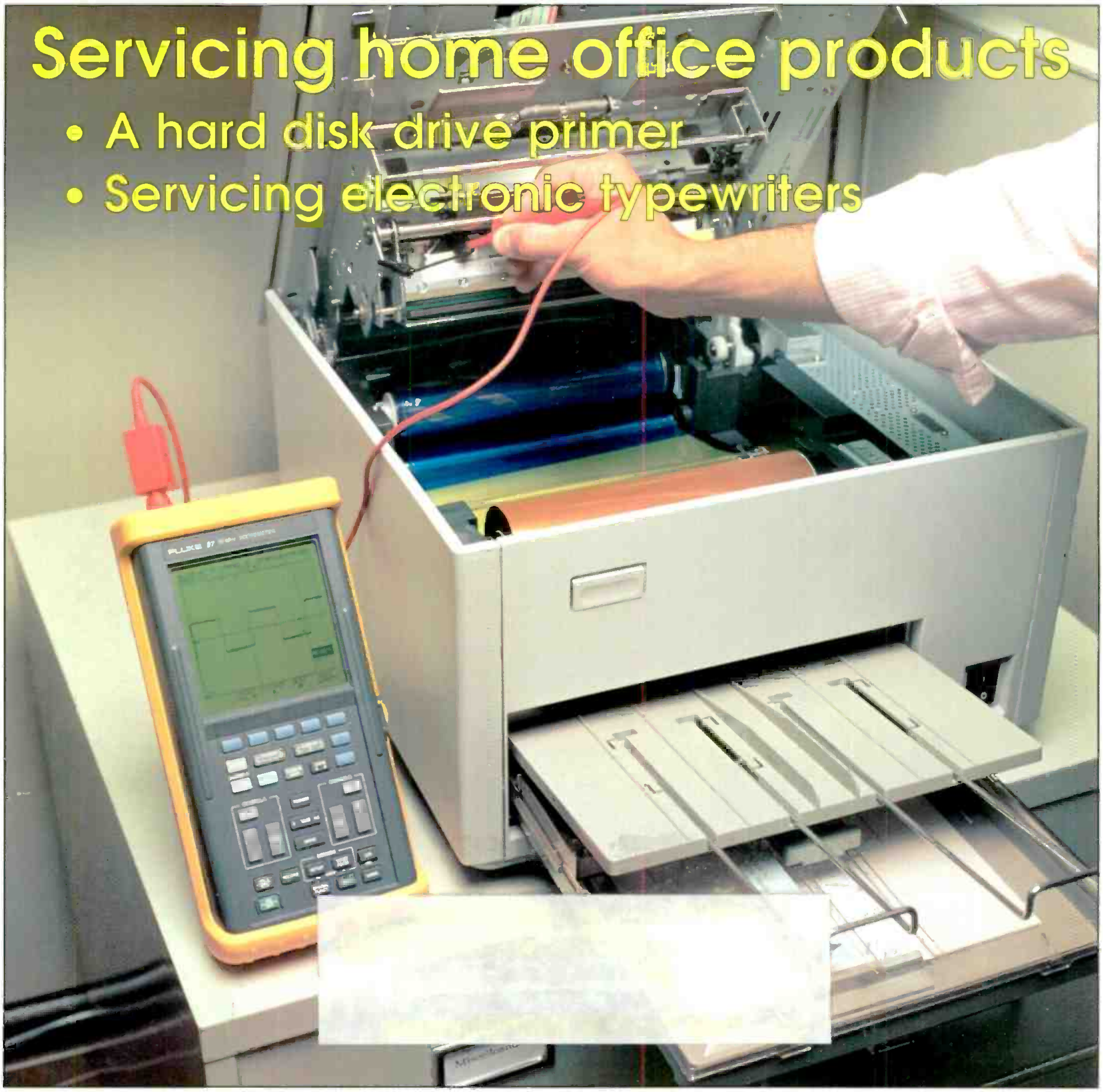
THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

July 1994/$3.00

NTSC Part I: Sync signals and timing

Troubleshooting the CD laser head assembly



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- A hard disk drive primer
- Servicing electronic typewriters

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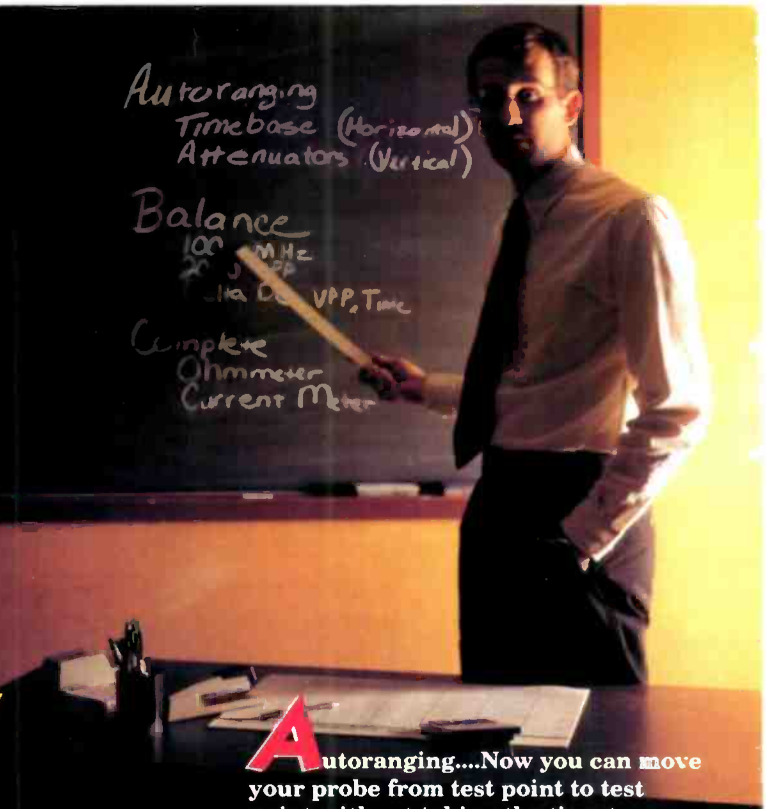

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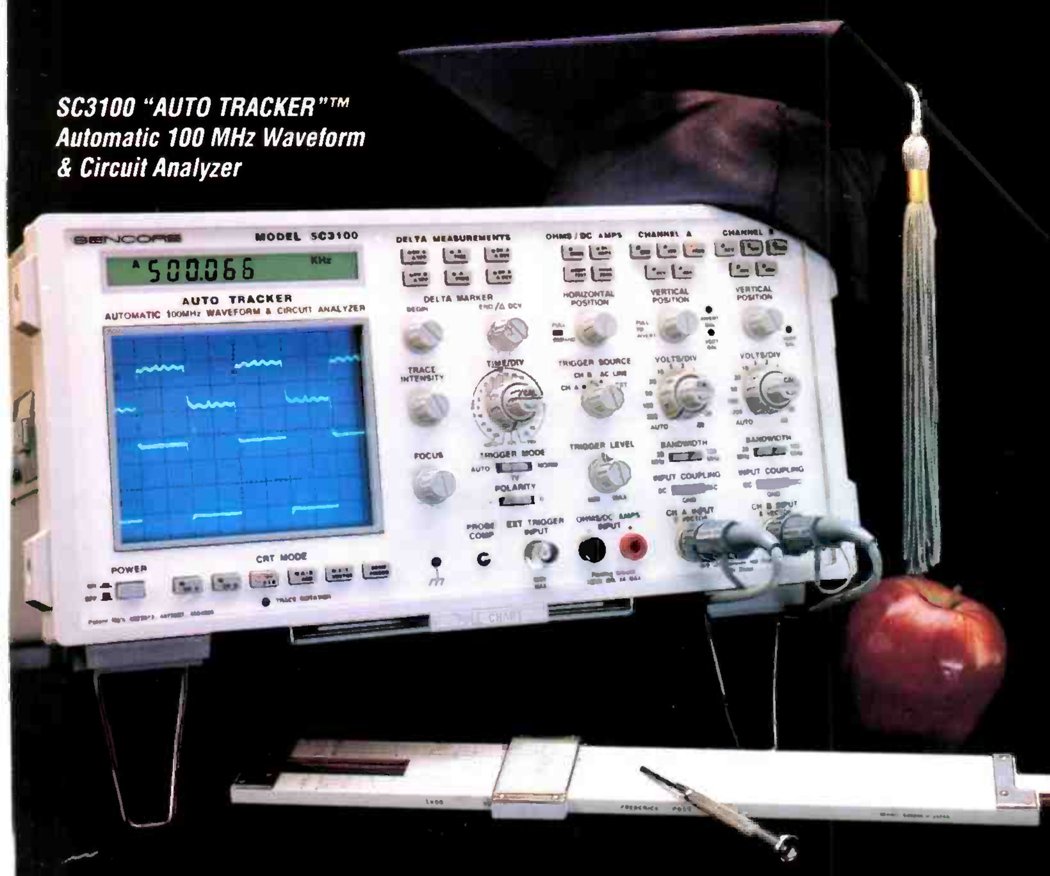

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Printed in the U.S.A.

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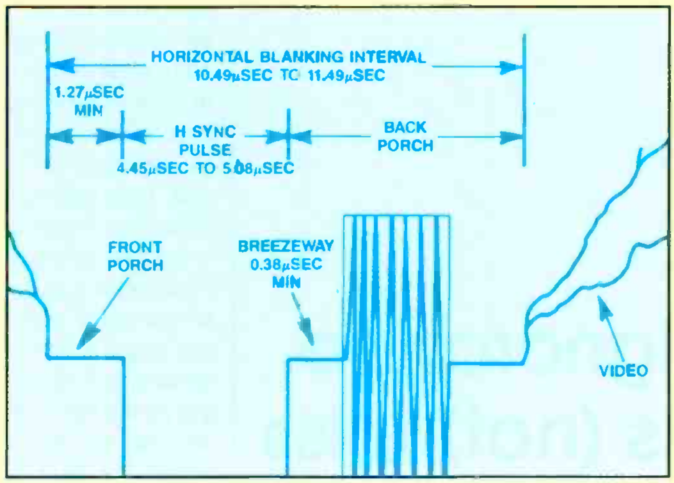

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ON THE COVER

News stories recently reported that in 1994 more people bought PCs for their homes than for business. Add the number of fax machines, copiers and other office products bought for home use and that represents a sizable base in residences that will eventually require service. (photo courtesy of Fluke)

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

Editorial

Ignorance is (not) bliss

Sam Wilson called me a few weeks back. It seems that he has received a couple of hundred requests for the capacitor color code listing that he offered to send to readers who requested one. Sam was a little bit surprised and overwhelmed by the numbers who requested that information. I was surprised too, but after a little reflection, it no longer seemed odd.

For one thing, it occurred to me that electronics is an abstruse area of study in which many subjects are hidden in varying degrees from its practitioners. We speak easily of electrons and electronics, yet no one has ever seen an electron, nor will anyone ever see an electron. Most accept on faith the explanations conceived by the brilliant minds of electronics science and imparted to us by teachers, confirmed to some extent by our own observations, and then go on.

Unfortunately, the disciplines of electronics, electronic engineering, electronics technology and all the related fields are very broad, very deep, and densely populated with concepts that are difficult to grasp and that are just not discussed in everyday conversation.

So what we have to deal with in electronics are difficult to understand concepts developed by brilliant minds that operate on a whole other level than the minds of ordinary mortals, passed down and filtered through the imperfect intelligences of professors and instructors, into our own less than perfect minds.

To make the situation still worse, there isn't time in any course of study to include everything, so teachers pass on an incomplete as well as imperfect body of knowledge to the students. What areas they emphasize and which areas they shortchange depends on what areas the instructor is most competent in, what areas they are most interested in, and what types of questions the students ask.

But that's only the start of the problem. Manufacturers and the engineers who work for them contribute to the problem. It is not their intention to do so, it just sometimes works out that way.

For example, where do they come up with their systems of identification of components? In the case of standard carbon composition resistors, identification is not bad. The resistors are marked with colors and each color stands for a number. Every technician learns the color code in his first year of technical school.

Generic discrete semiconductor designations also make sense, for the most part; 1N designates a diode, 2N designates a transistor.

Even some capacitor codes make sense, if you know how to interpret them. The problem is, some of the capacitor codes are familiar to us, but some capacitor value codes, either necessarily because of the small size of the capacitor, or used because the capacitor was manufactured for a use other than in electronics, leave the average technician high and dry.

In my conversation with Sam, he mentioned two examples of this. You may have occasionally run across a small capacitor that has a number on it. The first two digits designate the value of the component, and the third number indicates the number of zeros to add at the right hand side of the number. Then, because all of the capacitors so marked are in picofarads, you multiply by 10^{-2}.

For example, a capacitor marked 103 has a value of 10 followed by three zeros, or 10,000 picofarads, or 10,000 x 10^{-12}; or 10 x 10^{3} x 10^{-12}; or 10 x 10^{-9}; or 0.001µF.

And here's one that really might throw you for a loop. You'll occasionally find a fairly large capacitor, with the letter M in its value. That M doesn't indicate million, or mega, as electronics technicians are familiar with. In this case, the capacitor was installed in some kind of product ordinarily associated with a manufacturing plant; say a motor-start capacitor. Those folks are accustomed to using the letter M to designate thousands, that is the Roman numeral M.

The only way to be able to access all of this information is to pay close attention any time you're in a structured class, hoard any materials that you ever get your hands on that pertains to product identification, and constantly seek out this type of information when you run across any kind of component that you're not familiar with. Good luck.

And, by the way, if you ever run across a piece of information that puzzles you, write to me, or to Sam, or one of our other authors, in care of **ES&T**, and we'll try to find an answer and pass it along to you and to all of our other readers.

Nils Conrad Persson

Small appliance certification test

Technicians who want to order the open-book, mail-in test to be certified to work on small appliances (Type I technicians) can now do so by calling 1-800-394-TEST (8378). Tests cost $22 each and can be ordered with a VISA or MasterCard by calling the 800 number. It is answered 24-hours a day, 7 days a week.

Technicians and companies who wish to order by check should mail their payment of $22 per test to: NARDA CFC Test, Suite 310, 10 East 22nd Street, Lombard, IL 60148. Those with questions about the test or procedures may call the test administrator at 1-708-953-8956.

This is the test developed by an alliance of the Association of Home Appliance Manufacturers (AHAM) and the North American Retail Dealers Association (NARDA) and approved by the Environmental Protection Agency (EPA). The test package includes a 50-page comprehensive study manual, a 50-question test booklet, and test answer form. The self-study manual is designed to provide technicians with all of the information about refrigerant recovery and the impact of refrigerants on the environment, which they need in order to pass the certification exam. Technicians are able to study the booklet, answer the 50 test questions at their convenience and mail back their question and answer forms.

EPA requires that technicians answer 21 out of 25 (84%) questions correctly on each of the two sections of the test in order to be certified. Twenty-five questions in one section are on general ozone depletion, refrigeration topics and EPA regulatory requirements. The other 25 questions are Type I specific questions about leak detection, recovery techniques, safety, shipping and disposal.

Those who pass the test will get a certificate and wallet card indicating that they are certified to recover refrigerant from small appliances. Retests will be available for those who do not pass.

All technicians who service small appliances must be certified by November 14, 1994. Small Appliances, as defined by EPA regulations, are any of the following products that are fully manufactured, charged and hermetically sealed at the factory with five pounds or less of refrigerants: refrigerators and freezers designed for home use, room air conditioners including window air conditioners and packaged terminal air conditioners, packaged terminal heat pumps, dehumidifiers, under the counter icemakers, vending machines and drinking water coolers.

Sales of large screen TV and video products increase

The video market exhibited signs of gathering momentum in February as sales of color televisions 25-inches and over, TV/VCR combinations, projection TVs, VCR decks, and camcorders rose in the month, according to statistics released by the Electronic Industries Association's Consumer Electronics Group (EIA/CEG).

Big ticket items performed especially well in February. Strong increases were registered by both large screen direct-view and rear projection televisions, perhaps reflecting retailer confidence in consumer attitudes toward home theater. Replacement and upgrade sales of VCRs, continue to be made—witness the double-digit gain in sales of hi-fi stereo models.

"Since the color TV business is a replacement market, it is natural that consumers are upgrading to bigger screen televisions," says Jim Palumbo, Senior Vice President Sony Consumer Television Products Company. "They are recognizing that a big screen television is the centerpiece of a home entertainment system and family environment, and this is an ideal way to make movies, sports and music videos come to life. The continued growth in big-screen televisions reinforces consumer acceptance of the home entertainment concept and reflects changing lifestyles."

Sales of color televisions 25-inches and over rose 16 percent in February over the same period last year, helping to offset a 21 percent decrease in combined sales of 20-inch and 13-inch and under screen sizes. Overall, unit shipments of direct-view color televisions were basically flat in February.

Projection television sales rose at the fastest rate in more than two years, as all screen size categories tracked posted gains of more than 20 percent. Total sales of projection sets were up 44 percent in February, more than tripling January's 14 percent increase. The bigger the screen size, the better the sales were in February, as evidenced by the 127 percent increase realized by models 55-inches and over.

TV/VCR combination units logged another solid month in February, rising 35 percent. Growth was evenly distributed between the 13-inch and under, and 13-inch and over categories. Total sales are up 42 percent in the year-to-date.

VCR deck sales posted a three percent gain in February, rebounding from a 10 percent decline in January. Sales totaled 1.6 million in the first two months of this year. Hi-fi stereo models were especially strong in February, rising 24 percent. Hi-fi stereo units accounted for over 40 percent of total VCR volume in the month, up from the same period last year when hi-fi stereo models accounted for about 31 percent in total volume.

Camcorder sales rose two percent in February, adding to the six percent gain in the year-to-date category. Compact models rose seven percent in the month, offsetting an eight percent decline in sales of full-size units. The drop in sales of full-size units, however, was only the second in the last year.

Second annual Servicer Excellence Awards

Nintendo of America Inc. has chosen six World Class Service Centers as recipients of the 1993 Service Excellence Awards. The service centers demonstrated dedication and superior support to Nintendo and consumers in providing after-the-sale customer service support.

The winning service companies are:

National Winner—Falcon Electronics, Colorado Springs, CO

Northeastern Region—Doctor Video, Christiansburg, VA & United Radio, Inc., Syracuse, NY

Central Region—Appliance & Audio Repair, St. Charles, MO

Southeastern Region—Bayard Electronics, Dallas, TX

Western Region—Falcon Electronics, Denver, CO

Nintendo maintains a nationwide network of nearly 3,000 Field Customer Service Centers to provide consumers with product maintenance and repair, replacement components, and spare parts. Established in 1990 by Nintendo's National Field Service department, the network has grown considerably with locations across the U.S. and Canada.

Winners were evaluated quarterly on their quality of service, turn-around time of repairs, customer satisfaction levels, and outstanding marketing efforts throughout 1993.

The National Grand Prize winner is awarded four round-trip airline tickets to anywhere in the continental U.S. All winners receive an expense-paid four-day weekend for two to an awards presentation and gala banquet in their honor to be held March 25-28 in the Seattle, WA area.

"This is a way of recognizing our Independent Authorized Servicers who provide outstanding support to our consumers. More than one out of every three homes in America has a Nintendo system today," said Jim Rushton, director, National Field Service. "Nintendo consumers can rely on quality support every step of the way. That means excellent service, even after the product sale."

EIA announces free "hands-on" technical workshops

The Electronic Industries Association (EIA) offers several courses in VCR, digital/microprocessor applications, PC servicing and video laser disc servicing, covering theory and hands-on training. All workshops, except video laser are five days, 40 hours with an enrollment of 20 people; video laser disc is a three-day session. These courses will be presented in cities throughout the United States, during the current year.

Technician programs are co-sponsored by local chapters of the National Electronic Service Dealers Association and the International Society of Certified Electronics Technicians (NESDA/ISCET). Five-day workshops for electronics instructors in vocational education are co-sponsored by state departments of vocational education and local teaching institutions.

The workshops are provided at no cost to the attendee by EIA. Anyone interested in attending should contact EIA at 2001 Pennsylvania Avenue, NW, Washington, DC 20006; 202-457-4986.

EIA offers free resident workshops

The Electronic Industries Association (EIA) offers workshops on color television and VCR servicing throughout the year at five locations. These workshops are open to consumer electronics technicians and educators. While covering basic principles and practical troubleshooting on modern equipment, the courses are particularly suited for technicians who wish to be updated on their basic theory and troubleshooting abilities.

Considering the high quality and timeliness of these programs and the materials the attendees retain, EIA believes that the practical nature of these workshops will provide the attendees with new skills of immediate benefit.

These courses have an estimated $500.00 value, but EIA/CEG offers them free to qualified technicians. Attendees must provide their own transportation and lodgings while at the workshops.

For more information write to: EIA/CEG Product Services, Department 287, Washington, DC 20005. You can call at 202-457-4986 or Fax 202-457-4901.

Fiber optic installers conference expands, moves to CA

The next fiber optic (FO) Installers Conference, now called "Fiber U," will be held July 25-28, 1994 at the Sheraton Long Beach, CA.

To help the beginner, the conference has added a "novice course," with comprehensive training in the basics as well as an introduction to splicing, terminating, pulling and testing cables.

For those familiar with the basics, also available will be new courses on telecom, LAN, military FO and CATV networks. Of course, everyone can meet all the vendors and get hands-on training on the latest fiber optic components. They're planning to build and test a full indoor/outdoor fiber optic cable plant during the conference as part of the workshops.

The cost of Fiber U is $500.00.

The conference is oriented to anyone interested in learning more about the practical aspects of designing, installing and maintaining fiber optic networks. This includes:

- Electrical contractors
- Fiber contractors
- Users of fiber optic networks
- Systems integrators and VARs
- CATV and telecom planners, installers and maintenance personnel
- Military personnel

With the "novice track" and all the seminars and workshops, "Fiber U" can accommodate all levels and still provide an intensive learning experience.

For more information, contact Fotec, Inc., 529 Main St., Boston, MA 02129. You can also call 800-537-8254 or Fax 617-241-8616. ■

LOCATION	COLOR TELEVISION	VCR
EIA HQ, DC	JULY 13-15	SEPTEMBER 12-16
TRITON COMM COLL RIVER GROVE, IL		JULY 18-22 OCTOBER 17-21
TAMPA TECHNICAL INST. TAMPA, FL	OCTOBER 18-20	
NEC DALLAS CAMPUS DALLAS, TX	OCTOBER 18-20	
NEC COMMERCE CAMPUS COMMERCE, CA		OCTOBER 24-28

Dates and locations of free EIA "hands–on" workshops.

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 $24.75, two years $45. Foreign countries—one year $30.75, two years $57. 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, MicroComputer Journal, CQ Radio Amateur (Spanish CQ), CQ Amateur Radio Equipment Buyer's Guide, CQ Amateur Radio Beginner's Buyer's Guide, Popular Communications Communications Guide, and Electronic Servicing & Technology.

Literature

Computer products/services data sheets

Eagan Technical Services offers a collection of data sheets that describes the products and services they offer to users as well as servicers of personal computers. This is an international depot repair and parts company.

The brochure describes the repair services they offer for PS/2, Compaq, Dell and Grid system boards, LCD and plasma displays, and mechanical assembly repair and refurbishing.

Products offered by the company, as described in the brochure, are the TK-1000 and TK-2000 diagnostic systems for IBM PS/2 and Microchannel compatible computers, schematic diagrams of personal computers and monitors, system board sales and exchange, proprietary electronics components, and disposable and maintenance items for computer service.

Circle (15) on Reply Card

Computer replacement parts brochure

PartsPort, Ltd., announces the availability of its brochure of Hard-to-Find Computer Repair Parts. This four-page brochure lists many of the products offered by the company, including monitor flyback transformers, IBM proprietary ICs, and a selection of other semiconductor devices.

In addition to stocking a broad selection of computer and peripheral components, the company offers assistance in finding or reproducing parts.

According to the brochure, "We can machine or mold replacement parts for ATMs, laser printers, check sorters, banking equipment, telecommunications products and obsolete equipment. Send us a sample piece for evaluation.

Circle (16) on Reply Card

Test accessories catalog

ITT Pomona Electronics' new 36-page, full-color, New Product Test Accessories Catalog introduces over 100 new products, including Logic Analyzer Test Accessories, IEC1010-Safe Probes and Banana Jacks.

Among the products highlighted are a new logic scope probe, insulated scope probes, oscilloscope probes and DMM test lead kits, IEC1010 probe leads, fused probe kits, grabbers, cable assemblies and

adapters. Also featured are test clips and adapters for the latest IC devices, including the MC68360, 80486SLE, MC68HC-11 and other devices emerging in the marketplace. Other new products that are featured include boxes, test strips and laboratory power supplies.

Circle (17) on Reply Card

Test and measurement instrument guide

Herman H. Sticht Company has issued their new 1994 purchasing guide. The guide contains 96 pages with information and specifications on Sticht's complete line of hand and stationary tachometers, frequency meters, running time meters, insulation testers, stroboscopes, controllers, static eliminators and more. In addition, the catalog presents information on multimeters and test instruments by leading manufacturers worldwide.

Circle (18) on Reply Card

Servicing electronic typewriters

By Dale C. Shackelford

Until recently, typewriter repair was a specialty practiced only by trained service representatives who would drop by the office at the most inopportune moment to make the repair, or to cart off the machine for a week to perform the repairs.

Today, most electronic typewriters are lightweight, extremely portable and are a relatively inexpensive alternative to the multi-component computer. When an electronic typewriter breaks down, regardless of the cost of the unit, the owner will typically attempt to have the unit repaired. This is where the local electronic servicing technician can play a role.

Electronic, not electric

To begin, we must observe the distinction between an electric and an electronic typewriter. Electric units generally utilize an ac motor which powers a cam/gear system, that in turn drives the striking (print) mechanism against a ribbon, then onto the paper. The most common electric typewriters were manufactured by IBM, and were known as the Selectric series. These machines, in most cases, require servicing by a trained electric typewriter technician, as there can be literally thousands of rods, gears, pulleys and other moving parts which must be aligned with the utmost precision.

Electronic units, on the other hand, contain a minimum of moving parts, and rely primarily on traditional integrated circuitry to control various protocols such as print speed, memory and other basic functions. Electronic typewriters may contain RAM, ROM, PROM and EPROM circuitry, all of which require the unique repair skills of the electronics technician.

Many electronic typewriters, regardless of their capabilities, performance, price or manufacturer, exhibit many of the same symptoms of wear, neglect or abuse. In addition, virtually all electronic typewriters require similar procedures for repair and maintenance. With this in mind, we can look at some of the most common problems associated with these increasingly common electronic appliances.

Shackelford is an independent electronic servicing technician.

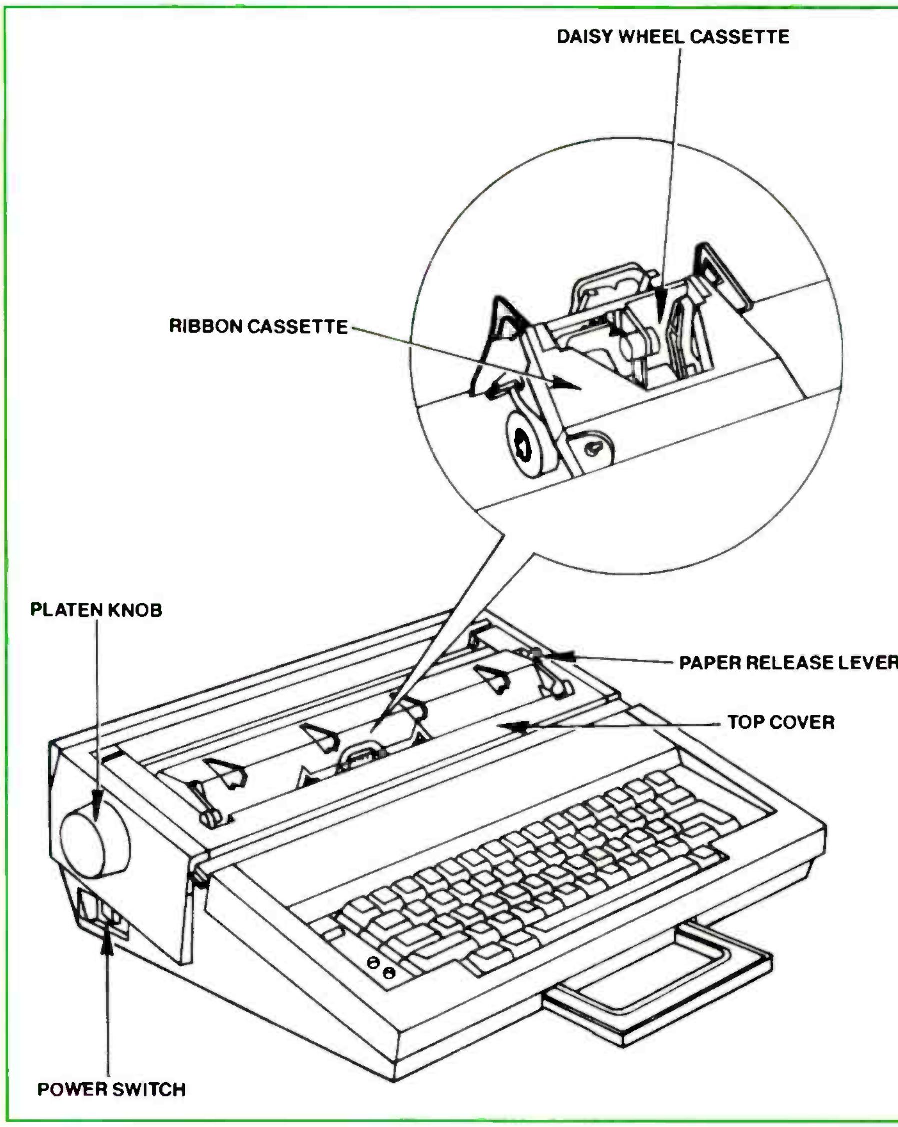
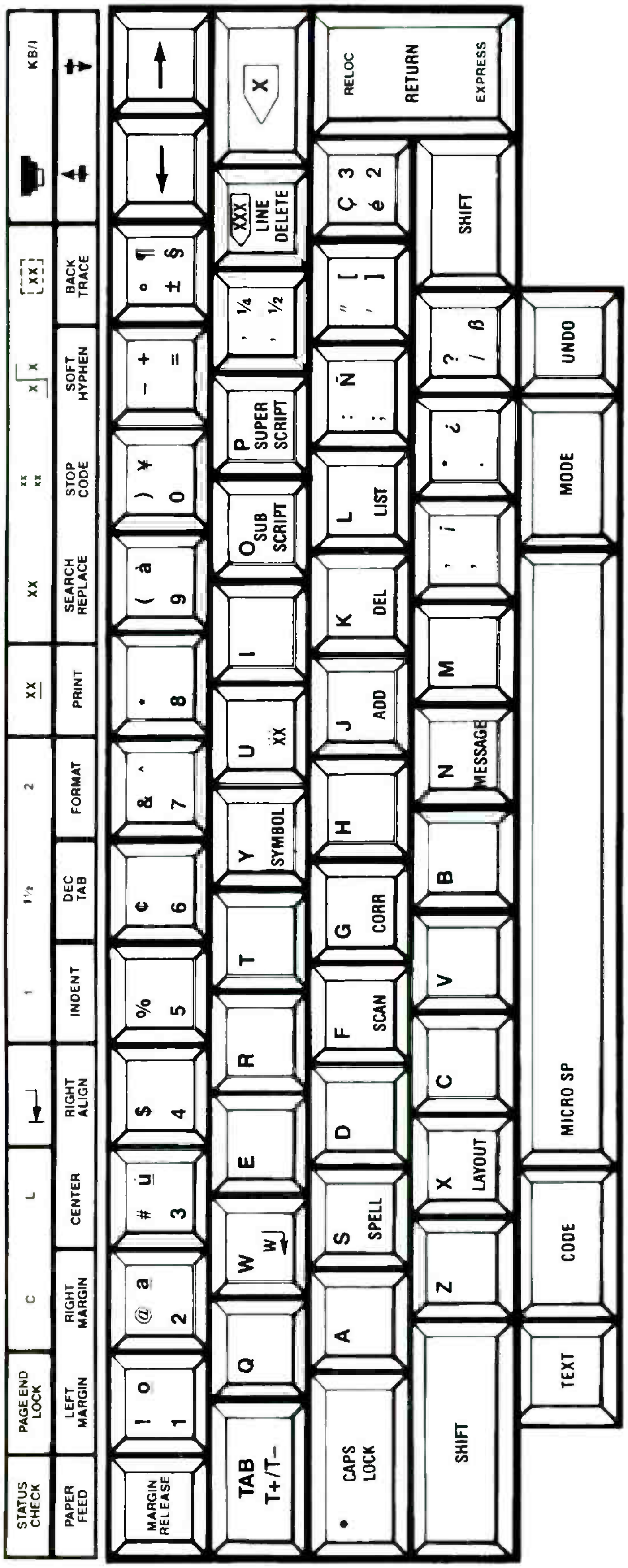


Figure 1.

Contaminated membrane

When depressing a particular key (or combination of keys) fails to result in a typed character, it is usually an indication that the unit has been exposed to moisture, dust or other contaminants which have found their way through the keys and between the conductive material on the bottom of the key and the contacts on the underlying sensor pad. These sensor pads, sometimes called membranes, are extremely delicate, and special attention to detail should be given in any attempt at cleaning them.

To determine if the problem lies with the connection of a particular key, or elsewhere within the system, try to activate the demonstration program found in most electronic typewriters. This program can usually be activated by depressing the CODE button, and pressing keys which do not indicate that they have a particular CODE function (Figure 1). In many cases, the combination of CODE/D will access this program, though this will vary



Note the CODE key at the bottom left. On this particular machine, the combination of CODE/D accesses the demonstration program.

Figure 2.

depending upon the make and model.

When activated, the demonstration program will print out a basic capabilities listing of the typewriter. If any of the characters are missing, or in the wrong order on the demo printout, the problem will likely be traced to one (or more) of the integrated circuits, not the keyboard. If the demo looks good, then the problem is most likely a contaminated membrane.

Correcting membrane problems

To repair a contaminated membrane, remove the keyboard and membrane from the typewriter chassis. If any of the contacts on the membrane or the keypad are shiny, they should be cleaned and dressed by lightly rubbing them with a clean swab and a cleaning chemical such as tape head cleaning solution. It would be best to check first to see what the manufacturer of the typewriter recommends. If the cleaning solution is too strong, or the contacts are rubbed too hard, the tracings will disappear, and the membrane will have to be replaced. Once all contaminated areas of the membrane have been cleaned sufficiently, contacts will be flat black in color.

Before reinstalling the membrane and keypad, it is a good idea to clean the contact points (usually a ribbon type connector) where the membrane connects to the printed circuit board. Once the membrane and keypad are reinstalled, you can check the operation without totally reassembling the unit if you bypass the safety interlocks that may be used on the machine.

Power supply problems

Another common malady suffered by portable electronic typewriters concerns the power supply, especially off-board transformers (power packs). While off-board power supplies do allow typewriters to be made smaller and lighter, these systems are very inefficient and create many problems for the consumer. Many problems can be traced to one of three points: the transformer, the small wires connecting the transformer to the typewriter or the receptacle/switch system.

As with most transformers, power pack units may be checked with a standard meter to determine power output, continuity of hookup wires and plug integrity. If sufficient power is reaching the typewriter, the problem is likely to be found in the receptacle/switch combination.

Power receptacle/switches (Figure 2)

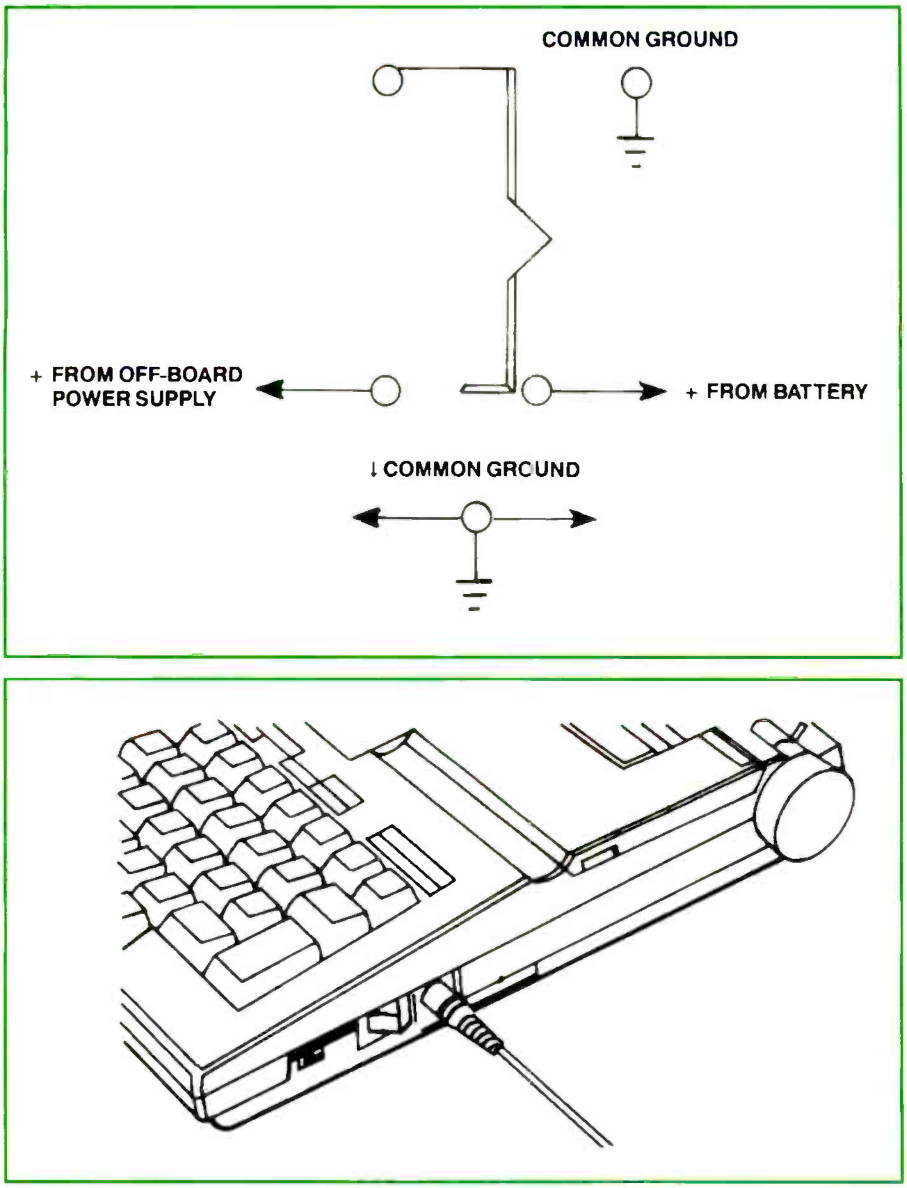


Figure 3.

are notorious for causing problems in a wide variety of appliances. Over time, the receptacle may become loose, causing broken connecting wires or solder connections. Play may develop in the receptacle so that the plug will not fit tightly into the socket (causing intermittent connections), or the spring/switch may become worn or broken, thereby allowing the unit to operate only from one power supply (batteries or off-board transformer). Simply replacing the power pack or the receptacle/switch combination should cure most of the power supply problems encountered with these devices.

Look for the obvious

Before beginning service on any electronic typewriter, be sure to check for the obvious. Is there a good ribbon in the machine? Is the ribbon the correct one for the typewriter? Is the daisy wheel (or other typing element, including dot matrix head) in good condition and properly positioned? Is the top cover closed? Many electronic typewriters utilize a safety interlock which will not allow the machine to operate if the cover is not secured. Are the batteries in good condition and properly installed? Is the voltage selection switch in the proper position? Any one (or more) of these basic observations could save hours of diagnosis time.

General maintenance

Some machines which may be brought in for service will require only general maintenance to make them operate like new. Some typewriters will inform the owner/technician of the maintenance required through a prompt or code on the LCD display (if applicable) while other machines will be brought in only after the owner detects a problem such as a grinding noise or deteriorating performance.

When a typewriter is accepted for maintenance, remove all accessories (ribbons, print wheels, etc.) and blow out the unit with dry, compressed air to remove any loose particles of contaminants. Short blasts of air should remove the typical contaminants such as correction paper/fluid residue, dust and hair, while a soft brush will aid in removing contaminants such as tape or dust bunnies which are often lodged in small gears.

Pinch rollers, paper carriages and feed systems can usually be cleaned with a special typewriter cleaning fluid, while some technicians have found tuner cleaner to work well in these applications when used sparingly. Once the internal workings have been cleaned, make sure to run a few sheets of paper through the system to absorb any pockets of moisture which may have collected. Small amounts of light weight (white) lithium grease can then be applied to the plastic gears, and carrier guides may be lubricated with powdered graphite, when used sparingly.

With the increased use of portable electronic typewriters both in business and in the home, many manufacturers of these products are looking to train service personnel, supply technical support and information to those interested in becoming authorized service representatives. If you feel that typewriter servicing would make a good sideline to your current practice, contact the manufacturer of these devices for more information. Three of the biggest names in portable electronic typewriters are listed below.

Brother International Corporation
Typewriter Division
P.O. Box 1332
Bartlett, TN 38184-1332

Canon U.S.A., Inc.
One Canon Plaza
Lake Success, NY 11042

Sharp Electronics Corp.
Sharp Plaza
Mahwah, NJ 07430

A hard disk drive primer

By John A. Ross

If you plan to service personal computers, you'll have to know about hard disk drives. Anyone who has worked with computer technology understands the importance of that storage device. You only need to lose data, or work with someone who has lost data because of a hard disk drive failure, to fully realize just how important hard disk drives are.

In light of that importance, this article describes the components of a hard disk drive, details the different types of drives, provides some basic information about installing different drives, and lists several excellent reference sources that cover hard disk drives and their interfaces.

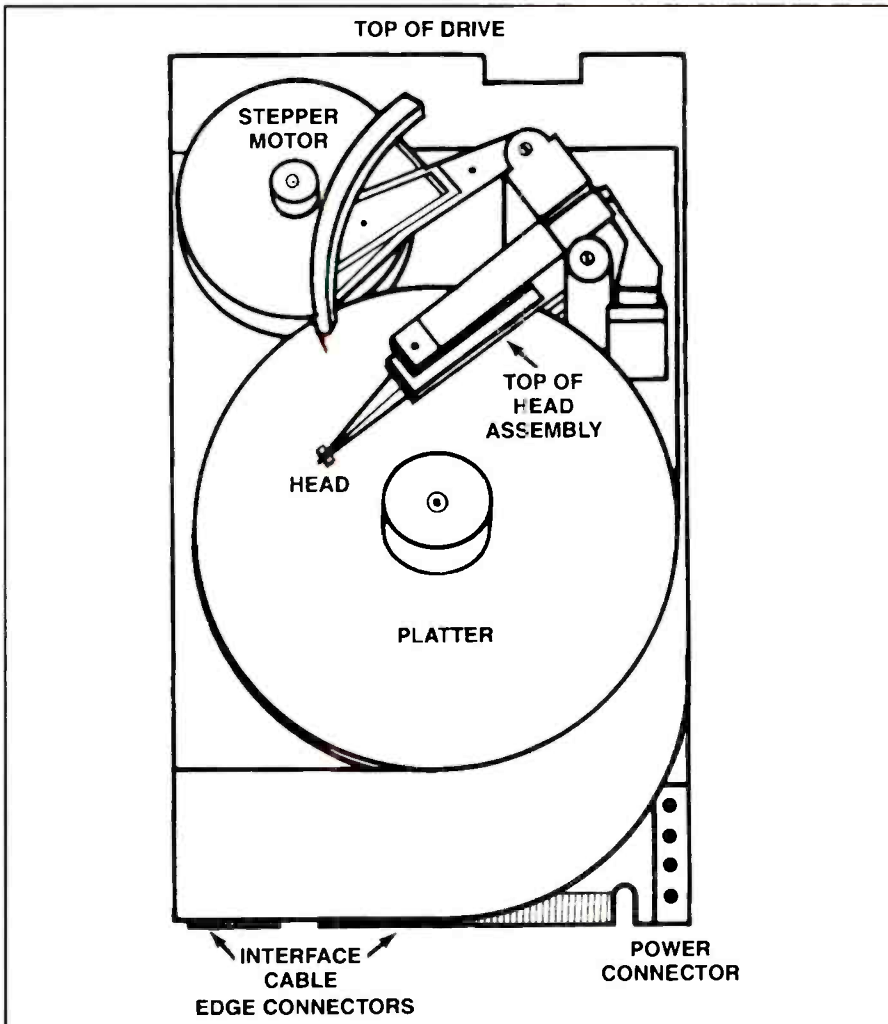


Figure 1. This is what a typical hard disk drive looks like with its cover removed. The drive assembly includes heads, cylinders, and platters. Each platter in the hard disk drive has two sides. In operation, read/write heads move across the platters while data is stored in tracks and sectors on the platters.

Hard disk drive basics

Hard disk drives rely on electromagnetism for data storage and transfer, just as floppy disk drives do. Data is stored on a hard disk when an electric current flows through an electromagnet. The electromagnetic action generates a magnetic field that is stored on the hard disk.

Data is read from a hard disk when the same electromagnet passes over the disk and encounters the stored magnetic field. When the encounter occurs, an electrical current identical to the current originally used to store data on the disk is generated.

In the case of the hard disk drive, the electromagnet is the *head*, while the disk is coated with a material that contains magnetic "domains." Before the head has "written" anything on the disk, the magnetic fields created by the magnetic domains are oriented randomly throughout the coating, and thus cancel one another out, along with any resulting field polarity.

As the disk spins, the head is moved across its surface. The head is aerodynamically designed, and it can truly be said to be "flying" just above the disk, in the air movement created by the disk's spinning motion

Writing to the disk

When the computer "writes" data to the disk, the magnetic field generated by the current through the head is focused in the area between the head and the platter. The close proximity of the strong magnetic field to the magnetic particles aligns the field domains on the platter into magnetic flux.

Reversing the current flow through the head coils also reverses the direction of the flux on the disk. The reversal of flux direction places a flux reversal on the platter. Each pattern of flux reversals represents the recording of data on the disk.

Reading from the disk

Passing a drive head over an area of the platter that holds flux generates current in the drive head. The direction of the current in the head matches the direction of the flux. Passing the head over an area where a flux reversal occurs causes the current in the head to change direction.

The weak reversed currents match the currents that passed through the head during the recording of data. Here, the head is in its "read" mode. The electronic circuitry in the drive and controller amplify and translate the currents back into usable data.

Because the read/write head is so close to the disk's surface during operation, it is important that no dust, dirt, smoke or other contaminants be allowed to enter the disk drive. Thus hard disk drives are

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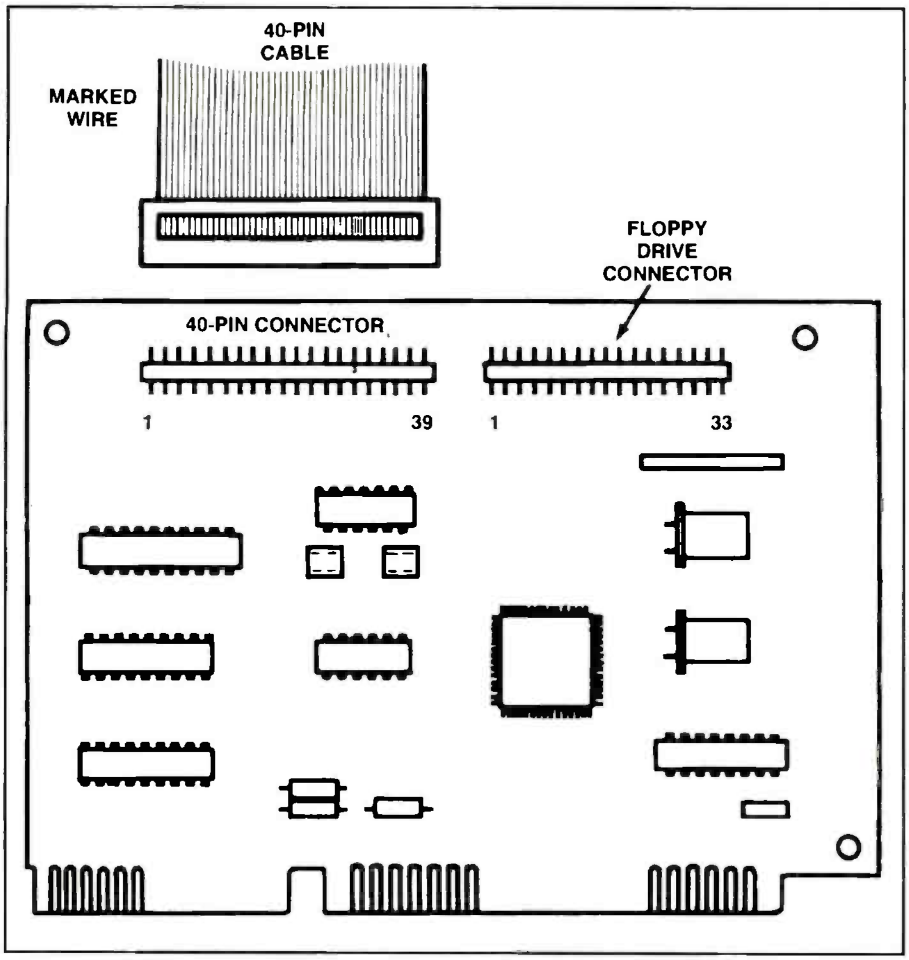


Figure 2. The IDE interface card has no "intelligent" electronics and works simply as an adapter. In IBM-compatible microcomputers, a 40-pin interface cable connects the drive to its interface while IBM computers use either a 40-pin or 72-pin cable.

sealed at the factory in clean rooms. A hard disk drive is, therefore, a sealed unit that works as a magnetic storage device for data.

Data encoding

The specific pattern of flux reversals on the surface of the disk that represents a bit of data is called the encoding method. Figure 1 shows a picture of a typical hard disk drive with its cover removed. As the figure shows, the drive assembly includes heads, cylinders, and platters. Each platter in the hard disk drive has two sides. During its operation, read/write heads move across rigid platters while data is stored in tracks and sectors on the platters.

Platters

Going back to Figure 1, the disk portion of the hard disk drive is a set of circular *platters* made of aluminum, plastic, or glass substrate. Data is stored on the coating that covers both sides of platter substrate. Lower-cost hard disk drives have oxide-coated platters while more expensive hard disk drives have a thin plating of metallic alloy on their platters.

The difference in performance between the two types of coatings may be appreciated by considering the number of magnetic domains per inch of track. Coated media hold up to 20,000 magnetic domains, while plated media hold up to 50,000 domains. In addition, plated platters are much harder than coated platters and, consequently, are less susceptible to head crashes.

As mentioned, some drives have glass platters. Glass platters have a smoother surface than the aluminum platters and can hold more data.

Tracks

If you removed a platter from a formatted hard disk drive and could see the formatting information, you would see a series of concentric circles. The circles are the "tracks" that hold data. With 1,000 or more tracks per inch of media, hard disk drives have high track densities. This measurement defines the number of tracks that can be written to a platter.

Sectors

Each track is divided into an equal number of magnetically-marked sections called sectors. In turn, each 512-byte-large sector has a sector heading that includes an identification field that holds an identification number that ranges from zero to 65,535.

Formatting a hard disk drive writes the identification field or address information to the hard disk. The address information includes the cylinder number, head number, and sector number of the current sector. Before any read or write operation occurs within the hard disk drive, the controller compares the address information with the desired cylinder, head, and sector.

Sector sparing reduces the number of available sectors per track by one. The set-aside sector is used to store defect information. Although sector sparing reduces the capacity of the hard disk drive, it hides defects from application software.

Zone Bit Recording places more sectors per track on the outside tracks of the platter. Because of DOS limitations, each sector contains 512 bytes of data.

Read/write heads

Hard disk drives have one read/write head per platter side. The read/write heads of a hard disk drive are pieces of magnetic material that pass over a moving disk surface that carries a magnetic flux. Because the common read/write head is a small horseshoe magnet wrapped with coils of wire, a generated magnetic field is concentrated between the prongs of the horshoe, or U. Disk drive logic sets up the current that passes through the coils. As you know, the direction of the flow of the electric current dictates the field's polarity.

Read/write heads are part of a simple mechanical assembly. Above and below each platter, a head is fastened to a spring-loaded arm that holds it against the platter. Thus, when the drive is not powered, the head lands on the disk.

When the platters spin at full speed, a cushion of air develops between the head and platter and lifts the head off the platter. The resulting gap between the head and platter is between 5 and 20 millionths of an inch. Any type of particle that blocks the gap causes the heads to read or write

Version	Partition Limit
2.0	16 Megabytes
2.1 up to 3.30	32 Megabytes
3.30 up to 4.0	32 Megabytes
4.00 up to 5.0	512 Megabytes
5.00 up to 6.2	2 Gigabytes

Table 1. A disk partition is a section of a hard disk drive set for a specific operating system and amount of space. DOS allows four partitions. Different DOS versions have different partition limits. Those limitations are shown in this table.

improperly. A head crash occurs when the head and disk damage one another during the landing. Rough handling or a small particle between the head and disk can cause head crash.

Three different types of read/write heads—*monolithic, composition and thin-film*—are used in today's hard disk drives. The amount of head gap and track density varies from low to high, respectively, with the type of heads used in the drive. As the previous example of head operation shows, the larger monolithic heads have an iron-oxide core wrapped with electromagnetic coils.

In the case of the composite process, a ceramic housing covers a ferrite core bonded to glass. Another manufacturing process that involves the use of integrated circuit techniques to deposit the read/write elements results in thin film heads. Thin-film heads offer a more precise magnetic pulse, so they allow high track densities.

When working with hard disks, knowing the meaning of a few head-related terms can help your understanding of overall drive operation. *Seek time* is the average time the heads take when moving between one track to another track.

Cylinders

Referring to Figure 1, the platters of a hard disk drive are stacked vertically. The identical track numbers on each platter taken together create a cylinder. As the heads pass over the platter, the tracks under all the heads are the cylinder.

Spindle motor

A spindle motor is a direct action motor that spins the platters in a hard disk drive. A ground strap dissipates static generated by spindle motor operation and grounds the spindle case motor.

Stepper motor actuator, and voice-coil actuator

A *stepper motor* actuator moves the heads over the platters. The stepper motor rotates a precise number of steps and converts those steps to linear motion. Inexpensive hard disk drives use stepper motor actuators.

A *voice-coil* actuator also moves the heads over the platters but uses a solenoid to influence the movement. Voice coil actuators move the heads faster than stepper motor actuators.

Interleave

Many hard disk drives can transfer data faster than the microprocessor can accept it. Interleaving forces the drive to slow its reading of data by renumbering the sectors. Rather than number the sectors sequentially, interleaving staggers the numbers of the sectors.

The staggering approach allows the computer to store data for one sector while two others are under the head. During one revolution of the platter, the system will read and store six sectors of data. In three revolutions, the system will read and store the data from all sectors.

Partition

A partition is a section of a hard disk drive set for a specific operating system and amount of space. DOS allows four partitions. Different DOS versions have different partition limits. Those limitations are shown in Table 1.

Hard disk drive interface types

As mentioned during the brief discussion of hard disk drive operation, specific patterns of flux reversals that store data bits are called encoding methods. Hard disk drives rely on two encoding methods called *modified frequency modulation* or MFM and *run-length limited* or RLL.

Aside from using different encoding methods, hard disk drives also utilize different interfaces. We can classify the ST-506/412 and ESDI interfaces as disk interfaces. The SCSI and IDE interfaces are

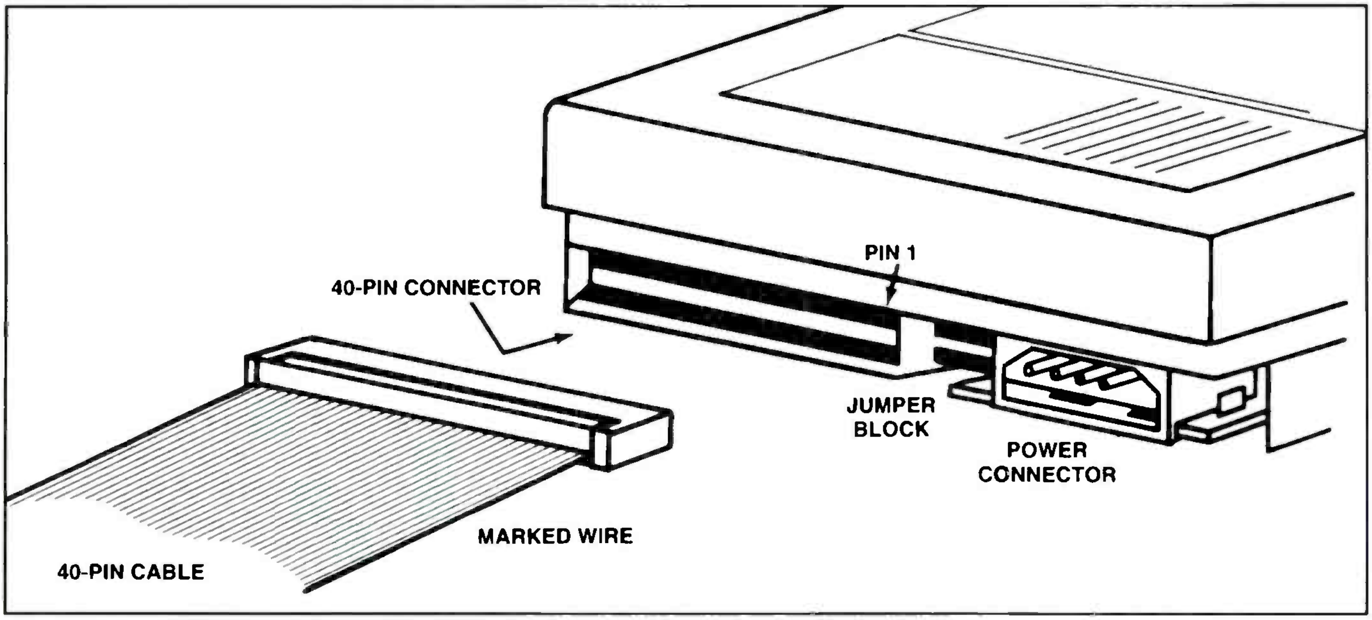


Figure 3. The IBM-compatible IDE interface cable connection.

classified as system interfaces. However, the SCSI and IDE interfaces utilize the ESDI electronics for communicating with the disk. The electronics that give the SCSI and IDE drives their names communicate with the drive controller.

MFM hard disk drives

Both the MFM and the RLL hard disk drives use a ST-506/412 interface. MFM hard disk drives use a fixed-length modified frequency modulation encoding scheme accomplished on the drive controller card. With the encoding scheme converting the digital bits received from the central processing unit into a pattern of magnetic changes or "flux reversals," the flux reversals are stored on the hard disk drive.

Simply put, the encoding scheme encloses clocking information with the data pulses. Since each flux reversal on the disk is evenly separated by time, the beginning of each bit also is separated from the others, and each bit uses an identical amount of linear space. Thus, the controller electronics can easily detect and correct single-bit errors. The MFM format specifies that the drive will contain seventeen sectors per track.

Important things to know about MFM drives

MFM drives usually have one terminating resistor pack and anywhere from two to four-drive select jumpers. A 20-pin drive data cable and a 34-pin drive control cable connect the drive to its controller card. If installing two MFM drives in a system, each drive requires a data cable. A dual drive control cable will work for both drives. The first drive attaches to the last connector on the cable while the second drive attaches to the middle connector. MFM hard disk drives require a low-level format.

RLL hard disk drives

Hard disk drives using the RLL encoding scheme have fifty percent more space and a higher transfer rate than drives using MFM encoding. Thus, in theory, a drive that has a capacity of 40 megabytes with MFM encoding can store 60 megabytes with RLL encoding. The key concept to remember when comparing the MFM and RLL encoding schemes is density.

The MFM encoding scheme utilizes a regulated amount of flux reversals. RLL encoding divides the MFM bit cells into three RLL bit cells and introduces an irregularity into the flux reversals because any of the three RLL bit cells may have a flux reversal. Note that the number of flux reversals per track does not change—only the regulation. As a result, the density of data doubles but the magnetic density stays the same.

In the paragraph above on RLL, the words "in theory" were used in comparing the capacity of MFM and RLL drives. One cannot simply match an MFM-encoded drive with an RLL controller and receive more disk space.

While the encoding method cuts the amount of data-checking information stored on the drive and has less flux reversals than an MFM drive, it requires more logic than the MFM scheme. Consequently, both the RLL controller and drive electronics must have more precise timing.

RLL controllers must have a more sophisticated error detection and correction circuit than MFM controllers. Since the RLL drives do not have the regular flux reversals seen with the MFM drives, the encoding method is more prone to errors.

Rather than having a stepper motor, an RLL drive should have a voice coil actuator and employ thin film media. Stepper motors can introduce tracking problems and temperature-induced errors. Thin-film media has a higher signal-to-noise ratio and a higher bandwidth. Drives that have a voice coil actuator and use thin film media are called "RLL Certified."

Important things to know about RLL drives

Installation tip: RLL drives will have 26 or more sectors per track.

Like MFM drives, RLL hard disk drives usually have one terminating resistor pack and anywhere from two to four drive-select jumpers. As with its older cousin, a 20-pin drive data cable and a 34-pin drive control cable connect the RLL drive to its controller card. The same rules that apply for installing two MFM drives in a computer system apply for RLL drives. RLL hard disk drives require a low-level format.

ESDI (enhanced small device interface) hard disk drives

In 1983, a group of hard disk drive manufacturers adopted a drive standard that would provide better error correction and higher transfer speeds. By building the encoder/decoder circuitry into the drive, the design team managed to provide an interface that could transfer 25 megabits of data per second.

In practice, most ESDI drives have a transfer rate of 10 megabits per second. The higher transfer rate also results from drives formatted at 32 sectors or higher per track and a 1 to 1 interleave supported by the controller. A combination of high data density and low interleave ratio allows a higher transfer rate.

Aside from the characteristics seen with the drive, the ESDI interface also offers other features. The enhanced command set within the controller allows the interface to read the capacity parameters of the drive. Therefore, the interface can control the defect mapping of the drive. In effect, this simplifies the installation of the ESDI drive set.

Installation of an ESDI drive does not require the use of a setup program or the writing of a defect map by the installer. With the ESDI interface commanding the defect mapping, the controller BIOS or the system BIOS reads the drive table directly from the drive. Since the computer system can read the drive defect map, the defect list can be written as a file to the drive.

Rather than having the installer type the defect list from the keyboard, the ESDI interface allows the controller and the low-level format program to update the defect list. Normally, the ESDI controller BIOS includes a low-level format program and a surface-analysis utility program.

Important things to know when installing ESDI drives

Installation tip: When installing an ESDI hard disk drive, set the drive type to one. The ESDI controller firmware handles compatibility problems. ESDI drive specifications are factory-encoded on the drive. The firmware also contains the low-level format program.

ESDI drives usually have one terminating resistor pack and anywhere from three to twelve drive select jumpers. Like the MFM and RLL drives, ESDI drives utilize one control cable and one data cable. The same rules for installing two MFM and RLL disk drives in a system apply to ESDI drives. ESDI drives require a low-level format and usually have an interleave set to one.

SCSI (small computer systems interface) hard disk drives

Developed in 1979, the small computer systems interface (SCSI) works from a logic level instead of the common device level. With the MFM, RLL, ESDI, and IDE disk drives, we mentioned controllers in the same breath as the drive.

However, the SCSI is a pure interface instead of working as a driver or a drive or a controller. A controller is inserted between the SCSI interface and the drive. Each SCSI system can accommodate eight controllers with one controller working as an interface between the SCSI and the computer system.

Since the interface uses the logic level and leaves the interface decisions to the attached devices, several different types of devices can be attached to the SCSI interface. The interface can handle as many as seven logical devices including hard disk drives, tape drive units, floppy disk drives, scanners, CD-ROMs and other peripheral devices. Jumpers on each attached device set a logical unit number for the device and identify them as logical units for the interface.

Hard disk drives intended for use with a SCSI system usually arrive as complete units called "embedded SCSI drives." One circuit contains the drive, controller, and SCSI adapter. While this adds convenience, it also limits the number of drives that can be attached to the SCSI system to seven.

With the controller portion of the set embedded within the drive, only one drive can be attached to the controller through a 50-pin drive header cable. Also, each SCSI bus address on the adapter can support only one drive. If the task requires more than seven drives, add more SCSI adapters to the SCSI system.

Important things to know when installing SCSI drives

Installation tip: When installing set the drive type to zero. The on- board BIOS on the SCSI controller will take care of any compatibility issues.

Technicians will find several terminating resistor packs on the SCSI drive. If connecting the SCSI drives as part of a daisy chain, remove all the resistors on the drives that make up the middle of the chain. Only the first and last drives require the terminating resistors. From three to twelve jumpers set the logical unit number of a SCSI drive. Usually, SCSI drives arrive already low-level formatted.

IDE (integrated drive electronics) hard disk drives

IDE hard disk drives have most of the controller functions built into the drive circuitry. Consequently, the drive and controller are a matched pair. As with SCSI drives, the drive name "IDE" refers to the interface rather than the drive. Because of the integrated nature of the drive, it will either connect to a limited-function-interface card installed in the system bus or directly to the motherboard.

Depicted in Figure 2, the interface card has no "intelligent" electronics and works simply as an adapter. In IBM-compatible microcomputers, a 40-pin interface cable connects the drive to its interface while IBM computers use either a 40-pin or 72-pin cable. Figure 3 shows the IBM-compatible interface cable connection.

All IDE drives use RLL encoding with 36 or more sectors per track, some have more than 16 heads, and some have more than 1024 cylinders. All these characteristics are worth noting. Most computer

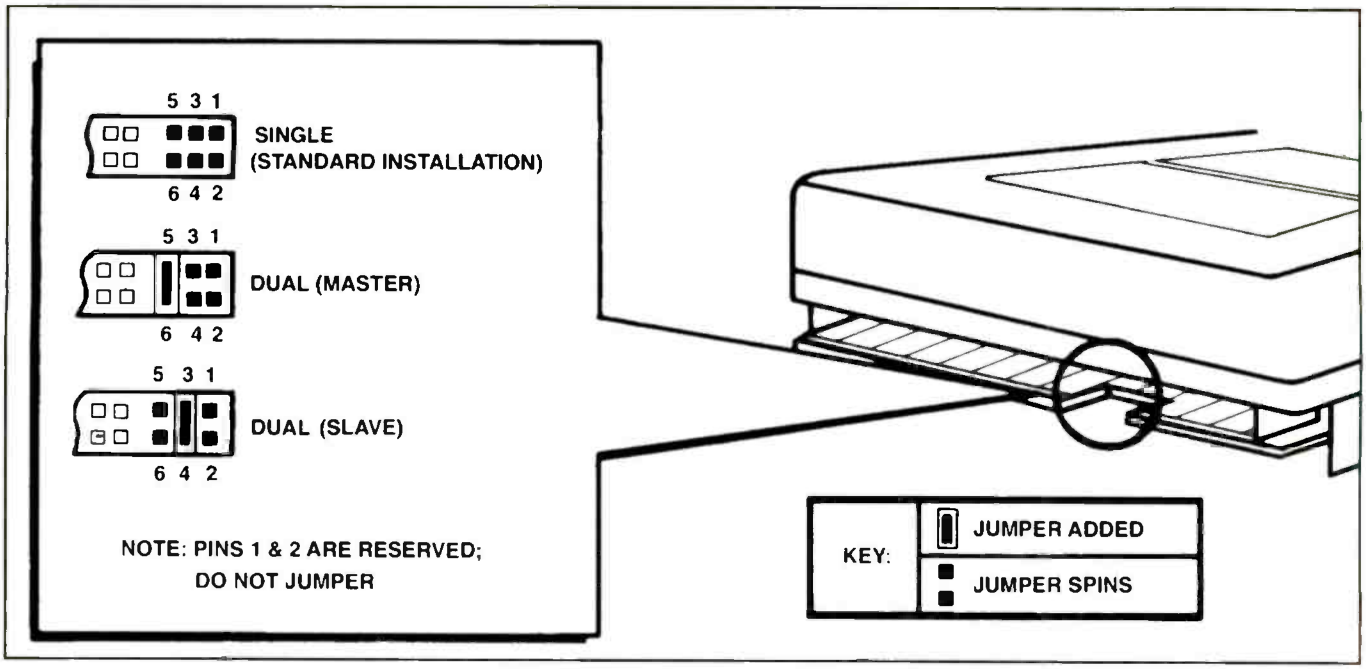


Figure 4. IDE hard disk drives do not have terminating resistor packs. However, a set of jumpers on the underside of the drive can be used to configure the drive as a master or slave. On a Western Digital Caviar drive, those jumpers are placed as shown here.

system BIOS drive type tables have limits of 17 sectors per track and 16 heads. In addition, DOS will recognize a maximum of 1024 cylinders for a hard disk drive. Because of those three factors, the installation of an IDE drive requires a translation of the drive physical information to logical information.

The physical information of a drive is the actual number of heads, cylinders, and sectors per track in the drive. On the other hand, logical information is the number of heads, cylinders, and sectors per track shown by the drive and seen by the system BIOS. To handle the translation, the electronics contained within the IDE drive and controller perform a mathematical calculation that matches the logical settings entered in the BIOS to the actual, physical values of the drive.

Important things to know when installing IDE drives

Installation tip: When installing an IDE hard disk drive, select a drive type that is equal to or less than the size of the hard disk drive in megabytes. Never select a type that specifies a capacity larger than the drive. Let the IDE drive and controller perform the translation.

IDE hard disk drives receive low-level formatting at the factory. Using common low-level format programs on an IDE drive after its installation may eliminate the factory defect map and may damage the drive. Some utility software applications can low-level format an IDE drive. Without the use of traditional low-level format, interleaving the drive is not required.

IDE hard disk drives do not have terminating resistor packs. However, a set of jumpers on the underside of the drive can be used to configure the drive as a master or slave. Figure 4 shows the location of those jumpers on a Western Digital Caviar drive. Only applicable to AT-style systems, the first drive is called the master while the second is called the slave. Micro House International recommends that technicians installing two drives in a system use drives made by the same manufacturer. Either connector on the IDE cable may attach to the master or slave drive.

Hard disk drive reference sources

Because of space limitations, this article cannot provide all information about hard disk drives and hard disk drive installations. However, many fine references about the subject exist.

The Micro House *Encyclopedia of Hard Drives* provides excellent, comprehensive specifications for all hard disk drives and drive controller cards. The three-volume set (Set-up Guide, Drive Settings, and Controller Cards) is an essential tool for your workbench and is available from:

Micro House International
P.O. Box 17515
Boulder, Colorado 80308
800-741-DATA
BBS: 813-441-8501

The book *Upgrading and Repairing PCs*, by Scott Mueller, provides not only information covering different hard disk types but is a storehouse of information about microcomputer systems. Like the Micro House Encyclopedia set, *Upgrading and Repairing PCs* is an essential tool for your shop. The text is published by the QUE Corporation and is sold by most bookstores. You may contact Mueller Technical Research by phone, fax, BBS or by mail:

Mueller Technical Research
21718 North Mayfield
Barrington, IL 60010-9733
708-726-0709
FAX: 708-726-0710
CompuServe ID: 73145,1566

Another very good reference for your shop library is *Troubleshooting and Repairing PC Drives* and *Memory Systems*, by Stephen J. Bigelow, published by Windcrest/McGraw-Hill. Bigelow's text provides an extensive overview of microcomputer hard disk drives and the procedures for installing all types of drives. ■

Removing conformal coatings

By James L. Witcher

For many years, the use of conformal coatings on electronic circuits was rarely used outside of the military, where they were common because of the special requirements of military equipment. With the growth of electronics into the industrial and consumer markets, however, new applications that require coating are coming about. Trying to service these products can become quite baffling. Following is a discussion of conformal coatings, with suggestions on how to service products which use them. With a little planning, the repair process can be made much easier.

The nature of conformal coatings

Conformal coatings are typically plastic films applied to the printed circuit board (PCB) with a thickness of 0.001 inches to 0.005 inches. Their purpose is to protect the PCB from the environment in which they will be used. Examples include traffic signals, hospital diagnostic equipment, automotive electronics, security alarms, public telephones, vending machines and more.

Moisture, solvent vapor, dust, fungus, and other contaminants can cause a circuit assembly to malfunction or quit working altogether. Conformal coatings are designed to prevent these outside factors from affecting the functionality of the PCB. The choice of which type of coating to use depends on properties needed.

Types of conformal coatings

Military specification MIL-I-46058C, the conformal coating specification, lists five types of conformal coatings: acrylic resin, silicone resin, polyurethane resin, epoxy resin and paraxylene resin (Figure 1). These types of coatings comprise the bulk of those being used by both consumer and military manufacturers.

Acrylic resin

The acrylic, Type AR conformal coating, is an economical, general purpose coating that is not recommended for use in harsh environments. AR coatings are the easiest to apply and rework because they are easily removed with solvents.

Coating Type MIL-I-46058C	Resin Type
Type AR	Acrylic Resin
Type SR	Silicone Resin
Type UR	Polyurethane Resin
Type ER	Epoxy Resin
Type XY	Paraxylene Resin

Figure 1. Military specification MIL-I-46058C, the conformal coating specification, lists these five types of conformal coatings. These types of coatings comprise the bulk of those being used by both consumer and military manufacturers.

However, the resistance to moisture, fungus, and solvent is much lower than that of the other types of coatings. The AR coatings are also somewhat brittle when fully cured causing adhesion problems in thermal cycles.

Rework and removal of the AR coating is accomplished by dissolving the coating in an appropriate solvent or stripper. Mechanical removal is also possible, but burning directly through the coating is not recommended. Once the defective component is replaced, the area should be cleaned and the AR coating reapplied.

Silicone resin

The silicone, Type SR coatings are very popular because of their diverse characteristics. They are very flexible making them excellent choices for harsh temperature environments (hot or cold or rapid changes). SR coatings have a high moisture/fungus and solvent resistance. These coatings are generally considered "best all around" coatings for most applications.

SR coatings can be removed using chemical or mechanical means. Since the coating is resistant to solvent, very strong chemical strippers must be used. Care must be taken to prevent damaging the board or components underneath the

Property	Type AR	Type SR	Type UR	Type ER	Type XY
Thermal Shock	2	5	3	2	3
Dielectric Strength	3	2	4	2	3
Moisture/Fungus Resistance	2	5	4	5	5
Chemical Resistance	1	3	4	5	5
Ease of Repair	5	3	3	2	1
Flexibility	2	5	3	2	2
Removal Methods					
Chemical	5	3	2	1	1
Thermal	3	2	4	3	2
Mechanical	4	3	4	4	4

Legend
1—Poor, 2—Fair, 3—Average, 4—Good, 5—Excellent

Figure 2. Once the coating type has been determined, the removal process can begin. Select the process that will take the least amount of time and effort. Do not remove more coating than is necessary.

Witcher is a Technical Applications Chemist for Tech Spray, Inc.

coating. Because of the heat resistant nature of silicone coatings, burn-through is not recommended.

Polyurethane resin

Polyurethane, Type UR coatings have very high solvent and moisture resistance. This type comes in two forms: one part and two part. Two part UR coatings offer quick cure times of one to three hours, but have short pot life once mixed. One part UR coatings are applied like conventional coatings, and then moisture in the air causes them to cross link or polymerize making them very durable. This type of UR can take up to three days to fully cure.

Because of the high chemical resistance of type UR coatings, very strong solvents/strippers must be used to completely remove the coating. Mechanical removal and burn can both be used to repair boards coated with a UR coating.

Epoxy resin

Epoxy, Type ER coatings are primarily two part systems with one exception. This type of coating is extremely resistant to moisture and solvent making it impossible to remove with a chemical stripper. (There are solvents that will remove epoxy resin coatings, but in general they will dissolve all the plastics used in making the PCB, as well). Burn through and mechanical removal are the only practical means of repairing a PCB coated with the ER coating.

UV curable epoxies

The exception to the two part epoxies are UV curable epoxies. These are one-part systems that contain a photo initiator. When the liquid coating is exposed to ultra-violet (UV) light, the initiator breaks up starting a chain reaction which changes the material to a solid plastic. In effect, the light acts as the "second part" in the epoxy system. This process is very fast, taking less than 60 seconds. Pot life of the epoxy is greatly extended and production time is reduced.

Paraxylene

The final type, paraxylene (Type XY), is the most chemically and physically tough coating. This is almost totally limited to military use. Rework is practically impossible since the coating is so resistant to solvent, heat and mechanical stress.

Removal methods

The most serious drawback to using conformal coatings is the difficulty in repair. To replace a defective component, the coating must be removed so the joint can be desoldered. Then once the component is reinserted, the surface must be cleaned, dried, and the coating reapplied. Choosing the appropriate removal method can help speed up the repair process.

Chemical stripping

Chemical stripping of the coatings is the recommended method if large areas of the PCB are to be reworked. The type of stripper depends on the coating used. Most manufacturers of conformal coatings offer a stripper specifically designed to remove their coating.

Two basic types of strippers have been used extensively in the electronics markets. Those based on methylene chloride tend to be very aggressive. The coating is removed in a matter of minutes. Care must be taken to remove the stripper before it begins to attack the permanent solder mask or components underneath the conformal coating.

Because of the toxicity of methylene chloride (it is now considered a human carcinogen), many companies have opted for a different technology. Dibasic esters, n-methyl pyrrolidone, and other solvents have been used to formulate strippers that are much safer to the user.

However, these coating removers require much longer to work, up to 8 hours, and in some cases will not remove the coating at all. To help speed up the removal process, place the boards in an oven at 120F since many chemicals become activated when heated. Consult with the manufacturer of the stripper to determine if heat can increase aggressiveness.

Once the coating has been removed, it is imperative that the stripper be completely rinsed off the board. Any remaining residue could cause the solder joints to corrode. A polishing rinse with solvents containing alcohol can help insure removal of all residue.

Thermal removal

Thermal removal is the direct application of heat to the coating. Hot air, hot knives, and soldering irons are the most common tools. This method is particularly handy for spot replacement of specific components. Most often, the soldering iron is placed directly on the coating to melt/vaporize it.

As with chemical removal, cleanliness after component replacement is very important. Burned or yellowed coating should be scraped off and the surface cleaned with a solvent before reapplication of coating.

Mechanical removal

Mechanical removal is recommended for the tougher silicone, epoxy, polyurethane and paraxylene coatings in spot replacement applications. Mechanical removal can be as simple as scraping off the coating with a sharp instrument. Several companies in the electronics market manufacture systems for mechanical removal of conformal coatings.

A much less expensive route is to go to the local hardware store and look for the rotary hand tools. These are small instruments which often come with a variety of bits ranging from wire wheels and grinding stones to intricate cutting tools.

When mechanically removing a coating, care must be taken to prevent damage to the components underneath. The pressure applied should be just enough to remove the coating. Excessive force can strain solder joints and components. After the components are replaced, be sure all dust and flux residues are cleaned before reapplying the coating.

Steps used in reworking

The first step in reworking a PCB that has been conformally coated is to determine what type of coating has been used. Only the most trained eye or very expensive laboratory equipment can determine the type of coating simply by observation. The best method is to contact the manufacturer of the PCB and get the coating specifications. It is imperative that the same type of coating used in the manufacturing process is used in the rework.

Mixing of coating types can have very unpredictable results. An epoxy coating would not adhere well to a silicone resin coating and vice versa. Different coating types expand and contract at different rates with changes in temperature. When two different types are used on a single application, changes in temperature can cause them to pull apart from one another and from the substrate.

Once the coating type has been determined, the removal process can begin. Select the process that will take the least amount of time and effort. Figure 2 and the discussions on removal methods can help make this choice easier. Do not remove more coating than is necessary.

Recoating the reworked portion of the circuit

After the PCB repair has been completed, the board should be prepared for reapplication of the conformal coating. Proper cleaning is critical. Remember that the coating not only protects the PCB from outside contaminants but also traps any existing contaminants permanently. A solvent designed for defluxing will help remove the flux and flux residues, and a polishing rinse of deionized water followed by polar solvents like isopropanol or ethanol will help insure that all ionic contaminants are removed.

The boards should be completely dry before attempting to re-coat. Any trapped moisture can cause the coating to blister and fail in the field. If necessary, place the boards in an oven at 120F for a couple of hours prior to coating.

Finally, using the coating type recommended by the manufacturer, reapply to the repaired board. Four types of application methods are commonly used: dip, pour, brush and spray. Dip and pour techniques are for completely re-coating the entire surface. Brushing allows a thick coat to be applied to a specific area, while spraying allows for a thinner coat to be applied. Be sure to re-coat to the same thickness as the original coating.

The electrical and physical properties of a coating depend on its thickness. Manufacturers will often specify a minimum thickness for optimum performance. Allow the coating to dry and cure as explained in the directions.

Specialized coatings

Proper repair of the conformal coating will insure that the PCB will function as before. Further, there are several coatings available to help eliminate specific problems. Encapsulants are viscous materials designed to cover and protect specific components or areas on a PCB. Strain relief materials help cushion components and areas that are placed under stress. And many adhesives are available to repair boards and components.

The use of conformal coatings is becoming quite common. The more components that are packed onto a board, the more sensitive that board becomes to outside contamination. Repair of these devices does not have to be difficult, but it does require a little planning up front. ■

Test Your Electronics Knowledge

Power calculations and miscellaneous

By Sam Wilson

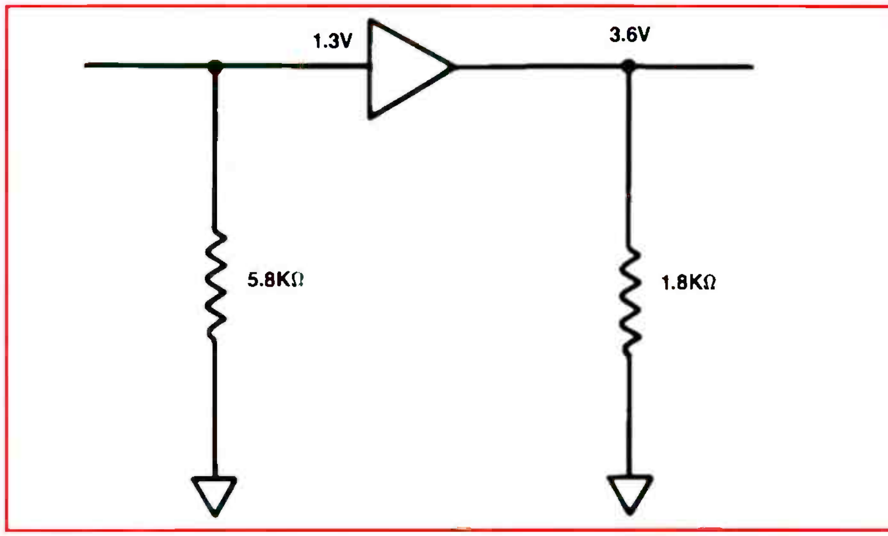


Figure 1. What is the dB gain of this amplifier?

1. A certain power amplifier increases the input power by 3dB. If the input power is 5.2W, what is the output power?

2. A certain transmission line introduces a 3dB loss to input power. If the input power is 9.8W, what is the power output from the transmission line?

3. Figure 1 shows an amplifier with a signal voltage input of 1.3V and an output signal voltage of 3.6V. What is the dB gain of the amplifier?

4. What is a stroboscope used for?

5. What does VCO stand for in a phase-locked loop?

6. Consider the Lissajous pattern of Figure 2. The horizontal sinewave frequency is known to be 450Hz. What is the vertical frequency?

7. What is the impedance of four 4Ω speakers in parallel.

8. Is the following statement correct?:

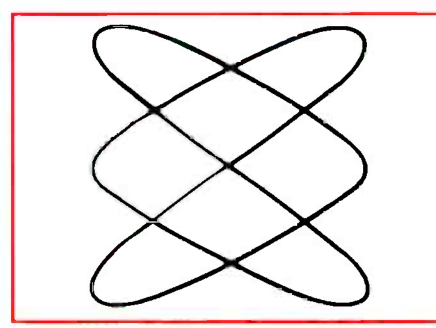


Figure 2. In this Lissajous pattern, the horizontal sinewave frequency is 450Hz. What is the vertical frequency?

Partition noise does not occur in a MOSFET.
A. correct
B. not correct

9. Is the following statement correct?: Decreasing the gain of an amplifier will automatically increase its bandwidth.
A. correct
B. not correct

10. Is the following statement correct?: The drain voltage of an enhancement MOSFET is never greater than 36V.
A. correct
B. incorrect

(Answers on page 46)

Wilson is the electronics theory consultant for ES&T.

Electronic servicing for performance and reduced environmental impact

By Dr. Mo Tazi

The chemicals used in servicing today's electronic equipment and systems are dramatically changing, and will continue to do so throughout the decade as more stringent environmental regulations are enacted which restrict and/or ban many of the traditionally used chemicals. Alternative chemistries have already been developed which reduce a product's potential to cause environmental impact, and it is these chemicals which will become the new mainstays of the electronics industry.

Today, a service technician has the option of choosing between a standard product, typically formulated with chlorofluorocarbons (CFCs) or chlorinated solvents, which have the potential to deplete the atmosphere's ozone layer, or selecting a new alternative product specifically engineered for high performance and lower environmental impact. Understandably, no one wants to choose between performance and environmental impact, because a product that sacrifices one attribute at the expense of another is not an ideal option.

Alternatives are available

Fortunately, there are no-compromise alternatives now available that achieve reduced environmental impact as well as dramatic gains in performance. By making a careful and informed choice, it is possible to select a product that offers comparable or even superior performance to the conventional formulation, while, at the same time, minimizes the potential impact on the environment.

In real-world electronics service, performance is the primary reason a technician selects a particular product for the desired application. After all, performance is something tangible that you can easily see. Environmental impact, however, is harder to imagine, because it takes an understanding of the chemistry of specialty products to grasp the impact that their usage has on the environment.

Tazi is Director of Research and Development at Chemtronics Inc.

Performance	CFC-Free Cleaner	Conventional CFC Cleaner
Product Required for Water Soluble Oil Removal (MG Solvent/1MG Oil)	33.0	94.0
Water Soluble Oil Removal Rate (MG/IN^2 Sec.)	11.0	5.0
Ozone Depletion Potential	0.00	0.78

Table 1. Alternatives have been found for CFC-based cleaner/degreasers that actually perform better while having little or no ozone-depletion potential. This table provides a comparison between two such products.

How chemicals affect the environment

Consider what happens when a traditional CFC-based compressed gas duster was used for routine contamination removal on a computer keyboard. As the dust and contaminants are blown away, chlorine is released into the atmosphere. This chlorine eventually reaches the ozone layer and begins a destructive thinning process. Halting this so-called thinning of the ozone layer is at the heart of legislation that is restricting the use of CFC-containing products, and will ultimately ban them from use.

The ozone layer is a natural protective shield that helps prevent harmful ultraviolet (UV-B) rays from reaching the earth's surface. This layer is vitally important because excessive ultraviolet radiation may lead to numerous health problems, including cataracts and skin cancer, and may also restrict the body's ability to ward off disease. Moreover, overexposure of UV light can potentially interfere with photosynthesis, thereby resulting in lower yields of crops, and may also affect the growth of photoplankton, which is a primary source of food for marine life.

Through extensive research, it has been learned that CFCs, substances that have been commonly used in many electronics chemicals, may be a factor in depleting stratospheric ozone. Ozone molecules contain three atoms of oxygen. When an electronics service technician uses a product that contains CFCs or chlorinated solvents, chlorine atoms are released. These chlorine atoms eventually reach the upper atmosphere where they attack ozone, causing one oxygen atom to break away from the ozone molecule, which then forms chlorine monoxide. The chlorine monoxide combines with another oxygen atom to form a new oxygen molecule and a chlorine atom. This begins a chain reaction in which the destructive process is repeated as additional ozone molecules are broken apart.

Now if the technician had selected an alternative, non-CFC product to clean the

Performance	CFC-Free Flux Remover	Conventional Flux Remover
Product Required for Rosin Removal (MG Solvent/MG Oil)	101.0	3673.0
Rosin Removal Rate (MG/IN² SEC.)	4.0	0.3
Ozone Depletion Potential	0.00	0.35

Table 2. Alternatives have been found for CFC-based flux removers that actually perform better while having little or no ozone-depletion potential. This table provides a comparison between two such products.

computer keyboard, there would have been no ozone-depleting substances released to damage stratospheric ozone.

Regulatory issues and environmental impact

Understanding the myriad environmental impact regulations is a complex task; however, only a very basic understanding of these regulations and the substances they affect is necessary. The two most important measures which impact the electronics industry are the Montreal Protocol, which was adopted in 1987 and amended in 1990 and 1992, and the U.S. Clean Air Act of 1990. In simple terms, these regulations require the reduction and eventual elimination of all ozone-depleting substances. Under the U.S. Clean Air Act, phase-out began on fully halogenated CFCs commenced in 1990, and carbon tetrachloride followed in 1992. Methyl chloroform, also known as 1,1,1-tricloroethane, a chlorinated solvent, began phase-out in 1993.

At present, Class I substances will be systematically reduced until they are eliminated entirely in the year 1996. It is important to note that these regulations are subject to further amendment, which may change phase-out dates. In addition, many states and municipalities have enacted environmental legislation that is more stringent than current national or international regulations. Through these mandates, electronics servicing technicians will find themselves forced into choosing alternative chemicals simply because the traditional products they have relied on will no longer be available.

How to make an informed choice

As regulations become more stringent, it will steadily become more important for the user to know exactly how a particular product impacts the environment, as well as how it affects the circuitry that the product will be used on. Choosing a chemical product may seem difficult these days, with all the talk about CFCs, chlorinated solvents and ozone depletion. But it isn't as hard as it may seem to make a decision as to which specialty chemical to select for a particular electronics application.

Many electronics chemical manufacturers provide information relating to a product's potential environmental impact through information on the label. Technicians should look for information about such chemicals as:

- chlorofluorocarbons (CFCs),
- hydrochlorofluorocarbons (HCFCs),
- chlorinated solvents (Cl. solvs),
- volatile organic compounds (VOCs),
- hydrofluorocarbons (HFCs), and
- ozone depletion potential.

With this information clearly provided on a product's label, an electronics technician can quickly and intelligently compare products and choose the one that offers the lowest environmental impact while meeting the desired performance requirements.

Applications and alternatives

CFC-containing products have been popular because they remove a wide variety of oils and contaminants, evaporate quickly and generally have excellent material compatibility: that is they don't chemically attack other materials. Because these products offered such dependable performance, manufacturers did not seek alternative formulations until concern arose over potential environmental concerns.

Choosing an alternative product may require more care to be taken on the part of the technician to ensure compatibility with components and PCB substrates because new chemicals may not offer broad-based material compatibility; that is, they may cause damage to some materials. However, alternatives exist for just about every segment of electronics service and repair, including:

- contamination removal,
- cleaning and degreasing,
- flux removal,
- testing for intermittent circuitry (freeze spray),
- desoldering components.

Cleaning and degreasing

In electronics cleaning and degreasing applications, such as cleaning/degreasing of VCRs and personal computers, one of the most popular conventional agents has been trichlorotrifluoroethane. An alternative chemical that will not contribute to the depletion of the ozone layer has been developed. It penetrates tight areas to remove oils, greases, dirt and fluxes while evaporating quickly. See Table 1 for a comparison of the CFC-based product with the newer non-CFC-based product.

Flux removal

Defluxing agents are commonly used for spot flux removal as well as cleaning relays, switches and connectors. Here many products were formulated with CFC-based solvent blends. Today there is a broad range of alternative products, specially formulated to effectively remove specific flux types. One alternative CFC-free flux removal chemical removes organic rosin fluxes and ionic soils offers excellent material compatibility and has no ozone-depleting potential. See Table 2 for a comparison of performance of a CFC-containing cleaner/degreaser with a newly developed CFC-free cleaner/degreaser.

Testing for intermittent circuitry

When repairing PC boards, circuit refrigerants, also known as freeze sprays, are typically used to locate intermittent electrical components and connections, or to cool an entire printed circuit board. As was the case with compressed-gas dusters, R12 (dichlorodifluoromethane), a CFC with an ozone depletion potential of 1.0 has been one of the most widely used. An alternative has been found that exhibits superior thermal properties and has no ozone-depleting potential. It quickly chills to -60F, then evaporates without leaving a residue.

Desoldering

Desoldering products and methods are evolving to complement the new alternative products. Today's high-performance desoldering braids are commonly available in rosin-fluxed versions, on both conventional and static dissipative bobbins.

Rosin-fluxed braids insure clean, contaminant-free desoldering and typically provide the quickest wetting action and better heat transfer over the pad or junction. The highest quality rosin flux braids meet military standard requirements.

One of the newest developments in desoldering braid is *no-clean* flux, which eliminates the cleaning process after desoldering and leaves almost no residue.

Conclusion

As more alternative products enter the market and as environmental regulations become increasingly stringent, it is becoming more important that a user of specialty chemicals has complete information on the product before making a purchase decision. Today's alternative specialty chemicals match or exceed the performance of conventional formulations with the advantage of reduced environmental impact. By becoming more aware of how specialty chemicals perform, their performance characteristics, and what impact the chemicals may have upon the environment, service technicians can best select the right product for the application. ■

Troubleshooting the CD laser head assembly

By Homer Davidson

When a CD player is brought in for service, the condition of the laser head assembly may be the factor that determines if the unit is worth repairing. The CD laser assembly is so costly that, if it's defective, many owners will replace the compact disc player instead of having it serviced. The technician can save a lot of valuable time and trouble in CD servicing by first making sure that the CD head assembly and beam assembly are functioning, by performing a few quick laser head tests (Figure 1).

Figure 1. The portable laser power meter will accurately indicate if the laser diode is emitting signal against the underside of the CD disc.

Clean up time

Before attempting to measure the laser head beam, clean off the lens assembly. Dirt and dust on the lens assembly may produce skipping and poor tracking. In most CD players, the laser head assembly is covered by a flapper or disc assembly and cannot readily be seen. Of course, in the portable and boom box combination CD player, the lens assembly stares right back at you.

Clean the lens with a lint-free cotton swab or cleaning paper found in CD cleaning kits. Camera lens cleaning solution is ideal. Wipe the lens gently to avoid damaging the supporting spring. Blow the excess dust away from the optical lens with a can of compressed air dust spray, available at electronic and camera outlets.

Safety

The laser head assembly is a delicate and critical component that should be handled with care. Keep fingers and tools away from the optical lens assembly. Remember, the infrared laser light is invisible. You can't see it. The laser assembly can be dangerous to your eyes. Never look directly into the laser beam or into the lens assembly. Keep your head at least 30cm (12 inches) from the lens assembly. Observe the warning labels found on the CD player.

The optical laser pickup assembly typically consists of the objective lens, focus-tracking coils, collimating lens, beam splitter, semi-transparent mirror, photo detectors, monitor and laser diodes. While working around or removing the laser assembly, wear a grounded wrist strap to prevent electrostatic discharge damage. Static electricity can damage the sensitive laser head assembly.

The entire optical block is a single unit. When you encounter a defective optical assembly, you have to replace it as a unit.

Laser head properties

The laser head diode material may consist of GaAs/GAAlAs, Ga-Al-As, or GA-AL-AS material. The wavelength of the laser head diode may vary from 750nm to 820nm. The wavelength of the average CD player laser is around 780nm. The laser power output may vary from 0.15nW to 0.7nW (Figure 2).

There are several ways to test the laser head emission:

- an infrared card indicator,
- current and voltage measurements,

Davidson is a TV servicing consultant for **ES&T**.

CD PLAYER	DIODE MATERIAL	WAVELENGTH	LASER OUTPUT
ALPINE AUTO CD 5900	GaALAs	780nm	0.4mW
ONKYO DX-200	GaAs/GaAlAs	780nm	0.4mW
PIONEER PD7010	Ga-AL-As	780nm	0.26mW
SANYO CP660		775nm to 830nm	0.7mW
SONY CDX-5	GaAlAs	780nm	0.4mW

Figure 2. The laser diode material, wavelength and laser power output of the various CD players.

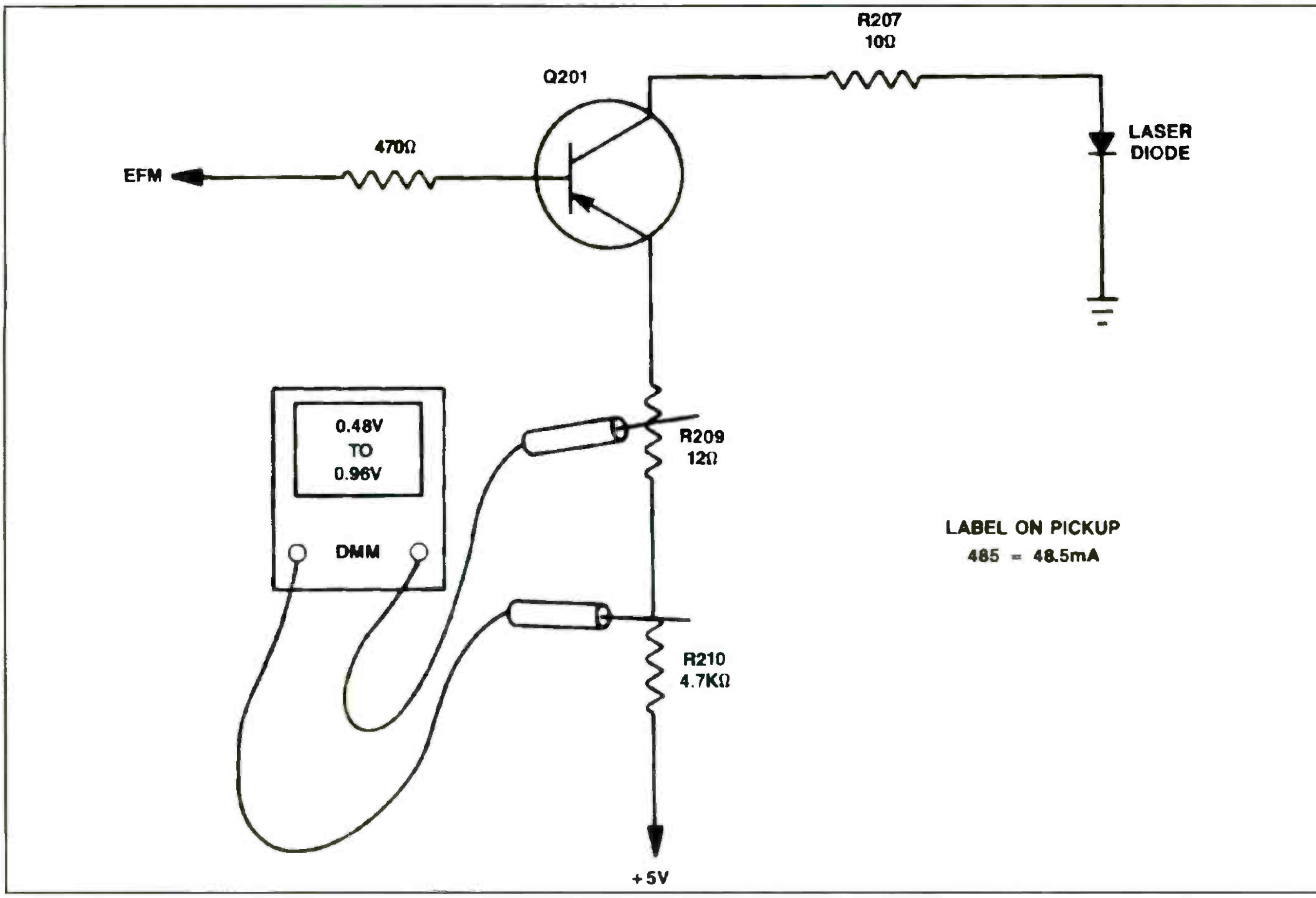


Figure 3. Voltage measurements across the emitter resistor can be converted to current, indicating if the laser diode is functioning.

- observation of the EFM waveform
- the laser power meter.

The easiest method to detect whether the laser is emitting an infrared signal is with the infrared indicator card, but the card does not indicate the amount of radiation emitted. The current and voltage checks will give the correct current drawn by the laser diode, but it is necessary to get inside the unit to make this measurement. The laser power meter is the best way to make this measurement: the meter is easily attached, and you can see the actual radiation measurement on the meter display.

Infrared card indicator

The infrared indicator is a plastic card that was designed for testing infrared remote controls. The card contains a small square that glows when it is irradiated by infrared. Expose the infrared card to ordinary light for at least 5 minutes before use. The small sensitive square area must be held directly over the lens area for correct test results.

The infrared indicator card will indicate infrared emission, but will not indicate the intensity, or tell you if the emission is sufficient to operate the optical lens pickup assembly. This infrared indicator card can be purchased at most electronic distributors, Radio Shack and RCA. The RCA part number is 153093.

Current and voltage checks

The laser diode emission checks can be made by measuring the amount of current drawn by the laser diode. Most CD players have a current label attached to the assembly. For instance, the laser label may read 0138-499, indicating the current value is 49.9mA. Remember, the current increases when the temperature rises and decreases when it drops. If the current that you measure is much greater than the current specified on the label, the APC circuit may be defective, or the laser diode may have deteriorated. In either case, the laser head assembly must be replaced.

In some CD chassis, a jumper wire may offer a test point where a current reading

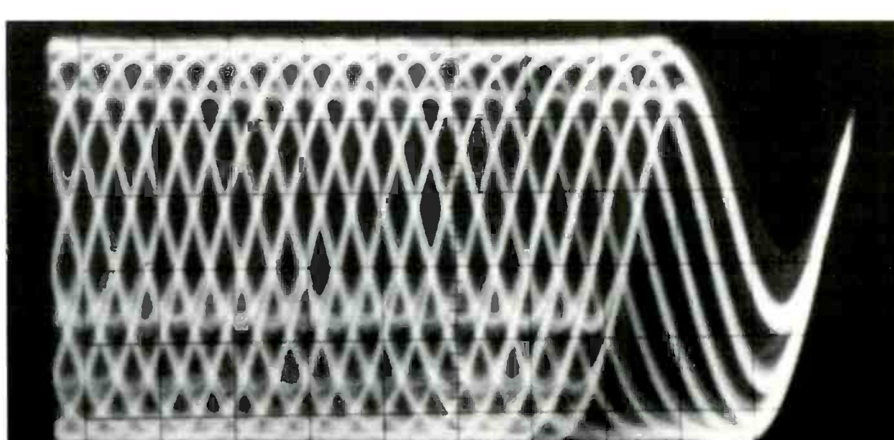


Figure 4. Presence of the EFM (eight-to-fourteen) waveform indicates that the laser optical assembly and rf amp are normal.

Figure 5. The laser power meter may also be used to test infrared TV and VCR remote transmitters.

can be obtained. Remove the plug and take a current measurement of the laser head diode. The current should match that shown in the CD service literature or on the laser power label.

Critical voltage tests

Another method to check the laser diode current is with a diode voltage measurement. Actually, in this case, the current drawn by the laser diode is determined by measuring the voltage across a fixed resistor in the laser drive emitter transistor circuit (Figure 3). Often, this voltage is less than 1V. Check the laser drive current by measuring the voltage across R209 (12Ω). Then compare the voltage measurement to the current label on the pickup assembly.

The current drawn by the laser diode equals the voltage divided by the resistance. In this case, where the resistance is 12V, simply dividing by 10, or moving the decimal point one place to the left, is a close enough approximation. If the voltage across R209 is 0.48V, the current should be roughly 0.048A or 48mA. The label on the pickup shows a reading of 485, which indicates 48.5mA.

In this case, the laser pickup head is normal. If the voltage measurement was 1V, the current would be too high and might indicate a defective laser diode. When the current is 10 percent or more in excess of the recommended value, replace the pick-up assembly.

EFM waveforms

The eight-to-fourteen (EFM) modulation waveform must be present or the CD player will shut down after searching. The correct EFM or "eye pattern" waveform is found downstream from the rf amp IC or transistor (Figure 4). The presence of this waveform indicates that the laser head and rf circuits are normal. Most CD players have a test point at which the eye pattern can be observed with the oscilloscope. The EFM signal is fed to the signal and servo processors and IC.

A low amplitude, jittery pattern, or no EFM waveform at all, may indicate a defective laser head assembly or rf amp circuits. Critical voltage and resistance measurements on the rf amp transistor or IC may determine if the rf amplifier is defective. When you find an improper EFM waveform at the rf amp but measure normal voltages on the rf transistor or IC, suspect a defective laser head assembly. In some cases you may have to replace the rf amp IC in order to determine if the EFM signal is present.

Although the presence of an EFM waveform indicates that there is an rf signal from the laser head assembly and the rf circuits, it does not indicate if the laser is drawing excessive current or has correct emission. The card indicator may indicate that infrared signal is present, but how much? Voltage and current measurements of the laser head circuits may provide a better indication of a defective laser diode, but this requires disassembly of the CD player. The quickest and best method to test the laser diode emission is with the laser power meter.

The laser power meter

Most CD player manufacturers recommend a certain laser power meter or provide them through the various electronic depots. I use an LPM 5673 Sanwa laser power meter (Figure 5). This low-priced meter is available through distributors.

This meter offers all required functions for the control of laser light sources. This instrument was particularly designed for service of the compact disc and laser disc

Figure 6. In most CD players, the infrared protecting interlock system must be defeated before the laser diode comes on.

Figure 7. The plastic lid of the portable CD player provides interlock protection as the lid must be closed before the unit will play.

players, with a narrow and tiltable probe. The instrument can be used on helium-neon lasers, such as used in distance meters and linear measuring instruments.

Besides CD player tests, the tester can check the function of cassette compartment LEDs in video recorders and the transmitting diode in infrared remote controls. The small black probe can be held against the end of the infrared remote to determine if the remote is emitting infrared signals.

There are three measuring ranges: 0.3mW, 1mW and 3mW, which can check all infrared lighting sources found in consumer electronics. The meter display includes three measuring ranges of measured light output with the upper scale at 0.1mW, intermediate scale 0.3mW and lower scale of 0 to 0.3mW, and an extra scale for the display of the condition of the battery that powers the instrument.

A wavelength selector switch will set the value length of the laser light at 633nm for helium-neon-red lasers, and at 750nm to 820nm for CD and LD players and for infrared measurement. The function switch determines the desired function and measuring range. Also, the function switch turns the laser meter off and on.

Figure 8. Check the suspected remote control with the infrared laser meter using the higher power ranges.

Using a laser power meter

To use this meter, connect the test probe to Jack 8. Set the function selector switch to the "Batt Test" position. If the meter hand stops in the good range, the batteries are normal and the tester is ready to check infrared light. The meter indicator will be deflected when the probe is turned toward sunlight or a service bench light. The probe should not be directly pointed at the sun or strong light, or the meter and probe might be damaged.

Check the battery condition each time the laser power meter is used. Observe the manufacturer's safety instructions in the service manual of the CD player. The specified laser output is listed in most CD manuals. Set the required measuring range with the function switch. Set the switch to the correct wavelength at 750nm to 820nm for CD or LD players.

In cases where the specified output of the laser diode in the CD player is not known, begin with the meter set to the highest range. Most CD player diode outputs are below the 1mW range. Rotate the switch to the 0 to 0.3mW range. Position the probe with the round window over the CD lens assembly. You may have to move the black probe around to get the maximum reading.

If the probe is positioned at an angle to the light beam, reflections will occur and result in a distorted measurement. Strong overhead light may cause an improper reading, so make your measurements away from the service center's main lighting. When the round hole of the probe is directly over the lens opening, the laser diode measurement will be maximum (Figure 6).

Keep the window of the probe clean of lint, dirt and smudges. If the sensor window is soiled, you'll get a distorted measurement. Clean off the sensor window with a cloth or swab moistened with the same solution used to clean the lens area of the CD player.

Read the measured value on the laser power meter. Compare this measurement with that given in the service manual for the compact disc player. Adjust the laser power output according to the manufacturer's service manual. If the service manual is not available, compare the readings with similar compact disc players.

Defeated interlock

CD players have an interlock system that prevents the laser from operating unless there's a disk in the tray and everything is properly closed up. This interlock system must be defeated during service in order to cause the laser diode to emit infrared light. Notice in Figure 6, in the case of this Sanyo CD player, a piece of cardboard is placed between the LED and the disc hole area keeping the LED light from striking the interlock sensor, thus providing operation of the CD player functions. Place either a piece of plastic tape or cardboard between hole and LED to make the player function. Remember, the laser beam is on when this interlock is defeated. Keep your eyes away from the lens area.

In most portable CD players, the top lid engages an interlock switch that turns on the player and laser diode when the lid is closed (Figure 7). A small screwdriver blade can be used to push down and engage the interlock switch, so that the intensity of the infrared light from the laser diode in this RCA CD portable may be measured.

Use a toothpick or a plastic pointed tool to defeat the interlock switch in other portable models. Clipping a wire across the interlock switch is another way to provide CD player action when the unit is opened up for service. Do not forget to remove the defeated interlock switch after repairs are made.

Testing remote control units

The laser power meter may be used to check infrared remote control units as well. If the plastic pickup is placed against the infrared source, the 1mW or 3mW range should be used (Figure 8). Comparison measurements of the defeated infrared remotes can be marked or indicated on the meter scale. A weak or defective infrared remote transmitter may provide insufficient or no measurement on the laser power meter. ■

Tips on using test equipment probes

By Vaughn D. Martin

Parts I, II, and II of test equipment probes were published in October and November of '93 and in January '94. This article provides a number of tips on using those test probes.

The most common mistake in making scope measurements is forgetting to compensate the probe. Improperly compensated probes can distort the waveforms displayed on the scope. The probe should be compensated as it will be used when you make the measurement (Figure 1).

The basic low frequency compensation (L.F. comp.) procedure is simple. Connect the probe tip to the scope calibrator outputs. Switch the channel 1 input coupling to dc. Turn on the scope and move the CH1 VOLTS/DIV switch to produce about four divisions of vertical display. Set the sweep rate to 1msec/div. Use a non-metallic alignment tool to turn the compensation adjust until the tops and bottoms of the square wave are flat.

Martin is Chief Engineer in the Automatic Test System Division at Kelly Air Force Base.

Choosing the right ground option

Make sure the ground in the device under test (DUT) is the same as the scope

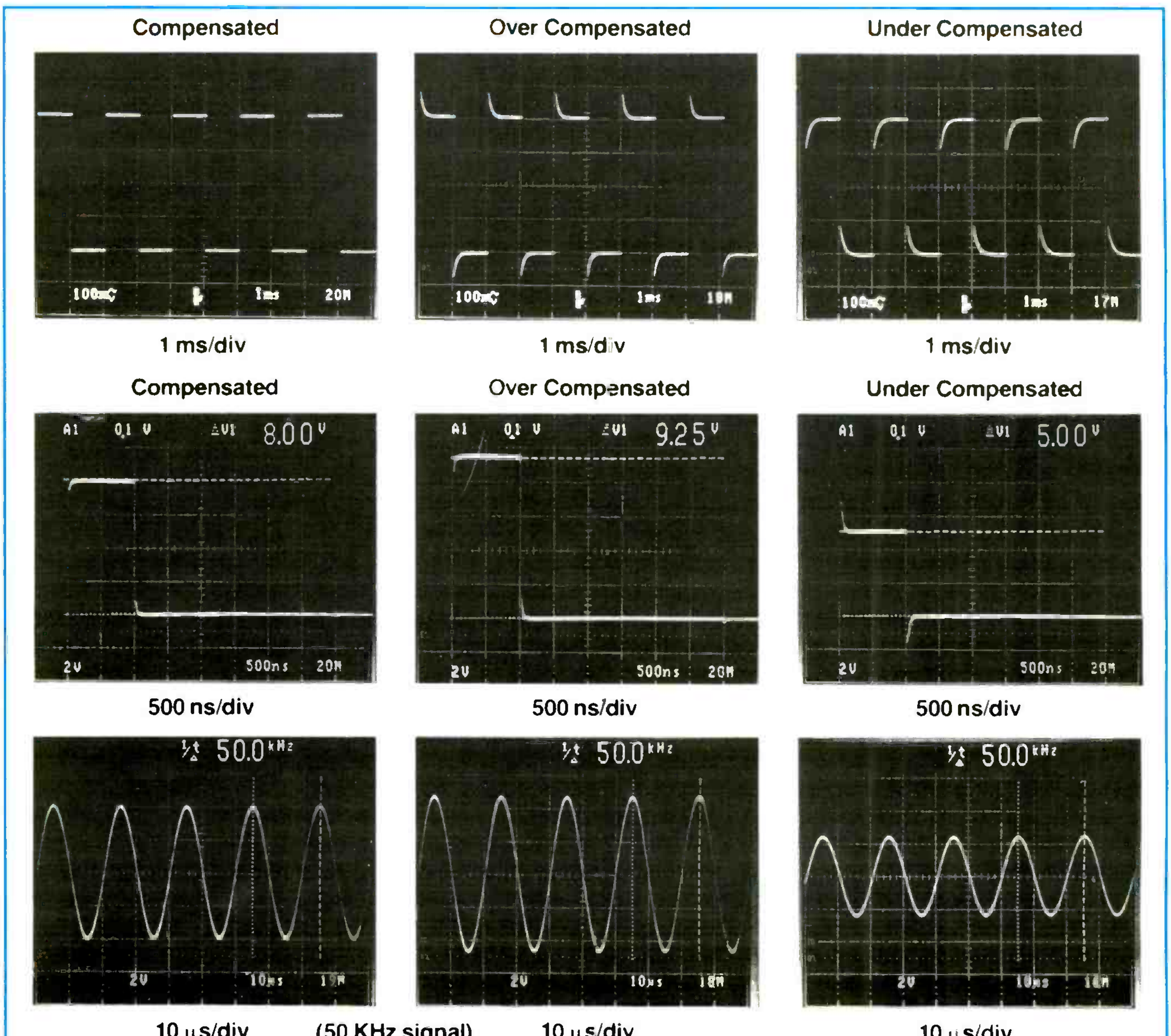


Figure 1. Compensating the probe.

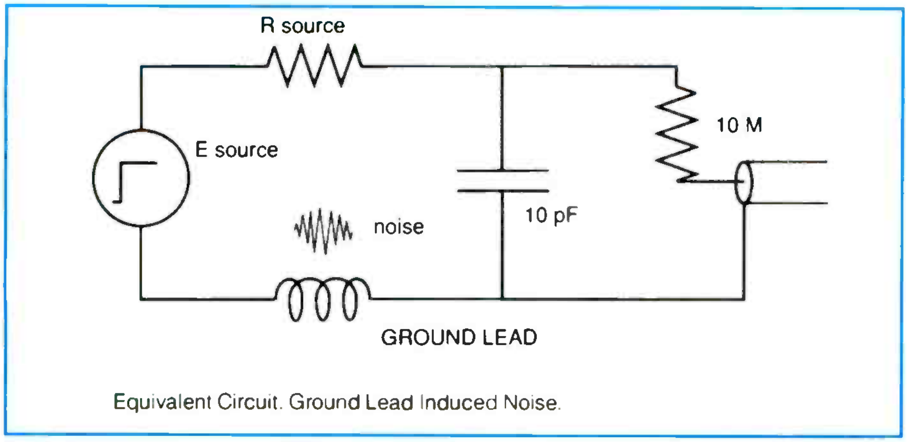


Figure 2. An equivalent circuit of induced ground lead noise.

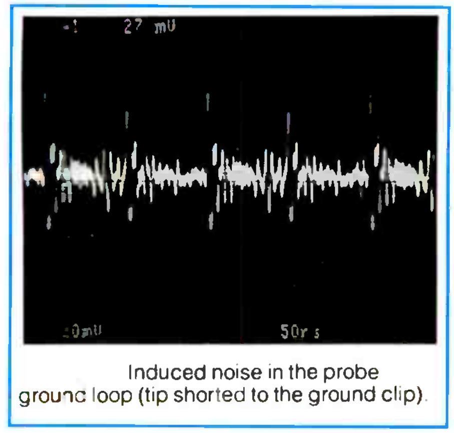


Figure 3. Induced noise in the ground loop with the probe tip shorted to the ground clip.

ground (don't assume it is). The scope ground is always common to the DUT ground if you are using the power cord and plug and it's plugged into the same three wire outlet system as used by the DUT. Check the circuit ground by touching the probe tip to the point you think is ground—before making a hard ground by attaching the ground strap of your probe.

When you're servicing a modern TV set, or other product that uses a full-wave bridge rectifier, however, be certain to plug the unit being serviced into the power line through an isolation transformer. If you plug both the unit to be tested and the oscilloscope into the same power line without isolation, at least one of the diodes in the power supply will be short-circuited, and you will damage the unit to be tested, and possibly the oscilloscope as well.

If you intend to probe many points in the same circuit and measure low frequencies, you can ground the circuit to your scope once, instead of every time you move the probe. Connect the circuit ground to the GND jack on the scope front panel. A special problem that occurs when measuring very high speed signals is ringing due to inductance in the ground-return path. Probes come with a wide range of grounding accessories, allowing you to pick the right ground leads for the DUT's signal frequency range.

Optional accessories include BNC-to-probe-tip adapters and etched circuit board (ECB) probe test jacks. Choosing the right tip for the frequencies measured can minimize ground-path ringing.

Caring for the probe tip

Following a few guidelines will prolong the lifetime of your probe tip. When you are not using the probe, cover the tip with the tip protector that is supplied with most probes. Use the correct adapter, such as an IC grabber or a retractor tip.

Don't use the probe to scrape through insulation, pry components from their sockets, or move components. Don't use the probe to hold down components while soldering in place. Remember, no matter how well it is made, every probe has its breaking point. All probes should be used with care, as you would any other precision tool.

Pitfalls in using probes

Watch out for these pitfalls:

- Using probes without checking low-frequency compensation.
- Not using ground leads or using ground leads that are too long (that cause ringing).
- Connecting a probe ground lead to elevated ("hot") circuitry. The resulting damage is not covered by probe warranties.
- Using too long a ground lead length. All things being equal, the shortest ground lead produces the highest ring frequency.

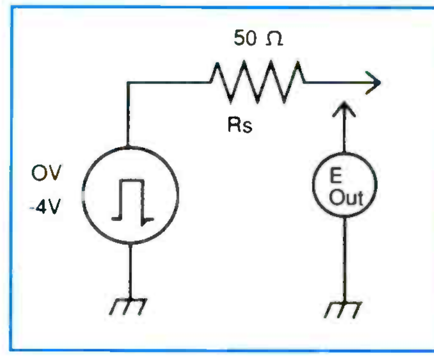


Figure 4. The principle of operation of a bias offset probe.

If the lead is very short, the ring frequency might be high enough to be outside the passband of the scope, and/or the input frequency content may not be high enough to stimulate the ground lead's resonant circuit. In all cases, use the shortest ground lead, consistent with the need for probe mobility. If possible, use 3-inch or shorter ground leads, such as the low impedance contact (Z lead).

The correct probe grounding method depends on the signal's high frequency content, and the need for mobility between test points. A 12-inch ground lead

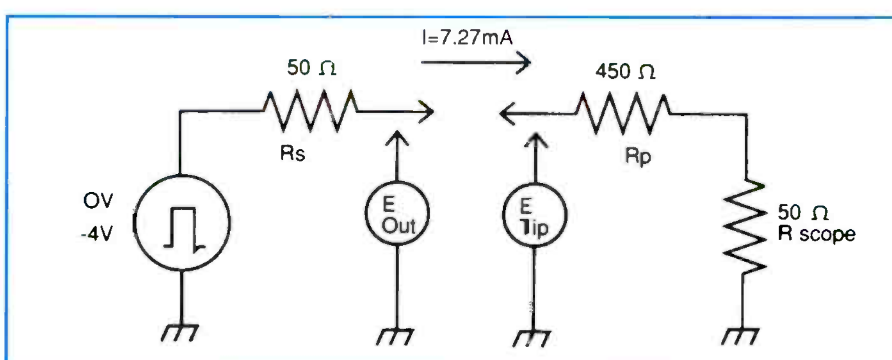


Figure 5. A bias offset probe connected to a 50Ω source.

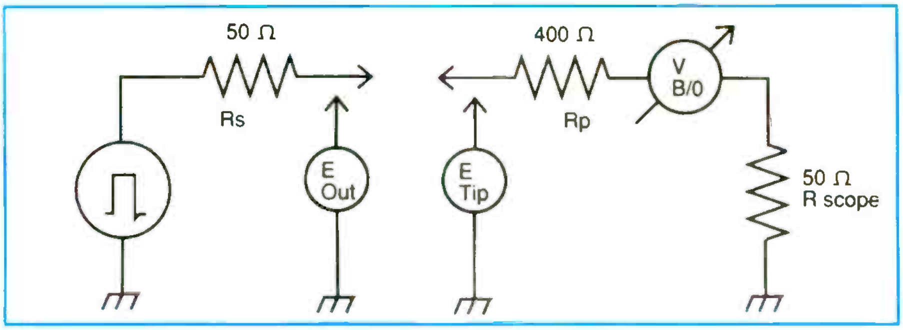
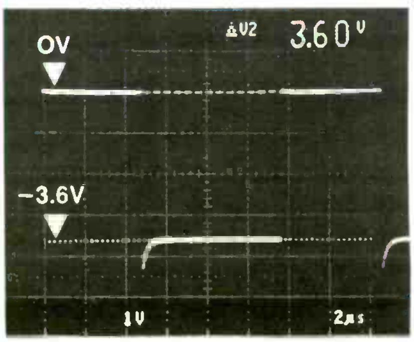
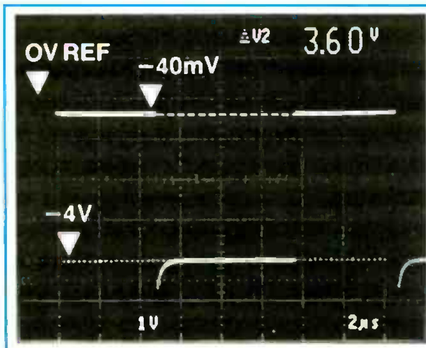


Figure 6. A negative-going pulse acquired by a 10MΩ probe.



Effect of connecting a 450 Ω Bias/Offset probe (offset = 0 V). Minus level has been reduced by 10%.

Figure 7. The same pulse as that in Figure 6, acquired with a 450Ω probe added.



. Bias/Offset adjusted for −4 V. Signal current at the −4 V level is zero. Current flow at ground level is maximum. Peak to peak amplitude remains the same (10% down).

Figure 8. Adjusting bias to offset loading effects.

may be perfect for many lower frequency applications. It will provide you with extra mobility, and nothing will be gained by using shorter leads.

Ground loop noise injection

Another form of signal distortion can be caused by signal injection into the grounding system. This can be caused by unwanted current flow in the ground loop existing between the common scope and test circuit power line grounds, and the probe ground lead and cable. Normally, all these points are, or should be, at zero volts, and no ground current will flow.

However, if the scope and test circuit are on different building system grounds, there could be small voltage differences, or noise on one of the building ground systems. The resulting current flow (at line frequency or noise frequency) will develop a voltage drop across the probe cable's outer shield, and be injected into the scope in series with the desired signal.

Inductive pick-up in ground loops

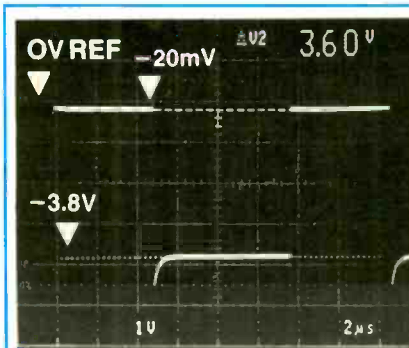
Noise can enter a common ground system by induction into 50Ω signal acquisition cables, or into standard probe cables. Proximity to power cables or other current-carrying conductors can induce current flow in the probe's outer cable, or in standard 50Ω coax. The circuit is completed through the building system common ground.

Prevention of ground loop noise problems

To eliminate or minimize ground loop noise problems, keep all signal acquisition probes and/or cables away from sources of potential interference. Verify the integrity of the building system ground. If the problem persists, open the ground loop:

- by using a ground isolation monitor,
- by using a line isolation transformer on either the test circuit or the scope,
- by using an isolation amplifier,
- by using differential probes.

NOTE: Never defeat the safety 3-wire ground system on either the scope or the test circuit. Do not "float" the scope, except by using an approved isolation transformer, or preferably, by using a ground isolation monitor.



Bias/Offset adjusted for −2 V. Load current distributed between the negative and positive-going swings. Peak to peak amplitude remains the same (10% down).

Figure 9. Adjusting bias to equally distribute current.

Induced noise in probe ground leads

The typical probe ground lead resembles a single-turn loop antenna when it is connected to the test circuit. The relatively low impedance of the test circuit can couple any induced voltages in the probe (Figure 2).

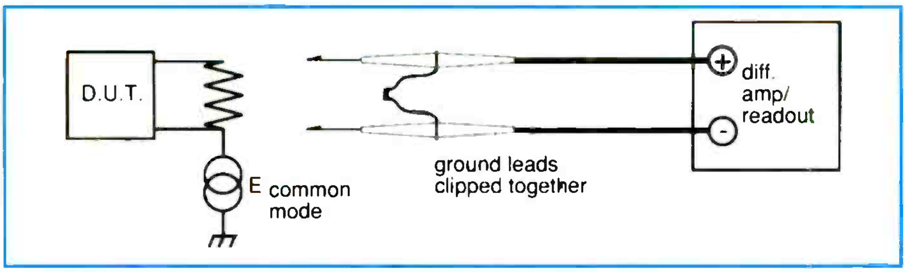
High speed logic circuits can produce significant electromagnetic (radiated) noise at close quarters. If the probe ground lead is positioned too close to certain areas on the board, interference signals could be picked up by the loop antenna formed by the probe ground lead, and mixed with the probe tip signal.

Is this what my signal really looks like?

If you suspect that the signal you're looking at contains noise, moving the probe ground lead around will help identify the problem. If the noise level changes, you have a ground lead induced noise problem. A more positive way of identification is to disconnect the probe from the signal source and clip the ground lead to the probe tip. Now use the probe/ground lead as a loop antenna and search the board for radiated noise.

Figure 3 shows what can be found on a logic board, with the probe tip shorted to the ground lead. This is radiated noise, induced in the single-turn loop and fed to the probe tip. The significance of any induced or injected noise increases with reduced working signal levels, because the signal to noise ratio will be degraded. This is especially true with ECL, where

(Continued on page 43)



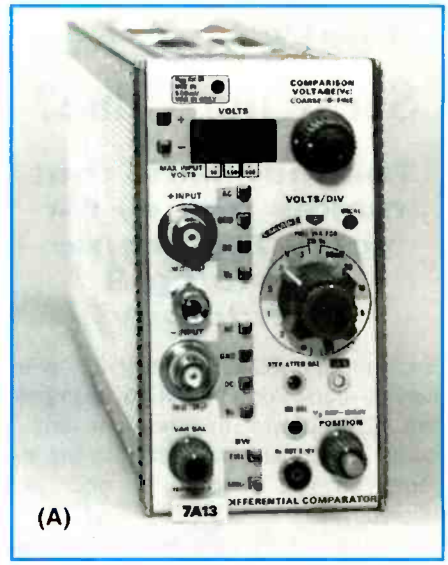


Figure 10. A basic setup for making a differential measurement.

signal levels are 1V or less.

In order to eliminate this problem, use an ECB-to-probe-tip adapter (test point) if possible. If this is not possible, use a Z lead or short flexible ground lead. Also, bunch the ground lead together to make the loop area as small as possible.

Bias/offset probes

A bias/offset probe is a special kind of low-Z design with the capability of providing a variable bias or offset voltage at the probe tip. These probes are useful for probing high speed ECL circuitry, where resistive loading could upset the operating point. They are also useful for probing higher amplitude signals (up to 5V), where resistive loading could affect the dc level at some point on the waveform.

Bias/offset probes are designed with a tip resistance of 450Ω (10x). When these probes are connected into a 50Ω environment, this loading results in a 10% reduction in peak-to-peak source amplitude. This round-figure loading is more convenient to handle than that produced by a standard 500Ω (10x) low-Z probe, which would work out at 9.09% under the same conditions. Bias/offset probes always present a 450Ω resistive load to the source, regardless of the bias/offset voltage selected.

The difference between bias/offset and standard low-Z probes lies in their ability to null current flow at some specific and selectable point on the input waveform (within 5V). To see how bias/offset probes work, let's take a typical 10 x 500Ω low-Z probe and connect it in the circuit (Figure 4). By taking a current flow approach we find that at one point on the waveform the source voltage is -4V; therefore, the load current will be:

4V/550Ω = 7.27mA

Therefore, the voltage drop across the 50Ω source resistance (Rs) will be:

7.27mA x 50Ω = 363mV

And the measured pulse amplitude will be 4 – 0.363V = 3.637V (E DUT), or about 9% down from its unloaded state.

If we substitute the 500Ω low-Z probe with a 450Ω bias/offset probe, the circuit will look like Figure 5. With the bias/offset adjusted for 0V, the effect on the circuit will be similar to a 500Ω low-Z probe, except for a small resistive change.

Figure 6 shows the source waveform acquired by a 10MΩ probe. Figure 7 shows the effect on the waveform when the 450Ω probe is added. As expected, the pulse amplitude has reduced from -4V to 3.60V or exactly 10% down.

Figure 8 shows the effect of adjusting the offset to -4V. The -4V bias opposes the signal at the -4V level and results in zero current flow, and the source is effectively unloaded at this point. However, when the signal returns to ground level, there is a 4V differential between the top of the pulse and the bias/offset source. Current will flow and Ohm's law will dictate that the top of the pulse will go negative by -40mV (10%).

Sometimes it is desirable to adjust the offset midway between the peak-to-peak excursions. This distributes the effect of resistive loading between the two voltage swings. Figure 9 shows the effect of adjusting the bias/offset to -2V. Current flow will be the same for both signal swings, and they will be equally down by 5%, for a total of 10%.

A summary of the use of bias/offset probes

- Bias/offset probes can be adjusted (within ±5V) to provide zero resistive (effective) loading at one selected point on the input waveform.
- Bias/offset probes can be used to simulate the effect of pull-up or pull-down voltages (within ±5V) on the circuit under test (voltage source impedance is 450Ω).
- Bias/offset probes always present a total resistive load of 450Ω, and reduce the peak-to-peak amplitude of 50Ω sources by 10%.
- For simplicity, we have ignored the effects of capacitive loading. Typically, bias/offset probes have less than 2μF tip capacitance. Bias/offset probes like the

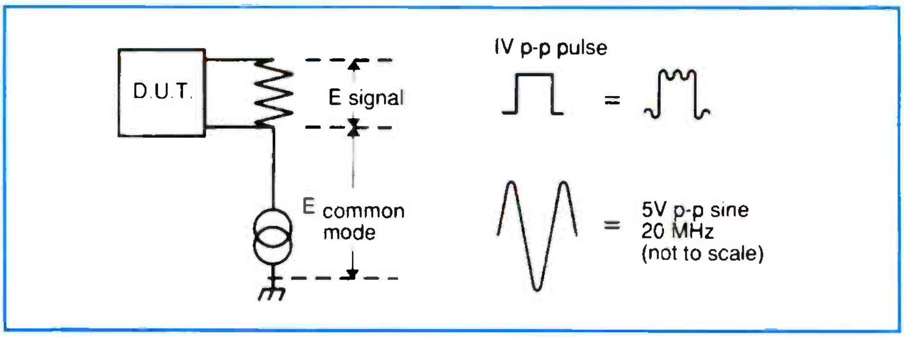


Figure 11. A simplified block diagram of a device under test.

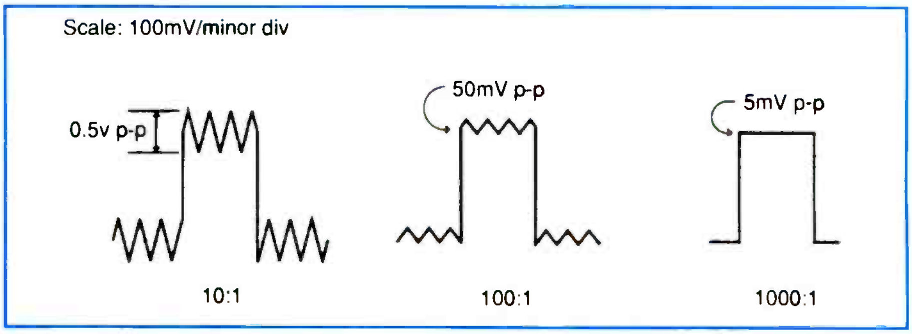


Figure 12. "Cleaning up" a signal by increasing the CMRR.

Tektronix P6230 or P6231 have bandwidths to 1.5GHz, 450Ω input R, and 1.3μF (P6230), or 1.6μF (P6231) input capacitance.

They provide offset voltages of ±5Vdc, and function with 1MΩ or 50Ω input systems (P6231, 50Ω only).

The P6231 is designed to operate with the Tektronix 11000 Series scopes, and obtains operating power and bias/offset from the scope. Offset is selectable from the mainframe touch screen.

Differential probing techniques

Accessing small signals elevated from ground, either at an ac level or a combination of ac and dc, requires the use of differential probes and a differential amplifier system. One of the problems associated with differential measurements is the maintenance of high common mode rejection ratio (CMRR) at high common mode frequencies. Poor common mode performance allows a significant portion of the common (elevated) voltage to appear across the differential probes inputs.

If the common mode voltage is pure dc, the result may be only a displayed baseline shift. However, if the common mode voltage is ac, or a combination of ac and dc, a significant portion may appear across the differential input and will mix with the desired signal.

Figure 10 shows the basic items necessary to make a differential measurement. Figures 10a and 10b are accessories for these measurements. The Tek 7A13 differential amplifier serves as a scope plug in and alleviates all offset problems. The HP1141A differential active probe, and its power module, the 1142A, provide a 1:1 division ratio through FET inputs with 200MHz bandwidth and a 3,000:1 CMRR.

Figure 13. The HP 1133A TV/video sync pod probe accessory.

In this example, two similar but unmatched passive probes are used. The probe ground leads are usually either removed or clipped together. They are never connected to the elevated DUT.

Figure 14. The HP 1137 A 5kV high-voltage probe.

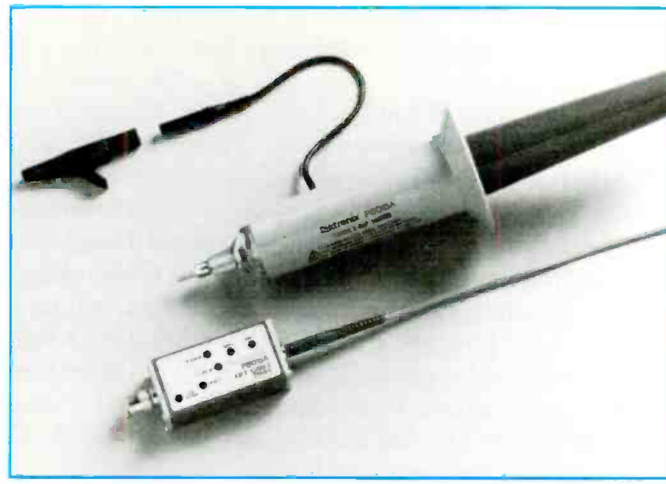


Figure 15. The Tektronix P6015A 40kV high-voltage probe.

CMRR depends upon accurate matching of the probe-pair's electrical characteristics, including cable length. System CMRR can be no better than the differential amplifier's specifications, CMRR degrades as a function of frequency.

Figure 11 shows a simplified diagram of a DUT with a pulsed output of $1V_{PP}$ floating on a $5V_{PP}$ 20MHz sinewave. CMRR at 20MHz is a poor 10:1 because of the unmatched probes.

Observed signal (referred to probe input) = $1V_{PP}$ pulse + ($5V_{PP}$ sine/10 = $1V_{PP}$ pulse + $0.5V_{PP}$ sine.

Figure 12a shows what the displayed waveform might look like under the conditions shown in Figure 11. In comparison, Figures 12B and 12C show what the displayed signal might look like at CMRRs of 100:1 and 1000:1.

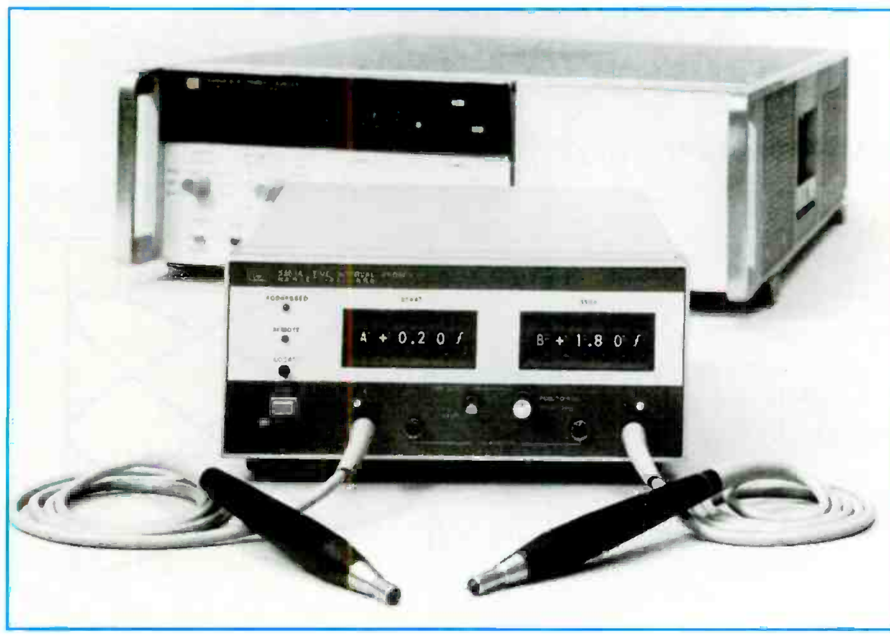


Figure 16. The HP 5363 time interval probe.

Differential probe types

There are two general types of differential probes: passive matched pairs and active one-piece differential probes. The Tektronix P6055 and P6135 passive matched probe-pairs provide a 100:1 CMRR at 20MHz when used with appropriate differential amplifiers, and can provide CMRRs of up to 20,000:1 at low frequencies. (P6135, 10,000:1, P6055, 20,000:1).

Active Differential Probes

Passive probes impose a limit on CMRR at high frequencies because of the physical and electrical characteristics, and the separation from the differential amplifier. This barrier is overcome by moving the differential amplifier out to the probe tips on an active differential probe. Now lead lengths and electrical parameters can be accurately controlled to produce superior high frequency CMRR performance.

The Tektronix P6046 active differential probe houses dual input FETs, a differential amplifier, and a line driver in the probe body. A 10X dual attenuator can be used to extend the basic operating range of the system, and various probe tips can be used to access variously spaced test points. At the scope's end, a power supply and a calibrated Volts/div switch provides ranges of 1mV/div to 200mV/div when the scope sensitivity is set to 10mV/div.

Because differential signal processing is performed at the probe tip, common mode rejection can be as high as 1,000:1 at 50MHz. Contrast this with 100:1 at 20MHz for the best passive probe-pair performance (See Figure 12). The P6046 system is compatible with a wide range of scopes and measuring devices with single-ended 1MΩ inputs. No external differential amplifiers are required.

Common mode linear dynamic range

Linear dynamic range figures are unique to active probes, and refer to the maximum voltage swing (dc + peak ac) between ground and the probe tip before some degree of non-linearity shows.

In the case of differential active probes, this parameter is called common mode linear dynamic range, and specifies the maximum voltage of the probe inputs from ground (dc + peak ac) before signal non-linearity manifests itself. The P6046 can access signals that are elevated up to

± 5V from ground (dc + peak ac) at 1x, and up to ±50V with the 10x attenuator.

Two types of handy TV service probes

The HP 1133A TV/video sync pod (Figure 13), gives clamped and unclamped video output, trigger output for line or frame, and is compatible to most standard broadcast composite video systems.

This sync pod gives you TV sync triggering for most analog and digital scopes, and provides clamped or unclamped video outputs. You can view these signal on your scope's vertical channels. You also have trigger outputs allowing you to view the video line of your choice.

This unit has a separate ac power module. It features a loop-through input (two female BNC connectors) which you can drive from 75Ω sources. This loop-through feature allows you to loop a 75Ω signal through the sync pod, then connect it to a video monitor or other device. The clamped and unclamped video outputs easily drive a high impedance (1MΩ to 10MΩ) probe connected to a scope.

The pod is compatible with broadcast standards M, N, C, B, G, H, I, D, K, K1 and L systems.

Another probe is the high voltage 1,000:1 divider probes used on TV high voltage power supplies. The probe shown in Figure 14 operates up to 5kV. However, if you need to go up to 40kV (peak pulse) you'll have to use one such as the one shown in Figure 15. This also handles frequencies to 100kHz and has from 12pF to 47pF shunt capacitance.

A time interval probe

The last probe we will cover is an unusual one you may never have even thought of, but it proves very handy. Refer to Figure 16, this is an HP 5363A time interval probe. You use this instrument probe with frequency counters. But, first, let's review how a frequency counter works.

In greatly simplified terms, a counter is a gate that opens and allows a counter to run as long as the gate is enabled. When the gate is closed, the count is totalized. Say the count is exactly 1,000,000 and the counter has a 10MHz time base (crystal). That means the gate was opened for 0.1 seconds so the waveform may have a 10Hz frequency.

What if you have two channels and the input processing circuitry and the delays in the two input cables to this counter vary slightly. This can be a real problem is you are seeking extremely accurate and repeatable measurements. This is where you can "equalize" each channel.

More specifically, taking a typical frequency counter, there are probes, internal cabling, and differential delays amounting to 700 picoseconds inside the timing channel. Therefore, the absolute accuracy of the time interval is an unknown but fixed amount. How can this be solved?

This time interval probe has a 20V dynamic range of ±10V on each channel in 10mV increments. This guarantees triggering at the same point on each channel by merely measuring one channel with an input signal and swapping the same signal to the other channel and adjusting this time interval probe, by 10mV increments, until the two channels have exactly equal results.

The large variety of test equipment probes, standard and specialized, provides the servicing technician with a number of ways to extend the usefulness of the test equipment on the service bench. A knowledge of some of these probes and their use can help the technician use the available test equipment to its fullest. ■

Test Your Electronics Knowledge

Answers to the quiz

(from page 19)

1. The output power is approximately twice the input power, or 10.4W. (See WDYKAE? in this issue.)

2. The output power is approximately one-half the input power, or 4.9W. (See WDYKAE? in this issue.)

3. 13.9W. If you tried to calculate the gain using the equation:

$dB = 20\log(V_2/V_1)$,

you got the wrong answer. That equation only works if the input and output impedances are the same. Calculate the input and output impedances using:

$P=V^2/R$.

Then use the equation:

$dB = 10\log(P_2/P_1)$.

4. It is used for measuring RPM (revolutions per minute).

5. Voltage controlled oscillator.

6. See Figure 3. Note that horizontal and vertical lines are drawn against the curve. The number of times the curve touches the vertical line divided by the number of times it touches the horizontal line is equal to the horizontal frequency divided by the vertical frequency. In this case 3:2 = 450:f_V. Therefore, f_V = (450 x 2)/3 = 300Hz.

7. 1Ω. It is calculated the same way as four 4Ω resistors in parallel.

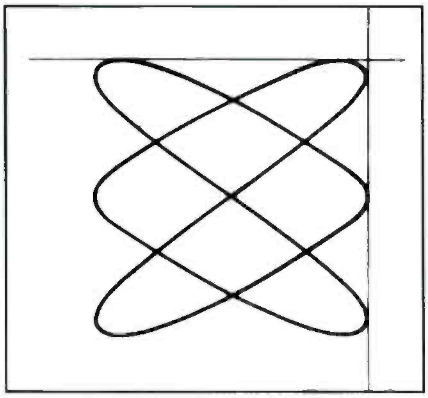


Figure 3. To solve TYEK question number 6, draw horizontal and vertical lines against the curve as shown here. The number of times the curve touches the vertical line divided by the number of times it touches the horizontal line is equal to the horizontal frequency divided by the vertical frequency. In this case 3:2 = 450:f_V. Therefore, f_V = (450 x2)/3 = 300Hz.

8. The correct answer is A. Partition noise occurs when a few of the charge carriers go (randomly) to the signal input electrode rather than the output electrode. That cannot happen in a MOSFET because the gate is insulated from the channel.

9. The answer is A. Gain and bandwidth are tradeoffs in an amplifier.

10. The answer is B. The voltage on the drain can be over 600V with respect to the source.

NTSC Part I — Sync signals and timing

By Arthur Flavell

This is the first in a series of three articles that will explore the NTSC video signal and how it relates to servicing video equipment. Part I looks at sync signals, their functions in circuit control and the composite nature of NTSC video. Part II outlines the luminance (black and white) and chrominance (color) signals. Part III shows how baseband video and audio signals are used to modulate RF carriers for use in video cassette recorders, broadcast, cable and MATV applications.

NTSC video

When color was added to television in the early 1950's, the need for new technical specifications and operating requirements was apparent. The National Television Standards Committee (NTSC) was charged with developing a broadcast system that would meet the needs of color transmission, yet be compatible with the existing monochrome (black and white) format. The NTSC color video signal standard was born.

NTSC video is a *composite signal*. Composite simply means that several independent signals are mixed together to form a single output. Included in the composite are vertical synchronization (V SYNC), horizontal synchronization (H SYNC), luminance (Y) and chrominance (C).

Flavell is owner of an independent consumer electronics service center in Alaska

What are sync signals?

Sync signals are square wave pulse trains with specific frequency, amplitude and waveshape characteristics. Their primary function is to control the operation of the sweep circuits in a monitor or television receiver, creating a properly positioned and stable reproduced picture. In addition, they are used as reference signals for other circuits, such as head switching and servo systems in VCRs.

In RF systems, sync produces a higher level of modulation than other elements of the composite signal. For this reason, received sync signals are often used in the control of AGC circuits. To ensure compatibility and optimum operation among the many types of NTSC equipment in use, sync signals must meet strict standards of frequency, timing and waveshape.

Where does sync come from?

Sync originates with the creator of the video signal. In commercial facilities,

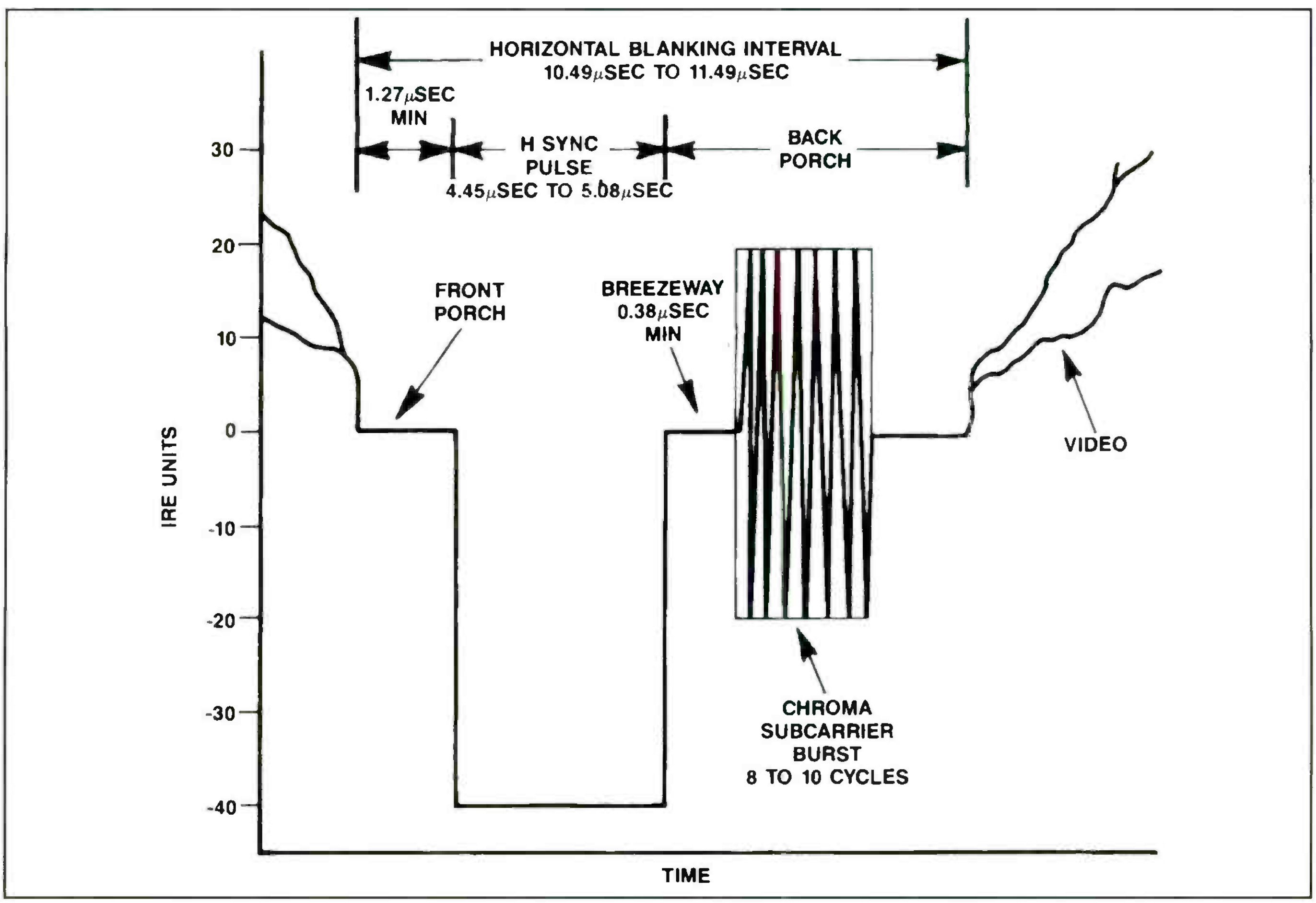


Figure 1.

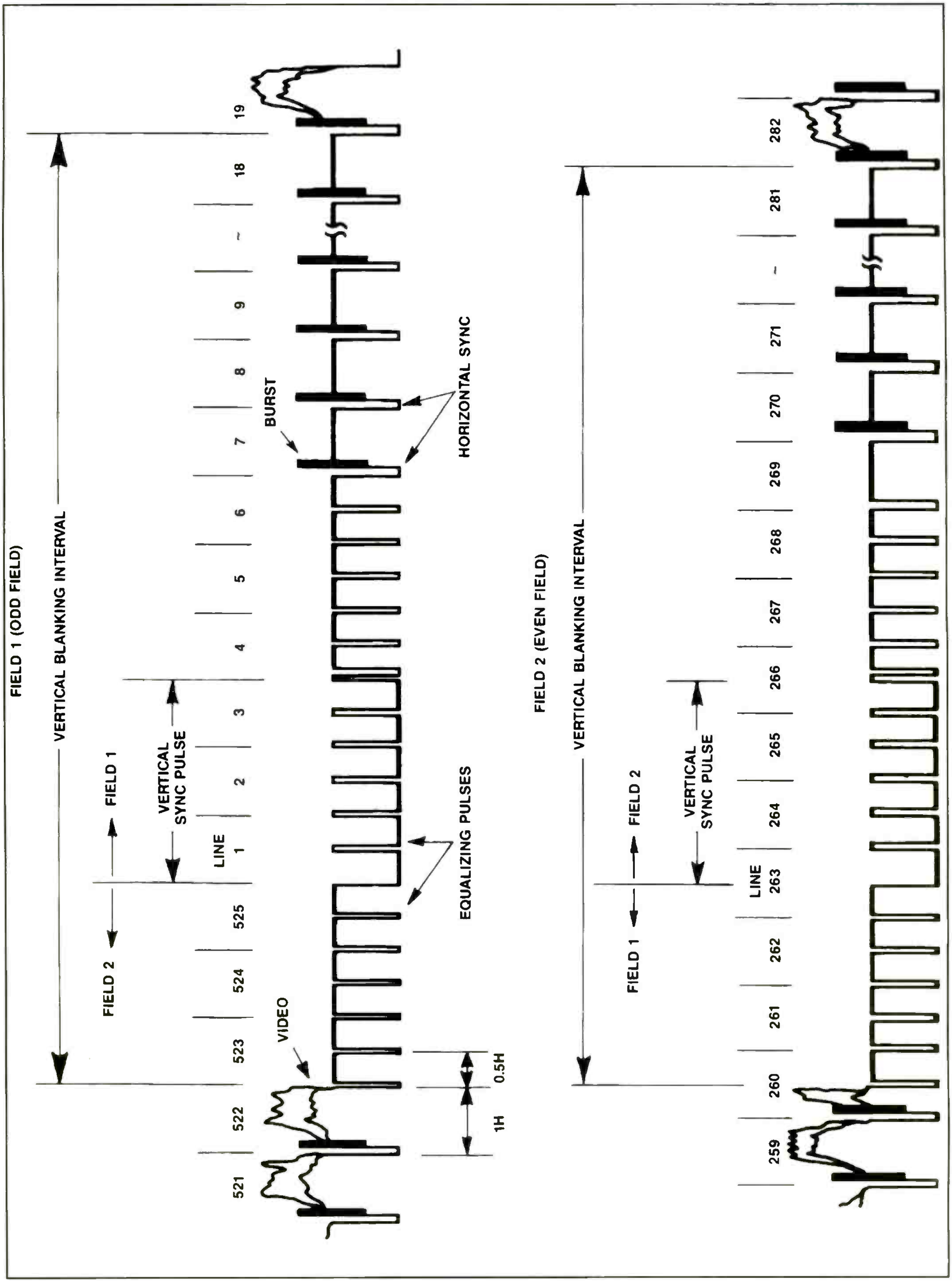

FIELD 1 (ODD FIELD)
VERTICAL BLANKING INTERVAL
FIELD 2
FIELD 1
VERTICAL SYNC PULSE
LINE
521
522
523
524
525
1
2
3
4
5
6
7
8
9
~
18
19
VIDEO
BURST
HORIZONTAL SYNC
EQUALIZING PULSES
0.5H
1H
FIELD 2 (EVEN FIELD)
VERTICAL BLANKING INTERVAL
FIELD 1
FIELD 2
VERTICAL SYNC PULSE
LINE
259
260
261
262
263
264
265
266
267
268
269
270
271
~
281
282

Figure 2.

such as broadcast TV or production studios, a master sync generator is used. In the case of local origination, such as a consumer camcorder, sync circuits in the camera produce the signals.

Virtually every frequency in the NTSC standard is mathematically related to the frequency of the *chroma subcarrier*. This frequency is specified as 3.579545MHz and is designated f_C.

Sync signals are derived from a highly stable, crystal-controlled oscillator. A master oscillator using a frequency of $4f_C$ (4 x 3.579545MHz) or 14.31818MHz is commonly used. Because the frequencies of sync signals are mathematically related to the chroma subcarrier frequency, they may be developed from the master oscillator by frequency division circuits.

Horizontal sync

The horizontal sync signal controls left to right scanning of the raster during picture reproduction. The NTSC standard specifies 525 horizontal lines for each complete picture. The horizontal scan rate is f_C divided by 227.5 or 15.734264kHz. The total time for one left to right scan is known as the horizontal interval. Its duration is the reciprocal of the scan rate or 63.556μseconds.

The sync pulse occupies only a small part of the total horizontal interval. It is a square wave in shape with a nominal duration of 4.64μseconds. When the leading edge of the sync pulse is detected, the sweep circuits reset the scanning electron beam to the left side of the picture in a process known as retrace.

Retrace occurs very quickly relative to the time of the left-to-right scan of the horizontal trace. To prevent the retrace from appearing to the viewer, the video circuits are blanked off for a period of time known as the *horizontal blanking interval*. It has a nominal duration of 11μsec (Figure 1).

Timing relationships during the horizontal blanking interval are critical to proper circuit operation. To provide easy reference to specific segments of the interval, different areas have been given names. The *front porch* is a minimum 1.27μsec interval from the beginning of the blanking interval to the beginning of the sync pulse. The *back porch* is the interval from the end of the sync pulse to the end of the blanking interval. The *breezeway* is part of the back porch and lies between the end of the sync pulse and the beginning of the *chroma subcarrier burst*.

Each of these intervals has a specific duration. These are particularly important when performing camera circuit alignments. Errors in alignment can result in compatibility problems, unstable pictures or total loss of sync control. Follow the manufacturer's specifications for setting timing intervals as closely as possible.

The sync signal must also meet amplitude requirements. The NTSC system specifies a standard video output of $1V_{PP}$ into a 75Ω load. To make alignment easier, this signal has been divided into 140 parts known as "IRE" units. The baseline for measurement is 0 IRE units and represents the blanking level. The area from 0 to 100 IRE units defines luminance limits. Sync occupies the area from 0 to -40 IRE units. The sync voltage is 40/140 x 1V or $286mV_{PP}$. Errors in adjustment of sync amplitude can result in erratic sync circuit operation. This may be evident as horizontal jitter or loss of sync control and picture tearing.

Vertical sync

The vertical sync signal controls top to bottom scanning of the raster. The rate of production of complete pictures is called the frame rate. Its frequency is determined by dividing the horizontal scan rate by the number of scan lines per picture (15.734264kHz/525) or 29.97Hz.

Video produced at the frame rate causes a noticeable flicker on the screen. To eliminate flicker, a system of *interlaced scanning* was adopted. In interlaced scanning, all the odd lines of the picture are scanned vertically followed by a scan of the even lines. Each vertical scan, consisting of half the picture lines, is called a field. Two fields produce one frame.

Field 1, or the odd field, begins with a full horizontal line and ends with a half line. Field 2, or the even field, begins with a half line and ends with a full line. Each field contains 262.5 horizontal lines. Fields are scanned at twice the frame rate (59.94Hz). This rate, combined with the persistence of the human eye, eliminates perceived flicker.

The vertical sync pulse occupies a space of three horizontal intervals (identified as 3H) out of each field. The sync pulse initiates vertical retrace, the period during which the scanning beam is returned to the top of the screen. To prevent this event from being seen, the video circuits are blanked for a period known as the *vertical blanking interval* (Figure 2).

The vertical blanking interval begins 3H before the end of each field. The leading edge of the sync pulse begins a new field. The first nine lines of the blanking interval contain specialized sync signals which are half the width and twice the frequency of horizontal sync pulses. These are known as equalizing pulses and provide synchronization of the horizontal circuits when interlacing fields which alternately begin and end with half scan lines.

Note the differences in the two traces of Figure 2 which illustrate the provisions made for interlace. Field 1 (upper trace) begins with line 1. Line 522, which is the last line of video in field 2, is 1H wide. Compare it to line 260 (lower trace). This is the last line of active video in field 1 and is only 1/2H long. The other half of line 260 begins the blanking interval.

The half line difference at the top of the picture is accounted for in the interval following the sync pulse. In field 1, line 4 is 1H wide. In field 2, line 266 is seen to be half blanking pulse and half at blanking level. Note that in field 1, this arrangement produces a 3H interval of equalizing pulses between the end of the sync pulse and the next full-width horizontal interval (lines 4,5 and 6). In Field 2, there is a 2.5H interval in the same area (second half of line 266 plus lines 267 and 268).

Vertical sync amplitude is specified at -40 IRE units, the same as H SYNC. Misalignment of V SYNC amplitude may cause vertical jitter, jumping or loss of sync control, resulting in picture roll.

Working with sync signals

Troubleshooting or aligning video sync circuits requires the use of an oscilloscope. If you do a lot of camera alignment, it is worthwhile to invest in a waveform monitor, a specialized oscilloscope designed for use with video signals. A triggered sweep scope with delayed sweep capability will also produce good results.

To observe horizontal waveforms, set the time base to 10μsec per division. Set the trigger input to "TV LINE." If your scope is not equipped with this feature, connect the external trigger input to a source of H SYNC in the equipment under test. This setup will display slightly more than one horizontal interval. The X10 or delayed sweep function will expand the trace so specific segments, such as the blanking interval and sync pulse, may be examined more closely.

To observe vertical sync waveforms, set the time base to 2μsec per division. Set the trigger input to "TV FIELD." Otherwise connect the external trigger input to a source of V SYNC in the equipment under test. This will display slightly more than one field of video. The X10 or delayed sweep may be used to expand the trace so the blanking interval and sync pulse may be more clearly viewed.

The blanking interval of either field may be viewed with this setup. Momentarily adjust the trigger level control to unlock the display and then reset it. It may be necessary to do this several times until the display locks onto the desired field.

Sync signals provide the reference for stable, compatible video in the NTSC system. An understanding of the source and nature of these critical signals will help you perform faster and more accurate service on a variety of video equipment. ■

Ten important CD waveforms

By Homer Davidson

When you're faced with a malfunctioning compact disc player, observation of some important waveforms in the various circuits of the unit may help to locate the defective circuit. A laser power meter test will determine if the laser diode is defective (Figure 1). Absence of RF or EFM waveforms may indicate a defective optical assembly or RF amplifier transistor or IC. The presence of a PLL–VCO waveform indicates that the VCO (voltage-controlled oscillator) circuits are functioning normally.

Presence of the focus error (FE) waveform, which is used in making focus tracking adjustments, across the focus coil may indicate that the focus circuits are normal.

A dead motor may produce a waveform that is a straight white line, while a rotating motor will produce a moving waveform. Waveforms taken on the sled and spindle or disc motors may indicate that all of the motor circuits are normal. Observation of waveforms within the compact disk circuits may help to locate the defective component.

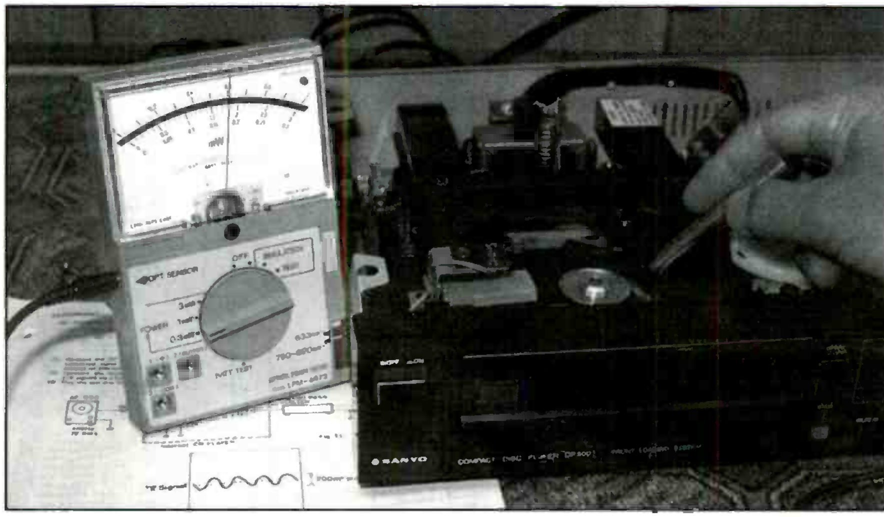


Figure 1. Measurement of the infrared power output of the laser head assembly using a laser power meter may uncover a defective laser diode assembly.

Laser power meter measurements

The best way to determine if the CD player's laser circuits are functioning is to measure the output of the laser with a laser power meter. Excessively high or unusually low power may indicate a defective laser diode. In most cases, if the laser diode assembly is defective the CD player will not be worth repairing.

Compare the laser power meter reading with laser power specification on the schematic or the CD player's power label. Check to be sure that the correct supply voltage is applied to the optical pickup assembly and observe the RF, or EFM, waveform to see if it looks correct before concluding that the laser head assembly is faulty.

Laser power adjustments

Laser power adjustments are made to insure proper operation of the laser diode. If the power output of the laser diode measured by the laser meter is near the value specified by the manufacturer's service data, most likely the laser diode is normal.

A low EFM waveform may indicate a defective diode. In some optical pickup assemblies, the VR adjustments mounted on the laser head assembly are adjusted at the factory and should not be touched. Often, laser power adjustment is needed only after replacing the laser diode optical assembly.

To check the laser power and make any necessary adjustments, place the power meter probe over the lens assembly and note the meter reading. Remember, never look directly at the laser lens assembly, and always keep your eyes at least a foot away from the laser when the unit is operating. With the interlock defeated, the laser diode will emit infrared light.

Locate the power adjustment (VR) on the main board or optical assembly. Check the manufacturer's test points and different control adjustments on the printed circuit board. Adjust VR so that the laser power output corresponds with the value specified in the service literature.

Test points and adjustments

Most CD players have test points and VR control adjustments on the main PC board. Often, however, the laser head adjustment is located on the optical assembly. Locate all test points before you try to take scope waveforms. Besides being useful in locating the cause of a defective circuit, the same test points may be used for making adjustments as well. Check the manufacturer's service literature for test points and VR adjustments.

Adjustments to the compact disc player should be made in an established sequence. Some manufacturers specify this sequence: laser power, PLL–VCO, focus offset, tracking offset and tracking gain. Other manufacturers list the required order of adjustments as laser power, skew, HF or RF level, focus gain, tracking gain, PLL–VCO, focus offset and tracking balance. Special screwdrivers or alignment tools may be needed for some of these adjustment screws. All adjustments are made with a test disc playing.

Waveform 1—RF or EFM signal

A normal RF or EFM signal will indicate that the laser diode optical assembly and RF transistor or IC are functioning. The EFM waveform may be observed at pin 20 of the RF amp (IC101) (Figure 2). You may find a test point given in the manufacturer's service literature on the main PC board (TP-RF). If the EFM signal is not present, the player may search and shut down. Check the laser diode and RF circuits in the case of constant shut down of the CD chassis.

The normal EFM waveform should

Davidson is a TV servicing consultant for ES&T.

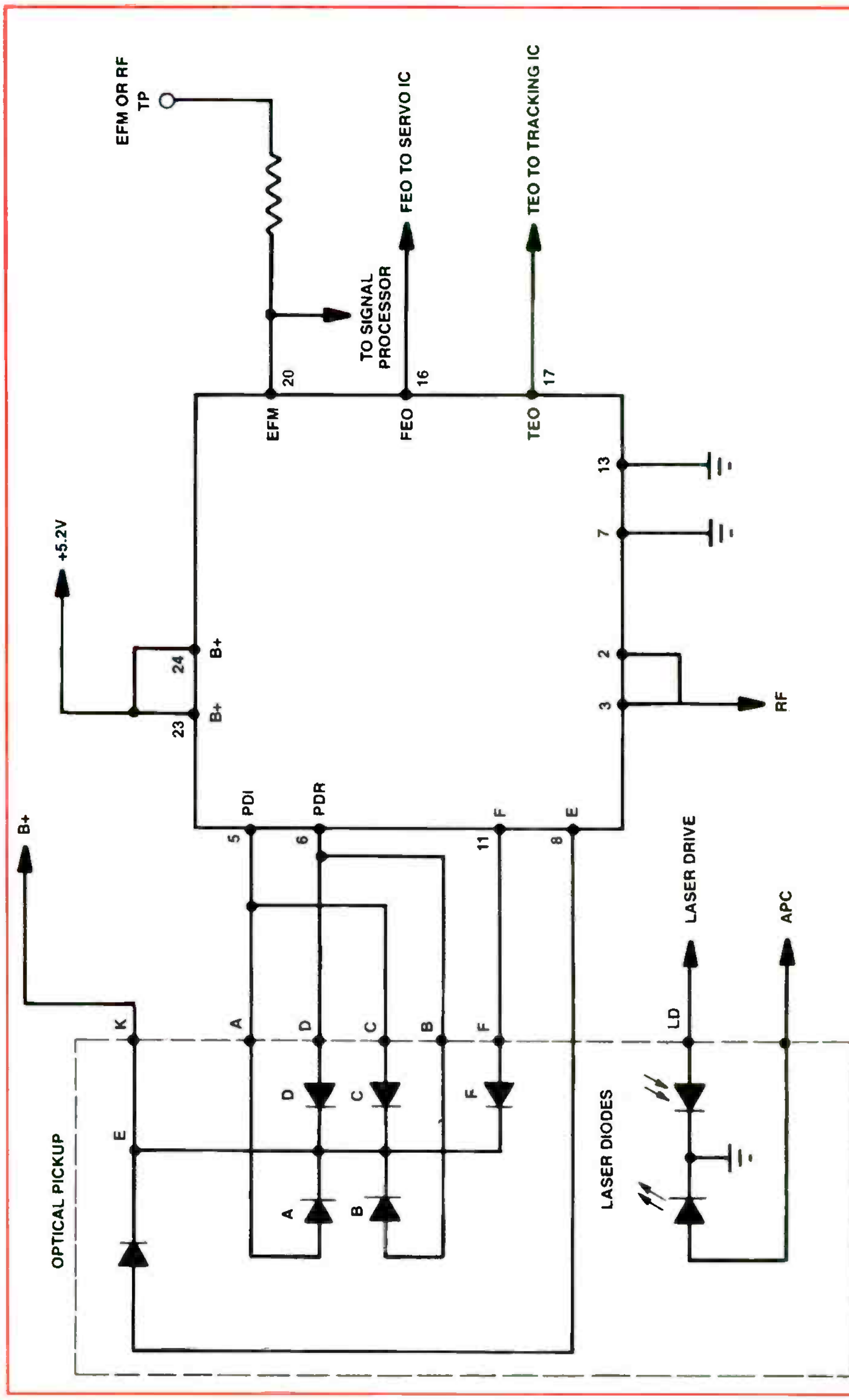


Figure 2. The EFM or eye pattern waveform may be observed at pin 20, or at the test point (TP-RF) in the CD player.

have a good eye pattern, represented by a clear-cut diamond outline. A vibrating or jittery eye pattern may indicate poor adjustment. Correct adjustment is to make the diamond-shaped area as clear as possible without excessive jitter (Figure 3).

To adjust the EFM signal, locate the RF, HF or EFM scope test points and level or gain control on the main PCB. Check the RF pattern on the scope. Adjust the tangential adjustment screw for maximum waveform or voltage reading as given in the service manual.

For example, in the RCA MCD-141 CD player, adjust the control so that the EFM signal waveform is 1.3Vpp on the oscilloscope. Similarly, in a Sanyo CP660 model, adjust the HF-EFM waveform to 1.5Vpp on the oscilloscope. A clean-cut and normal EFM waveform confirms that

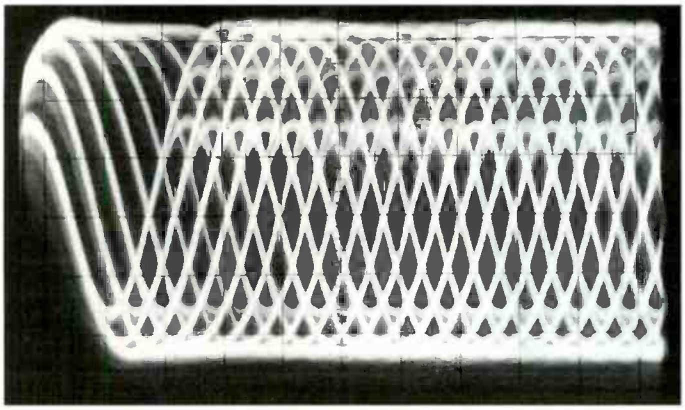


Figure 3. A good EFM waveform voltage should have a clear-cut diamond shape with very little jitter.

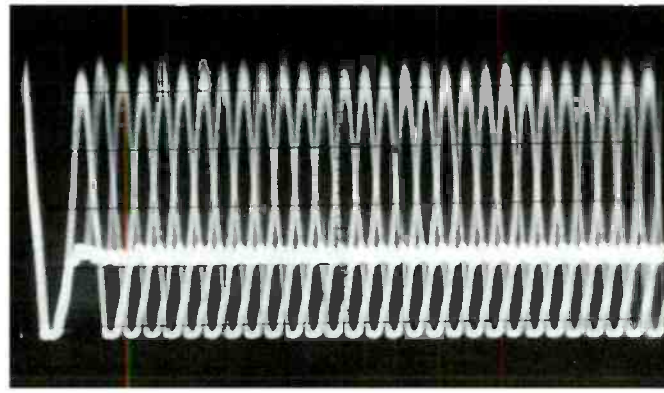


Figure 4. The PLL–VCO waveform voltage can be measured and adjusted from ground (bottom) to white or dark line. Some manufacturers use a frequency counter to adjust for the correct frequency.

the laser pickup assembly and RF amp circuits are normal.

Waveform 2—PLL—VCO signal

Presence of the phase-locked loop voltage-controlled oscillator (PLL–VCO) waveform indicates that the EFM voltage has reached the digital signal processor and servo IC. The VCO oscillator output signal is compared to the edge of the EFM signal read from the disc. The PLL–VCO oscillator adjustment can be made with the oscilloscope and frequency counter.

Some manufacturers use a frequency counter to set the frequency of the PLL–VCO, while others make the adjustment on the oscilloscope (Figure 4). Adjustment of the PLL–VCO frequency must be correct so that the optical lens assembly follows the disc motor and responds to dropouts caused by defects on the surface of the disc.

Locate the coil or transformer on the PC board, and connect the oscilloscope to the correct test points. Play a test disc. Observe the waveform on the scope. Adjust the coil until the specified dc voltage is from ground to a white or dark area on the waveform (1.2V to 1.5V). In a similar manner, connect the frequency counter to the correct test point and adjust the coil for the correct frequency listed in the service manual. Follow the manufacturer's PLL–VCO adjustments.

Waveform 3—Focus error signal (FE)

Presence of the focus error (FE) signal waveform indicates that the correct focus signal is reaching the RF amp to the focus servo IC (Figure 5). Adjust focus gain and offset for maximum output. The focus offset may include the RF and EFM adjustments, or they may be separate adjustments, depending on the manufacturer of the CD player.

Again, depending on the manufacturer, the focus offset adjustment may be called the jitter or eye pattern adjustment. The focus offset adjustment is about the same as the jitter adjustment (Figure 6). This focus adjustment can be made with a standard music compact disc and an oscilloscope. Connect the scope to the circuit test points on the pc board and play the disc. Adjust the VR focus offset adjustment until the EFM or RF waveform is maximum, and displays a sharply defined diamond-shaped pattern.

Waveform 4—Focus coil

If you're able to observe a focus coil waveform, you know that the focus signal is reaching the coil itself (Figure 7). The FE signal is sent from the focus-tracking servo to a focus driver IC or transistor that drives the focus coil located in the optical lens assembly.

If the focus drive signal was missing at the focus coil, you would observe a horizontal white line on the oscilloscope at this point. The focus error signal can be checked at the FE output terminal of the focus tracking servo IC, then followed to the focus driver and then observed at the focus coil leads (Figure 8). If you suspect that the focus coil may be open, turn power to the CD player off, then check continuity of the coil using the low ohms range of the ohmmeter.

Waveform 5—Tracking error signal (TE)

If you are able to observe the tracking error (TE) signal waveform at the focus-

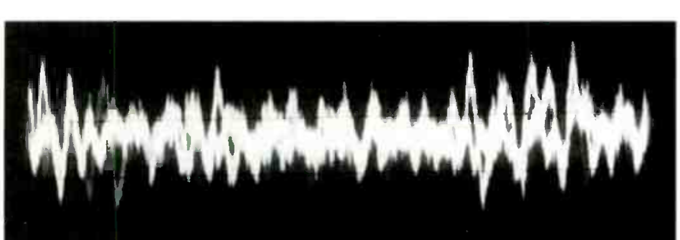


Figure 5. The focus error (FE) signal is taken at the RF amplifier IC or transistor circuit.

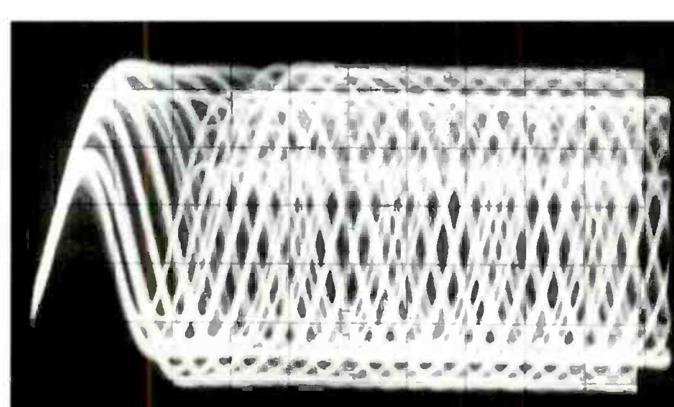


Figure 6. The jittery or bouncing EFM waveform may indicate improper focus error adjustment.

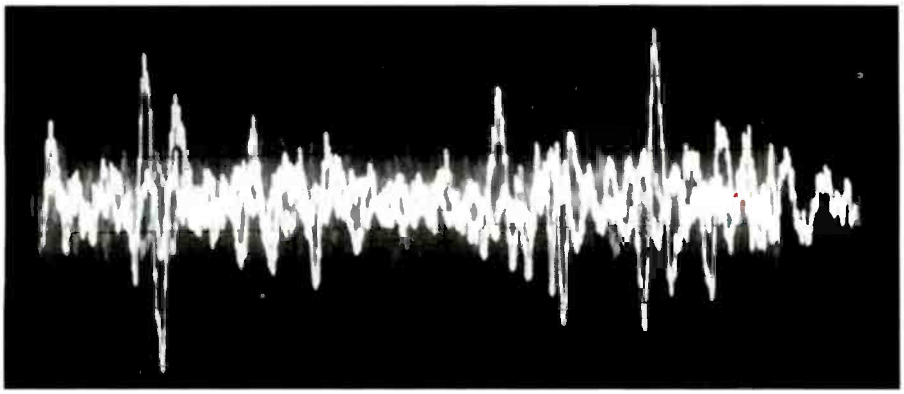


Figure 7. Connecting the oscilloscope across the focus coil winding indicates if signal is present at the coil assembly.

tracking servo, you have confirmed that the tracking signal has reached this point. The TE input and output (TEO) signals may be traced with the scope (Figure 9).

Usually, the tracking gain control is located at the TE input terminal of the IC. The presence of normal TE input and output signals indicates that the tracking signal is good to this point in the circuit.

When you observe a normal TE signal at the input terminal of the tracking focus IC but not at the output (TEO), the problem may be improper supply voltage to the IC, or a defective tracking-focus IC. Check the focus (FE) signal input and output before you conclude that the IC is the defective component.

To perform the tracking offset or balance adjustments, connect the scope to the TE signal test point and play a test disc. Adjust the SVR control so that the TE signal waveform is vertically symmetrical relative to 0V. You usually won't need to perform the tracking gain adjustment unless you have replaced the focus optical assembly or control.

Adjust the tracking gain so that the waveform is not varying or jumping around (no large waves). Adjust the tracking gain adjustment only after the focus and tracking adjustments are made. To make this adjustment, connect the oscilloscope across the tracking coil terminals and adjust tracking coil gain control for 1.8Vpp to 2.2Vpp. Follow the manufacturer's tracking offset and gain adjustments.

Waveform 6—Tracking coil

When the CD player is first turned on, the tracking and focus assembly can be seen searching, even if the player shuts down. Often, this indicates that the focus and tracking assemblies are normal. The tracking offset (TEO) signal can be scoped at the TEO terminal of the focus-tracking-sled servo IC. The tracking signal is fed to a tracking driver IC or two driver transistors. The driver output signal is applied to the tracking coil winding. A waveform taken at the tracking coil indicates if signal is present (Figure 10).

Waveform 7—No motor movement

Observation of the waveform at the motor terminals will reveal whether or not the drive signal is reaching the motor. If you observe a straight line, no signal is reaching the motor. Although a normal motor waveform will not show much movement on the scope, several lines may be seen together indicating that the motor is operating. A straight white line indicates no signal applied to the motor terminals (Figure 11).

Waveform 8—Sled motor movement

It is difficult to see a slide or sled motor operating while the disc is playing, as the motor is enclosed under the main PC board. A quick waveform taken at the sled motor terminals will indicate if the motor is operating. If the motor is operating, you'll see several thin lines on the scope (Figure 12). If you don't see a waveform here, trace the motor wires back to the main board. Often, the motor wires are soldered or plugged into the main PC board.

Check the motor waveform at the motor

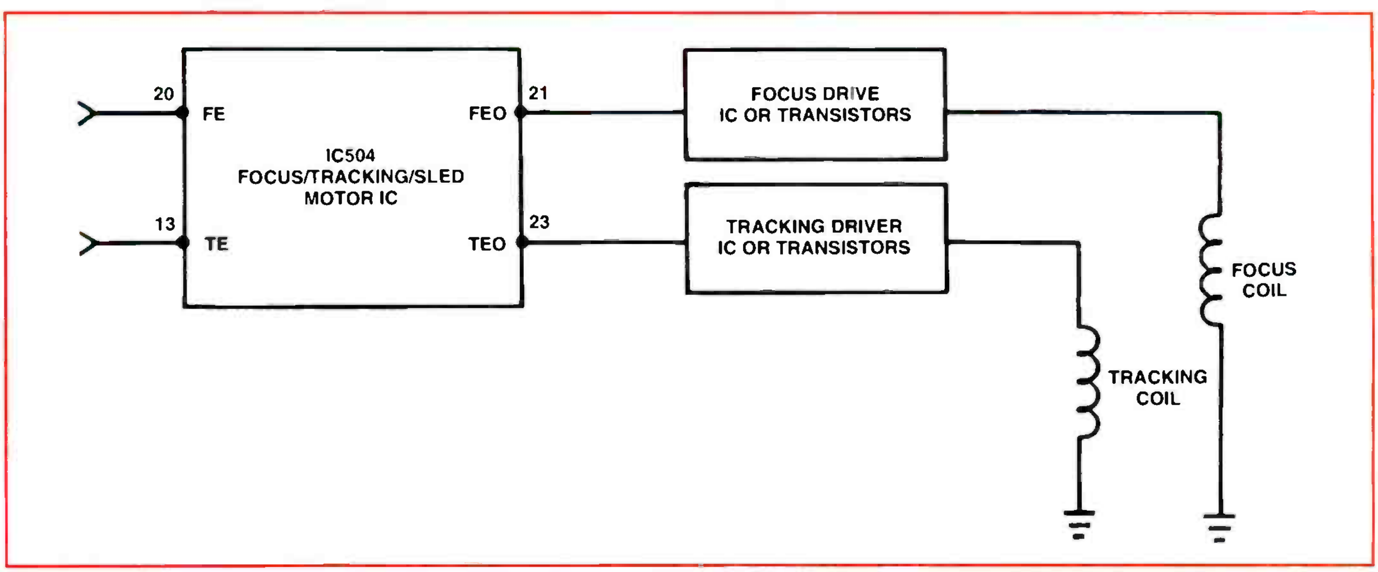


Figure 8. The focus error output (FEO) and tracking error output (TEO) signals are fed from the focus/tracking/sled IC.

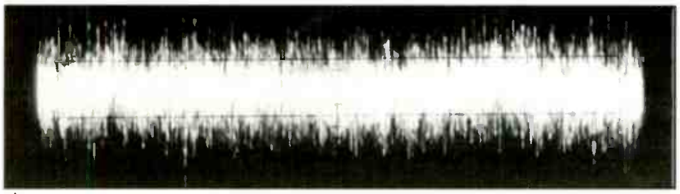


Figure 9. The tracking error (TE) signal can be signal traced with the scope from tracking IC to tracking driver and tracking coil.

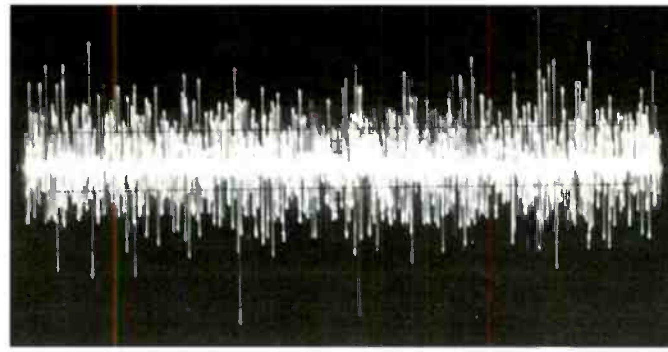


Figure 10. The tracking error (TE) waveform found across the tracking coil terminals.

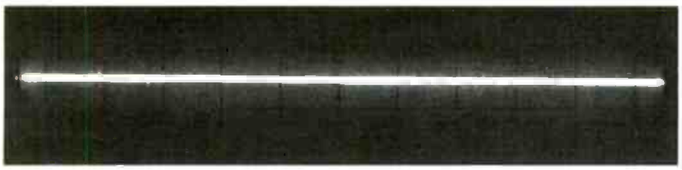


Figure 11. No motor movement may show a white line waveform without any motor lines.

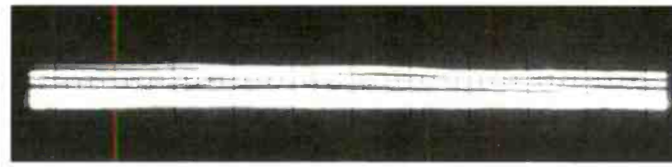


Figure 12. The sled motor movement may be seen as varying lines of a scope waveform taken at the slide motor terminals.

plug connections. Sharp pointed instrument prods pushed down inside the plug area will produce a good waveform. Clip the ground lead of the probe to common ground, since most motor windings are at ground potential.

The slide or sled motor is controlled by a signal from the same focus-tracking and sled servo IC. The slide motor control signal may be connected to the sled IC amplifier and to transistors or IC drivers. In some sled circuits, there may be a push-pull driver transistor in each leg of the sled motor terminals. In this case, one side of the slide motor terminals is not grounded.

Waveform 9— Spindle motor movement

The disc or spindle motor rotates the disc platform. The spindle motor is controlled by a signal from the digital signal processor and CLV servo IC. The disc or turntable motor is a variable speed motor: it starts at around 500rpm when the laser pickup is at the center of the disc, and slows down as the laser pickup moves toward the outer rim of the CD (to approximately 200rpm).

The master clock and spindle motor control circuits are fed to a spindle motor drive circuit that may contain two driver transistors or IC CLV servo. The disc motor is locked in with a correction signal from the CLV circuitry.

Defects in a spindle motor may cause it to be dead and not rotate, or may cause it to operate at the incorrect speed. The waveform applied to the spindle motor of a Sanyo CD player is shown in Figure 13.

Waveform 10—Oscillator waveforms

By observing the waveforms of crystal controlled oscillators waveforms in the digital servo and RAM circuits, you may be able to determine if supply voltage is applied to the IC processor and the component is operating. When the crystal-controlled oscillator is not functioning, you may assume the defect may be in the IC processor circuits.

The 4.19MHz crystal oscillator pins 31 and 32 of system control IC and 8.4672 MHz crystal oscillator on pins 53 and 54 of digital control processor in a Sanyo CP660 CD player may indicate IC302 and IC401 are normal (Figure 14). The timing control generator oscillator on pins 53 and 54 of an Alpine 5900 auto CD player may indicate a normal digital signal processor and CLV servo IC502.

Conclusion

Observation of waveforms throughout the compact disc player may help the technician quickly isolate a defective circuit or component. The most important waveform found in the CD players are the RF or EFM waveforms. Without this EFM waveform, the compact disc player will not operate.

Confirming that the laser diode is normal using a laser power meter test makes easy CD servicing. Check the manufacturer's service literature for correct laser offset and gain adjustments. The manufacturer may use special adaptors and alignment procedures, so check the service literature. ■

Figure 13. The spindle motor waveform may form lines close together and move up and down as the motor rotates.

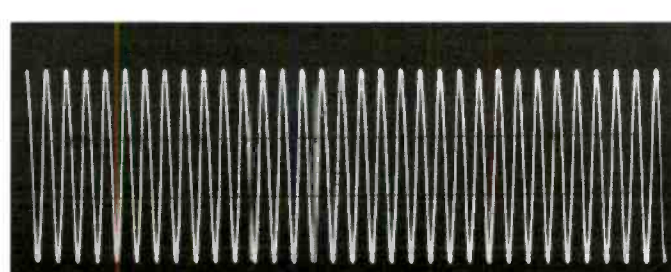


Figure 14. A 8.4672MHz crystal oscillator waveform found at pins 53 and 54 of a Sanyo CP660 player.

What Do You Know About Electronics?

The "Toss it" syndrome

By Sam Wilson

For years, the United States has been gradually painted into a corner; and, unless you start to do something about it, you're going to have your outdoor picnics on a mountain of garbage.

How many times have you heard these statements?

"If it costs less than $100.00, it is cheaper to throw it away than it is to fix it."

"It's not worth fixing. You can get a new one for about $60.00.

"Even if I wanted to fix it, I couldn't get parts for it."

"I'll tell you what, I'll give you $5.00 for it on a trade in."

So, an AM/FM receiver goes to the landfill because it needs a two-cent resistor. A small black & white TV receiver goes to the landfill because it needs a five-cent capacitor. A clothes dryer goes to the landfill because it has a broken wire. And on and on and . . . .

Used electrical equipment is fighting for space in a landfill already clogged with "disposable" diapers, hamburger wrappers and containers for household cleaners that will last 500 years without deteriorating.

In the next few years this country is going to be hit with a problem that many people are blissfully unaware of. Landfills are going to start closing down because there is no place to make new landfills. There just isn't that much land available. Add to that the NIMBY (not in my backyard) attitude, and the problem is very serious.

Wilson is the electronics theory consultant for ES&T.

If you are an electronics technician, service center owner, manufacturer or consumer, you are in a position to solve this problem, as well as the new baby's mom next door. If we're going to survive, we are going to have to stop throwing stuff away and start fixing things. Furthermore, you need to stop encouraging people to throw things away. This is a problem that *must* be solved.

Now think about this: when you throw that AM/FM radio away, you are not only hogging up the scenery and using up rapidly diminishing landfill space, you are also helping to use up one of our most important reserves: energy. It takes energy to build a new radio. Furthermore, it takes metals and chemicals. I know that this is going to be a big surprise to many people; but, we do not have an endless supply of these materials.

Is anyone listening?

I remember when tantalum capacitors first hit the market. There was some concern about the fact that the tantalum might cause a problem with the environment. A brave parts supplier in my area made a valiant effort to solve the problem. He put a barrel in the corner of his showroom with a sign asking technicians to throw their discarded parts into the barrel whenever they came to buy parts. There was a special emphasis on the tantalum capacitors, paper capacitors and transformers.

Within one week the barrel was half-full of cigarette and cigar stubs, wrappers from everything you could imagine.

Is that funny? Where do you suppose all the parts that were supposed to be in that barrel went? How do you recycle cigarette stubs?

Let's switch over to the way manufacturers are contributing to the landfill problem. My friend Frank, owner of a service business in Arizona, once told me that the greatest contribution I could make to the consumer servicing industry was to solve the parts problem. The shop owners couldn't do it. The technicians couldn't do it, and the manufacturers couldn't do it. So I guessed I'd better jump in. But I couldn't solve it either.

What does that have to do with the landfill problem? Here is a set that has been waiting six weeks for a part. The customer is irate. Solution: sell the customer a new set. Give a good trade in allowance. Then send the old set to diaper heaven.

Some electronic equipment that should be relatively easy to service is being sold in sealed containers. They are not repairable only because they are sealed and there is no service literature available. More landfill fodder.

Some equipment is being made with absolutely no servicing information available; not even a schematic. If you don't believe that, try to get a switching

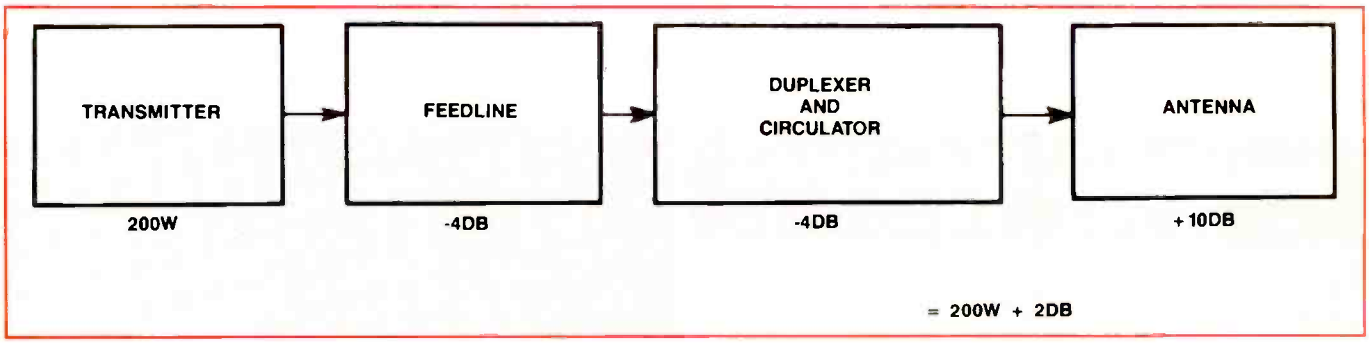


Figure 1. A system consists of a transmitter that has a power output of 200W, a feedline with 4dB loss, a duplexer and circulator with 4dB loss, and an antenna with 10dB gain. What will be the effective radiated power of this system?

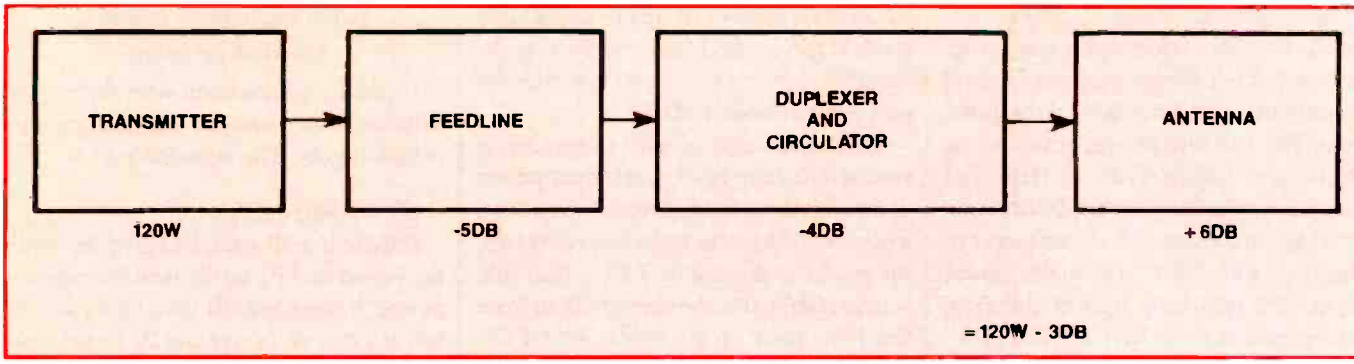


Figure 2. A system consists of a transmitter that has a power output of 120W, a feedline with 5dB loss, a duplexer and circulator with 4dB loss and an antenna with 6dB gain. What will be the effective radiated power of this system.

regulator schematic for a certain popular computer. That subassembly has been deemed by the manufacturer as not repairable. Now I am talking about profit and landfill fodder.

Is there any way out of this mess? Some companies make laundry products that have been selling refills for their bottles. That means that someone knows about the problem besides us. Is there anything you can suggest? Let me know. We're all in this together.

Where is my color code?

Joe Risse and I have just finished a two-book series. Those books deal with the FCC and CET tests as well as with other license and certification tests. To get the books finished we had to go on fire drill status. So I couldn't get the capacitor color codes out and I didn't have time to respond to other queries. If you are on the list of people waiting for something, you will probably have it by the time you read this. Sorry about that.

FCC test problems about radiated power

Let me introduce you to Phronsie Dwitrong. When he graduated from high school he took a job inspecting buggy whip holders. He also dabbled in radio service, so he started thinking about himself as an electronics technician. He even read some stuff about it in a library book.

After four years he started to look around for another job. An ad in the help-wanted section of the paper got his attention. They were looking to hire electronics technicians.

When he applied, Phronsie was told he would need an FCC license and he would also do well to try for a CET rating.

You know that the FCC has published all of the questions and answers for the

GROL (General Radio Operator License). Phronsie borrowed a copy from his former high school shop teacher and spent about two hours looking through the pages. He was sure he was ready, so he took the test. He wasn't ready. Here is an example of a question he couldn't answer.

"What is the effective radiated power of a repeater with 200W transmitter power output, 4dB feedline loss, 4dB circulator and duplexer loss, and 10dB antenna gain."

Phronsie took a wild guess and missed the answer by a mile.

The solution

(Note: in the FCC problems, the effective radiated power is referenced to a standard dipole.)

It's too bad that Phronsie didn't subscribe to ES&T. By reading this column he would know how easy it is to solve that kind of problem.

Every time the power is increased by 1dB, the power is multiplied by 1.259.

As shown in Figure 1, in the system described in the problem there is an overall gain of:

-4dB + (-4db) + 10dB = 2dB.

So the power will increase to:

(200 x 1.259) x 1.259 = 317W.

Just remember to multiply the power by 1.259 as many times as there are 1dB increases.

All of the FCC problems involve a value of power that is raised or lowered by an even number of dB, so this simple method can be used for every FCC problem that involves raising or lowering the power by a number of dB.

When the value of dB is negative, it means that there is a lower output power compared to the input power. In this case, *every time the power is decreased by 1dB, the power is divided by 1.259.* That rule is demonstrated in the next problem from the FCC pool of questions for GROL examinations.

"What is the effective radiated power of a repeater with 120W transmitter output power, 5dB feedline loss, 4dB duplexer and circulator loss and 6dB antenna gain? Refer to Figure 2.

Solution to the problem

The overall gain is -3dB. In other words, there is a 3dB loss. Therefore, the power is divided by 1.259 three times:

120W/1.259 = 95.3W

95.3W/1.259 = 75.7W

75.7W/1.259 =60.6W

The FCC answer is 60W.

This should come as no surprise to experienced technicians. It is a well-known rule that reducing power by 3dB cuts the power in half. Also, raising the power by 3dB doubles the power.

If you use the better value of 1.2589 in the above calculations, you get 60.1, and that is significantly closer to the actual one-half power mark.

Using logarithms to solve the first problem

If you are a technician who prefers the solution from a more formal stance, here is how it goes. The equation is:

$dB = 10\log(P_A/P_B)$

If there is a dB gain, let P_B be the starting power and P_A be the new (increased) power. If there is a dB loss, let P_A be the initial value of power and P_B be the new reduced power.

In the first problem discussed earlier, there is a dB gain, so P_B is the starting power (200W) and P_A is the new power. Then

$2dB = 10\log(P_A/P_B)$

Divide both sides of the equation by 10;

$0.2 = \log(P_A/200)$

Take the antilog ($\log^{-1}$) of both sides of the equation;

$\log^{-1}(0.2) = \log^{-1}[\log(P_A/200)]$

$1.584893192 = P_A/200$

$P_A = 1.584893192 \times 200 = 316.97$. Rounded off to three places that becomes 317W.

Using logs to solve the second problem

In the second problem, there is a 3dB loss. So P_A is the starting power (120W) and p_B is the new power.

$3dB = 10\log(120/P_B)$

Divide both sides by 10

$0.3 = \log(120/P_B)$

Take the antilog of both sides

$1.995 = 120/P_B$

Rearrange to get P_B alone on one side of the equation

$P_B = 120/1.995 = 60$ (approximately)

The truth is that decreasing a power by 3dB does not exactly divide the power by 2. Likewise, increasing the power by 3dB does not exactly double power. Those rules give a good approximation and they are used by the FCC to get answers to their problems. ■

Will Total Quality Management Work For You?— Part 10

By John A. Ross

TQM Point 10

Eliminate slogans, exhortations and targets for the work force asking for zero defects and new levels of productivity. Recently, I visited a human resources office to discuss some possible technology purchases. As I talked with the office manager about her needs, I noted that she had placed several humorous "teamwork" posters around the office. One of the posters said something like "Let's all pull together" and showed cartoon characters participating in a tug-of-war. Another advised that "Square Pegs Don't Fit" and displayed a character attempting to hammer a square peg into a round hole.

While each poster made an obvious point about teamwork, each also gave an implicit message about conforming to the needs of the organization. Certainly, organizations that have employees working and pulling together or where all employees follow the organizational mission should succeed.

Slogans can be counterproductive

The logic behind these posters and other organizational slogans makes Deming's tenth point about slogans, zero defects, and productivity goals seem contradictory. However, Deming understood that the use of slogans and exhortations could damage employee morale and impede organizational success.

Many times, employees who already exceed both qualitative and quantitative production goals and who already work as teams may find those slogans insulting. Indeed, the posters displayed in the human resources office only ask for more teamwork, production, and conformance, and imply that laziness or an uncooperative attitude exists. None of the posters recognized continuing excellence.

Rather than make slogans, productivity, and quotas the sole focus of the organization, Deming advises us to take another look at the various processes that make up work and production. The use of motivational slogans and the setting of numerical production goals solely emphasizes the power of management instead of the needed cooperation between management and employees. In addition, that emphasis implies that a division exists between managers and employees. Managers set the goals; employees reach the goals.

Employee empowerment

When employees are empowered, the situation changes. Organizational goal-setting requires the recognition that power exists not only in the hands of management but also in the hands of the employees. While managers must remain aware of potential budgetary problems, possible personnel conflicts, and market changes, employees have an acute awareness about working conditions, equipment needs, and morale problems. Thus, the recognition of existing power in both camps also requires a balancing and merging of the power interests.

Because of this sharing of power and knowledge, it makes sense for management to consult with employees about methods for improving organizational efficiency and production. Instead of asking employees to perform better with less or the same resources, managers should use their budgetary, personnel, market knowledge, and, most of all, their listening skills to ensure that resources go to the proper areas and that the talents of personnel match their responsibilities.

The empowerment of employees also places an obligation on them. While employees have the duty to tell management about possible improvements in working conditions and equipment, they also are obligated to keep from using their knowledge for the purposes of manipulating management for their own ends.

Integrating personal and organizational goals

All this points toward the integration of personal goals with organizational goals. Yet, this integration acquires a deeper meaning when we examine all the potential conflicts and consequences of goal setting and decision making. Both types of goal-setting, organizational and personal, may concentrate on efficiency, effectiveness, accountability and procedures, because the goal-setters assume that those characteristics are best for the organization and are what the ownership desires from its employees.

However, true organizational success depends on the understanding that goal-setting should revolve around both the characteristics of production and around principles such as honesty, equality, fairness, justice, and the protection of individual rights. Without the merging of those characteristics and principles, the organization and the individuals that make up the organization will encounter goal conflicts and will never achieve true success. With the merging of those characteristics and principles, the growing trust between departments and individuals will guide the organization to success.

Ross is a technical writer and microcomputer consultant for Ft. Hays State University, Hays, KS.

Additive vs subtractive colors

By Roger D. Redden

If you have worked on color TVs for quite a while, you may have had a conversation with a customer that was somewhat like this one.

Technician: "I'm sorry, but the problem with your TV is a bad picture tube. The blue gun in the picture tube isn't working."

Customer: "I thought that when the picture tube went out there was no picture at all. And what's a blue gun?"

Technician: "There are three electron guns in the picture tube. One gun lights up red phosphors, one green phosphors, and one blue phosphors. The proper mixture of light from these phosphors gives your TV's screen the normal colors. My picture tube checker shows that the blue gun in your tube is not working."

Customer: "OK, so that's why my picture has no blue. But why does everything look yellowish?"

Technician: "Without blue, there's only red and green. Red and green mixed together makes yellow."

Customer: "That's not right. I paint as a hobby, and I know that if you mix red and green together you don't get yellow, you get some shade of brown."

Technician (reaching back in the misty part of his memory to find something useful): "I'm sure you're right about mixing paint, but paint colors are *subtractive* colors, while colors from light are *additive*."

Customer: "I don't understand. Could you explain that to me?"

Technician (lamely, after finding only fog in the misty part of his memory this time): "That's just the way it works."

The fog encountered by the technician may not be his memory's fault. Since knowledge of subtractive colors is not needed to service color TVs, many of the books and courses, at least the older ones, that explain the operation of color TV, mention additive and subtractive colors, but either give no explanation of subtractive colors, or give only a very brief one.

The following explanation might have helped the technician talk to his customer about subtractive colors.

Redden is owner and operator of a consumer electronics service center.

A review of color vision

The most popular theory of how our eyes sense color is the Young-Helmholtz theory. According to this theory, three different groups of cones (light sensitive cells) in our eyes respond to a range of frequencies centered on the frequencies we see as red, green and blue. The frequency responses of the groups of cones overlap each other to varying extents, but each group responds most strongly to a particular range of frequencies that encompass one of those three colors. This overlapping response of the different groups of cones may be why we perceive either a single frequency or a mixture of two widely separate frequencies as the same color.

Figure 1 illustrates the idea of how we might see the color yellow when our eyes are exposed either to one frequency, or to a mixture of a red and a green frequency.

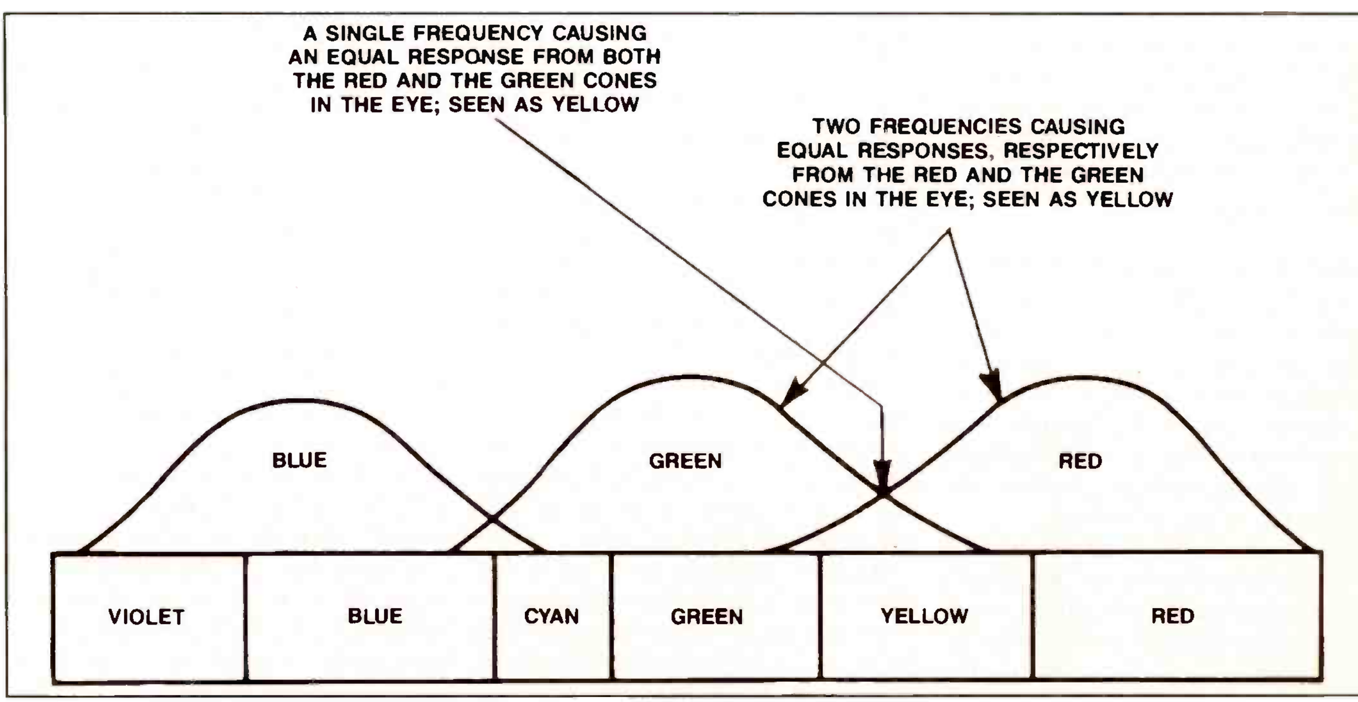


Figure 1. This is a drawing showing hypothetical response curves of the red, green and blue cones of the eye, and how two frequencies causing equal responses, respectively, from the red and the green cones might be seen as the same color as one frequency causing an equal response from both groups of cones.

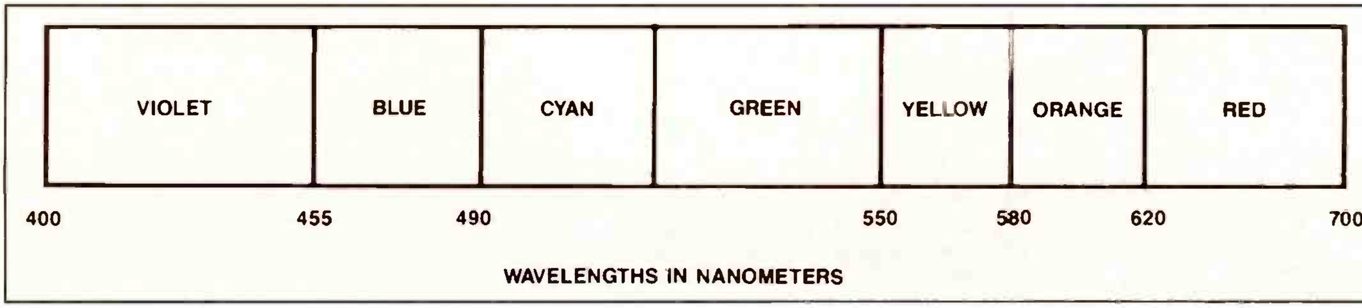


Figure 2. A rough sketch of the placement of colors in the spectrum of visible light, with wavelengths given in nanometers, or billionths of a meter.

The actual response of the cones of the eye is different from that shown in Figure 1; more complex, and apparently not altogether understood.

Compared to the vast range of electromagnetic frequencies that exist, our eyes respond to a relatively narrow band of frequencies between about 428 million MHz and 750 million MHz: a bandwidth of 272 million MHz. or 272×10^{12}.

The spectrum, or range, of visible light is normally shown using the wavelengths of the light, not the frequencies. This is the way it is shown in Figure 2, which is a rough graph of the visible spectrum showing the approximate positions of red, green, blue, yellow and cyan on the spectrum. Magenta is not shown because it does not occur as a single frequency in the spectrum, but only as a mixture of red and blue, colors taken from nearly opposite ends of the spectrum.

Mixing additive colors

After that brief review of how we see color, let's look at additive color mixing, the operation that TV technicians deal with daily.

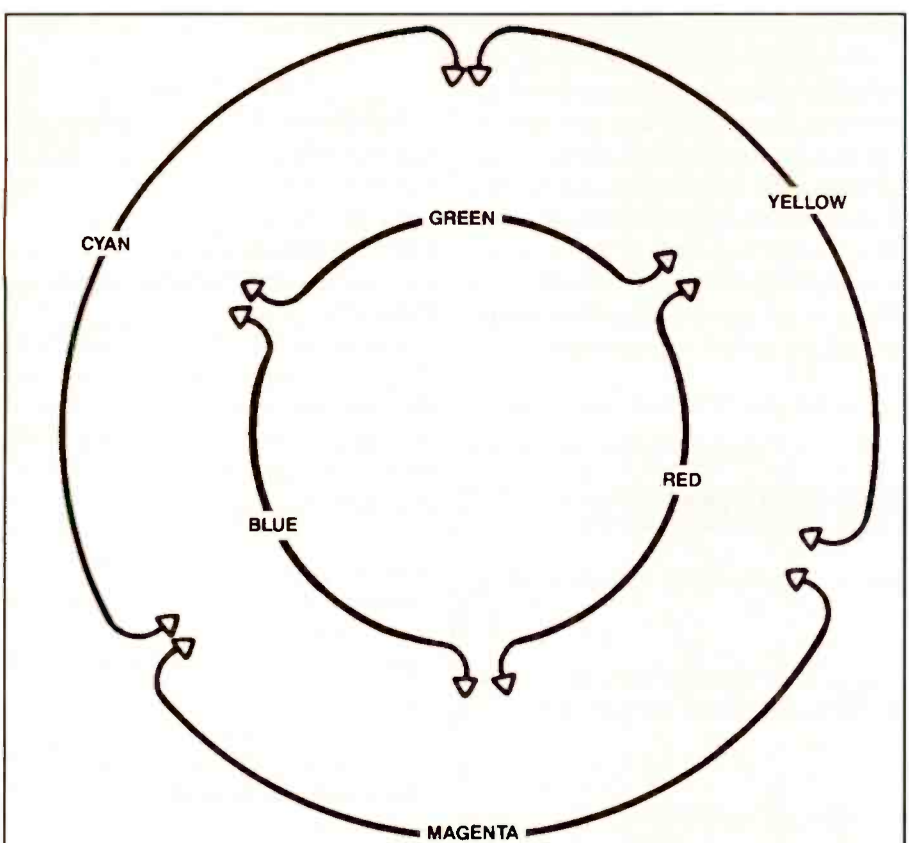


Figure 3. Any two primary additive colors adjacent to each other on the inside circle add to produce the color between them on the outside circle. Any two primary subtractive colors adjacent to each other on the outside circle subtract to produce the colors between them on the inside circle.

The essential fact about additive colors is that the sources of additive colors emit (or in special cases reflect) light, but do not absorb it. Thus, when we mix two additive colors together. neither absorbs any of the color supplied by the other.

For example, red light mixed with green light results in light containing both the original colors. Our eyes receive these colors and see the combination as if it were the single color yellow. In the same manner, our eyes perceive a mixture of green and blue as the color cyan, or a mixture of blue and red light as magenta.

As technicians, we know that the proper mixture of red, green and blue additive light produces white light: what we strive for when we adjust the screen or drive controls in a color TV for gray scale tracking.

Mixing subtractive colors

A subtractive color is usually produced by light reflected from the surface of an object. But while the surface of the object reflects some of the frequencies of the light which strike it, it absorbs the other frequencies which strike it. For example, a red surface strongly reflects a band of frequencies we see as red, probably weakly reflects a range of frequencies on both sides of the red frequencies, and absorbs all other frequencies.

A subtractive color can also be produced by a color filter, such as one used in a camera. Such filters absorb some frequencies and transmit, or pass, other frequencies of light. A blue filter, for example, transmits blue light while it absorbs (blocks) light of other colors.

To mix subtractive colors, we must keep in mind what each source absorbs as well as what it reflects. or, in the case of filters, transmits.

Seeing what is absorbed and what is reflected is easier using the primary sub-

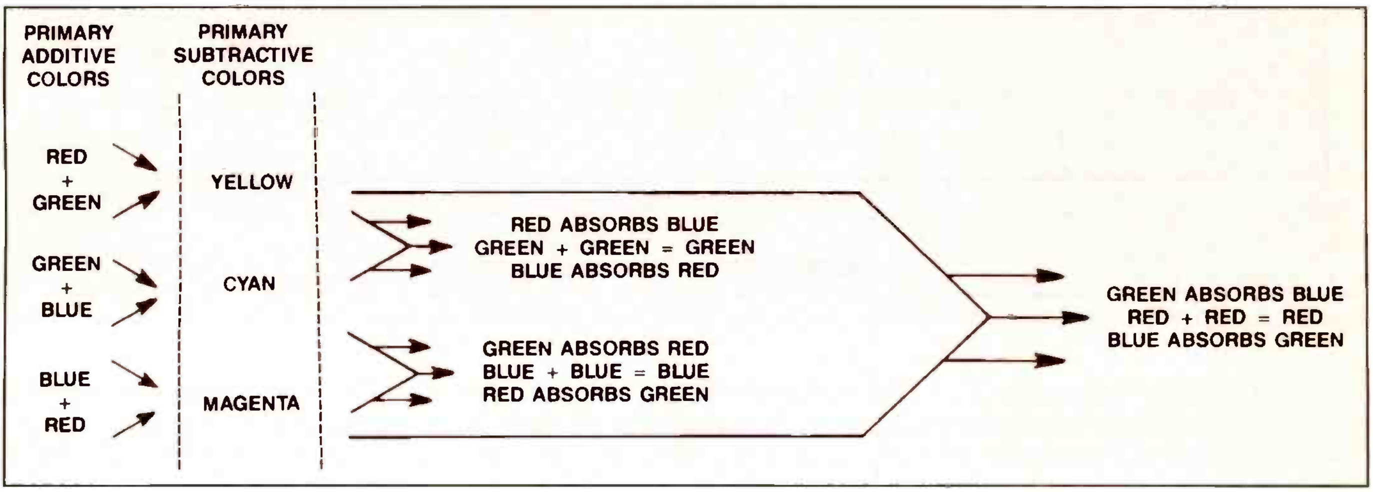


Figure 4. Starting at the left of the figure, light sources are added to produce secondary additive colors. The colors obtained, shown between dotted lines, are the primary subtractive colors. These primary subtractive colors combine with each other to reflect the colors after the equal signs.

tractive colors. Figure 3 shows that the primary subtractive colors are the ones we get when we mix the primary additive colors. For instance, a mixture of red and blue light produces magenta, which is a primary subtractive color. As the figure shows, the other primary subtractive colors are cyan and yellow; colors obtained by mixing green with blue and red with green when using the additive colors.

Figure 4 shows the primary additive colors mixed to form the primary subtractive colors. These colors in turn are mixed again to form red, green and blue. But in the second mixing, the mixing of subtractive colors, light is being absorbed.

When we mix the yellow with the cyan, the green that results reflects less total light than the yellow and cyan would reflect if they were unmixed. This is because the red light contained in the yellow absorbs the blue light from the cyan, and the blue light contained in the cyan absorbs the red light from the yellow.

What color results when we mix all three of the primary subtractive colors—yellow, cyan and magenta—together? These three primary subtractive colors, mixed together in the proper proportions, become black. A black surface absorbs all the light striking it; it reflects no light.

To see why no light is reflected, look carefully at Figure 4. We started on the left with two units of red, two units of green and two units of blue. In the process of mixing the yellow, cyan and magenta with each other, two units of red, two units of green and two units of blue were absorbed. Since the mixture absorbs all of the light energy striking it, none is reflected, and the surface appears black.

In the end, it's black and white

In color mixing, the terms additive and subtractive are very meaningful. Additive colors mixed together become brighter, and the right frequencies in the right proportions produce white light. Light has been added to light. In contrast, subtractive colors mixed together become dimmer, and the right frequencies in the right proportions produce a black surface. Light has been subtracted from light.

Instant replay

Now that we know more about additive and subtractive colors, let's put the technician back in our original scene, right after he says paint colors are subtractive while colors from light are additive, and the customer asks, "Could you explain that to me?"

Technician: "When the phosphors in the TV give off light, all of the red and all of the green color is emitted and we see the mixture as yellow. But subtractive colors, such as the pigments in paint, don't produce light, they just reflect some of it and absorb some of it. When you mix red and green paint, the red paint absorbs most of the green light that hits it. At the same time, the green paint absorbs most of the red light that hits it. The small amount of light still reflected appears to be brown."

Customer: "I'll ask my art instructor about your explanation of color. But for now, I want you to show on that checker of yours how you know my picture tube is bad."

Which shows that even when you're right, you can't convince some of the people some of the time. ■

Synthesized function generator

Global Specialties announces the Model 2003, a menu-driven digitally-synthesized programmable function generator. Up to 16 preset waveform configurations can be stored into memory and recalled automatically. The 32-character LCD display allows precise setting of desired frequency with up to 11 digits of accuracy. Operation modes include Trigger, Gated, Sweep, Hop, Burst, and External Trigger and Gate.

Waveforms include sine, square, triangle, positive ramp, and negative ramp.

Applications include repetitive testing, automotive, telecommunications, transmission line testing, filter response testing, and other applications where a number of exact frequencies, waveforms, and amplitudes have to be selected.

Circle (100) on Reply Card

Soldering

American Hakko Products' Model 929 soldering iron eliminates problems commonly associated with heat loss when soldering thick boards, large terminal connections, and enormous PC board traces.

With its fast heat-up, quick thermal recovery, and long tip life, the Model 929 allows operators to solder joints quickly and repeatedly.

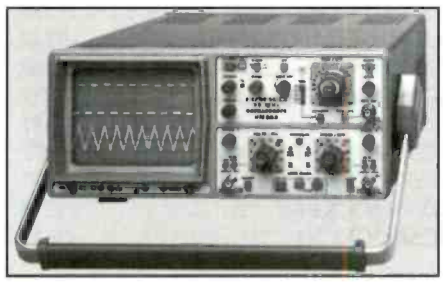
A built-in regulator maintains a constant tip temperature between ±0.5C (±/0.9F) of its setting, preventing damage to boards. The handle is comfortable and is heat insulated.

Circle (101) on Reply Card

Dual-channel oscilloscope

Hameg Instruments announces the introduction of the HM303, a 30MHz dual-channel oscilloscope, a successor to the original HM203. The improved vertical amplifiers have a sensitivity that goes down to 2mV/div., with a broadband design that limits overshoot to one percent.

Probe compensation adjustment is achieved through a built-in dual-frequency 1kHz/1MHz calibrator, which can be used to optimize probe-tip through display fidelity. The fastest sweep rate is 10ns/div., using the x10 magnifier. The scope can trigger on signals greater than



100MHz and on inputs less than one half a division on screen. An active sync-separator permits detailed examination of complex TV signals.

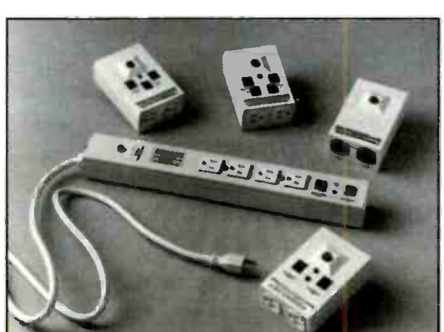
A feature not normally found on oscilloscopes is the built-in component tester, which uses a stabilized measurement voltage to rapidly test active and passive circuit components at the push of a button. A built-in low-noise switching power supply accommodates voltages between 90Vac and 260Vac at 36W.

Circle (102) on Reply Card

Surge suppressors

A new line of Perma Power surge suppressors is now available from *Shape Electronics*. With 30 models in the line, they provide surge protection for all types of electronic equipment used in the office or at home.

Four grades of surge suppressor models are available. Premium-grade models offer a lifetime product and equipment



warranty. They protect PCs and workstations used for data and word processing applications. Heavy-duty premium-grade units are applicable in test equipment, copy machines, and laser printers. Computer-grade models protect personal computer systems against power surge and noise protection for home computers, home entertainment, and appliance applications.

Circle (103) on Reply Card

Aerosol, non-CFC contact cleaner

Precision Cleaner II, a non-flammable, non-CFC, aerosol type contact cleaner, is being introduced by *Micro Care Corp*.

Non-toxic and plastic safe, this new formulation may be used in every industry to remove oils, grease, grime, dust, and general contaminants from precision electronic and mechanical assemblies. It gently cleans circuit boards, motors, switches, and other essentials in a variety of manufacturing, repair, testing, research, and medical environments.

This solvent is believed by the manufacturer to be the only commercially

available non-CFC contact cleaner that can effectively replace the use of CFC-113. It is non-conductive, will not burn, will not attack plastics, and cannot harm operating machinery.

The basic composition the cleaner incorporates is a new solvent derived from the perfluorocarbon family, plus HFC propellants and some minor additives. EPA approval of the product has been filed through the "Significant New Alternatives Program."

Circle (104) on Reply Card

These Photofact folders for TV receivers and other equipment have been released by Howard W. Sams & Co. for June and July 1994.

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25GT522FE1 3339

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CS4540A4 3336
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RS2568C4 3336
RS3182 C402 3328
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VR9614AT01 ....(sim. to) VCR-253
VR9622AT01 ....(sim. to) VCR-253
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VT8720AT01 ....(sim. to) VCR-253
13S401 3338

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CTC169BF2 3330
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F25251WNJX1 3337
F25651BLFE1 3337
F25651BLJX1 3337
F26251ETFE1 3337
F26631SEFE1 3337
F26631SEJX1 3337
F26633SEFE1 3337
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F35750STFM1 3330
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G25341WKCX1 3337
G26661CKCX1 3337
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G26681CKKF1 3337
G26683CKCX1 3337

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20E-S130 3329

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SRC20214 3340
VC8922AT01 ....(sim. to) VCR-253

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RS2080C205 3352
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VR9720AT01 ....(sim. to) VCR-254
VR9722AT01 ....(sim. to) VCR-254
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KV-27XBR36 3342
SCC-F16H-A 3342
SCC-F16K-A 3342
SCC-F17H-A 3342
SCC-F17K-A 3342
SCC-F78G-A 3347
SCC-F79F-A 3347

SYLVANIA
VC4010AT01 ....VCR-254
VC4020AT01 ....VCR-254
VC4024AT01 ....(sim. to) VCR-254

TOSHIBA
CF19C20 3348
TAC9370 3348

TT0394

By Roger D. Redden

Emerson Model ECR2100: Sams 2547-1
No audio, no video, HV rush heard

When this set was turned on, it produced a rushing sound of HV, but there was no audio, and the screen remained dark. When either the channel up or channel down button was pressed, the channels, as indicated by the LED display, changed continuously.

Although the screen was blank, when I turned the set off I thought I saw, just for an instant, a horizontal line across the center of the screen. Since the brightness and contrast controls were already turned to maximum brightness, I noted the position of the screen control (so I could reset it later. After turning the set back on, I slowly turned the screen control up and a horizontal line appeared.

I had recently replaced bad vertical output ICs in two similar Emerson chassis. Was this number three?

The voltage at pin 1 of IC401, the power input to the vertical output IC, was 0V, instead of the normal 9V. The resistance reading to ground from pin 1 was about 60Ω; abnormally low. Normal resistance is about 280Ω. Was it really as easy as another bad vertical IC?

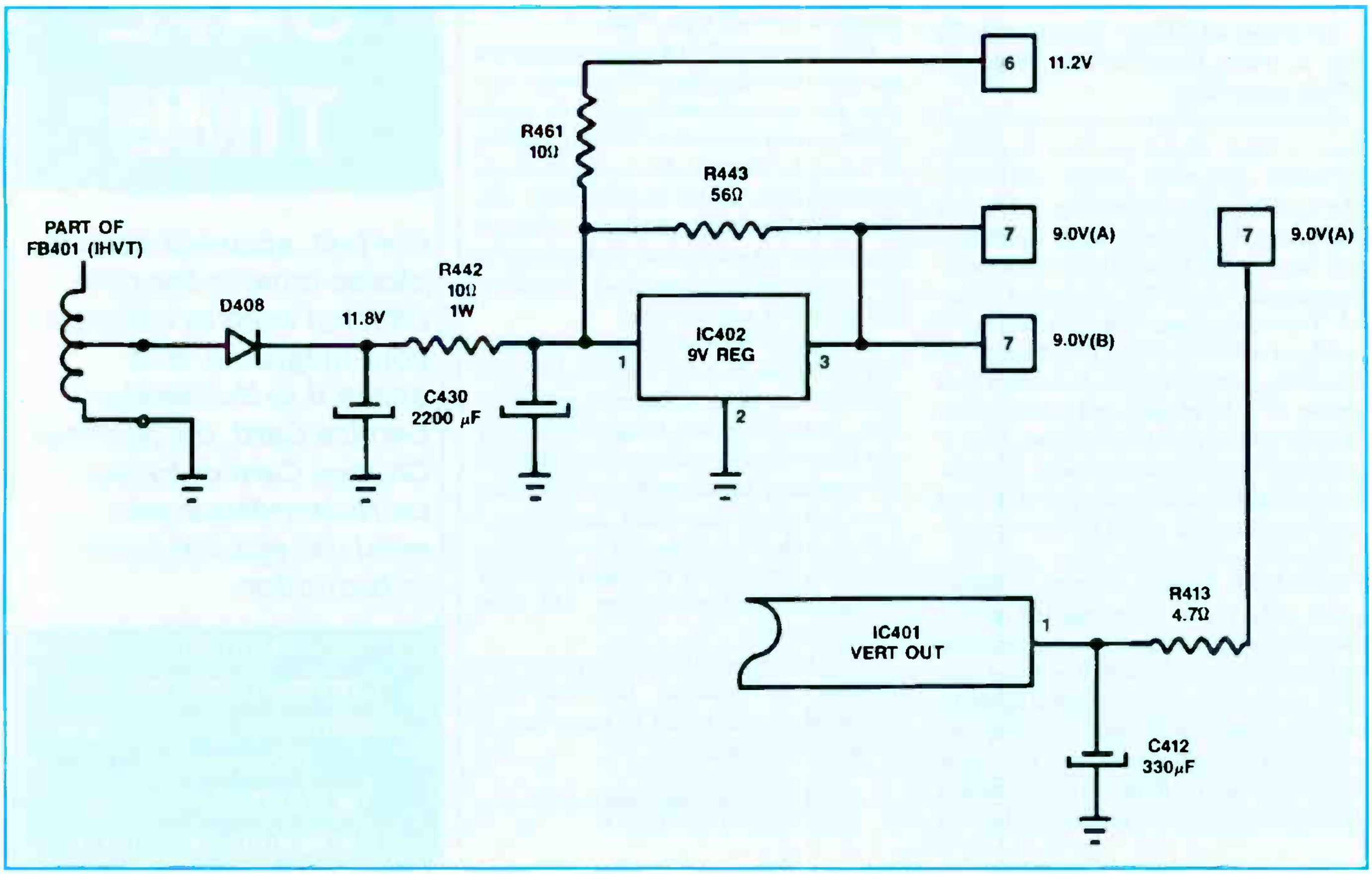
Not this time. After I removed the solder from around pin 1 of IC401 and again measured the resistance from this point to ground, I found that the resistance that caused the low ohmmeter reading was not the resistance from the pin of the IC, but from the foil to which the pin was soldered. This foil leads to R413. The resistance to ground from the lead of R413 away from pin 1 was 56Ω. When I followed the path toward the power supply, as shown on the schematic, it led me to R443, a 56Ω resistor.

Hmm. The ohmmeter showed 56Ω to ground and here was a 56Ω resistor. Was this a coincidence, or was there a short on the other side of that resistor where it connected to pin 1 of IC402, the 9V regulator. When I measured the resistance at pin 1, it indeed measured 0Ω. The only components at that point that should be able to cause a dead short were IC402 or C430.

A short at pin 1 of IC402 would have caused excessive current, that might have damaged D408 or R442. When I checked these components, D408 checked good, but R442 was open.

I touched my ohmmeter probe back to pin 1 of IC402. At least a dead short in a circuit with only two suspects should be easy to find. Unfortunately, the resistance readings were bouncing up and down.

Redden is owner and operator of a consumer electronics service center.



Books

Mastering Radio Frequency Circuits through Projects and Experiments, By Joseph J. Carr, TAB Books, 304 pages, 150 illus., $29.95 paperback, $37.95 hardcover.

Mastering Radio Frequency Circuits through Projects and Experiments, an entry in the TAB Mastering Electronics Series, is packed with hands-on bench experiments and projects readers can do. Students, beginning- and intermediate-level electronics hobbyists, ham radio operators and shortwave listeners will be particularly interested in this book by Joseph J. Carr.

Readers will learn how to design and build their own RF amplifiers, simple wire antennas, microwave integrated circuits, and receiver preselectors. They'll discover how to wind their own RF coils and transformers, repair fixed and variable capacitors, and build radio receiver circuits and bridges. Two especially illuminating and useful projects involve spectrum analyzers and time domain reflectors.

Carr is an electrical engineer and author of numerous technical articles and electronics books. He is a regular columnist for several electronics magazines, and has received awards for his knowledge and expertise in the field of electronics.

TAB Books/McGraw-Hill, Inc., Blue Ridge Summit, PA 17294-0850

Servicing PC-Based Equipment, By Don D. Doerr, Prentice Hall, 384 pages, $26.95 paperback.

Based on more than ten years experience, Don D. Doerr shows you how to service PC based equipment quickly and easily. The book is an indispensable source for diagnosing PC problems. Flow charts take you step-by-step through the troubleshooting procedure, until the problem is isolated. Troubleshooting tips help you solve problems without needing to send parts out for costly repair service. You learn how simple it is to protect and recover data quickly and easily. Doerr shows how to locate the best sources for parts, diagnostics, schematics and board repair. The most common questions asked by service technicians are covered.

This book features a DOS reference guide and a list of recommended utilities and step-by-step instructions for repairing and installing a hard disk. The book contains sections about common diagnostic software, boards and drives, system boards, expansion bus, diagnostic and post error codes, hard drives, floppy drives, monitors and keyboards, power supplies and power protection, automatic test equipment types, soldering equipment, fault isolation guides, and switch and jumper settings. It also contains the most frequently referenced service information. The book devotes a full chapter to buying a new PC. Servicing PC-Based Equipment features special reference sections on opportunities in the service industry, a vendor support list, a glossary, and complete index.

Prentice Hall, Paramount Publishing Education Group, Englewood Cliffs, NJ 07632

McGraw-Hill Circuit Encyclopedia and Troubleshooting Guide, Volume 2, By John D. Lenk, McGraw-Hill, 691 pages, $59.50.

The second and concluding volume of a compilation of information on electronic circuits, the *McGraw-Hill Circuit Guide, Volume 2*, features detailed material and data on hundreds of circuits commonly used in all phases of electronics.

Expanding on the well-received first volume (published in June, 1993), this noteworthy reference not only focuses on 700 additional integrated and discrete-component circuits, but also contains a wealth of new test and troubleshooting data. It explains how circuits operate and where they fit into electronic equipment and systems, groups all of the circuits by function, and gives a specific troubleshooting approach for each type of circuit.

With more than 750 detailed illustrations and schematic drawings, the reference supplies proven component values for actual circuits, gives sources and mailing addresses for each, and includes substitution and cross-reference tables to help locate substitute ICs. The book is designed so that the circuits can be put to work immediately or the circuit values can be easily changed to suit particular requirements.

A resource for engineers, technicians, and hobbyists, Volume 2 of this Encyclopedia covers many different types of circuits: audio-frequency, basic amplifier, RF and IF, special-purpose, power-supply/linear-regulator, battery-power and micropower, and power-processing. In addition, it examines classic op-amp, OTA and Norton amplifier, temperature indicator/controller, transducer/signal-conditioner, and comparator circuits.

Lenk has been a technical writer specializing in practical troubleshooting guides. He is the author of more than 75 books on electronics.

McGraw-Hill, Inc., Professional Book Group, New York, NY 10011

Tips *(Continued)*

I found that pressure on the circuit board would keep the short present. I suspected that there might be a solder-splash short on a trace from pin 1 of IC402, but even with the help of a magnifying glass I was not able to see one. Could there be a foreign object on the top of the board causing an intermittent short?

I carefully followed the path of the trace from pin 1 of IC402 on the bottom of the board, relating that path to the top of the board. I couldn't spot any foreign objects. But the path of the trace passed just beneath the antenna coax plug-in to the tuner, and R461 was located there, mounted high off the board. One of its leads appeared to touch the metal plug-in of the coax. Wiggling R461 slightly made the short come and go.

I resoldered R461 closer to the board so its leads could not touch the metal plug-in, and replaced R442. This returned the set to normal operation.

When R442 became open, this disconnected supply voltages to the video if and sound if circuits, as well as other circuits. Absence of supply voltages to several circuits explained the multitude of symptoms.

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S/M or schematics to buy or borrow for Kensonic Accuphase E-202 amp, for reference 240R (by Quadraflex) receiver and for Pioneer CT-7R cassette deck. *Contact Richard Sereda, College of San Mateo, 1700 W. Hillsdale, San Mateo, CA 94402.*

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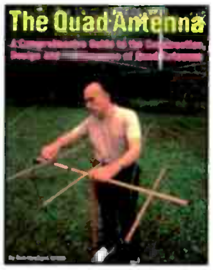

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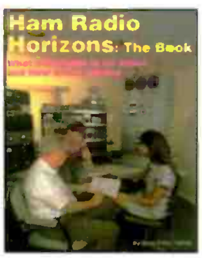

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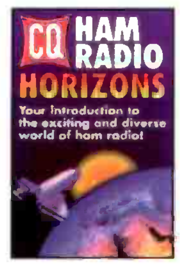

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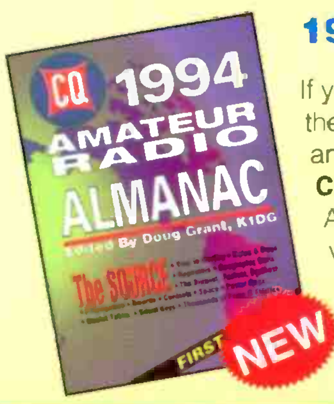

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