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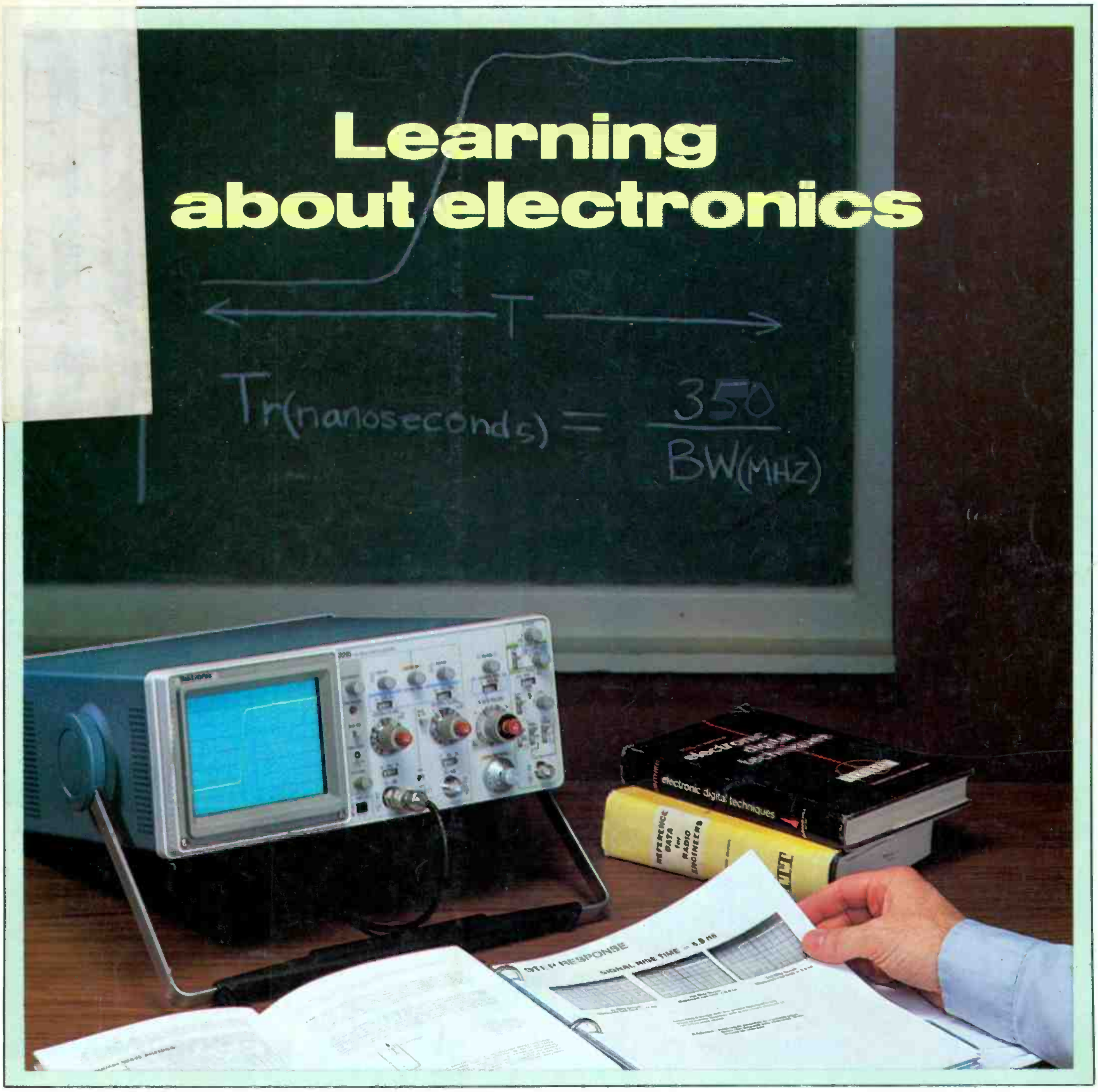
How to service Sharp's sweep circuits

Understanding decibels and time constants



The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

November 1983
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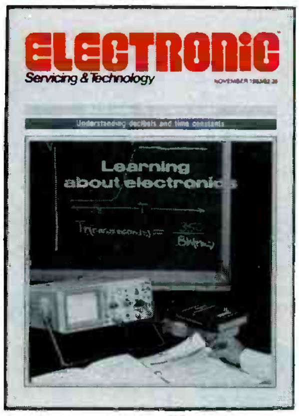

Electronics manuals, spec sheets and specific instruction handbooks are ideal sources for updating your electronics knowledge. For other methods of expanding your knowledge, see "Learning about Electronics" on page 24. (Cover photo courtesy of Tektronix.)

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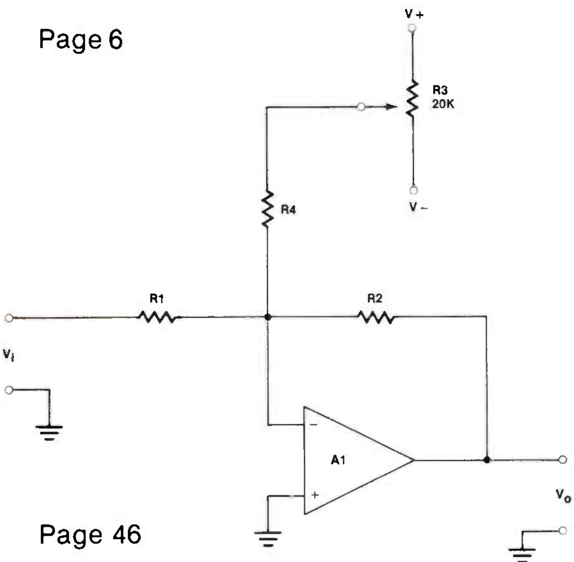

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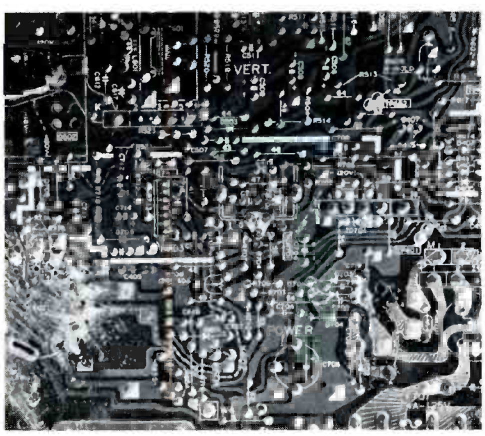

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Departments

Next month...

One of the more common items we see on the audio servicing bench is the cassette recorder. Although most repairs are the garden variety of clean-and-lube routines, occasionally we have to change a head or readjust the internal controls to get the machine back up to its operating potential. Kirk Vistain describes some of the adjustments that most commonly require attention.

Kill the umpire?

One of the problems with athletic events is that judging is done by mere humans, who are fallible. Even when officials are totally unbiased, they occasionally make mistakes. And have you noticed that when they make a bad call it always goes against your team?

In international athletic competition, the difficulties are compounded by nationalistic fervor. For example, according to researcher Joan de Regt of International Resource Development, an independent consulting firm in Norwalk, CT, "Political controversies often arise when you have a Yugoslavian judge who awards a Soviet gymnast an undeservedly high score, while an American judge might give that same gymnast an undeservedly low score. With the final outcomes of these events often decided by fractions of a point, it's a shame to see prejudice or political haggling obscure true athletic accomplishment."

How do you eliminate the human factor in judging events such as this? Why, turn it over to that electronic marvel, the computer, of course. It would work something like this. Computerized images for the ideal moves for the events would be recorded and made part of a computer database. When the athlete performs in competition, the performance would be recorded and transformed into computerized images, which would be compared with the record of the ideal routine. The score would be determined on the basis of this comparison.

According to de Regt, the use of such a system is likely to occur "sometime within the next four or five Olympiads," or roughly by the year 2000.

"It's not such a giant step to take," she says. "Many physicians are already using such imaging systems to analyze the mechanical factors involved in sports injuries."

This conjures up images of what might eventually be if this type of judging system were to be exploited to the fullest in all sports.

Just imagine in football, for example. We could put an electronic device inside the football and install sensors in the field. There would be no question of whether the offense had made the first down, or whether the ball had broken the plane of the goal line for a touchdown.

But it's in baseball that electronics could really do the job. Wouldn't it be great to eliminate all the umpires? For starters it would be a simple matter to get rid of the guy behind the plate. We'd replace home plate with a bar-code reading device like at the grocery store, and put bar codes on the baseballs and bats. Not only would you know if the ball was in the strike zone, you'd be able to detect whether the pitch was a fastball, curve, slider or sinker. You could also tell how fast the pitch was and if the batter swung early, late, high or low, or where he met the ball if he made contact. Sensors along the foul lines and base paths and at bases could take care of questions of fair or foul and safe or out.

But then, who would fans have to boo when a call went the wrong way? And who would Billy Martin kick sand on when he got frustrated? Baseball just wouldn't be the same without those men in blue whom fans just love to hate.

In this increasingly automated and computerized world, some jobs are best left to humans.

Nils Conrad Persson

ELECTRONIC Servicing & Technology

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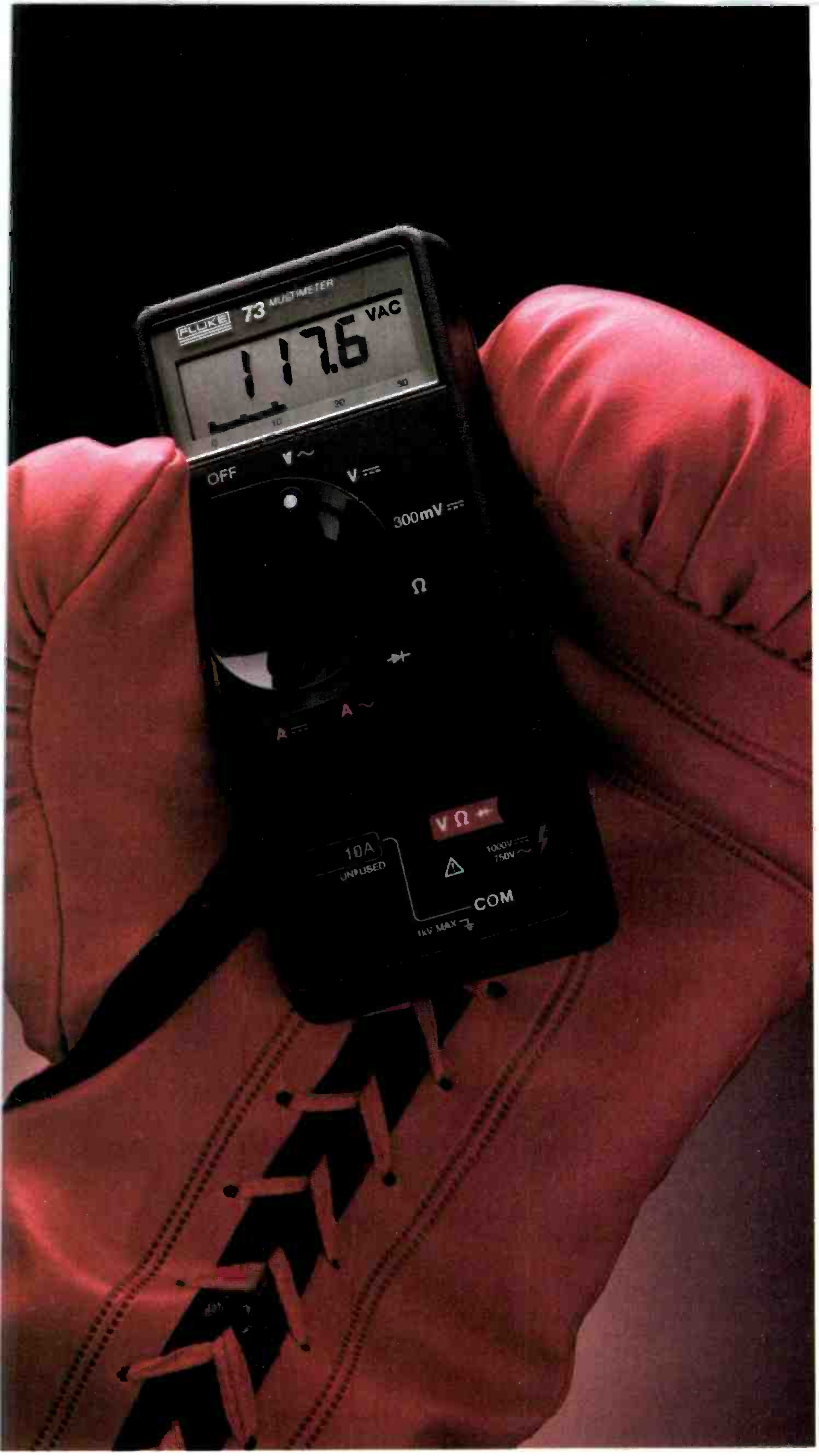

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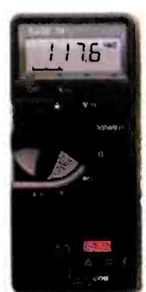

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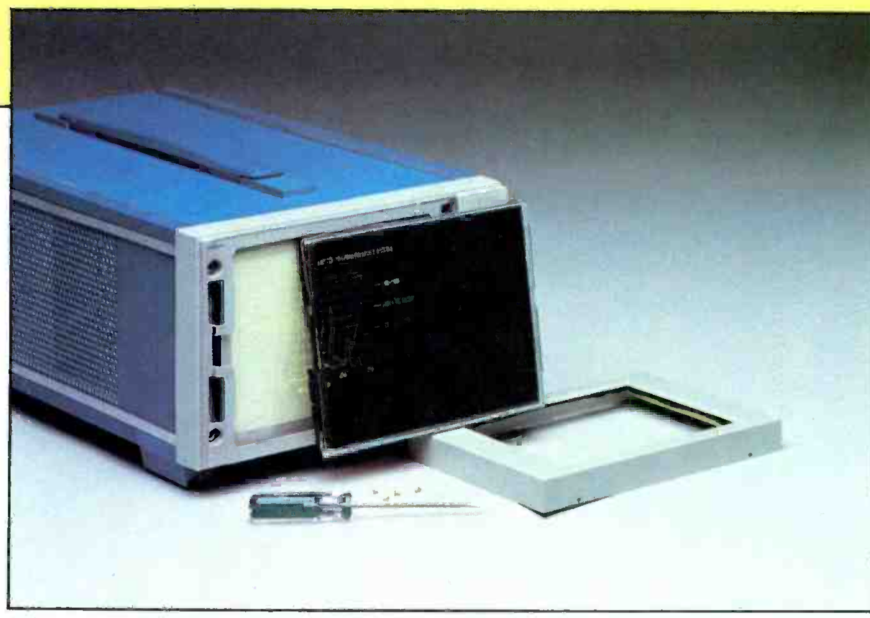
Technology

Liquid-crystal technology colors display capabilities

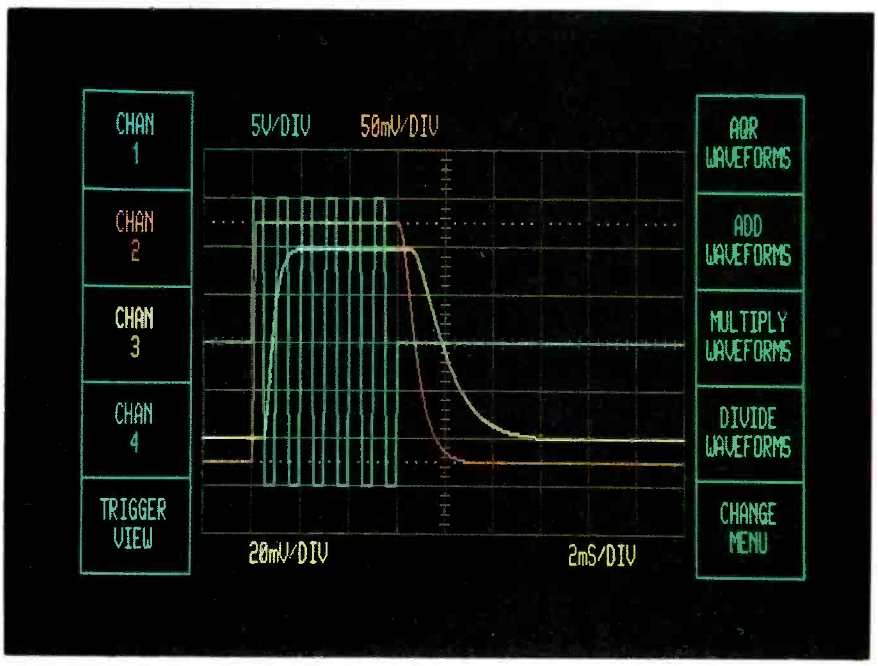


Tektronix' new color display system does not use shadow masks or penetration phosphors. Based on a combination of liquid-crystal and CRT technologies, the system combines a monochrome CRT and liquid-crystal "color switch" to produce a high-resolution, field-sequential color display.

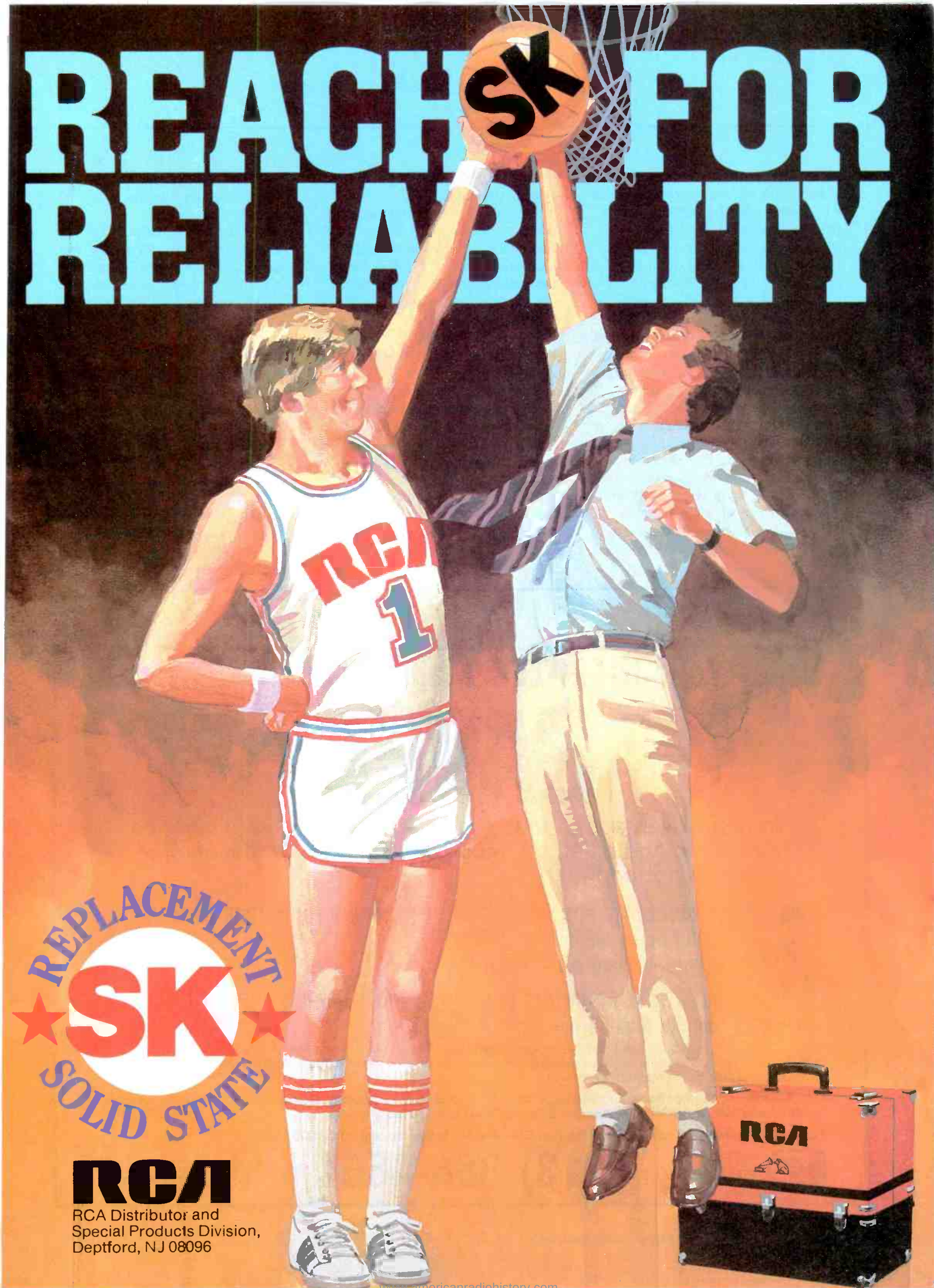
Because no shadow mask or patterned phosphors are used, the resolution can be as high as any monochrome CRT. This is a particular advantage in small display sizes where high-resolution color has not been practical before. Other advantages are inherent convergence (because only one electron beam is used), excellent contrast in high ambient light, and ruggedness, due to the absence of any fragile shadow mask or complex electron gun.

Previous attempts at producing a field-sequential system have suffered from the lack of a suitable fast color switch. The Tektronix liquid crystal color display uses a new, proprietary, fast liquid crystal optical switch combined with a monochrome CRT.

The assembly consists of a sandwich of special polarizers and Tektronix' proprietary liquid crystal π-cell. The liquid crystal color shutter acts similar to a



(Information and photos courtesy of Tektronix)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filter that switches between two states, one allowing primary color #1 to pass and the other passing primary color #2. The shutter switches between the two states in a few milliseconds upon the application of a low voltage electrical drive signal.

The CRT has a simple phosphor with two separate emission peaks that are typically, but not limited to, red and green. The phosphor does not require any patterning or special process steps. In any one field, the information written on the screen appears only in the color selected by the electronic switch. Each color is repeated at a 60Hz rate, requiring the 2-field system to run at a 120Hz rate. This field-sequential system can provide all possible mixtures of the two primary colors contained in the phosphor.

Research is continuing to extend the concept to three fields, with three primary colors, which will produce a full color gamut comparable to or better than conventional color display technologies.

Examples of where this new technology can provide color capability where it has not been practical before include:

- Small instrument displays, such as oscilloscopes, logic analyzers and spectrum analyzers. In the past, the need for high resolution to present waveform information has been a drawback. Now,Tektronix' liquid crystal color display's ability to function in both refresh vector and raster display modes makes new design breakthroughs possible.
- Small process control displays, such as those included on vacuum systems, can now include color for highlighting special situations and warnings.
- Computer workstations, where high-resolution is important.
- Word-processing equipment, where monochrome displays have been typically used because high-resolution color displays have either not been possible or too expensive. Tektronix' liquid crystal color display technology allows the addition of color without any resolution penalty. ES&T

How to service Sharp's sweep circuits

By Homer L. Davidson

In color TV receivers, most service problems originate in the sweep circuits or the power supplies. This certainly is true in 13in and 19in models by Sharp.

These models (Photofact 1959-2, for example) have several dc-voltage supplies produced by rectification of horizontal-sweep pulse or scan peaks. These voltage sources are stabilized by regulation of the +120V that is supplied to the horizontal-output transistor. However, the situation is complicated by two limitations. At turn-on, no horizontal sweep is generated, although it is necessary for proper operation of the +120V supply. This same +120V is essential for proper operation of the horizontal sweep. These contradictions are resolved through a series of small steps. An insufficient +120V supply at turn-on allows the horizontal sweep to operate weakly. The weak sweep increases the +120V actual voltage, which in turn strengthens the sweep, until the sweep is maximum and the regulated voltage is +120V. You must consider this interdependence of horizontal sweep and regulated voltage in troubleshooting of these two basic systems.

Low voltage and regulation

Figure 1 shows the complete low-voltage sources and +120V regulation for Sharp model C1935 (Photofact 1959-2). In normal operation of this circuitry, the full +164V from the bridge rectifier is applied to the SCR701 anode. SCR701 is gated into conduction by the I701 power-regulator IC at a time during each horizontal-sweep cycle as required to provide a constant +120V at integrating capacitor C708. An SCR, once it is gated on, continues conduction un-

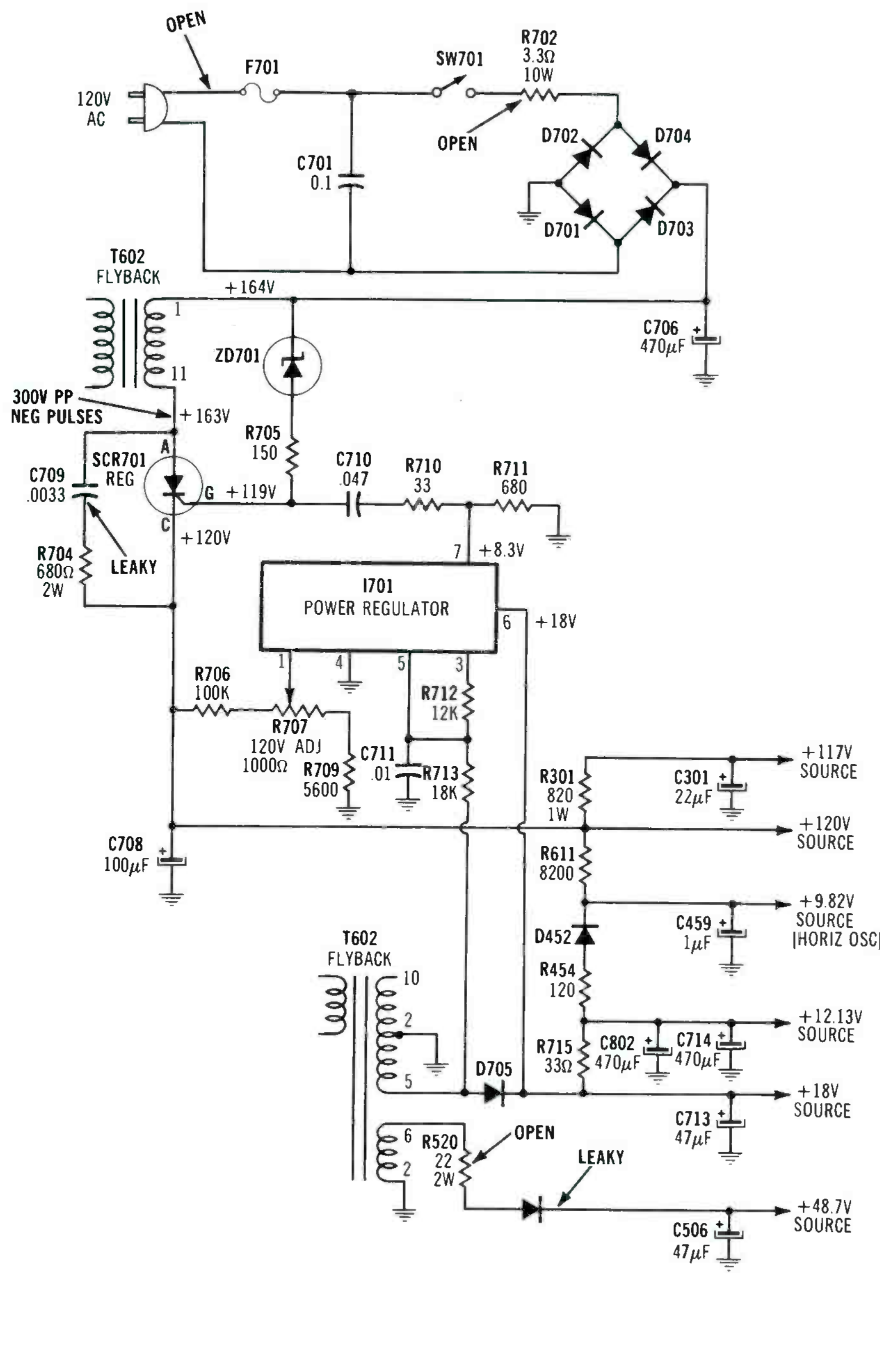

Figure 1. A bridge rectifier and C706 produce a filtered +164V supply that is regulated to +120V by SCR701 and I701.

til the anode voltage becomes negative relative to the cathode. Negative-going horizontal-sweep pulses from the flyback (pins 1 and 11) turn off SCR701. Power is applied to C708 from SCR701's rectification of these same negative-going pulses as well. Of course, all SCRs can be efficient rectifiers when supplied with proper gating and anode/cathode voltages. The +164V applied to the SCR701 anode changes the zero-voltage point of the anode negative-going pulses. Therefore, most of the pulse height is positive (rather than the usual negative) and it is rectified by the SCR701 anode/cathode diode action. C708 integrates these two source voltages (gated dc from the +164V plus rectified dc from the SCR) into an average voltage. When SCR701 is gated-on at the proper time during each horizontal cycle, a constant regulated voltage is produced.

It should be clear now why an insufficient voltage of about +76V is obtained from the +120V supply when there is no horizontal sweep: Without the SCR701 anode pulses, one of the power sources is missing, and the regulator gates-on the SCR at incorrect times.

Of course, the +120V regulator cannot operate correctly unless it is supplied with +164V from the bridge diodes that rectify the 60Hz line power. You should verify the presence of +164Vdc at the SCR701 anode before you waste too much time checking the regulator circuit.

A lower-than-normal supply voltage is obtained for the horizontal-oscillator circuit through R611 from the +120V source during start-up (or when the horizontal-sweep system is dead). When correct start-up activates the +18V source (from rectified horizontal-sweep power), D452 is forward biased and the oscillator voltage comes through R454, producing +9.82V supply for the oscillator. In other words, oscillator supply voltage comes through R611 during *start-up* and through R454 during normal *run* operation.

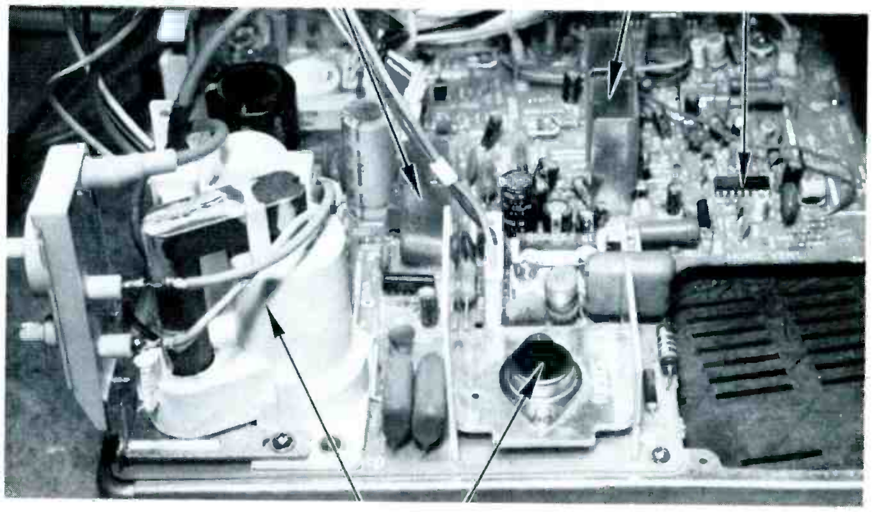

Figure 2. Arrows point to important components on the circuit board of a Montgomery Ward GSK12981B manufactured by Sharp. Clockwise from upper left, arrows indicate SCR701 heat sink, heat sinks for vertical output Q502 and Q503, I501, Q602 horizontal output, and the T602 flyback with focus and screen controls.

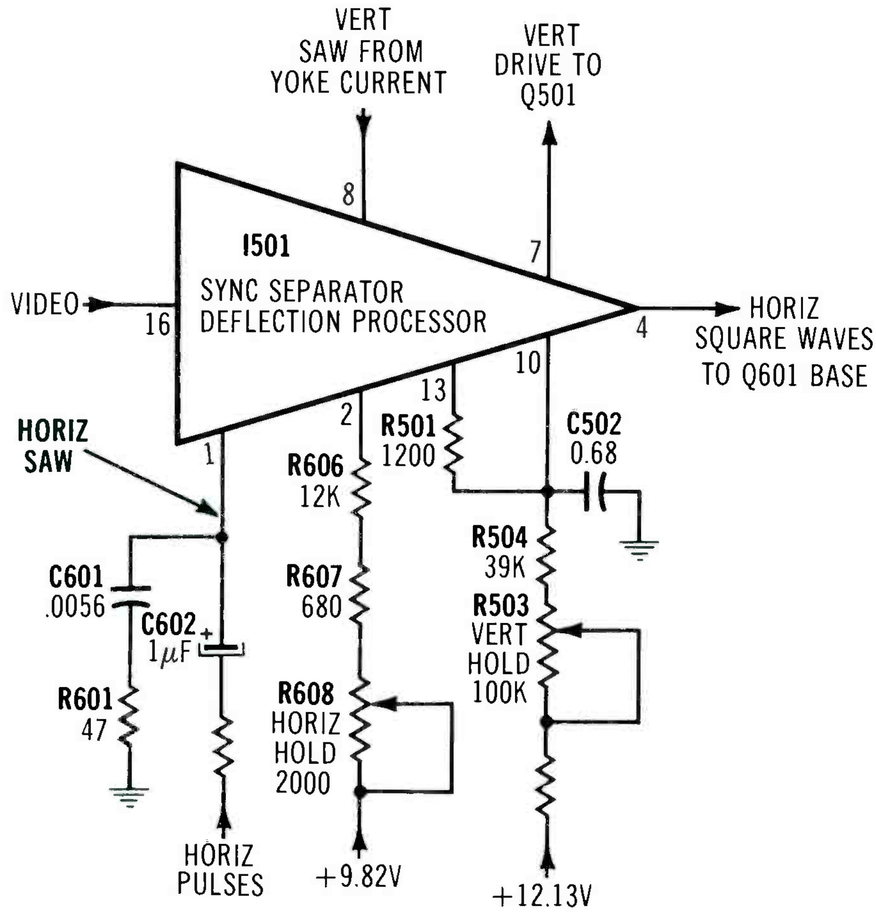

Figure 3. Solid-state components for sync separation, horizontal phase detector, horizontal oscillator and vertical oscillator are inside IC I501.

The dc power for the horizontal-driver and horizontal-output transistors comes from the +120V source at all times. However, at turn-on before start-up is complete, this voltage is less than

+80V. The low oscillator, driver and output start-up voltages can produce only weak sweep, even with a non-defective receiver. If start-up is not completed because of a sweep defect (or if start-up is followed immediately by shutdown), some of these stages might have a weak signal plus typically low start-up dc voltages.

The following are helpful suggestions for analyzing supply problems:

- Loss of horizontal sweep at the T602 flyback eliminates the high voltage, CRT screen voltage, CRT focus voltage, +171V boost supply, +12.13V source, +18V source and the +48.7V source.
- Loss of all +120V source also eliminates the +117V source and the horizontal oscillator start-up source voltage.
- The +117V source supplies only the sound-output transistors.
- The +171V boost source supplies only the red, blue and green output transistors that drive the CRT cathodes.
- The +120V regulated source supplies the horizontal-output transistor directly, the driver transistor through a dropping resistor, the +117V source through a resistor and the oscillator start-up voltage through R611.
- The horizontal oscillator operates after start-up from the +9.82V source.
- The +12.13V source supplies the vertical oscillator, some video and chroma stages and the IF stages.
- The +18V source supplies the sound IF stages and some chroma functions. Also, it supplies the +12.13V source (through resistors) and the horizontal oscillator start-up voltage.
- Two vertical-output transistors operate from the +48.7V source.

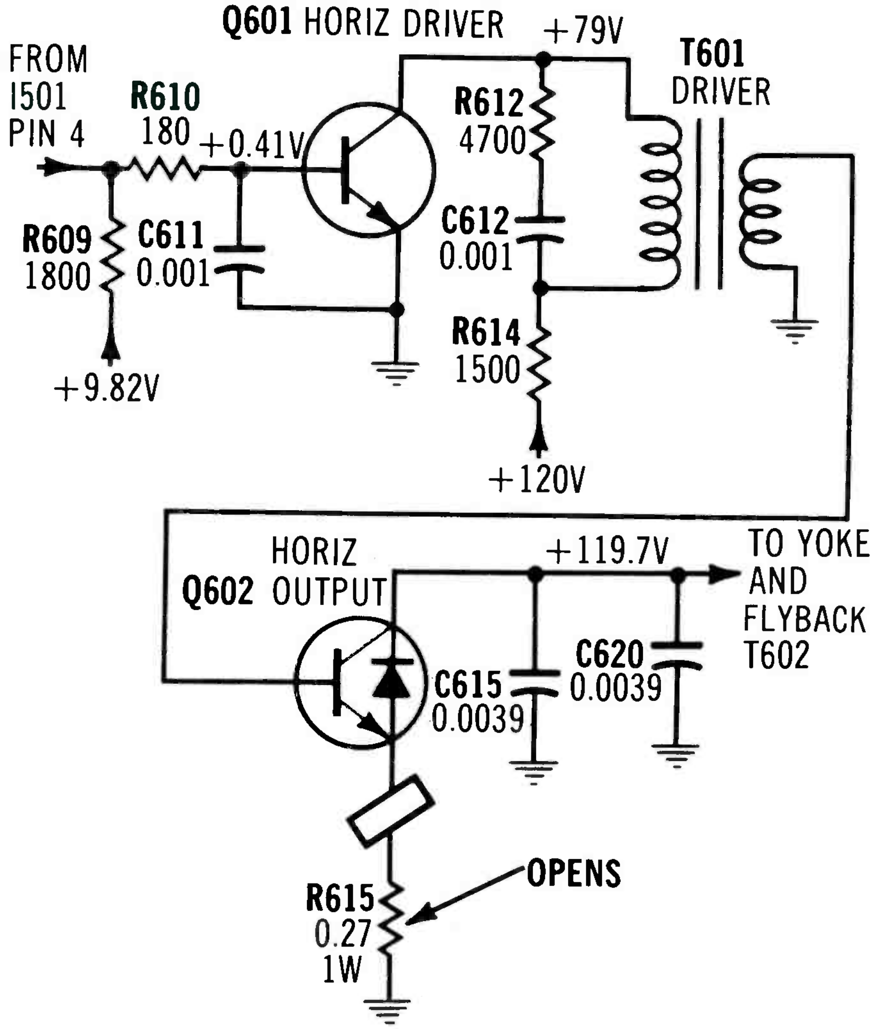

Figure 4. The horizontal driver and output stages are not unusual, except for the damper diode inside the Q602 transistor case and emitter resistor R615, which sometimes causes a motorboating of the +120V supply.

Servicing power supplies

Higher-than-normal voltages in the +120V source can be caused by leakage in SCR701 or C709 (0.0033μF), which feeds a steady current from the +164V supply to the +120V supply. A shorted ZD701 zener can maintain SCR701 in constant conduction. Also, a defective I701 regulator IC can produce excessive +120V source voltages, although this is rare. Another possibility is increased resistance in R706 (Figure 1).

Most SCR701 leakages can be found with a high-power ohmmeter (low-power mode voltage is not sufficient to check gate-to-cathode diode action), however the SCR should be removed from the circuit during the tests. Normal resistance between gate and cathode might measure 50Ω to perhaps 900Ω, depending on the ohmmeter used. Notice, however, that the ohmmeter polarity must apply the positive probe to the gate and the negative probe to the cathode. Resistances between anode and cathode or gate should be very high, perhaps above 5MΩ.

Low voltage from the +120V supply can be caused by these conditions: a low +164V line-rectified supply voltage, an increased resistance in R709, decreased R706 resistance or a loss of horizontal sweep.

Always remember that no more than +76V can be obtained from the +120V source unless the horizontal sweep is operating correctly.

Loss of all voltage in both the

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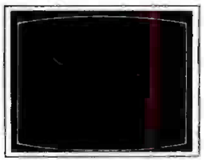
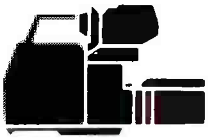


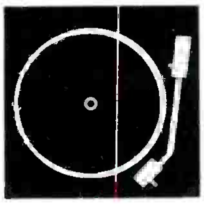


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+164V and +120V sources usually indicates that a strong overload (such as a shorted horizontal-output transistor) has blown the F701 4A fuse, or opened 3.3Ω R702. A shorted bridge rectifier also can ruin these two components, as can a shorted C706 main filter capacitor.

Horizontal-sweep problems

I501 deflection-processor IC (Figure 2, arrow at far right) contains the solid-state transistors for the horizontal and vertical oscillator circuits. A partial schematic is shown in Figure 3. Composite video comes into I501 at pin 16. The sync is separated inside I501 and applied to an internal phase detector. Horizontal pulses are integrated into sawteeth by R602, C602, C601 and R601. These sawteeth enter I501 at pin 1 where they are applied to the horizontal phase detector. Remember that sync and horizontal sawteeth are equally essential for solid locking and correct frequency. Whenever horizontal frequency is unstable, scope these signals at pins 16 and 1.

Horizontal-frequency square waves exit I501 at pin 4 and are applied to the Q601 base (Figure 4) as input signal and dc positive forward bias. Q601 inverts and amplifies the drive signal, and this stronger signal is coupled and impedance-matched by T601 driver transformer, which in turn drives the base of Q602, the horizontal-output transistor. Q602 then supplies sweep power to the deflection yoke and the T602 flyback.

Notice that the horizontal-output transistor is not a conventional type, but it has the damper diode inside the transistor case. Do *not* attempt to substitute a common type that does not have the diode. The transistor will fail when there is no damper diode. If possible, replace Q602 with the original 25D870 or 25D869 component.

All signals of the Figure 3 and Figure 4 circuits can be scoped safely, which makes the scope the instrument of choice for testing these horizontal stages. Scope the horizontal signal path starting with I501 pin 4 and continuing to the Q601 base, the collector of Q601, the Q602 base and finally the Q602 collector. When you locate the first missing or distorted waveform, you have isolated the problem to the circuit stage just prior to that point.

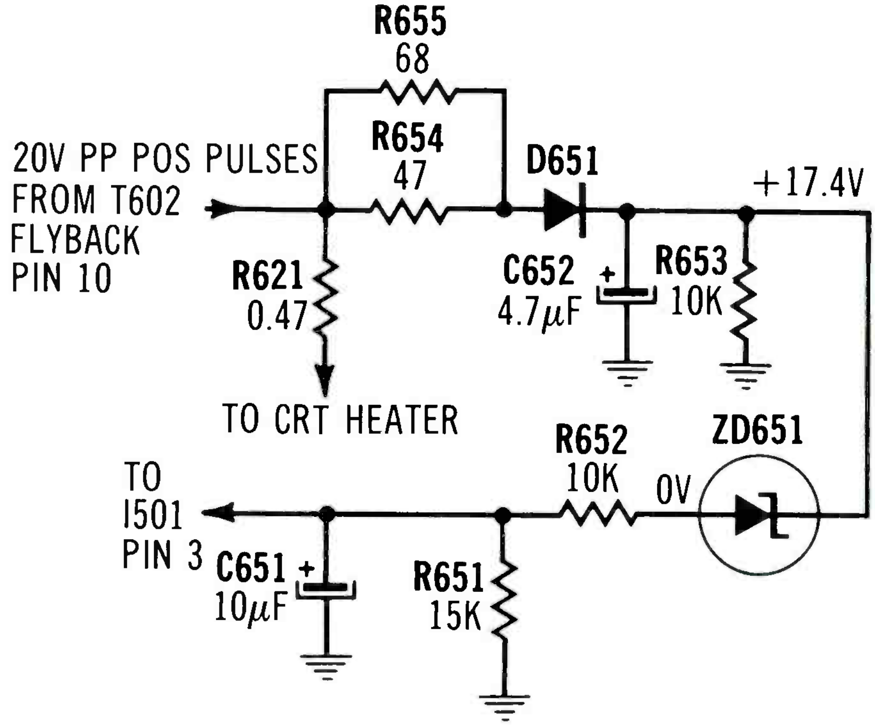

Figure 5. Horizontal pulses from the T602 flyback are rectified by D651, and the positive voltage is stored in C652. When the pulse amplitude (and the high voltage) is not excessive, the dc voltage does not exceed the 20V ratings of the ZD651 zener diode so no positive voltage passes through R652 to reach I501 pin 3. When the high voltage is excessive, voltage passes through ZD651, making pin 3 positive and the IC latches to remove the horizontal-drive square waves. Without drive to the Q601 driver transistor, the horizontal sweep is killed, and this also removes all scan-rectified power sources, eliminating the picture and sound.

In a number of sets, resistor R614 (Q601 collector voltage, Figure 4) has become open, removing the collector voltage and signal. A dc-voltage reading of about +9V without any square waves at I501 pin 4 usually indicates that the IC is defective and should be replaced. Low dc voltage readings at other I501 pins also can point to a defective IC.

Frequently, when a Q602 output transistor shorts, emitter resistor R615 burns from the overload. After a new Q602 is installed, the weakened resistor can cause a pulsating voltage in all supplies taken from horizontal-sweep power.

Horizontal shut-down operation

In theory, any time the high voltage becomes dangerously high (producing X-rays), an X-ray protection circuit should immediately reduce the high voltage to a safe value. However, none of the late-model color receivers do that. Instead, the horizontal sweep is eliminated, along with the high voltage, the raster and the picture. Most circuits maintain this condition until the power is shut off. If the overvoltage condition that triggered the shut-down is not permanent, the performance can be restored by turning off the receiver power for a minute and then switching it back on. Of course, if the overvoltage condition is still present, the start-up will be followed instantly by shut-down.

A schematic of the Sharp shut-

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down circuit is shown in Figure 5. Pulses from the flyback winding that supplies CRT-heater power are rectified by diode D651, producing about +17V to +18V. C652 acts as a peak-reading filter capacitor and also stores the voltage for a time to prevent erratic operation. Unless the flyback pulses are abnormally high, the C652 dc voltage does not go anywhere, because the 20V rating of zener diode ZD651 is not exceeded. Therefore, the zener anode and I501 pin 3 have zero volts, permitting normal oscillator operation.

If the flyback-pulse amplitudes increase abnormally for any reason (such as an open retrace-tuning capacitor or excessive regulated voltage), the ZD651 zener voltage is exceeded, forcing positive voltage through ZD651, R652 and I501 pin 3. This eliminates the output square waves at I501 pin 4. Without a drive signal, the horizontal-sweep circuit stops all operations, which eliminates raster, picture and sound; the receiver becomes totally dead.

A receiver that appears to be in shut-down mode presents several problems to technicians. The first decision is whether the shut-down action has occurred because the flyback pulses were excessive (the only valid reason for shut-down), or whether the shut-down circuit itself has a defect that triggers shut-down when no problem exists with excessive high voltage or pulse amplitude.

It is easy to defeat the shut-down circuit *(but this is not recommended, as it could result in damage to the set)*. Turn off the ac power, ground pin 3 of I501 and turn on the ac power. That's all. If the receiver previously had been in shut-down because of a defect in the shut-down circuit, the receiver now should operate correctly, including all supply voltages and the high voltage.

If excessive high voltage had caused the shut-down, the receiver should operate, but with possible danger from picture-tube damage before the power can be turned off. If you are willing to take that chance, and the receiver has sound and soon shows a picture, quickly test for +120V at the collector (case) of Q602 and then measure the high voltage. In case both voltages are normal, the problem evidently is a defect in the shut-down circuitry. Measure all shut-down components, particularly D651 and zener ZD651.

A safer method for proving whether or not shut-down is occurring and if it is from excessive high voltage is to operate the chassis from a variable-voltage 60Hz transformer. Start with about 50Vac and slowly increase the voltage until picture and sound are obtained. Again, slowly increase the ac voltage and notice if shut-down occurs (and at what line voltage). A normal receiver should withstand up to almost 130V before the shut-down activates. Shut-down at 90V to 100V hints at excessive +120V regulated supply, while shut-down at 100V to 110V might be caused by an open capacitor such as C615 and C620 in Figure 4.

When the +120V supply voltage cannot be adjusted by R107 to the correct voltage, R107 might be defective. With power off, rotate it and check the resistance.

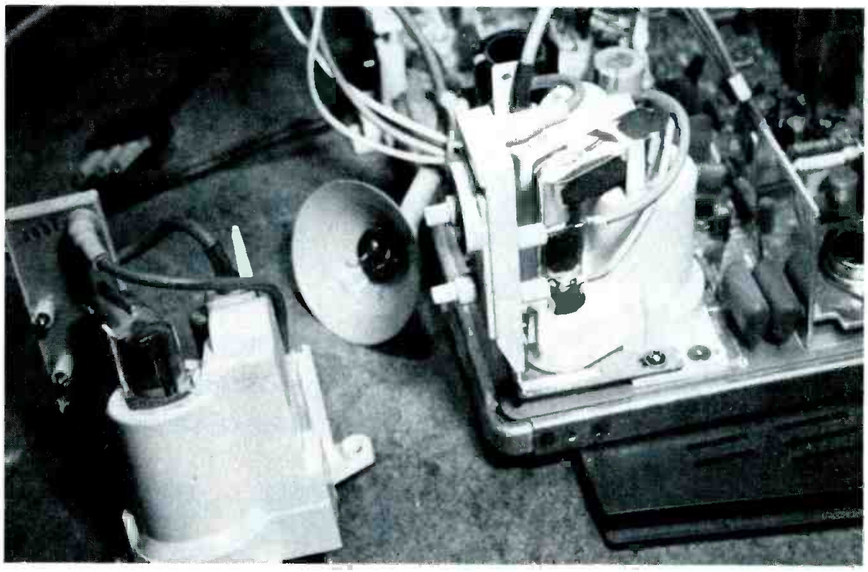


Figure 6. The new T602 flyback is shown mounted on the Sharp chassis, while the old flyback is at the left. Use only original-type replacements.

No sound, no horizontal sweep

When the receiver is completely dead, check the Q602 collector voltage. A reading of less than +70V hints at a defective bridge-rectified +164V supply, while a +76V or +78V reading indicates the horizontal sweep is not operating (the low voltage is caused by the lack of horizontal pulses at the SCR701 anode).

An open Q602 output transistor with an ohmmeter can have complications because of the internal damper diode. First, a voltage-drop diode tester or a high-power ohmmeter should be used to check the transistor out-of-circuit.

When the horizontal-output transistor does not have an internal damper diode, the resistance reading between collector and emitter should be high, regardless of probe polarity. But the damper diode in Q602 should give a typical silicon diode reading when the positive probe touches the emitter and the negative ohmmeter probe touches the collector. With the probes reversed, the reading should be in the megohms. Lower readings should arouse suspicions about the transistor.

The base/emitter and base/col-

lector junctions should be checked with both polarities in the same way. Forward-biased junctions should show typical resistances for the meter used, while reverse-bias polarity should produce resistance readings approaching infinity.

If Q602 tests normal, but the horizontal sweep is dead, check all significant dc voltages followed by scope analysis of any or all waveforms in the horizontal system. These measurements and some logical thinking locate the problem area.

Check all connections of the T602 flyback transformer on the circuit board's bottom side. Poor connections, particularly pins 1 and 11 for the SCR pulses, have been found there. Flybacks may require replacement (Figure 6).

Motorboating

When the +120V regulated supply voltage varies significantly at a slow rate, causing a motorboating sound in the speaker and a synchronized slow variation of picture width, replace resistor R615, the Q602 emitter-to-ground resistor (Figure 4). R615 is likely to need replacement after Q602 has shorted and been replaced. Use a 0.27Ω, 1W replacement for R615.

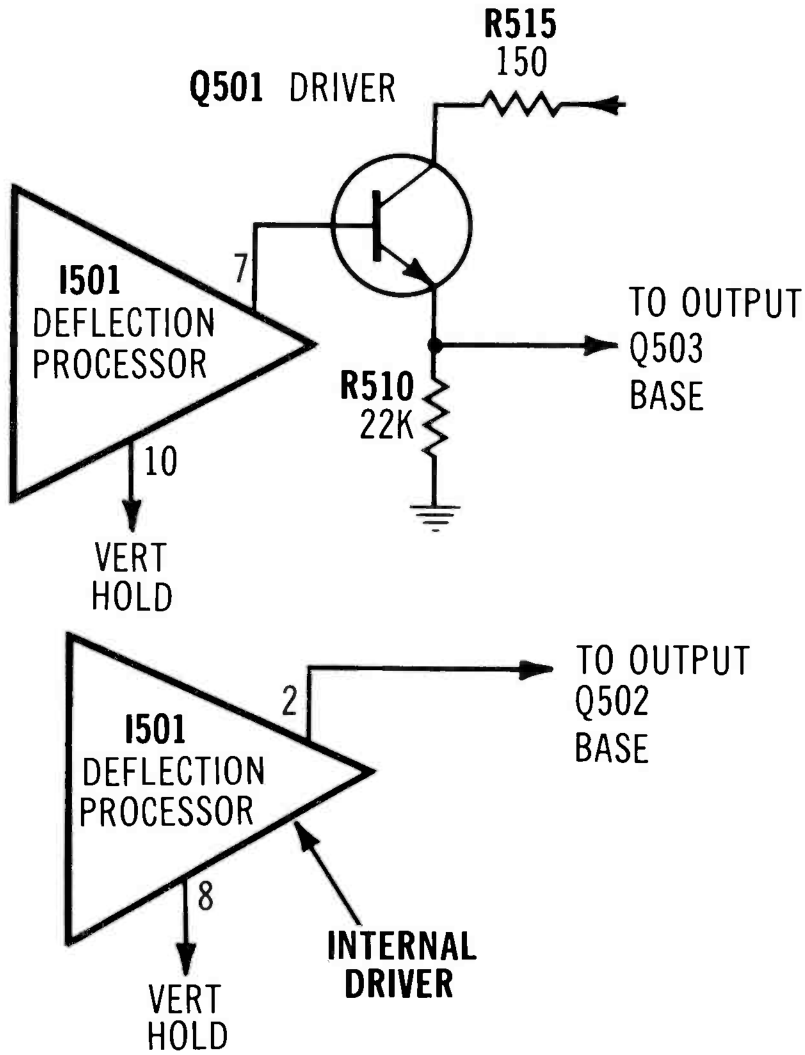


Figure 7. (A) In Sharp chassis, the vertical driver transistor (Q501) is external to I501, while Montgomery Ward and K-Mart color receivers made by Sharp (B) include the driver transistor inside I501. Notice the different pin numbers.

Vertical-sweep problems

Transistors for the vertical oscillator are inside I501. These are followed by a driver transistor and two NPN power transistors that supply vertical power to the yoke. It is important to note that the driver transistor is external to the IC in Sharp models (Figure 7A), while the transistor is inside the IC in similar models manufactured by Sharp for Montgomery Ward and K-Mart (Figure 7B). Pin numbers for the vertical-hold control and drive-signal output are different for the two versions, as shown.

Scope waveforms can prove the presence or absence of signal from I501 on to the yoke, and this is valuable. However, defects often distort the waveforms, making analysis difficult. Lack of a drive waveform at the proper pin (according to the circuit variations) might indicate a defective I501. Before removing the IC, measure the supply voltages at the input to R502 (at the vertical-hold control; +12.13V expected) and at I501 pin 15 (expect +9.82V). If these two voltages are within tolerance and there is low dc voltage and signal level at the output pin (pin 2 or 7), I501 should be replaced.

Output transistors Q502 and Q503 have been known to cause intermittent height when they open erratically. These intermittent transistors cannot always be found by in-circuit or out-of-circuit tests. Therefore, if they are suspected, replace both of them at the same time. Use the exact replacement, or use ECG373 universal transistors (Figure 8).

Erratic height also can be caused by corrosion on the vertical hold-control element. Spray the inside with tuner cleaner and rotate the control several times. If this reduces the erratic action, you should replace the control.

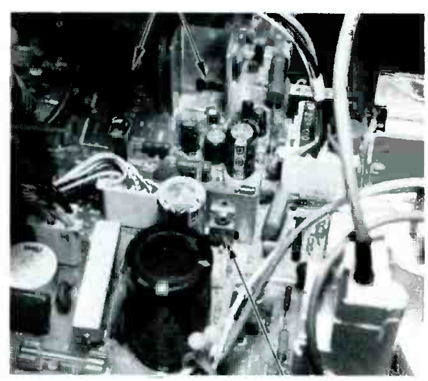


Figure 8. (Arrows at the top point to vertical-output transistors Q502 and Q503. At the bottom, an arrow points to SCR701 on its heat sink.

The regulator circuit uses the principle pioneered by RCA: Power from the +164V supply is released to C708 in timed bursts, with one pulse of dc current during each horizontal cycle. This is a practical example of *time constant* at work. C708 integrates the dc pulses. Heavier loads on the C708 filter require the dc pulses to be widened. The I701 circuit determines from the C708 voltage when during each horizontal cycle the SCR conduction should begin, and a positive pulse is applied to the SCR gate at that time.

Once started, the current conduction continues until the negative-going flyback pulses at the SCR anode become negative relative to the dc voltage at the SCR cathode. Conduction ceases at the same point during each horizontal cycle. *Rectification of the anode pulses adds voltage to the +120V regulated supply.* Notice that the horizontal driver and output transistors are powered directly from the +120V supply, so they are ready when the oscillator begins operation. During start-up, however, the oscillator receives a lower voltage from R611, thus forcing the sweep system to operate weakly. After start-up is finished and the sweep is operating at full power, the oscillator dc supply voltage comes through D452 and R454 from the +18V supply. Notice that all dc sources (except four operating from +120V) are generated by rectification of horizontal power. Therefore, these supplies will be dead when the horizontal sweep is dead.

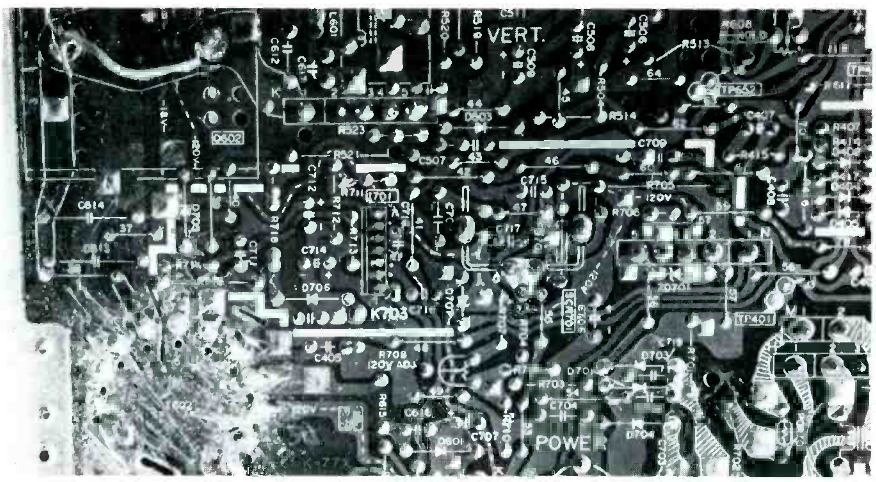


Figure 9. Locations of many components are printed on the bottom of the circuit board, and wider lines show the general areas for power, vertical and other systems.

One of the first tests when the height is insufficient involves measuring the dc voltages at the two vertical output power transistors. If these voltages are low, check 1KΩ R513 (brings +48.7V supply to R512 and C504) and 56Ω R516 that brings supply voltage to the Q502 collector. When yoke-coupling 470μF C507 is partially open, there will be no height.

Of course, defects in the supply voltages can produce height problems. Loss of +48.7V supply (Figure 1) might be caused by a leaky D503 that has burned open 22Ω R520. Replace both if D503 is defective. Also, remember D503 must be suitable for operation at 15,734.4Hz horizontal frequency. Do not use a 60Hz top-hat type.

The location of many circuit-board components are marked on the board's bottom (Figure 9). In addition, wide lines show limits of the principal areas, such as vertical and power.

ES&T

Books

Editor's note: *Periodically* ***Electronic Servicing & Technology*** *features books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publishers at the address given for each book, rather than to us.*

Electronic Miniatures—A Buyer's Guide, by S.E. Harris; Tab Books; 304 pages; $17.95 hardbound, $12.95 paperback.

This guide book tells what is on the market in miniature electronic gadgetry—cameras and tape recorders, electronic games, medical devices, computers, radios, televisions and more. The book covers the evolution of electronic miniatures, microelectronics, repair of microelectronic circuits, miniature television circuits, cassette recorders, miniature entertainment systems, miniature broadcast receivers, calculators, pocket computers, clocks and watches, microprocessors and assorted miniature gadgets.

Also included are electronic drill presses, personal smoke alarms, blood pressure/pulse monitors, radar detectors and a sports forecasting kit.

Published by Tab Books, Blue Ridge Summit, PA 17214.

Fundamentals of Stereo Servicing, by Joel Goldberg; Prentice Hall, Inc.; 299 pages; $22.95.

This working handbook covers stereo repair and troubleshooting techniques and includes block diagrams, schematics and in-depth circuit coverage. Guidelines are given for complete professional servicing of transformers, rectifier systems, bridge output systems, low-level amplifiers, AM and FM tuners, matrix decoders, switching decoders, cassette systems, cartridge systems, reel-to-reel systems, and discrete and IC circuits. The handbook gives professional safety precautions, step-by-step troubleshooting methods and how-tos for using test equipment.

The book shows how to identify input and output connections for each type of amplifier circuit, anticipate the approximate size and shape of input and output waveforms, pinpoint how input and output transducers help to produce a signal voltage and determine which type of tuner develops the audio signal from the modulated RF signal being transmitted.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632.

The Video Guide, by Charles Bensinger; Howard W. Sams & Company; 255 pages; $18.95.

This survey of current video equipment, trends, techniques and programs provides the reader with a general overview of the video industry today. Topics include cameras, VTRs, videotape monitors, projectors, videocassette systems, the video portapak, ENG systems, maintenance, troubleshooting and purchasing equipment.

Published by Howard W. Sams & Company, 4300 W. 62nd St., Indianapolis, IN 46268.

Concepts of Digital Electronics, by Harry M. Hawkins; Tab Books; 196 pages; $17.95 hardbound, $11.95 paperback.

This book shows how anyone can understand and use low-cost 7400 series integrated circuits to produce working digital devices including a power supply and a breadboard experimenter. Written in an easy-to-follow-and-understand style, the book shows how clocks, flip-flops, shift registers, logic gates and other digital devices function and explains how to use them in a variety of practical applications.

Several digital electronics concepts are introduced including the different number systems – binary, decimal, octal and hexadecimal. BCD, Baudot and ASCII codes and fundamental digital operations including AND, NAND, OR, NOR and Exclusive OR are covered. The author has included hands-on information on the basic principles of digital electronics experimentation and how-tos for troubleshooting digital circuits.

Published by Tab Books, Blue Ridge Summit, PA 17214.

Learning about electronics

By Conrad Persson, editor

The rapid pace of the electronics "revolution" has been much celebrated in the press, on television and in general conversation. Its effect on the lives of all of us has been profound. To many it means improved communications, expanded entertainment choices or electronic help in calculating and computing. To others it means a threat of unemployment as computers and robots perform more and more routine tasks.

To yet others, servicing technicians and electronic enthusiasts for example, it means still more to learn about electronic theory, practical applications of electronics and servicing, and repair of electronic products. Whether learning about this new electronic technology is an intellectual challenge or a drudge depends upon an individual's attitude, and of course whether or not he simply wishes to study or if he is obliged to study. Whatever the case, there is plenty of new material to study in electronics with more generated every day.

Several avenues

There are two pivotal decisions to be made when you're deciding about further education: What, precisely, do you need to learn and how will you learn it?

It's important to do a thorough analysis of exactly what it is you want to learn. I occasionally hear someone say, "I want to learn about computers," or something equally vague. The question that needs to be answered is, "What do you want to learn about computers?" The answer might be something like, "I want to take an introductory course in computers so I can understand the jargon and know how hardware and software interrelate, so that I can know what further courses to take to learn servicing." That doesn't pin it down completely, but it does state some specific goals.

Once the specific goals are set, the next consideration becomes how to achieve them. One simple but effective method might be to contact other technicians in your area. If you have a skill that they lack and vice-versa, why not arrange for a session in which you educate each other.

Self study

Another simple but less effective method is to buy a book on the subject and study it yourself. Depending upon a number of factors, including the complexity of the subject, the quality of the book, and your own self discipline, this experience might bring anything from complete understanding to fruitlessness. Home-study courses offer a major improvement over studying from books. The material is broken down into study units, someone tells you what is expected of you, and you get feedback through regular tests.

Schools and seminars

If time and money permit, a more effective way to learn is through structured class and lab courses. Here again there are many avenues. Public and private technical schools throughout the country offer a selection of courses from the most elementary introductory courses to detailed theory and design. If you have the time and the budget to travel, manufacturers of home electronic equipment offer to servicing technicians seminars on the operation and servicing of specific items.

Identifying the available resources

A local school may have just the course you need listed in its catalog. One of the book publishers might have just the book or series of books to fill in the gaps in your knowledge. One of the associations related to home electronics equipment manufacturing sales or service may have just the item of information you need or be able to point you in the right direction.

The following text lists a number of correspondence schools, book publishers and associations whom you might want to contact for further information on what educational opportunities they have to offer.

Trade associations

Electronic Industries Association (EIA)
Consumer Electronics Group
2001 Eye St., N.W.
Washington, DC
202-457-4919

Electronic Representatives Association (ERA)
20 East Huron Street
Chicago, IL 60611
312-649-1333

Electronic Technicians Association (ETA)
RR3, Box 564
Greencastle, IN 46135

National Association of Television & Electronic Servicers of America (NATESA)
5930 S. Pulaski Road
Chicago, IL 60629
312-582-6350

National Association of Retail Dealers of America (NARDA)
2 North Riverside Plaza
Chicago, IL 60606
312-454-0944

National Association of Recording Merchandisers (NARM)
1060 Kings Highway North
Suite 200
Cherry Hill, NJ 08034
609-795-5555

National Electronic Distributors Association (NEDA)
1420 Renaissance Drive
Park Ridge, IL 60068
312-298-9747

National Electronic Service Dealers Association (NESDA)
2708 W. Berry St.
Ft. Worth, Texas 76109
817-921-9061

Recording Industry Association of America, Inc. (RIAA)
888 Seventh Ave.
New York, NY 10106
212-765-4330

Technical book publishers

Hayden Book Company
Rochelle Park, NJ 07662

McGraw-Hill Book Company
1221 Avenue of the Americas
New York, NY 10020

Prentice-Hall
Englewood Cliffs, NJ 07632

Howard W. Sams & Company
4300 W. 62nd St.
P.O. Box 558
Indianapolis, IN 46206

Tab Books
Blue Ridge Summit, PA 17214

Van Nostrand Reinhold Company
135 W. 50th St.
New York, NY 10020

Home study

Cleveland Institute of Electronics
1776 E. 17th St.
Cleveland, OH 44114

Cook's Institute of Electronics Engineering
Desk 15
P.O. Box 20345
Jackson, MS 39209

Electronic Institute of Brooklyn
4823 Avenue N
Brooklyn, NY 11234

Grantham College of Engineering
2500 S. La Cienega Blvd.
Los Angeles, CA 90034

Heath Company
Benton Harbor, MI 49022

National Institute of Technology
1701 W. Euless Blvd.
Euless, TX 76039

National Technical Schools
456 W. Santa Barbara Ave.
Los Angeles, CA 90037

NRI Training for Professionals
McGraw-Hill Continuing Education Center
3939 Wisconsin Ave.
Washington, DC 20016

Trade schools

National Association of Trade and Technical Schools
2021 K Street, N.W.
Washington, DC 20006

ES&T

Feedback

Leakage testing

In response to the letter in June 1983 Feedback, I would like to add one item. Our shop does many repairs on line-operated musician's equipment. It is common to find some sort of capacitor from 0.05 to 0.3μF from one side of the line to the chassis, with both 2- and 3-wire line plugs right from the factory. The 2-wire types are common in older units, and you may find a switch to allow the hot side of the capacitor to be to either line side. The result is that:

a. To properly measure leakage, you must be sure that if a third (neutral) is used it is operational.

b. You will probably have to check both (or all 3) switch positions, and you may have to repeat this with the line cord in the case of a 2-conductor plug.

c. A value of 0.05μF allows about 2mA of ac 60Hz to flow, far in excess of the typically allowed 0.5mA of ac. Therefore, the older units may not pass today's leakage test, and no leakage specs exist on them anyway.

I highly recommend that any shop that sees a piece of line-operated musician's equipment not let one out of the shop without asking the customer about installing a 3-wire line and plug. Musicians are used to receiving shocks from equipment, but the liability situation is questionable. I make them sign a waiver. And no, you cannot remove the capacitor, because the musician may complain he cannot get rid of the "hum" problem.

R. Fleischer
South Lake Tahoe, CA

Capacitor cautions

I have just read Mr. Honey's article on capacitors ("Special Capacitors for Television, May 1983 **ES&T)** and did enjoy his knowledge of them, and found the article interesting and informative. I found myself driven to write to you about a serious bit of advice that he gives concerning the 4-legged capacitor used in many horizontal output stages.

He says "I prefer the separate capacitors instead of one large one for retrace use...I do not normally replace the 22-5001 capacitors (Zenith part number) capacitors with a 4-legged one...I replace the original part, usually with a better quality replacement...The reasons I prefer separate capacitors are simple. First, one large capacitor (4-legged or not) holds more heat internally and can accelerate failure."

While he is basically correct in his assumptions, his advice is totally incorrect and could bring lawsuits to anyone following it. The federal government has mandated that parts within critical areas are not to be modified in any way. Replacement of the 4-legged capacitor with several single capacitors is definitely modifying the circuit and makes you responsible for what you have done.

His knowledge of the circuit or his encouraged modification of it is wrong because of the legality of it – not the performance of the circuit. I do agree with his circuit logic but know your magazine or any other cannot support the advice he has given.

George Savage, CET
Doniphan, NE

Honey's reply

I believe Mr. Savage has misinterpreted my article, or perhaps I didn't express my thoughts clearly.

At no time have I advocated modifying "critical areas" with substandard parts. I also never implied that I replaced the 4-legged capacitor with several single capacitors, even though such a mod would be safer and more reliable.

I did suggest that "better than original parts be used" and that even when the manufacturer supplied a mod kit consisting of a 4-legged capacitor, I didn't use it. A circuit can be "redesigned" or repaired in any way I see fit, as long as safety factors are maintained or improved.

The replacement parts I suggested in all cases were better than the original. The whole point of the article was to supply enough information so that anyone could determine what type of capacitor would make an adequate replacement.

No law exists that says that "only the manufacturers original parts or part numbers must be used in repairing television sets." Anything can be used as long as it is equal to or better than the original OEM part.

Incidentally, a good way to test the 22-5001 Zenith capacitors to see if one or more are open, is to cut one loose while monitoring the high voltage (be sure set is off while cutting). If no voltage change is apparent when the set is turned on again, the capacitor is open. If the voltage changes 1 to 2kV, the capacitor was probably good. Replace the lead and continue. In this way, the bad ones can be weeded out a little faster if proper test equipment is not available.

C. A. Honey
Ontario, CA

Troubleshooting Tips

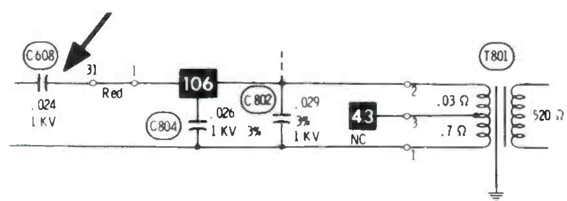
No sound and no picture
Sony KV-1711 chassis SCC-63A
(Photofact 1503-1 or 1625-2)

A customer who brought the Sony TV receiver to me explained that another shop had given up trying to repair it after six weeks. They had installed several F602 4A line fuses, an unidentified electrolytic capacitor and the D517 damper diode.

Usually, I carefully check all previous repairs, because mistakes often kept the previous technician from completing the repair. Unfortunately, I forgot to check this time.

A resistance check of the regulated +130V supply showed a 26Ω short to ground, which is sufficient to blow the line fuse. Rapid in-circuit tests of the bridge rectifiers and all transistors on the power-supply board did not locate any defects. I disconnected the wires from the audio-output and the horizontal-sweep circuits, and the short was gone from the +130V supply. Additional tests proved the short was in the horizontal circuit, so I reconnected the audio wire, leaving the horizontal wire disconnected. When 120V power was applied, the fuse did not blow, but R617 in the power supply began smoking from overload. I put aside the R617 question until later.

I tested all horizontal diodes and transistors by the voltage-drop function of my DMM, but none appeared to be bad. I tested the yoke, flyback and other components by resistance measurements, but found no defects. The 26Ω short remained as I unsoldered each flyback pin in turn until pin 10 of T501 was disconnected, eliminating the short. The +130V for the Q510 horizontal-output devices comes through R904 (10Ω) to pin 10. Next, I noticed a



jumper on the yoke plug that (when the plug is removed) opens the circuit between Q510 and T801, the high-voltage transformer. By opening the jumper, I proved the short was on the T801 leg of the wiring. The wire went back to the power-supply board, which held L601, L602 and C608. I was relieved to measure a 14Ω short in C608 (0.024μF 1000V) that coupled sweep power to the T801 primary. The primary low end is connected to the cathode of Q510 which is grounded through a 1.8Ω resistor. Therefore, C608 was responsible for the overloaded +130V supply.

After I replaced C608 and restored all connections, the short was gone, so I switched on the 120V power; F602 blew instantly. Then I remembered the D517 damper diode had been replaced by the previous technician. The soldering of D517 appeared to be satisfactory. I decided to re-install the old damper diode, because it tested fine externally and not all replacement parts will operate correctly in Sony machines. After one end of the new damper was unsoldered, I noticed the polarity was reversed. Of course, this connected its anode to the B+ through the flyback, producing a short when the voltage was higher than 0.7V. I re-installed the old damper diode.

When the receiver power was applied next time, the sound had a loud hum and the picture showed two wide black bars. I installed a new R617 (which I had forgotten to do earlier) and measured +158V at the +130V regulated supply. Junction tests of all regulator transistors revealed Q601 had an open base-to-collector junction and Q602 was shorted between emitter and collector. After these transistors were replaced and the regulated voltage adjusted for +130V, the receiver operated normally.

This case illustrates some of the complications from two separate defects, and the dangers of not checking all previous repairs for mistakes.

Phillip M. Jones
Martinsville, VA

Poor focus
Admiral 19C8248L
(Photofact 1766-1)

A blurred picture and lack of visible scanning lines indicated a problem with focusing. When I opened the receiver, I found that someone had butchered the focus-divider network, evidently in a misguided attempt at forcing the circuit to give better focus. I installed a new network, but this did not improve the focus. At CRT socket pin 9, the focusing voltage tested below 1kV, far below the expected 5kV.

High voltage at the CRT anode was satisfactory. A check of the focus control showed some roughness, so I installed a replacement component. Again, there was no improvement.

The focus voltage at the tripler measured about right. When I disconnected the wire to CRT-socket pin 9, the voltage at the wire jumped up to almost 5kV. This made me suspect that excessive picture-tube current was loading down the focus voltage. The CRT tested normal on a CRT tester.

I removed the socket from the CRT base and tested for leakage between pin 9 and all other socket pins. I found no leakage. I repeated all the previous tests and examined the schematic carefully, but without success.

Finally, I remembered that the only component not tested completely was the picture-tube socket. After I dismantled it, I noticed that the spark gap didn't look right, although it didn't test shorted. In desperation, I installed a new socket, and this cured the focus problem.

Although no arcing had been seen or heard, it was clear that the spark gap had been breaking down under the focus voltage. This is one lesson I will remember for a long time.

Mike B. Danish
Aberdeen Proving Ground, MD

Readers' Exchange

For sale: Electronic Servicing, 1968-1980, $50 plus shipping; Sams 38-700, $400 plus shipping; B&K 1076 TV analyst, $175. *Paul S. Funk, 607 E. Cherry Lane, Souderton, PA 18964; 215-723-2355.*

For sale: FM stereo pack, model CU-951UA with service manual, for Panasonic car radio, $15. *Al Crispo, 3225 Chipmunk Drive, New Port Richey, FL 33552.*

Needed: IC for Philco television, #IC5/46-5002-5, or Motorola HEPC6077P. *Wizard Electronics, Rt. 5, Box 522, Renick, WV 24966; 304-497-2066.*

Needed: Electronic Measurements Corporation (EMC) construction manual for model 801 comparator bridge and in-circuit capacity checker. Send photocopy or original COD. *Max Emerson, 1923 N. Texas, Weslaco, TX 78596; 512-968-3913.*

Needed: Service manual (in English) for NordMende Electronics (German) KM-394 distortion analyzer; working NordMende SRG-389 sine/square generator; parts/service manual for Sansui SD-7000 R-R tape deck (1971). *Steve Bender, Bengrun Research Labs, Box 28360, Queens Village, NY 11428; 212-776-2909.*

Needed: Simpson 498 field-strength meter, VHF-UHF tube type, and Hickok model 235A field-strength meter, VHF-UHF tube type. Batteries not needed; ok if inoperative. *Jim Shoemaker, 600 First St., Leechburg, PA 15656; 412-842-8321.*

Needed: High-voltage cup and socket for Panasonic color television, model CT-21P. State price. *George Saylor, 2319 Parrish St., Philadelphia, PA 19130.*

Needed: Service manual/schematic for model 1700, 115V, 60CPS, 21W Magnus organ. Will pay reasonable price. *Wilks Radio & Electric, 6056 Steubenville Road, SE, Amsterdam, OH 43903.*

Needed: Up-to-date tube layout charts for Mercury model 300 tube tester or address of company. *Earl P. Anderson, 1828 W. Jewell Ave., Milwaukee, WI 53221.*

Needed: Schematic diagram and power transformer for Marquette engine analyzer, model 40-175. *Ed Peterson, 751 Jakway, Benton Harbor, MI 49022.*

Needed: Sencore VA48, Sencore TF46 and Sencore UPS164. *Rod Wells, 4528 N. Dearing St., Fresno, CA 93726; 209-291-5071.*

Needed: Adapter cables for Sylvania Check-a-Color CK 1500X rig, transverter, matching cords and other updating equipment. *A. Johnston's Electronics, 14 Waldwick Court, Toms River, NJ 08757.*

Needed: Sencore LC53 *Nate Lilienthal, 29515 Quailwood Drive, Palos Verdes, CA 90274; 213-377-9913.*

Needed: Power transformer for Hewlett-Packard model 130A scope; P/N 910-148 replaced by P/N 9100-0078. *Dewey Landis, 2712 Mayfair N., Seattle, WA 98109; 206-282-2624.*

Needed: Service manual or schematic for Sears b&w television, model 5025, chassis 562.10453, 110Vac and 12Vdc, and same for Candle b&w television, model MT510 or MT510A, 110Vac and 12Vdc. *John R. Andrade, Rt. 1, Box 40, San Gregorio, CA 94074.*

Needed: IC ECG 782 and picture tube 370 AUB22 for Philco 13in color television. *J. Rosenblatt, 2063 E. 56 St., Brooklyn, NY 11234.*

Needed: Parts or a complete Hallicrafter model SX-62 receiver. *Paul Capito, 637 W. 21 St., Erie, PA 16502.*

Needed: Service manual and operator's manual for HyGain VHF marine transceiver, model 655. *Mark Moorman, P.O. Box 2923, Greenville, NC 27834.*

Needed: Tekfax volumes 101-105 and Supremes TV volumes 1-4, and 11. *C. T. Huth, 146 Schonhardt St., Tiffin, OH 44883.*

Needed: Instruction manual and schematic for Robyn CB transceiver tester, model MT-701. Will buy or copy and return. *Hubert McGraw, 10136 Renfrew Drive, El Paso, TX 79925.*

For sale: Sencore VA48, mint condition, with manual and probes, $800. *Robert L. Blount, 40 S.W. 8th Ave., Delray Beach, FL 33444.*

Needed: Sencore LC-53 Z-meter and Sencore VA48 analyzer. Both must be in A-1 condition. *David A. Tabor, Box 56, Killdeer, ND 58640; 701-764-5017.*

Needed: Schematic for Columbian Hydrosonics Aqua Probe, model CH-363. Will buy or copy and return. *Robert A. Ports, 1420 Appian Drive, Punta Gorda, FL 33950.*

For sale: Heathkit VTVM model 1M-5228. Includes probes, manual and extra 50kV probe; new and accurate; asking half of kit price. *C. Gillow, P.O. Box 177, Springer, NM 87747; 505-483-2363.*

For sale: 1600 Sams Photofact folders from 1 to 1850, $15. *Don's TV, 119 Lisann St., Tallmadge, OH 44278.*

For sale: Sencore VA48 analyzer; used less than 20 hours; $850. *Ron Carron, Box 365, Highland, KS 66035; 913-442-3255.*

For sale: New and used TV tubes, many boxed; 30 cents each plus $1.50 postage. Send stamped envelope for list. Will buy or trade for TV solid-state troubleshooting flow charts and books. *R. Stanley, 428 W. Roosevelt Blvd., Philadelphia, PA 19120.*

For sale: Two B&K 415 sweep/marker generators; one new, $250, one used, $100. *Jim Moyer, 417 E. Elm St., Tamaqua, PA 18252; 717-668-2607.*

For sale: Sencore VA48 analyzer and Sencore RC167 substitution box R/C. Both units, with manuals, $800. *Raoul Vazquez, 7251 S.W. 9 St., Miami, FL 33144; 305-264-6785.*

For sale: Sencore VA48 video analyzer, $825, manuals and probe included. Excellent condition; price includes shipping. *George Lazoryszak, George's TV, 4432 N. Chadwick St., Philadelphia, PA 19140.*

For sale: TV parts and equipment at good discounts. Send SASE. *Marvin Warmbrand, 8 Dusk Drive, Centereach, NY 11720.*

For sale: Avantek 120-degree LNA, $375, and Sa-TEC R2B receiver, $375. *WSEP, Sparta, WI; 608-269-2392.*

For sale: RCA junior volt ohmist with probes and service manual, $50; high-voltage probe, $15. *Al Crispo, 3225 Chipmunk Drive, New Port Richey, FL 33552.*

For sale: Sencore CR143 CRT tube tester, $125; Anders CM-100 capacitance meter, $60, used less than two hours. Buyer pays UPS postage. *Walter Fiscus, Audio Repair Service, Route 1, Box 345, Oxford, NC 27565; 919-693-1066.*

For sale: Jackson model 523 oscillograph and Jackson model 420 universal oscillator, manuals included. Manufactured in 1937 by the Jackson Electrical Instrument Company, Dayton, OH. These instruments are operable. *J. L. Carter, Box 464, Hooker, OK 73945; 405-652-2049.*

For sale: Sencore CB41 and CB42 CB analyzer in like-new condition. Includes manuals and test leads; $525 or best offer. *Martin Major, 15810 Sapwood St., Tampa, FL 33624; 813-961-7303.*

For sale: Sencore TF46 Super Cricket transistor FET tester, new, $145; B&K model 466 picture tube tester rejuvenator, used only on service calls, $65; Conar model 311 resistor capacitor tester, $25. All with manuals. *Paul's TV, 260 Main Cross, Charlestown, IN 47111; 812-256-3119.*

For sale: EICO model 145 multisignal tracer, $75; EICO model 944 flyback/yoke tester; Precision Tube master series 10-2 tube and battery tester, wood dovetail box, antique, $150. *Ed Barlow, Box 29, Tweed, Ontario, Canada K0K 3J0.*

For sale: Hewlett Packard model HP608D signal generator, $220; B&K model 2040 CB generator, $185; RCA 10J106 TV test jig, with cables, $215. *Jeffrey Jeffers, 337 Lambert Ave., Groveport, OH 43125; 614-836-5368.*

For sale: B&K model 1077B TV analyst, $300; B&K model 467 CRT restorer and tester, $300; Triplett 5in VTVM, $75. *J. L. Bachelor, 2538 Tam O'Shanter Drive, Cleveland, TN 37311; 615-472-8726.*

For sale: B&K 1077B TV analyst, $200; B&K 415 solid-state sweep/marker generator, $200. Both like-new condition; manuals and leads/probes included. *Tom's TV & Sound Service, 412 Grand Mesa Ave., Grand Junction, CA 81503; 303-243-1324.*

For sale: Heathkit model 1GB-1023 RF signal generator, $35; Heathkit model 10-101 vector scope, with manuals, hardly used, $65. Both for $100 plus shipping. *Don Kerkhoff, 1266 Vermont St., Quincy, IL 62301.*

For sale: B&K 1077B analyst, used only three times, $350. *H. Solano, P.O. Box 1074, Bricktown, NJ 08723.*

For sale: 85 books on radio and television and some on video; mostly hardback, all in excellent condition; $200 for all. *Daniel Seidler, 5827 S. Campbell Ave., Chicago, IL 60629.*

For sale: Hickok model 536 vacuum tube tester; Hickok model 209A VTVM; and Hickok model 675A oscilloscope. All probes and manuals included. *Edward H. Frazier, R. R. #2, Box 632, Brownsville, TX 78520.*

For sale: Sencore SC60 scope, $1150; Sencore CA55 capacitor analyzer, $275; and Leader LDM851 multimeter, $65. *Val Obal, 3201 S. 73 St., Omaha, NE 68124.*

For sale: Sencore LC53 Z-meter, like new; B&K model 1477 dual-trace, trigger-sweep oscilloscope, like new; Bell & Howell complete 16-volume TV course with or without hardware. Best offer for one or all; write for complete list. *Rod Wells, 4528 N. Dearing St., Fresno, CA 93726; 209-291-5071.*

For sale: Hundreds of old radio and TV tubes (boxed) for $1 each plus postage. Also old issues of *Radio News, Electronic World, Radio Craft, Audio Craft, PF Reporter, Electronic Servicing, Radio Electronics*, etc., $2 a copy plus postage; special price for whole lot. *J. R. Blundin, 151 W. 3 St., Mt. Carmel, PA 17851; 717-339-0402.*

For sale: Hammarlund SP-600 receiver, B&K model 470 CRT tester, and two teletypewriters. *W. A. Frederickson, 3103 W. 12 Ave. Ct., Broomfield, CO 80020.*

For sale: Tektronix model 212 scope, portable ac/NiCads, $600 or best offer; B&K 1476 scope, LN, with probes, $300 or best offer; and Wavetech model VCG116 function generator, general purpose, $400 or best offer. All working and with manuals; COD/UPS. *A&B Electric Company, 1883 E. Main, Rochester, NY 14609; 716-288-1520.*

For sale: Six like-new Admiral 3M2D chassis, $25 each; set of six DK3 6CW6 and 6LU8 tubes, $750. *Jenkins Service, 9 Airlane, Bridgeton, MO 63044.*

For sale: Sams CB Photofacts in intermittent sequence 1 through 257 (125 volumes). $250 plus shipping. *Richard E. Wood, Box 338, Lenn Road, Newburgh, IN 47630.*

Wanted: Good, used b&w CRT 16VDGP4 and Zenith flyback 95-3332-01. Miscellaneous recent Sams Photofacts for sale. *M. B. Danish, P.O. Box 217, Aberdeen Proving Ground, MD 21005.*

Needed: Schematic for a Panasonic AM/FM stereo receiver (model RE 8126). Inform me of your terms. *Thomas Lutz, Consumer Electronics, 614 Edwards St., Aurora, IL 60505.*

Needed: CK3000 Sylvania test jig; picture tube 490BLB22 or 19HNP22, used; yoke for a Sears color TV 80-77-4D or Y-268, used. *Richard Salazar, 10940 Sunnyslope Drive, Riverside, CA 92505.*

Needed: Service manual (in English) for NordMende Electronics (German) KM-394 Distortion Analyzer; a working NordMende SRG-389 Sine/Square generator; parts/service manual for Sansui SD-7000 R-R tape deck (circa 1971); service manual/owner's manual/parts for Acrosound ST-120 power amp (circa 1958). *Steve Bender, Bengrun Research Labs, Box 28360, Queens Village, NY 11428.*

For sale: B&K Model 415 solid state sweep/marker generator and B&K model 1077 TV analyst, both complete with cables, owner's manuals and schematics; both for $150 plus UPS delivery charges. *William D. Fowble, 217 W. Desoto Drive, Harbour Heights, FL 33950.*

Needed: Chroma IC Philco P/N 46-5002-5 or −21 or Sylvania ECG 782 or GEIC-224 or Workman 2057. Will pay going rate and shipping. *Bud TV & Stereo, 18480 S.W. TV Highway, Aloha, OR 97006.*

Needed: Schematic and parts list for Supreme Instruments Corporation tube and set tester, model 504A. Will purchase copy or original, or will copy and return. *Harold J. Helm, Economy Sales and Service, 40 Monument St., Freehold, NJ 07728.*

Needed: Sencore VA-48 TV analyzer, Sencore SG-165 stereo analyzer with original box and manuals. *Chuck Vostry, 111 Grenadier, Franklin, TN 37064.*

Wanted: Good NTSC generator. *Linear Audio, 3155 N. Long, Chicago, IL 60641.*

For sale: Commodore Vic 20 computer game cassettes, large selection, low prices. Send SASE for list. *Don Maurer, 2352 Grace Ave., Lebanon, PA 17042.*

For sale: TV test equipment. Send large SASE for list. *Maurer TV, 2a S. 4 St., Lebanon, PA 17042.*

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Linear ICs show analog can do the job

by Joseph J. Carr

Some people are under the impression that analog circuits are dead and gone, having been completely displaced by digital electronics. Makers of linear ICs can attest that the analog world is not only alive but thriving. Even many digital instruments require an analog subsystem for data acquisition. There are cases where linear IC devices will do a job better or cheaper than a digital circuit, while in still other cases the analog linear IC is the only way to do the job. This article will cover linear ICs, how they are used and how to troubleshoot those you suspect are bad in a circuit. The ubiquitous operational amplifier (op-amp) is a good place to start.

Op-amp basics

The operational amplifier was originally designed to perform mathematical *operations* in analog computers. Although analog computers aren't used today, the properties that made the op-amp suitable for that application also make it highly useful in a wide variety of dc and ac circuits. Some modern instruments, incidentally, are little more than fixed-program analog computers.

Figure 1 shows two different circuit symbols commonly used for operational amplifiers. The version in Figure 1a is the one most commonly encountered, while Figure 1b is used by a few companies and is technically the *official* symbol. The only significant difference, however, is that one has a straight back, and the other has a curved back. The terminals are the same on both. The pinouts shown in Figure 1a are the so-called industry standard. They don't fit all op-amps, but they are sufficiently common to warrant comment. Originally they were used on the 741 device but are now found on op-amps of all quality levels.

The V+ and V− terminals are the power connections. Note that there is no ground terminal on the op-amp. The V+ is an independent power supply that is positive with respect to ground, while V− is negative with respect to ground,

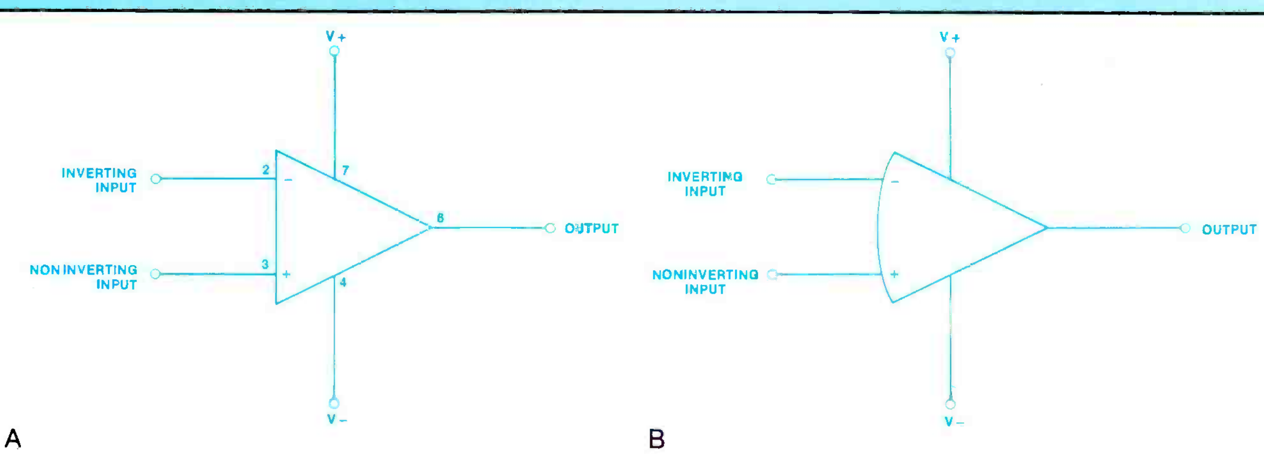


Figure 1. Op-amps have one inverting input and one non-inverting input. A is the most commonly used op-amp symbol; B is used by a few companies.

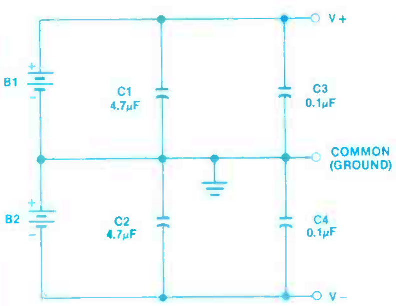


Figure 2. The power supply used for an op-amp must be bipolar.

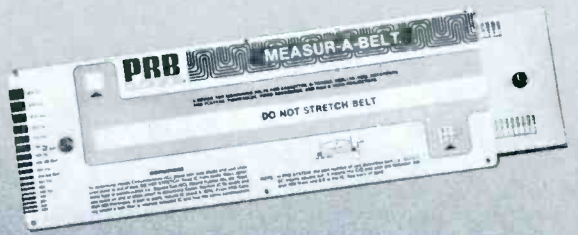
even though no separate ground connection exists on the op-amp.

The output terminal is self-explanatory. The output signal will swing positive or negative between certain limits less than V− and V+.

The inputs on almost all op-amps consist of a pair of differential inputs. In theory, only the inverting input is needed, but all common op-amps also have the noninverting input.

The difference between the two inputs is a matter of *phase*. The inverting input produces an output signal that is 180° out of phase with the input signal. In other words, a *positive* voltage applied to the *inverting* input produces a *negative* output voltage (the inverting input is marked with a minus sign). The noninverting input, which is marked with a plus sign, produces an output that is in phase with the input signal. A *positive* voltage applied to the *non-inverting* input will produce a *positive* output voltage.

Since the op-amp output may have to swing either positive or negative, a bipolar dc power supply is needed. Figure 2 shows a typical power supply for an op-amp circuit. Although batteries are shown here, in most cases electronic power supplies will be used. Note that there are two separate



power supplies: V+ and V−. The V+ supply is positive with respect to common, while V− is negative with respect to common. The power-supply common is also used as the signal common, and may also be the ground (chassis) connection.

The capacitors shown in Figure 2 are not always used, but are needed in many cases for power-supply decoupling. The capacitors are always good practice and are especially needed in multi-stage cascade circuits, when high frequency (uncompensated) op-amps are used, or where the power supply lines may be noisy.

There are two capacitors on each line in Figure 2. The high-value type is used for low frequencies, while the low-value one is for high frequencies. The low-value capacitor should be mounted as close to the body of the op-amp as possible. If multiple op-amps are used, a separate pair of 0.1μF capacitors is needed for each op-amp.

The one case where the capacitors are not always used is on frequency-compensated (unconditionally stable) devices such as the 741. Those types of op-amps trade off frequency response in favor of stability, so they will only operate properly to 8 or 10kHz.

Ideal op-amps

An ideal op-amp would exhibit the following properties:

- zero noise contribution
- infinite frequency response
- infinite open-loop gain
- zero output impedance
- infinite input impedance
- differential inputs "stick together"

The first two ideal properties are never approached, but are thrown in for benefit of the purists who would insist, correctly, that such factors affect performance.

The third property tells us that there is no limit to gain. In real devices, open-loop voltage gains (A_{VOL}) range from 200,000 to more than 1,000,000. An implication of this condition is that closed-loop gain is controlled totally by the feedback network.

Zero output impedance (Z=0) means the output will function as an ideal voltage source. Real devices usually have Z values of less than 100Ω.

If infinite input impedance could be achieved, neither input would either sink or source current. Real devices have Z_{in} value of 1MΩ to 10^{12}Ω, and so will be considered ideal in most cases.

The final condition requires some explanation. The differential inputs must be treated mathematically as if they were at the same potential. If a voltage is applied to the noninverting input, for example, the same potential will be found on the inverting input. This is not just some theoretician's concept, but can actually be measured with a voltmeter. The property is the most frequently used in our simplified circuit analysis.

Inverting followers

Figure 3 shows the op-amp configuration called the *inverting* follower. The noninverting input is grounded and so is at zero potential. The signal is applied to the input resistor, R_1.

Because of Kirchoff's Current Law (KCL), we know in Figure 3 that I2 = I1 (the ideal op-amp does not draw current). We also know from Ohm's law that

$$I_1 = V_{in}/R_1$$
and
$$I_2 = V_{out}/R_2$$

KCL tells us that these equations are equal:

$$V_{out}/R_2 = -V_{in}/R_1$$

The *transfer function* of a circuit is the ratio of the input voltage to the input voltage (V_{out}/V_{in}), and is called the *gain* (A_v). Solving for this ratio yields:

$$-V_{out}/V_{in} = R_2/R_1$$
or
$$-A_v = R_2/R_1$$

These equations tell us that the gain is set only by the ratio of R_2 to R_1. The minus sign indicates that phase reversal takes place.

An example

Suppose we need a gain of −100, and an input impedance of 10K.

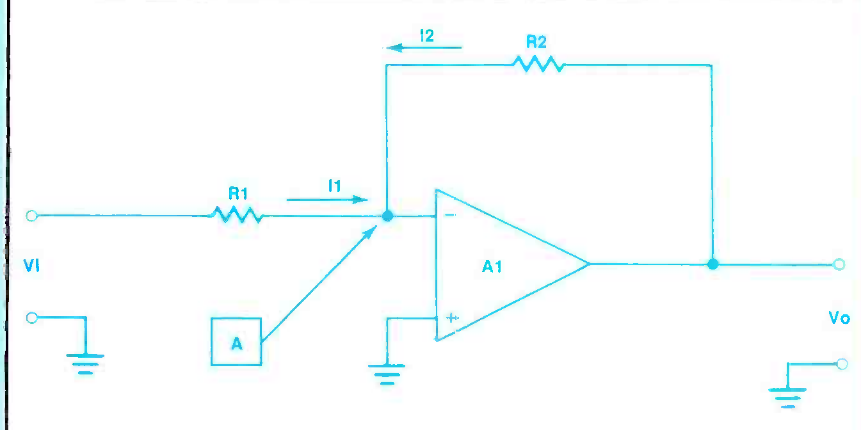


Figure 3. The gain of the op-amp inverting follower circuit is set by the ratio R_2/R_1.

Rearranging the equation for A_v will allow us to find R_2 that will yield a gain of – 100.

$$R_2 = -A_vR_1$$
$$R_2 = -(-100)(10K)$$
$$R_2 = 1000K = 1M\Omega$$

In the example above, we used the value of R_1 as the amplifier input impedance. This is true because point A is essentially at ground potential due to the grounding of the noninverting input. Even though point A of Figure 3 is not actually grounded, it behaves as if it were grounded. This situation is called a *virtual ground.*

A problem with the inverting follower circuit is that the maximum input impedance is limited to the value of R_1. In some practical circuits, this value can be somewhat low. A solution to the problem is the noninverting follower circuit.

Noninverting followers

The noninverting follower circuits of Figure 4 apply the signal to the noninverting input of the operational amplifier. There are two configurations: the unity gain (4a) and with gain (4b).

The unity-gain noninverting follower of Figure 4a has a voltage gain of one because it uses 100% negative feedback. Uses of this circuit include buffering with neither loss of voltage amplitude nor change of phase, and impedance transformation made possible because of the high input impedance and low output impedance.

Because $V_{out} = V_{in}$, and the output impedance is very low, we must conclude that the unity-gain noninverting follower does offer power gain, even though voltage gain is unity.

The circuit in Figure 4b is a noninverting follower with gain. Using an analysis similar to that used above for the inverting case, but taking into account that point A is at a potential equal to V_{in} rather than ground, we arrive at the following gain equation:

$$A_v = R_2/R_1 + 1$$

The gain version of the circuit can be used for exactly the same applications as the unity-gain version, but with voltage gain as well as power gain.

Op-amp problems

Practical op-amps do not match the idealized version. One major problem is output offset voltages. This term means that the output voltage will be nonzero at a time

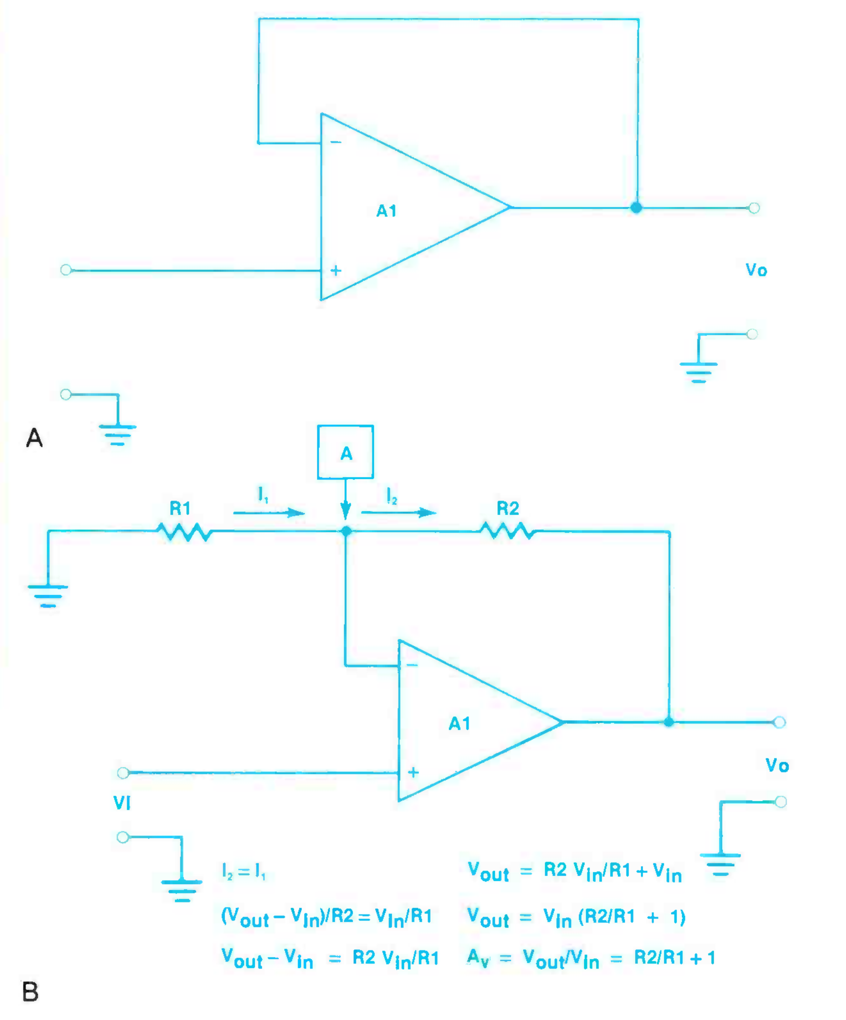


Figure 4. The non-inverting follower op-amp circuit may be used as a buffer or impedance matching device by making the feedback resistor equal to zero (A). If the circuit is connected as in B, gain wil be $A_v = R_2/R_1 + 1$

when it should be zero. For example, if $V_{in} = 0$, then V_{out} should also be zero. In many cases, however, it will not be zero.

There are several causes of output offset voltages; among them are the input bias currents. If bipolar transistors are used in the input stage, their bias currents will be available at the (−) and (+) input terminals. In that case, the input impedance is not infinite. Figure 5 shows a simple method for reducing the effect of this current. The output offset is caused by current from the (−) input flowing in R_1 and R_2, creating an input offset voltage that is amplified by the gain. If we force the bias current from the (+) input to flow in the same resistance, it will produce an equal but opposite offset voltage, and the two cancel each other. The net result is zero. Resistor R_3 in Figure 5 is called a *compensation resistor* and serves this purpose. Resistor R_3 has a value equal to the parallel combination of R_1 and R_2.

The method of Figure 5 solves only one form of output offset voltage problems. Those of Figure 6, however, solve all forms of normal output offset voltage problems, including that caused by input bias currents.

Figure 6a shows a circuit that is used when the op-amp is equipped with a pair of *offset null* terminals (not all so equipped). A potentiometer is connected between the offset nut terminals, and its wiper is connected to the V− power supply terminal. This potentiometer is adjusted to produce $V_{out} = 0$ when the V_{in} input is shorted to ground (or common). Alternatively, the potentiometer is sometimes adjusted for $V_{out} = 0$ when the (−) and (+) inputs are shorted together.

A more universal scheme is shown in Figure 6b. Here we null the natural output offset by using the potentiometer to introduce a counter-offset of a magnitude and polarity to completely cancel the offset voltage. Adjustment of the

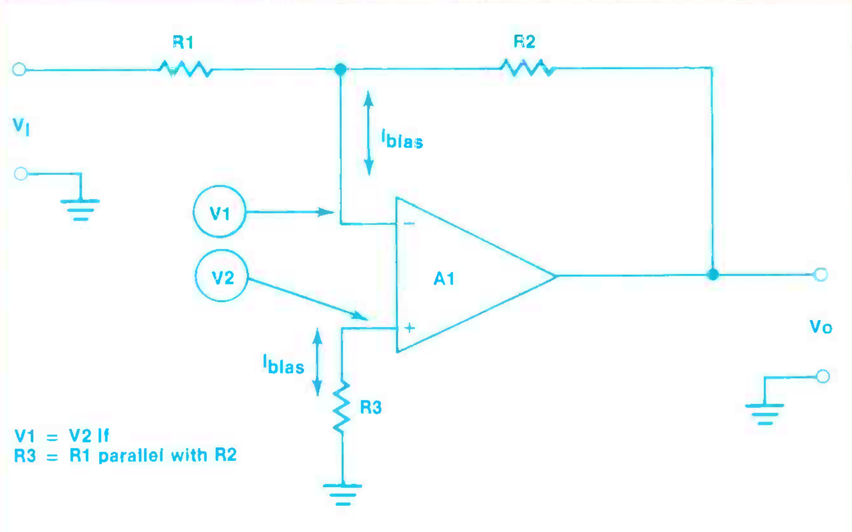


Figure 5. If bipolar transistors are used in the input stage of the op-amp, their bias currents will cause an output offset voltage. Addition of R_3, equal to the parallel combination of R_1 and R_2 will compensate for this offset.

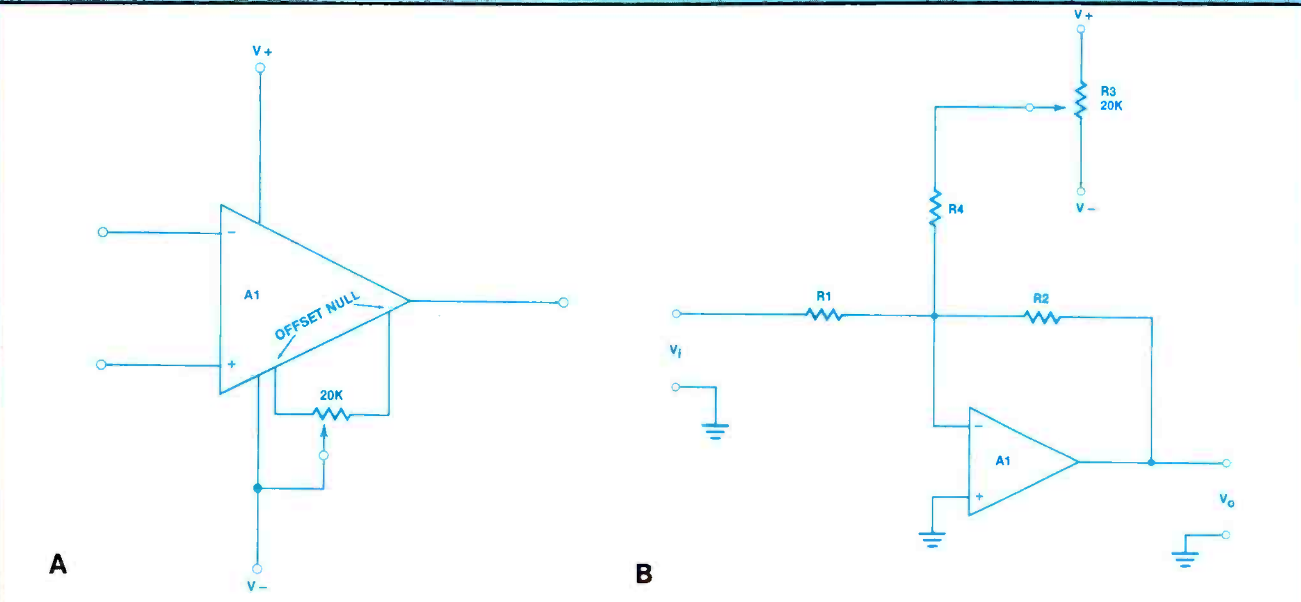


Figure 6. Some op-amps are provided with a set of offset-null terminals to provide for output-offset compensation.

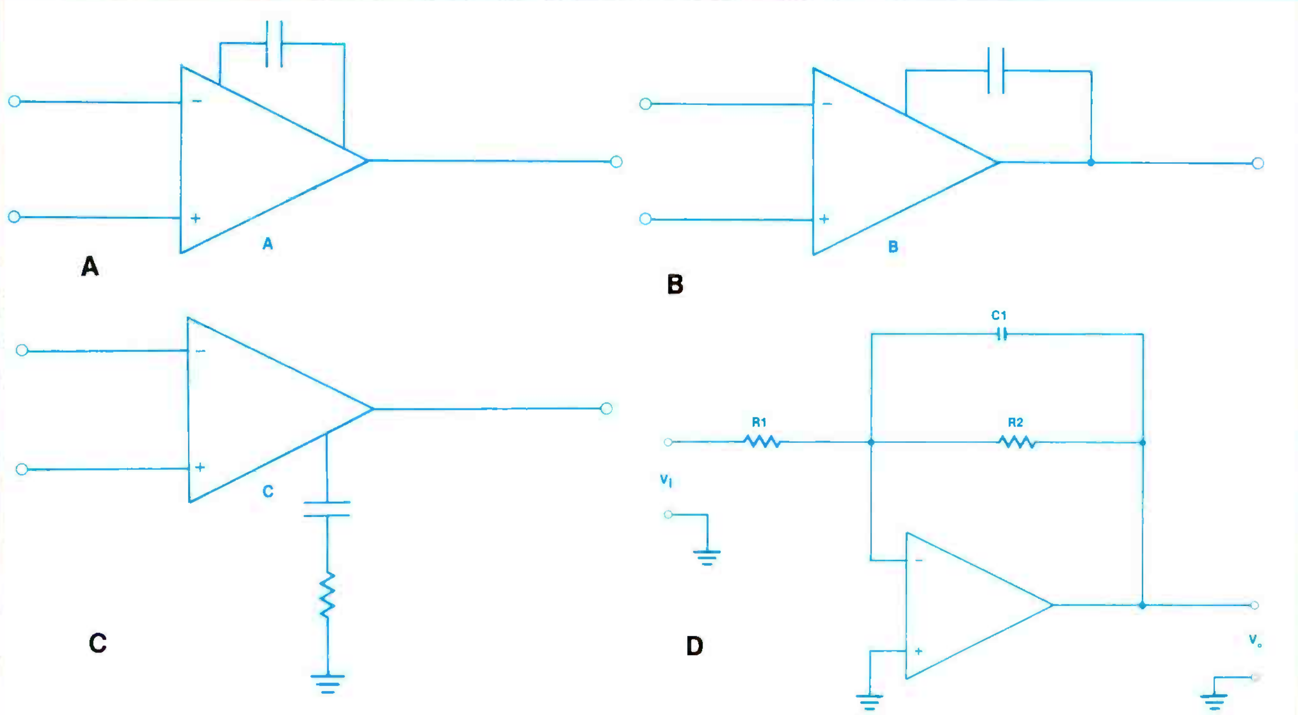


Figure 7. Op-amps will oscillate under some conditions. It may be necessary to limit the frequency of the op-amp by adding external components in order to preclude oscillation.

potentiometer is accomplished by setting the input voltage to zero (shorting the input(s) to ground). The potentiometer is then adjusted for an output voltage of zero.

Frequency compensation

Some operational amplifiers have such limited frequency response that they are said to be *unconditionally stable.* A 741 device, for example, operates only to a few kilohertz. Others, however, have much wider bandwidths, and under some circumstances will oscillate at some natural frequency. For these amplifiers, other means must be found. Figure 7 shows several methods for reducing the frequency response.

Figure 7a shows the use of a capacitor across a pair of frequency compensation terminals (which are also sometimes the dc offset terminals. Typical values for the capacitor are 10pF to 1000pF. Figure 7b shows a feed-forward capacitor between a compensation terminal and the output terminal. In Figure 7c we have an RC network between the compensation terminal and ground. The final method, in Figure 7d, shows a capacitor shunting the feedback resistor. At low frequencies, where X_c is much higher than R_2, the gain is essentially R_2/R_1, or $(R_2/R_1 + 1)$ in noninverting followers. At higher frequencies, the gain falls off at a rate of –6dB/octave. The frequency at which the gain starts falling off is measured from the –3dB frequency as defined by:

$$f = 1/2\pi R_2C_1$$

ES&T

Test your electronic knowledge

By Sam Wilson, ISCET test director

These questions are similar to questions used on the various CET tests. All questions on the actual CET test are multiple choice, and a grade of 75% or better is required for passing. This month's questions are all about power supply. (Answers on page 57)

1. Which of the following is true regarding the rectifier diodes in Figure 1?
   A. The diode-resistor combination doesn't make sense.
   B. The combination assures equal forward voltages across the resistors.
   C. The combination assures equal reverse voltages across the resistors.
   D. The PIV of the combination is the same as the lowest PIV rating of the three diodes.
   E. The PIV rating of the combination is the same as the highest PIV rating of the three diodes.

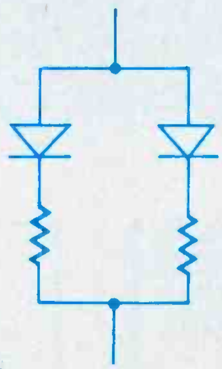


Figure 2.

2. Which of the following is the purpose of the resistor in the rectifier diode-resistor combination of Figure 2?
   A. Limit the forward current through the diodes.
   B. Assure that both diodes will conduct.
3. Which of the following is true regarding the rectifier diodes in Figure 2?
   A. The diode-resistor combination doesn't make sense.
   B. The combination assures equal forward voltages across the resistors.
   C. The combination assures equal reverse voltages across the resistors.
   D. The PIV of the combination is the same as the lowest PIV rating of the two diodes.
   E. The PIV rating of the combination is the same as the highest PIV rating of the two diodes.
4. The circuit of Figure 3 is
   A. a discriminator.
   B. a ratio detector.
   C. a full wave rectifier.
   D. a voltage doubler.
   E. two half-wave rectifiers.
5. The broken line between the primary and secondary windings in Figure 3 represents
   A. a self-resonating transformer.
   B. a saturable reactor.
   C. an auto transformer.
   D. Faraday shield.
   E. a phase shifter.

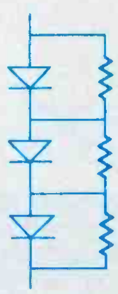


Figure 1.

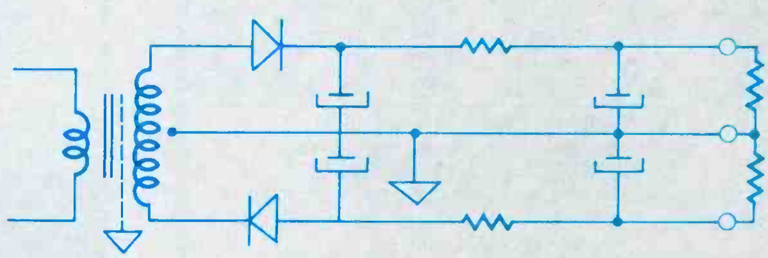


Figure 3.

6. The purpose of the 4.7Ω resistor in Figure 4 is
   A. to limit the output voltage to a given value.
   B. to improve the supply regulation.
   C. to protect the diode.
   D. to protect the output load resistance.
   E. None of these choices is correct.
7. The output voltage of the supply in Figure 4 should be about
   A. 140V.
   B. 100V.

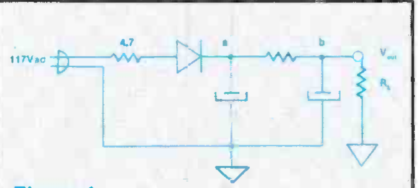


Figure 4.

8. In the circuit of Figure 4 you will find the audio power amplifier connected to which point?
   A. a
   B. b

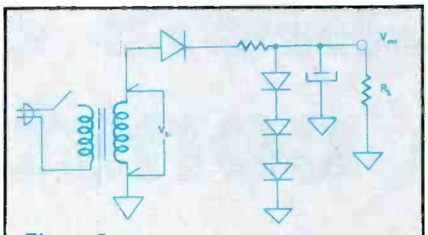


Figure 5.

9. All of the diodes in the circuit of Figure 5 are silicon types. Which of the following is true regarding this circuit?
   A. The output is short circuited.
   B. The diodes are connected in the reverse direction.
   C. The diode current must be equal to the load current.
   D. In order for the circuit to work properly, V_{IN} must be at least 25V.
   E. The output voltage is about 2.1V.
10. The circuit in Figure 6 is
   A. a short circuit across the secondary.
   B. a bridge rectifier.
   C. an open circuit.
   D. a preregulating circuit and full-wave rectifier.
   E. ok if all of the diodes are reversed.

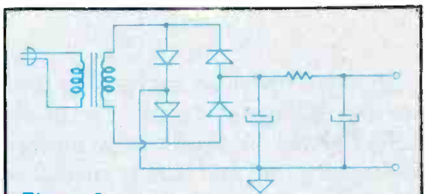


Figure 6.

ES&T

Understanding decibels and time constants

By Sam Wilson, ISCET test director

The two previous articles in this series (August and October **ES&T**) have covered the invention of logarithms and their relationship with epsilon (*e*). In this article, we will show how epsilon is related to the charge of a capacitor.

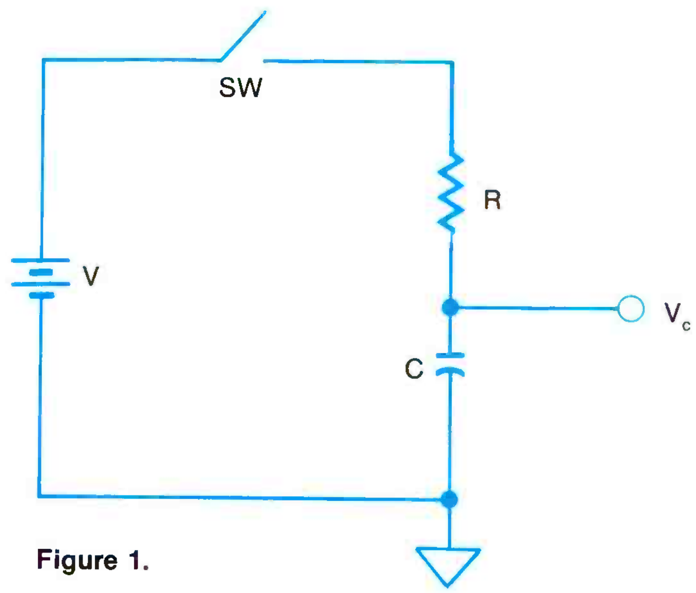


Figure 1.

Why study math?

Mathematics is a shorthand method of expressing relationships in electrical and electronic circuits. Technicians should think of mathematics as being an aid (rather than a hindrance) to analyzing electronic circuits and systems. Unfortunately there is so much new technology to be learned that the importance of basic mathematics relationships is often underestimated.

I have heard technicians boast that they have worked many years in electronics and never even used Ohm's Law.

Suppose a technician measures the voltage across a resistor and finds that voltage is too low according to the manufacturer's specifications. He immediately knows that the current or resistance (or both) is too low. He knows that because he knows Ohm's Law. He knows that the voltage across a resistor depends directly upon the current and resistance. In other words, he knows that V = I x R.

Every time a student learns an equation, he is learning a shorthand method of remembering relationships in circuits. Imagine trying to learn about electronics by dealing with Ohm's Law stated, "The amount of voltage drop across a resistor is dependent upon the amount of current flowing through that resistor, and it is also directly dependent upon the amount of resistance of that resistor."

Can you imagine having to learn 20 or 30 laws similar to that before you could begin to understand basic electric circuits? Fortunately you don't have to. The simple equation V = IR tells it all.

Time constants

How was the time constant equation (T = RC) obtained? Consider the circuit of Figure 1. The capacitor is discharged. It will start to charge the instant the switch is closed. The mathematical equation for the voltage across the capacitor (v_c) at any instant of time after the switch is closed (t) is:

$$v_c = \left(1 - \frac{1}{e^{t/RC}}\right) V$$

Where V is the applied voltage, R and C are the resistance and capacitance in ohms and farads respectively, and *e* is epsilon (2.71828).

A special case occurs when t is made equal to R x C.

$$\frac{t}{RC} = \frac{RC}{RC} = 1$$

For t = RC, the equation becomes:

$$v_c + (1 - \frac{1}{e^{t/RC}})V$$

$$= (1 - \frac{1}{e^1})V$$

$$= (1 - \frac{1}{2.71828})V$$

$$v_c = 0.632V, \text{ or, } v_c = 63.2\%\ V$$

This equation shows that the voltage across the capacitor is 63.2% of the applied voltage when t = RC. That is the reason that the voltage on the capacitor after *one time constant* equals 63.2% of the applied voltage.

An important thing to note from this discussion is that *e* is a factor in calculating the growth of voltage across a charging capacitor. This peculiar number (2.71828) is related to many fields other than electronics and biology.

The time constant equation (T_c = R x C) is useful when you want to find how long it takes a capacitor to charge to 63.2% of the applied voltage. But how do you find the voltage across the capacitor for some other value of time? If you have a calculator, it is a simple matter to use the equation for v_c. If you do not have a calculator, follow the step-by-step procedure to increase your insight into the time constant.

Sample problem

In the circuit of Figure 1, the following values apply: V = 5V, R = 1MΩ and C = 1μf.

What is the value of v_c 0.5s after the switch is closed? (For this type of problem, always assume the capacitor is discharged to start.)

Solution

The time (t) is 0.5s, and the value of R x C is:

$$R \times C = 1 \times 10^6 \times 1 \times 10^{-6}$$

$$\text{or } R \times C = 1s$$

The equation can now be solved:

$$v_c = (1 - \frac{1}{e^{t/RC}})V$$

$$= (1 - \frac{1}{e^{0.5/1}})x5$$

$$V_c = 1.97V$$

So, in 0.5s the voltage across the capacitor has increased to slightly less than 2V.

The equation for v_c can be used for many practical problems. However, in technicians' books, T_c = R x C is often given as the only time constant equation. And for full charge of the capacitor, the equation is given as T_c = 5 x R x C.

Is the capacitor really charged to the full supply voltage in five time constants? Not quite. If you use t = 5 in the equation for v_c, you will find that the voltage across the capacitor is 99.3% of the supply voltage at the end of five time constants.

So when does the capacitor actually become fully charged? Never. You can raise *e* to any large number and if your calculator can work with that number, you will find that the capacitor is not quite charged to the full supply voltage.

The value of five time constants for full charge was chosen because, for all practical considerations, the capacitor is fully charged after that amount of time.

Arriving at the equations

How did they arrive at the equation for decibels, time constants and Ohm's Law? The curve for the response of the human ear to loudness and the curve that shows the voltage across a capacitor during charge are both logarithmic.

If you were an early experimenter working on hearing measurement and graphed your results, you would soon come to the conclusion that the general shape of the curve is the same for all people with normal hearing. If you had a basic math background, you would recognize that you are dealing with a logarithmic response, so you would write an equation that involved logs for the hearing response.

The process of writing an equation from a curve is called *curve fitting*. This is not to play down the valuable contribution of the people who did this important work. But, technicians are sometimes puzzled about where certain equations come from.

You could not derive the equation for decibels without first making a lot of measurements to see what type of response you are dealing with. Equations that are derived this way from data are called *empirical equations*.

The equation for V_c was derived the same way. Data was taken and curves were drawn, then the equation that fit that curve was written. Therefore, V_c is an empirical equation.

It is interesting to note that Ohm's Law (V = IR) was derived empirically. Georg Ohm lived in the shadow of his brother, who was a famous biologist in Europe.

Ohm studied the relationship between voltage and current, then wrote an equation that related the two. His first published paper gave an equation that was not correct. Fortunately, he reworked the equation and soon published it in the form we use today.

So far in this series we have talked about the concept of decibels and time constants. In a future issue, we will continue with the time constant equations and then give examples of practical problems that can be solved with the equations discussed up to this point.

Troubleshooting symmetrical output circuits

By Bud Izen, CET/CSM

The most common type of audio-output circuit uses two transistors in what is commonly called a push-pull or complementary arrangement. There are many specific examples of circuits of this type, but fortunately only three basic variations on the theme. These are the push-pull transformer-coupled type, the true output-transformerless (OTL) type and the most common of the three, the quasi-complementary type.

The easiest to understand is the garden-variety transformer-driven output stage (Figure 1). You will come across this circuit or its close cousins in all tube circuits, older transistorized products and less-expensive products. Because a majority of the products in the service market now are solid state, we'll just look at transistor circuits, but the exact same analysis applies to tube circuits.

The output transformer is driven by both Q1 and Q2. The signal inverter make the top and bottom signals fed to each device a mirror image of each other because they are 180° out of phase. Each device is biased into cut-off either half of the time (pure class B operation) or slightly less than half of the time (class AB operation). This overlap in conduction is created in order to eliminate *crossover distortion,* which can occur if one device turns on as the other turns off. This can be easily observed on the scope as a "notch" appearing as the waveform crosses the zero-conduction point.

When either transistor conducts, it induces a voltage across the entire transformer primary, which is then coupled to the transformer secondary and therefore appears across the speaker. Depending on the design choice made by the manufacturer, the out-of-phase signals used to drive each device may be furnished by a single inverter stage, which affects only one of the output devices (the bias makes sure when each one starts to conduct), or may be fed by an input transformer. Such a transformer provides two signals, each 180° out of phase with the other (Figure 2).

Transformer coupling

The disadvantages of using transformers are phase distortion due to the reactance of the transformer, loss of low-frequency response due to core loss, weight increase, increased cost and the resulting increase in product size, and energy consumption due to transformer inefficiency. The main advantage of using transformers is ease of design, and a lesser advantage is that short circuits in the driver stage are isolated from the output stage and vice versa. For this reason, troubleshooting is fairly straightforward.

A more complex circuit

Neither of the circuits of Figures 1 or 2 are practical enough to work, yet they are not far from being usable. A realistic circuit using a single transistor as a phase splitter is shown in Figure 3. The signal at the collector of Q1 is 180° out of phase with that on the base, which can be treated as being in common emitter configuration. The signal at the emitter is in phase with that at the base, and can be thought about as being in common-collector, or emitter-follower configuration.

The gain of the Q1 stage is set by the ratio of R3 divided by R4, and is adjusted so that the signals from collector to ground and emitter to ground are essentially equal, and opposite in polarity. Q1 and Q2 are then biased into class B or AB operation by resistors R5 and R6. Capacitors C1, C2 and C3 are necessary in order to avoid quiescent operating point shift. Although more parts are required to accomplish this design than the previous one, frequency response is better and the cost is lower.

The complementary output circuit

Figure 4 shows a somewhat more complicated design that requires neither a phase-splitting device nor a transformer. By using one NPN and one PNP device (each the other's complement), push-pull action occurs without any external help. The two transistors are placed in series across the dc power supply. Resistors R3 and R4 provide fuse protection and some amount of thermal stability. R1 and R2 provide base current paths at the proper time.

Diodes D1 and D2 (often part of a single unit) provide bias stability in the following manner. Under normal conditions, the two transistor bases are about 1.2V apart. In an NPN device, the base is normally 0.6V more positive than the emitter, while in a PNP device the base is 0.6V more negative than the emitter. Ignoring the small drop across R3 and R4, the bases should measure normally about

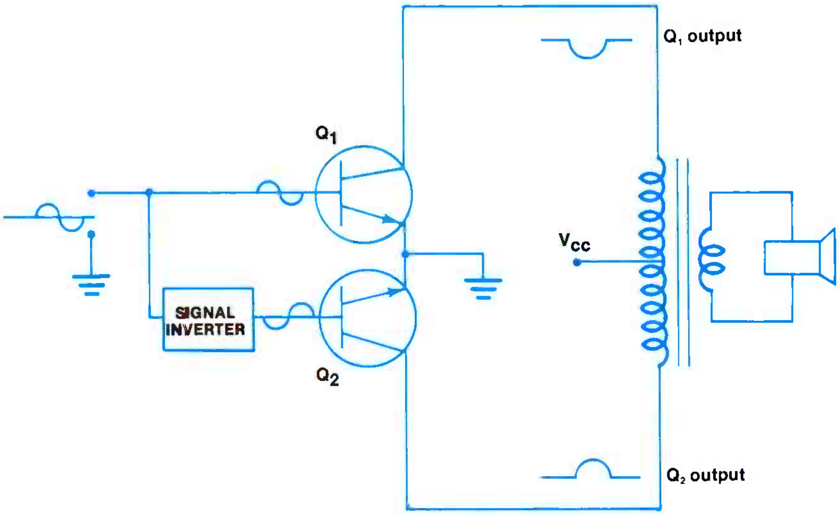


Figure 1. A push-pull output driven by a signal inverting stage.

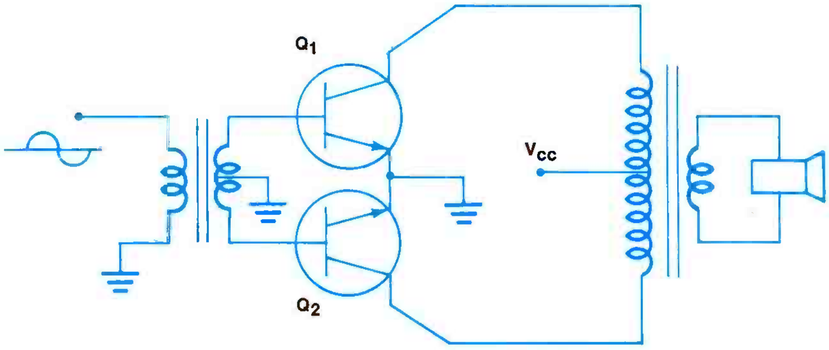


Figure 2. A push-pull output driven by a phase-splitting driver transformer.

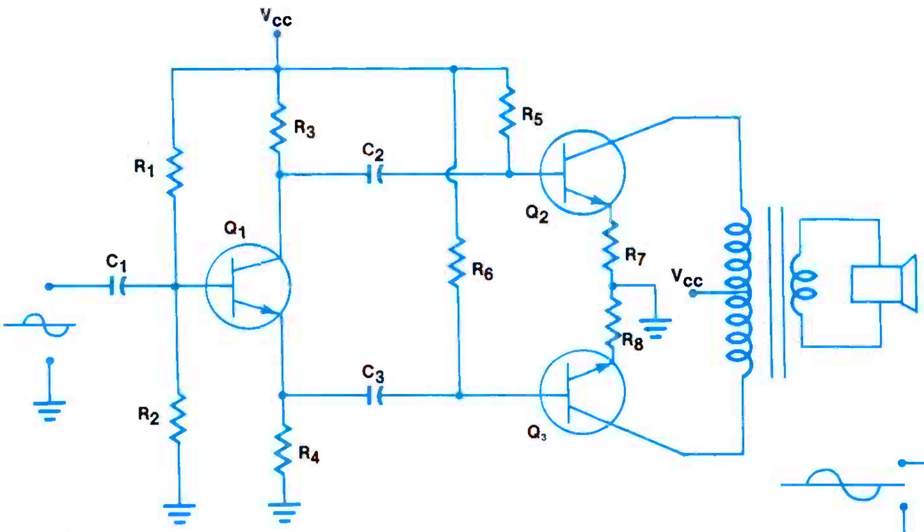


Figure 3. A circuit using a single transistor as a phase splitter.

1.2V apart constantly because the emitters are essentially tied together.

The diodes are mounted very near the output transistors, often secured to them or mounted on the same heat sink. The temperature response of the diodes is matched to that of the transistors. As the temperature of the devices increases, causing the transistors to increase in conduction, the voltage across the diodes decreases, limiting base current. Therefore, thermal runaway can be controlled.

Avoiding a critical error

A word of caution is necessary at this point. Because the diodes are matched to the output devices, if it is ever necessary to replace the diodes, use only exact replacements. Also, if new output devices are required in circuits like this, it is wise to order the diode unit(s) as well. In the case of a part number or type change when the ordered parts are received, this will ensure that a repair brings the unit back to specs without worry or unnecessary delay. There is nothing more annoying than to install substitute devices with different numbers than the original parts and have the unit fail because the temperature characteristics of the diode are not the same as that of the replacement device.

Obviously, the same caution applies when using general substitutes for original parts. They may or may not work, even if the

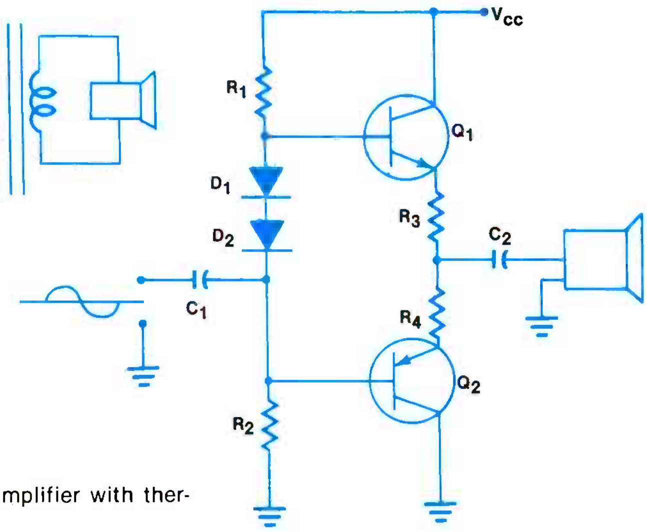


Figure 4. A basic complementary-symmetry amplifier with thermal stabilization.

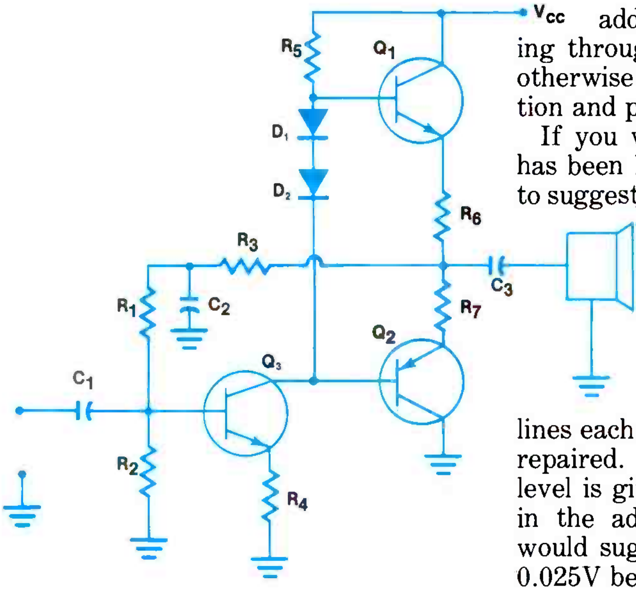


Figure 5. The circuit of Figure 4 preceded by a class-A voltage amplifier.

manual says they will. In general, you will always be better off replacing output devices with exact replacements. The higher the power of the amplifier, the more likely this is to be true. If the amplifier is direct-coupled, this will be crucial in avoiding disaster.

To illustrate this, the service manager of a local branch of a chain stereo store told me that one day a local servicer came in to drop off an amplifier. The servicer complained that the "darn thing just wasn't any good," and was "impossible to fix." He had replaced virtually every transistor in the unit with a well-known general substitute device.

Unfortunately, the amplifier was completely direct coupled. All it took was a little bias shift, and every single substitute device was destroyed. Replacement of the transistors with exact replacements and output current adjustment was all it took to repair the unit.

The analysis continues

Because the output of the circuit in Figure 4 is taken from the emitters, no matching transformer is needed. However, because the design requires that half of the dc supply voltage be dropped across each device, steps must be taken to keep dc out of the speaker. C2 is added to block dc from passing through the voice coil, which otherwise would cause core saturation and possible coil burnout.

If you work on a speaker that has been burned out, don't forget to suggest to the customer that the amplifier should be checked for possible dc presence. Likewise, it is always necessary to check for presence of excessive dc on speaker lines each time an output circuit is repaired. Usually a maximum dc level is given on the schematic or in the adjustment procedures. I would suggest that no more than 0.025V be present.

Becoming more practical

The circuit of Figure 4 is still not quite practical, but is close. Because Q1 and Q2 are emitter-followers, the output stage has a voltage gain of slightly less than one. It is therefore necessary to provide at least one stage of voltage gain before the output. Figure 5 shows the circuit of Figure 4 redesigned with Q3 added as a pure class-A voltage amplifier. R3 and R1 couple back negative feedback to stabilize the gain of Q3 by monitoring a rise in voltage at the junction of C3, R6, R7 and R3. The Q3 operating bias is obtained through that same source, while obtaining collector bias from R5, D2 and D1. C2 is provided to eliminate any signal voltage feedback. This circuit is now practical enough to find application in many sorts of products, but it can be refined further.

Disadvantages of coupling capacitors

Coupling capacitors have several undesirable characteristics. They cause phase distortion because they have more reactance at low frequencies than at high frequencies. Coupling capacitors that are used to couple the signal from output devices to speakers while blocking dc must be very large in size (often thousands of microfarads) because of the low impedance nature of output circuits. In order to avoid pronounced phase shift and accompanying voltage-divider action, the capacitive reactance should be no more than 10% of the speaker load resistance at the lowest operating frequency. If such is not the case, loss of bass response is often the result. Physically large capacitors are expensive and limit the overall compactness of the amplifier.

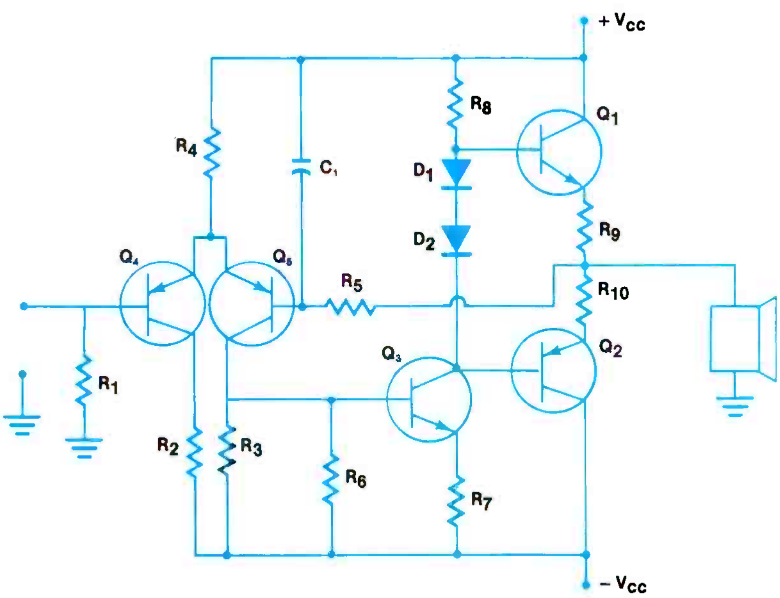


Figure 6. dc-coupled complementary amplifier.

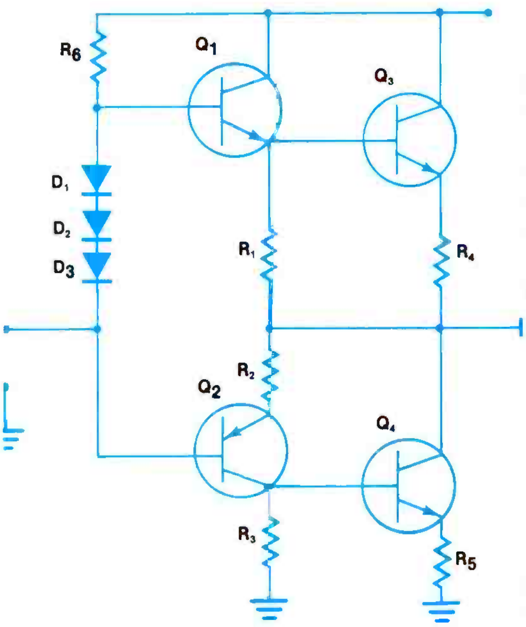


Figure 7. Quasi-complimentary symmetry.

A solution to the problems

Figure 6 shows the circuit of Figure 5 modified to eliminate the need for all coupling capacitors. Instead of using one source of Vcc, the original Vcc is divided into two supplies, one negative and one positive. Initial engineering of the output transistor biasing will ensure that the speaker output line will have essentially 0Vdc on it. Transistors Q4 and Q5 are added as a differential pair. As long as the speaker line remains at 0Vdc, Q5 essentially does nothing. If the voltage on the speaker line rises (in either the positive or negative direction), Q5 will change conduction so as to restore balance. R4 serves as a constant current source for Q4 and Q5, allowing this action to occur.

The voltage on the speaker line is referred to as the *offset* voltage. The offset voltage is monitored by the current flowing through R5. The dc levels can then be altered, depending upon the direction of offset shift.

Troubleshooting analysis

As an example, let's examine what would happen if the offset voltage increased negatively. Q5 would turn on harder, its collector voltage would fall, increasing the drop across R3. The voltage at the base of Q3 would be less negative, turning on Q3 more and lowering its collector voltage. In turn Q1 would turn on harder and Q2 would conduct less, regaining zero offset. In order to analyze the reverse situation, a positive increase in offset voltage, merely change the words in the above analysis. Change *up* to *down*, *fall* to *rise*, *less* to *more*, *harder* to *less hard* and *lowering* to *raising*. The final result is the same: restoration of zero offset.

Improving damping factor

The application of a concept called *damping factor* is a major concern to users and manufacturers alike. In order for the amplifier to be able to control speaker cone movement, the ratio of speaker impedance to amplifier output resistance must be fairly high. Elimination of the output capacitor improves that ratio as the capacitive reactance increases the output impedance when such a capacitor is used. Because the circuit of Figure 6 accomplishes this task, you will find its application in many high-quality amplifiers. Circuits such as these produce damping factors from 20 to 50 and above.

More power needed

Unfortunately, with few exceptions, complementary NPN-PNP pairs are hard to match for high-power applications. Above 10W or so, NPN power types become expensive, too. Factors like temperature coefficient and beta drift become critical in high-power applications, and slight discrepancies in such characteristics usually result in catastrophic failure. When high power is needed, a complementary pair is often used as a driving stage, while two NPN types are used to actually provide the power. This type of circuitry is commonly called *quasi-complementary symmetry*. Circuits combining the features of both circuits in Figures 6 and 7 are common.

Figure 7 shows a typical, simplified but accurate representation of such an output configuration. When a positive voltage is presented to the base of Q1, increased conduction takes place in both Q1 and Q3. Notice how the collectors of Q1 and Q3 are tied together and that the emitter of Q1 feeds the base of Q3. This is called a Darlington-pair configuration. Sometimes manufacturers provide such a pair in a single conventional 3-lead package. Watch out for this in making substitutions. The net result is that Q1 and Q3 act together to simulate a high-power NPN device.

Similarly Q2 and Q4 are connected to simulate a high-power PNP device. When a negative signal is presented at the base of Q2, it turns on, making the voltage on its collector less positive and causing Q4 to conduct harder.

In order to stabilize the voltage drop between the bases of Q1 and Q2, diodes D1 through D3 are used, often integrated into a single package as previously discussed. Three diodes are needed because there are now three junctions to stabilize (Q1, Q2 and Q3). Resistors R1 through R5 are used to provide thermal stability and fuse protection. They are not always used in such circuits. In all respects, these types of circuits can be analyzed just the same way as the true complementary circuits previously discussed.

A final caution

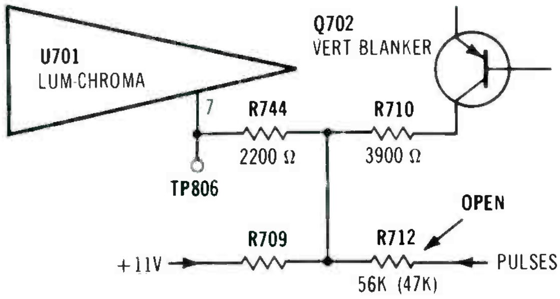
After the repair of an output circuit of an audio amplifier, it is vitally important to make sure that the cause of failure is not external. Many times output circuits can be blown by shorted speaker wires, an excessive number of speakers being driven by the unit, or by something defective in one of the speakers themselves. Many servicers I know will not warranty an output circuit repair unless the customer brings in the speaker wire and sometimes even the speakers themselves. Doing anything less is taking a gamble.

It is also entirely possible that when the output stage failed, the speaker system was simultaneously damaged. Failure to check out this possibility leaves you open to all kinds of unpleasant possibilities. ES&T

Symcure

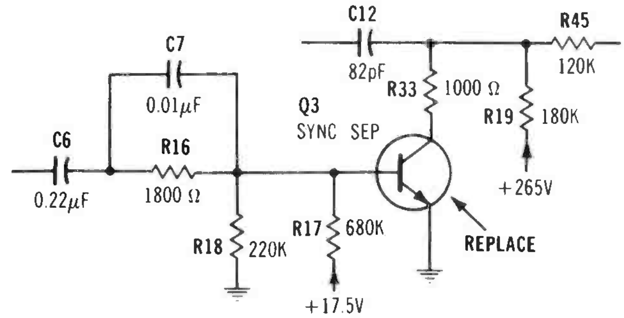
Symptoms and cures compiled from field reports of recurring troubles

Chassis—RCA CTC108 1
PHOTOFACT—2030-2



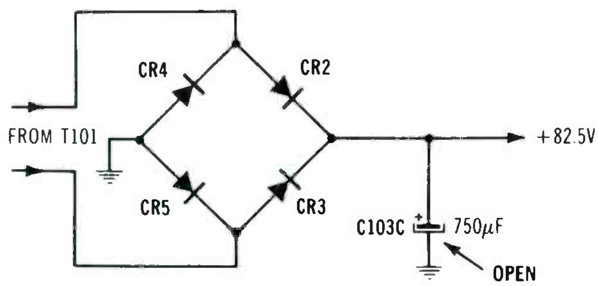
Symptom—Normal sound, but no raster
Cure—Check resistor R712, and replace it if open or increased in value

Chassis—RCA CTC53E 2
PHOTOFACT—1201-1 or 1342-2



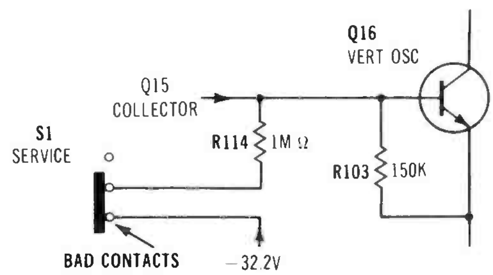
Symptom—Erratic horizontal pulling in picture
Cure—As a test, replace Q3 sync separator

Chassis—RCA CTC76 3
PHOTOFACT—1468-2 or 1616-1



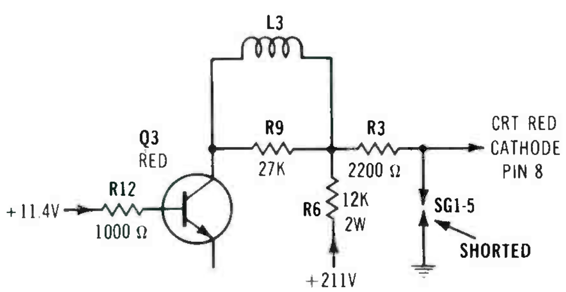
Symptom—Insufficient height at bottom and erratic vertical rolling
Cure—Check filter capacitor C103C, and replace can if any section is open

Chassis—RCA CTC97 4
PHOTOFACT—1862-1 or 1931-2



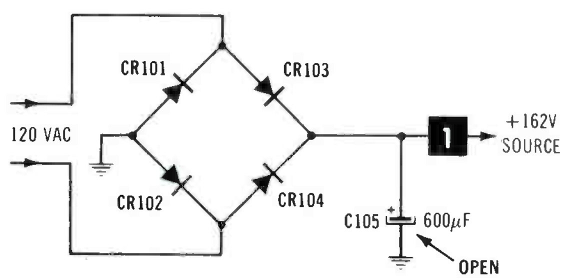
Symptom—Intermittent rolling or loss of height
Cure—Check the service/normal switch, and replace it if contacts are erratic or leaking to ground

Chassis—RCA CTC111 5
PHOTOFACT—2038-1



Symptom—Bright red screen with retrace; shut-down after a few seconds
Cure—Check spark-gap SG1-5 on the kine-drive board, and replace it if shorted

Chassis—RCA CTC109 6
PHOTOFACT—1952-1



Symptom—Receiver began operating by itself and cannot be switched off, also the picture has an hour-glass shape with ac-hum instability
Cure—Check C105 filter capacitor, and replace it if open

Answers to quiz

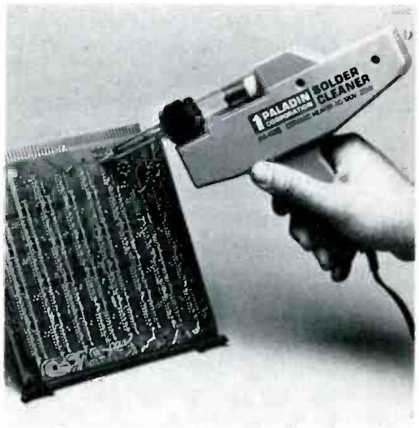
(from page 48)

1. *C* There is no assurance that the reverse resistances of diodes are equal even though they have the same type number. It is possible that a reverse voltage can be excessive across one of the diodes if its reverse resistance is high compared to the other two. The high-resistance resistors in Figure 1 have identical values and they equalize the reverse voltage drop.
2. *B* If one diode has a forward voltage of 0.7V and the other has a forward voltage of 0.8V, they cannot be connected directly in parallel. The reason is that if the 0.7V diode starts to conduct, the other one will never have enough voltage across it to start it into conduction. The resistors assure that when one diode starts to conduct, the voltage across that branch will be high enough to start the other diode.
3. *D*
4. *E* Discriminator and ratio detectors require tuned transformers.
5. *D* The purpose of this shield is to prevent electrostatic coupling between the primary and secondary.
6. *C* In a few cases this resistor has been used for two purposes. It protects the diode from the surge current that occurs when the capacitors are first charged. At the same time it may be used as a fuse to protect the supply from a constant overload.
7. *A* The output capacitor charges to the peak voltage of the input minus the drops across the filter, diode and surge limiter.
8. *A* Power amplifiers do not require a highly filtered dc voltage. By connecting the power amplifier to point a, it is not necessary to have a high current flowing through the filter resistor.
9. *E* With about 0.7V across each diode, the output voltage will be about 2.1V.
10. *A* The only limit to the secondary current on each half cycle is the forward voltage drops across the diodes.

Products

Powered solder cleaner

The *Paladin* PA 1715 is the result of a technology that puts electric power desoldering within reach of small electronic assembly and service operations. Unique features include a virtually

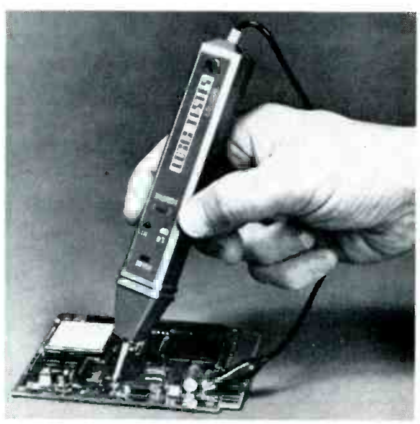


maintenance-free ceramic substrate heating element, and iron and chrome-dipped tip that outlasts ordinary tips five to one. The straight-duct designed solder-collector cartridge prevents solder from clogging, sticking or interfering with the vacuum pump.

Circle (133) on Reply Card

Logic probe tester

Logic Probe Tester LG1000 by *Vaco Products* simplifies the task



of servicing logic circuits by instantly detecting faulty circuits so repairs can be initiated. It has a built-in power supply, making an external power cord unnecessary. A power-on-demand switching system permits power to be turned on automatically only while the probe is being used, for the ultimate in cost-effective operation. This tester is sensitive to minus voltage and features a negative voltage indicator.

Circle (85) on Reply Card

VCR battery packs

LCOMP, a distributor of electronic equipment, now offers sealed, rechargeable lead-acid battery packs for portable VCR equipment. Made by Gates Energy Products and assembled by LCOMP, the battery packs can be used for replacement or spares for original factory equipment.

The 12V, 2.5Ah, sealed batteries come in three configurations: 0810-0177 for Sony BP20, 0810-0178 for JVC PBP-1, and 0810-0179 for Sony BP60 systems. Other configurations are available for other portable videotape systems from LCOMP.

Circle (130) on Reply Card

Electronic grade coolant

An electronic circuit/component coolant to aid in servicing video games and vending machines has been introduced by *Chemtronics.* The coolant, named Freez-It, is designed to make thermal intermittent troubleshooting of circuit boards and electronic components easier. Applied as an aerosol spray, Freez-It will freeze to -65°F. Rapid chilling of suspected components allows individual components to be isolated for instrument testing.

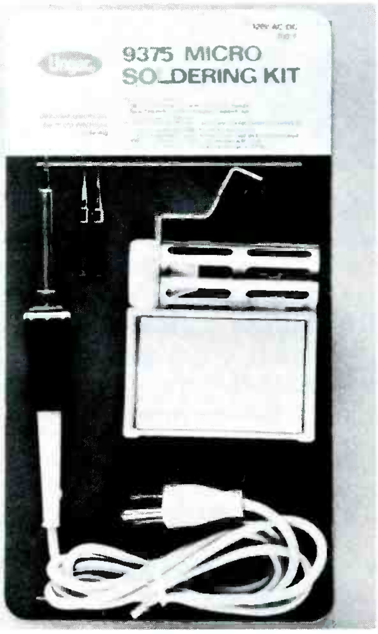
Freez-It coolant also can be used to prevent transformer burnout. Other uses include low-temperature testing of circuits and equipment, preventing cold solder joints, soldering delicate, heat-sensitive components and aiding in shrink-fit assembly

Circle (79) on Reply Card

Microcircuit soldering kit

A kit including soldering iron, tips and holder, from *Ungar,* is designed for precision microelectronic soldering.

The 9375 Micro-Soldering Kit includes a 3-wire handle that is slimmer than earlier models to facilitate close-tolerance soldering, a ThermoDuric heating element, tips of three different configurations and a holder assembly.



Thermo-Duric heating elements reach temperature and recover quickly, and eliminate electric leakage, which could ruin microcircuits. The three precision tips supplied in the kit are a needle point (0.005in. diameter at the point), a 0.03in-wide spade point and a 0.06in-wide screwdriver. Nine other tips are available.

Circle (87) on Reply Card

Aerosol flux remover

Developed for electronic production, re-work and repair, *Chemtronics'* new aerosol flux remover speeds the removal of activated and non-activated rosin flux and ionic soils from electronic subassemblies, printed circuit boards, switches, connectors and semiconductors, silicone wafers and other electronic components.

Flux-Off, a highly concentrated CO_2 propelled solvent, removes tough deposits without harm to delicate components. It will also effectively remove other contaminants such as dirt, grease and molding compounds without leaving a white residue.

Circle (75) on Reply Card

Floppy disc drive maintenance

Dumont Magnetic Technology has announced third-party maintenance, repair and refurbishment service on floppy disc drives. Nearly every variety of floppy disc drive from companies such as Shugart, Tandon, MPI and Qume can be repaired and refurbished to the companies specifications. In addition to complete drive service, Dumont has a head repair facility and can repair most heads without additional cost.

Circle (76) on Reply Card

Capacitance meter

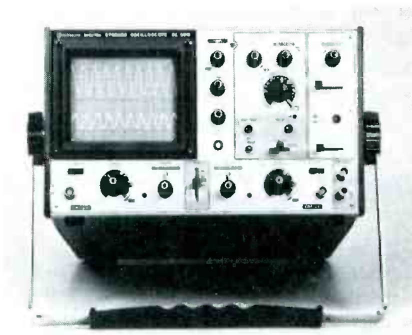
The 3002 autoranging capacitance meter, from *Global Specialties,* combines the precision, range and flexibility of bench-top models with the convenience and operating efficiency of a hand-held, portable unit. This meter provides direct readings of capacitance from 1pF to 19,990μF with eight automatically selected ranges providing accurate measurements of capacitance without manual switching.

The dual-threshold measurement technique eliminates reading errors due to dielectric absorption. By using dc charging characteristics to determine true capacitance, the 3002 can determine capacitance in cable, switches and other electronic components and hardware in addition to capacitors and capacitor networks.

Circle (84) on Reply Card

Digital storage oscilloscope

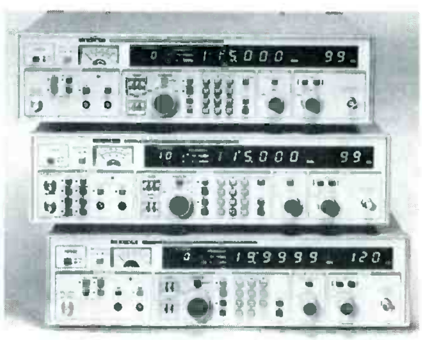
Hitachi's VC-6015 digital storage scope features a memory capacity of 1000 words per channel with a writing speed of 1μs per word to 1ms per word. The VC-6015 has a pretrigger function that enables the capture of an event before the trigger pulse occurs, a feat that up to now was impossible with conventional CRT-storage type scopes. The pretrigger position may be set at 0, 2, 5 or 8 divisions, and the trigger point is displayed on the CRT as an intensified point, allowing the user to determine its relationship to the captured waveform.



Circle (78) on Reply Card

Signal generators

Leader Instruments has introduced three new programmable synthesized AM/FM RF signal generators. The new series of generators features convenient keyboard control of frequency and output level. Semi-automatic operation is available by pre-programming up to 100 different test conditions.



The LSG-217 offers an output frequency range of 0 to 70MHz in two bands, 0.1 to 19.9999MHz in 100Hz steps and 20 to 70MHz in 1kHz steps. Output level range is 0 to 120dBμV in 1dB steps.

Circle (81) on Reply Card

Portable light

Headlights, from *Brighteyes of California*, are a self-contained, portable light source for the repairman or inspector. They direct bright light where you look while leaving both hands free for tools, writing or adjusting. They light when you put them on, and there are no switches, cords or battery packs to snag or break. Headlights are designed to be worn comfortably with or without glasses, and allow you to get as close to the work as you wish.

Circle (80) on Reply Card

Digital multimeter

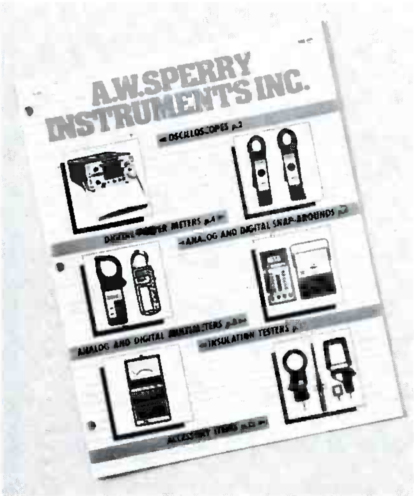
A new, 3½-digit auto-manual ranging hand-held digital multimeter with 0.7% dc accuracy, overload and transient protection, high energy fuse, diode test and audible continuity check is available from the *B&K-Precision* Test Instrument Product Group of Dynascan Corporation.

Model 2806 features auto-ranging or step-through manual ranging for all voltage and ohm measurements, and manual ranging on amp measurements. The dc voltage ranges are 200mV, 2000mV, 20V, 200V and 1000V, and the ac voltage ranges are 2000mV, 20V, 200V and 750V.

Circle (85) on Reply Card

Literature

A. W. Sperry Instruments has released a new full-line catalog, MC-499 Issue A. The catalog features the entire AWS line of test equipment including oscilloscopes, analog and digital snap-arounds, analog and digital multimeters, power meters, insulation testers, indicating devices and accessory items.



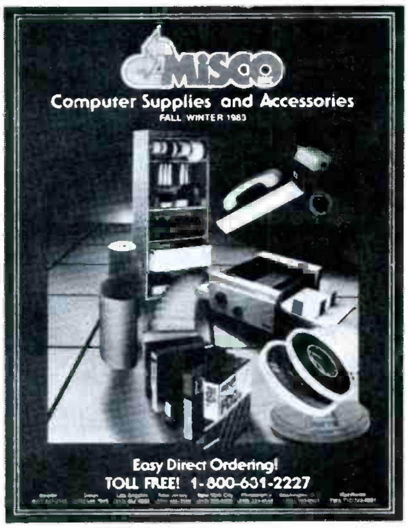
Circle (100) on Reply Card

Etco Electronics has released a new 112-page catalog featuring thousands of items from the fields of electronics, communications, telephone, cable TV and video, in addition to a complete parts selection for the hobbyist or repair shop.

A 16-page section of the catalog has been devoted to telephone and related equipment for small systems applications as well as for the home user. Simple systems that can be user-installed are shown.

Circle (105) on Reply Card

The new 96-page Fall/Winter Catalog is now available from **Misco.** The catalog offers more than 200 new items and contains three new product section categories. All products are available for immediate shipment by phone or upon written order. The company offers supplies and accessories for computer and word processors, including a complete line of Clean Room cleaning and decontamination products.



Circle (101) on Reply Card

Circle (33) on Reply Card

Classified

Advertising rates in the Classified Section are 50 cents per word, each insertion, and must be accompanied by payment to insure publication.

Each initial or abbreviation counts a full word.

Minimum classified charge $10.00.

For ads on which replies are sent to us for forwarding (blind ads), there is an additional charge of $3.00 per insertion to cover department number, processing of replies, and mailing costs.

Classified columns are not open to advertising of any products regularly produced by manufacturers unless used and no longer owned by the manufacturer or distributor.

FOR SALE

SCRAMBLED TELEVISION, encoding/decoding. New book. Theory/circuits, $9.95 plus $1 shipping. Workshop, Box 393ES, Dept. E, Bethpage, NY 11714. 7-80-tfn

TUBES FOR TV AND RADIO—35¢ ea. Washington TV Service, 1330 E. Florence Ave., Los Angeles, CA 90001. 1-83-12t

CABLE TV CONVERTER/DECODER. LOWEST PRICE ANYWHERE. Oak N-12 or Jerrold SB-3 replacement $79.00, Combo with 35 channel converter $139.00, Jerrold DRX-3DIC with remote $179.00. Send $2.00 with order or for catalog, refundable with your order to: CK Electronics, 397 Route 18 East, Suite 377, East Brunswick, NJ 08816, 201-739-2671. 10-83-2t

COMPLETE JERROLD WIRELESS REMOTE/DESCRAMBLER—full warranty, $159.00. Complete Oak descramblers, full warranty, $169. Trap/filters in line type, $49, 2 min. installation, SG613 transistors, only $6.99. Original Toshiba 2SC1172B, only $1.99 with hardware. 100/450, 80/480, 200/300, 40/450, 25 1st only $1 each mixed or single lot. Super special while they last 800-860 41 each safety caps Zenith type, 10 lot only $2.50. Bulk 2SC1172B only 50 lot, $1.69. Redcoat Electronics, 104-20—68th Drive, Forest Hills, NY 11374, (212) 459-5088. 5-83-tfn

CABLE CONVERTERS, DECODERS. Free catalog! APS, POB 263, Newport, RI 02840. 6-83-12t

SUBSCRIPTION TV MANUAL, covers all three major scrambling systems, only $12.95. Includes theory, circuits,. waveforms and trouble shooting hints. Save your VIDEO GAME CARTRIDGES on EPROM with our EPROM duplicator. Plans $9.95. Catalogue $2.00, refundable. RANDOM ACCESS, Box 41770A, Phoenix, AZ 85080. 8-83-tfn

2SC1172B's, 50 LOTS—$1.69; 2SC1308K's, original Sanyos, 50 lots—$1.99; Cheater cords, 25 lots—35¢; pol- and non-polarized. 1,000 ft. reels of RG 59 U. Coax Cable—$39/roll. Minimum order $75. Redcoat Electronics, 104-20 68th Drive, Forest Hills, NY 11375, 212-459-5088. 10-82-tfn

ELECTRONIC SURPLUS: CLOSEOUTS, LIQUIDATIONS! Parts, equipment stereo, industrial educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog ETCO-011, Box 762, Plattsburgh, NY 12901. 6-78-tfn

SPRING SPECIALS on Popular Electrolytics—40/450V—75¢; 80/450V—85¢; 100/450V—95¢ 200/300V—$1.05. Quantity 20 lot only. Minimum order of $50. SUPER SPECIALS. Bulk Zenith safety capacitors 800-860, 12 lot only $2.50 each. REDCOAT ELECTRONICS, 104-20 68th Drive, Forest Hills, NY 11375, 212-459-5088. 10-82-tfn

REPLACEMENT COLOR YOKES-DEALERS ONLY. Zenith 95-2501-2532-2887 etc. $22.95. Magnavox 361380-1 etc. $24.95. Sylvania $24.95. American-made fuses in bulk-example 3AG 2 regular price .23 each our price .12 each. Factory packaged GE transistors at discounts. Example GE-20 regular price $1.10 our price .65. Request circular on your letterhead. David Sims Enterprises, Inc., 665 East Jericho Tpke., Huntington Sta., NY 11746, 800-645-5030, NY State (516) 549-3925-1592. 10-82-tfn

TUBES—Receiving, Industrial and Semi-conductors, factory boxed. Free price list. Low; low prices. **TRANSLETERONIC INC.,** 1365-39th Street, Brooklyn, NY 11218E, 800-221-5802, 212-633-2800. 5-82-tfn

TV TROUBLE ANALYSIS TIPS. Over 300 symptoms/remedies by circuit area; tough ones over the years. Save time and money. Send $12.50 to CHAN TV, 8151 Grandview Rd., Chanhassen, MN 55317. 5-82-tfn

PRINTED CIRCUIT boards from your sketch or artwork. Affordable prices. Also fun kit projects. Free details. DANOCINTHS INC. Dept. ES, Box 261, Westland, MI 48185. 5-81-tfn

SONY-PANASONIC-RCA-ZENITH-EXACT REPLACEMENT PARTS-LARGE INVENTORIES-SEND PART OR MODEL NUMBERS-WILL UPS OR COD-GREEN TELE-RADIO DISTRIBUTORS, 172 SUNRISE HIGHWAY, ROCKVILLE CENTRE, NY 11570. 5-82-tfn

AUTOMOBILE RADIO and tape replacement parts: Delco, Chrysler, Philco-Ford, Motorola, Panasonic and many others. Large inventory. Laran Electronics, Inc., 3768 Boston Road, Bronx, NY 10469. (212) 881-9600, out of New York State (800) 223-8314. 5-79-tf

COLOR PICTURE TUBES direct from manufacturer. Prices from $55 to $75 exchange. One year warranty. Send your old tube ups to ATOLL Color Tubes, 6425 West Irving Park, Chicago, Illinois 60634. Phone: 312-545-6667. We also sell equipment for rebuilding CRT's. 9-83-3t

FOR SALE (CONT.)

ATTENTION TECH/SHOP OWNERS—Profits getting smaller with increasing cost of parts? Take advantage of our buying power and huge inventory on well known electronic products and replacement parts. Prices below dealer cost. Write for information. United Services Assoc., Old Grand Union Shopping Ctr., Rt. 9W, Stony Point, N.Y. 10980, 914-942-2173. 7-83-tfn

CB RADIO BOOKS, kits, modifications. Catalog $1.00 refundable. APS, POB 263, Newport, RI 02840. 6-83-12t

SOUTHERN CALIFORNIA SALES AND SERVICE OPERATION available; Over .2 million gross 1982; Thirteen years in area with excellent growth and high visibility. Audio/Video Sales and Servicenter, 26837 Bouquet Canyon Road, Saugus, California 91350, 805-255-5562. 9-83-3t

ADVENT VIDEO PARTS and service available from professional electronics. Call 504-467-1717 for further information. 9-83-3t

FOR SALE: SAMS 900 to 1695, total 300, price $450. CEC P.O. BOX 383, Bellflower, CA 90706. 11-83-1t

RETIRED: Sell or Trade entire inventory TV parts, Modules, Test Equipment, Sams, RCA & Zenith prints. Cost over $19,000, sell $9,500. A. Hudson, 935 Center Ave., Red Bluff, CA 96080 (916) 529-0350. 11-83-1t

COMPLETE SERVICE SHOP. Parts, Sams, Test equipment, tools, fixtures for TV, stereo, CB and Radio Service. A turnkey operation, except for van and building. (704) 739-5983 after 6 pm. 11-83-1t

INDIVIDUAL PHOTOFACT FOLDERS (not sets) under #1200. First class postpaid $3.00. Loeb, 414 Chestnut Lane, East Meadow, NY 11554. 11-83-3t

WANTED

WANTED FOR CASH: 50, 53, 6AF6, 6HU8, 304TL, 4CX1000A, 4-1000A, all transmitting, special purpose tubes of Eimac/Varian. DCO, Inc., 10 Schuyler Avenue, North Arlington, New Jersey 07032. Toll Free (800) 526-1270. 5-82-tfn

PHOTOFACTS WANTED. Numbers 900 to 1100. LB Television, 326 Kingston Avenue, Brooklyn, NY 11213. 11-83-1t

TELEVISION SERVICE SHOP in Florida or California. Call or write ATOLL TV, 6425 West Irving Park, Chicago, IL 60634; Ph. 312-545-6667. 11-83-3t

BUSINESS OPPORTUNITIES

NORWALK, CALIFORNIA ESTABLISHED TV AND STEREO SERVICE AND SALES very busy money maker, excellent location, low rent, very good lease, 2300 square feet, 10 minutes to beaches and Los Angeles. $40,000 includes inventory, large enough for living quarters, owner retiring, phone 213-863-1919. 11-82-tfn

SPEAKER RECONING: Most makes, sizes, models. For prompt service send to Mercury Speaker Reconing, 2018 W. Division St., Chicago, Illinois, 60622; (312) 278-2211. 9-83-tfn

COLORADO'S WESTERN SLOPE BECKONS: Established R.V. Repair and Sales business. Good lease, good terms. Century 21-Old Homestead, John McDermott, 737 Horizon Drive, Grand Junction, Colo. 81501 or call (303) 243-5100. 10-83-2t

RESIDENTIAL SECURITY ALARM sales are exploding and the Rampart Associate Program offers you ENORMOUS PROFIT POTENTIAL PLUS EXCITING RESIDUAL INCOME. Rampart's success and reputation are a result of a total business format approach for the residential, small commercial market and its new low cost system, the Rampart REACTOR, with central station monitoring. We provide product, marketing and management training with complete backup. Start part time, full time. No experience necessary; just a strong desire to succeed and help your customers. Investment only $2,850. With only 6% of the market penetrated, now's the time to get yourself started in what Time Magazine calls the "**runaway growth industry.**" Call Mr. Roberts 1-800-823-8002 or write, Rampart Ind. Inc. One Oxford Valley, Langhorne, PA 19047. 11-83-tfn

BUSINESS OPPORTUNITIES

LEARN TO REPAIR HOME VIDEO GAMES IN YOUR OWN SHOP! Did you know that more than 9 million HOME VIDEO games have been sold? Now you can learn to repair! Atari, Coleco, Intellivision, or Atari 400/800 computers in your own shop. Our courses are taught on VIDEO TAPE (Beta or VHS) and come with a manual containing all the necessary technical information you will need to do repairs. For more information or to order, call: Electronic Institute (800) 221-0834 (outside N.Y.) or (212) 377-0369 (in N.Y.) Customized live in shop training courses are also available, call for more information and price schedules. 7-83-tfn

10 YEAR ESTABLISHED TV SALES and SERVICE BUSINESS (service equipment included) with TV rental business in same building. Excellent downtown location with 2000 sq. ft. floor space, side service entrance, new parking lot being built. Owner will help finance and assist initial operation of store. Call 207-696-4242. 11-83-1t

TV TUNER REBUILDING BUSINESS, LOS ANGELES, CALIFORNIA 23 years same location, other interests, requires sale very reasonable, (213) 342-4745. 7-83-tfn

TELEVISION SHOP LIQUIDATION: All parts, shop and office equipment for sale. Send "stamped envelope" for parts lists. Samar TV, 8 Dusk Dr., Centereach, NY 11720. 11-83-1t

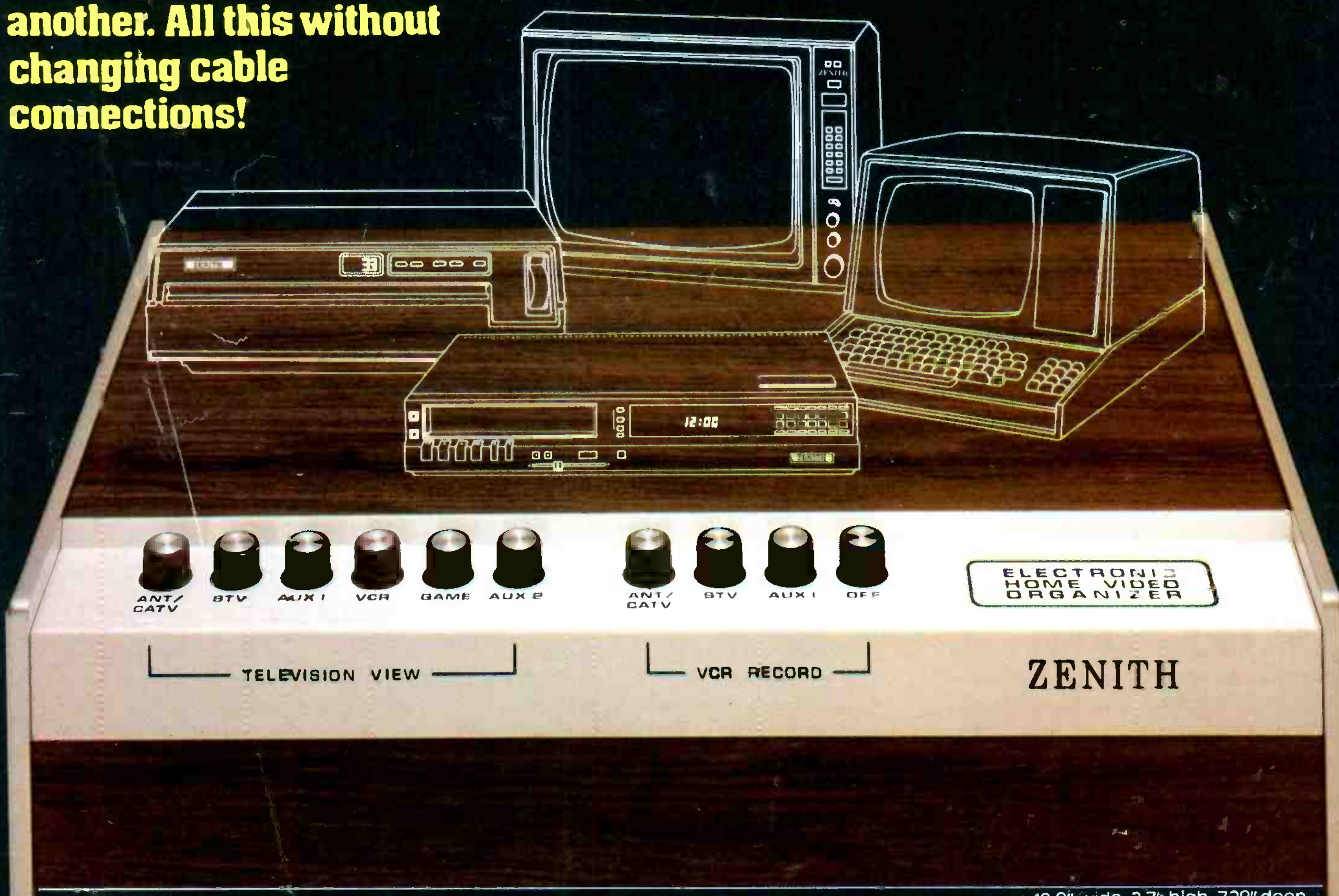
HELP WANTED

Advertisers' Index

Don't touch that connection!

New Zenith push-button VIDEO ORGANIZER permits switching from one program source to another without changing cable connectors.

Permits selection of up to six different program sources for viewing. Up to three different sources for recording. Even lets viewer watch one program source while recording another. All this without changing cable connections!



Model S10W

10.8" wide; 2.7" high; 7.28" deep

At last the nuisance of changing cable connections by hand is a thing of the past!

With Zenith's new Video Organizer, separate input and output jacks facilitate a complete connection of TV and VHF/UHF antenna or cable TV antenna, subscription TV decoder, video disc player, video cassette recorder, video game and home computer or other auxiliary video equipment.

So videophiles switch from one program source to another with push-button ease – without changing connections.

Equally important, the Video Organizer's advanced engineering design by Zenith results in low insertion loss and high isolation. Eliminates electromagnetic interference for maximum picture quality. And permits greater flexibility in use and ease of operation for more hours of uninterrupted home video enjoyment.

Write now for more information and the name of your Zenith distributor so you can start cashing-in on the fastest growing segment of the TV business!

ZENITH®

The quality goes in before the name goes on.®

Zenith Radio Corporation/Service, Parts & Accessories Division/11000 Seymour Avenue/Franklin Park, Illinois 60131

Double Your Troubleshooting and Testing Productivity . . . Or Your Money Back!

Six-digit readout: Automatically tracks every CRT test. We call it digital autotracking. It's patent pending.

Bright dual-trace CRT: 60 MHz (−3 dB); 100 MHz (−12 dB).

Delta PPV, Time, Freq: Measure any part of a waveform for PPV, time or frequency using Delta measurements. Just dial in the waveform section you want to measure and push.

Simplify Freq ratio tests: Automatically compare input/output ratio of multiply/divide stages from 1:1 to 1:999,999 with the push of a button.

Autotracking DCV, PPV, Freq: Measure DCV to .5%; PPV to 2%; freq. to .001%. Just push a button for either Channel A or B.

One probe input: One probe input per channel for all measurements - digital and scope - with 5 mV to 2000 V measuring range. (2 lo-cap probes provided.)

Super sync: ECL provides rock-solid sync trigger circuits with only 4 controls; includes TV sync separators for video work.

U.S. Patent Pending
Financing Available

The first scope with push button digital readout. If you use general purpose oscilloscopes for troubleshooting or testing, we can double your present productivity with the SC61 Waveform Analyzer, the first instrument to turn every conventional scope measurement into an automatic digital readout.

No more graticule counting. Connect only one probe to view any waveform to 100 MHz. Then, just push a button to read DCV, PPV, frequency and time — automatically!

There are no graticules to count or calculations to make, which speeds every measurement.

The digital readout is from 10 to 10,000 times more accurate as well.

Plus you have everything you want to know about a test point, at the push of a button, which speeds troubleshooting tremendously.

A special Delta function even lets you intensify parts of a waveform and digitally measure the PPV, time or frequency for just that waveform section.

And it's neat. No more tangled leads, piles of probes or dangling cords. The SC61 is an entire test station in one unit.

The one and only. There are other scopes with digital readout, but none of them completely automate every conventional scope measurement so you can automatically analyze any waveform without counting one single graticule. Totally automatic waveform analyzing at the push of a button. It will make all the difference in your productivity.

Double your productivity. When we say the SC61 will double your productivity, we're being conservative. We've seen cases of three, four, even ten time increases in productivity with this first-of-its-kind, automated oscilloscope. Every situation is different, however, so try the SC61 and judge for yourself. Here's our offer.

Money back guarantee. If the SC61 does not at least double your productivity during the first thirty days, you may return it for a full refund, including freight both ways.

Call today. Get the entire SC61 Waveform Analyzer story. Call toll-free today, and ask for our eight page color brochure. It could be the most productive call you make this year!

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Alaska, Hawaii, Canada and South Dakota call collect (605) 339-0100

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