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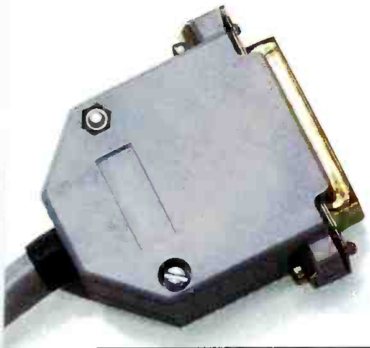
ELECTRONIC™

Servicing & Technology

FEBRUARY 1988/$2.25

Critical Sound Problems • Troubleshooting Microprocessor Circuits

Servicing the Commodore 1541 Disk Drive—Part II



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- 2 µsec signal pulse trap.

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Breakout Box

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- Includes spare Red/Green LED set.
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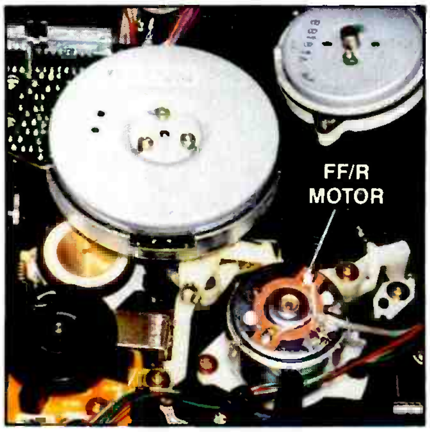

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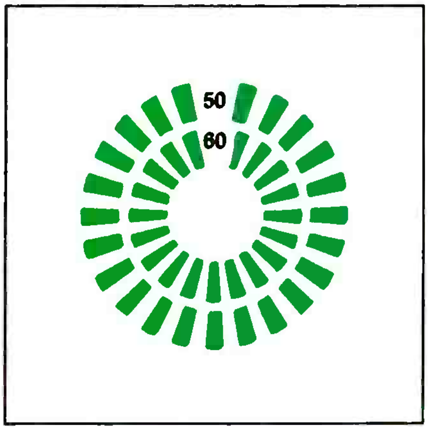

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SPECIAL REPORT

VCR servicing

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ON THE COVER

The proper troubleshooting and testing equipment and techniques, combined with a knowledge of what the symptoms reveal, will help determine the cause of trouble symptoms. (Photo courtesy of E-Z Hook.)

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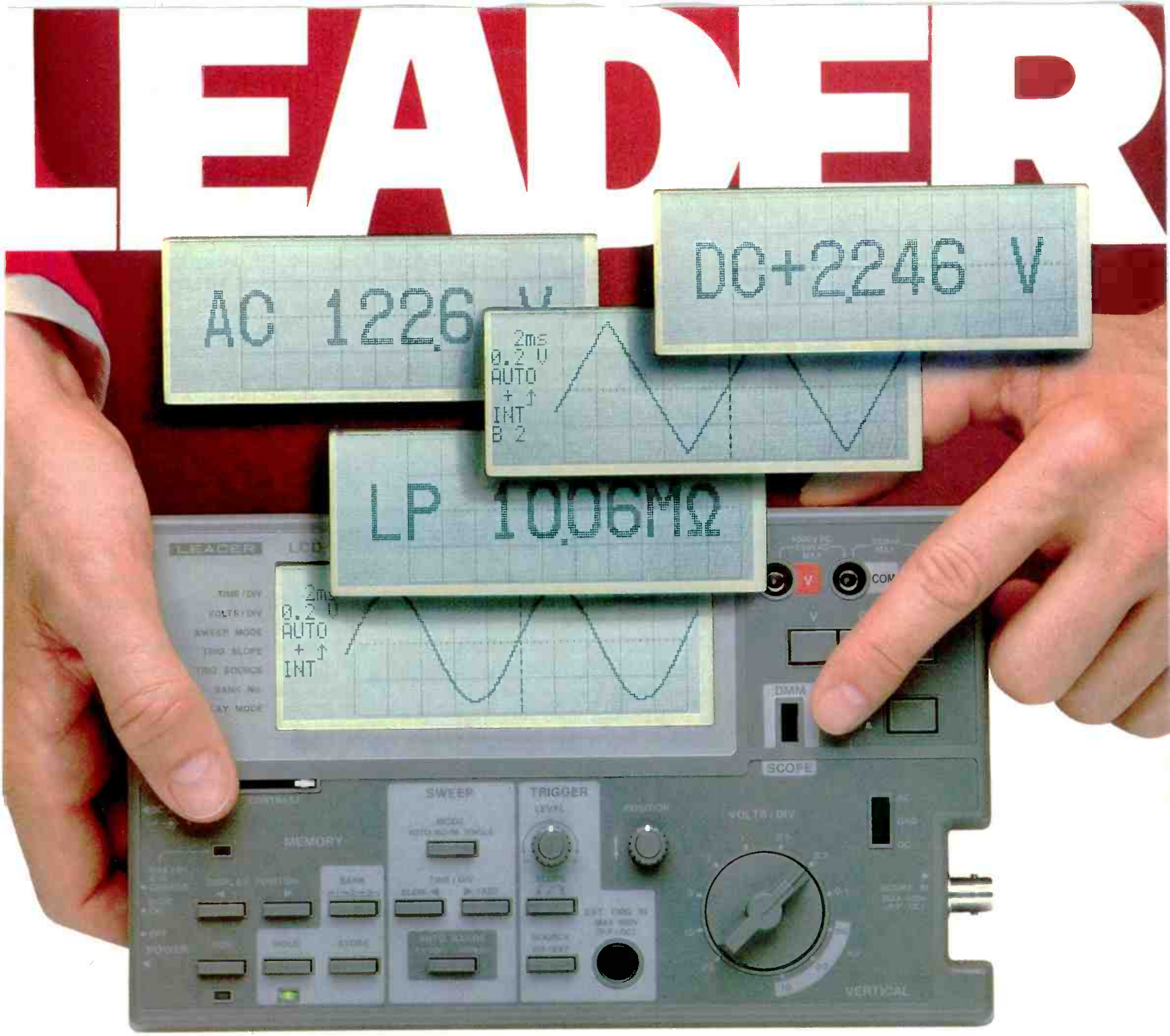

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The VCR era

Not too many years ago, the idea of home entertainment barely existed. In fact, life being what it was, there wasn't a lot of time for entertainment. Some of the media of entertainment were playing cards, the checkerboard, the stereopticon. Sometime in the early 1900s the radio was introduced. At first its usefulness as an entertainment device was limited because the only output was headphones. It did, however, manage to connect each home that possessed one with all the rest of the world, something that had not before existed.

The idea of radios as home entertainment evolved as radios became easier to operate and amplifiers were added. The addition of loudspeakers allowed the entire family to be included in what was going on in the world.

The phonograph made it possible for families to possess their own copies of any music available—and to play it anytime they wanted to. Even if the fidelity was low, the excitement was high.

Later in this century, it became possible to transmit pictures through the airwaves, and soon homes throughout the world were enthralled by flickering gray images on TV screens.

Television has been so improved that even on a system such as NTSC, generally conceded to be an inferior system for transmission of pictures, TV programs are incredibly lifelike and vivid.

For years broadcast television has brought movies into our homes, but they are "edited for TV," whatever that means, and shown at hours that may not be convenient for a lot of people. Cable television regularly brings people more movies, more often, with less editing, but still at set times with limited choices.

The VCR is in the process of changing the definition of home entertainment, however. Now it's possible to record a program that you would otherwise miss and view it when it's convenient for *you*. And of course, with more and more movies being released on tape, you can buy almost any movie you want to watch and play it as many times as you wish. Or, during the week, you can go to the local grocery store and rent a movie for a buck.

And if you have a hi-fi stereo VCR, surround-sound capability and a large-screen television, you can view a movie with almost the same vividness as you can at the local theater.

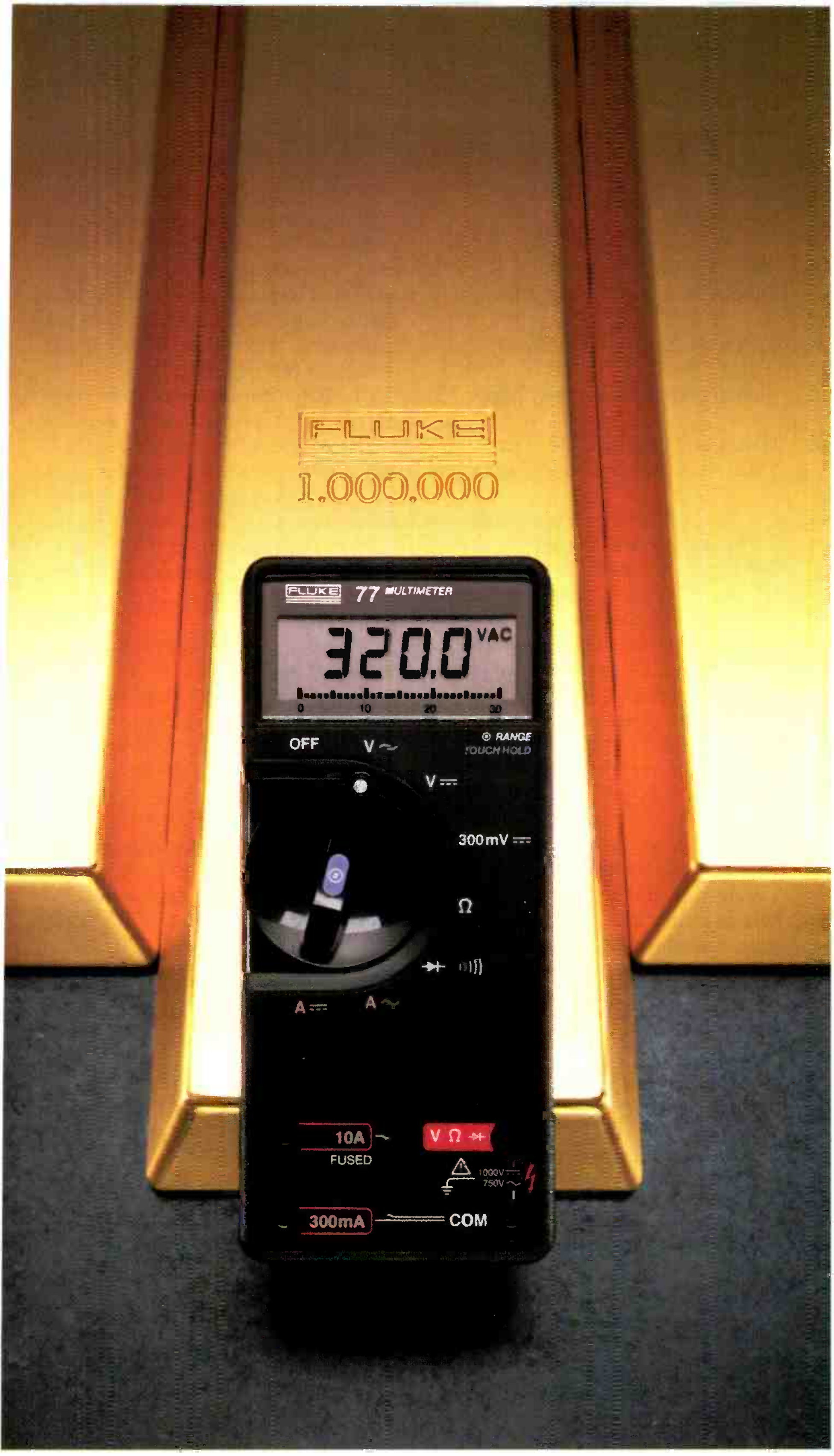
The interesting thing is that whatever change the definition of entertainment undergoes because of the VCR, it doesn't seem to include any reduction in the movie-theater-going of the average movie fan. On the contrary, as people become more aware of movies through home viewing, moviegoing seems to be increasing.

VCRs are allowing individuals and families to tailor their own visual entertainment to their own tastes and schedules. But it's becoming more and more apparent that there's a lot more entertainment involved. There are tapes that provide instructions in physical fitness, cooking, home repair, maintenance and improvement. There are videotapes that will help you improve your golf swing or help you develop your child's baseball skills. There are even tapes that will allow you to turn your television into a crackling fireplace or an aquarium (that you'll never have to clean or feed) to help you relax, or tapes that will take you on a thrilling aerial tour of the Grand Canyon or other scenic wonder.

No doubt there will be more and more uses developed for the VCR, but wherever it ultimately leads, this consumer electronic product, made available little more than a decade ago, has become a standard part of the average American household, just as the radio, the phonograph and the television have before. And a lot of those units are eventually going to need to be serviced.

Our special report on VCR servicing in this issue is presented in recognition of this growth in the VCR population and the need for information on diagnosing and repairing them.

Nils Conrad Persson



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News

NBS discloses DAT evaluation method

The National Bureau of Standards (NBS) has disclosed the method in which it intends to evaluate the CBS proposal for copy prohibition. (The scheme, called CopyCode, notches out any musical information at 3.18kHz in the original; when the crippled signal is detected, the DAT disables the record circuit.)

The NBS will attempt to answer three questions:

- Does the digital copy-code scanner system achieve its purpose in preventing digital audiotape machines from recording?
- Does the system degrade the quality of pre-recorded software into which the notch has been inserted?
- Can the system be bypassed; if so, how easily?

The evaluation is expected to be completed in early 1988.

VCR servicing training schedule

The EIA/CEG (Electronic Industries Association Consumer Electronics Group) will continue to operate the three current resident training schools for VCR servicing techniques and is negotiating with a trade school in Long Beach, CA, to become the fourth resident training school. Scheduled free sessions for 1988 will be held on the following dates:

May 2-6, Aug. 29-Sept. 2
Illinois Technical College, Chicago, IL

March 28-April 1, June 27-July 1, Sept. 26-30
United Electronics Institute, Tampa, FL

March 21-25, June 20-24, Oct. 3-7
Video Technical Institute, Dallas, TX

ISCET honors technicians

The International Society of Certified Electronics Technicians (ISCET) has set aside March 8, 1988 as National Electronics Technicians Day to recognize the high standards of performance and excellence maintained by professional technicians. ISCET maintains the certification program for professional electronics technicians. The criteria for certification require technicians to be knowledgeable in both fundamental electronics and the more advanced theory applicable to their specialty field. March 8 will be set aside as a national testing day for certification of electronics technicians. For more information, contact the ISCET headquarters at 2708 W. Berry, Fort Worth, TX 76109; 817-921-9101.

UL proposes capacitor standard

Underwriters Laboratories (UL) is proposing UL 1414, the updated standard for safety for across-the-line, antenna-coupling and line-bypass capacitors for radio- and television-type appliances, for recognition as an American National Standard.

UL 1414 covers capacitors rated 85°C that are employed in nominal 125V and 250V, 50Hz to 60Hz circuits and double-protection capacitors that are employed in nominal 125V circuits in radio, audio, video, television and similar appliances in applications in which breakdown of the capacitor may result in a risk of fire, electric shock or injury to persons.

The proposed standard is a revised version of ANSI/UL 1414-83, which is presently recognized as an American National Standard. UL is seeking review and comment from interested individuals and organizations to help develop a consensus upon which continued recognition of UL 1414 by the American National Standards Institute (ANSI) can be based. For more information, contact L.M. Cohen at UL, 333 Pfingsten Road, Northbrook, IL 60062; 312-272-8800, ext. 2692.

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Feedback

Measuring the horizontal pulse

In your November 1987 issue you published a very good article on "Troubleshooting Startup Circuits," by Gregory Carey, CET, which I found to be very informative.

I would like to add one comment that I think might be helpful to some technicians. In reference to measuring the horizontal circuit waveform with the scope, many shops do not own a scope that can measure the horizontal pulse directly without risking damage to the scope. I use the following method.

I loose-couple the scope probe to the horizontal output transistor, either by placing it approximately ½ inch to 1 inch from the collector of the transistor, by hooking the ground lead to ground or by clipping the probe to the insulation of the wire that feeds the collector, if applicable. I then put the scope on 20µs and ½V to 1V per division voltage range. I can safely look at the horizontal duty cycle and observe if the waveform shows any ringing that would indicate a problem in the output circuit.

I hope this information will help those readers who own scopes that will not safely take a 1,000V pulse.

Robert J. Cardone, CET
Norcross, GA

Books

Editor's Note: ES&T *periodically features books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publisher at the address given, rather than to* **ES&T**.

CET Exam Book, by Ron Crow and Dick Glass; TAB Books, 280 pages; $13.95 paperback, $21.95 hardbound.

The latest technical information needed by students preparing to take the associate-level CET Exam and by electronics technicians in general is provided in sample quizzes and discussions of exam questions. The authors also offer tips on entering the electronics job market and information on each of the various electronics specialties at the Journeyman level.

Published by TAB Books, P.O. Box 40, Blue Ridge Summit, PA 17214; 717-794-2191.

Solid-State Electronics Theory with Experiments, by M.J. Sanfilippo; TAB Books, 336 pages; $16.95 paperback, $25.95 hardbound.

The author presents an introduction to semiconductor theory, describing simple solid-state devices and how they should be tested and used in designing circuits. Projects at the end of each chapter reinforce concepts and allow readers to experiment with the applications described in the text. Subjects covered include GaAsFETs, special-purpose diodes, op-amps, integrated circuits, oscillators and pulse circuits.

Published by TAB Books, P.O. Box 40, Blue Ridge Summit, PA 17214; 717-794-2191.

Microcomputer Hardware, Operation and Troubleshooting with IBM PC Applications, by Byron W. Putman; Prentice-Hall, 268 pages; $37.33, hardbound.

The author uses a system-oriented, 3-level approach, first discussing components and subassemblies at block diagram level, providing a functional description of each signal group. Each device is then integrated into a subsystem that performs a distinct function. Systems analysis and troubleshooting are presented last.

Published by Prentice-Hall, Englewood Cliffs, NJ 07632; 800-223-1360.

How to Become a Successful Consultant in Electronic Servicing; ATC Books; $25.

Associated Technology's new book "for the success-oriented professional" contains discussions on locating clients, setting fees, developing business plans and writing contracts. Also included are discussions of ethics and professional advertising.

Published by ATC Books, 804 Jordan Lane, Huntsville, AL 35816; 205-895-9187, ext. 174.

IBM PC Peripheral Troubleshooting & Repair Guide, by Charles J. Brooks; Howard W. Sams; $21.95.

This step-by-step procedures manual uses a cookbook approach to present computer peripheral service and repair methods. The book presents the basic theory of operation, hardware descriptions, preventive maintenance, and troubleshooting and repair techniques for all major peripherals compatible with the IBM personal computer.

Published by Howard W. Sams & Company, 4300 W. 62nd St., Indianapolis, IN 46268; 800-428-SAMS.

Compact Disc Troubleshooting & Repair Guide, by Neil R. Heller and Thomas Bentz; Howard W. Sams, 208 pages; $19.95.

A concise and complete introduction to the field of digital signal processing and compact disc players is presented with charts, tables and illustrations. The book explains the audio signal and its problems, discusses basic digital theory, and presents hardware, lasers, circuits, adjustments and tracking.

Published by Howard W. Sams & Company, 4300 W. 62nd St., Indianapolis, IN 46268; 800-428-SAMS.

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2546-1 . . . CTH-2690R, PC-28N90R, PC-28NE

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2545-1 . . . . . TL9960AP/65AD/68AK, TT9908AW/09AE, TU9952AU
2548-1 . . . . TP3947AE/AH/AX, chassis ALDC113
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RCA
2546-2 . . . . VDM140

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2548-2 . 564.48702650, 564.48702651

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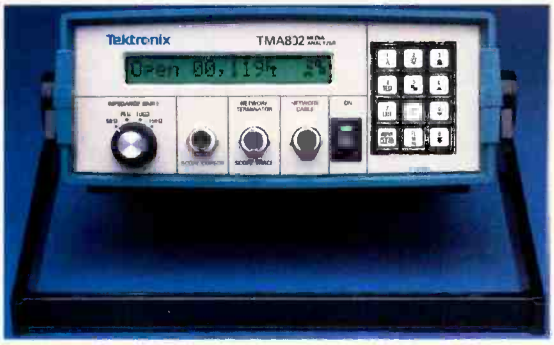

Introducing the TMA802 Media Analyzer

The Tek TMA802 is an easy-to-use, cost-effective tool that can quickly and accurately evaluate the condition of the network cable, and can effectively monitor traffic load on your local area network.

One instrument…to pinpoint the location of major cable faults; to couple with an oscilliscope for a detailed view of the entire network; *and* to monitor traffic load in complex networks and multi-vendor environments.

Non-intrusive, the TMA802 diagnoses problems on fully-operational LANs, without network disruption.

Compatible with the entire family of IEEE 802 LANs, the TMA802 supports Ethernet, Cheapernet, Starlan, MAP Token Bus and IBM Token Ring networks.

Three powerful modes:

- Standalone Mode, for quick cable status reports.
- Scope Mode, for a detailed network view including transceivers and terminator via a 50MHz oscilloscope.
- Monitor Mode, for accurate reports of cable traffic load independent of protocol or vendor.

Versatile and efficient, the TMA802 is capable of testing coax or twisted-pair based LANs, reporting distance in feet or meters, or roundtrip propagation delay in nanoseconds.

Rugged and reliable, the 8-pound TMA802 is portable, battery-operated, and built to Tektronix standards which assure operation in the field under a wide range of environmental conditions.

For a demonstration or more information, contact your nearest Tektronix Sales Office, or the Communications Network Analyzers Division, Tektronix, Inc., 625 S.E. Salmon, Redmond, OR 97756, USA. Telephone 503/923-4415.

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Three-dimensional camcorder

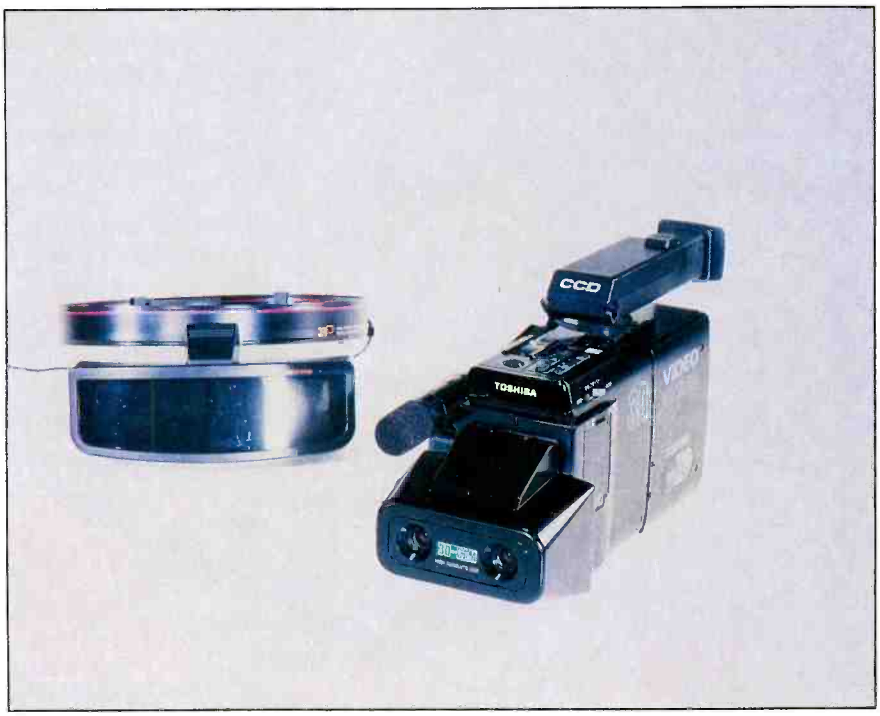
Toshiba Corporation has developed a VHS-C camcorder that shoots 3-dimensional (3-D) pictures. The recorded 3-D images can be reproduced on a TV screen in color using conventional VCRs. The image is viewed with special liquid-crystal glasses.

How it works

The 3D-CAM camcorder, which incorporates two eye-like microcamera heads using charge-coupled devices (CCDs), shoots two pictures simultaneously, one for each eye. In addition to reproduction of completed or prerecorded videotapes using a conventional VCR unit, images can also be relayed directly from the 3D-CAM to a TV screen using the device's playback function.

The 3D-CAM, which weighs a little more than 3½ pounds, serially records pictures shot by the two camera heads onto a VHS-C videocassette tape at 60 times per second. Viewers see these images through liquid-crystal glasses synchronized with the images; the right and left views are occluded in quick succession, so that the respective images are seen by the appropriate eye. The right and left images are mixed in the brain to create a stereoscopic image.

An adapter between the VCR (or 3D-CAM) and the glasses synchronizes the images with the glasses. This method is the same one used in conventional 3-D videodisc players, which means that the same liquid-crystal glasses can be used with the new 3D-CAM unit.



The 3D-CAM records 3-dimensional images that can be played back on conventional VHS VCRs. Liquid-crystal glasses (on the left) connect to an adapter for 3-D viewing. One lens can be used alone to film regular videos as well.

Removing flicker

Basic stereoscopic methods used to tire viewers' eyes because of the *flicker phenomenon*. This flicker phenomenon occurs in conventional NTSC format TV sets that show 60 pictures per second, 30 pictures for each eye in alternating sequence controlled by the special glasses and adapter.

The 3D-CAM system has eliminated the flicker by reproducing each picture twice on the screen for each eye to achieve the normal viewing speed for standard videos of 60 pictures per second per eye. This has been achieved by digital memory technology including LSI frame memories.

In effect, each eye views 60 pictures per second from the total of 120 pictures per second; the doubled number of pictures results from faster scanning. However, reproduction speed is doubled to achieve perfect color with no flicker. This means also that reproduction can take place using conventional VCRs along with a unit that includes an A/D converter, a frame memory and scanning-speed converter, and a special TV set that can scan twice as fast as a conventional television. ES&T

Test your electronics knowledge

By Sam Wilson, CET

1. Which of the following best describes the action of a Hall effect device?
A. A voltage is developed when a magnetic field is present.
B. A magnetic field is developed when a voltage is present.
C. It behaves like an inductor.
D. It stores energy in the form of a magnetic field.

2. Which of the following best describes the action of a ferrite bead?
A. A voltage is developed when a magnetic field is present.
B. A magnetic field is developed when a voltage is present.
C. It behaves like an inductor.
D. It stores energy in the form of a magnetic field.

3. Is the following statement correct? *The dB gain of an amplifier can always be determined by using the equation:*

$$dB = 20 \log (\text{output voltage} / \text{input voltage})$$

A. Correct.
B. Incorrect.

Wilson is the electronics theory consultant for **ES&T**.

4. Is the following statement correct? *The power company charges you for the total amount of power you use each month.*
A. Correct.
B. Incorrect.

5. A current of 1mA is flowing in a circuit. However, when a milliammeter is inserted into the circuit to measure the current, the indicated value is 0.9mA. What is the percent error caused by the meter? (Assume the meter reading is accurate.)
A. 1%
B. 10%
C. 9%
D. 90%

6. The rise time of a square wave delivered to an oscilloscope vertical input terminal is $0.01\mu s$. Assuming a perfect square wave, what is the approximate bandwidth of the scope vertical amplifier?
A. 1MHz
B. 10MHz
C. 20MHz
D. 50MHz
E. None of the above.

7. A universal motor can operate on
A. any voltage.
B. any frequency.
C. any value of current.
D. ac or dc.

8. A technician is replacing a power transformer. He notices that there is a braided wire coming out of the transformer, but it is not shown on the schematic. The braided wire should be
A. cut off as close to the transformer case as possible.
B. grounded through a $0.1\mu F$ capacitor.
C. grounded through a 10Ω, 5W resistor.
D. None of the above.

9. A disadvantage of tantalum electrolytic capacitors over the aluminum type is
A. shorter shelf life.
B. poor temperature stability.
C. lower operating voltages.

10. Is the following statement correct? *A coulomb is a quantity of electric charge associated with a total of 6.28 x 10^{18} electrons.*
A. Correct.
B. Incorrect.

Answers are on page 41

Special Report
Special Report

VCR servicing

According to information released in December by the Electronic Industries Association Consumer Electronics Group (EIA/CEG), as of November 1987 more than 51 million VCRs had been sold to U.S. dealers since the introduction of VCRs here in 1975.

More than 11.8 million VCRs were sold during the first 11 months of 1987, 2.5 percent more than the number sold during the same period in 1986.

VCRs have a lot of moving parts that are subject to wear and breakage under normal conditions and to an even greater extent when subject to abuse. Camcorders (which represent about 1.35 million of the 11.8 million VCRs sold during the first 11 months of 1987) are subject to even more abuse because they can be expected to be used outside: at the park, on the beach, in places where it's dusty, wet, hot, cold.

Of the 420 readers who responded to a reader opinion survey in our September issue, more than 80% said they want to read about VCR servicing in **ES&T**. In answer to the question "What kind of information is the **most** useful to you?" (VCR servicing, TV servicing, CD servicing, Computer servicing, Audio servicing, Other), slightly more than 45% answered "VCR servicing." The only category of information that received more votes in this survey as being *most* useful was TV servicing information at more than 60%. (The total adds to considerably more than 100% because some people checked more than one box even though we asked them not to, which shows just how important servicing information is to our readers.)

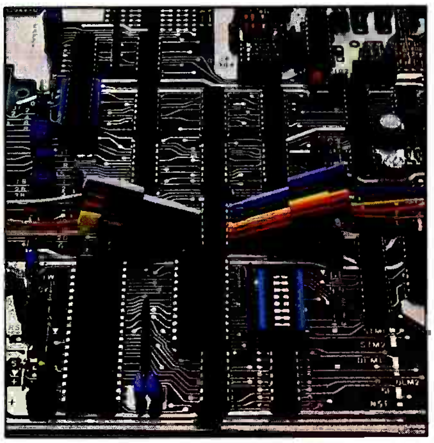
That's why we're bringing you this special report on VCR servicing. There are millions of VCRs in millions of homes in this country. They have heads that are going to require cleaning; belts that stretch, slip or break; bearings that wear; motors that burn out; gears that become stripped; components that malfunction. Because VCRs are so complex, no article or special report can even begin to cover the subject comprehensively. This special report won't try to do that. But the three components of the report (diagnosing VCR head problems, troubleshooting a Fisher VCR and the Profax schematics of a GE 1VCR2018W VCR) should help you feel a little more comfortable with VCRs and give you some solid VCR troubleshooting information.

If you need even more help, EIA/CEG is planning a series of classes at its VCR servicing training schools (see "News" on page 6 for dates). The workshops are conducted by EIA-trained instructors who will teach a 40-hour, 5-day course designed to train and upgrade currently employed consumer electronic technicians.

The training session covers electrical and mechanical functions of playback, recording and servo control. Technicians who attend should expect lots of hands-on experience gained through various lab exercises and actual troubleshooting. Both VHS and Beta formats will be covered.

The best thing is, classes are free of charge, although the technicians attending must be currently employed in a consumer electronics servicing capacity. (To find out how to attend one of these workshops, contact: Product Services, Electronic Industries Association, 2001 Eye Street N.W., Washington DC 20006; 202-457-4919.)

VCRs have changed and are continuing to change the definition of home entertainment. Their unique servicing requirements are changing the nature of electronic servicing. Read this special report for information that will help you when you encounter a problem in a VCR.



Special Report
Special Report

Isolating head-related failures in VCRs

By Gregory D. Carey, CET

Head-related failures represent a high percentage of VCR problems involving electronic components. To service head-related problems, you need to know the symptoms that may be caused by bad heads and which circuits (besides heads) can cause conditions that mimic bad heads. You will also need to know how to confirm whether the heads are really the problem before you call in your order to your head supplier.

The delicate, spinning video head assembly falls victim to many mishaps. They move past the surface of a VHS tape at 12.9mph (or 15.4mph on a Beta tape). After playing 100 90-minute movies, the heads have traveled about 2,000 miles! No wonder they wear out. If the head runs into a speck of dirt or bad tape splice at 15mph, the fragile tip can get knocked right off the head assembly.

Three things complicate isolating head-related troubles:

- Many other failures mimic a bad head;
- the signals near the heads are difficult to measure; and
- the heads are expensive and specialized, making it difficult to stock all the heads needed for trial-and-error troubleshooting.

Playback problems are the first thing you should look at, because most head defects affect the playback circuits long before the recording circuits. Because all VCRs use the same heads to record or play back a tape, repairing a playback problem usually corrects any recording problems as well.

Many problems can cause a poor picture. Only some are caused by circuits related to the video heads. Sometimes a technician changes the heads in frustration, because he did not realize that the original symptom could not be caused by the video heads.

Carey is an application engineer at Sencore. He has run more than 800 seminars for service dealers.

Be sure you know the symptom

Defective heads cause several different symptoms. If you are new to VCR servicing, you may not know exactly what to look for. As a result, many video symptoms that don't involve the head at all receive the label *head problem.*

As a rule, remember that a head-related problem always affects the entire picture all the time. Depending on whether one or both heads are involved, the picture may be completely missing or may be present with a high level of noise. If any part of the picture is clear, however, you do not have a head problem.

Here's a typical example of this condition in a 4-head VHS VCR. Three-quarters of the picture is noisy, but one quarter of the screen is clear. In many cases, when a technician sees this he will immediately replace the head assembly, sometimes more than once. New heads, however, cannot correct the problem because this symptom is not caused by bad heads. Because there is clear video for a part of the screen, the symptom confirms that both heads are good. (Here, the problem is a defective head-selection relay.)

To understand why this is true, you need to understand how the video heads process the video signal. First, the heads are always used in pairs. If the VCR has more than two heads, they are still used two at a time during normal playback. A 4-head machine has two pairs of heads; one pair is the correct width for the fastest tape speed (SP on VHS or Beta I), and the other pair is correctly sized for the slowest (EP or Beta III) tape speed. However, the four heads are still used two at a time.

A 3-head machine has an extra head for cleaner special effects, such as freeze-frame or scan. Only two heads are used during normal play. A 5-head VCR is a 4-head machine with the extra head for clean effects. A hi-fi VHS machine uses two *additional* heads to record and play back the FM audio carriers, which results in head assemblies with four, five, six or even seven of these spinning heads.

Beta hi-fi decks, incidentally, do not need the extra audio heads, because the FM audio carriers are handled by the same heads that process video.

As the video heads play the tape, each picks up signal half of the time. This gives the second head a chance to move around the back side of the head drum, out of contact with the tape, until it is ready to make contact with the tape again. Each head produces an output for 1/60th of a second—the exact time necessary to produce one field of video information (60 fields form the 30 frames for each second of interlaced video). Switching between the heads is synchronized to the video signal and should happen a few horizontal lines (six to seven) before the vertical sync pulse.

With this understanding, you can see that if both heads are defective, there will be no video. If only one head is defective (as is often the case), the good head continues to provide video while the bad head causes either noise or no signal. The good head picks up the 262.5 horizontal lines needed to form one complete video field from top to bottom on the screen. The bad head then adds 262.5 lines of noise, which also extends over the entire screen.

If even the smallest part of the screen

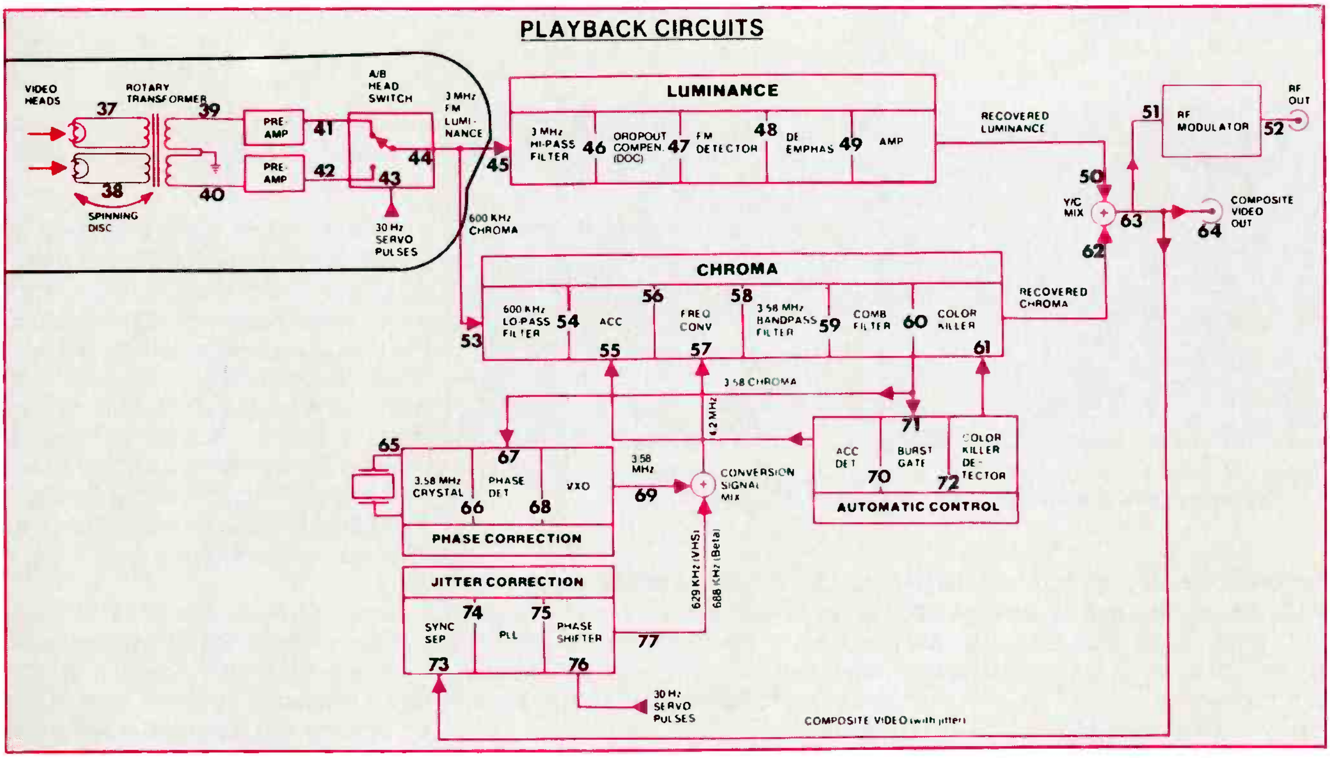


Figure 1. If any of the circuits from the video heads through the video-head switch are defective, they will mimic a bad head. This includes the head-switching pulse coming from the servo circuits at test point 43. (Courtesy of Sencore.)

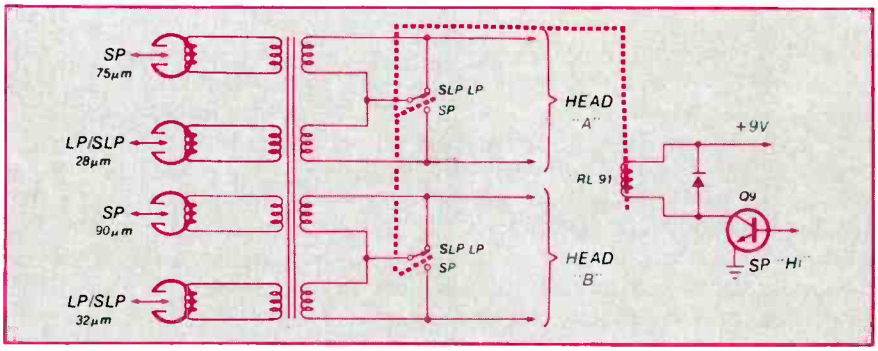


Figure 2. A 4-head VCR uses the heads in pairs. A relay or electronic circuit selects the pair that corresponds to the tape speed. (Courtesy of RCA.)

has a clear picture, you know that both heads are working part of the time. If they can work part of the time, they can work all the time, so the problem must be elsewhere.

Understanding the symptoms can save you from wasting time troubleshooting the heads when there is nothing wrong with them. But there are many other circuits that can cause symptoms that look exactly like a bad head.

What else causes a head symptom?

Confirming that the entire screen is affected does not necessarily confirm that the heads are bad. There are nearly a dozen other circuits that cause symptoms that look similar to a bad head. In short, any of the circuits from the video heads to the head-switcher output can mimic a bad head.

• *Connectors and wires:* Mechanical connections are often overlooked, but problems here can interrupt a head signal anywhere along the way. A broken wire or a bad electrical connector may cause the same symptom as a head with no output.

• *Rotary transformers:* These special components move the signal from the spinning heads to the stationary circuits. Just as the name implies, these are transformers with one rotating winding. This coil lies next to a similar stationary winding. Each video or audio head has its own pair of rotary transformers. A short or open in either winding will cause a symptom identical to a bad head.

Many people mistakenly believe that the transformer must be rotating to transfer a signal. A rotary transformer works as well when it is standing still as when it is turning. As you will see later, this lets you test the transformer while the VCR is stopped and the power is removed.

• *Record/playback switches:* VCRs use the same heads to record and to play the tape. This calls for switching between the recording and the playback circuits. Early VCRs use mechanical switches, activated by the "piano key" operation buttons. These often develop a few ohms of resistance, which can interrupt the playback signal. Later VCRs use a matrix of switching transistors. If one transistor is bad, it causes the same symptom as a bad head. Newer decks use integrated circuits (ICs). These too can fail, causing the same symptom as a bad head.

• *Head selectors:* VCRs with more than two video heads need circuits to choose the correct heads. Some use electro-mechanical relays; others use electronic switches. One important difference between problems in these circuits and those caused by record/playback switching is that these problems will depend on the speed of the tape being played. Use test tapes recorded at different tape speeds to force the VCR to select the head circuits that show the problem.

• *Head amplifier:* Each video head has its own amplifier on the main printed circuit board. If the amplifier for one head is defective, the symptom will look similar to a bad head. Because the signals coming from the tape are very small (less than 0.5mV) and frequency-modulated (FM) besides, you may not be able to measure the input to these amplifiers.

• *Head switcher:* All VCRs have a switch after the head amplifiers to select which head will provide an output. The switch mutes the noise coming from the head that is not in contact with the tape. When this circuit fails, it can leave one head connected continuously, or it can fail to turn on the other head. Either of these conditions will look just like a bad head because half of the signal from the switcher output will be missing or contain high levels of noise.

• *Head switching signal:* The head switcher is controlled by a 30Hz signal coming from the servo circuits. If this signal is missing or low in amplitude, the switcher will stay stuck in one position. The results are the same as a bad switcher, but the cause is outside the IC instead of inside.

Hopefully, you are beginning to see why it's not always a good idea to order the new heads and change them when you see a "bad head" symptom. Sometimes the heads *are* defective and new heads do the trick. But at other times, the problem is in one of the other circuits. Here's where troubleshooting methods make a big difference.

Isolating the trouble

The stages that can cause "bad head" symptoms make symptom/cure methods inaccurate. There are several ways you can turn to improve your odds of finding the component responsible for the problem.

Other than dc voltage tests, a meter doesn't offer much help, because the signals in the head circuits are around 4MHz. The upper frequency limits for most meters are generally from 20kHz to 100kHz.

A good oscilloscope or waveform analyzer offers more information. You can play back a tape while confirming whether the signals are present at different test points through the video circuits. When making tests, remember that the signals are FM, so wave shape is unimportant. Most tests will involve comparing the peak-to-peak levels at various test points to the values shown

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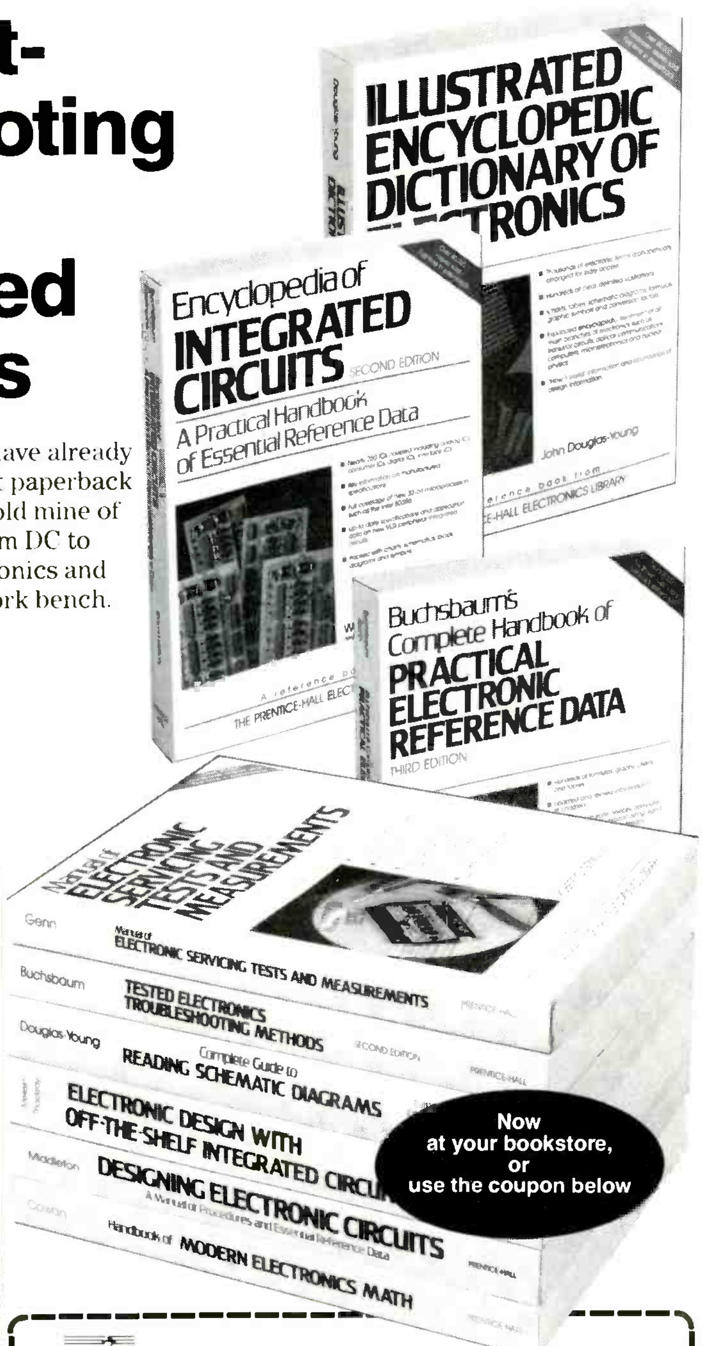

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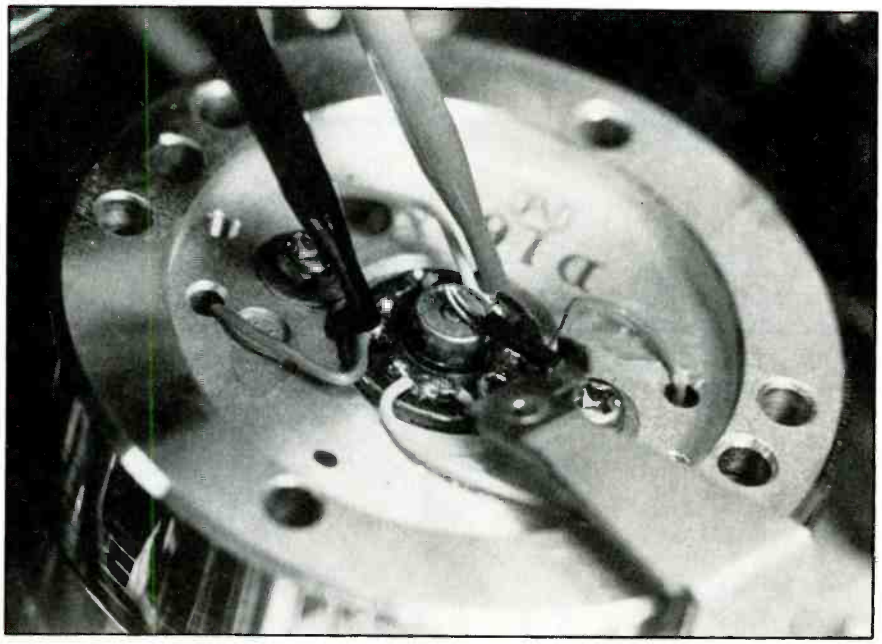


When injecting substitute signals, stop the heads and inject the signal at the rotary transformer connector at the center of the head drum.

on the schematic. Be aware that a few problems may replace the tape signal with a noise signal that has a level close to the correct peak-to-peak level. With FM involved, it's sometimes difficult to tell the normal signal from noise.

Scope methods can give misleading information during tests at the input of the video head amplifiers. The first problem is that the signal is usually smaller than the scope can measure. Some VCRs have signals as small as 0.5mV. A second problem happens when connecting the scope probe to the high-gain amplifier input: The amplifier may go into oscillation, which produces a waveform that has nothing to do with whether the heads are producing a signal.

These limitations make some form of signal injection helpful. With signal injection, you feed a signal into a test point to see if the following circuits respond correctly.

For example, a function generator capable of operating in the 3MHz to 4MHz range can be used to substitute for the video head signal. A function generator, however, will not include video modulation, so you must use a scope to see whether the substituted signal made it from the injection point into the circuits.

An important signal injection step is duplicating the circuit's normal signal. You should use signals of the correct frequency and amplitude. If you use too much signal, you may force it through a defective stage and incorrectly conclude that the stage is working. If you use too little signal, good circuits may seem defective because they do not respond to the substituted signal.

The normal signal level at the input of the head amplifiers is between 0.5mV and 5mV rms. Most function generators do not produce signals this small, so you may need to use external attenuators.

Also, you may need to prevent the signals already in the circuits from mixing with the substituted signal. This calls for opening the signal path in front of the test point you are feeding. When you do this, be attentive so that you don't also interrupt a dc bias voltage, because the lack of bias on a stage may lower its gain.

Opening a series capacitor generally will interrupt the ac signal without affecting the dc bias. However, if a stage has no blocking capacitor between the stage you want to feed and the preceding stage, the stage is probably direct-coupled and cannot be interrupted without upsetting the bias. If so, you may be able to back up another stage and interrupt the signal a stage earlier. As you move back through more stages, be sure that noise picked up by the open input does not cause additional confusion. You may

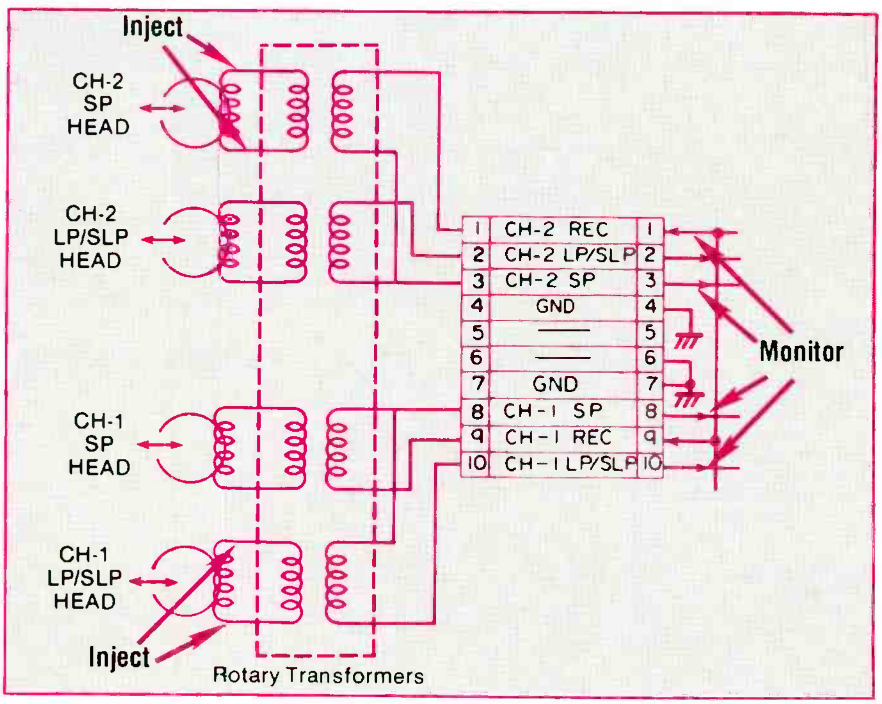


Figure 3. Inject the 4.5MHz test signal at each head while measuring the resulting output at the connector that feeds the main circuit board. This tests all connections and the rotary transformer windings.

need to shunt this open stage to ground to prevent noise.

The use of a dedicated VCR analyzer prevents all these problems. First, the analyzer provides a modulated signal, so it's not necessary to try to interpret the results partway through the circuits. You simply look at the screen to see if the FM signal is making its way from the injection point to the output. Second, the output has the correct levels to feed any stage from the head amplifier to the FM detector. Third, special *swamping circuits* (built into the test cable) remove the existing signal from the circuits without the need to disconnect components. You simply adjust the signal to the level corresponding to the circuits and clip the test leads to the circuit test point. The swamping networks remove the ac signal without upsetting the dc bias.

Testing rotary transformers

Substituting signals lets you check all the circuits from the point where the heads connect to the printed circuit board, on to the output. However, this still leaves one major component in question. You cannot easily move your injection point back to the video heads while they are spinning at 3,600rpm. How can you separate head problems from bad rotary transformers?

The answer lies in the fact that the transformer does not have to turn to couple signals. Because the transformer also works while the heads are stopped, you can inject a 4MHz signal into a video head while you monitor its peak-to-peak level at the rotary transformer output. (The transformer *output* is the connector on the main circuit board where the head signals *enter*.)

The signal level isn't critical here because you are not expecting the other circuits to work normally—they are turned off. Use 1V to 2V at the head input. The transformer normally steps this voltage up about 50%. You can compare one transformer section to the next, so voltage difference isn't important either.

Repeat this at each combination of head and transformer. Each should produce the same output. If one reads low, you know that path has a problem. The next step is to determine whether the problem is in the transformer or the head associated with the transformer.

A low output might show a bad transformer or a shorted head. To find out which, unsolder the wires running between the video heads and the transformer connectors, but don't remove the head assembly yet. Then, inject the signal right at the transformer connection. If the transformer outputs now balance, you have confirmed a shorted head. If they are still out of balance, you've confirmed a bad transformer. Now, you've moved all the way back to the heads themselves, eliminating other possible problems before replacing the head assembly. ES&T

Special Report
Special Report
Special Report

A VCR repair case history

By Victor Meeldijk

When you're servicing a consumer electronics product like a VCR, it's tempting, once you've located and corrected what seems to be the cause of the problem, to ignore other minor malfunctions—just button the product back up and go on to the next project. It always pays, however, to give the unit you've just fixed a thorough operational test, looking for other problems if everything isn't as it should be. Here's a case in point.

Meeldijk is reliability/maintainability engineering manager for Diagnostic/Retrieval Systems, Oakland, NJ.

A Fisher Model 510 that was more than five years old would not completely fast-forward or rewind (FF/R) a T-120 tape cassette. In rewind, the tape speed would drop (the tape footage counter readout would slow down), accompanied by noises that indicated the belts were slipping as the supply reel became full. The same thing would happen as the take-up reel became full in the fast-forward mode. The model 510 has a tape-transport mechanism identical to other models such as the 515 and 520 VCRs. The 510, however, does not have fast cue and review functions. To speed through commercials, you must use the fast-forward/rewind (FF/R) functions. This makes the transport mechanism wear out faster.

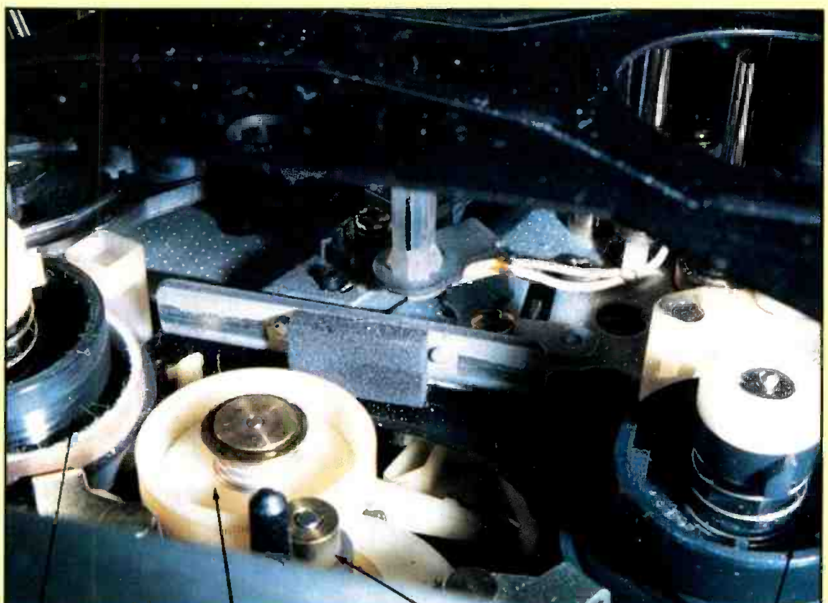


Figure 1. Top view of the tape-transport mechanism.

The FF/R functions

Figure 1 is the top view of the tape-transport mechanism. The FF/R functions are controlled by a separate motor (reel motor, Fisher P/N 4-5254-0030) from the play/record function. Other parts involved in FF/R are the winder assembly (P/N 143-0-4204-00200), wind assembly roller (P/N 143-0-4804-00100) and the supply and take-up reel assemblies (P/N 143-0-4104-00100 and 00200,

The FF/R problem occurs as a result of slippage between the winder assembly and the reel clutch tires.

respectively). The parts of the reel assemblies that wear out are the (video) clutch tires, which are not identified or sold separately by the Fisher Corporation. (Projector Recorder Belt in Whitewater, WI, sells the clutch tires: PRB P/N ST1.420).

Approaching the problem

The FF/R problem occurs as a result of slippage between the winder assembly and the reel clutch tires, which had become smooth and had a glazed surface. (See Figure 2.) The first repair attempted was roughening the surface of the clutch tires with a fine emery cloth. (Table 1 lists the VCR disassembly steps necessary to remove the reel assemblies and reach the clutch tires.)

The first repair attempted was to roughen the surface of the clutch tires with a fine emery cloth.

Figure 3 shows the supply reel clutch tire after roughening. The tissue shows tire residue. The result of this repair attempt, however, was very little improvement in FF/R operation.

Next, the clutch tires were replaced. The FF/R operation was vastly improved and the tape would completely fast-forward and rewind. However, tape slowdown still occurred near the ends of the tape, which still slipped. Slippage

Main article continued on page 23.

Figure 2. VCR take-up reel. Note the glazed appearance of the clutch tire.

Figure 3. Clutch tire after roughening with fine emery cloth. Tissue shows tire residue.

Table 1.
Reel assembly removal steps

1. Remove the two tape-transport cover screws, press the cassette eject button, and lift off the tape-transport cover.

2. Press the transport mechanism down. Pry off and remove the reel fix washers and the band brake assembly washer (visible through holes in the transport mechanism).

3. With the tape-transport mechanism up, lift the free end of the band brake assembly and move it away from the supply reel.

4. Slowly lift the supply reel up and out of the VCR. Be sure you don't lose the washers that are on the reel shaft underneath the reel. (The order of these parts on the reel shaft is: washer; bearing thrust assembly, with small ball bearings on it; another washer; a smaller washer; and, finally, the reel itself).

5. To remove the take-up reel assembly, take the counter pulley belt off the reel and repeat step 4 instructions.

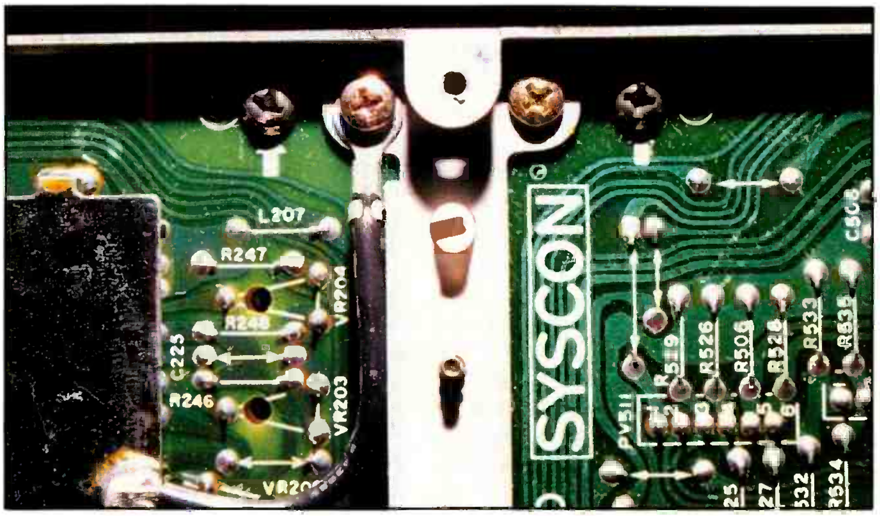


Figure 4. The main VCR printed circuit card is secured at the ends and center.

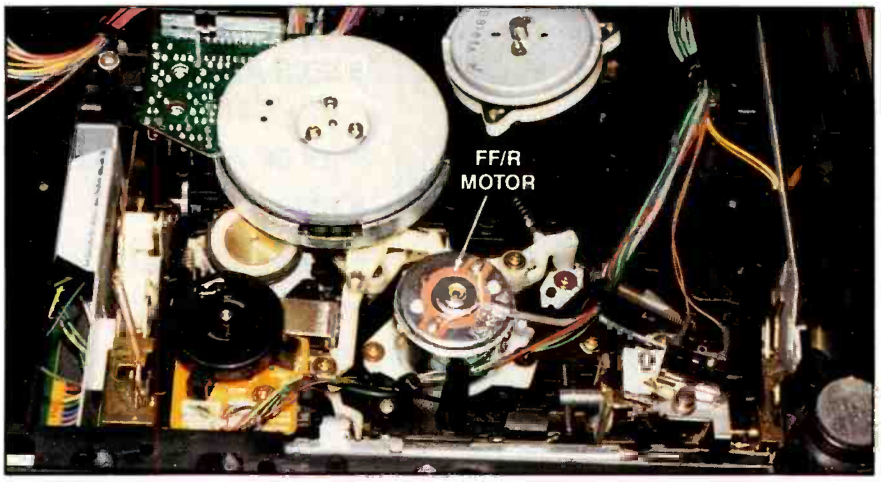


Figure 5. Underside of the tape-transport mechanism.

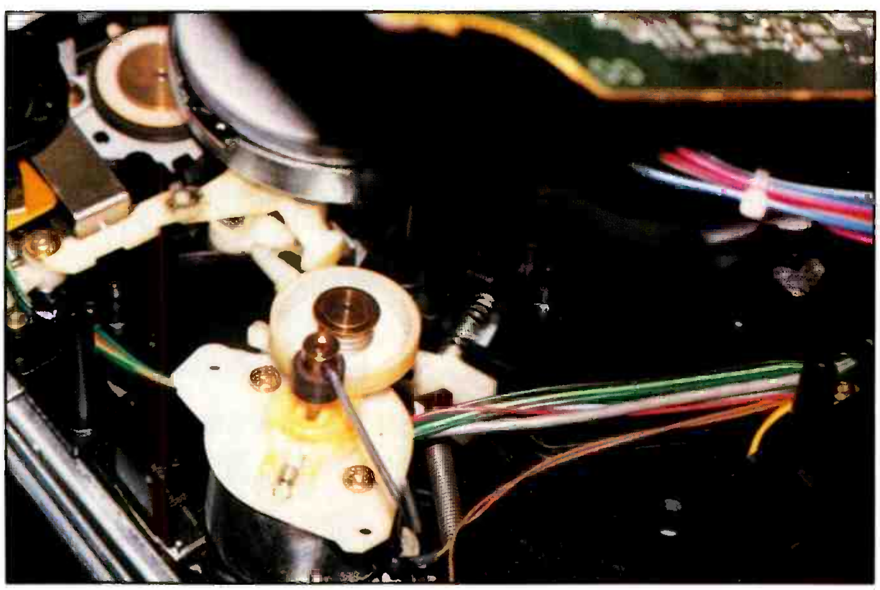


Figure 6. With the motor and wind assembly exposed, remove the wind assembly roller using an Allen key.

Table 2.
Winder assembly removal steps

1. Unplug the VCR and turn it upside-down.

2. Remove the bottom cover. (Remember where each screw goes, because they are not all the same length.)

3. **CAUTION:** ICs on the printed circuit board mentioned next are sensitive to electrostatic discharge. You should wear a grounding wrist strap to perform the next operation. If you don't, be sure not to touch the circuit areas of the cards.

   Locate the eight hold-down screws on the circuit board (see Figure 4) and remove them. As noted before, keep track of where each screw goes, because they are not all the same length.

4. Gently push the card assembly back. Using the center metal bar, lift the printed circuit assembly at the front; it will pivot at the rear end of the card. Prop the card up (a screwdriver can be used at the left side).

5. Examine the underside of the tape-transport mechanism and locate the FF/R motor and wind assembly. (See Figure 5.)

6. Remove the two screws securing the motor and wind assemblies and turn the assembly upside-down to expose the wind assembly roller and winder. (See Figure 6.)

7. Remove the wind assembly roller using an Allen key, then lift the roller and winder off the motor shaft. (If you don't have the proper size Allen key, take a slightly larger one and file one end to fit the roller set screw.)

8. Replace the winder assembly, putting the spring from the old unit on the new assembly. Make sure the spring doesn't impede proper tension of the winder gear when the roller is placed back on the motor shaft.

Continued from page 20.

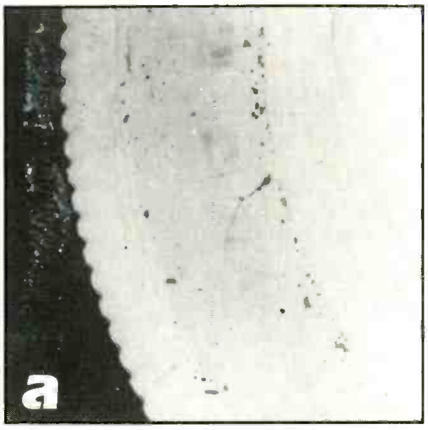
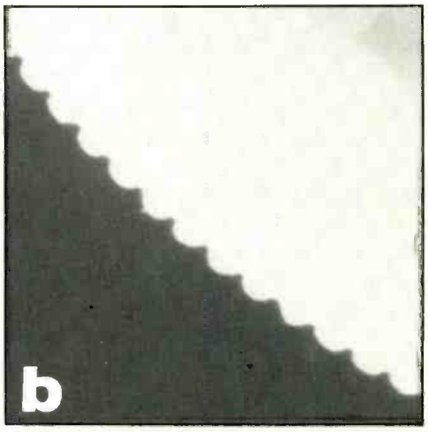


Figure 7. Compare A, the old winder assembly gear, with B, the new one. Note the degree of wear on the gear at A, which caused slippage.



also occurred on FF/R turn-on.

The third repair step was replacement of the winder assembly. (Table 2 lists the

The third repair step was replacement of the winder assembly.

disassembly steps required to perform this replacement.) Figures 7A and 7B show the old and new winder assembly gears. Note the tooth wear on the old gear. This last step restored full FF/R operation, and tape slowdown and slippage noises completely disappeared.

Although the VCR was repaired, a question remained: Would replacement of the winder assembly alone have fixed the unit? With the original clutch tires put back, the VCR operation was tested. Performance deteriorated and tape slowdown and slippage noises reappeared.

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ifications and features on the company's product line, including analog and digital clamp-on volt-amp-ohmmeters and multimeters, capacitor analyzers, digital tachometers, pyrometers and

Servicing the Commodore 1541 disk drive--Part II

By Andy Balogh

This is the final part of a 2-part article on troubleshooting the Commodore 1541 disk drive. Part I covered the basics of disk-drive operation and troubleshooting. Part II will cover specifics of the 1541 mechanics and electronics.

Now that you know the basics of how the disk drive works, you're ready to tackle specific problems with the 1541 disk drive. The problems most commonly encountered with the disk drive are often related to some kind of malfunction in the mechanical section. Some basic adjustments can often solve the problem.

Troubleshooting the mechanics of the 1541

The most common problem with the Commodore 1541 disk drive is its inability to properly read a prerecorded disk. If the red LED on the drive flashes often and erratically when the drive is reading and if the computer hangs up, a head-tracking problem should be suspected. The first thing to do is watch what the drive is doing. Then follow this preliminary procedure:

1. Begin by removing both covers and the PCB (disk controller card) in the drive. Lay the PCB to one side with board connectors still connected. Make sure the frame does not come in contact with the PCB because contact will short out the PCB. Put a layer of insulating material between them.
2. When a disk is inserted into the drive, make sure the disk is properly seated and the drive will eject the disk when the door is opened (Alps model only). If it does not eject, you will find that the latch mechanism has jumped over. Gently lift it up and back where it belongs. A disk that does not eject is improperly seated and will cause reading problems.

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3. Make sure the disk itself is rotating when the drive motor is turning. If it isn't, the pressure cone shaft may need lubrication. Another possibility is that the pressure cone may not be exerting enough pressure to rotate the disk. In the Alps models, this could occur because of a loose or bent latching pin, which forces pressure on the disk when the door is closed. In the Newtronic models, the latching pin forces pressure by pressing against a detented piece of plastic. Repeated opening and closing of the lever wears down this plastic piece, which loses its pressing ability. The only alternative short of replacing the whole mechanical unit is to try to build up the height of the plastic by gluing a thin piece of plastic on top of it.

It is good practice to also check the drive belt. The belt should be snug and should not slip. If it is stretched, replace it. Before installing it, clean all the drive pulleys with alcohol to remove any old rubber residue.

4. Next, clean the head. Use alcohol and cotton swabs as you would for any audio head.
5. Physically move the head with your fingers along its siderails and feel if there is any binding of the movement. (Make sure the door is closed.) If there is any binding, spray a little machine oil into a cotton swab and apply it to both sides of both rails.

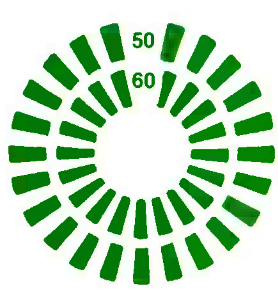

Figure 1. If you're servicing a Newtronic drive that has no strobe disk, you can simply copy this one or cut it out and attach it to the flywheel.

6. Last, adjust the drive speed. On the base of the drive motor there is a strobe disk. Load the formatting program into the computer and execute it. (Be sure you're using a "scratch" disk that has no important information on it.) This will cause the drive motor to run for approximately 2½ minutes. Then, under a fluorescent light, observe the 60Hz markings on the strobe disk. They should appear to be stationary or close to it. If they aren't, adjust the speed control pot on the drive board to stop the strobe lines from moving. It is difficult to get the marks to stand perfectly still, so it is acceptable for them to move very slightly in the counterclockwise position.

If you come across a Newtronic drive that has no strobe disk, simply copy Figure 1 and attach it to the bottom of the flywheel.

Radial alignment procedure on the Alps drives

The main reason the stepper motor drifts out of alignment is because the read head "loses" its position and the DOS directs the stepper motor to go back to the beginning (track 1) and start over. This repeated banging of the *track 1 stop* is what causes the stepper motor to shift. This also causes the track 1 stopper to slip. The radial alignment procedure requires the following steps:

1. Begin by loading and listing the directory of the disk into the computer. If a "file not found" error occurs, the stepper motor is out of alignment. Verify that it is not an electronic problem first by substituting a known-good disk controller card. The drive must be able to read the directory in order to perform further alignment. If a "file not found" error occurs on a directory command, slightly loosen the stepper motor screws and rotate the whole motor about 1/32 to 1/16 of an inch in a clockwise direction. Try reading the directory again. If

the file is still not found, repeat the procedure until you can read it.

If you have repeatedly adjusted the stepper motor in every possible position and the drive still cannot read the directory (it should read as a "file not found" error, not a "read" error), then a defect in the track-select circuitry exists. Verify a track-select defect by switching the disk controller card with a known-good card, then repeating the procedure.

2. The next step is to check the position of the track 1 stopper adjustment. This is done by running a test program such as "Performance Test," which comes with the 1541 drive. These tests will permit you to position the head to any track. In this instance, select track 1. Once the head is in the track 1 position, adjust the stop for a clearance of 0.01 inch or less between the stop and the

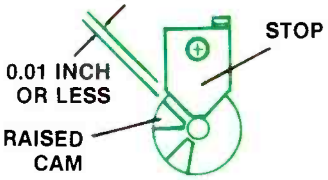

Figure 2. With the read/write head in the track 1 position, adjust the stop for a clearance of 0.01 inch or less between the stop and the cam located on the right side of the head assembly.

cam located on the right side of the head assembly. (See Figure 2.)

3. Once you have checked the track 1 stop, load a medium-sized program (about 100-150 blocks long) and run it. If it runs, proceed to step 4. If it doesn't, go back to step 1 and slightly adjust the stepper motor. Keep repeating the procedure until the program loads.

4. If the alignment is slightly off, many programs may load and even the performance test may run, but you will have problems with some copy-protected programs that give the drive a real workout. This usually causes the problem in the first place. Make a final test by loading the computer with such a program. Load it three or four times. If it loads every time, alignment has been accomplished. If it does not, go back and slightly adjust the stepper motor again until it does load. The red LED should be lit continuously while the drive is loading. A momentary flash during loading is normal and should be ignored.

Another problem a technician may encounter during an alignment procedure is that the drive motor does not rotate and a "file not found" error appears. Here is what's happening: Suppose you type

LOAD "COPY FILE PROGRAM", 8

and you inadvertently insert the wrong disk into the drive. Naturally, a "file not found" error occurs. You then insert the proper disk, type the same command, and immediately a "file not found" error occurs. The drive didn't even try to look for the program (did not rotate).

The problem is that the DOS doesn't know that you changed the disks. When you instructed the DOS the second time to look for that program, that program name was already present in the DOS. Because it had already looked for it and didn't find it the first time around, the same message appears again. This human error can be eliminated if you enter the initializing command or simply turn the drive off and power up again between loading commands.

Troubleshooting the electronics of the 1541

Another problem encountered in the 1541 drive is when it is powered up and the drive continuously runs. The drive was actually designed to do this, that is until the microprocessor instructs it to stop. After power-up, the drive runs approximately two seconds. During that time, the MPU in the drive is starting up the system. When everything is set, a high appears on the reset line and the drive stops. This knowledge is useful if you have a drive that runs approximately two seconds after warm-up and then stops. You can be assured that you have a clock pulse and the MPU is operating.

If the drive doesn't stop, the 6502 MPU usually will be defective. If it isn't, troubleshoot it as you would any computer: Look for a clock pulse, address and data lines, etc. A few drives were shown to have faulty start-up ROMs (UB4 on 1541, 1542 boards).

A drive that does not run on power-up is caused by one of two defects: a defective power supply or a shorted inverter chip. A defective power supply is quickly verified by observing if the green LED power indicator is lit. In the case of a drive that will not rotate when powered up, but rotates for about a second when shut off, the problem could be a shorted inverter chip (UB1). In the latter case, a digital probe should find a low on both sides on the inverter. In another drive showing this symptom, the problem was a defective interface chip (UC3).

Sometimes you may encounter a drive whose stepper motor is inoperative. Verify this by observing the head after a command is loaded and executed. If the head does not attempt to reposition itself (accompanied by a "file not found" error), the track-select circuitry is suspect. Load the following program:

```
10 OPEN 15,8,15,"I"
20 OPEN 8,8,8,"#"
30 PRINT #15,"U1:"8;0;1;0
40 PRINT #15,"U1:"8;0;30;0
50 GOTO 30
```

While the program is running, check for pulses on the interface chip (UC2). If pulses are missing, substitute UC2. If pulses are present, check in order the controller (UC1) and the inverter buffer (UD2). Also check for pulses on the stepper drive transistors (Q8 thru Q11 on 1541 and 1542 boards).

Another problem is that the drive reads properly but writes "garbage." This is not to be confused with a drive that does not write at all and displays a write error (more on this later).

A drive that writes incorrectly either displays garbage or a "file not found" error upon playback and is accompanied by track 1 head banging (the DOS can't interpret the garbage instructions). When troubleshooting this problem, first check for a writing waveform on the read-write head (use the format command and a scratch disk). Check the waveform while the drive is formatting. If the waveform is not present, check the writing transistors and associated circuitry. If it is present, substitute controller chips one and/or two. These chips are the customary densely packed memory interface chips that frequently fail in computers; they are no less likely to fail in the disk controller cards.

An erase head not functioning can also cause the printer to write garbage; if data is written on top of data, the DOS cannot interpret it. If you encounter this symptom, verify whether a bias oscillator pulse is present on the erase head. If not, check the erase transistors and associated circuitry. If the pulse is present, check the erase head for continuity (about 11Ω), then by substituting controller chip number one (on 1541 and 1542 boards).

If a "write" error always appears, this indicates a problem with the write-protect detector circuitry. First check for a high logic reading at the write-protect pin (pin 6) of controller chip number 1. If the readings are correct, check controller interface chips 1 and 2 again by substitution. If the readings are incorrect, check out the optical write-protect circuitry.

Another problem with the 1541 disk drive is a "device not present" error that occurs when a command is entered. If the power switch is on (verified by the green LED), the drive may have a changed device number. The ,8 used in the load and save commands is the device number assigned to the disk drive. You can change the device number to any number from 8 to 11 by cutting jumpers 1 and 2, located near the front center of the disk controller card. By observing which jumpers are cut and which are not, you can determine what device number is being used. (Refer to the chart below.)

Table 1.
Determining device numbers

Device number	Jumper 1	Jumper 2
8	Closed	Closed
9	Open	Closed
10	Closed	Open
11	Open	Open

If you try all the device numbers and a "device not present" error occurs no matter which number you use, check interface chip number 3 (UC3) by substitution. Caution: Some programs will crash when read from a drive that's not assigned the number 8. When troubleshooting, always change the device number back to eight to be on the safe side. You can easily confuse a hardware problem for a software problem.

Another possibility of a "device not present" error can result from a chip failure in the Commodore 64 computer itself, not the drive. Substituting the complex interface adapter (CIA 6526) chip (UC2) in the computer usually will solve this problem. You can easily verify whether it is a computer or drive problem by substituting a known-good drive with the computer. If a "device not present" error still occurs, you obviously have a computer problem.

Sometimes you may encounter a drive that performs normally for about two minutes, then acts erratically, sometimes accompanied by the green power LED going out. This symptom is usually caused by a thermal failure of one of the two bridge rectifiers (CR1, CR3). The output of CR1 should be greater than 8.5Vdc. If it isn't, the result is that the two voltage ICs (VR1, VR2) cannot output their respective regulated voltage without those minimum input voltages. Replacing the defective bridge is the only solution.

Another problem encountered is a non-responsive drive. That is, after a command (e.g., LOAD "*",8) is entered, the computer states "searching for," and the drive does nothing. The computer's cursor is also lost. What we have here is an internal communication problem within the drive. This means the instructions sent by the computer are either being "lost" in a serial bus conflict, or there is a defect in the decoding process. The solution is first to check input/output buffer chips 74LS14 (UC1 for 1540 drives, UA1 for 1541 and 1542 drives); 7406 (UB1 for 1541 and 1542 drives only); and 74LS86 (UG2 for 1540 drives, UD3 for 1541 and 1542 drives). Second, check for a defective interface chip (6522)—there are two. Another possibility is the main controller chip 325572-01 (UC1) on 1541 and 1542 boards.

Read errors are often the most difficult to service. They can be caused by most of the circuitry involved. First verify whether it is an electronic or a mechanical defect by substituting another disk controller card. Also make sure you are using a known-good disk. If substituting the card does not solve the problem, make sure you check the read-write head for continuity. The head has a center-tapped coil and all three leads must be checked. If substituting the card does correct the problem, check the following chips on the defective card for missing or incorrect waveforms: interface ICs (UC3 and UC4), MPU 6502 (UC4), RAM buffer IC (UB2), DOS programs within ROM chips (UB3 and UB4), and the controller chip number one (UC1). Check by substitution.

On the earlier 1540 and 1540 revised boards, noise radiation (glitches) caused numerous read problems. These boards can be identified by the jumper wires added with and without added resistors and capacitors on both sides of the board. The jumper wires were added to alleviate this "noise" problem. The most practical solution short of re-engineering is board replacement.

Quiz answers

Questions are on page 12

1. A. Hall devices are used to sense the presence and strength of magnetic fields. Figure A shows a model for this behavior. When there is no magnetic field, the charge carriers disperse because they have the same polarity. The magnetic field causes them to crowd against one side. That produces a charge imbalance and a voltage across the edge of the device.

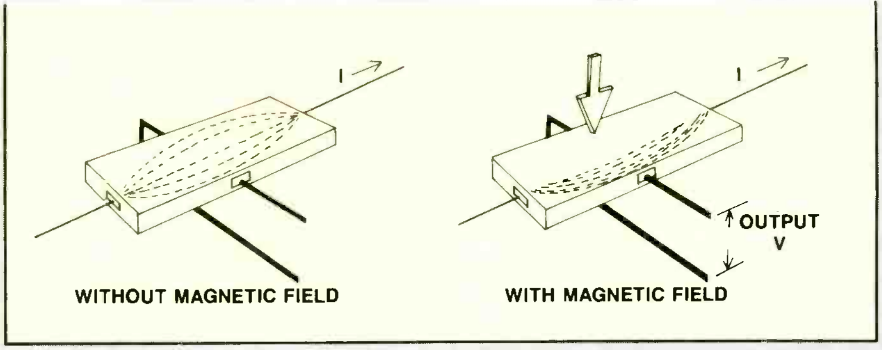

Figure A. Hall devices sense the presence of magnetic fields. Without the field, the charge carriers are dispersed. With the field, the charge carriers crowd to one side, producing a voltage across the edge of the device.

2. C. The conductor is threaded through the center of the ferrite bead. The result is the same as though an inductor was connected in series with the conductor.

3. B—Incorrect. The only way the equation would be correct is if the input and output resistance are the same value. That is seldom the case.

4. B—Incorrect. The power company charges for energy, not power. Power is the time rate of expending energy. So, kilowatt-hours come out like this:

kilowatt-hours = (energy/time) x time = energy

5. B—10%. The percent error is calculated as follows:

$$\% \text{ error} = \frac{(\text{expected} - \text{actual})}{\text{actual}} \times 100$$

$$= \frac{(1\text{mA} - 0.9\text{mA})}{1\text{mA}} \times 100$$

$$\% \text{ error} = 10\%$$

6. E—None of the above.

bandwidth = 0.35/rise time
= $0.35/0.01 \times 10^{-6}$ seconds
bandwidth = 35MHz

This is based on a commonly used rule of thumb that states that in the case of optimum transient response, the product of bandwidth and rise time is approximately 0.35.

7. D—ac or dc. Universal motors are used in electric drills.

8. D—None of the above. The braided wire is connected internally to a Faraday shield. It prevents capacitive coupling between the primary and secondary windings. The shield is used to prevent high-frequency noise and transients in the secondary circuit. The shield connection—the braided wire—should be connected directly to ground.

9. D. The operating voltages are lower compared to the same size aluminum-type electrolytic capacitor.

10. B—Incorrect. The value should be 6.25×10^{18}. The number 6.28 is approximately equal to 2π. ES&T

Troubleshooting microprocessor-based circuits

Part II-- A step-by-step approach

By Tom Allen

This is Part II of a 2-part article exploring the changes in electronics troubleshooting brought about by the growing popularity of microprocessor-based products. Part I discussed how analog, digital and microprocessor-based systems differ and why traditional troubleshooting equipment is no longer sufficient. Part II presents a methodology for successful troubleshooting of microprocessor-based systems, describing the equipment needed, the basic steps for any test and the most efficient sequence for performing the tests.

Technicians who are new to microprocessor-based troubleshooting often start out with a "shotgun" approach. Using the test equipment they are familiar with—multimeters and oscilloscopes—

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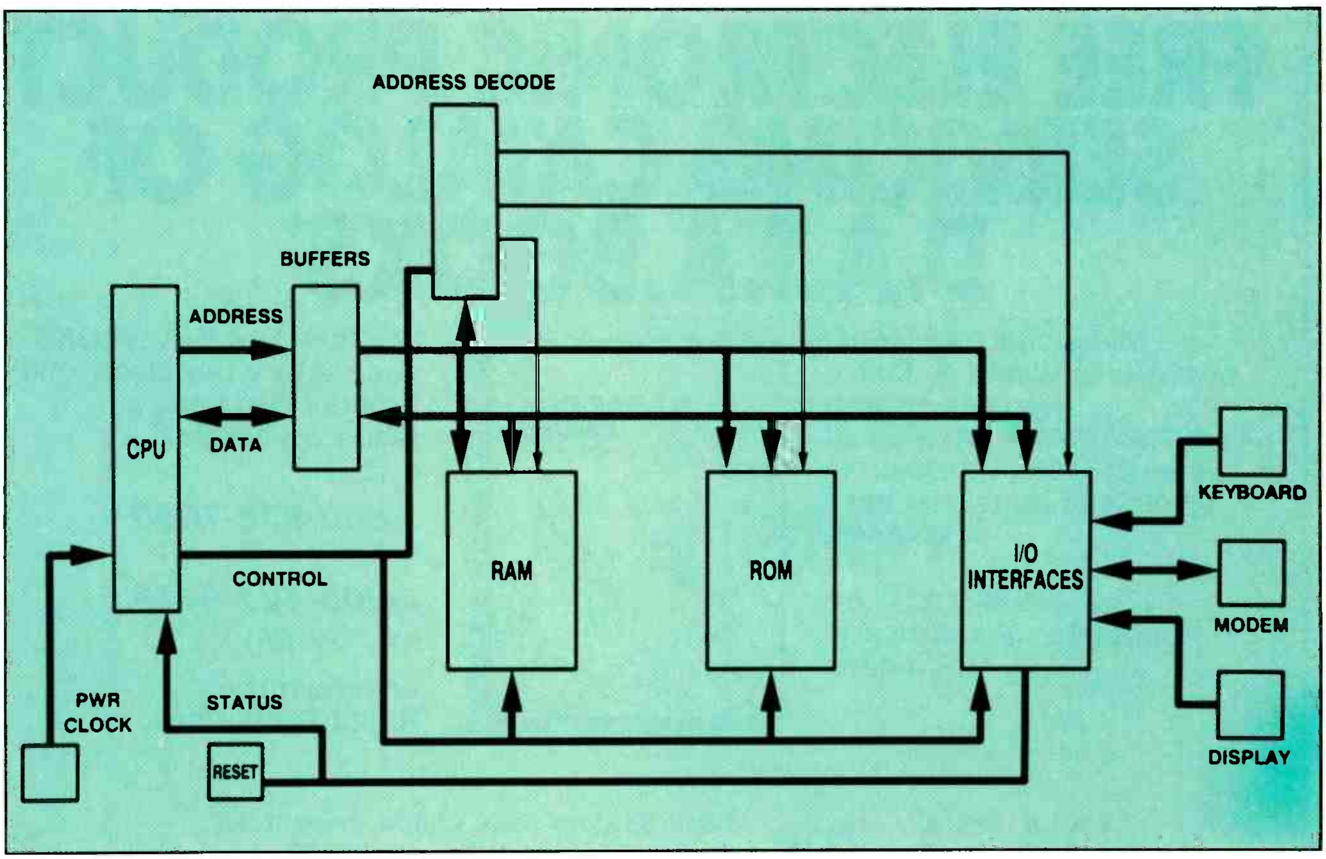


Figure 1. This block diagram shows the components of a typical μ-based circuit. The emulative tester is effective for troubleshooting microprocessor-based circuitry because it emulates the functions of the key components.

DMA emulators borrow clock cycles from the microprocessor while it is performing internal operations and uses these brief intervals to perform data reads and writes.

they check different parts of the circuitry at random, looking for a component that appears to be faulty. However, because of the complexity of microprocessor-based circuitry and the likelihood that faults will be timing-dependent, this type of approach is not only time-consuming but will often fail to locate the true cause of the problem.

Successfully troubleshooting microprocessor-based systems depends on three key elements: using the right equipment, performing the right steps and testing the circuitry in the right sequence. By following the simple guidelines presented here, you can significantly increase the efficiency and success of your troubleshooting efforts.

Using the right equipment

Emulative testers are among the most effective and easiest to use for troubleshooting microprocessor-based circuitry because they emulate the functions of a key component of the microprocessor kernel—either the microprocessor itself, the ROM (read-only memory) chip or the DMA (direct memory access) controller. (For a diagram showing these and other components in the microprocessor kernel, see Figure 1.)

Because emulative testers work in much the same fashion as the components they emulate—sending out read and write commands to various parts of the circuitry—they offer the advantage of testing the board from the inside out. This approach is much more effective than backdriving the circuitry from the edge in because it allows every component on the board to be thoroughly exercised, resulting in more complete fault coverage. (In contrast, an edge-in approach cannot locate certain types of faults because it can only address those components that are capable of being back-driven.) Emulative testers also have the advantage of allowing the board to run in its native environment during the test process, which allows both static and timing-dependent faults to be detected.

The emulative testers used for example purposes in this article are the Fluke 90 series testers, which are DMA emulators. Like the DMA controllers they emulate, these testers borrow clock cycles from the microprocessor while it is performing internal operations (a process known as *cycle stealing*) and use these brief intervals to perform data reads and writes. They can thus test a board while it is operating in its normal environment, which is useful for troubleshooting boards that exhibit problems when running their own control software. Another advantage of DMA emulators is that they typically clip over the board's microprocessor rather than plugging into the microprocessor or ROM socket, allowing them to test boards with soldered-in components.

DMA emulators do require a board with a microprocessor that supports DMA operations (that is, a board capable of receiving and acknowledging DMA requests). Also, DMA emulators—like other emulative testers—require detailed information about the board's microprocessor, so you need to select one that is designed to work with the microprocessor on the boards you will be testing.

Performing the right steps

In microprocessor-based troubleshooting, as with other types of electronic troubleshooting, the technician performs five basic steps at each test point:

- *stimulus*: injecting a known data pattern into the circuit;
- *response*: collecting the response to the stimulus at a different point in the circuit;
- *measurement*: measuring the response (determining the logic level of a line; determining whether a read or write took place);
- *interpretation*: comparing the actual response to the expected response to determine whether the response is good or bad; and
- *decision*: deciding where to test next, based on the results of the previous test.

One of the advantages of emulative testers is that they perform many of these steps automatically, minimizing the amount of knowledge and experience required of the technician.

For example, all emulative testers perform the stimulus, response and measurement functions automatically. Most emulative testers also provide some degree of interpretation, although not necessarily for all tests. For example, most of the bus, memory and I/O tests may provide some form of interpretation to indicate whether the component being tested is good or bad. In a few cases, however, the technician must compare the measurement returned by the tester with some external value to find out whether the component passed or failed the test. The ROM test, for example, yields a checksum value that must then be compared with the ROM checksum from a known-good board of the same type. If the two match, the technician knows the chip is functioning properly.

Handling of the final step—decision—depends on the individual tester. Some are capable of making their own decisions as to the next part of the circuitry to be tested; others rely on operator input.

Testing in the right sequence

In testing microprocessor-based boards, the general rule is to follow the natural flow of the signal as it moves from the microprocessor through the circuitry. Thus, you begin with the kernel components and then move outward toward the edge of the board. Once you locate a node (a junction point in the circuit) that has a faulty response, you trace backward through the circuitry until you find a point where the input (response from the previous node) is good but the output is bad. The component between the node with the good response and the one with the bad response is likely to be the source of the problem.

Most emulative testers contain a number of built-in tests that simplify the test process considerably. Although these tests differ somewhat from one tester to another, they generally fall into three broad categories: bus tests, memory tests and I/O tests. You usually would perform each group of tests in the following order.

Bus tests: Bus tests verify the driveability of the address, data and control lines inside the buffers and address decoders, identifying any lines that are tied high, tied low or tied together. It's important to always test the bus lines first, because the tests for the rest of the circuitry will not yield valid results unless the bus lines are performing properly.

Memory tests: Memory tests exercise each of the board's memory components: RAM (random access memory), both static and dynamic; ROM, which contains built-in instructions for the microprocessor; and any peripherals (such as keyboards or printers) that are *memory-mapped*, using memory addresses rather than I/O addresses.

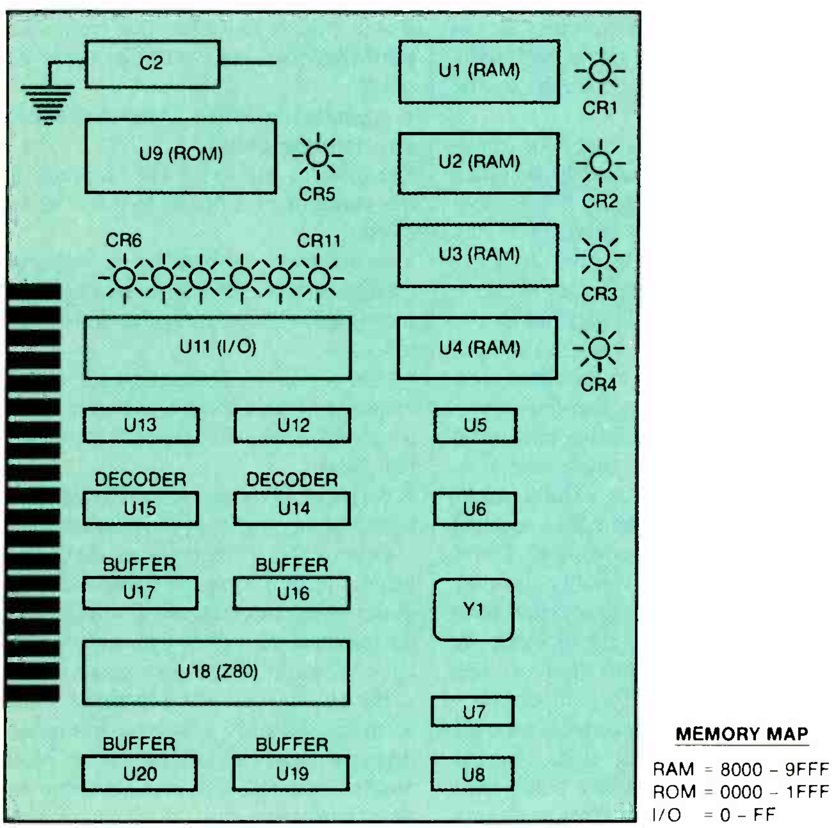


Figure 2. The emulative tester troubleshoots the main board of a typical home computer by testing at power-up, then performing tests inside and outside the kernel.

RAM tests let the technician exercise any RAM address range. The technician specifies the starting and ending addresses and the tester takes it from there. RAM tests basically consist of writing a data pattern to each address in the specified range and then reading the data stored at each location to verify that what is stored matches what was written. The data patterns typically used for this test are designed to test each digit both high and low—for example, a hex 55 (10101010) followed by a hex AA (01010101).

Because ROM, by definition, is read-only memory, a ROM test can only read the existing contents of ROM. It cannot write anything to it. To perform the *ROM checksum test*, the tester reads the contents of each ROM address location and adds them together, producing a checksum value. To find out whether a board passed or failed the checksum test, the technician compares the checksum value obtained through the test with that of a known-good board of the same type.

Tests for memory-mapped peripherals are identical to RAM tests, except that instead of specifying the RAM address range, you would specify the address range for the desired peripheral.

Some memory problems can't be isolated with the basic memory tests because they appear only after a certain period of time has elapsed—anywhere from a few seconds to an hour or more. A chip with this type of problem tests good initially, but loses data over time. In-depth memory tests check for long-term data retention by waiting a specified period of time between the point at which data is written and the point at which it is read.

To perform a test of this type, the technician specifies the desired address range, the number of minutes the test is to take and the data pattern to be written. The tester then writes that data pattern to every address in the selected range. After waiting the specified number of minutes, the tester goes back and reads every address in the range to verify that the data pattern there is the same as the one it sent out. During the wait period, the technician may change the board's environment in some manner (by altering temperature or voltage or possibly flexing the board) to verify its ability to operate properly under a range of conditions.

I/O tests: I/O tests are used to test peripherals that are accessed through I/O addresses rather than being memory-mapped. Just as with memory tests, these tests involve writing data to a specified address range and reading the results. If the data stored at each address corresponds to the data written to that address, the I/O port is functioning properly.

To illustrate how this general troubleshooting methodology can be applied to a particular test problem, let's take a look at how you might use an emulative tester to troubleshoot a main board from a typical home computer. (See Figure 2 for a block diagram of the board.) We'll start with the tests that the tester performs automatically upon power-up, then discuss kernel tests and conclude with the tests used to troubleshoot circuitry beyond the kernel.

Power-up tests

To begin testing a board with the tester, you turn off power to the board, connect the microprocessor clip to the board's microprocessor and turn the power back on. This initiates a series of tests that verify both that the tester is operating properly and that the board is functioning sufficiently to be tested. If the power-up tests identify a problem, an error code on the display will specify its nature. Board problems identified through these power-up tests include:

• *Malfunctioning power supply*—The tester derives its power from the board's power supply. The tester cannot operate without a functioning power supply, so failure of this test simply results in a blank display.

• *Malfunctioning clock*—The tests cannot be performed without a functioning microprocessor clock because the clock determines the period during which a response is stable and can be measured. For the board to pass this test, the tester must be able to sense both the rising and falling edge of the clock signal.

• *DMA request line*—The tester must be able to drive the DMA request line in order to borrow cycles from the microprocessor. It ensures that these lines are drivable by performing a DMA request line test, not only at power-up, but also every time it attempts a DMA access.

• *DMA acknowledge line*—After requesting a DMA access, the tester waits until receiving a DMA acknowledge signal from the microprocessor before initiating a test. Because the tester cannot operate unless the DMA acknowledge line is responding properly, the power-up tests include verification of a proper DMA acknowledge response.

• *Wait line*—Some of the longer tests require that the tester temporarily halt the operation of the microprocessor. To do so, the tester sends it a *wait* signal via the wait line (one of the microprocessor control lines). The wait-line test performed during the power-up sequence ensures that the wait line is not stuck high or low.

• *Reset line*—After the tester has halted microprocessor operation with a wait signal, it needs to send it a *reset* signal to tell it to resume operation. The reset-line test ensures that the reset line can be driven by verifying that it is not stuck high or low.

If the power-up tests identify either one of the above board problems or a problem with the tester itself, that problem must be fixed before proceeding. Normally, however, the tester will display a prompt at the conclusion of the power-up tests, indicating that it is ready to begin testing.

Troubleshooting inside the kernel

Inside the microprocessor kernel, you begin with the bus tests and move on to memory and I/O tests. Once you locate the general nature of the problem, you use the probe tests to pinpoint its exact location. In this example, we will assume that there are two kernel problems: address line A3 is shorted to ground and data line D4 is open.

As pointed out above, the first kernel components you should test are the buses. If they aren't working properly, none of the other tests will yield valid results. To initiate the bus test, you just press the "test bus" button on the tester. At the end of the bus test, the tester displays the following message:

Test Bus Fail
Address A03 Lo

From this message, you know that address line A3 either is shorted to ground or is being forced low by some other line. This is all the information you need to begin a troubleshooting procedure that will quickly locate the source of the problem.

Your first step is to power down the board and use a multimeter to test for a short to ground. In the case of this example, this is as far as you need to go, because the problem is indeed a short to ground. If this procedure had failed to locate the short, however, you would assume the line was being driven low by another line and use the probe address test to locate the source of the problem.

With the combination of the bus test and a multimeter, you have now correctly identified the first problem as an address line short and accurately pinpointed its location. However, the second problem—an open line—cannot be identified by the bus test, which can only identify lines that are tied high, tied low or tied together. To find this problem, then, you will need to move on to another test. Referring to the sequence of tests described above, you see that the next step after testing the bus lines is to verify that memory devices are working properly.

To begin memory testing, you push the mem test button on the tester. Then, referring to the memory map on the board's schematic, you key in the address range for RAM (in this case, 8000-9FFF). The tester immediately begins writing a data pattern to each address in the specified range and reading the results. At the end of the test, the display reads:

Test Memory
Fail @8000 AA BA

This tells you that there was a failure at address 8000: When the tester wrote AA to that location, what it read back was not AA but BA.

To see what happened at the next address, 8001, you press ENTER. The failure message is the same as for the previous location. Each time you press ENTER, the address location increases by one, and each time the failure message is the same. Because the failure is the same at all addresses, it is safe to guess that the problem lies with a data bus line rather than an address bus line.

To pinpoint the problem more closely, you might try taking a closer look at the failure message, translating the hexadecimal numbers into binary format as follows:

Write Data		Read Data	
A	A	B	A
1010	1010	1011	1010

In other words, the pattern that the tester wrote (AA) is expressed as 1010 1010 in binary format, and the pattern that the tester read back (BA) is expressed as 1011 1010. Each digit in these 8-bit binary words corresponds to one of the eight data lines. Data lines are numbered from D0 to D7 (moving from right to left), and the incorrect read occurred in the fifth digit from the right (where the tester read back 1011 instead of 1010), so it appears the problem lies in D4.

To verify that this is indeed the problem—and to pinpoint its exact location—you now need to back-trace through the circuitry from the point at which the failure was identified (from the RAM chip). You do this by using the synchronized probe and the appropriate probe test. The probe tests send out a continuous data pattern over the selected line while you probe it at different points to verify its driveability.

In this case, you suspect that the problem lies in a data line, so you would select the probe data test. If you were looking for a problem with an address or control line, however, you would select the probe address or probe control test instead.

To initiate a probe test, you first select the type of line to be probed (probe data, in this case) and the specific line to be tested (D4). You then begin probing to locate the source of the problem. If the line is driveable at the point where the probe is touching it, the probe's red LED turns off, its green LED illuminates, and the tester's display identifies the line ("D4 Found"). If the line is open, tied low or tied high, the probe's red LED stays on, no green LED appears, and the word "Found" does not appear on the display. If two lines are tied together, both the red and green LEDs illuminate, and both lines are identified as "Found".

By referring to the schematic, you see that pin 6 of the RAM buffer is connected to pin 7 of the microprocessor. When you probe pin 6 of the RAM buffer, the probe's red LED stays on and the display does not identify D4 as being "Found," indicating that the line is either open, tied low or tied high at this point. However, you have already ruled out its being tied high or low by running the bus test, so you know the problem here is an open line.

Next, you probe pin 7 of the microprocessor. Now the probe's red LED goes off, its green LED illuminates, and the tester display identifies the line as "Found." You have now successfully isolated the location of the open D4 trace as being between these two pins.

Troubleshooting outside the kernel

The main difference between troubleshooting outside the kernel and inside the kernel is that the automatic bus tests work only inside the kernel. Therefore, in troubleshooting outside the kernel you have to use another means of verifying whether lines are tied high, tied low or tied together.

For the purposes of this example, let's assume that the problem is that address line A2 is shorted to data line D2. We'll also assume that you have already run the bus test and gotten no failure messages because the problem is located outside the kernel.

Your next step, as before, is to test memory, starting with RAM. Again, you select "test memory" and enter the RAM address range. At the conclusion of the test, the tester displays the following failure message:

Test Memory
Fail @8000 55 00

As before, you begin stepping through the addresses in the range, pressing ENTER to increment the address by one each time. But, unlike the previous example, the data read back by the tester is different at each location. Therefore, you don't have any clues to the nature of the problem.

In such a case, the best solution is to use the QuickTrace probe test, which sends out a continuous data pattern on all lines at once while you probe various nodes in the circuitry. If the line that the probe is touching is driveable, the red LED on the probe goes off, the green LED illuminates, and the line's identity appears on the tester display. If the line is not driveable, the red LED stays on, the green LED does not illuminate, and no identification appears on the tester display. If two lines are tied together, both the green and red LEDs illuminate and both lines are identified on the display. Using QuickTrace and a schematic, then, you can easily trace any line throughout the board's circuitry.

After selecting the QuickTrace test, you begin probing at the point of the failure—the RAM chip. As the probe touches pin 1, the red LED turns off, the green LED illuminates, and the tester display identifies the line as address line A7. This tells you that address line A7 is driveable.

You continue probing the RAM chip pin by pin until, suddenly, you get a different response: Both the red and green LEDs illuminate on the probe, and the display identifies both address line A2 and data line D2. You have now correctly identified the nature of the problem: Address line A2 and data line D2 are shorted together.

At this point, you might be able to pinpoint the location of the short with simply a visual inspection. If not, you could use a current tracer to find the point at which the two lines are shorted.

An inexpensive emulative tester simplifies microprocessor-based troubleshooting considerably by performing most of the five troubleshooting steps automatically. By using the proper equipment and following the methodology laid out in this article, even technicians new to microprocessor-based troubleshooting will find it a quick and efficient process. ES&T

Circle (23) on Reply Card

Critical sound problems

By Homer L. Davidson

One of the difficulties with TV sound problems is that they may originate in the sound circuits or they may be caused by malfunctions in the circuitry upstream of the sound detector.

For example, symptoms of dead, weak and distorted sound, popping and motorboating, intermittent sound problems and stereo sound problems are caused by the sound output circuits (Figure 1). Improper tracking and sound bars in the picture may be caused by malfunctions upstream.

Most TV audio problems occur in the audio output circuits. Of the defective audio parts I have encountered, 85% are open or leaky solid-state devices. Of course, perfectly good transistors and ICs frequently are replaced when related components are actually the cause of the problem. Open coils, leaky diodes, burned resistors and open coupling capacitors may actually be the culprit.

There are many ways to approach troubleshooting these circuits:

- Basic voltage and resistance measurements alone may be enough to locate the defective audio component.
- The defective IC may be located using input and output scope tests.
- Critical voltage and resistance measurements at each terminal may prove the IC is defective.
- Transistor in- and out-of-circuit tests may point out a leaky or open transistor.
- The intermittent IC, transistor or electrolytic capacitor may appear normal during voltage and resistance measurements. The problem may be located only with the scope or with replacement of the component.

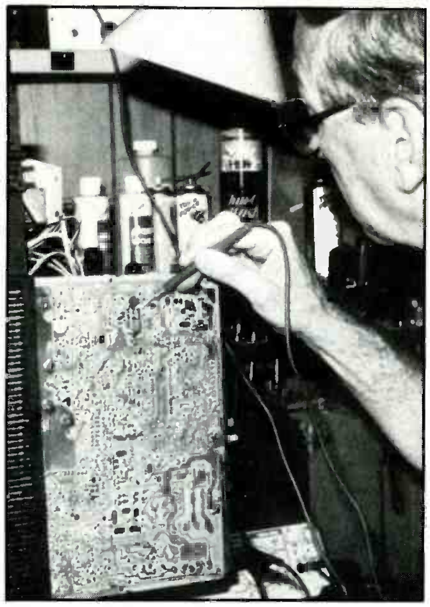


Figure 1. Critical voltage measurements on the audio circuits may locate the defective component.

- Another way to isolate the defective sound circuits is to inject a signal from an external audio amplifier at various points in the defective sound system. At which stage sound stops or starts coming from the speaker may isolate the problem.

Dead sound circuits

A malfunctioning TV section is always easiest to locate and repair when that portion of the circuitry is completely dead instead of operating improperly or only intermittently. Signal tracing with the scope or signal injection using an external audio amp quickly locates the dead stage in the audio circuits.

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

Once you've found the dead stage, the defective component may be located through critical voltage and resistance measurements. Incorrect voltages at leads of the IC or transistor indicates that either the component or the low-voltage power supply source is defective. Don't overlook the possibility that weak or distorted sound problems may be caused by malfunctions in the low-voltage power supply.

In a Sanyo A2C9000 chassis, accurate voltage measurements pinpointed the cause of a no-sound symptom. For starters, I checked to make sure that the speaker was OK by clipping an external speaker to the output leads. Even with this speaker connected, there was no sound. My next step was to probe with the multimeter for dc voltages. The supply voltage source at pin 5 of the sound IC, IC201 (see Figure 2), was only 1.37V. Because the specification says this voltage should be 18.6V, I immediately suspected that IC201 was leaky and disconnected pin 5 from the circuit with solder-wick and soldering iron.

Even with pin 5 disconnected, however, the supply voltage at the circuit board trace was still only 1.5Vdc, suggesting problems within the low-voltage power supply. Tracing the 18V source back to the power supply indicated that the power supply was normal. Further voltage checks revealed that the voltage where capacitor C216 connects to the supply line was 5.9V. A low resistance measurement across C215 (220μF) with power turned off indicated the capacitor was leaky. If I had not made those further voltage tests, it would have been easy to jump to the conclusion that IC201 was leaky, replace it, and still have the same dead sound problem.

Weak and distorted sound

A defective component in the sound circuits may result in weak sound, distorted sound or both weak and distorted sound. The weak sound symptom without any distortion or hum may result from defective electrolytic coupling or bypass capacitors. When this symptom is observed, always check the small electrolytic coupling capacitors in the AF or driver circuits. These capacitors may dry up or open and change value to 1μF to 3.3μF capacity. These capacitors seem to have a tendency to open after a few years of operation. Large speaker coupling capacitors that open may be the cause of weak or dead sound symptoms.

A weak sound symptom may result from an open or leaky AF IC or transistor. The weak sound circuit may be signal-traced with the scope or external audio amp to locate the defective stage or circuit. If you suspect an IC or transistor in the sound circuits, a shot of coolant spray on that component may restore the audio signal. If so, you have isolated the problem to that component. Often, a defective audio output transistor or IC will cause a combination of weak and distorted symptoms.

Weak sound was noted in the speaker of a Samsung CT333KA-TV chassis. (See Figure 3.) The voltage at the collector terminal of Q602 had increased to 135V, and a check with a scope at the base of Q601 of the external audio amp showed a weak audio signal. The audio signal on the IC601 side of coupling capacitor C654 was the same weak signal, so the capacitor was not the problem. Probing with the DMM revealed that the voltage at pin 5 of IC601, specified to be 11.5V, had decreased to 1.7V. Replacement of IC601, a KA2101, with an SK3072 universal replacement restored the sound to proper operation.

Excessive distortion

Tunable distortion suggests a problem somewhere in the stages preceding the audio detector, while constant audio distortion suggests a problem in the audio output circuits. Just a touch up of the quadrature coil with a broadcast program tuned in may be all that's necessary to eliminate tunable hum and distortion (Figure 4).

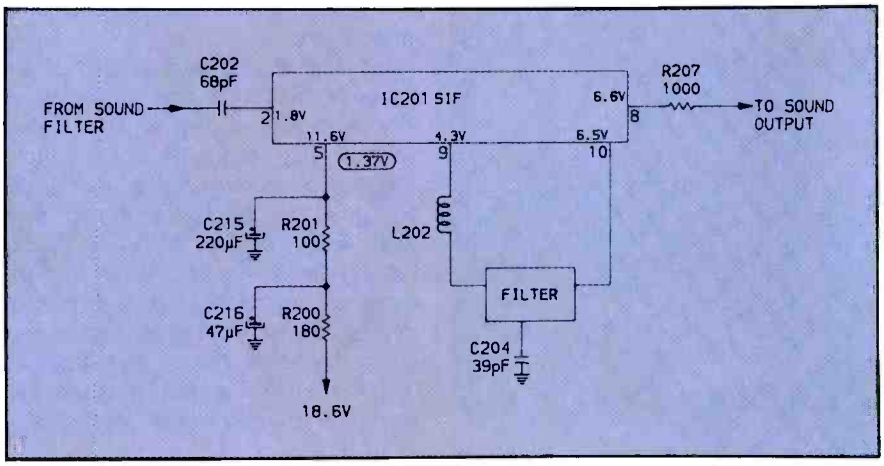


Figure 2. Although a leaky sound IC201 was originally suspected, further checks showed that the low voltage on pin 5 was caused by a leaky bypass electrolytic capacitor (C215) in this Sanyo A2C90000 chassis.

Poor sound accompanied by a loud rush as the station is tuned in, followed by distortion during the program, points directly to the quadrature coil circuits. If the sound changes after a few weeks or drifts off, suspect a defective capacitor or coil in these circuits. Change the entire quadrature coil assembly if all components are located inside the shielded coil.

Slightly muffled sound

In one RCA CTC108 chassis I worked on, the sound was slightly muffled. Sometimes the sound was normal, but just did not sound right, with a little trashy noise on some channels. The discriminator coil (L201) was adjusted, but the problem was still there. (See Figure 5.) I noticed L201 was very broad in adjustment. I replaced sound output processor U201, but there was no change in symptoms. All voltages were quite normal.

Next, I made resistance measurements at all IC terminals across connecting components. L305 had a resistance of 0.36Ω and appeared good. Next, I replaced the discriminator coil assembly, because my experience with several other RCA sets showed that capacitor C209 (7.5μF) had a tendency to drift with the same results.

A continuity check of the take up coil (L307) showed that it was open. A follow-up ohmmeter test on the coil after it was removed from the chassis confirmed that it was open. Replacement of L307 restored crisp, clear audio.

When the symptom is excessive hum, go directly to the sound output transistor or IC components. Spray each transistor or IC with coolant and notice if the hum clears up for a few seconds. Next, check each transistor for leaky or open conditions. Accurate voltage and resistance

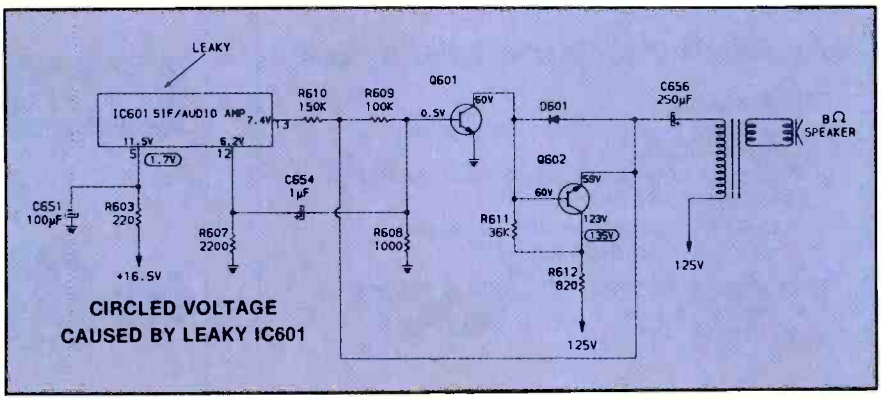


Figure 3. Weak sound in a Samsung CT333KA chassis was caused by the audio amp, IC601. Replacement with an SK3072 universal replacement solved the problem.

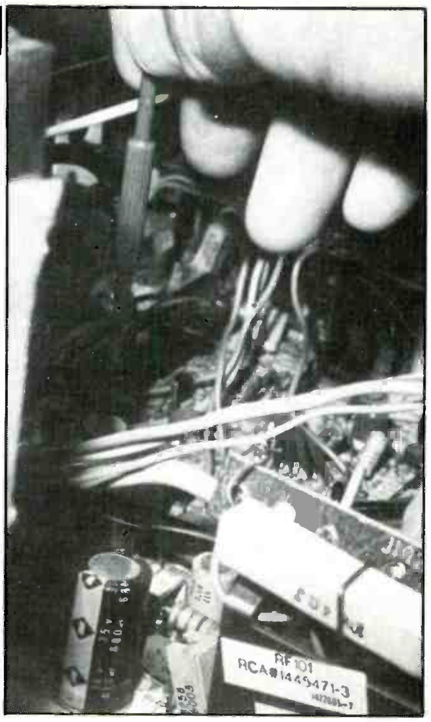


Figure 4. Just a touch up of the sound or quadrature coil may be all that's necessary to eliminate tunable hum and distorted sound in the speaker.

measurements at each terminal of the IC may locate the leaky IC. Signal-trace the audio circuits with the external audio amp to locate the defective stage or IC component.

In single-ended audio circuits, check the audio output transistor for leakage. These transistors operate at a higher voltage than most transistor output stages and run quite warm. Check the voltage at the collector terminal. Normal voltage is from 95V to 135V. Extremely low collector voltage may indicate a leaky transistor; high voltage may be caused by an open transistor or emitter resistor. Before replacing the output transistor, check the bias and emitter resistors for burns or a change in resistance.

Distorted sound

The owner of a Montgomery Ward model GGV17560A complained that the audio was distorted. I traced the audio signal from the sound IF audio amp IC to the transistor output circuits. The collector voltage at Q2010 (see Figure 6) was only 17.6V. Q2010 and Q2020 showed signs of leakage in-circuit and were removed to verify whether or not they were defective. The driver transistor (Q2030) was normal. Q2010 and Q2020 were replaced with GE-252 and GE-253 universal replacements, respectively. While the transistors were out of the circuit, all small resistors were checked and were determined to be of the correct values. When the set was turned on, the sound was back to normal.

Distortion in ICs

Today, most color and B&W chassis have IC components throughout the audio circuitry. As an example, you might find a separate IC called the IF/AF amp and another IC called the audio output IC. In small, portable chassis, the complete audio system may be in one IC or it might be combined with the sweep and video circuits in a single large IC. (See Figure 7.)

Distortion that you suspect is caused by a faulty IC may be signal-traced with the scope or external audio amplifier. Make sure the speaker is normal by clipping another test speaker across the audio line output terminals. It's best to remove one speaker lead when checking for a distorted or noisy speaker. After determining that the speaker is normal, proceed to take voltage and resistance measurements at each IC pin terminal.

Often, critical voltage measurements will turn up a leaky audio output IC. Sometimes spraying the suspected IC with coolant will restore the sound momentarily. Inspect the small components for cracked resistors or loose terminals. Poorly soldered connections on the IC terminals may produce intermittent or distorted sound. Once you've tested all of the surrounding circuitry and determined that it's not defective, your only option is to remove and replace the suspected IC.

Leaky Quasar IC

A Quasar PDTS-980 chassis set exhibited distorted sound. After taking voltage measurements at terminals 9, 10 and 12 of IC 201 (Figure 8), I suspected this IC. This sound processor includes the sound and quadrature coils with complete sound output circuits. Voltage at pin 10 was only 7.2V. Voltage at pin 9 had dropped to 7.9V. The IC body was running quite warm after only a few minutes of operation, and R208 (33Ω) was hot and had burn marks. Replacement of IC201 with an ECG1231 universal replacement IC restored proper sound.

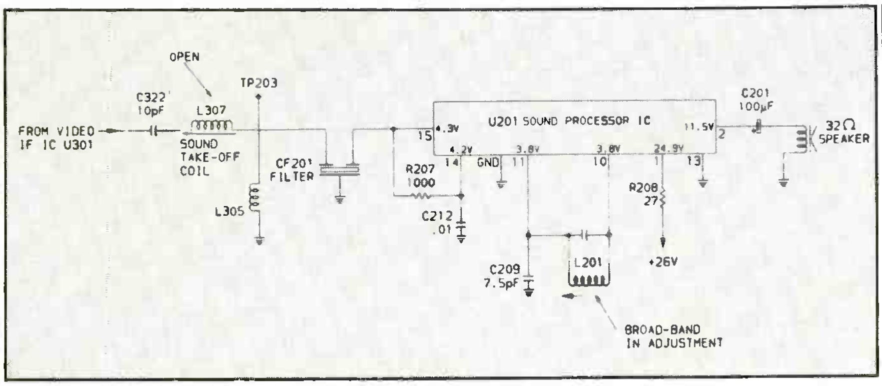


Figure 5. Slightly muffled sound was heard in the RCA CTC108 chassis on certain stations. Replacing take-off coil L307 solved the audio problem.

Intermittent sound

Intermittent problems in the audio may be caused by just about any component. The most common intermittent symptoms are caused by transistors, ICs, capacitors and poor board connections. Poorly soldered connections on the IC or transistor terminals may cause intermittent sound. Cracked wiring or terminal connections on connecting sockets and harness wiring are the cause of many intermittent conditions.

Signal-tracing the audio circuits with the scope or an external audio amp may help to locate the defective component. It will occasionally happen that when a

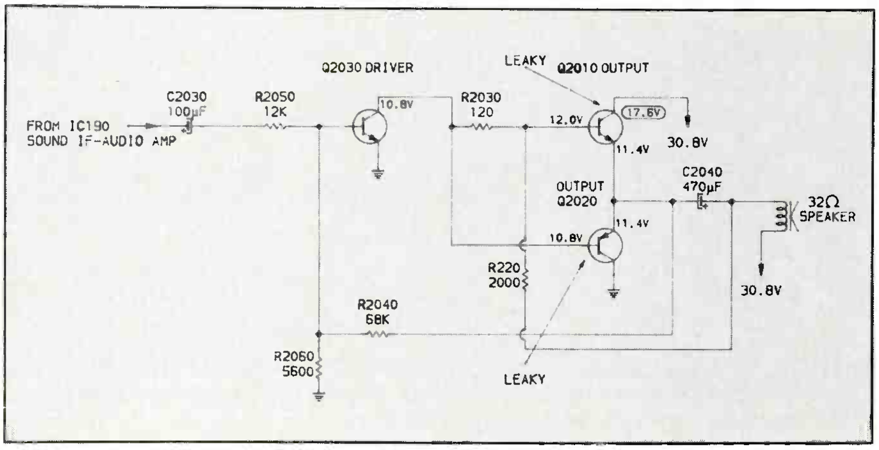


Figure 6. Replacing both output transistors, Q2010 and Q2020, in the sound output stage of a Montgomery Ward GGV17560A model cured excessive sound distortion.

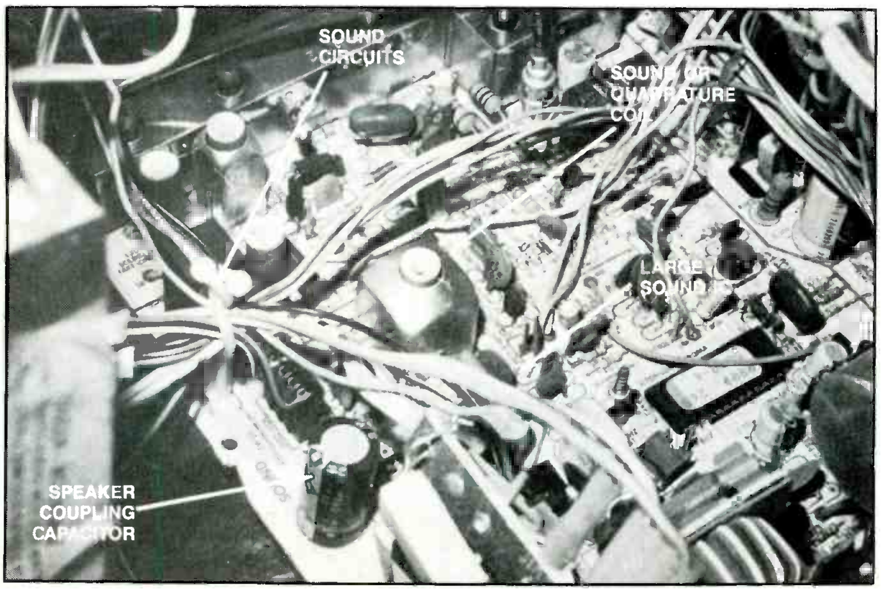


Figure 7. In today's TV chassis, the complete sound circuit may be found in one IC component or combined with other TV circuit functions in a large IC.

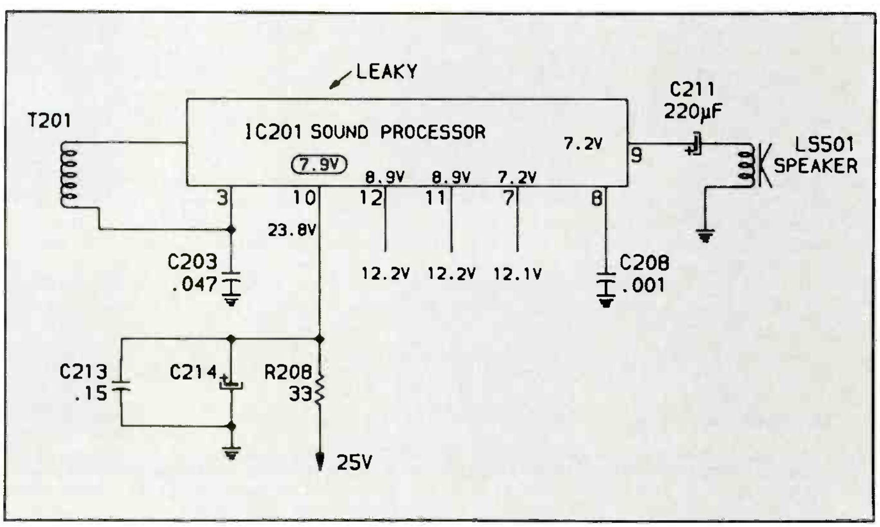


Figure 8. In one Quasar PDTS-980 chassis, low voltage at several pins of output sound processor IC201, accompanied by higher temperature of this IC than expected, indicated that the IC was leaky.

test probe is touched to a transistor or IC terminal, the intermittent will disappear and not return for hours. In a case like this, alternately applying coolant and heat may uncover the most difficult intermittent. Sometimes, however, temperature cycling produces no results. Soldering all connections around the suspected area may solve the tough dog intermittent.

Old faithful

The most common cause of intermittent or weak sound symptoms is a defective speaker coupling capacitor. (See Figure 9.) I have known these capacitors to fail in a number of TV chassis even when the receiver was fairly new. The electrolytic coupling capacitor may vary from 50μF to 470μF and is usually mounted upright or flat along the circuit board. Wiggling these capacitors as the sound becomes dead, intermittent or weak sometimes will cause changes in the sound, confirming that the capacitor is faulty.

The audio signal may be traced with the external audio amp or speaker. Another permanent-magnet (PM) speaker with a 50μF capacitor soldered to it may be used as the sound indicator. Any type of PM speaker may be used here as the impedance and size is not important for the purpose of this test. Clip one speaker lead to chassis ground and touch the other end of the capacitor to the IC audio output pin (Figure 10).

Another approach is to shunt a known good capacitor across the suspected one. Often, when a good electrolytic capacitor is shunted across the suspected one, the sound comes right up. The capacitors are easily replaced without bringing the set to the bench.

Intermittent sound

A J.C. Penney 685-2048 model had sound that would abruptly get louder or softer. The sound really acted up when cables from the chassis to the control units were moved. Raising the chassis on its left side caused the sound to become intermittent. Visual inspection revealed poorly soldered connections at cable connections P/J 202. Removal of the long shield and resoldering all socket board connections cured this intermittent.

Poor board-component connections is a frequent cause of intermittent sound. Often, pushing down on the chassis with an insulated tool (carefully, without applying too much force) will quickly locate the intermittent section. Prodding components with a pencil or pen may indicate a poorly soldered board connection. Suspect broken wiring when the board is large and has little center support. These boards may warp and pull wiring from feed-through eyelets, resulting in cracked wiring. Sometimes the foil wiring is very thin and, with rough handling, is easily broken. These fine-line wire cracks can only be seen with a magnifying glass. Bridge and repair the broken wiring with pieces of hookup wire.

One dead channel

Stereo sound is found in many of today's more expensive TV chassis. When the program is broadcast in stereo, an LED lights, indicating that the program is in stereo. As with any other broadcast signal, the stereo audio signal may drift or appear noisy in extreme fringe areas. A stereo/mono switch is usually provided so the stereo may be switched to mono audio sound when stereo problems occur.

In the RCA CTC131 chassis, the audio switching board contains the control, switching and stereo audio circuits. This board is mounted to the left and top side of the regular chassis. In one particular chassis, the sound in the left speaker was dead. The red LED was on, indicating the program was in stereo. The left-channel sound remained dead even when the stereo/mono switch was switched to mono.

Inspecting the chassis and circuit diagram a little closer, I found that the audio signal for the left channel was fed from U1 through Q11 to a common large IC (U5) for both channels (Figure 11). The audio signal was traced from pin 9 of U1 to the emitter terminal of Q11 and pin 5 of U5. No audio signal was found at the right output terminal, pin 2. The audio signal out of the right channel was normal.

Although the voltages read by the multimeter at each terminal of the left channel pins of U5 varied less than 1V from the printed specifications, there didn't appear to be any other possible cause of the problem, so the audio IC was ordered out. Replacing U5 with the original part number (175722) restored the dead left channel.

Unusual sound problem

The audio signal processing in RCA's

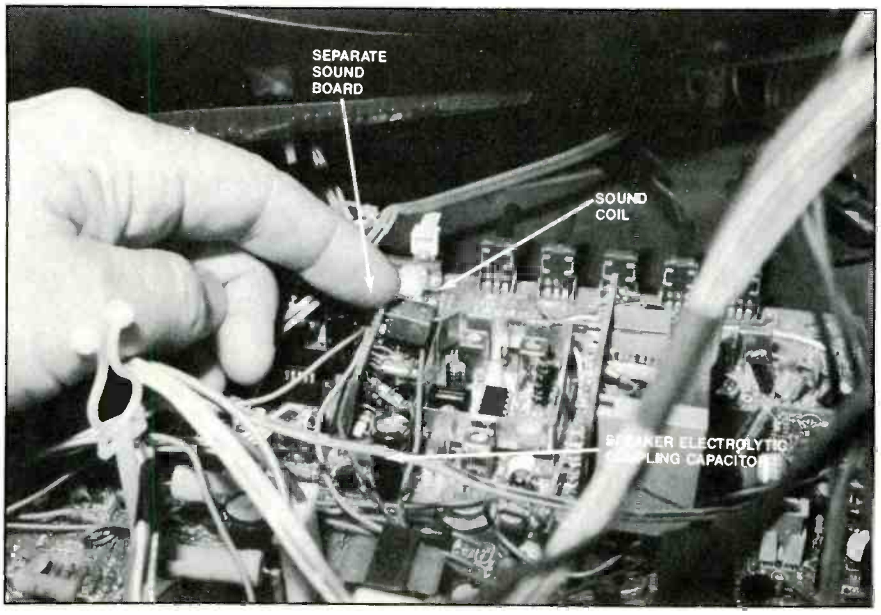


Figure 9. When the symptom is intermittent, weak or dead sound, the electrolytic coupling capacitor between sound IC and speaker is always suspect.

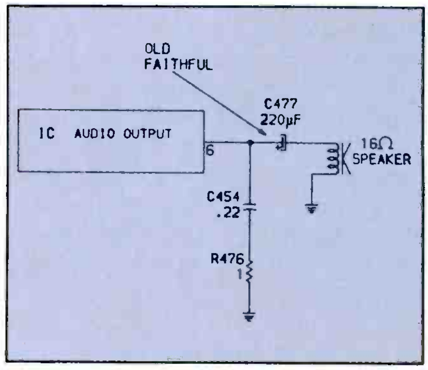


Figure 10. Use of an external speaker in series with a 50µF capacitor clipped across the speaker leads may reveal a defective coupling capacitor.

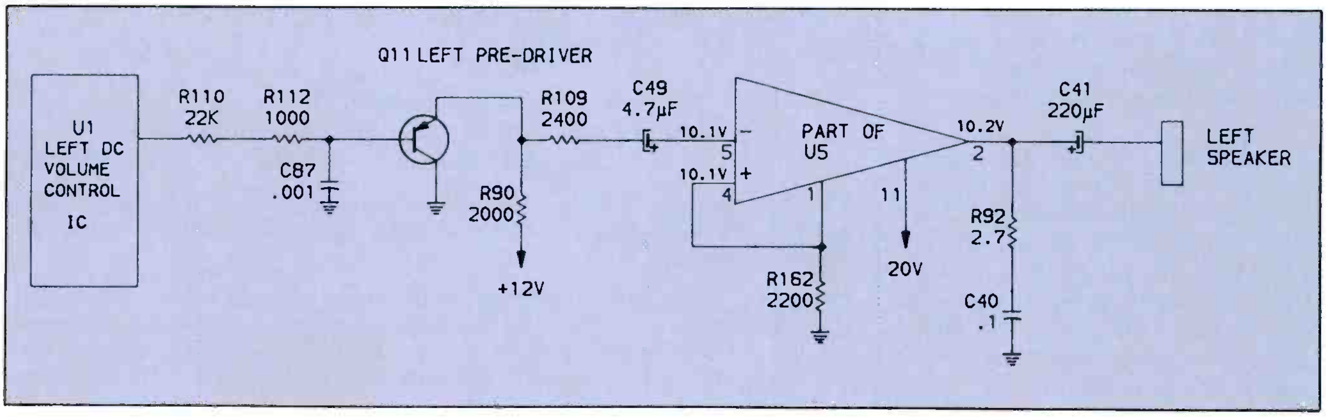


Figure 11. The cause of a dead left channel in an RCA CTC131 chassis was traced to a defective U5 sound output IC.

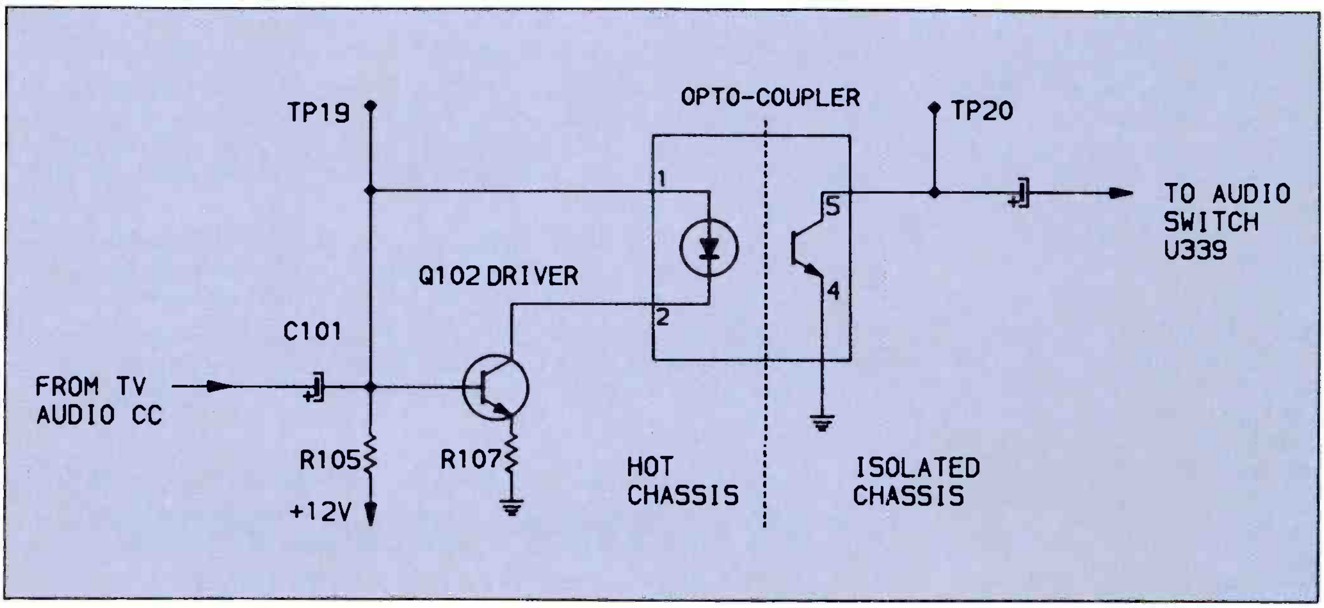


Figure 12. A defective opto-coupler, U102, caused a dead left channel in an RCA CTC121 color monitor. This coupler can be checked with diode-transistor tests.

CTC121 color monitor chassis with a left and right speaker output is controlled by audio opto-isolators. This device converts the audio signal into a light that varies in intensity with the audio level. The light passes through an isolated medium to a photo-sensitive transistor, which converts the light signal back to an electrical signal identical to the original audio source. These opto-isolators are installed to electrically isolate a hot chassis from the isolated sound chassis.

In one RCA monitor (CTC121 with MVS audio chassis), there was no off-the-air audio signal. The signal was scoped from pin CC of the 4.5MHz sound IF and detector stage to test point (TP19) of the MVS audio chassis. (See Figure 12.) Approximately $1V_{pp}$ should be found at TP19 and TP20. No signal was found at TP20 at the output end of opto-coupler U102. A diode test across terminals 1 and 2 was normal, but terminals 4 and 5 seemed to be open. Replacing U102 with the actual output part number solved the monitor off-the-air audio signal.

Although the external audio amp may not be as accurate as the scope in audio signal tracing, it will still allow you to isolate the weak, distorted or dead stage. Use the scope to locate an extremely weak or slightly distorted symptom. The scope is ideal to check the input and output audio signal of IC audio components.

After servicing a set with an audio problem, always replace metal shields and cable ground wires to eliminate hum pickup. Apply silicone grease between the metal back and the heat sink when replacing large audio power ICs. Replace the separate metal copper heat sinks found mounted on top of the power output IC component. These heat sinks should be replaced after the IC is mounted. Be careful when soldering the heat sink tabs to the metal chassis ground wiring to prevent overheating and damaging the new replacement.

Take resistance measurements between each terminal of the replacement IC and chassis ground to ensure that all soldered joints are good and that no pin terminals are shorted out. Likewise, compare these measurements to those you would expect in a normal channel in stereo audio sound systems. If the resistance is not the same or within a few ohms, suspect a defective resistor or capacitor still in the circuit.

ES&T

What do you know about electronics?

Magnetostriction

By Sam Wilson, CET

In this issue, I have included a discussion of magnetostriction. The name implies that there is a contraction of a material in the presence of a magnetic field. Actually, the behavior of a ferromagnetic material in the presence of a magnetic field is somewhat more complicated. First, however, I'll deal with the comments of one of our readers.

Reader Garrett Jupp of Keene, NH, sent a letter explaining his concept of voltage. He objects to calling volts a unit of work.

Volts as units of work

"Dear Mr. Wilson:

"I am an avid reader of your articles and have learned a lot from your insights. However, I disagree with one observation in 'The fall of E' (page 58, October 1987): 'Voltage is a unit of work.' When it stands alone, V, or E as you wish (I like V also), is unapplied energy. Work is done when energy is applied.

"V is described as amperes times resistance. But the ampere is described as Coulomb movement divided by time. Ohm's law therefore contains an element of time. Work has no time component.

"I accept the analogy that work is force times distance. There is no time element here. A foot-pound (ft-lb) worth of work could take a second or a month. I agree that the pound in this physical relationship is analogous to the volt, but I have a problem with distance and amperes being analogous. I'm more comfortable with the analogy between distance and the number of coulombs that pass a point in the circuit.

"Watts times time is the accepted description for electrical work, and it has time involved, you say? Yes, but it has time involved twice. The watt describes the rate at which work is being done, or power. Power is work divided by time.

watts = work/time

A watthour = (work/time) x time, and time cancels.

"If you will accept 'C' as the symbol for a given number of coulombs past a resistance, and watts times time as measure of work, I think I can make my point through the cancellation of terms.

Given: work = watts x time

$$1 \text{ watthour} = \frac{\text{work}}{\text{time}} \times \text{time}$$

(time cancels)

W = I x V

I = C/t

Then: W = (C/t)V

work = (C/t)(Vt)=C x V

"Time cancels, leaving work = C x V where W is in watts, t is time, C is as described above.

"Looking at it another way: I can find no way to equate kilowatthours, the accepted measure of work, with volts. I appreciate your going over this and would welcome your comments."

My answer

Thank you very much for taking the time to write. The job of making measurements and assigning units is the work of physicists. So, to determine the unit of voltage I refer to the following quotations from physics books.

Taken from *College Physics* by Weber, Manning & White: "The potential difference V between two points is the work done per unit charge when a charge is moved from one point to the other. The defining equation is:

V = work/charge = w/q

"Conventionally, q is always understood to be a *positive* charge, thus making definite the algebraic sign of the potential difference in any particular case.

"The unit of potential difference in the mks [meter-kilogram-second] system is the volt. One *volt* is defined as the potential difference between points in an electric field such that one joule of work must be done to move a charge of one coulomb between the points considered."

Taken from *The Feynman Lectures on Physics* by Feynman, Leighton and Sands: "The potential difference V is the work per unit charge required to carry a small charge from one plate to the other."

To go outside the world of physics, here is another explanation from a technician's book, *Electronic Circuit Fundamentals* by Walter J. Eeir: "The potential difference between two points is defined as one volt when 0.738 foot-pound (ft-lb) of work is necessary to move one coulomb of charge from one point to the other.

"The unit of work (or energy) in the meter-kilogram-second (mks) system of units is the joule. The joule is equal to 0.738 ft-lb of work, so that one volt is the potential difference between two points when one joule of work is required to move one coulomb of charge from one point to the other."

Returning to your letter, it is not necessary to define volts in terms of current and resistance as you suggest because voltage exists without either. However, you are right that there is an energy relationship related to voltage.

You understand, I am sure, that energy and work—for a particular application—are numerically equal. That is because energy is defined as *the capacity to do work*.

Yes, power in watts is work per unit of time or energy expended per unit of time. The watthour is a unit of *energy*, not power. It is interesting to note that you pay the *power* company for *energy*

Wilson is the electronics theory consultant for **ES&T**.

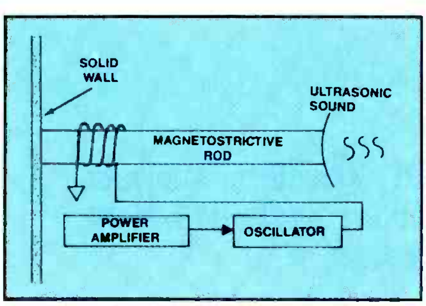


Figure 1. Certain materials, such as nickel and nickel alloys, change in dimension in a magnetic field. Strong ultrasonic waves can be produced by the magnetostrictive effect.

(which is measured in kilowatthours).

You are correct in saying that current is a *quantity* of electricity per unit of time. Let's take the volts and amperes relationship in power.

power = volts x amps
= (force x distance) x (quantity/time)

Rewriting,

power = [(force x distance)/time] x quantity

where (force x distance)/time is the unit of power, and that is not changed when you multiply by a quantity.

apples x 6 = 6 apples
unit x quantity = unit x quantity

Thanks again for your very interesting and professional letter.

Magnetostriction

There are certain materials, such as nickel and nickel alloys, that change in dimension when they are in a magnetic field. The change is very small—usually on the order of one part per million. A good way to use this effect is to place a rod of the material in a varying magnetic field that is produced by an ac current. Strong ultrasonic waves can be produced by the magnetostrictive effect. Figure 1 shows a simplified diagram of the system.

It is often assumed that a rod made of a magnetostrictive material decreases in length as the strength of the magnetic field increases. That is not exactly true.

Assume that the rod is inserted into an increasing magnetic field. When the field strength is first increased, the length of a magnetostrictive rod increases slightly in length. This is called the *Joule effect*.

After the initial increase in length to a point called the Villari reversal point, the length of the rod starts to decrease until it is back to its original length. With a further increase in field strength, the length of the rod continues to decrease until a point is reached where increasing field strength produces no change in physical dimension.

If the rod is bent, application of a magnetic field will try to straighten it. This is called the *Guillemin effect*. Also, application of a magnetic field will try to untwist it. That is the *Wiedemann effect*.

Finally, the amount of magnetism induced in a rod is changed when the rod is compressed along its length. The name for this is the *inverse Joule effect*.

Products

UPS with interface

American Power Conversion has introduced the model 520ES uninterruptible power source, which has a built-in interface to communicate to personal computers and file servers. The interface allows the UPS to signal the computer that power has failed, allowing the computer to automatically close files and shut down. The 25-pound system delivers up to 520Va of power and includes 270J of surge protection and an EMI/RFI filter.

Circle (75) on Reply Card

Digital logic probes

Contact East has introduced six models of high-speed digital logic probes that are circuit-powered and have automatic pulse stretching to aid detection, latching memory and switchable threshold levels. All are compatible with DTL, TTL, MOS and CMOS logic families, and two of the probes can test the faster ECL devices. Some models have audible pulse-tone.

Circle (76) on Reply Card

Tool kit

The GEMINI series, model 71A316 tool kit from *HMC* contains name brand tools in a 6½-inch aluminum case that

is lightweight but strong enough to stand on. The case has two removable pallets, a recessed combination lock, a heavy-duty continuous hinge.

Circle (77) on Reply Card

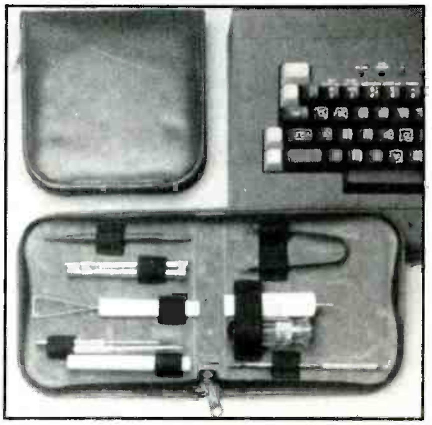
Vacuum desolderer

The MBT-210 vacuum desolderer from *PACE* uses electronic, load-sensitive, turbo-heat boost circuitry that compensates for temperature drops due to heat sinking, allowing instant solder reflow on multiple-lead components. Tip temperature is selectable within 1°F and is indicated on a read-out display. The unit also incorporates the Snap-Vac vacuum generation system, which eliminates resweat problems, and a static dissipative desoldering handpiece.

Circle (78) on Reply Card

PC computer service kit

The JTK-9 PC service kit from *Jensen Tools* includes a screwdriver han-



dle with four interchangeable blades, CMOS-safe IC insertion and extraction tools, a screwstarter, a key cap puller, a spudger/DIP switch setter and a disposable penlight. The tools are contained in a 7"x7"x1" zippered case.

Circle (79) on Reply Card

Oscilloscopes

Tektronix has introduced two 100MHz oscilloscopes—the 2245A and 2246A PaceSetter models—that offer cursors and a CRT readout for reading and measuring time/voltage data. The 2446A also features store/recall of up to 20 front-panel setups and "smart" cursors that follow changes in the voltage, trigger and ground level of the displayed waveform. Both feature an auto setup feature that allows the scopes to set up and display the proper waveform at the push of a button. Horizontal and vertical accuracy is 2%; sensitivity is 2mV.

Circle (80) on Reply Card

Sweep/function generators

The *Simpson* models 421 and 422 sweep/function generators provide front-panel selection of sine, square and triangle waveform outputs. Sweep frequencies have selectable start/stop ranges with 100:1 linear and 1,000:1 logarithmic sweep ratios. Sweep ranges may be set at any two points within the 0.5Hz to 5MHz range of operation, and sweep times can range from 0.05 seconds to 30 seconds. The TTL output will drive up to 10 loads with 25ns rise/fall time.

Circle (81) on Reply Card

Protection devices

Dynatech has introduced the PC and FAX Protector and the PC and Modem Protector. The PC and FAX Protector protects one ac outlet and one telephone receptacle from voltage spikes and surges. The PC and Modem Protector protects four ac outlets and one telephone receptacle. Rated energy absorption is 181.5J with power dissipation of 1.815MW over 100μs. The units are warranted to withstand a 6,000V strike.

Circle (82) on Reply Card

S-VHS test generators

Leader Instruments has announced an equipment upgrade on the model LCG-396, LCG-400 and LCG-420 video test signal generators. The generators now supply the separate Y (luminance) and C (3.58MHz chroma) signals that are normally routed between components of the Super VHS system. Instruments that have already been purchased may be factory modified by the company.

Circle (83) on Reply Card

Hand-held voltmeter

The model 110 hand-held digital safety voltmeter from *Tegam* is fully automatic and doesn't require range or function selection. The unit automatically checks

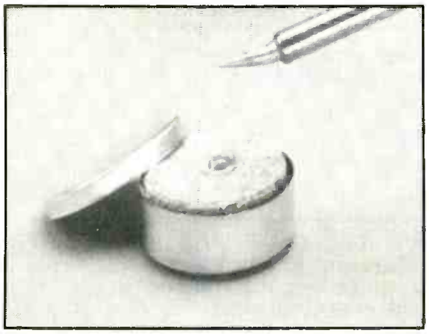
for both Vac and Vdc, compares and identifies the strongest voltage, selects the appropriate function, annunciates the active function and displays the voltage reading. The probe tips are protected by retracting sleeves and each probe contains a high-voltage resistor.

Digital tester

The DM1000 card-sized digital tester from *Eaglestone* features full auto-ranging and an LCD display that not only shows the reading, but tells if ohms, continuity, ac or dc was selected. A built-in beeper makes it easier to check continuity. The tester has a 500V ac/dc and 20MΩ range, 0.7% basic accuracy and low-battery warning.

Soldering iron tinner/cleaner

Multicore Solders has introduced the TTC1 soldering iron tip tinner/cleaner. The cleaner, which is a small block of electronics-grade solder powder and chemicals compacted into the shape of a thick disc, removes the tin/iron intermetallic layer and wets and tins the tip in one step. The chemicals are non-corrosive and have a low evaporation point.



Wrist-strap monitor

The GAM-3 wrist-strap monitor from the *Pilgrim Electric Company* detects triboelectric charge and warns that static charge has built up faster than the wrist strap can drain it off. When the unit is plugged into a standard 120Vac 15A or 20A outlet, it determines whether the outlet's polarity is correct and its ground is adequate to discharge static. The monitor also confirms the integrity of the wrist-strap and tether, alerting the user if a break occurs. The monitor provides a 1MΩ current-limiting safety resistor to protect the operator against electrical shock and transient voltage spikes. ES&T

Video Corner

Troubleshooting recording problems

By Conrad Persson

In a VCR, just as in any other consumer electronic product, a symptom or set of symptoms may be caused by more than one type of malfunction. Take problems with the recording function, for example. If a VCR is not recording properly, this may point to problems in the luminance/chroma (Y/C) circuits or in the servo system.

Close observation of the symptoms along with a little logic can save time in tracking down the cause of the problem. Let's take a GE 1VCR3000X, for example. Let's say you suspect that the problem is in the servo stages. In this

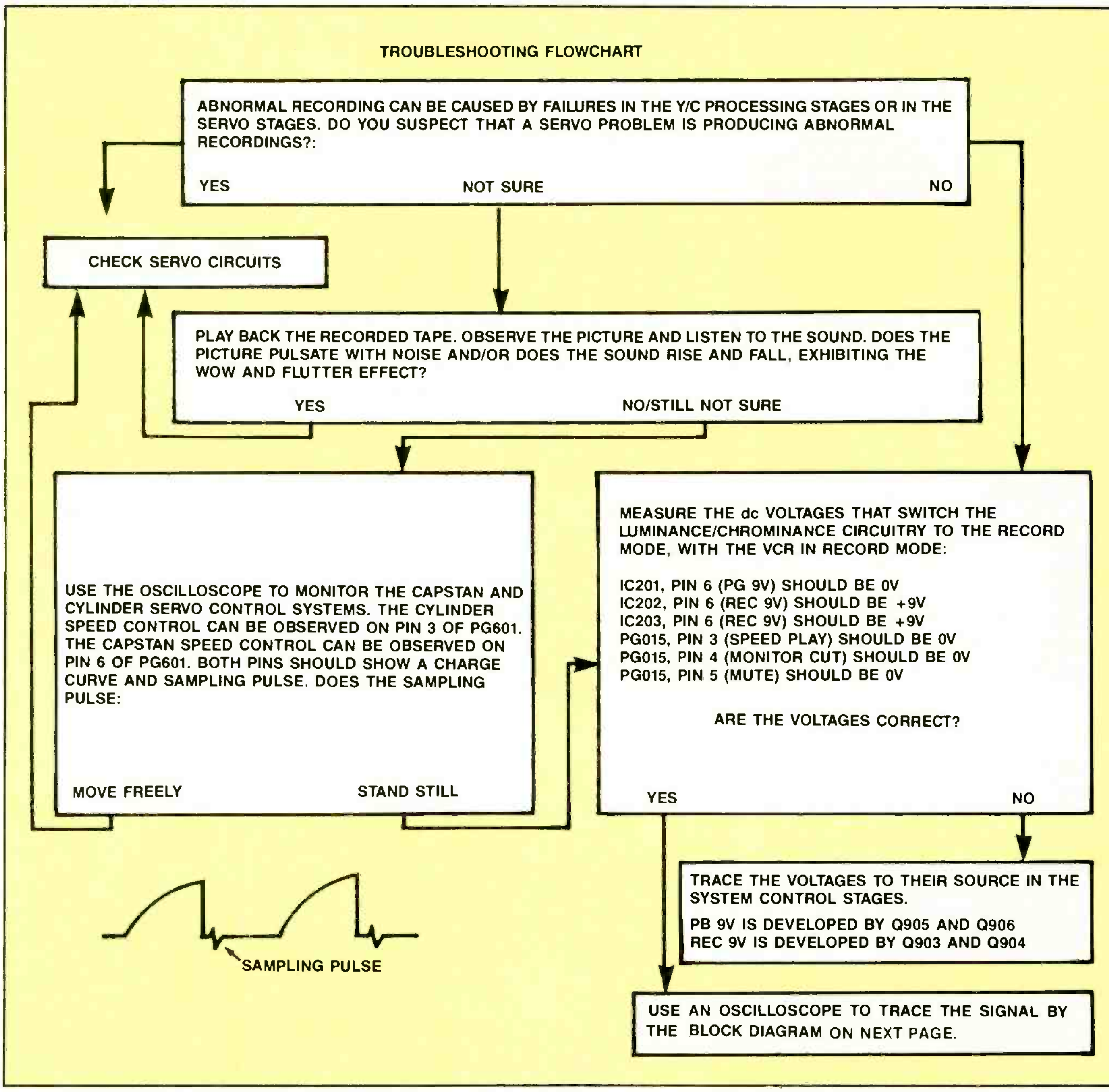


Figure 1. If a VCR is not recording properly, use this flow chart to determine if the problem is in the Y/C circuits or the servo system. IC numbers are specifically for the GE 1VCR3000/3010.

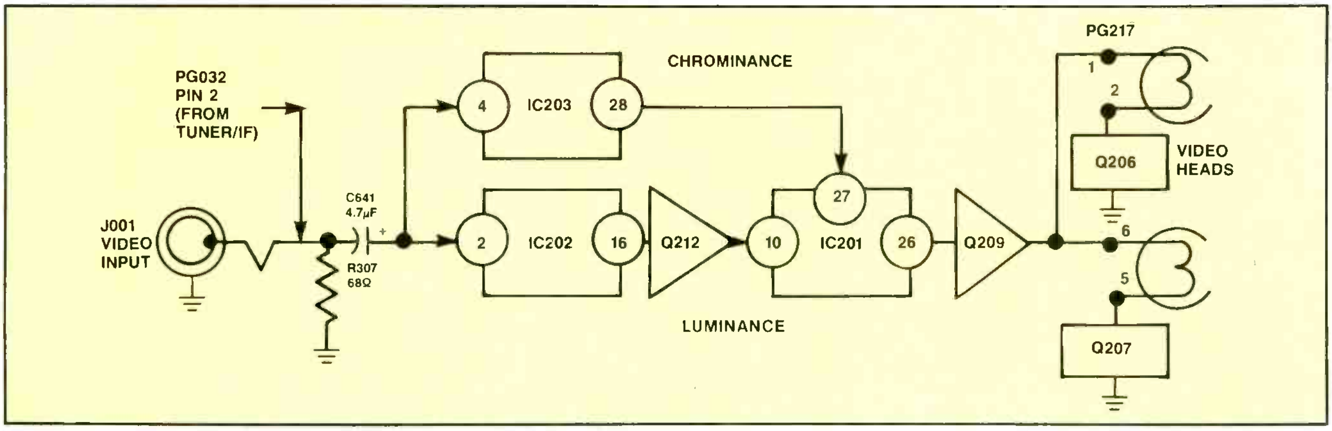


Figure 2. If the problem is in the Y/C circuits, use an oscilloscope to trace the signal through this portion of the circuitry.

case you should go directly to the servo stages. If you suspect the Y/C circuits, you would go directly to those circuits and begin your troubleshooting there.

But what if you're not sure where to start? That's where the logic begins. You have to observe the symptoms more closely and see what they're telling you about the nature of the problem. In this case, play back a tape that you've recorded on the faulty VCR, carefully observing the picture on the screen. If the picture pulsates with noise or if the sound rises and falls (wow and/or flutter), the problem is probably in the servo system.

The accompanying flow chart, courtesy of GE, will help you determine if the problem is in the Y/C circuits or the servo system. If you decide the problem is the Y/C circuits, the block diagram will help you trace the signal. ES&T

Persson is editor of ES&T.

Computer Corner

House wiring provides the path

By Conrad Persson

One of the things consumer electronics companies are working on that is destined to cause a monumental change in the home is the *home bus*. For example, in the editorial in the October 1987 issue, we talked about the fact that EIA/CEG is in the process of drafting a home automation standard that will use power lines, twisted wire pairs, coaxial cables and infrared to control audio/video, lighting, major appliances and security systems.

NEC Home Electronics (U.S.A.) has announced what they claim is the first line of commercial products to incorporate its Home Bus for high-speed data communication over common household wiring. They believe widespread adoption of the home bus could lead to

Persson is editor of **ES&T**.

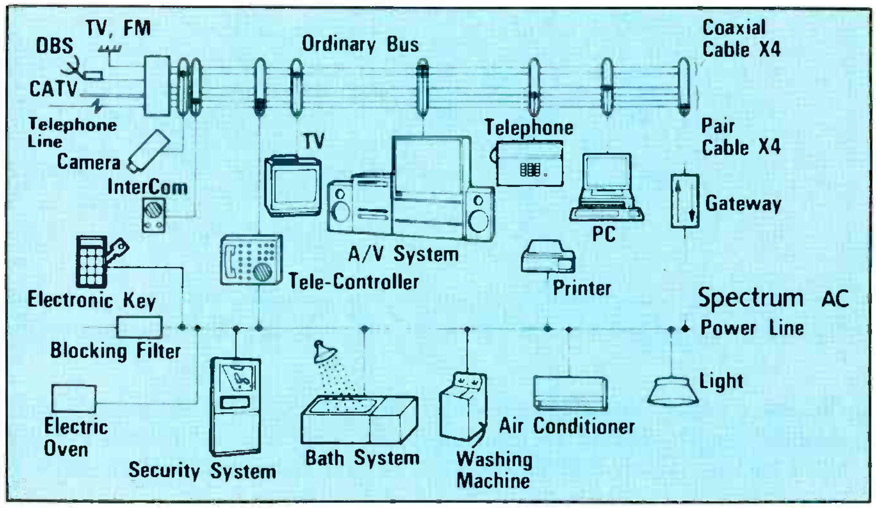


Figure 1. The home bus system, made possible by the increasing computerization of all kinds of consumer electronics products, will provide interconnection among separate and diverse computer and A-V components and appliances in the home and office environment. (Art courtesy NEC)

a new generation of household appliances within three years.

The information accompanying this announcement makes an interesting point: Today, every top-of-the-line audio or video product is *smart*—it has its own microprocessor brain. The same goes for home security systems, telephones, furnaces, even microwave ovens. One shortcoming remains: Even smart appliances still cannot communicate with each other, so consumers who currently use these products must operate each one separately.

The next step for the home electronics industry is to tie such machines together and make each of them simpler to use, according to Phil Rittmueller, head of new product development for NEC Home Electronics. He asserts that the home entertainment center is as complicated to operate today as it will ever get, adding that in some cases its complexity inhibits use of the system.

The implications of the home bus for personal computing are powerful. The NEC system is a true databus that will allow 9,600-baud communication between computers or from a computer to a printer. With such a system, any electrical outlet can be a local area network port. The computer and the printer can be anywhere in the home.

Audio-visual components

Also envisioned is an audio-visual (A-V) center that can remember the programs you like to watch and will turn itself on at the right time with the right station already tuned in. The entire center is expected to have a single set of simple controls. It also should come with a hand-held remote control that will work from anywhere in the home.

One single component will have the capability of being the commanding unit for all the A-V equipment. The user will only have to operate its controls to command all A-V equipment anywhere in the home. And all of this interconnection will take place over a home bus linking equipment from a variety of manufacturers.

Although the home bus will make things easier for the consumer, it appears (at least on the surface) that this new computer bus system will make things more complicated for the servicer. When a problem arises, it will become a matter of whether the problem is in the controlling unit, the controlled unit or somewhere in the bus in between. It also would appear that this new generation of consumer electronics equipment will require more in-home troubleshooting just to isolate the problem to a specific device. More sophisticated test equipment and definitely more specialized knowledge on the part of anyone who attempts to fix the new equipment also will be a requirement. ES&T

Troubleshooting Tips Wanted

Electronic Servicing and Technology needs additional consumer-product Troubleshooting Tips. Most types of case histories are suitable, especially those with unique, puzzling or misleading symptoms.

List the brand, model and Photofact number followed by a narrative telling the original conditions or symptoms, the various troubleshooting steps, and the components replaced to restore the original performance. Please include a simple hand-drawn schematic of the stage that has a defect.

$10 will be paid for each Troubleshooting Tips published. Your name and city will be listed, unless you ask to remain anonymous.

Send all Troubleshooting Tips to:

Troubleshooting Tips Department
Electronic Servicing and Technology
P.O. Box 12901
Overland Park, KS 66212

Audio Corner

DAT: Where's it at?

By Kirk Vistain

I know what you're thinking. Do we need six incompatible tape formats, or only five? Well, being as the sixth is the most faithful reproducer and would blow the others completely away, you have to ask yourself one question: "Is DAT where it's at?" Well, is it, record industry?

Do we need six incompatible tape formats?

Does this on-again, off-again DAT affair remind you of anything? Didn't we suffer through the promises and delays of the CD player? Maybe this is more of the same, but there's a catch. Digital audiotape machines can record. The people who supply our need for music are afraid that DAT will kill CD sales, thanks to the virtually perfect copies it can make. So they're doing their best to keep DAT out of the United States until the hi-fi manufacturers make piracy too difficult to be practical.

Japan, in its way, has tried to comply. First they set the sampling frequency to 48kHz so direct digital copies were impossible. Still the record moguls complained. The analog transfer still produced a dub that was far too faithful. Next, CBS promoted a scheme called CopyCode, which, to the best of my understanding, notches out any musical information at 3.18kHz in the original. When the copy prohibition circuitry in the DAT detects this crippled signal, it disables the record circuit. Imagine how serious music listeners feel about this scheme. Even if they don't own a recorder, they will have to suffer the degradation of their signal sources. Given the fact that the CD is the most faithful medium yet devised, it makes no sense to cripple it with some wacky anti-piracy scheme that professional pirates will have little trouble circumventing anyway.

Fortunately, the CopyCode thing is not going over well with anyone but the record producers, so it may be dead. Those of you who read the financial section probably have heard that Sony of Japan just dropped $2 billion to acquire CBS records. Whether this has anything to do with DAT is moot. Meanwhile, the whole question is still debated in Congress. All this for a simple tape recorder.

Technical considerations

Just in case we should see the DAT sometime in this century, let's get technical for a while. All wisecracking aside, digital audiotape machines are intriguing. RDAT is the full name of the consumer format. R stands for *rotary*. Those of us who service VCRs would find the system quite familiar. Figure 1 compares the systems.

DAT uses a rotary drum with two heads positioned 180° apart. Unlike the scheme used in VCRs, the tape wrap (the arc over which the tape contacts the head drum) is only 90°. The output, therefore, is discontinuous. The data streams out in bursts separated by areas of no signal.

It would sound pretty bad if this were analog, but through the magic of digital processing and RAM, the problem disappears. Simply store the first burst of data, wait through the null, store the second, then output them as one continuous block. CD players use a similar process to eliminate jitter.

The designers chose azimuth recording and overlapping tracks, as is common on VCRs.

DATs don't have erase or control heads. Erasure is accomplished by recording new information over old. Tracking is accomplished with an ATF circuit reminiscent of that used in 8mm machines. The differences are significant, but that's a topic for the future, when and if I can figure it out.

The designers chose azimuth recording and overlapping tracks, as is common on VCRs. The head gap is actually wider than the track pitch, so subsequent tracks partially overwrite previous ones. By setting the azimuth of one head to +20° and the azimuth of the other to −20°, a total of 40° of azimuth difference occurs between tracks. At the frequencies used by DAT, this means that head A will have little response when traversing the track recorded by head B, and vice versa. Thus crosstalk is mitigated.

Of course, to those of you familiar with CDs, it will come as no surprise that Reed-Solomon error correction codes (ECC) are used along with a CRC

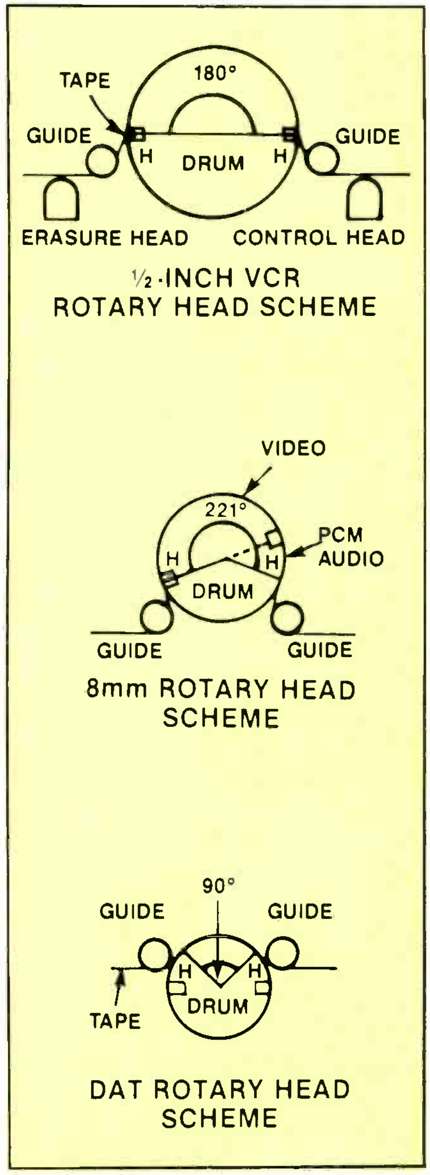


Figure 1. This comparison shows the difference between DAT, 8mm and VHS VCR rotary head schemes. DAT has a tape wrap of only 90°, which results in discontinuous output. Digital processing makes output continuous.

Vistain is the audio consultant for ES&T.

(cyclical redundancy check) scheme. In all, about a third of the data recorded on DAT is some sort of ECC when it's used as an audio medium. However,

True to current design practice, servos abound.

DAT could also be used for computer data storage. Because interpolation can't be used, error correction must be beefed up to the point where ECC accounts for about five times as much storage space as does the actual data. Although 16 terabytes are available for audio recording, maximum computer data storage is only about 1.2 gigabytes.

Servos

True to current design practice, servos abound. Of course, there's a drum and capstan servo, but also a reel servo to control tape torque. In general, these are digital. The speed of the rotating

How about 20Hz to 22kHz, unmeasurable flutter and wow, 96dB dynamic range, and virtually no THD? That's what DAT can do.

part, be it capstan, drum or reel, is sensed via an FG (frequency generator) or PG (pulse generator) signal and compared to a stable crystal reference. The resulting output is used to control both speed and phase.

Audio specifications

How about 20Hz to 22kHz, unmeasurable flutter and wow, 96dB dynamic range, and virtually no THD? That's what DAT can do. Of course, aren't we all used to that by now, thanks to compact disk? But this thing *records*. Who knows whether the market can support another recording format. A metal tape in a good music cassette deck can yield roughly the same frequency response. Flutter and wow, after a certain point, are not a big consideration for most listeners.

With people already complaining about the excessive dynamic range of CDs, it's hard to see the advantages of DAT overcoming the high prices and jaded consumer appetite. Manufacturers must entice us with something more than just super ultra fidelity and the magic of digital, or this thing may turn out to be just another Elcaset.

Readers' Exchange

Editor's note: Readers' Exchange items are published in the order they are received. We are happy to offer this service at no charge to you, our readers, but ask that:

- Items are legibly written or typed.
- Your name and address are included on the same page as your item (envelopes and contents can become separated). Phone numbers also should be included; if you don't want it published, please indicate.
- Please limit any item to no more than three units or approximately four lines.

Please understand that **ES&T** is in production six weeks to two months *ahead* of publication date.

WANTED

Service info for Unicom Electronics Ps-11R power supply; Tandy 26-3127 64K Color Computer II; EMP/GTS MM-101 manual mini modem (by Eltec, Hong Kong); Garrard Lab 95B turntable; Johnson 323 Messenger CB; Apple IIe Pro System Duo-Disk, Imagewriter, Printer Monitor II; Icom 735 ham transceiver; Loonam FM30 modem; Designers for Industry TV2CU (F.A.A.) tube tester; Jerrold CM-6C (F.A.A.) amplifier/marker; URM-64A/TS-419 signal generator; RCA SGT-250 videodisc player. Will purchase or pay copy cost. *Mike Adams, Haney Vo-Tech Center, 3016 Hwy. 77, Panama City, FL 32405; 904-769-2191.*

Service manual or schematic for a Qonaar 2000 security system. Includes main control unit with telephone dialer and fire, burglar remote units. Will buy original, pay for copies or copy and return. *D. Strykowsky, D&S TV Service, 947 Duncan Ave., Yeadon, PA 19050; 215-626-4565.*

New or rebuilt 7DP4 and 10BP4 picture tubes; Col-R-Tel color wheel from mid-1950s, complete. *George Mayne, 307 Moxon Drive, Rochester, NY 14612; 716-865-5227.*

A complete "D-C-I Pulse Monitoring Program" set, published by Tele Tech, Amarillo, TX. *Luther Sellers, 74 Bradley St., Buffalo, NY 14213; 716-883-2601, leave message.*

Knight 83Y135 signal tracer with manual and 83YX137 AF generator with manual. *C.T. Huth, 229 Melmore St., Tiffin, OH 44883; 419-448-0007.*

Service T/M or schematic for GE PJ7100 and PJ700 video projectors; Sylvania H01-2 TV chassis (part of D13-2). *DMT, P.O. Box 9064, Newark, NJ 07104.*

Information and schematic diagram for a Micro Instrumentation and Telemetry Systems audio sweep generator, or information on the 14-pin DIP used in this unit, S/N C 11918. *Ernest L. Lusk, 1981 Essex Ave., La Verne, CA 91750.*

Wooden Zenith radio knobs, will pay up to $2 each; pre-1950 radio and TV advertising and promotional items. *Doug Heimstead, 1349 Hillcrest Drive, Fridley, MN 55432; 612-571-1387.*

CRT for Tektronix model T922 scope. *Greg Oliva, 473 Granada Drive, S. San Francisco, CA 94080; 415-952-0845.*

Panasonic PV5800 VCR; Magnavox VR8453SL01 VCR. *Frank Aznar, 1111 Main St., Patterson, NJ 07503; 201-742-9551.*

Service manual for TEAC model A-4010S reel-to-reel tape deck. *Larry's Island TV, 2244-C Periwinkle Way, Sanibel, FL 33957; 813-472-4100.*

Information about where to purchase 8-track tape cartridge pads (the styrofoam type). *August C. Weiss, 11658 Harvard Drive, Norwalk, CA 90650; 213-865-7842.*

Service literature for DISCO DSC-500A portable color TV/FM/AM/TR (company went out of business). *H. Sievers, 6819 Willamette Drive, Austin, TX 78723.*

B&K 1653 isolated ac supply, variable isolated 0-150Vac, 2A continuous output; RCA modules MDH001A hor. and MDR001A regulator for CTC85. *George John Demaris, 7387 Pershing*

Ave., Orlando, FL 32822-5743; 305-277-3746.

FOR SALE

ICs, $.20 per chip plus postage; numbers available are: SI ED-11S 7924 024A, 7940 029, 7838 044B, 7921 023, 7922 024B; SI ED-9 7945 36, 8042 062, 8113 020, 8033 059, 7915 028D: ED-9 8116 019, 8113 ED-018, 8104 008, 8104 063, 8104 063A; MC10469 UB (ECG 4069), CD 40106 BE (ECG 40106); ED-11S 7940 044A, MC14007 UB, SI ED-9 8103 063A. *E.J. Dvorak, Box 94, 1013 Fulton Ave., Dorchester, NE 68343; 402-946-3041.*

Simpson Electric model 467 true RMS digital multimeter, measures to 1,000Vdc, 750Vac, 2,000ma ac-dc amps, 20MΩ, includes leads and batteries; Dumont model 1062 oscilloscope, 50MHz bandpass, dual amplifier inputs, main and delay sweeps, 100% solid state, $400; Deihl model Mark III scanner, turn on any shut-down TV, $250. Add $10 for insured shipping. *Fred Jones, 407 Morningbird Court, Niceville, FL 32578.*

TV tuners and flybacks, send s.a.s.e. for list; R.C.P. Flybacker flyback and yoke tester, $35 (will trade for test equipment). *Ralph A. Deterling III, 62 Conant Road, Lincoln, MA 01773; 617-259-8377.*

B&K Precision model 1248 digital IC color generator, excellent condition, $250. *Michael Rowell, Gohmert Audio/Visual, Start Route Box 38A, Meyersville, TX 77974; 512-275-8951.*

Sencore PS163 dual-trace scope, with manual (dc 8MHz usable to 15MHz), $200 OBO; B&K 1460 single-trace scope with manual (dc 10MHz), $150. Both scopes include probes. *Ray's TV, 4821 East View Drive, New Orleans, LA 70126; 504-246-6205.*

B&K 1077B TV analyzer, $195; Conar TV pattern generator, $20; computer keyboard, $15. *Harvey Montgomery, 1602 Antelope Road, Elberton, GA 30635; 404-283-3055.*

1-660 color bar generator. Will trade for 209 meter. *George Payad, Service Dept., Payad Radio-TV, 125 E. Main St., Staunton, IL 62088; 618-635-2111.*

TV tubes, including color tubes, flybacks, triples and modules. All guaranteed and half price. All electronics. *G. Barzily, 84-39 120th St., Kew Gardens, NY 11415; 718-847-7965.*

Govt. T/Ms, only $15 each—what are you looking for? *DMT, P.O. Box 9064, Newark, NJ 07104.*

B&H Micro Fische with Panasonic service cards from 1965 to 1982; TV test equipment, like new—send s.a.s.e. for list, make offer. *Ken, Ken's Electronics, 331 San Jose, Fairfield, CA 94533.*

Sams manuals, $2.50 each, includes postage (TSM1,2,3,6,11,27,30,35,42,49,52,54,55,57-59, 61,62); Realistic DX100 communications receiver, in good working order, with owner's manual, $50; Sony model PT79R remote control timer less hand unit, $25; Military TS505D/U VTVM, complete but missing meter, $15. *Donald H. Nash, 1444 Pulaski St., Port Charlotte, FL 33952; 813-629-3934.*

Tektronix 545A oscilloscope, "L" plug-in and scopemobile, $200. *Kenneth Rafuse, Bauer Ave., Manorville, NY 11949; 516-878-6677.*

New Sencore FC71 frequency counter in original carton, never used, with antenna, ac adapter and battery, $900. *Suave's Electronics, Box 194, Two Rivers, WI 54241; 414-794-7221 days or 414-793-3104 after 5:30 p.m.*

Sencore Z-meter, LC53, excellent condition, with leads and manual. $550 firm, includes shipping. Contact Sam W. Jacobs, CET, 412-694-2700 noon until 1 p.m. Monday through Friday. *Derry Electronics, Derry, PA 15627.*

B&K 162 transistor checker with manual, very good condition, $30 or best offer. *George John Demaris, 7387 Pershing Ave., Orlando, FL 32822-5743; 305-277-3746.*

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VCR REPAIR SOLUTIONS FOR VHS MODELS. Volume 1-150 Symptoms and cures-$11.95. Volume 2-$11.95. All 300, $19.95. Eagle Electronics, 52053 Locks Lane, Granger, IN 46530. 12-87-6t

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TV/VCR FAILURE HISTORIES—Multiple cures for most problem areas. Send $6.95 with mfg. and model number to TECH CURES, 4825 Fredericksburg Road, San Antonio, Texas 78229. Money will be refunded with free sample, if model is not on database. 01-88-2t

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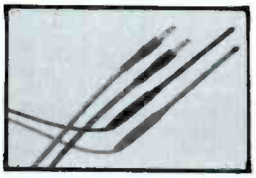


Circle (2) on Reply Card

NEW SMD OSCILLOSCOPE PROBES AND TEST PROD KITS O.K. Industries introduces SMD oscilloscope probes and test prod kits. The SMD Oscilloscope Probes, designated the PP5000 Series, are slim, precision probes designed for testing SMD circuits. The 0.8mm tip and slim-body probe allow improved viewing angles necessary for testing circuitry.

Specifications range from 30MHz to 275MHz, x1 and x10 attenuation and are available with readout actuators.

The new SMD tweezer prod kits, designated the TW300 (BNC connector) & TW300/BN (banana cable connector), for SMD testing can adapt to most multimeters. The tip contact is gold plated beryllium copper, the rating is 400Vrms, 3A and the cable length is 1.2 meters.

The TPK110 Test Prod Kit features ultra-thin test prods to maximize tester viewing angles. The rating is 250Vrms, 3A, the tip is made of stainless steel at 0.8mm and the cable length is 1 meter.

List price for probes starts at $52.00. List price for Test Prods and Tweezers starts at $13.95 for tweezers and $24.95 for test prods.

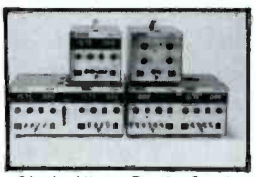
Contact: O.K. Industries Inc., 1-800-523-0667. (In N.Y.S. call (914) 969-6800.)

Circle (3) on Reply Card

BATTERY POWERED DIGITAL STORAGE UNIT O.K. Industries Inc. introduces an all new battery operated, ultra portable instrument providing A/D conversion and up to 1K memory storage in a hand-held, 2 lbs. package. Designated the DS2202 this Digital Storage Unit is powered by four 1.5V "C" cell batteries. The DS2202 has a real-time bandwidth of 200kHz and is AC or DC coupled with 0% or 50% pre-trigger selection, single shot, role or refresh modes. The units non-volatile memory can store waveforms up to four years. The vertical sensitivity is 5mV/division and has 8 bit resolution. The DS2202 has an analog plot output of .02V/div. The unit can interface with any oscilloscope and sells for less than $500.00.

A wide range of optional precision oscilloscope probes with bandwidths to 350MHz are also available.

Contact: O.K. Industries Inc.: 1-800-523-0667 (In N.Y.S. call (914) 969-6800).



Circle (4) on Reply Card

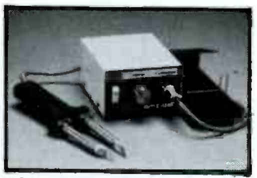
PRECISION BENCH TOP, LABORATORY POWER SUPPLIES The PS732 Series have dual $3\frac{3}{4}$ digit display for simultaneous metering of current and voltage. Output controls provide 0.1% accuracy for voltage readings and 0.3% accuracy for current readings. Moreover, where as typical $3\frac{1}{2}$ displays reduce resolution and in effect lose the advantage of high accuracy output, the PS732 series $3\frac{3}{4}$ digit display provides resolution to 0.01V and 0.001A over the entire range. The result is excellent accuracy and resolution providing true precision output.

A front panel switch provides rapid and exacting set up of current limits without manually shorting the outputs and without having to place the circuit under load. The PS732 Series can operate in constant current or constant voltage modes. The display provides a clear indication when the supply crosses over from constant voltage to constant current.

Specifications are as follows:

PS732	Single Output	0-30V/0-2A
PS732-Q	Dual Output/Quad Mode	2X0-30V/0-2A or 0-30V/0-4A or 0-60V/0-2A or 0 ±30V/2A
PS732-K	Triple Output	0-30V/0-2A & 0-30V/01A & ±5V/7A

Prices start as low as $345.00. Contact: O.K. Industries Inc.: 1-800-523-0667/914-969-6800 (NYS).



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NEW SMD REMOVAL UNIT O.K. Industries Inc. introduces a new Hot Tweezer System. Designated the SMT-W2, this powerful unit features variable temperature and high reliability.

The SMT-W2 incorporates an ergonomically designed handpiece which can be comfortably held by any operator regardless of hand size. Two eight watt ceramic heating elements provide exceptional temperature stability and sufficient power to remove any SMD from chip to resistors large quad packs.

A full range of tips are available including 5mm tips for resistors or capacitors, mini-flats or SOIC's and right angle tips for PLCC's to 84 pins.

List price is $425.00.

Contact: O.K. Industries Inc., 1-800-523-0667. (In N.Y.S. call (914) 969-6800.)

Circle (6) on Reply Card

INDUSTRIAL POWER SOLDERING IRONS O.K. Industries introduces a new industrial power soldering iron series. Designated the New SA-8 Series, these irons are extremely slim, light weight, ergonomically designed, production quality irons.

These irons offer: • highly accurate temperature stability which prevents damage to boards and components • quick heat up time with rapid temperature recovery • silicone rubber heat guard which provides operator comfort and a positive grip for safety • long-life corrosion resistant tip • grounded tip for CMOS safe soldering.

The SA-8 Series solder irons have a maximum equivalent rating of 30, 40 and 50 watts. All irons have a three wire grounded power cord.

Prices start as low as $24.95.

Contact: O.K. Industries Inc., 1-800-523-0667 or (914) 969-6800 (NYS).

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Circle (7) on Reply Card

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That's why you should start taking advantage of your Zenith parts distributor's R&R Exchange Program now.

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