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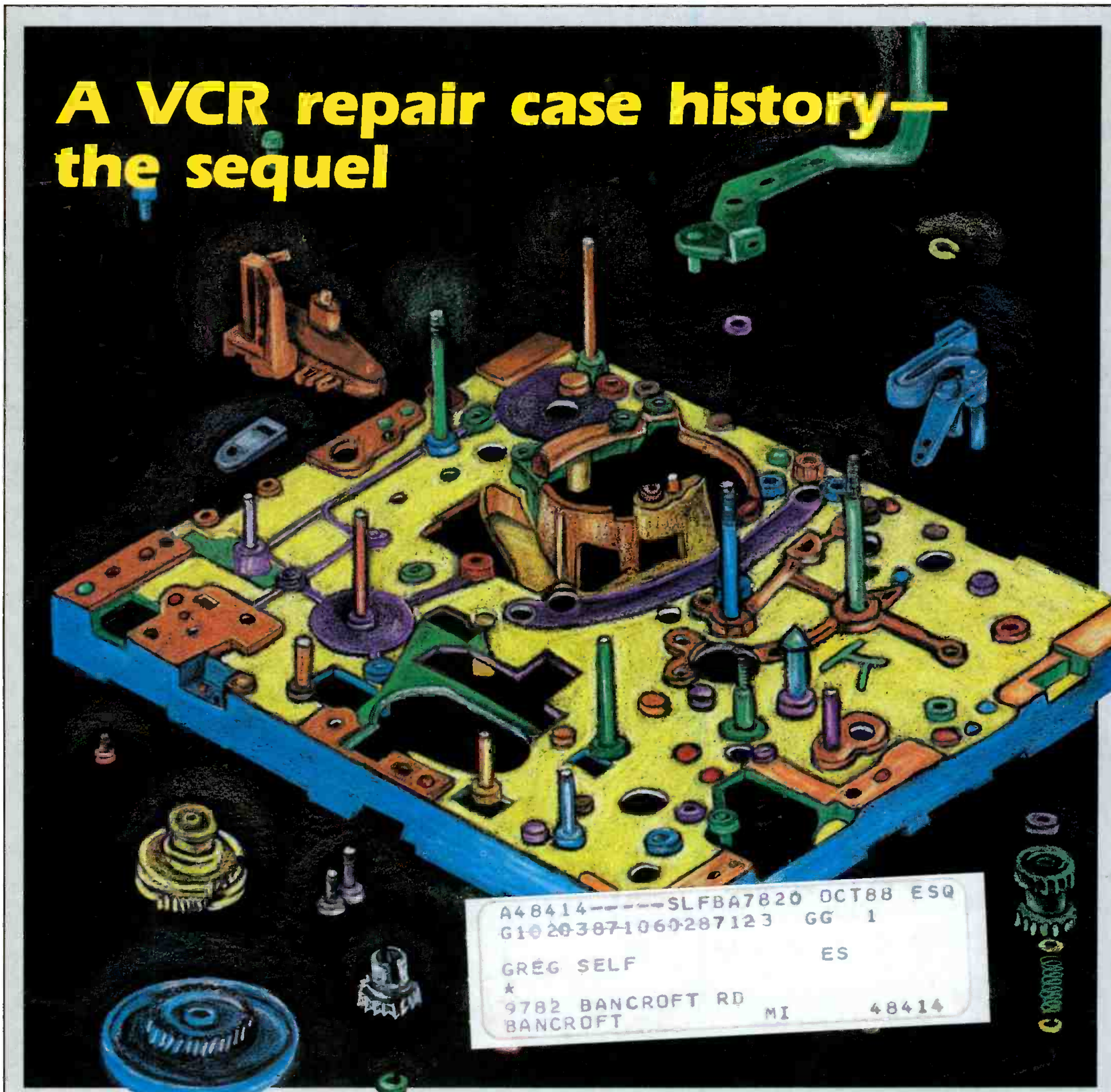
Cleaning supplies for computer maintenance



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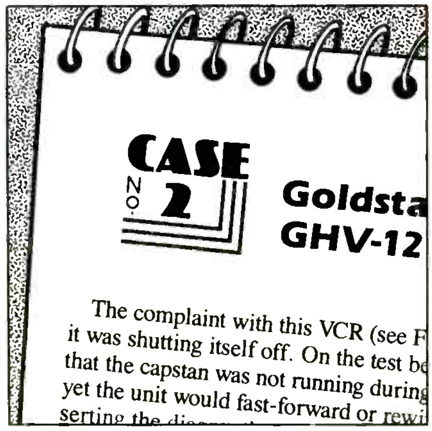

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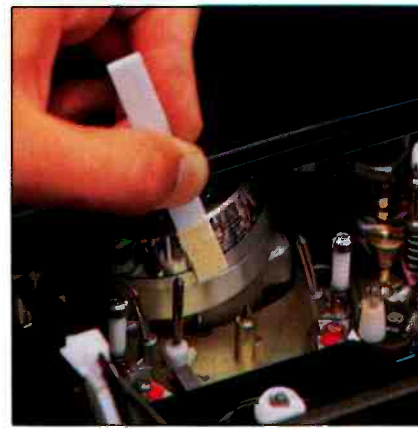

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FEATURES

DEPARTMENTS

ON THE COVER

All those little moving parts in a VCR may look like alien territory to most electronics servicers. In fact, mechanical problems are the cause of a majority of VCR failures. The two most common problems—dirty heads and rewind mechanism failures—are mechanical problems any VCR servicer should be able to handle. *(Concept and design by Barbara Miles, graphic designer.)*

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ELECTRONIC Servicing & Technology

What's the problem with electronics product design?

The audio system in my Japanese-made car is great. The sound is everything you could possibly want in a car audio system. It has AM/FM stereo with station seek, a stereo cassette with auto reverse and automatic program search. Wonderful. And I can preprogram up to five stations on both AM and FM so that, with a touch of a button, I have whatever station I want.

So what's the problem? Well, operating an auto radio has to be a tactile operation. In every other car I've owned, to operate the radio I would just lean over, eyes still on the road, and find the volume control, tuning knob or station preset buttons by touch.

The sound system in my new car is so wonderfully sleek that all the controls but the on/off/volume are electronic push buttons, mounted flush with the surface of the radio. When I reach over to change the station or perform some other operation, keeping my eyes on the road, I get no tactile clues at all. Even worse, if I touch the radio to try to get a clue, I might push one of the station preset buttons I didn't mean to push. Or the AM/FM selector button. Or one of the station tuning buttons.

So I find myself looking at the radio when I should be concentrating on the road. Unfortunately, the radio isn't really well-designed visually. Oh, it looks great, but no matter how many times I operate it I have to think about what I'm doing and what buttons to push. And as flat and sleek as the instrument panel is, when I'm driving down a normal city street with normal bouncing around, it's hard to get my finger on the right button because there's no place to rest my hand while tuning.

So is the current crop of consumer electronics not well designed? The answer is probably yes and no, depending on your point of view.

Take VCRs, for example. Many people think they're too complicated—a lot of consumers can't even hook them up. Once they are hooked up, a lot of consumers can't take full advantage of their marvelous features. The move toward using bar codes for programming a VCR to record a TV program is being made because thousands—perhaps millions—of people don't know how to operate the programming buttons on their VCRs.

The cry is to keep all the features but simplify the controls so that they're easier to operate and understand. No doubt there's merit in that. On the other hand, the very nature of the operation is that it's complex.

No doubt it's possible for the manufacturer to design products better in order to simplify some of these operations, but there's no getting around the fact that the more things a product is capable of doing, the more complex its operation will be. In the final analysis, then, it's not only that the machine is complicated but that the operating environment is complex as well. The machine is simply a reflection of that environment.

Consumer electronics manufacturers probably will be able to simplify the operation of their products—after all, the auto manufacturers did when they invented automatic shift and other automatic controls. Still, when you ask a product to do a lot of things, it necessarily becomes complex and complex to use, so not all of the blame should be placed on the shoulders of the manufacturers.

But let's not let the manufacturers off too easily. In many cases, they opt for the elegant electronics approach to manufacturing a product, which is not necessarily the best approach for the people who operate it. The "solution" to this problem probably rests with technological evolution. The complaints of consumers will no doubt prompt manufacturers to take steps to reduce the complexity of their products where possible and to consider the user and the conditions of use when engineering today's consumer-electronics technological marvels. Consumers also will gradually become more conversant with the intricacies of these devices.

In the meantime, servicing technicians are the people in the middle. You're probably going to run into situations where a customer calls you out for a "broken" VCR and you get to explain about the TV/VCR button. And of course, there will be those customers who think you personally designed these "dumb things." All you can do is what servicers always do—hope your next call is for a nice, intermittent TV shutdown problem.

Nils Conrad Persson

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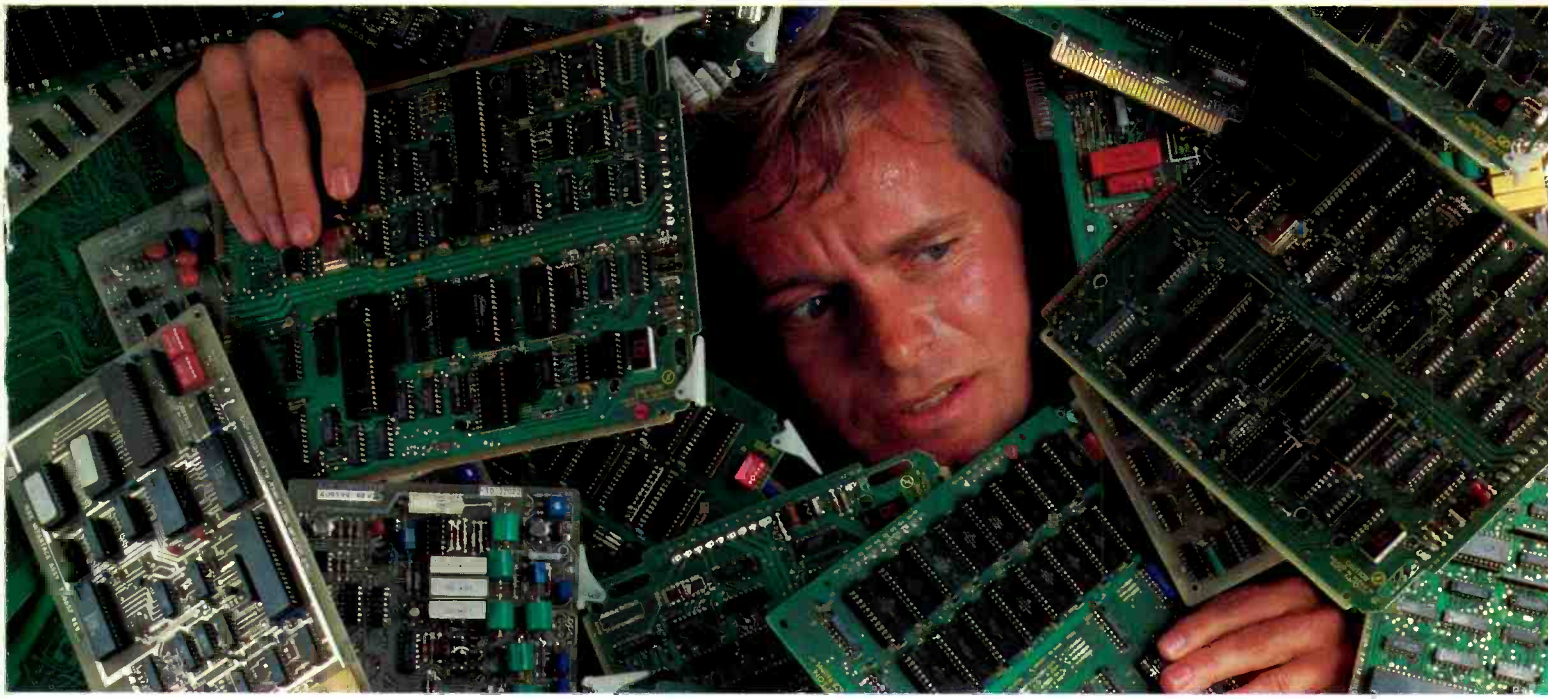

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News

Tektronix launches seminar schedule

Tektronix has announced the Measurement Application Series, a series of educational seminars designed to introduce test-and-measurement engineers and technicians to new technology and applications. Tektronix has prepared two of the seminars, which will cover the 2445B, 2465B and 2467B analog scopes and the DSO series of portable scopes.

For more information, contact the company at P.O. Box 500, Beaverton, OR 97077; 800-TEK-WIDE, extension 3028.

Tegam solicits application information

Tegam is looking for information about special applications including the results of using the company's electrical and thermometric test meters. Customers can send two paragraphs describing the application and results, along with a reproducible 35mm photo of the application. If the application is accepted, the customer will be given the choice of a cash amount or a substantial percentage off the list price of any unit Tegam manufactures in exchange for the right to use that application.

EIA supports HDTV compatibility

The Electronic Industries Association Committee on Advanced Television (EIA ATV) has agreed that any system adopted for high-definition TV (HDTV) should be compatible with the current NTSC system now in operation in the United States. The committee has also agreed that the NTSC signal received by the home viewer must not be degraded by the HDTV system, and that the transition to HDTV must be smooth in order to protect both consumers' and broadcasters' investments.

Reader's survey predicts sales

A recent *Better Homes and Gardens* Consumer Panel survey of subscribers found that 12% of the respondents own a portable video camera but 20% intend to buy one. Among those who intend to buy a portable video camera, 36% plan the purchase within the next year; 64% say it will be one to two years from now.

The panel is composed of 1,000 subscribers who are demographically representative of the 7.4 million *Better Homes and Gardens* magazine subscribers.

EIA/CEG plans HPL demonstration

The Electronic Industries Association's Consumer Electronics Group (EIA/CEG) Engineering Department and its Standards Committee will demonstrate a new technology, home products link or HPL, in a variety of home appliances. The demonstration will be held in booth number PT-13 at the 1989 Winter Consumer Electronics Show.

HPL is a communications standard developed for home automation. The standard has three aspects: the media, which are the physical carriers of the message; a control language, which will tell the appliance what to do; and an application language to allow products of different manufacturers to work together.

The 1989 Winter Consumer Electronics Show will be held Jan. 7-10 at the Las Vegas Convention Center and surrounding hotels. For more information, contact the EIA/CEG at 2001 Eye St. N.W., Washington, DC 20006; 202-457-4919.

UL proposes standards

Underwriters Laboratories (UL) is proposing two updated standards for recognition as American National Standards by the American National Standards Institute (ANSI). UL 961, the updated Standard for Safety for Hobby and Sports Equipment, covers electrically powered hobby and sports equipment rated 250V or less. These requirements cover equipment intended for the home entertainment and amusement of adults. UL 1283, the updated Standard for Safety for Electromagnetic Interference Filters, covers EMI filters connected to 600V or lower potential circuits, including facility filters, cord-connected filters, direct plug-in filters and appliance filters used to attenuate unwanted radio-frequency signals generated from electromagnetic sources. UL is seeking review and comment to help develop a consensus upon which continued recognition of the standards can be based. Contact L.M. Cohen at UL, 333 Pfingsten Road, Northbrook, IL 60062-2096 (312-272-8800, ext. 2692) for a free copy. ES&T

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Electronic Servicing & Technology is the "how-to" magazine for technicians who service consumer electronics equipment. This includes service technicians, field service personnel and avid servicing enthusiasts who repair and maintain audio, video, computer and other consumer electronics equipment.

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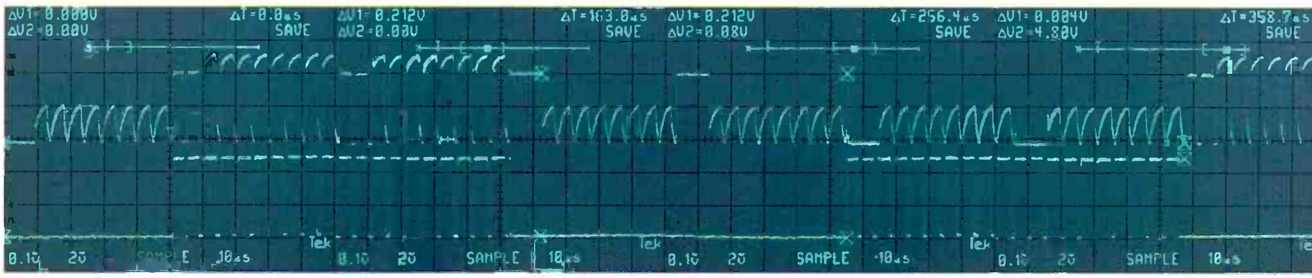

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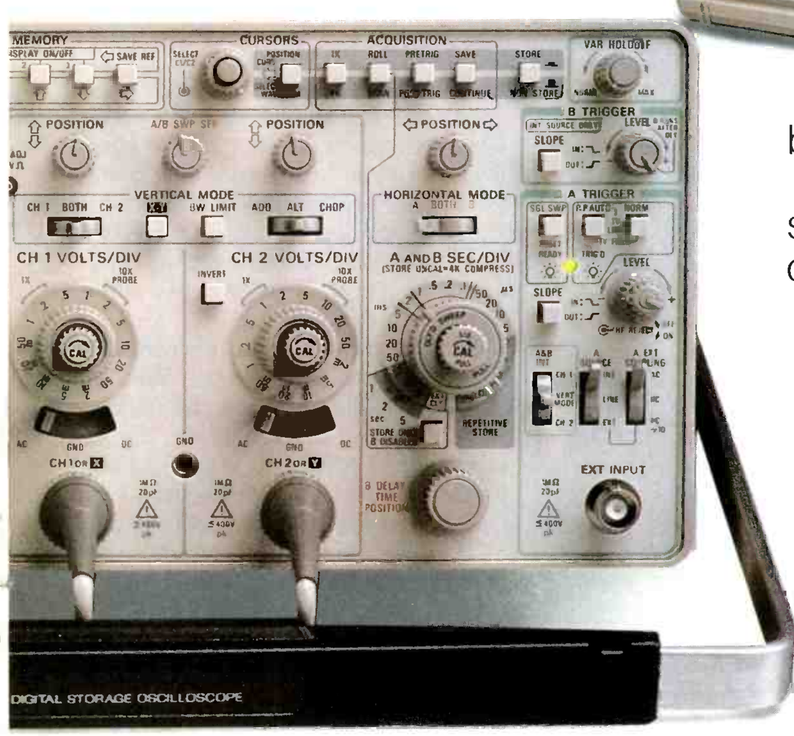

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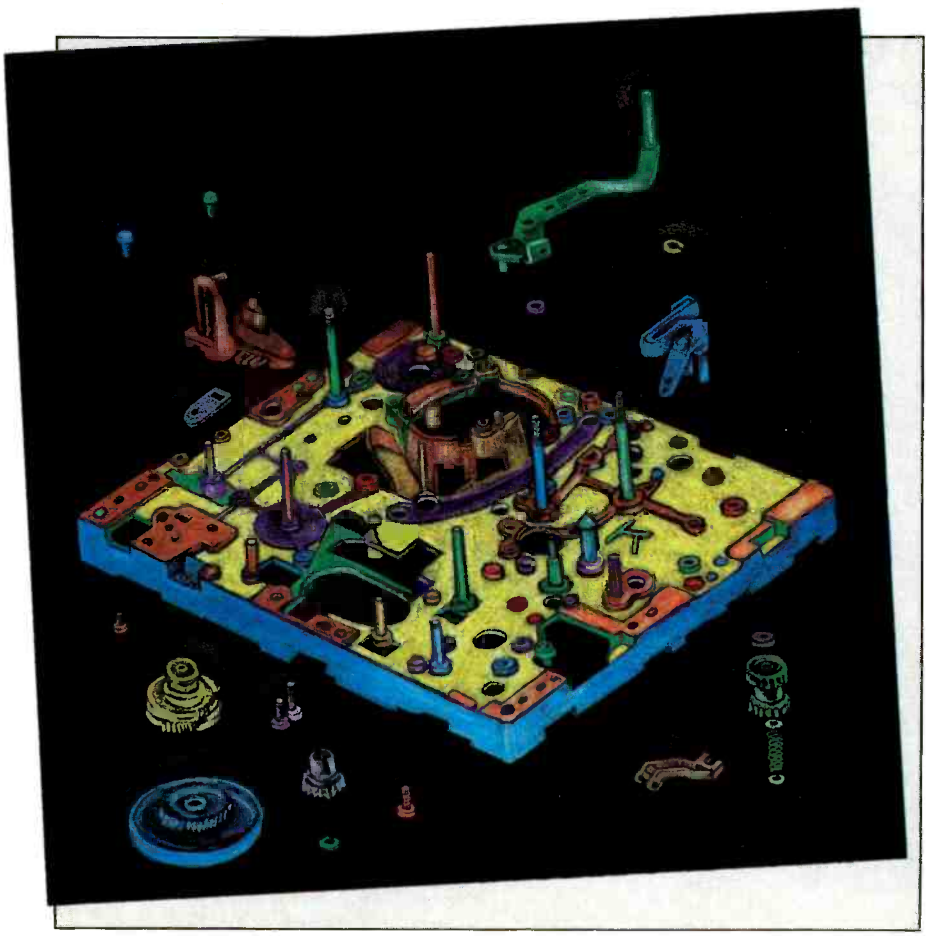
A VCR repair case history—the sequel

By Victor Meeldijk

Becoming an *electronics* servicer doesn't necessarily mean you can forget about mechanics, especially when your field of expertise is VCR servicing. A typical New York city repair shop estimates that 70% of all VCR repairs involve mechanical problems. The most common problem is dirty heads. (For more information on cleaning VCRs, see "Maintenance and Cleaning of VCRs" in the May 1987 issue of **ES&T.**) The second most common VCR problem, according to the Electronic Industries Association (EIA), is rewind mechanism failures.

Meeldijk is the reliability/maintainability engineering manager at Diagnostic/Retrieval Systems.



The first VCR-repair case history, which appeared in the February 1988 issue, analyzed a fast-forward and rewind (FF/R) problem on a Fisher model FVH-510. This time, we'll take a look at a 2-year-old Fisher model FVH-839 with similar problems.

Another FF/R problem

As was the case in the first article, this VCR didn't fast-forward or rewind properly. When FF/R modes were selected, it would take a few seconds for the tape to actually start moving, and the VCR eventually would not move tape at all. Then, after a few attempts at trying to rewind tape, the VCR would not start up. When the rewind mode was selected, the motor would start, then stop as if it had stalled out. Cue and review functions continued to work normally.

Figure 1 is a top view of the tape-transport mechanism showing the tape reels (Fisher part number 143-0-4104-00900, supply; and 143-0-4104-01100, take-up reel), gear idler (143-0-4904-00900) and idler spring (143-2-6604-04500). FF/R problems generally are caused by the idler tire, but if the idler spring has come loose, the same symptoms will occur. Cue and review functions continue to work because the reels are directly driven by a gear in the idler assembly rather than the idler tire.

To watch the motion of the reels and finger test the reel torque, you can fool the VCR into thinking a tape cassette has been inserted into the machine. First, unplug the VCR, take out the two screws on the left and right sides of the cover and, from the rear, lift the cover off the VCR. Next, place a piece of tubing or part of a multiwire coax cable jacket over the tape sensor. (See Figure 2.) Then, with the power on, press up on the levers on the top left and right sides of the cassette tape tray until the tray starts moving (use forefingers to push the levers and thumbs to push the tray).

Figure 3 shows the levers when the tray is in the lowered position. An alternate method is to insert a cassette but hold on to it so it is not pulled into the VCR as the tray lowers.

As soon as the tray is down, press down on the cassette sensor switch near the take-up reel. (See Figure 4.) If this is not done immediately, the tray will automatically return to the upper loading position. While depressing the cassette sensor switch, which will light the cassette picture on the loading door, press either the FF or R buttons to observe reel movement. If they are moving, you can test the torque by trying to slow down their movement with your fingers. If they stall easily, there will not be enough torque to move the cassette tape.

To return the tray to the up position, press down the cassette sensor switch and hit the eject button—quickly move your fingers out of the way after you hit the eject button.

If the rewind-stalling symptom is not immediately present, it is because the master cam has reset after the machine has been disconnected from the ac power. Running the VCR in the rewind mode when the tape does not move will cause the mode-select and master cam to move out of sync. When this happens, the recorder sounds and acts as if it is stalling in the rewind mode. When ac power is cycled off and on (using the power plug), the clicking noises heard when the VCR is plugged in is the transport mechanism resetting itself.

Once it has been verified that the idler tire has to be replaced, follow the disassembly steps in the sidebar. Unlike other VCRs, the idler assembly is mounted to the underside of the chassis, and the disassembly steps to reach it are lengthy. The disassembly steps listed in the table, however, do not follow those contained in the Fisher service manual. In the service manual, the idler/idler gear is removed after the capstan motor is removed. Reassembly involves align-

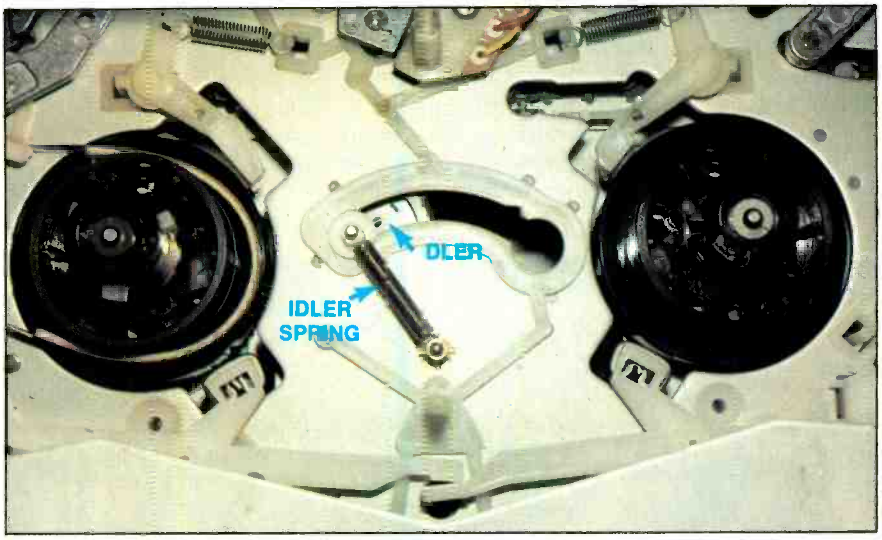


Figure 1. In this top view of the tape-transport mechanism, the idler is just visible underneath the chassis.

Figure 2. You can cover the tape sensor with a piece of cable jacket.

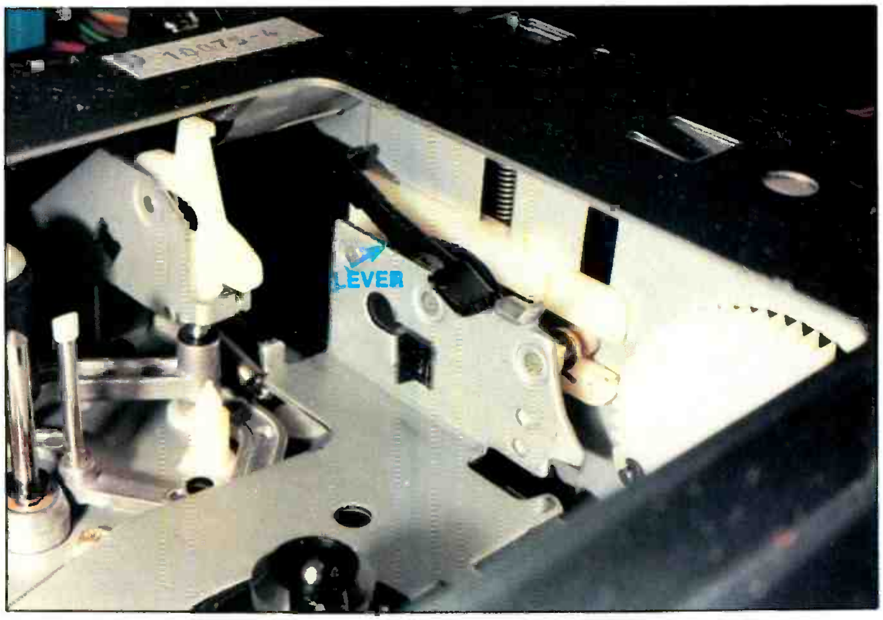


Figure 3. This photo shows the levers when the tray is in the lowered position.

ing the master cam and tension arm. Using the steps outlined in this article, you can avoid removing the capstan motor and making other alignments. When the old idler tire is removed, you will note that it has a smooth and shiny appearance. The new tire, on the other hand, is dull and has a rough surface texture.

Temporary repairs

Before replacing the idler tire, I attempted a number of alternative repair methods. First I used a rubber revitalizer, although they are not normally advertised for this purpose. After treatment, some initial tape slippage occurred (as evidenced by a slow-moving tape-footage counter), but then the VCR started to operate normally. However, this "fix" only lasted one day. The treat-

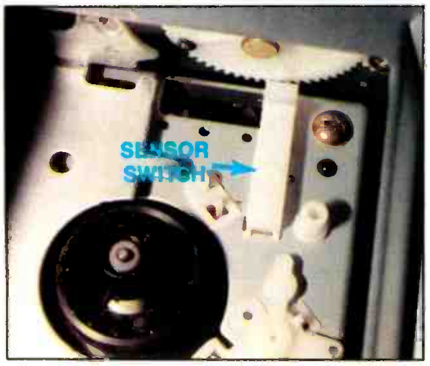


Figure 4. The cassette sensor switch is located near the take-up reel.

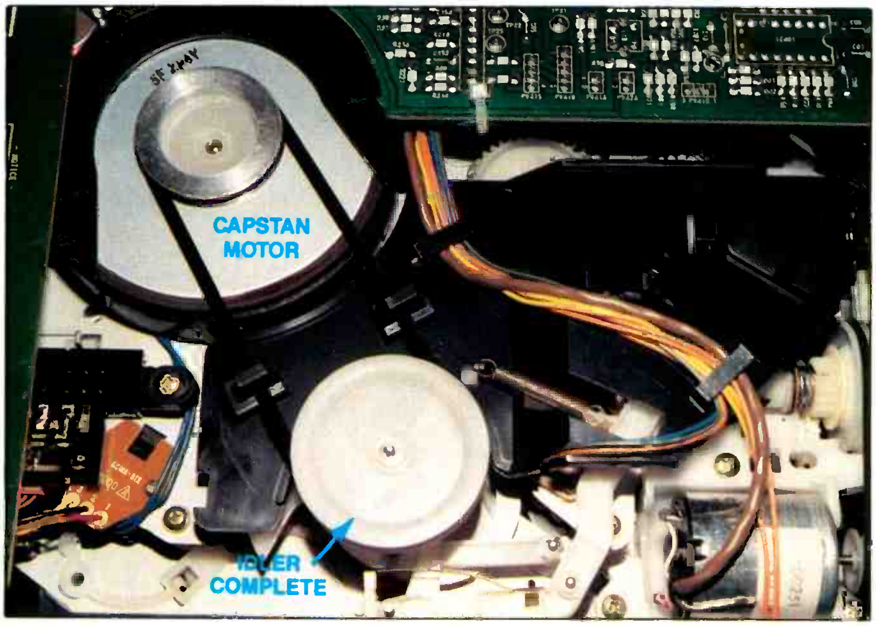


Figure 5. The capstan motor and idler complete assembly are visible from the underside of the VCR.

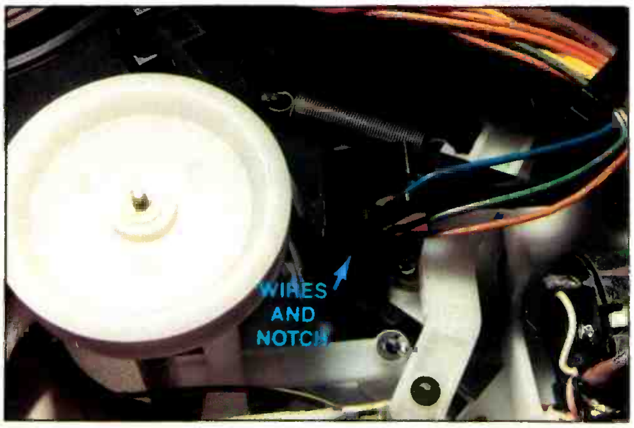


Figure 6. Move the harness wires out of the notch in the plastic reel assembly bracket.

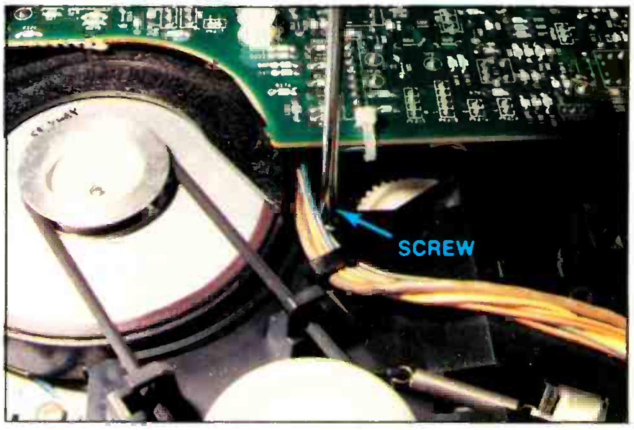


Figure 7. Remove the Phillips screw holding down the plastic reel assembly bracket.

Figure 8. Two tabs secure the plastic bracket to the chassis.

Figure 9. To move the gear into an area where it can clear the chassis, turn the idler gear assembly to the left.

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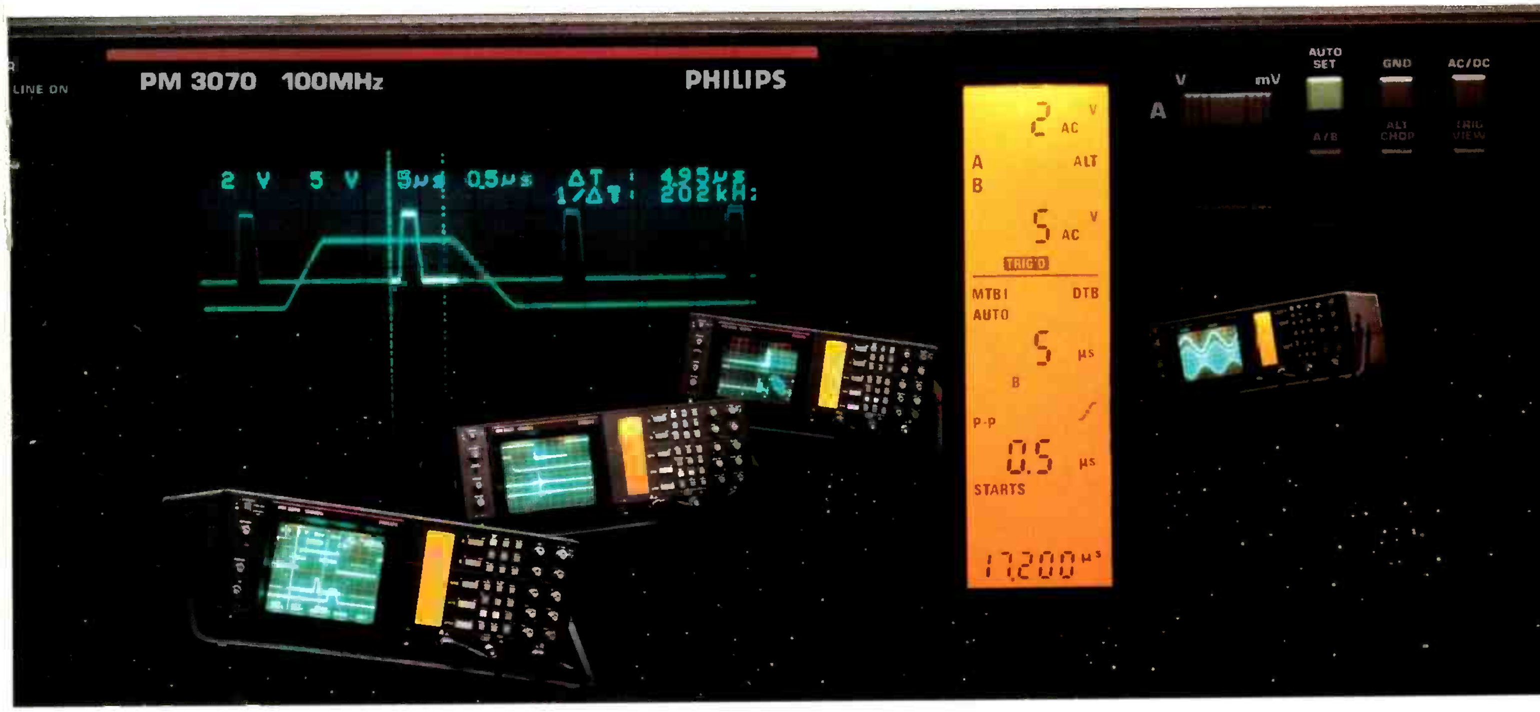

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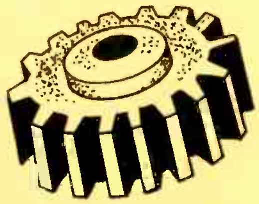

VCR disassembly steps

1. Disconnect power from the VCR and remove the top cover. (Remove the two screws on each side of the unit, then lift the cover up from the rear.)

2. Remove the idler spring (Fisher P/N 143-2-6604-0450).

3. Lift off the stopper washer (143-2-6304-01800) that secures the take-up reel.

4. Holding onto the take-up reel sub-brake take-up assembly, slowly lift the reel out of the VCR. Be careful not to loosen the washer (143-2-6304-02900 or 0300 or 03100, depending upon adjustments made to the VCR) just under the reel. Slowly release the brake assembly so the spring (143-2-6604-04300) doesn't fly loose. Note: the VCR uses a Hall-effect sensor and magnets embedded in the reel to send signals to the tape-footage counter.

5. Put the cover back on but do not screw it in place. Turn the VCR over and remove the screws securing the bottom cover. Lift the cover off from the front of the VCR.

6. With the cover removed, you can see the capstan motor and gear (idler complete) assembly (143-2-7504-00400 or 00600, depending upon the VCR). Refer to Figure 5. Remove the drive belt and work the harness wires out of the notch in the plastic reel assembly bracket. (See Figure 6.)

7. Shift the wire harness to expose the Phillips screw holding down the bracket. Use a number 2 screwdriver to remove it. (See Figure 7.)

8. Look for two tabs that secure the plastic bracket to the chassis. Figure 8 shows the left-side tab. Press in on the tab and lift the bracket until the tab clears the chassis. You cannot take out the plastic bracket because of the wire harness.

9. Remove the stopper washer (143-2-630401500) holding the idler gear assembly (143-2-6304-00600) and turn the assembly to the left to move the gear into an area where it can clear the chassis. Lift the assembly out of the VCR (refer to Figure 9). As with the reel assembly, be careful not to lose the washer under the idler gear assembly (refer to Figure 10).

10. Remove the stopper washer (143-2-630401500) holding the idler (complete—143-0-4904-00900). Turn the idler wheel to the left, which will free it from the chassis, and lift it out of the VCR. With the idler wheel out of the machine, the tire can be removed and replaced. Replacement tire dimensions are 0.985 OD, 0.885 ID and 0.120 thick. Complete idler assemblies can also be purchased from various repair-part companies, if necessary.

11. To reassemble the VCR, follow the disassembly steps in reverse order. When replacing the idler wheel on the shaft, make sure that the gear is to the left and that the left arm of the "wishbone" is on the left side of the metal (brass) attached to the idler arm control. (See Figure 5.) It is also recommended that you grease the idler and reel shafts during reassembly.

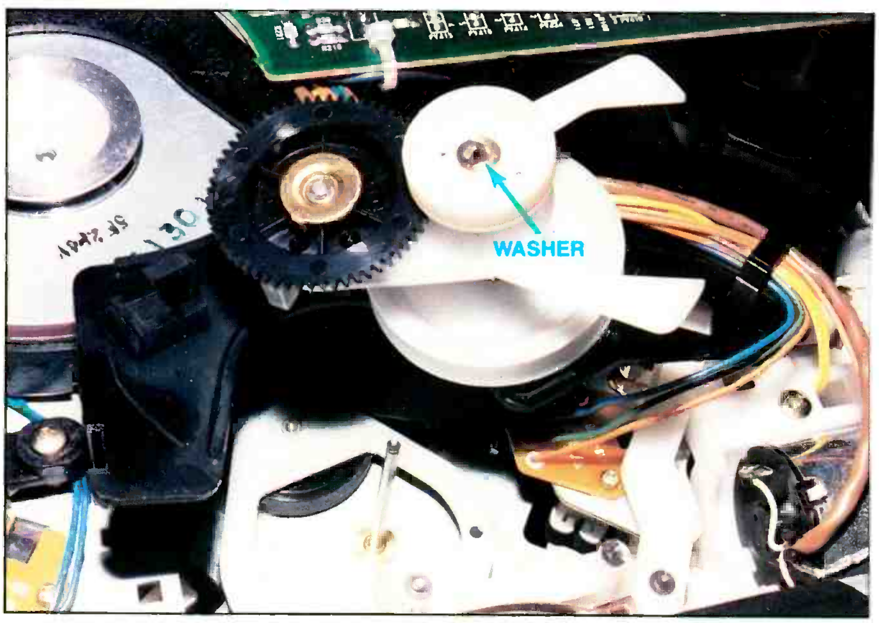

Figure 10. Be careful not to lose the washer under the idler gear assembly.

ment was repeated with the same results; after the tire dries out, slippage starts again.

For the second repair, I used an O-ring from a faucet repair kit. The O-ring was, however, a little too small; this problem, coupled with the ring's smooth surface, made it an unworkable substitute. Next, I tried cutting a rubber grommet to size using a hobby knife. This tire worked for a few FF/R cycles, but it proved to be too soft and disintegrated, leaving residue on the idler. A neoprene hose washer worked much better and would be an excellent temporary substitute except that it is almost impossible to cut the inside of the washer perfectly round. Although the washer works, the cassette tape is unevenly packed onto the reel. It does not appear at this point that there is an acceptable substitute for a properly manufactured idler tire. ES&T

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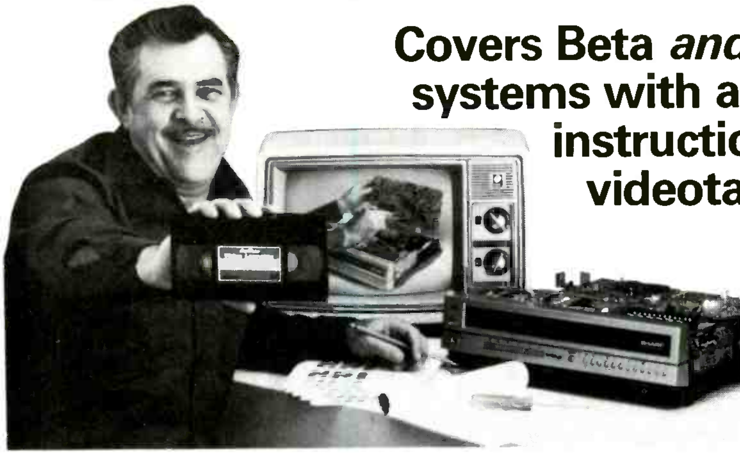

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The 16Mbit DRAM

Recent advances in memory-chip design have resulted in vast improvements in memory capacity within this decade. For example, at the beginning of the 1980s, mainstream memory capacity was 64kbits. Today, however, 1Mbit capacity—16 times the capacity of 64K—is dominant in the market, and 4Mbit capacity should become available in the near future.

Even higher capacity chips eventually should be available. In fact, Toshiba has already developed an experimental 16Mbit dynamic random access memory (DRAM) chip. The device can memorize more than 2 million alphanumeric characters, which would allow the contents of the New York Times newspaper (about 64 pages) to be stored on a 12mm×17.5mm chip.

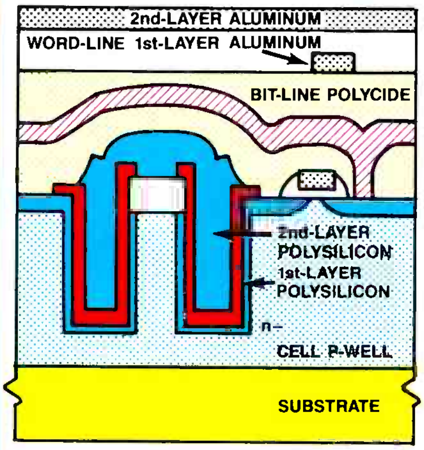


Figure 1. The 16Mbit DRAM uses a stacked trench capacitor cell structure to eliminate the electric leakage between capacitors. The polysilicon layer on the side walls of the trench allows impurities to be diffused thinly and evenly.

The experimental device integrates about 34 million elements (transistors and capacitors) on a single chip. Its access time (the time required to read one bit of information) is typically 70ns—70 billionths of a second. Toshiba applied 0.7-micron microlithographic technology to the new device, compared with 0.8-micron rule, which will be used in the company's 4Mbit DRAM.

A new structure of basic elements

In order to reduce the chip size and increase its reliability, Toshiba researchers developed a new structure of memory cell (a basic element to memorize one bit of information) called a stacked trench capacitor cell (STT). This structure eliminates the electric leakage between capacitors, which will cause errors in stored information. In the case of the 16Mbit DRAM, the distance between the adjacent capacitors, in which information is stored in the form of electric charges, is much narrower than that of the 4Mbit DRAM because of its higher integration. Therefore, it was difficult to avoid the electric leakage.

Although the trench structure was developed for the 4Mbit DRAM, the 16Mbit DRAM also has a polysilicon layer on the side walls of the trench, through which the doping of impurities is carried out. With the polysilicon layer, impurities can be diffused thinly and evenly, possibly eliminating the leak current.

In addition to random access capabilities, the newly developed chip has a high-speed serial-access mode that makes possible quick writing and reading of serial information.

With conventional random-access operation, a microprocessor freely assigns an address to every bit of information stored in the chip, and each address must be designated again when the information is read. A designated address must be cleared each time before another bit is read. This process is too slow for reading serial information such as TV picture signals and sound signals.

The serial-access mode of the new device divides the memory area into two sections and automatically stores serial information (of up to 2,048 bits) by every four bits on each section alternately. Only the first bit of information requires an address. Consequently, the mode takes only 10ns to write and read serial information. At present, the most advanced commercially available memory chips, specialized for handling serial information and applied to VCRs, take a minimum of 30ns to perform the same task.

Because of the large memory capacity and its quick write/read capabilities for serial information, the 16Mbit DRAM could be used for future high-definition TVs or other high-speed image/graphic processing systems. However, the new chip will take several more years for completion and application. ES&T

Test your electronics knowledge

By Sam Wilson, CET

1. Is the following statement correct? "When an electric current flows through a resistor, the amount of heat generated is in accordance with Watt's law."
A. Correct
B. Incorrect

2. Which of the following is an advantage of a Kelvin bridge over a Wheatstone bridge?
A. A Kelvin bridge can be used over a wider range of temperatures.
B. The lead resistance of the component being measured is balanced out with the Kelvin bridge.

3. What is the advantage of an electrostatic voltmeter over a digital voltmeter being used with a high-voltage probe?

4. Name two components that can be used to make a parametric amplifier.

5. The voltage across the resistor in Figure A is
A. maximum at resonance.
B. minimum at resonance.

6. The voltage across the resistor in Figure B is
A. maximum at resonance.
B. minimum at resonance.

7. The tall antenna that you see at an AM broadcast station is an example of a
A. Hertz antenna.
B. Marconi Antenna.

8. On a certain TV receiver, some of the stations are received with poor color but the other stations have good color. Investigate
A. the color killer.
B. the antenna system
C. the offending TV stations.

9. Mobile telephone service started in
A. 1940.
B. 1960.
C. 1976.
D. 1982.

10. In the phase-locked loop system in Figure C, the frequency at the VCO output is
A. 6,250kHz.
B. 1,250kHz.

Wilson is the electronics theory consultant for ES&T.

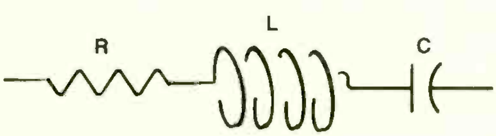


FIGURE A

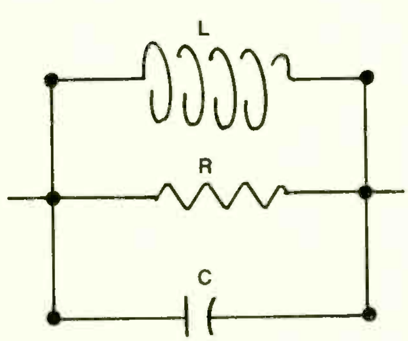


FIGURE B

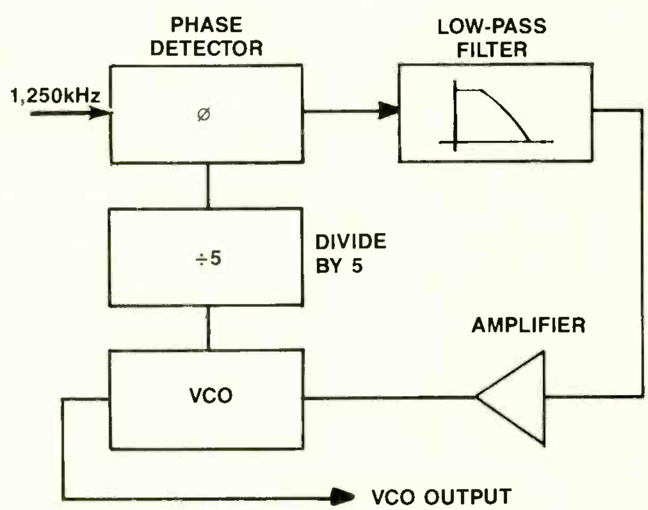


FIGURE C

Answers are on page 59.

Servicing VCR servo systems

By Stephen J. Miller

When was the last time a VCR servo problem drove you up the wall? Does it seem like just yesterday? No surprise—servo problems can be difficult to troubleshoot for a variety of reasons. Often the motor involved will either refuse to run at all or will run extremely fast. These conditions often will cause the unit to auto-stop before measurements can be made. Also, because servo circuits are loop circuits with the outputs feeding back or controlling the inputs, all servo voltages and waveforms often will be incorrect in defective equipment.

In short, when they are broken, servos can be dogs to troubleshoot. Fortunately, a method is available to speed up your troubleshooting. With a device that I have built, and that is described in this article, dubbed the servo diagnostic device, you can break the vicious loops, manually control the circuit, and quickly find the defective components. The use of the device for servo servicing has two main advantages. First, inserting the device allows the technician to split the circuit in half for a quick determination of the problem's location. If the problem is in the motor section, replacement is usually indicated because these motors often are only available as a complete assembly. The second advantage is that, by manually controlling the motor with the diagnostic device, you can monitor various servo signals under actual operating conditions.

Miller is a senior bench technician for a Lancaster, PA, repair company.

How servos work

Before getting into the device, let's review how servo circuits operate. Videotape technology requires the motors to be precisely speed- and phase-controlled in order to reproduce good video and audio. Should the drum motor's speed or phase be incorrect, the audio will be OK but the picture will be out of sync. If the capstan speed is wrong, both an out-of-sync picture and garbled, off-pitch audio will result. Problems with the capstan phase usually won't hurt the audio, but either a snow bar will float through the picture (EP mode) or an alternating display of a clear picture and a snow field will result (SP mode). The snow bars or fields are caused by the video heads wandering into either the wrong azimuth track or a guard band.

Figure 1 is a simplified block diagram of the capstan servo. Two separate types of motor control are used: speed control and phase control. The speed-control circuit compares the speed of the capstan motor to a reference frequency

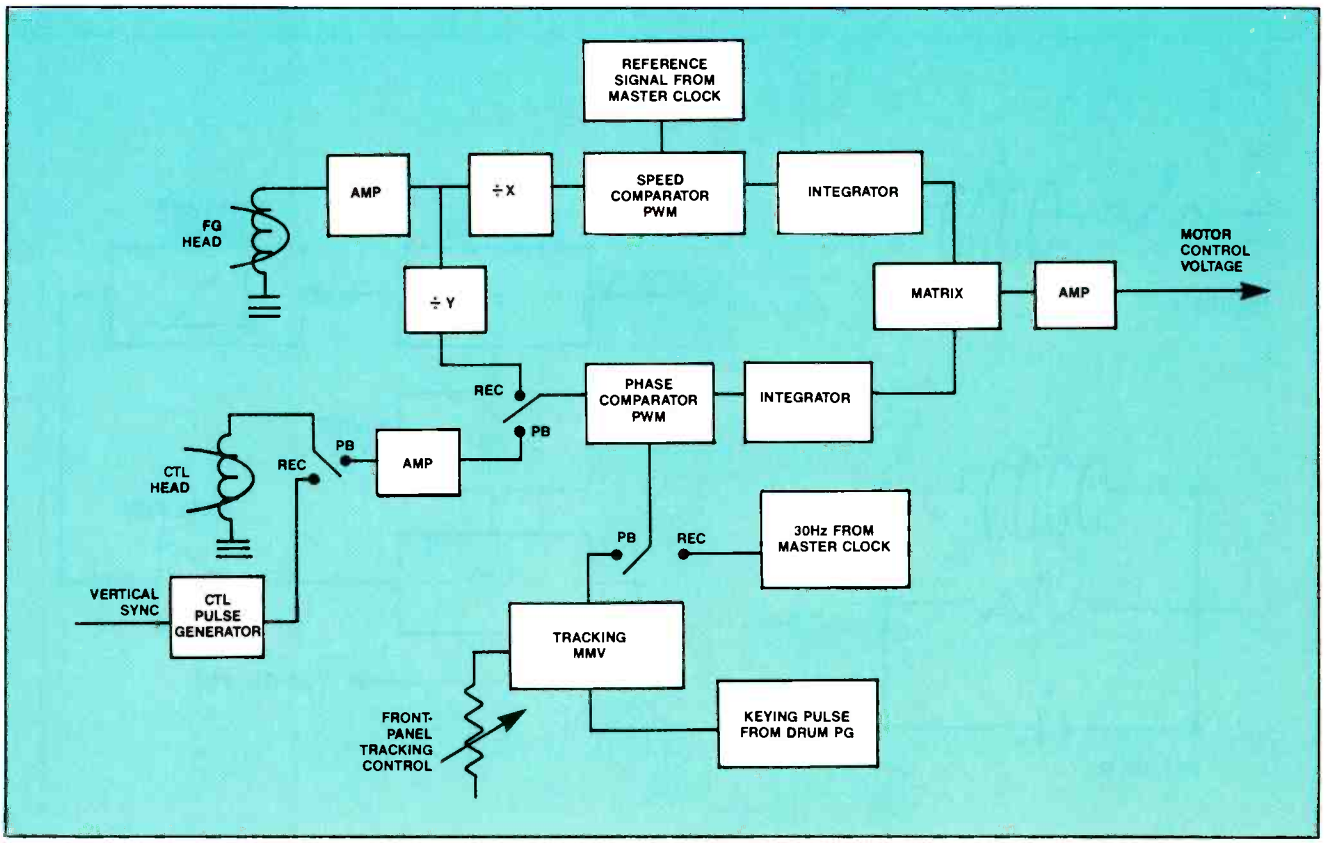


Figure 1. A simplified block diagram of the capstan servo. Two separate types of motor control are used: speed control and phase control. The speed-control circuit compares the speed of the capstan motor to a reference frequency and adjusts the motor speed until they are exactly alike. The phase-control circuit performs a similar task, but it is concerned with the motor phase.

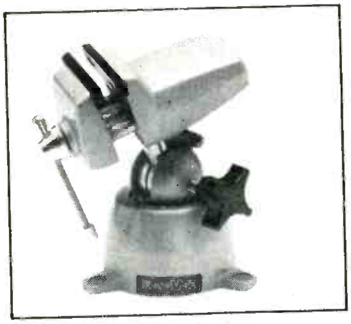
and adjusts the motor speed until they are exactly alike. The phase-control circuit performs a similar task, but it is concerned with the motor phase. Motor speed and phase are interdependent quantities, so it is useful to consider speed control as a coarse adjustment and phase control as a fine adjustment of the motor's rotation.

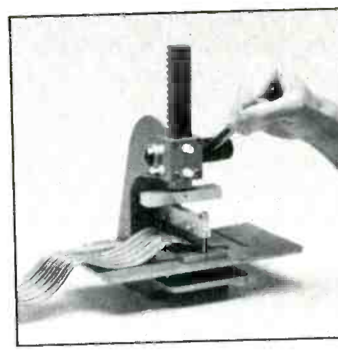
A pick-up coil placed near the edge of the capstan flywheel gives a relative indication of motor speed. This coil, commonly referred to as the *frequency generator* or FG head, generates pulses as a series of magnets embedded in the flywheel are moved past it. The frequency of these pulses directly indicates the motor speed—the faster the motor turns, the higher the FG frequency will be.

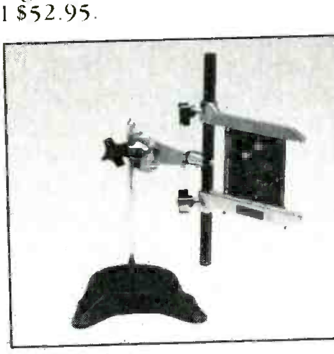
Referring back to the block diagram, this FG signal is amplified and then sent to a variable-frequency division block before being applied to the speed-comparison block. This variable-frequency division block is regulated by the system-control section of the VCR. The division rate is changed depending on what speed the unit is in (SP, LP or EP) or for special effects such as speed search. Dividing-down the FG signal allows the reference signal to the speed-control block to be kept constant while still allowing the VCR to speed-control a number of different tape-transfer rates.

The speed-comparison block compares the divided-down FG signal with a reference signal. It then outputs a signal proportional to the error that exists between the two inputs. This error signal is an ac waveform called a *pulse-width modulated* or PWM signal. In a PWM system, the magnitude of the error signal is proportional to the width of the ac pulses. The frequency of the PWM signal never changes; only the width of the pulses is varied in response to errors. If both inputs to the comparison block are identical, the PWM output is a 50%-50% duty-cycle waveform. Should an error exist, the comparison circuit will vary the duty cycle in response to that error.

The integrator block, sometimes called a low-pass filter, integrates or







averages the PWM signal into a dc voltage. This dc voltage represents the magnitude of the error signal. Figure 2 shows three PWM waveforms: (a) the motor turning too slow, (b) the motor turning exactly on speed, and (c) the motor turning too fast. By finding the average of the pulse trains, we can see that the dc output voltage would be 25% of the peak voltage for the first case, 50% of the peak for the second case, and 75% of the peak for the third case. In a properly operating VCR, this dc output voltage will be centered around 50% of peak with momentary rises and falls to correct for errors.

The next block matrixes together the dc speed-error voltage with a dc phase-error voltage. This combined error voltage is amplified and then sent to the motor as a control voltage to vary the motor speed and phase.

The phase-control circuits

In the playback mode, the phase-control circuit compares a pulse from the tracking monostable multivibrator (MMV) with the pulse coming from the control or CTL head. This CTL pulse is used in playback to phase-control the capstan so that the proper video head is centered on the correct track at all times. The tracking MMV is keyed by a pulse from the drum motor called a *drum PG pulse.* This keying signal synchronizes the two servos. Varying the front-panel tracking control advances or delays slightly the tracking MMV pulse to allow the viewer to adjust the servos slightly for a snow-free picture. After the phase-control PWM is integrated, it is applied to the matrix circuit previously described.

Because of the importance of a good CTL pulse for proper servo operation, cleaning the CTL head should be the first troubleshooting step for capstan phase-control or speed-selection problems.

Phase-control PWM outputs are commonly set to a default 50%-50% duty cycle. After the speed loop locks onto the proper speed, the phase loop is allowed to vary from the default setting. This arrangement keeps the phase loop from interfering with the speed loop's attempt to correct a speed error. Therefore, it is common to find 50%-50% duty-cycle waveforms on the phase PWM output terminals whenever the speed loop is not locked, even in the stop mode. This arrangement is normal and does not indicate a problem.

In the record mode, the phase-control PWM block receives both a divided-down sample of the FG signal and a 30Hz reference signal from the master clock. Therefore, in record, the capstan servo phase-adjusts the capstan motor to a 30Hz reference signal. Also, vertical sync pulses are used to key a CTL pulse-generator circuit to record a CTL pulse train on the bottom edge of the tape during record.

The drum servo

The drum-servo block diagram is shown in Figure 3. Because the drum motor turns at a constant speed regardless of the tape speed, the drum servo is much simpler than the capstan servo. In the speed-control loop, an FG head is used to develop a signal that is proportional to motor speed. The FG signal is fed to a speed-control PWM and then to an integrator in the same manner in which the CTL pulse is fed to the capstan servo.

The drum phase-control loop uses a drum-phase generator or PG head to produce a signal that indicates drum phase. PG pulses are generated by either a PG head and a pair of magnets mounted on the rotor or by Hall-effect elements in the motor. PG pulses are 30Hz in frequency.

Thus each pulse represents one revolution of the motor. These pulses are amplified and then sent to the PG monostable multivibrator (PG MMV) block. In the PG MMV block, the PG pulses are used to trigger a monostable multivibrator whose duty cycles are adjustable. The output of the PG MMV is used both for drum-phase control and as a head-switching signal.

The on- and off-time duty cycles of the PG MMV are adjusted so that head switching occurs at 6.5 horizontal lines before vertical sync. This adjustment ensures that the critical vertical sync interval is free of switching noise, yet the switching point is low enough on the screen to be hidden in the overscan of the CRT.

In the playback mode, the phase-control PWM receives the PG MMV signal and a 30Hz reference signal from the master clock. It outputs a PWM signal in accordance with the phase relationship of these two inputs. In the record mode, the two inputs are the PG MMV and a specially shaped vertical sync pulse. In record, then, the drum-phase loop locks the drum-motor phase to the same phase as the vertical sync in the signal being recorded.

Servicing older VCRs

Older VCRs have similar servo circuits except for the control blocks. Instead of PWM outputs, the older servos used sample-and-hold circuits that provided a dc output. Figure 4 provides an example of a sample-and-hold comparator. One input to the comparator is either a ramp or a trapezoidal waveform. The other is a narrow sampling pulse. The dc output of this comparator is equal to the instantaneous dc voltage of the ramp waveform at the moment the sampling pulse occurs. In normal operation, the sampling pulse arrives at the approximate mid-point of the ramp. Therefore, if the two inputs drift out of phase, the sampling point will walk either up or down the ramp, causing a

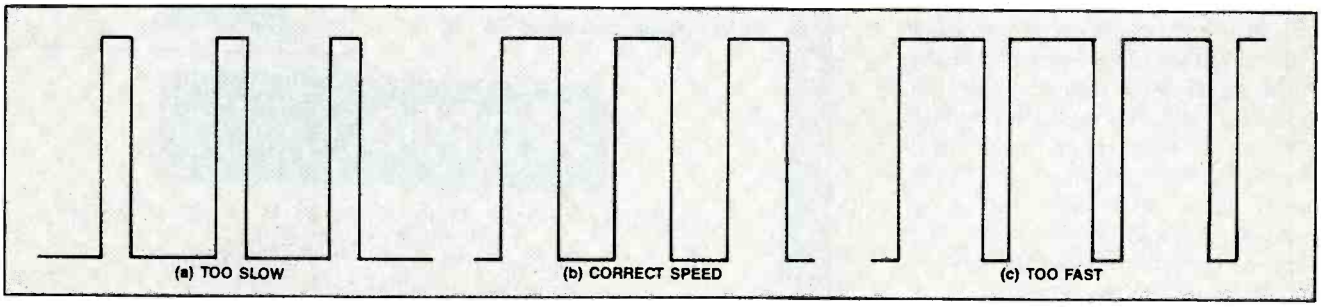


Figure 2. The integrator block, sometimes called a low-pass filter, integrates or averages the PWM signal into a dc voltage. This dc voltage represents the magnitude of the error signal. This figure shows three PWM waveforms: (a) the motor turning too slow, (b) the motor turning exactly on speed, and (c) the motor turning too fast.

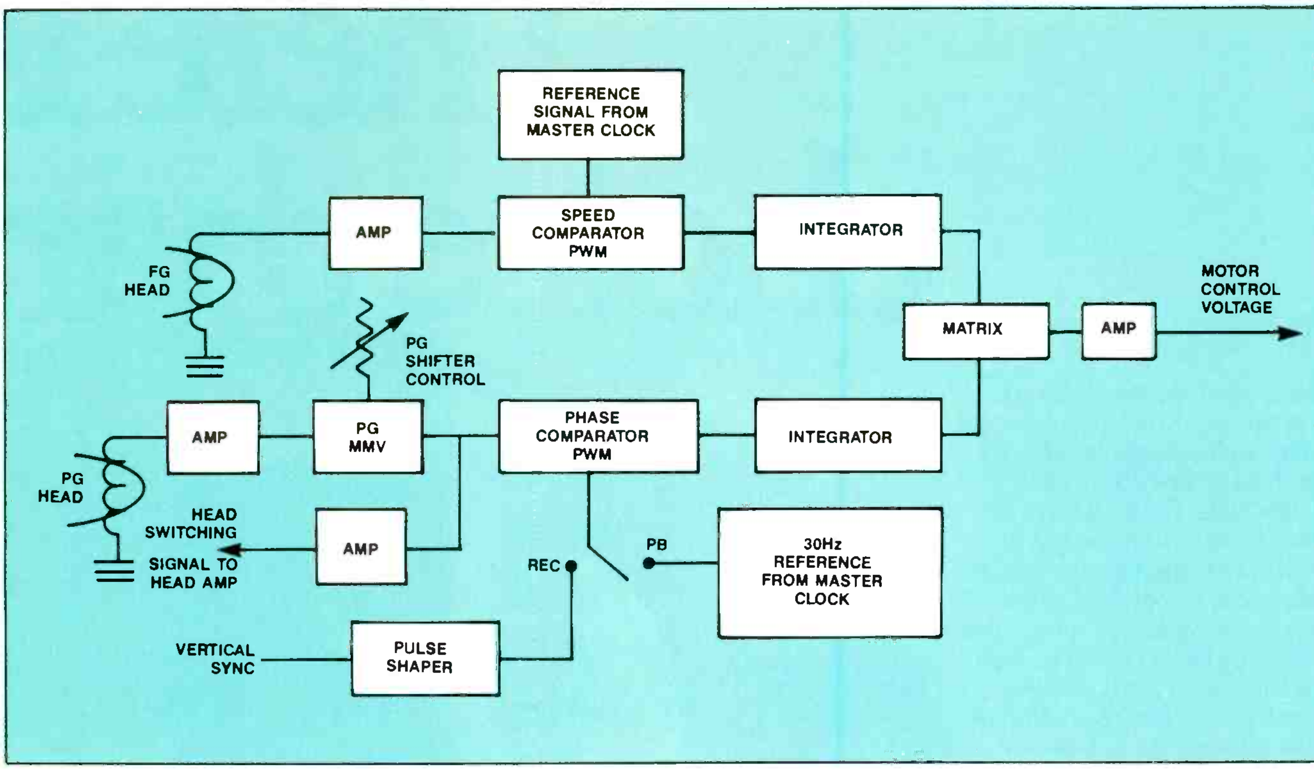


Figure 3. The drum-servo block diagram. Because the drum motor turns at a constant speed regardless of the tape speed, the drum servo is much simpler than the capstan servo.

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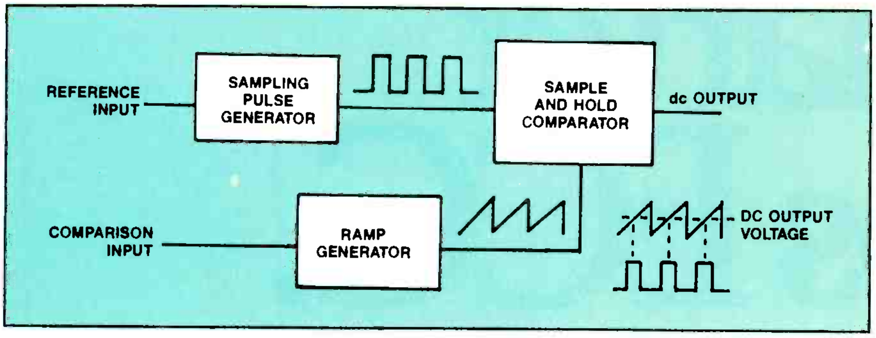

Figure 4. Instead of PWM outputs, older servos used sample-and-hold circuits that provided a dc output. In a sample-and-hold comparator, one input to the comparator is either a ramp or a trapezoidal waveform. The other is a narrow sampling pulse. If the two inputs drift out of phase, the sampling point will walk either up or down the ramp, causing a corresponding change in output voltage.

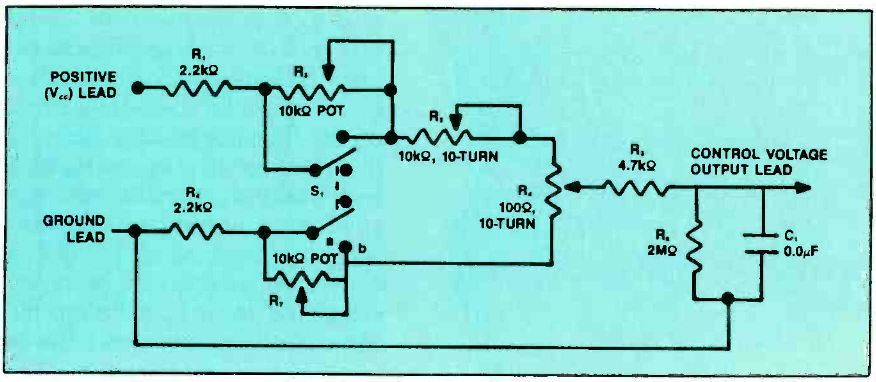

Figure 5. The schematic diagram for the servo diagnostic device. R_3 provides coarse speed adjustment while R_4 allows fine speed adjustment. R_2 and R_7 provide adjustments of minimum and maximum voltage. S_1 is a DPDT center-off switch that provides three operation modes: kick-start, run and stop. R_1, R_5 and R_8 provide current limiting during kick-start operation. The network comprised of R_5, R_7 and C_1 forms a current-limiting filter.

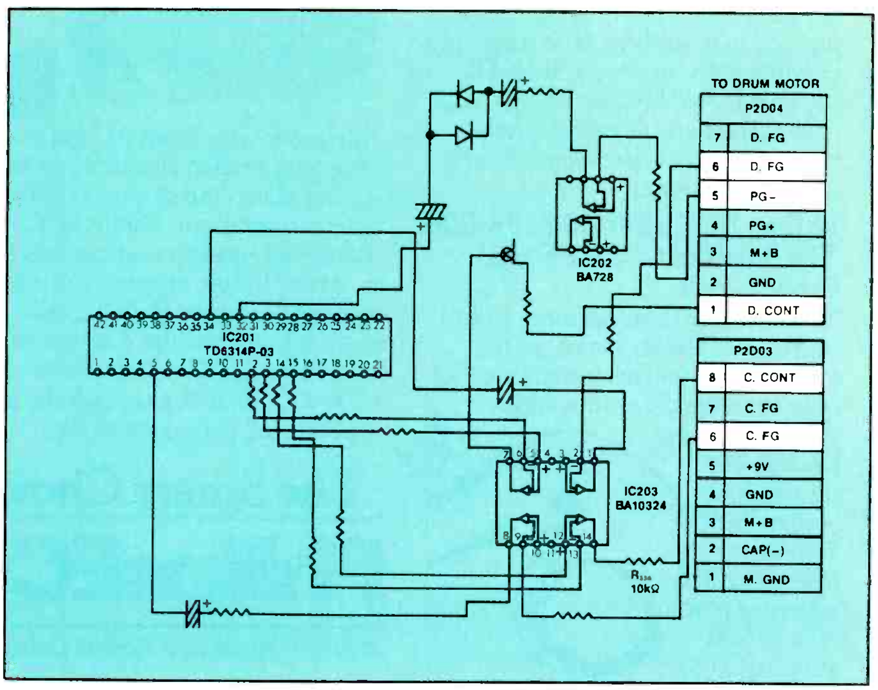

Figure 6. This capstan motor-drive IC for a GE VCR requires two power-supply inputs: +5V on pin 13 and +12V on pin 24. In addition, three other inputs are required for operation: a torque-direction signal on pin 11, a reference voltage on pin 15, and a speed-control signal on pin 16.

corresponding change in output voltage.

In servicing servo circuits in older VCRs, always perform the entire servo alignment before troubleshooting or replacing components. A large number of these units simply need their servo alignment touched up. Two examples are the Sony SL-5000 series and the RCA VKT series. I have repaired many of these machines by simply realigning the servo circuits. Another important point is to always perform the servo alignment after replacing parts in the servo circuits of these older machines. The newer PWM machines have few if any servo alignment adjustments.

How the diagnostic device works

So far, we have described the servo circuits up to the control voltages feeding the drive ICs. Individual parts for these motor assemblies often are not available, so we must treat them as black boxes. All you need to do is provide the motor with the proper inputs and monitor its performance. If it doesn't perform normally, it must be replaced. Figure 5 shows the schematic diagram for the servo diagnostic device. R_3 provides coarse speed adjustment while R_4 allows fine speed adjustment. R_2 and R_7 provide adjustments of minimum and maximum voltage. These resistors, which are preset during construction of the device, center the adjustment range of the voltage divider to approximately half of V_{cc}, which is the operating point used by most VCRs.

S_1 is a DPDT center-off switch that provides three operation modes: kick-start, run and stop. S_{1a} is closed in the high position. S_{1b} is closed in the low position. However, in the run position, neither section of S_1 is closed and therefore neither R_2 nor R_7 is bypassed. The run position is the normal operating position of the diagnostic device with the high and low positions being used only to either kick-start or stop the motor. Directly proportional IC systems use high to kick-start, run for normal operation, and low to stop the motor. Inversely proportional IC systems use low to kick-start, run for normal operation, and high to stop the motor.

R_1, R_5 and R_8 provide current limiting during kick-start operation. The network comprised of R_5, R_7 and C_1 forms a current-limiting filter. (Component specifications and part numbers are available in Table 1. Adjustment procedures are available in Table 2.) The only critical components are R_3 and R_4, which must be 10-turn linear taper pots.

The basic function of my device is to provide a stable, precisely variable reference voltage. Breaking the servo loop at the motor-control voltage point and inserting the device allows you to troubleshoot the servo circuit quickly and accurately. The first step generally is to kick-start the motor to get it rotating and then determine if it will run at the correct speed. Failure of the motor to perform properly points to the motor as the defective component. After the motor has been cleared, the device allows the VCR to be run with an actual tape while real-time normal operating conditions exist. With S_1 in the center-off position, both switches are open and the device is in the run position. With S_{1a} closed, the device's output voltage is forced into a higher-than-run state. This higher-than-run voltage will kick-start those servo circuits whose motor speed is directly proportional to the control voltage; the voltage will stop those circuits whose motor speed is inversely proportional to the control voltage. With S_{1b} closed, the output voltage is forced lower than normal. Again, depending on the particular VCR, this will either kick-start or stop the motor.

R_4 is normally set to mid-range initially. R_3 is adjusted until the output voltage corresponds to a motor speed of slightly faster than normal SP speed.

Table 1
Parts list

Part	Specifications
R_1, R_8	2.2kΩ (¼W, 5%)
R_2, R_7	10kΩ trimmer pot
R_3	10kΩ, 10-turn pot (Clarostat 73JA series)
R_4	100Ω, 10-turn pot (Clarostat 73JA series)
R_5	4.7kΩ (¼W, 5%)
R_6	2MΩ (¼W, 5%)
C_1	0.1µF Mylar
S_1	DPDT center-off

Table 2
Adjustment procedure

Step 1: Place R_3 and R_4 to mechanical center.
Step 2: Apply +5V from positive input to ground.
Step 3: Connect a DVM between the output lead and ground.
Step 4: Place S_1 in the low position and adjust R_2 for 0.75V.
Step 5: Place S_1 in the high position and adjust R_7 for 3V.

For inversely proportional machines, this voltage would be lower than the normal SP voltage of 2.5V. An input of approximately 2.3V works well. After connecting the device and pressing play, I would place the switch in the low position momentarily to kick-start the motor before returning the switch to the run position. If the motor is OK, audio and video playback should be faster than normal. Coarse and fine controls (R_3 and R_4) are then adjusted to slow the capstan down to the correct speed.

Machines with directly proportional drive ICs would use an initial voltage setting that is higher than the normal SP voltage. These machines also will use the high switch position for kick starting.

To understand how the device works with both proportional drive ICs and inverse drive ICs, you need to understand how the motor-drive circuits of VCRs operate. Figure 6 shows a capstan motor-drive IC for a GE VCR. This

Main article continued on page 28.

CASE No. 1 Goldstar GHV-57FM

This VCR (see Figure 8) arrived for service with two problems: the playback picture had a snow band moving through it and the audio exhibited wow and flutter. Breaking the capstan servo loop by lifting R236, I inserted the diagnostic device at pin 8 of P2D03. By pressing play and placing the switch to high momentarily to kick-start the motor, I was able to control the motor speed with the coarse and fine controls of the device. With the device in the circuit, the unit produced good audio, and a clear picture would hold for several seconds before dropping out. These symptoms proved that the capstan motor could be properly controlled. Checking the inputs to the capstan phase comparator, I found a normal CTL pulse on pin 20 of IC201 and a normal tracking MMV signal on pin 28. Turning to the capstan phase-output pin 14 of IC201, I observed no PWM output waveform. Wicking-out pin 14 and monitoring the signal on the IC pin showed no PWM signal. Because all inputs were normal, I replaced the black box labeled IC201. The VCR then worked properly.

CASE No. 2 Goldstar GHV-1233FM

The complaint with this VCR (see Figure 8) was that it was shutting itself off. On the test bench, I observed that the capstan was not running during the play mode, yet the unit would fast-forward or rewind properly. Inserting the diagnostic device, I found that the capstan motor was capable of operating with the correct speed and torque. Checking the FG input signal on pin 5 of IC201, I found an abnormal ac waveform of much too high a frequency. Furthermore, this waveform existed even in the stop mode with the capstan flywheel stationary. Tracing the circuit back, I found that IC203 was oscillating. Momentarily flexing the board caused the oscillation to stop, and close inspection of the foil side disclosed a poor solder joint to pin 7 of plug P2D03. This pin is the low side of the FG head, and with this open connection, the circuit broke into oscillation. Repairing this solder joint returned the VCR to normal operation.

CASE No. 3 GE 1VCR5002X

This VCR (see Figure 6) came in with the complaint that it was eating tapes. On the bench, I found that the capstan motor would not rotate in any mode. Inserting the diagnostic device into pin 6 of IC2601, I found it impossible to make the motor run. Checking the inputs to the motor on plug 2601, I found both the 12V and 5V supplies as well as the reference voltage to be present. Also present was the correct torque direction voltage of 0V in play. This torque direction line is a tri-state line with 0V signaling forward, 2.5V signaling stop, and 5V signaling reverse.

Because individual parts are available for this motor, I continued to troubleshoot. After verifying that the drive coils and Hall effect devices were good, I replaced the drive IC 2601, which brought the unit back into operation.

CASE No. 4 MGA HS-348UR

This VCR (see Figure 9) also arrived with the complaint that it was eating tapes. On the bench, I found that the head motor was not running. With the head motor stalled, the capstan would pull the tape over the loading posts, mangling it in the process. IC4A3 is the drum-motor drive IC; pin 11 is the speed control voltage input. After wicking out pin 11 of IC4A3, I attached the diagnostic device directly to pin 11. Putting the unit into play, I was able to make the drum motor rotate and I could control its speed.

I checked the drum FG input signal on pin 26 of IC 4A0 and found it to be normal. Checking the drum speed-control PWM on pin 14 of IC4A0, I found no ac and 5Vdc. Isolating pin 14 from the circuit did not change the voltage conditions. Having confirmed that the inputs were correct but the output was not, I replaced IC4A0 and the VCR was fixed.

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Circle (19) on Reply Card

Main article continued from page 25.
motor-drive IC requires two power-supply inputs: +5V on pin 13 and +12V on pin 24. In addition, three other inputs are required for operation: a torque-direction signal on pin 11, a reference voltage on pin 15, and a speed-control signal on pin 16. The torque-direction input is a tri-state digital input that tells the drive IC which direction to spin the motor—0V signifies forward, 2.5V signifies stop and 5V signifies reverse. The reference input is a constant 2.5Vdc level to which the speed-control signal will be compared. The drive IC compares the speed-control and reference inputs, then adjusts the motor speed in accordance with the degree of difference between them. The larger the difference, the faster the motor speed. The particular IC shown in Figure 6 decreases motor speed as the speed-control voltage increases; it increases motor speed as the speed-control voltage decreases. In other words, the higher the speed control voltage, the slower the motor.

These drive ICs are very high-gain devices in that very small changes in the speed-control voltage correspond to large changes in motor speed. Therefore, to manually control the motor accurately, you must be able to adjust the speed-control voltage in very small increments. To accomplish this, the diagnostic device has to be a precisely adjustable voltage divider network. With the device, I can fine-tune the speed-control voltage with a degree of precision exceeding ±0.01 volts. At first glance, you might think that the device could be replaced with a simple variable bias box. However, no bias box is going to supply vernier adjustment.

The choice of components in the diagnostic device was dictated by several design criteria. The voltage divider network had to be fairly low-impedance to prevent the possibility that the drive IC might load down the device. The need for precision control mandated both the 100:1 ratio between the coarse and fine adjust posts and the use of 10-turn controls. In theory, C_1 could be eliminated from this dc circuit. However, I have included it for filtering purposes. In the real world, stray ac signals are floating everywhere. Because of the fairly long

Continued on page 41.

Using the kick-start function

In case you were wondering, kick-starting is not dangerous or damaging to the VCR. In fact, all VCRs automatically kick-start the motors each time they are started. Kick-starting is necessary to overcome the friction in a stopped motor. The kick-start procedure involves momentarily starting the motor at a faster than normal speed and then letting it coast down to the correct operating point. For instance, look at the GE VCR in Figure 6. If I apply exactly 2.3V to the speed-control input with the motor stopped, nothing would happen. However, if I apply 2.3V and momentarily spin the capstan flywheel with my finger, the motor will take off and run. Because this IC increases motor speed as speed-control voltage decreases, I can electrically kick-start the motor by momentarily starting the motor with a lower than normal voltage. With the diagnostic device, this is accomplished by placing the switch in the low position. The procedure is really just equivalent to starting the motor in fast-forward speed to get it going.

To illustrate kick start, refer to Figure 8. IC203 contains a summing speed-control voltage amplifier (the op-amp on pins 12, 13 and 14). Pin 12 is the capstan phase-control voltage input; pin 13 is the capstan speed-control voltage input. In the stop mode, Q_{204} is on and keeps pin 12 low. This keeps the op-amp output low and the motor stopped. When the system-control circuit commands the capstan to turn, Q_{204} turns off and pin 12 floats to the default value of 2.5V. Because the motor is stopped, pin 13 of IC203 is low. With pin 12 at 2.5V and pin 13 at 0V, the output pin 14 will be at Vcc or 9V. This output will cause the motor to begin turning rapidly. IC201 then senses the motor speed and adjusts pin 13 of IC203 until the capstan speed is correct. Thus VCRs automatically provide their own kick-start. The diagnostic device simply mimics this feature.

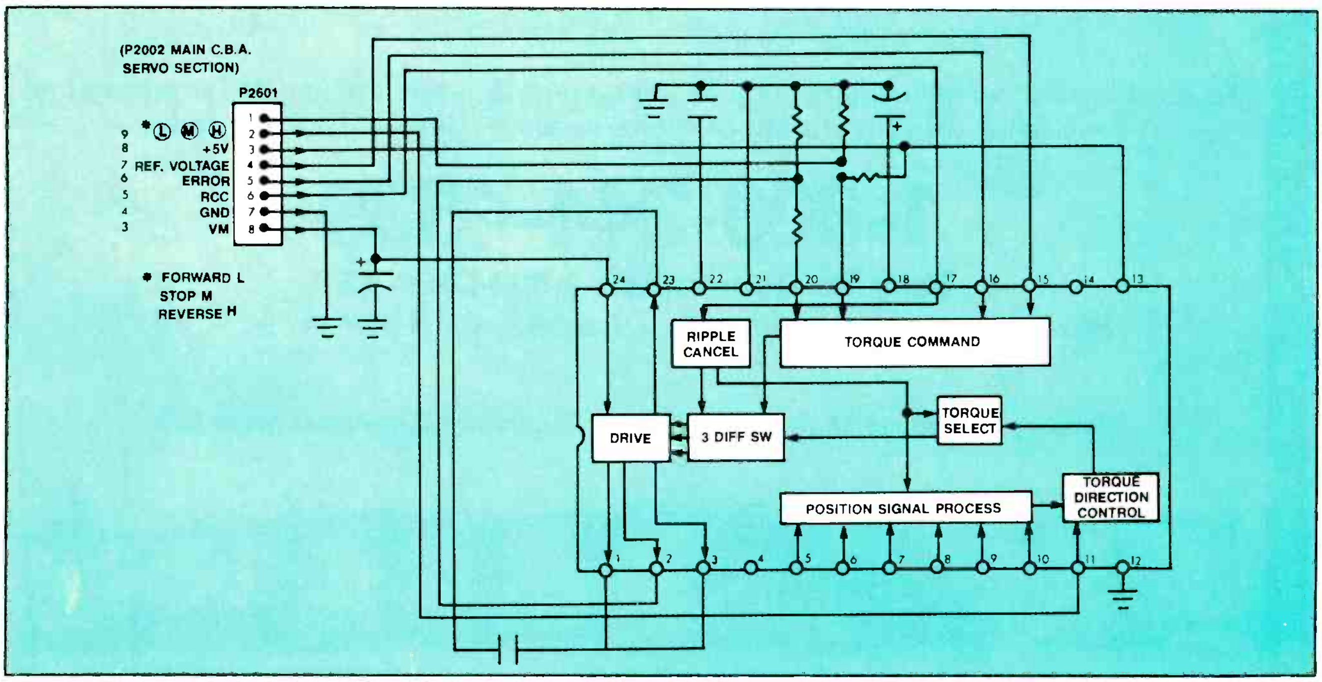

Figure 7. A general flowchart for troubleshooting with the device. Voltage-control logic varies from manufacturer to manufacturer.

HITACHI CT3020W/CT3020B MAIN SCHEMATIC DIAGRAM

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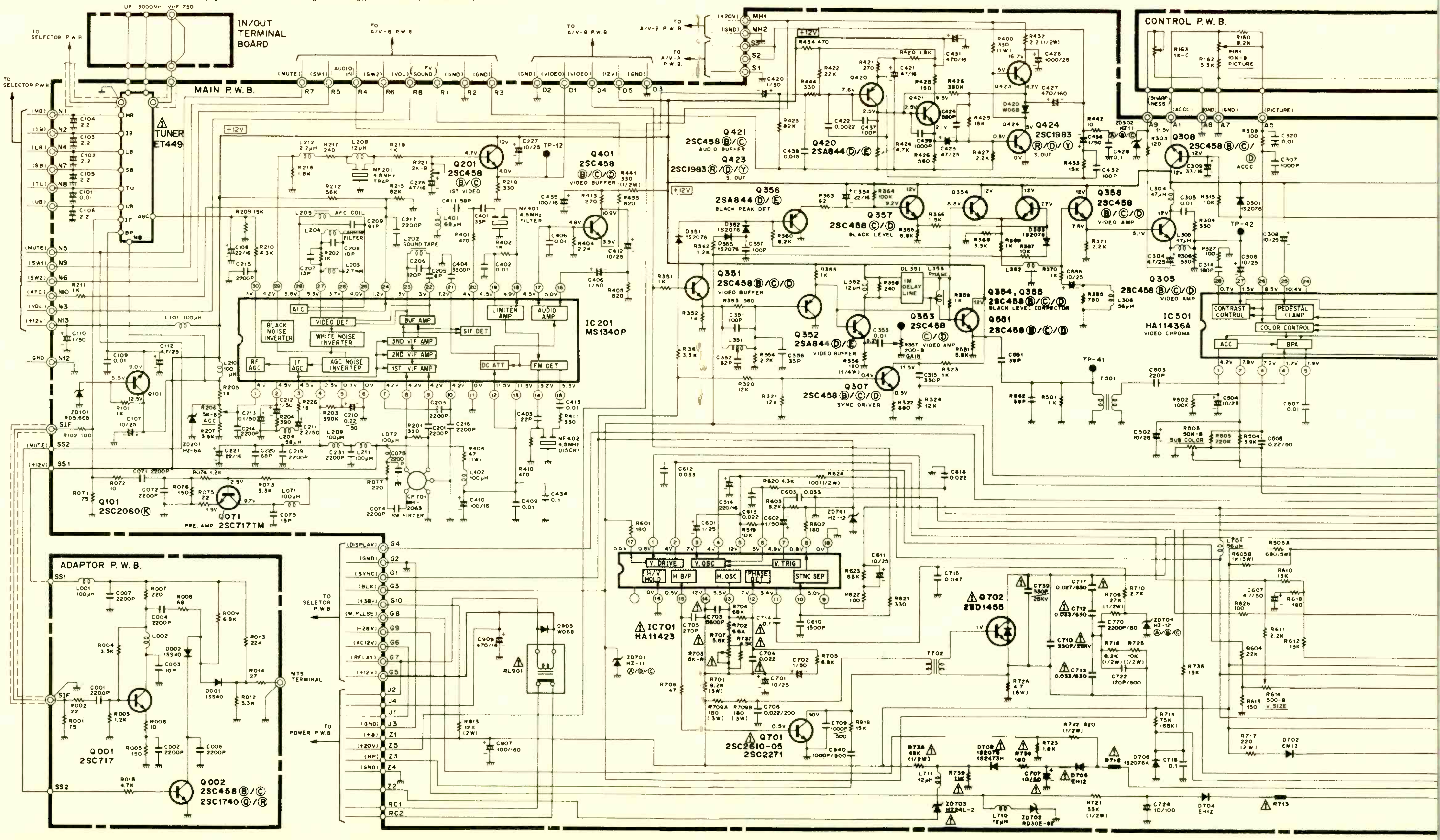
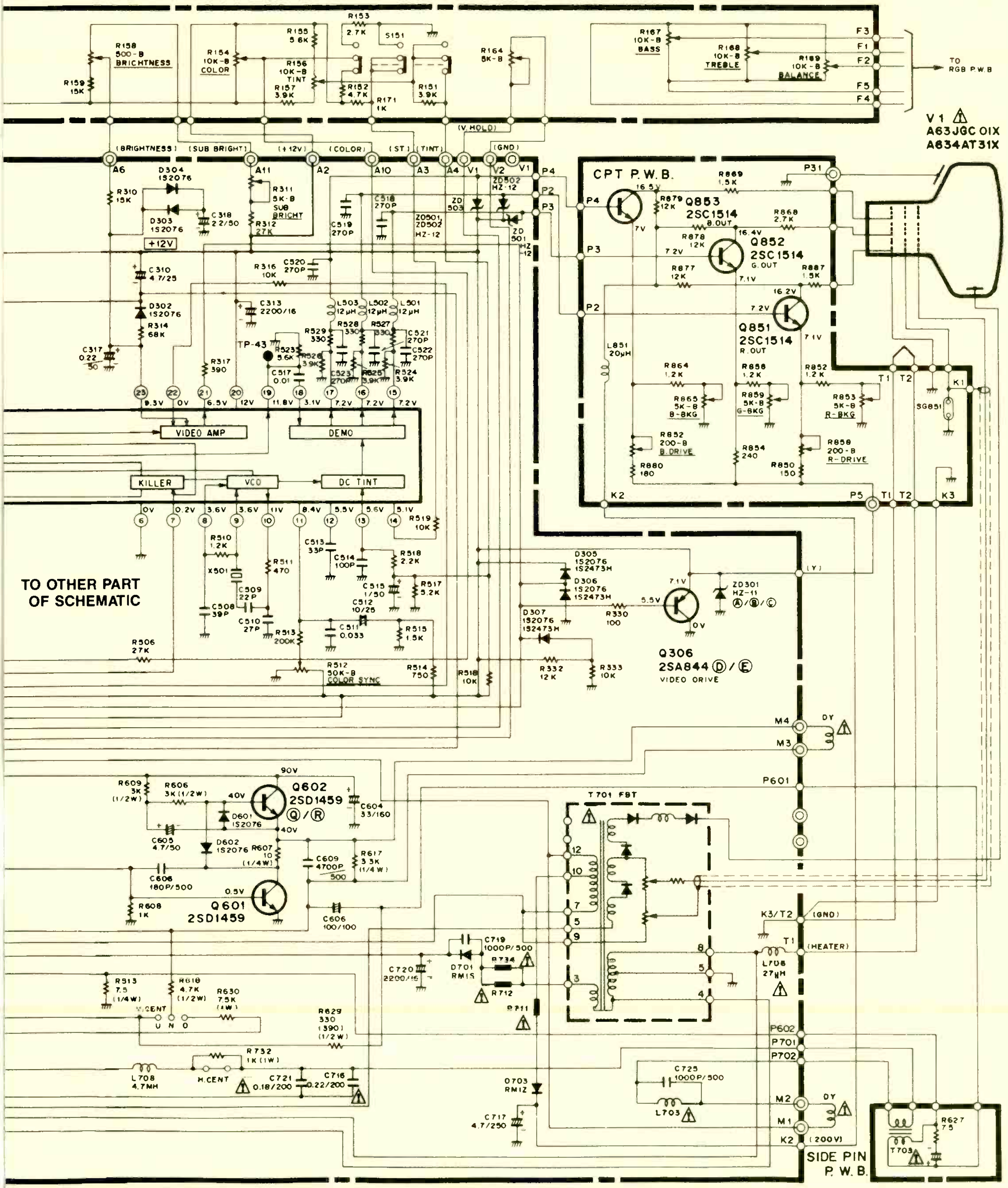


HITACHI CT3020W/CT3020B MAIN SCHEMATIC DIAGRAM



Zenith CM-139/B-3 (I) SD2511G/SD2581H

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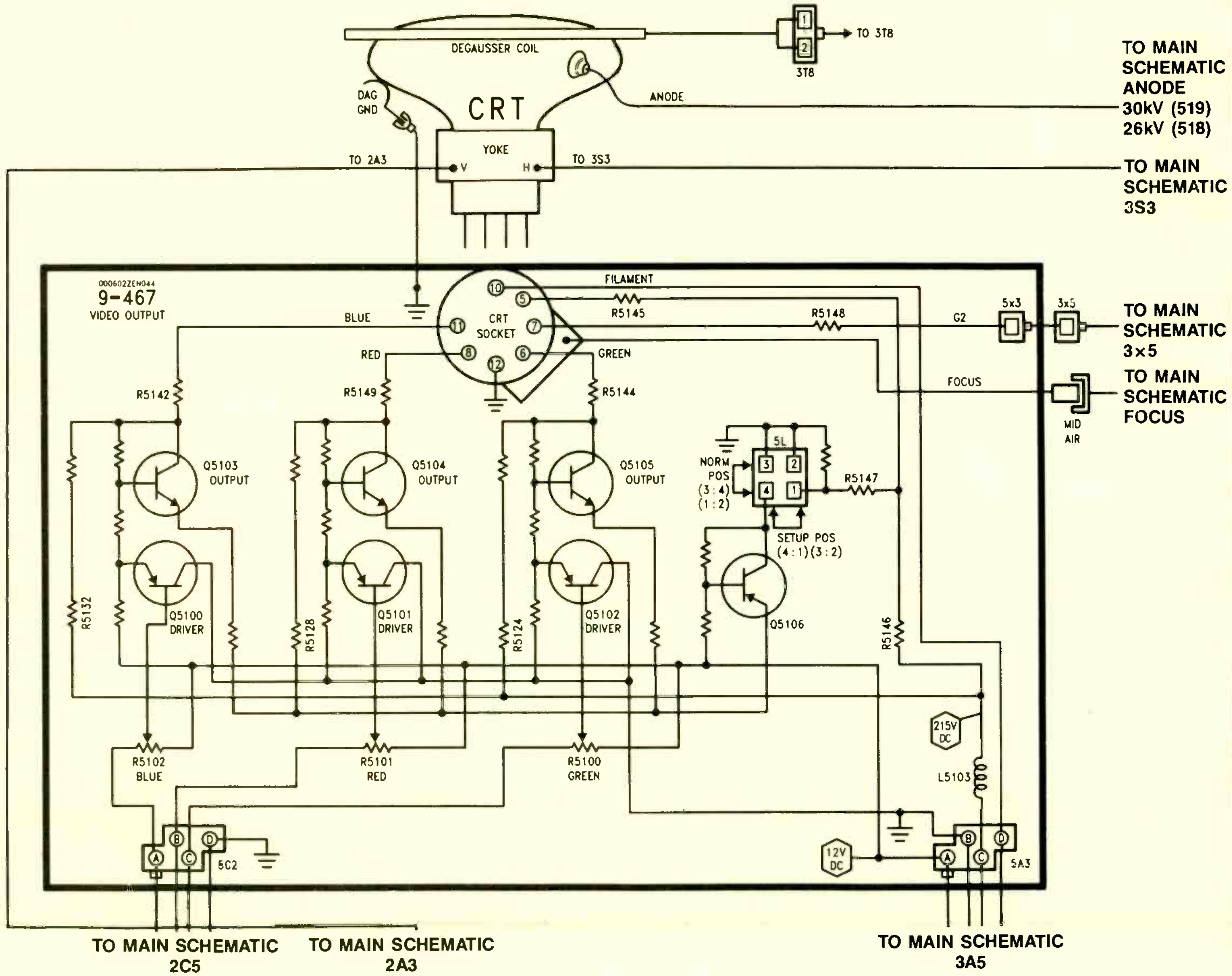

ES&T Manufacturers schematics PROFAX 3034

October 1988

Zenith CM-139/ B-3 (I) Color TV

Zenith CM-139/B-3 (I) SD2511G/SD2581H

Zenith CM-139/B-3 (I) SD2511G/SD2581H

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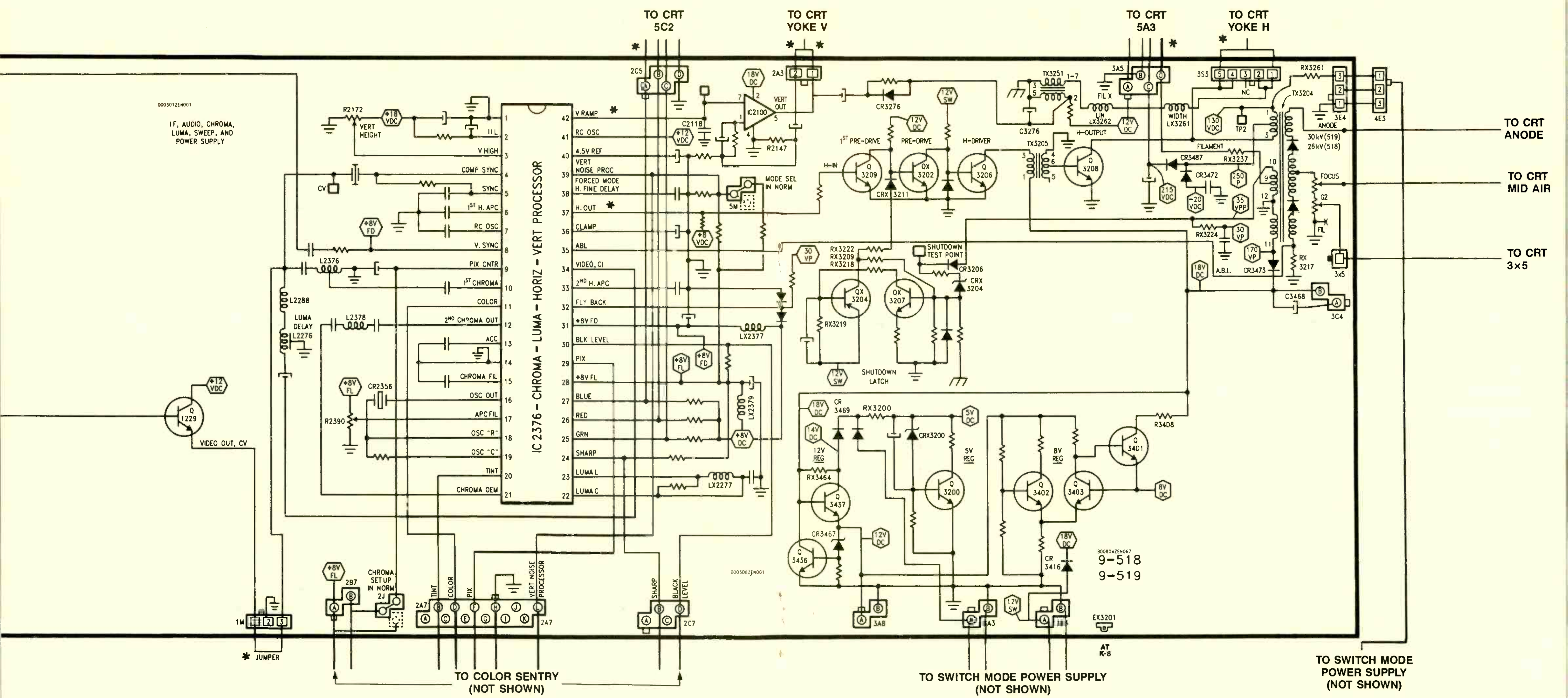

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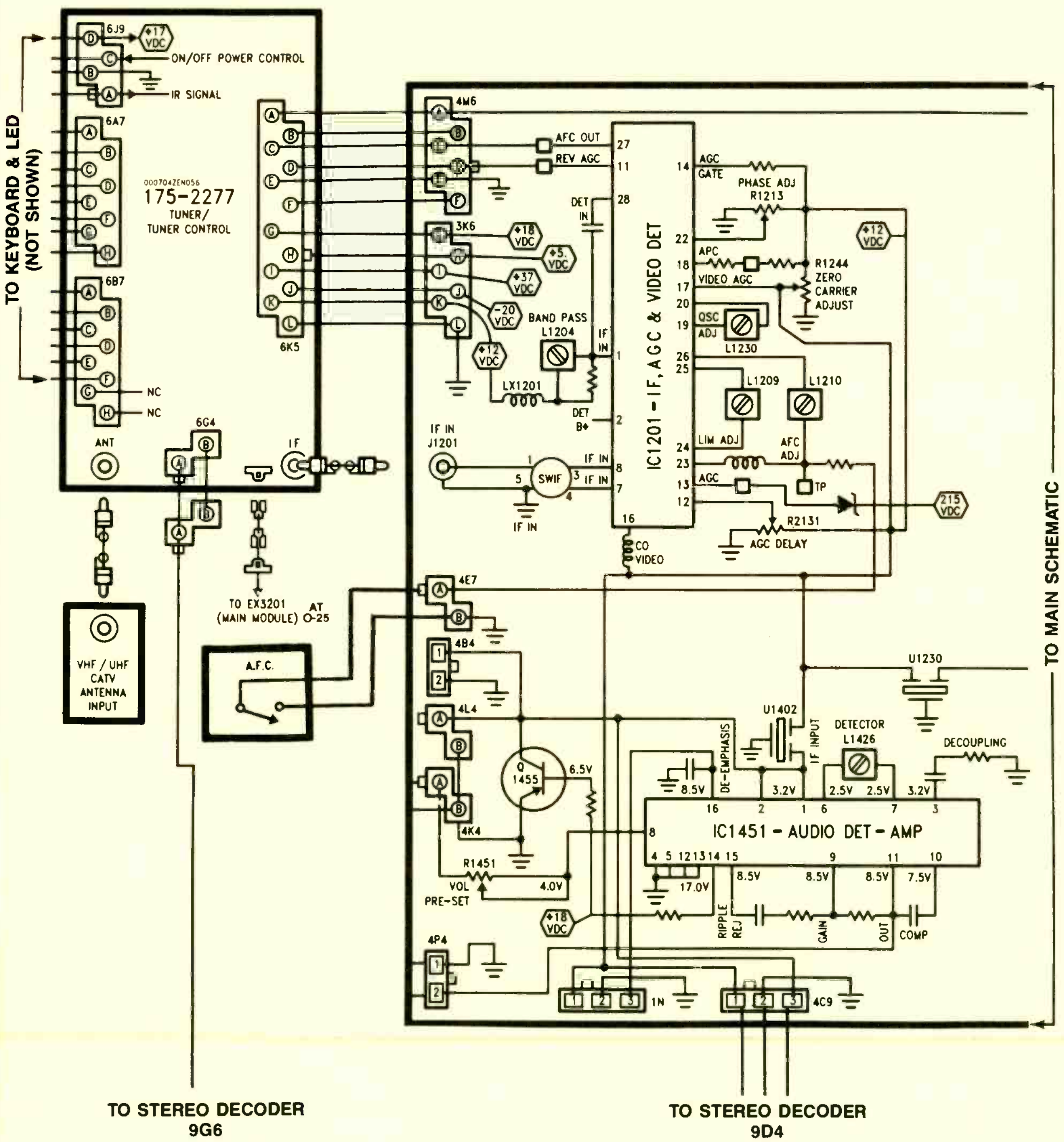

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Schematic

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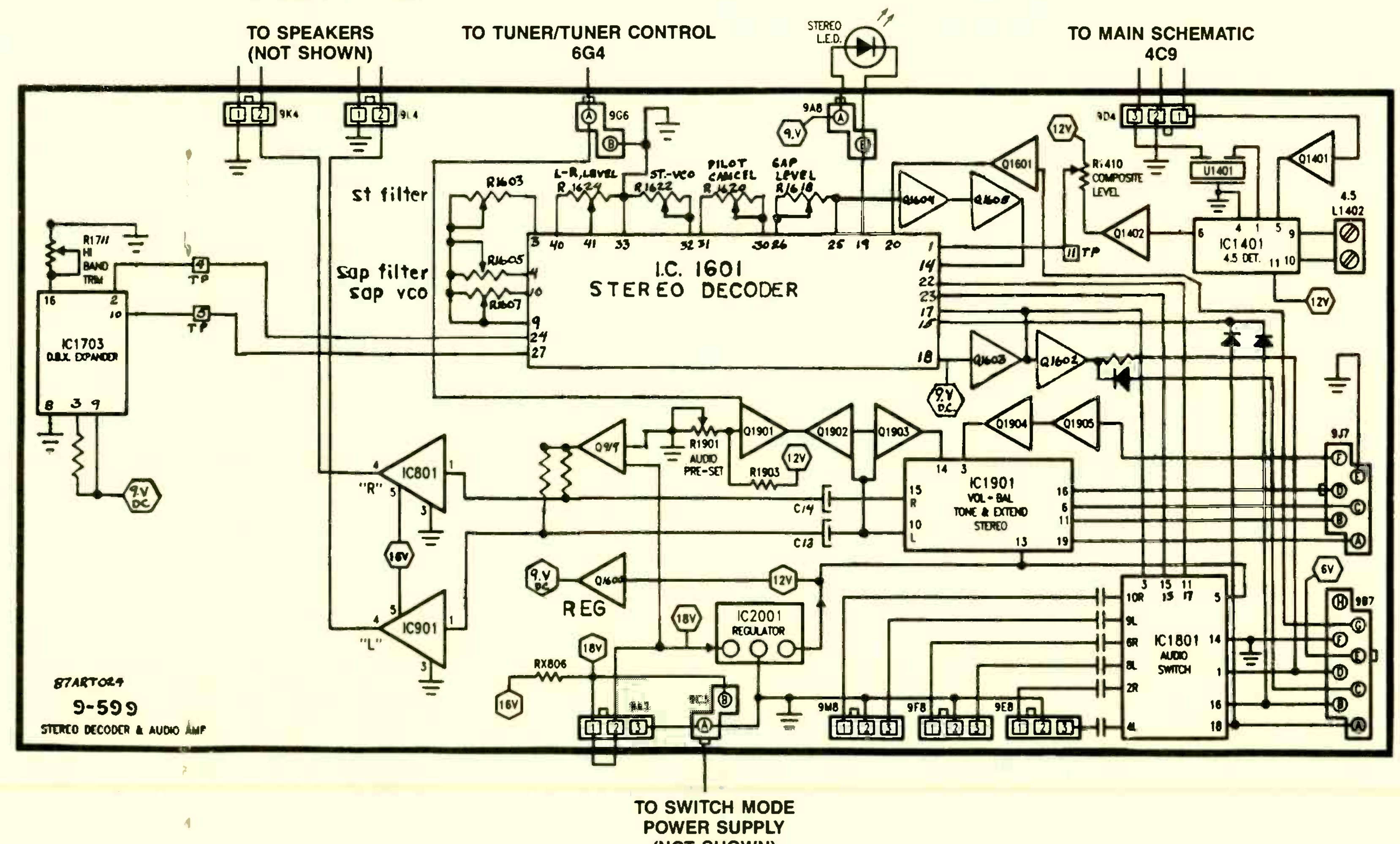


Continued from page 28.

hook-up wires used to connect the device to a VCR, it is possible to pick up some of these signals and carry them into the VCR, causing erratic control of motor speed. C_1 provides a low-impedance path to ground for these signals. R_6 is simply a damping resistor across C_1.

Using the device

When using the device, you should connect the positive or Vcc terminal to the same power-supply line that supplies the control-voltage amplifier you are disconnecting. Also, the ground cable always attaches to circuit ground. Always totally disconnect the voltage-control amplifier from the motor or motor cable. Do not simply parallel the device into the circuit. Test results obtained from such a parallel arrangement will be meaningless because the servo loops will be fighting with the device for domination of the voltage control line.

Figure 7 gives a general flowchart for troubleshooting with the device. Voltage-control logic varies from manufacturer to manufacturer. Matsushita (Panasonic) generally uses reverse logic—that is, the lower the control voltage, the faster the motor; the higher the control voltage, the slower the motor. In reverse-logic machines, the high position of the switch would be the stop position and the low position would be kick-start. Other manufacturers, such as Sharp, Goldstar and MGA, often use a standard logic—the higher the voltage, the faster the motor. Therefore, the use of the switch positions on the device are reversed, with the high position being used to kick-start the motor in these machines.

As with all digital circuits, digital servo circuits must have a master-clock input signal in order to operate. A common source of a master-clock signal is 3.58MHz from the chroma section. Always verify the presence of master-clock, power-supply and reference voltages when troubleshooting servo circuits.

Use a tape recorded in SP for servo troubleshooting with the device. Adjust the coarse control until the audio sounds normal, then adjust the fine control to stabilize the picture. With the device properly adjusted, the playback picture will remain clear for several seconds before going to snow as the heads drift into the guard bands. After several more seconds, the picture will again become clear. This is normal and indicates both that the motor is capable of running at the proper SP speed and that the diagnostic device is properly adjusted. EP tapes are tricky to adjust with the device because the EP operating point of the capstan motor is very close to the motor stall point.

The diagnostic device has proved to be very useful, not only in servo circuits but also in varactor tuning systems. By attaching the device to the voltage tuning line, a technician can quickly determine whether the tuner or control circuitry is the problem. That's another story for another time, however. Using the diagnostic device has helped me troubleshoot servos faster, easier and with greater accuracy. **ES&T**

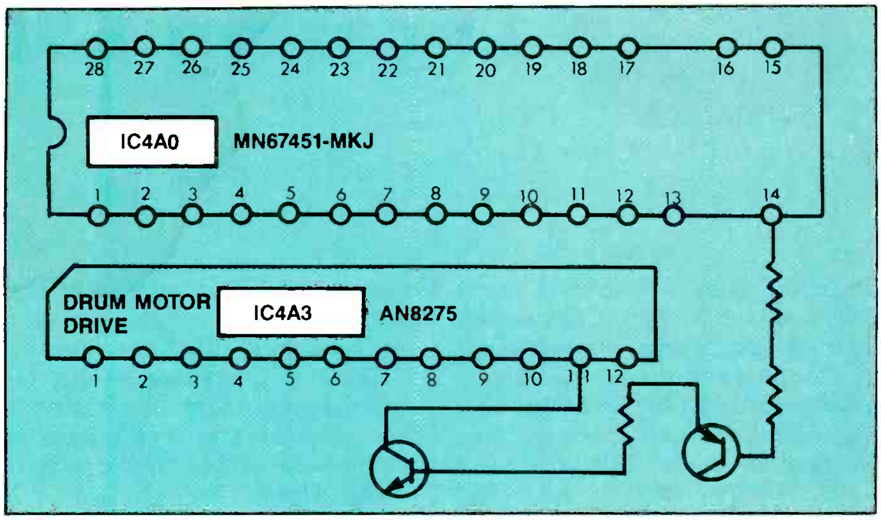


Figure 8. This VCR arrived for service with two problems: the playback picture had a snow band moving through it and the audio exhibited wow and flutter. The capstan motor would not rotate in any mode. A new drive IC 2601 brought the unit back into operation.

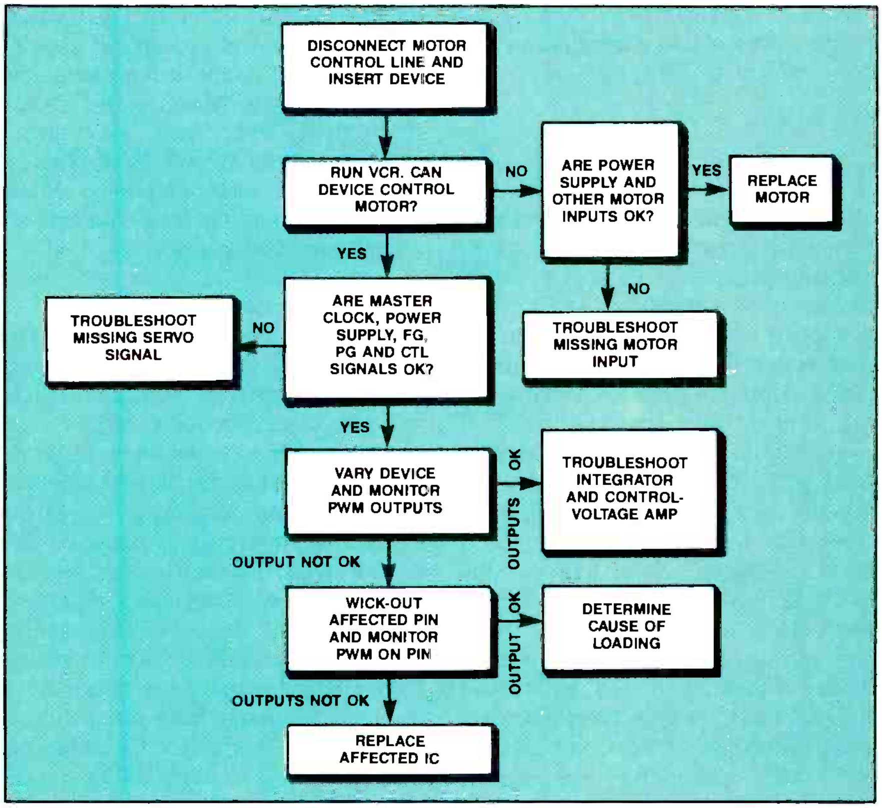


Figure 9. In this VCR, which was eating tapes, the head motor was not running. A IC4A0 fixed the VCR.

Prevention special

Locating ESD hazards

By Dan C. Anderson

In touring countless facilities in search of electrostatic discharge (ESD) hazards over the past 22 years, we consistently find the same errors being made and explain again and again how simply they may be avoided, often at less cost than the methods in use. This article is a simplified summary of commonly observed errors and the "fixes" for them.

It is most often what the facility stops doing, rather than what it does, that can prevent ESD damage to microelectronic components and the assemblies containing them.

To understand the damage caused by electrostatic discharge (ESD), you must first understand that ESD is a spark. This simple term for a complex, rapid, damaging discharge of what was previously a static charge accounts for your wince when you touch a metal-plated doorknob after crossing a dry rug. That spark, if you felt it, was of at least 3,500V. Humans can't detect a spark of lower voltage, although electrostatic discharges happen virtually every time we shake hands or touch metal or carbon. Note, too, that the spark happened between conductive surfaces, in this case the salty sweat layer of your skin surface and the metal surface of the knob. Indeed, virtually all ESD of damaging type takes place between conductive surfaces, and there are only three meaningful ones: metal, metallic carbon and human sweat. These three materials cause virtually every incidence of ESD damage.

Before a discharge can take place, one of the conductive surfaces must become charged. This charge is almost always caused by induction—your shoe sole, having separated from a dry carpet, becomes charged by the separation and then induces its charge, somewhat lessened, upon the surface of the nearest conductor (your skin in this case). Note that the rubber or plastic shoe sole could not have been discharged by the doorknob in a sparking manner but must induce its charge on a conductor that can throw a spark at a metal or carbon-faced surface or the skin of another person.

Once the concept of the "doorknob syndrome" is grasped, the methods of stopping the spark (preventing ESD damage) become much more easily understood and enforced. A painted doorknob would resist a spark. Therefore, to prevent such a spark, you should put an insulating or static-dissipative layer over all spark-producing surfaces with which slightly charged components or a printed-circuit board containing charged components might come into contact.

Eliminate the spark

All work-station surfaces, tote-box surfaces, bag surfaces, or foam or cushioning surfaces that can touch static-sensitive electronic components should never be conductive enough to produce sparking discharges. Instead, they must be *antistatic* or *static dissipative;* that is, they must be incapable of producing charges on separation from other materials and, even more important, they must be incapable of producing a spark readily on contact with charged conductors. Antistatics bleed off the charge from such conductors sparklessly, a bit more slowly and therefore safely from an ESD point of view. With exceptions too few to be significant, if you don't have a spark, you don't have damage.

Therefore, the long-accepted method of using exposed conductive surfaces (which are spark-producing) to prevent ESD (a spark) is at last being recognized to be the wrong approach and to be a leading cause of ESD damage.

Even when shielding is needed—whether for RF, EMI or the currently accepted but misleading term "static shielding"—metal or carbon layers are thought to be needed for sufficient conductivity to provide this shielding. But the conductive layer need not and indeed should not be exposed to cause sparks, shorts, shock to personnel or the very ESD damage it was intended to prevent. In every case, the conductive layer should be covered with or sandwiched between layers of antistatic or static-dissipative materials. This in no way interferes with its shielding properties, but instead prevents the spark-production on contact with items.

Case in point: The modern home computer is required to have RF shielding such as metal-spray, wire mesh, heavy plating and the like. However, it is rare to find exposed metal on the outside face of any modern computer because it was learned that charged human fingers throw sparks at the old metal locks. Theses sparks often resulted in crashed programs or otherwise harmful glitches. Now they "paint the doorknobs," burying shielding layers under plastic or enamel. The identical principle applies to bags and boxes containing circuit boards.

Eliminate charge-producing plastics

Just as all spark-producing carbon or metal surfaces must be covered, so the plain, charge-producing plastics must be carefully, religiously and systematically removed from all possible contact with—or even near approach to—ESD-sensitive components and assemblies. Plain (non-antistatic) poly bags, tote boxes, cushioning bubbles and foams must be eliminated from the entire servicing facility; they should be replaced with good brands of antistatic poly (these are ordinarily colored pink). To allow plain plastics in an antistatic area is as ridiculous as going on a stringent diet but continuing to eat one's regular meals. The pink antistatic plastics exist to *replace* the standard, charge-producing ones. Even if you don't buy the pink plastics, get rid of the standard plastics. It is far more important to eliminate the chargers than it is to buy pink substitutes for them.

One of the most ironic practices we encounter is that of keeping the instructions on static spark prevention in com-

Anderson is president of Anderson Effects.

mon vinyl shop travelers, which carry enough static charge to peg static meters at quite some distance. The same is true of the acetate notebook-page covers used to keep pictures, schematics and the like clean. Both can be readily replaced with pink antistatic versions, or the papers can be used naked—paper, cotton and wood, at the speeds of movement reached in ordinary handling, constitute no realistic ESD hazard.

Before you spend money on coating innocent cardboard boxes or corrugated cartons with carbon lacquer, which converts their surfaces into potentially harmful spark-producing "doorknobs," determine the ability of such a box to cause ESD damage when plain. If the plan was to use the carbon as a shield, it should have been buried between the non-sparking plies of the paper. Better yet, it should have had a foil or other truly RF-shielding layer buried between the plies.

It is far more important to eliminate the chargers than it is to buy pink substitutes for them.

No plain poly bag full of nuts and bolts should approach a workbench, even though the bag's contents are not static sensitive. Murphy's law states clearly that the bag will approach a sensitive circuit somewhere. Replace all such bags with paper or with pink antistatic bags, whose premium price over plain poly is almost unnoticeable today. Good pink antistatic bags abound, although you are well advised to know the brand name and the reputation of each one. Indeed, because of the many poor imitations of Richmond's original RCAS 1200 "pink poly," which are responsible for many horror stories of lost properties and the like, the government now requires that all MIL-SPEC bags such as those meeting MIL-B-81705 to be marked with the manufacturer's name for traceability. There are also some effective blue versions of antistatic poly for those who prefer it over pink (for whatever reason). However, pink is far and away the most widely accepted and recognized color for antistatics, and pink stands out as unusual in industrial or military areas, for quick recognition.

Other anti-static measures

White styrene foams can easily be dipped into antistatic solutions with red food color added so that they come out pink, which not only indicates that they have been dipped but also that they conform to the generally accepted "pink means antistatic" training. Thus even the worst-trained operator can see that he should not bring a non-pink or otherwise unidentified plastic to the station or near circuitry without having it checked with a static meter. Such foams can, if treated and colored pink, replace expensive carbonized types that can cause corrosion and sparks on contact. One way to show the absence of ESD damage potential from a treated styrene foam container is to use a device called a Zapflash, manufactured by Anderson Effects.

This tool measures conductive or spark-producing surfaces. The pocket-size tool resembles a pocket flashlight or penlight with a probe at one end and a red lamp at the other. It contains a transistorized circuit and three 1.5V N-cells. If the device is held at the casepoint (where your fingers would rest on a pencil) in one hand and the probe is grasped with the other hand, the red lamp lights, indicating that the sweat of your body surface has conducted the current from probe to casepoint. Resistances of about 5MΩ or less will suffice to light the bulb. Therefore, the device functions as a one-handed continuity checker, with your other hand being the other probe. To find if a surface is sparkingly conductive, you would check the tool against the other hand to see if it is functioning, then touch one hand to the surface in question and touch the same surface with the probe. If the light goes on, the surface is made of metal or carbon, or is as conductive as human sweat, all of which are too conductive to touch charged devices safely.

A hand-held static meter is the other indispensable tool for making an intelligent evaluation of materials and conditions encountered during a plant tour or ESD walkthrough. All such meters should be zeroed by pointing at one's other hand, since the two hands are electrically at the same potential due to the sweat layer connecting them—a handy reference. A conductive or antistatic bag or box picked up in one hand will, after a stroke against clothing or the like, show no charge to the meter in the other hand; common or non-conductive plastic surfaces will. The Zapflash can then be used to tell which of the non-chargeable materials is so highly conductive as to be an ESD hazard.

Thus, to make a tour, one needs the static meter (to find the charge-producing "rugs" or non-conductors) and the Zapflash (to find the "doorknobs"—the spark-producing metal or carbon surfaces which need to be painted over or covered by antistatic layers).

Modern table tops and work stations no longer have the once-recommended black carbon or stainless steel surfaces because both have been shown to be hazardous. They caused rapid sparking ESD discharges and even shock to people. Therefore, almost universally, such tops are now antistatic or static-dissipative, meaning they will not charge or spark. It therefore makes little sense to place on such a table either a black carbon-faced bag or, even worse, a bag with metallization on its outer surface. In either case, the doorknob so carefully buried is now back to cause sparks.

Shielding bags or boxes whose conductive layers (if needed at all) are safely buried beneath antistatic layers are the only ones safe to use. Any bag whose exterior surface is conductive needs to be replaced at once, both as an ESD damage hazard and as a source of sloughed conductive particles, possible electrolytic corrosion, and severe if not fatal shock to personnel should it inadvertently touch high voltage sources. Indeed, the effect of a black bag or metallized-surface bag touching the leads of a power supply can be spectacular. The danger vanishes if buried-metal bags or antistatic pink ones are used.

Making the tour

So, with a few fundamentals mastered, we begin the plant tour generally where you receive packaged products such as replacement parts, noting that many of the devices and components are still being shipped from vendors or suppliers improperly packed, either with plain polyethylene wraps, white styrofoam cushioning, colorless bubble-type cushioning, or sometimes even packaged in black conductive poly bags or blue-metal ex-

Static meters show how large opposite charges develop as tape is separated above them. The nearby radio, however, "hears" no sparks unless the separation is violently rapid.

Even seemingly innocuous actions can develop a substantial static charge. Here, unrolling Scotch tape generates opposite charges on the roll and on the unrolled strip. Bringing the tape strip near an LED display causes a trickle of discharge through the LEDs, as shown by the lighting of some of the LED segments.

Be cautious with poly bags, which may have exposed carbon or metal on the surface—a shock or ESD hazard.

Table 1.

Eliminating ESD hazards in the workplace

1. Eliminate spark-producing conductive surfaces.

2. Eliminate charge-producing plastics.

3. Apply antistatic coatings where applicable.

4. Use test equipment to check for the presence of static producers and spark producers.

4. Always enforce the wearing of grounding wrist straps at the work bench.

5. Install signs that remind technicians of the ESD problem.

6. Use static-free vacuum solder-removal tools.

7. Make sure that aerosol chemicals, freeze sprays and the like are not causing static buildup.

teriors. All of these items should be repackaged carefully, or the original improper packaging should at least be moistened and removed before the item goes near a work station.

You should advise the vendors or suppliers of such packages to use acceptable non-sparking pink or blue wraps and to use only shielding bags with safely buried metal layers when shielding is necessary. In the case of shop travelers, for example, it is certainly unnecessary to shield the paper contents; a pink antistatic envelope suffices superbly.

On into the servicing areas. Check for mandatory wearing of wrist grounding straps by all seated technicians. Such straps are a capital investment because a well-made strap can last almost as long as the desk itself; therefore, select reliable brands and do not skimp on initial cost. Connect the strap to a ground point not on the surface of the table but under its front edge so that the table surface is unencumbered and the connection to ground is assured. Never use the buried conductive layer of a table top to convey the static from the strap to ground. This method needlessly complicates and adds resistance to this path.

Tabletops of wood or any other unchargeable nonconductor often suffice. Special tops are unnecessary, but if they are used, the middle conductive layer may be grounded to the same point as the grounded wrist strap. All straps must contain a resistance of 250kΩ minimum, although a nominal 1MΩ is generally found today to prevent shock hazard by limiting current through the body if you or a metal bag you are holding contacts live circuitry.

Signs (such as "CAUTION: STATIC DISCHARGE CAN DAMAGE COMPONENTS. DO NOT HANDLE UNLESS YOU ARE WEARING A WRIST STRAP.") should be placed at every station to remind the worker to don the strap before touching any work, even if they don't think the unit is ESD-sensitive. This is the only way to form the habit for the day when the devices grow even more vulnerable, as is the trend today. Check wrist-to-ground connection frequently.

Check plastic tote boxes with a static meter at rest, then after stroking once with a sleeve or other textile. Those that charge should be dipped in a long-term antistat and labeled with pink-dated paper stickers when they dry. Pink-dating allows you to check over a period of months to determine if a new dip is needed and is far less expensive and more immediate than replacing all tote boxes with permanently antistatic ones. Paint or lacquer black conductive boxes to prevent sparking, or use them only with pink-bagged components, never naked components or assemblies. Bottoming or lining such boxes with pink foam also helps.

The idea of surrounding the boards or components with antistatic bags or lidded boxes is to keep the casual, possibly charged fingers or other conductors from touching devices. Therefore, bags or boxes should only be opened at work stations by persons who are properly grounded through wrist straps, and the area should be clear of chargeable plastics. Yet we rarely tour a plant in which we cannot touch unprotected or unbagged boards, and this should not be possible, much less permitted. The surrounding pink or static-shielding bag will prevent all in-house ESD damage if the rules are consistently observed. Also, if grounding wrist straps are used, floor mats become unnecessary, as do special antistatic floor treatments, although the latter are a good "percentage play" and do not require special shoes or foot straps as conductive floors and mats do. Walking on conductive floors with rubber soles will charge the sole; walking on a properly antistatic-treated floor will not.

At the servicing bench, never use common blue "solder suckers"; replace them with static-free types. Static meters show this hazard; simply trigger a blue model over a meter and observe the spike.

In shipping areas, if applicable, use only pink antistatic styrene foam loose-fill, never the white chargeable ones. Foam-in-place packaging should always use a pink antistatic poly to replace the commonly encountered blue, high-density poly used in such processes. This poly can generate incredible static voltages. Pink antistatic foams should replace all white foams; the additional cost is minimal compared to the losses caused by ESD.

Editor's note: Many of the suggestions in this article appear in Anderson's videotaped presentations on ESD damage prevention. These tapes are available free of charge on loan from that company. ES&T

Prevention special

Preventive maintenance: Cleaning supplies for computer maintenance

By Gil O'Brien

As every technician knows, periodically cleaning personal computers and electronic systems is essential to uninterrupted, trouble-free operation. Routine equipment maintenance by service professionals as well as by users significantly reduces the risk of downtime, data loss and breakdowns that result in costly repairs.

The basic idea behind computer cleaning procedures is easily understood: cleaning removes oxides, dust, grease and other environmental contaminants that can reduce electrical conductivity and trap heat. Cleaning also imparts some protection against frictional wear, corrosion and static build-up. However, the variety of advanced, specialized cleaning products now available are frequently overlooked in favor of less reliable and often outmoded techniques.

This quick review of modern, high-technology cleaning products will provide technicians with a shopping list of chemicals and materials designed to increase their productivity and effectiveness. Another section will briefly outline maintenance products that may be used by computer end-users for doing their share of preventive maintenance.

O'Brien is a technical consultant for Chemtronics.

Solvents and cleaning agents

Several types of solvents and cleaning agents are available in both aerosol and liquid form to remove performance-inhibiting contaminants from computers and peripheral equipment. The principal applications of solvents and cleaning agents are:

- removing oxides from tape heads and drive components.
- cleaning printer mechanisms.
- degreasing contacts and circuit boards.
- removing organic flux after soldering.

Although personal preference and habit often determine which cleaning solvents technicians will use, other more objective factors such as safety, effectiveness and convenience will be considered here. For the purpose of comparison, electronic cleaning solvents can be divided into four major categories based on chemical composition: chlorofluorocarbons, chlorinated solvents, alcohols and blends.

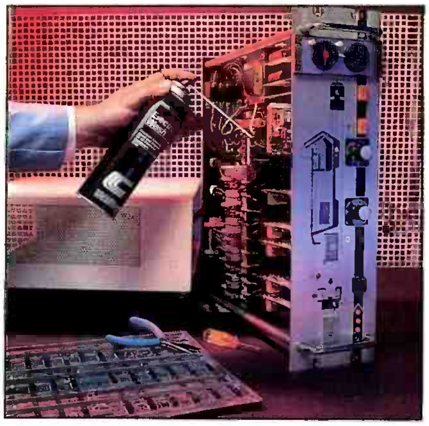
Chlorofluorocarbons, like TF solvent (trichlorotrifluoroethane), are the most chemically stable cleaning agents. They are non-flammable, non-toxic and non-reactive with most metals, plastics and rubber. Chlorofluorocarbons are also powerful degreasers and are typically offered in both liquid and aerosol sprays.

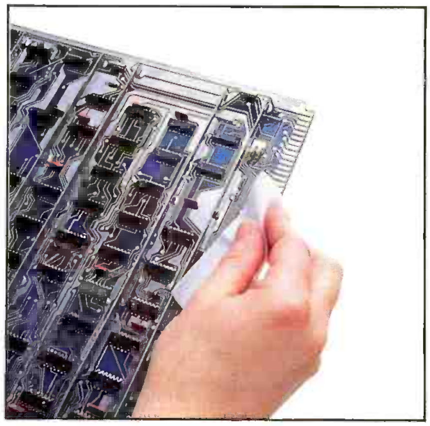
Aerosols are preferred by many technicians because they deliver a continually fresh supply of uncontaminated solvent with a pressure capable of dislodging and removing even encrusted grease and gunk without scrubbing. Aerosol solvents can be applied effectively using a lint-free cloth for catching overspray and wiping. It should be noted that carbon-dioxide propelled aerosol systems provide the greatest initial spray pressure.

Chlorinated solvents, such as 1,1,1-trichloroethane, are the strongest electronic cleaners used today. They are also non-flammable and are available as both liquids and high-pressure aerosols. Chlorinated solvents, however, are more toxic and slightly more unstable than chlorofluorocarbons. They also have a tendency to cause swelling in certain types of plastics.

Alcohols such as isopropanol are commonly used for electronic field service. Although they are good general-purpose solvents, alcohols have several notable disadvantages. Alcohols are flammable, they are not available as aerosols and they can react with some plastics.

A number of excellent blends are also





widely available. Each blend possesses a specific measure of solvency, reactivity and flammability. When using these products, refer to the package label for content and capabilities, as well as precautions against adverse reactions with materials to be cleaned.

Applicators

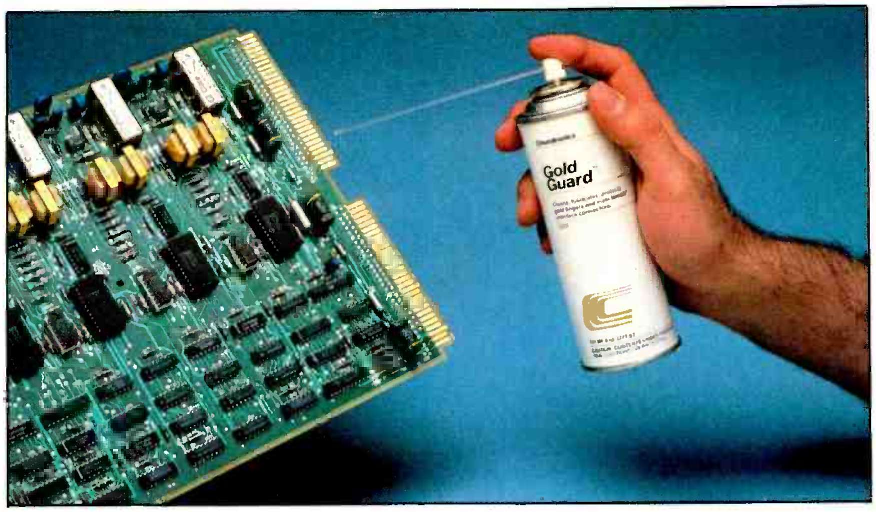
For many years, household cotton swabs have been routinely used to apply solvents and remove contaminants from electronic surfaces. Although inexpensive and readily available, everyday cotton swabs produce lint and are not correctly sized or textured for many cleaning jobs.

A superior alternative is found in the large variety of specialized swabs and applicators made with tips of polyurethane foam, polyester cloth and other advanced synthetic materials. These state-of-the-art products are designed to be highly absorbent, thoroughly clean and completely free of particles and extractables.

Available in a wide assortment of sizes and shapes, these new-generation foamtip swabs are thermally mounted (without contaminating adhesives) on handles with the correct length and flexibility for every type of precision cleaning application.

Presaturated pads and swabs

Rapidly gaining in popularity with service technicians, disposable presaturated pads and swabs offer the ultimate in field maintenance conven-



ience. These products contain a premeasured amount of liquid solvent in combination with an application device—either a cloth pad or a foamtip swab—sealed in individual foil packets. Users simply tear open a packet, clean the surface and then discard the used cleaning item.

Premoistened pads and swabs possess several distinct advantages. They are easy to store and use; they are used only once, so surfaces are not exposed to contaminated liquids; and they eliminate the need to carry or dispense solvents in the field.

For cleaning tape heads and transport mechanisms, presaturated, lint-free pads containing either solvent or isopropanol are available. Presaturated non-residual isopropanol swabs serve the same purpose and are especially useful for hard-to-reach areas. For cleaning edge connectors, contacts and equipment housings, solvent pads are highly recommended.

Compressed gas dusters

Made from a microscopically clean, moisture-free, inert fluorocarbon (dichlorodifluoromethane), compressed gas dusters deliver powerful jet action that instantly removes dust and particles from even the most inaccessible areas of computer equipment. They are especially useful for blowing paper dust out of printers, for removing abrasive contaminants from magnetic tape heads before cleaning, and for cleaning dusty PCBs, switches and computer keyboards.

Compressed-gas dusters generally are invaluable for cleaning delicate components in applications where liquid solvents are inappropriate or inconvenient. Any surface, no matter how sensitive, can be safely cleaned with a compressed gas duster without risk of abrasive damage or microscopic contamination.

Packaged in convenient, slim-line cans, many of these dusters come with plastic tubes for pinpoint application and variable control trigger valves for easy one-hand operation. Larger sizes with reusable chrome valves, supplementary filters and flexible extension tubes are available for high-volume benchwork.

Contact cleaner/lubricants

Combining precision cleaning agents with fine-grade lubricants, these advanced products are designed to clean, restore and protect fragile electronic contacts. Available as aerosol sprays as well as premoistened pads, contact cleaner/lubricants are especially useful for preserving micro-thin precious metal surfaces against frictional wear, fretting, oxidation and corrosion.

Applied periodically to PCB connecting fingers and other delicate electronic connectors, contact cleaner/lubricants prolong the life and preserve the critical electrical continuity of metallic surfaces.

When choosing a product of this type, look for these important properties: high-temperature lubricity, low volatility, fretting protection, controlled "creep" onto neighboring surfaces, oxidation stability (to prevent the formation of gummy by-products) and compatibility with adjacent materials.

Computer cleaning supplies

Although complex repairs and major servicing should be performed by professional technicians, the PC user should regularly perform many critical routine maintenance procedures such as magnetic tape head cleaning, static control and CRT screen and keyboard cleaning.

Periodic user maintenance of magnetic tape heads removes deposits of signal-inhibiting contaminants and prolongs head life. As previously discussed, magnetic tape head cleaning is best accomplished by first freeing the abrasive particulate with a blast of compressed gas, then scrubbing the head with a disposable, presaturated pad or swab. Both solvent and isopropanol are effective for this purpose.

Periodic CRT screen cleaning by computer users is highly recommended to remove contaminants that inhibit or distort vision and result in eye strain and loss of operator efficiency. Highly effective screen cleaning products are available in both aerosol sprays and premoistened pads.

The most convenient and advanced products in this category consist of twin disposable cloth pads sealed in twin foil packets. The first packet contains a special anti-static screen-cleaning solution; the second packet contains a lint-free dry pad to wipe the screen clear. Easily stored in an office desk, these screen cleaners safely remove fingerprint oils and airborne contaminants while controlling static-generated dust build-up.

Computer users and service technicians both need to do their part in the preventive maintenance program in order to keep computers operating and trouble free. Servicing technicians should let the computer user know what his role is in keeping the computer operational and trouble free. ES&T

Troubleshooting tips

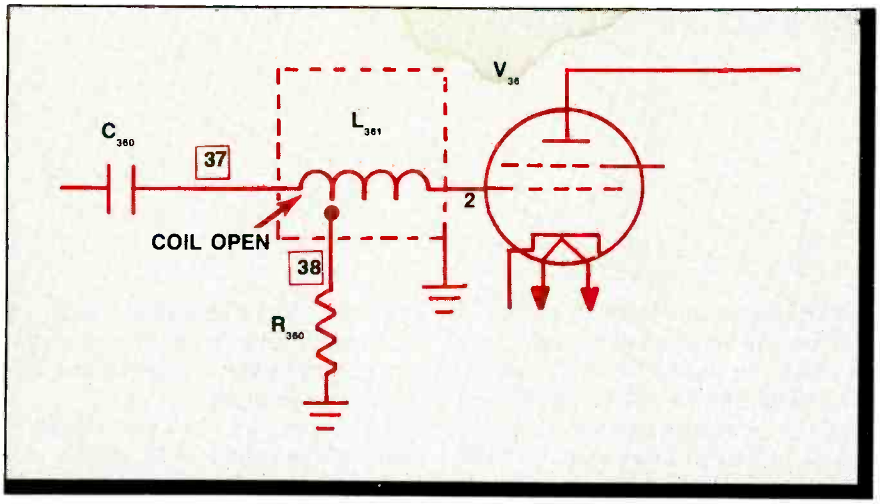


Figure 1. An open circuit between Circuitrace point 37 and ground was the clue to the disconnected coil lead in this TV with no sound.

Symptom: No sound
Set ID: Sears 528.4188005
Photofact: 1192-3

This set had a good color picture but no sound. My first step, substituting new tubes for V36 and V37, did not help at all. I next checked the voltage supplies that power those two tubes (Circuitrace points 2, 5 and 7). These voltages were all OK as were the other voltages for these two stages. I turned off the power and checked all the resistance readings (given in the Photofact chart) for V36 and V37. Nothing was abnormal.

Remembering that an AGC problem can affect the sound, I checked everything in the circuitry of V33b and found nothing unusual. I then decided to try using signal substitution. I fed a 400Hz signal into the grid of V37b, which produced a nice, clear sound from the speaker. Obviously, no signal was being fed to this stage.

Turning off the power, I returned to the schematic diagram for another study. Because I had already carefully checked out stages V37a and V36, I concluded that the problem had to lie somewhere in the circuitry that feeds the control grid of V36. I began to make resistance checks, and it wasn't long before I located an open circuit between Circuitrace point 37 and ground. This portion of L_{361} (which didn't affect any of my earlier resistance checks) was open.

Sure enough, after removing the metal shield, I discovered that one of the coil leads had become disconnected. The lead was just long enough to reach the solder lug, and I was able (with extreme care) to resolder it. This restored the sound circuit to normal operation. I have no idea what caused the lead to become disconnected, but I felt very satisfied at having diagnosed and fixed the problem.

George Marechek
Cheverly, MD

ES&T

What do you know about electronics?

Thevenin's theorem

By Sam Wilson, CET

Editor's note: Last month's "What Do You Know About Electronics?" stated that 4-terminal active networks would be covered in this issue. However, that subject will appear in a future issue.

Let's continue the discussion of network theorems and laws without the use of mathematics. I've had a little trouble keeping the math completely out of the discussion, but I'm getting better as the series goes along.

If you stay within the range of current values allowed, a regulated power supply acts like a constant-voltage generator. A constant-voltage generator is a necessary part of Thevenin's theorem. Hold that thought.

In the circuit in Figure 1, all of the resistors are assumed to be *linear* and *bilateral*. A linear resistor follows Ohm's law. If you double the voltage across it, the current through it will also double. Current flows equally well through a bilateral resistor regardless of which direction it is going in. By contrast, a diode is unilateral; current flows only in one direction. Thevenin's theorem won't work in a circuit unless all resistors are linear and bilateral.

All of the batteries in the circuit in Figure 1 have internal resistance, so they are not Thevenin generators. The internal resistances are marked R_i on the drawing.

It is assumed that you know all of the resistance values including values of R_i. Every resistor has a different value of resistance, and the batteries have different voltage ratings.

Here is your job. You are to make a graph of the values of R_x against the current through R_x. To make matters worse, you have been given 25 of these circuits, and a graph is required for each circuit. Each one has batteries and resistors that are different from every other one.

Of course, this task could be done mathematically. However, it takes two men and a boy to calculate just one of the values of I_x. This isn't a problem—it's a career.

Using Thevenin's theorem, however, we can reduce this problem to simple Ohm's law calculations. We can even get around those calculations because we're going to do this without math.

Fasten your seatbelts! We're going to start with a statement of Thevenin's theorem. (Note: if you are subject to fainting spells, you should skip the material in italics.)

In any 2-terminal network composed of linear, bilateral circuit elements and one or more sources of voltage, the voltage across the two terminals can be determined by assuming an equivalent constant-voltage source, V_{TH} (called a Thevenin's generator), and a single linear, bilateral series resistor, R_{TH} (called the Thevenin resistance).

Here's another way of saying it. If you remove the resistor (R_x), you will have a 2-terminal network. The terminals will be A and B. Then, no matter how complicated the network, you can replace it with a simple (Thevenin equivalent) circuit like the one in Figure 2.

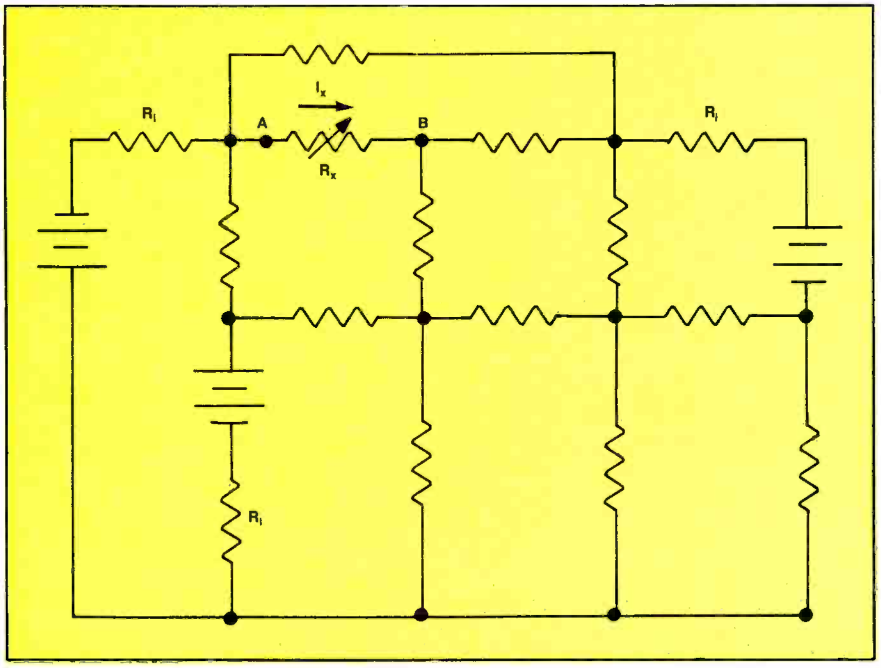


Figure 1. If you stay within the range of current values allowed, a regulated power supply acts like a constant-voltage generator. All of the resistors here are assumed to be linear and bilateral. A linear resistor follows Ohm's law. If you double the voltage across it, the current through it will also double.

Wilson is the electronics theory consultant for ES&T.

Can we get from the circuit in Figure 1 to the circuit in Figure 2 without math? It's easy when you are a subscriber to **ES&T**:

Step 1: Remove R_x. Set it aside for the following steps.

Step 2: Measure the voltage across terminals A and B with a high-impedance meter.

Ideally, the voltmeter should have infinite resistance, but a digital meter with an input resistance of 11MΩ (or more) will work very well.

The voltage you just measured is V_{TH} in Figure 2. Enter that value of V_{TH} on that drawing.

Step 3: Replace every battery with a resistor having a resistance equal to R_i for that battery. Decade boxes work well here.

Step 4: Measure the resistance between terminals A and B.

That number is the value of R_{TH}. Enter the measured value in Figure 2.

Now take a regulated power supply, adjust its output to the value of R_{TH} and connect it in series as shown in Figure 3. Add R_x in series with a current meter as shown in Figure 3. Measure the current for each of 20 values of R_x and make your graph. Using the simple Thevenin circuit, you can get the same values of current that you would get if you adjusted R_x in the circuit in Figure 1 and measured the current.

You might ask, "Why not just use the original circuit? Make the measurements there and you don't have to build the Thevenin generator." The answer to

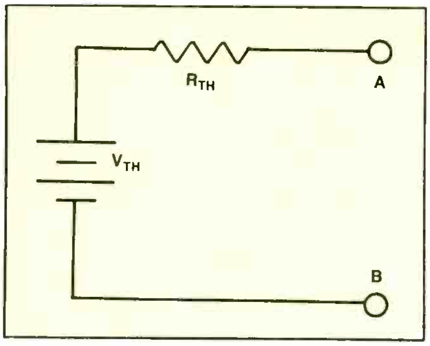


Figure 2. If you remove the resistor (R_x) in Figure 1, you will have a 2-terminal network. The terminals will be A and B. Then, no matter how complicated the network, you can replace it with a simple (Thevenin equivalent) circuit like the one here.

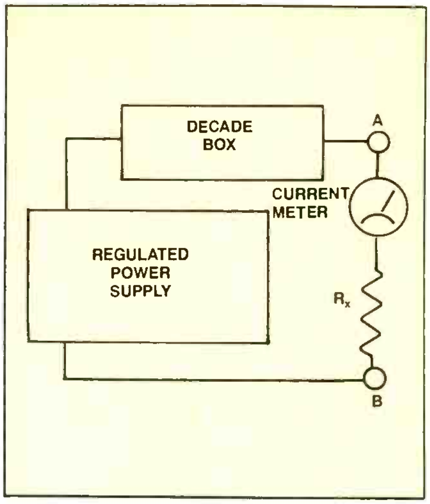


Figure 3. To get from the circuit in Figure 1 to the circuit in Figure 2, follow these steps: remove R_x; measure the voltage across terminals A and B with a high-impedance meter—this voltage is V_{TH}; replace every battery with a resistor having a resistance equal to R_i for that battery; measure the resistance between terminals A and B—that number is the value of R_{TH}; adjust the output of a regulated power supply to the value of R_{TH} and connect it in series; add R_x in series with a current meter and measure the current for each of 20 values of R_x.

that question is that the experiment is used to explain Thevenin's theorem. It is not supposed to be a practical application.

You could use mathematics to *calculate* the open-circuit voltage (V_{TH}). You also could use math to calculate R_{TH}. That's the way it's usually done.

If the circuit in Figure 1 is only on paper (maybe as part of a design problem), you would have to build that circuit before you could make the appropriate measurements.

If you have a flair for math, it is easy to calculate V_{TH} and R_{TH}. It would be a lot easier to construct the circuit in Figure 4 than it would be to put together the circuit in Figure 1. Take it one step further: If you know V_{TH} and R_{TH}, you could easily calculate the currents through R_x using Ohm's law.

In next month's installment, we will extend the idea of Thevenin's theorem to include Norton's theorem. Then we will look at an application of Thevenin's theorem that does not have all linear, bilateral circuit elements.

Who's law?

I guess about two-thirds of my day is spent reading. Part of this reading is done to reaffirm the things I thought I knew. In fact, I have four categories for all the subjects I read:

1. Things I know and know that I know.
2. Things I know and didn't know that I know.
3. Things I didn't know and didn't know that I didn't know.
4. Things I didn't know and know that I didn't know.

I have the most trouble with categories 1 and 3, especially category 1. Just as soon as I begin to believe I've got the real picture, something comes along and blurs it.

I'm not the only one. Recently I was reading a new book on electronics theory and I ran across this blunder: "Whenever current flows through a resistor, the amount of power dissipated in the form of heat is given by Watt's Law: $P = I^2R = V \times I = V^2/R$."

You and I know that's NOT Watt's Law! However, as an author I know those mistakes creep in, especially when you're meeting a deadline. The book is very well done. You make a bad mistake if you reject a book on the basis of a few errors.

By the way, who's law is it? See "Test Your Electronics Knowledge" in this issue. ES&T

Books/Photofact

The Digital IC Handbook, by Michael S. Morley; TAB Professional and Reference Books; 624 pages; $49.50, hardbound.

This handbook offers circuit designers access to specifications, prices and technical data on a full range of digital ICs. Chapters cover a comparison of logic families, gates, flip-flops, latches, mutivibrators, buffers, transceivers, encoders, decoders, data selectors, counters, shift registers, arithmetic circuits, memories and microprocessors. Appendices contain listings of digital ICs sorted by family and function. Each entry includes the part number, temperature grade, description, pin count, maximum power, 100-piece price and supplier code.

TAB Professional and Reference Books, Blue Ridge Summit, PA 17294-0850; 717-794-2191.

Master Guide to Electronics Circuits, by Harry L. Helms; Prentice-Hall; 293 pages; $34.

This guide—a compilation of the latest circuit designs and applications that have appeared in recent electronics magazines, applications notes and databooks—covers the range of contemporary electronics technology. Dozens of new application areas are addressed, with emphasis on topics such as robotics, printers and automotive applications. Sources of materials are listed for each schematic for further reference.

Prentice Hall, Route 9W, Englewood Cliffs, NJ 07632; 201-767-5937.

New Handbook of Electronic Data, by Martin Clifford; Prentice Hall; 385 pages; $31.

This handbook minimizes the research necessary for finding specific electronics information. The most commonly used formulas are included without getting involved in the theory behind them—explanations are used to clarify the use of a formula or its derivation. A knowledge of elementary algebra and trigonometry are recommended.

Prentice Hall, Route 9W, Englewood Cliffs, NJ 07632; 201-767-5937.

Enhanced Sound—22 Electronics Projects for the Audiophile, by Richard Kaufman; TAB Books; 180 pages; $9.70 paperback, $15.95 hardbound.

This book describes 22 easy-to-build projects that will provide better sound for bargain prices. The book provides basic information for those who have never worked with electronics before: how to recognize and choose components, how to prepare circuit boards and how to solder. BASIC computer programs help readers design their own speakers and enclosures.

TAB Professional and Reference Books, Blue Ridge Summit, PA 17294-0850; 717-794-2191.

Handbook of Polyphase Electric Motors, by John E. Traister; Prentice Hall; 209 pages; $37.

The comprehensive guide details how to select and install polyphase motors, how to perform routine preventive maintenance and how to troubleshoot any problem.

Prentice Hall, Route 9W, Englewood Cliffs, NJ 07632; 201-767-5937.

PHOTOFACT

HITACHI
2606-1 . . . . CT2660, CT2661

PANASONIC
2600-1 . . . . CTJ-1355R
2604-1 . . . . . . CTJ-2570R/ CTJ-2579R

PHILCO
2600-2 . . . CHASSIS 19C705/08/15/17

QUASAR
2601-1 . . . . . . TL9981BK/82BW/88BP, TT9901BE

RCA
2603-1 . . . . FMR470E/75W/77E/90D, FMR505W

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2603-2 . . . . 564.42152750/52
2604-2 . . . . 564.42702750
2605-1 . . . . 564.42352750/51
2602-2 . . . . 564.42902750

SONY
2601-2 . . . . . KV-2725R/26R/28R/29R
2602-2 . . . . KV-1929R (CH. SCC-754Z-A)
2605-2 . . . . KV-27HFR (SCC-A61A-A, SCC-A66B-A, SCC-A05D-A)

ES&T

Build your own

Microwave oven test bottle

By Donald P. Hopkins

One method of determining the radiation pattern inside the cooking cavity of a microwave oven is to place a cup of water in each corner and cook for two minutes, then check the temperature of each cup. This time-consuming method can be done much faster by making your own microwave energy radiation tester from a bottle and four neon lamps. This test fixture gives visual indication that the magnetron tube is functioning properly, and it tests the stirring motor and blade.

My first attempt to check for radiation in an oven was with a 10-inch square piece of cardboard on top of a cup of water in the oven. A hole near each corner of the cardboard held a NE-51 type lamp. When the oven was energized, all four lamps lit brilliantly, then burned out or exploded. The experiment was a failure.

My next attempt to check the oven's radiation was with a one-quart juice bottle filled with water. (Use a jar that is specified as safe for the microwave.) Four NE-2 lamps were glued with silicone seal to the outside. (See Figure 1.)

After experimenting with the length of the leads, I found that making a loop with them and twisting the wires ¼-inch from the body of the lamp worked best. The loop formed with the leads of the lamp acts as an antenna and produces an electric potential great enough to ionize the gas in the lamp. If the leads are too long, the wires from the lamps will burn off. At any moment, depending on the position of the stirring blade, one or more lamps will be lit. (See Figure 2.)

My first test fixture worked great for many months and immediately became a tool for each microwave oven repair.

Servicing guidelines

When you service microwave ovens, it is recommended that you monitor the high voltage. Do not use any meter unless it can check up to *negative* 5,000Vdc. And *do not* use a TV repairman's HV probe by connecting it backward. Use the proper tools.

I have wondered a few times about the current going into the magnetron tube. I recommend not measuring it. This current is very dangerous and can destroy a meter instantly. With this fixture, there is no need to check the tube's current. Just monitor the high voltage, which also can indicate what the problem is in many cases. The high voltage normally will be from −1,800Vdc to −3,600Vdc, depending on the load. This voltage is more lethal than the 30kV on a TV picture tube with the set energized. The current that a TV set can deliver to the anode is only about 2mA; the microwave oven can deliver about 500mA—sufficient to kill a person quickly. If this article does anything, let it provide caution to the servicer. In summary, always monitor the high voltage, if only to remind you to be careful.

Always replace the line fuse because it tends to go bad with age. Don't depend on an old fuse—you may get a recheck. ABC 15 is the most common, then ABC 20. Some ovens use a 20A plug fuse or a cartridge fuse.

A few tips

Microwave ovens usually are easier to repair than TVs, but they also have their "hide and seek" antics. For example, when the high voltage is on the magnetron and the oven seems to be operating normally but is not cooking, usually either the magnetron tube is defective or the filament voltage is missing. As Figure 3 shows, the transformer in this oven has two secondary windings, one of which is used to provide filament voltage to the magnetron. If this portion of the transformer fails, no voltage is supplied to the filament of the magnetron. Even if you have high voltage and the oven appears to be operating normally, the magnetron will not operate. This symptom may be encountered even in ovens that use a separate filament transformer because the high voltage normally will still be present even if the filament voltage is absent.

When the filament voltage is missing and the high voltage is present, two tests are necessary. After unplugging the oven and discharging the capacitor, disconnect the leads to the magnetron tube and check continuity, then check the filament secondary as shown in Figure 4. Sometimes, if you pull on the leads to the tube, a loose connection may temporarily seem all right, then surprise you with a recheck in a few days. Other times, replacing the connector crimped onto the wire of the filament winding of the transformer can restore the 2.5Vac for the tube's heater.

Never solder a solderless connector to the terminal it is pushed onto. On several occasions, I have found a defec-

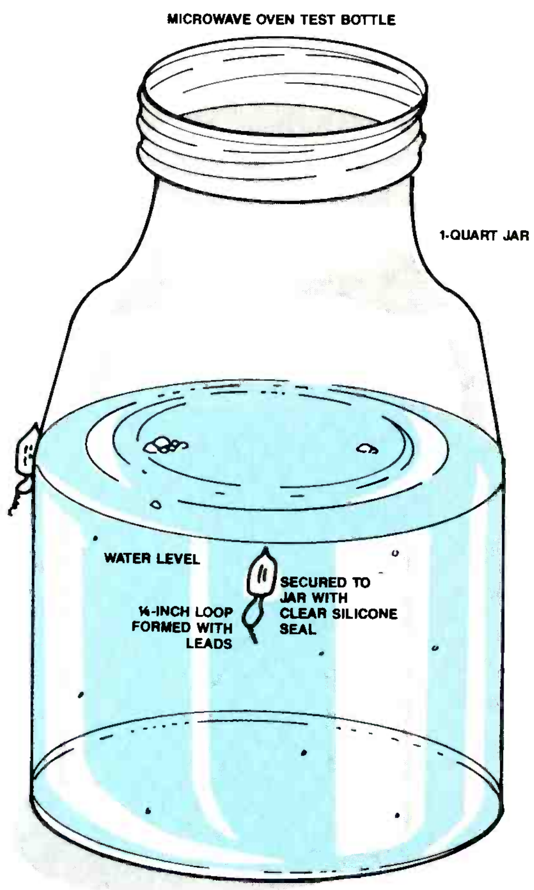


Figure 1. To check the oven's radiation, you can use a microwave-safe, one-quart juice bottle filled with water. Four NE-2 lamps glued with silicone seal to the outside show hot or weak spots.

tive lead that connects the filament winding to the magnetron tube filament connector, and a new wire fixed the problem. Do not attempt to use red high-voltage wire intended for TV use. Only use 18-gauge stranded wire with a 5kV insulation rating, and crimp on the connectors with a V or W crimp, not with pliers.

Because of the high current drawn by the primary of the high-voltage transformer, you might find burnt connectors on door switches, and the wire may need to be replaced. A professional technician will replace the wire and connector, using judgment to do a good job. Magnetron heaters seldom open. The tube usually shorts out first.

Check the fuse

The microwave energy from the waveguide section is distributed into the cooking cavity by the stirring blade on top of the cavity. The energy bounces between the walls of the tuned cavity, attenuated by the food. The food molecules become warm by absorbing the microwave energy.

When radiation is introduced into an empty cavity, arcing may result between the door gasket or in a corner. The resulting burn carbonizes quickly, and further arcing will load down the high voltage enough to open the line fuse. Ovens with a large load, like a turkey or roast, normally draw close to 15A from the 120V line, causing the fuse in the oven to become warm. After a year or two, the fuse may open. Always replace the fuse with the proper 15A or 20A ceramic line fuse, as specified by the wiring diagram supplied inside the shroud. Glass fuses may break and make a mess when they pop.

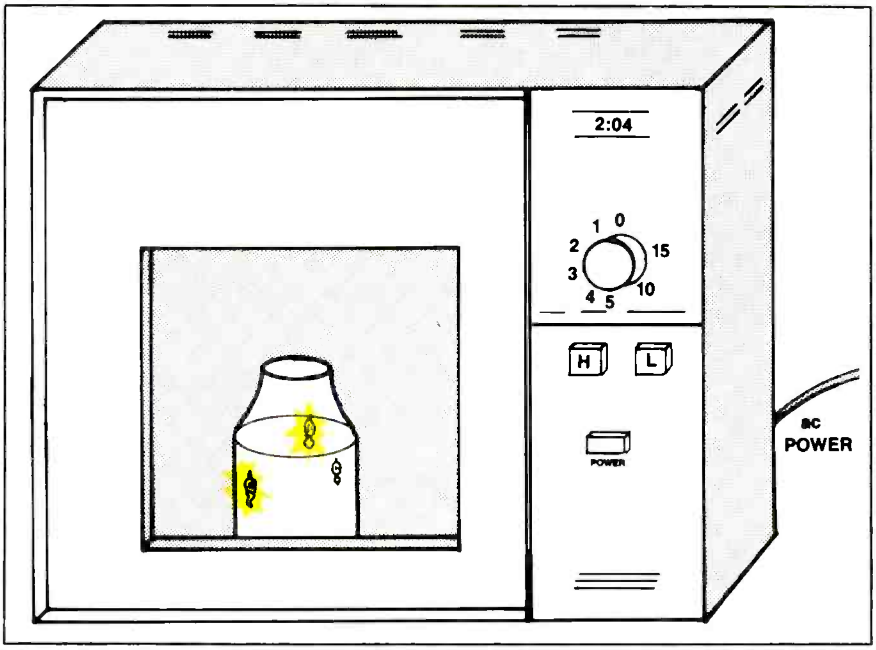


Figure 2. A loop formed by twisting the leads ¼-inch from the body of the lamp acts as an antenna and produces an electric potential great enough to ionize the gas in the lamp. At any moment, depending on the position of the stirring blade, one or more lamps will be lit.

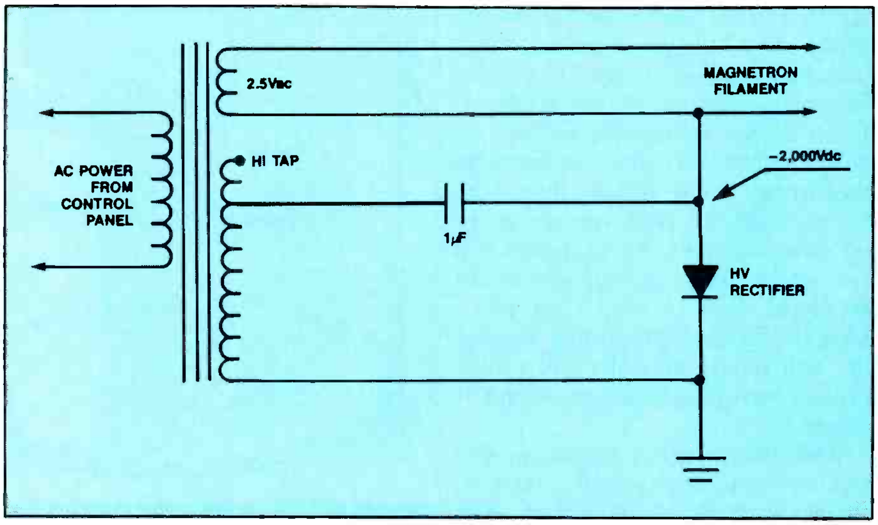


Figure 3. The transformer in this oven has two secondary windings, one of which is used to provide filament voltage to the magnetron. The magnetron tube requires −2,000Vdc on the cathode and 2.5Vac on the heater.

The lamps

As the microwave energy penetrates the neon lamp, the neon gas molecules are excited and become ionized. The silicone adhesive holding the lamp in place helps to absorb the energy slightly and helps dissipate the heat from the lamp. If no water is in the jar, a hot spot results and a tic mark may be burnt into the glass.

The NE-2 lamps may need to be replaced after 10 to 30 minutes of operation. Few lamps last more than an hour because of the high intensity and strain. Replacement is easy and should be done after the bottle is used several times.

The lamps will blink and flicker as the microwave energy is directed into the cavity. The cold and hot corners can be identified quickly, but turn the tester 90° to be sure a lamp is not weak. You can bend the stirring blade slightly to direct the energy evenly, but sometimes this procedure can be time consuming.

The container of water acts as a load and may need a trip to the faucet before it starts to boil. Don't allow the water to become too hot or the glass may crack. This is a tester, and it shouldn't be used for more than three minutes at a time.

It's a good idea to check the variable power cooking functions to see if they are working. When 25% power is in use, for example, the neon lamps will be energized for several seconds followed by a rest period, then energized again. Always check the variable power functions as part of the thorough checkout each oven should get after repairs are completed.

What to check

Always use the multiplier probe when measuring the high voltage. Forget about measuring the current through the magnetron—it's too dangerous, and the reading isn't that meaningful. The load

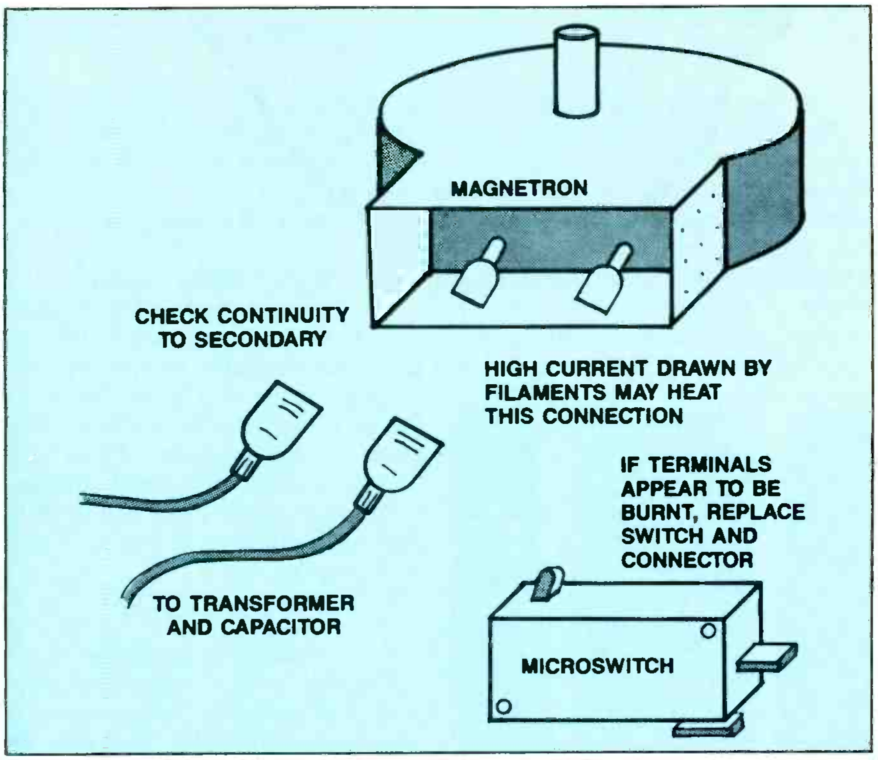


Figure 4. When the filament voltage is missing and the high voltage is present, two tests are necessary. After unplugging the oven and discharging the capacitor, disconnect the leads to the magnetron tube and check continuity, then check the filament secondary.

placed inside the cooking cavity may vary, and different ovens have differing characteristics.

If the neon lamps are lit dimly and radiation is not strong, try moving the lead on the HV transformer to the high side. This option boosts the output from the magnetron when the tube becomes weak with age. If there is no change, check the 1μf capacitor. These capacitors sometimes open internally and can only allow several hundred volts to the tube.

Most customers with older ovens would prefer to replace the unit with a new, full-featured model rather than spend more than $150 for the installation of a magnetron tube. I recommend shopping around for replacement magnetrons. For example, one parts house may sell the brand-name tube to the servicer or dealer for more than $100, while a discount store might sell the same tube for $45. If the price to the customer is too high, you may lose the sale and the diagnosis time. I have recouped from this situation by making the cost more reasonable to the customer. ES&T

Breakout box

The Blue Box 100 RS-232 breakout box and cable tester from *International Data Sciences* features 100 LEDs, 50 monitor points and 25 breakout switches. Other features include TD to RD cross-over switches; RTS, CTS, DCD and DTR switch control; piggy-back stacking jumpers; a cable tester; and a remote cable test adapter that tests continuity. All signals can be interrupted to allow for cross patching. An 8-position DIP switch provides control of often used signals.

Circle (73) on Reply Card

Pliers

Tool Tron has introduced the CLAMP-n-LOC micro-plier, commonly known as a hemostat or forceps. The plier is lighter and easier to use in hard-to-reach applications.

Circle (74) on Reply Card

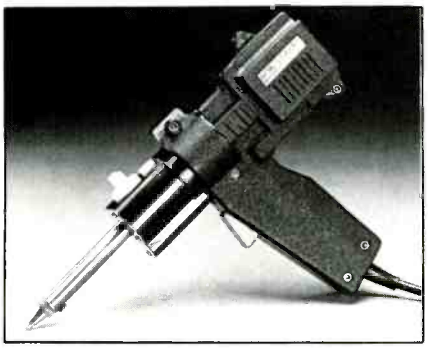
Micro-ohmmeter

The model 444 micro-ohmmeter from *Simpson* is designed for low-resistance measurement applications. Testing voltage (100μV maximum) and current (5mA) are designed to ensure against punching through contamination or corrosion. The unit features a 20,000-count, $4\frac{1}{2}$-digit display, four resistance ranges (20mΩ to 20Ω, with 1$\mu\Omega$ resolution), user-adjustable setpoints that activate audible and/or visual alarms, and two selectable measurement modes.

Circle (75) on Reply Card

Desoldering gun

The SA-55 trigger-action desoldering gun from *OK Industries* combines a 28W heating element with a piston-



driven vacuum pump. The ac-powered gun takes 3.5 minutes to reach its regulated temperature of 645° from a cold start.

Circle (76) on Reply Card

Hand-held multimeter

The 80 Series $3\frac{3}{4}$-digit, sealed, hand-held multimeters from *John Fluke Mfg.* feature simultaneous minimum/maximum/average recording and frequency, duty cycle, and capacitance functions. The Fluke 87 and 85 have extended Vac to 20kHz and dc voltage accuracy to within 0.1%. The true-rms Fluke 87 also has a $4\frac{1}{2}$-digit (20,000 count) mode and

a Peak MIN MAX recording mode. The Fluke 83 has an ac voltage response to 5kHz and dc voltage accuracy within 0.3%. The meters feature MIN MAX Alert, which signals that a new minimum or maximum value has been recorded, and Input Alert, which warns the user if the leads are connected to the wrong jack.

Circle (77) on Reply Card

Dual-trace oscilloscope

The model 1541A oscilloscope from *B&K-Precision* features 1mV sensitivity and V-mode operation, which allows two signals to be displayed in sync. The scope has 5mV full-bandwidth sensitivity and offers a flat response over the entire 40MHz bandwidth. Other features are 20 calibrated sweeps, 8.8ns rise time, x-y operation, z-axis input, and sum and difference capability.

Circle (78) on Reply Card

DMMs

Goldstar Precision Co., Ltd., has introduced the 7000 Series digital multimeters. The hand-held DM-7143 and bench-mounted DM-7241 manual-ranging models feature a $4\frac{1}{2}$-digit LCD display, over-load protection, basic accuracy of 0.05%, diode and continuity checks with audible alarm, and a measured value-hold function. The DM-7333 manual-ranging DMM has a $3\frac{1}{2}$-digit LCD display and transistor, capacitor and frequency-check terminals. The DM-7435 is autoranging with a transistor-check function.

Circle (79) on Reply Card

Work-holding system

The PanaVise Workholding System, available from *Jensen Tools,* features five interchangeable components, including three jaws. A 5/8-inch shaft fits into either of two screw-down PanaPositioner (base) components or a vacuum base. Also available is a fourth base featuring a low profile and a permanently mounted 5/8-inch shaft with a 3/8-inch −24 threaded end.

Circle (80) on Reply Card

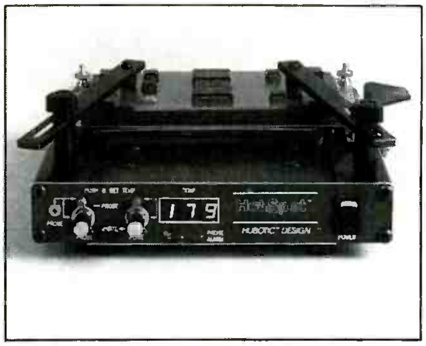
Hand cable strippers

The JCS series of hand cable strippers from *Rush Wire Strippers* have an adjustable-depth swivel blade that cuts insulation on large cables, both longitudinally and circumferentially. The tools can be used on cables measuring from 5/32-inch to 2-inch OD over insulation. Solid, stranded and multicore cable can be stripped to any strip length, and windows of insulation can be removed along the length of the cable.

Circle (81) on Reply Card

Surface-mount preheating system

The *PACE* HS-150 HotSpot digital surface-mount preheating system uses a conductive heating design to direct heat only where it is needed. Features include a closed-loop temperature controller, a set/read function and a digital temperature display. An external probe allows the operator to perform temperature profiling and monitoring of the work surface during the heating process.



An audible and visual alarm is activated when the probe reaches a set temperature.

Circle (82) on Reply Card

Office machine lubricant

Acculube II from *Lubricating Systems* is a non-toxic, biodegradable office-machine lubricant made from a pure organic base. The product cleans, lubricates, prevents rust, minimizes friction and protects surfaces. It can be used on metal, wood or plastic finishes. The lubricant does not attract dust and dirt and will remove lacquering from petroleum-base lubricants.

Circle (83) on Reply Card

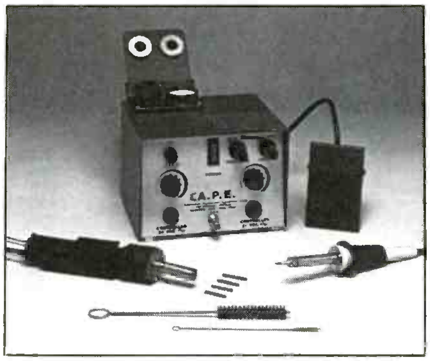
Static ground wrist strap

Desco Industries has introduced a static ground wrist strap with a Speidel band. Each link is laminated with a 2 mil thickness of PVF plastic film that should provide 10 to 20 times longer life than ordinary static wrist bands.

Circle (84) on Reply Card

Solder extractor

The *A.P.E.* model EX-501 solder extractor has a self-contained diaphragm pump that provides PSI air pressure and delivers 18 to 24 inches Hg. It is safe for use with static-sensitive components.



The extractor includes the model EX-1000 desoldering handpiece and a separate soldering iron, which feature temperature-controlled 24V heating elements.

Circle (85) on Reply Card

Word recognizer/trigger probe

The P6408 word recognizer/trigger probe from *Tektronix* decodes digital words up to 16 bits wide and is compatible with most standard logic families. Its SMG Grabber Tips allow the probe to reach circuitry with lead spacings down to 50 mils. The probe operates asynchronously or synchronously and has HI ($\geq +2V$) and LOW ($\leq 0.07V$) input levels for work with TTL and TTL-compatible logic.

Circle (86) on Reply Card

Tuner adaptor

Thomson Consumer Electronics has introduced the GE model 1CVA900 tuner adaptor, which allows any camcorder to record off the air. The unit has 155-channel capacity including 99 cable channels and offers digital keyboard/scan tuning, frequency synthesis tuning, A-V output jacks and unswitched ac outlet. The accessory also supplies an auxiliary signal for pix-in-pix VCRs.

Circle (87) on Reply Card

Feedback

The sixth color-code band

The following letter is Sam Wilson's answer to a query from Russell Offhaus about the second question in the June 1988 "Test Your Electronics Knowledge." The question was, "A certain resistor has six color-code bands: orange, orange, orange, red, red, orange. When it is connected across an ***exact*** *5V supply, what is the maximum current that can flow if the resistor is in tolerance?" The answer given was 0.0015321A based on a resistance value of 3.33kΩ ± 2%. Mr. Offhaus had never seen a sixth color band, and he also questioned the resistance value Mr. Wilson calculated.*

Dear Mr. Offhaus,

I just received a letter from **ES&T** magazine regarding the 6-color code for resistors. I have sent a copy of the page from the catalog that gives the full 6-color code (see Figure 1), which stands for the TC designator.

By the way, this is a recent addition to the color code, so any reference before 1987 would be of no use. Also, it is primarily for precision resistors. Any company making standard resistors would probably not have it.

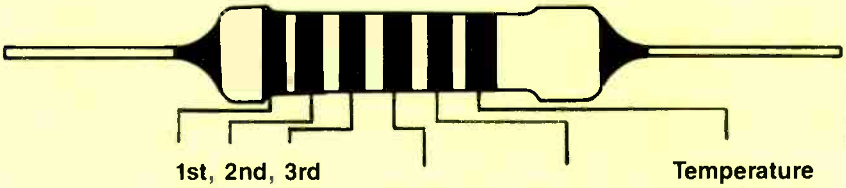
Sam Wilson

Dear Sam,

Thank you for your information on the sixth band color code. I have no need to purchase any precision-type resistors at this time, but if I did I would contact the Allen-Bradley company. However, when I did, to ask them about the six color codes, they were unaware, as was Ohmite. Not that it is any big deal, but I believe the resistor value should be 333kΩ, not 3.33kΩ. Using the multiplier (red), I come up with 333 × 10^2, or 333,000.

Russell R. Offhaus
Chincoteague, VA

Editor's note: I'm not sure how this got so confused, but according to my calculations, neither Sam nor Mr. Offhaus is correct. Three orange bands give the number 333. A red multiplier color band gives a multiplier of 10^2, or 100, for a resistance of 33,300. The correct answer to this question, then, is 33.3kΩ, not 3.33kΩ or 333kΩ. For more information about the sixth color-code band, see "What Do You Know About Electronics?" in the October 1987 issue.



Color	1st, 2nd, 3rd significant figure	Multiplier	Tolerance	Temperature coefficient
black	0	1		
brown	1	10	±1%	
red	2	10^2	±2%	±50ppm/°C
orange	3	10^3		
yellow	4	10^4		±25ppm/°C
green	5	10^5	±0.5%	
blue	6	10^6		
violet	7	10^7		
gray	8	10^8		
white	9	10^9		
silver		10^{-1}		
gold		10^{-2}	±5%	

Editor's note: The photo credit for the September 1988 cover was inadvertently left off in the "On the cover" section in the table of contents. The photo was provided by HMC, a distributor of electronics products.

Handling pulse amplitudes

In the August 1988 issue's "Test Your Electronics Knowledge," question number one states a word of caution that is wrong. The article said, "Caution: your scope must be able to handle pulse amplitudes as high as 120V to 150V."

For a brief explanation: The pulse amplitudes from the collector of the horizontal output transistor (or stage) can range in the 800V to 1,500V area. This is "plus" (added to) it's dc (B+) potential above its ground (whether it's delta or chassis grounded).

An erroneous word of caution like this could cause someone to either hurt themselves from not expecting that amount of voltage to be there and/or "smoke" some low-grade scopes.

Paul W. Molbert, ET
Jackson, LA

Editor's note: Yes, there was an error in the information given in Question 1 of "Test Your Electronics Knowledge" in the August 1988 issue. The question should have read:
"At the collector of the horizontal output stage, you should measure the regulated dc voltage that is specified on the schematic. You should also see pulses that repeat every 63.5µs. How wide are the pulses? (Caution: Your scope must be able to handle pulse amplitudes as high as 1,200V to 1,500V.)"

Do you have a comment, a gripe or some other valuable information that you would like to share with the editors and/or readers of *ES&T?* Please address your comments to: Feedback, Electronic Servicing & Technology, P.O. Box 12901, Overland Park, KS 66212.

Answers to the quiz

Questions are on page 17.

1. B—Incorrect. The power dissipated by a resistor is measured in watts, but it was Joule who first evaluated the conversion of current (through a resistance) into heat.

2. B. The Kelvin bridge is especially useful for measuring low values of resistance where the lead resistance can be an important part of the resistance being measured.

3. Electrostatic voltmeters have a much higher input resistance. They are used as laboratory instruments. Figure D shows the principle of operation. They are made with two capacitor plates, one of which is movable. The capacitor is charged by the voltage being measured. The movable plate is attracted to the opposite plate and moves toward it against a spring force. A scale on the movable plate shows the voltage.

4. Capacitors and inductors. Parametric amplifiers are made with reactive components. Their operation depends upon the storage of energy. At the peak point of storage, outside energy is added.

5. A—The voltage is maximum at resonance. At resonance, the impedance of the series-tuned circuit is very low, so the current is limited only by the resistance. The high current through the resistor produces a high voltage drop.

6. A—The voltage is maximum at resonance. The impedance of the parallel-tuned resistor is maximum at resonance, and the voltage across it is maximum. The resistor lowers the circuit Q. That in turn makes the circuit tune over a wider range of frequencies. The resistor is sometimes called a *swamping resistor.*

7. B—Marconi antenna. The broadcast antenna is a quarter-wavelength type. A Hertz antenna is a half-wavelength type.

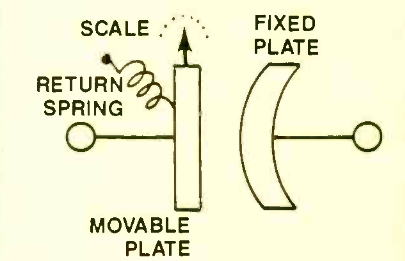


FIGURE D

8. B—the antenna system. This is the best possibility of the choices given.

9. A—1940. Because of the high interest in cellular phones today, it would be easy to assume that mobile phones are a totally new concept, but the 1930s and 1940s produced some very sophisticated equipment.

10. A—6,250kHz. The VCO frequency has to be five times the frequency at the input to the phase detector. That way, when it is divided by five it will be equal to the 1,250kHz input, and their phases can be compared in that stage. ES&T

Servicing the compact disc player—Part I

By Martin Clifford

This is the first part in a series on servicing compact disc players. Part I will deal with narrowing down the possible causes of the trouble symptoms.

Troubleshooting compact disc (CD) player systems can involve five possible sources of trouble: the compact disc; the compact disc player; the associated high-fidelity sound system; the external power supply consisting of a battery (or batteries) or the ac power line; and the user of the CD player.

Compact disc player systems are user-friendly, and considering the state of the art and the electronic sophistication of both the compact disc and its player, the system is remarkably easy to use. It is, for example, simpler to set up and operate than an analog phono record and turntable, particularly because no compact disc player adjustments are required.

Is it the disc or its player?

It is easy enough to assume that all compact discs are perfect because they have no moving parts, but discs can be warped and may have faults, such as pin holes or scratches, that are invisible or practically so.

Often enough a customer will bring a CD player into a service facility with the complaint that the player does not track properly. The audio, for example, will have constant dropouts. Although this problem could be caused by a bad laser-beam optic assembly or misalignment, the trouble can be as simple as a defective disc.

Therefore, the obvious first step in servicing any compact disc player is to start by playing a disc known to be in good working order. Every user of a CD system and service technicians as well should set aside one disc for this purpose and regard it as a test disc. When an apparent problem with a CD crops up, this method can be used to determine whether a disc or its player is at fault.

As a final check, examine the problem disc. Hold the disc up to the light and check for pinholes. Examine the surface. The light from the reflective surface should be uniform. Use a strong, steady light from an electric light bulb (but not a fluorescent) and tilt the disc slowly to check for scratches.

Determining phase response

A phase test can be made of the CD player using audio test tones of 2kHz and 20kHz. The two signals should have simultaneous zero-axis crossing in the same direction (Figure 1). This would indicate an ideal phase response. Such phase accuracy results in superior stereo imaging.

Do this test by using a twin test-tone signal with 2kHz in the left channel and 20kHz in the right. Their zero-crossings at the center should show almost perfect coincidence.

Sources of interference

In some instances, the complaint may not be about sound reproduction but about the effect the CD player has on other electronic in-home components—radio and television reception or computer operation.

CD players generate and use radio-frequency energy, and if they are not installed and used properly in strict accordance with the manufacturer's instructions, they can cause radio-frequency interference (RFI).

A CD player must be type-tested by the manufacturer and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when the compact disc player is installed in any residence.

There is no guarantee that interference will not occur in a particular installation. However, if the compact disc player does cause interference to radio or television reception, or if it causes erratic operation of a computer, there are certain steps that may cure the problem.

Removing the interference

The first step to take is to make sure that the compact disc player is the source of the interference. Turn on the radio receiver, television set or computer and get the device to operate with the compact disc player turned off. Then turn the player on and note whether interference occurs. The result can be horizontal wavy lines across the television set or computer screen, noise in a radio receiver, or incorrect results out of the computer.

Television interference (TVI) can be caused in two ways: by feedback through the ac power lines and by broadcast interference, in which the compact disc player radiates a signal.

To check on interference via the power line, turn on both the TV set and the CD player. As a first step, try reversing the TV's power-line plug (if the plug is not polarized). Sometimes this simple expedient will produce a cure. If it doesn't, try connecting the TV to a different outlet. If the set's power-line cord isn't long enough, use a 25-foot or

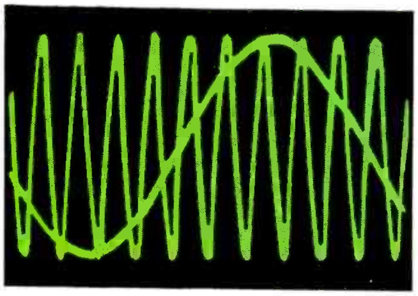


Figure 1. A phase test can be made of the CD player using audio test tones of 2kHz and 20kHz. The two signals should have simultaneous zero-axis crossing in the same direction. (Courtesy Analog & Digital Systems.)

Clifford, a freelance writer, has published more than 75 books on electronics.

50-foot extension cord. Keep trying different outlets until you find one that eliminates the interference. If this method does not remove the TVI and you want to continue using the same outlet, you can do so by installing a line-noise filter.

Power-line interference

It is possible that changing TV outlets will not eliminate the interference but will only reduce it slightly. In that case, the interference not only stems from the power line but also by pickup from the TV antenna, its transmission line (the download) or both.

The downlead of the TV antenna will be either 300Ω transmission line or 75Ω coaxial cable. If it is coaxial cable, you can eliminate it immediately as a possible interference signal pickup source because all such line is shielded with metallic braid that is automatically grounded when connected to the TV's antenna signal input terminals.

If the downlead is 300Ω transmission line, also known as 2-wire lead or twin lead, the line could be unshielded. If so, replace it with shielded 300Ω line.

You can also substitute 75Ω coaxial cable for the 300Ω twin lead, but you would have to install an impedance matching transformer (balun) at the antenna (if that antenna is rated at 300Ω) and at the antenna input terminals on the TV. These terminals are usually rated at 300Ω.

The TV antenna also could be picking up the interfering signal. If the antenna is equipped with a rotator, try turning the antenna to see if changing its orientation will eliminate the interference. If your antenna does not have a rotator, you can experiment with a rabbit-ear indoor type. Connect it in place of your regular lead-in and then rotate the antenna for a minimum interference pickup point. That is the approximate direction in which your antenna should be turned. The position of the antenna may need to be a compromise between the best TV signal pickup and minimum interference pickup.

If a radio receiver is picking up an interfering signal, run a test with the CD player and the receiver both on. Try using a different outlet just as you would with a TV set. If the interference is on AM, adjust the loopstick on the back of the receiver for minimum RFI pickup. If the interference is on FM and the receiver uses unshielded twin lead, follow the same procedure as you would for a TV set.

If RFI is interfering with your computer, connect the computer to a different outlet, use a line-noise filter or locate the computer in a different room as far from the CD player as possible.

For further information, you might consult the "How to Identify and Resolve Radio-TV Interference Problems" booklet prepared by the Federal Communication Commission. The booklet is available from the U.S. Government Printing Office, Washington, DC 20403. Stock No. 004-000-00354-4.

ES&T

Interfacing computers to the analog world—Part V

By Joseph J. Carr, CET

The first few parts in this series have described analog-to-digital (A/D) and digital-to-analog (D/A) converters. Last month we looked at techniques for performing an A/D conversion. This month we'll look at some practical data converters.

The last four installments of this series discussed popular ADC (analog-to-digital converter) circuits and the basic approaches to data converter design. The next several installments will take a look at several low-cost data converters that are frequently found in practical circuits and equipment. In selecting the examples from the many that are on the market, I examined whether these are available from either the mail-order advertisers in hobby magazines or from one or more of the replacement semiconductor lines that are typically sold by local electronic parts distributors. That selection limits the examples to those that ES&T readers are likely to encounter, should they wish a little hands-on "lab" self-instruction.

Carr, an electronics engineer, has published several books on electronics and is a frequent contributor to ES&T.

Digital-to-analog converters

A digital-to-analog converter (DAC) is a circuit or device that converts a binary word from a computer or other digital instrument to a proportional analog current or voltage. A number of different manufacturers offer low-cost, 8-bit IC DACs that contain almost all of the electronics needed for the process. The only electronics that might not be included are the reference source (which some DACs do contain) and some operational amplifiers for either level shifting or current-to-voltage conversion.

Two general forms of DAC are seen on the market: multiplying and non-multiplying. The multiplying DAC uses an external dc reference source and produces an output that is proportional to the product of the reference voltage (or current) and the binary input word. The DAC-08 is an example of a multiplying DAC. A non-multiplying DAC uses an internal reference source.

The DAC-08

For this article, I have selected the DAC-08 device. This 8-bit DAC is now something of an industry standard and is available from several sources including Precision Monolithics, its originator. The DAC-08 is a later-generation version of the old Motorola MC-1408 device. For non-PMI sources, this DAC is sometimes referred to as the LMDAC-0800.

Figure 1 shows the basic circuit con-

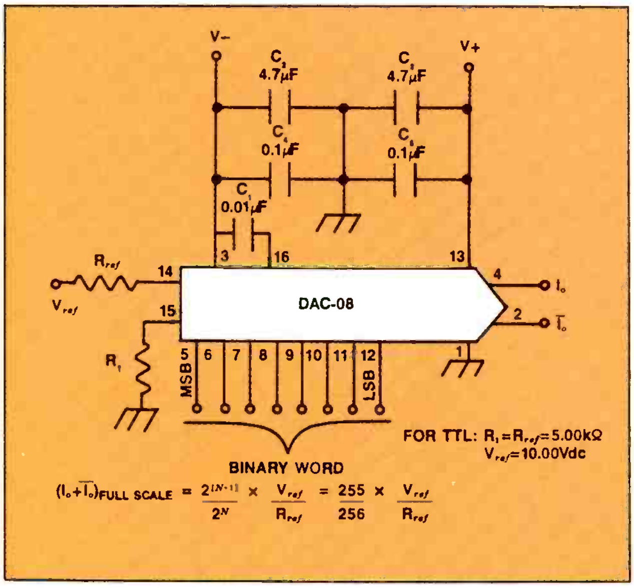
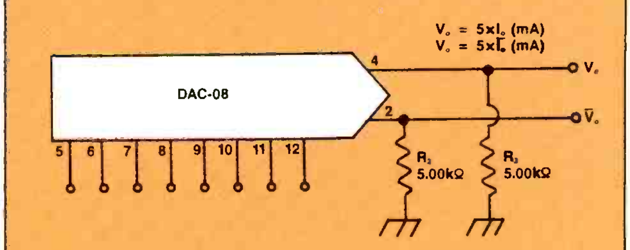


Figure 1. The internal circuitry of the DAC-08 is the R-2R ladder. However, it has two complementary outputs: I_o and not-I_o. Two types of input signal are required to make this DAC work: analog reference and digital word. One is the reference current, I_{ref}, applied through pin number 14. The other is the 8-bit digital word, which is applied to the IC at pins 5 through 12.



CONDITION	BINARY CODE	V_o
Full scale	11111111	−9.96Vdc
Half scale	10000000	−5.00Vdc
Zero	00000000	0.00Vdc

Figure 2. This circuit shows the connection of the DAC-08 (less power supply and reference input) required to provide the simplest form of unipolar operation over the range of approximately 0V to 10V. The circuit works by using resistors R_2 and R_3 as current-to-voltage converters. When currents I_o and not-I_o pass through these resistors, you get a voltage drop of IR or 5.00kΩ × I_o (mA).

figuration for the DAC-08. In subsequent circuits, I will delete the power-supply terminals for the sake of simplicity because they will always be the same as shown in Figure 1. The internal circuitry of the DAC-08 is the R-2R ladder. (See Computer Corner in the July issue for more on R-2R ladders.) However, it has two outputs: I_o and not-I_o. These outputs are complementary: If the full-scale output current is 2.0mA, then I_o + not-I_o = 2mA (that is, I_o=1.25mA, not-I_o=0.75mA).

Two types of input signal are required to make this DAC work: analog reference and digital word. One is the reference current, I_{ref}, applied through pin number 14. This current may be generated by a precision reference voltage source such as the REF-01 (or other) and a precision low-temperature-coefficient resistor to convert V_{ref} to I_{ref}. For TTL compatibility at the binary inputs, make V_{ref} 10.00V and R_{ref} 5,000.0Ω (precision).

A digital-to-analog converter (DAC) is a circuit or device that converts a binary word from a computer or other digital instrument to a proportional analog current or voltage.

The other type of input is the 8-bit digital word, which is applied to the IC at pins 5 through 12, as shown. The logic levels that operate these inputs can be preset by the voltage applied to pin number 1 (for TTL operation, pin number 1 is grounded). In the TTL-compatible configuration shown, LOW is 0V to 0.8V; HIGH is +2.4V to +5V.

Unipolar operation

Figure 2 shows the connection of the DAC-08 (less power supply and reference input) required to provide the simplest form of unipolar operation over the range of approximately 0V to 10V. When the input word is 00000000, the DAC output is 0V, ±dc offset error. A half-scale voltage (−5V) is given when the input word is 10000000. This situation occurs when the MSB (most significant digit) is HIGH and all other digital inputs are LOW. The full-scale output will exist only when the input word is 11111111 (all HIGH). The output under full-scale conditions will be −9.6V rather than 10V as might be expected. (Note: 9.96V is 1-LSB less than 10V.)

The circuit in Figure 2 works by using resistors R_2 and R_3 as current-to-voltage converters. When currents I_o and not-I_o pass through these resistors, you get a voltage drop of IR or 5.00kΩ × I_o (mA).

A problem with this circuit is that it has a high source impedance (5kΩ, with the values shown for R_2/R_3). We can solve that problem with the circuits discussed next month. ES&T

Coming Up in

ELECTRONIC
Servicing & Technology

November

Power Conditioning Equipment Update: Today's consumer electronic products are susceptible to damage from power line spikes, surges, sags and dropouts. ES&T describes some of these problems, and shows you the kinds of equipment available to solve them.

Wire and Cable: ES&T offers a look at the different kinds of wiring products and their characteristics.

December

Replacement Parts: Finding the correct replacement for a failed part is one of the biggest problems facing electronic servicing technicians. ES&T provides you with information on where to find replacement parts, and where to get information on selecting and obtaining replacement parts.

Changes in Consumer Electronics Servicing: Consumer electronics servicing has changed over the years. ES&T describes the increase in sophistication of the technician and the equipment needed to cope with these changes.

January

Personal Computer Servicing--Special Report: The number of personal computers found in homes and offices is constantly increasing. ES&T addresses the specific problems that plague personal computers, and explores ways to correct the problems when they occur. You'll also learn about the role depot repair, breakout boxes and logic probes play in servicing personal computers.

Technology Update--DAT: Digital audio tape is a technology that promises to deliver the audio quality of compact disc, but adds the ability to record at home with near perfect sound quality. This ES&T article will describe for you the current status of this technology, and explore how it differs from existing tape recorders.

Plus ES&T's Regular Monthly Departments

Elements of video optics —Part III

By Carl Bentz

This material was adapted from "Elements of TV Optics," published in Broadcast Engineering, August 1986. Information for this article was provided by Angenieux, Canon, Fujinon, Schneider and Tamron.

Apertures and f/stops

One method of reducing lens distortion is through the aperture control of an iris. The circular iris blocks rays passing through areas near the lens edge. Removing the errant rays reduces the effective diameter and aperture of the lens. The image is not as bright because there is less light being gathered into it.

Optical systems are rated by *relative aperture*. Commonly known as the *f/stop* number, the rating is derived from the focal length (FL) and effective diameter (d) of the clear lens area, or f/=FL/d. An f/4 lens has a focal length that is four times the effective diameter. If the effective diameter is increased by a factor of two, the aperture becomes f/2.8; reducing the diameter by half provides a relative aperture of f/5.6.

The smaller the numeric value of the f/stop, the faster the lens is rated. Fast lenses with large effective diameters allow more light to pass. Consequently, faster shutter speeds (or shorter exposure times) can be used in film cameras. Less light is needed to televise a picture. As the numeric value increases, exposure time increases.

Another rating uses transmission or *T/stops*. In this method, the value relates the amount of light that passes through the lens and strikes the film surface. Cinematographers claim T/stops to be more accurate for the work than f/stops.

Fields in focus

The aperture of a focal-length lens controls the depth of field. With larger apertures, the camera can be sharply focused only on the chosen subject and on objects a few feet in front of and behind the subject. In other words, if the subject is in the foreground and is sharply focused, everything in the background will be out of focus. If the subject is quite distant and is sharply focused, everything in front of the subject will be out of focus. If the subject is in the middle distance and is sharply focused, everything in the foreground and background will be out of focus.

Bentz is the TV technical editor for *Broadcast Engineering* magazine.

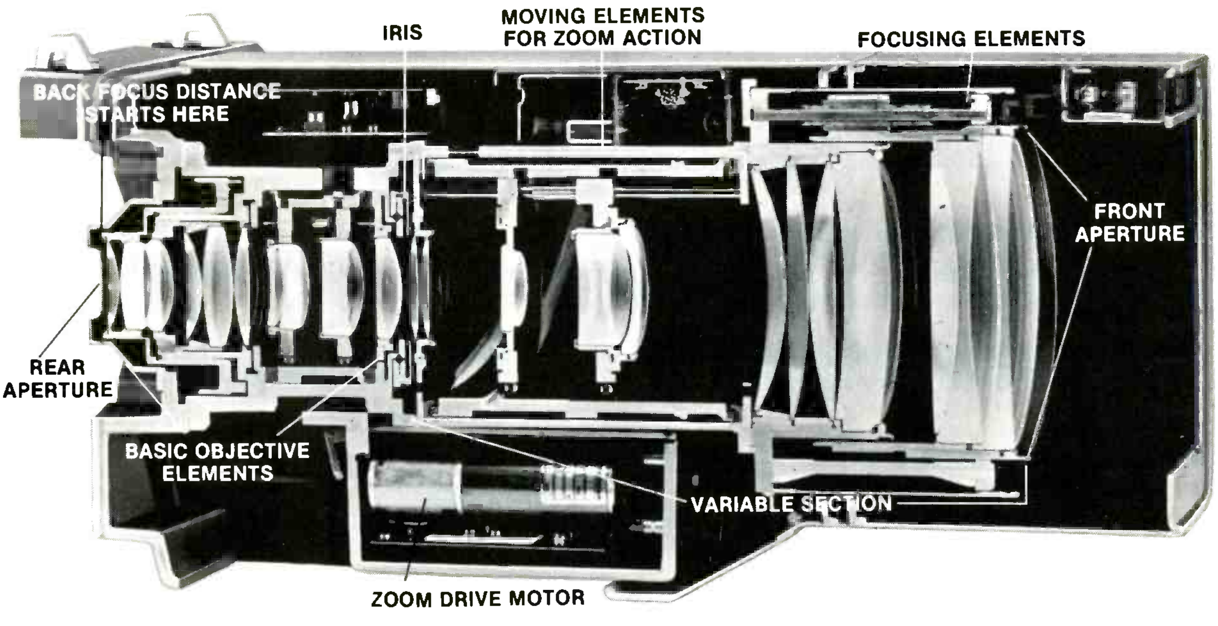


Figure 1. The cross-sectional view of a Schneider 30X 1.5-inch zoom lens system shows the relative placement of 31 individual pieces of glass, some cemented together for better light transmission characteristics.

This depth of field—the range of distances over which objects in the picture are in focus—increases as the lens aperture decreases.

If the aperture is reduced to a pinhole, the depth of field is effectively infinite. The light level is insufficient to be practical, however. Early photography with the camera obscura used small apertures instead of lenses and required exposure times from minutes to hours.

The focal length of the lens also affects the depth of field and the relative perspective of the viewed image. For longer focal lengths, depth of field decreases, and the perceived distance between objects—the key to visual perspective—seems to decrease.

An immovable lens

A simple magnifying glass is moved to provide the best image. With cameras, however, the lens is fixed and images must always be in focus at the specific point behind the lens. For photography, the image must focus on the film plane. In a TV camera, the image must fall on the pickup tube.

The distance from the most extreme point of the back element of the lens to the faceplate of the green tube or CCD is called the *back focus distance,* and it varies from camera to camera. As a result, optical systems are designed for specific camera models. Some amount of adjustment usually is possible, although it is generally a minimal amount. The red and blue distances should be equal to the green, but sometimes those two tubes must be physically moved to achieve correct back focus.

Another factor of the lens that should be matched to the camera is the *clear aperture of the rear lens.* If the aperture is too small, only a small portion of the faceplate is illuminated. If the rear aperture is too large, part of the image spills beyond the beam-swept area of the faceplate.

Introducing zoom

Prior to zoom optics, a set of fixed focal-length lenses were mounted on a turret at the front of the TV camera. When the director wanted a closer view, the operator turned the turret to position a longer lens. The concept presented problems for TV news cameras because turret assemblies with several lenses were heavy. For convenience, if nothing else, the zoom lens was developed.

To achieve a variable focal length, at least three groups of elements are needed. (See Figure 1.) The front *stationary objective* group can be adjusted over a limited distance with the focus ring. Next is a *movable zoom* group. Finally, a rear *stationary prime* or *relay* group determines final image size as light passes into the camera head. The rear group also fixes the back focal length.

Simple lenses could be used to create a zoom optical system, but each group normally consists of more than one element. As a simple example, a convex lens is effectively split to form two plano-convex types at the front and rear of the system. A divergent corrective lens used with each reduces optical aberrations.

The elements of the groups are cemented together for stability. Materials used for optical cements are critical because their refractive indices have an effect on the overall refraction.

Between the front and rear groups, a zoom or magnifying group also contains corrective elements. When positioned correctly, the zoom group sees the image produced by the objective group and creates a new image from it. The rear relay group picks up the image from the zoom group and relays it to the beam splitter and pickup devices.

The focal length of a zoom system may be further altered with a range extender. A 2X range extender between the zoom and relay groups doubles the image size and the focal lengths at both ends of the zoom range. Unfortunately, the laws of physics require the aperture to be halved.

In a well-designed zoom lens, a scene that is in focus at the closest (longest focal length) setting remains in focus as the lens is adjusted to its widest angle setting (shortest focal length). However, lens systems with a special macro portion of the zoom range for extremely close work often require adjustment of the focus.

Next month, we'll continue this series with a discussion of how the full-color image is separated into red, green and blue images. ES&T

SYMCURE/ Troubleshooting Tips guidelines

ES&T is now paying $60 per page (six different cases of symptoms and their solutions) for accepted Symcure submissions.

The term *Symcure* is a contraction of two words: symptom/cure. Problems that are published in the Symcure department are those that have occurred more than once.

This is the kind of problem you can solve without even a second thought because you've already seen so many of that particular brand and model of set with those symptoms; in almost every case, it will be the same component that fails or the same solder joint that opens.

It is preferred that you submit six or seven symptoms and cures for a single TV model.

ES&T is also paying $25 per item for accepted Troubleshooting Tips.

A Troubleshooting Tip describes a procedure used to diagnose, isolate and correct an actual instance of a specific problem in a specific piece of equipment. Its value, however, lies in the general methods described.

A good Troubleshooting Tip has the following elements:

- It should be a relatively uncommon problem.
- The diagnosis and repair should not be obvious and should present something of a challenge to a competent technician.
- It should include a detailed, step-by-step description of why you suspected the cause of the problem and how you confirmed your suspicions—anything that caused you to follow a false trail also should be included.
- It should describe how the repair was performed and any precautions about the possibility of damage to the set or injury to the servicer.

For Symcures and Troubleshooting Tips, please also include:

- the manufacturer's name;
- the model and chassis number;
- the Sams Photofact number; and
- a sketch of the schematic area where the fault was found. (Include a major component such as a transformer or transistor to provide a landmark for the **ES&T** staff.)

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- Mail to: Readers' Exchange, Electronic Servicing & Technology, P.O. Box 12901, Overland Park, KS 66212.

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

WANTED

Schematic and/or service manual for Hitachi VT88A VCR. Can buy or copy. *Gene McNaughton, 129 McDonald Blvd., Belleville, IL 62221; 618-235-5769.*

Schematic or service manual for Panasonic RS-281S home stereo. Will buy or copy and return. *Rick's TV, 218 S. 5th St., Menno, SD 57045; 605-387-5379.*

Beltron model 8080A CRT rejuvenator. *B. Batko, 4392 Cherryhurst Drive, Stow, OH 44224.*

Record/play head (new or used) for a Craig 2405 reel-to-reel. No longer available from Craig. Advise as to price and shipping. *A.J.'s Electronics, 601-A Herbert St., Port Orange, FL 32019; 904-767-0672.*

Schematic diagram page for a Pioneer SX-202 AM/FM stereo receiver. Not willing to pay Pioneer $9.98 for service manual. *John Lowry, 2296 Peytonsville Road, Franklin, TN 37064.*

CRT for B.M.C. data display monitor, model BM-AU9191U. Tube has 370NWB22 marked on it. Am also interested in substitute information. *Thomas Zwinger, TZ TV, 918 N. Concord, S. Saint Paul, MN 55075.*

Schematics for the following TVs: Sonyo ser. number 16708326—TO-130 AA; Zenith chassis 4B25C19; Sylvania ser. number CL 22488 T-1, chassis D 16155-0141071; RCA model GP 592L; Emerson model 26648, chassis 924A. *Al's Electronics, 3556 Larkin Road, Biggs, CA 95917.*

Schematic and information on a Tour Sound product, power system module 242S stereo sound master stereo 850C; schematic and service information on a VOX Churchill model VII9 amplifier made by Thomas Organ Co., output 120W 2Ω. Will pay for copies. *Arthur R. Vickery, P.O. Box 742, Torrington, CT 06790.*

Technical ship owner newsletter, issues #4, #6 and any other issue you may supply. We are interested in buying such information. *L. Romero, 3A BB-7 El Cortijo, Bayamon, PR 00620; 809-799-8032.*

Sony schematic diagram and/or service manual for TC-580. Copy OK. Will pay any reasonable fee. *Jim Hamric, 501 Forrest Ave., E. Brewton, AL 36427.*

December 1984 issue of Electronic Servicing & Technology. *James H. Jiranek, Ia.-89-1655, Farmington, IA 52626.*

Conar model 255 scope for parts; NRI equipment prior to 1960. *William P. Jarvis, 1214 Fifth Ave., Beaver Falls, PA 15010-4444; 412-846-7735.*

Operating manual for Tektronix model 454 dual-trace scope. Will pay a reasonable price. *Hector Zeno, Hector's TV Service, 3811 S. Manhattan Ave., Tampa, FL 33611; 813-831-4189.*

Schematic, service manual or Sams #53 for Zenith model 8G005YTZ1 transoceanic receiver. *David Parkinson, 160 Ralston Ave., Mill Valley, CA 94941.*

Good, used GE EP76X22 yoke or equivalent. Will throw the set away before paying $75 quoted by GE. *Leo E. Smith, P.O. Box 945 Vet Home Sect. J., Yountville, CA 94599.*

Chip designations (obliterated on unit)/schematic/any available service info for a Hybrid-8 by Video Interface Products. *Art Zack, 20120 Eagles Nest Road, Miami, FL 33189.*

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TV test equipment, parts and Sams. Call or send SASE for list. *Angleo Alessi, 29 Cross St., New Windsor, NY 12550; 914-562-9152.*

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Sams CB manuals, CB 8 to CB 200, $2 each; B&K model 1075, $75; B&K model 1465 oscilloscope, $150; assorted AR and TR manuals, $2 each. *John McLean, Glass Electronics, 2315 Fourth Ave. N., Billings, MT 59101.*

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VA-48 TV and video analyzer with two adapters, $600; TF-46 portable Super Cricket transistor checker, $200; B&K model 467 picture-tube restorer analyzer with CA-28 universal adapter, $250; Sencore model TF-40 transistor checker, $75. *Angelo Alessi, 29 Cross St., New Windsor, NY 12550; 914-562-9152.*

B&K model 177 VO meter, $90; B&K model 290 VO meter, $120. Both like new. *Alex R. Minelli, 718 Michigan St., Hebbing, MN 55746; 218-263-3598.*

RCA model WR-99A crystal-calibrated marker generator, $100; RCA model WR-514A TV Sweep Chanalyst, $100; Heath model IT-5230 CRT tester/rejuvenator, $70; RCA model WO33A scope, $30; Heath model SM2320 3½ digit DMM, $45; Heath model 3100 breadboard trainer and courses for ac, dc, semiconductor, soldering, $100. *Jeff Merrell, Box 46, Young America, IN 46998; 219-699-7255.*

Degaussing coil, $15; Sencore SM152 sweep marker, $95; Sencore DS148A scope, $75; B&K 1077B analyst, $175; Sylvania CK3000 test jig, $160; Telematic TA-3000 transverter, FVS-3950 focus supply, $50 for both; Sencore BE156 dc supply, $25; Superior 76 CR bridge, $20; Precision 177 VTVM, $15; GC 36-524 RC selector, $10. *Fremont TV & Electronics, 407 E. Main St., Fremont, WI 54940; 414-446-2239.*

Nearly complete Sams Photofacts to #2536; other manufacturers' service data; test equipment; parts inventory. Send SASE for list. *David A. Day, Flori-Day Electronics, 44 Avenue E., Apalachicola, FL 32320; 904-653-9637.*

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Sylvania 376 series (B&W) TV console, needs picture tube, $60 plus shipping or best offer. *Fremont TV & Electronics, 407 E. Main St., Fremont, WI 54940; 414-446-2239.*

A.B. Dick mimeograph machine with manual, $30 plus shipping; service manuals, text books, radio and TV parts; new standard brand tubes in manufacturers' cartons, 90% off list price. Send large SASE for list. *M. Seligsohn, 1455 55th St., Brooklyn, NY 11219.*

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Zenith model VR9750J beta VCR, built by Sony, in mint condition with only 20 hours run time, $125—I'll pay shipping charges. *Bob Goodman, P.O. Box 452, Alexandria, LA 71309; day phone: 318-442-7170; night phone; 318-640-1466.*

B&K Precision model 552, used only once, includes all manuals and cables, $300. *Richard L. Jackson, 312 Second Ave., DeWitt, IA 52742; 319-659-9942.*

ECG model FET-43 analog multimeter, 10M input impedance, seven dc volts range, six ac volts range, rms peak-to-peak, six resistance range, plus many other features, $40 plus shipping. Used only once. *Stanley Todorow, G8468 Belle Bluff Drive, Grand Blanc, MI 48439; 313-695-0271.*

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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. 6-88-tfn

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