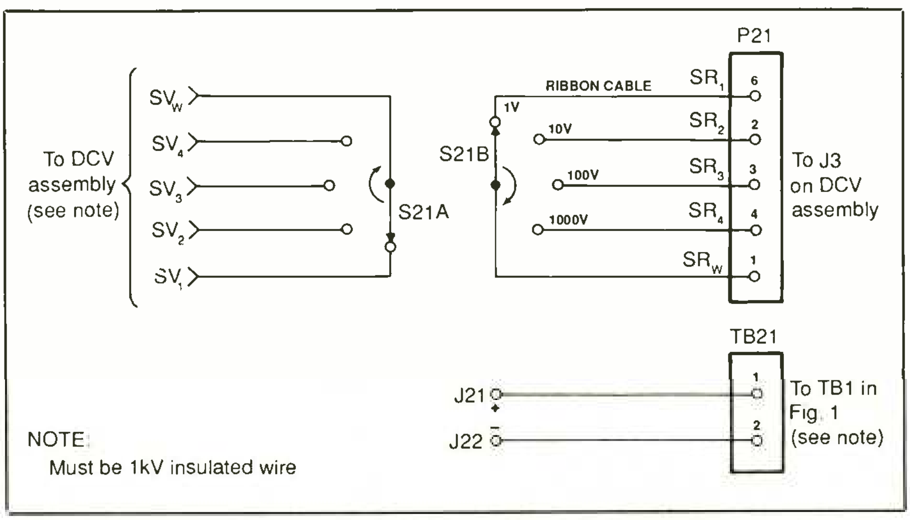


Fig. 5. An optional four-range add-on module for basic accessory shown in Fig. 4.

DIP switch *S5* permits selection of decimal point and range indication. Remote range selection is made possible with the Fig. 5 optional switch subassembly When this option is used, it replaces the screw and DIP switches in the Fig. 4 circuit.

Light-emitting diodes on still another separate subassembly provide visual indication of the range selected. These connect into the Fig. 4 circuit via contacts 7 and 8 on *J3*. Contact 7 ties to the anode of the mV LED, contact 8 to the anode of the v LED.

Zener diodes *CR1* and *CR2* provide transient and over-voltage protection for the DMS. As designed, the DigiVolt-DC module can measure up to 500 volts dc. Under no circumstances should you attempt to use it to measure greater than 500 volts unless external scaling resistors are added; otherwise, the system can be damaged.

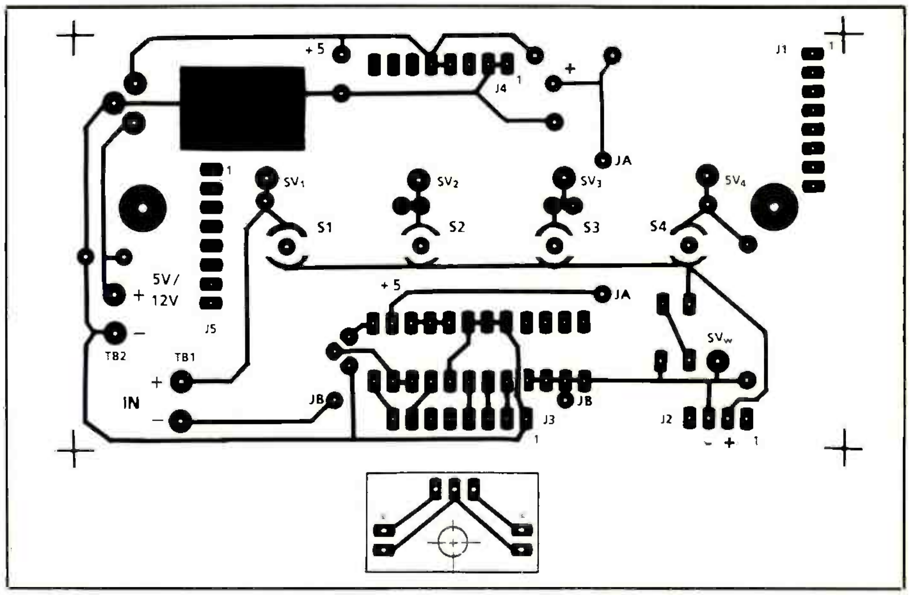


Fig. 6. Actual-size etching and drilling guides for DigiVolt-DC main (a) and LED display (b) printed-circuit boards.

Construction

Because the DigiVolt-DC is designed to be used as a companion to the original DMS, it is important that it be assembled on a printed-circuit board to assure that the two assemblies will properly mate through their headers. You can fabricate your own pc boards using the actual-size etching-and-drilling guides shown in Fig. 6. Alternatively, you can purchase ready-to-wire etched, drilled, plated and silk-screened pc boards from the source given in the Note at the end of the Parts List. If you make your own boards, you can also make component overlays, using the large wiring guide shown in Fig. 7 (see "Dress Up Your Projects," *Modern Electronics*, September 1985).

Wire the main board exactly as shown in Fig. 7, starting with the resistors and capacitors, taking care to properly polarize the electrolytic capacitor. Next, install and solder into place the diodes and transistor, again making sure they are properly based before soldering any of their leads to the copper pads on the bottom of the board.

All resistors used in this circuit must be of the metal-film or wire-wound variety to ensure temperature stability. Use care when reading their color codes because precision resistors have five color bands and are easy to confuse with carbon-composition resistors used by the military that also have five bands.

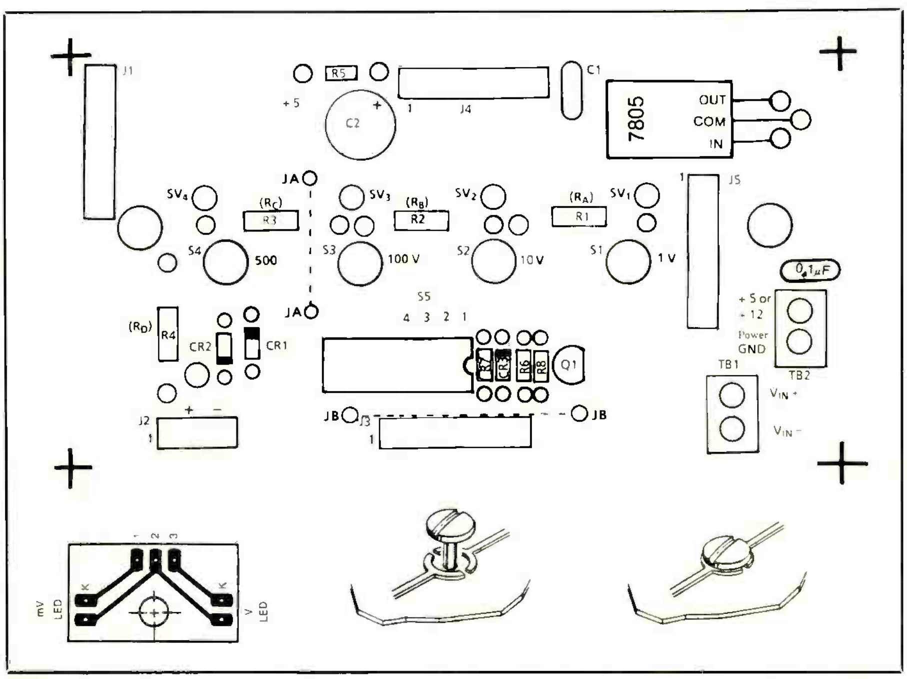


Fig. 7. Wiring diagrams for main and LED boards and details of screw-type switches used in project.

Table 3. Switch Positions for Different Ranges

Range/ Switch	999 mV	9.99 V	99.9 V	999 V
S1	ON	OFF	OFF	OFF
S2	OFF	ON	OFF	OFF
S3	OFF	OFF	ON	OFF
S4	OFF	OFF	OFF	ON
S5-1	ON	OFF	OFF	OFF
S5-2	OFF	ON	OFF	OFF
S5-3	OFF	OFF	ON	OFF
S5-4	ON	OFF	OFF	ON

Next, install the headers in the indicated locations as follows. First, cut the header strip into four eight-pin and one four-pin strips. Then, working from the the component side of the board, plug the longer-pin ends of the eight-pin strips through the holes in board locations J1, J3, J4 and J5 until the supporting plastic firmly seats against the surface of the board and then into the corresponding female header on the DMS module. Repeat with the four-pin header in the J2 location.

Inserting the header pins into the female headers for the soldering operation assures that the DigiVolt-DC and DMS modules will be properly aligned. After soldering all pins on the DigiVolt-DC's headers to the copper pads, unplug and set aside the DMS. Now install two-pin terminal blocks in locations TB-1 and TB-2. Make sure the wire holes in these blocks face the edge of the board before soldering them into place. Then install and solder into place a length of bare solid hookup wire in the JA to JA location on the board.

You will note in the large wiring diagram that provisions are made on the pc board for installation of a 7805 regulator to provide regulated +5 volts to the DMS if you use the circuit with a 6- to 20-volt dc external power supply (instead of the 5-volt dc power supply described for the original DMS module). The external power supply connects to the DigiVolt-DC subassembly via contacts 1 (+) and 2 (−) of *TB2*. If you use this optional regulator, make sure it is properly based before soldering its pins to the copper pads on the bottom of the board. Also, before installation, bend the pins back at a 90-degree angle before insertion so that the regulator will lie flat on the surface of the board.

The screw switches used for *S1* through *S4* in this module consist simply of a No. 6 machine screw driven into holes in the pc-board assembly. Open and closed positions of these switches are achieved by backing out on the screws until the heads no longer contact the copper traces on both sides of the run and tightening down on the screws until they do, respectively. The detail drawings in Fig. 7 illustrate the "on" and "off" conditions of these switches.

Decide now if you are going to use the DigiVolt-DC module as a single fixed-range DPM or a four-range general-purpose DVM. If you intend the former, tighten down the *S1* through *S4* switch screws until their heads contact both sides of the trace runs in all four cases. Then install and solder into place the DIP switch in the S5 location.

If you plan on using the project as a general-purpose DVM, install an eight-pin socket in location S5 instead of the DIP switch. Then use an appropriate-length ribbon cable terminated at one end in an eight-pin DIP plug that will now install in the socket to make the connections to the two-section, four-position rotary switch that will be located on a switching subpanel. (Note: If you cannot locate an eight-conductor ribbon cable with eight-pin plug, use a 14- or 16-pin socket and 14- or 16-conductor cable with plug instead.)

Strip ¼ inch of insulation from all eight conductors of the ribbon cable. Tightly twist together the fine wires in each conductor and sparingly tin with solder. Now, referring back to Figs. 4 and 5, connect and solder the free ends of the ribbon cable conductors to the appropriate lugs on the rotary switch. Then mount a red banana jack in the hole labeled "+" and a black banana jack in the hole labeled "−" and use hookup wires to connect these into the circuit via *TB1* contacts 1 and 2, respectively.

Use a spray solvent to carefully

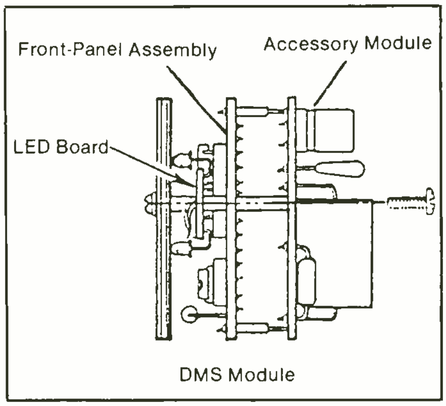


Fig. 8. Assembly drawing for DMS/DigiVolt-DC system.

clean all solder flux from the circuit-board assembly. Flux is conductive, especially under high-humidity conditions, and can cause parallel-resistance circuits that can result in measurement errors.

Now install and solder into place a pair of light-emitting diodes on the small LED display subassembly as per the smaller guide in Fig. 7. This done, strip ⅛ inch of insulation from all conductors at both ends of a 3-inch length of three-conductor ribbon cable. Separate the conductors at both ends a distance of ½ inch. Then tightly twist together the fine wires at both ends of the cable and sparingly tin with solder.

Plug the conductors at one end of the cable into the unoccupied holes in the small LED display board and solder into place. The other end of the cable goes to the DMS board. Connect and solder the conductor from hole 1 on the LED assembly to pin 8 of *J3* on the DMS board, the conductor from hole 2 on the LED board to pin 4 of *J4* on the DMS board, and the conductor from hole 3 on the LED board to pin 7 of *J3* on the DMS board. Leave the LED board dangling until checkout of the circuit is done.

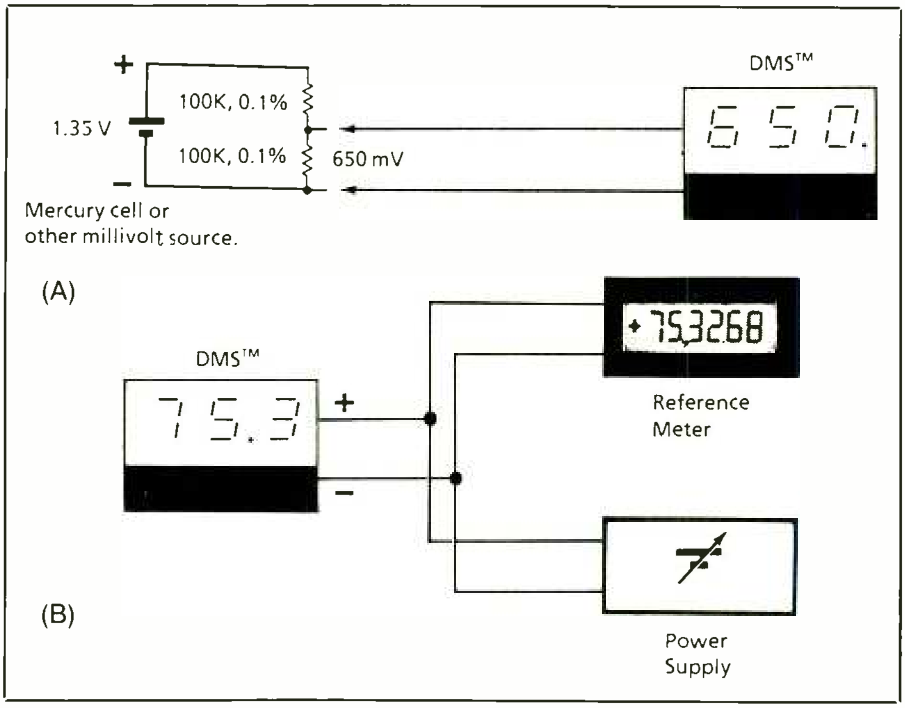


Fig. 9. Checkout arrangements for (a) DMS calibration and low range (1 volt) and (b) upper-range calibration (10, 100 and 1,000 volts).

Checkout

You need a tested and calibrated DMS module to check out the voltage-measuring system using the DigiVolt-DC accessory. At this point, the DMS module should have no resistors installed in the R_X and R_Y locations, and R_Z should be a jumper wire. You should also have a 0.1-microfarad disc capacitor installed in the C_Z location.

If you are using the optional +5-volt regulator on the DigiVolt-DC's circuit-board assembly, connect a 12- to 20-volt dc power supply to the assembly via *TB2* (observe polarity) before connecting the assembly to the DMS module. Check for presence of +5 volts between + pin 4 and − pin 1 of *J4*. If you do not obtain a +5-volt reading when your meter's "hot" and common probes ate touched to pins 4 and 1, respectively, of *J4*, power down the circuit and check the basing of the regulator IC. Do not proceed until you've corrected the problem.

If you are not using the optional voltage regulator, or you've finished performing the above voltage check, plug the DigiVolt-DC module onto the back of the DMS module, as shown in Fig. 8. Connect two test leads to the V+ and V− contacts of *TB1* and an appropriate power source to the *TB2* terminals (observe polarity here!) and turn on the power supply. Now short together TP+ and TP− on the DMS board. The display should now read "000." indicating a 0-volt input.

Any problems at this stage suggest one or more bad solder joints or headers as possible causes. Make whatever corrections are required to obtain the proper display indication and then proceed with checkout.

• *Selectable-Range Checkout.* Refer to Table II to position DIP and screw-switch settings for the lowest range (1 volt or 999 millivolts). If you are using the remote switch-panel option, set the rotary switch to the lowest-range position and connect test leads to *TB1* or the banana jacks on the switch panel.

Using the setup shown in Fig. 9(a), observe the reading displayed by the DMS. This should be the same "650" obtained when calibrating the DMS module, since this is a straight-through connection. This test verifies operation of the mV LED.

For the remaining ranges, a variable voltage source that can supply up to 500 volts dc and a meter with a known accuracy up to 500 volts dc are required. Position the screw and DIP switches (or the rotary range switch on the switch panel if you're using it) to the highest (1,000-volt) range and adjust the source and meter for a reading of 250.00 volts. Connecting the DigiVolt-DC's leads

(Continued on page 84)

How To Read Oscilloscope Waveforms (Part II)

More useful tricks of the trade for getting the most out of your oscilloscope

By Robert G. Middleton

In this installment, our focus is on principles of comparative circuit-action tests, use of a dual-trace oscilloscope for speedy troubleshooting, and dc components in basic waveforms. In next month's conclusion, we will finish up with sawtooth waveform characteristics, common distortion factors, and abnormal waveshape analysis.

Comparative Tests

Comparative circuit-action tests are of considerable value when troubleshooting malfunctioning electronic systems because complete information concerning the "good" and "bad" waveforms is available. Also available is supplementary data that results from unit operation under weak-signal and strong-signal conditions. Too, cross-checks can be made by suitable "bugging" of the circuitry in the good unit.

As shown in Fig. 1, comparative circuit-action tests are performed to best advantage with a dual-trace oscilloscope. The reference printed-circuit-board assembly is in a unit that functions normally, the test board in a similar malfunctioning unit.

Signal voltages for channels A and B are taken from corresponding test points in the two circuit assemblies. In this example, the reference signal goes into the scope's channel A input, the test signal into the channel B input. In turn, the reference waveform is displayed above the test waveform on the scope's CRT screen. Hence, the person doing the troubleshooting observes the comparison waveforms simultaneously instead of sequentially as is the case with a single-trace scope. Simultaneous display is helpful inasmuch as the person doing the troubleshooting does not have to remember what the reference waveform looked like.

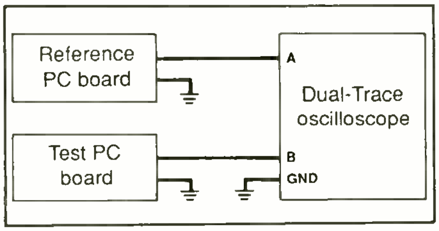


Fig. 1. Comparative circuit-action tests are best performed with a dual-trace oscilloscope.

Last month, mention was made of phase checks being made with a single-trace scope, using Lissajous patterns. Phase measurements are facilitated with a dual-trace scope as in Fig. 2, which illustrates a phase check between the input and output waveforms of the unit under test. As a practical consideration, the peak points in the waveform are not sharply identified on the scope's screen, whereas the base-line crossover points are sharply identified. Accordingly, it is good practice to evaluate phase relationships in terms of crossover points. Note, therefore, that the upper waveform is lagging the lower waveform in Fig. 2.

In any reactive circuit, phase is a function of frequency. Therefore, it is frequently informative to run a phase characteristic-versus-frequency check for a malfunctioning unit and to compare it with a similar check on a reference (good) unit. You will discover that the phase angle usually changes rapidly with respect to frequency over one frequency interval, whereas the phase angle may change slowly over another frequency interval.

Bear in mind that the phase angle is almost zero over the midband portion of a wideband amplifier in normal operation. However, the phase angle is truly zero at only the midband frequency and slowly changes into leading phase angles below and lagging phase angles above the midband frequency.

Tilt in the square-wave response is a common trouble symptom. Tilt is caused by phase shift of the low-frequency components with respect to the high-frequency components in the square waveform.

A downhill tilt, as illustrated in Fig. 3, is due to leading low-frequency components with respect to high-frequency components in the square waveform. It is usually caused by a

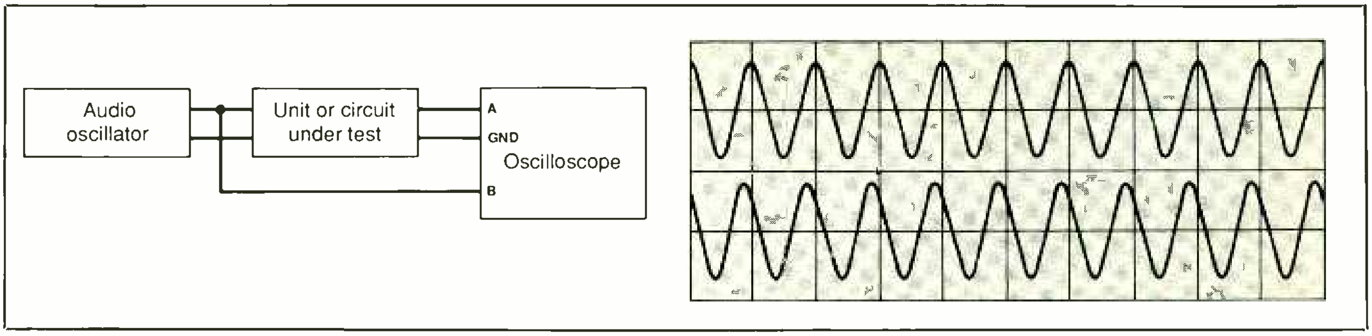


Fig. 2. Basic example of a phase check with a dual-trace oscilloscope.

loss of capacitance in coupling capacitors, though it can also result from any circuit fault that reduces the time constant of the coupling configuration. Keep in mind that when a coupling capacitor starts to lose a portion of its capacitance, downhill tilt will become evident in the square-wave response before any decrease in amplitude becomes discernible. As might be anticipated, downhill tilt is aggravated by reducing the frequency of the test signal.

As is the case with any other electronic device, test equipment can eventually develop a malfunction. For example, a square-wave generator might eventually develop downhill tilt in its low-frequency output waveform, and an oscilloscope might develop tilt in its low-frequency square-wave response. However, a true dc scope cannot develop square-wave tilt because it employs no coupling or decoupling capacitors.

This circumstance affords a handy quick check for square-wave generator tilt. If tilt is being caused by a square-wave generator defect, as illustrated in Fig. 3, the tilt will be displayed on the CRT screen when the scope is operated in its dc mode. On the other hand, if tilt is displayed only when the scope is operated in its ac mode, it is evidently being caused by a defect in the oscilloscope itself.

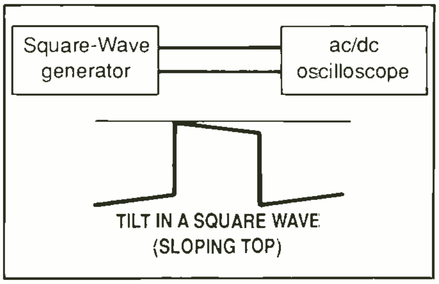


Fig. 3. A quick check to determine whether tilt in square-wave response is cause by the signal generator or the oscilloscope.

Impedance Checks in Semiconductor Circuits

Comparative impedance checks are easily made with a test setup such as shown in Fig. 4. This is a general approach, since it is made in "dead" circuitry and is equally informative whether the unit under test is working or inoperative. If the circuit branch under test is linear and has a reactive component, a true ellipse is displayed on the oscilloscope's screen, as shown. However, let us consider a potentially nonlinear example, as exemplified in Fig. 5. This is a three-port series-parallel RC network with an associated one-port diode circuit. This diode qualifies the anticipated test data.

At low test-voltage levels (below the turn-on level of the diode), the impedance pattern observed at Port 1 will be a true ellipse, as will be the displayed patterns at Ports 2 and 3. In this example, the response at Port 4 is negligible.

Next, at a higher input test voltage level, the impedance pattern at Port 1 exhibits noticeable flattening, as illustrated in (1) in Fig. 5. Then, if Port 1 is short-circuited to Port 3, a "tennis racquet" impedance pattern like that in (3) is displayed at pertinent frequencies. This distorted pattern results from conduction of the diode connected at Port 3.

An impedance check from Port 4 to ground in Fig. 5 results in a virtually resistive pattern, as shown in (4). Observe now that if a jumper is connected from Port 4 to ground, an impedance check from Port 3 displays an almost ideal diode characteristic, as in (3 to 4). This diode characteris-

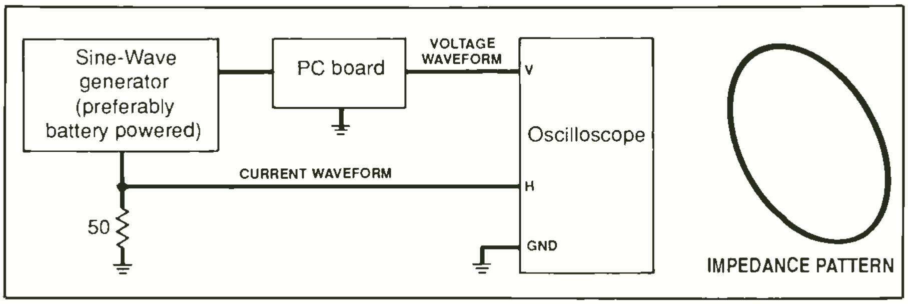


Fig. 4. Test setup for making comparative impedance checks at various frequencies.

tic pattern has a "hook" that shows that its horizontal excursion results from a low forward resistance and that its extensive vertical excursion results from a high reverse resistance.

Equivalent Circuits

It is most helpful to recognize that, at any given test frequency, any RC network has an equivalent circuit consisting of a resistance in series with a capacitance. Thus, in Fig. 6 the parallel arrangement of R_p and X_p has the equivalent series configuration represented by R_s and X_s.

The relationships of R_p, X_p, R_s and X_s are given by the RXZ diagram for the parallel circuit. By the same token, the series arrangement of R_s and X_s in Fig. 6 has the equivalent parallel configuration represented by R_p and X_p. Again, the relationships of R_p, X_p, R_s and X_s are given by the RXZ diagram, which is now read "from series to parallel." Observe that R_p and X_p have substantially higher values than R_s and X_s and also note that the phase angle is the same for both the series and parallel circuits.

Consider next the equivalent series RC circuit for the series-parallel RC configuration in Fig. 7. The parallel arrangement of R_pX_p has an equivalent RC series circuit comprising R_s and C_s. It is evident that *C1* will be effectively in series with C_s, as indicated. In turn, the series combination of *C1* and C_s can be reduced by the "product-over-sum" formula to find C_{eq}. It follows that the simplest possible equivalent circuit is made up of C_{eq} connected in series with R_s. It also follows that the impedance pattern for the series-parallel RC configuration must be a true ellipse.

Although equivalent circuits provide a powerful tool for circuit-action analysis, it is essential to also keep their limitations in mind. It has been stressed that an equivalent RC series circuit, for example, holds true at only one frequency. This is just another way of saying that the equivalent circuit is valid for sine-wave tests but is not applicable to square-wave tests, for example. The reason for this limitation is that a square wave is built up from a very large number of harmonically-related sine waves (theoretically from an infinite number of sine waves). In turn, each harmonic in a square wave will "see" a different impedance in the initial RC network, compared to the impedance it "sees" in the equivalent RC series circuit. Stated otherwise, the square-wave response for the initial RC network will be different from the square-wave response for the equivalent RC series circuit.

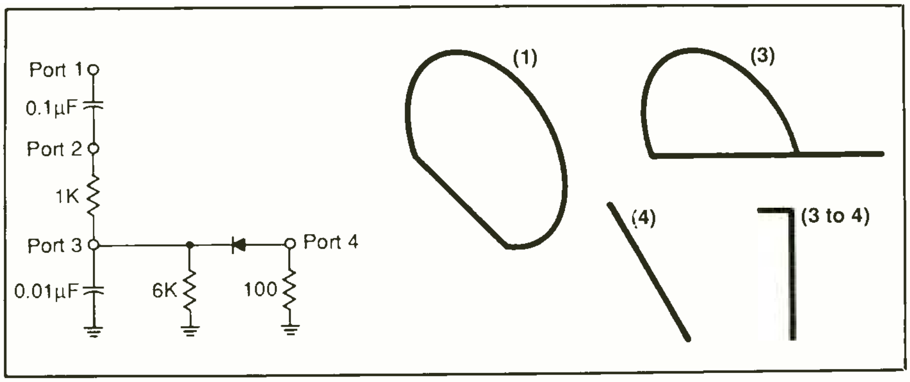


Fig. 5. A series-parallel RC network that includes a diode and has two basic types of impedance patterns.

Quasi-Linear Action

There is no sharp dividing line between linear and nonlinear circuit action from a practical standpoint. We frequently work in a "gray" area that can be regarded as either a linear or a nonlinear arrangement, depending upon acceptable assumptions. For example, a transistor is basically a nonlinear device. However, in small-signal operation, its nonlinearity is often neglected and the transistor is assumed to provide linear amplification. This situation can be termed "quasi-linear" circuit action.

At input signal levels that exceed accepted small-signal limits, harmonic (waveform) distortion can no longer be ignored, and circuit action is then considered nonlinear. However, if significant negative feedback is employed, the nonlinear circuit can be linearized for all practical purposes. Linearization is obtained at the expense of gain, which can be offset by adding one or more transistor stages to the network to maintain the original gain figure. As a practical consideration, the percentage of total harmonic distortion (THD) reduction provided by negative feedback is essentially the same as the percentage of feedback provided in the circuit.

It is important to keep in mind that negative-feedback action has one limitation that must occasionally be taken into account when troubleshooting a circuit: clipping action. If clipping occurs either at the cutoff level or the saturation level in a transistor amplifier, no improvement in response can be obtained regardless of the amount of negative feedback used. This is just another way of saying that when clipping occurs, amplifier gain and negative-feedback action cease throughout the clipping interval.

Components in AC Waveforms

Nearly all waveforms encountered in transistor circuitry consist of ac waveforms with dc components. A basic example of an ac pulse waveform with a dc component is shown

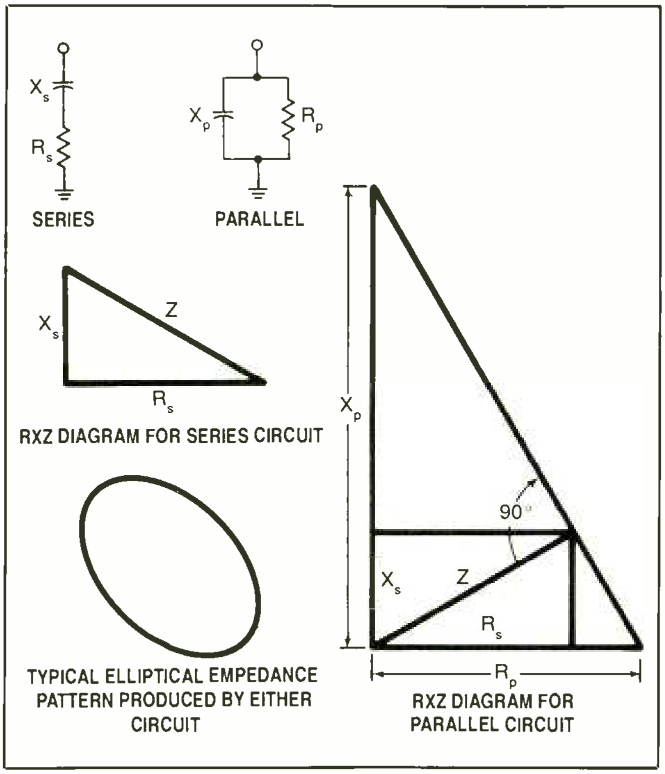
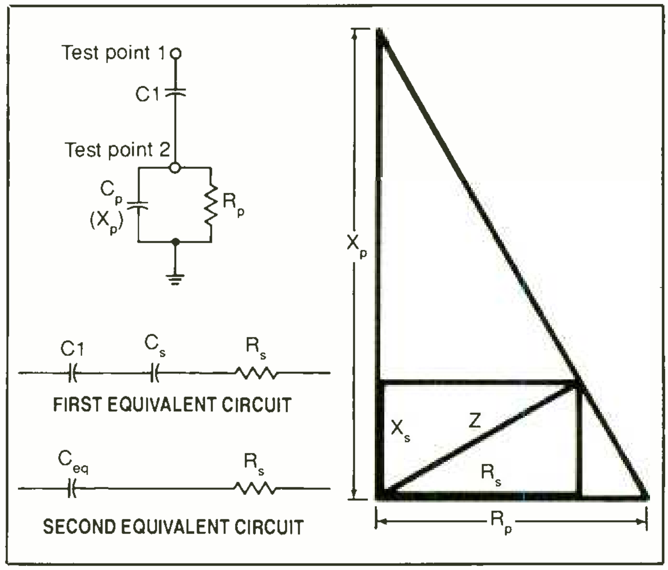


Fig. 6. An RXZ diagram for equivalent series and parallel RC circuits.

Fig. 7. Reduction of a basic series-parallel RC configuration to equivalent RC series circuit at a given frequency.



in Fig. 8. This dc component has a value of 10 volts, and the ac pulse is superimposed on the dc component level. This pulse waveform has a peak-to-peak value of 8 volts, its positive-peak value is 6 volts, and its negative-peak value is 2 volts. The 0-volt line (level) in the diagram corresponds to the resting level of the scope beam when no signal is applied to the input.

Applying a +10-volt potential to the input of an oscilloscope causes the beam level to rise from the solid line to the dashed line in Fig. 8. If the ac pulse is added to the +10-volt input, the ac waveform will then be displayed in relation to the dashed line as shown. The average value of the waveform is now zero. Now, if the scope is switched to its ac function, the dc component is blocked and the ac waveform is then located on the screen with the dashed line occupying the solid-line level. This is the way you can quickly check the dc component in a waveform on your scope's screen.

It is evident that switching the scope from its dc to its ac function is a time saver in comparative circuit-action tests. When a malfunctioning electronic unit is first tackled, you may not know whether the fault is dc- or ac-related. Simply switching the scope from its dc to its ac function can resolve this question in a snap as you proceed with waveform comparison tests. Although a DVM could be connected in parallel with the scope's input circuit, it is more time consuming to repeatedly observe the meter's display than to merely observe the associated level shifts on an oscilloscope screen.

As a final practical note, you will often be plagued by the question of acceptable tolerances on voltage values and waveshapes. Unfortunately, there is no hard and fast rule in a situation like this; thus, experience must serve as the operative guide. For example, although it is commonly said that dc voltages can vary by ±20 percent without causing definite trouble symptoms, this is only a rough rule of thumb. Base bias voltages, for instance, are very critical, whereas collector dc voltages are usually not so. An exception is the case of direct-coupled amplifier circuitry in which the collector of the driver stage connects directly to the base of the driven stage.

Tolerances on waveshapes is a highly involved consideration. For example, you may be called upon to work on a hi-fi amplifier or a utility

(Continued on page 90)

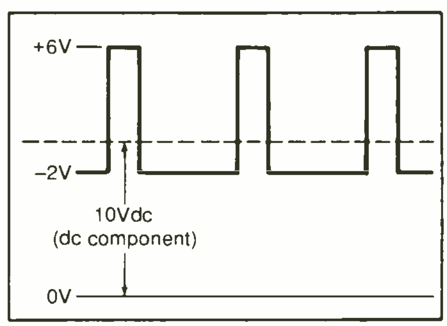
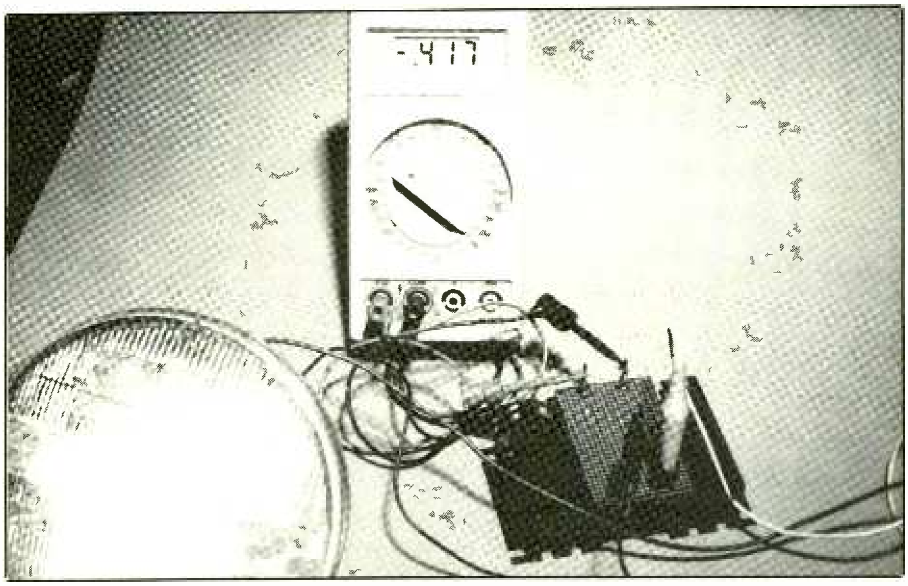


Fig. 8. An elementary example of an ac pulse waveform riding on a dc component.

High-Current Shunt for DMMs

Lets you measure dc currents in excess of 10 amperes

By Harold Wright



Most of today's DMMs have a maximum dc current range of 10 amperes. If you wish to measure currents in excess of 10 amperes with these instruments, you need a high-current shunt. Commercial shunts are quite expensive—$85 or more for the clamp-on types. There is an economical alternative, though, which we present here.

The Solution

Shown in the Fig. 1 schematic diagram is the low-cost solution to the expensive shunt dilemma. Here, the current to be measured is passed through the power resistor and the DMM set to dc volts measures the voltage across the resistor. Obviously, for this to be a convenient measurement, the power resistor's value should be selected to provide a direct reading that does not require conversion; thus the reason for selecting a 0.1-ohm value. Accuracy is important, too. Therefore, the power resistor should have a tolerance of not more than 1 percent.

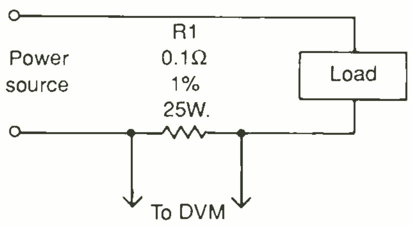
Using the arrangement shown in Fig. 1, a 15-ampere current through the power resistor would cause 1.5 volts to be dropped across the resistor. All you do now is mentally move the decimal point one place to the right to obtain a reading of 15 amperes.

Since the current through the resistor need be applied for only a second or two, just long enough to obtain a stable meter reading, the resistor will usually not have time to warm up appreciably. Therefore, it does not necessarily have to be rated at the full wattage produced by the current/resistance formula. Consequently, a 30-watt power resistor should be usable to measure currents as high as 50 amperes. Beware, though, to avoid applying a current in excess of the power rating of the resistor for longer than a couple of seconds; otherwise, you are likely to permanently damage the resistor, or at the very least change its resistance value.

Construction

Building this high-current dc add-on shunt is very simple and straightforward. If your spare-parts box does not contain a large heat sink (the bigger, the better), purchase one. This will be used as a "chassis" on which you mount the power resistor and provide the means by which to attach it to the load and meter in use.

Dale has a 0.1-ohm, 1-percent-tolerance power resistor that is fairly reasonably priced. It is available from any outlet that handles Dale parts. This resistor is encased in steatite and is surrounded by a heavy integral aluminum heat sink. If you cannot find a source for this resistor, you can use any other manufacturer's resistor or tie together in parallel two 0.2-ohm power resistors (the resulting resistance will then be 0.1 ohm). Just make sure to obtain a resistor with a high enough wattage



PARTS LIST

R1—0.1-ohm, 25-watt or greater, 1% tolerance power resistor (see text)

Misc.—Large heat-sink assembly (see text); perforated or unclad phenolic or epoxy-fiberglass board blank; suitable connectors for load and meter; heavy bus wire (12 gauge or larger); machine hardware; etc.

Fig. 1. Schematic diagram of shunt that extends current-measuring capability of typical DMM beyond the usual 10 amperes.

rating for your needs. If you use the parallel arrangement, assuming the same wattage rating for each resistor as for the single 0.1-ohm resistor, you get double the wattage of the single resistor.

Place the resistor on the heat sink and mark the locations for the mounting holes. Remove the resistor and drill the holes in the marked locations. This done, spread a liberal amount of heat-transfer compound on the mating surfaces of the heat sink and resistor and mount the resistor in place with machine hardware.

Next, cut a piece of perforated board or unclad phenolic or epoxy-fiberglass blank to a size that bridges the resistor and contacts surfaces on both sides to allow it to be mounted on the heat sink. Install at opposite ends of this board pairs of five-way binding posts, banana jacks or other suitable connectors for making hookups to the meter and load (see Fig. 2). Drill holes in the heat sink to mount the board in place. If necessary, use a tap to make threads in the holes drilled in the heat sink to accommodate the machine screws you are using.

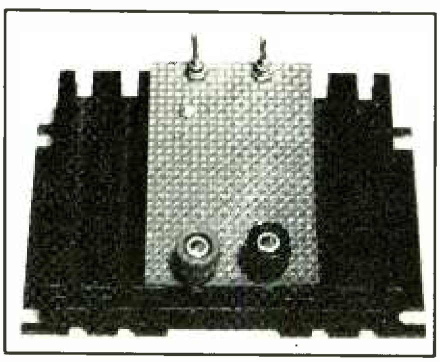
Referring back to Fig. 1, wire the connectors on the board to the power resistor. Heavy bus wire *must* be used to make the connections. Use at least 12-gauge wire to produce the smallest possible voltage drop on them. Otherwise, your readings will be off because of the added resistance of the wiring, and the wires themselves are likely to heat up very rapidly when high currents are applied to the accessory.

Of equal importance is the soldering operation. Use a heavy-duty soldering gun to make these soldered connections. When you are finished, check out each connection with an ohmmeter set to its lowest range. Your readings should register as close to zero ohms as possible.

Application

Shown in the lead photo is a typical setup arrangement for using the high-current shunt. A Beckman Model 310 digital multimeter is used here to measure the dc current when a 12-volt dc car battery was used to power an automobile headlight load. The meter registered a 0.417-volt drop across the project's power resistor, as can be seen in the display. (Note that in a measurement like this, the minus sign in the display has no meaning, just the magnitude of the measurement.) Moving the decimal point one place to the right yields a reading translated into current of 4.17 amperes.

You may not need this accessory very often, but when you do, you will be happy you spent the time and money to build it. **ME**



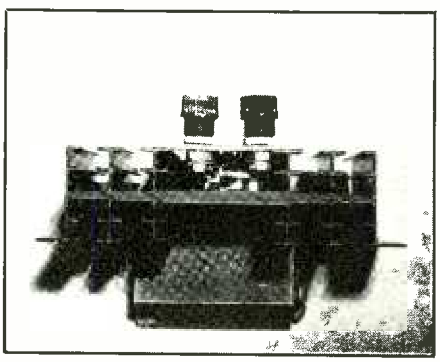


Fig. 2. Top (left) and side (right) views of project. Note connectors at opposite ends of perforated board for load and meter.

Xenon Flashtube Circuits

By Forrest M. Mims III

Xenon flashtubes are well known for their role in photography and use as warning beacons for aircraft, emergency vehicles and antenna towers. They are also used in some photocopy machines and flash photolysis.

Many kinds of flashtube systems are available as commercial products. They range from inexpensive photographic strobe units and portable warning beacons to sophisticated systems designed for capturing transitory events on film.

What follows is a basic introduction to the design and construction of do-it-yourself xenon flashtube circuits, both single- and repetitive-flash designs. Several important safety procedures are also covered. Even if you are not now interested in building your own xenon flashtube system, the information provided here should help you to better understand the operation of flashtube circuits.

A Basic Xenon Flashtube Circuit

Drive requirements for xenon flashtubes are quite demanding. The discharge voltage applied to the tube must be at least several hundred volts, and the trigger voltage required to initiate a flash must have a potential of several thousand volts. While these very high voltages require careful attention to circuit layout, the design and construction of xenon flashtube circuits is not overly difficult.

Shown in Fig. 1, for example, is the block diagram for a simple manually triggered xenon flashtube circuit. In operation, the high-voltage supply simultaneously charges the circuit's main capacitor and the flashtube's trigger capacitor.

The main capacitor, also known as the photoflash or discharge capacitor, typically has a capacitance value of from a few tens to several hundred microfarads. Smaller capacitance values are used in flashing strobes, and larger values are used in photographic flash units. This capacitor is usually charged to several hundred volts, although in some circuits it is charged to a few thousand volts.

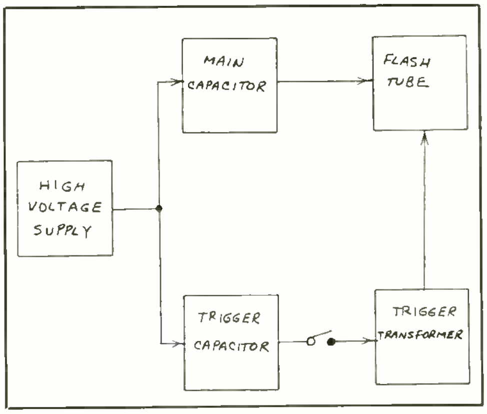


Fig. 1. Block diagram of a flashtube trigger circuit.

The trigger capacitor usually has a capacitance value of only a few tenths of a microfarad. It is most often charged to the same potential as the main discharge capacitor.

Note in Fig. 1 that the main capacitor is connected directly across the flashtube. This is possible because the xenon gas inside the tube acts as an insulator as long as the voltage across the tube is less than the ionization potential of several thousand volts. In other words, the charge on the main capacitor does not leak through the flashtube prior to triggering.

Note also that the trigger capacitor is connected to the trigger transformer through switch *S1*. The trigger transformer has a high turns ratio. Thus, when *S1* is closed and quickly dumps the charge on the trigger capacitor, the few-hundred-volt pulse that is applied to the secondary winding of the transformer is stepped up to produce a brief pulse of several thousand volts in amplitude. This high voltage is applied to the flashtube by means of a wire electrode around the tube or a conductive strip applied directly to the tube's outer surface.

Since the trigger electrode is external to the flashtube, this is known as external triggering. In some circuits, the trigger pulse is applied directly to one of the flashtube's two terminals; this is known as internal triggering. Other methods of triggering a flashtube are also possible, but external triggering it probably the most common, especially for small battery-powered flashtube circuits.

When the high-voltage pulse from the trigger transformer is applied to the flashtube, the xenon gas inside the tube is almost instantaneously ionized. When ionization occurs, a path of conduction is established, allowing the main capacitor to discharge through the flashtube. The trigger voltage produces a very faint thin blue arc inside the flashtube. Because the current discharged through the tube by the main capacitor is considerably greater than that produced by the trigger transformer, the resultant discharge is a brilliant plasma that fills the entire flashtube.

Figure 2 shows schematically how the block diagram in Fig. 1 is implemented with actual electronic components. The main capacitor that discharges through the flashtube in this circuit is *C1*, while *C2* is the trigger capacitor and *T1* is the trigger transformer. In operation, both *C1* and *C2* are charged by the high-voltage power supply. When *S1* is closed, *C2* is connected across *T2*'s primary. The high-voltage pulse that appears across *T1*'s secondary then ionizes the xenon gas inside the flashtube, thereby providing a conductive path for the discharge of *C1*.

A xenon flashtube might fracture or explode when the energy discharged

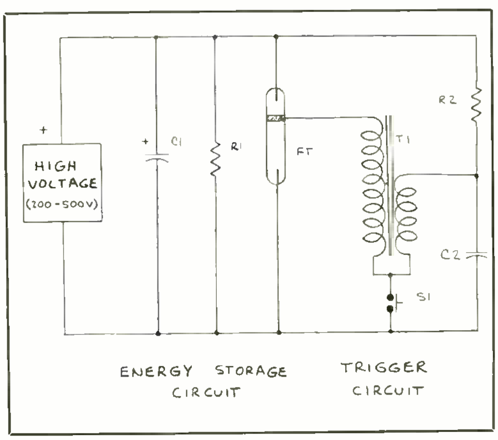


Fig. 2. Schematic diagram of a basic flashtube circuit.

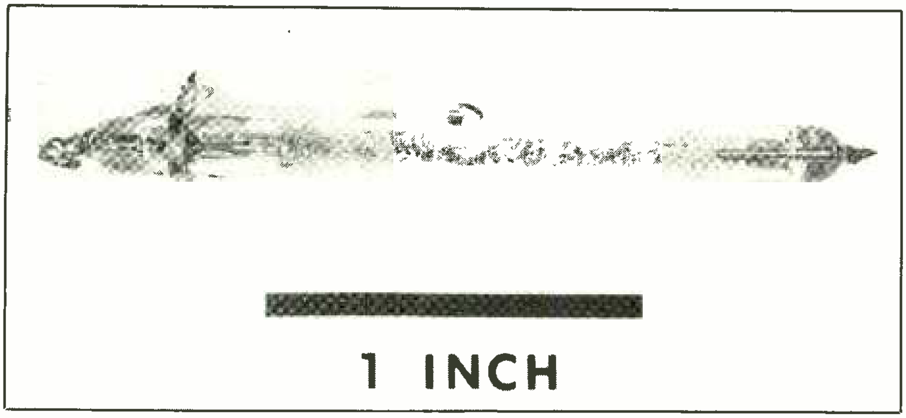


Fig. 3. This flashtube was fractured when its explosion energy was exceeded.

through it exceeds the so-called explosion level. The energy in joules stored in the flashtube's discharge capacitor is half the product of its capacitance and the square of the voltage stored in the capacitor. For example, a 300-microfarad capacitor charged to 300 volts has a stored energy of $(0.0003 \times 300^2)/2$, or 13.5 joules.

Operating a flashtube well below the explosion energy will greatly increase its lifetime. It will also prevent a possible explosion of the flashtube itself.

Incidentally, note in Fig. 2 that *R1* is connected across *C1*. The charge stored in *C1* can produce a dangerous or even fatal electrical shock, which is why this "bleeder" resistor is incorporated into the circuit. Its purpose is to discharge *C1* when the power supply is switched off. This safety measure is included in the circuit to protect troubleshooting technicians from harm. With this thought in mind, and because xenon flashtubes are potentially dangerous, let's pause to consider some important safety precautions before looking at some real circuits you can build.

Safety Precautions

Always keep in mind that *xenon flashtube circuits can be hazardous.* They are powered by potentially dangerous or even lethal voltages. Bear in mind, too, that flashtubes can explode if they are driven too heavily. For these reasons, the following safety precautions *must* be observed when you work with or around xenon flashtubes and the circuits that power them:

- Xenon flashtubes can explode if operated above a particular energy threshold. Therefore, xenon flashtubes *must* be mounted behind a transparent explosion barrier. Additional protection from flying shards of glass can be provided by wearing safety goggles.
- Some xenon flashtubes, particularly those fashioned from quartz, emit substantial ultraviolet radiation. Anyone exposed to the light from such lamps must be appropriately warned of possible UV hazard, and their eyes and skin must be protected.
- Avoid observing the flashes from a xenon flashtube at close range. High-energy tubes can produce sufficient concentrations of radiant energy on the retina to produce a lesion or even a burn.
- The power supplies used with xenon flashtubes operate at potentially dangerous or even lethal voltages! The flashtube discharge capacitor is particularly dangerous! *Never* assume that such a capacitor is discharged. Therefore, before attempting to work on *any* xenon flashtube circuit, no matter how small, *always* disconnect the power source and then carefully discharge the flash capacitor by shorting together its terminals several times with a screwdriver that has an insulated handle. If possible, first partially discharge the capacitor by allowing it to fire the flashtube to which it is connected. Then remove the power and short its terminals. *Use great caution!*

Some engineers and technicians who work around high voltages always keep one hand in a pocket. This helps in preventing a discharge path through the chest from being established, which could occur if you use two hands to work on the circuit and accidentally touch a high-voltage point. However, even very experienced personnel have been injured and killed by accidentally touching the high-voltage terminals of xenon flashtube power supplies.

- Use corona dope (GC Electronics Cat. No. 10-5002 or equivalent) or insulating varnish to insulate all exposed terminals and leads that carry high voltage.
- Always connect a bleeder resistor (10 megohms typical value) across the terminals of a flashtube's main discharge capacitor.
- Never exceed the explosion energy of a xenon flashtube. The tube will fracture and very possibly shatter. Shown in Fig. 3 is a flashtube that fractured when I connected it to a large photoflash capacitor that, when charged, exceeded the tube's explosion energy.
- Children and others who are not experienced in electronics should never attempt to assemble, disassemble or troubleshoot xenon flashtube circuits.

Before closing this discussion on safety, I would like to relate a relevant personal experience. In 1970, I was working at my workbench with a 1,000-volt voltage multiplier that I had assembled to power a flashtube. The divider consisted of a string of diodes and 10-microfarad capacitors, each charged to 350 volts by a miniature supply powered by a 3-volt battery. Because of the high-voltage hazard, I had placed my left hand in a pocket to avoid a potentially dangerous electrical shock.

As I worked on the circuit, the springy diode string and capacitors suddenly slid from my workbench and into my lap. Just as I reached out to grab the circuit with my free hand, the high-voltage leads from the multiplier touched my pants leg. There was a loud pop, a puff of pungent smoke, and I was catapulted back-

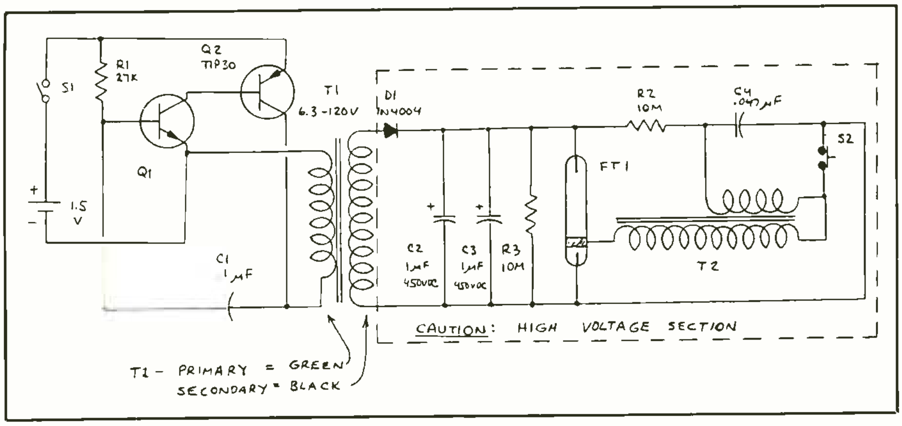


Fig. 4. A single-flash xenon strobe circuit.

ward from my chair against an adjacent wall. As I lay on the floor, still stunned by the shock, I noticed that the discharge had burnt a hole through my trousers and had formed a small crater in my left thigh. Though this happened 18 years ago, I remember it as vividly as if it happened yesterday.

I certainly hope you will regard my experience as a suitable warning about the potential hazards of the circuits that follow. The lesson I learned is that even a shock that isn't fatal can cause a violent muscle spasm that might swing an arm into a hot soldering iron or, as happened in my case, toss you against a wall and onto the floor.

Single-Flash Circuit

Virtually all commercial flashtube circuits use custom step-up transformers to generate the several thousand volts discharged through the tube by the main capacitor. In Fig. 4 is shown the schematic diagram of a single-shot xenon flashtube circuit that can easily be constructed from readily available components. Instead of a difficult-to-find special step-up transformer, the circuit makes use of a common low-voltage transformer (*T1*). Many kinds of small xenon flashtubes and miniature trigger transformers will work in this circuit.

Transistors *Q1* and *Q2* in the Fig. 4 circuit are shown connected as a simple oscillator. The fast-risetime pulses from the oscillator are applied to the 6.3-volt winding of *T1*. The low-voltage pulses that appear across this winding are multiplied by the high turns ratio of the transformer's 120-volt secondary to emerge at a much higher voltage. Therefore, even when the oscillator is powered by a single 1.5-volt cell, pulses that have a peak amplitude of 170 volts and a duration is 150 milliseconds appear across *T1*'s 120-volt winding. The 170-volt portion of these pulses has a duration of about 40 milliseconds. For the remainder of the 150-millisecond pulse, amplitude falls to about 100 volts.

Parallel-connected capacitors *C2* and *C3* serve as the main capacitor for the flashtube. These capacitors are connected directly across the 120-volt winding of *T1*. Bleeder action for *C2* and *C3* in this circuit when power is shut off is provided by *R3*.

While *C2* and *C3* are being charged, *C4* is being charged to the same voltage through *R2*. Closing *S2* causes *C4* to discharge through the primary of trigger transformer *T2*. This induces a very-high-voltage pulse across *T2*'s secondary. In turn, this pulse produces an ionized streamer arc inside the flashtube. Capacitors *C2* and *C3* then discharge through this conductive path, thereby causing the flashtube to emit a brilliant flash of light.

Since *C2* and *C3* have a total capacitance of only 2 microfarads, they will rapidly recharge in only a few seconds. Afterwards, *S1* can be closed again to cause another flash to be produced.

Construction of the Fig. 4 circuit is generally straightforward. Various flashtubes and trigger transformers might have different pin and lead connections; so be sure to follow the specifications supplied with the items you use. The high-voltage secondary winding of *T2* is often identified by a red dot, and primary winding uses heavier wire than the secondary.

Remember that *C2* and *C3* are charged to a few hundred volts and that a spike that has a peak amplitude of several thousand volts will appear across *T2*'s secondary when *S1* is closed. Therefore, all components and leads that carry these high voltages should be securely installed as neatly as possible. Use insulated wire

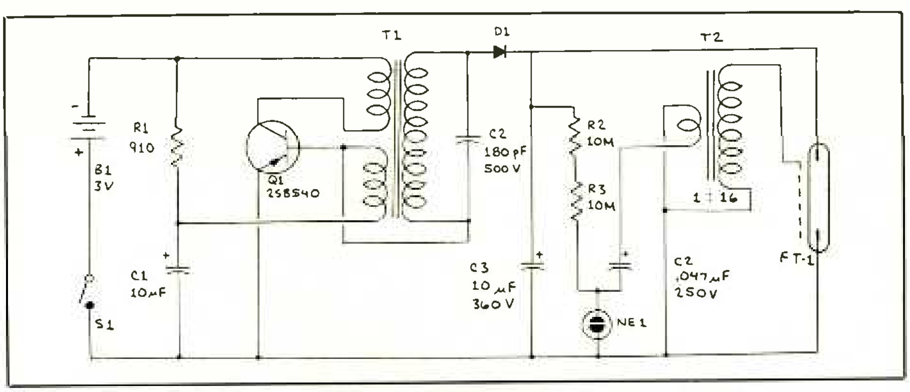


Fig. 5. Internal circuit of a commercial xenon strobe light.

for all connections. In the case of *T2*, the connection to the flashtube's trigger electrode should be as short and direct as possible. Should this connection pass close by another wire or component, there is an excellent chance that the high-voltage spike will arc its way to ground.

For both personal safety and circuit reliability, I coat all exposed high-voltage connections and terminals—especially those of the flashtube—with corona dope.

Commercial Recycling Strobe Light

Xenon flashtubes that flash automatically every second or two are often used as warning, marker and tracking beacons for many purposes. Before looking at some self-recycling xenon flashtube circuits you can build, let's examine the commercial circuit (now discontinued) shown schematically in Fig. 5.

While the Fig. 5 circuit may at first appear to be quite different from the basic circuit shown in Fig. 4, it is actually quite similar to it. The only significant difference is that the circuit includes an oscillator that automatically actuates the flashtube about every 2 seconds. The circuit drives the flashtube at only a small fraction of the tube's explosion energy, thereby insuring a useful life of millions of flashes. Two C-size flashlight cells power the unit for nearly a full day, though the flash interval lengthens after about 8 hours of operation.

The high-voltage supply in the Fig. 5 circuit is made up of *R1*, *C1*, *Q1* and *T1*. The last serves two functions: it provides the feedback needed for *Q1* to oscillate, and the low-voltage pulsations across its primary windings appear as high-voltage pulses on its high-turns-ration secondary winding.

The high voltage at *T1*'s secondary is rectified by *D1* and stored in *C3*. Diode *D1* also prevents *C3* from discharging backwards through *T1* and *Q1*. Simultaneously, *C2* is charged to the power supply voltage through *R2*, *R3* and the primary of trigger transformer *T2*.

When the charge on *C2* exceeds the breakdown voltage of neon glow lamp *NE1*, the lamp fires. Then *C2* rapidly discharges through *T2*'s primary and causes a very-high-voltage pulse to appear across *T2*'s secondary. This pulse is applied to the trigger electrode of flashtube *FT-1*. Almost immediately, the ionized gas in *FT-1* provides a low-impedance discharge path for *C3*.

While *C3* is discharging, the flashtube emits light. After a few microseconds, *C3* discharges and the flashtube ceases to emit light. Capacitors *C2* and *C3* then begin charging again to repeat the cycle.

Flashes produced by the Fig. 5 circuit are quite bright, but they are not nearly as bright as those produced by a photographic strobe unit. This is because the value of the main capacitor (*C3*) in Fig. 5 is only 10 microfarads. The main capacitor in photographic strobe units usually has a capacitance value of at least a few hundred microfarads.

The value of *C3* in Fig. 5 can be increased to increase the brightness of the light per flash. However, increasing *C3*'s capacitance will also increase the capacitor's charging time. Therefore, it will be necessary to increase the charging time of *C2* so that the trigger pulse is not applied until *C3* is fully charged. The end result is that the recycle time will be much longer than the 2 seconds given by the values specified in Fig. 5.

Incidentally, note in Fig. 5 that the circuit does not include a bleeder resistor across *C3*. The bleeder resistor might have been omitted by the manufacturer for economy purposes or because the strobe unit was installed in a well-sealed enclosure. The relatively small value of *C3* is another possible reason for omitting the bleeder resistor. But even a 10-microfarad capacitor can give a nasty shock.

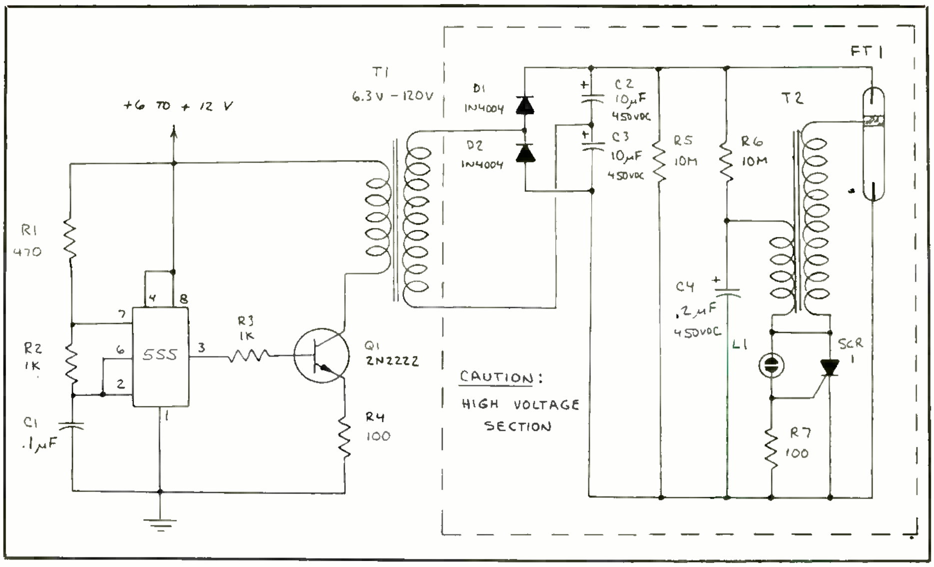
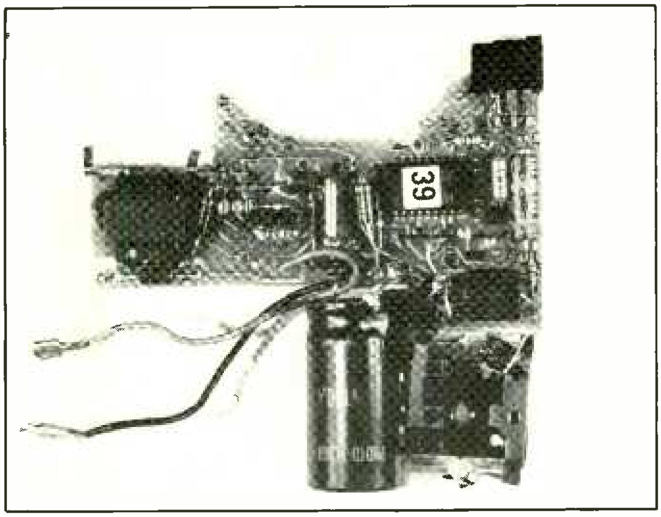


Fig. 6. A xenon strobe flasher circuit.

Recycling Xenon Strobe Light

There are many ways to make a recycling xenon strobe light. The circuit shown schematically in Fig. 6 is one of several such circuits I have designed and tested.

In Fig. 6, a 555 timer IC is connected as a pulse generator that drives switching transistor *Q1* through resistor *R3*. Each time the 555 timer switches *Q1* into conduction, a pulse of current that has a potential near that of the timer's supply voltage is applied to the 6.3-volt winding of transformer *T1*. The potential of this pulse is magnified by *T1*'s turns ratio. Consequently, a much higher voltage appears across *T2*'s 120-volt winding.



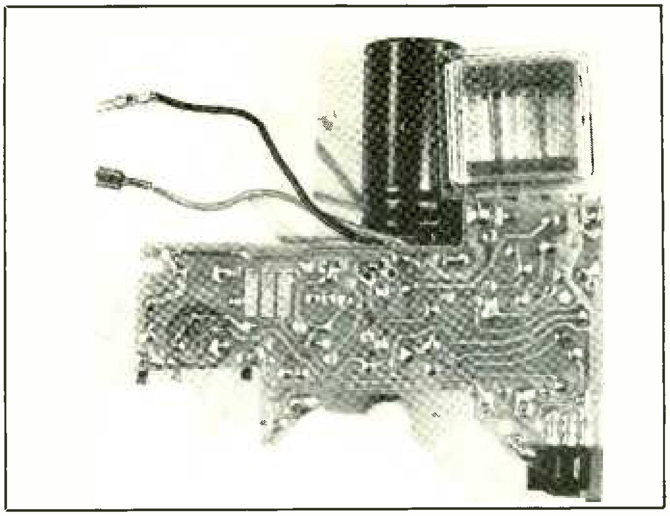


Fig. 7. Component (left) and solder (right) sides of a strobe circuit assembly removed from a Kodak disk camera.

When the supply voltage is from a 9-volt battery, the output from *T1* is a 200-volt square wave.

This 200-volt square wave is applied to the input of a voltage doubler made up of *C2, C3, D1* and *D2*. Capacitors *C2* and *C3* also serve as the main discharge capacitors for the flashtube. Connected across the output of the doubler, *R5* provides safety by serving as a bleeder resistor.

While *C2* and *C3* are being charged, *C4* is being charged to the same voltage through *R6*. When the charge on *C2* reaches the breakdown of neon lamp *L1* (80 to 100 volts), the lamp switches on. The junction formed by *L1* and *R7* is connected to the gate of silicon-controlled rectifier *SCR1*. Therefore, when *L1* switches on, a voltage pulse is applied to *SCR1*'s gate, thus switching the SCR into conduction.

When *SCR1* is conducting, *C4* is provided a low-impedance path through it and the primary of trigger transformer *T2*. When *C4* discharges through the primary of *T2*, a very-high-voltage spike is induced across the transformer's secondary. This trigger pulse then ionizes the flashtube, thereby permitting *C2* and *C3* to dump their stored charges and, in the process, create a brilliant white plasma inside the tube.

Construction of the Fig. 6 circuit is fairly straightforward. As with the Fig. 4 circuit, many kinds of small xenon flashtubes and trigger transformers can be used. Also as noted above, be sure to connect the tube and transformer correctly.

Selection of an SCR for this circuit presents no problems so long as the device is rated for at least 400 volts. For best results, it may be necessary to try several different neon lamps. It may also be necessary to alter the circuit's supply voltage, but keep it below 12 volts.

With the component values specified in Fig. 6, the circuit flashes about once each second. The flashes are sufficiently bright to enable the circuit to function as a warning light. The values of capacitors *C2* and *C3* can be increased in size to provide even brighter flashes. However, this will increase the time between flashes because *C2* will require more time to charge.

Some neon lamps switch on at too low a voltage for this circuit to function properly. When this happens, the voltage across *T2*'s secondary will be insufficiently high to trigger the flashtube into conduction. Therefore, if the remainder of the circuit appears to be working properly, try substituting another neon lamp for *L1*, perhaps one made by a different manufacturer. You might also try connecting two neon lamps in series with each other. This will have the effect of doubling the turn-on voltage of a single lamp. Keep in mind, though, that *T1* might not supply enough voltage to switch on the two lamps in series.

If the circuit still fails to function, double check to make sure the 555 timer is oscillating. Also, make sure the flashtube's terminals are coated with corona dope. Then check for low-impedance leakage paths from the "hot" side of *T2* and the voltage multiplier to ground.

Contamination on the circuit board and/or poorly insulated leads might be the problem. Remember that the pulse of several thousand volts that appears across *T2*'s secondary can easily be diverted to ground via an arc between poorly insulated terminals or wires or by contamination on the circuit board or even the glass surface of the flashtube.

Miniature Xenon Beacons

The do-it-yourself circuits in Figs. 4 and 6 both use a readily available power transformer. While this transformer is easy to find and inexpensive, even small 300-milliampere versions are much larger and heavier than the tiny step-up transformers used in miniature photographic strobe units. Although miniature step-up transformers can be purchased, I prefer to salvage them from discarded or defective strobe units or pocket cameras that contain such strobes. This method also provides a handy supply of trigger transformers and miniature flashtubes, the last often installed in a reflector with a protective shield.

In Fig. 7, for example, are shown photos of the component and solder sides of a circuit board retrieved from a now-discontinued Kodak disk camera. The main discharge capacitor is the large dark cylinder adjacent to the two wires in the left photo. The back of the flashtube's reflector head is next to the capacitor. The trigger transformer is below the flash head, and the step-up transformer for the power supply is at the far right side of the circuit board.

In the right photo in Fig. 7, the flashtube reflector assembly is clearly visible. In both photos, you will note that the flashtube and its trigger transformer are mounted in very close proximity. Note, too, that the exposed terminals of the flashtube are not insulated or coated with corona dope. This is possible because they are not close to other conducting surfaces.

Since so many different kinds of commercial flash units are available, it is not possible to cover the subject in detail here. The most important point is that you must always remember that disassembling a flash unit to salvage the components inside it is potentially hazardous. Therefore, it is absolutely essential that you follow the safety precautions detailed above. In particular, *always* be sure to fully discharge the main discharge

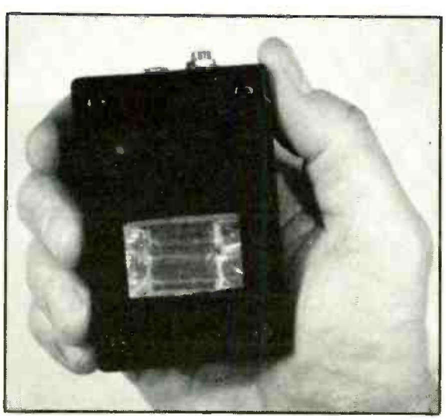


Fig. 8. A homemade miniature strobe unit built from salvaged components.

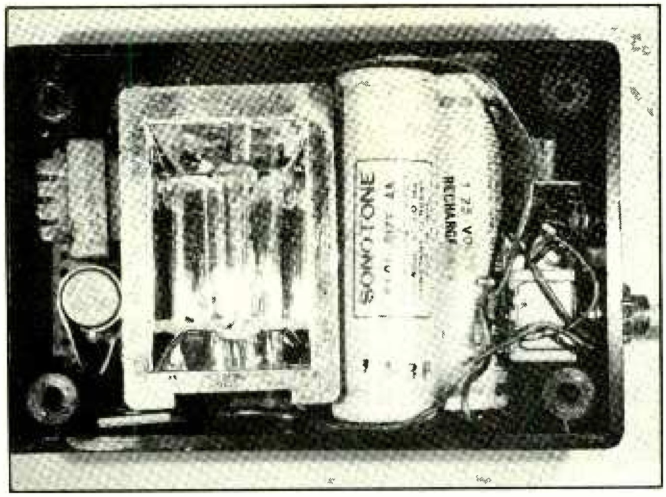


Fig. 9. Interior view of strobe Fig. 8 strobe unit.

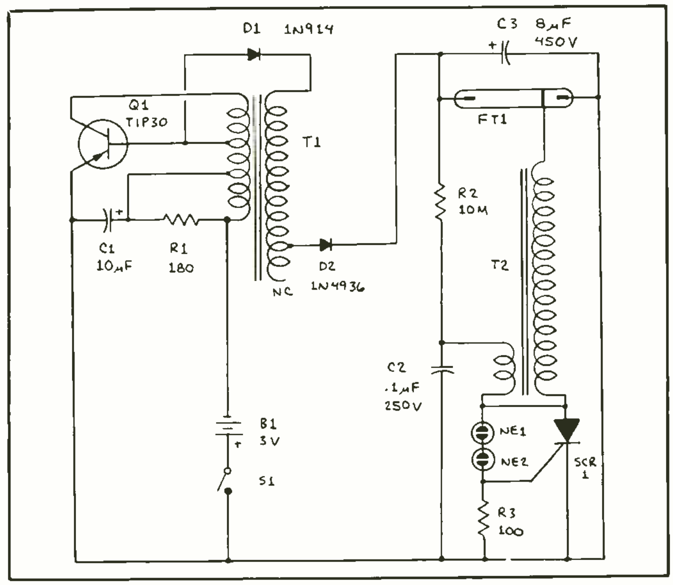


Fig. 10. Flashing strobe assembled from salvaged components.

capacitor with a screwdriver that has an insulated handle. This step is necessary because a photoflash capacitor can retain a charge for many days. Also, *always* remove the battery from a flash unit *before* opening its case.

Instruction manuals for some flash units may warn against disassembly. Warnings may also appear both on and within various flash units. The back side of the circuit board shown at the right in Fig. 7, for example, was covered by a yellow plastic insulating label clearly marked with high-voltage hazard warnings. For your personal safety, it is essential that such warnings be observed.

When salvaging commercial photographic strobes, it's helpful to make a circuit diagram because the step-up transformer is generally designed to double as an oscillator. Knowing the original circuit will help you to either copy it or optimize your own version of the circuit.

One problem with this procedure is that sophisticated photographic strobes often have special sensor circuits that switch off the flashtube after a predetermined amount of light has been generated. Generally, you will have to ignore these additional circuits.

Figure 8 shows just one of the half-dozen or so miniature flashing strobes I have assembled using components salvaged from commercial flash units purchased for a few dollars each. This unit measures 1 × 2 × 3 inches and weighs only 4 ounces. It is powered by two rechargeable nickel-cadmium AA cells, is fitted into a plastic project box and has fastened to it a homemade belt clip.

Over the past 10 years, this particular belt clip has accompanied me many hundreds of miles during both local and long-distance bicycle rides. During the day, the flasher is clipped to a bike pack while its batteries are recharged by a home-made solar panel. At night, it clips on the back of my bike shorts, where it operates for about 4 hours on a full charge.

Figure 9 is an interior view of the strobe unit with the cover of the project box removed. The step-up transformer and oscillator transistor are adjacent to the flashtube/reflector assembly. The flashtube is protected by a piece of clear yellow-tinted plastic cut from a report cover and cemented to the inside of the opening cut in the cover. The plastic doubles as a filter that gives the flashes a distinctive yellow hue.

Referring to Fig. 10, in operation, *Q1* oscillates due to feedback received from *T1*. The low-voltage pulsations across *T1*'s primary appear as a high voltage across *T1*'s secondary. Main discharge capacitor *C3* is charged to this voltage through *D1*. Meanwhile, *C2* is also being charged. When its charge reaches the breakdown voltage of the two neon glow lamps, the SCR is switched on. This delivers a pulse to the primary of trigger transformer *T2*. The very-high-voltage pulse that appears across *T2*'s secondary then ionizes the flashtube and permits *C3* to discharge.

The discharge capacitor in most photographic strobes has a capacitance of a few hundred microfarads. Since *C3* has a capacitance of only 8 microfarads, the flashtube will have a very long useful life. The brightness of each flash can be substantially increased if the capacitance of *C3* is increased to 20 or 30 microfarads. However, this slows the flash cycle to an unacceptable rate of only one flash every five seconds or so. If the value of *C3* is reduced to a few microfarads, battery life will be increased, but the flashes will be too dim for practical use.

The SCR in Fig. 6 is not always essential. The circuit you build can be triggered by the turn-on of the neon lamps alone. You can experiment by simply omitting the SCR entirely and trying different neon lamps. If the two lamps in series don't fire, try a single selected lamp. **ME**

Active Filters & Switching Power Supply Book From Motorola

By Harry L. Helms

Among the most popular applications of operational-amplifier ICs over the years has been in active-filter circuits. The term "active filter" denotes one in which some gain is part of the filtering process. In conventional passive filters, composed of inductors and capacitors, some degree of signal loss is inevitable. Moreover, passive filters are not suitable for use with weak signals since most of the input signal would be dissipated within the passive circuit.

Active filters overcome both of these problems. There are three main types of active filters: *low-pass*, *high-pass*, and *bandpass*. A low-pass filter allows all frequencies below a certain point to pass unimpeded but greatly attenuates all frequencies above that point (generally known as the *cutoff* or *bandstop* frequency). A high-pass filter operates in the opposite fashion, allowing all frequencies above a certain point to pass, but attenuating all below the cut off frequencies. A bandpass filter might be thought of as a combination of the two, allowing all frequencies within a certain range to pass, but attenuating all frequencies above and below that range.

Since most of the circuitry required for an active filter can easily be integrated in silicon, it was perhaps inevitable that active-filter ICs would appear. One company that has been a leader in this area is Linear Technology of Milpitas, CA. One useful device from it is the LTC1062 low-pass filter device. This device can process input signals from dc to 20 kHz and introduces very little noise across that frequency range.

The internal circuitry of the LTC1062 closely approximates a fifth-order Butterworth filter. An external resistor and capacitor are used to form a fifth-order "rolloff" at the output, which puts the filter outside the dc path to provide high dc accuracy. This makes the LTC1062 suitable for use in precision and instrumentation applications.

Cutoff frequency is determined by an internal clock circuit that can be externally driven. Attenuation is typically 30 dB/

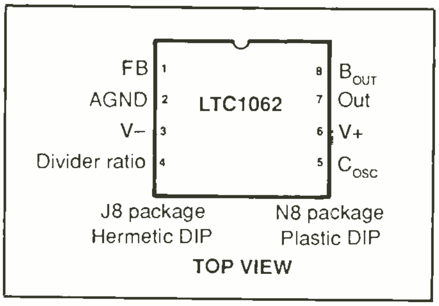


Fig. 1. Pinouts for Linear Technology's LTC1062 active filter.

octave, and the attenuation decreases as the clock and cutoff frequencies increase.

The LTC1062 can operate from a single +5-volt supply or from a dual-polarity source of up to +8 volts. Figure 1 shows the pin connections for this device. Pin 8 is the output of an internal buffer and forms an ac signal path with pin 1 (labeled FB). Pin 5 (COSC) can be used with an external capacitor connected from pin 5 to ground. (If the capacitor is a polarized type, it should be connected from pin 5 to pin 3, the negative supply voltage pin.) The capacitor lowers the internal oscillator frequency.

If pin 5 "floats," an internal 33-pF capacitor sets the oscillator frequency at about 140 kHz with a +5-volt supply. An external capacitor reduces the oscillator frequency by the formula:

(33 pF)/(33 pF + external capacitor value)

Pin 4 is the divider-ratio pin that controls an internal switched capacitor network so that the internal oscillator frequency is divided by 1, 2, or 4. The divider ratio is controlled by a voltage that uses the midpoint of the supply voltage range (i.e., 0 volt to maximum supply voltage) as a reference. For example, the divide-by-two "trip point" is typically ±1 volt from the middle of the supply-voltage range.

Linear Technology has developed several interesting applications circuits for the LTC1062. Figure 2 illustrates one designed to filter ac signals present in large dc voltages. This circuit is designed to accept a 100-volt dc input and will sharply attenuate all signal variations from pure dc. The internal clock is driven with an external signal of approximately 100 kHz. Note that despite the high input voltage, the supply voltage is a modest dual-polarity 5 volts.

The LTC1062 is especially suited for low-pass filters having extraordinarily low cutoff points. Figure 3 presents a circuit with a 5-*Hz* cutoff frequency. The two 10-microfarad capacitors are solid tantalum types.

The LTC1062 can also be used in *notch* filter configurations. A notch filter is a circuit that removes a very narrow frequency segment, or "notch," from an input frequency range. The clock frequency can even be used to tune the notch (the frequency of the segment that is rejected). The "clock-to-notch" frequency is 79.3:1, and it can be obtained by the circuit shown in Fig. 4. In this circuit, resistors *R3*, *R4* and *R5* are all 10K units. The

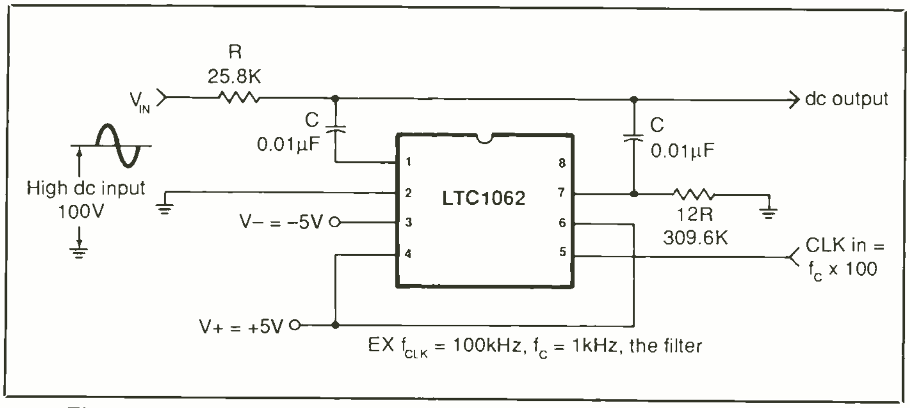


Fig. 2. An LTC1062 circuit that filters ac signals present in large dc voltages.

SOLID-STATE DEVICES...

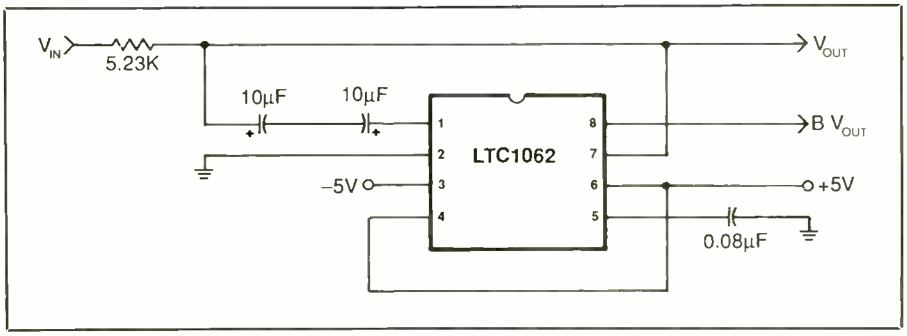


Fig. 3. A circuit with a 5-Hz cutoff frequency. The two 10-microfarad capacitors are solid-state tantalum types.

LTC1062 Specifications	
Supply voltage	Single-polarity +5V or dual-polarity up to ±8V
Input frequency range	0 to 20 kHz
Maximum clock frequency	4 kHz
Source or sink current	40 µA

values of the remaining resistors are found by using the formula:

R1/R2 = 1.234

clock frequency/notch frequency = 79.3/1

If precision 1-percent resistors are used in the Fig. 4 circuit, a notch up to 40 dB deep can be obtained.

Often, several different cutoff frequencies are needed from a single circuit. Figure 5 shows how a 74HC4052 multiplexer IC is used to switch various values of resistors in and out of the external RC circuit of an LTC1062. The circuit illustrated gives cutoff frequencies of 500, 250, 125, and 62.5 Hz.

There are many other fascinating applications of the LTC1062 contained in two applications notes from Linear Technology: "Application Considerations for an Instrumentation Lowpass Filter" (AN #20) and "Unique Applications for the LTC1062 Lowpass Filter" (AN #24), both of which are available from Linear Technology sales offices and representatives. You can also obtain copies by writing on your corporate or professional letterhead to Linear Technology Corp., 1630 McCarthy Blvd., Milpitas, CA 95053-7487.

New Exar Devices

Exar Corp. is another company offering "active filters on a chip." Its recently an-

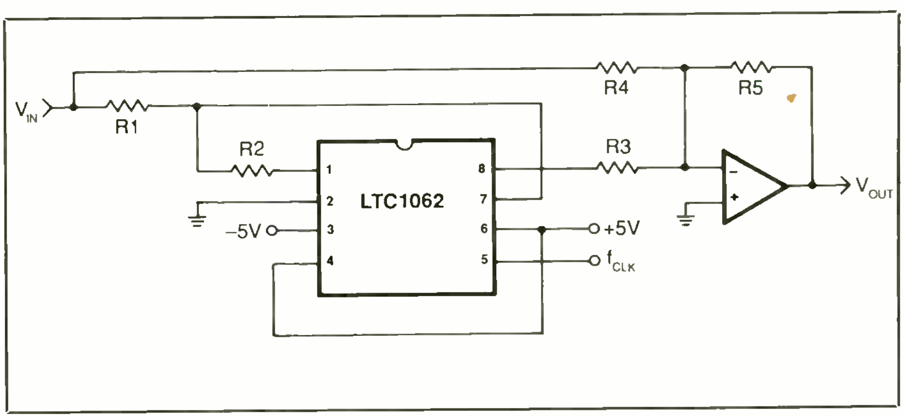
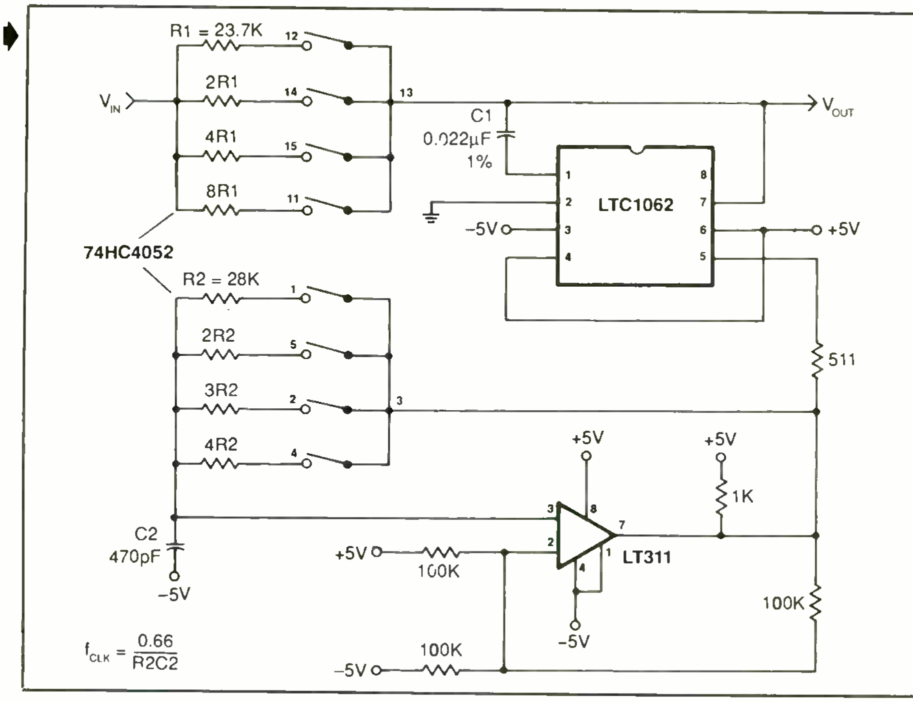


Fig. 4. Circuit arrangement for using the LTC1062 as a notch filter.

Fig. 5. Using a 74HC4052 multiplexer to give LTC1062 multiple cutoff frequencies.



nounced XR-1010 switched-capacitor filter is an interesting example of how versatile these devices have become. The XR-1010 can be configured as a low-pass, high-pass, bandpass, or notch filter with only external resistors and capacitors required to determine the operating mode and frequencies.

Like the LTC1062, the XR-1010 has its own internal clock; however, an external driving clock signal is required. The XR-1010 can be cascaded to produce even "sharper" filters. Complete information on this device, including design formulas, are contained in data sheet XR-1010 titled "Second Order Switched Capacitor Filter."

A device that is very suitable for providing the clock signal required by the XR-1010 is the XR-2209 precision oscillator. This is an integrated variable-frequency oscillator whose output frequency can range from 0.01 Hz to over 1 MHz. The frequency is set by an external resistor and capacitor. Both triangle and square-wave outputs are provided, and both outputs are highly linear. Complete information on this device can be found in data sheet XR-2209 "Precision Oscillator." Data sheets for both the XR-1010 and XR-2209 can be obtained from Exar Corp., P.O. Box 49007, 2222 Qume Dr., San Jose, CA 95161-9007.

Switcher Information

Switching power supply circuits and devices are the subject of Motorola's recent publication, *Switchmode: A Designer's Guide for Switching Power Supply Circuits and Components.* This 76-page book focuses on Motorola devices and technologies, but it is also a good basic guide to the theory behind and designing of switching power supplies. Request your copy from your nearest Motorola sales office or directly from Motorola Literature Distribution, P.O. Box 20912, Phoenix, AZ 85036. **ME**

Comdex: An Overview, New FAX Board, Laptop-Computer Battery-Monitor/Reconditioner Software

By Ted Needleman

I've just gotten back from the Spring Comdex in Atlanta, and I'm both impressed and just a little disappointed. Comdex is the premier trade show for those in the computer industry. Held twice a year, the Spring Comdex is usually in Atlanta at the Georgia World Congress Center (though it will be held in Chicago next year). The Fall show is always held in Las Vegas.

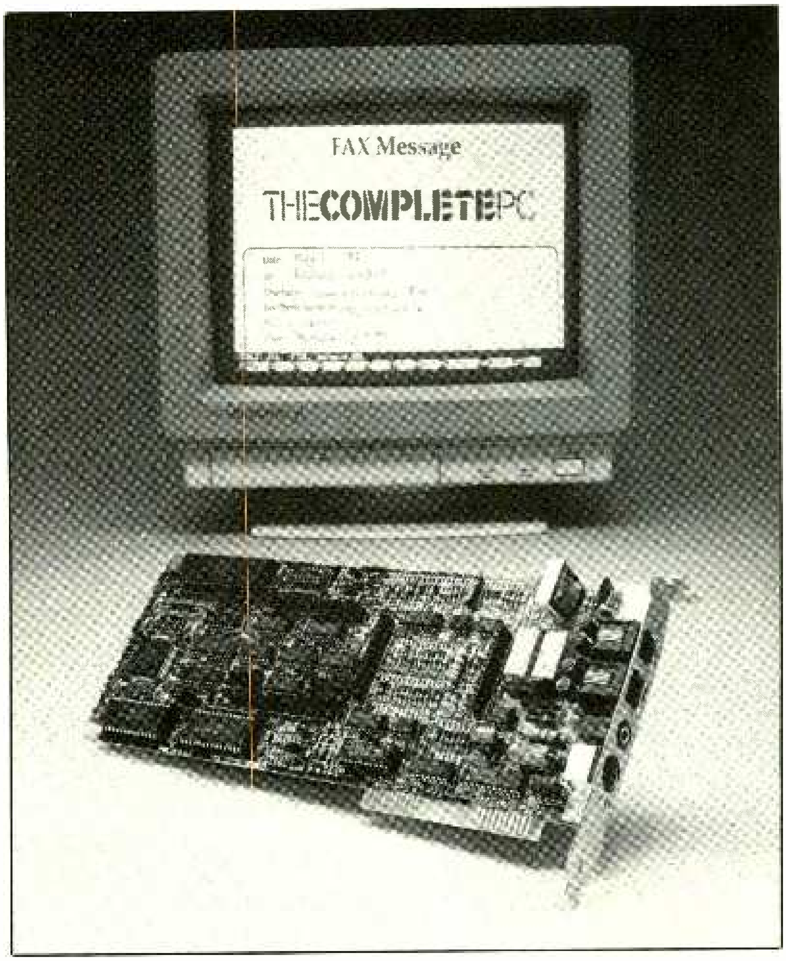
It's been a few years since I've attended a Comdex, and I'd forgotten how overwhelming it is to gaze out at a sea of booths. This year's show, the smaller of the two, set new records. There were over 850 exhibitors and an estimated 60,000 plus attendees.

Walking miles every day, and going from booth to booth, impressed me with both the size of the show, and the health of the industry. Journalists hope to see a few new products that will knock them right off their feet, of course. Sometimes this happens, sometimes it doesn't. The latter was true at this show.

While I did see (and requested to see) a few products that impressed me, the show and the industry at large seemed to be in an evolutionary, rather than revolutionary state. Many companies were displaying 80386-based machines. Just as the 286-based AT compatibles seem to have completely taken over from the original 8088-based PCs, 386 systems will soon be the "standard." In many cases, though, this will be overkill.

Computers using 80386 CPUs running at 20 and 25 MHz are fast, powerful, and (if you're not a Macintosh person) the best choice today for those running CAD (computer-aided design) or multi-user/multi-tasking software. But this power carries a price tag over and above the obvious initial cost of acquisition.

The CPU can support huge amounts of memory, but with RAM prices rising through the roof (prices on RAM chips have almost tripled in the last year), fewer and fewer of us can afford to load up on memory. Fast machines also call for faster (and costlier) hard disks and other peripherals. For many business users, the 386 computers offer a reasonable price/performance ratio, however.



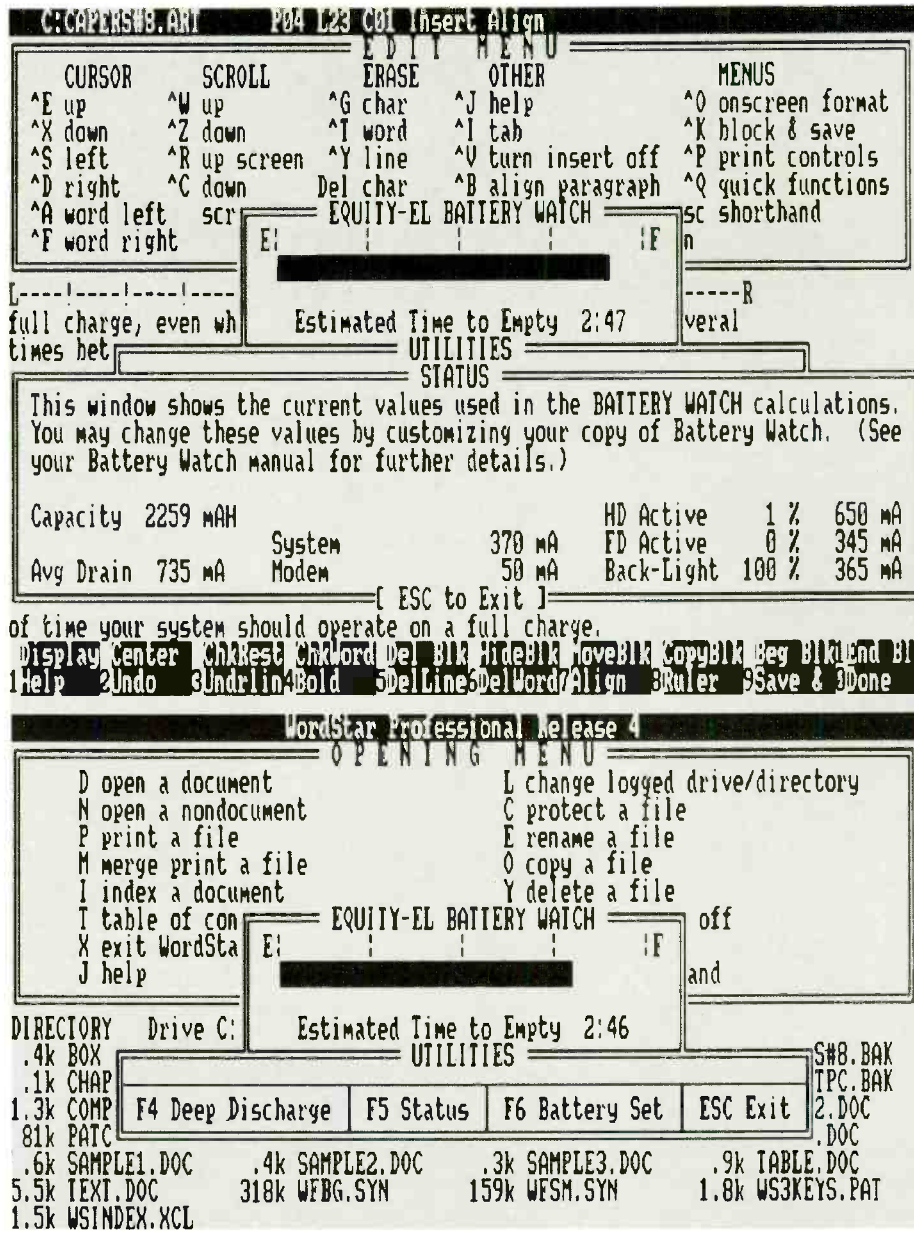
The Complete PC's 9,600-baud computer facsimile board.

I did observe several other interesting trends at the show. This looks like it may finally be the year of the laptop and/or portable. Although a handful of these systems have been around in one form or another for quite a while. Now it seems that almost every other booth at Comdex was displaying either a laptop or "Lunchbox" (Compaq III clone). Many of these were labeled as awaiting FCC approval, but I'd expect to see the prices really start to plummet on this configuration within six months or so. Those booths that were not showing portables or 386 systems, all seemed to be showing FAX boards.

Also very much in evidence was the new operating system from Microsoft and IBM—OS/2. First introduced last year by IBM for its new PS/2 systems, OS/2 promises to be the next major operating system for 286- and 386-based computers. It breaks both the 640K RAM memory barrier in MS-DOS, and the 32-megabyte disk partition barrier. It also offers true multitasking, a 16-megabyte real address space (with a 1-gigabyte virtual memory limit), MS-Windows like the Presentation Manager interface, and a host of other features. Unfortunately, to do all this requires at least 2, and preferably much more, megabytes of RAM, a large, fast hard disk, and at least EGA (and preferably VGA) level graphics adapters and monitors. A 32-bit-wide address and data bus, while not absolutely necessary, also helps speed things up. IBM designed a new type of bus, called Micro Channel, to support this. Announced prior to the show, and displayed at Comdex, were 386 systems from Tandy and Dell which use the new Micro Channel bus.

The cost of upgrading a current 286 system (a "standard" 8088 PC cannot run OS/2) will most likely preclude many of you from immediately switching over to OS/2. After all, it doesn't really offer all that much more to the average user. But "Power Users," those who really try to wring minicomputer level performance out of their desktops, are going to flock to OS/2, despite the cost.

One of the stranger things I noticed at Comdex were 8088/80286-based computers housed in Macintosh-type cases. These were exhibited in five or six different booths. While I agree that the Mac is cute and space-effective, these Mac impostors don't really make much sense to me. In fact, they remind me somewhat of the kit cars that were so popular in the '60s. You might remember these Fiberglas bodies that you bolted onto a VW chassis to convince everyone that your beat-up Volks was a $30,000 sports car.



Printouts from Traveling Software's "Battery Watch" TSR utility keeps tabs on laptop computer's battery condition. These printouts show the bar-type "fuel-gauge" display (center), along with estimated time to empty in minutes and seconds, when the program is called up.

The FAX

If you've been following this column, you might remember that I've been playing with a few computer facsimile boards over the last year or so. A specialized type of modem, they allow you to exchange facsimile messages with either dedicated FAX machines or other PCs equipped with a FAX board. Facsimile has been around for some time now but it appears that this year, fueled by the the availability of inexpensive upgrades for PCs, the industry is really going to take off. Several columns ago, I reviewed an inexpensive FAX board from The Complete PC. At the time, I was impressed with both its inexpensive price ($350) and its ease of installation and use. My only reservation was its speed, 4,800 baud rather than the more standard (and costlier) 9,600. Well, my reservation has been put to rest.

At Comdex, The Complete PC announced its newest product—a 9,600-baud version of The Complete FAX. Besides the 9,600-baud speed, the new board has some additional welcome features. A modem option provides a standard 2,400-baud modem, allowing you to communicate with bulletin boards and information services without eating another slot in your system. The new board also provides on-board ports for The Complete Hand Scanner, and an interface for Canon-based page scanners. This also frees up additional slots in your computer. The base price of the FAX board is $599, making it one of the least expensive 9,600-baud FAX boards you can buy. At the time I spoke to them, the price of the modem option and the Hand Scanner without its stand-alone interface were not yet established, but I'd expect them to be reasonable.

Watch This

Another company I visited with at Comdex was Traveling Software. They put out the LapLink package I reviewed in a prior column, as well as a complete catalog of accessories and software for laptops and portables. Introduced at the show was a new software package—Battery Watch. Using a battery-powered portable is convenient, but presents two major problems. The first is that when the "Low Battery" indicator starts to blink, you only have a few minutes of time remaining. If you don't shut down the system quickly, you stand a good chance of losing whatever you happen to be working on.

Most portables' documentation give some indication of what kind of time you can expect from a fully charged set of batteries, but this is an approximation at best, and can vary by as much as several hours. For example, the Epson Equity LT I've been using has a claimed battery life of five to seven hours on a charge, unless you have a hard disk and/or back-lit screen (which mine has). In this case, the expected use on a charge is "less."

So far, I've been averaging about two hours or so on a charge. This is definitely "less," but may be even shorter than it has to be because of a characteristic of Ni-Cds called "memory." In any case, with a two-hour active life, I had taken to leaving a label on the LT's cover to record use at each session. That way, I don't start something that I know will take an hour when I can expect only another half-hour of charge in the batteries.

Battery Watch is a terminate-and-stay-resident (TSR) utility that, when triggered with the "shift/alt/B" key sequence, pops up a fuel-gauge showing remaining time to full discharge. It keeps a running track of how long you've used the system since the last full charge, even when the system is powered up and down several times between charges. When you do recharge, you are asked to press the F10 function key as part of the autoexec power-up sequence.

Battery Watch supports about 10 different makes of laptops, and questions you during installation about the particular configuration of options (such as a back-lit screen and hard disk) your system has. The software knows the total capacity of the Ni-Cds used in each of the supported systems, and the current draw of each system and option. It calculates the total hourly current draw of the configuration specified, and divides the total battery capacity by this figure to determine the amount of time your system should operate on a full charge. The actual calculation of remaining time is made every two seconds of use, (and stored on disk) and the computer's configuration can be customized to more accurately reflect your particular set-up.

As mentioned previously, though, Ni-Cds don't always operate to their rated capacity. Nickel-cadmium batteries have two characteristics in which they differ considerably from carbon-zinc and alkaline cells. The first of these is their duty cycle. A Ni-Cd battery will perform its entire duty cycle at almost the same output. At the end of the duty cycle, the output falls off abruptly to almost nothing. The carbon-zinc and alkaline batteries will run down gradually as they are used.

The second Ni-Cd characteristic is called "memory." If you constantly recharge a Ni-Cd cell at the same point in its discharge cycle, it will "remember" this point as the end of its duty cycle and "think" that it needs to be recharged. While the Ni-Cds in my Epson may actually have a rated duty cycle of three hours, I tend to recharge at about two hours or so. In effect, it appears that I've "trained" my laptop to a shorter life.

Happily, this problem can be solved by subjecting the Ni-Cds to a deep discharge—running them until they are flat-out dead, and then recharging them to full capacity. This often has to be done several times. Battery Watch has an option to do this. It takes control of your system and forces the computer to run until the battery's power is exhausted. Then you recharge for the recommended number of hours and, hopefully, find you've convinced your battery pack that it can last longer than it thinks it can.

Sometimes, you'll need to deep discharge several times. I've run through the deep-discharge cycle once, and added another 15 minutes or so to the cycle, but it looks like it will take another time or two before I get the three hours of use Battery Watch says my Epson LT should have.

Traveling Software's Battery Watch is certainly a cleverly designed utility, and at $39.95 it's a good value to those of you who use a laptop the software supports. The company is always updating its software, so rather than listing the computers, I'll advise you to give them a call to see if your particular system is supported.

ME

Company Names & Addresses

9600 Baud FAX Board
The Complete PC
521 Cottonwood Drive
Milpitas, CA 95035
800-634-5558
408-434-0145 in CA

Battery Watch
Traveling Software
19310 North Creek Parkway
Bothell, WA 98011
206-483-8088

LETTERS...

(from page 7)

not all are willing to fill a glass vacuum thermos with the stuff, though they have no qualms about filling a stainless-steel thermos bottle.

Finally, it's generally safer if liquid nitrogen splashes on bare skin than onto clothing, since it quickly "boils" away on contact with warm flesh. If you use protective gloves to handle the liquid nitrogen, use rubber or another waterproof type.

Gordon McComb
Canoga Park, CA

Erratum

• While going over the "Vocal Warning Burglar/Car-Theft Alarm" in the February 1988 issue, I noted a couple of discrepancies. One is that pins 7 and 15 of IC8 in Fig. 1 are shown connected directly to ground, which is not reflected in the pc guide in Fig. 3. The other is that C7 and C24 are listed twice in the Parts List, both times with different values. Can you clear up these discrepancies?

U.N. Owen
New York, NY

Delete from Fig. 1 the line that connects the two pins to ground. The only connection for these two pins should be back to the C13/R16 junction. The correct value for both capacitors is 0.1 microfarad.—Ed.

Printed-Circuit Boards

• A finalized design for a 6″ × 6″ double-sided printed-circuit board for my "Printer Multiplexer" (June 1988) is now ready. This board is designed to accommodate Centronics-type Champ connectors for hookups to the computers and a ribbon cable to a terminating Champ connector that plugs into the printer. Cost of the commercial version of the board is higher than I had anticipated; so I will have a batch made only if there is enough interest. My source will make 25 boards that can sell for $22.75 each (less if there is more interest). Therefore, if any reader is interested in obtaining this board, let me know. Please do *not* send money now! If I receive at least 25 responses, I will write back to let you know what the final cost will be and only then request payment.

Brian Beard
Lucid, Inc.
P.O. Box 292
Mary Esther, FL 32569

Xerox Ventura Publisher For Professional Page Layouts

By Art Salsberg

The Xerox Ventura Publisher (*XVP*) software package for laying out pages of text and graphics with a personal computer is a leader in the desktop publishing field. We worked with its upgraded version 1.1, a page-composition program that consists of 11 non-copy-protected disks in a neat disk container that has a plastic control knob to push each succeeding disk upward for easy handling, plus beautifully produced manuals. Its suggested retail price is $895, though discounts often exceed 40 percent.

XVP runs on IBM PC/XT/AT/PS2 machines and other true compatibles. At least 512K is required, though 640K is recommended. You also need a hard-disk drive with from 1 MB to 3 MB of free space, depending on printer drivers and fonts being used, plus a mouse pointing device. Equipment used to examine the software program were XT- and AT-compatible computers; monochrome, CGA and EGA color displays; Epson and Okidata 9-pin dot-matrix printers (Ventura doesn't support 24-pin printers); a Hewlett-Packard LaserJet II laser printer; and Logitech's Logimouse C7 pointing device.

Ventura Publisher Overview

Originally released in late 1986, the latest version, Release 1.1, incorporates a host of enhancements. These provide greater support for imported graphics, text and printers, as well as improved interactive page-composition capabilities, among other new benefits that total 80 additional features. Furthermore, three correction patch disks were made available December '87 to registered owners to take care of minor bugs discovered, nearly half of which relate to support of the PostScript page description language.

Xerox Ventura Publisher is one powerful program! It provides users of IBM PC, XT, AT, PS/2 and compatibles with the efficient means to choose and manipulate type, add artwork and photos (the latter requires using an image scanner), and combine text and graphics to one's liking for page layouts. Furthermore, its compatibility with various hardware and software is incredibly wide. And as powerful as *XVP* is, it can even be used well with a slow 8088-CPU personal computer, high-density floppy disk drives and an Epson dot-matrix printer (after erasing 260K of sample files), though a speedier computer system, hard-disk drive and laser printer is preferable.

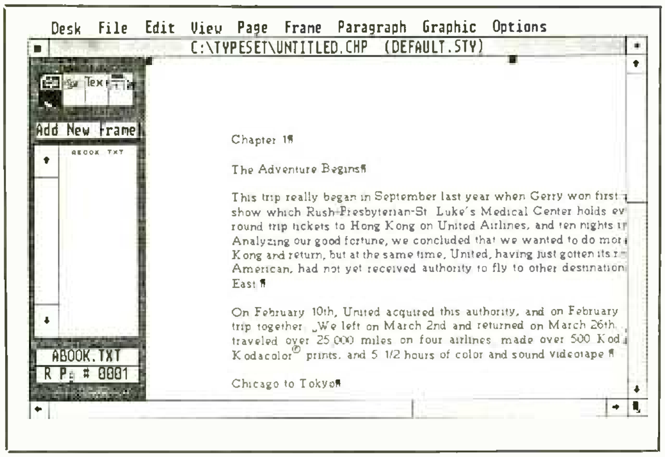
The program's versatility is almost boundless. It can import and export files from a vast number of application programs, such as WordPerfect, WordStar, Xywrite, Lotus 1-2-3, PC Paintbrush, ASCII files, and on and on. It can drive a battery of different printers, from Hewlett-Packard's LaserJet to Apple's Laserwriter, and even low-cost dot-matrix types, as well as PostScript and Interpress typesetters. It accommodates full-page video displays such as Xerox's and MDS Genius, too.

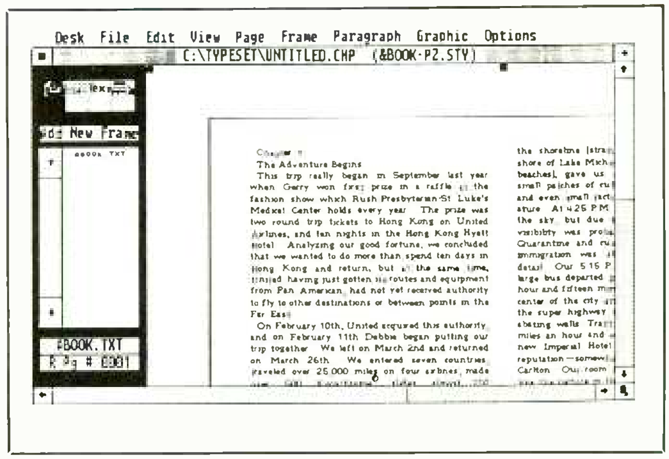
Among its many outstanding features are *XVP*'s "style sheets." These represent common publishing applications, such as layouts that can be loaded for books, brochures, technical manuals, magazines, newsletters, financial tables, invoice forms, letters, proposals and reports, etc. Moreover, style sheets can be modified to suit a particular need. It all makes desktop publishing life immeasurably easier since one does not necessarily have to design documents. This is further enhanced by the availability of an enormous range of type faces, sizes and styles (limited by the chosen printer's ability to produce them, of course).

The screen face of *XVP* makes use of Digital Research Inc.'s GEM interface, giving it a Macintosh-like appearance. All the helpful pull-down menus one could wish for are there to click on with a mouse (or key in the highlight bar with cursor-movement keys and Enter). And screen matter is displayed as WYSIWYG (what-you-see-is-what-you-get), so the final print output will not come as a surprise. (There'll likely be some minor differences, naturally, since video displays and printers do not share the same display capabilities.)

With some 80 features that are only additions to its original release, imagine how much space it would take to cover everything that *XVP* can do.

Just tapping only some new enhancement highlights are a word-processor converter for IBM's Document Content Architecture; graphics converters for





(A) Xerox Ventura Publisher's main screen. The large, blank area is the working section that contains the underlying page frame. Clicking a mouse on the Frame-Setting icon in the function box (the first icon among four in the upper-left corner) turns the box from white to black). Loading a file from a word processor, causes the text to be displayed in the work area, as shown. A style sheet selection can be made if one wishes, which would automatically reformat the text in the manner desired. In this case, it automatically converts to a two-column format, as illustrated in (B). Clicking on the second icon in the Function Box sets up for the "tagging" of matter to produce different type, say, a large-size type face for a chapter title, another size and weight for a heading, etc. The change effected is shown in the dot-matrix-printed sample shown on the next page. In the normal view shown, you won't see the entire page. However, selecting the View menu gives you the option of seeing all the material in a reduced form. In this two-column format, you'd see two columns, but the text would not be readable in the interest of increasing redrawing speed. If it were a full page being reduced, text would likely be readable.

A Little History

Let's take a brief historical tour of Xerox Corporation's accomplishments in areas related to computerized publishing. As we all know, the company came to the fore with the xerographic process that revolutionized office work, eliminating the need for those finger-smudging carbon papers. It's a business enterprise that can be pointed to with pride for its creativity and marketing acumen. Nonetheless, Xerox missed the boat in some computer-oriented areas that it originated.

For example, did you know that Xerox dominated the laser-printer field in the early Eighties with models that started at $18,000 and moved up to almost $½-million? But it did not recognize the prospects of quickly expanding the laser-printer market with more modestly priced (and lower-performance) models. It left that to Japan's Canon, whose semiconductor-laser and drum system was the heart of Hewlett-Packard's $3,500 LaserJet Series II laser printer (and reviewed in *Modern Electronics*, June 1988) that burst on the scene four years ago.

The Apple Macintosh graphics concept, too, was derived from developments made by Xerox Corp. at its Palo Alto Research Center, but never carried forward to a moderate-cost computer system. It did it once more in the software field with its Interpress document-description language, also developed at PARC. This is a very efficient device-independent program that supports very-high-performance printers that can print complex matter up to 120 pages per minute! It's said to be the model upon which the popular PostScript programming language embraced by Apple and others (and Xerox Ventura Publisher's chief competitor) was based.

Cannot Xerox, one wonders, point some of its products to the great unwashed? Well, maybe it can't bring itself to go all the way down to the "low end," but it [is] a major player in the relatively new microcomputer desktop publishing field with its $895 list-priced (often sold for around $500) Xerox Ventura Publisher. It competes in a large MS-DOS desktop software pool that ranges in price from less than $100 to about $8,000.

It runs neck and neck with Postscript as the largest-selling desktop page-making software on the market today. Lower-priced packages are beginning to breathe down its neck, however; at least in number of packages if not dollars. Will Xerox wind up losing its front-runner status as it sometimes has in the past with some of its developments? It may well have its present market share reduced if it does not produce a junior version of *XVP* that sells for much less for people who do not need as much page-composing power. At this juncture, however, the Xerox Ventura Publisher is certainly one of only a very few choices for anyone who plans to do truly serious page-makeup work on an IBM or compatible microcomputer.

HPGL, Macintosh, and Dr. Halo; a new capability of cropping line art as well as images; converting HP soft fonts to Ventura files; varying PostScript font size from 1 to 254 points; handling downloaded PostScript fonts and converting Adobe screen fonts; substantially decreased PostScript printer's print time and optional removal of PostScript prologue to speed print time further; printing left or right pages only; anchoring pictures to a point in text; increased text file size from 150K to about 500K per chapter; installation changes without reinstalling from scratch; number of chapters per publication increased from 64 to 128 and text and picture files per chapter also from 64 to 128; increased tags from 64 to 128; support for alternate paper tray and manual-feed paper; etc.

A compatibility guide (dated March 15, 1988) for *XVP* numbers 14 pages, which will give you some idea of the large number of programs, printers and displays handled by this astoundingly versatile desktop publishing software.

In-Use Comments

Installing *XVP* 1.1 isn't a quick job since a host of disks have to be switched as one goes along. Furthermore, some have lots of data on them that floppy-disk drives just cannot handle speedily. In most instances, though, all 11 disks do not have to be used. (A set of six 3½-inch diskettes is also available as an upgrade package for $35.) Moreover, installation, bolstered by an automatic installation procedure, is easily accomplished, time aside. All the GEM files are set up in one directory as compared to the original version's multiple directories.

Once installed and loaded by typing "VP," *XVP*'s main screen is displayed, most of which is a large blank work area. About 20% of the screen is taken up by a full vertical section at the left that contains function boxes for the user to choose by clicking a mouse cursor on one, such as a graphic-drawing icon or text-editing icon, file-name listing, and other information. Framing the rest of the display's perimeter are narrow full-length areas that contain other information such as the menu line from which options chosen activate dialog boxes that offer selections that'll produce pull-down menus; scroll bars, title bar, etc.

> **Chapter 1**
>
> **The Adventure Begins**
>
> This trip really began in September last year when Gerry won first prize in a raffle at the fashion show which Rush-Presbyterian-St. Luke's Medical Center holds every year. The prize was two round trip tickets to Hong Kong on United Airlines, and ten nights in the Hong Kong Hyatt Hotel. Analyzing our good fortune, we concluded that we wanted to do more than spend ten days in Hong Kong and return, but at the same time, United, having just gotten its routes and equipment from Pan American, had not yet received authority to fly to other destinations or between points in the Far East.
>
> On February 10th, United acquired this authority, and on February … We left on March 2nd … countries, traveled over … dachrome® slides, almost … and sound videotape.
>
> **XEROX Ventura Publisher, Version 1.1**
>
> **Demonstration/Training Software**
>
> …here over the Western Pacific, we are 8 hours and 42 minutes out of Los Angeles with about 2 more hour to go to Tokyo. We were about an hour and ten minutes late out of Los Angeles.
>
> Travel Log
>
> So far, it's been a long and interesting day and I guess it's just about half over. We did the following:
>
> Arose at 5:30 A.M.
>
> Left the house at 7:00 A.M.

A printout of an example text that used tags to change typography for "Chapter 1" and "The Adventure Begins" (the latter with an underline) from the body type was produced on an ordinary 9-pin dot-matrix printer. New pages are generated automatically to hold more text, retaining heading formats established (unless changed by the user). PG UP and PG DN keys allow one to easily shift between pages.

Accompanying the three-ring reference binder supplied with the software are a training-guide manual and a quick-reference handbook. Both are spiral bound, and the latter is on heavy, coated stock that has index tabs. We used the training guide extensively to familiarize ourselves with the in's and out's of Xerox Ventura Publisher.

Some reviewers have commented on how difficult it is to learn how to use *XVP*. Working with it, and following the guide, indicated that it's as learnable as any very powerful program is. That is, getting it up and running is not an overwhelming challenge. Naturally, there are more advanced twists and turns than anyone can easily get into and remember. It's this type of great power that attracts people to such programs in the first place, although utilizing it to its fullest can never be considered simple. The basic workings of the program were easily followed, however.

As with all popular programs that are very versatile and have many advanced capabilities, a number of fine applications books devoted to Xerox Ventura Publisher provide many helpful pointers. Furthermore, Xerox has 22 *XVP* training centers around the country for users to learn everything from basics to advanced maneuvering of the desktop publishing program. Nothing works better than actually using such a program over a period of time, of course.

A print job with a desktop publishing system begins with typing and editing text with a word processor, whether it's WordPerfect or another familiar favorite. *XVP* has its own built-in word processor, too, though it's naturally more limited than full-blown ones. It's especially useful when editing or rewriting matter that's been prepared and saved in the format used by your external word processor. Preparing copy on an external word processor, one simply imports the files to Xerox Ventura Publisher. (Its correct, full name is *Xerox Desktop Publishing Series: Ventura Publisher Edition.*) Changes made in the text by the internal word processor are automatically reflected in the external word processor, and vice versa, a convenient time saver.

XVP also incorporates a drawing package to simplify making different line-box shapes, callout lines, etc. Icons give you a variety of automatic choices, such as rectangle, box text, line, and rounded rectangle. The program's graphics capability is extended to artwork created with many other programs and images that are digitized by a scanner and converted to PC Paintbrush or GEM files.

A page layout is started by creating a frame for the page and then filling it with matter, such as text from a word processor or combining it with pictures. Smaller frames can be created within the main frame, too, with whatever selected margins and column settings you wish, as well as different type faces. You can set up matter with a wide choice of type styles, weights, margins, number of columns, alignment, indentation, rule lines, character spacing (kerning), and so on, that are automatically carried forward to succeeding pages unless a change is desired. Other *XVP* automatic functions simplify work, such as automatically upgraded figure numbers, page-count numbers (in Arabic or Roman numbers, letter characters and even spelled-out numbers).

The program offers automatic indexing, hyphenation, table of contents, and table of figures, among others. It also enables the user to collate printed pages, choose double-sided page printing, any width rule and border, select from among six paper sizes up to 18 X 24 inches, and many more options too numerous to list here. One that most people will not use at this time, but is wonderful to have in the bag, is the capability of selecting eight colors (including black and white) for printing on a color printer. Shaded backgrounds can be dropped in as well.

Choosing typographic attributes is performed by "tagging" paragraphs or phrases within them with your format selections. As you work along, you can view single pages you create in their actual size or enlarged size (doubled), as well as facing pages.

It all moves along beautifully due to the well-thought-out program that leaves little that can be wished for. Background utilities, such as Sidekick, cannot be used, however.

In short, Xerox Ventura Publisher has set a high standard for microcomputer desktop publishing software, whether used for creating professional-looking single pages or a thousand pages for a monumental book. Combining relatively easy use for a powerful program, the capability of doing virtually anything that one can wish to do to enhance printed pages, great compatibility with printers and other software programs, and marvelous manufacturer and third-party support, the Xerox Ventura Publisher is clearly a top-notch production.

Though it can be used well for creating only a page or two, it truly shines when a large volume of pages are being produced. Here's where its automatic features really save time. If you want one of the best, and intend to make use of its great versatility for producing outstanding page composition that also features good operational speed and a typeset look on IBM or compatible personal computers, *XVP* is highly recommended. It is really moderately priced considering everything it offers. **ME**

CIRCLE 48 ON FREE INFORMATION CARD

CIRCLE 30 ON FREE INFORMATION CARD

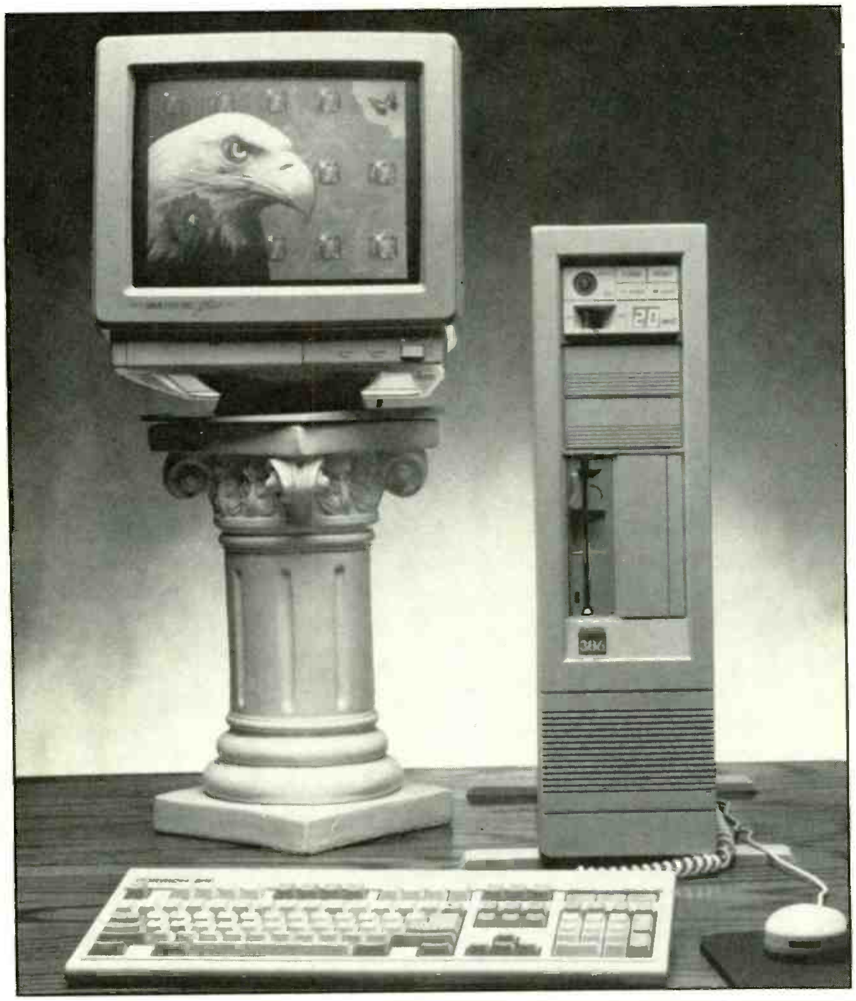
Comdex Atlanta

By Curt Phillips

Evolution, not revolution, was the rule at Comdex Spring in Atlanta's World Congress Center. The biggest splash was made by a plethora of new, fast machines based on the Intel 80386 microprocessor chip. The novelty was not that these machines exist, but that it seemed as though everyone with a garage and a soldering iron was manufacturing one.

Though NEC, Acer (formerly Multitech), Fortron and several other companies were showing their new 20-MHz '386 machines and comparing them to the "industry standard" Compaq Deskpro 386/20, a real battle of words was being waged among the several companies that were touting their machines as the "world's Fastest." One marketing executive got quite upset when I told him that his was the fourth different "world's fastest" PC I has seen that day.

While Micro 1 claimed that its Model 90 was the fastest, Systems Integration Associates (SIA) was touting its 386/25 as the winner. The SIA 386/25 features a 25-MHz motherboard with cache memory using 64K of 20-nanosecond static RAM, which allows it to operate at a zero wait state. The SIA supports both the Intel 80387 math coprocessor (20 MHz or 25 MHz) or the higher-speed Weitek 1167 coprocessor daughterboard. Micro 1's Model 90 operates at a 20-MHz, zero-wait-state speed and also features a 64K static RAM cache and support for the 80387 math coprocessor.



The Fortron 80386 computer uses an Intel 80386 microprocessor that operates at a 20-MHz speed. This is just one of many new '386 machine introductions.

Wading into the fray against these two speedsters was the Everex Step 386/25, claiming a Landmark CPU speed test rating of 41.0 (compared with the Deskpro 386/20's 32.5 rating). The Everex uses a 128K static RAM cache.

Caching

Caching has been widely used to speed up the apparent throughput of hard disks by loading the data from the most recently used disk sectors into dynamic RAM, providing faster access.

Now that the 80386 microprocessors are outrunning the dynamic RAM, static RAM caching has come into vogue. Since computer programs have a tendency to access the same RAM addresses repeatedly, these cache systems use ultra-fast static RAM (20-nanosecond in the SIA machine) to store data from the slower dynamic RAM. If the program seeks the same address again, the data is read from the static RAM with zero wait states, circumventing the multiple wait states that dynamic RAM can require.

With the availability of the Intel 82835 cache controller chip, manufacturers have on one chip everything needed to set up static RAM as a cache. The 82835 even has the ability to intelligently manage the cache, rather than simple-mindedly storing just the most recently accessed data, thus improving performance even further.

Although many system designers have found the 82835 to be optimal for disk caching, the team at Everex designed its own caching system, which they say is superior to the Intel chip and reportedly contributes to superior performance.

Battle of the Buses

The introduction of the IBM PS/2 Models 50, 60 and 80 last year threw the PC world into disarray, since their Micro Channel bus architecture is totally incompatible with the PC and AT bus.

A modification of this bus structure is required for the 80386 machines because without full 32-bit access to memory, their performance is significantly degraded. Indeed, as explained above, even under ideal circumstances, access to dynamic RAM can slow the machine down.

Beyond the question of 32-bit access to memory, the Micro Channel architecture (MCA) provides arbitration for the coprocessor boards that future applications may require. But, of course, some parts of the MCA are patented and must be licensed from IBM.

Compaq has more or less ignored the coprocessor question in its Deskpro line by retaining the PC/AT bus and adding a special 32-bit slot for memory expansion. Tandy and Dell Computers (PCs Limited) have meekly agreed to pay the licensing fees and announced MCA PS/2 clones.

AST Research has created, in its SMARTSlot bus architecture, a true rival to the MCA. The SMARTSlot is what the MCA should have been, providing full downward compatibility with PC and AT boards while providing the bus arbitration logic needed for coprocessor boards and allowing for 32-bit memory expansion.

To encourage other companies to adopt the SMARTSlot architecture, AST has provided complete design specifications to every manufacturer that has asked for them. Unfortunately, AST officials at Comdex didn't know of any other companies that were planning to use the SMARTSlot. As I looked over the myriad of '386 offerings, the overwhelming majority followed the Compaq example by sticking with the PC/AT bus and offering a 32-bit memory-expansion slot. A few of the '386 microcomputers used Compaq-compatible memory boards, but most used memory boards that are unique to their machines.

In the near term, the lack of an open 32-bit bus standard won't have major impact. So far, the Micro Channel architecture incompatibilities have caused far more problems than it has provided advantages. But as microcomputer applications become more sophisticated and complex, such a bus structure will be needed. And if that whole arena is controlled and licensed by one company, the price competition that has led to affordable PCs won't be repeated. I don't think it's too late to establish a viable alternative to the MCA. But I do think time is running short.

Dauphin's LP-286 laptop, based on a 12-MHz 80286 microprocessor and carrying a retail price tag of only $2,695 for a 20-megabyte or $2,995 for a 40-megabyte hard disk version, could cause some manufacturers to change the pricing for their laptops.

Laptops

High-power microprocessors, big hard disks and lower prices were the features that were getting attention among laptop aficionados at Comdex Spring.

Zenith Data Systems, a leader in laptop systems, unveiled the TurbosPort 386, a portable 80386 machine with a 40-megabyte hard disk. With a 12-MHz 80386 chip and 2 megabytes of RAM, it can't compare with the blazing speed of the previously mentioned '386 machines, but it's a very powerful portable. Note: Despite clever photographs that make it appear so, the TurbosPort 386 is *not* a laptop. However, it can be powered by a battery for about a half hour.

Laptop users are now asking for more hard-disk storage and several companies met these wishes by offering 40-megabyte hard drives as options. Included in these were the Zenith SupersPort 286, which offers a 12-MHz (zero-wait-state) 80286 microprocessor and 1 megabyte of RAM with either a 20- or 40-megabyte hard disk. It also features a 1.44-megabyte 3.5-inch floppy drive. The 40-megabyte version will retail for $5,599, the 20-megabyte at $4,999.

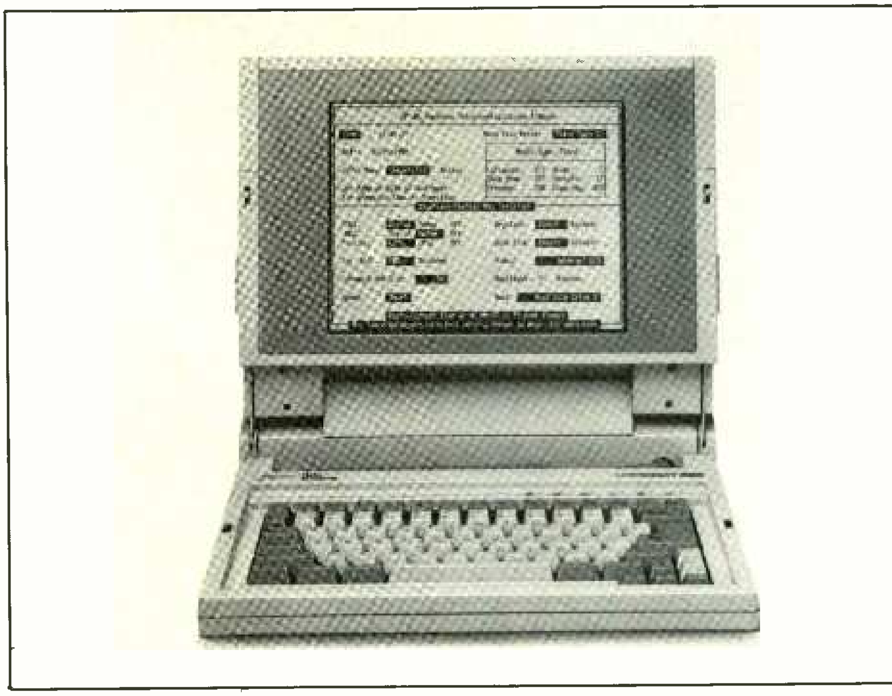
Although the Zeniths are high-quality machines, the value leader must be the Dauphin LP-286. The LP-286 offers a 20-megabyte hard disk, a 1.44-megabyte 3.5-inch floppy, and a 12-MHz, one-wait-state 80286 for a $2,695 retail price. A 40-megabyte hard-disk version will retail for $2,995. At about one-half the cost of a Zenith, this computer could be a real deal, if it is reliable, etc. I saw one operate for about 10 minutes and it looked fine, with a nice back-lit supertwist LCD screen, but being a laptop is tough duty. If it can stand the rigors of day-to-day use, the LP-286 could cause some price modifications among the other laptop manufacturers.

I noticed that Dauphin Electronics has the same address and telephone number as Fusion Electronics, which introduced an 8088-type laptop. I guess low prices always make me suspicious.

Of course, low prices and good deals are not always synonymous. Amstrad was showing its PPC640, an 8-MHz 8086 portable machine with a full-size keyboard and an internal 2,400-baud modem included for $1,199. Still, it was a very awkward design for a portable. Its screen is very hard to read because it is small and is not back-lit. Despite its low price, I think you could find a better deal on a used machine from someone who wants to upgrade to a 286 laptop.

Apple/IBM Marriage

With all the hoopla about microcomputers using fast 80286 and 80386 processors, it at first seemed odd to me that Cordata would introduce a machine whose distinguishing characteristic was IBM PC and Apple II compatibility. I joked with the Cordata public relations representative that the WPC Bridge was a perfect marriage of two obsolete technologies.



Zenith Data Systems' TurbosPort 386 is a portable computer built around a 12-MHz 80386 processor, 2 megabytes of RAM and 20- or 40-megabyte hard disk. Though it can be operated on battery for about a half hour, it is not a true laptop computer.

Yet, as I though about it some more, the WPC Bridge could make sense for some people. As Cordata says, the programs written for the IBM PC and Apple II comprise the world's two largest software libraries. This software encompasses just about every game, educational program, and business program you would ever need.

I don't like the fact that they built the monitor into the computer case, but if you want to run both Apple II and IBM PC software, this machine is definitely worth a look.

If you already have a PC-type machine, Diamond Computer Systems offers the Trackstar, a PC expansion board that will enable you to run Apple II programs.

VGA Cards

If everyone with a garage and soldering iron is making '386 machines, almost as many companies were showing "true 100-percent hardware- and software-compatible" VGA cards.

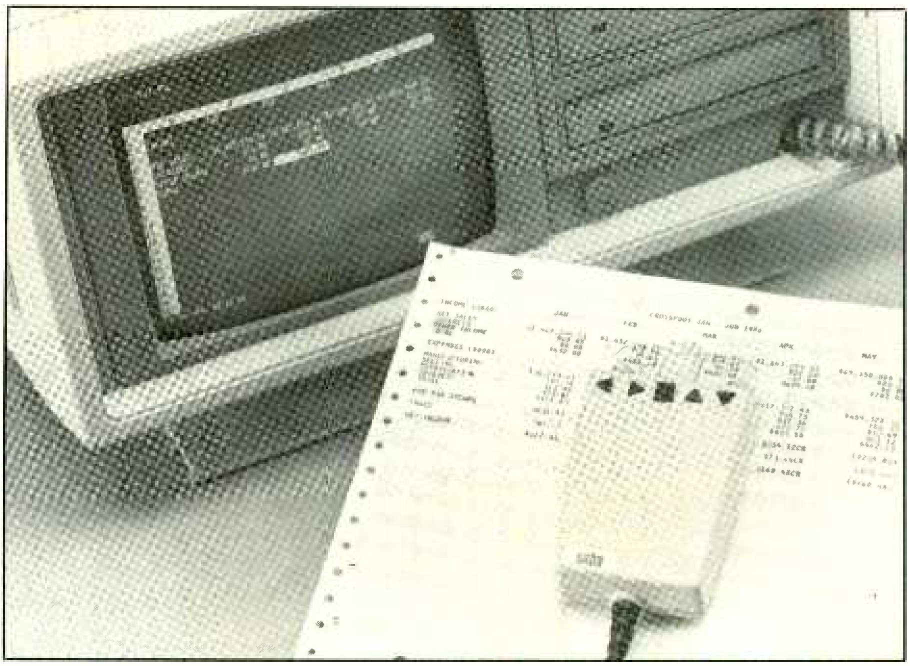
At the Show, it seemed that the video card market was segmenting itself into the color card for the masses (CGA) and the color card with the best "standard" resolution (VGA), with the old EGA standard left out. Nonetheless, with the low prices being charged for EGA boards, several vendors reported that EGA card sales were brisk.

Although EGA cards are relatively inexpensive, EGA-resolution monitors are only slightly less expensive than VGA-compatible MultiSync-type monitors. With video standards in a state of flux, this is a bad time to spend a lot of money on a type of system that may soon be abandoned.

Your comments and suggestions are welcome. You can contact me through The Source (BDK887), Delphi (CURT-PHIL), CompuServe (73167,2050) or at P.O. Box 678, Garner, NC 27529. ME

SABA Handscan: Reduces Keyboard Entry Work

By John McCormick



If you have ever been faced with page after page of typed addresses or tables of figures that needed to be transferred to your computer programs, you know that this would normally be the start of the most tedious of computer jobs. But the $650 Saba Handscan examined here may offer an affordable alternative to this drudgery. (Upgraded software, Version 3.0, has been introduced, along with a price increase to $799, but we were unable to get a test copy. Its enhancements include an ability to read documents generated by many line printers, support for the new IBM keyboard and expanded character substitution options. There's no upgrade charge for registered Handscan software Version 2.0 used for our test.)

The Handscan from Saba Technologies (Beaverton, OR) is an optical scanner about the size of a large mouse, capable of reading text and numbers directly from typed material into your MS-DOS computer.

This means that you can transfer numbers into spreadsheet cells or text into database fields by merely moving the cursor to the cell and passing the scanner across the data.

Optical Character Recognition has advanced from only reading those funny marks on the bottom of your checks to scanning nearly any typewritten or computer generated text, with some expensive scanners even able to read the typeset material found in magazines or books.

Unlike image scanners, OCR scanners don't stop after capturing an image; their software compares the scanned image with stored images to convert it into the appropriate ASCII symbol.

Description

The five-button Handscan comes with a 7-foot-long cord that connects to a full-length card you install in any IBM PC, XT, AT, or compatible computer.

The Handscan isn't currently available for Tandy 1000 or IBM PS/2 Model 50, 60, or 80 computers (although it will work with the PS/2 Model 30 and other Tandy MS-DOS computers).

The SABA unit itself can run in a 256K RAM computer, but since it is designed to work with a spreadsheet, word processor, or database, you really need about 640K to run both the Handscan and your applications software. As usual, a hard disk will make life easier, although it is not absolutely required. As long as you have about 220K RAM free after loading DOS and your favorite application software you probably have enough memory already.

In addition to the "scan" button that activates the scanner, there are four programmable buttons on the hand unit. When used with the scan button, it can be used to perform up to eight functions, such as moving the cursor, inserting symbols (@#$%&), emulating the TAB or ENTER key, or doing nearly any other job that would let you continue scanning without moving back to your keyboard, including starting program macros.

Although the SABA documentation only lists about 24 different type fonts which are directly supported, this is not the whole story. In tests, I found that the software can read a number of other fonts that are not listed but whose character shapes are close enough to standard fonts to be recognizable.

The SABA Handscan can read some laser printer output, but only that which emulates normal typewriter and daisy-wheel printer output; the SABA Handscan won't read any proportional pitched type fonts or microjustified text, either. So the Handscan can't read books, magazines and newspapers, which are normally typeset.

Operation

Installing the SABA is simple; just insert the full-length board in your IBM PC or compatible computer and run the installation program.

The software works with most programs including Lotus 1-2-3, Multiplan, and Supercalc spreadsheets; and dBASE, R:BASE, and Paradox databases, among others. It is also compatible with DESQview (windowing environment), Sidekick, and Superkey.

It is *not* compatible with SAMNA Word III, XyWrite, MS Windows, or the Leading Edge word processor.

A full 640K of RAM is recommended for using the SABA Handscan, as cited earlier, because it is a memory-resident program. You also need room for DOS as well as your applications program. With all features loaded, SABA uses

220K RAM, but this can be reduced to 160K if necessary in a crowded system.

The program files take up 190K of floppy or hard disk space, with an additional 80K disk space needed for each font file loaded (you would not normally load more than one or two font files from the supplied selection).

In most cases, this is all that is needed, but if there is an address conflict (two I/O devices set to the same memory location) the Handscan's I/O address is easy to change using DIP switches on the expansion board.

The documentation is clear and straightforward, including samples of the supported fonts for comparison with your material. There are even sample documents included so you can test out your installation without worrying if you have selected the correct font.

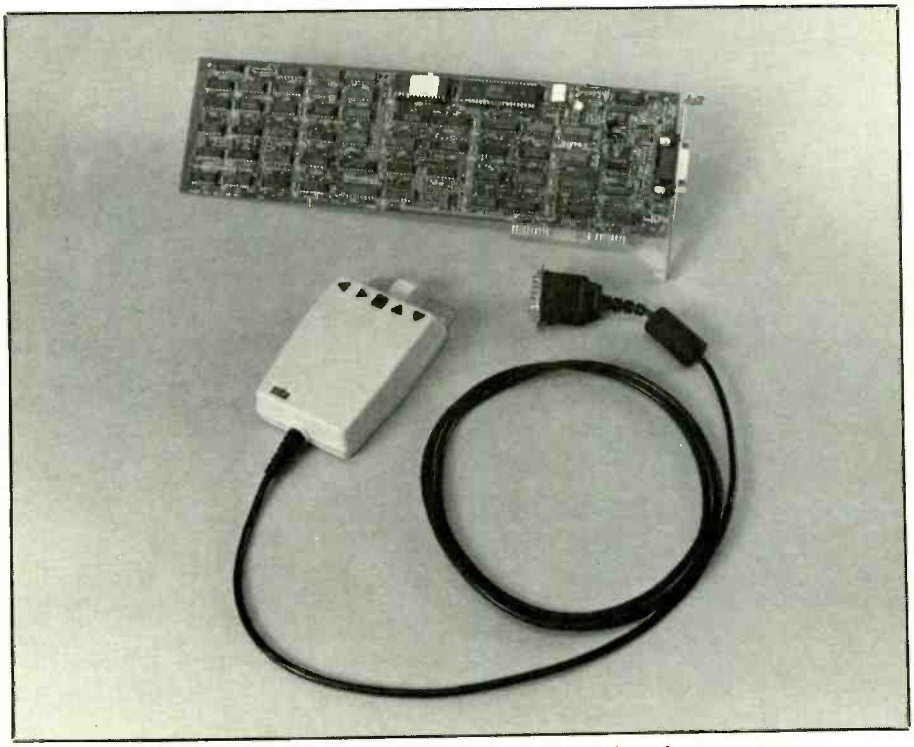
The software will help you pick the correct font, but it doesn't do so automatically. This is the biggest problem for beginning users. In practice, I find that it is fairly easy to identify type styles, especially with the pages of samples included in the documentation's Appendix B. In any case, most users of the package will have documents produced on the same printers day after day.

I also found that setting the font to Courier 10 let me read many documents with acceptable accuracy.

After selecting the best font (either by eye or using the utility program), you return to your application program and move the screen cursor to the location where you want data to appear. To scan, you place the scanner's guide just to the left of the data you want to transfer, press the scan button, and pass the scan head across the text or numbers in a smooth rapid motion. The speed is not at all critical and the movement doesn't have to be perfectly straight; the scanner's optics are pretty forgiving.

The OCR recognition process is complex. How fast it works will depend on the speed of your computer, but on a 4.77-MHz PC or XT, you will be able to scan at a rate of about 10 characters/second of mixed letters, special characters, and numbers.

With a faster computer you will be able to scan more quickly. However, you will normally need time to relocate the scanner at the next item to be scanned so the software will catch up with your scanning while you are moving. There is a character buffer in the software that allows you to scan faster than the data is actually translated onto the screen. A beep indicates when the buffer is full, signaling you to pause or slow down.



Saba's hardware consists of plug-in board and three-button mouse.

I found that I could achieve 95% to 100% correct character scans at a rate of about 35 characters/second (about 400 words/minute) on an 8-MHz AT-compatible computer, but only in short bursts because of the time it took me to realign the scanner after each line.

If you are entering numbers in a spreadsheet you might want to program one of the Handscan's function buttons to jump to the next cell, freeing you from moving back and forth between the scanner and the keyboard.

When scanning only numbers, set the software to "numbers only." Doing this, the computer can compare the scanned image with fewer possible matches. As a consequence, the processing speed will go up by about 30% and the accuracy will usually increase, too.

The only important practical limitation that the Handscan has is its inability to scan most laser printer output as well as all typeset text found in magazines, newspapers, and books. Typeset material achieves its smooth look and even margins by varying the distance between individual letters, depending on just how many characters there are on each line. Most scanners just can't handle this constant spacing change.

A tiny percentage of books as well as self-published newsletters are not typeset, but these are rare, so don't expect to scan things like telephone books, newspapers, or the pages of *Modern Electronics* with the SABA Handscan.

If you really need to scan books or magazines (and it might be a copyright violation to do so), look at the $9,500 Kurzweil Discover 7320 from XEROX Corp., which does an absolutely marvelous job of such scanning, but is useless for entering numbers in your spreadsheet.

Justified printing, which evens the

margins by inserting spaces between words (but not varying the distance between letters as in microjustification), will be scannable by the SABA Handscan as long as it is in one of the standard fonts normally supported by the software.

Scanning photocopied material is fine too, unless it has been enlarged or reduced. The printed portion of standard forms like invoices usually can't be scanned, however, although the important information (which is usually typed) can easily be read while the rest of the form is ignored. Here are some examples of how useful the Handscan can be. You could easily write a program on your typewriter at home, then scan it line by line into your computer at work (or vice-versa), or you could take a budget prepared on a typewriter and scan it into your computer.

At some defense contractors, the SABA is regularly used to transfer data which can't be transmitted electronically or moved on magnetic media because of security considerations (you can't take any magnetic media out of many secure installations) and if you have ever had data wiped out by airport security or customs you know how handy something as simple as typed information can be.

Another very important category of text that the SABA Handscan will soon be able to recognize is that produced by the high-speed line printers used with mainframe computers. Its obvious that for transferring limited amounts of data from a mainframe computer (perhaps in accounting) to PCs based in other offices, the SABA Handscan would overcome a lot of problems.

These and other type fonts will be added to the Handscan's software, and since these are merely software changes you can upgrade very easily when the new fonts are available. You should contact SABA technical support at (800) 654-5274 for the latest list of supported fonts.

Conclusions

For its intended application of scanning individual pieces of data into computer programs like spreadsheets or database information, the SABA Handscan is not merely as good as 5- to 10-thousand dollar page scanners I have used; it is actually superior because it is nearly impossible to limit the costlier page scanners to just the data you wish to enter in these applications.

In testing 10 scanners costing from $650 to $11,000, with some listing over 100 recognized fonts and others listing only 20 or 30, the SABA Handscan does as well as any of the others when you stick to clear dark print that is not proportional or typeset.

Anyone who regularly receives typed material, a portion of which needs to be entered into computer programs, can probably find a place for the Handscan, especially when the useful data is buried in a lot of unneeded text.

If you need to scan entire pages, then look to the page scanners. Although the SABA Handscan can be used for this on an occasional basis, it really isn't designed for that sort of work.

Some planning can make a lot more business data readable by the SABA; for instance, merely requiring that forms be printed in standard fonts or that word processor output not be proportional pitch will cost nothing in time and equipment changes, but will make the transfer of data much faster.

If you think the SABA Handscan would be helpful, I suggest you locate a local dealer who will let you test some samples of your text to make certain it is compatible. If you use letter-quality Okidata, Epson or IBM printers, an office-style typewriter, or daisy wheel printer with Courier 10/12, Prestige, Elite, or Pica fonts, you should have no problem. Furthermore, many printers or typewriters not specifically supported have fonts close enough to one of these to be readable.

It certainly isn't for everyone, but the SABA Handscan offers a lot of data-transfer potential for a reasonable price. **ME**

BOOKS

IBM AT Clone Buyer's Guide and Handbook by Edwin Rutsch. (Modular Information Systems, 431 Ashbury St., San Francisco, CA 94117. Soft cover. 406 pages. $24.95.)

If you are thinking of buying an IBM PC/AT, compatible or clone computer, this book can save you a great deal more than its modest cost and prevent you from making a decision you will regret. Written for both the first-time and experienced computer user, it should quickly guide you to just the make, model and configuration of AT-class computer you need. Its section on the personal computer's development gives the beginner an overview from a user's point of view. It also addresses the question of whether the true IBM AT or a clone version is for the reader, or even if a less powerful 8088-based or more powerful 80386-based computer is more suited to his needs.

Capsule reviews of 15 popular AT-style computers are provided, but a generalized catch-all "review" groups all "no-name" clones together. Considering that a no-name clone may be the only route to owning an AT-type computer for many buyers, it would have been better if the author had chosen, say, five models from those advertised every month in major computer magazines. Fortunately, a chapter on where to purchase the computer is reasonably informative and complete. The same is true for the chapter that analyzes, without being more than superficially technical, the various elements that make up the computer. At the very least, this chapter will familiarize the reader with the physical appearance of the various elements and how they interrelate with each other.

The book's sections on assembling an AT clone and upgrading an existing XT-style computer to AT status are complete enough for the reader to "build" an AT-style computer from "stock" parts. Differences in hardware from different sources keep these sections very general, though. Just as important as building the computer is troubleshooting it if it does not work, which is the exclusive topic of the closing chapter. At the back of the book are appendices that give names and addresses of companies mentioned, computer magazines and computer shows and swaps, as well as a listing of IBM diagnostic disk error codes.

This "buyer's guide" contains useful hints and tips throughout. Composed on a desktop publishing system, it is nicely laid out and its light, easy-to-read text is tastefully illustrated with photos, line drawings and public-domain Victorian-era engravings.

Passport to World Band Radio, 1988 Edition. (International Broadcasting Services, Ltd., Box 300D, Penn's Park, PA 18943. Soft cover. 400 pages. $14.95 plus $1.95 P&H.)

This is an interesting approach to international shortwave programs and equipment, integrating an equipment buyer's guide, short articles relating to shortwave listening broadcasting schedules. The large-format (10″ × 7″) book's articles cover SW listening opportunities in a handful of countries, including Latin American ones, China and Ghana, as well as Weather broadcasts, a Middle-East map with frequencies, and a neat image of a personality, the U.S.S.R.'s Vladimir Posner, who has been seen on many U.S. TV talk shows.

A large section on world band radios, divided into portable and tabletop equipment, will be very helpful to anyone planning to buy an SW receiver. Each model's attributes and performance qualities are thoroughly explored, and each is given comparative ratings based on eight classifications (Poor to Superb).

A following section lists worldwide shortwave broadcast frequencies by country (alphabetized). Next is a section on blue paper stock called "Worldscan: The Blue Pages." Arranged in order of frequency, it gives one quick access to which country is broadcasting on the specified frequency, the time, transmitter power, target zone, alternative frequency, jamming information, and more. Bar lines and other graphic symbols are used to give all this information at a glance. A few pages of a Lexicon on Terms concludes the book. Without doubt, this is a thoroughly useful book for anyone into (or interested in starting) listening to broadcasts from around the world.

NEW LITERATURE

Test Instruments Brochure. A new six-page, four-color brochure that highlights the Professional Series of Test Equipment is now available from Simpson. It lists significant features, advantages and benefits of the company's Models 712, 713 and 714 frequency counters, 421 and 422 sweep/function generators, and 560 menu-driven multimeter. For quick reference, key specifications for each instrument are itemized in a table on the last page. For a copy of The Professional Series brochure, write to: Simpson Electric Co., 853 Dundee Ave., Elgin, IL 60120.

Logic IC Selection Guide. A Selector Guide that gives detailed information on its new family of FACT advanced CMOS logic devices is available from Motorola. The colorful 8-page Guide gives designers an easy way of comparing and selecting standard logic elements by discussing the FACT technology and providing tables that give Logic Family Comparisons and device details (functionality, pin count and SOIC package profile). Two pages discuss CMOS Logic Surface Mount and a final two pages list authorized Motorola distributors in the U.S. and Canada and domestic and international sales offices. For a free copy of publication No. SG-122/D, contact your local Motorola Sales Office or distributor, or write to: Motorola Literature Distribution Center, P.O. Box 20912, Phoenix, AZ 85035.

Temperature Sensor Handbook on Floppy Disk. RdF Corp. has a 5.25-inch floppy disk that contains its temperature measuring handbook with data to facilitate application engineering calculations performed on personal computers. The diskette features computation of resistance-versus-temperature tables for RTDs and millivolts vs. temperature for a variety of thermocouples. It also generates wire tables for a variety of different materials (copper, aluminum, constantan, platinum, etc.). Full data and specifications for RdF's line of industrial RTDs and thermocouples are also included. Systems designers and engineers can obtain this free diskette by writing to: SGM & Co., Inc., 59 Longwater Dr., Norwell, MA 02061.

Stepper-Motor Brochure. Stepper-motor performance and various determining factors are examined in the latest issue of *Motorgram* from Bodine Electric Co. Discussed are operating characteristics relating to EFSS and slew speeds; limitations presented by low-frequency and mid-frequency resonance and how to compensate for the latter; and some reliable damping methods for rotor oscillation. Also included are data on load inertia. Additionally, this issue contains an applications case history on a Bodine Type K-2 motor used in a scanning laser-beam gauge. For a free copy of *Motorgram* Volume 67, No. 3, write to Bodine Electric Co., 2500 W. Bradley Pl., Chicago, IL 60618.

Digital Thermometer Kits Brochure. A new four-page, two-color brochure from Thermo Electric describes in detail (including prices and photos or dimensioned line drawings) the company's line of Minimite® digital thermometers and accessories. Among the accessories listed are a variety of temperature probes, lead assemblies and master handles, all arranged in a handy table on the last page. Ordering information is provided. For a free copy, write to: Thermo Electric, 109 N. Fifth St., Saddle Brook, NJ 07662.

Flashlamps & Laser Components Catalog. A 16-page "Technical Guide of Flashlamps and Laser Components" catalog from TJS, Inc. lists the company's full line of products and a lot of technical information designed to help the user to identify the exact product he needs. Among the technical subjects covered are: explosion, ultraviolet and ozone hazards, spectral output of noble gases, cooling, envelope material, electrical circuits, lamp selection calculations, and pulse forming networks. Each subject is accompanied by charts and diagrams. The catalog portion lists krypton, xenon and mercury lamps, YAG rods, flow tubes, Q switches, mirrors and lenses. Detailed technical specifications are provided. For a free copy, write to: TJS, Inc., P.O. Box 95, Denville, NJ 07834.

Power Semiconductor Catalog. The comprehensive, 82-page 1987 power semiconductor catalog from Semikron covers Semipack thyristor/diode power modules, bridges, diodes, thyristors, transistors, assemblies, selenium rectifiers and other circuit components. Included in the descriptions are electrical, mechanical and thermal specifications and dimension drawings. Also included in the catalog is a handy table for calculating rectifier circuits. For a free copy, write to: Semikron Inc., 11 Executive Dr., Box 66, Hudson, NH 03051.

 (from page 23)

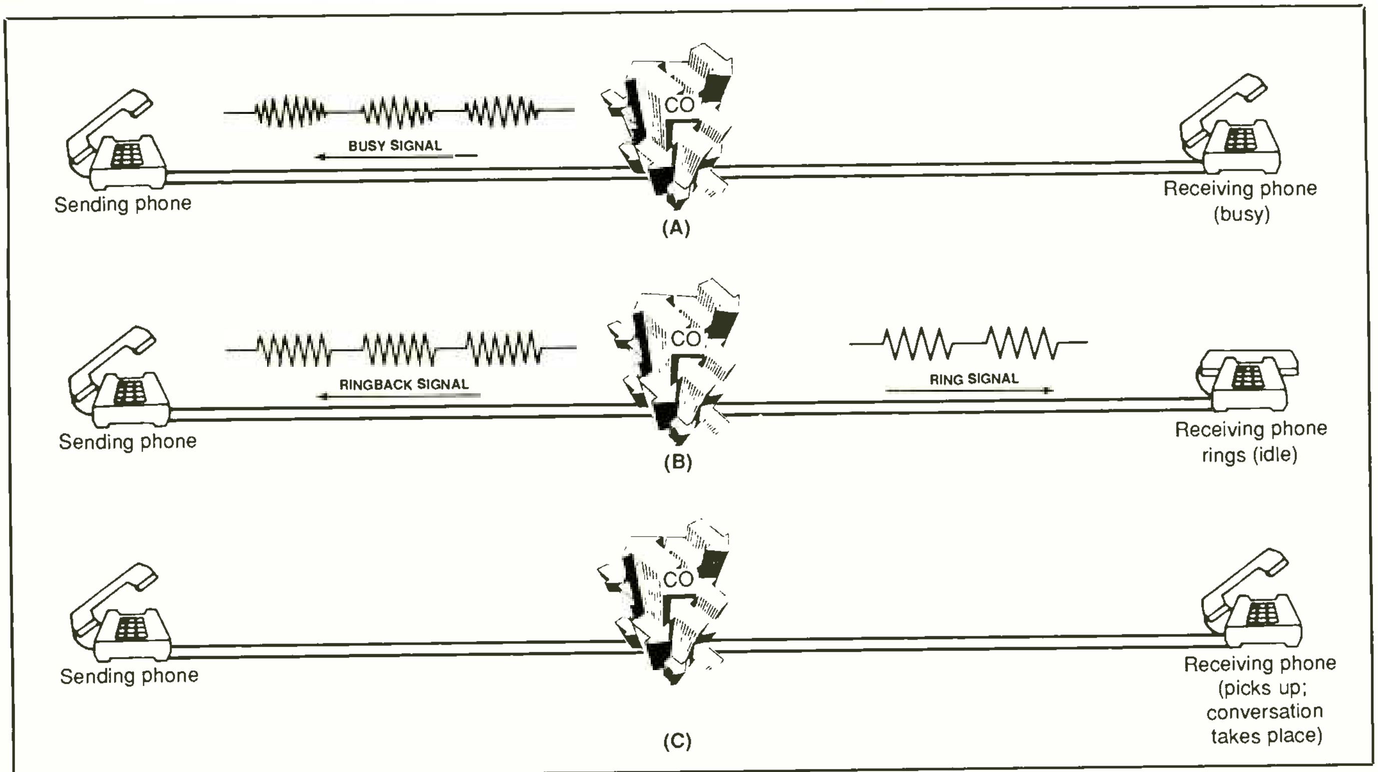


Fig. 9. Central Office returns to an originating instrument a busy signal or a ringback signal when the phone being called is (A) off-hook or (B) on-hook. It makes a through connection (C) when the receiver of the instrument being called is picked up.

check your wiring when you are done with the installation.

The installation procedure is as follows:

(1) Choose a convenient location in which to mount the new modular jack. A secure surface, such as a wooden baseboard, is always a good choice. If you must mount the jack on a masonry surface (plaster, sheetrock, etc.), secure it in place with plastic screw anchors. When deciding on a mounting location for the jack, always steer clear of ac wiring and plumbing, especially if you must drill through walls or floors. A typical installation is shown in Fig. 10.

(2) Decide now from where you are going to take the telephone signal. The easiest place may be an existing jack in another nearby room, a hall, etc. Route the cable that will connect the new jack to your existing telephone wiring along a path where you will be able to hide the cable if you can, or where it will not be obtrusive if it must be out in the open, such as along floor molding and around door frames.

(3) Remove the cover from the box at which you are going to make the connections to the new jack to expose wiring and terminals of the connector block. If the pick-off is to be from an existing box to which the incoming telephone line is connected, remove the jack's protective cover. If you are taking the telephone line for your new phone installation from a wall-mounted jack, remove the jack from the wall.

(4) Loosely run telephone cable from the new jack to the pick-off source, snaking it through walls and floors as needed. Leave 12 inches or so of slack at both ends of the cable run.

(5) Carefully remove about 5 inches of outer plastic jacket from the cable at the source end. If you use a utility knife or diagonal cutters to do this, make sure you do not cut through or nick any of the conductors inside the plastic jacket. Having removed the plastic jacket, you will see four conductors with green, red, yellow and black insulation. Strip ½ inch of insulation from all four conductors at this end of the cable.

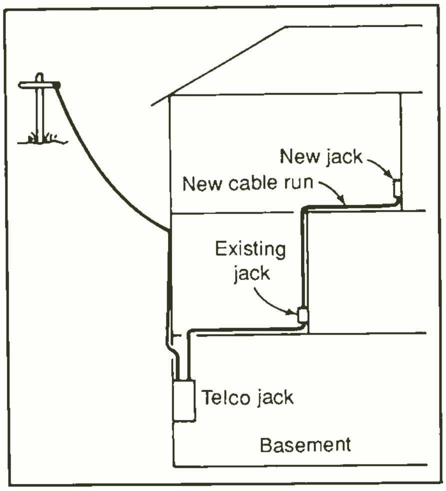


Fig. 10. A typical residential telephone wiring scheme.

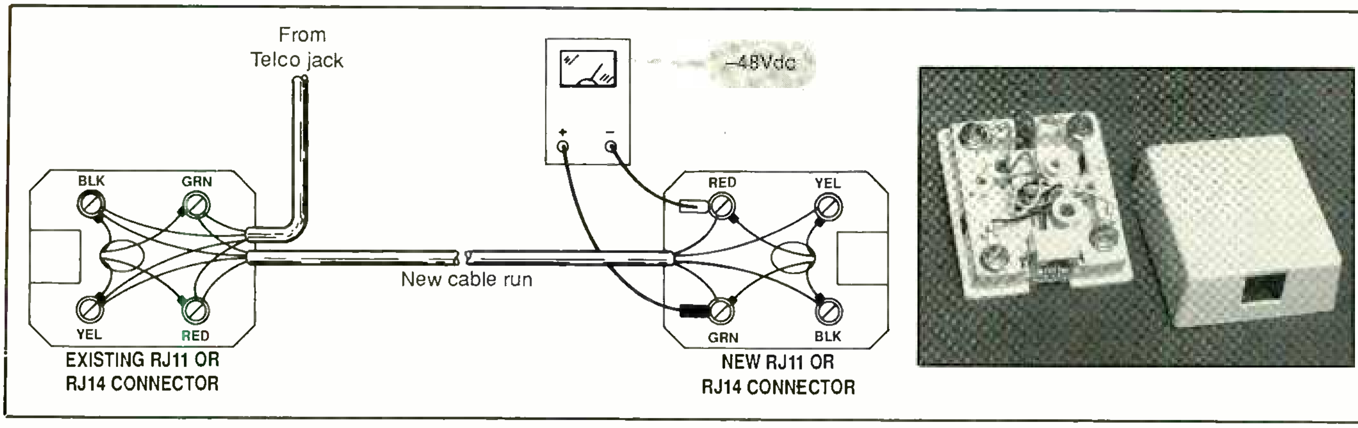


Fig. 11. Jack wiring details for residential telephone installations.

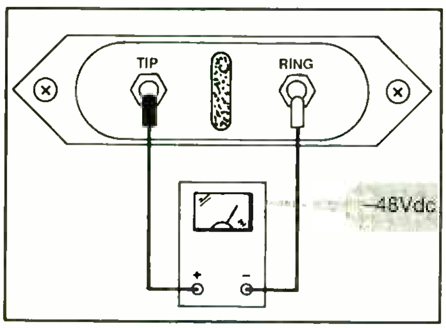


Fig. 12. Determining which conductor is the "tip" and which is the "ring" in an old-style ceramic telephone jack.

(6) Loosen the screw to which the green-insulated phone-line wire is connected, wrap one-half turn of the green-insulated exposed copper wire of the cable run and tighten the contact screw. Repeat for the three remaining conductors, matching insulation colors as you go.

(7) Repeat the connection procedure outlined above at the other end of the cable for the new jack. When you are finished, both ends of the cable should be wired to the terminal blocks as shown in Fig. 11.

(8) Check the voltage and its polarity across the newly installed jack, using the arrangement in Fig. 16, taking care to properly polarize the meter's test probe points. You should obtain a reading of about −48 volts dc if your wiring is properly done.

(9) Dress back the slack at both ends of the cable and replace the covers on the jacks or remount the jack on the wall.

(10) Finish up by stapling the cable run neatly into place along its entire length. Be careful to avoid shooting a staple leg through the cable itself!

Plug the telephone instrument into your newly installed jack, lift the handset off the hook and listen for a dialtone. When you do hear a dialtone, call someone at another number to verify that your installation is working. If you do not hear a dialtone, disconnect the instrument from the jack and recheck your wiring. Correct any errors in wiring before placing the telephone instrument in service in the new location.

Note: Older residential telephone wiring may not be color coded. If this is the case with your installation, use a dc voltmeter or a multimeter set to the dc voltage function to identify which conductor is which. If you connect the meter directly across the telephone line and obtain a −48-volt or so reading, the tip and ring conductors are as identified in Fig. 12. If your reading is +48 volts, conductors are just the opposite of that shown in the figure. Once you have identified the tip and ring conductors, you can wire the new jack as detailed above, leaving the yellow- and black-insulated wires unconnected. The red-insulated wire now goes to the ring conductor's contact, the green-insulated conductor to the tip contact.

This concludes this installment. Next month, we will conclude with telephone troubleshooting and ways to identify and correct some typical problems. **ME** mel coating a distance of ¼ inch at both ends of the wire. This wire must be exactly 4½ inches long to assure that the circuit will tune to the center of the FM broadcast band.

Wrap the wire around an ordinary lead pencil so that you end up with 3½ closely spaced turns with two "tails" that are parallel to each other and of equal length on opposite sides of the pencil. Slide the coil off the pencil and gently spread the turns evenly so that the inductor's two leads drop into the L1 holes in the board (see Fig. 4).

Adjust the height of the coil above the ground-plane surface of the board so that ⅟₁₆ inch of lead length protrudes from the center of each pad on the bottom of the board. Solder both leads into place. If you use bare hookup wire to wind the coil, inspect the installation to make sure that no turns short to each other, the ground plane on the board or any nearby components.

When you have completed wiring the board, examine the assembly very carefully for inadvertent short circuits between closely spaced pads and conductors. Pay particular attention to the top of the board to verify that all grounded leads are properly soldered to the ground plane and that all leads that are not supposed to be grounded are fully insulated from the ground plane. If in doubt about the latter, use an ohmmeter set to its lowest range or an audible continuity tester to verify that you have the required insulation between component lead and ground plane in each case.

Check all solder joints for good soldering. If any connection appears to be suspicious, reflow the solder on it. If you locate a solder bridge, reflow the solder and use solder wick or a solder sucker to remove it. Most problems in projects like this can be attributed to poor soldering.

Plug the IC into the socket, making sure you properly orient it. Also, make certain that no pins overhang the socket or fold under between socket and IC as you push it home.

For optimum circuit stability, it is best to house the circuit assembly inside an all-metal enclosure that has a removable top to permit internal access for fine tuning the the tank circuit. Use an enclosure that is at least 2 inches high so that you can mount the circuit-board assembly horizontally and spaced about ¼ or ½ inch above the bottom panel. Use metal spacers to mount the assembly so that the copper border around the solder side is electrically connected to the metal of the enclosure to ensure that the metal box is also at r-f ground potential.

A telescoping-type transistor-radio replacement antenna that extends to 12 to 18 inches is suitable for use with this project. Bear in mind, however, that you should use as short as antenna as needed for consistent operation at the desired range over which the project is to be used.

Use plastic hardware to mount the antenna to the enclosure so that it does not short to any part of the metal box. Also, locate the antenna close to the connecting pad on the printed-circuit board where the connection between the two is as short as possible. Capacitor *C11* will be used to make the actual connection between antenna and the collector of *Q3*.

POWER switch *S2* is optional and should be included if you anticipate long periods of time (weeks or more) during which the project will not be used. This switch and TEST pushbutton switch *S1* should be located on the top or side of the enclosure where it will not physically or electrically interfere with the circuit-board assembly and as far as possible from the antenna so that when operating either there will be minimum hand-capacitance effect coupled to the antenna circuit.

Use a snap-type battery connector to make connection to the 9-volt battery used for *B1*. Be sure to wire this connector so that the battery's negative terminal (connector's black-insulated lead) connects to the ground plane on the circuit board. Then plug the red-insulated connector wire into the B1- hole and solder into place. Secure the battery inside the enclosure with either a standard 9-volt battery clip or a length of double-sided foam tape.

Connection to the telephone line *must* be made via a telephone cord that has a modular connector at the end that attaches to the telephone line. Such cords are readily available from any outlet that stocks telephone accessories. Use of a modular connector is an FCC requirement, aside from the fact that it makes it easy to plug in and remove the project from any phone connector block.

If the only cord you can obtain has connectors at both ends, cut off one connector. Then remove about 1 inch of outer plastic jacket and strip ¼ inch of insulation from the ends of the exposed red- and green-insulated conductors. (If there are other conductors besides the red and green ones, clip them off flush with the plastic jacket.)

This project's circuit is ac coupled to the telephone line. Therefore, it is not necessary to observe any particular polarity when wiring the telephone cord into the circuit via the indicated holes in the circuit board. Route the cord into the enclosure through a rubber-grommet-lined hole and tie a knot in it about 3 inches from the prepared end inside the box, to serve as a strain relief, before plugging the wires into the board's holes and soldering them into place.

Checkout & Use

Use an ordinary FM broadcast-band radio (portable or otherwise) to check out circuit operation. For initial tests, do *not* connect the project to the telephone line. Also, *IC1* need not be installed in its socket at this time. During testing, the circuit-board assembly and antenna should be mounted in and on the project's enclosure to avoid any shift in frequency after circuit tuning.

With a 9-volt battery plugged into the snap connector, operate the transmitter either by having an assistant hold down the TEST button continuously or by temporarily connecting a wire jumper across the terminals of *S1*.

Place the FM radio 10 or 20 feet away from the transmitter to obviate overloading the radio with excessive signal strength. Now very slowly tune across the FM band until you hear the transmitted 2-kHz audio tone. If you are unable to detect any signal from the transmitter, its carrier may be tuned outside the FM radio's band. In this event, change the transmitter's operating frequency by spreading or compressing the turns of *L1* to raise or lower, respectively, the frequency until you are able to find the tone within the FM band. Be careful to avoid shorting the turns to each other or the circuit-board's ground plane!

When you do hear the 2-kHz tone, tune the FM radio to a dead spot on the dial and place it about 20 feet away from the transmitter. Now use a plastic tuning tool to adjust the spread of the turns of *L1* until you once again hear the 2-kHz tone. Work very carefully because only a very slight adjustment of the coil's turns should yield the proper results. Remember, to raise the frequency, spread the turns and to lower it, compress them.

Check that the signal is still present in the radio when you place the cover on the project's enclosure. If necessary, "tweak" the coil slightly to keep reception of the tone signal at the dead spot on the FM dial.

If you are unable to hear the 2-kHz audio tone in the FM radio at any setting of the dial and with any spreading or compression of the coil's turns, you will have to troubleshoot the circuit. Start by checking the electronic switch, using a dc voltmeter to check the reading at the collector of *Q5* to verify that the *Q4/Q5* switching circuit is operating. (Use a meter with at least a 20,000-ohms/volt input sensitivity for this test.) You should obtain a reading between 8 and 9 volts when the TEST button is closed, assuming the battery is reasonably fresh.

Carefully check the circuit-board assembly to make sure you installed all components in their respective locations, that the components are of the correct value or number in each case and that the diodes and transistors are properly oriented or based. Also make sure that none of the turns of *L1* are touching each other or anything else in the circuit. Review the winding instructions for the coil to ascertain that you have wound *L1* correctly.

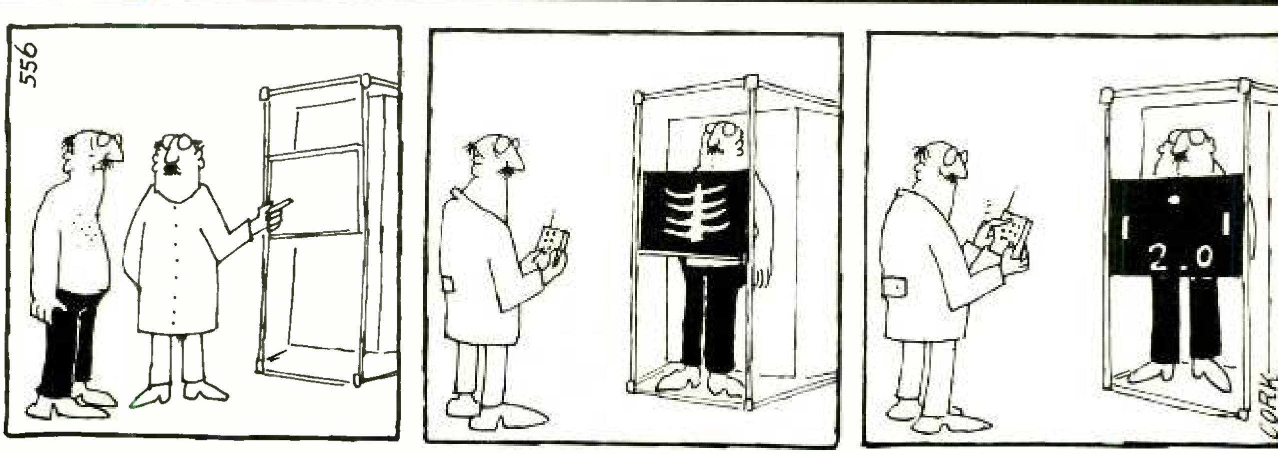
Use the dc voltmeter to measure the voltage across *R4*, which should yield a reading of 4 volts when *Q2* is drawing current. To check the *Q1* circuit, you need an oscilloscope. Use the scope to observe the sawtooth waveform across *C1*; presence of this waveform indicates that the 2-kHz oscillator is operating as it should.

Once you are satisfied that the circuit is performing properly with the TEST pushbutton switch closed (or shorted), unsnap the connector from the battery and install *IC1* in its socket (if you have not already done so during construction). Observe correct orientation. This done, snap the connector back onto the battery and plug the project's phone cord into any convenient telephone-line outlet.

Now have a friend call your number. When your phone rings, you will hear the project's 2-kHz "ring" signal in your FM radio, verifying that the project is operating properly.

Once you have tuned the project to a dead spot on the FM dial, it is best not to change the length of the antenna. If you do change its length, a very slight change in operating frequency may result, which will require slight readjustment of the radio's tuning.

To use the project, connect it to the telephone line and place your FM radio some distance away from it. To verify that the system is working, press the TEST button. That is all there is to it. You can now carry the FM radio with you and have confidence that you will not miss a call as long as you are within range of the project's transmitter. ME



as shown in Fig. 9(b) should cause the DMS to display "250" and the V LED to come on.

Adjust the power supply for a 50.00-volt output and set the DigiVolt-DC to its 100-volt range. The DMS should now display "50.0" and the V LED should be on. Finally, adjust the power supply for a 5.00-volt output and set the DigiVolt-DC to its 10-volt range. Now the DMS should display "5.00" and the V LED should be on. Any trouble at this point is indicative of something being wrong with the voltage-dividing scaling resistor network or/and the switches.

• *Fixed-Range Checkout.* To check the fixed-range version of the project, connect a 5-volt dc power supply to the DMS via the appropriate pins on header *J4*. Connect a four-pin header to *J2*, with test leads connected to pins 1 (common) and 4 (+). Note that pin 2 is "common" if R_Z is used

Apply power to the circuit. Connect a suitable reference voltage to the input and observe the DMS's display and LED indicators. Since the DMS was already calibrated when it was built, this check verifies operation of the scaling network. If the value is slightly off, you can adjust GAIN trimmer on the DMS module to compensate for inaccuracies in resistor values. This is possible only on the *fixed*-range version of the the meter because the trimmer affects the basic gain of the DMS and would affect *all* ranges on the selectable-range version.

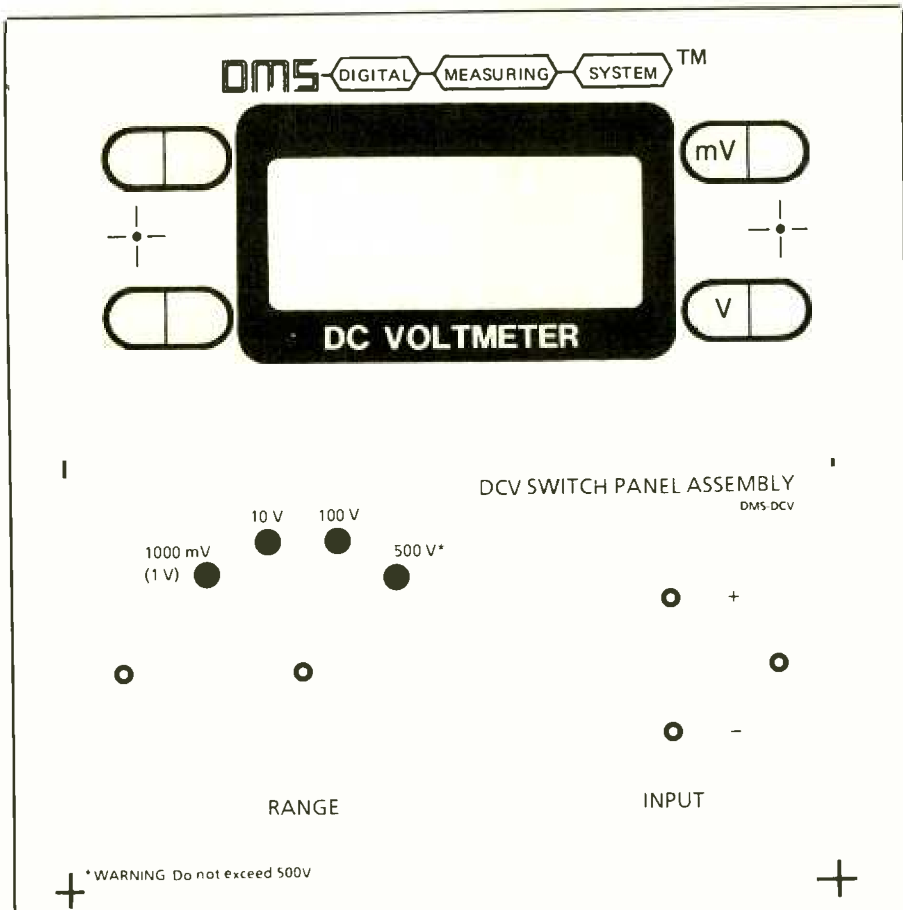


Fig. 10. Actual-size artwork for front-panel inlays.

Final Assembly

Turn off the power and unplug the DigiVolt-DC module from the back of the DMS module. Prepare the DMS and switch subassembly panels using the actual-size artwork shown in Fig. 10 as inlays. A simple way to do this is to either cut out or make same-size photocopies of both pieces of artwork and sandwich each between two same-size sheets of thin (preferably 1/32-inch) Plexiglas or Lexan and with a red filter, such as red cellophane between the rear of the inlay and the rear plastic sheet, as shown in Fig. 11. Before making the sandwich for the DMS panel, however, cut out and discard the white area inside the display window surround and the "D" shaped areas to the right of the mV and V legends.

Clamp together the DMS panel sandwich and carefully drill through the entire assembly the two holes in the center of the target symbols between the oval-shaped outlines on both sides of the display window surround. Then clamp together the switch subassemby panel sandwich and drill the holes centered at the left and right ends of the panel and appropriate-size mounting holes for the rotary switch and banana jacks.

Loosely mount the rotary switch in its hole and slide onto its shaft a pointer-type control knob. Rotate the knob to each of its position stops in turn and note how the knob's index lines up with the range dots on the switch panel. Reposition the switch as needed to make the index line up properly. Then, without moving the switch, remove the control knob and tighten the mounting nut. Replace the knob.

Mount red banana jack *J21* in the hole labeled "+" and black banana jack *J22* in the hole labeled "–." Then, referring to Fig. 5, use short lengths of hookup wire to connect the banana jacks into the circuit. Note that the red jack connects to terminal 1, the black jack to terminal 2 of *TB1*.

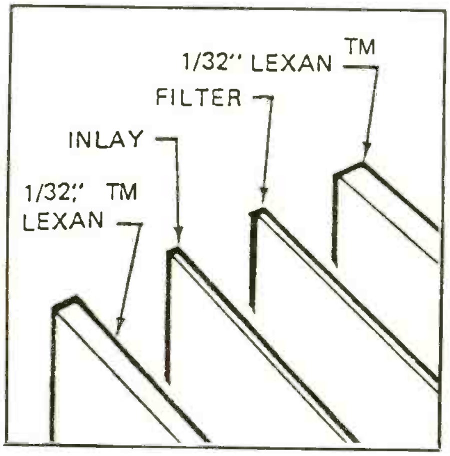


Fig. 11. Assembly drawing for putting together front-panel "sandwiches."

Feed 6-32 × 1-inch machine screws through the two holes in the DMS front panel and follow up with a ¼-inch spacer in both cases. Slide a ¹⁄₁₆-inch-thick washer onto the ends of the screw on the left side of the panel and the LED board onto the end of the other screw. Follow up on each screw with another ¼-inch spacer, the DMS board assembly and a ½-inch threaded spacer. Align the LEDs on the small board in the D-shaped cutouts and make the threaded spacers finger tight. Finish up this assembly by plugging the DigiVolt-DC assembly onto the back of the DMS module, securing it in place by driving 6-32 × ¼-inch machine screws into the open ends of the spacers.

At this point, you're finished with assembly, other than to house the subassemblies in suitable enclosures. If you built the fixed-range DPM version, you need an enclosure just large enough to accommodate it. If, on the other hand, you built the multi-range general-purpose DVM version, select an enclosure that will allow the DMS/DigiVolt-DC and switching subassemblies to be mounted in it, either stacked or side-by-side. Don't forget to make arrangements for bringing into the enclosure a power cable. **ME**

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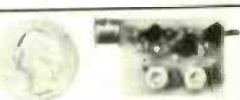

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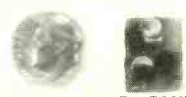

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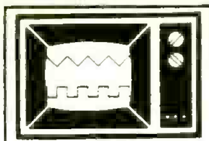

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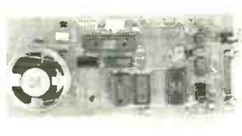

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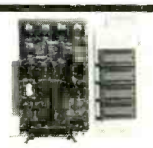

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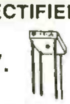

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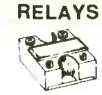

ELECTROL# S2181
CONTROL:
Rated 5.5 to 10 Vdc
(will operate on 3-32 Vdc)
LOAD:
10 Amp @ 240 Vac
2 1/4" X 1 3/4" X 7/8"
CAT# SSRLY-10B
$9.50 each
10 for $8.50 each
QUANTITY DISCOUNT!
25 for $7.00 each
50 for $6.00 each
100 for $5.00 each

OPTO SENSORS

TRW# OPB815
U shaped opto emitter and sensor unit.
CAT# OSU-3
2 for $1.00

Clairex# CLI800W
U shaped unit with flange mount.
CAT# OSU-2
75¢ each

ITT PUSH BUTTON

ITT MDPL series. 3/4" X 1/2" gray rectangular key cap. S.P.S.T. N.O. Push to close.
RATED:
0.1amp switching,
0.25 amp carry current. P.C. mount

CAT# PB-8 65¢ each
10 for $6.00 • 100 for $50.00

XENON FLASH TUBES

3/4" long X 1/8" diameter
CAT# FLT-1 2 for $1.00

PHOTO RESISTOR ASSEMBLY

Center-tapped photo resistor mounted in plastic case (can be easily removed). 700 ohms light, 36K dark, 1/4" diameter.

CAT# PR-4 $1.00 each
10 for $8.50

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CIRCLE 33 ON FREE INFORMATION CARD

Oscilloscope Waveforms *(from page 47)*

amplifier. A hi-fi amplifier may be rated for a THD of less than 1 percent, whereas a utility amplifier's THD rating may be no greater than 10 percent. Insofar as circuit-action waveshapes are concerned, it is practically impossible for you to recognize a 1-percent level of distortion. On the other hand, a 10-percent level of distortion in a sine wave is quite obvious. The bottom line, therefore, is that circumstances alter cases and that you must know the circumstances that determine acceptable tolerances.

There is also the matter of the accuracy of the test equipment. Hence, if the circuit or device being tested has a rated THD of 1 percent, the output of the audio signal generator used to perform the test should have an output distortion rated at considerably less than 1 percent. The oscilloscope being used should also have a response distortion figure of much less than 1 percent.

If you cannot discern a 1-percent level of distortion in a sine-wave display, you must employ a more critical type of display or supplement your oscilloscope with a harmonic-distortion meter. A more critical type of display is a Lissajous pattern because, in the midband region of an amplifier, the pattern is a slanting line. It is comparatively easy to evaluate the line for curvature and to observe distortion of 1 percent. **ME**

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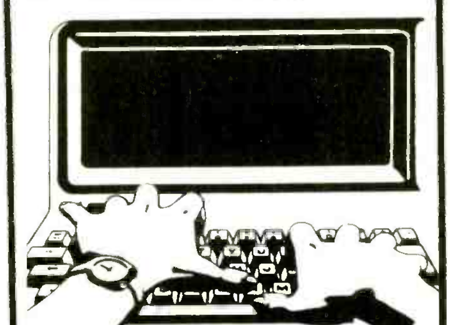

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