

The magazine for consumer-electronics servicing professionals

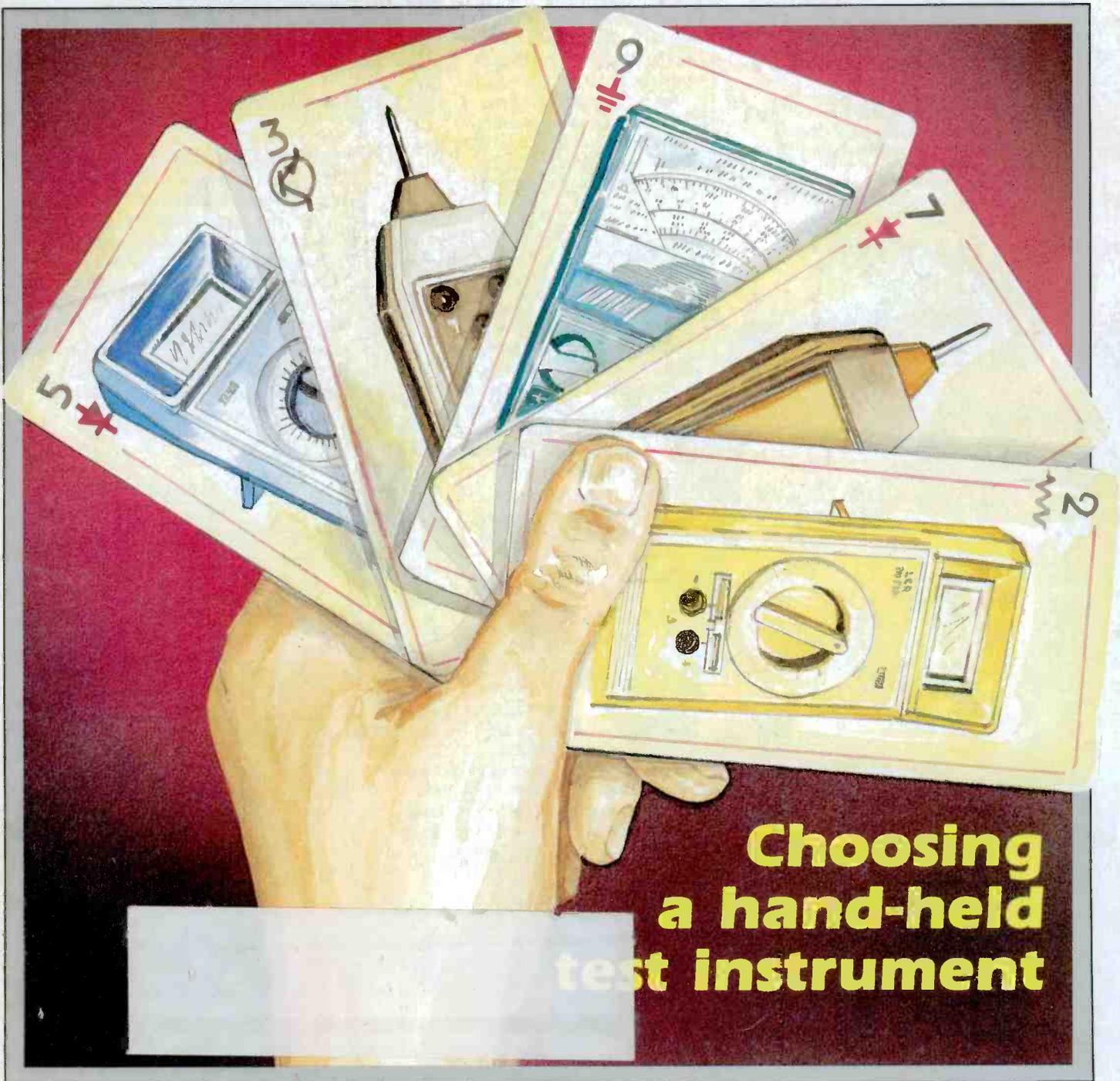
# ELECTRONIC

**Service & Technology**

DECEMBER 1988/\$2.50

**Service Sharp's small color TVs • The case of the missing diode**

**What do you know about...Kirchhoff's voltage law**



**Choosing  
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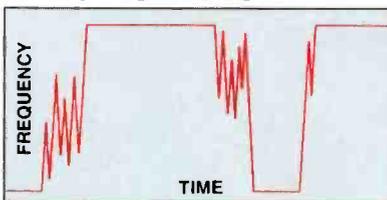
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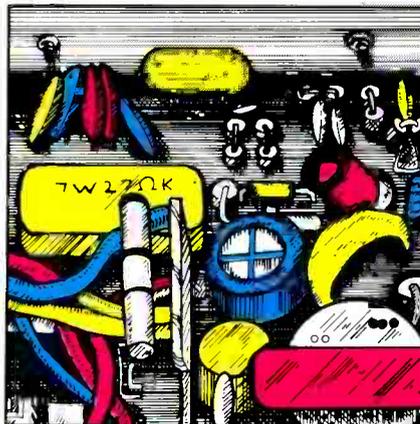
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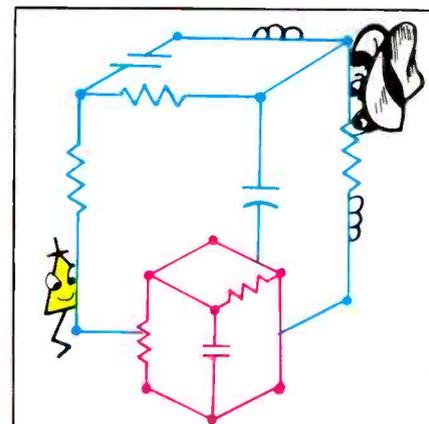
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## FEATURES

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By George Gore

With the selection of specialized test equipment getting better every year, deciding which test instrument you want can get pretty complicated. What equipment would be best for the kind of servicing you do? What specifications should you look for? Which accessories would you use the most? Here's an overview of the equipment you might choose for your most common applications.

### 14 Servicing Sharp's small color TVs—Part I

By Homer L. Davidson

Servicing small-screen TVs is really no different than servicing large-screen TVs, unless you consider those tiny little components you can hardly hold onto and the cramped spaces under the TV's hood. To gain back the time you lose wrestling with these minis, you need to know exactly

where to go once you figure out what's wrong. If you run into any of the symptoms described here, you're well ahead of the game.

### 22 The case of the missing diode

By Conrad Persson

OK, you've tracked the problem component down and you know, beyond a shadow of a doubt, that it's diode xyz. Problems over, right? Not a chance—now you've got to track down the *diode*. It can make you feel more like a private eye than an electronics servicer. Here are some ideas to get your investigation on the right trail.

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## ON THE COVER

Choosing the best hand-held test equipment for your purposes doesn't have to be a gamble. Whether you're interested in a multipurpose device or a highly specialized instrument designed for one purpose, there is a wide selection of inexpensive, hand-held electronic measuring instruments to choose from. (Concept and design by Barbara Miles, graphic designer.)

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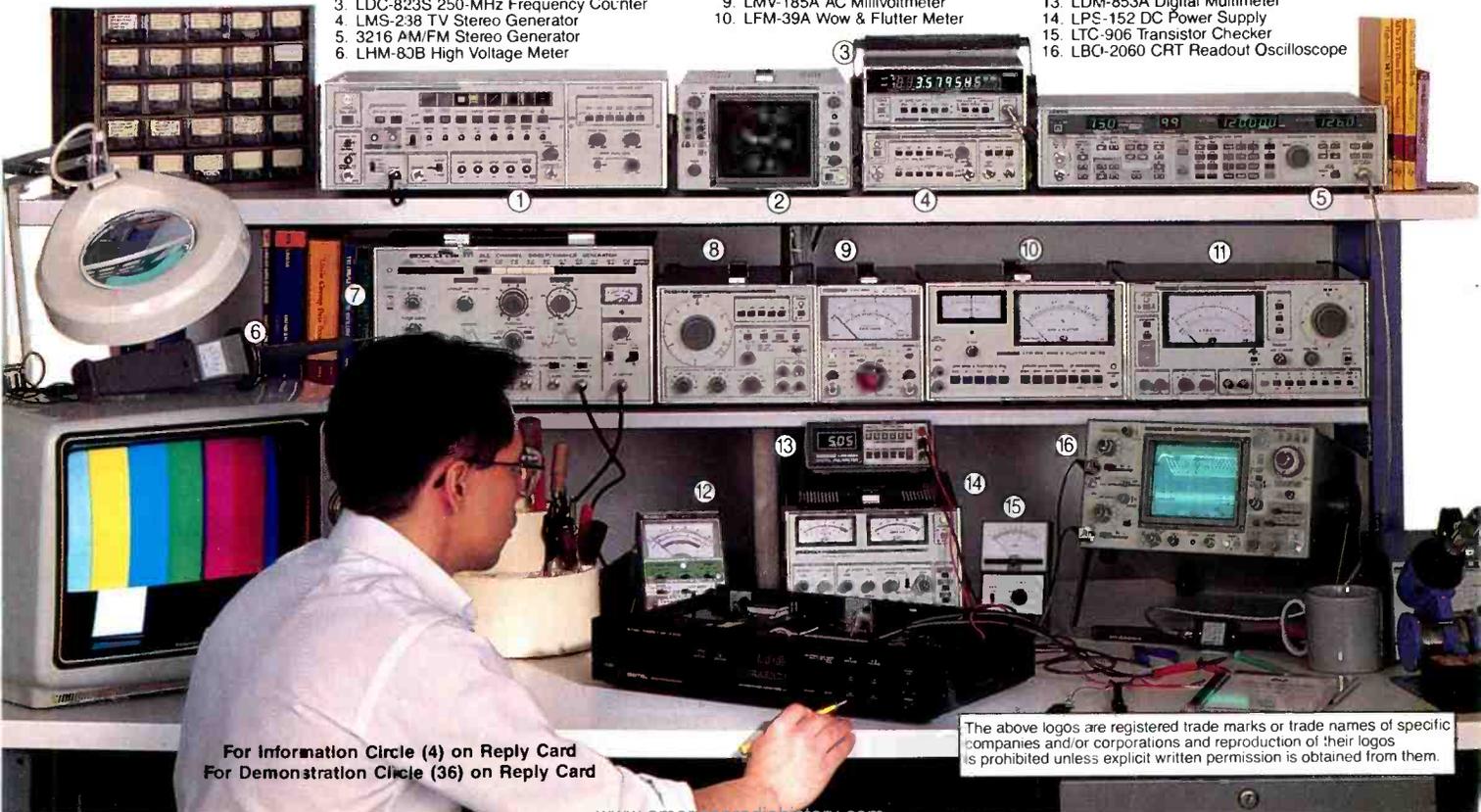
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# For want of a diode...

For want of a nail a shoe was lost  
For want of a shoe a horse was lost  
For want of a horse a rider was lost...

This little bit of verse ends up with a kingdom being lost, all because of one nail that wasn't available for a little equine servicing.

The want of a part for a TV or VCR is certainly not going to be that serious a problem, but the verse illustrates an important point that we sometimes lose sight of: A 25-cent diode that's not available to restore a TV to service is not simply an unavailable part—it really represents a TV that cost several hundred dollars and is not available for service.

If looked at that way, the thousands of dollars worth of replacement parts that are on back-order throughout the country represents millions of dollars worth of TVs, VCRs and microwave ovens that are just sitting, taking up valuable space in someone's servicing facility waiting to be repaired and leaving a gaping hole in someone's living room or kitchen.

Of course, there's no way to eliminate this problem entirely. No matter what anyone does, the inventory of replacement parts is huge and no one can precisely predict at what rate parts will fail, so there are bound to be times when replacement parts just aren't available. But there are things everyone can do to help minimize the product out-of-service time due to unavailability of parts.

For starters, there are the manufacturers. Sometimes a product is rushed to market prematurely in order to meet the competition head-on, or a product is more successful than had been anticipated. The result—the manufacturer becomes a huge customer for the parts manufacturer and there are no extra parts left over for replacement. If it turns out that one or more of the specially made components in the product is prone to failure, the result may be disaster: no replacement parts.

The obvious solution to this problem

is to make product introductions more orderly. As long as there is competition, there will occasionally be chaos in product introductions, but it's in the manufacturers' best interest to create this kind of problem as seldom as possible. Consumers who have new products that fail and are out of service for an extended period of time are likely to pass that manufacturer's product by the next time they're shopping.

Another problem is hoarding. When a replacement part is in short supply, servicing technicians, distributors and everyone else in the parts pipeline has a tendency to hoard as many of that part as they can get their hands on against the time when they need them. This practice, of course, exacerbates the problem. Again, there is no solution to this problem except for servicing shops to be aware of this kind of problem and, in times of parts shortages, to track down the guys who are hoarding and try to get the parts.

Servicing technicians can also do their part to alleviate problems due to shortages of replacement parts. From many of the articles and tips we receive, it becomes obvious that it's not uncommon for a misdiagnosis to tie up a consumer electronics product for some time awaiting a part that's not even defective. Then, when the part comes in and is installed and the product still doesn't operate, the owner has to wait yet again while the technician checks over the problem and orders a replacement for a part that's truly defective.

Once again, this kind of problem is going to crop up no matter how diligent a technician is in doing his job, but it's incumbent on technicians to do their jobs as competently as possible in order to minimize this kind of situation. Both of the Troubleshooting Tips in this issue are examples of technicians going that extra mile to get the job done right and keep the customer from spending any more time or money than necessary to get their sets repaired. Nice work, guys.

*Nile Conrad Person*

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## VICA announces skill olympics winners

Six winners were announced in the Electronics Products Servicing Contest held during the 24th annual Vocational Industrial Clubs of America's (VICA's) United States Skill Olympics last June. The electronic products servicing contest consisted of problems designed by the technical committee of the Electronic Industries Association Consumer Electronics Group (EIA/CEG), a major sponsor of the electronics servicing portion of VICA, under the auspices of the Product Services Committee. One of the awards received by the winners was a 1-year subscription to **Electronic Servicing & Technology** magazine.

The first section of the contest consisted of six individual test stations including VCR, TV and audio troubleshooting; digital experiments; and test equipment problems. The second section evaluated the contestants' ability to mount components, solder and assemble circuit boards. A safety station was also included.

VICA is the national educational organization for students in trade, industrial, technical and health occupations. It sponsors the U.S. Skill Olympics annually in recognition of vocational students' achievements and to encourage them to strive for excellence.



The winners of the VICA U.S. Skill Olympics postsecondary division electronic product servicing section were, right to left, Lynn Ronnebaum, KS, second place; Keith Shankle, OK, first place; and Johnny Boston, AL, third place. The awards were presented by Frank Steckel (far left) of the EIA.



The winners of the VICA U.S. Skill Olympics secondary division electronic product servicing section were, right to left, Ricardo Colon, PR, third place; Phillip Bowser, PA, first place; and Paul Adolph, OH, second place. The awards were presented by Don Hatton (far left) of the EIA.

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Servicing & Technology

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

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# Choosing a hand-held test instrument

By George Gore

Although the cost of most professional equipment has been going up in recent years, servicing technicians have had a buyer's market in test instruments. The IC chip revolution has done more than give us low-cost computers and disposable calculators. It has also helped to spawn a broad variety of inexpensive, hand-held electronic measuring instruments. Some are very specialized for measurement of a particular parameter such as temperature; others combine a multitude of capabilities in one convenient device. That's particularly important for the consumer

Gore is a product development engineer at B&K-Precision, Div. of Maxtec International.

electronic servicing technician trying to lighten his or her load.

Selecting the right instrument for the right job is a lot easier when you know the basics of these instruments and the terminology used to describe their capabilities and performance characteristics.

Aside from technical characteristics, some kinds of instruments are better suited to one kind of application or another. Should you check a digital circuit with logic and pulser probes? A DMM? An IC comparator? An IC tester? Even engineers who work with technology on a daily basis are often confused by the myriad of choices when selecting an instrument. In this article,

we will look at the most popular hand-held instruments and briefly explore the basics of each. We'll also provide definitions of common terms, grouped by the kind of instrument they relate to.

## Multimeters

All multimeters measure the basic electrical quantities of ac and dc volts, ohms and current. In addition to these basic electrical quantity measurements, some multimeters also provide dBm, frequency, period, data hold, peak hold, logic level, capacitance, temperature measurement and more. Measurements are displayed in either analog or digital format.

The analog format has a bar graph or a scale that is swept by a pointer. You read the quantity by noting where the pointer rests on the scale. Digital display format gives direct readings of quantities in numerical form.

### Multimeter applications

Multimeters are available in bench- and hand-held types, which are both very portable. The bench-type multimeter lends itself to applications in the design engineering, research and development, education and technician arenas. Hand-held multimeters are commonly used in consumer electronics servicing. Their size allows them to be easily transported or fitted easily into a briefcase-size tool kit.

### Key specifications

Some of the basic parameters for a multimeter are

- dc volt accuracy.
- analog or digital display format.
- bench or hand-held type.
- added measurement capability.

### Accessories

Generally, standard test leads are provided with multimeters. Specialized probes, clamp-on probes and carrying cases are also available.

Probes are used to connect the point of measurement to the input of the in-





strument. The standard type of probe is normally supplied with each instrument. In addition, a wide variety of probes are available for special applications, and to expand the versatility of many instruments.

Some special probes used with multimeters include

- high-voltage probes, which extend the measuring range;
- current probes, which clamp around the wire to measure current;
- demodulator probes, which convert a radio frequency signal into a dc voltage (this probe is also used with oscilloscopes to display the modulation envelope);
- temperature probes, which convert the multimeter into an electronic thermometer. Models are available for surface measurement of solids and for immersion into liquid or gas. A typical application for an immersion probe would be measurement of ambient temperature in an environmental test chamber.

#### Multimeter terms

**Accuracy:** A specification that states how closely a meter indicates the actual value of a measured signal, measured in percent of error. Zero percent indicates a perfect meter.

**Data Hold:** A DMM feature that allows the user to press a button and hold (or freeze) an instantaneous reading on the display indefinitely.

**DMM:** Abbreviation for digital multimeter.

**Frequency response:** The range of frequencies that can be measured by a meter without exceeding a specific amount of error.

**Input impedance:** The combined ac and dc resistance (mostly consists of resistance) at the input of a multimeter or other instrument. This resistance, if low enough, can load certain circuits being measured and cause measurement

errors. An input impedance of 10M or greater virtually assures freedom from loading in most types of circuits.

**Peak hold:** A DMM feature that holds the highest instantaneous value attained during a continuous series consisting of changing levels of voltage or current.

**Precision:** The degree to which a measurement is carried out. As a rule, the more digits a DMM displays, the more precise the measurement will be.

**Ranging:** Matching the sensitivity of the meter to the signal being measured. *Underranging* occurs when the meter's range is set to levels much greater than those being measured, thereby sacrificing precision. *Overranging* occurs when the meter range is set to measure smaller levels than those being measured, thereby causing an off-range or off-the-scale reading. The best measurement is obtained when the meter range is set in-between these two conditions. Ranging is accomplished manually (by the user manually selecting appropriate ranges) or automatically (by meter circuitry).

#### Component testing instruments

These instruments include a wide range of products used for testing individual components. These products include LCR meters, capacitance meters, transistor checkers and X-Y type component testers.

#### Component testers

Component testers apply an ac voltage across the device and measure the resulting ac current. Each value and type of component produces an individual "signature," which is displayed as a graph of voltage vs. current on a CRT. Because the component testers apply an ac signal to the device and no actual measurements are made, the testers can be used on unpowered devices (or combinations of devices) in-circuit or out-of-circuit. Components that can be tested include resistors,

capacitors, inductors, diodes, transistors and integrated circuits. The versatility of these units make them ideal for a wide variety of electronics applications, including service shops, field service, engineering laboratories, production testing, school laboratories and home use by hobbyists.

#### Transistor checkers

These instruments usually test in- or out-of-circuit performance of diodes and transistors. Measurements include leakage and gain checks. Many transistor checkers can also be used to identify the leads of a device.

#### Capacitor and LCR meters

Capacitor and LCR meters are dedicated to checking the value of out-of-circuit components. As their names imply, capacitance meters measure the value of capacitors, and LCR meters measure the value of inductors (L), capacitors (C) and resistors (R).

A typical capacitance meter gives a direct reading of capacitance. Up to ten ranges give precision readings from 0.1pF to 999.9mF, which includes virtually all capacitors used in electronic equipment. The instrument has applications in electronic engineering labs, production, service shops and schools. It can be used to check tolerance, sort values, select precision values, measure unmarked capacitors, select matched sets, and measure cable or switch capacitance. Battery operation, light weight and small size make it a truly portable instrument.

#### Counters

A counter is used to provide an accurate measure of signal cycles or pulses over a standard period of time. They are used to totalize or to measure frequency, period, frequency ratio and time interval.

#### Counter applications

Counters are used in a wide range of applications from frequency measure-

ment of 2-way/land-mobile radios to research and development labs.

#### *Key specifications*

Counters are available for single functions (frequency only), multiple functions (frequency, period, totalize) or universal (frequency, period, totalize and time interval) measurements. Some basic specifications are

- frequency range.
- resolution.
- time-base accuracy.
- sensitivity.

#### *Counter terms*

**Frequency:** The number of complete cycles per second (how many times a waveform repeats itself per second), measured in hertz (Hz).

**Frequency ratio:** Measurement of the frequency ratio of two different input signals as applied to two different input channels.

**Period:** The time required for a single cycle of the input event to occur. Measured in seconds or fractions of a second, the period is also the reciprocal of frequency (time = 1/frequency).

**Period averaging:** Sampling a number of input periods and displaying the average of these sampled periods.

**Prescaler:** A frequency-divider circuit that extends the high-frequency measurement capability of a counter.

**Resolution:** Smallest increment of change that can be displayed. The degree of resolution is selectable on many counters. Higher resolution selection requires a longer time for a measurement.

**Sensitivity:** The lowest amplitude (strength) signal that the counter will count. Measured in fractions of a volt.

**TCXO:** Temperature compensated crystal oscillator. The time base of the highest quality frequency counters is a TCXO, which provides the highest possible accuracy and stability.

**Time-base accuracy:** The accuracy of a counter is determined by the stability of its internal time base. Stability is measured in parts per million (ppm) while the counter undergoes temperature and operating voltage variations.

**Time interval:** Measurement of the time difference from the edge of one channel's input signal to the edge of another channel's input signal.

**Totalize:** Continuous counting of the number of events that have occurred since the counter was reset.

### **Digital circuit testers**

#### *The logic probe*

The logic probe allows quick observation of the logic state present at the point in a circuit. Typically, the probe is a hand-held, pencil-like instrument. The probe tip is touched against a logic input or output of an IC or circuit terminal and detects logic HI or LO states. If a logic HI is detected, a red "HI" LED lights; if a logic LO is detected, a green "LO" LED lights. The technician saves a lot of time by never bothering with exact logic voltages. The probe simply indicates the logic state on a line at a given time, which the technician needs to know for this task. The logic probe can be used with TTL as well as CMOS circuits.

#### *The logic pulser*

The logic pulser allows the technician to test gates and other logic devices in-circuit. Because most in-circuit ICs are influenced by the outputs of other in-circuit ICs, a means of forcing the inputs of the IC under test HI or LO is needed. When the logic pulser is touched against an input of an IC under test, the pulser overcomes whatever logic state that is being forced on the IC under test by other ICs. Using a logic probe, the technician then monitors the output of the IC under test and looks for the expected logic pattern as dictated by the logic symbol of the IC under test. The logic pulser can be used with TTL as well as CMOS circuits.

#### *IC comparators*

IC comparators serve two basic functions:

1. In the MONITOR mode, the IC comparator monitors all pins of an IC under test simultaneously. This is the equivalent of connecting a logic probe to each IC pin. Connecting a probe to every pin would hardly be feasible. However, the IC comparator has an in-circuit IC test clip that connects all pins of the IC under test to a flat-lead cable, thereby connecting all pins of the IC to the comparator LED monitors.
2. In the IC TEST mode, the IC com-

parator allows an in-circuit IC to be compared against a known-good, same-type IC placed in the comparator's reference socket. While the circuit containing the IC under test is operating, the comparator TEST switch is pressed. If the in-circuit IC under test matches the responses of the reference IC (the IC placed in the comparator socket), an LED lights, indicating that the IC under test is good.

As you can see, the IC comparator can save a great deal of time when you're troubleshooting ICs with many pins or many ICs at a time. A TTL IC comparator tests TTL DIP ICs having up to 20 pins. A CMOS IC comparator tests CMOS DIP ICs having up to 20 pins.

#### *IC testers*

Some manufacturers offer compact, easy-to-use, hand-held instruments that can be used as either a 20-pin logic monitor or an in-circuit CMOS IC tester (using the comparator method). Because the IC tester draws so little current, it can usually draw its power from the equipment you want to test. To help prevent accidental damage to the IC tester, reverse polarity protection is usually provided.

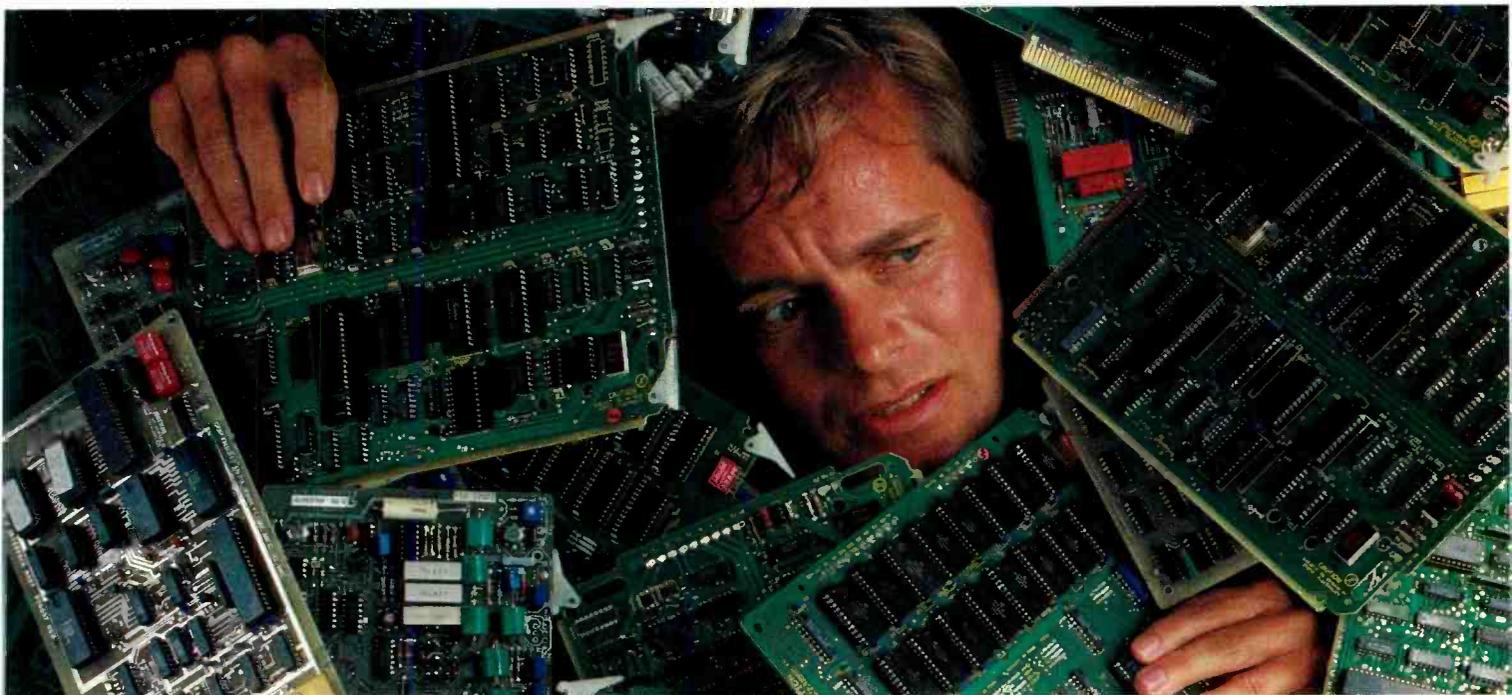
The IC tester usually comes with two IC clips. One can be used for ICs with 20 pins or fewer; the other can be used in tighter spaces for ICs with 16 pins or fewer. Also provided is a list of testable ICs and the data necessary for testing those ICs.

When used as an IC tester, the instrument compares the logic states of the IC under test with those of a known-good reference IC. If all logic states are equal, a GOOD indicator lights. If not, an LED is lit for each pin of non-equal logic states. By allowing you to test ICs while they are still in the circuit, the IC tester helps you avoid the time-consuming task of removing each device from the circuit board. It also helps you avoid the risk of damaging the IC or the PC board when removing or reinstalling the device.

When used as a logic monitor, the IC tester indicates the logic state of each IC pin for CMOS ICs with up to 20 pins. Logic high is indicated by a lit LED; logic low is indicated by an extinguished LED. This function continuously monitors each pin of the device and, therefore, follows changing as well as constant logic states. When compared to using a standard logic probe that can



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check only one IC pin at a time, the IC tester is much faster for checking the logic states of ICs that are suspected of malfunctioning.

## Digital testers for digital circuits

Digital signals (and the analysis of them) differ greatly from the analysis of analog (linear) signals.

When analyzing an analog signal (as commonly encountered when troubleshooting analog equipment such as RF, video and audio circuits), we concern ourselves with the capability of measuring a wide range of voltage or current. While you work from the input to the output of any receiver or amplifier, voltage requirements may range from several millivolts to several hundred volts. The ability to measure specific levels of voltage or current helps us locate defects in the circuit. For this reason, an instrument that accepts and accurately quantifies the wide range of voltage and current levels encountered in analog circuitry is necessary.

Multimeters and oscilloscopes are examples of analog instruments. Note that the term *digital* multimeter merely implies that the display is digital; the instrument still is designed to give a measurement of an analog signal.

Digital signals occur as either one or two distinct voltage levels. One level is used to denote an ON state; the other level is used to denote an OFF state. As stated earlier, no voltage levels in-between the ON and OFF states are used or recognized. For example, when you turn a light switch on, the light is either on or off; no state such as "in between on and off" is possible.

These distinct levels are referred to as *logic states*. Again, the two logic states used in a digital circuit are the ON state, typically represented by a positive voltage level whose exact voltage is not important, and the OFF state, typically represented by the absence of a voltage (zero volts). The ON state is also called a 1, with the number 1 denoting presence of an ON. The off state is called a 0, denoting absence or opposite of an ON or 1.

TTL digital circuits operate from a +5V source and have a logic high threshold of 2.4 typical. Any value above the threshold is a logic HI. The logic low threshold is 0.8V typical. Any value below this threshold is a logic LO.

CMOS digital circuits operate from a +3V to +15V source (usually +15V) and have a logic high threshold of about

70% of source voltage. Any value above this threshold is a logic HI. The logic low threshold is about 30% of source voltage. Any value below this threshold is a logic LO.

Noting that a logic state consists of one or two distinct voltage levels, you can easily see that an instrument that indicates a wide range of voltages is unnecessary and cumbersome when checking digital states.

## Multi-function hand-held instruments

Although specialized instruments such as a separate frequency counter or capacitance meter may be the best choice for a specific range of tasks, there is a new class of instruments that provide many functions in one hand-held package. For example, an instrument might include a 41-range voltmeter, an ammeter, an ohmmeter, a frequency counter, a capacitance meter, a logic probe, a transistor and diode tester, and an audible continuity checker. This kind of instrument costs about the same as a conventional digital multimeter, but it gives the user access to five instruments in one. Although a separate capacitance meter or frequency counter will probably have a broader range than those accessible on the combination instrument, that extra range may not be needed for the measurement task at hand.

For example, if the intended application is to measure test frequencies and the audio and ultrasonic ranges, the hand-held combination instrument will more than handle the need. If the signal to be measured is at an RF frequency, such as that used for a 2-way radio, then a separate frequency counter must be used.

Determining which kind of test instrument you need should be based on your own measurement requirements. After you have decided on a type of instrument, compare the offerings from several major brands and see which represents the greater value for your specific needs. Buying an instrument made by a reputable manufacturer is very important. It gives you the assurance that the feature and specification information presented is factual, that you can expect satisfactory reliability, and that the instrument is serviceable if a problem should develop.

Finally, purchase your instrument from a distributor you trust. A good distributor can be very helpful in matching the best instrument with your needs.



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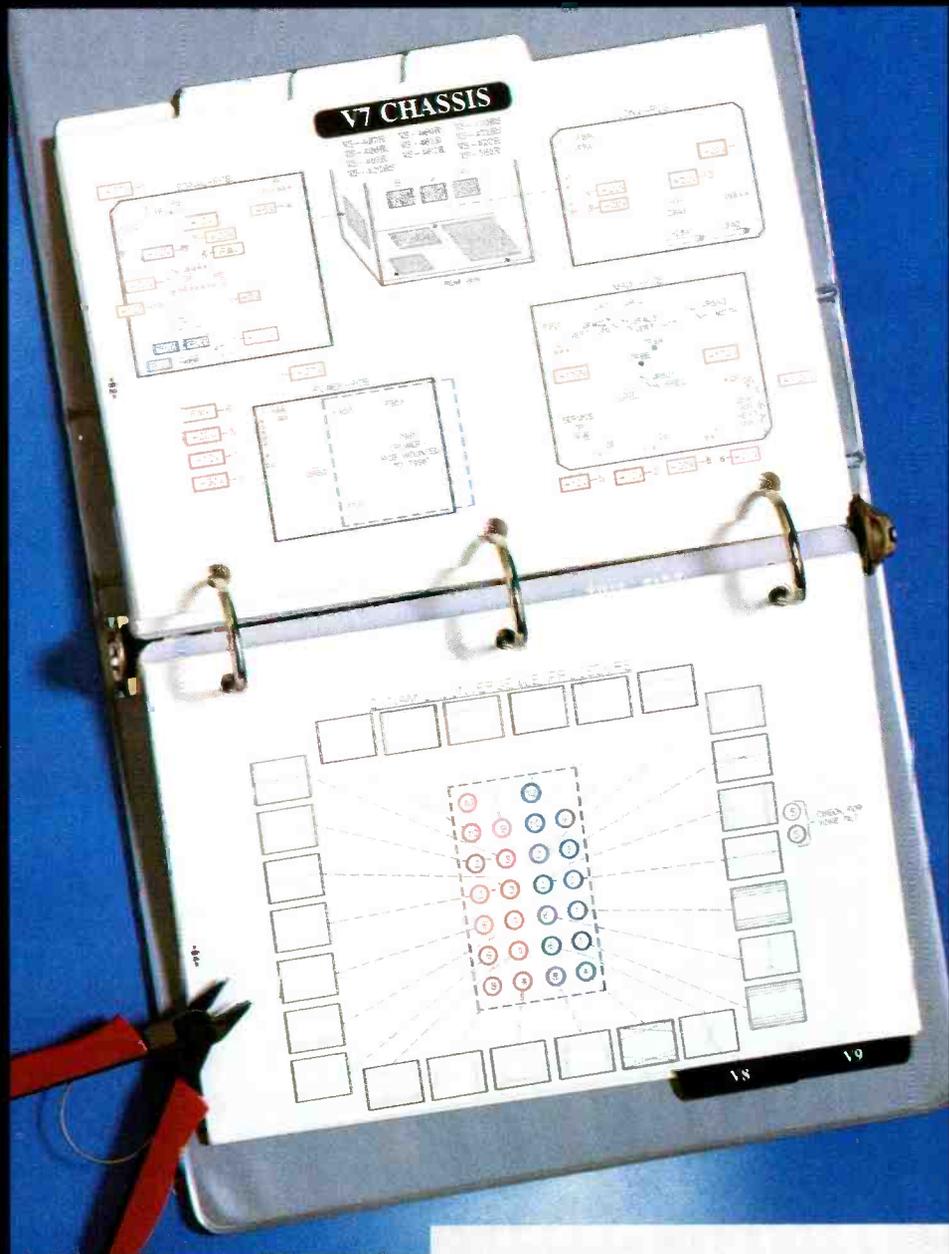
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# Servicing Sharp's small color TVs—part I

By Homer L. Davidson

When you compare the servicing of small-screen color receivers to large-screen color receivers, there are more similarities than differences. New receivers have no surplus of space, regardless of the brand or picture size. However, as the picture size shrinks, some components and their spacings must shrink in proportion. Capacitors, coils and resistors become smaller, but human fingers remain the same size, thus posing some problems for technicians. You can overcome this disadvantage by gathering additional knowledge such as the specialized information in this article, which covers two Sharp 9-inch models.

## General features

Sharp models 9H100 and 9H102 are 9-inch color TV look-alikes that have

Davidson is the TV servicing consultant for ES&T.

many similar characteristics. However, they are not twins because the 9H102 (H5 chassis) has many more boards and features. Evidently the 9H100 (H4 chassis) is the standard version, having only six circuit boards. Eight circuit boards are used in the 9H102 to accommodate the extra circuits, complicating the troubleshooting both physically and electronically.

Twelve varactor-tuned channels are selected by two switches at the right side of the slide rule-type readout. The switches move the tuning to either the left or right channel. At the extreme right is the 2-position on/off switch. Below the left and right switches is the thumb-adjusted volume control. Customer-operated controls (brightness, color, tint and picture) are located on the right side of the cabinet.

The high voltage is not adjustable in either model. In the 9H100, the +125V

supply voltage is adjustable, but there are no +125V adjustments in the 9H102.

The 9H102 has a TV/video switch for connecting to a VCR, and audio muting eliminates undesirable sound during station changes. 9H100 has neither of these features.

Only the 9H102 can be operated with standard 120Vac or 12Vdc from a car battery or similar source. There are two +125V power supplies, one for ac operation and another for 12V operation. Automatic diode blocking and mechanical switching selects the proper power supply: the 120V supply when the 120V cable is plugged in, the 12V supply when the 12V cable is plugged in.

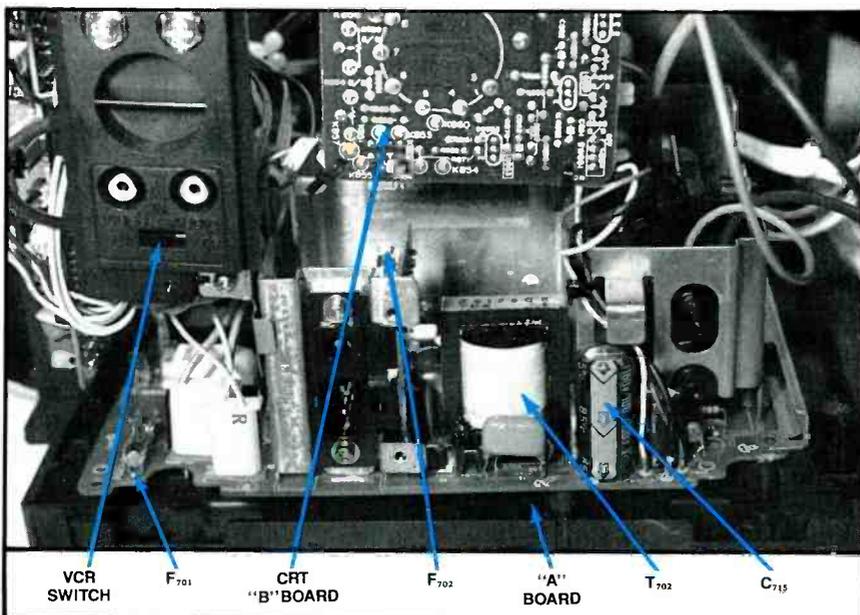
Although most of the equivalent circuit functions are nearly identical in the two models, many details and component numbers are different. Therefore, all case histories and schematics will show the model number.

## Preliminaries

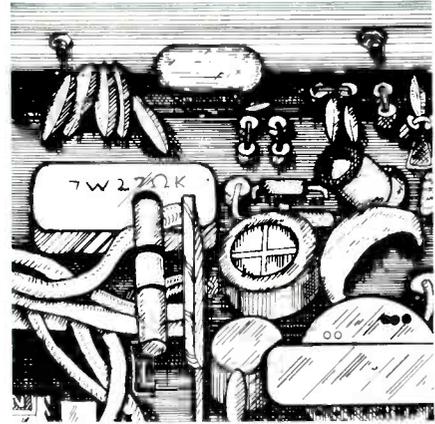
With small television receivers such as these 9-inch models, the boards and components are packed so tightly in certain areas that some amount of disassembly is required at times.

The photograph (to the left) of a Sharp 9H102, taken from the rear, shows how easily accessible the two fuses are after the cabinet has been removed. At the extreme lower left of the photo, on the main chassis, is F<sub>701</sub>, a 4A line-power fuse. F<sub>702</sub>, the 6.3A fuse for the 12V input from a battery, is at the center of the photo. T<sub>702</sub> is a converter transformer for the ac-operated +125V supply. C<sub>715</sub> is the 100 $\mu$ F capacitor that makes the rectified voltage peak-reading and also filters the same +125V supply.

Partial disassembly of the receiver is necessary for access to some components. For example, to remove components from under the picture tube, remove the metal bracket supporting the



This rear view of a Sharp 9H102 receiver (H5 chassis) shows easy access to the two fuses. Arrows point out other components, including converter transformer T<sub>702</sub> and filter capacitor C<sub>715</sub>, which filters the +125V supply rectified from T<sub>702</sub>.



PWB-F and PWB-D circuit boards. The large circuit board can be moved to the rear a short distance after you remove five screws that go through large circuit board A and into the plastic cabinet bottom. If you find questionable or defective components under the picture tube, remove the two large screws that hold down the picture-tube assembly, then slide the picture tube forward and to the side for access to these components.

### 9H100 regulator functions

Figure 1 is a slightly simplified schematic of the Sharp 9H100 low-voltage power-supply and regulator. At the left is the 120Vac input for a conventional full-wave bridge dc power supply that produces +156V for only two circuits, both ending at SCR<sub>701</sub>. One branch of the +156V supply goes through a flyback winding. With this arrangement, the positive dc supply voltage and negative-going pulses from the flyback are applied to the SCR<sub>701</sub> anode. These negative pulses stop all SCR conduction at the end of each horizontal cycle.

Conduction of SCR<sub>701</sub> starts each time its gate receives a positive pulse from IC701 pin 7. The timing of the pulse is determined by the circuit according to the current needed for maintaining exactly +125V at the SCR cathode. Regulation is synchronized to the receiver's horizontal frequency by the application of pulses from flyback pin 5 through R<sub>714</sub> to IC701 pin 5. The other +156V branch brings power to SCR<sub>701</sub>'s gate during start-up.

### OFF-ON operation

Have you noticed in Figure 1 that no switch or relay is provided to turn on and off the 120Vac power? That omission is deliberate. A manual switch is replaced by circuitry that is compatible with remote-controls. With the receiver plugged into 120Vac, the +156Vac

source operates continuously. While the TV function is OFF, the power used is very low, just enough to keep C<sub>706</sub> charged.

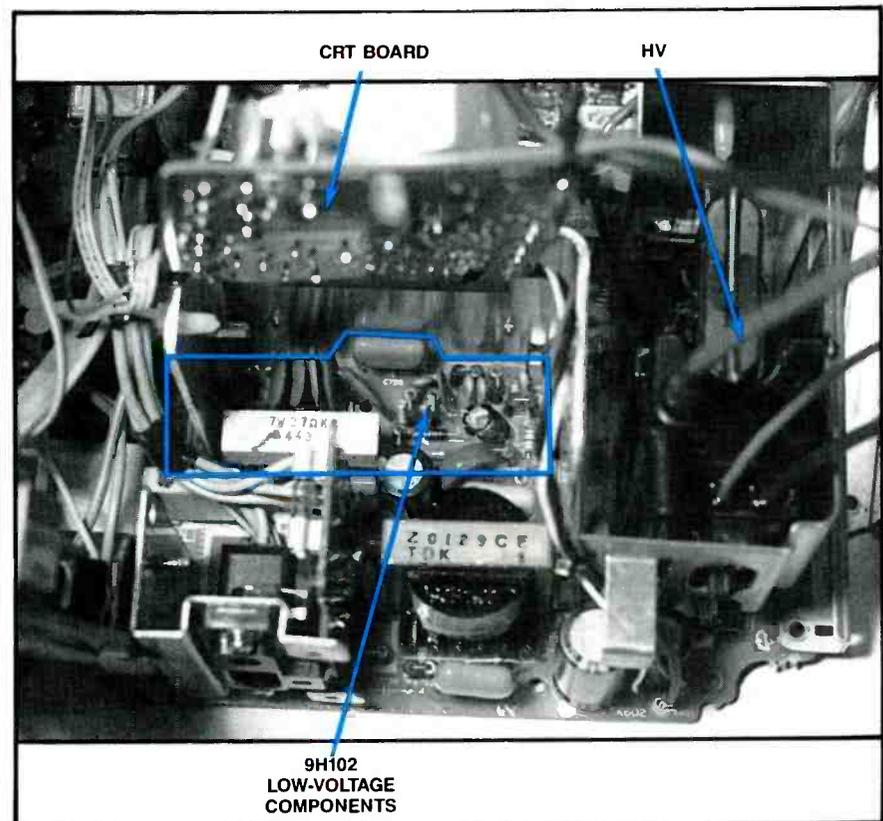
Electronic switching is used to provide on-off operation of TV picture and sound. A simple 2-position single-pole/double-throw switch grounds one switching line or the other.

With the receiver operating normally, the OFF switch position grounds IC701 pin 5 through diode D<sub>706</sub>, greatly reducing the amplitudes of the horizontal-frequency sawteeth and dc voltage at pin 5. This eliminates the positive-pulse output from IC701 pin 7. As a result, the +125V supply filters

and the voltage falls somewhat. At the same time, transistor Q<sub>1102</sub> is biased to cut off by the ON/OFF switch, causing the SCR<sub>701</sub> gate to receive a very low positive voltage from this source. SCR<sub>701</sub>'s conduction stops and the +125V supply voltage goes down near zero. All functions (except +156V) stop operating during this OFF time.

Sliding the ON/OFF switch to the ON position changes several circuits. First, pin 5 of IC701 is no longer grounded through D<sub>706</sub>. Therefore, when supplied with B+ voltages, IC701 can perform all functions, including the production of pulses that drive the gate of SCR<sub>701</sub>.

Q<sub>1101</sub> biases Q<sub>1102</sub> so its C/E



In model 9H102, most low-voltage components are grouped together on the circuit board under the CRT socket.

resistance is decreased to a near short, which causes the SCR<sub>701</sub> gate dc voltage to rise from about zero to the Q<sub>1102</sub> maximum of +85V. Somewhere during that time, start-up begins, with some SCR<sub>701</sub> conduction. As the SCR<sub>701</sub> operation becomes stronger, diode D<sub>707</sub> is reverse-biased, disconnecting the switching circuitry, and a small current between the SCR cathode and the gate brings up the SCR gate voltage from +85V to slightly below the SCR cathode voltage. Then the cathode and gate dc voltages increase simultaneously, with the SCR<sub>701</sub> cathode always 1V more positive. Stability is reached when SCR<sub>701</sub> regulates correctly and the output at the cathode measures +125V. Start-up is finished, and the Sharp 9H100 receiver is ON with TV picture and sound.

When the receiver is turned off by sliding the ON/OFF switch to the OFF position, IC701 pin 5 is grounded through D<sub>706</sub>. This stops the SCR<sub>701</sub> gate drive. Also, the SCR<sub>701</sub> gate rapidly approaches zero dc voltage because Q<sub>1102</sub> is biased into a virtual open circuit. All SCR<sub>701</sub> operation and receiver functions quickly stop. The 9H100 receiver is off.

### Testing 9H100 low-voltage regulator

A strong indication that the power supply is or is not operating correctly

can be obtained quickly by measuring five source dc voltages: +156V, +125V, +18V, +12V and the other +12V source. The +156V source can be measured at the positive terminal of C<sub>706</sub> (the large 470μF filter capacitor) or at the common cathodes of D<sub>704</sub> and D<sub>703</sub> bridge diodes. Approximately the same voltage is present at the SCR<sub>701</sub> anode, mixed with negative-going pulses.

Regulated +125V originates at the SCR<sub>701</sub> cathode and is the principal B+ source for the horizontal-driver transistor, the horizontal-output transistor and the sound-output transistors. Measure the +18V source at IC701 pin 6. This +18V supply has some regulation only because it is rectified from flyback horizontal pulses. There are two +12V supplies, both taken from this +18V. You can locate them by tracing, perhaps by finding the dropping resistor and filter capacitor for each one. For example, IC801 pin 3 has one of the +12V supplies obtained through R<sub>427</sub> and filtered by C<sub>410</sub>. The other +12V supply connects to IC201 sound IC pin 20 through R<sub>221</sub>, and filtered by C<sub>216</sub>. Although there are +28V and +150V sources, most television stages, except SCR and deflection, obtain B+ from the +18V and its two +12V sources. For example, the two 12V sources have a total

of 18 or more branches, involving many additional stages and circuits.

### Finding testpoints

The low-voltage power supply usually can be checked quickly by a few voltage and resistance measurements. Of course, we should try the easy things first, so adjust the +125V control and test with a DMM whether the voltage varies correctly. If the +125V was low during the test after the control was turned higher, measure the B+ voltage at C<sub>706</sub>, the principal filter capacitor. A reading of +156V or higher indicates that the B+ circuit is operating correctly through the diode bridge to C<sub>706</sub>. Measure the dc voltage at the SCR<sub>701</sub> cathode terminal, expecting +125V. A complete loss of the +125V source might be caused by

- an open T<sub>602</sub> flyback winding (terminals one and two).
- a defective IC701 low-voltage regulator.
- an open in ZD<sub>701</sub> zener diode.
- a defective horizontal-output transistor Q<sub>602</sub>.
- a defective SCR<sub>701</sub> regulator.
- leaky capacitors or resistors that have drifted out of tolerance.

Of the components on that list, the horizontal-output transistor (HOT) is the

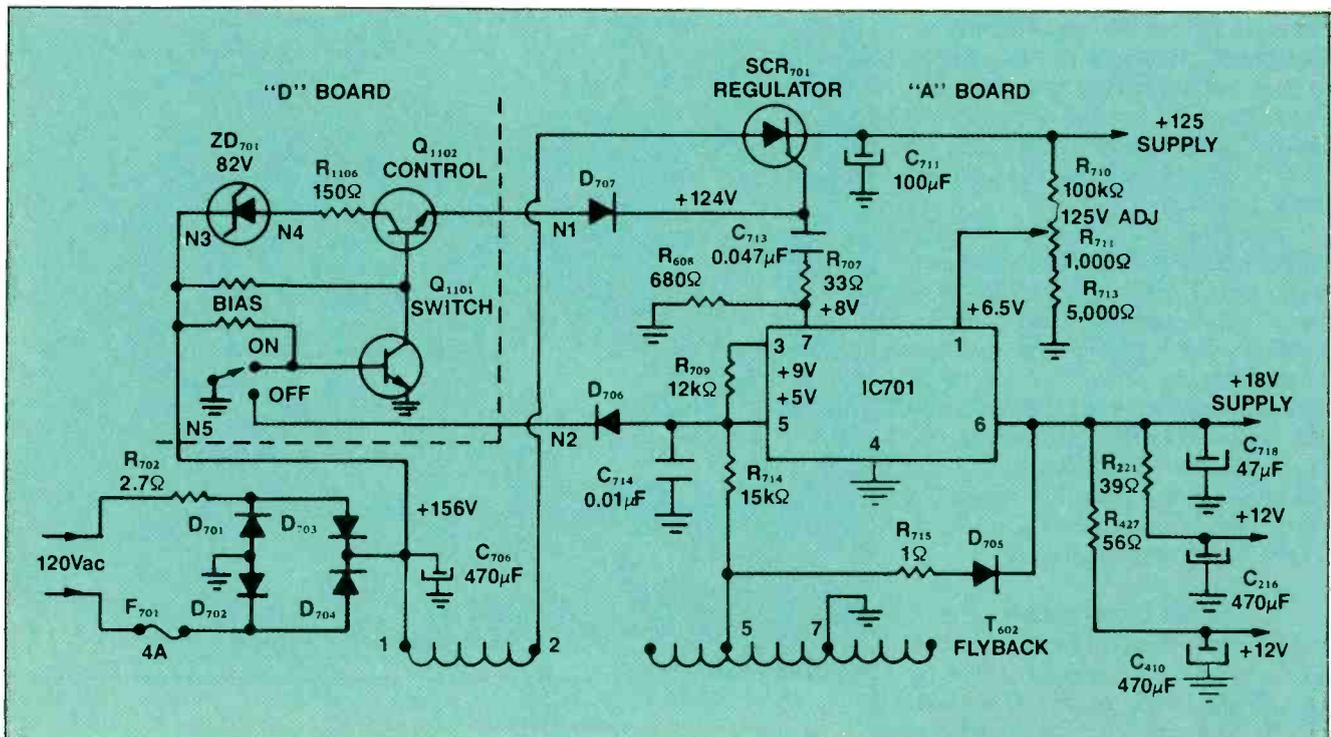
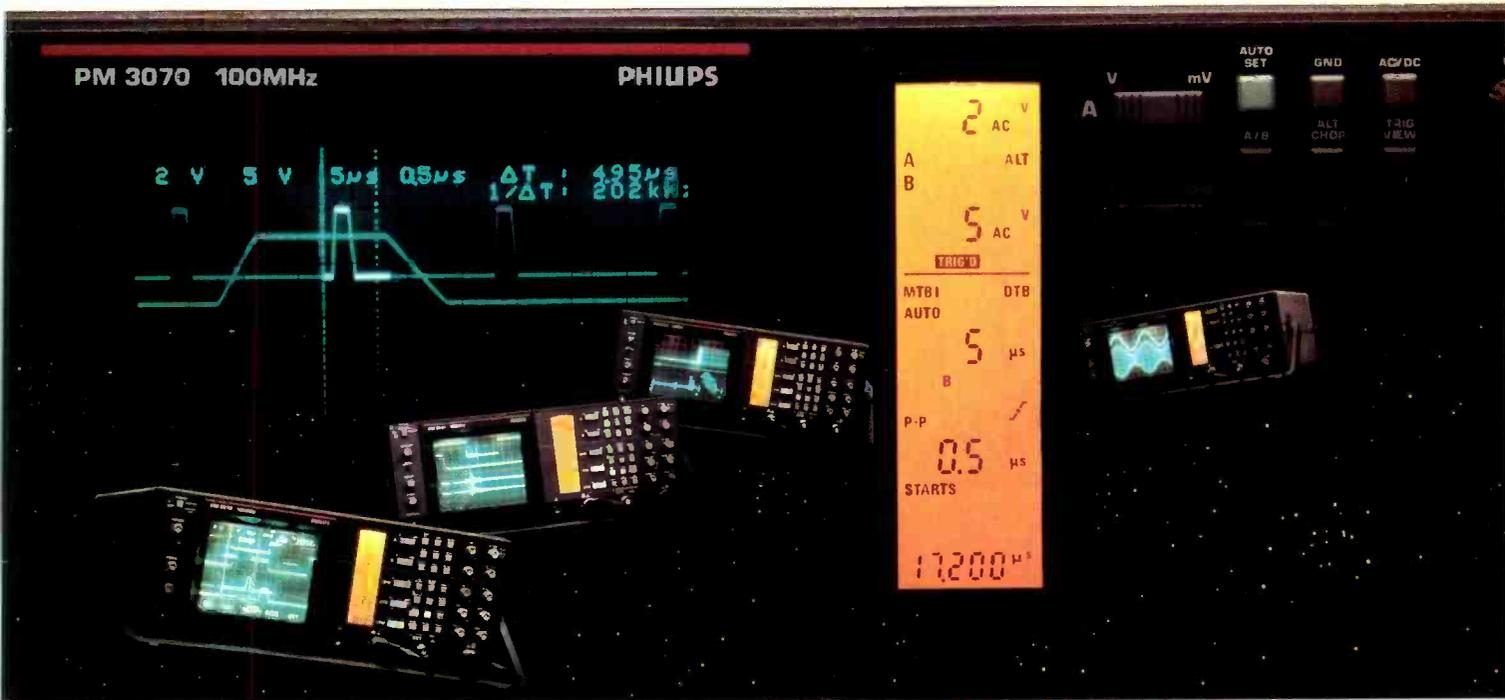


Figure 1. A first glance at this Sharp 9H100 partial schematic might show a conventional SCR-regulated low-voltage power supply without much complexity. But a more detailed examination shows additional circuitry. Dc voltage of the SCR<sub>701</sub> gate does not vary in step at all times with the +125V source, as is customary with SCR circuits. Instead, the gate intersects another circuit that controls the gate voltage at times.



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most likely to fail, so test it first. With power off, measure the resistance between the body of  $Q_{602}$  output and ground (with negative meter wire to ground—remember the damper diode is inside and will conduct with reversed polarity). A leaky output transistor is indicated by a low reading. Remove  $Q_{602}$  and test at the collector wire or socket. If the abnormal low-resistance reading is gone, you know the problem was in the HOT. If the collector socket measures higher than  $2k\Omega$ , begin checking other components.

If you have to determine whether the problem is caused by the power supply or the horizontal-deflection system, use the following procedure:

- temporarily parallel a  $47\Omega$  10W resistor between +156V at the positive terminal of  $C_{706}$  and the +125V source at test-point TP701 (this bypasses the regulator);
- power-up the chassis and find out whether or not the horizontal circuits are working;
- a no-raster condition in this situation strongly suggests that the power supply was OK and that the horizontal circuits are not operating—check them carefully;
- if bypassing the regulator in this manner results in operation of the horizontal, indicated by appearance of the raster, you have isolated the problem to the power supply. Measure the dc

voltage at IC701 pin 7, expecting +7V. No voltage or low voltage points to a leaky IC701. A normal +7V reading indicates an open SCR $_{701}$ . Then, remove SCR $_{701}$  from the circuit and take accurate resistance measurements (forward and leakage) between all terminals. Replace all components found to be defective.

- Remember to disconnect the resistor used during tests, measure the +125V source and the +18V source, and check the television functions for correct operations.

### Lightning damage

Repairs to correct lightning or power-outage damages might cost more than the portable color TV is worth. Therefore, carefully estimate the costs of total damages before ordering any parts. In this 9H102 chassis, several low-voltage components were ruined, but the receiver was worth the repairs.

During the first tests, I found the F $_{701}$  4A 120Vac fuse was open, the 2.7 $\Omega$  surge resistor was open, and two bridge diodes (D $_{702}$  and D $_{704}$ ) were shorted. I replaced these small components, but the receiver still didn't operate. At pins 14 and 15 of IC701, dc voltages were very low, which indicates IC701 might be leaky. Also, no voltage was measured at TP701 (+125V source). I haven't included a schematic of the 9H102 power supply in this article, but if you service

a 9H102, the details set forth here will help after you locate the components on the chassis. The 4A fuse would hold only for a few seconds and blow from overload. Continuity of the T $_{702}$  converter transformer was normal. I tested all diodes of the low-voltage regulator circuit, but all readings were normal.

Because of these findings, I strongly suspected the IC701 power regulator. Installation of a new IC701 restored the set to normal operation. Replace the IC701 with a factory RX-1X0308CE22.

### Servicing no-raster/no-sound symptoms

When a 9H100 with its H4 chassis has no raster or sound, look for defects in the low-voltage power supply, horizontal circuits or high-voltage shut-down circuits. If the sound is normal but the screen is dark, check the video or high-voltage circuits. Also, use the methods previously explained to test the low-voltage circuits.

A shorted  $Q_{602}$  horizontal-output transistor might blow the 4A fuse repeatedly before the problem is identified. Measure the resistance between the collector (body) of  $Q_{602}$  output transistor and ground. Remember that the positive test lead should be touching the collector with the negative connected to the transistor emitter (which is connected to ground). The damper diode is inside (see Figure 2) with its cathode con-

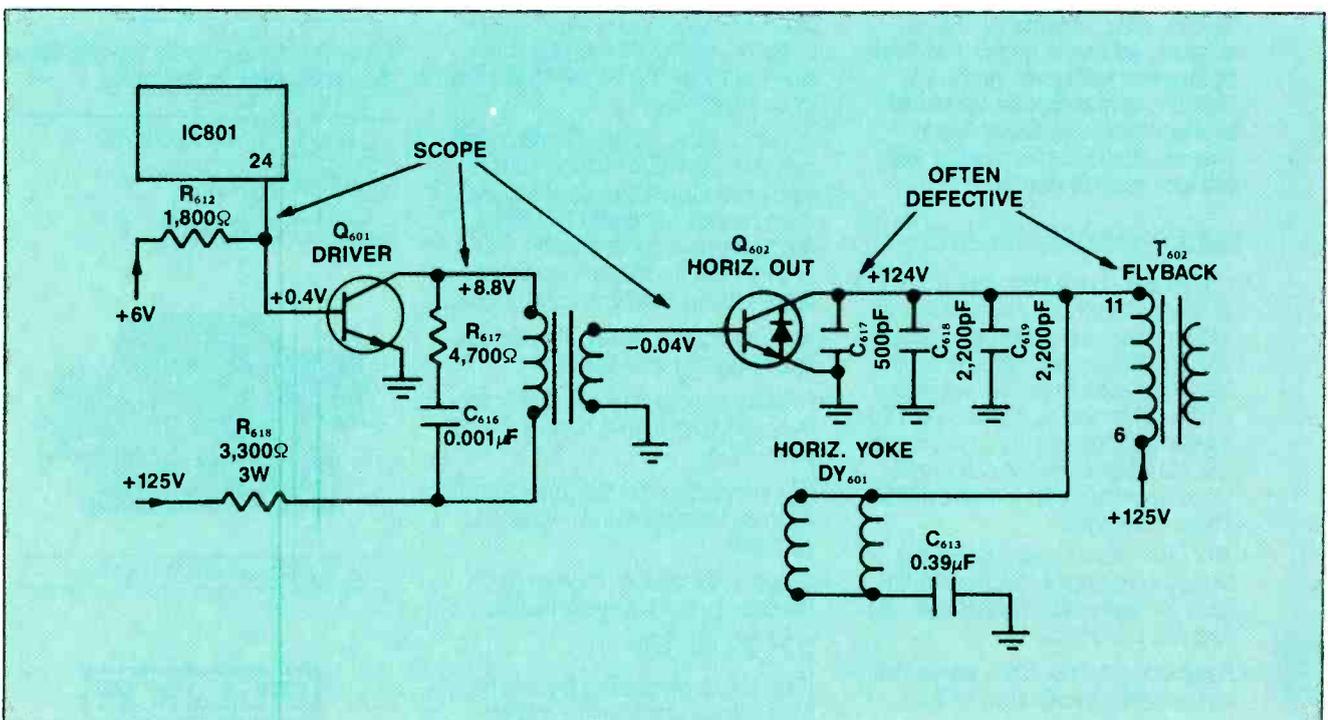
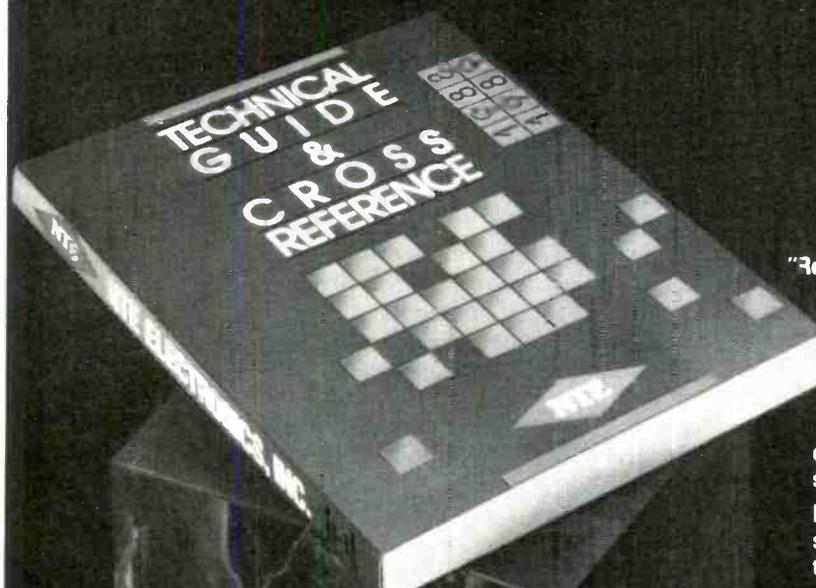


Figure 2. Use a scope to locate a horizontal stage with a major defect. Arrows on the schematic mark the three best points for scoping.

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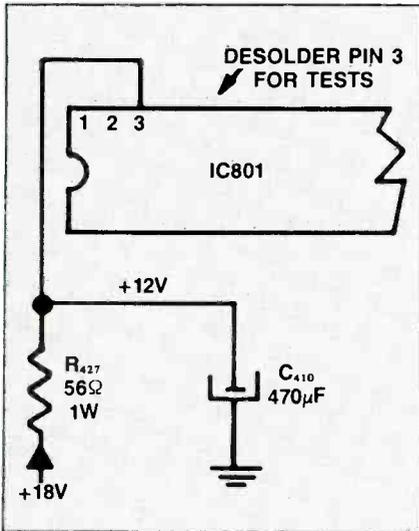
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BS&T 12/88

Circle (1\*) on Reply Card

nected to the transistor's collector and its anode connected to the transistor's emitter. Therefore, reversing the test-lead polarity can give misleading or incorrect readings through the damper diode. Replace  $Q_{602}$  when a low-resistance reading is obtained with both polarities. Replace a defective  $Q_{602}$  with original part number VS2SD1396CA or universal SK9422.

Terminal 24 of IC801 emits horizontal-frequency square waves that



**Figure 3.** When the +12V source voltage is too low at IC801 pin 8, disconnect pin 3 of the IC from the circuit board. Then notice if the supply voltage for pin 8 is much higher without the load of IC801. A "yes" answer indicates IC801 is drawing excessive current. While pin 3 is disconnected from the circuit board, test the resistance between pin 3 and ground. Any reading lower than 2kΩ is a strong reason to replace a leaky IC801.

are sent to the base of  $Q_{601}$  horizontal-driver transistor (Figure 2). A complete loss of these pin-24 square waves might indicate a defective IC801. But first, check the B+ supply at terminal 3, expecting +12V. A very low voltage there can indicate a leaky IC801 or a defect in the power source. Disconnect terminal 3 of IC801 from the circuit board (see Figure 3) and measure the resistance of terminal 3 to ground. If the reading is lower than 2,000Ω, replace IC801. (It is shorted internally.)

If the previous test did not show without doubt that IC801 is shorted, unplug the 120Vac power and keep terminal 3 disconnected. From an external power supply, inject +12V between IC801 terminal 3 and ground. (Excessive +12V test current or an overload of the external power supply prove that IC801 is defective.) Then scope terminal 24, expecting to find horizontal-frequency square waves. Normal square waves at terminal 24 indicate that IC801 is normal, and any loss of horizontal must occur further downstream. Weak and distorted square waves or no waveform would point to a defect in the IC801 internal horizontal oscillator.

When the base signal of  $Q_{601}$  horizontal-driver transistor is missing, 3,300Ω  $R_{618}$  will become very warm during operation. Check  $Q_{601}$  for leakage, and scope IC801 terminal 24 for a waveform of any amplitude and wave-shape. Those square waves that should be at terminal 24 are equal to the output from the usual horizontal oscillator and buffer. They are essential

for operation of the horizontal-deflection system. Replace IC801 or  $Q_{601}$  if they are defective. Or, as a last resort, replace them if no other defect can be found after many tests.

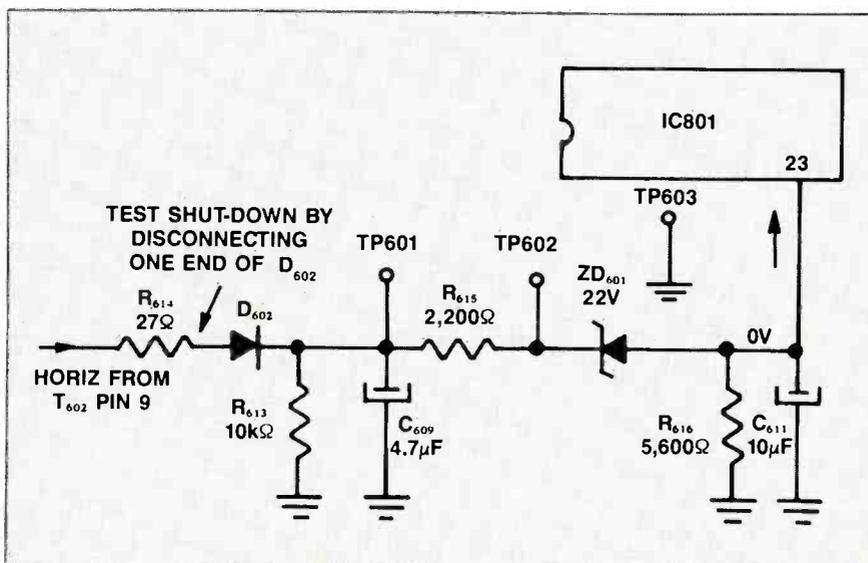
When the base waveform of  $Q_{602}$  horizontal-output transistor appears normal but shut-down occurs quickly, suspect the  $T_{602}$  flyback transformer (perhaps a winding has shorted turns). Watch the scope carefully because the  $Q_{602}$  base waveform sometimes can be seen a split second before shut-down occurs. Although this case could have been included in the next section (about analyzing incorrect shut-down), the next step should be testing the flyback for shorted turns. First, measure the inductance of each winding using an inductance meter (some new LCR portables at reasonable prices are now available) or use a ringer. If these steps do not identify a defect, go through the sequence of tests with reduced line voltage as described in the next section.

#### High-voltage shut-down

In the 9H100 model (H4 chassis), an X-ray-protective circuit monitors the high voltage by continuously testing the amplitude of pulses from a low-voltage winding. If the amplitude of these pulses exceeds the design point (no adjustment is provided) a protective circuit (see Figure 4) inside IC801 stops operation of the horizontal oscillator, causing shut-down. Turning off the power (or shut-down itself) unlatches the protective lock after all horizontal sweep has stopped. When power is next turned on, the circuitry attempts start-up as usual, but when the excessive-amplitude horizontal pulses appear, the circuit latches again, stopping the horizontal-oscillator operation and producing another shut-down. This sequence is slightly more than one cycle of the x-ray-protective circuit.

One good method of determining whether the shut-down is forced because of excessively high voltage or a defect in the x-ray-protection circuit itself is to operate the set from a variable-output-voltage transformer. Monitor the +125V power source and high voltage at the anode connection of the CRT.

Start with the output voltage of the variable transformer at about 40V and gradually increase it. If the +125V source reaches 125V long before the receiver input voltage reaches 120Vac, the reason for shutdown is that the low-voltage power supply and regulator are



**Figure 4.** Part of the x-ray protective circuit is composed of separate components with the remaining circuitry inside IC801, where a positive voltage at pin 23 activates circuitry that stops the horizontal oscillator (also inside IC801).

defective and are allowing excessive voltage to reach the +125V source. If the high voltage exceeds +18.5kV before the +125V source reaches only +80V, suspect a defective horizontal-output circuit or a flyback and its connecting components. However, suspect defects in the HV-protective (shut-down) circuits if the chassis goes into shut-down before the HV reaches 18kV at the picture tube.

Another method of checking high-voltage shut-down is to desolder one end of D<sub>602</sub> diode from the circuit board (Figure 4). Monitor the high voltage at the CRT anode very carefully. To avoid arcs and damage if the HV is very high, apply 120Vac to the chassis and quickly notice the HV reading before immediately unplugging the power. If the HV reading was between 18kV and 20.5kV, the HV is normal, and the defect is in the protective circuit itself. If the reading was 21.5kV or higher, the abnormally high HV probably is caused by problems in the low-voltage power supply or the horizontal-output circuits, and the protective circuit is functioning correctly.

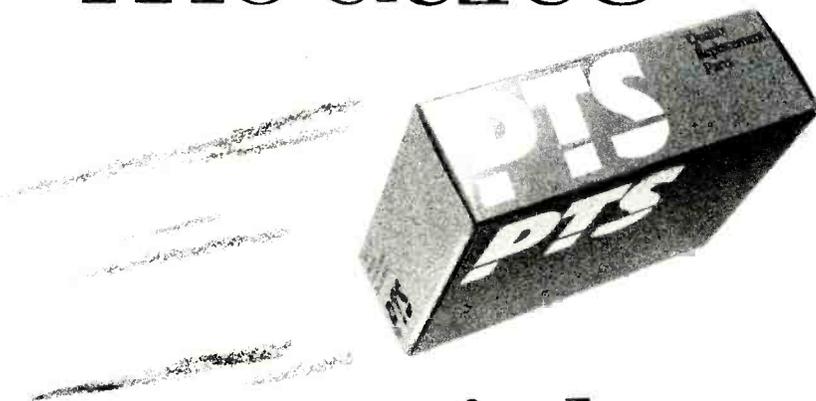
Reinstall the D<sub>602</sub> diode after all repairs are made; when the receiver is operating normally, test for correct shut-down operation as follows:

- Check the TP601 voltage. It should be about +18.5V (TP601 testpoint is in the X-radiation-protection circuit).
  - Induce shut-down by connecting a 6,800Ω 1/2W resistor between testpoint TP601 and the cathode of diode D<sub>503</sub>, the +28.5V rectifier, with short clip leads. Shut-down will occur immediately. The TP601 dc voltage was increased sufficiently by the extra resistor that zener diode ZD<sub>601</sub> is forced to conduct, thus passing voltage and current to IC801 pin 23. This stops the horizontal oscillator inside IC801, and loss of horizontal triggers shut-down. Disconnect the test resistor at once and notice whether the receiver operation does not return when you remove the test resistor. (If it does, more repair work is needed.)
  - To restart the horizontal oscillator, touch a short clip lead from TP602 to ground (TP603). Remove the clip lead when the whole receiver operates again.
- NOTE: Use this same procedure for both the 9H100 and 9H102.

Next month, we'll begin Part II with some specific trouble symptoms and what steps you should take to solve the problem.

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# The case of the missing diode

You may know exactly which diode will cure your TV's blues, but finding it...now that can require some super sleuthing.

By Conrad Persson

Is finding that elusive diode starting to make you feel like Sam Spade? Consider this description of a product directory put out by one of the publishers of integrated circuit guides:

"... lists more than 80,000 standard ICs—including 10,000 new devices—grouped by basic category. It also includes a military parts list, a part number index and an alternate-source directory that lists more than 92,000

Persson is editor of *ES&T* magazine.

current and discontinued devices."

Answer the question? And that's only ICs. Now add in the number of other semiconductor devices (diodes, transistors, SCRs, diacs, triacs), resistors, capacitors, inductors—the sheer number of replacement parts becomes truly mind boggling. And think about this: Every time manufacturers devise some wonderful new technology such as surface-mount products, there are hundreds or perhaps thousands of new part numbers to contend with. No wonder so many readers have told us that identifying and locating parts is a problem.

Of course, only a fraction of those ICs are used in consumer-electronics products. Still, the number of individual part

numbers used in consumer-electronics products is immense and growing at an alarming rate.

## Identifying the part

When you are identifying the replacement part you need for a repair, the first step is to diagnose a fault in a malfunctioning product to the component level. (Of course, you have to make sure that you have, in fact, diagnosed the cause of the problem.) Once you have found what appears to be the cause of the problem, you should stop and think about what you have found—is this the root cause, or is it only one symptom of a problem somewhere else?

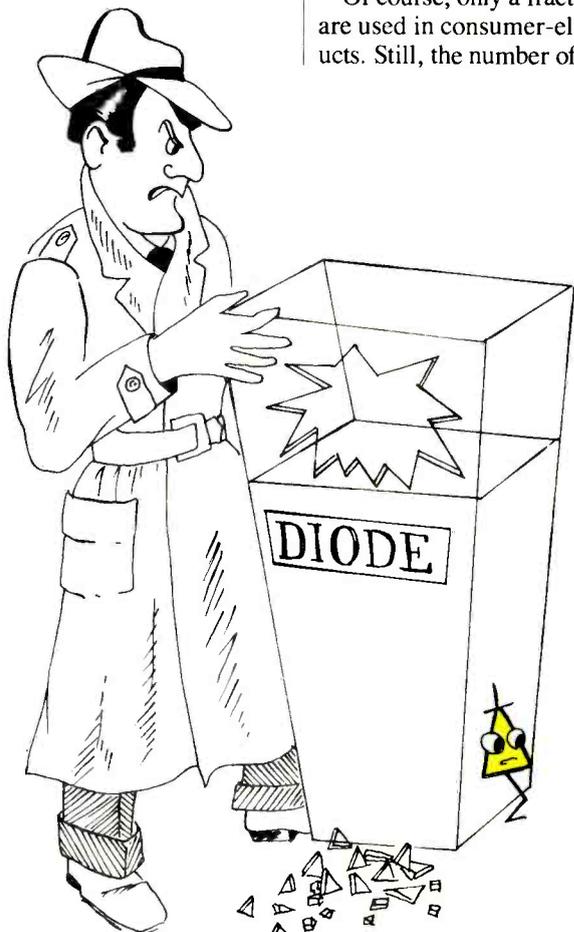
The troubleshooting tip on page 48 is a good example of the benefits of proceeding with caution in this manner. For example, if Mr. Silver had considered his diagnosis complete when he determined that the tuner was faulty, he would have wasted time and money and still not had the problem fixed. And think about the situation if the tuner assembly was back-ordered from the manufacturer. Even after he had double-checked and found that the problem wasn't in the tuner, he double-checked and found that his next suspicion, the IC, wasn't the problem either.

In this case, the technician was spared the possibility of ordering (and possibly back-ordering) a special part by using well-honed troubleshooting techniques to isolate the problem to a part that is available anywhere.

## Once you find the culprit

Once you have isolated the problem component, the next step is ordering the part. Here are some suggestions from the parts manager for a major manufacturer of imported consumer-electronics products:

- Obtain the manufacturer's service manual for the product you're working



on. Besides providing schematics and other information on servicing the unit, the documentation provides a parts list with manufacturer's part numbers for replacement parts. Without this information, the technician has to give a description of the part to the distributor, who has to look up the part number. Besides taking up valuable time for the distributor, it introduces the possibility of error.

- Shop carefully for a competent stocking distributor of replacement parts for the line you plan to service. If you don't, you may wind up with a "distributor" who is nothing more than a broker who relays your order to the manufacturer's parts depot.

- Order an exact replacement part by the manufacturer's part number wherever possible. There are generic replacements for many parts for today's products, even for integrated circuits, but using exact replacements is the only way to make sure you're getting a part that is of a grade that will give long life in the particular application. In cases where parts are identified as being safety critical, NEVER substitute with a part other than an exact manufacturer's replacement part.

Parts suppliers in general suggest that you include the following information:

- Part number.
- Model number of the unit.
- Description.
- Quantity.
- Account number.
- PO number if applicable.
- Date ordered.
- Your company name, address and phone.

#### A helpful hint

This idea comes from Leo Cloutier, owner of a consumer-electronics servicing facility in California. He now uses fax (Facsimile) for checking on parts.

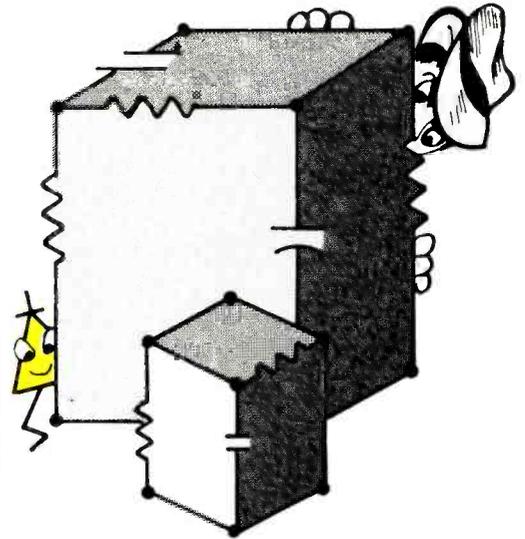
Most of the time you might call a distributor, be put on hold, then, once you identify the part, you are told that the distributor will get back to you. Instead, Mr. Cloutier writes the part information on either a plain piece of paper or a form provided by the distributor, then faxes it to the distributor. The fax machine automatically identifies his business and his phone and fax number, so he doesn't even have to write that down. The distributor usually gets back to him in a short time, either by phone or fax, with the price quote or whatever other information is pertinent.

An added benefit of the \$650 fax machine he uses is that it doubles as a copier.

#### A supplier for some of those hard to find parts

A few years ago, TV sets bearing the name Bohsei were available in some stores throughout the country. Almost as suddenly as it showed up, the company disappeared, leaving apparently no source of repair parts for Bohsei TV sets that had been sold in this country. Another company that had done business in this country for many years and then stopped, leaving a replacement parts vacuum, was Garrard, British manufacturer of turntables and changers. Wollensak, one-time source of tape recorders here, also stopped doing business in the United States.

There is a source of supply for *some* replacement parts for products by all of these manufacturers. Audio Parts Co., a California-based specialty parts distributor that carried replacement parts for these manufacturers while they were doing business in this country, purchased the companies' remaining stocks of replacement parts. If you need parts for any of the three companies mentioned above, Audio Parts *might* have it.



The company's address is:

Audio Parts Co.  
1070 South Orange Drive  
Los Angeles, CA 90019

A company spokesman gave us the following two numbers to call: 800-999-5559 and 213-933-8141. If you call the company with a parts request, the operator will look it up and get back to you with a postcard letting you know whether they have it and what the price will be.

#### Containing the information explosion

As we said at the outset of this article, the number of replacement parts and part numbers seems to be increasing geometrically. When the number of replacement parts was relatively small (how many different vacuum tubes were ever made compared to the sheer volume of semiconductor devices), the burden of supplying the right replacement for a faulty part might be considered to rest squarely on the shoulders of the supplier. We might all wish that that were still the case, but unfortunately it's not.

In many cases today, if the servicing facility is going to get the right parts in a timely manner, the servicing facility is going to have to maintain its own information bank. Again, unfortunately, such a setup is not inexpensive. On the other hand, the alternative—having a faulty product waiting for the proper replacement part instead a satisfied

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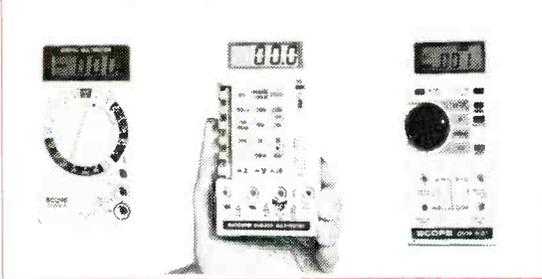
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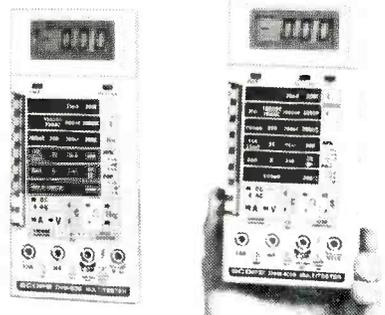


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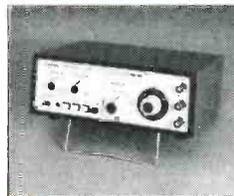
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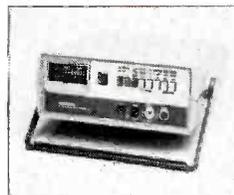
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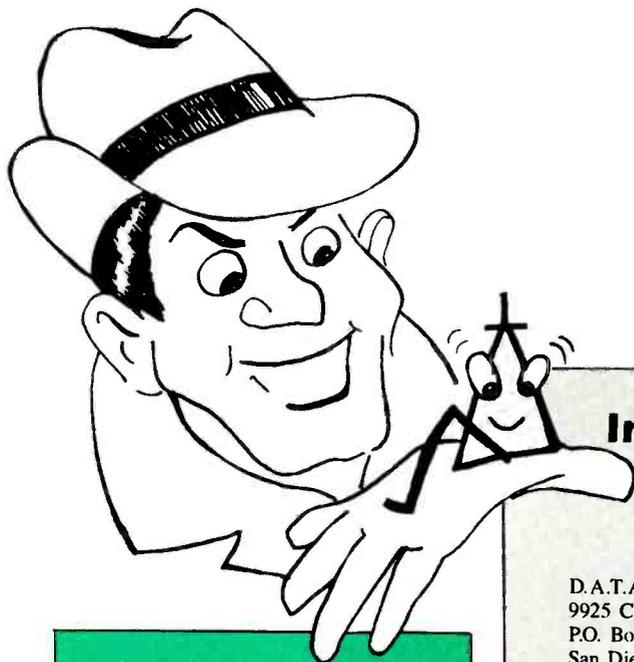
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## Help us help you

For many reasons, obtaining replacement parts for faulty consumer-electronic products seems to be increasingly difficult. In our August 1989 issue, we will feature a Replacement Parts Showcase that will be packed with information to help servicing technicians locate those hard-to-find parts.

The more input we can get for this showcase, the better. We invite all of our readers—servicing technicians, service managers, store owners, distributors, catalog parts suppliers and manufacturers—to send us your thoughts, suggestions, little-known information and anything else that will help other readers locate hard-to-find replacements.

For example, did it help any of you to find out that you can order some Bohsei parts from Audio Parts Co.? Do you know of some distributor or other source that has a stock of parts for discontinued products? Do you know of any parts suppliers we didn't list here who can supply hard-to-find parts?

We'd like to hear from any of you who have anything to say about the replacement parts situation, whether it's a description of problems you have had in locating repair parts, valuable information on locating sources of repair parts, or suggestions for information you'd like to see us include in our Replacement Parts Showcase in August.

Let us hear from you. Send comments, suggestions or ideas to:

**Replacement Parts Showcase Editor**  
**Electronic Servicing & Technology**  
P.O. Box 12901  
Overland Park, KS 66212

## Information sources

D.A.T.A. Business Publishing  
9925 Carroll Canyon Road  
P.O. Box 26875  
San Diego, CA 92126  
619-578-7600

Designer Technology  
4009 Pacific Coast Hwy.  
Torrance, CA 90505  
213-376-0805

EIA/CEG  
2001 Eye Street N.W.  
Washington, DC 20006  
Temporary address (effective  
April 25, 1988 until further  
notice): 1722 Eye Street, N.W.,  
Suite 300  
Washington, DC 20006  
202-457-4919

IC Master  
Hearst Business Communications  
645 Stewart Ave.  
Garden City, NY 11530  
516-227-1300

customer smiling as he hands you a check—is also not inexpensive. Having your money tied up in a lot of the wrong parts isn't cheap either.

Today's consumer-electronics servicing facility should probably have its own library. In addition to the obvious things like service manuals, replacement-parts catalogs and possibly Sams Photofact folders, there is a handful of books that any serious repair facility should at least consider having. Some of them are free; others will cost up to a hundred or so dollars. However, if such a library will consistently help a servicing facility find the right part quickly, it might be just as worthwhile to have on hand as that new high-priced oscilloscope that helps you find the problems fast.

One free book that does contain a lot of good information is called the *Consumer Electronics Replacement Parts Source Book, January 1988*, published

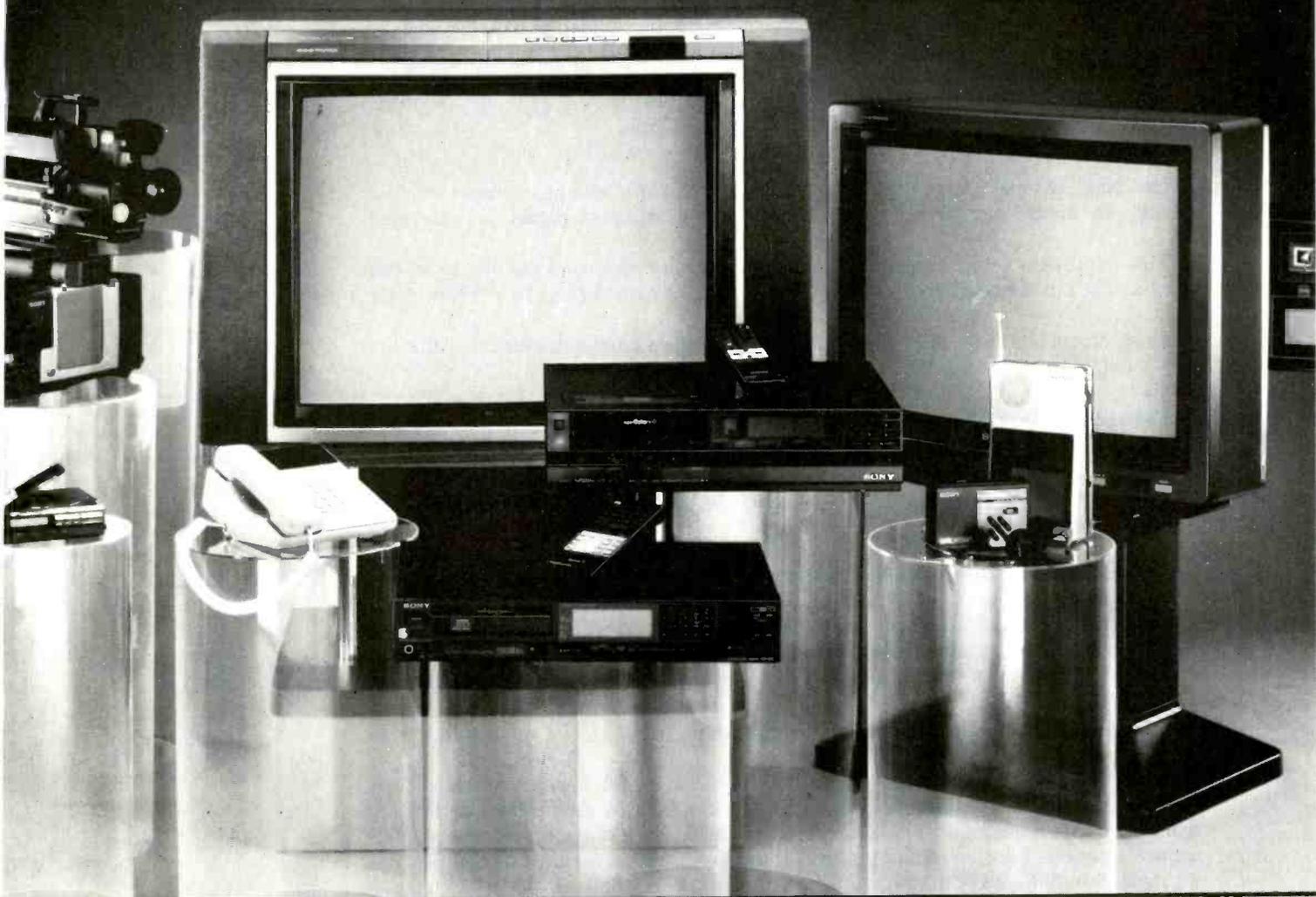
by the Electronic Industries Association/Consumer Electronics Group (EIA/CEG). (See the sidebar for the association's address.) This 104-page book contains listings of distributors for all of the consumer-electronic product manufacturers who cared to return the EIA's questionnaire forms. It contains listings from ADCOM Service Corp. (replacement parts for Dual) to Zenith. Some of the listings run several pages long.

Some other free books that can be very helpful are the replacement-parts catalogs from Philips ECG, RCA SK, GE, New Tone, etc., but you already know about those. You can get most of them from your distributor. (The addresses of these organizations are listed in the sidebar accompanying this article.)

Some other references will cost some money. If they're useful, they may be worth the price. One of these is a series of in-depth digests published by D.A.T.A. Business Publishing. There are quite a number of digests on several different classes of products: five on discrete semiconductors, and one each on diodes, transistors, optoelectronic devices, thyristors and power semiconductors. Five digests cover integrated circuits: one each on digital ICs, linear ICs, interface ICs, memory ICs and microprocessors. Each of these digests is priced at \$125. If it's important to you to stay current, the company offers updates. Semi-annual updates for each of the discrete semiconductor digests are available for an annual subscription price of \$75, and quarterly updates are available for each of the IC digests at an annual subscription price of \$75.

Another reference is the IC Master. This one will set you back \$140 for a 3-volume set. This set is actually produced for the electronic design engineer who's looking for ICs to perform some function necessary in the end product he's designing. Volume 1, the master selection guide, is indexed both by the function of the IC—what the IC does in the circuit—and by IC part number. Also included is a part-number guide that tells you what information you can learn about the IC just by reading the part number. An application note directory gives you a list of the application literature on a given part that's available from manufacturers throughout the industry. An alternate source directory helps you find other part numbers that will perform the same function. **ES&T**

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# Test your electronics knowledge

By Sam Wilson

In this month's quiz, we will supply the definitions of terms and you will pick the right term for the definition. A list of *possible* answers is given first. (There are more possible answers than questions.) The definitions are from a Sylvania publication. The answers are given upside-down at the bottom of the page.

- |                        |                   |                       |                 |
|------------------------|-------------------|-----------------------|-----------------|
| A. access time         | F. enable         | K. parallel operation | P. slewing rate |
| B. asynchronous inputs | G. half adder     | L. passive elements   | Q. Tallahassee  |
| C. buffer              | H. linear circuit | M. register           | R. toggle       |
| D. clear               | I. NAND           | N. serial             | S. word         |
| E. ring counter        | J. OFFSET         | O. skewing            |                 |

1. The change in input voltage required to produce a zero output voltage in a linear amplifier circuit. In digital circuits it is the dc voltage on which a signal is impressed.

2. This term refers to the technique for handling a binary data word that has more than one bit. The bits are acted upon one at a time. It is like a parade going by a review point.

3. An asynchronous input, also called *reset*, used to restore a memory element or flip-flop to a standard state, forcing the Q terminal to logic 0.

4. Those terminals in a flip-flop that can affect the output state of the flip-flop independent of the clock. Called set, preset, clear, reset or dc set and reset.

5. A circuit whose output is an amplified version of its input, or whose output is a predetermined variation of its input.

6. To switch between two states as in a flip-flop.

7. An interconnection of computer circuitry made up of a number of storage devices (usually flip-flops) to store a certain number of digits, usually one computer word. For example, a 4-bit \_\_\_\_\_ requires four flip-flops.

8. A group of bits treated as an entity in a computer.

9. A special form of counter, sometimes called a Johnson or shift counter, which has very simple wiring and is fast. It forms a loop or circuit of interconnected flip-flops so arranged that only one is 0. As input signals are received, the position of the 0 state moves in sequence from one flip-flop to another around the loop until they are all 0. The first one then goes to 1, followed by the other flip-flops in sequence until all are 1. It has  $2 \times n$  possible counts where n is the number of flip-flops.

10. To permit an action or the acceptance or recognition of data by applying appropriate signals (generally a logic 1 in a positive logic) to the appropriate input.

11. Refers to time delay or offset between any two signals in relation to each other.

12. A boolean logic operation that yields a logic 0 output when all logic input signals are logic 1.

13. A switching circuit that combines binary bits to generate the sum and the carry. It can only take in the two binary bits to be added and generate the sum and carry.

14. The organization of data manipulation within computer circuitry where all the digits of a word are transmitted simultaneously on separate lines in order to speed up operation, as opposed to serial operation.

J ✓

N

D

B

H

R

M

S

E

F

O ✓

I

G

K

Wilson is the electronics theory consultant for ES&T.

1-I; 2-N; 3-D; 4-B; 5-H; 6-R; 7-M; 8-S; 9-E; 10-F; 11-I; 12-O; 13-G; 14-K; 15-C

## Literature

### Electronic parts/equipment catalog

The 48-page *Surplus Traders* catalog specializes in electronic and computer parts and equipment. The majority of items are available in large quantities and are often difficult to find. Trade inquiries for the catalog will be filled at no charge when submitted on company letterhead. Hams, hobbyists and experimenters may obtain a copy by sending \$2 to Surplus Traders, P.O. Box 276, Alburg, VT 05440; 514-739-9328.

### Service newsletter brochure

*Lynco Publications* is offering a brochure describing its newsletter, *Just Between Us*. The quarterly newsletter is customized for individual service companies to send to their own lists of customers, prospects and community leaders. Three of the four pages contain interesting and informative articles intended for a general audience. The fourth page is reserved for the selling message of the sponsoring company.

Circle (131) on Reply Card

### Surge suppressor catalog

The Electra Guard Surge Suppressor Program brochure from *CPS Electronics* describes the company's consumer-grade product line of surge suppressors. The brochure includes product specifications for 1- to 8-outlet units with indicator lights, push button circuit breakers, lighted on/off switches and EMI/RFI protection.

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### Tool catalog

The 160-page catalog from *Jensen Tools* features new tools, tool kits and test equipment for TVs, VCRs, computers, printers and other electronic equipment. The catalog describes the company's line of more than 40 specialty tool kits, plus a new line of products for fiber optics and wire/cable systems.

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### Tool/test equipment catalog

*HMC* has published a fully illustrated buying guide of electronic tools, test equipment and supplies for the manufacture, assembly and repair of electronics. The catalog includes test instruments, tool kits, soldering/desoldering systems, lamps and magnifiers, anti-static products and precision hand tools.

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December 1988 *Electronic Servicing & Technology* 41

# What do you know about electronics?

## Kirchhoff's voltage law

By Sam Wilson, CET

You and I both know that voltage is not a force. It is a unit of work. That's why you don't see the term *electromotive force* in modern technology textbooks. It confuses the issue. Even so, in the privacy of my own home, I analyze circuits by thinking of voltage as being a pressure that pushes current through a circuit.

And, of course, we all know that electric current is not a flow of electrons. It is a flow of charge carriers that *may* be electrons under certain conditions. However, if I'm tracing a circuit path, I mentally chase electrons through the conductors and components.

You can still find a few books that carry these ideas. They are sent in plain brown wrappers. It is a good idea to keep them out of the hands of young folks who are likely to get married to models.

Wilson is the electronics theory consultant for ES&T.

At the risk of being called old-fashioned, I'm going to talk about Kirchhoff's laws by using the old water-pipe analogy. I do this even though I know it will spawn letters to the editor demanding that I be turned out to pasture and replaced by an up-to-date thinker.

Figure 1 shows an engine block, a radiator and a water pump. It is a model for an electric circuit. The water pump acts like the voltage. The water flow is like the current. The opposition to the flow of water (caused by the radiator and engine block) is like the resistance in the circuit.

When the water flows through the radiator, there is a drop in the water pressure. Also, there is a drop in the pressure when the water flows through the block. The total amount of pressure drop is equal to the pressure created by the pump.

Imagine, for a moment, that this isn't

true. If there is still pressure left over when the water gets back to the pump, that water pressure would help to turn the pump. With that idea, you could get some perpetual motion started.

If the pressure dropped to zero before the water got back to the pump, the water would stop flowing. It couldn't get back to the pump, so the flow would not be continuous. In the closed system in Figure 1, the drops in pressure are exactly equal to the pressure created by the pump.

Using the water-pipe analogy, the same thing happens in the equivalent circuit in Figure 2. The applied "electromotive force" is the battery. The electrical pressure created by the battery equals the voltage drops created by the resistors.

Kirchhoff knew this when he formulated his voltage law: "The sum of the voltage drops around a circuit equals the applied voltage."

### Kirchhoff's current law

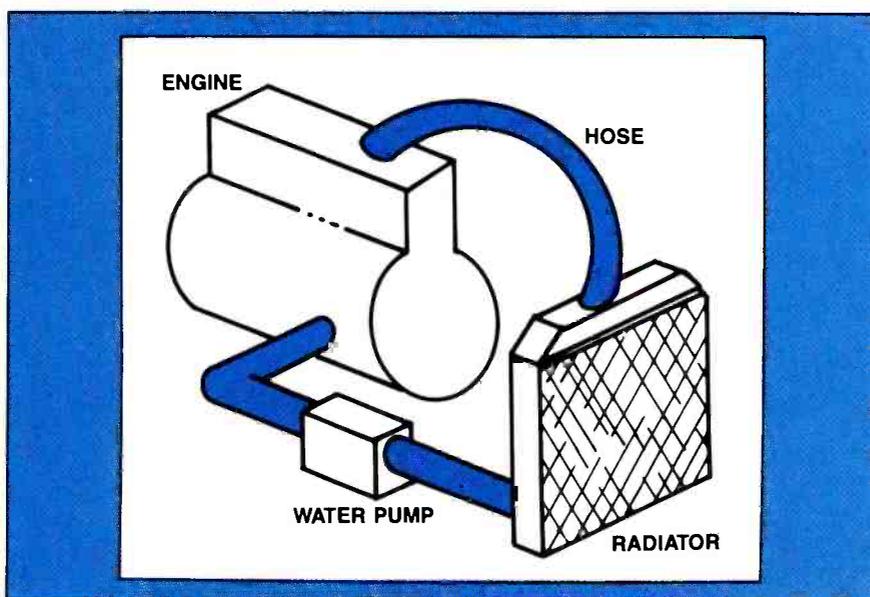
Now, think of two rivers coming together. Let's use the Ohio River and the Mississippi River. The water flowing into the junction of the two rivers just *has* to equal the water flowing away from the junction.

At this point, students want to discuss evaporation, a large hole in the ground and the water that is used by St. Louis. You're not a student, so you won't need to ask about those things.

Maybe it is safer to use the water pipes shown in Figure 3. The amount of water flowing in equals the amount leaving. Kirchhoff said the same thing, but he talked about electric current: "The sum of the currents flowing into any junction equals the sum of the currents leaving that junction."

That is why the emitter current in Figure 3 equals the sum of the base and collector currents.

Kirchhoff's laws are really common

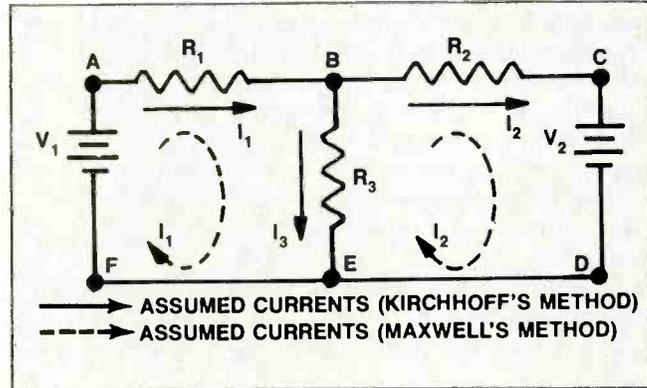
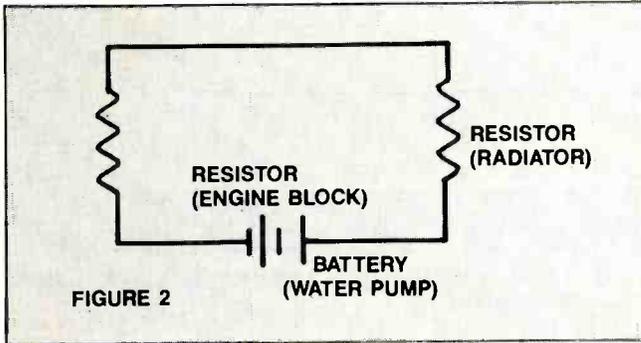
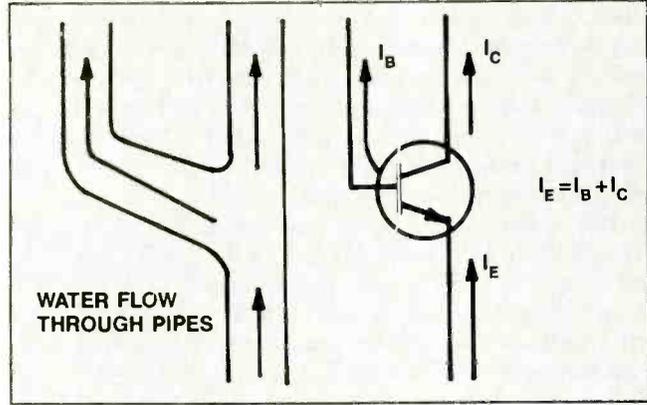


**Figure 1.** An engine block, a radiator and a water pump can serve as a model for an electric circuit. The water pump acts like the voltage. The water flow is like the current. The opposition to the flow of water (caused by the radiator and engine block) is like the resistance in the circuit.

**Figure 2.** The applied "electromotive force" in Figure 1 is the battery. The electrical pressure created by the battery equals the voltage drops created by the resistors.

**Figure 3.** If you use a water-pipe analogy to current flow, the amount of water flowing in equals the amount leaving. Kirchhoff said the same thing, but he talked about electric current: "The sum of the currents flowing into any junction equals the sum of the currents leaving that junction." That is why the emitter current equals the sum of the base and collector currents.

**Figure 4.** This circuit might be a dc circuit in a car. The battery ( $V_2$ ) is being charged by a generator ( $V_1$ ). All of the resistances for the head lights, tail lights and other electronic components are combined and represented by resistor  $R_3$ . Applying Kirchhoff's laws to find the current through  $R_3$ , you assume a current for each branch and draw arrows to represent the assumed currents (as shown by the solid lines). In Maxwell's loop method, you assume there is a current flowing around each closed loop, as shown by the dotted lines.



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sense put into words. You are liable to get the idea that the laws are just about useless when you are looking at complicated systems. Actually, the laws make it possible to analyze very advanced systems. I'll give a relatively simple example. (See Figure 4.)

This might be a dc circuit in a car. The battery ( $V_2$ ) is being charged by a generator ( $V_1$ ). All of the resistances for the head lights, tail lights and other electronic components are combined and represented by resistor  $R_3$ .

If you want to find the current through  $R_3$ , it can be done by applying Kirchhoff's laws. First, assume a current for each branch and draw arrows to represent the assumed currents (as shown by the solid lines). Don't worry about direction. If you assume the wrong direction, you will get the right value, but your answer will be negative.

Next, write enough current law equations to include all of the unknown currents. You must also write enough voltage law equations to include all of the unknown currents.

You can see that at junction B, the

current entering ( $I_1$ ) must equal the sum of the currents leaving ( $I_2 + I_3$ ):  $I_1 = I_2 + I_3$ .

That takes care of the current law.

If you go around closed-circuit A B E F A (or any other closed loop) the

voltage drops have to equal the voltage applied. Voltage drops are equal to  $I \times R$ . Therefore,  $I_1 \times R_1 + I_3 \times R_3$  are the sum of the voltage drops and must equal applied voltage  $V_1$ :  $V_1 = (I_1 \times R_1) + (I_3 \times R_3)$ .

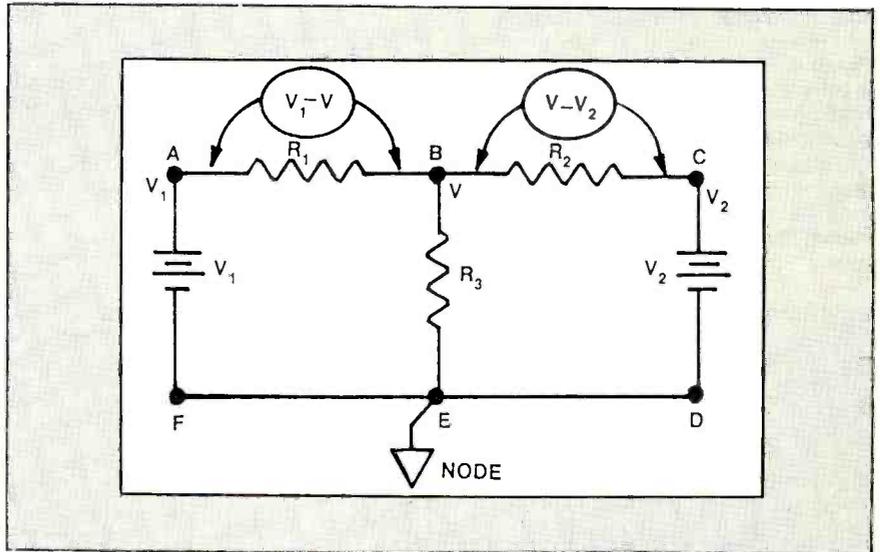


Figure 5. In a simpler method of solving the problem posed in the text, called nodal analysis, voltages are assumed rather than currents.

Coming Up in

# ELECTRONIC

Servicing & Technology

January

## Personal Computer Servicing--Special Report

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

## Technology Update--DAT

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

February

## VCR Servicing--Special Report

This ES&T special report discusses VCR technology. How they work, how they're constructed, how to go about diagnosing problems in them, and how to service them.

## Satellite TV Servicing

ES&T looks at the components of a satellite system. You'll learn how they're interconnected, and how to isolate the problem to a specific component when malfunctions occur.

Plus ES&T's Regular Monthly Departments

You need to write another voltage equation because you have not included  $I_2$ , so write an equation for closed-circuit B C D E B. Altogether, you will have three equations. One is for current and two are for voltage. There are three unknowns:  $I_1$ ,  $I_2$  and  $I_3$ . If you are able to strap on the full armor of algebra, you can attack the problem of three equations and three unknowns. Fortunately, the procedure can be simplified.

### Maxwell's method

This is sometimes called Maxwell's loop method, Maxwell's mesh method or the Maxwell-Helmholtz method. In this case, you assume there is a current flowing around each closed loop, as shown by the dotted lines in Figure 4. You only need to write two voltage equations here. There are two loops, so you end up with two equations and two unknowns.

Note that there are two currents,  $I_1$  and  $I_2$ , flowing through  $R_3$ . To get the actual current through  $R_3$ , you have to subtract  $I_2$  from  $I_1$ . Still too much trouble? Read on.

### Nodal analysis

It is possible to make a further simplification of the solution. In this method, called nodal analysis, voltages are assumed rather than currents.

The circuit is redrawn in Figure 5. A point is chosen to represent the node—that is, the 0V point. In this case, point E has been chosen and the node symbol has been added. You know the voltage at point B, so you assume  $V$  for that voltage.

Go back and look at Figure 4. Note that current  $I_1$  flows through  $R_1$ . That current is equal to the voltage across  $R_1$  divided by the resistance of  $R_1$  (Ohm's law).

In Figure 5, the voltage across  $R_1$  is the difference in voltage between points A and B. In other words, the voltage across  $R_1$  is  $V_1 - V$ , so you can represent  $I_1$  as being  $(V_1 - V)/R_1$ . You can represent  $I_2$  as being  $(V - V_2)/R_2$ . Finally, you can represent the current through  $R_3$  as being  $V/R_3$ .

You already know that the current equation for point B is  $I_1 = I_2 + I_3$ . If you substitute into the current equation, you get

$$(V_1 - V)/R_1 = (V - V_2)/R_2 + V/R_3$$

which is the same as saying  $I_1 = I_2 + I_3$ . The only unknown in this equation is

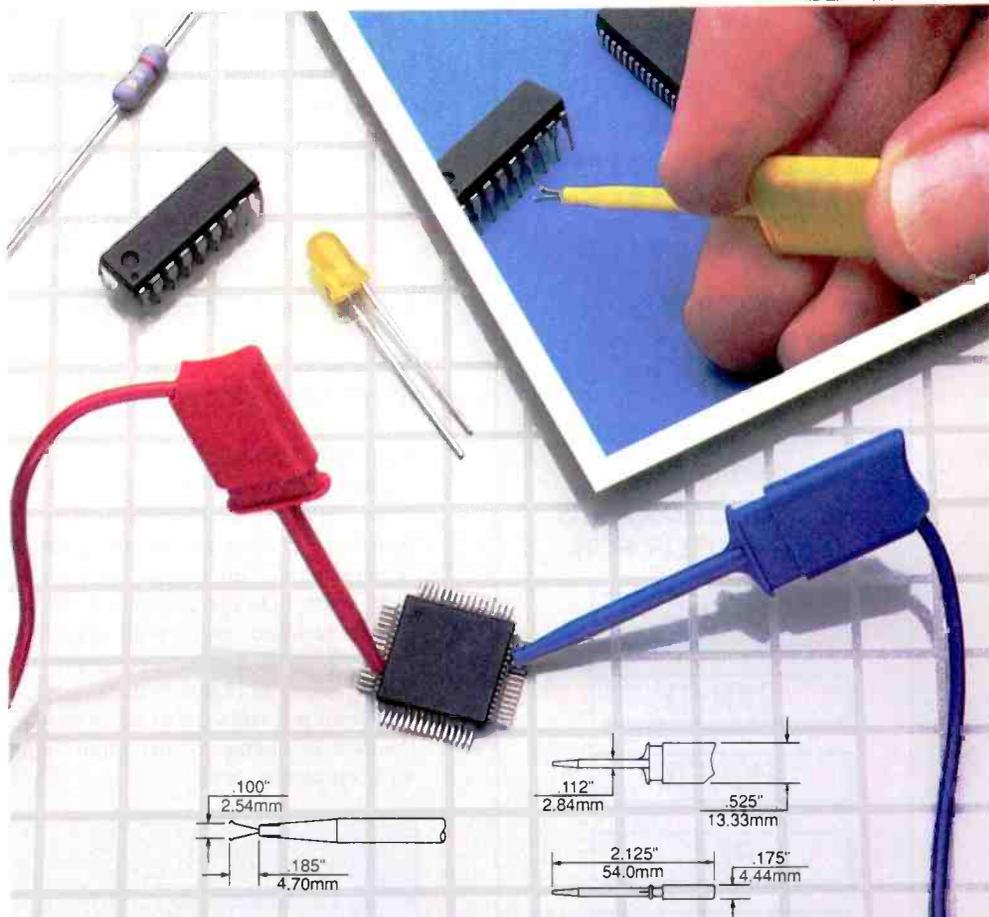
$V$ , so you have one equation and one unknown. That is simple if you know very basic algebra. After you find the value of  $V$ , you can determine  $I_3$  by Ohm's law.

Maxwell's method and the nodal method are actually simplifications of Kirchhoff's laws, so he should get most of the credit.

There is more to Kirchhoff's laws than just the voltage and current laws. Using the laws or the simplified versions, it is

possible to determine currents and voltages in very complicated circuits. Of course, you need the math to get values. However, just thinking through the analysis as we have done will give you some good insight into circuitry.

There is a limitation on the use of Kirchhoff's, Maxwell's and nodal solutions. The resistors must be linear. In other words, if you double the voltage across any resistor in the network, the current through it must double. **ES&T**



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# TRITRONICS

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## Feedback

I am at odds with an answer given in the September 1988 edition of **Electronic Servicing & Technology**. Perhaps I am missing something in my training or perhaps, as happens on occasion, there has been a misprint. I thought, however, to go to the source.

In "Test Your Electronics Knowledge" (page 10), the answer to question 6 was given as choice A.

I think the correct response is D. Without any idea given of the input signal, the circuit may be:

INPUT	CIRCUIT FUNCTION
Sine wave	1. coupling circuit 2. phase shift circuit 3. high-pass filter
Square wave	differentiating circuit

**Thomas G. Vlazny, CET  
Milwaukee, WI**

Dear Mr. Vlazny,

Let's start by defining the term *differentiating*. In mathematics, it is the process of finding the rate of change of one variable with respect to another. Very often it is the process of finding how a variable varies with respect to time. (Time is the second variable.)

The circuit in Figure A does just that. Its output is a voltage that depends upon the rate of change of the input signal with respect to time.

The simple differentiating circuit in Figure A must operate within a chosen time period. In other words, the output will be a voltage that is proportional to the rate of change of the input voltage for a specific period of time. Here are a few examples:

Consider Figure X. If you deliver a dc voltage to the input, the output will be 0Vdc (after the capacitor has changed). Why? Because when you differentiate a constant, you get zero—no rate of change.

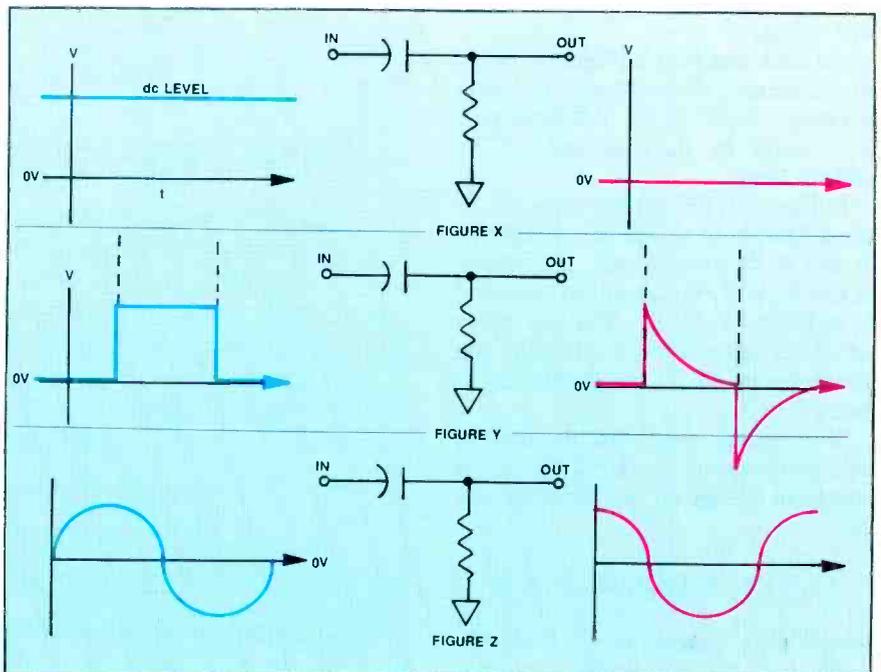
As shown in Figure Y, when you apply a square wave to the input, you get a high spike voltage at first. That corresponds to a fast rate of change of voltage. Following that, you get 0V corresponding with no rate of change.

Figure Z shows what happens when you apply a sine wave to the input. The output is a sine wave that has been shifted 90°. In other words, it is a cosine wave. That's because when you differentiate the sine of X, you get the cosine of X. There are many similar examples for any input to the circuit.

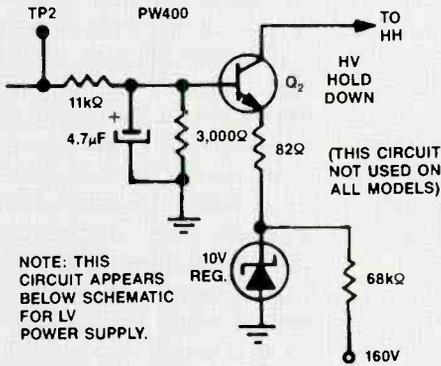
So, it is called a differentiating circuit because it can be used to differentiate a voltage that represents a variable. This circuit (with some improvement) can be used in an analog computer. Choice A is the best choice of those given in the question.

**Sam Wilson**

**ES&T**



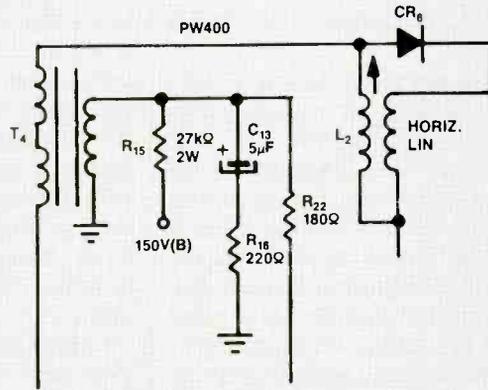
**RCA CTC46H**  
Photofact 1243-2



**Symptom:** Horizontal hold won't sync picture, HV won't adjust.  
**Cure:** Check  $Q_2$ . Replace if shorted.

1

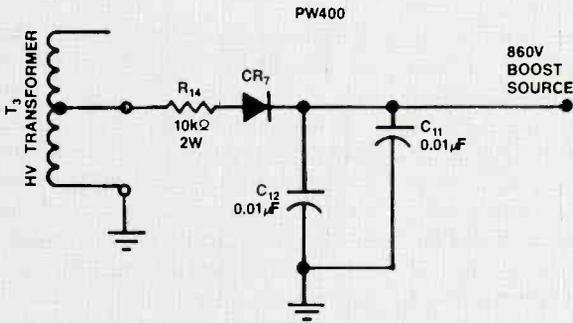
**RCA CTC46H**  
Photofact 1243-2



**Symptom:** Grainy picture and multiple ghosts after warm-up.  
**Cure:** Check  $CR_6$  and replace it if it is defective. Use only RCA part number 142569. (Note: Diodes are critical in this chassis. SK3051/156 won't work.)

4

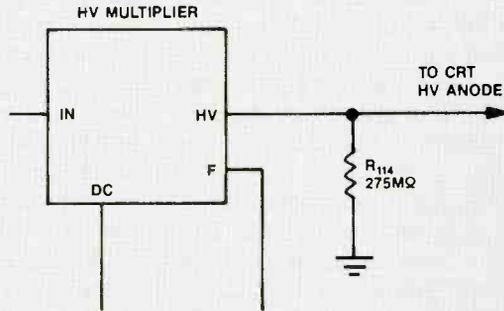
**RCA CTC46H**  
Photofact 1243-2



**Symptom:** Low brightness, no service line.  
**Cure:** Check  $CR_7$ . Replace it if it has high forward resistance.

2

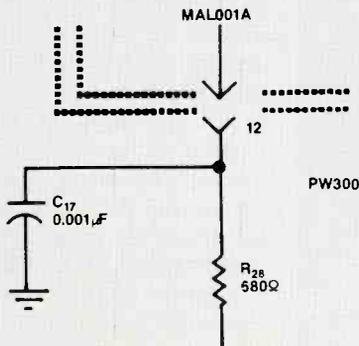
**RCA CTC46H**  
Photofact 1243-2



**Symptom:** HV arcing, no raster.  
**Cure:** Check  $R_{114}$  and replace it if it is open. (Note: HV arcs to mounting of insulated housing when  $R_{114}$  opens.)

5

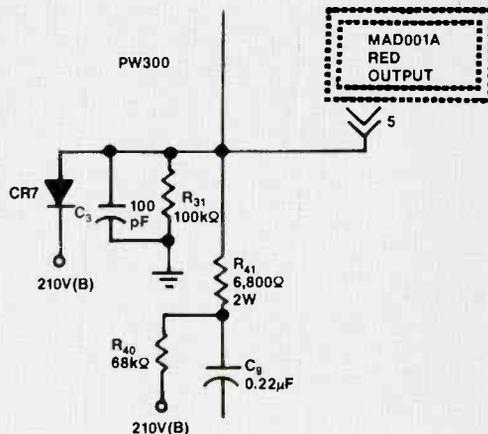
**RCA CTC46H**  
Photofact 1243-2



**Symptom:** Retrace lines on screen.  
**Cure:** Check  $R_{28}$ ; replace it if it is increased in value.

3

**RCA CTC46H**  
Photofact 1243-2



**Symptom:** Low brightness, dim service line.  
**Cure:** Check  $R_{40}$ ; replace it if it is open.

6

# Troubleshooting tips

## Symptom: Dead tuner

Set ID: Curtis Mathes VCR, AV725

This VCR was receiving no TV channels at all in either air or cable mode. When video was injected, the VCR displayed good video. I inspected the RF connectors, which sometimes cause loss of tuner functions. When the RF is at fault, snow usually appears on the screen. This VCR had no snow, only a black screen, as though the line or video input had been selected with no input. On that assumption, I decided to bypass the RF input switch and drive the tuner directly, but there was no change.

Next, I finished disassembling the unit to expose the bottom of the VCR and the PC board. I was sure that the tuner was the problem, but before I ordered one and waited three weeks, I decided to check the voltages going to the tuner to make sure they were there and that they were varying with band selecting. BT was there but did not vary. BU, BS and BV had no voltage and did not vary when the band-select was switched. Thank goodness I checked first or I would have wasted a lot of time and money.

I decided that it was about time to check the schematic. (See Figure 1.) I traced the voltages for these pins back to the band-switching IC (IC7001 AN5072, U/V tuner and power control),

and mentally checked the part number to see if it was something we stocked. It wasn't, so I decided that before I ordered one, I'd do some further checking. I checked the supply voltages to this IC. The schematic called for 32.1V supply to pin 6. Pin 6 measured 3.2V, so I figured it must be a misprint. Because this IC wasn't in stock, I decided to determine if it was actually a misprint—32V seemed too high for most ICs.

I traced back to the supply through a 1W series current-limiting resistor, 1,300Ω R<sub>7041</sub>. I found 48V on one side and 3.2V on the other. The presence of the 48V made me think that the 32.1V on the schematic wasn't a misprint. I then removed power and tested the resistor. It tested OK, and it was not hot to the touch.

Something must be loading down the supply line. Was it the IC? Before I parked this VCR to wait for the IC, I wanted to confirm my assumption that the IC was the culprit and was loading down the supply. I desoldered pin 6 on the IC and measured the voltage at the resistor. This voltage was still 3.2V, so the problem was not the IC. I shut the unit off and measured the resistance to ground. The reading was around 1kΩ, not a short as I suspected it would be.

This was really getting to be frustrating. None of the assumptions I

made based on experience were paying off here. I studied the print and discovered that there were only 4 connections at this point: a long foil run to a plug that went to another board, R<sub>7041</sub>, pin 6 of the IC, and a 0.01μF capacitor. I desoldered the plug run on the other board and hoped that that didn't restore the voltage to its proper value, as that would have started me on a whole other diagnostic track. It didn't. Next, I desoldered the capacitor, C<sub>7001</sub>. The voltage went to 32V as marked on the schematic.

Out of circuit, the capacitor tested OK on the Z-meter. Perhaps it was thermally intermittent.

This one problem confirmed that it definitely pays in time and money to double-check all assumptions, even if they seem absolutely correct at the time.

David Silver  
Findlay, OH

Symptom: No video, muted sound  
Set ID: Fisher VCR, FVH-805

With a tape inserted and the PLAY button pressed, this machine functioned normally mechanically, but there was no video and the sound was muted. In the E-to-E mode (using the VCR tuner only), the sound and picture were normal. I ruled out clogged heads because the TV monitor showed a fine-grained snow rather than the coarse grain that's seen with dirty heads.

We didn't have a service manual for this model, but I decided to go as far as I could without one. A visual inspection of the VIDEO/AUDIO circuit board (4-2264-029900) was helpful because connector PA206 was well-labeled, showing labels along each pin: 9.5V, Rec 9V, PB 9V. The voltage at the pin that was marked PB 9V read 4.5V instead of 9V.

Still entertaining doubts that I could repair this set without the service manual, I turned the power off, disconnected plug PA206 from the bottom of the board and measured resistance to ground from the line marked PB 9V. The reason that the voltage measured low at this point seemed to be that this resistance was very low. Desoldering a couple of jumpers on the board allowed me to isolate this portion of the circuitry. When I desoldered capacitor C<sub>9</sub> (see Figure 2), suspecting that this could be

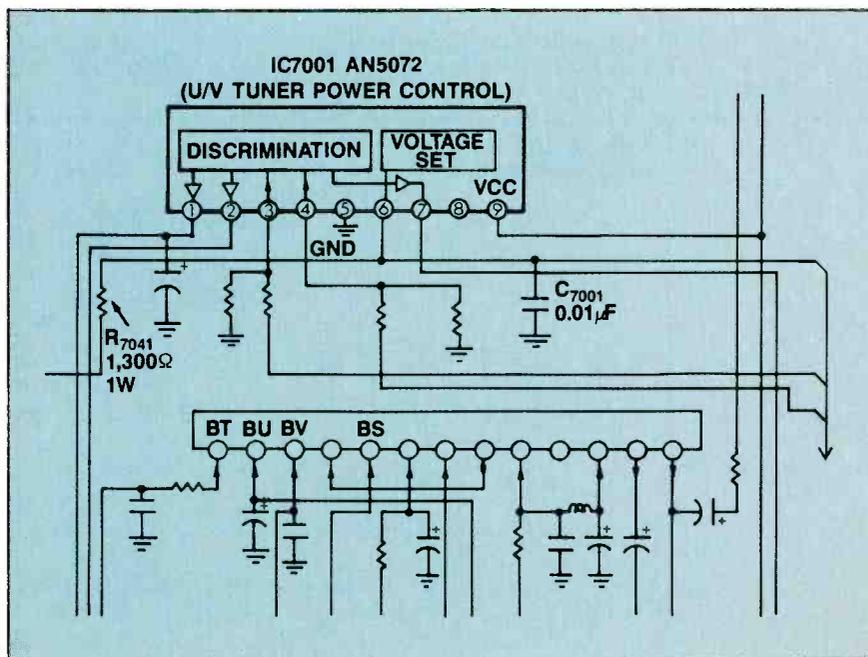


Figure 1. A possible thermally intermittent capacitor was causing this VCR to receive no TV channels in either air or cable mode.

the cause of the problem, the resistance increased. The capacitor was shorted.

Before simply replacing the capacitor and returning the set to service, I decided to do a few further checks to see if there was more to the problem than just this. I started by tacking in a replacement 220 $\mu$ F, 10V capacitor and turning power on. When I put the VCR in PLAY mode, I again read 4.5V where I should have read 9V.

I followed the wires from connector PA206 and came to the collector of transistor Q<sub>518</sub>. Suspecting that this transistor was contributing to the problem, I removed it from the circuit and tested it. It was leaky. I felt it would be a good idea to double-check the trouble path, and I managed to find a manual for a similar unit, a Fisher model FVH-720. Although the circuit symbols were dif-

ferent, component values and part numbers were close enough to reconstruct the failure and to order replacement parts.

Evidently capacitor C<sub>9</sub> shorted, drawing excessive current through Q<sub>518</sub> until it failed. I ordinarily use exact replacement parts in VCR repair, but a 10V capacitor in a 9V circuit seemed like an inadequate rating. Just to be on

the safe side, I used one rated at 25V.

A circuit problem such as this one ordinarily could not be located without the service manual, but the combination of a well-marked board and a service manual for a similar unit made this problem a happy exception.

Walt Schuman, CET  
Grass Valley, CA

ES&T

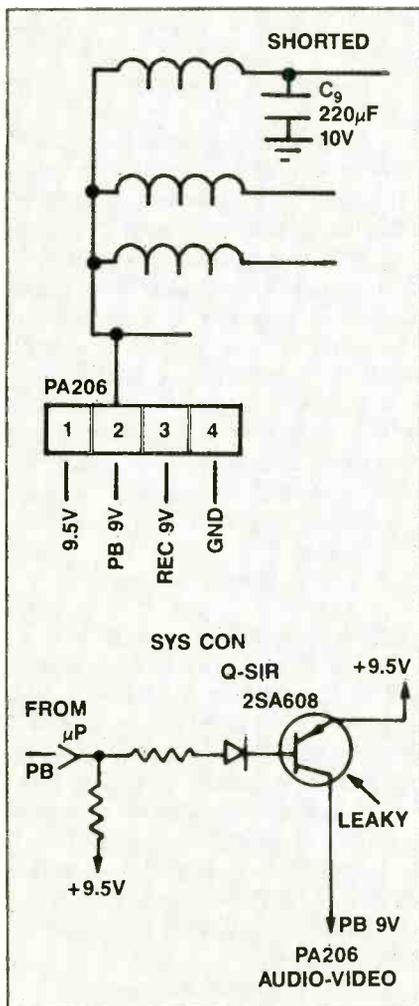


Figure 2. A shorted C<sub>9</sub> drew excessive current through Q<sub>518</sub>, causing the transistor to fail. The result was no video and muted sound.

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## Transient suppressors

*NTE* has introduced a line of MOVs and zener over-voltage transient suppressors. The MOVs range in clamping voltage from 42V to 1,240V with energy ratings from 0.8J to 180J. The zener unidirectional and bidirectional over-voltage types provide low zener impedance and fast response times.

Circle (75) on Reply Card

## Soldering systems

The Unger UTC Series soldering systems from *HMC* have a temperature range from 400°F to 800°F and are equipped with either a macro iron, a micro iron or a high-capacity iron. The systems meet military specifications for tip temperature ( $\pm 10^\circ\text{F}$ ), tip-to-ground resistance ( $2\Omega$  max.) and tip voltage potential (2mV). The CMOS-safe systems are calibrated without disassembly and are fully grounded from tip to plug.

Circle (76) on Reply Card

## Desoldering station

*Leads Metal Products* has introduced the model 7200 ENDECO power vacuum desoldering station, which runs on shop air and has no filters to clog. The station features a rapid vacuum that cools component leads and a fast ejection of molten solder and contaminants. It includes a lightweight desoldering iron that operates at 40W and idles at 20W. The station is equipped with eight tip sizes, a cleaning tool and a spittoon for contaminants.

Circle (77) on Reply Card

## Pocket-size multimeters

*A.W. Sperry Instruments* has introduced the SP-10A and SP-15A hand-held analog multimeters. The SP-10A has dc and ac voltage ranges of 10V/50V/250V/500V, dc current of 250mA, resistance ranges of 1k $\Omega$ /10k $\Omega$ /100k $\Omega$ , and 1.5/9V battery check. The SP-15A has dc voltage ranges of 5V/25V/250V, ac voltage ranges of 5V/25V/250V/1,000V, dc current ranges of 0.5mA/5mA/250mA, resistance ranges of 1k $\Omega$ /10k $\Omega$ /1M $\Omega$  and an instant continuity buzzer.

Circle (78) on Reply Card

## Logic tester

*Daitron* has introduced the IL-2200 OMIC logic tester, which permits measurement of 14-22 pins simultaneously with its 2-piece connector for TTL and

CMOS ICs. The system features hook contacts, guides between pins, and 2-color LED indicators to measure detectable voltage over 60%, below 35% or in between.

Circle (79) on Reply Card

## Protected outlet strip

*Scooter Products Group* has introduced the model SP4M Guard-It surge-protected outlet strip featuring modular protection, an anti-static grounding jack and full MOV protection. The unit handles peak surge currents up to 6,000A and a less than 1.0ns clamping time.

Circle (80) on Reply Card

## Management software

*ServiceMagic*, introduced by *MAGIC Solutions*, is a software package for managing field service and repair operations. The software tracks on-site service, repair and hot-line telephone support activities; maintains service contracts; and manages work orders. The program has user-definable codes and an integrated database that can generate work orders from hot-line telephone support.

Circle (81) on Reply Card

## Silicone receiving tubes

*International Components Corporation* has introduced three plug-in, high-performance, solid-state silicone *ServiceMaster* receiving tubes. The tubes replace 62 common tube types: The model SST-100 replaces 32, the model SST-200 replaces 21 and the SST-300 replaces 10.

Circle (82) on Reply Card

## Breakout boxes

Easy BOB models 775 and 785, introduced by *Beckman Industrial*, are battery-powered, 100-LED breakout boxes that feature faceplate output voltage pins and pulse trapping. The model 775 will monitor and reconfigure all 25 incoming and outgoing RS-232C lines for positive and negative voltages, and it can be used with PC parallel communications. The model 785 is also a full-function cable tester and will send and receive test voltages simultaneously.

Circle (83) on Reply Card

## Storage bin

LOCK-A-BIN, a locking storage and transport bin for small parts, has been

introduced by *Alacra Systems*. The stackable, virtually indestructible bin features a hopper that enables assemblers to pick parts up to 28% faster than from conventional bins. It holds parts as small as 0.04-inch in diameter and meets static decay and conductive material requirements.

Circle (84) on Reply Card

## Factory air rework system

The BTR-15 from *OK Industries* is a rework/repair system that utilizes factory air for vacuum pressure and suction and is available in 115V and 230V. The system provides closed-loop thermocouple control and a vacuum rise time of less than 0.15 seconds to reach pressures greater than 23 inches Hg. It features zero-voltage heater switching and a 100W, 24V desolder handpiece that is directly grounded for low tip-to-ground resistance and tip-potential levels.

Circle (85) on Reply Card

## Sweep/function generator

The model 3017 sweep/function generator from *B&K-Precision* covers from 0.2Hz to 2MHz in seven ranges and provides sine, triangle and square waveforms, plus TTL pulse and CMOS pulse signals. The generator features variable duty cycle; internal or external sweep/source capability with continuously adjustable sweep width to a maximum 1,000:1 ratio; adjustable sweep time from 0.5 to 30 seconds with selectable linear or logarithmic operation; adjustable output level from 0dB to -20dB; and variable dc offset.

Circle (86) on Reply Card

## Computer system service kit

*Jensen Tools* has introduced the JTK-2000, a service kit for complete computer system maintenance. The tool selection offers more than 100 standard and specialized tools, including Torx drivers, ball-end hex drivers, a phone-line tester, a keycap puller, IC and contact insertion/removal tools, soldering equipment, pliers, wrenches, screwdrivers and nutdrivers, plus optional test equipment.

Circle (87) on Reply Card

## Cable tester

The Cable Scanner, introduced by *MicroTest*, is designed to pinpoint cable

faults in LAN cabling systems. The tester features time domain reflectometry measurements (cable RADAR) without the need to disconnect workstations from the net, cable resistance measurements, noise level measurements and an audible continuity checker.

Circle (88) on Reply Card

### Portable oscilloscope

The Tektronix 2247A portable oscilloscope features a counter/timer and automatic rise/fall-time and propagation-delay measurements. The 100MHz, 4-channel scope offers auto setup, on-screen cursors and up to 20 pre-programmed measurements.

Circle (89) on Reply Card

### Driving tool

The SqueezeDriver, available from WorkTools, is a mechanically driven tool that doesn't use batteries or electricity. The tool will install and remove fasteners and features interchangeable

bits in 1/4-inch hex format and three modes: high torque, low torque and ratchet. Average no-load RPM in squeeze mode is 130-150. Average maximum torque is 35 inch-pounds; high-torque driving capability is up to 100 inch-pounds.

Circle (90) on Reply Card

### Polishing bar

CooperTools has announced the Weller WPB-1, a polishing bar for buffing and restoring soldering tips. The bar will clean oxidation from hot and cold tips.

Circle (91) on Reply Card

### Software package

The Philips PM 2240/001 TestTeam PC software, announced by John Fluke Mfg., provides a simple environment for writing test and measurement programs and allows program testing with build-in facilities for syntax checking, debugging and error-handling. All functions

offered are available via pull-down menus and pop-up windows.

Circle (92) on Reply Card

### Repair kit

Pace has introduced CIR-KITs, repair kits for repair of assembled PC boards. The kits include more than 30 sizes of eyelets, tracks plated to Mil specs in various pad diameters and widths, an abrasive stick and a setting tool. The kit is available in three models, basic, advanced and master.

Circle (93) on Reply Card

### Soldering equipment analyzer

The battery-operated G310 miniature soldering equipment analyzer from Hexacon Electric Company digitally displays a soldering iron's tip temperature, ESD resistance and voltage leakage. An interface port for chart recording or a data logger is also provided.

Circle (94) on Reply Card



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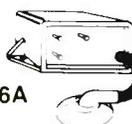
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Circle (19) on Reply Card

# Interfacing computers to the analog world—part VII

By Joseph J. Carr, CET

The first few parts in this series have described analog-to-digital (A/D) and digital-to-analog (D/A) converters. Last month we looked at methods for converting  $I_o$  to an output voltage with a low output impedance. This month we'll finish this series with a closer look at A/D converters and an introduction to the methods for interfacing digital computers to the non-analog outside world.

## A/D converters

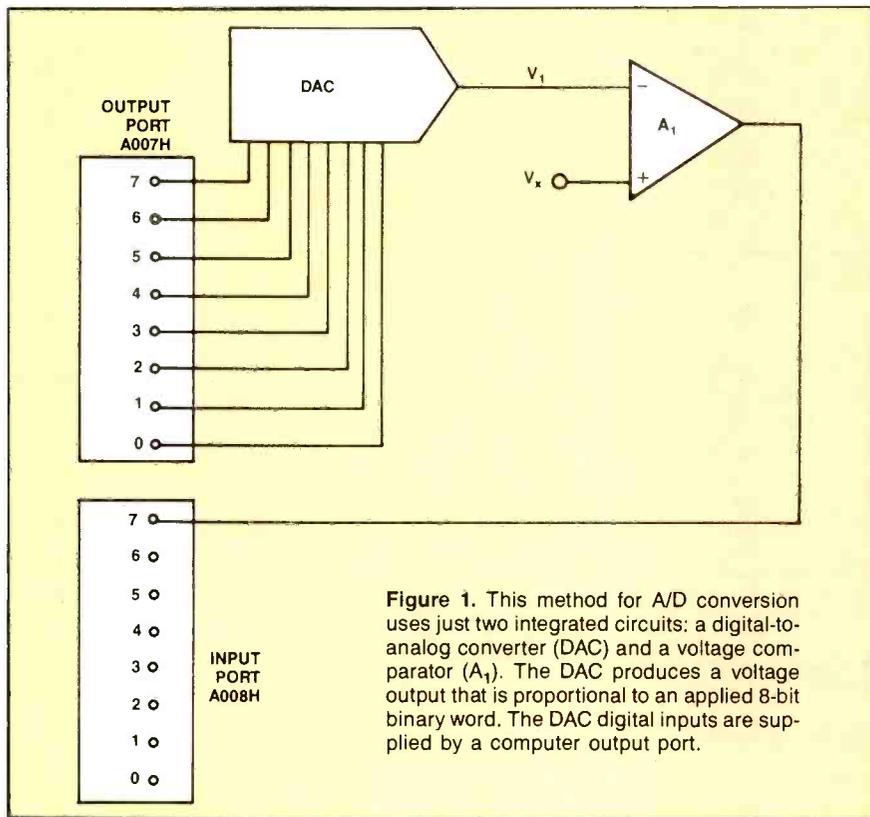
A large number of instruments, transducers and other devices operate in the *analog mode*. These devices use a voltage or current to represent some physical parameter. For example, a blood-pressure transducer used in

hospitals typically produces a dc voltage output of  $50\mu\text{V}$  per volt of excitation per millimeter of mercury pressure ( $50\mu\text{V/V-mmHg}$ ). This potential is amplified and displayed in the form of blood pressure numbers or an analog waveform on either an oscilloscope or a strip-chart recorder. More and more, such instruments (not just medical blood-pressure monitors) use programmable digital computers and microprocessors. The job of interfacing these instruments requires converting analog voltages (or currents) to a proportional binary number to be input into the digital computer.

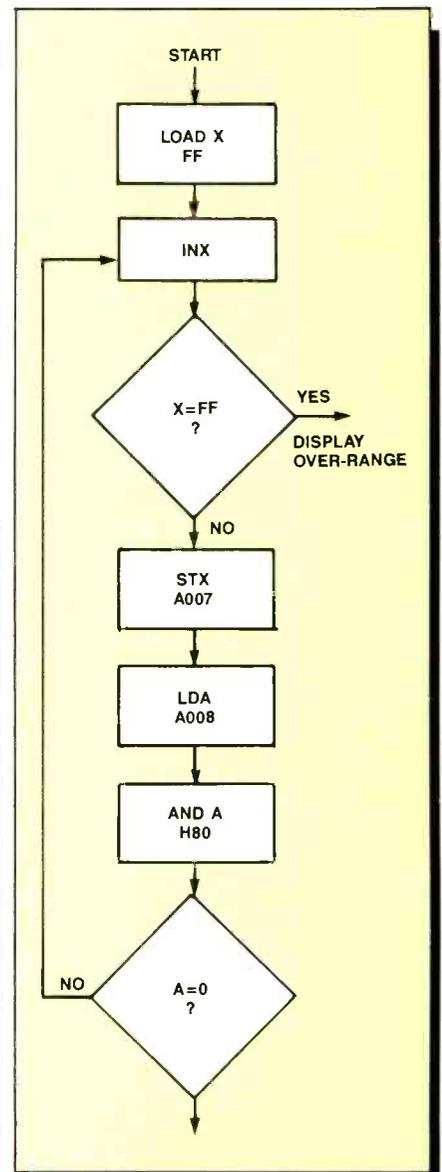
An analog-to-digital (A/D) converter is a device that will produce a binary word output that is proportional to the applied analog voltage. Any specific A/D converter will have a certain range.

Unipolar A/D converters typically have ranges of 0V to 1V, 0V to 2.5V, 0V to 5V or 0V to 10V. In such a converter, the binary word will represent voltages

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



**Figure 1.** This method for A/D conversion uses just two integrated circuits: a digital-to-analog converter (DAC) and a voltage comparator ( $A_1$ ). The DAC produces a voltage output that is proportional to an applied 8-bit binary word. The DAC digital inputs are supplied by a computer output port.



**Figure 2.** As this flow chart for an A/D converter program shows, the idea is to cause the output of the computer to ramp from 00000000 to 11111111, which forces the DAC voltage output to ramp from zero to full-scale.

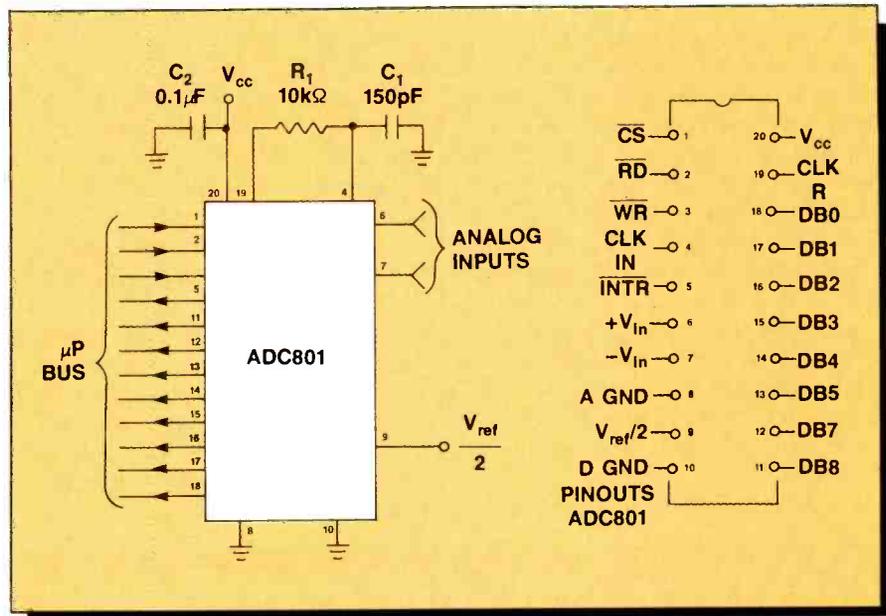
in a manner similar to the 0V to 10V case shown below:

Unipolar voltage	Binary word (8 bits)
0V	00000000 (zero scale)
5V	10000000 (half scale)
10V	11111111 (full scale)

For the bipolar case, such as -5V to +5V, the coding is a little different:

Bipolar voltage	Binary word (8 bits)
- 5V	00000000
- zero	01111111
+zero	10000000
+5V	11111111

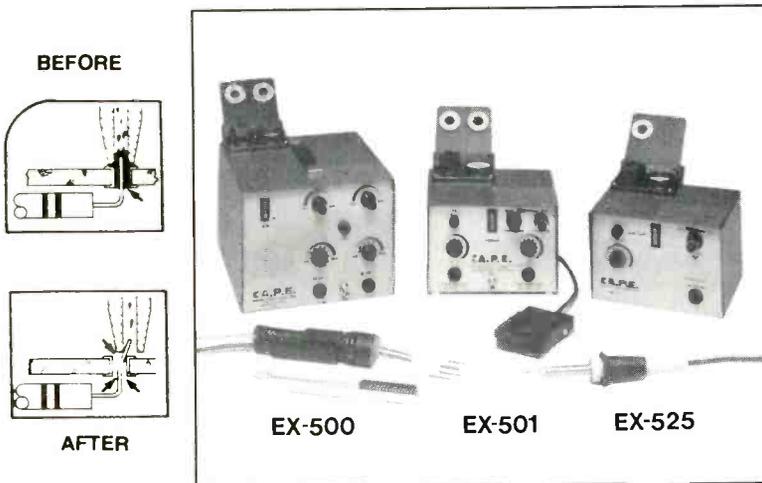
In the unipolar case the coding is relatively straightforward. Binary 00000000 represents 0V and the max-



**Figure 3.** The ADC-0801 device is a single-channel A/D converter that is easily interfaced to almost any digital computer. In the circuit variant shown here, the timing is accomplished by an RC network consisting of  $R_1$  and  $C_1$ . This device has a tri-state, 8-bit output port, so it can be interfaced directly to the microcomputer bus. Alternatively, the same lines can be connected to an 8-bit input port on a computer.

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December 1988 *Electronic Servicing & Technology* 53

imum binary number 11111111 is the full-scale voltage (+2.5V, +5V or +10V). The number of possible states is  $2^n$  where n is the bit length of the binary word. For an 8-bit machine, therefore, the number of possible states is 256. Because the 0V state is represented by 00000000, that leaves 255 different levels for voltage representation. This offset coding leaves us with a maximum full-scale voltage that is lowered by the value of voltage change caused by a change in the least-significant bit (LSB) of the binary word. For a 10V A/D converter, the 1-LSB voltage is 40mV, so the maximum voltage is 10V-0.040V, or +9.96V.

There are a number of different ways

to put together an A/D converter, far more than can be accommodated here. For additional information, see my book, *Microprocessor Interfacing: A/D-D/A*. We will, however, examine two methods that are popular with microcomputer users.

#### Methods for A/D conversion

Figure 1 shows a simple, minimum-hardware method for A/D conversion that uses just two integrated circuits: a digital-to-analog converter (DAC) and a voltage comparator ( $A_1$ ). The DAC produces a voltage output that is proportional to an applied 8-bit binary word. The DAC digital inputs are supplied by a computer output port.

The voltage comparator ( $A_1$ ) is a device that will produce an output that tells us whether or not the applied voltages are equal. In this case, comparator  $A_1$  compares voltage  $V_1$  (the DAC output) and the unknown input voltage  $V_x$ . When  $V_1$  is less than  $V_x$ , the output of  $A_1$  is HIGH. But when  $V_1$  is equal to or greater than  $V_x$ , the output of  $A_1$  is LOW.

The output of comparator  $A_1$  is applied to a computer input port at bit 7 (MSD). When  $V_1$  and  $V_x$  are not equal, the binary word applied to the port is 1xxxxxxx (where x denotes "don't care"). When the two voltages are equal, the word applied is 0xxxxxxx. With these facts in mind, let's take a

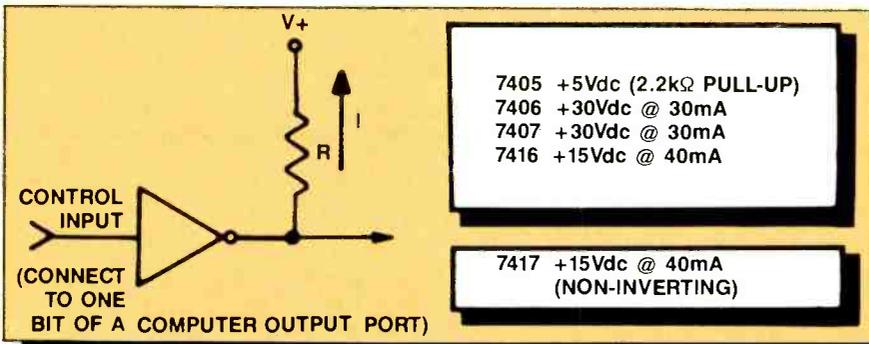


Figure 4. Figure 4A shows an open-collector TTL inverter (or non-inverting buffer), which requires a pull-up resistor (or other load) between the output terminal and the V+ voltage to act as a current source. A table of various TTL-type numbers is shown in Figure 4B.

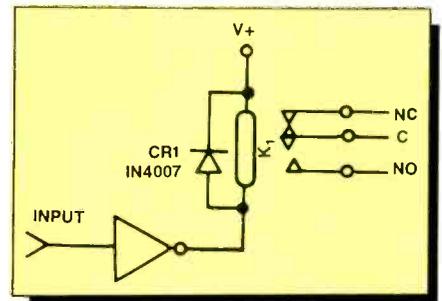


Figure 5. To interface a light-weight sensitive relay to the computer, the relay coil ( $K_1$ ) must have a resistance that will limit the current to 30mA or 40mA, depending upon the type of inverter used.

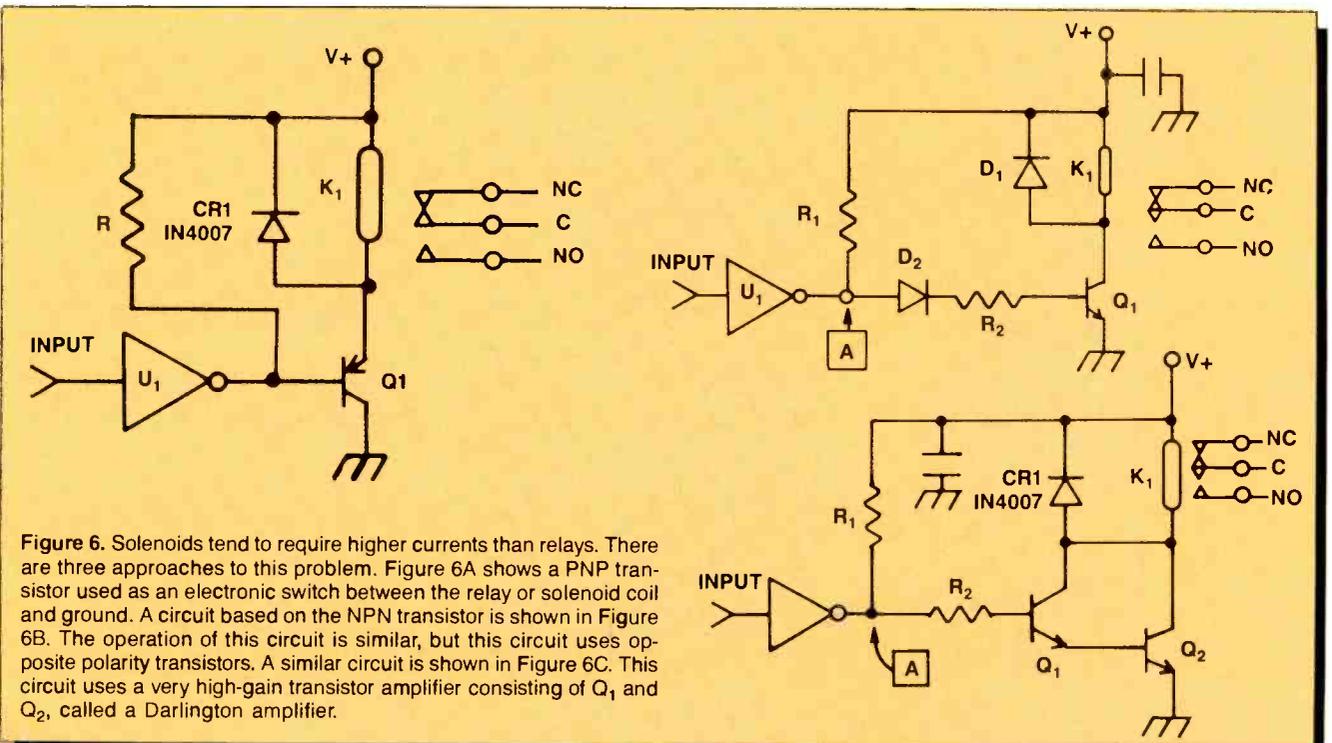


Figure 6. Solenoids tend to require higher currents than relays. There are three approaches to this problem. Figure 6A shows a PNP transistor used as an electronic switch between the relay or solenoid coil and ground. A circuit based on the NPN transistor is shown in Figure 6B. The operation of this circuit is similar, but this circuit uses opposite polarity transistors. A similar circuit is shown in Figure 6C. This circuit uses a very high-gain transistor amplifier consisting of  $Q_1$  and  $Q_2$ , called a Darlington amplifier.

look at Figure 2 and determine how this software-controlled A/D converter will function.

Figure 2 shows the flow chart for an A/D converter program. The idea is to cause the output of the computer to ramp from 00000000 to 11111111, which forces the DAC voltage output to ramp from zero to full-scale. In the example below, we are assuming a 6502-based microcomputer in which an output port is memory-mapped to address hA007 and an input is at hA008. The steps required are:

1. Load the X index register with hexadecimal number hFF (binary 11111111).
2. Increment the X-register. On the initial run through the program, this step brings it to h00.
3. Test for over-range. If the X-register incremented to hFF, the program must

take into account that, if no result is obtained in the steps to follow, an over-range situation occurred. The program must then display a message to that effect.

4. Next, load the contents of the X-register into memory location hA007 (which is the output port). The X-register contents are thus output to the DAC, which produces a voltage proportional to the value of X-register.

5. The accumulator (A-register) is loaded with the value of memory location hA008, the input port. This value is lxxxxxxx if  $V_1$  is not equal to  $V_x$ . It is lxxxxxxx if the voltages are equal.

6. We now compare the input word from hA008 to test for the condition of the MSD. We can do this by using the AND instruction and an operand of h80 (binary 10000000). According to the rules of logical-AND operation, 0 AND

0 = 0, 0 AND 1 = 0, 1 AND 0 = 0, 1 AND 1 = 1. Thus, when 0xxxxxxx is present, the result of the AND operation is 0, and when lxxxxxxx is present, the result is 1. We complete the test by testing for zero (6502 Z-flag = 1) using the BNE instruction.

7. If the result is non-zero, we branch back to the increment X-register point and start over until the result is zero. Alternatively, if the result is zero, the contents of the X-register represent the analog voltage applied ( $V_x$  so the program falls through).

### IC A/D converters

At one time, A/D converters were both terribly complex and terribly expensive, especially when more than three or four bits were required. I can remember \$2,000 prices on 12-bit A/D converters. Today, however, there are a lot of different A/D converters available on the market, at low cost for the most part, in both hybrid and monolithic integrated circuit form. The market has too many to do justice to the complete picture in a single article. The devices selected in this article are generally available to hobbyists through outlets such as Jameco (and its Jim-Paks sold through distributors), Digi-Key and others.

The ADC-08xx series of chips, available from several sources, are microprocessor and microcomputer compatible and are intended specifically for the type of system we might need. Figure 3 shows a basic circuit for the ADC-0801 single-channel version. (ADC-0808 is an 8-channel model; ADC-0816 is a 16-channel model.)

The ADC-08xx devices have a tristate, 8-bit output port, so they can be interfaced directly to the microcomputer bus. Alternatively, the same lines can be connected to an 8-bit input port on a computer.

The ADC-0801 device shown in Figure 3 is a single-channel A/D converter that is easily interfaced to almost any digital computer. In the circuit variant shown here, the timing is accomplished by an RC network consisting of  $R_1$  and  $C_1$ . Not shown in this circuit is the use of the control lines such as CS, RS, WR and INTR. The specific use of these are determined by the exact application and would differ from microprocessor to microprocessor. The

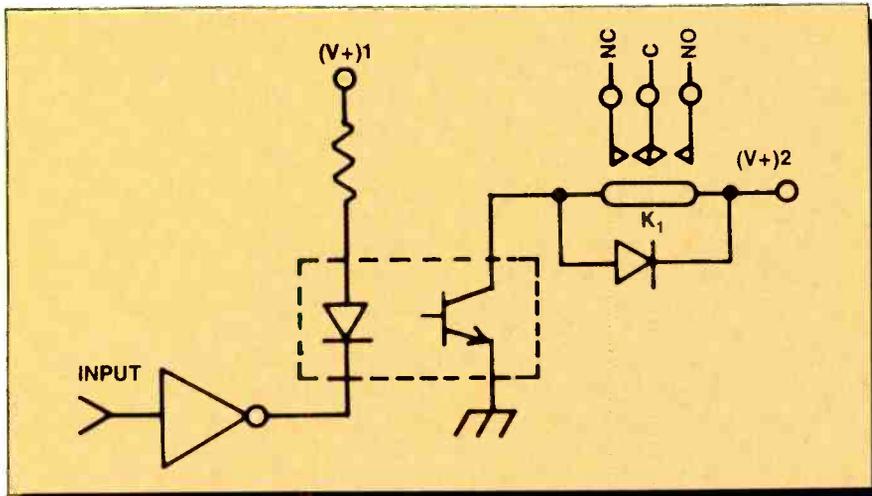


Figure 7. One very common problem is interruption of the computer operation due to glitches generated by the coil CEMF. An opto-isolator can overcome that problem.

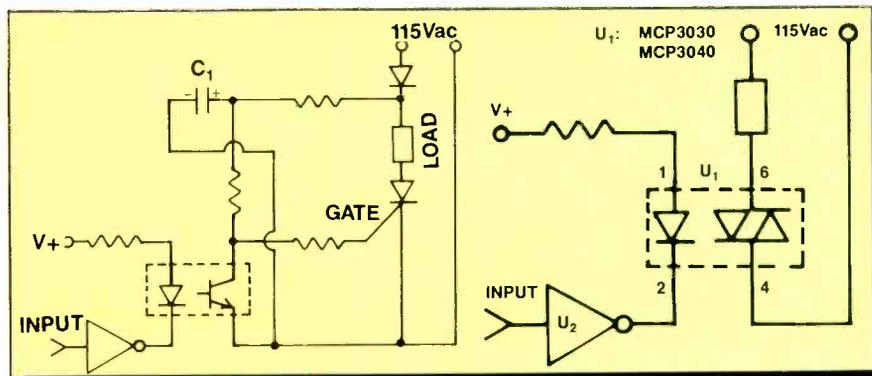
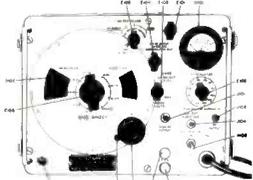


Figure 8. Another reason for using an opto-isolator is interfacing the 110Vac line. The opto-isolator can drive a relay (as in Figure 7) or an SCR, as shown in Figure 8A. The transistor in the opto-isolator controls the gate current of the SCR. Figure 8B shows an opto-isolator that uses a triac as the output device. Inherent in this type of device is a phototransistor or photodiode built into the triac gate structure.

## Signal Generators SG-103/URM-25F



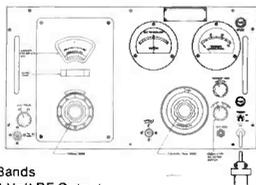
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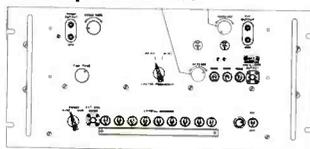
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*National Semiconductor Linear Data Book—1982*, which is available from Jameco and others, gives details for connecting several different computer chips to this family of devices.

### Other interfaces to the outside world

There are several methods available for interfacing digital computers to the non-analog outside world. Examples of devices in this class are light-emitting diodes (LEDs), relays, solenoids and the 110Vac line.

In all cases, we assume a computer output port on which at least one bit is available for use as a control flag. In the cases of the input sensors at the end of the article, of course, we are assuming that an input port is available. All of our circuits require the bit to be either HIGH or LOW in order to turn on (depending upon design). In most cases, the computer output port does not have the drive capacity to directly drive the control circuit. Personal computer output ports usually drive only one or two TTL loads, or about 1.6mA to 3.2mA. As a result, we need to connect either a TTL inverter or a non-inverting buffer to the computer output port in order to increase the drive capability.

Figure 4A shows the open-collector TTL inverter (or non-inverting buffer) used for this application. A table of various TTL-type numbers is shown in Figure 4B. An open-collector TTL device requires a pull-up resistor (or other load) between the output terminal and the V+ voltage to act as a current source. Although the TTL package must operate at +5Vdc (like all TTL), certain devices can operate with output terminal potentials up to +30Vdc at currents of 30mA or 40mA. The load or pull-up resistor must be selected to limit the current to the device maximum at the maximum permitted voltage.

When the inverter input is LOW, the output is HIGH. With this condition, the load is not grounded, so no current flows. Alternatively, when the input is HIGH, the output is LOW, so the load is essentially grounded and has a current flow through it.

LEDs can be interfaced to the computer through the same kind of circuit as Figure 4A. The LED is placed in series with a pull-up resistor that limits the current to a value consistent with the LED requirements (usually 15mA). For

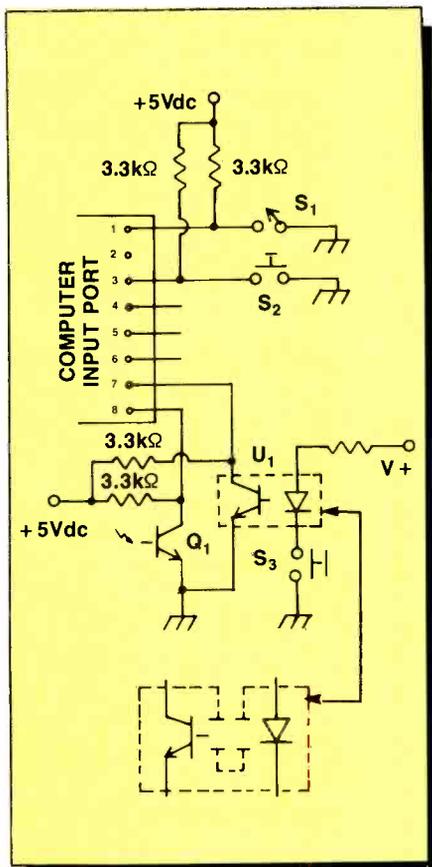
+5Vdc situations, a 330Ω series resistor is generally used.

Figure 5 shows how to interface a relay to the computer. The relay coil (K<sub>1</sub>) must have a resistance that will limit the current to 30mA or 40mA, depending upon the type of inverter used.

The diode connected in shunt across the relay coil is used to de-spoke the high-voltage counter-electromotive force (CEMF) that is normally generated when the magnetic field surrounding the energized coil collapses at turn-off. This diode is normally reverse-biased, but when the spike comes along it is of opposite polarity, so it forward-biases the diode. This diode must have a 1,000V PIV rating (1N4007 is sufficient and low-cost).

For those cases where the relay current is small, we can use this simple case, but where the coil current is higher, another circuit is required. Also, solenoids tend to require higher currents than relays. Figure 6 shows three approaches to this problem. Figure 6A shows a PNP transistor used as an electronic switch between the relay or solenoid coil and ground: The collector-emitter path or the transistor is in series with the load, and the base is connected to the output of the open-collector inverter. When the input is LOW, the output of U<sub>1</sub> will be HIGH, which forces the base and emitter potentials of Q<sub>1</sub> to be nearly equal. When the input goes HIGH, however, the U<sub>1</sub> output goes LOW, so the base of the PNP transistor is at a lower potential than the emitter. This condition forward-biases the PNP transistor, which turns it on. This circuit operates the relay or solenoid when the input is HIGH.

The transistor selected for Q<sub>1</sub> must have adequate collector current, collector-emitter voltage and collector power dissipation ratings. Don't make the mistake, however, of thinking that the collector dissipation rating is merely the product of the voltage and current ratings. Many transistors have a power-handling capability that is lower than the product of the maximum permitted voltage and maximum current. In addition, the transistor must also have sufficient beta gain to cause it to saturate when the base goes low. The ratio of the relay coil current (which is also the transistor collector current) and the base



**Figure 9.** It is sometimes desirable to build either a custom keyboard or special input sensors to get the computer's attention. Some of these sensors are shown here connected to a common input port. Attached to bits 1 and 3 are a pair of SPST switches. Attached to bit 7 is an opto-isolator. This type of input device is used where the external circuitry is either incompatible with the computer or dangerous to the computer's continued health. The opto-isolator could also be replaced with a similar device as shown in the inset. The interrupter is an opto-isolator in which a slot is cut to permit an external blinder vane to interrupt the path between the LED and the phototransistor. A simple phototransistor is shown at bit 8.

current (which is limited to the ability of the inverter to sink it) is the minimum allowable beta rating.

A circuit based on the NPN transistor is shown in Figure 6B. The operation of this circuit is similar, but this circuit uses opposite polarity transistors. When the input is HIGH, the output of  $U_1$  is LOW, so point A is essentially grounded. Under this condition, the transistor is unbiased, so it is cut off. This relay is de-energized. But when the input of the inverter is LOW, the output is HIGH, so point A is at a positive voltage. Under this condition, the tran-

sistor is biased hard-on and is thus in saturation. The relay or solenoid coil ( $K_1$ ) is grounded and is therefore energized.

A similar circuit is shown in Figure 6C. This circuit uses a very high-gain transistor amplifier consisting of  $Q_1$  and  $Q_2$ , called a *Darlington pair* or *Darlington amplifier*. The beta of this type of amplifier is the product of the beta ratings of  $Q_1$  ( $H_{fe1}$ ) and  $Q_2$  ( $H_{fe2}$ ). Consider a case where a gain of 200 is used for  $Q_1$  and a gain of 80 is used for  $Q_2$ :

$$\begin{aligned} H_{FE} &= H_{fe1} \times H_{fe2} \\ H_{FE} &= 200 \times 80 \\ H_{FE} &= 16,000 \end{aligned}$$

If two identical transistors are used for  $Q_1$  and  $Q_2$ , they have the same beta. The overall beta is the beta of either squared. In most cases, a driver transistor is used for  $Q_1$  and a power transistor is used for  $Q_2$ . Several semiconductor manufacturers offer Darlington amplifiers in single transistor packages. One replacement semiconductor line offers devices with collector dissipation ratings of anywhere from 600mW to 160W and beta ratings of 1,000 to 90,000. Some Darlington amplifiers can be driven directly from the computer output (by virtue of its extremely high beta) without the need for the inverter.

#### Isolated interfaces

There are situations where it is advisable to isolate the computer output from the relay or solenoid circuit. One very common problem is interruption of the computer operation due to glitches generated by the coil CEMF. We can overcome that problem by using an opto-isolator as shown in Figure 7. In this case we show the lightweight relay situation analogous to Figure 5, but any of the other circuits can also be adapted to this application by replacing the inverter output with the collector of the phototransistor output of the opto-isolator (both require pull-up loads, after all).

Another reason for using an opto-isolator is interfacing the 110Vac line. We can use the opto-isolator to drive a relay (as in Figure 7) or an SCR (Figure 8A). In the example of Figure 8A, the transistor in the opto-isolator controls the gate current of the SCR. At one

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time, the phototransistor form of opto-isolator was the only type available. Today, however, we have other forms to select from. Figure 8B shows an opto-isolator that uses a triac as the output device. Inherent in this type of device is a phototransistor or photodiode built into the triac gate structure.

### Custom input sensors

It is sometimes desirable to build either a custom keyboard or special input sensors to get the computer's attention. Figure 9 shows some of these sensors connected to a common input port (for the sake of illustration—rarely would so many different kinds be attached to the same port). Attached to bits 1 and 3 are a pair of SPST switches. When its switch is open, each input bit is pulled HIGH by a 3.3k $\Omega$  pull-up resistor. Although the bit might be "naturally HIGH," use of a pull-up resistor ensures that noise doesn't accidentally make it appear temporarily LOW. When the switch is closed, the bit drops LOW. A program must be written to scan these bits and test for HIGH/LOW condition. When the LOW is found, the program then reacts according to the programmed action desired.

Attached to bit 7 is an opto-isolator. This type of input device is used where the external circuitry is either incompatible with the computer or dangerous to the computer's continued health. An example of incompatibility might be circuits where V+ is enough greater than +5Vdc to be potentially damaging to the IC. Another example might be a noisy signal source. I once owned a model 33 teletype machine that threw spikes from its internal solenoids onto the power supply line, and so could not be directly interfaced to my old Digital Group computer without causing programs to bomb out. An example of unhealthy applications include high-voltage circuits or circuits using a different ground plane (often because of high voltage being present). Although a switch was shown in Figure 9, the control of the LED could be achieved with other forms of circuit as required.

We could also replace the opto-isolator with a similar device as shown in the inset. The interrupter is an opto-isolator in which a slot is cut to permit an external blinder vane to interrupt the

path between the LED and the phototransistor. Your computer printer uses a device similar to this one as a paper-out sensor. The paper passes through the slot, blinding the phototransistor. When the paper runs out, the phototransistor is no longer blinded and sounds the alarm to the outside world.

Another application for this type of interrupter is in home burglar alarms. The interrupter could be placed on a window or door jaw, while the blinding vane is on the window or door itself. As long as the window or door remains closed, the phototransistor is blinded. But if someone breaks in, the vane blinds the phototransistor and trips the alarm. At least one commercial computerized alarm system allows the operator to follow the progress of the bad guy through a premises by charting which doors are opened and closed. This neat trick is accomplished by each interrupter sensor being connected to a different input port bit, with the computer suitably programmed to find it.

One final sensor is the simple phototransistor shown at bit 8. A friend of mine is a mechanical engineer who oversees large, industrial-style furnaces and boilers that heat large apartment and office buildings. He designed and built an integrated boiler controller. All large boiler furnaces have either a photocell or thermocouple to let the control operator know when the flame is turned on. By using the infrared form of phototransistor looking in each furnace window, he was able to monitor the existence or non-existence of flame (the purpose is to shut off the fuel oil if the flame snuffs out). Not all applications for this sensor need be so exotic, however. You could install a computer home controller system, one function of which is to raise the national flag in the morning when the sun comes up. A phototransistor could be the sun-detector.

Over the past months, we have examined a number of different methods for interfacing digital computers with the outside world. We looked at analog-to-digital converters (A/D), digital-to-analog converters, and other "non-analog" devices in the outside world. The details of how to make the input and output bits used to control these circuits can be deduced from your computer instruction manuals.

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# Books/Photofact

**Understanding & Repairing CB Radios—For the Professional Technician**, by Lou Franklin; C.B. City International; 365 pages; \$29.95, paperback (add \$2.50 for shipping).

This reference is designed to aid the professional technician or serious radio hobbyist in solving any type of CB radio problem. The book discusses technical specifications and measuring equipment and describes basic electronic troubleshooting techniques as they relate to CB radios. Virtually every type of circuit found in CB radios is analyzed, and a separate chapter discusses antenna problems and installation.

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**Handbook of Radio Communications Servicing and Maintenance**, by Harry L. Helms; Prentice Hall;

128 pages; \$28, hardbound.

This book outlines the basic operating theory and principles of 2-way radio systems. The basic tests and measurement procedures required by the FCC are described, along with the necessary equipment. The book also covers diagnostic and troubleshooting strategies and advanced technologies that are likely to be implemented in the future.

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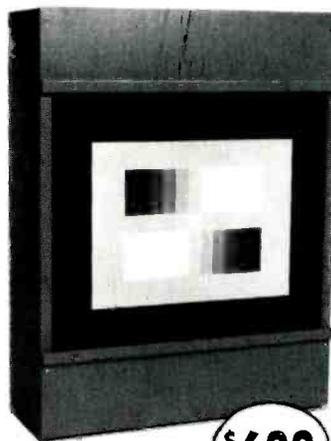
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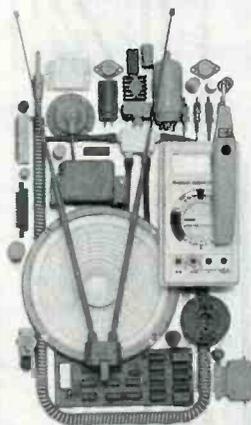
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**Audio Corner**

**Servicing the  
compact disc player  
—Part III**

By Martin Clifford

Being able to list the symptoms of a compact disc fault does not mean there is just a single solution, but it does narrow the search, usually to a number of possibilities. Servicing, then, is really a matter of selection and elimination. Here are some common trouble symptoms and their possible causes. When you run across a CD problem, try these simple fixes before considering more drastic measures.

**Disc is in tray, but there is no sound**

If the front-panel indicators are lit, you know the CD player is receiving line power. Check to make sure the disc is inserted with the label side up, then connect a pair of headphones. If you hear sound, the fault is probably not in the player, but it may be in the connecting cables to the sound system or in the system itself. Try another sound-source input to that system, such as a phono record. If there still is no sound, the fault is in the system. If there is sound, the problem lies in the connecting cables between the player and the system. Also, make sure the CD player's output level control is not set to its fully counterclockwise position. Rotate this control to determine if this produces sound output.

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

Make sure the sound-source control on the high-fidelity system is set for CD playback. Check the volume control on the pre-amp or power amp of the sound system to make sure it is not set fully counterclockwise.

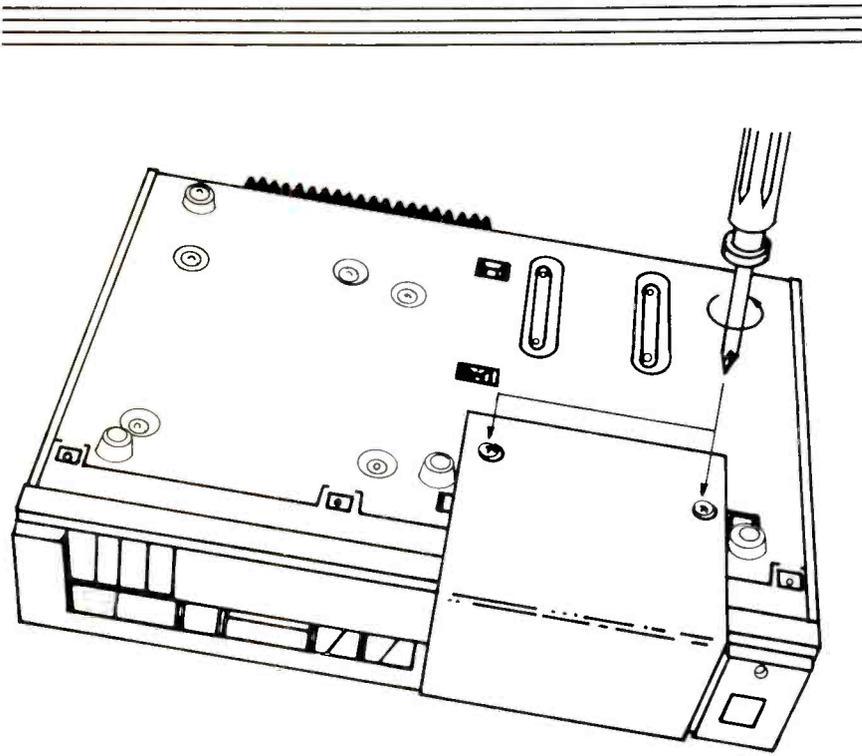
Try transferring the connecting leads between the CD player and the AUX or CD terminals on the high-fidelity system to a different sound-source input such as phono. If this produces sound output, the fault is somewhere between the AUX terminals and the amplifier input circuitry.

**Disk drawer problems**

If a foreign object gets caught in the disk drawer, press the OPEN/CLOSE control to reopen the door. Never try to force the drawer to open or close, and never use a tool such as a screwdriver to try to open or close the drawer.

The drawer is not a storage area and is designed for CDs only. Don't try to put more than one disc into the drawer. When you have finished playing a disc, don't leave it in the drawer. Remove it and put it back in its jewel box or any other storage device designed specifically for holding CDs. You should be able to put the disc in the drawer easily and smoothly. If you can't do this, examine the drawer to make sure someone has not inadvertently put something else in it.

When the CD player is not in use, the



disc drawer should be kept closed. This will prevent dust from settling in the drawer where it would be transferred to the disc when the disc is inserted.

#### Intermittent sound

In a case such as this, the fault could be in the CD player or the following sound system, but the most likely cause is a dirty or scratched disc. There is also a possibility, although slim, that the disc is warped. Try playing a different disc, preferably one that is known to be good.

Intermittent sound may also be caused by a loose connection in the cabling between the CD player and the sound system. With the CD player operating, move the connecting cable to see if this affects the sound.

Intermittent sound can also be due to a combination of factors involving both the disc and the CD player. A good quality player will be more tolerant of disc faults and will be able to compensate for them much more efficiently. The problem of intermittents is much more prevalent with low-end CD players.

#### Remote control doesn't work

The most common cause of remote-control failure is a battery problem. When the remote control doesn't work, try operating the CD player manually. The batteries are generally AA types. Be sure to insert them using the correct

polarity. Always replace both batteries at the same time.

#### No response from function buttons

The player normally will not operate if you depress a function button while the display is flashing on and off. Wait until the display turns on and remains on, then try again. Keep in mind that the unit will not go into PLAY mode if more than one function control is pressed at the same time.

#### Unusually long search time

This symptom can be caused by a fault on the disc such as dirt or a scratch. A disc may appear clean, but dirt that is microscopic and, therefore, invisible to the unaided eye can produce this problem. Try using a disc known to be in good working order and also try cleaning the disc when this problem occurs. A long search time with no results may also occur if you put the disc into the drawer wrong side up.

#### Brand new CD player doesn't work

CD players are transported with shipping screws fastened into the unit to protect the optical scanning mechanism from any movement. These screws must be removed from the CD player in order for it to work. (See Figure 1.) The owner should keep these screws because they will be needed if the CD player is ever to be shipped.



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# Common hard-disk problems

More and more inexpensive personal computers are showing up with hard disc drives. Technology has advanced to the point that a manufacturer can offer a 20MB hard-disk drive with controller for just a few hundred dollars. In the last few months, retailers and mail-order companies are advertising computers with 20MB hard disks for prices as low as \$1,000. And because they are highly complex electromechanical devices, they can be expected to fail. With prices like these and significant failure rates, those of you who service personal computers can expect to be called on to service hard-disk drives.

There are a number of technological variations in the method of construction

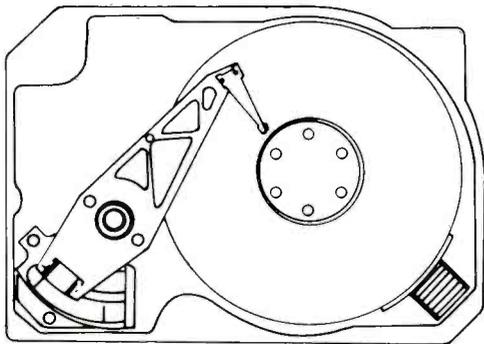


Figure 1. The XT 1000 series hard-disk drive.

and operation of hard-disk drives, but there are also a number of features that are common to all hard-disk drives.

In all hard-disk drives for personal computers, the disk is an aluminum platter coated with a magnetizable material, much like floppy disk construction except that the disk itself is rigid aluminum instead of flexible plastic. Where more capacity is desired, several disks are stacked on a common shaft, each with its own read/write head. All disks rotate together and all heads

move at the same time, although only one head is activated to read or write at one time.

To achieve high reading and writing speeds, the disk must spin at high speed. Furthermore, to achieve the high density of information recorded on a hard disk, the head must travel very close to the magnetic material on the surface of the disk without touching it. The closeness of the head to the disk is achieved by using the air movement created by the rapidly spinning disk to actually "fly" the head above the surface of the disk. The term "head crash" is a literal description of what happens when a piece of dust manages to infiltrate the disk drive and gets into the flight path of the head above the disk, or when a power failure causes the disk to stop turning and the aerodynamics created by the spinning disk no longer keeps the head flying.

Because of the high speeds and close tolerances involved, the hard disk is a sealed unit that is assembled in a clean room. Servicing of a hard-disk system by the technician at the site consists of checking the disk unit and its controller board and perhaps performing some software servicing on the disk, such as reformatting. If the disk drive itself is defective, there's nothing the servicing technician can do other than replace it and send it back to a facility that has a clean room and the proper repair and rework equipment.

### Troubleshooting hard disk problems

One of the best things you can do if you'll be responsible for troubleshooting specific personal computers over a period of time is to keep good records of faults that occur, because it's not uncommon for a disk drive that seems to be repaired to fail again in the same manner later. One IBM XT model 286, for example, had a problem that occurred, then seemed to be fixed, then gradually got worse until it finally quit operating altogether.

The first time the problem occurred, the disk drive spent a lot of time searching for DOS, then after a while it just gave up and exhibited the message

"DISK BOOT FAILURE" on the screen. The computer was brought up by booting DOS on the floppy disk drive. After the hard drive was formatted and the information on it restored from the backup floppy disks, everything seemed to be fine...for a while.

Several weeks later, the same thing happened and the same procedure restored the disk to service for a while. Finally, the hard disk labored one day for a long time, trying to boot DOS, but just gave it up and flashed the message "1790 FIXED DISK FAILURE" on the screen. No amount of rebooting would get anywhere. IBM diagnostics were run but revealed nothing wrong. In desperation, the technician replaced the disk drive and tried to format it. Nothing. The disk drive remained out of service for a week, and the computer was kept operating using the floppy drive.

Later that week, two other hard-disk drives were installed with no improvement in the situation. Finally, with no other alternatives left, the technician replaced the disk controller card. After reformatting the disk again, he placed it into service and the problem hasn't occurred since.

### Other common problems

**Problem:** The system fails to boot up the first time it is turned on but works properly after it is reset.

**Solution:** The drive may have failed to come up to speed fast enough. Often, this is not the fault of the hard disk. The system may be powered by an old, inexpensive clone power supply which may not have enough power available to spin the disk up to proper speed before a time-out fault occurs.

**Problem:** The drive fails when it is first turned on in the morning but works properly after 20 to 30 minutes.

**Solution:** Some drives are temperature-sensitive and operate erratically when the drive has been below room temperature for long periods of time. This is especially true in the case of half-height drives. There is not much a technician can do short of sending the

The problem/solution segments in this installment of Computer Corner are adapted from *MSM* magazine's Tech Tips department, September 1988, contributed by N.S. Khalsa, Computer Clinic.

offending drive back for rework. Try another drive or a warmer room.

**Problem:** The hard-disk controller had to be replaced. Now intermittent read errors occur.

**Solution:** Differences in PLL frequencies between controller boards may be enough to cause errors reading old data, so whenever a controller board is replaced, the drive should undergo primary formatting with the new controller. If a surface scan of the media shows no problems but the software still reports errors, run CHKDSK on the drive. Perhaps the formatting is all right but some record pointers have been altered.

**Problem:** The drive is only a couple of months old, but it now has a bad sector. The drive is reformatted and the bad sector locked out. The drive now seems all right. Is it?

**Solution:** It is not uncommon that a few

bad sectors will turn up in the first few months of use of a hard drive, in spite of the best efforts of the manufacturer to weed out all marginal ones at the factory. If it happens more than a few times, then perhaps the medium is soft or the heads are damaged. Bad sectors can turn up anywhere, even in the directory, where serious data loss can result. For this and other reasons, backups of all important files should be made.

**Problem:** The drive begins making a loud screeching sound, so it is shut down. Presumably there has been a head crash.

**Solution:** This assumption is probably incorrect. Head crashes on 5-inch drives are just not as spectacular as were crashes on the old big drives. A loud screech is usually caused by a bearing and there will probably be more than enough time to back up the data. Backup should at least be attempted because bearing replacement is most often a job

for a facility with a clean room, which means sending the hard disk off—with the data that's recorded on it.

**Problem:** The drive appears to format properly until it does the last track and does a restore. Then it fails.

**Solution:** Check to see if the head is stepping. Head stepper-motor driver ICs fail frequently, and the drive thinks it is formatting sequential tracks when it is actually sitting in one place the whole time. When it begins to verify track #0 and reads the track ID of the last track, it fails.

**Problem:** The system will not boot from the hard disk, but when a floppy disk is used to boot the system, the hard disk is readable.

**Solution:** Try to restore the boot track by using DOS command SYS C:. If that does not work, back up the hard disk and do a FORMAT /S to restore the boot.



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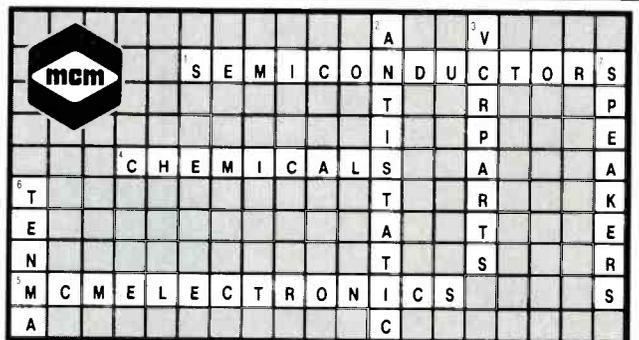


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## Servicing VCR mechanical problems

By Victor Meeldijk

Diagnosis of mechanical faults in a VCR can be almost as elusive and frustrating as electronic problems. The one advantage with mechanical problems is that you have a physical entity that you can see and touch. My experience with a squeaking mechanism in this Fisher VCR is a good example of how step-by-step logical analysis can help you isolate the cause of a mechanical problem.

### The VCR squeak

A few weeks after I replaced the clutch tire in a Fisher model FVH-839 VCR, the unit started to make squeak-

ing and squealing noises in play and record modes. The first thing I suspected was possible slippage from the new clutch tires, caused by some type of run-in phenomenon. I decided to ignore it. A little reflection made me conclude that this analysis couldn't be correct because the clutch tires are only used in this model for fast-forward and fast-rewind operations. In the play and record modes, a gear in the idler assembly directly drives the reel assembly.

The next thing I suspected was slipping belts, the cause of many strange squeaks and squeals in audiocassette recorders. In this case, I suspected the drive belt (Fisher part number 143-2-7504-00400) because it turns the

idler gear. Removal of this belt, however, also stops the reel take-up assembly and, although the noises stop, you cannot isolate the exact cause of the problem. (CAUTION—If this belt is removed and a tape is put into play and then stop mode, the reels will not turn to retract the tape back into the cassette cartridge. Tape damage will result!)

To try to isolate the problem, I turned both reels a little by hand and heard squeaking from the take-up reel. The squeaking made me suspect that the reel shaft needed lubrication. After lubrication, turning of the reel shaft still produced squeaks.

My next step was to carefully examine reel operation in play and stop modes. I noted that the sub-brake take-up

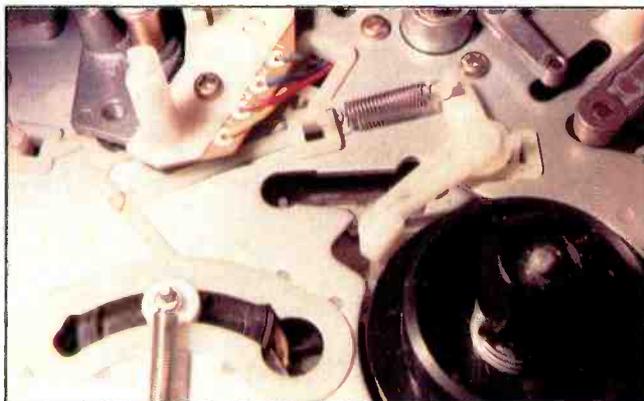


Figure 1. The take-up reel and sub-brake assemblies.



Figure 2. A close-up of the sub-brake T in stop mode.

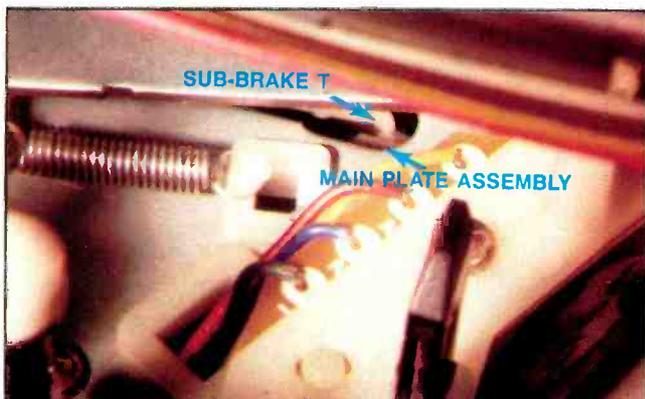


Figure 3. The curved arm of the sub-brake T in the middle of the tape-loading operation. Extra pressure is applied by the T during tape loading.

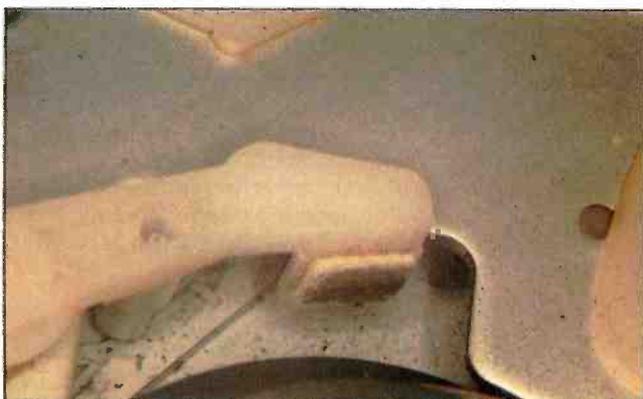


Figure 4. Dirt on the sub-brake T pressure pad.

Table 1

VCR brake conditions vs. operating modes

Brake Mode	Main brake S	Main brake T	Sub-brake S	Sub-brake T	
				PR	SR
Stop	on	on	on	on	off
Loading	off	off	on-off	on-off	on-off
Unloading	off	off	off-on	on-off	on-off
FF	off	off	on	on	off
Rewind	off	off	on	on	off
Play	off	off	off	on	off
Cue	off	off	off	on	off
Review	off	off	on	on	off
PB pause	off	off	off	on	off
Record	off	off	off	on	off
Rec. pause	off	off	on	on	on
Eject	on-off	on-off	on	on	off

PR = Primary pressure of 30gm/cm

SR = Secondary pressure of 60gm/cm

manual (individual mode condition), a summary of which is in Table 1, the sub-brake T always exerts a primary pressure on the reel of 30gm/cm with a higher secondary pressure of 60gm/cm sometimes applied. Only the main brakes are on or off in the various modes.

Figure 2 shows the sub-brake assembly in the stop mode. Notice the curved arm coming off the body of the brake. Figure 3 shows the same arm in the middle of a tape-loading operation. Notice how the main plate assembly (part number 143-0-5104-01600 or 01601) is now pressing against the curved arm, which in turn results in increased secondary brake pressure.

Careful examination of the sub-brake showed that the pressure pad was dirty, causing the squeaking noises as it pressed against the take-up reel. (See Figure 4.) Cleaning the pad helped for a while, but the noises reappeared after a few weeks, indicating that pad wear is also part of the problem and the sub-brake T should be replaced.



assembly (part number 143-0-5204-00500 or 01200) always presses against the reel. (See Figure 1.) Removing the sub-brake spring (part number 143-2-6604-04300) stopped the noises. The cause of the squeak was now obvious: It had something to do with the

brake pressing on the take-up reel.

I consulted the Fisher technical manual to determine if constant engagement of this sub-brake was normal or if the brake should release in play/record modes.

According to Table 11 in the Fisher



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B&K 1077B TV Analyst, \$150; B&K model 1248 digital IC color generator, \$200; B&K picture-tube checker/rejuvenator, \$150; Diehl Mark V analyzer (still in box), \$200; B&K variable isolation transformer, \$70; NRI VCR servicing course with VHS instruction tape and schematics (books are unmarked), \$75; Sencore Y33 yoke and high-voltage ringer, \$30; Sams Photofax, more than 170 copies between #1200 and #2100, \$60. All test equipment in good working order with test leads and manuals. *Roy Morgan, P.O. Box 830074, San Antonio, TX 78283; 512-654-7321 after 5 p.m. CST.*

Large quantity Sams, \$18.50/10 (#1200-#1500), tubes, yokes, flys, test equipment, modules. *Henry, P.O. Box 637, W. Haverstraw, NY 10993; 201-248-1176 or 914-942-2173.*

Sencore VA62 universal video analyzer, VC63 VCT tester accessory, NT64 pattern generator, EX 231 expander jack, complete with manuals and cables, \$3,000. *Craig Schwan, 20432 Hollywood, Harper Woods, MI 48225; 313-772-8345.*

Tandy Color Computer III with disk drive plus seven game cartridges and five game disks, including Flight Simulator II, all for \$225. *George Saylor, 2319 Parrish St., Philadelphia, PA 19130.*

Former TV repair business has for sale 78 Sams manuals, Sencore test equipment, TV parts in original boxes, nearly new used TV parts, a lighted advertising sign (can change front for your business). Send SASE for prices. *Ronald Bryant, Jr., Wadsworth Ave., Waverly, OH 45690; 614-289-2565 or 614-289-2710.*

Beckman Industrial SCOPEMATE 2 IC and component tester, like new, \$300. *Arthur Arnold, Jr., 1745 Kenbrook Rd., Lebanon, PA 17042; 717-272-1080, 4-9 p.m. EST.*

Heath sweep generator kit, still in box, \$100; Eico scope #482, \$100; B&K #1248 color bar generator, \$100; Eico signal tracer, \$65; B&K E2000 RF generator, \$150; B&K #415 sweep marker generator, \$100; Global Logic Monitor, \$35; B&K #667 tube tester, \$95; Eico battery eliminator and charger, \$90. *Orland Lynd, 2300 Harvard Way #124F, Reno, NV 89502; 702-825-6157.*

Heathkit audio VTVM, \$20; Heathkit capacitance meter, \$20; Bell & Howell model 34 scope, \$35 (CRT OK); Hickok model 600A tube tester, \$25; Heathkit model TS-4A TV alignment generator, \$50. Manuals with all but VTVM and cap. meter. *Home Electronics, 69 Main St., Greenwich, NY 12834; 518-692-9336.*

Sencore test equipment: VC63 VCR test accessory; NT64 NTSC pattern generator; VA62 video analyzer. Excellent condition, includes all manuals, probes and accessories. Asking \$3,100. *Ronald E. Bryant Jr., 134 Wadsworth, Waverly, OH 45690; 614-289-2565 or 614-289-2710.*

ETD Telefax Publication: 1623 to 1770, total publications 117, color test jig with Telematic adaptors: YA-12, 15, 49—CD:51, 53, 63, 67—SY:887; tubes: 5-14A7, 1-250, 2-807, 9-25Z5, 1-25Z6, 3-117L7, 1-117N7, 3-117Z6. Make offer. **WM J. Maida, 274 Sable Palm Place, Longwood, FL 32779; 407-869-6138.**

Sams TV Photofacts from beginning to 1984 in 12 metal boxes; factory schematics—Zenith, RCA, GE Sylvania, Sanyo & Hitachi; approx. 2,500 new tubes; assortment of transistors; Zenith, RCA, GE modules; assortment of yokes, flybacks, transformers. All for \$4,000. **Lad Kalinics, 485 N. Main St., Toledo, OR 97391; 503-336-3280.**

255 Sams photofacts, #700 through #1089, \$1 each or \$100 for all, plus shipping. **Ray's TV, 4821 E. View Drive, New Orleans, LA 70126; 504-246-6205.**

Sencore SC61, in original carton, \$2,200; Sencore LC53/FC221, \$400; Sencore NT64 pattern generator, \$200; Diehl Mark V analyst, \$350. All in mint condition. Add shipping. **Tom Condon, 321 Moreland St., Staten Island, NY 10306; 718-351-5765.**

B&K 415 sweep/marker generator, like new, with manual and all cables, used only twice, \$125. **Videotronics, 343 Hickman St., Bridgeville, PA 15017; 412-221-8013.**

Magnavox modules: T989, T991, T995, T809, T815; some Zenith modules; assortment of small tubes. **Curry Electronics, 422 N. Fifth St., Marshall, MN 56258; 507-532-6473.**

B&K 1431 3-inch solid-state triggered sweep oscilloscope with manual, no high voltage, CRT OK, \$20. **George John Demaris, 7387 Pershing Ave., Orlando, FL 32822-5743; 407-277-3746.**

UST-5000, \$120; UST-705, \$80; UST-T50, \$25; Chaparral PR-1A/S, \$30; CM 6129, \$25; CM6228, \$25. Shipping extra. **Fremont TV & Electronics, 407 E. Main St., Fremont, WI 54940; 414-446-2239.**

Macintosh Laboratories MC2300 solid-state audio power amplifier, 2-channel, 300W/channel, weighs 128 pounds; 1983 Leasametric equipment. Best offer over \$850 plus shipping. **Bob Shafer, 8119 S. Sandy Hook Terrace, Clinton, WA 98236; 206-321-5178.**

VA-48 TV video analyzer, perfect condition, \$600; Sencore model T.F. 40 Cricket transistor checker, \$75. Like new. **Angelo Alessi, 29 Cross St., New Windsor, NY 12550; 914-562-9152.**

Simpson Electric model 467 DMM, measures up to 1,000Vdc, 750Vac, 2A ac-dc, 20M, includes leads and battery, \$100; HP model 130C scope, 500kHz bandpass, \$195; Tektronix model RM504

scope, 450kHz bandpass, \$165. COD or add \$10 for insured UPS shipping. **Fred Jones, 407 Morn- ingbird Court, Niceville, FL 32578; 904-678-1803.**

Sencore SGI65 AM/FM stereo analyzer with all documents, like new and still in original shipping carton, cables, etc. are original, \$700 firm. **Wayne Virkler, 29 Bouldercrest Lane, Vernon, CT 06066; 203-875-9639 evenings and weekends.**

Seven 1-hour videotapes for Sony AV8600, etc. (my AV8600 is damaged beyond repair)—best offer gets them. **John Augustine, 530 N. Ninth St., Reading, PA 19604; 215-372-5438.**

Sams (#2082 to #2228), never opened, \$5; B&K 415 sweep/marker generator, \$125; tube testers and other equipment. **R. Walthers, 5921 Velma Ave., Las Vegas, NV 89108; 702-646-4045.**

Sams P.F. #1 to #2,000, \$2 each plus shipping. Also have more than 8,000 new radio and TV tubes, many obsolete. Send list of what you can use, we will buy or swap for VCR service manuals. **Neil's Electronics & Discount, Rte. 1, Seabrook NH 03874.**

Heath IO-4560 5MHz scope, \$60; EICO model 232 VTVM, \$30; older NTS electronic course with digital trainer, \$20. **Kenneth Morvant, 5415 White's Ferry Road #68, W. Monroe, LA 71291; 318-396-8346.**

**ES&T**

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**CB RADIO REPAIRS/MODIFICATIONS:** Books, plans, kits, high-performance accessories since 1976. Catalog \$2. CBCI, Box 31500E, Phoenix, AZ 85046. 10-88-4t

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**MATTER CONVERTER?** Would you like to build one? For more information send \$10.00 & SASE to Donald M. Scott, Dept. 1, P.O. Dwr. 1180, Verona, MS 38879. 12-88-1t

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**TV/VCR TUFF TIPS** listed by mfg. & model. Over 400 tips. \$21.95. TV Tips only \$11.95, VCR Tips only \$13.95. **VCR CROSS-REFERENCE** listing for electronically similar manufacturers, RCA, GE, Sylvania, Panasonic, Quasar, Magnavox, Philco, & J.C. Penney, \$19.95. **TV/VCR FAILURE HISTORIES.** Multiple cures for most problem areas. Send \$7.95 with mfg. and model number. Money will be refunded with free sample if model is not on database. Add \$1.50 postage and handling. **TECH CURES, 4825 Fredericksburg Road, San Antonio, Texas 78229. 12-88-TFN**

**VCR PLUS CAMCORCER TECH TIPS**—large bonus issue, complete all brands. Send \$9.95 to KEN GARRISON, P.O. BOX 567, Bradenton, FL 34206 for prompt delivery. 12-88-1t

**REDUCED 75%**, Diehl Mark V scanner \$249, Diehl Mark III scanner \$99. New. 2805 University Ave., Madison, Wis. 53705, 608-233-9741, 608-238-4629. 12-88-1t

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**SONY BROADCAST & INSTRUCTION MANUALS.** Series BVW, DVR, DXC, VO, VP, BVH, etc. \$25.00 each. Florida Electronics, (305) 741-0997. 12-88-1t

**TEXTRONIX** Wave Form Monitor Type 528, \$1,000 ONO, TEXTRONIX 1420 NTSC Vectorscope \$1,700 ONO. Florida Electronics, (305) 741-0997. 12-88-1t

**TV TROUBLESHOOTING:** 200 problems/solutions. Nothing old listed. \$12.00. Jones, Box 702, Niceville, Florida 32578. 12-88-3t

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