THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

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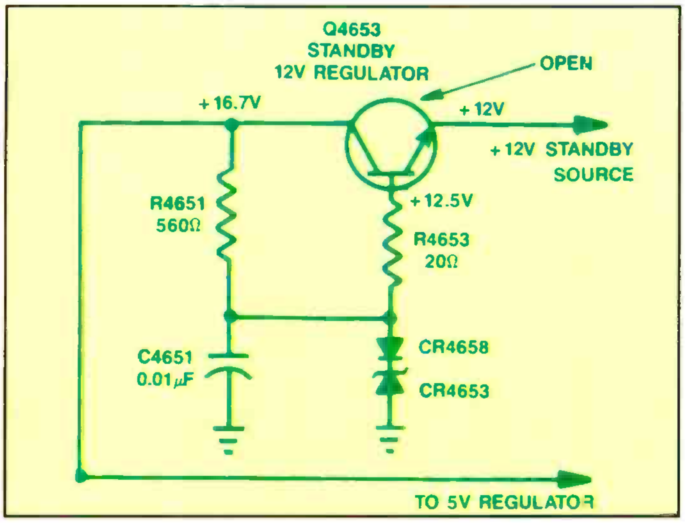

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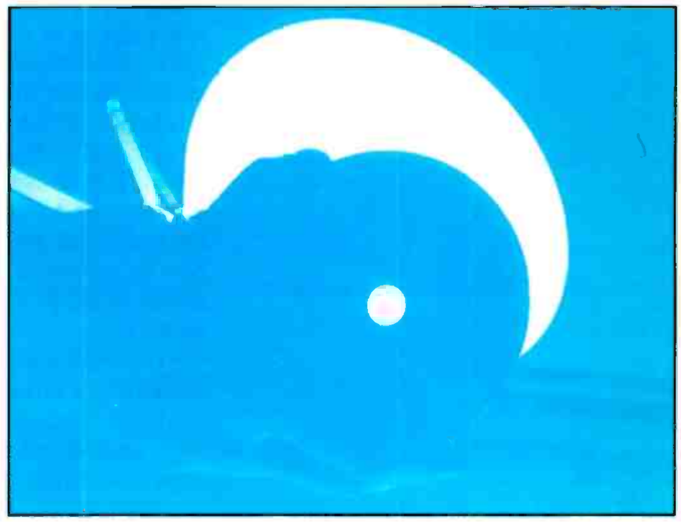

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FEATURES

THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING
ELECTRONIC Servicing & Technology

DEPARTMENTS

ON THE COVER

The IBM personal computer has spawned a host of compatible computers in configurations based on the 8086, 8088, 80286, 80386 and 80486 microprocessors. These products are subject to problems that are both hardware and software related. Understanding the hardware and the software, and how they interact can lead to some lucrative servicing and upgrading business for technicians and service centers. (Photo courtesy of Chemtronics.)

Articles wanted

Electronic Servicing &Technology is a magazine for servicing technicians. The sole purpose of ES&T is to bring information to technicians that will help them in some way to do their job. The kinds of articles we publish are:

• Servicing articles. In these articles, we present actual case histories of what kinds of problems occurred in a product, how the technician troubleshot the problem, how he arrived at a conclusion as to the nature of the problem, and how he corrected it.

• Theory articles. In this kind of article, we introduce information on how certain products, circuits within products, or even generalized circuits work. For example, an article in this category might be about an oscillator, or a switching power supply, or an AFT circuit. In many cases, we combine aspects of servicing articles with theory articles, so that we present an article that discusses both the theory of a circuit, as well as failure mode information and servicing tips.

• General troubleshooting articles. On occasion we present articles on how to go about troubleshooting consumer electronics products in general terms. This type of article contains ideas and suggestions on the nature of consumer electronics products, the nature of how they malfunction, and general suggestions on how to proceed from a description of the problem to determination of the component(s) causing the problem.

• New technology articles. In this kind of article, we present an overview of the technology on which certain new products are based. This type of article might be anything from a simple surface look at how the product works in general and what it is made up of, to a complete dissection of the unit, including schematics, block diagrams, photographs, diagnostic flow charts, etc.

• We also present brief articles such as troubleshooting tips, in which a service technician provides us with a description of a problem that he encountered in a consumer electronic product that needed servicing, and describes how he went from observation of the problem to correction.

• Symcure articles. These are brief items in which a service technician reports the problem he encountered in a product, and which components he replaced to cure the problem.

• Business articles. Business articles, such as those that appear in Business Corner discuss the problems encountered in operating a consumer electronics service center, and provide information and suggestions on how to operate the business aspects of a service center.

Consumer electronics servicing is changing every day, and no one understands the problems involved better than someone who is performing that service. We invite readers to contribute articles in any of the areas described above. We are also open to suggestions about other article possibilities.

Readers have told us that they especially want to see hands-on, this-is-how-I-did-it servicing articles on TV, VCR, personal computers, video games, microwave ovens, cordless and cellular telephones, stereo systems and compact discs.

Here are some of the elements that help make an article useful to readers:

• Schematic diagrams, block diagrams and photographs.

• Information on how to remove fasteners to get inside the product.

• Precautions, such as high voltage, possibility of eye damage from the laser in a CD player, danger to the product from overvoltage, rough handling, electrostatic discharge.

• Any unusual or exotic circuitry.

• Descriptions of circuit design/operation, typical failure modes, and approaches to troubleshooting.

If you would like to consider writing an article for ES&T, which will gain you the recognition and gratitude of your fellow servicers, and a modest cash payment, let us know. Write to me at Electronic Servicing & Technology, PO Box 12487, Overland Park, KS 66282-2487, or call me at 913-492-4857. I'll be happy to send you a set of our writers' guidelines.

If you're not an accomplished writer, don't worry about it. We don't expect everyone to be a writer. If you can provide us with some good basic information on how circuits and products work and how to fix them when they go bad, we can turn it into a finished article.

And we don't expect all servicing technicians to be artists. If you can provide us with hand drawn schematic diagrams and sketches, or with copies of the portion of the manufacturer's schematics that show the circuit segments of interest, we can turn it into finished artwork.

If you have any thoughts at all about contributing material to ES&T, write or call now. ■

Nils Conrad Persson

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Literature

Test instrument catalog

Bel Merit's new summer product line catalog features detailed specifications and descriptions of portable and bench-top test and measurement instruments designed for the engineer, student or technician who tests, repairs or assembles electronics equipment.

Some new product highlights include new multi-function digital multimeters with holster, clamp-on current meters, frequency counters, sweep/function generators, dc power supplies, audio and RF signal generators, voltage testers, continuity checkers, and circuit analyzers.

Circle (25) on Reply Card

Capacitor catalog

The new NTE capacitor catalog describes the company's line of capacitors. Most are available in axial or radial lead. The line includes: subminiature aluminum electrolytic; subminiature non-polarized aluminum electrolytic; high frequency aluminum for horizontal deflection; resin dipped solid tantalum; 105C subminiature aluminum electrolytic; 50V ceramic disc; 1000V ceramic disc; mylar/polyester film; motor run; motor start; mounting hardware; 2 Wire and 3 Wire for ceiling fans.

Circle (26) on Reply Card

Catalog of test equipment, tools and supplies

The 204-page 1993 catalog from Contact East lists hundreds of new test instruments and tools for plant and facilities operation, maintenance directors, engineers, production managers, and purchasing agents. Featured are quality products from brand-name manufacturers like Fluke, Tektronix, Weller, 3M, Microtest, Simpson, etc. for testing, repairing, assembling, and maintaining electronic equipment. Product highlights include: insulated hand tools, cordless power tools, thermometers, DMMs, power line monitors, UPS (uninterruptable power supplies), telecom tools and test equipment, tool kits, safety cabinets for storing flammable and corrosive materials, portable digital storage scopes, wire sorters, network testers and ESD-safe ergonomic chairs. Also included are DMMs, communications test equipment, clamp meters, hand tools, soldering/desoldering systems, measuring tools, frequency counters, shipping containers, static protection products, batteries, ozone safe cleaners, adhesives, inspection equipment, workbenches, tool kits, cases and more.

Circle (27) on Reply Card

Interference phase cancellation handbook

A new handbook from Microwave Filter Company, IPC/92, describes Interference Phase Cancellation, a practical method for suppressing interference which occurs at the same frequency as the desired signal or which occurs so close to it that application of conventional filters is impractical.

IPC/92 summarizes the phase cancellation theory, describing six most common interference problems, 15 different examples, solutions and product instructions. Some areas discussed are co-channel reception, ghosting due to reflection, in-channel harmonic reception, wide-band noise across low band channels, undesired adjacent FM carriers and microwave inband interference. The handbook also explains methods applicable to CATV and other cable systems, interference to VHF-microwave receivers, interference to TVRO installations and interference to UHF/cellular paging.

Circle (28) on Reply Card

Test accessories catalog

Pomona Electronics' new, 142-page 1993/1994 Catalog of Electronic Test Accessories introduces several new DMM test accessory products and an expanded line of oscilloscope probe kits including an active differential probe kit. The all new catalog also introduces a guide to offer accurate SMT test clip selection for new low-profile, fine-pitch packages such as SQFP, SSOP and PQFP styles.

Twelve major product categories are presented with an easy-to-use index and include the company's most popular selection of jumpers and cables, boxes, plugs and jacks, connectors, adapters, single-point test clips and static control devices. Highlighted new products include test clips, probes and cable assemblies designed to meet safe operating requirements per IEC 1010 standards.

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC
Servicing & Technology

Electronic Servicing & Technology is edited for servicing professionals who service consumer electronics equipment. This includes service technicians, field service personnel and avid servicing enthusiasts who repair and maintain audio, video, computer and other consumer electronics equipment.

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Electronic Servicing & Technology (ISSN 0278-9922) is published 13 times a year by CQ Communications, Inc. 76 N. Broadway, Hicksville, NY 11801. Telephone (516) 681-2922. Second class postage paid at Hicksville, NY and additional offices. Subscription prices (payable in US dollars only): Domestic—one year $24, two years $40. Foreign countries—one year $30, two years $52. Entire contents copyright 1993 by CQ Communications, Inc. Electronic Servicing & Technology or CQ Communications, Inc. assumes no responsibility for unsolicited manuscripts. Allow six weeks for delivery of first issue and for change of address. Printed in the United States of America.

Postmaster: Please send change of address notice to Electronic Servicing & Technology, 76 N. Broadway, Hicksville, NY 11801.

CQ Communications, Inc. is publisher of CQ The Radio Amateur's Journal, Popular Communications, ComputerCraft, CQ Radio Amateur (Spanish CQ), CQ Amateur Radio Equipment Buyer's Guide, CQ Amateur Radio Antenna Buyer's Guide, Popular Communications Communications Guides, and Electronic Servicing & Technology.

High technology services industry maintains growth despite economic slowdown

The current recession is having some impact on the international high-technology services industry, but revenues continue their growth, according to George Keller, Executive President of AFSMI, the Association For Services Management International. Keller, whose organization comprises senior services management throughout the world, predicts 1993 services revenues to reach a record $155 billion, up some 12 percent worldwide over 1992's $140 billion in revenue.

Keller pointed out that the changes now taking place in the economy are benefitting the services industry as manufacturing and marketing weaken.

"We have gone through a period of improving technology," Keller commented, "in which high-technology equipment has become so reliable that the customer has a wide range of choices of highly reliable products. This has impacted on major high-technology providers such as IBM, Digital Equipment, and UNISYS.

"At the same time companies are reporting cutbacks in manufacturing, they are expanding their services operations with notable success. The trend in our industry has seen a steady movement from the sale of hardware to services. Further, it has also moved from service geared merely to maintaining equipment to service designed to meet total customer needs," Keller said.

"Today's high-technology services specialists are professionals, able to assume responsibility for entire operations —from developing specifications to meet specific needs to handling every phase of high-tech services design, installation and operations."

Worldwide, the high-tech services industry has a work force of some 800,000 from support and service technicians, field engineers and programers to diagnostic and management professionals.

Kelly reported that the North American market is still the largest, with some $54 billion in services revenues for 1992. Europe—primarily Western Europe—is growing rapidly with 1992 revenues of $48 billion. By the end of the decade, Keller projected Europe as the largest market with total revenues of $158 billion.

The fastest-growing area is the Pacific, including Japan, East Asia and Australia/New Zealand. It is presently generating some $38 billion in high-technology services revenues, however, making the Pacific segments the second-largest high-technology services market.

New association for servicers formed

Today a group of owners of independent service companies announced the formation of the United Servicers Association Inc. (USA) The association is dedicated to the preservation and independence of the entrepreneurial service companies. The group has appointed David M. Ashton as its Executive Director. Ashton has over three decades of experience with the service industry. The past seven and a half years he has served as the Managing Director of the National Association of Service Dealers and as the Director Operations for the National Association of Retail Dealers of America (NARDA) Inc.

The members of the association believe that the consuming public is entitled to competent technicians and reasonable charges and acknowledge the fact through its code of ethics and the by-laws being established. Member programs being established are varied and are expected to be cost effective. Many of these programs are not available to many of the independent servicers today according to USA. Some of these programs are Central Computing, Association Referral, and Library (tech literature sharing).

Interested independent servicers and other service organizations are invited to contact David Ashton at 800-432-0792 or write to United Servicers Association Inc., P.O. Box 626, Westmont, IL 60559 for additional information.

Cable systems must standardize to reduce consumer frustration

Cable subscribers have the right to enjoy all of the features that TVs and VCRs offer, according to the Electronic Industries Association's Consumer Electronics Group, in comments filed with the Federal Communications Commission (FCC).

These comments were filed in response to the FCC's request for more information on compatibility between cable systems and consumer electronics equipment in compliance with the Cable Television Consumer Protection and Competition Act of 1992.

EIA/CEG stated that the same TVs and VCRs that provide highly satisfying performance when used to receive broadcast signals cannot be used so successfully with cable. The root cause of this problem is that cable is not standardized in the same manner as electricity, AM and FM radio, and TV broadcasting. To the contrary, the thousands of cable systems can use any number of methods to deliver their service.

"Consumers are finding it harder and harder to use many of the features of their televisions and VCRs due to impediments by cable companies," said Gary J. Shapiro, EIA/CEG vice president. "Many of these problems are not caused by faulty consumer product design but by cable companies scrambling channels, changing cable converter remote control codes or changing the channels on which they are delivering programs, to name a few."

With nearly 300 million TVs and VCRs in use there is no practical way to alter these products to make them more accommodating of the increasingly diverse characteristics of local cable systems, but there are a number of measures that can be taken to make cable service for consumers friendly.

According to the EIA/CEG, the Commission should act now to stabilize the cable environment. What is defined as TV or VCR cable-ready today will not work on cable tomorrow, if the cable companies are permitted to change constantly and unpredictably:

- the number of channels delivered to the home,
- their channel mapping schemes,
- the remote control infrared codes for cable converters and
- standards for transmission, compression, and scrambling.

Joint comments between the EIA/CEG and the cable industry were also filed today on technical aspects of television and cable compatibility which the two industries agreed upon. ■

Understanding and troubleshooting personal computers

Part I—Introduction and history

By John Kull

In 1981, IBM first released the "PC" to the marketplace. It was an overnight success. Today, the PC continues to be a big seller among business and consumer electronics products. Unexpectedly, IBM set the standards for the computer industry—standards that were quickly followed by many companies, eventually leading to the birth of the "clone" industry.

Also called a "compatible" computer, a clone is one that operates exactly, or almost exactly, like an IBM personal computer. Now, the PC industry is divided between IBM and the clones.

This article takes an in depth look at IBM and the clone systems, with a special emphasis on the clones. The PC has evolved a great deal since its humble beginning, but, like any other consumer electronics product, it *is* subject to failure. A good understanding of any piece of equipment is vital in deciding how to service it properly.

This is a three-part article that begins with this brief introduction and history, offers some troubleshooting tips for the PC, and then finishes with some case histories. The purpose is to provide a basic understanding of each component in the PC and how the components interact to form a complete system. It will also cover major component replacement and will provide information on obtaining replacement parts and rebuilding services.

System components

There are many styles of IBM and clone PC's. The basic components of each function the same. A basic computer system consists of the following components:

- case and power supply
- motherboard
- floppy and hard drives
- serial ports
- parallel ports
- video and disk controller cards
- keyboard.

In addition, other optional equipment may be present (Figure 1).

Case and power supply

The case is the shell that contains the system components. Cases come in several styles. A desktop case sits horizontally and is available in standard and mini configurations. A tower case stands vertically and is used for space-saving conditions. Tower cases are available in mini, standard or large configurations. Standard and large configurations have room for additional disk drive bays (4 to 8), and have higher wattage power supplies.

A third style

A variation of the desktop style is lower than the desktop case. This design is used by IBM in the PS/2 and PS/1 computers and by many clone manufacturers.

The power supply mounts in the rear of the case and contains a fan for air circulation. The power supply delivers +12V, -12V, +5V and -5V to the motherboard and disk drives.

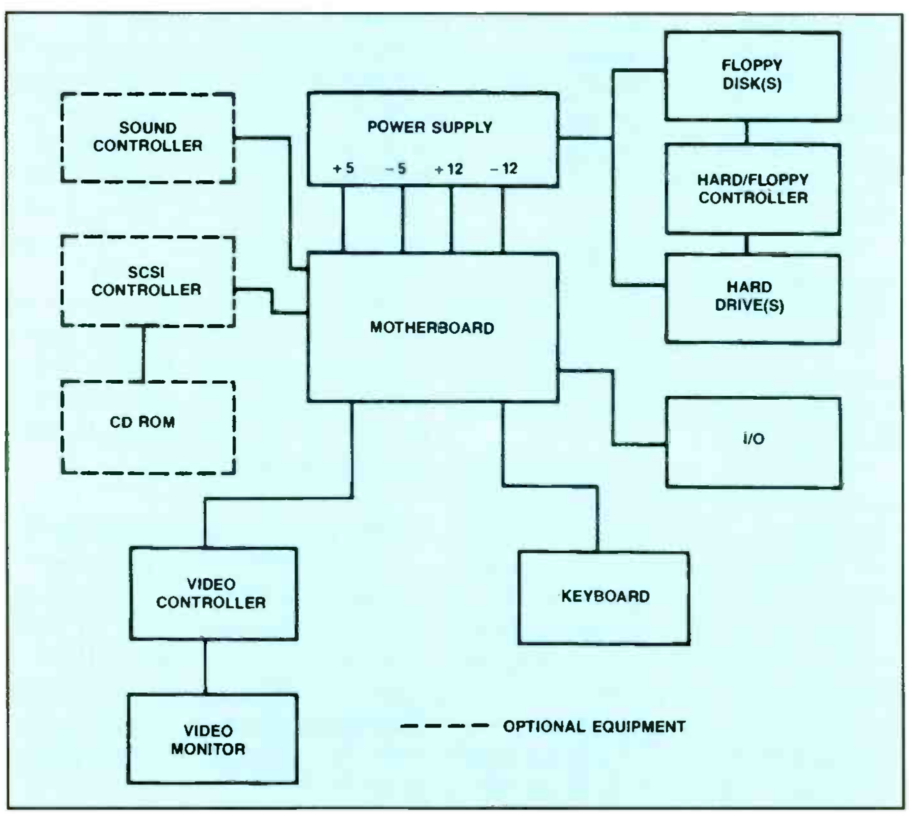

Figure 1. The IBM personal computer is interconnected as shown in this block diagram.

Power rating is calculated by multiplying each supply voltage by its current rating and adding the totals. Common power ratings are 150W, 200W, 230W, and 250W. The power capacity depends on the system motherboard, number of hard and floppy drives, system memory and additional system components.

Motherboard

The motherboard contains the microprocessor, memory, system clock, expansion connectors, keyboard connector, and additional support circuitry (Figure 2). Motherboards are classified by their size (mini and standard), microprocessor type and system clock speed. IBM refers to the motherboard as the system board.

Motherboards may be integrated or non integrated. The integrated motherboard incorporates the video, disk controller(s) and I/O functions on the motherboard. The non-integrated motherboard has video, disk controller(s) and I/O on separate expansion cards. IBM incorporates integrated motherboards in the PS/2 and PS/1 computers and many clone manufacturers also use integrated motherboards.

The main component on the motherboard is the microprocessor. Microprocessors have evolved rapidly since the birth of the PC. The following is a brief history and description of the major microprocessors used in motherboards.

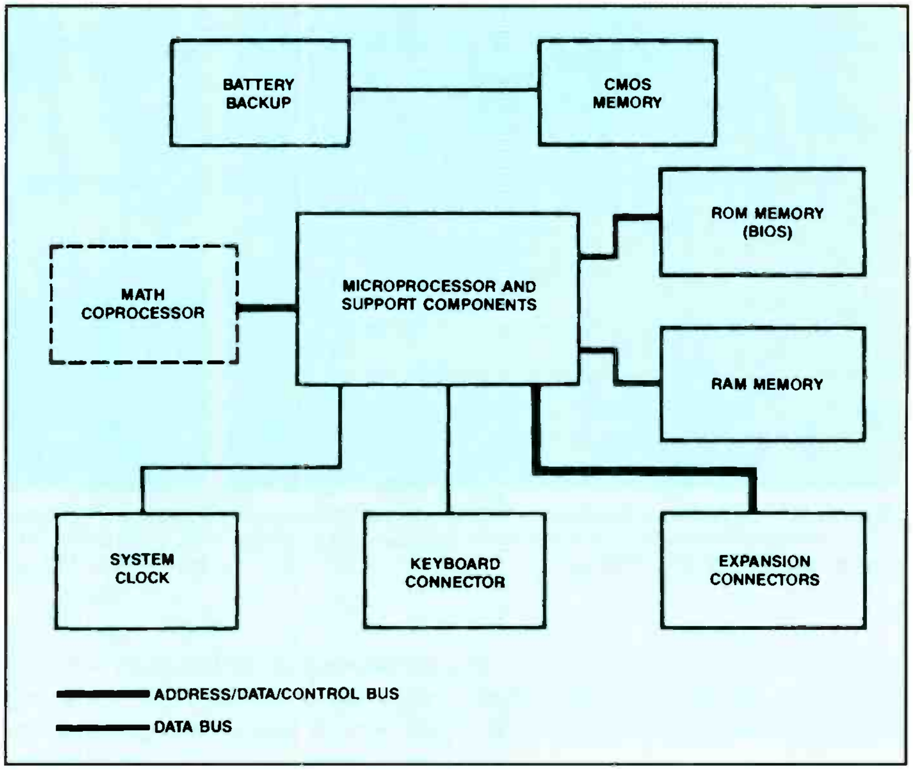

Figure 2. The motherboard contains the microprocessor, memory, system clock, expansion connectors, keyboard connector, and additional support circuitry.

The 8086 and 8088

The 8086 is a 16-bit microprocessor designed by Intel for use in the first IBM PC. The 8086 has 20 address lines, allowing it to address 1M byte of memory. In addition, it has a 16-bit data bus for data transfer to and from system components, and is packaged in a 40-pin DIP package. Typical clock speeds are 4.77MHz, 8MHz, and 10MHz.

Unfortunately, the early computer industry used an eight-bit hardware system. However, the 8086 was used later by IBM in the PS/2 models 25 and 30. Intel designed the 8088 to solve the 8-bit hardware problem.

The 8088 is a 16-bit internal, 8-bit external microprocessor. It is functionally identical to the 8086, except that it has an 8-bit data bus. Internally, it's structured as a 16-bit machine, but communicates with the outside world at 8 bits. The hardware problem was solved and the 8088 was the first microprocessor used in the IBM PC and clone machines. Clock speeds are the same as the 8086.

The 80286

The 80286 is a 16-bit internal and external microprocessor. The 80286 has 24 address lines, making it capable of addressing 16M bytes of memory and a 16-bit data bus. The 80286 also added many new features such as protected-mode operation, integrated memory management, and multitasking (which allows the processor to perform several tasks simultaneously), and completely backwards compatibility with all existing hardware and software. Package styles include a 68-pin PGA, and PLCC and LCC, surface mount configurations. Typical clock speeds are 8MHz, 10MHz and 12.5MHz.

The 80386

The 80386 microprocessor is a 32-bit internal and external microprocessor. It has 32 address lines allowing it to address 4G bytes of memory. Like the 80286, it added many new features such as increased memory addressing, faster clock speeds, and multitasking. It is compatible with all older hardware and software. It is packaged in a 132-pin PGA package and is usually socketed. Typical clock speeds are 12.5 MHz, 16MHz, 20MHz, 33MHz and 40MHz.

The 80386SX is essentially a stripped down version of the 80386 and is less expensive as well. It is a 32-bit internal, 16-bit external microprocessor. It has 24 address lines and can address 16M bytes of memory. The external data bus is 16-bits wide, while the internal bus is 32 bits. Like all the other processors, it is compatibile with all existing hardware and software. It is packaged in a 100-pin quad flat pack surface mount package. Typical clock speeds are 16MHz and 20MHz.

The 80486

The 80486 is a 32-bit internal and external processor. In many ways it is similar to the 80386. It has 32 address lines and can address 4G bytes of memory. It contains an internal cache memory and math coprocessor. Memory caching stores frequently used data for quick access by the processor. Like previous processors it has backward compatibility with all existing software and hardware. It is packaged in a 132-pin PGA package and is usually socketed. Typical clock speeds include 25MHz, 33MHz, and 50MHz.

The 80486SX, like the 80386SX is essentially a stripped down version of its

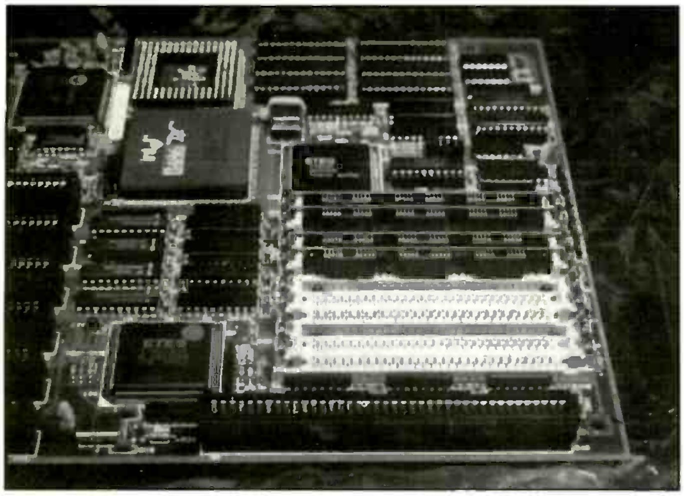

Figure 3. Typical SIMM configurations are 256K x 9, 1 MEG x 9, and 4 MEG x 9. Motherboards that use a 386 or 486 processor often contain a mixture of DIP and SIMM memory.

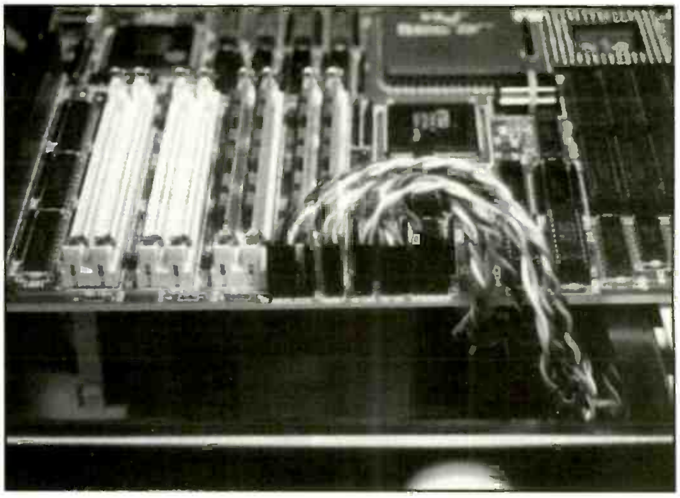

Figure 4. The motherboard has several vital connections that tie it into the system. Two five-pin connections labeled P8 and P9, supply power (+5V, +12V, -12V, ground, and power good.)

parent, with the math coprocessor removed. The 80486SX also runs at slower clock speeds of 20MHz and 25MHz.

Microcomputer chip clones

The V20 is NEC clone of the 8088. It is pin for pin compatible with the 8088 and can be used as a direct replacement.

Many third party companies have "clone" versions of the 80286, 80386 and the 80486. They are technically compatible, but some users comment that the speed is slower than the Intel version.

The math coprocessor is not required for the system to operate, but can speed up math intensive operations such as spread sheets and graphics. All microprocessors can interface with a math coprocessor. Most motherboards contain a socket, normally near the microprocessor, for the coprocessor.

Memory

All computers require memory to function. Memory is arranged in units called bytes. A byte is a group of eight binary digits, or bits, that represent data or a computer instruction. A ninth bit is added for parity, or error detection. 1024 bytes is 1K of memory.

Access time is the time required to retrieve data after a memory request by the processor. Access time is measured in nanoseconds. A number on the chip indicates access time, with the last digit dropped. For example, 12 and 7 would indicate 120 and 70 nanoseconds.

RAM (random access memory) is used by the processor for temporary storage of programs and data. ROM (read only memory) is used to store programs and data permanently. The motherboard ROM contains the system BIOS (basic input output system).

Besides RAM and ROM all 80286 and above motherboards have CMOS RAM. CMOS RAM is backed up by a lithium battery and contains system setup information. The setup information is used by the BIOS to interface to the system hardware. Hard and floppy drive type, memory configuration, system date and time, and video adapter type are stored in CMOS RAM.

Cache RAM is used by 386 and 486 microprocessors to store data that is frequently accessed by the processor. Cache RAM is faster than conventional RAM and therefore speeds up memory access.

Memory is usually socketed and can easily be replaced. Memory IC's are configured in groups, or banks. Memory can be in traditional dual in-line packages (DIPs) or in small surface mount modules called SIP (single in-line pin) or SIMM (single in-line memory modules). SIMM boards mount vertically in sockets and are the standard used in newer computers. Typical SIMM configurations are 256K x 9, 1 Meg x 9, and 4 Meg x 9. Motherboards that use a 386 or 486 processor often contain a mixture of DIP and SIMM memory (Figure 3).

The original IBM PC offered 64K of base memory, with capabilities to expand to 512K. The XT model had capabilities of expansion to 640K. At the time, this seemed like an incredible amount of memory. Original designers did not imagine needing more. Today, it is possible to have upwards of 32 to 64 MB of memory on a motherboard. A basic system configuration is 1M byte base and 1 to 4M bytes of extended memory.

Expansion connectors

All communication with peripheral devices is via expansion boards that plug into the I/O or expansion connectors. An expansion slot is an edge card connector mounted parallel to the length of the motherboard. IBM PC, XT and many clone style motherboards contain six to eight expansion connectors. IBM PS/2 and some clone manufacturers that use the integrated motherboard designs provide four expansion connectors. Expansion boards plug into the motherboard and physically mount to the rear of the case. Connections are through the rear of the case, or internally on the board itself.

The expansion connectors provide an extension of the microprocessor's signals for external device communication. An expansion connector, or slot, is identified as 8, 16 or 32 bits. The original PC and XT motherboards have only 8-bit connectors. An 8-bit connector has 62-pins that carry 8 data lines, 20 address lines, all power supply voltages and additional interfacing signals.

Motherboards with 80286 and higher processors have an additional 36-pin connector with the 62-pin connector to provide room for eight additional data lines and four additional address lines. Most motherboards offer a combination of 8- and 16-bit slots. 32-bit slots are on 386 and 486 computers and are used primarily to add memory to the system once the on-board limit has been reached.

In 1987, IBM introduced the MCA, or micro-channel architecture, connector standard to the computer industry. This connector has smaller pin spacing (0.05 inches) and is not compatible with previous hardware cards. The connector allows for true 32-bit data transfer. MCA is actually a collection of new standards that implement 16- and 32-bit extensions, video and matched memory options. IBM PS/2 Model 50 and above use MCA.

The clone industry did not follow the IBM scheme, but introduced its own standard called enhanced industry standard architecture, or EISA. The original standard is referred to as ISA. The EISA standard allows backward compatibility by adding a connector between the existing connectors.

Motherboard connections

The motherboard has several vital connections that tie it into the system (Figure 4). Two five-pin connections labeled P8 and P9, supply power (+5V, +12V, -12V, ground, and power good.) The connector layout and designations are standard on early IBM machines and the clones. (See Table 1 for pin designations and functions.)

The key lock and power connector on the motherboard is a 5-pin connector responsible for the keyboard lock feature and the power indicator LED.

The turbo switch connector changes the system speed on dual speed units. On 386 and 486 machines this connector enables/disables the cache memory feature. It is often a 2-pin connector and the switch connector is a 3-pin connector.

Besides the turbo switch, a turbo LED connection is provided. This LED indicates the state of the turbo switch. A hard drive activity LED indicates when an access to the hard drive occurs. This LED connects to the hard drive controller or hard drive. Check hard drive/controller documentation for details.

The external battery source connector provides the option of adding external batteries in place of the on-board lithium battery. A battery select jumper is used together with this connector to indicate which battery source will be used.

The video select jumper setting is set to color or monochrome depending on the monitor card installed.

The cache memory select jumper selects the amount of cache RAM installed, if applicable. On new motherboards this jumper should be preset. However, it's always a good idea to double-check. When adding additional cache RAM, this jumper will need to be reset.

I/O expansion cards

Input/output (I/O) cards provide the interface from the CPU to external peripheral devices such as a modem, mouse or printer. I/O cards usually contain two RS-232 serial communication ports, labeled Com1 and Com2 and the standard parallel printer port and game port. Specialized cards are also available that provide multiple serial, parallel or game ports. The I/O ports may be configured as stand-alone cards, part of an IDE controller card, or built into the motherboard.

To communicate with the microprocessor, peripheral devices must send an interrupt request (IRQ) signal to the microprocessor. The IRQ signal tells the microprocessor that the device is requesting attention. Interrupts are assigned priority levels that are controlled by the interrupt controller on the motherboard. An 8088 has eight interrupts available and the 80286 and above boards have sixteen.

In addition to these interrupts, peripheral devices are assigned a port address. This hexadecimal location determines where data will be written to and read from. Jumper settings on the card enable/disable individual ports and assign IRQ and port address selection.

Video display adapters

Before discussing monitors and video display adapters, let's define a few terms. A *pixel* is the smallest dot that a monitor can display. *Dot pitch* refers to the physical spacing of the three-color triads that compose one pixel. This quantity is expressed in millimeters. Typical values range from 0.28mm to 0.52mm. The lower numbers, are the more defined or crisp pixels. The term *resolution* is the active video area expressed in pixel units (For example: 640 x 200).

Video display adapters provide the interface to the video monitor from the central processing unit (CPU). The original IBM PC offered a monochrome display adapter (MDA.) This adapter supported text in 80 columns by 25 rows and included crude block graphics. Another is the Hercules graphics adapter. Hercules graphics adapters are compatible with the IBM text mode but define their own graphics which must be supported by special software.

The lowest resolution color display is the color graphics adapter (CGA). It supports text and graphics modes of 640 x 200. CGA uses a horizontal scan rate of 15.525KHz and a vertical rate of 60 Hz. It connects to the monitor via a 9-pin D-sub connector.

Enhanced graphics adapters (EGA) support text and graphics resolutions of 640 x 350. EGA uses a horizontal scan rate of 22.1KHz and a vertical rate of 60Hz. Connection to the monitor is also via a 9-pin D-sub connector.

Video graphics array (VGA) supports text and graphics resolution of 640 x 480. It uses a horizontal scan rate of 31.5KHz and a vertical rate of 70Hz. Connection is via a high density 15-pin D-sub connector. VGA is probably the most popular standard on the market today. Dip switches and software enable the adapter to support lower resolution monitors. VGA cards contain video RAM that is faster than conventional memory and provide faster screen redrawing. Video RAM is usually in 215K bytes, 512K bytes or 1M increments. The amount of RAM determines the maximum available colors that can be displayed.

Super video graphics adapter (SVGA) is an enhanced version of the VGA standard. It supports all the features of the

Signal/Function	Color	PIN #
Power Good	ORG	1
+5V	RED	2
+12V	YEL	3
-12V	BLU	4
Ground	BLK	5
Ground	BLK	6
Ground	BLK	7
Ground	BLK	8
-5V	WHT	9
+5V	RED	10
+5V	RED	11
+5V	RED	12

Table 1. IBM personal computer motherboard power supply pin designations and functions.

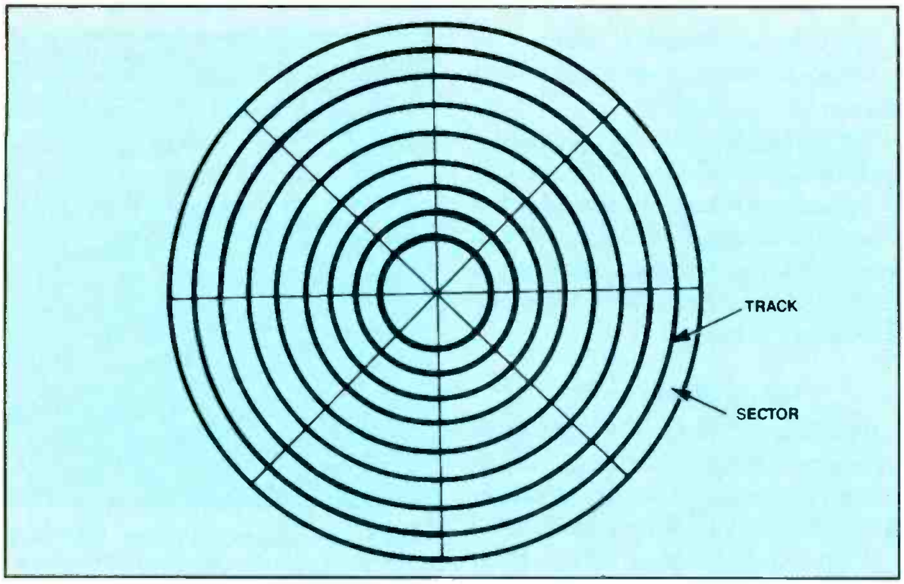

Figure 5. Floppy disk(s) are divided into circular areas called tracks. The tracks are divided into pie sections, called sectors.

VGA, but includes higher resolution mode of 1024 x 768.

IBM also introduced the multi controller gate array (MCGA). This was a mixture of previous standards used by IBM and is a scaled down version of VGA. MCGA was used in the PS/2 models 25 and 30.

All IBM PS/2 systems integrate the video controller into the motherboard. On the original PC and XT machines a system dip switch must be changed to accommodate a new display adapter.

Floppy/hard drives

The hard and floppy drives provide permanent storage for program data and files. Disk drives store digital information as magnetic impulses on a magnetic disk. The disk rotates and a head moves across the surface to read and write information. A floppy drive contains two heads (top and bottom) and a hard drive contains stacked disks and heads that move between the surfaces.

Disks are divided into circular areas called tracks. The tracks are divided into pie-shaped sections, called sectors (Figure 5). Formatting a drive prepares the blank disk for use by writing codes on the disk to define the tracks and sectors. Formatting a disk writes over any information previously stored on it. If an accidental formatting occurs, a utility program can unformat the disk and recover the information, if data hasn't been written on it.

To communicate with the microprocessor, floppy drives connect via a 34-conductor ribbon cable to the drive controller. The ribbon cable has connectors for two drives, designated A and B. Drive A connects to the end of the cable and B to the middle connector. The controller attaches to the opposite end. The controller handles the data transfer to the processor and controls the drive. A four conductor cable supplies +12V, -12V and +5V to the drive (Figure 5).

Floppy disk drives come in two sizes, 5.25 inches and 3.5 inches. The size refers to the physical diameter of the disk. Besides the physical size, each type of drive is available in low density and high density format. The disk density refers to the amount of data that can be stored on the disk. A low density 5.25 inch disk can store 360K bytes of data; a high density 5.25 inches, 1.2M bytes. A low density 3.5 inch disk can store 720K bytes; a high density 1.44M bytes. 3.5 inch drives are also available in 2.88M capacity. High density drives can read/write low density disks, however, the reverse is not true.

Two parameters that are very important in hard drives are average access time and transfer rate. Average access time is the average time required for a drive head to access a particular byte of information. Transfer rate is the speed in bytes at which the drive and controller can transfer data to the motherboard.

Hard drives are classified by the type of encoding method used to store data on the disk. Modified frequency modulation (MFM) and run length limited (RLL) drives were two early data encoding technologies. MFM drives are available in multiples of 20M byte increments and RLL drives are available in multiples of 30M byte increments.

Both MFM and RLL require a controller card for interface to the PC. MFM and RLL controller cards are not interchangeable. MFM and RLL drives each connect to the controller with a 34-pin control cable and a 20-pin data cable. Typical access times for these drives are 25 to 50mS. MFM and RLL drives are still available, but are harder to obtain and are more expensive than the newer integrated drive electronics (IDE) drives.

The IDE hard drive has the controller electronics built into the drive. A controller card is sometimes necessary, however its price is minimal and usually other functions, such as I/O, are combined on the card. An IDE controller card sells for around $25 to $40, versus an MFM, which sells for $80 to $100. The IDE drive attaches to the controller with a single 40-pin ribbon cable.

An IDE drive offers the benefits of lower power consumption and increased speed and storage. IDE drives have access times as fast as 12mS with storage capabilities as high as 1G byte. When replacing an MFM or RLL it's usually a good time to suggest an upgrade to an IDE.

Keyboard

Keyboards communicate with the motherboard serially via a 5-pin DIN connector. Keyboard signals include keyboard clock, keyboard data, ground and +5V. Several variations of keyboards have existed. The original PC and XT included an 84 key keyboard. When IBM introduced the AT class computers the style and function of the keyboard was changed. The AT style keyboard is not compatible with the PC and XT units. Models are available that can be switched to either XT or AT mode.

Troubleshooting

Now that you have an idea of what an IBM compatible personal computer consists of, you're ready to start troubleshooting. For some suggestions on how to go about troubleshooting one of these computers, turn to part II of this article in this issue.

Part II—Troubleshooting

Troubleshooting a PC is very much like troubleshooting any other piece of consumer electronics equipment. You listen to the customer's complaint and then you have them try to duplicate the steps that caused the problem. This *may* not be necessary if the problem is obvious. You then decide whether the problem is hardware or software related. Many problems can be created with new hardware or software installation. Ask them questions such as: "Have you installed any new expansion cards lately? Any new software lately? What type of terminate and stay resident (TSR) programs are installed?"

Software consideration

A working knowledge of software is necessary in troubleshooting PC problems. A full discussion of software is beyond the scope of this article, but reference books are available on software and hardware. Some are listed at the end of this article.

Software is an integral part of the PC system. There are three levels of software on the PC. The first level is the BIOS, or basic input/output system. The BIOS programs perform system testing at power up and provide the interface to the hardware for higher levels of software. The next level is the disk operating system, (DOS). DOS provides the system prompt (C>) that most users are familiar with. DOS interprets commands given to it by a user or program and interfaces with the BIOS to perform the desired function. The third level is application software.

These programs include applications such as word processors, and spread sheets. They are loaded after DOS and require DOS to operate.

Diagnostic software is available to aid in diagnosing system problems. Common examples of diagnostic software include Checkit, QAPlus, Quicktech, Portest and Service Diagnostics. These programs vary in price and ability, but can be very useful in servicing. Many programs offer the ability to perform automatic testing and provide error logging. This can be of great help in a system with an intermittent problem.

Powering up the system

A computer completes a sequence of steps upon power-up. Observing the steps and noting how far the process proceeds can be a vital tool in troubleshooting. The first step is the power on self tests (POST). These tests are contained in the system BIOS. The BIOS performs system hardware tests and signals if an error has occurred. IBM machines send a numerical code to the screen if an error has occurred, while some BIOS manufacturers use a series of beeps. POST codes are unique to each BIOS manufacturer, so it may be necessary to contact the manufacturer for documentation.

After the POST tests, the communications ports, the printer ports and game ports are initialized. The floppy drive initialization is followed by the hard drive initialization. Once the drives are initialized, the BIOS proceeds to boot up, or load the operating system. The BIOS first searches the "A" floppy drive for a boot disk. If no bootable disk is found, it proceeds to the hard drive and searches the boot sector for the operating system.

Once the operating system loads, it searches for the system files autoexec.bat and config.sys. The config.sys file contains statements that define how the system is configured. In addition, commands that load device drivers are listed here. Device drivers are programs used for high and expanded memory, mouse operation and other applications. Refer to a DOS manual for specific details of these and other DOS files.

Autoexec.bat is a batch file of DOS commands that executes upon startup. This file executes DOS commands and loads programs automatically. Check the contents of this file carefully for programs that may be causing conflicts. TSR programs load into memory before other programs and execute in the background. These programs can often be the cause of conflicts and system lockup. Check out these possibilities before proceeding to hardware problems.

Once you have ruled out software as the problem, it's time to look at the hardware. PC's contain CMOS IC's, so static precautions should always be observed when removing and installing components. Remove the system cover by removing the rear panel screws that secure it. (IBM PS/2 models have two thumbscrews located on the top rear of the case.) Slide the cover forward carefully and out of the way. Sometimes when removing the cover you may accidentally dislodge a connector, so pay attention.

Perform a thorough examination of the interior components. Look for signs of overheating, such as darkened areas on PC boards or wiring discoloration. Look for loose or damaged connectors on expansion boards, disk drives and the motherboard. It's a good idea to blow out the interior with compressed air to remove excess dust and debris. If everything looks good then check out the power supply.

Power supply troubleshooting

Computer supplies are switch-mode type supplies that provide +12V, -12V, +5V, and -5V. Power supply voltage measurements can be made on connectors J8 and J9 at the motherboard (Figure 6).

Common problems include a blown

power fuse, shorted diode bridge, shorted output transistors and open output capacitors (Figure 7). Line voltage is rectified by a discrete diode bridge and provided to the output switching transistors. When the diode bridge or output transistors fail the main fuse blows.

A no-output condition can be caused by an excessive load on the supply, open output capacitors and output transistor failure. When replacing the output capacitors, be sure to use high-frequency type capacitors. Standard electrolytic capacitors will not work. If an excessive load is suspected, disconnect the hard drive and the floppy drives one at a time and monitor the power supply voltages. A defective motor or other component in the drives may load down the supply.

The cooling fan is an integral part of the power supply and the computer system. The fan cools the components of the supply and draws air into the computer case for cooling. Cleaning the air intakes on the case and on the power supply aids in keeping the internal components cool. Excess dirt can build up and cause premature failure or binding. If the fan stops, a high internal case temperature can result and cause component damage.

Typically, it may be cheaper and more economical to replace the supply. (The defective unit can be repaired at the service center or scrapped for parts.)

To remove the supply for repair or replacement, disconnect all power connections on the motherboard and disk drives. Remove the screws on the rear of the case that secure the power supply. In some designs, additional mounting screws may be present on the bottom of the case and it may be necessary to remove disk drives or other components that may be blocking removal.

When ordering a replacement supply it is necessary to specify the case style and wattage. Desktop and tower cases may use the same wattage supplies, but the case style is different. Install the new supply by following the above steps in reverse order. When connecting the motherboard connections, J8 and J9, take care to orient them properly. When installed properly, the black wires from each connector will be side by side. Power up the system and check the supply voltages with a DMM.

If you suspect a problem with a particular expansion card, check to see that it seats properly in the expansion connector. Over time a card may gradually "creep" out of the connector, creating intermittent problems. If in doubt, remove the mounting screw at the back of the case and remove the card. Examine the card and card contacts and clean as needed. Replace the card and retest the system.

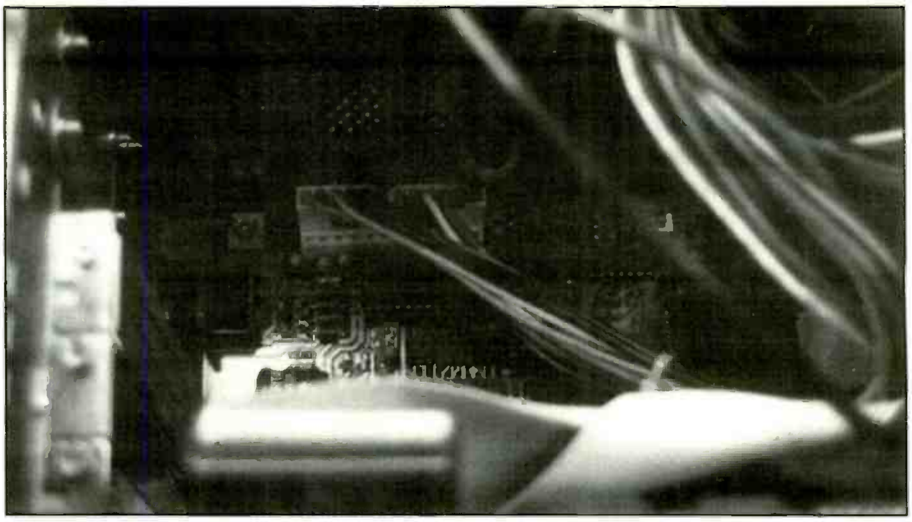

Figure 6. Power supply voltage measurements can be made on connectors J8 and J9 at the motherboard.

If the problem persists, run a diagnostic program such as Checkit and check the IRQ and port address settings of the system. Then, check the expansion board jumper settings and see if a conflict exists. Two expansion cards or peripherals *should not share the same IRQ or port address*. Often, they may work fine if used separately, but, if the two devices try to work simultaneously the system may crash or lock-up.

A word of caution: Diagnostic software may not always "find" every card in a particular system. If in doubt, check the card installation manual or specification sheet. It's a good idea to keep a record of each system you service by serial number and record the IRQ, port address and CMOS system configuration. This information will be helpful in future service calls.

If you are unable to remedy the problem, exchange the card with a known good card. If the problem persists, then try the original card in another slot to rule out the possibility of a bad expansion connector. If no solution is found, it's likely the problem lies in the motherboard.

Motherboard repair

Motherboards are present in many varieties. Depending on the type that the system has will determine how far you can troubleshoot. IBM PS/2 motherboards are coated with a protective epoxy that makes component replacement almost impossible. Most motherboard manufacturers do not sell schematics, however, a system or layout manual may be available. The Layout manual provides main component identification, jumper and connector settings, memory configuration and other related information. This information is often crude at best and makes troubleshooting to component level difficult. However, there are alternative methods.

Motherboard problems can be diagnosed by the CPU during the POST test, which is performed when the system is powered up. If an error occurs, a code will be generated and displayed. Some systems also emit a series of beeps. The codes are unique to each BIOS manufacturer; so you must have the code information.

Expansion cards are available that plug into the motherboard and aid in diagnosing POST codes. These cards interpret the POST codes and provide a recommended action to take, such as replacing a specific component. Some POST test board manufacturers provide the code interpretation or offer technical support with their product. Most cards also have LED's to indicate power supply voltage conditions. (See listing at the end of the article.)

Another product is diagnostic test ROMS. The existing BIOS ROMS are removed from the system under test and the diagnostic ROMS are installed in their place. The system is powered up and the

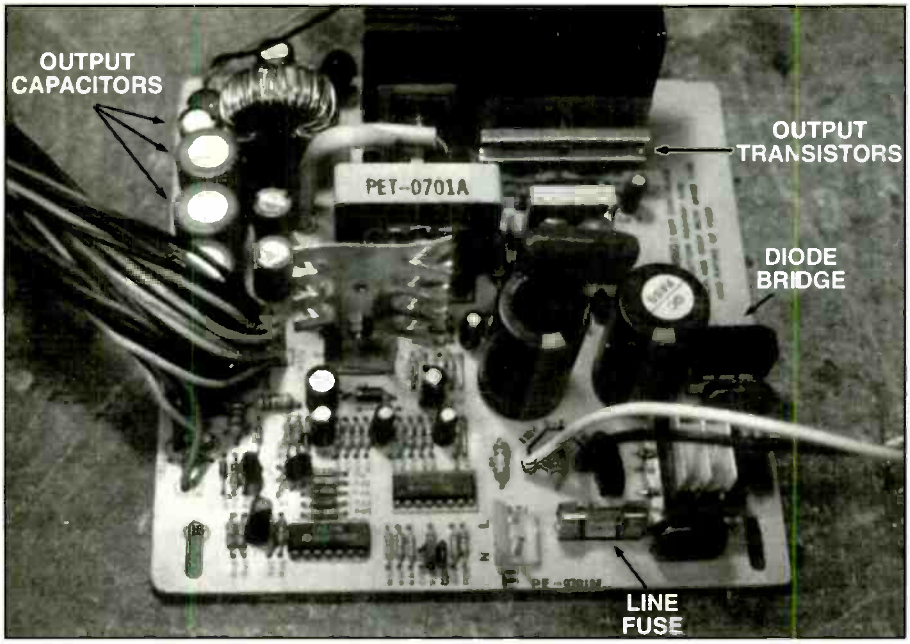

Figure 7. Common IBM and clone personal computer power supply problems include a blown power fuse, shorted diode bridge, shorted output transistors and open output capacitors.

test ROMS check out the system and provide error codes when a problem occurs. If a failure occurs, a recommended action is suggested. If the computer display is not functioning, beep codes signal a test failure. Other features may be included and vary with the price of the kit. (See listing at the end of the article.)

When a system memory error occurs, the BIOS will usually list the defective area. Using the motherboard layout information you can determine which bank of chips is defective. If the layout information is not available, diagnostic software such as Checkit, provides a bad RAM chip location feature that can be used to locate a bad RAM chip. This can be useful in locating the defective chip or SIMM board. In older systems, memory consisted of discrete DIP IC's in sockets. In newer systems, memory consists of SIMM boards. These are also in banks and replaced as a unit.

SIMM memory boards mount vertically in sockets and are held in place by spring tabs on each end of the board. Press on the tabs to release the board and tilt it back toward the motherboard to release it. Reverse the procedure to replace the unit. Memory must always be replaced with memory of the same or greater speed. If slower memory is installed the system may experience memory related errors or a system crash.

When upgrading a system memory, consult the motherboard documentation for details of upgrade increments. Memory is upgraded in specific increments depending on the amount installed. Motherboards typically contain eight SIMM sockets, grouped in units of four, labeled bank 0 and bank 1. The capacity of the SIMMS installed dictate the total amount of system memory. Each bank of SIMMS must contain the same capacity SIMM boards (256K x 9, 1M x 9, 4M x 9 etc.).

Unlike memory, other IC's on the motherboard may or may not be socketed. Some are also in surface mount packages. If you have the facilities to replace surface mount components you may want to go to component level. Otherwise, you may want to replace, or exchange the motherboard.

Replacing the motherboard

A motherboard is replaced by first removing all expansion cards. Then remove the power supply and front panel connections. Locate the board mounting screws and remove them. Sometimes, it may be necessary to remove a disk drive or other component to access a particular screw. Some motherboards use a combination of screws and plastic standoffs to mount the board. Removal of the board may require sliding it sideways to release the plastic standoffs from their mount. Once the board is removed the standoffs can be transferred to the new board.

Before installing the new board check all the jumper settings to make sure they are correct. The motherboard documentation will explain each jumper and setting option.

Most cases have extra mounting holes in them to accommodate different style motherboards. When installing the new board, line up as many holes as possible and secure the board. Look for possible shorts under the board (metal case to PCB traces). Using the new board's documentation as a reference, reconnect the front panel and power supply connections.

The next step is reinstalling all the system expansion cards. Insert each card and make sure it seats properly in the expansion connector. When you have completed installing all the cards, recheck all your connections before powering the system.

When a motherboard is first installed you must run the CMOS system set-up program to properly configure the system. This program is contained in the BIOS and stores the system configuration information in the CMOS RAM. Execution of the program is usually performed automatically with a new board installation. The motherboard documentation should provide information on how to invoke the program manually. IBM systems do not have the CMOS utility contained in the BIOS, but instead, require the systems reference floppy disk to be used to boot the computer. The reference disk contains the system setup utility, that will be invoked automatically when the system is booted from this disk. The reference diskette also contains other utility programs for system troubleshooting.

The setup programs prompt you for the date and time, floppy drive sizes and types, hard drive type and the type of monitor installed. (Disk drive types will be discussed in the next section.) Enter the information as requested and exit the program when completed. The program will prompt you to save the information as you exit.

Hard and floppy drives

Working with disk drives and system components requires that internal cables be disconnected and reconnected. It is important that pin 1 of each cable and connector match. Manufacturers use several methods on cables and connectors to designate pin 1. One edge of each ribbon cable has a colored stripe to designate con-

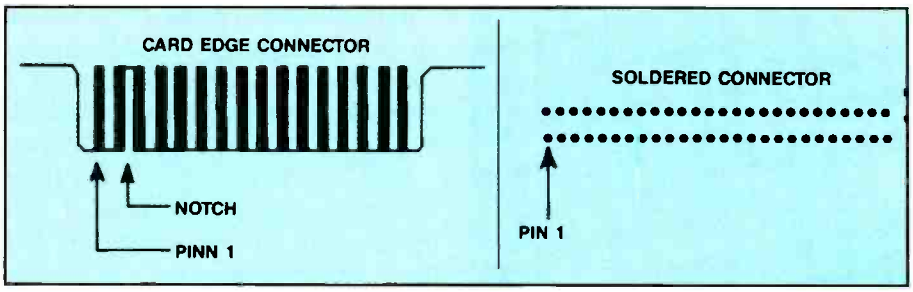

Figure 8. Pin 1 may be designated by such characteristics as a notch near the pin, or a square soldered connector. In addition, any distinguishing marks on only one conductor designate pin 1.

ductor 1. If a card-edge connector has a notch near one end, that is pin 1. Look for a label designating pin 1 on a PC board. If the board has no label, pin 1 may be designated by a square (as opposed to a circular) solder pad. In addition, any distinguishing marks on only one conductor designate pin 1 (Figure 8).

Diagnosing a problem with a floppy disk drive can be a straightforward procedure. Check the obvious items first: lodged disk or other debris in drive, loose or damaged cable connector, or no power to drive. After these checks, eliminate the drive or controller as the problem. Exchange the drive with a known-good drive. If the problem persists, your controller card is suspect. Another area to check is the CMOS setup information. Verify that the drive size and density are correct. If this information is corrupt or invalid a problem may occur.

The most common problems that occur with floppy drives involve misalignment. As the drive ages, the stepper motor assembly begins to wear, and the drive head does not line up with the data and format information on the disk. Alignment problems may not show up until a disk is read from another computer. A misaligned drive may read and write its own data, but, have difficulty reading information written by another drive.

A commercial software package such as QAPLUS/FE can be used to check for proper alignment and assist in realignment. Realignment consists of running an alignment disk in the defective unit and adjusting the mounting of the stepper motor or head actuator. This is usually accomplished by loosening mounting screws and moving the head actuator in small increments. However, in many cases, it may be more economical to replace/exchange the drive on-site. A new floppy drive costs between $50 and $80.

To replace a floppy drive, first disconnect power from the system. Remove the controller and power cables from the rear of the drive. Locate the mounting screws on both sides of the unit and slide it forward. Some drives are secured to mounting rails that attach to the front of the case. Install the new drive and test. If upgrading from a low density to a high density drive, run the CMOS setup program and change the drive type.

Hard drive problems

Hard drives suffer from some of the same problems as floppy drives, however, the "fix" is different. A hard drive cannot be aligned mechanically in the field. A hard drive is a sealed unit that's assembled in a "clean" room. Never remove the cover of a hard drive. Dust particles in the normal environment can destroy a hard drive. The heads of a hard drive skim across the disk surface at a distance less than the thickness of a human hair. A small dust particle appears as a mountain to a disk head.

Reformatting a hard disk

As the drive ages the head actuator gets out of alignment with the data and formatting information. To realign a hard drive a low level format must be performed. Low level formatting rewrites the track and sector information and will compensate for head actuator wear. Unfortunately, all program data will be lost, unless a special program like SpinRite or Norton Utilities is used.

Utility programs are available to perform a low level format, but, most hard drive controllers also provide this feature in the controller BIOS. Before you perform this procedure, back up all data on the hard disk, or this procedure will erase everything on the drive. To access this program, type DEBUG at the DOS prompt. At the DEBUG prompt, type "G=C800:5". This executes the built-in formatting routine. The following procedure will only work on MFM and RLL drives. Low level formatting is not recommended on IDE drives. If this doesn't work the system may lock up. Reboot and try C800:6, C800:CCC or C800:8. This is a drastic process, but the new formatting information compensates for the head actuator wear.

After low level formatting, run the DOS program FDISK. FDISK partitions, or divides the hard disk for use with DOS or another operating system. After FDISK is run, a high-level format must be performed. This is accomplished with the DOS Format command. (Refer to a DOS manual for use of DEBUG, FDISK and FORMAT.) After reformatting, all software must be reinstalled. Before reinstalling the software, check the disk for bad sectors. Hard drives can fail just when you need them, so always make back-up copies of your software and data and recommend this practice to your customers.

Bad sectors and file fragmentation

Bad sectors are another problem that hard drives experience. If a section of the magnetic media becomes unreliable, data stored there becomes corrupted. This can lead to program crash, or data loss. Many commercial programs such as SpinRite, Norton Utilities and PC Tools have programs that can search a hard drive and find and tag bad sectors. Once tagged, the sectors will not be used again. If bad sectors occur in the boot record area of the disk, the drive may become unbootable, or unable to load the operating system. The drive can still store data but cannot be used to boot the operating system.

Another problem is file fragmentation. As data is added to the disk it is stored in the available space on the disk. Often, the available space is not in contiguous sectors. As files are written and deleted the available space becomes scattered around the drive. When a file loads, the drive head must search around to find all the data. This causes wear and tear on the drive and increases program loading time. Commercial programs such as Norton Utilities, PC Tools and SpinRite also provide a file defragmentation program.

If a hard drive becomes unusable, commercial software may be used to recover the data. If software cannot recover the data, commercial recovery and refurbishing services are available.

Replacing a hard drive

To replace a hard drive, first disconnect power from the system. Remove the controller, data, and power cables from the unit. Next, remove the mounting hardware and remove the drive. Install the new drive and attach the power and controller cables. Check the drive documentation and determine the drive type. The drive type defines certain disk parameters, such as number of heads, sectors and the total Megabyte storage capacity. This information is provided with a new drive, or can be obtained from reference books.

Once you have determined the drive type, power-up the system and invoke the CMOS set-up program. Enter the new drive type number when prompted. If the drive type is not available, many BIOS manufacturers offer a Type 47, "user defined" option. The "user defined" type allows you to manually enter each drive parameter as requested, thus creating a new drive type.

The next step is preparing the disk for use. When you boot up the first time after a new drive installation, you must use a floppy diskette with DOS on it. Place the disk in the "A" drive and power up the computer. If you have an MFM or RLL drive, perform a low level format, partition, and high level format. If installing an IDE drive, partition and high-level format only. After formatting, install DOS and other software as needed. Run a disk diagnostic program to verify everything is OK. (If the computer is booted with DOS 5.0, it will automatically prompt you to partition and format the hard disk.)

As mentioned earlier, MFM and RLL drives are harder to come by and more expensive than a comparable IDE. It's usually a good idea to suggest an upgrade. The customer will get a faster drive and benefit from the increased performance.

Solving some actual problems

Parts I and II of this article series provided some background on the development of IBM compatible personal computers and some general troubleshooting suggestions.

Part III, also in this issue, reports on some case histories of problems that occurred, and gives an detailed explanation of how those problems were successfully solved.

Part III—Case histories

One of the best ways to learn about servicing is to read about actual problems that have been encountered by technicians, and follow the details of how they went about isolating and correcting the problems. The following are descriptions of real-world problems in personal computers, and the steps taken to restore the computers to operation.

Computer locks up during power up

I was called in to assist with a computer repair; one that unexpectedly turned into a long learning experience. It was explained to me that the computer would begin to boot up and would lock-up with the message " Memory parity error." No problem, I thought, it's just some defective memory. I explained to the computer operator that I would take the system to the service center, decide what memory chips were defective and replace them. I said that I would have the system back up the next day.

I took the unit to the service center and removed the cover. I saw socketed memory chips in four rows. All I needed to do was determine what chips were defective and replace them. I had no documentation on the DTK motherboard, so I contacted DTK for assistance. I was told that a schematic was not available, but, they would fax me a copy of the installation manual. The installation manual contained memory layout and jumper setting information.

I decided to remove two banks of chips and configure the unit for 512k of memory. I would test a bank one at a time to narrow the problem down to a single bank of chips. The system worked fine with 512k, so I added another bank and retested the system. This set exhibited no problem. I installed the last bank and the system appeared normal. However, after trying to load a program, the parity error reappeared. I purchased new chips and installed them. The system appeared normal, but it didn't take long for problems to reappear.

I contacted DTK and they were convinced the newly-installed memory was bad. To test the new memory, I reconfigured the system for 576K using the new memory chips. I tested the system and everything appeared normal. I figured the problem must be in the memory addressing or parity circuit of the last bank. Since I had no documentation, I was left to guessing which chips might be bad, based on their function and proximity to the defective bank.

I spent several hours tracing the PC foils with no good suspects. Since the motherboard was an 8088 we decided to buy a new board. (Typically it's easier to replace the board than to spend the labor in man-hours trying to repair it. In addition the board could be repaired by a third party vendor for less than my labor costs.) We contacted a local supplier and obtained an 80286 motherboard for $125.00.

The new board was installed and the system was returned to the office. A couple of days later I received a call. It seemed my problems were not over. The computer operator explained she was getting an error when she tried to pull up a file and she had misspelled the name. The system would lock-up and her only option was to reset the machine, losing all her work. The problem only occurred while running Word Perfect. All other software ran with no problems.

Not being an expert at this particular word-processing program, I studied the manual for clues. I contacted the manufacturer of the software and asked for help. No suggestions would remedy the problem. I tried reloading the software, and several memory options, but it still locked-up. I tried loading the software on another machine and it worked fine.

I contacted the local vendor for help. He had never heard of the problem, but he let me speak to his software expert. We tried several option settings but no change. I questioned whether the motherboard could be at fault. It seemed like a software problem, since it only happened with Word Perfect, but, I asked him to send me another Motherboard.

I installed the new Motherboard and the problem disappeared. After calling the vendor to explain the motherboard fixed the problem, he explained he had found out that this motherboard had some BIOS problems that made it not 100% IBM compatible.

Program runs slow

I was called in by another company that had a computer that was operating very slowly. A spreadsheet took 25 minutes to load! I didn't use spreadsheets very often but I could not imagine one that large! The computer was an IBM PS/2 Model 70. It had an 80386 processor running at 20 MHz, 2 MB RAM and a 80 MB hard drive. It's not exactly a speed demon, but it shouldn't be a turtle either. I had the computer operator load the spreadsheet while I watched. The hard drive activity light stayed lit almost constantly as the hard drive crunched away. I suspected that her hard-drive was very fragmented. This can cause increased wear and tear on a drive and cause it to slow down.

I thought that a disk defragmenting program such as the Norton Utilities program, Speed Disk, would help. I knew that it wouldn't be a total cure, but it would be a start. A defragmenting program re-organizes the files on the drive and puts all their parts in a consecutive order. This makes the drive work less to access the file. I ran the defragmenting program and reloaded the file. This time it took 18 minutes, about a 36% increase; still a long time to wait for a sheet to load.

Most spreadsheet programs take advantage of expanded memory if available. To utilize the memory, a memory manager program must be loaded. I wondered if the expanded memory was being used. I checked the config.sys and autoexec.bat files for evidence of a memory manager, but found nothing. I installed the EMM386.EXE program included in DOS 5.0 and configured the system to use the extra 1 MB of memory.

Again the sheet was loaded. It now took around 12 minutes to load. We were headed in the right direction.

The accountant at the same company mentioned that she had the same spreadsheet on her portable computer and it only took a few minutes to load. She had stopped using the portable because the hard drive had crashed and she almost lost the hospital's entire budget. She said she didn't understand why the portable was faster, since it was several years older than the IBM.

I checked the portable's system configuration and found it was an 80286 with 4 MB of memory and a math coprocessor, running at 12 MHz. I surmised that the extra memory and coprocessor made the difference, even though the portable was an older machine.

A spreadsheet is a math-intensive program and is a good candidate for a coprocessor chip. I suggested we add memory and a coprocessor to the system. We ordered 4 MB of memory and a coprocessor. I installed the parts and reconfigured the system to utilize the memory and coprocessor. The spreadsheet now loads in slightly less than one minute.

Keyboard failure

The keyboard was the problem in another computer service call I made. It locked up in the middle of a program and won't do anything! This is the problem description I received. I took the keyboard with me to my service center and I plugged it in to my computer and verified the problem. The keyboard would not respond at all. I noticed the number lock, caps lock and scroll lock LED's did not light when the computer booted up. Ordinarily, during boot-up these LED'S light momentarily. I wondered if the keyboard was getting power.

I removed the screws from the back of the unit and separated the two halves. The keyboard cord terminated into a five-pin connector on a PC board. The circuit board had few components; a micro controller, and a few support components. The silk-screen on the board indicted the signals and voltages at the connector. I checked the connector to see if it was receiving power from the 12V supply. No voltage was present. I suspected an open in the keyboard cord. I flexed the cord while I monitored the voltage. At one point midway in the cord I managed to obtain a reading momentarily.

Since I could not find a direct replacement, I purchased a keyboard extension cable and cut the connector off one end. I reterminated the connector internally and tested the keyboard; it worked fine. Keyboards are relatively inexpensive, but in some cases they can be repaired economically. It may be beneficial to exchange a defective keyboard for a customer and repair theirs for another job.

Conclusion

The personal computer can be an exciting and challenging piece of equipment to troubleshoot. On the other hand, it can be time consuming and frustrating. The personal computer, like other consumer products, is changing rapidly. A good library of reference books, articles and parts information is a must to keep pace.

Personal computer parts and services

Disk Drive Services

- Maxdata Technology
  800-354-2952
  Fax: 714-434-3873 (Hard drive repair and sales)
- Advanced Data Technology
  12821 Western Ave
  Garden Grove, CA 92641
  800-333-3748 (Hard drive and tape drive repair)
- Unitek Co
  408-395-0382 (hard disk services)
- Uptime Computer Support Services
  Valencia, CA
  805-254-3384
  Fax: 805-254-1950

Motherboard Services
• Eagan Technical Services
1380 Corporate Center Curve
Eagan, MN 55121
612-688-0098 (Specialize in IBM PS/2)
• Southern Technical
1437 Story Ave
Louisville, KY 40206
502-585-5635
Fax: 502-584-6008 (IBM and Epson Parts and Service)
• PCB Depot, Inc.
703-437-6769 (Motherboard repair for Packard Bell, Dell, KLH and others)
• Micro Repair Center
1139 Stone Gate Road
Shrub Oak, NY 10588
800-829-6671

Power Supply Services
• Skyline Engineering
1374 Arcade Street
Saint Paul, MN 55106
612-771-9624
Fax: 612-771-4052 (power supply repair)
• Compusol Inc. 714-253-9533
Fax: 714-253-9532

Monitor Parts and Repair
• CRC International
186 University Parkway
Pomona, CA 91768
714-468-9711
Fax: 714-468-9667
• Servonics Corp
14 Kendrick Road
Wareham, MA 02571
508-295-6372
Fax: 508-295-9089
• 3E Corp.
165 Front Street
Chicopee, MA 01013
800-682-5175; 413-594-2772
Fax: 413-594-7283

Miscellaneous Parts
• P.C. Parts Express
1221 Champion Circle, Suite 105
Carrolton,TX 75006
214-406-8583
Fax: 214-406-9081
(Epson, IBM, NEC, H.P., AST, Compaq, Canon parts)
• AUT, INC
1310 S. Dixie Hwy.
Suite 18W
Pompano Beach, FL 33060
800-741-2490
(Repair and spare parts for IBM, Zenith, Okidata, Apple, Wyse, Panasonic Star, Citizen)
• PC Parts, INC
4415 North Front Street
Harrisburg, PA 17110
800-666-9373; 717-233-6650
Fax: 800-288-9373
717-233-2774
• Service 2000
5301 E. River Road
Mineapolis, MN 55421
800-466-2000
612-571-9554
Fax: 612-571-3847 (IBM Parts)
• Computers Etc. Inc.
6005 N.W. 63rd
Oklahoma City, OK 73132
800-299-2573; 405-722-0095
(IBM Board level components and proprietary I.C.'s)

In addition to these vendors, many PC parts can be obtained from well-known vendors such as MCM Electronics, Parts Express, Mat Electronics, JDR Microdevices and others.

Diagnostics

Hardware Diagnostic Boards
• POST-CODE MASTER
Micro Systems Development
4100 Moorpark Ave.
San Jose, CA 95117
408-296-4000
• POCKET POST Data Depot
1525 Sandy Lane
Clearwater, FL 34615
813-446-3402
800-275-1913(Tech Support)
• PC FIXER
Sibex, Inc.
1040 Harber Lake Dr.
Safety Harbor, FL 34695
813-726-4343
• AT ROM POST:KICKSTART 2
Landmark Research Int'l
703 Grand Central St.
Clearwater, FL 34616
800-683-6696
800-683-0854(Tech support)
• WINDSOR POST
Windsor technologies
130 Alto St.
San Raphael, CA 94901
415-456-2200
• R.A.C.E.R. II
Ultra x, Inc.
P.O. Box 730010
San Jose, CA 95173
408-988-4721
• POST PROBE
Micro 2000
1100 East Bway, 3rd fl.
Glendale, CA 91205

Diagnostic Software
• MICRO-SCOPE
Micro 2000
1100 East Broadway, 3rd Fl
Glendale, CA 91205
818-547-0125
• QAPLUS/FE 5.1
DiagSoft, Inc.
5615 Scotts Valley Drive
Suite 140
Scotts Valley, CA 95066
408-438-8247
• CHECKIT PLUS
Touchtone Software Corp.
2130 Main St.
Suite 250
Huntington Beach, CA 92648
800-531-0450
714-969-7746
• QUICKTECH
Ultra-X, Inc.
P.O. Box 730010
San Jose, CA 95173
408-988-4721
• PORTEST
Microsystems Development
4100 Moorpark Ave.
San Jose, CA 95117
408-296-4000
• SERVICE DIAGNOSTICS
Landmark Research
703 Grand Central St.
Clearwater, FL 34616
800-683-6696
• THE NORTON UTILITIES
Symantec
10201 Torre Ave.
Cupertino, CA 95014
408-253-9600

References

• Inside the IBM PC and PS/2, by Peter Norton, Brady publishing
• Peter Nortons Advanced DOS 5, by Peter Norton, Brady publishing
• Upgrading and repairing PC's, by Scott Mueller, QUE Publishing
• The Winn Rosch Hardware Bible, Winn Rosch, Brady Publishing
• The XT-AT Handbook, by Choisser & Foster, Annabooks

Analog signature analyzers—part II

By Vaughn Martin

Part I of this three-part article, which ran in the June 1993 issue of **ES&T**, introduced the analog signature analyzer, a CRT based instrument that makes measurements of components with the power off. That installment examined the theory of operation of the signature analyzer, and demonstrated that there was little likelihood that use of the signature analyzer would overstress either a component under test or the analyzer itself.

Applications examined in that article showed how to make and properly interpret measurements on passive components. This installment will proceed with making more measurements on components that are more involved than mere passive components. The figures in this story are numbered consecutively, starting from part I, so the first figure number in this part is 19.

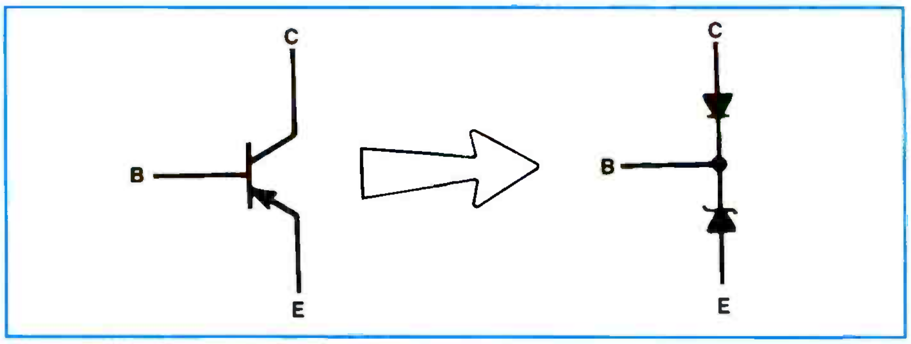

Figure 19. The equivalent circuit of a transistor. Note that it consists of two junctions.

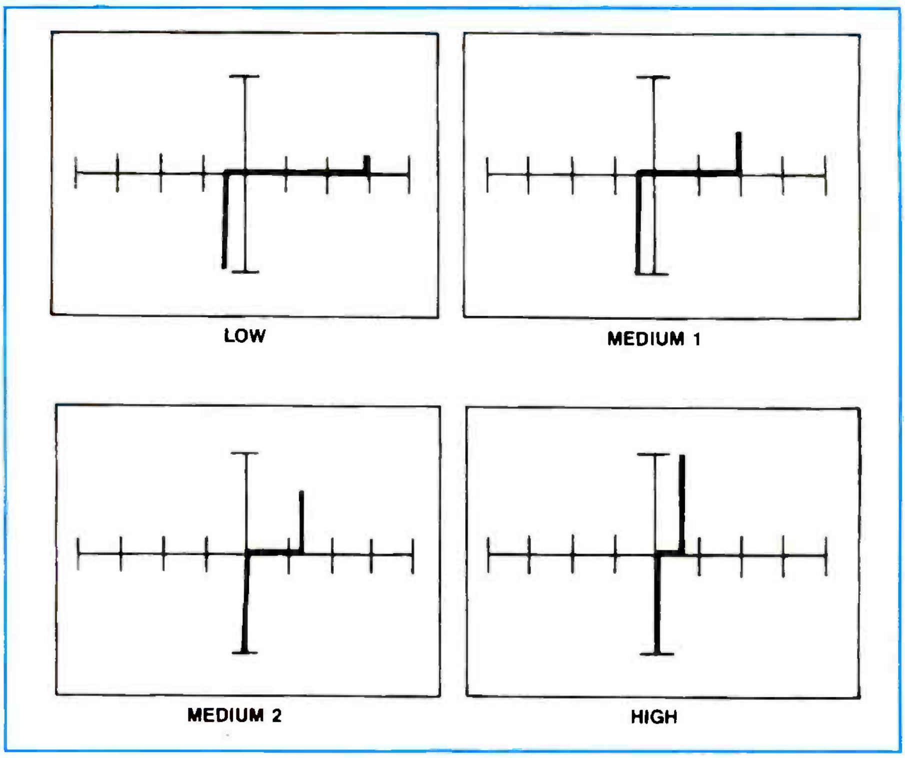

Figure 20. The signature of a 2N3904 transistor.

Testing a transistor

Testing a transistor using an analog signature analyzer is more involved than testing passive components, and certain precautions must be taken. Let's review some elementary material upon which we will base our assumptions.

First, an NPN transistor exhibits a zener diode effect. That is, a transistor has normal diode voltage drop under forward bias conditions (Figure 19) and a zener breakdown under reverse bias with V_Z usually in the 6V to 10V range.

Referring again to Figure 19, the transistor test examines a series of two junctions; a simple diode in series with a zener diode. When the collector is positive with respect to the emitter, the C-B diode is reversed biased and the combination appears as an open circuit.

This is to be expected since the normal operation of an NPN transistor uses C-E voltage. There is no base drive in the test circuit. When the collector is negative with respect to the emitter, the C-B diode is forward biased and the B-E junction goes into zener breakdown.

Figure 20 shows the signatures of each of the three configurations of a 2N3904 NPN transistor, all taken on the HIGH range at 60 Hz with the emitter common. Note the line to the left of the display pointing downward on the C-E and C-B configurations. This is the low impedance section of the signature (remember the resistance test) and it is the sum of the voltage drops across the two junctions.

Precautions when testing transistors

Use of a signal analyzer may alter the gain (h_{fe}—also referred to as ß, or beta) of a bipolar transistor when the emitter is tested, as in the case of either the base-emitter or collector-emitter test circuits.

While the heating of the transistor dur-

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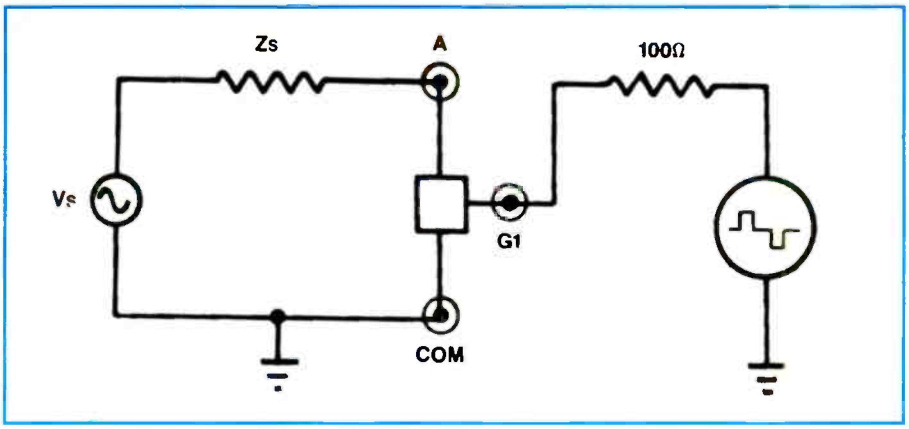
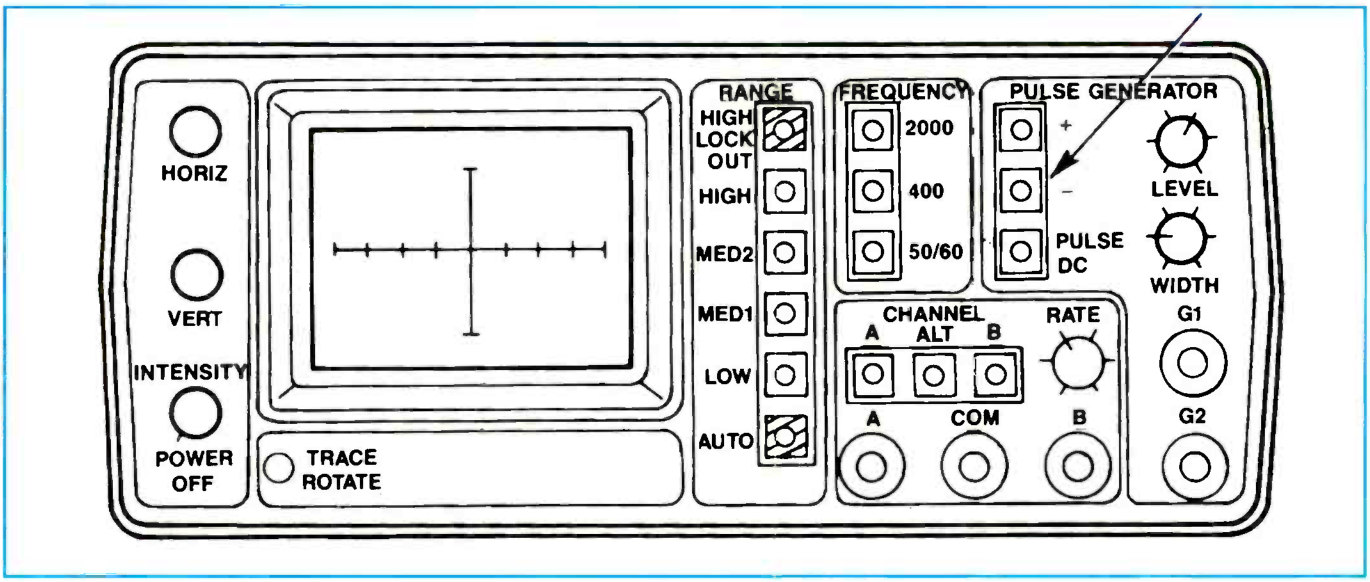


Figure 21. Pulses produced by the pulse generator, shown here in block diagram form, place the device under test in its active region allowing the user to more thoroughly characterize the device.

Figure 22. The arrow in this diagram points to the pulser section's control buttons.



ing the test may temporarily change its gain (most noticeably in the lower ranges), a permanent shift in gain may result when the base-emitter junction is forced into reverse breakdown (approximately 6V to 20V). This shift in gain is a function of the duration of the test and the range, with MED2 and HIGH producing the smallest permanent shifts in gain.

This shift in gain will not necessarily cause problems, because most bipolar transistor circuit designers allow for a wide variance of h_{fe} in their designs. This built-in tolerance is referred to as beta sensitivity.

There are exceptions to this rule-of-thumb. Instrumentation designs, for example, may be calibrated exactly to a certain value of h_{fe} or precision differential amplifiers using matched transistors. Do not use an analog signature analyzer to test such components.

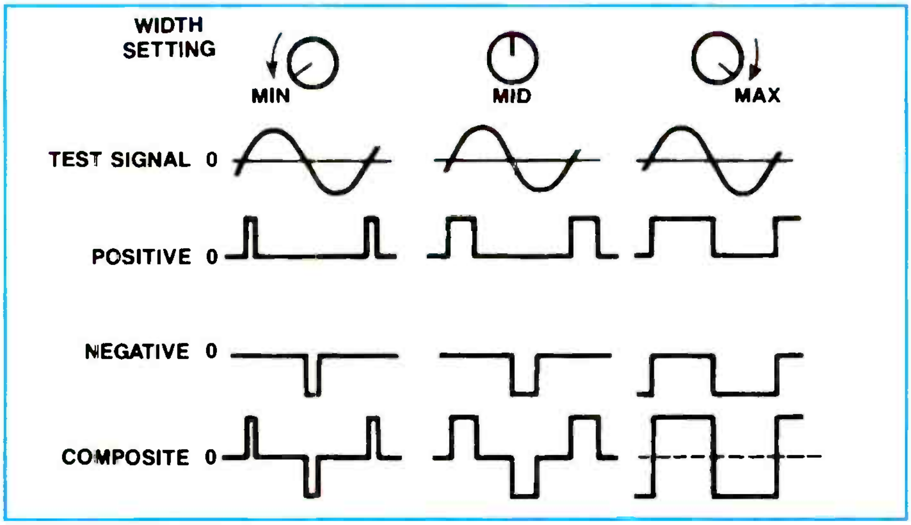


Figure 23. Manipulating the width control produces different signatures.

Suggestions to Minimize Changes in h_{fe}

The following three-step procedure will help to minimize the effects of changing gain of a transistor when testing it with a signature analyzer.

1. Keep the duration of the test as short as possible.
2. Use the MED 2 or HIGH ranges.
3. Identify the collector, base, and emitter. Next, test the collector-base junction to determine if it is an NPN or PNP. Since the emitter is not tested, there will be no effect on h_{fe}. Use the built in pulse generator to avoid reverse biasing the base-emitter junction.

To use the pulse generator requires an additional lead from the pulse generation

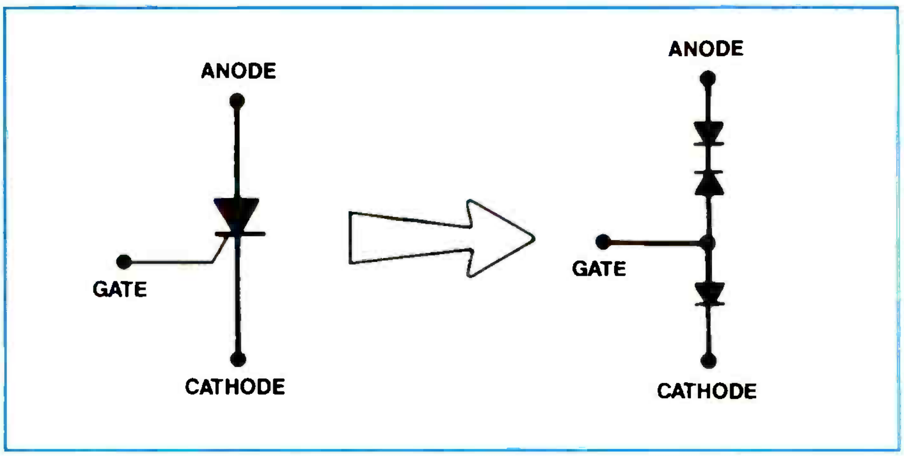


Figure 24. An SCR can be represented by this equivalent circuit.

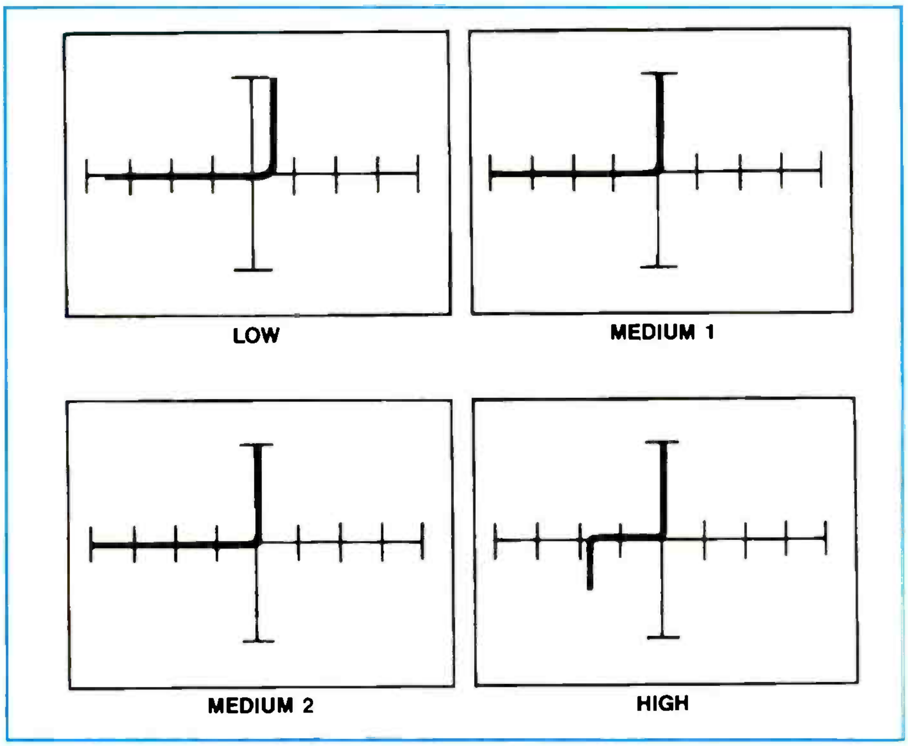


Figure 25. The anode-gate and cathode-gate junctions of an SCR have these signatures.

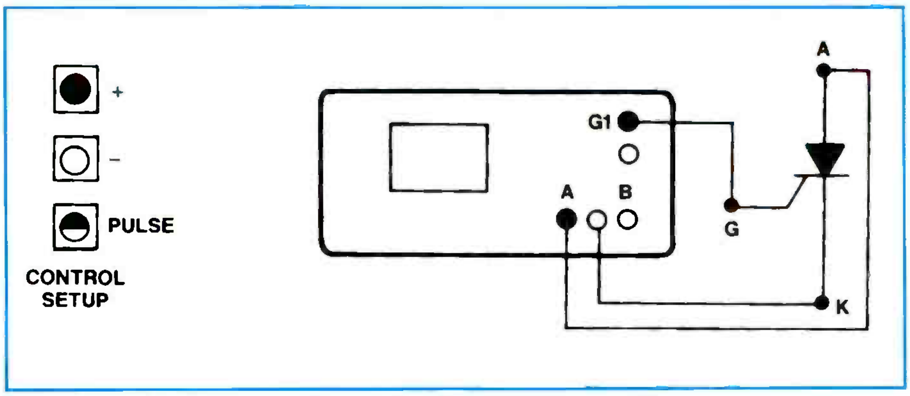


Figure 26. The analog signature analyzer is set up as shown to test an SCR using the internal pulse generator.

section which drives the transistor's base. Start with the level control set at zero (fully counterclockwise). Under these conditions the display shows a signature that is the same as that for a collector-base junction of an NPN transistor in the MED 1 range because the pulse generator output (G1) at zero level is equivalent to a 100 Ω resistor connected to common. This appears as almost a direct short in that range.

With the width control turned fully clockwise, as the level is increased slowly from zero, a threshold is reached where the "open circuit" horizontal line in the first quadrant begins to move upward.

This constant current signature is like that produced by a transistor curve tracer, except that only one curve is shown here instead of a whole family of curves. If the level is increased further, the horizontal portion of the signature will then appear as a nearly vertical line, indicating a low impedance.

If you vary the width control to about 40%, two signatures will be superimposed on one another. This composite figure means that the transistor under test is actually switching ON and OFF, as opposed to being ON all of the time. This is one procedure to prevent overstressing the transistor.

Investigating the internal pulse generator

The previous discussions have mostly involved two test leads for two terminal testing. This method yields much needed information about three terminal devices as well.

There are times when you need a pulse to characterize a device, such as a triac or an SCR. This pulse places the device under test in its active region; the analog signature analyzer is actually turning the device on and off quickly. Let's examine this internal pulser.

The pulse generator, shown in block diagram form in Figure 21, drives the controlling pin of a device under test. The normal two terminal mode of operation is enhanced when this happens.

When the dc mode is selected, a 0Vdc to 5Vdc level is produced at pulse terminals G1 and G2. The polarity is again controlled by the positive and negative buttons (see the section of the signature analyzer pointed to by the arrow in Figure 22). Pressing the positive button enables

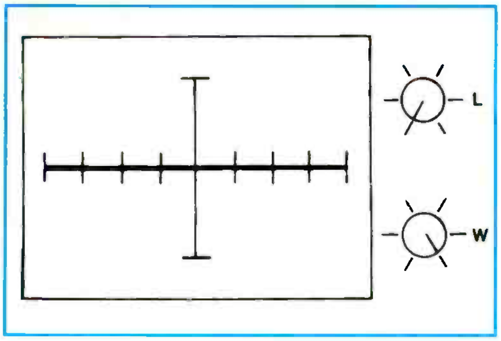


Figure 27. An SCR gives this signature when it is pulsed.

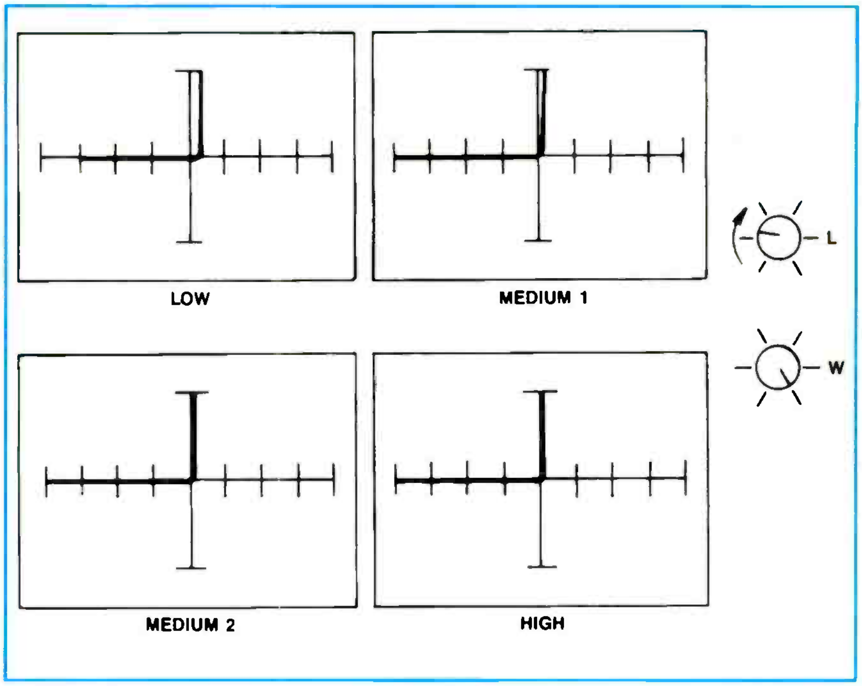


Figure 28. The signature of an SCR being pulsed at turn on resembles the signature of a diode.

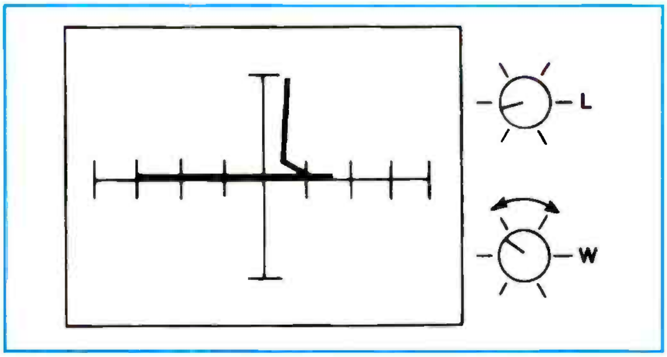


Figure 29. The signature of an SCR being properly turned on in the Low range.

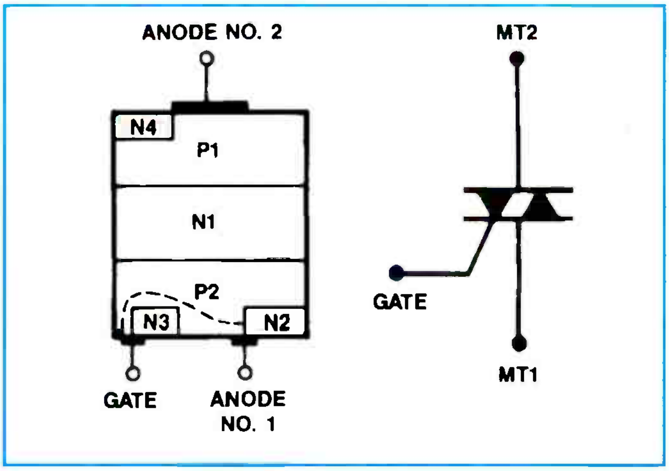


Figure 30. A triac can be represented by this schematic diagram.

a positive dc output and disables the negative button. The negative button enables a negative dc output only when positive is off.

Using this configuration, it is easy to change polarities with only one button. First, you press the negative button (which is remembered by the control logic), then the positive one which switches the output polarity back to positive.

The next time the positive button is pressed, the positive output is turned off which re-enables the negative output. Thus, each time the positive button is pressed the output polarity will toggle between positive and negative.

The width control has no effect in the dc modes. Refer to Figure 23 for the output waveforms produced by this internal pulse generator.

In the pulse mode, this circuit uses the zero crossings of the test signal to trigger a pulse. When positive (+) is selected and enabled, a positive going crossing triggers a positive pulse. When negative (-) is selected and enabled, a negative going crossing triggers a negative pulse.

If both polarities are enabled, then both positive and negative pulses are produced on alternate zero crossings (composite pulses); again refer to Figure 23.

Applications using the internal pulser

Let's start with an SCR (see Figure 24, its schematic symbol and equivalent circuit). An SCR appears as a diode across its gate-cathode junction. Note that the gate-cathode breakdown voltage can be observed in the HIGH range.

The analog signature analyzer displays these two back-to-back diodes, so to speak, as an open circuit (see Figure 25). The signatures for the anode-gate and cathode-gate junctions are open-circuit horizontal signatures in all ranges (again, see Figure 25).

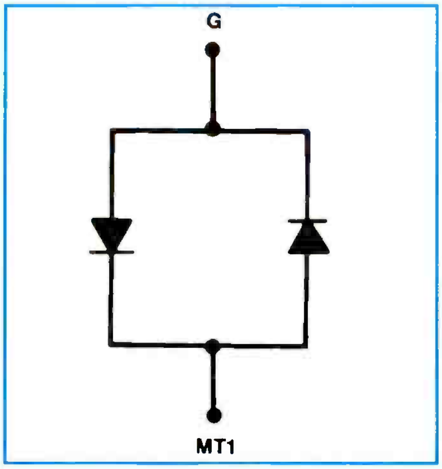


Figure 31. The main terminal 1 (MT1) of a triac.

However, the pulse generator section of this analog signature analyzer can drive this gate. Refer to the test set-up in Figure

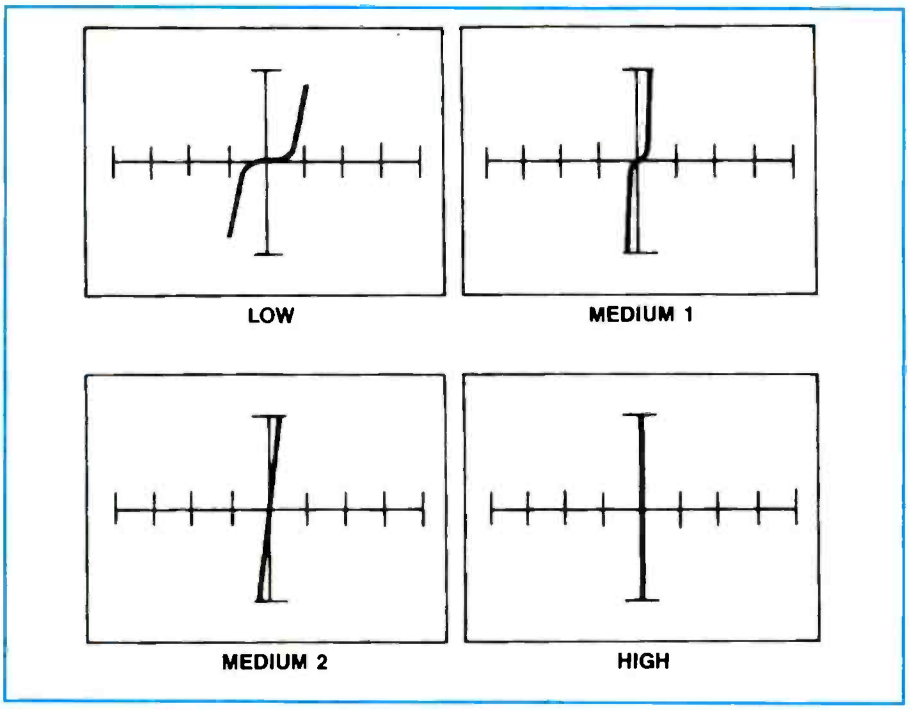


Figure 32. A triac gives this signature.

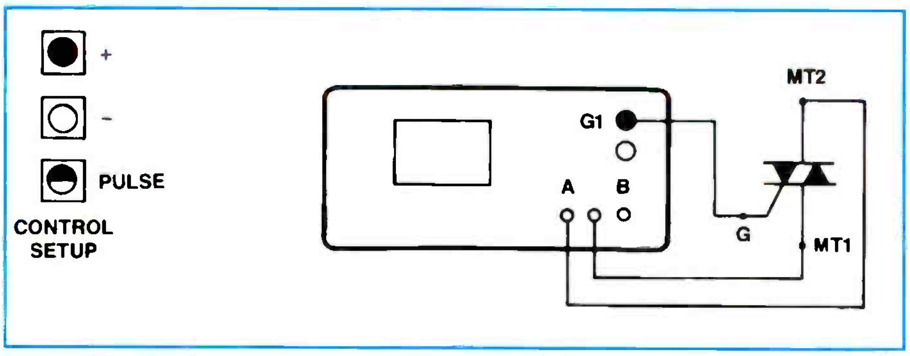


Figure 33. The analog signature analyzer is set up as shown here for pulse testing a triac.

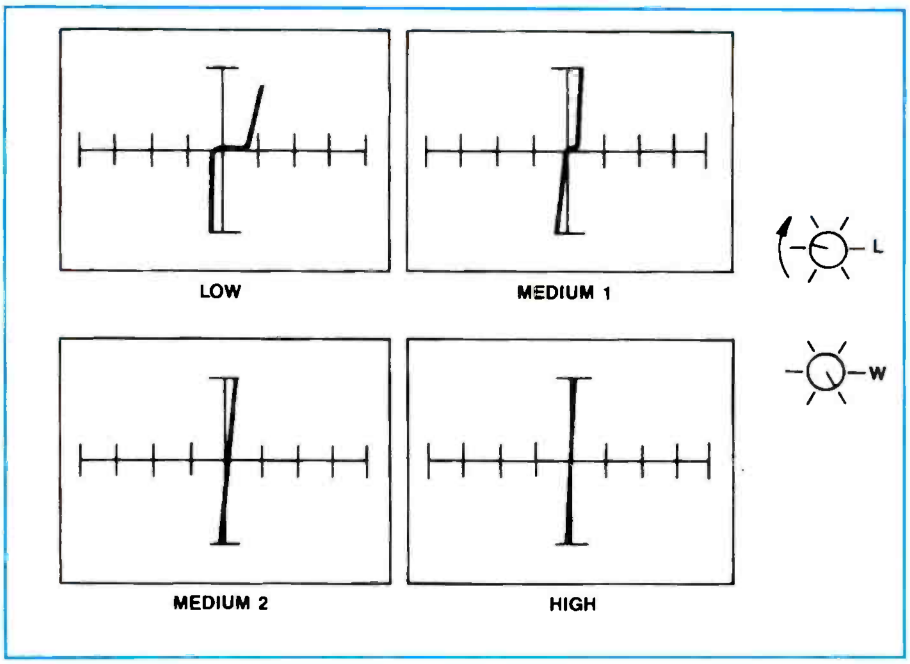


Figure 34. Bi-directional turn-on characteristics of a triac.

26. With the level control set at zero, a horizontal trace is displayed (see Figure 27). This is expected since SCRs normally show an open circuit between anode and cathode or between anode and gate.

Using maximum pulse stimulus, that is the width set at maximum, a point is reached as the level is increased where the SCR turns on and the signature resembles that of a diode. Figure 28 shows this effect in all of its phases.

The width control for this pulser can be varied over most of the range without producing any change in the LOW range signature (see Figure 29). This indicates a normal SCR that is switched on by any pulse exceeding some minimum duration. It remains on and conducts until the anode-cathode signal changes polarity.

The best ranges for testing SCRs are LOW and MED1 since they supply more current. An SCR requires a certain minimum "holding" current to produce normal controlling and conduction action.

If you use the MED 2, or the HIGH range, you will not be able to supply sufficient current to properly trigger the SCR and force it into conduction. Figure 29 shows an SCR being tested in the LOW range and functioning properly.

Testing triacs

A triac is a bi-directional semiconductor device which is the equivalent of two SCRs in parallel, but connected in opposite directions. The triac was developed to extend the positive or negative supply of an SCR, and allows firing on either polarity with either a positive or a negative gate current pulse. Figure 30 shows the internal construction and schematic of a triac semiconductor.

Figure 31 shows the main terminal 1 (MT 1) and the triac's equivalent circuit: two diodes in parallel. The resulting signature is shown in Figure 32. The signature for MT2-Gate and MT2-MT1 are open circuits in all ranges. This is before you apply the internal pulser to this device.

A typical test set-up using the internal pulser is shown in Figure 33. With the level control at zero, an open circuit trace will be displayed.

As the level control is increased from zero width, the triac eventually turns on in the first quadrant just like an SCR. Then with an increase in level, the triac turns on in the third quadrant. It also produces

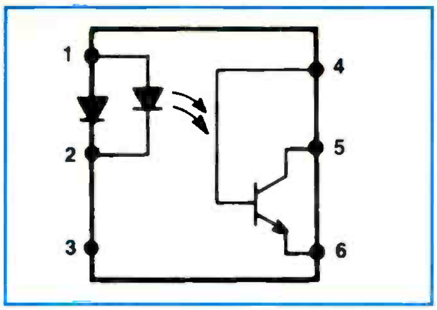


Figure 35. A 4N25 transistor optocoupler can be represented by this schematic diagram.

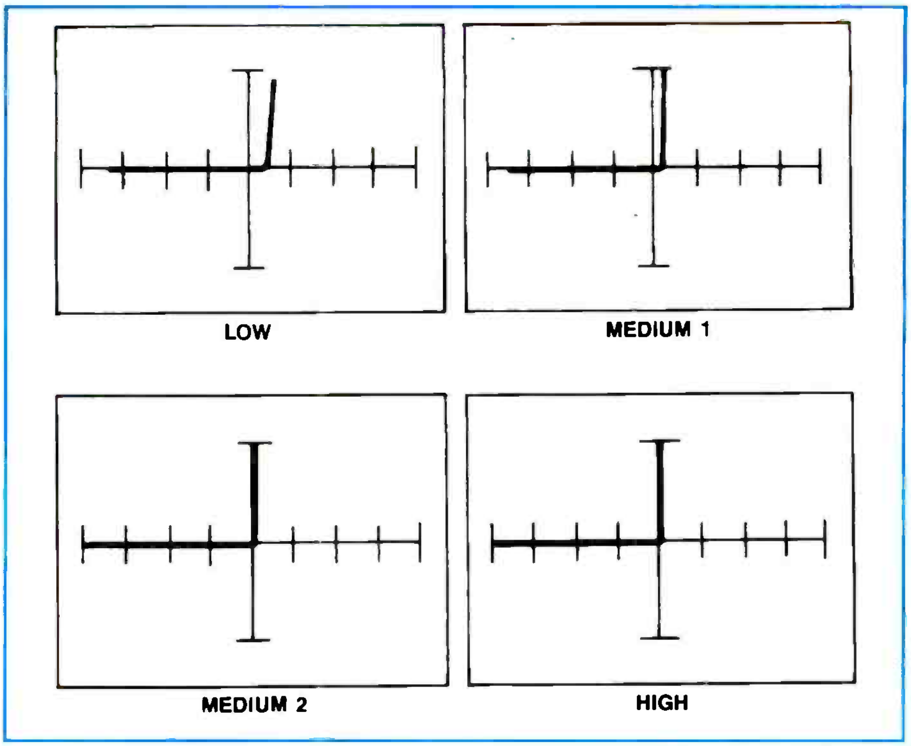
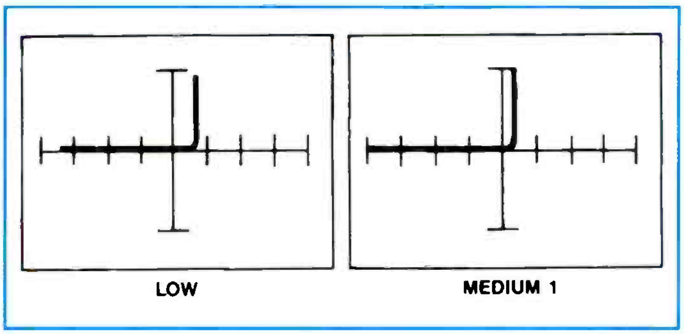


Figure 36. A standalone LED yields this characteristic signature.



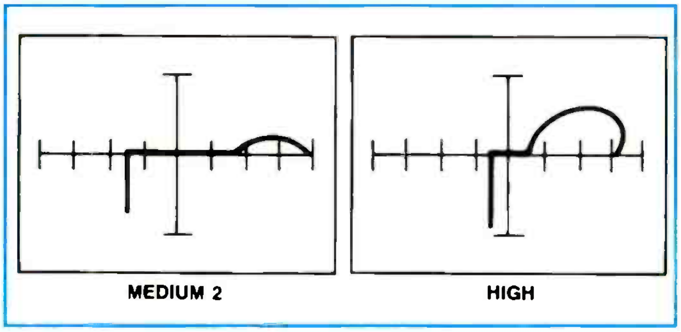


Figure 37. The transistor optocoupler's base-emitter junction yields this signature.

Figure 38. The transistor optocoupler's collector-emitter junction yields this signature.

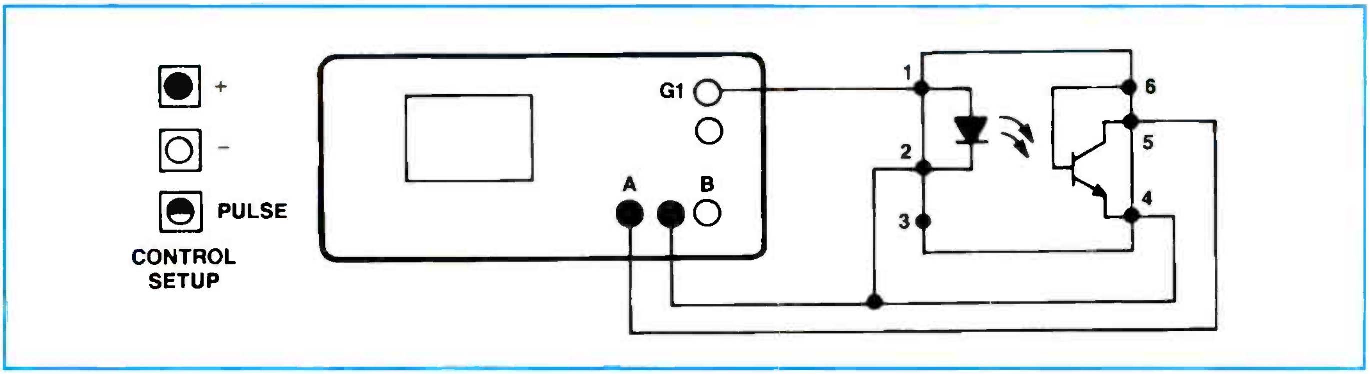


Figure 39. The analog signature analyzer is set up as shown here for testing a transistor optocoupler.

the back-to-back characteristics shown in Figure 34. This normal bi-directional conduction is characteristic of a triac in the ON state.

In virtually all other ways, triacs are similar to SCRs. There is little change in the LOW range signature with various settings of the width control once the triac has been turned on.

This verifies that a triac will continue to conduct after a pulse fires the gate. The MED2 range and HIGH ranges, as with the SCRs, have insufficient gate driving current capacity to properly fire a triac.

Optoelectronic applications

Many VCRs and other home entertainment electronics use a variety of opto-

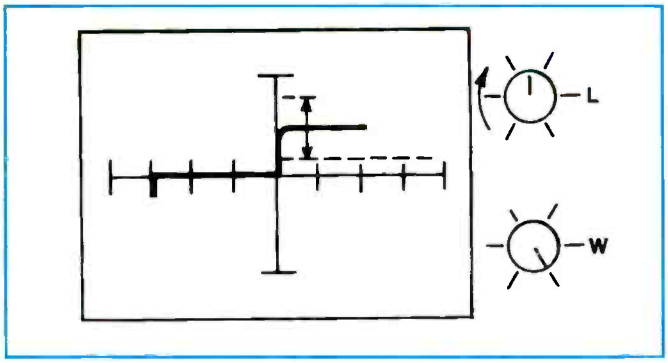


Figure 40. Increasing the applied signal level shifts the signature.

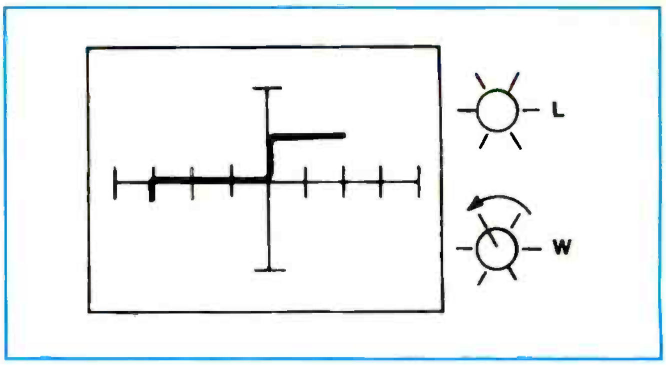


Figure 41. Setting the width control of the analog signature analyzer at MAX causes this final resultant shift upward of the signature.

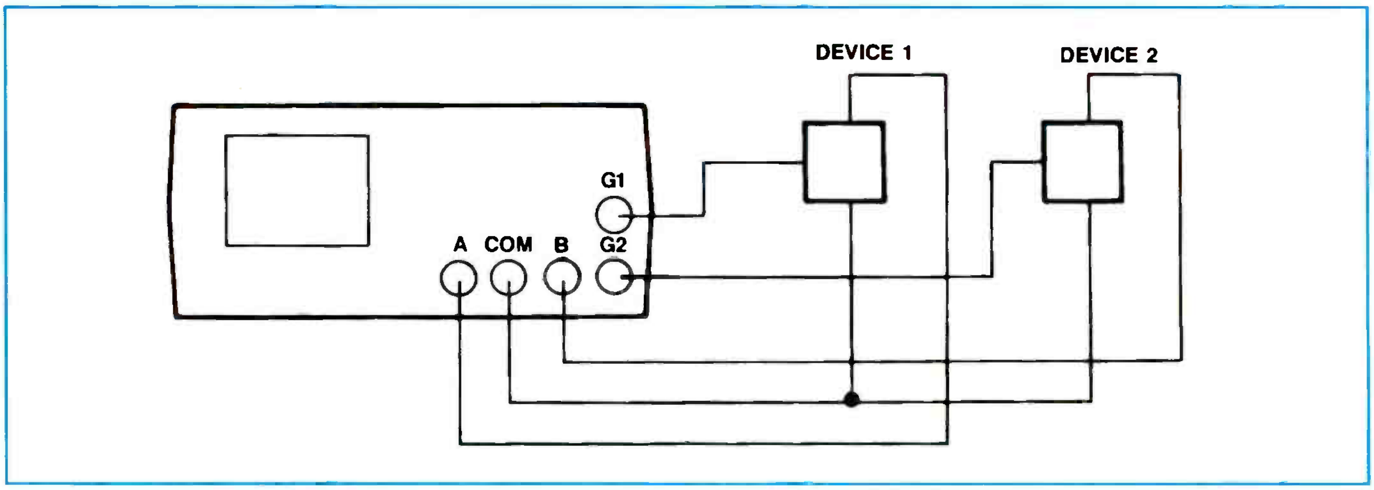


Figure 42. The signature analyzer is set up as shown to provide a composite signature.

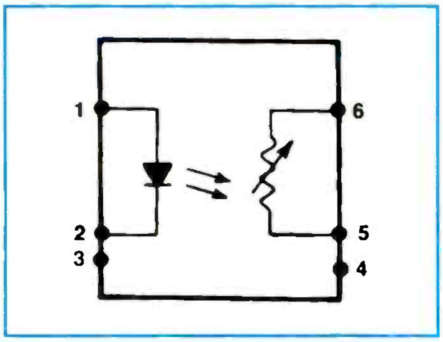


Figure 43. A photocell optocoupler can be represented by this schematic diagram.

electronic devices. Let's examine a transistor optocoupler and then a photocell optocoupler. These are often used to detect a light level and then turn something on or off.

Optocouplers

The optocoupler is an optically coupled and optically isolated semiconductor device. It is designed to transform electrical inputs (signals) into optical energy, which is converted to an electrical output.

So, you have an electrical-to-optical, and back to electrical transformation of energy. You may ask, why start out with electrical energy and end up with the same? The answer is that the optical coupling provides electrical isolation between input and output, much as an electromechanical relay provides.

These devices consist of a gallium arsenide infrared diode and a silicon photodevice which provides high-voltage isolation between the input and output. Optocouplers are available in the following forms:

- Transistor optocouplers
- Darlington transistor optocouplers
- SCR optocouplers
- Triac optocouplers
- Photocell optocouplers

Let's start with the transistor optocoupler (see Figure 35). This is a 4N25, a very common transistor optocoupler consisting of a gallium arsenide infrared light-emitting diode coupled to a silicon phototransistor. This IC comes in a 6-pin mini-DIP plastic package.

Using the analog signature analyzer in its two-terminal mode, you can gather a lot of data about the 4N25. First, you could examine the standalone LED itself (see Figure 36). Next, you could examine the transistor. This NPN output transistor can be examined via its base-emitter or its collector-emitter junctions (see Figures 37 and 38).

However, despite verifying that the input and output (LED and phototransistor) are operating correctly, you have yet to verify that the coupling between the two is working. To do this you'll need to pulse the input and see what the output looks like, assuming it responds. To do this you'll have to use the internal pulse generator within the signature analyzer.

Figure 39 shows the setup for using this internal pulser. The optocoupler shown in

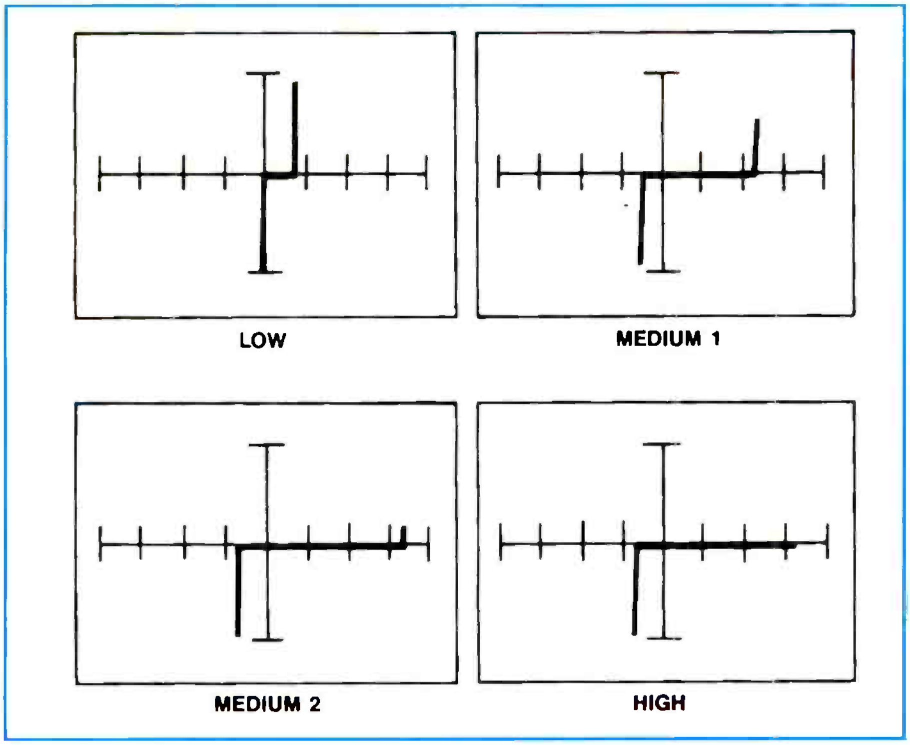


Figure 44. When the photocell optocoupler is set up in the two- terminal mode, it yields this signature.

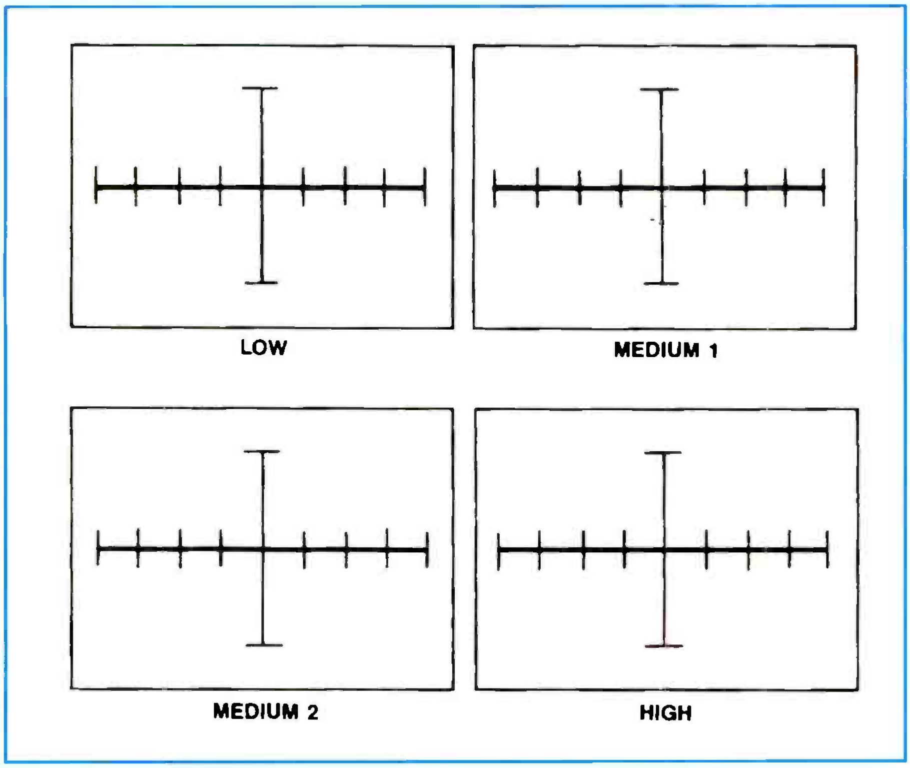


Figure 45. This is the signature of the photocell optocoupler's light sensitive resistor when the optocoupler is connected in the two-terminal mode.

this figure has an NPN transistor as its output device. You should note that pins 2 and 4 need to be connected with a jumper to establish a common point for the signature analyzer.

You will use the test lead, and with the level control at zero and the pulse width at a maximum setting, the same signature will be produced that was shown in Figure 39. This should not be a surprise since there is no drive at all to the LED. Understandably then, the optotransistor experiences no current input.

As you increase the level, you will note that the horizontal trace in the first quadrant will move upward like an NPN transistor driven directly by the pulse generator (refer to Figure 40).

There are two main differences between the transistor driven directly and the optocoupler transistor. First, the signature of the optocoupler in the third quadrant is different from that of the transistor with direct drive. Second, the sensitivity of the first quadrant signature to the level control is much lower with the optocoupler than with the transistor.

This sensitivity is lower because the optocoupler's CTR (current transfer ratio), which is the ratio of collector current in the phototransistor to the forward current in the LED, is lower than the CTR of the transistor.

The CTR for most optocouplers is approximately one, whereas the beta of the output transistor by itself is between 50 and 200. This is why you will observe a decreased level control sensitivity when testing optocouplers.

The optocoupler can be tested with an ac source by turning the width control to half way, giving a duty cycle of approximately 50 percent. The resulting composite signature is equivalent to the signatures of Figure 41 (MED 1). They are superimposed upon each other.

The first quadrant curves are at half intensity because of the switching action of the pulse generator. The third quadrant is at full intensity because the pulse generator does not affect the signature.

You may want to compare two devices. One may be a known good device, while the second may be a potentially or suspected to be faulty device. You can accomplish this by using the second pulse generator output and the alternate mode (See Figure 42).

The photocell optocoupler

The photocell optocoupler example was chosen, because, of all the different optocouplers listed previously, this one differs because its output device is not an active silicon device. This device (Figure 43) has a symmetrical bilateral photoconductive cell as its output.

The schematic symbol for this device is a resistor with an arrow. The arrow indi-

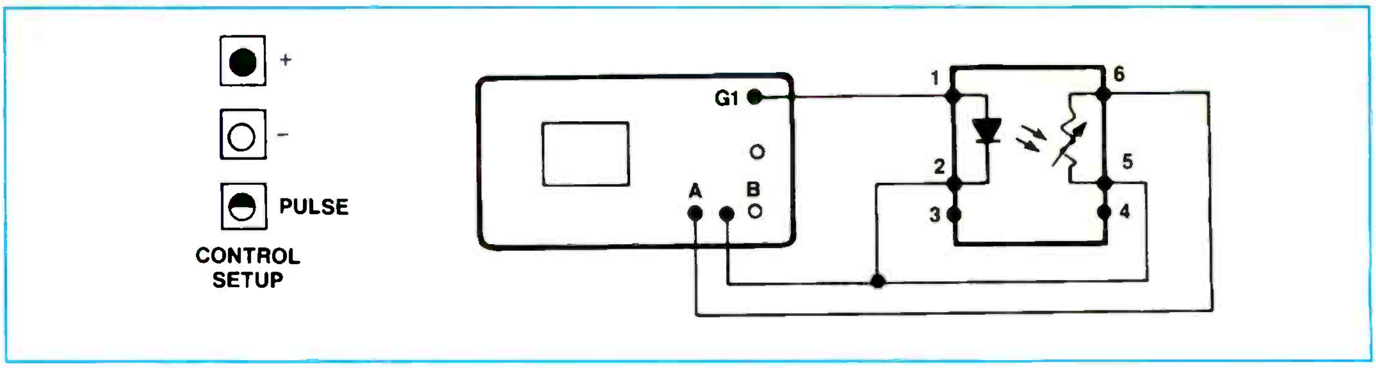


Figure 46. A Clairex CLM51 photocell optocoupler was connected to the analog signature analyzer as shown here in order to generate its signature using the pulser.

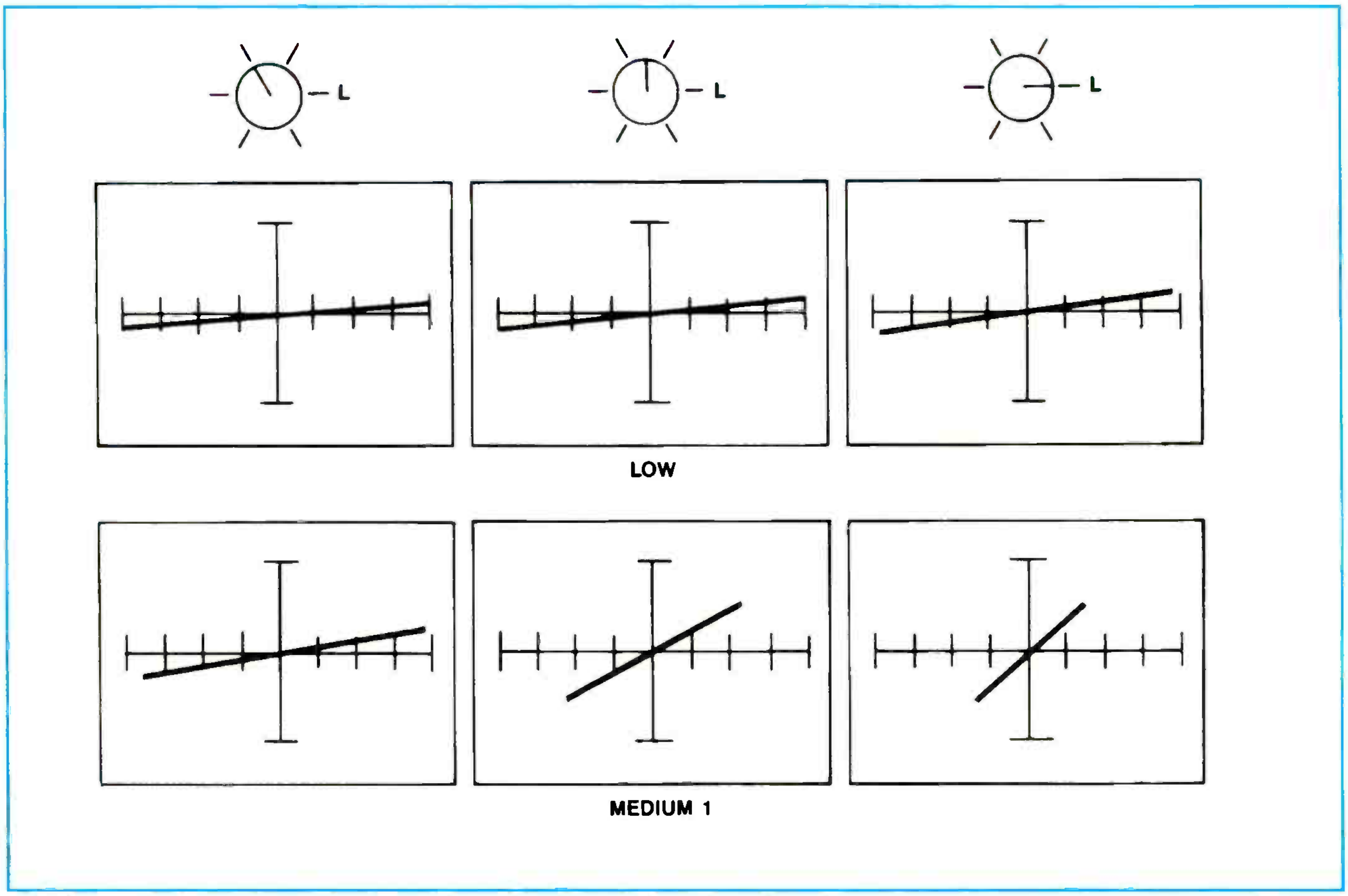


Figure 47. This is the signature obtained when the photocell optocoupler was connected to the pulser of the analog signature analyzer.

cates that it is variable. The two lines with arrows on the end indicate beams of light or that the resistance of this variable resistor is light sensitive.

The actual example used here is a Clairex CLM51. Like the other optocouplers, its output is electrically isolated from its input. When the input LED is not conducting, the output is not coupling energy. In this turned "off" state, the light dependent resistor has a resistance in excess of 1MΩ. Therefore, in this case, it appears as an open circuit to the analyzer.

If you elect to use the signature analyzer in the two-terminal mode, the CLM51 optocoupler will exhibit signatures like those in Figure 44. If you take full advantage of the analyzer and use it in the pulse generation mode (Figures 45 and 46) you will get signatures such as are shown in Figure 47. Figures 45 and 46 show the LED, followed by the light sensitive resistor within the photocell optocoupler respectively.

The next, and final, part of this series, will examine testing components in parallel and active digital ICs and microprocessor bus structures. It will also take a look at some very advanced analog signature analyzers. They will automatically pinpoint and probe (with a micro-positioner XY plotting fixture) a board totally under computer control.

Data I/O programming system

The Data I/O Model 212 Logic and Memory Programming System is available now from *Jensen Tools Inc.* for technicians who service microcontroller systems, computers and other electronic systems using EPROMs or PLDs.

Data I/O programmers provide wide-device support and exceptional reliability. A low-end model makes cost-effective choice when the job requires checking or copying EPROMs and programmable logic, basic prototyping and design, or small scale production capability. This unit is designed to stand alone or interface with a PC. By using the front panel and screen an operator is able to copy and check EPROMs quickly. The logic system follows device manufacturers' specified programming algorithms, enabling the user to verify and edit fuse maps.

Components include a base programmer, a Memory Module or Logic Module, and PROMlink-6 Ltd. DOS software. The modules are also offered separately.

Circle (30) on Reply Card

Catalog of non-CFC aerosol chemicals

Philips ECG offers a catalog for its full-line of non-CFC aerosol chemicals.

The Advanced Technology Aerosols catalog contains detailed descriptions and application information on each aerosol product. This complete line of aerosol chemicals has been entirely reformulated using some of the latest technologies and chemicals geared toward conserving the environment.

These products are free of chlorofluorocarbons (CFS) and 1.1.1 trichloroethane. The chemical agents selected belong to a family of compounds known as hydrochlorofluorocarbons (HCFCs) which greatly reduces the ozone-depleting effect. HCFCs are 95% less damaging to the ozone layer than past formulations that used CFCs. Functional effectiveness of the new aerosols is similar to that of the past generation of chemicals for most applications.

The catalog also contains electronic solder products designed for high-performance electronic soldering. Advanced tin/lead wire solders offer constant flux-to-metal ratio. These solders are fast wetting and flowing.

Circle (31) on Reply Card

Electromagnetic radiation monitor

A portable instrument that is designed to measure extremely low frequency (ELF) magnetic fields such as those emitted from appliances, electronic devices, and power lines is being introduced by *Walker Scientific Inc.*

The ELF60D Electromagnetic Field Monitor can measure magnetic fields from 0.1Gauss to 19.99Gauss that are generated by devices operating over the 40Hz to 400Hz range. Featuring an internal sensor, this portable hand-held instrument automatically calculates field strength to let users detect "hot spots" and avoid excessive, prolonged exposure.

Circle (32) on Reply Card

Pro Gold info Circle (6) on Reply Card

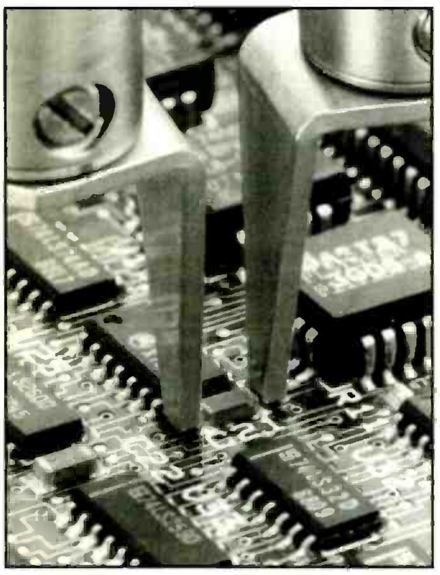
DeoIT info Circle (7) on Reply Card

New tips for surface mount component removal

Pace, Incorporated introduces a new family of "hot-bar" tips for the TT-65 ThermoTweez handpiece for removing various surface mount components.

Initially available: hot-bar tips with contact lengths ranging from 0.03 inches to 2.0 inches.

These new tips provide direct-contact thermal transfer to all of the solder joints on various two-sided surface mount components including: chip components, SOTs, SOICs, SOJs, SIMMs, and connectors. The "tweezing" action provided by the handpiece allows for easy,



one-handed removal from the circuit board.

The handpiece is powered by a heat control system which provides heat delivery in response to work load demands. This permits surface mount component removal at safer, lower working temperatures (302C and lower) while achieving consistent repeatable results.

Circle (34) on Reply Card

Talking multimeter/thermometer

Newport Electronics announces its new Model HHM1 high-performance compact digital multimeter that also measures temperature from dual Type K thermocouples. The HHM1's built-in voice annunciation gives readings for voltage, current, resistance and temperature. Standard features include very high,

0.25% basic dc accuracy, display hold, autoranging, differential temperature measurement and true RMS ac measurements.

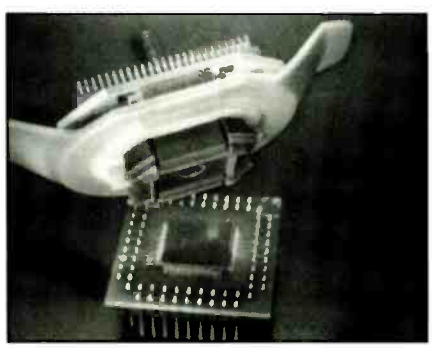
The front-panel display indicates the measurement function units, thermocouple probe (T1, T2 or T1 minus T2), display hold and low battery. All DMM connections are made from the front, while the rear has connections for two thermocouple probes, adaptor and earphone, as well as a 3-position volume switch.

Plug-in voice chips for the HHM1 are available for English, German and Japanese. Chips can be easily changed.

Circle (35) on Reply Card

SQFP test clips

ITT Pomona Electronics has announced availability of test clips designed to enable accurate, full pin-count test access to the newest 80- and 100-pin Small Quad Flat Package (SQFP) semiconductor devices pro-

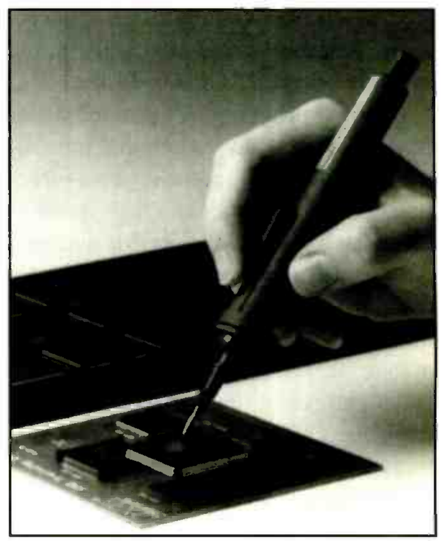


duced at 0.50mm lead spacings and 1.4mm case heights.

Designated the Models 5871 (80-pin) and 5872 (100-pin), the new clip designs provide flexible contacts at 0.0197 inch lead spacing (pitch) to assure positive electrical contact with each pin while under test. A mechanical lock-on design assures continued accurate connection even when the board is tilted or placed on edge. The low profile test clip design provides a stable electrical path to a scope or other instruments. The clip is designed to accommodate the higher signal speeds of the latest devices. The new test clips have been used successfully with SQFP devices from AT&T, Cirrus and Intel.

Both models feature a new, patented low-profile clip design that allows the test clip to be used on an on-board surface mounted device (SMD) while the host board is inserted into its standard-

Circle (36) on Reply Card



Component handling wand

Pace, Incorporated introduces the HP-65 HandiPik, a self-contained, hand-held device which allows the operator to quickly and easily pick up and place a wide variety of electronic components.

The tool does not require the use of an external vacuum supply, so the operator can conveniently carry it in a shirt pocket. Simple finger-actuation creates a vacuum at the tip to pick up the component. After placement, re-actuation of the finger switch breaks the vacuum. The handpiece itself is made of lightweight static-dissipative material. A selection of three sizes of vacuum cups is provided.

Circle (37) on Reply Card

Test your electronics knowledge

By J.A. Sam Wilson, CET

In this issue I am continuing the series of questions taken from one of the first CET tests, centered on theory and practice of television. There was only one test at that time. The Associate-level test and other options came later. Credit must be given to Lew Edwards who helped ISCET get a start by making the first CET tests.

1. Proper termination of a TV receiver transmission line is required to prevent what condition on the line?
   A. ghosts
   B. snowy picture
   C. standing waves
   D. oscillations

2. The amplitude of the vertical sync pulse is what percentage of the maximum composite video modulation?
   A. 10%
   B. 25%
   C. 50%
   D. 75%

3. In capacitor specifications, what does NPO mean?
   A. negative temperature coefficient
   B. positive temperature coefficient
   C. negative positive zero temperature coefficient
   D. special temperature coefficient

4. The term "Q" of a coil means
   A. ratio of inductance to capacitance.
   B. ratio of conductance to impedance.
   C. ratio of reactance to resistance.
   D. ratio of reluctance to reactance.

5. A marker generator is used to ______________ the various points on a frequency response waveform.
   A. sweep
   B. identify
   C. pin down
   D. generate

6. The FIRST thing to check on a customer's complaint of no color is
   A. color killer setting.
   B. AGC setting.
   C. fine tuning.
   D. color AFPC adjustments.

7. The tint control of a color receiver tunes or adjusts the
   A. burst amplifier.
   B. color phase detector.
   C. reactance coil.
   D. oscillator coil.

8. A wattmeter measures what two values in a circuit?
   A. inductance and capacitance
   B. voltage and impedance
   C. current and resistance
   D. voltage and current

9. A milliammeter may be converted to a voltmeter by
   A. adding a shunt resistor.
   B. adding a series resistor.
   C. adding a resistor in parallel.
   D. adding a diode rectifier.

10. A grounded-collector transistor amplifier may be compared to what equivalent tube circuit?
   A. grounded grid amplifier
   B. cathode follower circuit
   C. plate detector circuit

(Answers on page 50)

Ten RCA CTC140 chassis symptoms

By Homer Davidson

In the past few years the RCA CTC140 chassis has been produced with many different letters on the end of chassis numbers and in a variety of cabinets. Chassis with numbers from CTC140AD to CTC-140SE have experienced several different service problems. Although many of the failures have been located in the VIPUR (variable interval pulse regulator) low voltage power supply, a collection of case histories in different circuits are given in this article (Figure 1).

Besides regular through-hole components, the CTC140 chassis also has surface mounted devices (SMD) under the chassis. Extreme care must be used when servicing this unit so as not to drag the chassis across the bench, or place the chassis on top of sharp objects that might damage the small components. Be careful not to twist the chassis when removing or raising it to replace components so you don't damage connections to SMDs.

The case histories presented here may be applicable not only to service TV chassis with the same chassis number, but in servicing other similar TV chassis. Because the chopper type circuits have been found in many imported and domestic chassis, often the failures are the same.

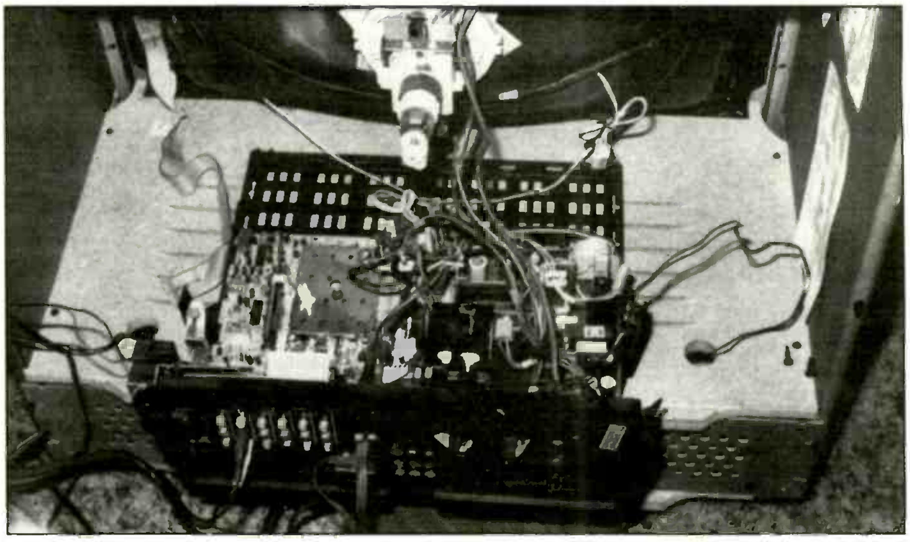


Figure 1. The RCA CTC140 chassis has appeared in many different cabinets in the past few years.

Dead set

When you encounter a dead CTC140, go directly to the VIPUR low-voltage power supply and check the main fuse, F4001 (5A). If the fuse is blown, suspect a shorted bridge rectifier diode or VIPUR output transistor (Q4100). Transistor Q4100 has failed in many chassis as a result of overload, or failures in the low voltage circuits (Figure 2). When the VIPUR output transistor becomes leaky, check resistor R4111 (0.15 ohms) to see if it is open.

Remember, these input power supply circuits operate with a hot ground. Voltage or resistance measurements to common ground will give false readings. All components on the primary side of the VIPUR output transformer (T4100) operate with a hot ground, including the regulator IC (U4100) and bridge rectifiers. So, take all measurements on the primary power supply circuits with reference to the hot ground (TP4003).

Overloaded conditions in the secondary low voltage circuits may be caused by a leaky horizontal output transistor (Q4400), leaky yoke or safety capacitors, or silicon diodes in the SIP (single-in-line package) board. The SIP board contains CR4701, which provides the 134V source to the horizontal circuits; CR4702, which provides a +26V source; and CR4703 which provides a +17V source.

In many early CTC140 chassis, these diodes have poorly soldered connections at each end (Figure 3). Inspect carefully to see if there are cracks in the solder at either end of the diode. Simply resoldering all diode terminals has cured many dead chassis. To get to this board, turn the chassis over, unsolder the terminal pins and pull out the SIP board.

The set abruptly went dead

I have been able to service several CTC140SE chassis which abruptly went

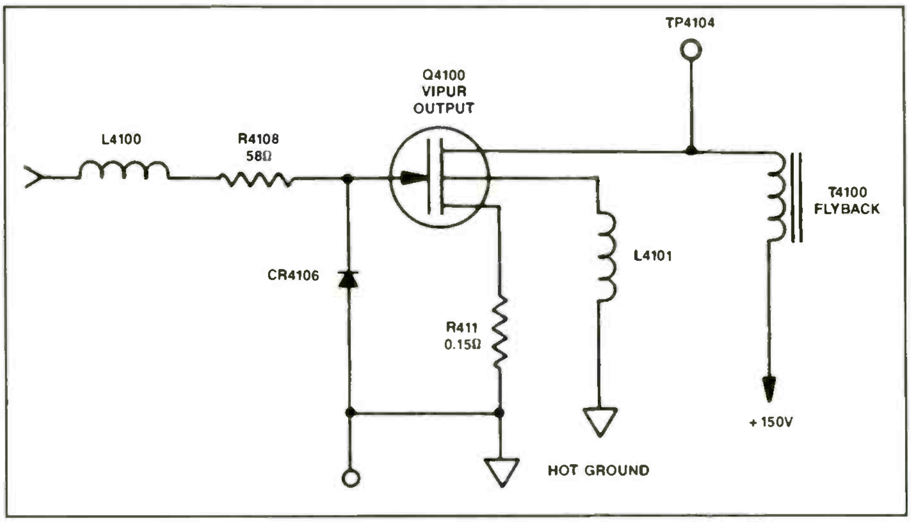


Figure 2. Suspect leaky VIPUR output transistor (Q4100) when you measure raw B+ of 150V on the drain terminal.

Davidson is a TV sericing consultant for ES & T.

dead, on site. A frequent cause of this malfunction is a poor soldered terminal of CR4701 (Figure 4). To confirm that this component is the cause of the problem, check the voltage at the horizontal output transistor.

Low voltage, or zero voltage at this point will confirm that the problem is a bad joint at CR4701. Again, remove the SIP board from the chassis and resolder both ends of CR4701.

Check all three diodes with the diode tester and resolder diode terminals before replacing the board. Be sure to make good soldered connections of the SIP board to the PC board chassis. Replace any defective diodes with diodes rated at 3A. You may find all diodes are normal and resoldering the terminals is all that is required.

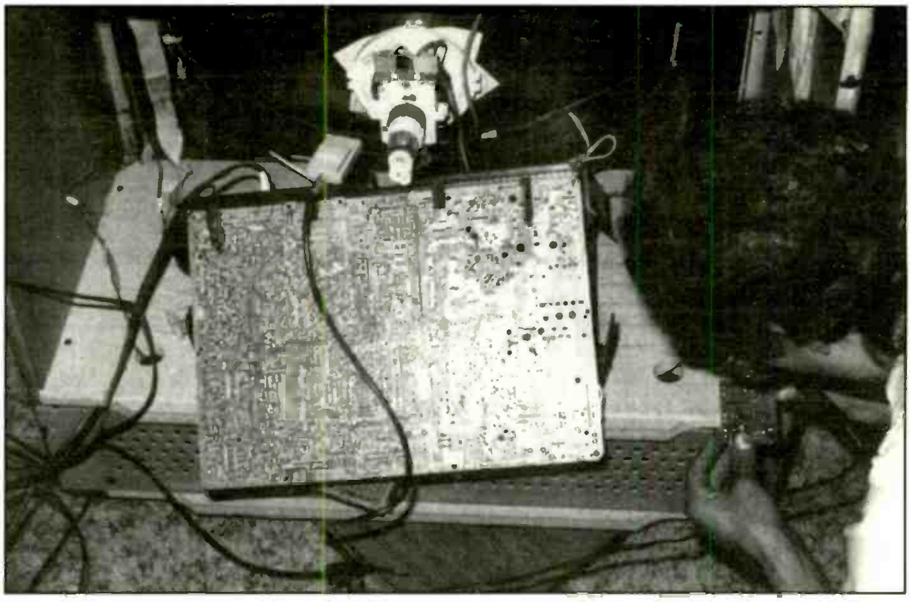


Figure 3. Inspecting the SIP diode PC board and soldering connections.

Raw B+ 150V - no sweep

When you encounter a CTC140 with no sweep, measure the voltages at Q4100. If you measure +150V at the drain terminal of Q4100, suspect that either the VIPUR output transistor (Q4100) or the horizontal output transistor is defective. Check from the collector terminal of the HOT to chassis ground for leakage. Suspect that Q4400 is open if you measure higher than normal voltage (130V) at the collector terminal. When the horizontal output transistor is leaky, the VIPUR output transistor may also be damaged.

A leaky damper diode or safety capacitor (C4402) may damage Q4400 and blow the line fuse (Figure 5). C4402 may be a 0.0155µF at 1.2kV, or 0.043µF in the 27-inch chassis, while a 0.56µF is found in other chassis. If the capacitor is faulty, substitute it with an exact replacement. Check horizontal and VIPUR low voltage transistors, damper diode and safety capacitors for blowing fuses and no horizontal sweep.

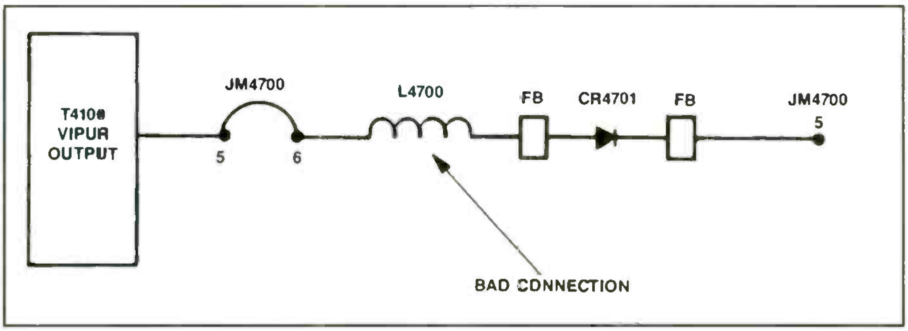


Figure 4. The set just went dead in a CTC140SE chassis with poorly soldered CR4701.

Green power light will not turn off

In another CTC140SE chassis, sometimes the green power light would stay on all the time. At other times, pressing the On/Off button had no effect: no sound, no picture and no high voltage.

When this condition occurs, check for leaky CR4201 and CR4104 diodes within the primary circuit of the VIPUR output transformer.

Notice that pin 9 of T4100 goes to the hot ground and pin 11 connects to the

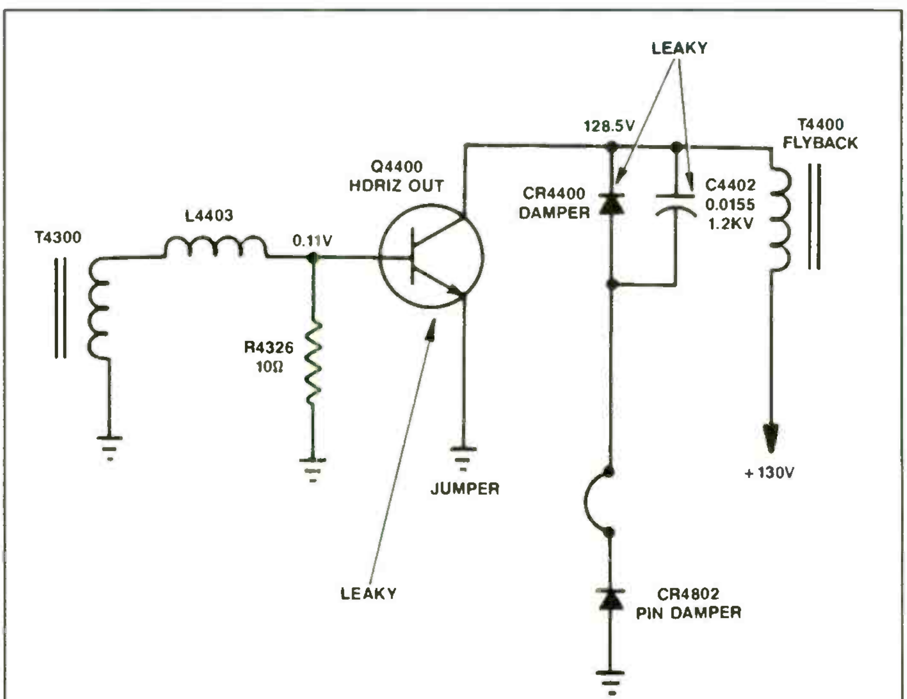


Figure 5. A leaky Q4400, CR4400, and C4402 may damage the VIPUR output transistor.

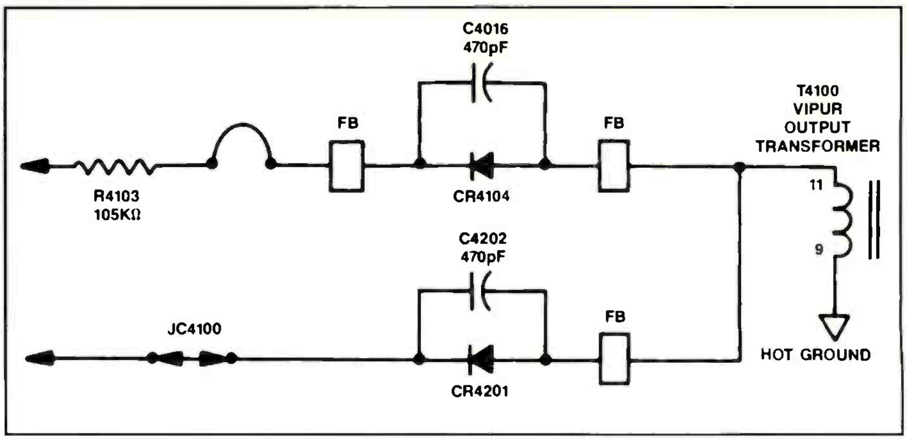


Figure 6. Check CR4104 and CR4201 for leakage or open conditions if the green power indicator light stays on, or if the symptom is no picture, no high-voltage.

anode of CR4104 and CR4201 (Figure 6). The cathode terminal of CR4201 goes to jumper connection JC4100 of Q4201, degaussing transistor, while the collector terminal connects to the VIPUR regulator IC (U4199) circuits.

In one RCA G27251 model, the symptom was no picture and no sound with the stereo light on. When the push on button is pressed, the light may shut off. In this case, check for open CR4104 diode in pin 11 lead of T4100 VIPUR transformer.

Replace ferrite beads on each side when replacing diodes. Notice these components are in the hot ground side of the VIPUR transformer.

Chassis shutdown

In some CTC140 chassis, the chassis may shut down or you may find excessive pulling in on both sides of the raster. The 130V supply source from the low voltage power source may be quite low in some cases. You may think this is a horizontal output transistor or damper diode problem. Most likely, however, the trouble lies in the pincushion circuits.

Go directly to the pin output transistor (Q4804) when bowing is noted at the sides of the picture. The center part of the picture may be normal. Check Q4804 for leakage. If the transistor has a leakage above 100Ω the sides will bow inward. When transistor leakage is below 50Ω, the B+ voltage will be lower and sometimes the chassis will shutdown. These pin cushion PW4800 circuits are found only in the 27-inch chassis.

Firing lines in the picture

Firing or arcing lines within the raster or picture are sometimes difficult to locate. Remove the antenna lead to see if noise is picked up by the antenna. Notice if the lines are dark or white. Usually, dark firing lines are found in the chassis. In the case of one set I serviced, moving the set would make the firing lines appear. The

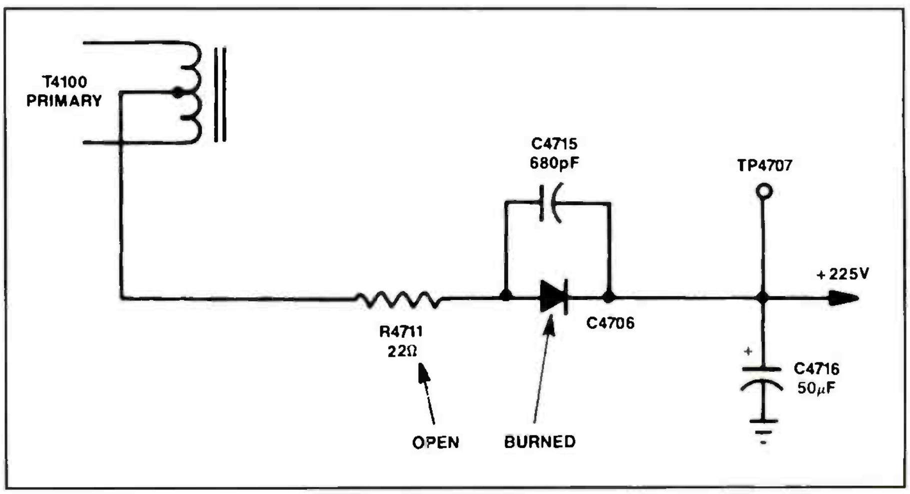


Figure 7. Open R4711 and burned CR4706 produced heavy retrace lines in the picture.

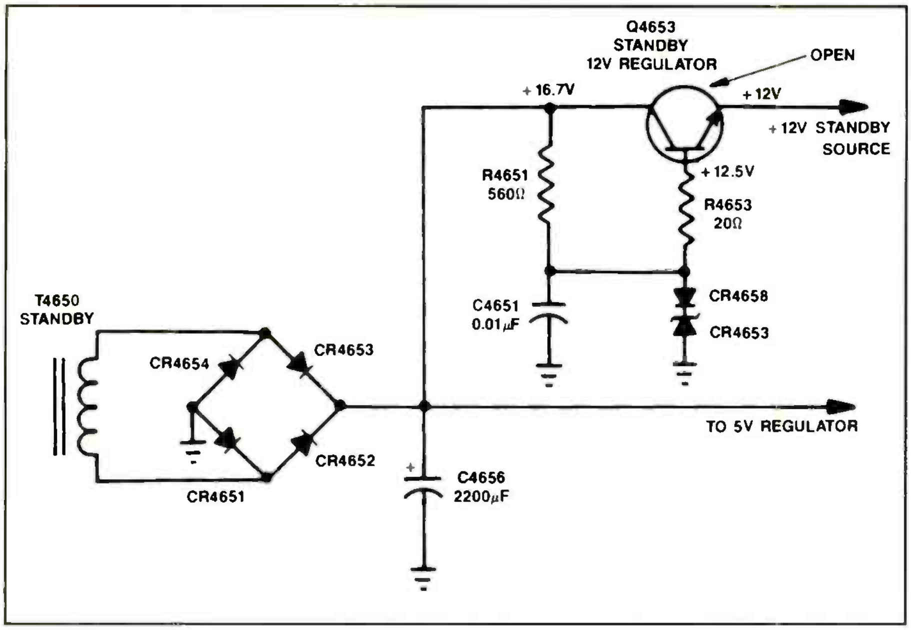


Figure 8. The remote failed to operate with an open standby 12V source transistor (Q4653).

lines looked like high voltage arcing or anode lead arcing.

I removed the anode lead from the HV socket of the picture tube. After discharging the high voltage, I cleaned the socket with cleaning fluid. I inspected the anode lead. It appeared good. I inspected all grounds and found them to be normal.

The noise really acted up when I wiggled the flyback, so I resoldered all pins on T4400, the integrated high voltage transistor (IHVT), but the symptom remained. A closer inspection of the horizontal output transformer revealed a crack. Replacement of T4400 corrected this firing line symptom.

Heavy retrace lines

The heavy retrace lines in the picture on one set suggested that the screen control was set too high. Readjustment of the screen controls did not help. A voltage

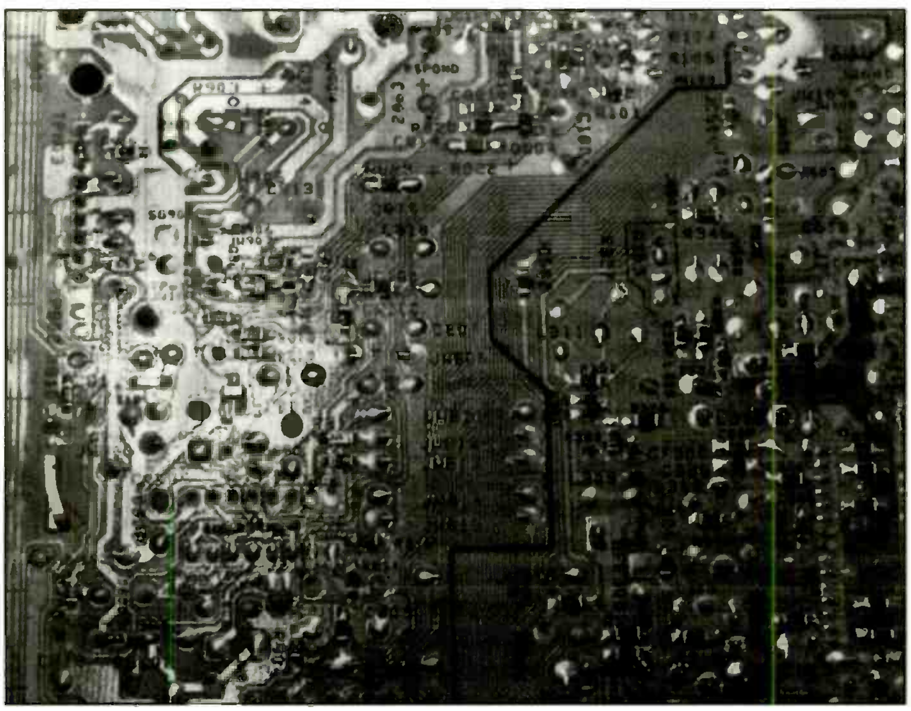


Figure 9. Notice the tiny surface mount devices (SMDs) and thin PC wiring on the bottom side of the PC board.

test of the CRT socket indicated very low screen voltage (normal 225V). The same voltage was found at TP4707 (Figure 7). An inspection of the surrounding circuit revealed that capacitor C4706 in the 225V source was burned. Resistor R4711, a 22Ω, 1/2W resistor was also found open. Replacing C4706 and R4711 restored the 225V source and eliminated the heavy retrace lines.

Snowy picture

Two different CTC140 chassis came in at the same time, both with a snowy picture. One chassis would play normally and then snow up, while the other had snow in it all the time. In both cases, the antennas were checked with another portable TV before pulling the sets into the service center. The snow was being generated by a problem in the TV chassis.

I inspected the antenna input cable and tuner. Sometimes moving the tuner would cause the snow to come and go in the intermittent chassis. I plugged a tuner subber into the IF cable of each set. A normal picture in both cases suggested the problem was caused by a defect in the tuner or tuner connections in both chassis.

Soldering all connections around the tuner solved the problem in the set that was intermittently snowy. The picture on the other set remained snowy no matter what was done to the connections. For this set a replacement tuner was ordered. When the new tuner was installed, the picture returned to normal.

Fuzzy picture

A fuzzy picture on one set looked as though it was caused by a defective tuner. Tapping around on the chassis near the tuner would sometimes cause the symptom to clear up. The picture would sometimes remain normal indefinitely. Other times it would be normal for thirty minutes and then fuzz up. For starters, I resoldered all tuner connections.

When the tuner sub was connected to the IF cable input, the signal and picture were normal. The set was left to run for four hours with the tuner sub connected. It was beginning to look as though the tuner was the problem, then finally the chassis acted up. This indicated that the tuner was normal.

Tapping around upon tuner and IF section really made the chassis act up. In one chassis with this problem, resoldering all pins on the U2310 section eliminated the fuzzy picture. In another chassis, resoldering poor terminal connections of the IF amp transistor (Q2300) solved the fuzzy symptom.

Standby hang up

The remote transmitter would not turn on this 27-inch RCA console. At first I suspected that the remote was faulty. A check of the batteries showed that they were brand new. An infrared indicator card indicated that the remote was sending out a fairly good signal.

A quick voltage measurement upon standby electrolytic capacitor, C4656, indicated B+ voltage (Figure 8). The 5V standby voltage was normal, but there was no 12V source voltage. Voltage tests on the 12V regulator transistor (Q4653) showed zero volts at the emitter and +18.7V at the collector terminal. I removed Q4653 from the circuit and tested it out of the circuit. It was faulty. Replacing the 12V standby regulator transistor solved the remote problem.

Conclusion

Use extreme care when handling the TV chassis with SMDs mounted on the bottom PC wiring side. Breakage of SMDs or poor end connections may cause intermittent symptoms. Be careful when soldering connections on the wiring side of the board to prevent damage to SMDs. Notice the very thin PC wiring and SMDs on the bottom side of the board (Figure 9). This PC wiring can be broken with rough treatment in turning the chassis over and pulling the chassis across the service bench. Use a mat or piece of carpet to protect the PC board. ■

Special purpose semiconductor diodes

By Dale C. Shackelford

On almost a daily basis, electronics servicing technicians are called upon to work with circuitry that contain general purpose rectifier and small-signal diodes, present in almost every electronic device. These generic diodes, however, represent but a fraction of the diode types used by manufacturers in products that consumer electronics servicing technicians may be called upon to service or modify.

To help technicians better understand (thus better service) circuits that contain special purpose semiconductor diodes (Table 1), this article presents a brief overview of these components, with a short description of the theory of operation.

Like their modern counterparts, the two element electron (vacuum) tubes used extensively in electronic circuits prior to the semiconductor were also known as diodes. They too provided unidirectional conduction available today in the smaller semiconductor packages common in modern circuitry.

In today's products, semiconductor (PN junctions) diodes are the rule, although many high-power/high-frequency circuits are better served by the vacuum tube diodes because of their ability to operate at higher power levels, often exhibiting a higher resistance when reverse biased than their modern descendants. Some of these applications include amateur/short-wave radio power boosters (linears), guitar amplifiers and public address systems.

Vacuum tubes do have some drawbacks, however: they require separate (heater) filament circuits, they generate excessive heat, and they require more physical space than semiconductors.

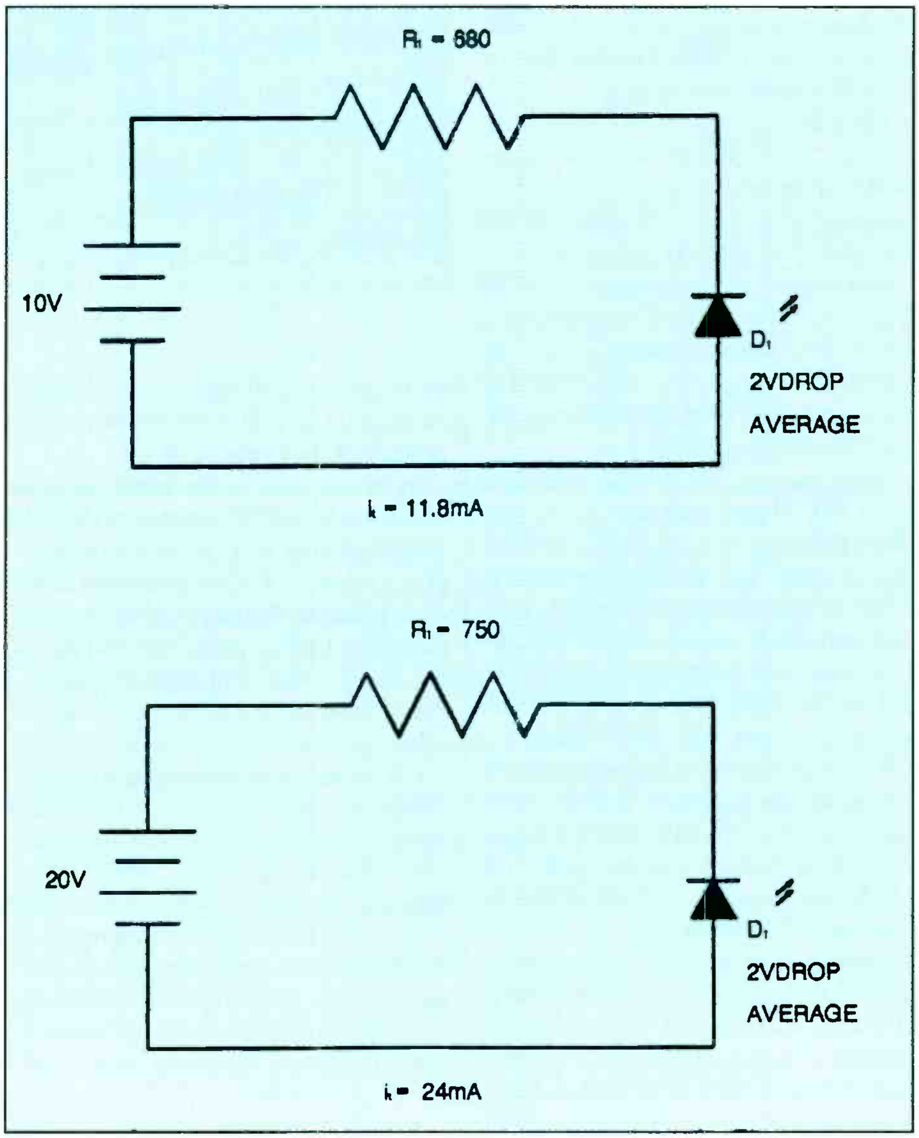


Figure 1. LEDs are intended for use in low-power applications.

Light emitting diodes

The most widely recognized and used type of special purpose semiconductor diode is the light-emitting diode (LED). Like other diodes, LEDs will pass current in one direction only. But unlike their brethren, LEDs emit visible or infrared light when forward biased because they use gallium, arsenic and phosphorus in their construction.

Other types of diodes are constructed primarily of silicon or germanium; opaque materials which block the passage of light.

Although red LEDs are the most common, green, yellow, blue, orange and even white (clear) LEDs are available for use in applications ranging from digital readouts to coffee pots. With special construction and doping, some LEDs are adequate for use in lasers and other high-powered optical devices, including remote control transmitters.

While LEDs are relatively durable components, they are intended for use in low-power circuits (3V to 6V), and current lower than 30mA. Where LEDs are required in higher powered circuits, a limiting resistor is placed in series with the diode to protect it (Figure 1), or a special

Shackelford is an independent electronic servicing technician.

low-power circuit is constructed for it.

LEDs are most often powered by direct current, but will respond to alternating current as well. When ac is applied, the LED will blink on and off (as the polarity of the ac is reversed on each cycle) at the frequency of the ac signal. If the ac frequency is low enough, the blinking will be detected by the human eye. Usually, however, the frequency of the ac signal is high enough that the LED appears to be in a steady on condition.

LEDs are manufactured in a wide variety of package configurations. The single round, square or rectangular packages are the most familiar. Seven-segment and multiple digit displays are common in television tuners and digital clocks, while LEDs which contain small oscillators (to make them blink on and off when powered by dc) are typically used in alarm or indicator panels where the light must attract immediate attention.

Some packages are actually two separate LEDs in one, with each LED emitting a different color (Figure 2), depending on which way the package (not the LED) is biased. These bicolored packages are useful in applications where the LED must indicate both on and off conditions. The ECG 3016, for example, can be biased to emit red or green light.

Bar graph meters, VU meters and panel indicators are generally nothing more than a number of LEDs within a single package or "strip," with the individual LEDs controlled by an LED driver IC (such as ECG 75494).

Regardless of their package or configuration, their light intensity or spectrum, all LEDs operate upon the principle of forward conduction; that is, LEDs emit light when they are forward biased. LEDs are usually preferred over incandescent or neon lamps because they require lower source voltages to operate, they are smaller, and they operate at lower temperatures (which results in longer life).

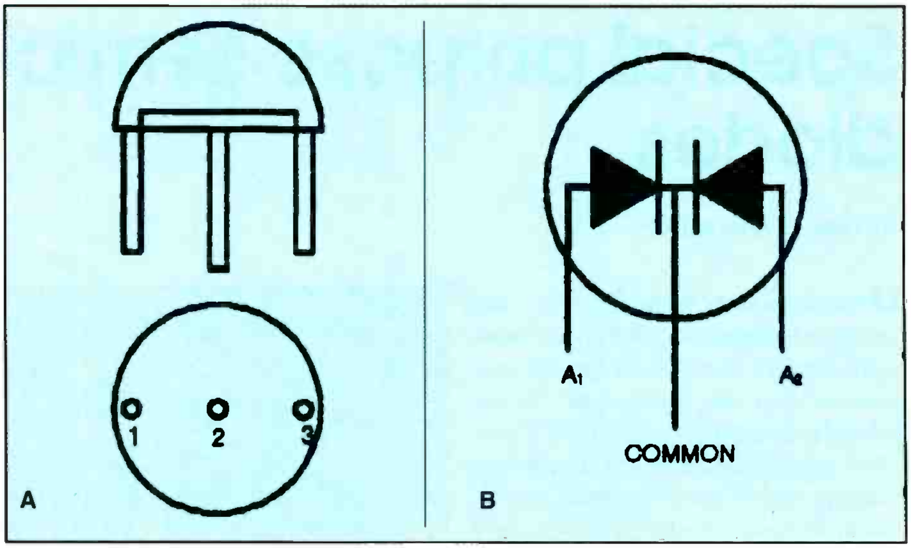


Figure 2. Some LEDs actually have two different color LEDs in a single package.

Optoisolators

Optoisolators are single-package components (often IC chips) that take advantage of the ability of an LED to not only emit light when stimulated by an electrical signal, but to convert light to voltage. When a typical LED is exposed to strong light, a small voltage will be developed across the leads (anode to cathode). The voltage measured will of course depend on the amount and brightness of the transmitted light, as well as the chemical composition of the receiving diode.

In an optoisolator, the input signal is connected to an LED. Light from the LED strikes another LED or phototransistor that is mounted in close proximity in the same package. The electrical output from the output LED or phototransistor drives the output circuit. This optical link provides complete electrical isolation between input and output circuits.

Optoisolators are most often used in situations where a low power circuit must control, yet be totally isolated (electronically) from a high power circuit. They may also be used to link two (or more) completely incompatible computers so that they may exchange data. Used in conjunction with relays or switching transistors, optoisolators are very efficient at controlling slave circuits in a wide variety of applications.

In addition to using an LED as the "receiving" component in an optoisolator, many manufacturers have constructed these units with diacs, triacs, SCRs, FETs and NAND gates and photoelectric cells. Often they are used in conjunction with photoelectric amplifiers such as the photo-Darlington amp.

Basic optoisolators are sometimes constructed by hobbyists with a single transmitting and a single receiving LED wrapped in aluminum foil to provide a reflective surrounding and to keep out unwanted light. In this application, the diode colors must be matched as closely as possible, as LEDs are most sensitive to the type/color they are designed to emit (red is most sensitive to red, green is most sensitive to green, etc.).

Zener diodes

Another widely used type of special-purpose semiconductor diode is commonly known as the zener. Zener diodes are unique in that the resistance of the component when it is reverse biased remains high until the source (biasing) voltage reaches or exceeds the breakdown voltage of the diode. Once the breakdown (also known as the avalanche point) voltage has been reached, current flow abruptly rises from practically zero to a point limited by the peripheral components and the internal resistance of the diode itself.

Because zener diodes are most often oriented so that any voltage higher than the breakdown voltage is shunted to ground, they are capable of acting as voltage regulation circuits, or the basis thereof. An added benefit of using zener diodes in voltage regulation circuits is that regardless of the variations in source voltage, or current drawn by the load, the voltage, once the zener is operating in the breakdown region, will remain constant. Zeners, unlike typical rectifier diodes cannot be accurately checked with a standard VOM to determine their condition because they are designed to operate within the breakdown region.

Zener diodes are available in various voltage ratings, from the 2.4V, 1/2W (ECG 5000A), to the 200V, 50W (ECG 5296A), and unlike most diodes, are not

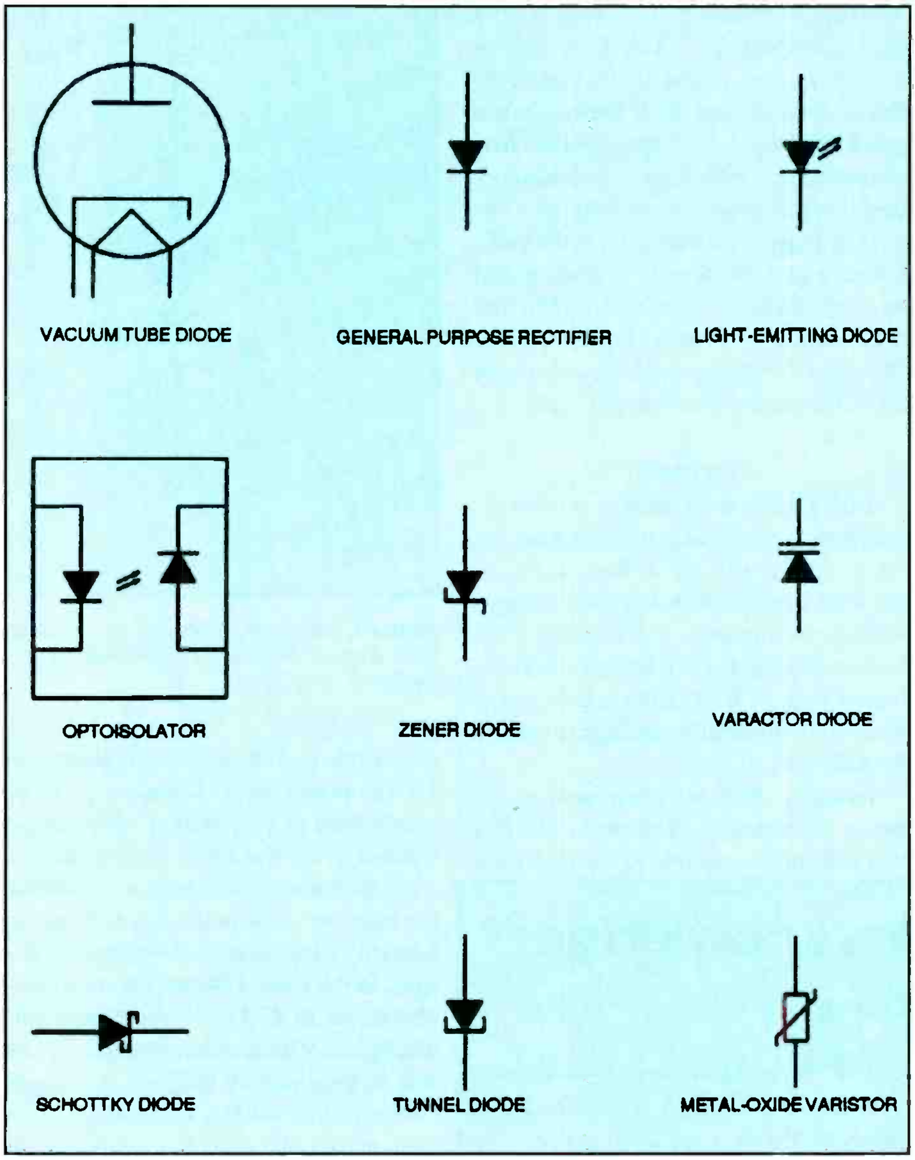


Table 1. A basic semiconductor diode provides rectification; that is, it passes current in one direction but blocks it in the other direction. Other, special-purpose diodes provide such functions as emitting light (the LED) or acting as a voltage-controlled capacitor (the varactor). Several special-purpose diodes are shown here.

damaged when continually operated in the breakdown region or reverse voltage bias mode. Due to these unique operating characteristics, zener diodes are sometimes called "constant voltage" diodes, and are found in power supply applications from electronic typewriters to orbiting satellites to television receivers.

Varactor diodes

Another component that has become very prevalent in television and radio receiver circuits is the varactor diode, which is most often found in the tuner sections of these devices, making them highly selective, very sensitive and extremely stable across a wide frequency spectrum.

Varactor diode tuning systems take advantage of the internal capacitance present across the PN junction of all semiconductors. Varying the reverse voltage across the varactor effectively varies the internal capacitance of the diode. Thus varactors exhibit all of the characteristics of a voltage-controlled capacitor, making them very useful in automatic fine tuning systems and frequency locking circuits sometimes found in programmable radio frequency scanners and TV receivers.

Although all diodes have some amount of internal capacitance, varactors are specially constructed to enhance this phenomenon by narrowing the depletion layer (barrier) so that a hyperabrupt PN junction is formed, resulting in increased capacitance. Small changes in the reverse biasing voltage of a varactor have a pronounced linear reaction upon the capacitance of the diode as compared to other types of diodes. Some circuits utilize a single varactor to tune AM radio receivers across their entire frequency band (535 kHz to 1600kHz).

Schottky diodes

The working speed of any computer is directly related to how fast the transistors and diodes used in the circuit construction can turn on and off. Obviously the higher the operating frequency of the computer, the faster the semiconductors must switch from one state to the other without storing a charge. Typical diodes are rarely suited to high-frequency applications, but the construction of the Schottky diode allows complete stage switching at frequencies well over 300MHz.

Sometimes used in flyback circuitry where the diodes must respond to very short duration spikes, Schottky diodes (often called hot-carrier diodes) use metals such as gold, silver or platinum for one side of the junction (usually the P side), while traditional semiconductor material (doped silicon) is used for the other (N) side. When the diode is forward biased, electrons cross the PN junction into the P (or metal) side. Since the metal has virtually no "holes" (electronically speaking), there can be no electrical charges stored as would be done in a traditional diode. This results in a virtually instantaneous recovery time.

Because of the low offset voltage of a forward biased Schottky diode (0.25V) as opposed to the offset voltage of a typical rectifier diode (0.7V), Schottky diodes are sometimes found in special application low voltage power supplies. Unless there is a specific need for this low offset voltage, however, the expense of the Schottky diode as compared to the general purpose rectifier diode will not justify the use of the Schottky in low-voltage power supplies.

Tunnel diodes

Tunnel diodes (also known as Esaki diodes) are most often found in (relatively) low frequency oscillators and similar circuits. These oscillators, which produce an alternating or pulsating signal electronically are used in a myriad of devices, including signal generators and consumer electronic appliances.

When tunnel diodes are operated in the forward direction, a condition is reached where they exhibit a "negative resistance" characteristic. At this point, the current flow through the diode decreases as the voltage continues to rise. At forward voltages above and below the negative resistance point, the resistance increases as the voltage increases.

According to Ohm's law, this results in rising current and a rising voltage. Thus a small fluctuation of biasing voltage anywhere near (above or below) the negative resistance region will greatly vary the resistance of the diode, making it very versatile in oscillation circuits. Tunnel diodes, however, do not operate very well at frequencies above a few MHz.

Shockley diodes

Unlike most other diodes, the Shockley diode utilizes two PN junctions rather than the single junction found in most other diodes.

Shockley diodes are often used as "switches" as, until the applied voltage reaches the avalanche point, the diode will remain in an off state, exhibiting a very high resistance. Once the triggering voltage has been reached or exceeded, the diode is turned on, with the resistance measuring just a few ohms. These characteristics make the Shockley diode very useful in the construction of variable frequency pulse generators. With the addition of a gate, the Shockley diode would be a typical SCR (Figure 3). When you need a device with the characteristic of a Shockley diode, you might be able to use an SCR; just don't connect the gate.

Varistors

Although the term varistor is often associated with a resistor whose value varies inversely with the voltage across it, the term varistor also describes a single package component which is the electronic equivalent of two zener diodes connected back to back. Like zeners, varistors are commercially available in various breakdown voltages.

Varistors are most often used in the power input circuits of electronic devices that may be susceptible to damage from power line spikes and other pollution on 120Vac power lines. Varistors are commonly used in conjunction with various types of power line filters or conditioners.

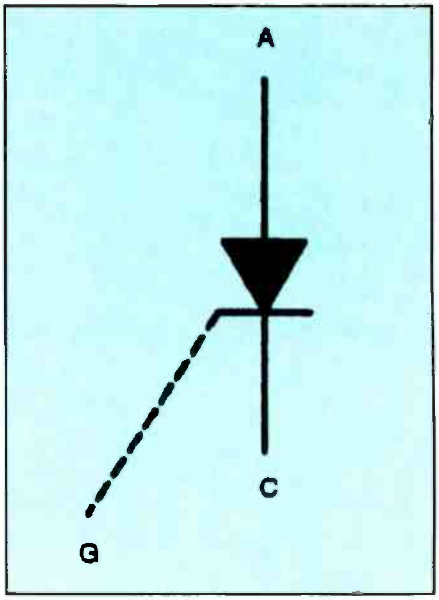


Figure 3. A Shockley diode has two PN junctions. It's much like an SCR without a gate connection.

As mentioned, varistors are available (or may be constructed from zener diodes) in a wide variety of breakdown voltages. In the United States, the most popular is the ECG 1V130 (or equivalent) which has a breakdown voltage of 184 Vdc (approximately 130Vac), and a peak current rating of 400A. Connecting a varistor across the primary windings (or power line) will clip all power line spikes at a comfortable 130Vac, protecting valuable equipment from damage, and possibly fire. It is not a bad idea to place a varistor across the ac line coming into the home or service center.

With advancing technology, semiconductor components are allowing the construction of circuits/appliances which generate less heat, are smaller in size and are more reliable. Even now, Gunn diodes are being used to generate low power microwave oscillations in the X-band (10 GHz) with voltages less than 20V. Opto-isolators are being used to allow data transfer between computer systems that are completely (electronically) incompatible, as well as to control high-powered (480Vac) circuits with low powered (9Vdc) systems. Given the current rate of advance of diode technology, the special purpose diodes of today may well become the general purpose diodes of tomorrow.

Test your electronics knowledge

Answers to the quiz *(from page 41)*

1. C. Yes, I *know* that a snowy picture can result from improper termination of the line. I *know* that under certain conditions leading ghosts can appear when the line is not properly terminated. However, they are conditions that appear on the picture—not on the line as the question asks.

2. B. It is the same answer yesterday, today and tomorrow.

3. C. Capacitors with an NPO rating do not change their capacity when their temperature changes within a range of temperatures set by the manufacturer.

4. C. The "Q" of a coil means *Q*uality factor. In the very early days of radio the best quality meant the highest reactance/resistance ratio for sharpest tuning. That is no longer true. A high Q coil will tune too sharply to pass a video signal.

5 . B. The manufacturer gave the points to be marked.

6. C. From the answer to this question you can see why the manufacturers had to eliminate the fine-tuning control. No matter how carefully you explained the proper method of adjusting the fine tuning control, you often had to go back and adjust it for the customer.

7. B. The tint control on a color TV receiver was another case where the customer was unable to make proper adjustments. Now the TV station provides the means for automatic tint control.

8. D. Most wattmeters provide a method of giving the product of V and I.

9. B. This question has been asked in many different ways on CET tests. In early FCC tests it was necessary to *calculate* the value of a series multiplier.

10. B. The term "grounded collector" is seldom used today. *Emitter follower* and *common collector* are the terms now being used.

Restoring scratched compact discs

By Matt J. McCullar

Compact discs, laserdiscs, and CD-ROMs take substantial abuse just from normal play. No matter how delicately they are handled by their owners, CDs pick up scratches and gouges from loading and unloading, and from spinning in the tray. Sometimes accidents happen; discs get dropped onto the floor and take a mean bounce or two, or they bang into the player tray when the user's hand slips.

Manufacturers claim discs will last indefinitely; what they fail to mention is discs last indefinitely only as long as they stay in the box. In the real world, their days are numbered just as with any other type of recording.

When the plastic is gouged or scratched, it may not be possible for the laser pickup to read the data from the disc below the gouge. When this happens, the CD player tries to fill in the missing data. If the scratch is severe enough, the listener hears a "skip."

While most stereophiles probably think that a disc with a scratch this severe is damaged beyond use and should be discarded, it is possible in some cases to smooth out the scratch so that the disc will play just as sweetly as it did when it had just been taken out of the box.

Even large gouges, given enough time and determination, can be eradicated so no skips remain. No longer will you or your customers have to toss out a disc because of a scratch. No longer must you purchase a new, expensive alignment test disc due to damage.

What materials do I need?

The record-care product manufacturers sell a liquid that contains a fine abrasive that may be used to rub out scratches in CDs. There are alternative products that will also work, and are less expensive. Metal polishes, for example, contain extremely fine abrasive particles suspended in a liquid. Brasso, available at any hardware store, is very effective for rubbing out scratches in CDs.

You might want to experiment with other similar materials, but you should experiment on a disc that you don't care about until you're sure that the abrasive is fine enough that it won't cause scratches that will make the problem worse.

Also required are a few clean, lint-free cloths; the softer the better. Baby diapers work great. They will provide a soft surface to work on and will also polish away the scratch.

To repair a scratched disc, spread out a cloth on the workbench and place the disc on it, damaged side up. Shake the can of abrasive liquid and apply a little of it to another cloth. Then, holding on to the disc with one hand, use your other hand to wipe the polish onto the affected area.

Polishing out a scratch is very much like waxing a car. First you rub in a coat of the material, then you wait a while for it to dry, then you buff it off with another cloth. This takes some patience, because several minutes are required for the liquid to dry. But keep at it; it works. Make short, brisk strokes along the scratch, rather than across it. Replenish the polish with a fresh amount of liquid from time to time. Polish and buff.

Within a few minutes you will notice a difference. Hold the disc up to the light. You can see that the scratch is much less noticeable than before. It may take a lot of elbow grease, depending on how deep the scratch is, but it's well worth it. When you can no longer see the scratch, wash the disc with water and allow it to dry before attempting to play it.

As seen in Figure 1, polishing out a scratch involves polishing away plastic.

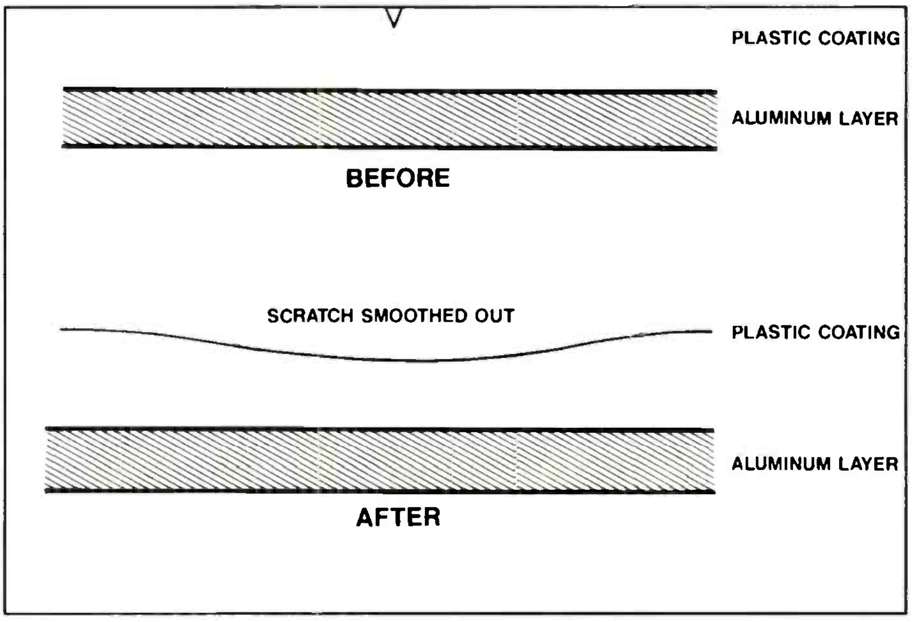


Figure 1. Polishing out a scratch in a CD involves polishing away plastic. The idea is to form a depression in the surface of the disc, the slope of which is gentle enough so the laser won't get confused when reading the data underneath it.

McCullar is an independent computer and electronics servicing technician.

The idea is to form a depression in the surface of the disc, the slope of which is gentle enough so the laser won't get confused when reading the data underneath it. With a scratch, the transistion from clear plastic to a large hole causes confusion.

The polishing liquid won't damage a disc over the long term, but it is advisable to keep a fan going or open a window while you're doing this, to avoid prolonged breathing of the fumes.

Which scratch is which?

Today's players contain error-correction circuits that do a superb job in correcting most "data hits." But on a disc that contains many scratches, it may be difficult or even impossible to find out which one is actually causing the player to skip by just looking at it.

Since polishing a scratch can take some time, it is better to find out which one to work on in advance. The best way to do this is to listen to the disc and note how far into the music (or video, or data, or whatever) the errors begin. Keep it in mind that CDs begin at the center, and move outward.

A skip that begins within just a few minutes is likely to be located near the hub, and a skip that takes half an hour or more will be near the middle of the disc. A skip 60 minutes or more into the disc is located near the outer edge.

What this won't fix

If the scratch is so deep that you can see daylight through it, then it has damaged the aluminum layer that contains the digital data. Damage this severe cannot be repaired, no matter how much you polish. The disc is ruined. (See Figure 2)

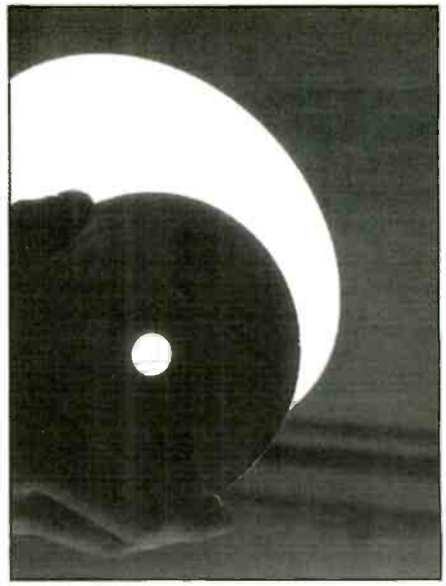


Figure 2. If the damage to the disc is so severe that the scratch has gone through the metallic layer, you might as well discard the disc. No amount of polishing is going to improve the way this disc plays.

How can I use this?

I've used this technique on ordinary compact discs, laserdiscs, CDVs, CDIs, and CD-ROMs. Imagine how much it costs to replace a laserdisc or CD-ROM disc these days. Replacements have exorbitant prices, if replacements even exist. Knowing how to repair them is an excellent advantage, particularly if a disc used in the shop to align and test disc players suddenly reveals a wicked scratch.

You may try offering this service to your customers. How many times have you opened a CD player to find a disc stuck in it? It might be worth repairing a damaged disc for a customer. If you're a manager and don't want your technicians spending time on a project like this, assign it to someone else in the service center. It might work to your advantage. ■

What do you know about electronics?

The tunnel diode oscillator circuit

By J.A. Sam Wilson, CET

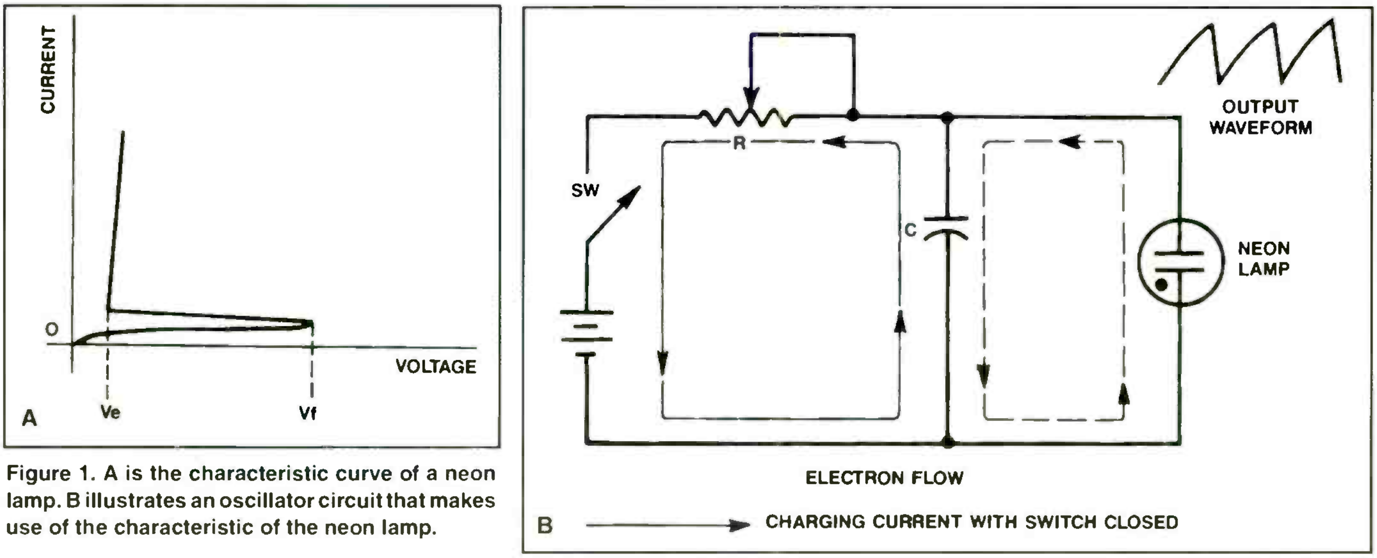


Figure 1. A is the characteristic curve of a neon lamp. B illustrates an oscillator circuit that makes use of the characteristic of the neon lamp.

Before I present an actual tunnel diode oscillator circuit, I want to compare the tunnel diode with a neon lamp. In high-class engineering talk the two devices are called *duals*. They do the same kind of job but one works primarily with voltage and the other works primarily with current.

Neon lamp characteristic

Figure 1 shows the characteristic curve of a neon lamp and an oscillator circuit that makes use of the characteristic. Moving on the curve between 0 and V_f you will note that—starting from zero—a slight increase in the voltage across the lamp causes a slight increase in current through it.

When the voltage has increased to the firing potential (V_f), the neon lamp fires and the voltage across it drops to a lower value. That value is the extinguishing potential and it is marked V_e on the curve.

At V_e the current through the lamp increases rapidly with a small increase in voltage. In fact, if you don't put a current-limiting resistor in the circuit the neon lamp can be quickly destroyed!

When the switch is first closed in the circuit of Figure 1 the capacitor (C) begins to charge through the resistor (R). The charging path is shown with solid arrows. When the capacitor voltage reaches the firing potential the neon lamp conducts and discharges the capacitor until

Wilson is the electronics theory consultant for ES & T.

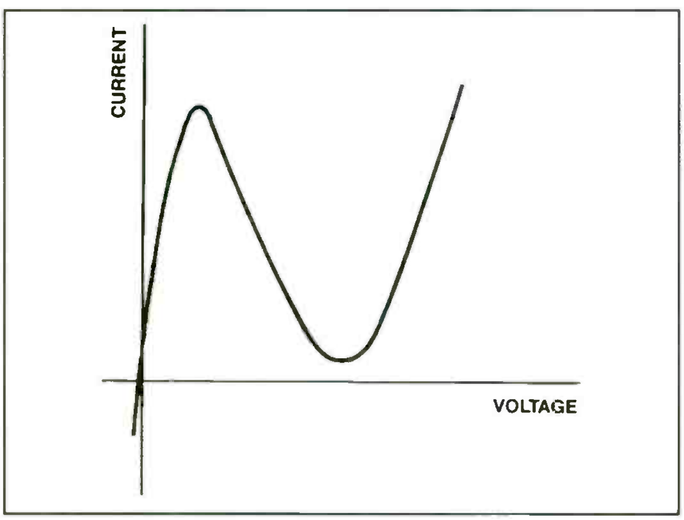


Figure 2. The neon lamp has a characteristic curve that looks like this.

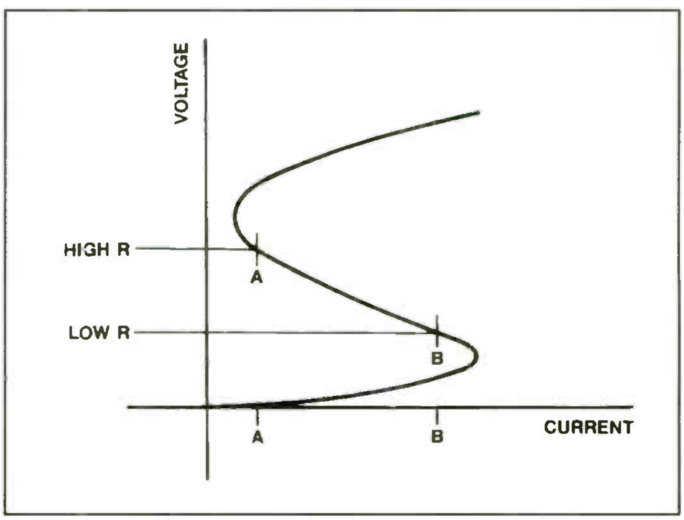


Figure 3. The characteristic curve of a tunnel diode with current shown as the independent variable.

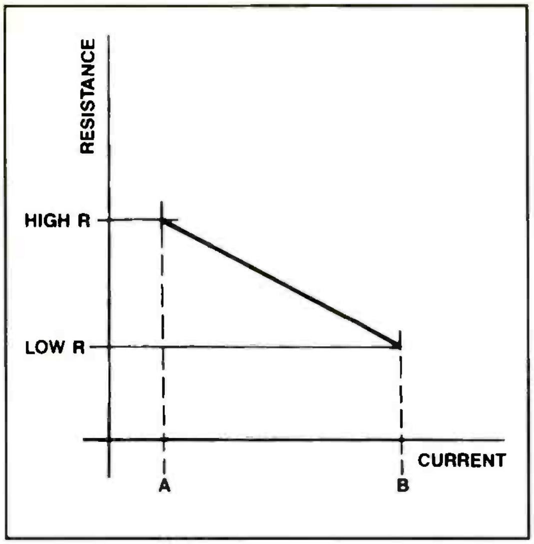


Figure 4. In the "negative-resistance" portion of its characteristic, the resistance of the tunnel diode decreases as the current increases, as shown here.

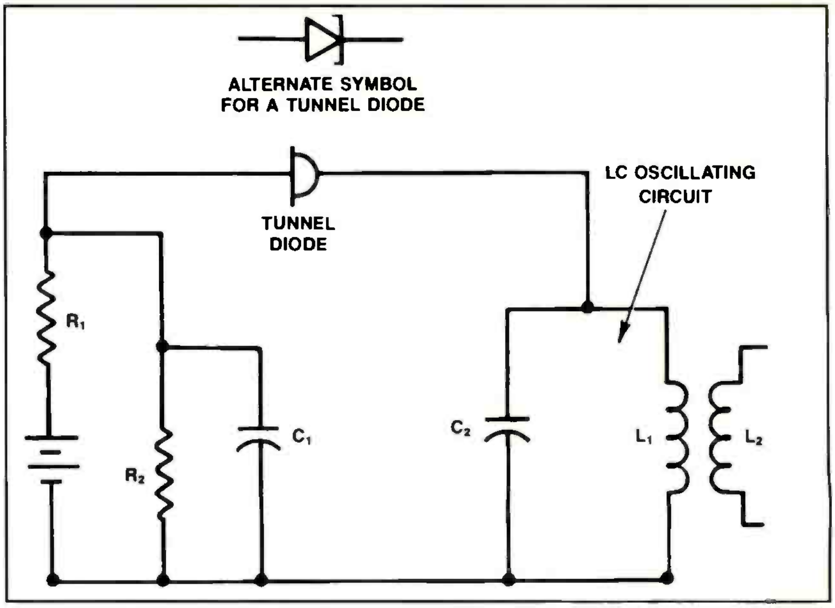


Figure 5. A tunnel diode can be used as the basis for an oscillator.

the voltage across it reaches V_e. The discharge path is shown with broken arrows.

The capacitor is not completely discharged during the discharge cycle. When the neon lamp no longer conducts—due to the lowered voltage across it during discharge—the capacitor starts to charge again. As shown on the output waveform there is a continuing charge and discharge of the capacitor. The result is a sawtooth-like output waveform.

Tunnel diode characteristic

Now, consider the characteristic curve of a tunnel diode as it is usually shown. See Figure 2. The voltage is shown on the X-axis (called the abscissa) and the current is shown on the Y-axis (called the ordinate). There is a basic rule for showing graphs and you should know it. Traditionally, the independent variable is shown on the abscissa and the dependent variable is shown on the ordinate.

To make the characteristic curve of

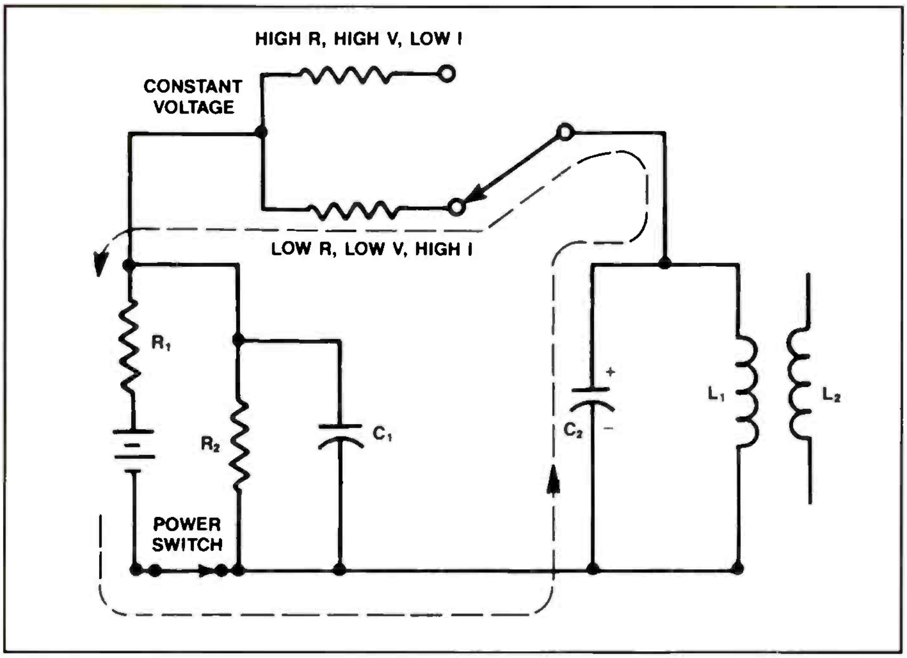


Figure 6. In this circuit, the tunnel diode is represented as a switch and two resistors. Here, the power switch has just been closed.

Figures 1 and 2, the voltage across the device is increased and the resulting current is plotted for each marked value of voltage. Since the value of voltage is being varied it is an independent variable.

The current on the Y-axis is the result of the voltage being applied across the diode. In other words, it depends upon the voltage, so, it is the dependent variable. The curves of Figures 1 and 2 follow the traditional method of making graphs.

Here is something to think about: it is possible to change the graph of Figure 2 to make a point clear. For example, the characteristic curve of the tunnel diode can be drawn to show what happens to the voltage as the current through the device is increased. That would mean the current is the independent variable and the voltage is the dependent variable. The curve with the current shown as the independent variable is shown in Figure 3.

When you compare the characteristic curve of the neon lamp in Figure 1 with the tunnel diode curve of Figure 3 you can see why the two devices are called *duals*.

In order to get the curve of Figure 3 you can trace the curve of Figure 2 on tracing paper. Be sure to include the abscissa and ordinate and mark them as I and V. After you draw the curve, turn the paper over and hold it up to the light. That is a graphical technique that works in many other cases.

About the meaning of the word switch

When we talk about switches we are often referring to On/Off devices. A light switch is an example.

It is important to remember that a switch can also be a device that selects between two levels of voltage or current or resistance. The neon lamp in the above circuit discussion is an example. It switches ON at the *firing potential* (V_f) and it switches OFF at the *extinguishing potential* (V_e).

You can see in the characteristic curve of Figure 3 that the tunnel diode switches between two points. In that case, the switching is between two currents instead of two voltages.

I have marked two points on the curve of Figure 3 that will be used as switching points. At point A the current is low and the voltage is high. At point B the current is high and the voltage is low.

When I say the voltage at point A is "high" I mean in comparison to the voltage at point B. Likewise, when I say the current at point A is "low" I mean in comparison with the current at point B.

Ohm's law tells us that if a low voltage across a device results in a high current then it follows that the resistance of the device is low. If a high voltage across a device results in a low current it means the resistance of the device is high.

So, when the current through the tunnel diode increases from A to B the device is actually switching from a high resistance to a low resistance. When the current decreases from B to A it is switching from a low resistance to a high resistance.

In Figure 4 I have represented the characteristic of the tunnel diode at points A and B as being a switch between two different resistances.

The tunnel diode oscillator

Figure 5 shows a basic tunnel diode oscillator. As I said in the previous issue,

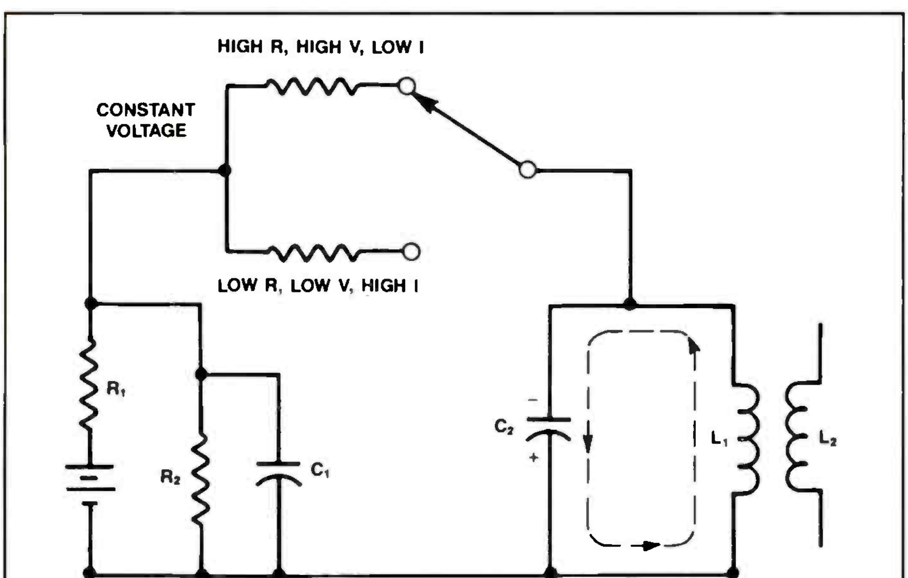


Figure 7. When the capacitor nears full charge, the charging current decreases, which switches the tunnel diode to the high-resistance condition.

oscillation is sustained by using a switching or amplifying device. Its purpose is to add power supply energy to an L/C circuit to replace oscillating energy that is lost due to heat. The heat comes from the oscillating current flowing through circuit resistance.

In Figures 6, 7, and 8 I have replaced the tunnel diode with a switch that selects between a high resistance and a low resistance. Resistors R_1 and R_2 and capacitor C_1 make a voltage divider with a nearly-constant output voltage.

Here are two very important points regarding the model of Figures 6 and 7:

- A low voltage across the diode can switch the diode to the high-current, low-resistance mode of operation; and,
- A low current through the diode can switch the diode to the high-voltage, high-resistance mode.

In other words, the diode can be switched by current *or* voltage.

When the power switch is first closed, capacitor C2 charges along the path shown by solid arrows in Figure 6. The current is high and the voltage is low. Therefore, the switch is in the low-resistance position.

When the capacitor nears full charge the charging current decreases. That switches the tunnel diode to the high-resistance position shown in Figure 7. The LC (actually L_1C_2) circuit is disconnected from the power supply by the high resistance. The capacitor cannot continue to hold its charge, so, it discharges through the inductor as shown by the broken arrows in Figure 7.

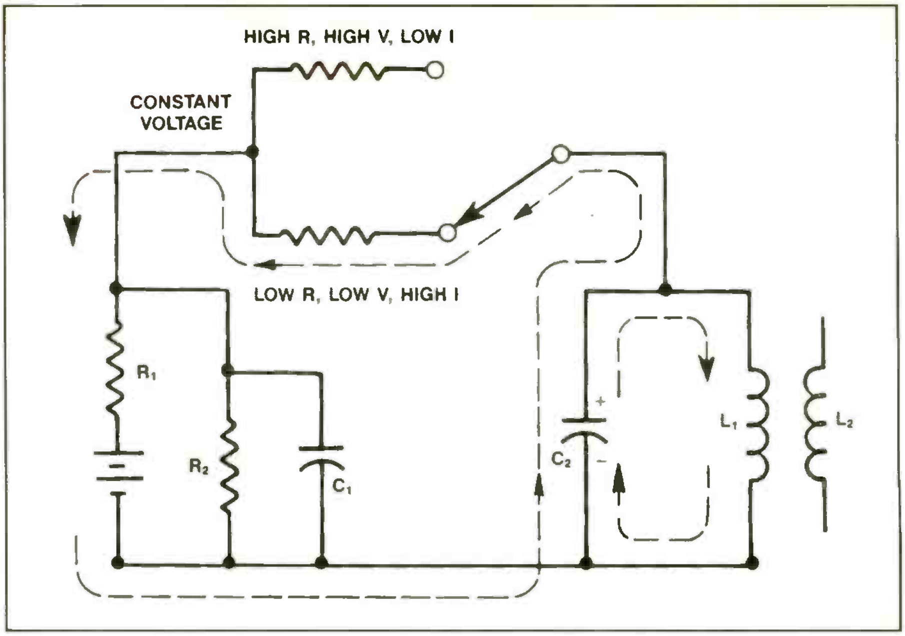


Figure 8. Once the coil induced voltage drops to zero, the capacitor charges in the opposite direction.

When the discharging current tries to decrease (after the capacitor is discharged) the field around the coil collapses.

According to Lenz' Law, the induced voltage across the coil will always be of a polarity to prevent the current through it from changing. The discharge current is trying to decrease, so, the induced voltage will keep it going. The result is that the capacitor is charged in the opposite direction from what it was in Figure 6. See Figure 7.

The coil induced voltage eventually drops to zero, and the capacitor charges in the opposite direction. During this period the capacitor is charging as shown in Figure 8. The charging current is equal to the current due to the coil plus the current of the supply, and, the capacitor charges to the full-charge condition.

When the voltage across the capacitor approaches the full-charge value, the voltage across the tunnel diode decreases. The tunnel diode voltage equals *(the voltage at point X)* minus *(the voltage across the capacitor)*. That means there is a low voltage across the diode. The low voltage across the diode switches it to the high-current position when the capacitor is fully charged.

That is how the tunnel diode switches the power supply energy into the system to replace heat energy lost on the previous cycle.

When the circuit is working properly the capacitor reaches the full-charge condition each cycle. The tunnel diode is only conducting long enough to accomplish that full charge.

The overall result is a sinewave current that is coupled to the outside world by the secondary coil (L_2). ■

Beware of emulation

By Conrad Persson

One of the things that microcomputers do for us is to increase the flexibility of everything that they're used in. Today's personal computers and peripherals are extremely flexible. For example, because many computer peripherals, notably printers, contain their own microcomputers, they may be programmed to perform the same as a peripheral manufactured by a different manufacturer.

Take as an example the Panasonic KXP1124 dot matrix printer. It can be set up to emulate either the Epson LQ-850 or the IBM Proprinter X24E. According to the documentation that comes with the KXP1124, when it comes from the factory it is set up to emulate an Epson printer. By manipulating the soft keys on the front of the printer, it can be changed so that it will emulate the IBM printer.

But the flexibility doesn't stop with the hardware. The software is flexible as well. Take word processors as an example. Most good commercial software programs have the ability to drive a number of different printers. The way the operator selects which printer will be used will depend on the particular program.

With the popular program, WordPerfect, the operator first selects the print function, either from the keyboard or the menu, and then is presented with a menu from which he may choose the menu item "select printer." When that item is chosen, the screen shows which printer drivers are available in the software, and highlights the particular printer that is currently chosen, or selects a new printer.

In the case of another software program, XyWrite, the operator selects the printer software by pressing F5 to place the cursor on the command line then types in the command to load the particular printer driver desired. To load the driver for the Panasonic KXP1124, the operator types in LDPRN 3PAN1124.PRN.

But flexibility can be confusing

All of this flexibility in the world of IBM compatible personal computers is wonderful. It allows the operator a world of choices. But the more choices available, the more possibilities there are for confusion. Here's a case where the flexibility built in to the computer system caused problems.

A friend of mine, call him Carl, called me and told me that he was having problems printing out a document on a computer he was using. The system was an IBM 80286 with a Panasonic KXP1124 printer. The software program in use was WordPerfect.

The problem was that every document he printed had lots of extraneous characters. Where there should have been spaces, there were odd characters such as a diamond, or a Greek letter omega, or an upside down question mark. At the beginning of every line there was a less-than sign.

Tracking down the problem

Being familiar with the KXP1124 printer, I felt that I might be able to help Carl, so I paid him a visit. The documents he showed me looked strange indeed.

I asked Carl to go through the procedure to print out a document. The printer that was currently selected within WordPerfect was the KXP1124.

On a hunch, I decided to check to see how the printer was actually set up. This in itself becomes an interesting exercise, because many of the keys on the KXP-1124 have dual functions. For example, one of the keys can be used to make the printer operate more quietly, albeit more slowly. It is marked QUIET. However, under the key is the word MENU.

In order to access the second function that the key performs, you first press the FUNCTION key at the right of the printer. When the FUNCTION key is pressed, the ON LINE/FUNCTION LED blinks on and off continuously to show that the FUNCTION key has been pressed.

Now pressing the QUIET key gets you to a menu on the LCD display screen instead of causing the printer to operate in the quiet mode. On this printer, you can then scroll through all of the menu items either by repeatedly pressing the QUIET/MENU key, or pressing the LF (line feed) or FF (form feed) key.

Pressing the key several times caused the LCD display to step through a number of items until it came to the word EMULATION. At this point pressing the key marked P.CUT (ITEM) revealed the currently selected printer emulation. Not surprisingly, the currently selected printer emulation was IBM.

No wonder the documents being printed looked funny. The computer was printing to a Panasonic KXP1124 printer, but the printer, which was in fact a KXP1124, had actually been set up to emulate an IBM Proprinter. Pressing the LOAD/PARK (SELECTION) key changed the display to EMULATION EPSON.

Of course, there's still another confusion factor. The KXP1124 was designed to emulate one of two popular printers, not to operate on unique characteristics of its own. So when WordPerfect was set up to output to the KXP1124, the WordPerfect programmers had actually set it up to output Epson compatible data.

Things are seldom what they seem

Because so much can be done in software, because products are designed with soft keys, because many computer-related products are designed so that they can emulate other products, things are often different from what they appear to be.

When a technician who is servicing a computer or computer-related product runs into a strange problem, he should always be alert for the possibility that a peripheral has been set up to emulate another product, and that may be the cause of the problem.

The complexity that is built in to today's computer-related products makes them flexible but it's almost impossible to service them without documentation of some kind. Always make sure that the user's manual, operating instructions, or service manual is on hand when you start working on one of these products. ■

Persson is editor of ES & T.

Better audio through digital compression

By the ES&T Staff

The world of audio has gone digital. It doesn't take a genius to see the truth of that statement. Digital compact discs (CDs) have just about elbowed vinyl LPs from the marketplace. Digital audio tape (DAT) and digital compact cassette (DCC) are here. All of this digital audio is getting listeners used to hearing the best in audio.

Unfortunately, while the sound quality of broadcasting has improved considerably over the past several years, it has not been able to keep up with the quality of recorded sound. Digital compression may soon change all that.

Digital consumer, computer and telecommunications products all have in common the need to process vast amounts of digital data at very fast rates—fast enough to appear instantaneous to users. Very high-speed digital signal processors (DSPs) are capable of processing the data load, but there are practical limits to the amount of data that can be easily stored or transmitted. Hence the need for digital compression technology.

In simple terms, digital compression refers to various software and integrated circuit hardware techniques used to "squeeze" information by removing unnecessary data. This information is then encoded and either transmitted or stored on tape or disc. The user's equipment later decodes the information and fills in the data that was removed for compression. This latter process is called "decompression," though both the compression and decompression processes are usually referred to together as "compression."

Many people associate compression with images, both still and moving. However, audio information is also compressed for digital transmission and storage. In fact, some potential applications, such as digital radio require audio compression only. With other applications, such as HDTV, audio compression opens more room, or bandwidth, for extra video information or audio channels.

This article was based on information provided by Texas Instruments.

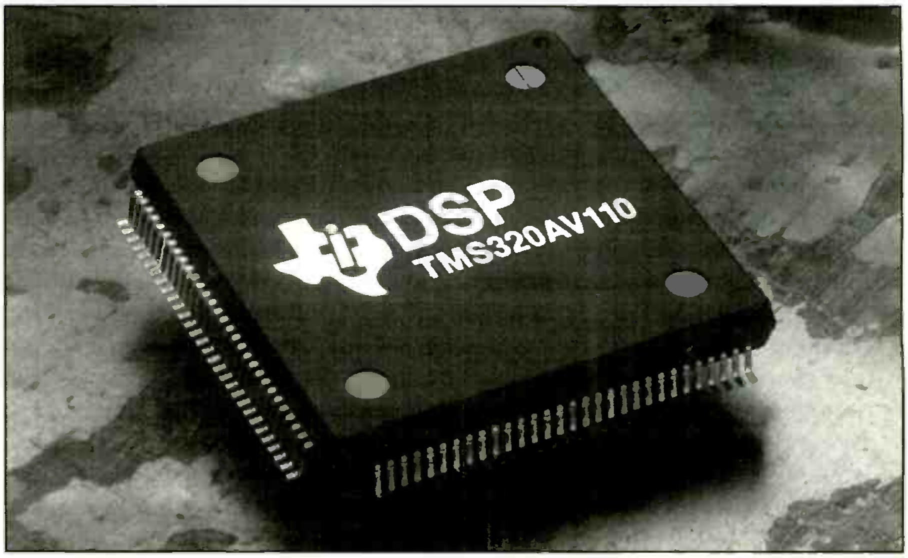


Figure 1. Digital audio compression, made possible by IC technology such as TI's TMS-320AV110, shown here, will extend the advantages of CD quality sound to many products that currently offer sound of less exacting quality.

These compression techniques are based on the International Standards Organization's (ISO) Joint Photographic Experts Group (JPEG) standard for still images, and Motion Picture Experts Group (MPEG) standard for audio and full-motion video.

Raw, uncompressed digital audio and video data requires too much processing to make electronic equipment cost-effective and practical for many applications. The JPEG algorithm compresses each frame of video data by removing information to which the human eye is not sensi-

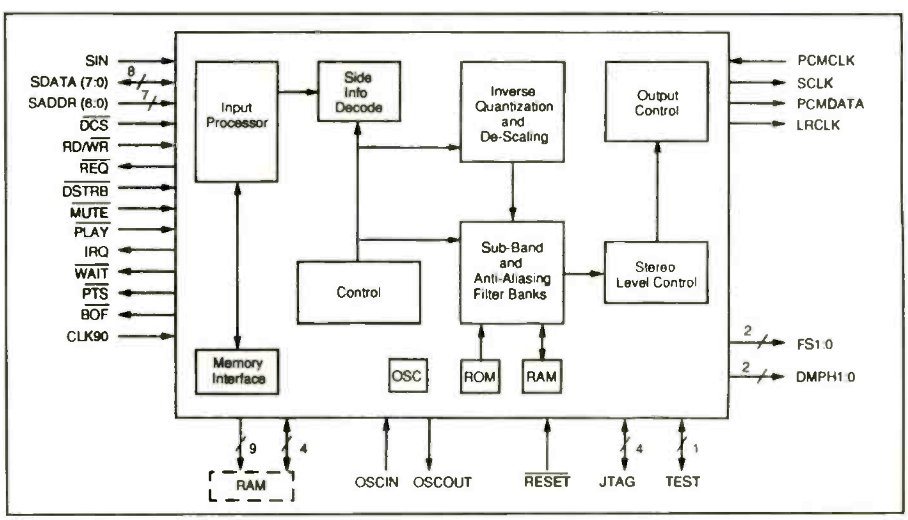


Figure 2. This is a block diagram of the circuitry inside the TMS320AV110 MPEG audio decoder.

tive. MPEG extends this compression technique by transmitting only the part of each video frame image that differs from the one before it.

With JPEG technology, video can be compressed enough to store and manipulate video on a personal computer. With MPEG technology, over 70 minutes of audio and video data can be stored and played from an 80-cent compact disc, providing a less expensive distribution medium than videotape.

Products applying digital compression technology

Consumer electronics products that are candidates for application of digital compression technology include digital radio receivers, digital cable and direct broadcast (DBS) television decoders, HDTV, interactive compact discs (CDI), digital camcorders and videocassette recorders, digital compact cassettes and minidisks, and CD-ROM-based karaoke and video games. To be competitive in their markets, these products must be produced in high volume at low cost and have low power requirements to prolong battery life between charges.

Applications for digital compression technology also exist in the areas of personal computers and telecommunications.

Digital compression is a reality

It won't be long before consumer electronics service centers begin to see products with digital audio compression circuitry in them. In May, Texas Instruments introduced a new IC that will be able to produce CD quality sound in emerging consumer electronics products and entertainment systems. The device, the TMS-320AV110, for use in products ranging from portable CD players to advanced digital television services, produces quality audio by decoding digital data that has been stored in a compressed format.

And while this technology can no doubt be expected to be as reliable as the rest of today's ultra-reliable consumer electronics componentry, it will fail on occasion, which will introduce new failure modes for consumer electronics servicing technicians to contend with.

An awareness of this new technology will help technicians be ready for products that employ it when it arrives on the service bench. ■

Using a service form

By Dale Shackelford

One of the most obvious characteristics of consumer electronics servicing is variety. The types, brands and models of products serviced is incredibly varied, causing service centers to constantly read and study just to keep up with changes and new products. The customers are varied, coming from all walks of life, bringing with them all types of attitudes. The only common thread among customers is their need to have a product serviced.

And service technicians are varied. Some technicians are more highly skilled than others, some are more ambitious than others, some have better people skills than others, some are more organized than others.

Even the owner or manager of a consumer electronics service center will reveal variety over a period of time. One day he'll have a tendency to do things one way, another day, he'll do it another way.

Imposing order on variety

All of this variety is a good thing; it makes life interesting. Moreover, variety in one area compensates for variety in another. Because some technicians are better at servicing VCRs than others, for example, it is possible for the service manager to assign the different technicians to the products that best suit their skills and temperament.

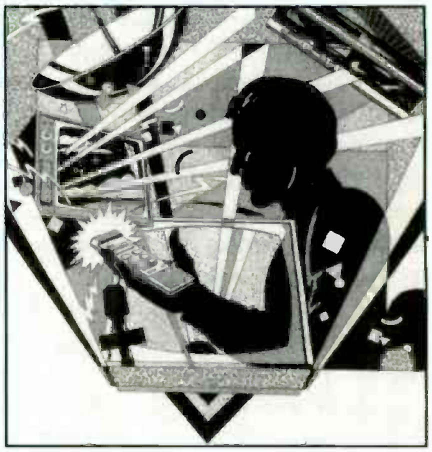
On the other hand, it is also important to bring some order to the variety that exists. One way to create order in servicing is to make sure that every time a product is presented for service, that the information that is recorded is substantially the same. One way to make sure that the information recorded for all products serviced is consistent is to use a form.

Information to be recorded on the form should include a description of the product, the owner of the product, and other such identification information. Also of value would be a record of the owner's description of the symptom, and the work performed by the technician.

Electronics servicing technicians, whether the sole proprietor of a small service center, or a member of a 20 technician service center, can ill afford the time, and therefore the expense, of eliciting every detail necessary for proper identifications of symptoms, warranty information, schematic availability and pick-up/delivery instructions from each customer, though such information is vital to the proper overall operation of an electronics service center. Use of a form allows service centers to gather this information with a minimum of effort.

Here's a form you can use

Many service centers, especially the larger ones, no doubt already have devised some kind of form for recording customer/product information. Some use the ones supplied by NESDA or NARDA. Some use a computer to record this information. For those service centers that do not at the moment use some type of form and whose operation could be improved by adopting a standard customer information sheet, we offer this one, which will allow service facilities, both large and small to obtain information from customers concerning their products brought in for service.



If the form suits your operation as is, simply copy it (both front and back). This will allow you to present customers with a professional looking questionnaire that will fill the needs of most service centers. You may add the name and address of your business.

If the form doesn't suit your needs as it stands, you may modify it as you see fit and use it in its modified form.

While the form is designed to provide needed information for the servicing technician, it also gives the customer a detailed account of the service performed on the product, including cost breakdowns and information that might be of assistance to any technician who might service the unit in the future.

By retaining a copy of the second page for their files, the service center will have a complete record of all service performed, costs, taxes and other information that will be needed at the end of the year or during times when it becomes necessary to provide documentation of activities, including inventory, customer returns, or tax preparation. ■

Shackelford is an independent electronic servicing technician.

CUSTOMER NAME ______________________________

ADDRESS ______________________________

TELEPHONE/FAX # ______________________________

PRODUCT TO BE SERVICED (TV, VCR, COMPUTER, ETC.) ______________________________

DESCRIPTION OF PRODUCT (COLOR/SIZE/ETC.) ______________________________

MODEL ______________________________ SERIAL# ______________________________

BRAND______________________________ OTHER I.D.# ______________________________

APPROXIMATE VALUE $______________________________

CAN YOU SUPPLY OWNER'S MANUALS OR SCHEMATICS ON THIS DEVICE? ______________________________

LIST ANY PREVIOUS SERVICE/MODIFICATIONS TO THIS UNIT: ______________________________

____

IN YOUR OWN WORDS, DESCRIBE THE PROBLEM WITH THIS UNIT: ______________________________

____

UNDER WHAT CONDITIONS DOES THIS PROBLEM EXIST? (CHECK ALL THAT APPLY):

CONTINUALLY__________ INTERMITTENTLY__________ AFTER WARM UP__________

PRIOR TO WARM UP__________ WHEN MOVED__________ WHEN STATIONARY__________

LIST ALL PERIPHERAL, AFTERMARKET OR ACCESSORY EQUIPMENT THAT YOU NORMALLY USE WITH THIS DEVICE (ANTENNAS, CABLES, EXTERNAL SPEAKERS, REMOTE CONTROL UNITS, ETC.)

____

WOULD YOU MAKE THESE PERIPHERAL OR ACCESSORY DEVICES AVAILABLE TO THE SHOP IF NEEDED? __________

DEVICES DELIVERED ______________________________

I REQUEST TO BE CONTACTED PRIOR TO REPAIR IF THE COSTS WILL EXCEED:

$______________________________

I CAN BE CONTACTED AT THE ABOVE TELEPHONE NUMBER BETWEEN THE TIMES OF: ______________________________

IS THIS UNIT UNDER AN EXISTING WARRANTY? ______________________________

IF YES, HAVE YOU SUPPLIED WARRANTY DOCUMENTS? ______________________________

NOTICE

Once service has been completed, this document will be returned to the customer, with the reverse side completed by the servicing technician. Please keep this document for future reference, and supply this form to any technician who may service this unit in the future.

TECHNICIANS NOTES

CUSTOMER SERVICE NUMBER:________________________ TECHNICIAN:____________________ DATE:__________

SYMPTOMS OBSERVED BY TECHNICIAN: ____

____

DIAGNOSIS: ____

PARTS NEEDED____

PARTS INSTALLED (NOTE COST OF EACH) ____

SUPPLIES USED: ____

LABOR (TIME & DESCRIPTION): ____

WERE SAFETY CHECKS PERFORMED?____________________ BASIC SERVICE ADJUSTMENTS MADE?__________

____

LIST ACCESSORIES RETURNED TO CUSTOMER: ____

RECOMMENDATIONS MADE TO CUSTOMER CONCERNING THIS UNIT: ____

____

SERVICE CHARGES: $ ____

PARTS: $ ____

LABOR: $ ____

OTHER (SPECIFY): $ ____

APPLICABLE TAX: $____

TOTAL COST: $ ____

PICK UP/DELIVERY INSTRUCTIONS

Note any special instructions designated by the customer concerning the pick up or delivery (telephone customer for pick up time, special identification, etc.):

____

____

____

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Schematic/service manual for Bradford model #53736/service # 2004G31 8-track recorder/ player.R. B. Wetherell, 14 West St., Wakefield, RI 02879.

Need M-5142P integrated circuit, used in the sound stage of a Sony KV-1201 color TV. Part is no longer available from Sony National Parts Center. Please write indicated price to: Carlos Urbina, 1 Calle 14 No. 1128 Norte. Torreon Coahuila 27000, Mexico.

Service manual/schematic for GE radio 7-2970A, Boman CB-535, YORX radio R5180. Call collect, Major Meckling, 913-467-3921/8431.

High voltage divider P/N 7615407 and H/V Quadrupler P/N 761634 for Barco V Star 5 projector. Galaxy model 2000 VCR/TV; requires video heads. Used or new parts. Call 614-899-9049.

Schematic, parts list, parts layout, Murata M1200 Fax, especially power supply. Leonard Prince 767, W. Rosslyn Ave., Fullerton, CA 92632.

Oscilloscope 60MHz or 100MHz plus TV and VCR service equipment. Will pay cash. Call 914-236-4773 or write Andy Bagatta Sr., A-Plus Electronics, P.O. Box 1036, Marlboro, NY 12542.

Telephone test equipment to check operations of phones, answering machines, etc., such as B&K 1045, 1050. Write: Mr. Roger S. Goldberger, 3909 Dora Circle, Harrisburg, PA 17110, 717-652-1703.

Looking for one or more replacement styli for Micromatic Magnavox stereo model 1P3718, purchased new in 1969. Marjorie Maddox, 7824 NE, 54th St., Kansas City, MO 64119.

Parts for Sony TV KV-1397R: Vertical IC CX 20192 part #8-752-019-20, Relay #1-515-346-13. Ed Herbert, 410 N. Third St., Minersville, PA 17954.

Fisher VCR service manuals; source for VCR RF modulators by VCR model number. Ed Herbert, 410 N. Third, Minersville, PA 17954.

Flyback for Mitsubishi VS 505U projection TV, part #334-B07001. Bill Hawley, 1383 Garden Crest Circle, Raleigh, NC 27609. 919-515-3895 or 787-6920.

Looking for 3A3C tubes. M Seligsohn. 1455-55th St., Brooklyn, NY 11219.

Used test equipment for TV/VCR/Stereo repair B&K Service manuals all brands. B&K 520B transistor tester. Mike 403-783-5454.

Panasonic PV5000 Omnivision VCR. Two-piece recorder, tuner combo, in good condition or recorder unit for PV5000 in good condition. Call Jackson VCR 205-643-5906.

Working loading assembly for JC Penny's model #686-5075. Ken Kuyasa, 6910 Hopkins Rd., Mentor, OH 44060, 216-255-4158.

A tuner converter of any make to use for TV above channel 13, use for cable reception—state price, make and condittion. Haruo Kawamoto, P.O. Box 97, Pepeekeo, HI 96783.

Schematic and parts source for KLH model 54 dual function receiver. J.Evans, 120-29, 192nd St., St. Albans, NY 11412.

GE Flyback EP97X41. Fernie Garcia. 213-753-3126, 2907 W. Florence Ave., Los Angeles, CA 90043.

Schematic for Video Interface Products Hybrid 8 special effects generator. Marconi Instruments TF 1066/6 FM signal generator. 301-464-8513. Call collect. Ask for Fred.

Fluke series 10 multimeter; model #11 or #12; 7705 capacitance meter. George Demaris, 7387 Pershing Ave., Orlando, FL 32822, 407-277-3746.

Curtis Mathes TV console Model #G611R with cabinet only for parts. 135-North A St., Oxnard, CA 93030.

Tripler and focus tap ECX-B, 0085C for Seville model 661C and capstan motor RCA 150538 for model VGA 170. McHenry, 602-249-2325, 6225 N. 20th La., Phoenix, AZ 85015.

Schematic for Symphonic VCR model 4500. FCC ID ADT9V5VCR-4000. Also, JC Penny AM/FM stereo model 683-1962, code no. C309. Buy or borrow. Arthur Hill, 2616 Lincoln, St. E., Canton, OH 44707.

Need service information or schematic for Supra SV-45 VCP. Ron Kearney, P.O. Box 10, Dorris, CA 96023. 916-397-4233.

B&K 470 CRT checker adaptor socket #CR-42: source for all VCR RF modulators by VCR model number. Ed Herbert, 410 N. Third St., Minersville, PA 17954.

Power transformer for Fisher integrated amp model number CA871. Transformer number IS 4-2512-24900 with three secondaries. John Senchok, PO Box 427, Seymour, CT 06483.

Schematics or copies for Emerson VCR-755, Fisher FUH-4000 and Magnavox VR-9512 AT01. Will pay reasonable cost. Jerry Wilson, 290 Mellridge Rd., Edmonton, KY 42129, 502-565-1615.

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2445 Tektronix scope, calibrated/certified 3/93. $2000.00 or best offer. Marv, 603-878-1150.

Sencore VA 48 analyzer. Just back from factory calibration—perfect. With all cables and manuals. $500.00. Gateway Service, 919-246-5266 days, 919-246-2260 nights.

Sencore equipment, great shape SG165 stereo analyzer used once . Much more. Best offer. Send SASE (legal size) to Fred Ingersoll, 6845 Lathers, Garden City, MI 48135.

TV shop manuals, Riders, Sams Photofacts and auto radio series and equipment..Jay's Radio & TV Service, 15 West Lake St., Chisholm, MN 55719.

Sams and Manufacturers' data: VCR, video cameras, camcorders, TV, projection TV, organs, stereo, CB. A.G. Tannenbaum, PO Box 110, E. Rockaway, NY 11518, 516-887-0057 or Fax 516-599-6523.

Sencore SC61 waveform analyzer, $1700.00, CR70 beam builder, $650.00, DVM56 microranger, $250.00. All in excellent condition, includes probes, manuals and schematics. 605-333-4852.

Sencore VCR analyzer VC93, VA62A generator/ analyzer, PR-57 isolation transformer/variable AC/ safety leakage tester, CR70 pic tube analyzer/rejuvenator. All cables, HV probes, Sencore test tapes, manuals included. Balance of loan $151.00/month for approx. 3 1/4 years. Subject to bank approval. Equipment is new and in mint condition. 717-458-6734.

New training tapes. Minor VCR repair I & II, minor camcorder repair, and top ten VCR electronic problems. $25.00 each or $90.00 all four. Call 412-832-3718.

Text books, service manuals, parts, tubes-90% off list price. Send two 29¢ stamps. M. Seligsohn, 1455-55th St., Brooklyn, NY 11219.

B&K 510 transistor tester, $110.00, B&K 820 capacitor tester. $110.00, and Leader dot generator, $38.00. Boulevard TV & VCR Service, 1431 Robinson Ave., Havertown, PA 19083, 215-446-4519.

B&K 510 transistor checker (used), $149.00, a Viz 504 B/408 sine/sq/ wave audio generator (new), $190.00. John's Repair Svc., 142 Jackson St., Philadelphia, PA 19148, 215-389-1147.

Tektronix, TDS420 oscilloscope. Excellent condition, like new, $6500.00. Financing available, 702-435-3201.

Sencore equipment—SM152 sweep generator, $150.00, PS29 scope $200.00, MU150 tube tester, $130.00, UPS164 power supply, $100.00, plus lots more. Contact for full item listing. Asking $699.00 for all or make offer, plus shipping. Al Nikora Sr., 5298 Argyle Ct., Sterling Hgts., MI 48310, 313-268-6938.

Sencore PA 81 w/field battery and SG80. Both complete with all accessories and covers. Hardly used 2 1/2 yrs. old. $3800.00 for both. Coastal TV Service, PO Box 352259, Palm Coast, FL 32135-2259, 904-437-4450.

Sencore SC-3080 waveform analyzer, 80MHz usable to 100MHz, six months old, EC, $2500.00. Call Kent at 314-845-0010 days.

Sencore VC93, $2200.00, Sencore VA62A, $2100.00, Tentel gauges (complete set). $1200.00; all used less than six months with original cartons, probes and documentation. Gary, Seattle, WA, 206-932-1384.

Diehl Mark V horizontal output circuit tester, excellent condition, make offer. Call John, 616-363-2142.

Sencore SC61, $1495.00; VA62 and VC63, $1495.00; LC53 and SCR224, $595.00; PR57, $250.00; all for $3500.00. All used less than 10 hrs. and original cartons and manuals. Ken goetsch, 12698 Shorewood Dr.,S.W., Seattle, WA 98146, 206-241-0507.

Sylvania Panels—$300.00 for all: 1 piece each of 02-37501-2, 02-37502-5, 02-39198-2, 02-39220-13, 02-39942-1, 02-41656-1, 02-41749-1, 02-43972-1, 02-45021-1, 02-45263-1, 02-45713-1, 2 pieces each of 02-45716-1 and 02-39988-1. Panels are either new or rebuilt and in boxes. Will pay shipping within the lower 48. Koleske TV, 1606 N. Edgewood Ave., Appleton, WI 54914, 414-734-5340.

Sencore SC60, $700.00. Sencore VA48, $500.00. Recalibrated & updated. Sencore CG25, $75.00. Variac, $75.00. Call 215-486-0227.

Old tubes at reasonable prices. Send your want list or request a list that will be available later. Bob Holladay, 5 East Plaza, Paris, TX 75460.

Sencore VC93 VCR analyzer, $2500.00, never used. Sencore VA62A video analyzer, $2500.00, like new. Original packaging and instructions, both for $4500.00. Call Bill, 818-443-1080.

Sencore CR-70 "CRT beam builder" like new in box $600.00, Leader LD-170 distortion analyzer, no books like new $350.00 leader LSG 231 stereo generator, $300.00 mint with books. Will trade for catalin radios, Emerson, Motorola, Addision, etc. Dan, Bob's Radio and Television, 2300 Broad St., San Luis Obispo, CA 93401, 805-543-2946.

Sencore VC93 all format VCR analyzer. Like new, purchased Jan. 1992. Includes all connectors/cables and manuals., $2100.00 or best offer. C 'n U video (ask for Andy), 703-755-4989 after 4 pm.

Generator time mark, Tek. type 180A, $60.00, Monitor medical test unit, Tek. type 67-7, model 6-99, $75.00 Photrometer, Rouy, model LCZ, $25.00. Harry Werner, 1615 Gowans Rd., Angola, NY 14006. Call 716-549-5428.

AVCOM PSA-35 portable 4GHz spectrum analyzer. Internal rechargeable battery and 18V LNB supply. Includes carrying case/strap, instruction manual and videotape. Made for satellite system field work. $1500.00. Keith Conroy, 10310 Woods Rd., Utica, NY 13502., 315-735-1554.

Selling out—$4500.00 takes all Sencore VA62, VC63, NT64, SC61, LC53, CR70, plus much more—Tentel, B&K, Leader, RCA, Bell & Howell, 3M, Sams, Books . . . N.O., LA. 504-652-5831.

VCR parts (used) upper and lower video head drums for, Sears 934-53510650, Funai FLC-1100, Samsung VR2640, Magnavox VR9720AT01, and Lloyds 838. Also, some cassette housings, transformers and loading motor's, for above VCRs. Call Jackson VCR, 205-643-5906.

TF46, SC61, VA62, VC93, LC102, SCR250, PR57, CR70, Little Huey, NT64, Ex.231, $8500.00 Firm. Ed Grocott, 24E Tehama St., Orland, CA 95963, 916-865-5027.

Microfiche viewer (14 in.), screen. Hi-Lolens/lamp. Quality unit topper Co. 20 Lbs. $40.0C. DMT, PO Box 9064, Newark, NJ 07104.

TV/VCR repair shop. VA62, NT64, VC63, BH2160, HP6215A, SM152, BK1249A, BK310B, everything goes—manuals, parts. Great deal at $7000.00. NH 603-764-5214.

Manufacturers Parts and Literature Directory

This monthly section is sponsored by manufacturers to help you find the parts and technical literature needed to service their equipment. Call them for replacement parts or for the name of their nearest distributor.

Hitachi Home Electronics **401 W. Artesia Blvd.** **Compton, CA 90220** **800-HITACHI**	**Mitusubishi Electronics America** **5757 Plaza Drive** **Cypress, CA 90630** **800-553-7278 fax 800-825-6655**	**NEC Tehcnologies** **1255 Michael Drive** **Wood Dale, IL 60191** **800-366-3632**
Panasonic **50 Meadowlands Parkway** **Secaucus, NJ 07094** **800 545-2672**	**Philips ECG** **1025 Westminister Drive** **Williamsport, PA 17701** **800-526-9354 fax 800-346-6621**	**Quasar** **50 Meadowlands Parkway** **Secaucus, NJ 07094** **800-545-2672**
Technics **50 Meadowlands Parkway** **Secaucus, NJ 07094** **800-545-2672**	**Thomson Consumer Electronics** **2000 Clements Bridge Road** **Deptford, NJ 08096** **800-257-7946 fax 800-524-1498**	**Zenith Electronics Corp.** **1900 N. Austin Avenue** **Chicago, IL 60634** **312-745-2000**

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FOR SALE

THE DOG CATCHER 2.0 is a repair tips program. See our ad on page 41.

REMEMBER, It's not the quantity of TIPS but the Quality of Solutions that makes the difference. Our 10,000 TECH-TIPS cover VCR-VCP-TV/VCR Combo CD/LD-FAX-Camcorder/VHS/SVH/C/8MM/ Camera-Stereo TV Monitors/TV/Computer-Rear/ Overhead Projection Amplifiers-Microwave-Satellite. Our program is actual day to day repairs, written by technicians for technicians. No need for you to spend time updating your data base or paper binders. We send you a complete revised program at each update of your choice (computer or paper format). Outside technicians & students love the portability and say it is a must for the field where time is very critical. As an added extra, we provide you with an FCC ID Cross reference list which saves the expense of purchasing service manuals you may already have and just don't know it. Also, when you join our ongoing program we will send you a key to streamlining your company into profitability overnight! (We actually did it!) **CALL NOW (305) 474-2677 FOR A "FREE" DEMONSTRATION DISK OR PAPER FORMAT** or mail request to **TV-MAN SALES & SERVICE, 8614 SR-84, Ft. Lauderdale, FL 33324.**

SENCORE test equipment for sale. DVM-56-A - $500, SC-61 - $2,000, FC-71 - $800, PA81 - $1,200, Call Al, 512-272-5124

VCR AND TV SERVICERS ** Make those hard repair jobs easy with our up to date symcure information **1800 item VCR symcure file and 1200 item TV tough dog symcure file available on IBM compatible disk and print out. VCR disk w/po $85.00 print out only $45.00. TV/dog, disk w/po $85.00 print out only $45.00. VCR Tune Up Center, 2610 Bay Road, Redwood City, CA 94063. 1-800-777-7883

****** **The TIP Computer Program** ******
The **BEST** technical tip database program on the market today. **One of the largest tip databases in the country — over 12,000 tips!!!** Used by National Association members & officers. HIGHER INTELLIGENCE SOFTWARE, 60 Farmington Lane, Melville, NY 11747 (516) 643-7740

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CABLE TV DESCRAMBLERS/CONVERTERS Wholesale Outlet. All major brands. Money back guarantee. 1 year warranty. **THE CABLE CONNECTION 800-764-5400. DEALERS WANTED.**

VHS-VCR Repair Solution Sets I, II, III IV, V, VI, VII, VIII. Each contains 150 symptoms and cures, updated cross reference chart, free assistance, $11.95 each, all eight $79.95. Schematics available. Visa/MC. Eagle Electronics, 52053 Locks Lane, Granger, IN 46530.

COMPUTER AIDED TV/VCR REPAIR SOLUTIONS: 5 1/4" IBM compatible disks, 1,000 VCR, Printout $83, Disks $72. 5,400 TV, Printout $135, Disks $113 (Harddrive). Add to or quick scan by chassis, model and stage. Two solutions pays for it. Electronic Solutions, 407 W. Ave. "N", San Angelo, TX 76903.

TV–VCR SHOPS: Now fix those tough dogs! A program of over 2800 fixes on disk. One fix could pay for all. Only $99.95. TECH-DAT, 212 Earth Row, Waynesville, MO 65583. To order call 1-800-280-2100. VISA & Mastercard Accepted.

Tech ReSource: National database lists hundreds of Distributors By Manufacturer. **FIND THOSE ELUSIVE PARTS!** IBM Compatible, w/hardrive. $24.95 ppd, 3.25/5.5. Mike Humphrey CET, PO Box 1414, Noblesville, IN 46060

SENCORE FS-74 field strength mtr. w/TV monitor - $2,000, Sadelco digital field strength mtr. model #200 all bands - $400. R.C. Electronics, Inc. 508-477-0771

TV CASE HISTORIES: Booklet with 1,750+ histories. Satisfaction assured. Only $35 (first-class shipping add $1.50). Mikes Repair Service, P.O. Box 217, Aberdeen Proving Ground, MD 21005. Same mailing address 29 years. Send SASE for samples.

SENCORE: VA-62–$1,450, SC-61–$1,400, CR-70–$700, LC-76–$600, VA-48–$450. All like new with original manuals, leads and boxes. 908-725-1200.

TEST EQUIPMENT SALES has what you are looking for, Quality Equipment at low prices! Scopes, meters, counters, Sencore PR57's and more. Call now (603) 434-2544 or write, Test Equipment Sales, PO Box 986, Londonderry, NH 03053.

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40 YEAR OLD ELECTRONIC SERVICE COMPANY FOR SALE. 6 Bench Techs - 2 outside service vehicles. C.O.D. (no warranty or sales). Building Included 7500 sq ft., Land 27,000 sq ft. prime corner location. Miami Florida over 1 mil, 1-305-220-3106. Spanish Helpful.

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MUST SELL, RETIRING. Small growing shop established 1984. VCR, Camcorders, photo equipment. Potential for more. Lets negotiate. Call Rich 304-269-7850.

ELECTRONICS BUSINESS & BUILDING FOR SALE: 3,700 sq. feet building. Can be divided for potential rental income. Large garage. 15 years same location. Full equipped, huge parts inventory. Serious buyers only. $275,000. Ft. Lauderdale, Florida. 305-763-1234.

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