The how-to magazine of electronics...

AN INTERTEC PUBLICATION

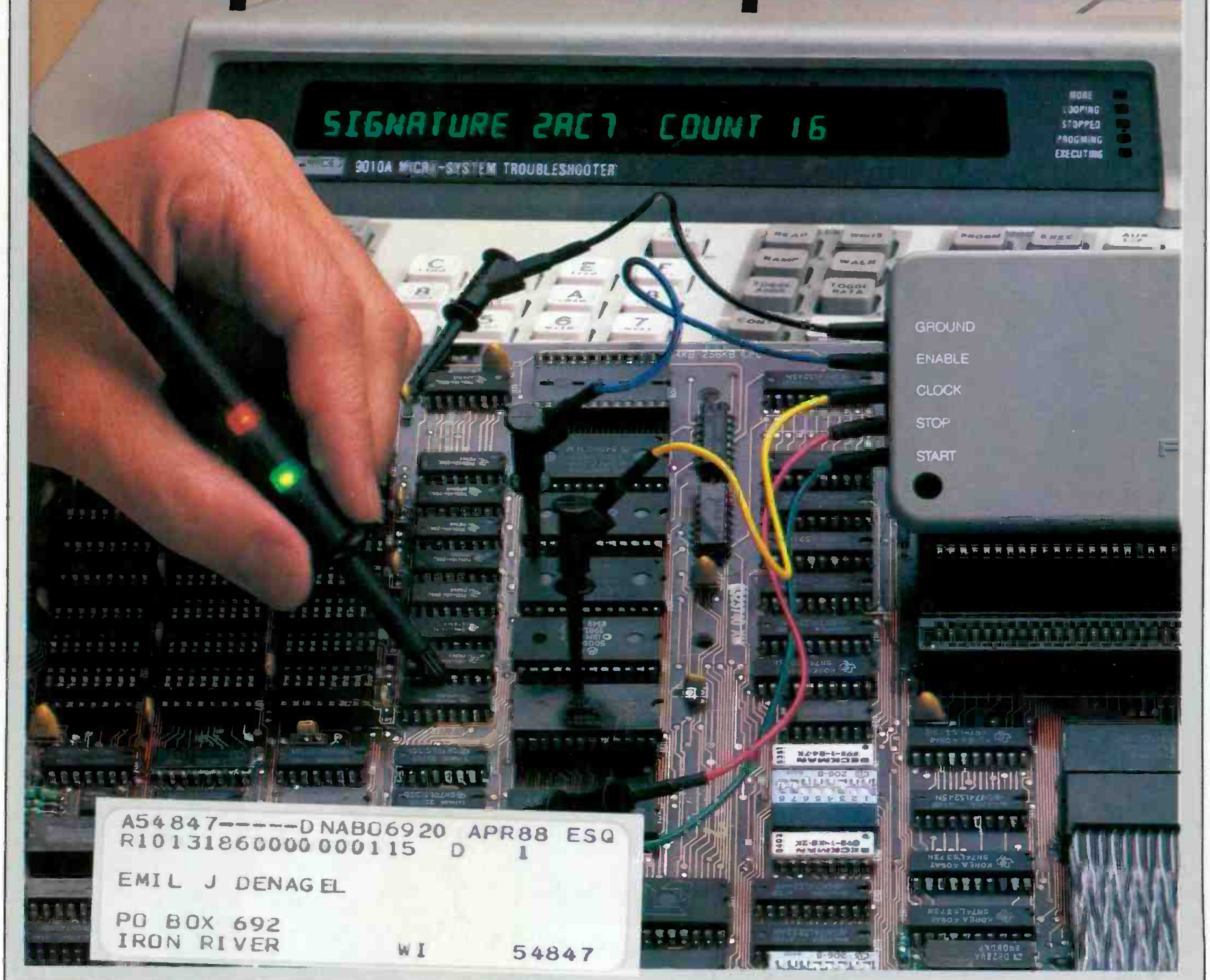
ELECTRONIC Servicing & Technology

JULY 1987/$2.25

Troubleshooting low voltage regulator circuits

Solid-state rectifiers • Electronic steering

Test equipment for personal computers



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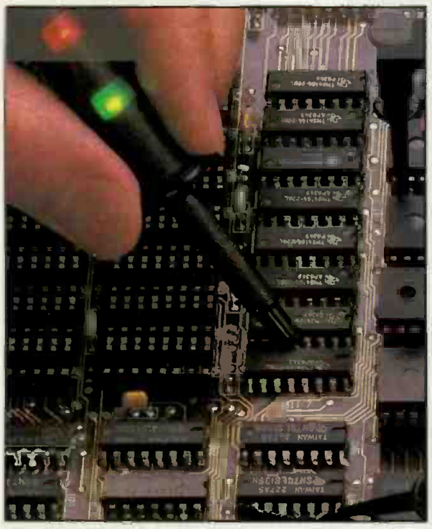
Volume 7, No. 7 July 1987



Page 12
Because software influences computer operation, computer circuitry tests can be misleading.

Page 10
Miniaturized lasers can bring laser technology to areas that previously were inaccessible.

Departments:

Aug. 10–15 NPEC '87

Register now for technical seminars (and good fun, too)

An array of technical seminars is being lined up for the 1987 National Professional Electronics Convention that will be held August 10-15 in Memphis, TN.

The highlight of the educational lineup will be a 6-day, 40-hour, hands-on, basic VCR school. Normally presented only to instructors by the Electronic Industries Association's Consumer Electronics Group, this year's school will also be open to interested technicians. (However, student numbers will be limited for the hands-on session and it will be open only to those who commit to take the entire 40-hour course.)

On Saturday, Sharp Electronics and Toshiba America will split the day with two courses for more advanced technicians. Sharp will conduct an advanced VCR servicing school, while Toshiba instructs in servicing digital VCRs. On Tuesday, Hitachi will conduct a full-day session on Servicing Video Camcorders.

Other seminars that have been scheduled (although dates and times were not firmly set when this issue was printed) are: (1) Servicing Tough-Dog VCR Servos (Sencore); (2) Logically Servicing a Systems Control Microprocessor (Sencore); and (3) an all-day session on Servicing the New NEC Multispeed Computer.

Two additional seminars have been arranged expressly at the request of instructors. These forums (which are open to all attendees) will deal with (1) Job Placement for Graduating Students and (2) Trade School Curriculum Changes Required by Advancing Technology. Other technical seminars are being considered and may be added to the final agenda. The week-long convention also features golf and tennis outings on Monday, business management seminars on Tuesday, an electronics trade show on Wednesday and all day Thursday, then an opportunity for dealers to meet manufacturing officials on Friday. Special social events are planned throughout the week.

The 1987 NPEC will be held at the famed hotel, The Peabody, near Memphis' Beale Street jazz district. Prices may include numerous sponsored meals, admission to the trade show, golf or tennis outings, all technical or management seminars, and all other activities for the 6-day event. Check with NPEC.

At the door and mail-in rates are $160 for the first registrant from a family or business and $140 for each additional member. The rate for children is $75.

For a list of companies and other organizations that will have booths at the trade show, see the accompanying box.

For more information, write to NPEC '87, 2708 W. Berry St., Ft. Worth, TX 76109, or call 817-921-9061.

Meet these exhibitors at NPEC '87

Borg Warner (Extended warranties)
EIA/CEG
Electronic Servicing & Technology
GC Electronics
GE/RCA
Hitachi
ISCET
Kinyo (Head cleaners)
NAP
NEC
NESDA
Ogment
Panson
Projector/Recorder Belt
PTS
Radio Electronics
Sencore
ServicePlan
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Shield Electronics
Tech Serv
Ted Ferguson Insurance
3M
Video Aid

REGISTRATION FORM

Complete this form, detach and mail to **NPEC '87, 2708 W. Berry St., Ft. Worth, TX 76109; Phone 817-921-9061**

Name ______________________________

Firm name ______________________________

Address ______________________________

City ______________________ State ________

Zip ________ Phone ______________________

Indicate the number of people in your group to participate in each of the following:

Mon. Golf Outing	Mon Tennis Tourney	Mon.-Fri. Instructors Conference	Tues. Mgmt. School	Wed. House Meet.	Thurs. Trade Show	Fri. Mgrs. Session	Sat. Tech. School	Sun. Night Banquet
____	____	____	____	____	____	____	____	____

Member of (check appropriate boxes):
☐NESDA; ☐ISCET; ☐TESDA; ☐Non-Member; ☐Distributor
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☐Press; ☐Sales Rep.; ☐Other ______________

Print legibly the names (including nicknames) of all attendees as the names should appear on the name badges:

Full convention Registration Includes all programmed meal functions and banquet, golf and tennis outings, door prize drawings, trade show, dealer's/manufacturer's sessions and all meetings and workshops.

Send, or pay at door	Full registered (fully paid) adult:	Each add'l. adult from same family or business:	Totals
	$160	**$140**	**$**________
Daily Registration Rate	$40	$40	$________

Special program for children and young adults may include some separate meal and/or social functions.

Young Adults;
Ages 13-19 (List names and ages below). No. at $90 each ________; Amt. $ ________
Children's program;
Ages 5-12 (List names and ages below). No. at $75 each ________; Amt. $ ________

Tot. No. Adults: ______ Tot. No. Children: ______ Check No.: ______ Date: ______ Tot. Amt. $______

Arrival Day ____; Date ____; Time ____

Departure Day ____; Date ____; Time ____

Make check payable to **NESDA**: mail to 2708 W. Berry, Fort Worth, TX 76109
Visa ☐ ; MasterCard ☐ No. ______________________

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Special Room Rates: Single or double, $70. Children under 18 free if using same accommodations.
Room Reservations: Will be handled solely by the hotel but through NESDA. When we receive your convention registration, we will send you a card for making room reservations directly with The Peabody at our special convention rates. But do register early to ensure a room.
To guarantee a room at The Peabody, reservations must be made by July 10, 1987.

Test your electronics knowledge

By Sam Wilson, CET

The questions in this quiz deal mostly with troubleshooting subjects. So, it should be easy for experienced technicians.

1. When a logic 1 is delivered to point A in Figure 1 the output should be at
A.) logic 0.
B.) logic 1.

2. You suspect that the local oscillator is dead in a certain table model AM radio. You tune the radio to a strong station 1.1MHz. Assuming it has an IF frequency of 455kHz, it should play if you inject a pure sine wave frequency of _____kHz into the converter at the oscillator input.

3. You want to determine the impedance of a speaker so you put the circuit of Figure 2 together and adjust R2 for
A.) zero current.
B.) maximum positive deflection.
C.) maximum negative deflection.
D.) 20mA.

4. After you have correctly adjusted R2 in the circuit of Figure 2, you remove it from the circuit and measure its resistance. If the speaker has an impedance of 8Ω the resistance of R2 should be approximately _____Ω.

5. Identify the type of diode illustrated in Figure 3.

6. The cathode of the diode in Figure 3 is connected to lead
A.) x.
B.) y.

7. A milliammeter is connected across the *on-off* switch of a small AM radio. (See Figure 4.) This radio has an RF section. It also has two IF sections. The audio power section has push-pull amplifiers. In addition to checking the *on-off* switch, the milliammeter in this test setup can be used to check the
A.) IF stages.
B.) RF stages.
C.) audio power section.
D.) the local oscillator.

8. An emitter-base short of the transistor in Figure 5 is shown with a broken line. The collector voltage should be
A.) 12V.
B.) 0V.

9. The amplifier in Figure 5 is connected in a
A.) common emitter configuration.
B.) common base configuration.
C.) common collector configuration.

10. If the resistor marked R in the circuit of Figure 5 is open, the transistor will be
A.) saturated.
B.) cut off.

Answers are on page 63.

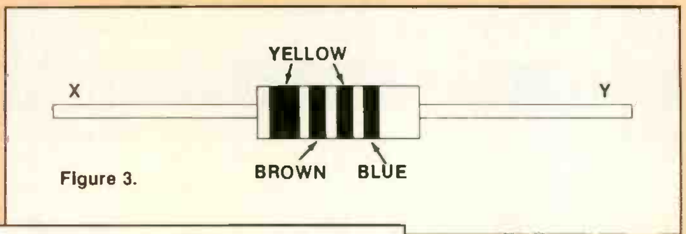

Figure 3.

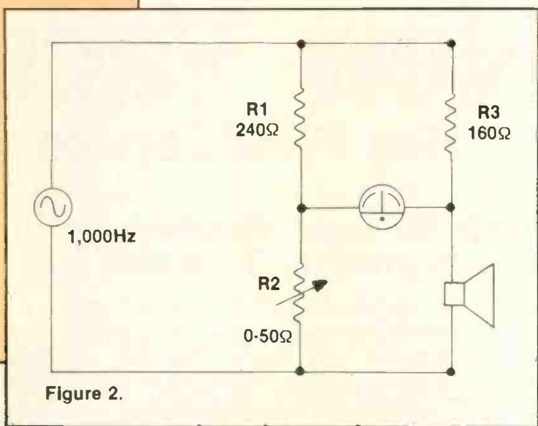

Figure 2.

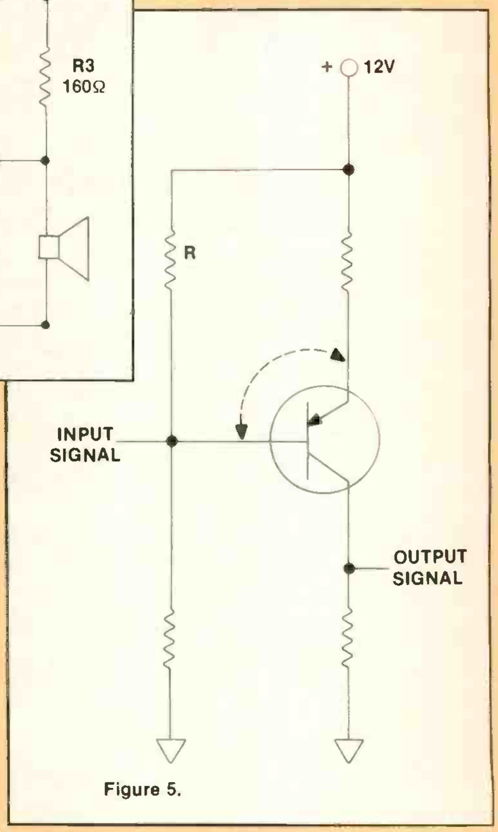

Figure 5.

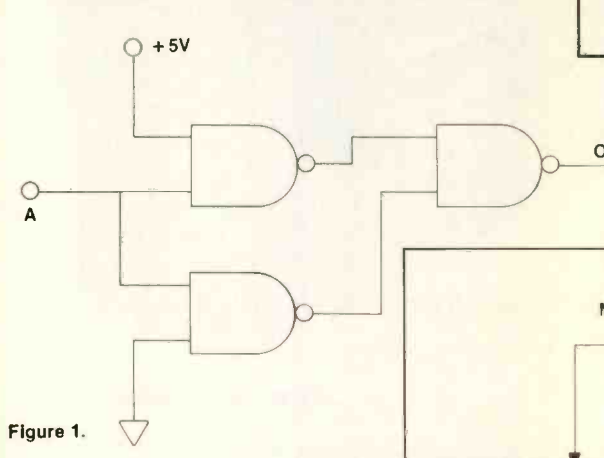

Figure 1.

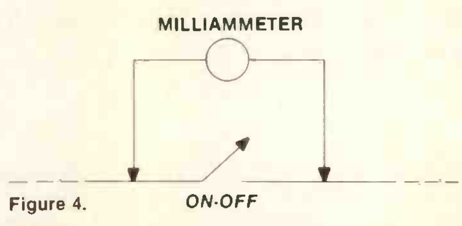

Figure 4.

No film? No processing? Instant playback?

This is a CAMERA??

The untraditional Casio VS-101 electronic camera records and stores images on standard video floppies, playing them back instantly through any standard television. The camera-TV connection is simple and direct. Printouts are possible with the optional color video printer (VP-10).

The action is fast and furious? This still camera incorporates a high-resolution auto-exposure system with shutter speeds up to 1/1000s to freeze the fastest movements into a sharp, clear image available for instant replay or later reference.

Up to 50 frames for recording/playback can be stored on a single video magnetic floppy disk. A built-in erase function allows multiple reuse of each disk.

Introduced at the Summer Consumer Electronics Show, Chicago, in June, the VS-101 will be available to consumers after Dec. 1, 1987.

Editorial

So you're not interested in computers

Want a good reason to learn about servicing personal computers? How's this? According to the 1987 edition of the "Consumer Electronics Annual Review" published by the Consumer Electronics Group of the Electronics Industry Association, "...many manufacturers feel that by the year 2000 consumers will be spending more for home information processing and communications equipment than they will for purely entertainment products.

"Functions normally associated with a business office are performed in nearly every home. Income and expenses have to be kept track of, appointments to be made and messages to be taken and delivered. There's correspondence to be handled, and where there are students in the house, reports to be researched and written. For many years businesses have turned to electronics for products that simplify and improve information handling. Now similar, though much more affordable, and often less complex products that bring office-like efficiencies to the home are being made and marketed by consumer electronics manufacturers.

"Almost 3.8 million personal computers were sold for home use last year and, with software and accessories, represented a $3.8 billion business. Today a personal computer housed in a typewriter-like console, and with brain power equal to that of the room-sized multimillion dollar computers of the 1960s, can be purchased for less than $300, though prices run up to $2,000 depending on the functional capabilities, memory power and accessories included.

"The term 'computer literate' has become more than a catch phrase to describe those in the know. It's now a requirement for graduation from many high schools and colleges, and some colleges include the cost of a computer for each student in their tuition. 'Keyboarding,' or how to interact with a computer, is being taught at the elementary grade level.

"In the home, computers are used for financial and family function planning, record keeping, educational enrichment, training and word processing. Connected to the telephone lines through a built-in or add-on device known as a modem, computers provide access to outside data banks containing a vast variety of research information, along with business, professional and transportation directories, games and message centers that serve as electronic bulletin boards for computer owners with similar interests. Modems also let computers be used for home shopping, banking and travel reservation services that are now becoming available."

If you have made the decision not even to consider servicing personal computers that are used in the home without at least considering what's involved in learning about them and getting geared up to service them, you may be taking a chance on letting the consumer electronics revolution pass you right by.

Nils Conrad Persson

1987 Source Code and Data Code booklet

If you've ever puzzled over the manufacturer or vendor source of any electronics product, this booklet is for you. The Engineering Department of the Electronic Industries Association publishes its "Source Code and Data Code" booklet annually.

Alphabetic and numeric symbols are assigned and registered by the EIA's Engineering Department. This service, which is free to EIA members, is available to all manufacturers of electronic equipment and components for an annual registration fee of $30.

The EIA code provides for adding numerals to the source code symbol to identify the year and week of production. Altogether, coded electronic products may be identified as to production sources, or as to the vendor assuming product responsibility, as well as to the time period in which they were manufactured. The Source Code and Data Code booklet contains an alphabetical and numerical listing of those code numbers that are stamped or marked on all electronic products.

Copies of this booklet are available for $1 each from the EIA Engineering Department, EIA, 2001 Eye St. NW, Washington, DC 20006.

Diehl files bankruptcy

The United States Bankruptcy Court, Northern District of Texas, has announced the filing of a petition for Relief under Chapter 7 of Title 11, U.S. Code, on February 13, 1987, by Vince E. Diehl (525-80-3413) and Judy A. Diehl (194-36-3580) doing business as Diehl Enterprises; Diehl Industries; Diehl Engineering; Diehl Publications, 6004 Estacado Lane, Randall County, Amarillo, Texas 79109.

The Case Number is 287-20088-7, dated April 29, 1987.

The announcement bears this statement: "Creditors: File your claims *NOW*. Claims not filed by claims bar date generally are not allowed. BAR DATE is August 19, 1987."

Three items are brought out in the announcement.

Item No. 1 – Section 341(a) Meeting Date: May 21, 1987, at 3:45 p.m. in Room 112, U.S. Courthouse, 205 E. 5th, Amarillo, TX 79101.

Item No. 2 – Filing deadline for Section 523(c)/Section 727 Complaints: July 21, 1987.

Item No. 3 – Section 524(d) Discharge Hearing: August 17, 1987 at 1:30 p.m. in Room 314, U.S. Courthouse, 205 E. 5th, Amarillo, TX 79101.

There's still time for free summer workshops

VCR and digital/microprocessor 1-, 2- and 5-day workshops have been organized by the Consumer Electronics Group of the Electronic Industries Association (EIA) in the listed cities and on the

The how-to magazine of electronics

ELECTRONIC *Servicing & Technology*

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

SUBSCRIPTION PRICES: one year $18, two years $30, three years $38 in the USA and its possessions. Foreign countries: one year $22, two years $34, three years $44. Single copy price $2.25; back copies $3.00. Adjustment necessitated by subscription termination to single copy rate. Allow 6 to 8 weeks delivery for change of address. Allow 6 to 8 weeks for new subscriptions.

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INTERTEC PUBLISHING CORPORATION

indicated dates. For specific sites and local contacts, call the national headquarters of co-sponsoring service organizations: NESDA/ISCET in Ft. Worth, 817-921-9061 or 9101 (for Philadelphia and Chicago courses call NARDA/NASD, Chicago, 312-953-8950).

Some subjects in VCR course

- Electrostatic sensitivity
- Isolation transformer
- Dismantling of VCR
- Cleaning tape heads, paths, belts
- VHS, Beta systems
- Theory of recording
- High, low frequency problems
- Types of power supply
- Record, playback paths
- Switching (EE/VV modes)
- TV signal selection
- Demodulation

Some excercises from digital workshop

- Power supply
- Light emitting diodes; dip switch and binary counting
- Logic levels; logic probes; logic pulsers; logic gates
- Voltage and binary comparators
- Monostable and astable applications for the 555
- D/A and A/D converters
- Phase lock loop
- Microprocessor and memories

Ohio	VCR	July 6-10
Memphis	VCR	July 13-17
Kansas City, MO	VCR	July 21-25
Macon, GA	VCR	July 27-31
Tacoma, WA	mp	August 21-22
Norfolk, VA	VCR	August 25-29
Boston	VCR	Aug. 31-Sept. 4
Philadelphia	VCR	To be set
Chicago	VCR	To be set

The following workshops are structured specifically for instructors in vocational education, and are co-sponsored by State departments of vocational education.

Nebraska	mp	July 6-10
California	mp	July 6-10
Nevada	mp	July 13-17
Alabama	mp	July 20-24
Michigan	mp	July 27-31
West Virginia	mp	July 27-31
North Dakota	mp	August 10-14
Memphis	VCR	August 10-15

Camcorders up 103% in April '87 vs. April '86

Sales of camcorders, the camera/VCR combinations designed for family moviemaking, zoomed to more than 107,000 units in April of this year, compared with 53,000 sold to the nation's dealers during April 1986. For the first four months of 1987, camcorder sales were 50% ahead of the sales in the same time period, last year.

Color television also is enjoying strong sales: The industry is selling color TV sets this year at the average rate of 48,000 per day. Projection and B&W television sales reflect a reduced demand (10% and 14%, January through April), but sales of VCRs continue to run slightly ahead of 1986, as of the end of April. ES&T

Technology

Miniaturized, more powerful lasers introduced

New microlaser product: Infrared and green-light microlasers in a wide range of powers will be available in this same package which measures 4-inches long by 1¾-inches in diameter.

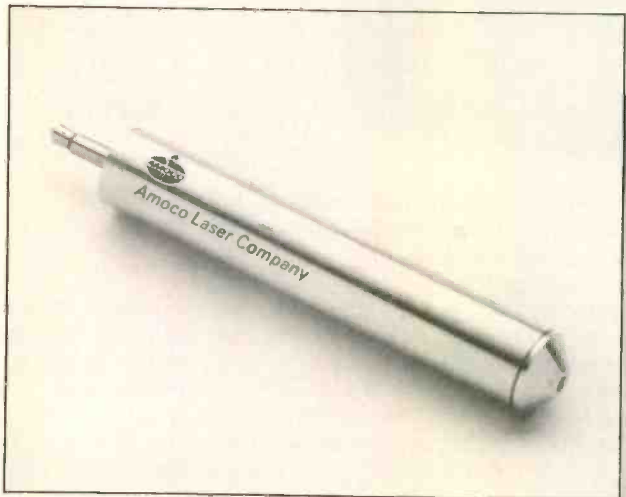
A family of miniaturized laser products developed from revolutionary microlaser technology has been introduced.

"Vastly smaller, more efficient, and superior in performance, microlasers can be mass produced at significantly reduced costs," according to Tom Wolfram, general manager of Amoco Laser Company, the company that developed the technology. "A technological breakthrough, microlasers will not only replace existing gas tube discharge lasers, but also will stimulate new product development in consumer markets."

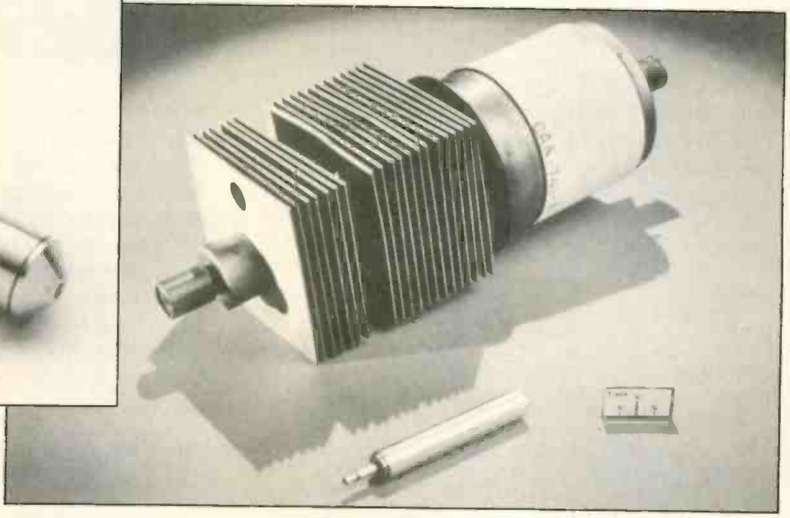
"Capable of improving the quality of high resolution projection television, film scanners and color printers, microlasers also will facilitate new radar scanners for aircraft and automobile collision avoidance systems," Wolfram adds.

These microlasers represent the first uniform technology that can address virtually all laser applications requiring green, blue, red or infrared laser light. Unique hybrids, microlasers combine laser diodes, the size of a grain of salt, to optically pump solid-state laser materials with nonlinear optical crystals to provide frequency modification.

Amoco Laser Company's plans were to introduce its first microlasers in mid-May 1987. The initial products are infrared microlasers operating at wavelengths of



Low cost, high-volume laser products will be available in the near future in this ultra compact module.



The microlaser (pictured bottom right) is expected to rapidly replace current air-cooled ARGON-ION lasers (pictured center).

1,064nm and at 1,320nm in the power range of 25mW to 100mW. A low noise power supply will be introduced with the new infrared and the green-light microlasers.

The second introduction, scheduled for fall, will launch two frequency-doubled, green-light, 525nm microlasers. One version will be at 2mW with a higher power model offered at 5mW CW.

Combining the high efficiency, small size and ruggedness of laser diodes with the excellent beam quality and broad range of wavelengths of solid-state lasers, these new microlasers will have immediate applications in optical instrumentation, telecommunications, optical sensing and scanning, color display and optical memory, according to Wolfram.

Shrinking not only the laser but also the power supply from the size of a refrigerator to a hand-held package, the microlaser requires only 2W of electrical power while equivalent gas discharge-tube lasers consume 2kW of power.

Other operating advantages microlasers have over gas-discharge tube lasers include:

- Efficiency – up to 1,000 times higher
- Size – up to 100 times smaller
- Optical Noise – up to 1,000 times less
- Voltage – 100 to 1,000 times lower
- Service Life – up to 50 times longer
- Power Control and Modulation

Microlasers represent a major advance in laser efficiency, compact size, ruggedness, power and versatility.

Because these devices can be mass produced, product prices are expected to drop by orders of magnitude over the next few years. Amoco foresees a price reduction from the current ten thousand dollar range for comparable products to below one-hundred dollars in the next five to seven years.

This technology is expected to open large new markets in the same way that transistors not only replaced vacuum tubes in existing products, but also ushered in vast new markets for electronic devices.

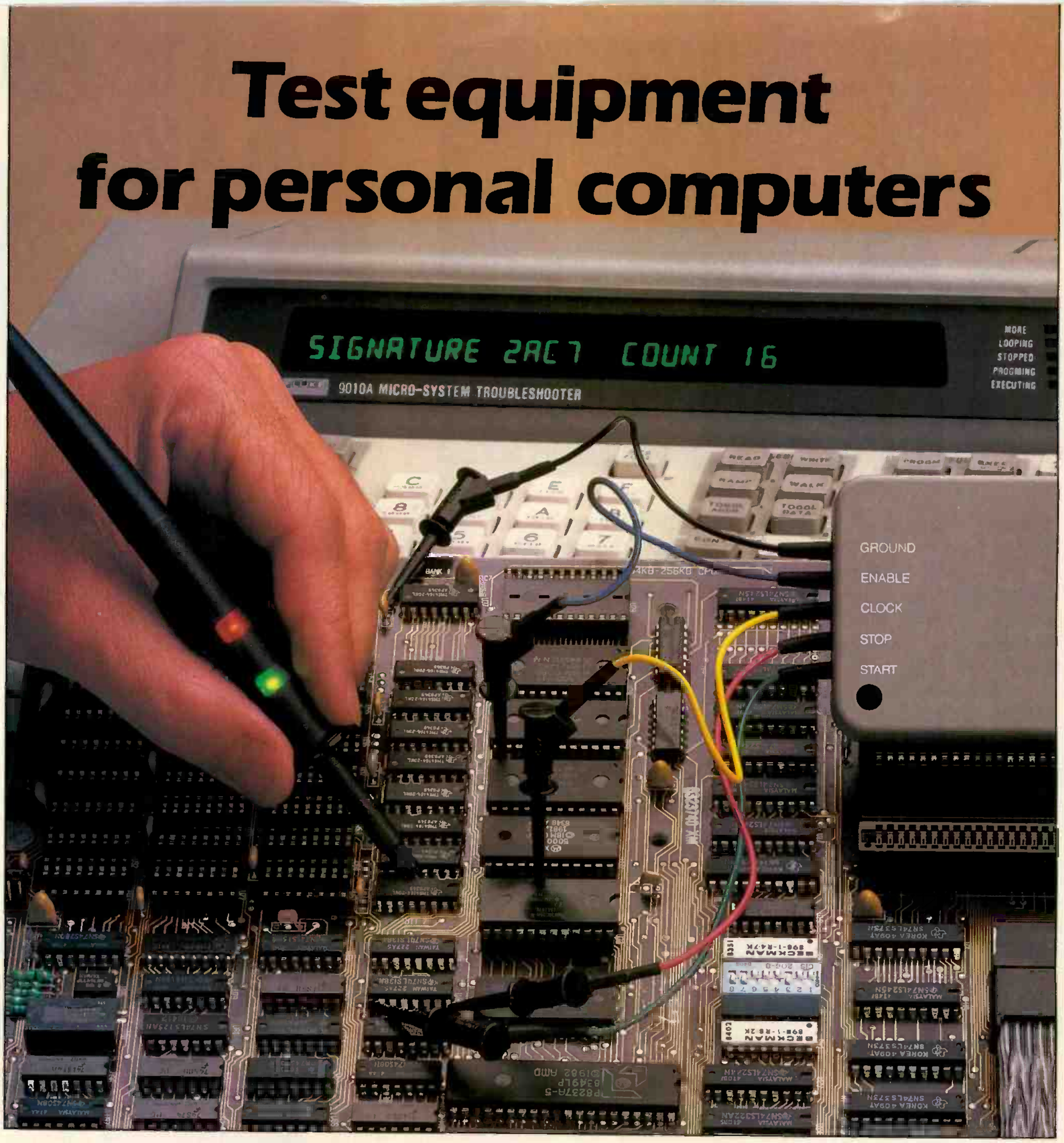
Like the first computers that were the size of rooms evolving into hand-held calculators, the microlaser has been miniaturized to fit easily into consumer products. Because of their low cost, ruggedness and efficiency, microlasers will go places lasers have never gone before, such as into the living room in color projection television. And they will dramatically improve applications in optical instrumentation, telecommunications, optical sensing and scanning, color display, laser printers, optical memory, as well as target designation and range finding.

Microlasers are unique hybrids combining laser diodes to optically pump solid-state laser materials with nonlinear optical crystals to provide the laser with a broad range of colors: infrared, red, green, blue and ultraviolet lasers to serve virtually all markets.

Based on a proprietary design that lends itself to low-cost manufacturing methods, microlasers are designed for high-volume OEM customers, but all customers will benefit from Amoco reduced costs.

ES&T

Test equipment for personal computers



By Conrad Persson

Besides a thorough knowledge of the theory of operation of the unit being serviced, in this case computers, the most important tools to bring to servicing are the right pieces of test equipment. For starters, of course, there are the standard pieces of test equipment that are on the bench of any competent technician: a good DMM and a good wideband oscilloscope.

Specialized test equipment

Unlike most consumer electronics equipment, the operation of a personal computer is determined by the software used to operate it as well as the physical circuitry it's composed of. For that reason, observation of symptoms and drawing of conclusions as to the nature of the problem based on those observations, while a valid approach to the problem, may be misleading. Furthermore, while they can solve some problems, the DMM and oscilloscope have limitations when applied to computers. Specific digital test equipment can isolate problems that analog test equipment wouldn't even be able to touch, and in many cases, can *speed* the diagnosis of even those problems that could have been solved otherwise.

The kinds of digital test equipment

Test equipment for personal computers runs the gamut of sophistication from the simplest nodal testers up through the extremely sophisticated units that can be plugged right into the microprocessor socket to exercise the complete microcomputer system and automatically track down the circuitry where the fault lies.

New GPS Series: Tek sets the pace with SmartCursors™ and push-button ease.

Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	
Price	$2400	$1875

Work faster, smarter, with two new general purpose scopes from Tektronix. The four-channel, 100 MHz 2246 and 2245 set the new, fast pace for measurements at the bench or in the field. They're easy to use and afford, by design.

On top: the 2246 with exclusive integrated push-button measurements. Measurements are accessed through easy, pop-up menus and implemented at the touch of a button. Measure peak volts, peak-to-peak, ± peak, dc volts and gated volts with new hands-off convenience and on-screen readout of values.

SmartCursors™ track voltmeter measurements in the 2246 and visually indicate where ground and trigger levels are located. Or use cursors in the manual mode for immediate, effortless measurement of waveform parameters.

Both scopes build on performance you haven't seen at the bandwidth or prices. Lab grade features include sweep speeds to 2 ns/div. Vertical sensitivity of 2 mV/div at full bandwidth for low-level signal capture. Plus trigger sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.

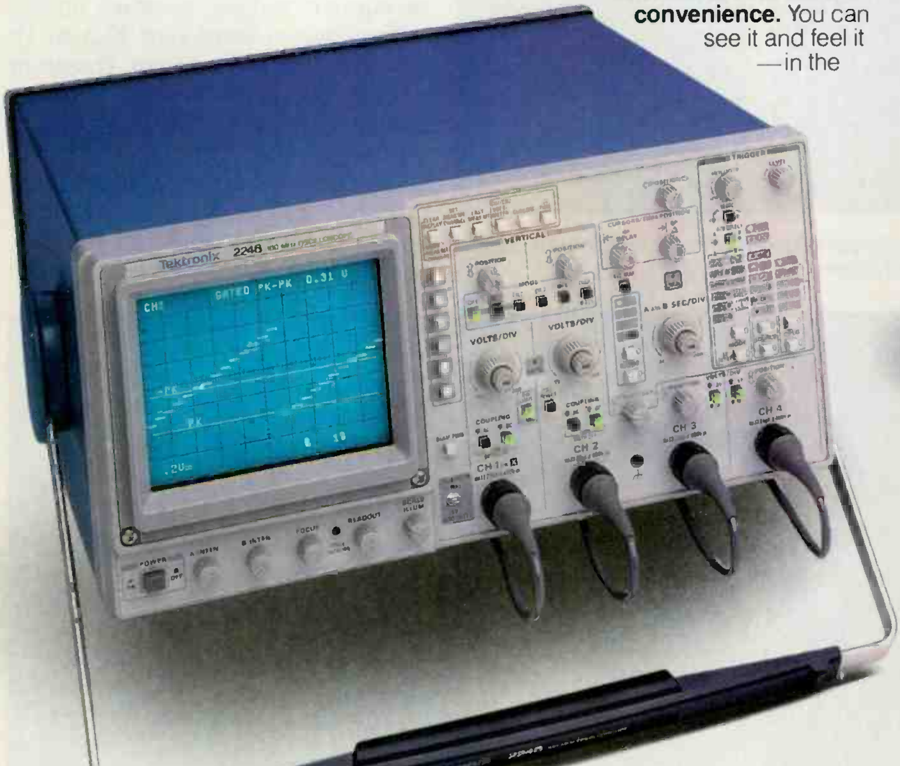
Accuracy is excellent: 2% at vertical, 2% at horizontal. And four-channel capability includes two channels optimized for logic signals.

Best of all, high performance comes with unmatched convenience. You can see it and feel it —in the responsive controls and simple front-panel design, in extensive on-screen scale factor readouts, and in simplified trigger operation that includes Tek's Auto Level mode for automatic triggering on any signal. Start to finish, the GPS Series saves steps and simplifies tasks.

Get out in front! Call toll-free today to order, to get more details or a videotape demonstration.

1-800-433-2323

In Oregon, call collect 1-627-9000



Featuring four channels, flexible triggering, extensive CRT readouts and push-button ease of use, the new Tek 2246 (left) and 2245 (above) bring high-quality, low-cost analysis to diverse applications in digital design, field service and manufacturing.

Tektronix®
COMMITTED TO EXCELLENCE

Circle (33) on Reply Card

The logic probe

As we discussed just last month in the June 1987 issue of ***ES&T*** in an article entitled "IC Tester," if you have the knowledge and skills to trace a problem in a personal computer system to a specific area of the circuitry, you may isolate the problem using a logic probe.

The logic probe indicates the logic state of a point being tested, whether it is at a logic HIGH or LOW. A sophisticated probe will have indicators to show if the test point is HIGH or LOW or exhibiting pulses. Some will even have a memory or pulse stretcher that will show the presence of a one-shot pulse that is of such short duration that either it's insufficient even to light the indicator, or lights it too briefly to be recorded by the human eye.

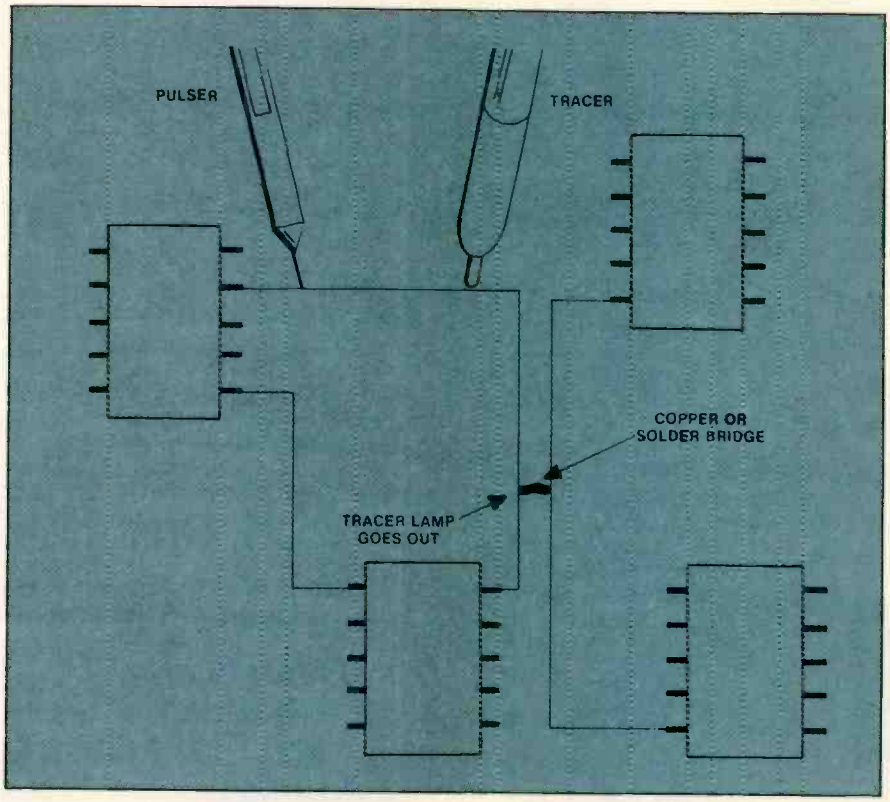


Figure 1. You can use the current tracer in conjunction with the logic pulser to locate short circuits caused by solder or copper bridges.

The logic pulser

The logic pulser is the active counterpart to the logic probe. When you place its tip against an IC pin and push the button, it will inject a pulse, or a train of pulses, into the IC to seek an aberrant response.

The logic current tracer

Another piece of low-level test equipment that can help in locating problems in personal computer and other digital circuitry is the current tracer.

Even in an extremely thin printed circuit conductor, a change in current induces a magnetic field. A number of test-equipment manufacturers have designed probes that will sense a minute magnetic field and hence current changes in printed circuit wiring.

This device is called a current tracer and is useful in troubleshooting personal computer circuits; for example, to locate solder or copper bridges, or stuck nodes.

To locate a short (see Figure 1), you can use the current tracer in conjunction with the logic pulser. Simply place the pulser on the circuit wiring near the pin that's the source of the signal that's disappearing. Then place the current tracer downstream from the pulser and slowly move the tracer

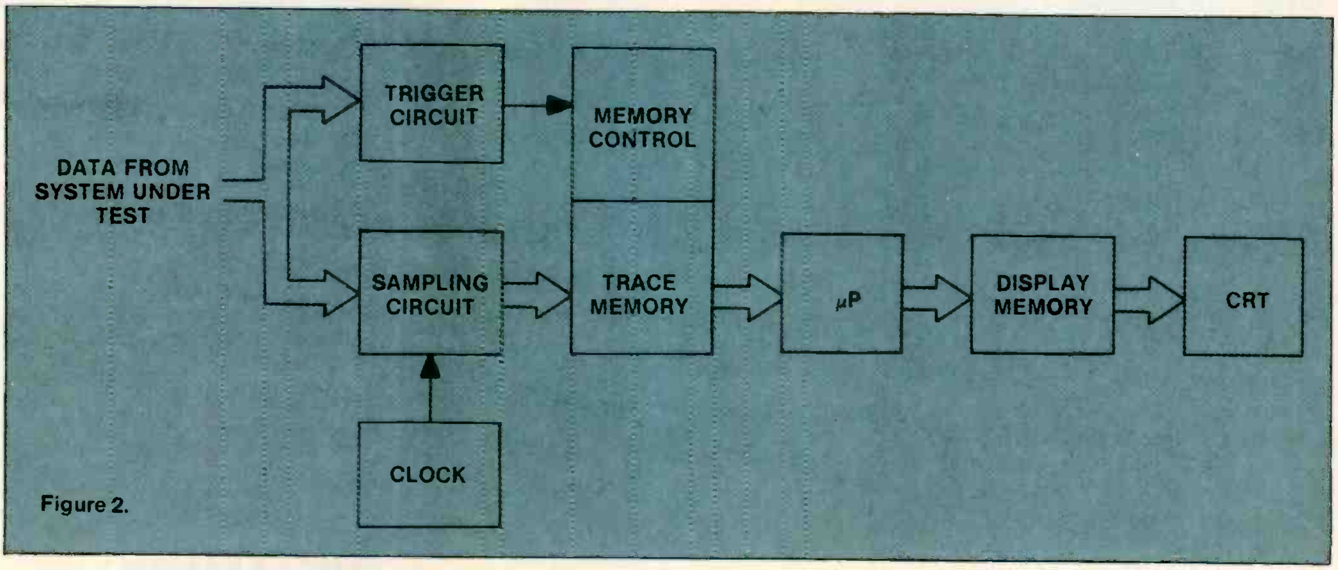


Figure 2. A timing analyzer works by sampling the input waveforms to determine whether they are high or low. It is concerned with only one voltage threshold.

along the circuit foil. When the current tracer's light goes out, you've just passed the point where the short is located.

Logic test clips

A logic test clip is a testing device that clips directly over an integrated circuit package. As you release the spring tension on the clip after placing it over the IC, one test probe comes into contact with each pin on the IC. Each test probe is connected to an LED that indicates whether that point in the circuit is at a logic HIGH or LOW.

Logic analyzers

Most logic analyzers are really two analyzers in one. The first part is a timing analyzer, while the second part is a state analyzer.

A timing analyzer is the part of a logic analyzer that is analogous to an oscilloscope: They can be thought of as close cousins. The timing analyzer displays information in the same general form as a scope, with the horizontal axis representing time and the vertical axis as voltage amplitude.

Sampling the input signals

A timing analyzer works by sampling the input waveforms to determine whether they are high or low. It cares about only one voltage threshold. If the signal is above threshold when it is sampled, it will be displayed as a 1 or high by the analyzer. By the same criterion, any signal sampled that is below threshold is displayed as a zero or low. From these sample points, a list of ones and zeros is generated that represents a 1-bit picture of the input waveform. As far as the analyzer is concerned, the waveform is either high or low—no intermediate steps. This list is stored in memory and also used to reconstruct a 1-bit picture of the input waveform, as shown in Figure 2.

The state analyzer

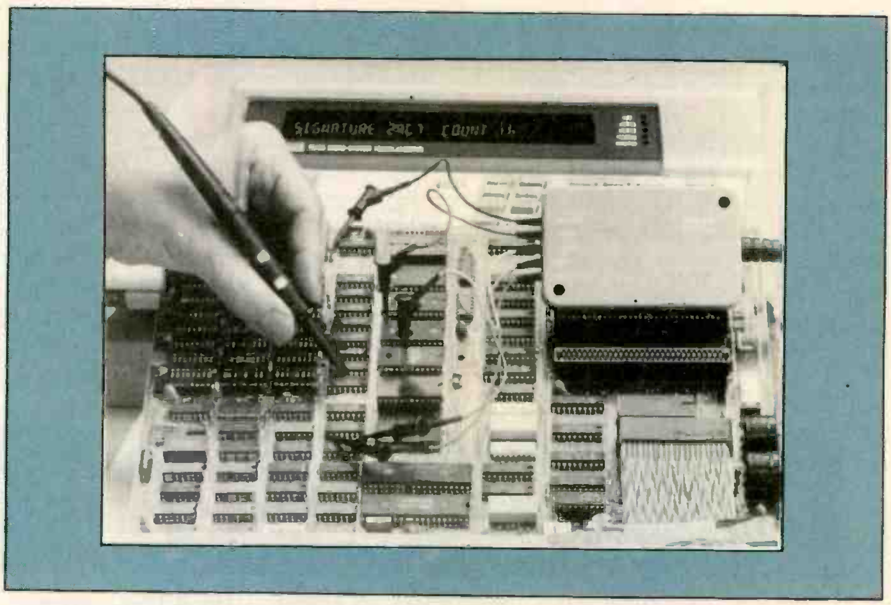
A state analyzer is used most often to trace the execution of instructions through a processor system. Each memory cycle's data, address and status codes are captured and displayed as they occur on a microprocessor's buses.

A state, for a logic circuit, is a sample of a bus or line when it is valid (the state of the signal is sampled).

For example, take the simple "D" flip-flop, like the one in Figure 3. Data at the "D" input will not be valid until a positive-going clock edge comes along. Thus, a *state* for the *flip-flop* exists when the clock edge occurs.

Now imagine that you have eight of these flip-flops in parallel (Figure 4). All eight are connected to the same signal as a clock. When a positive transition occurs on the clock line, all eight will capture data at their "D" inputs. Again, a state occurs each time they get a positive transition on the clock line. These eight lines are analogous to a microprocessor bus.

If you connected a state analyzer to these eight lines and told it that



A computer-system tester, such as this series 9000 unit by Fluke, plugs directly into the microprocessor socket. Software written by the tester's manufacturer, or in some cases the user, exercises all elements of the computer system and offers a diagnosis of the problem.

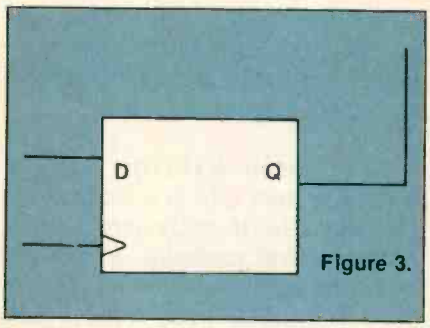


Figure 3. A state for a logic device such as this "D" flip-flop is a sample of a bus or line when it is valid.

a positive transition on the clock line is the instant when you want to collect data, the analyzer would obey. Activity on the inputs will not be captured by the state analyzer unless the clock is going from a low to a high state.

Computer-*system* testers

The heavy artillery of the personal computer testers are the testers that can be plugged right into the microprocessor socket and used to operate the system in a controlled manner that systematically leads to location of the fault. In other words, the piece of test equipment replaces the microprocessor chip itself, and under software written by the testing unit's manufacturer, or in some cases, by the user, sends commands to the rest of the system being tested that are designed to test every point in the system. Then it records the responses and from the data collected makes a determination of the nature of the fault.

It's kind of like having a superfast technician pulsing and probing every point in the system, recording the results then interpret-

This test device, the AID/88 by Vu-Data, is designed specifically to test one type of personal computer, IBM PCs and compatibles that are based on the 8088 processor. The software (or more correctly *firmware*) for this unit comes in the form of ROM that is preprogrammed and plugged into the tester.

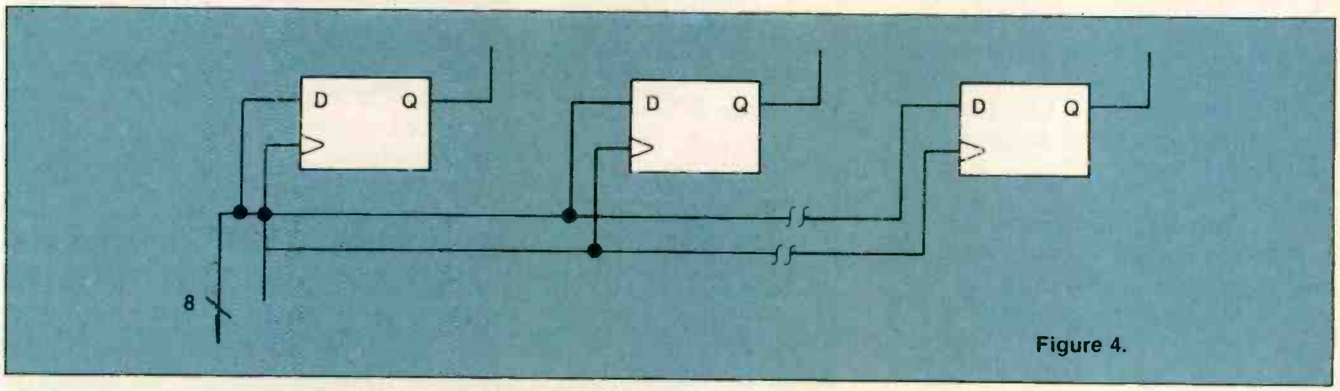


Figure 4. If you connect a state analyzer to these eight lines and tell it to collect data when there is a positive transition on the clock line, the analyzer will follow your directions.

ing the data to make a determination as to the cause of the problem.

There are several different types of computer-system testers. Some of these units are designed to test only one brand of computer, or only computers based on one kind of microprocessor. Other computer-system testers can test just about any kind of microcomputer system using so called *personality* modules that adapt them to the particular system being tested.

One of these test units is the Fluke 9000 series of Micro-system Troubleshooters. According to the brochure for the 9010A, a programmable test device, "There's no need to learn a processor's programming language to operate a Fluke Micro-System Troubleshooter. Four built-in, preprogrammed test routines are provided to automatically check the entire µP kerner-Bus, RAM, ROM, and I/O. One keystroke initiates all four. Each is a comprehensive routine with descriptive diagnostics to help guide you to the fault."

The brochure goes on to provide a partial list of processors supported: 1802, Z80, 6502, 6800, 6802, 6809, 8048, 8080, 68000 and more.

Another unit, not programmable, but designed to operate with software developed on the 9010A, is the 9005A.

Another PC tester

Because the IBM PC is such a popular computer, a lot of attention has been given to producing everything for use with it from software to accessories. Such is the case with test equipment.

Another manufacturer of test equipment, called the AID/88 for this personal computer, is Vu-Data Corporation. According to this company's brochure, "The basic AID/88 PC Tester is intended to be used to troubleshoot to the component level the system board in the IBM PC 1 PC, XT and portable personal computers. Functions of the AID/88 are applicable to any PC that is IBM PC compatible, using an 8088 microprocessor."

Because the AID/88, unlike the Fluke test units, is specifically designed to test the IBM PC, its test programs actually are installed in the unit in a hardware memory (ROM), also called *firmware*, so it is neither necessary nor possible to program the unit, or to load software into it prior to testing.

The choice is broad

No one ever said that consumer electronic servicing would be easy. As the range of consumer electronic products and their complexity becomes ever greater, merely choosing the level of test equipment needed becomes a difficult exercise. As demonstrated here, the range of choice of test equipment for personal computers is broad: everything from DMMs and oscilloscopes, through simple logic testers, right up to sophisticated programmed or programmable test units that all but automatically test the unit. ES&T

Solid-state using, abusing

By Joseph J. Carr, CET

It's inevitable every summer. An afternoon thunderstorm makes its hour-long sweep across town, pouring out torrents of rain and causing a dancing display of electrical pyrotechnics to light up the sky. That magnificent temper tantrum of nature throws scores of transient high-voltage slugs of electrical energy onto the power lines–and pops the rectifiers in dozens of pieces of electronic equipment.

Although most don't meet their demise in so spectacular a manner, solid-state power supply rectifiers are a major source of failure in electronic equipment. During a period when I worked in a large service organization, we kept records on repairs made by both in-house technicians and contractors. Power supply problems formed the overwhelmingly large percentage of faults, and the rectifier diode was a big contributor.

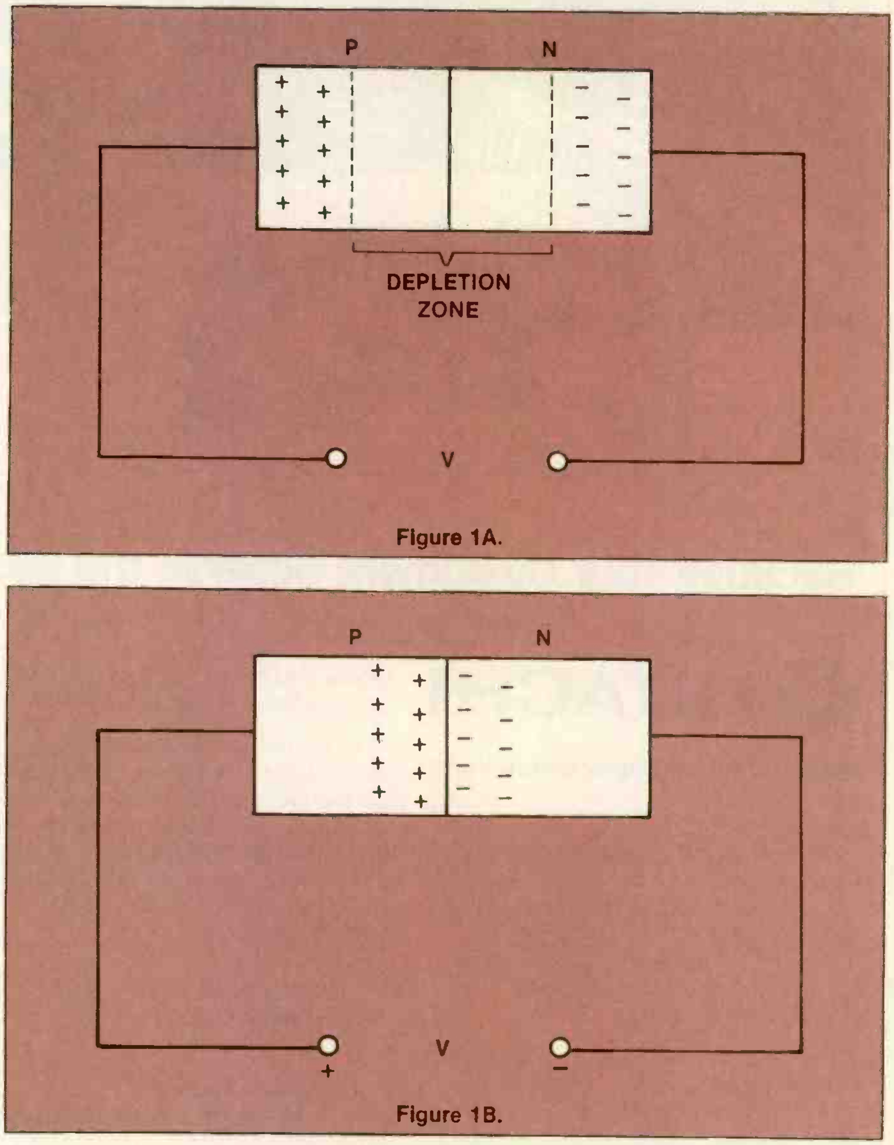


Figure 1. Because a semiconductor diode allows current flow when biased in the forward direction but impedes current when biased in the reverse direction, it is useful in rectifying ac to dc.

Some rectifier problems are caused by high voltage transients on the power lines, as in the little scenario given above. In other cases the problem is that the engineers who designed the circuit underspecified the rectifier, and the owner eats the mistake for years to come. I recall one famous HF single-sideband transceiver that was reknowned for reliability problems. It turned out, however, that almost all repairs involved not the transceiver but its ac power supply. When used in mobile applications, the set worked well (and long) for the customer. But when it was taken inside and made a base station–BLAM!–the darn thing would go down every few months. The entire problem was the solid-state rectifiers: they were underspecified. Beefing up the rectifier to the correct type removed the problem, eliminated costly (and embarrassing) call-backs and made the owner think we were the only people for about 50 miles who knew any smoke about radio transmitters.

What is a rectifier?

The word *rectify* means "to make right" or "to remove impurities." You probably can guess that the main requirement for a rectifier is that it convert bidirectional ac into a unidirectional form of current. Although industry once used mechanical switches and vacuum tubes to accomplish that job, all

rectifiers: and selecting

modern circuits rely on solid-state PN junction rectifiers.

The modern solid-state rectifier really isn't so modern after all. Various versions of the rectifier date back to the dawn of the radio–indeed the electrical–age. But all common rectifier diodes in use today are silicon PN junction diodes (see Figure 1), and those date back 25 years. During my apprentice days in the late fifties, we used 500mA "tophat" rectifiers to replace the older selenium types. In fact, many technicians simply bridged the silicon rectifier across the terminals of the dead selenium unit–until they found that practice caused more problems than it solved.

The PN junction diode rectifier (Figure 1) consists of a piece of silicon semiconductor material that is doped with impurities to form N-type material at one end, P-type material at the other end. The charge carriers (which form electrical current) in the N-type material are negatively charged electrons, while the charge carriers in the P-type material are positively charged "holes."

The reverse bias situation is shown in Figure 1A. In this case the negative terminal of the voltage source (V) is connected to the P-type material, while the positive terminal is connected to the N-type material. Positive charge carriers are thus attracted away from the PN junction toward the negative voltage terminal, as negative charge carriers are drawn away toward the positive terminal. That leaves a *depletion zone* in the region of the junction that contains no carriers. Under this condition, there is little or no current flow across the junction. Theoretically, the junction current is zero, but in real diodes there is always a tiny leakage current (the smaller the better).

The forward biased case is shown in Figure 1B. Here the polarity of voltage source V is reversed from Figure 1A. The positive terminal is applied to the P-type material, and the negative terminal is applied to the N-type material. Because like-charges repel, the charge carriers in both P- and N-type material are driven away from the power supply terminals toward the junction. The depletion zone disappears and current flows in the circuit.

From the above description, you can tell that a rectifier diode is able to convert ac into dc because it allows current to flow in only one direction.

Figure 2 shows the standard circuit symbol for the solid-state rectifier diode (Figure 2A), along with some common shapes of actual diodes. The *input* side where ac is applied is the anode, while the dc output is the cathode. The diodes shown in Figures 2B through 2G are positioned so that the respective anodes and cathodes are aligned with those of the circuit symbol in Figure 2A. Rectifiers 2B through 2E are epoxy or plastic package devices, and are the type seen by most readers. The cathode end will be marked with a rounded end (2B), a line (2C), a diode arrow (2D) or a plus sign (2E).

The diode shown in Figure 2F is the old-fashioned (now obsolete) tophat type. Unless otherwise specified, the tophat type can safely pass a current of 500mA, while those in Figures 2B through 2E generally pass 1A (or more, for larger packages).

The stud-mounted type shown in Figure 2G is a high-current model. These diodes will be rated at currents from 6A or more (50A and

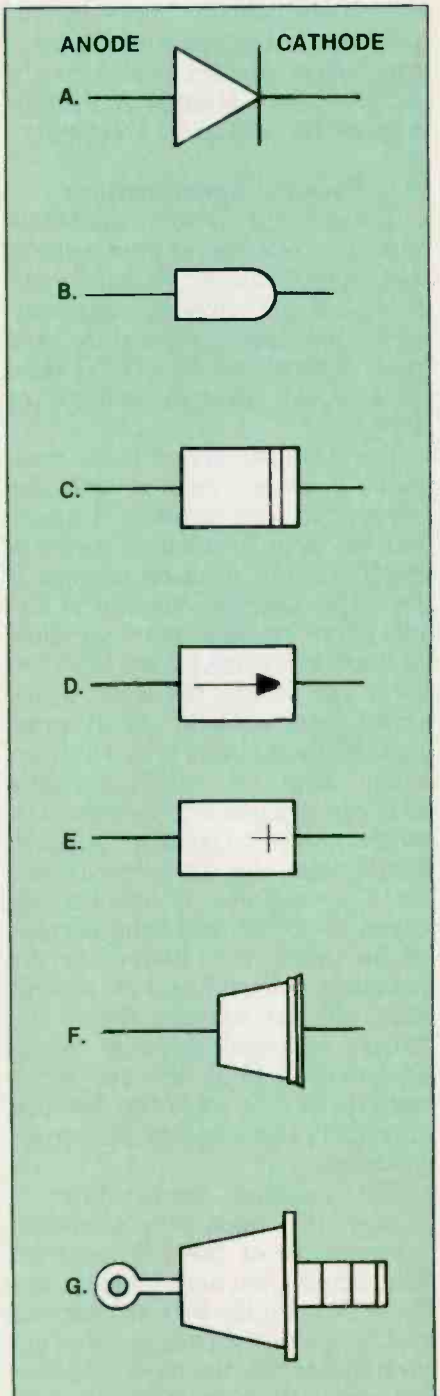


Figure 2.

Figure 2. Semiconductor diodes come in a number of different shapes and sizes.

100A models are easily obtained). These diodes are mounted, using a threaded screw at one end, which also forms one electrical connection. The other electrical connection is the solder terminal at the other end. Unless otherwise specified, the solder terminal is the anode, and the stud-mount is the cathode terminal. Exceptions to the polarity rule are sometimes seen. The reverse polarity diodes either will have an arrow symbol pointing in the opposite direction (the arrow always points to the cathode), or an *R* suffix on the type number (for example, 1NxxxxR).

Rectifier specifications

The use and abuse of solid-state rectifers revolve around several key specifications: forward current, leakage current, surge current, junction temperature and peak inverse voltage (PIV) (also called peak reverse voltage or PRV).

The forward current is the maximum constant current that the diode can pass without damage. For the popular 1N400x series of rectifiers, the forward current is 1A. The leakage current is the maximum current that will flow through a reverse biased junction. In an ideal diode, the leakage current is zero while in quality practical diodes it is very low. The maximum surge current is a rating that can get you into trouble. The surge current typically is much larger than the forward current, so it sometimes is erroneously taken to be the operating current of the diode. It is defined as the maximum short-duration current that will not damage the diode. "Short duration" typically means 1/60-second. Don't use the surge current as if it were the forward current (a common but disastrous mistake).

The junction temperature is merely the maximum allowable temperature of the PN junction. The actual junction temperature depends upon the forward current and how well the package (and environment) rids the diode of internal heat. Although typical junction temperatures range from +125°C to +150°C, good design requires as low a temperature as possible. One reliability guide asks us to keep the junction temperature to a maximum of +110°C.

Several years ago an itinerant "wholesale" parts company made the rounds of the shops on the East Coast offering what seemed to be tremendous deals on electronic parts. The 1,000V PIV @1A rectifiers they offered were, well, a little short of the mark. It turned out that they would not work for long in color TV sets unless the entire lead length were left uncut on the diode. That made for very sloppy-looking repairs! The problem was that the diodes were overspecified. The unscrupulous dealer needed some 1A diodes, so he made them from 500mA types by a little creative spec writing. After all, why go buy some 1A diodes when you can make them with a magic marker. Be careful of "deals."

The peak inverse voltage (PIV) is the maximum allowable reverse bias voltage that will not damage the diode. This rating usually is the limiting rating in certain power supply designs, and the least often heeded. Later in this article we will learn how to select the PIV rating for practical power supplies.

Rectifier circuits

Figure 3 shows a solid-state rectifier diode (D1) in a simple half-wave rectifier circuit. In Figure 3A, the diode is forward biased: The positive terminal of the voltage source is connected to the anode of the rectifier. In this case, current (I) flows through the load resistance (R). In Figure 3B, we see the opposite situation. Here the negative terminal of the voltage source is applied to the anode, so the diode is reverse biased. No current flows.

The circuit of Figure 3 is called a *½-wave rectifier* for reasons that become apparent when examining Figure 3C. In this figure, the output current through the load (R) is graphed as a function of time when an ac sinewave is applied. From time T1 to T3 the diode is forward biased, so current flows in the load (also from T3 to T4). But during the period T2 to T3 the diode is reverse biased, so no current flows. Because the entire sinewave takes up the period T1 to T3, only half of the input wave is used. The output waveform shown in Figure 3C is called a *½-wave rectified pulsating dc* wave. The "pulsating" part comes from the fact that it is not pure dc.

The ½-wave rectifier is inexpensive, but wastes energy due to its use of only one-half of the input ac waveform. We increase efficiency by making use of the entire waveform in a fullwave rectifier circuit. Figure 4A shows the standard fullwave rectifier based on a special transformer that has a center-tapped secondary winding. Because the center tap (CT) is used as the 0V reference (and in most circuits is grounded), the polarities at the ends of the secondary are always opposite each other. One one-half cycle, point A, is positive with respect to the CT, while point B is negative. On the next half cycle, point A is negative and point B is positive with respect to the CT. This situation makes D1 forward biased on one half cycle, while D2 is reverse biased. Alternatively, on the next half cycle, D1 is reverse biased and D2 is forward biased.

Let's follow the circuit of Figure 4A through one complete ac cycle (times T1 through T3 in Figure 4B). On the first half cycle (T1 to T2), point A is positive, so D1 is forward biased and conducts current; D2 is reverse biased. Current I1 flows from the CT, through load R, diode D1 and back to the transformer at point A. On the alternate half cycle, current I2 flows from the CT, through load R, diode D2 and back to the transformer at point B. Now notice what happened: I1 and I2 are equal currents, generated on alternate half cycles, and they *flow in load R in the same direction*. Thus, we have unidirectional current through load R flowing on both halves of the ac sine wave. The waveform resulting from this action is shown in Figure 4B, and is called *fullwave rectified pulsating dc*.

We can eliminate the center-tapped secondary requirement by using the fullwave bridge rectifier circuit of Figure 5A. This circuit requires twice as many rectifier diodes, but allows us to use a simpler transformer. The opera-

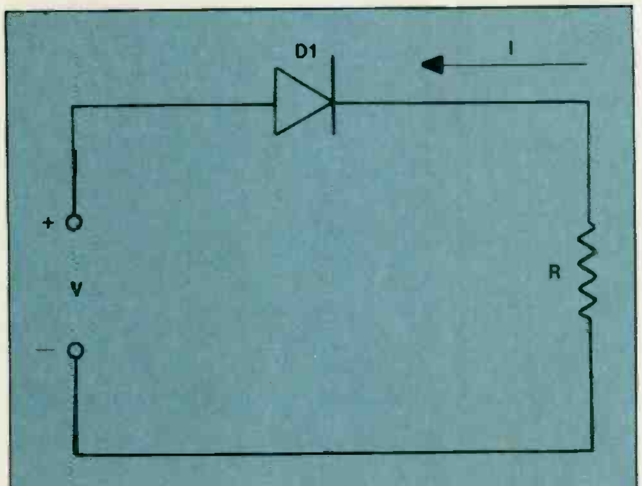


Figure 3A.

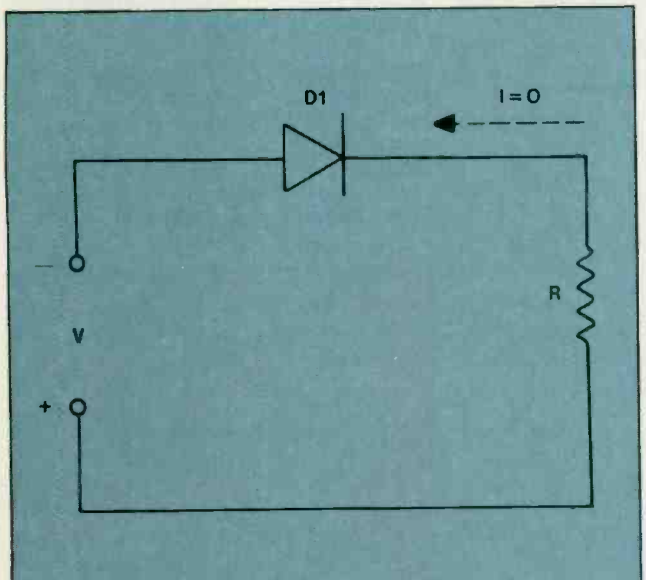


Figure 3B.

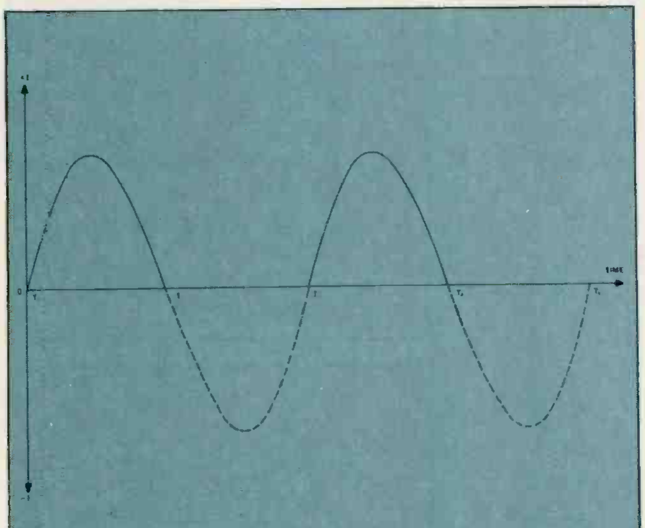


Figure 3C.

Figure 3. Connected this way, a semiconductor acts as a ½-wave rectifier. The output of a ½-wave rectifier is a pulsating dc, as shown in C.

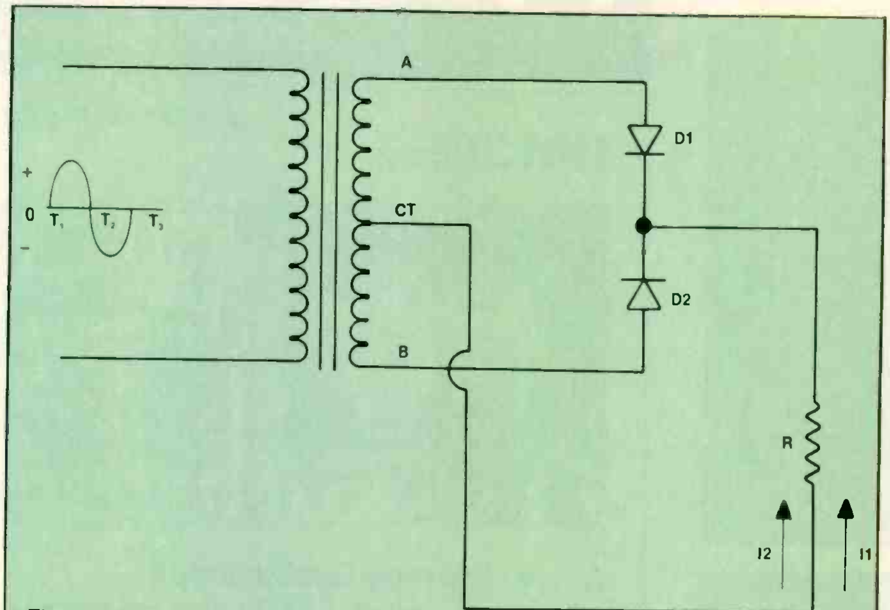


Figure 4A.

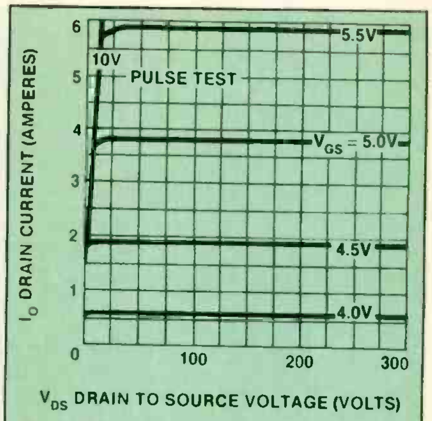


Figure 4.

Figure 4. Using a center-tapped transformer and two diodes, you can construct a fullwave rectifier as shown here. The output is a pulsating dc, see B.

Figure 5. Another way to construct a fullwave rectifier is to connect four diodes in a bridge configuration (A). Because a bridge rectifier is such a commonly used circuit, it is available in prepackaged units (B). Another rectifier configuration is the half-bridge rectifier (C).

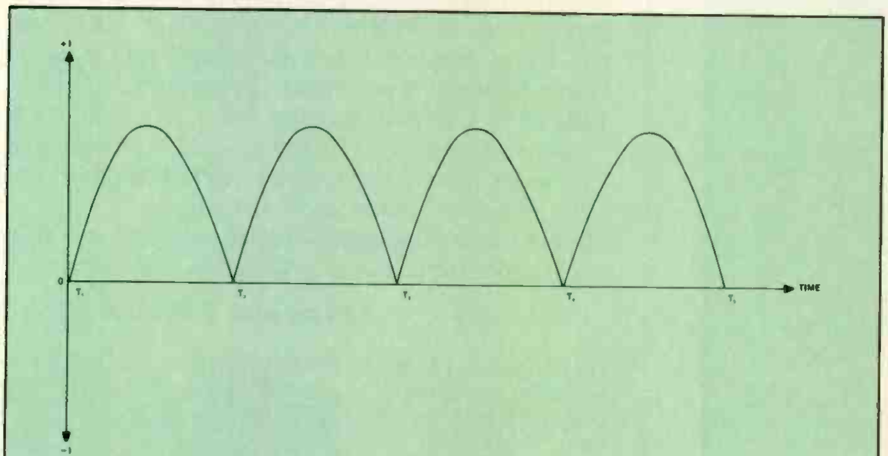


Figure 4B.

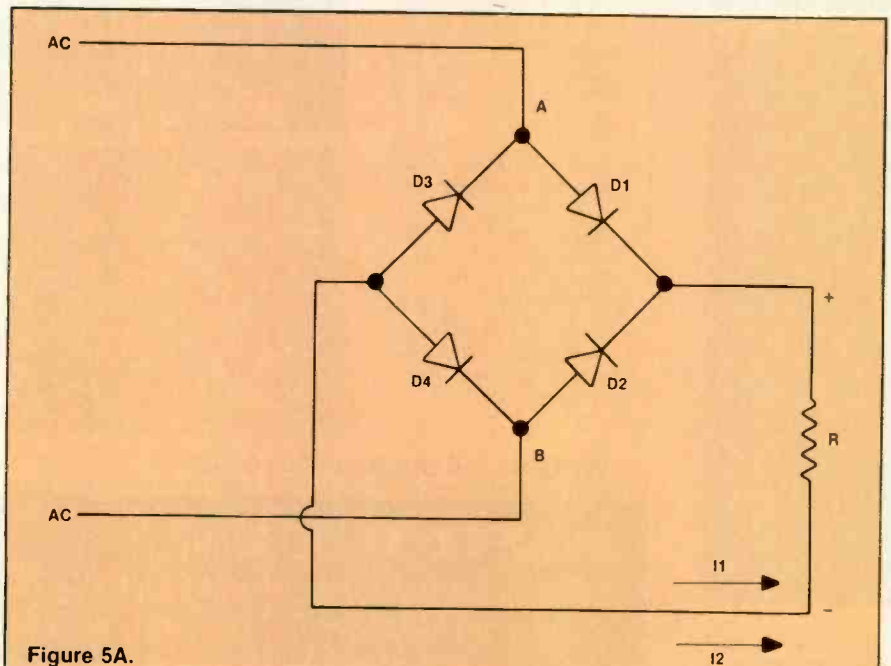


Figure 5A.

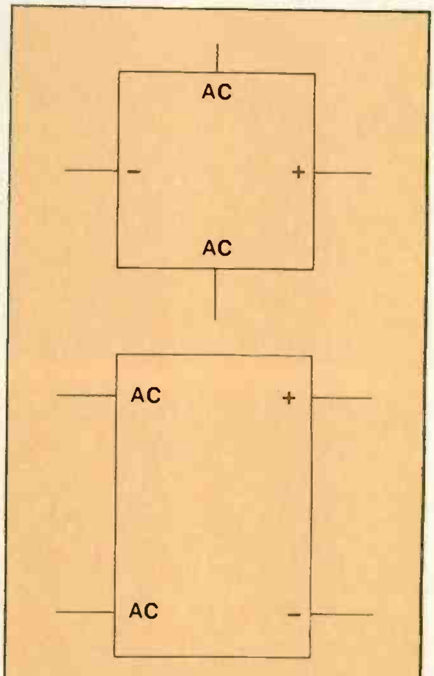


Figure 5B.

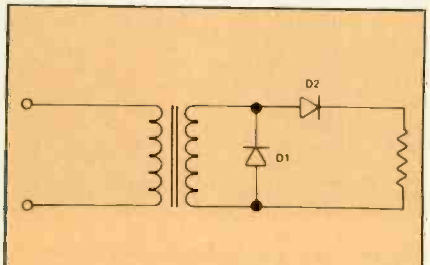


Figure 5C.

tion, however, is similar. On one half cycle, point A is positive and point B is negative. Current I2 flows from the transformer at point B, through D4, load R, diode D1 and back to the transformer at point A. On the alternate half cycle, point A is negative and point B is positive. In this case, current I2 flows from point A, through diode D3, load R (in the same direction as I1), diode D2 and back to the transformer at point B.

In some cases, you might want to build a bridge rectifier using four discrete diodes (D1 to D4). In most modern equipment, however, a bridge stack is used. These parts comprise a bridge rectifier built into a single package with four leads coming out. Figure 5B shows the two alternate circuit symbols for bridge rectifier stacks.

Figure 5C shows a half-bridge rectifier. This circuit is used more today because of the dual polarity power supplies used in a lot of equipment. Operational amplifiers and some CMOS devices typically require ±12V dc power supplies. We can take a fullwave bridge rectifier stack and couple it to a center-tapped transformer to make a pair of ½-wave rectified dc power supplies. The CT is the common (or ground), while the bridge positive terminal supplies the positive voltage and the negative terminal supplies the negative voltage.

The pulsating dc waveform is almost as useless for electronic circuits as the ac input. However, we can filter the pulsating dc output to form nearly pure dc. Although the subject of filtering is beyond the scope of this article, we must consider at least the simplest form of power supply filter in order to correctly select a rectifier for any given application. Figure 6A shows a simple power supply with a brute-force filter capacitor (C) shunting the load to filter the pulsating dc into nearly pure dc. This capacitor will charge to a potential equal to the peak voltage, which is 1.414 times the applied rms voltage.

Selecting rectifier diodes

The two parameters that you will use most often to specify practical power supply diodes are the *forward current* and *peak inverse voltage*. Get these right, and in almost all cases the rectifier will work long and hard for you.

The forward current rating of the diode must be at least equal to the maximum current load the power supply must deliver. That's common sense. But in the real world there also is a necessity for a safety margin to account for tolerances in the diodes and variations of the real load (as opposed to the calculated load). It also is true that making the rating of the diode larger than the load current will greatly improve reliability. A good rule of thumb is to select a diode with a forward current rating of 1.5 to 2 times the calculated (or design goal) load current, or more if you can get it. Although selecting a diode with a very much

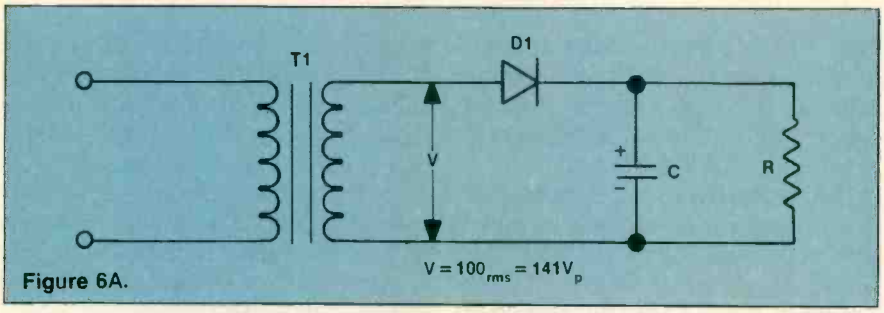


Figure 6A.

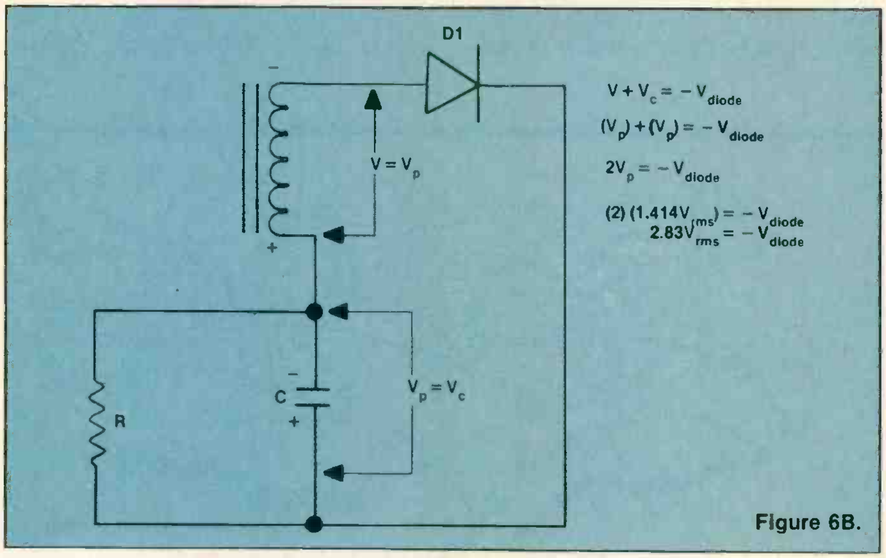
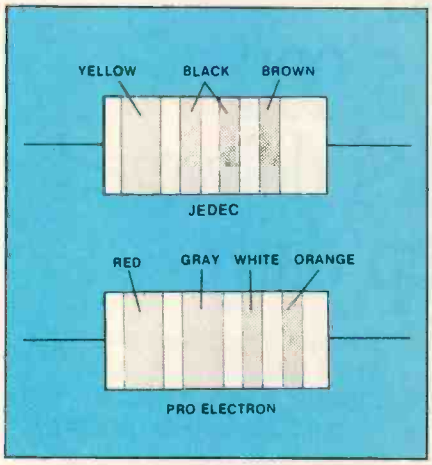


Figure 6B.

Figure 6. A capacitor is used to smooth the rectifier's dc output (A). When the capacitor voltage and the transformer voltage are additive, their sum appears across the diode (B). Thus, choose a rectifier diode with PIV rating of at least 2.83 times the applied rms voltage.



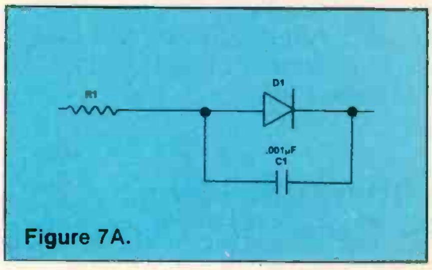


Figure 7A.

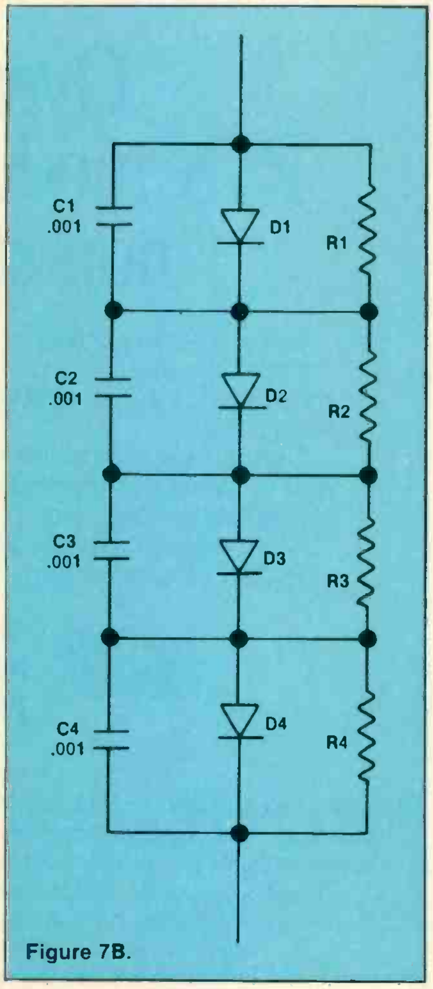


Figure 7B.

Figure 7. A resistor in series with the diode limits the forward current (A). A parallel capacitor will bypass high-voltage transient spikes around the diode that otherwise could destroy the PN junction. In B, several diodes in series increase the PIV rating. The resistors equalize the forward voltage drop across each diode.

larger forward current (for example, 100A for a 1A circuit) is both wasteful and likely to make the diode not work like a diode, it is generally the rule to make the rating as high as feasible. The 1.5-to-2-times rule, however, should result in a reasonable margin of safety.

The peak inverse voltage (PIV) rating can be a little more complicated. In unfiltered, purely resistive circuits, the PIV rating need only be greater than the maximum peak applied ac voltage (1.414 × rms). If a 20% safety margin is desired, then make it 1.7 × rms voltage.

Most rectifiers are used in filtered circuits (Figure 6A), and that makes the problem different. Figure 6B shows the simple capacitor filtered circuit redrawn to illustrate better the circuit action. Keep in mind that capacitor C is charged to the peak voltage with the polarity shown. The voltage across the transformer secondary (V) is in series with the capacitor voltage. When voltage V is positive, the transformer voltage and capacitor voltage cancel out, making the diode reverse voltage nearly zero. But when the transformer voltage (V) is negative, the two negative voltages (V and Vc) add up to twice the peak voltage, or approximately 2.83 × rms voltage. Therefore, the absolute minimum value of PIV rating for the diode is 2.83 times the applied rms. If you prefer a 20% safety margin (a good idea), then make the diode PIV rating 3.4 × rms (or more).

Using rectifier diodes

In most cases, especially low-voltage power supplies needed by most electronic equipment, you can get away with using the diodes as shown in the circuits above. In Figure 7A, however, note the so-called proper way to use the solid-state diode rectifier. The resistor in series with diode D1 (R1) is used to limit the forward current. Many circuits, especially those with capacitor-input filter circuits, exhibit a surge current at initial turn-on. This current sometimes can pop the diode, so R1 is used to limit the possible damage. The value of resistance used for R1 is typically 5Ω to 20Ω. In most cases, however, you can eliminate R1 by using a diode with a rating larger than the load current (for example, the two-times rule).

Capacitor C1 in figure 7A is used to bypass high voltage transient spikes around the diode. These spikes possibly could blow the diode PN junction. In fact, high voltage line spikes make diodes pop with disgusting routine. Placing the capacitor in parallel with the diode will eliminate much of that problem. The working voltage (WVdc) of the capacitor should be equal to or greater than the PIV rating of the diode.

By use of 1,000V PIV diodes even in low-voltage circuits, you can eliminate much of the damage caused by transients, therefore, you would not need the capacitors. You also can eliminate the capacitors if a metal-oxide varistor (MOV) spike suppressor is used across the ac supply voltage.

Figure 7B shows the method for using several diodes in series to increase the PIV rating. Assuming that the PIV ratings of the diodes are equal, then the overall rating is four times the rating of one diode. In general, we use 1,000V PIV diodes in these circuits, so for the circuit shown the PIV rating is 4,000V.

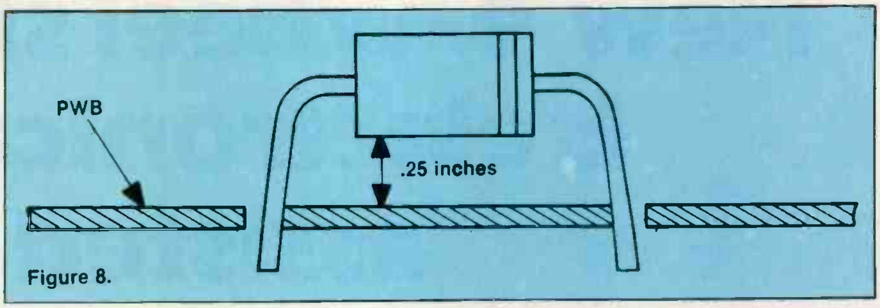


Figure 8. Mounting a diode a fraction of an inch above the circuit board allows air to circulate, keeping the diode cooler to protect the board from diode heat.

The capacitors used in Figure 7B are for exactly the same purpose as in Figure 7A. The resistors, however, are needed for a different purpose. They equalize the forward voltage drop across each diode. A 470Ω 1W resistor typically is used for 1,000V PIV diodes. The wattage rating is required not because of the power dissipation of the resistors, but for the voltage rating (yes, resistors *do* have voltage ratings).

Figure 8 shows the proper method for mounting an axial lead rectifier on a perfboard or printed circuit board. This method is used anytime except where excessive vibration is expected, which includes most stationary projects or equipment. The space beneath the diode body allows air to circulate (keeping the diode cooler) and prevents diode heat from damaging the board.

Older equipment that comes in for repair often uses hard-to-get or expensive vacuum-tube rectifiers. We can use solid-state diodes to replace these tubes in almost all cases. For smaller rectifiers, we need only wire the solid-state diode across the pins of the rectifier tube socket. In other cases we need to use an external perfboard or other tactic to mount the diodes. Such cases include those with multiple diode rectifiers such as Figure 7B.

Conclusion

Although solid-state rectifiers are among the most common electronic components used by technicians, they also are among the most common causes of failure in electronic projects or repaired equipment. By following the rules given above, you will successfully select the correct rectifier, and prevent reliability problems.

ES&T

New 4-wheel steering is electronically assisted

The growth of electronics in all areas of consumer products has been accompanied by a great deal of fanfare. Few people are unaware of such developments as microwave ovens, compact disc players, satellite TV. The electronics revolution in automobiles has been far more subtle: electronic innovations such as trip computers, computerized fuel injection, etc., have been introduced into cars somewhat quietly.

A recently introduced electronic automotive refinement is 4-wheel steering.

Mazda Motor Corporation has presented an active 4-wheel-steering (4WS) system as an option on selected passenger car models.

The system will be available beginning this summer in the Japanese domestic market, and later this year in the United States. It will be a highlight of Mazda's international size passenger car.

Four-wheel steering utilizes all four wheels to steer the vehicle when it is being turned. The system is unique because of its speed-sensing capability; the direction and amount of the rear wheel steering angle during cornering is determined not only by the driver's input to the steering wheel, but also by electronic controls that measure and respond to the vehicle's speed.

The driver's input to the steering wheel is mechanically transmitted by the rotation of a shaft that con-

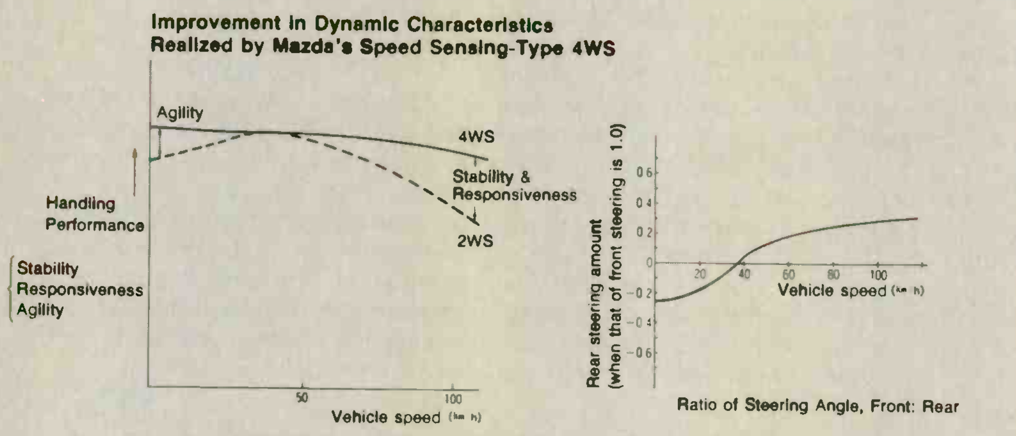
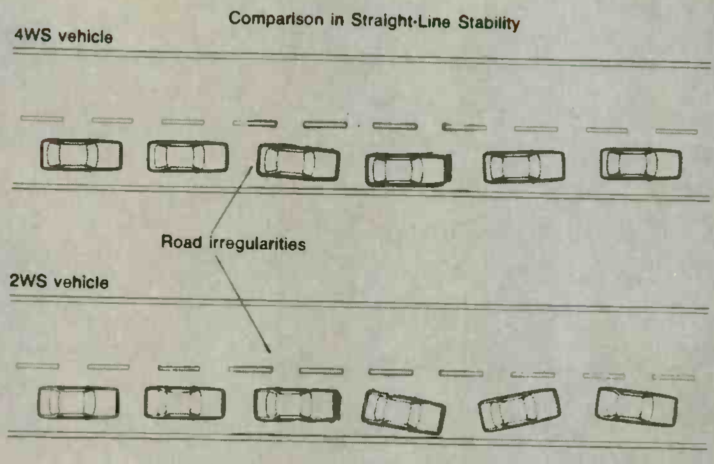


Figure 1. With 2-wheel steering system, vehicle handling may become less stable and responsive as driving speed increases. Change in vehicle characteristics at varying speeds is small with 4-wheel steering system.



Advantages of 4-wheel steering system

Some major advantages of the system are:

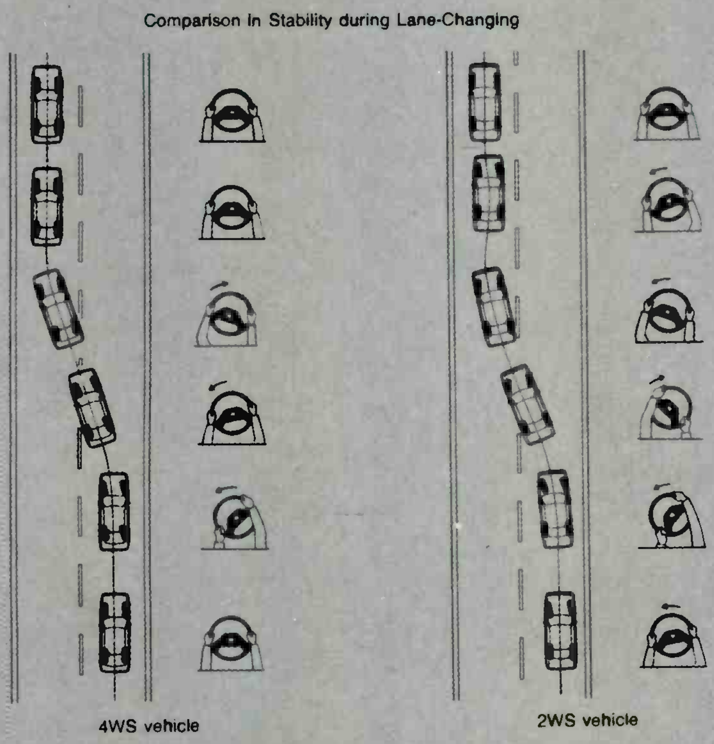
• *Cornering Capability*
The vehicle's cornering behavior is more stable and controllable at high speeds and slippery roads.

• *Steering Response*
The vehicle's response to steering input becomes quicker and more precise throughout the vehicle's entire speed range.

• *Straight-Line Stability*
The vehicle's straight-line stability at high speeds is improved; negative effects of road irregularities and crosswinds on its stability are minimized.

• *Lane Changing*
Stability in lane changing at high speeds is improved. High-speed slalom-type operations become easier, and the vehicle becomes less likely to go into a spin even in situations when the driver must make a sudden change of direction.

• *Low-Speed Maneuverability*
By steering the rear wheels in the direction opposite of the front wheels at low speeds, the vehicle's turning circle is greatly reduced. Making it easier to maneuver on narrow roads and during parking.

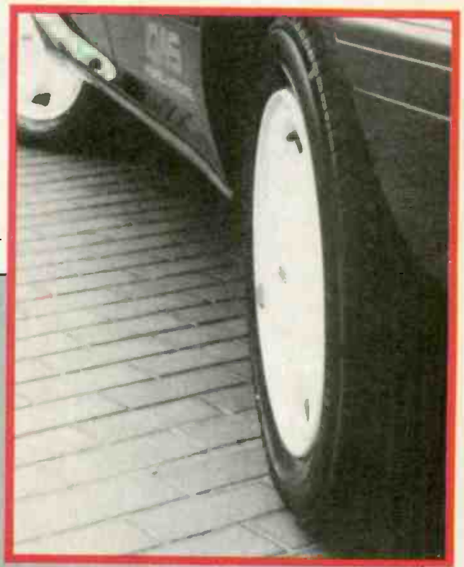


nects the front and rear steering systems. The rear steering system incorporates a mechanism to transform the steering input and an electronic system to control it.

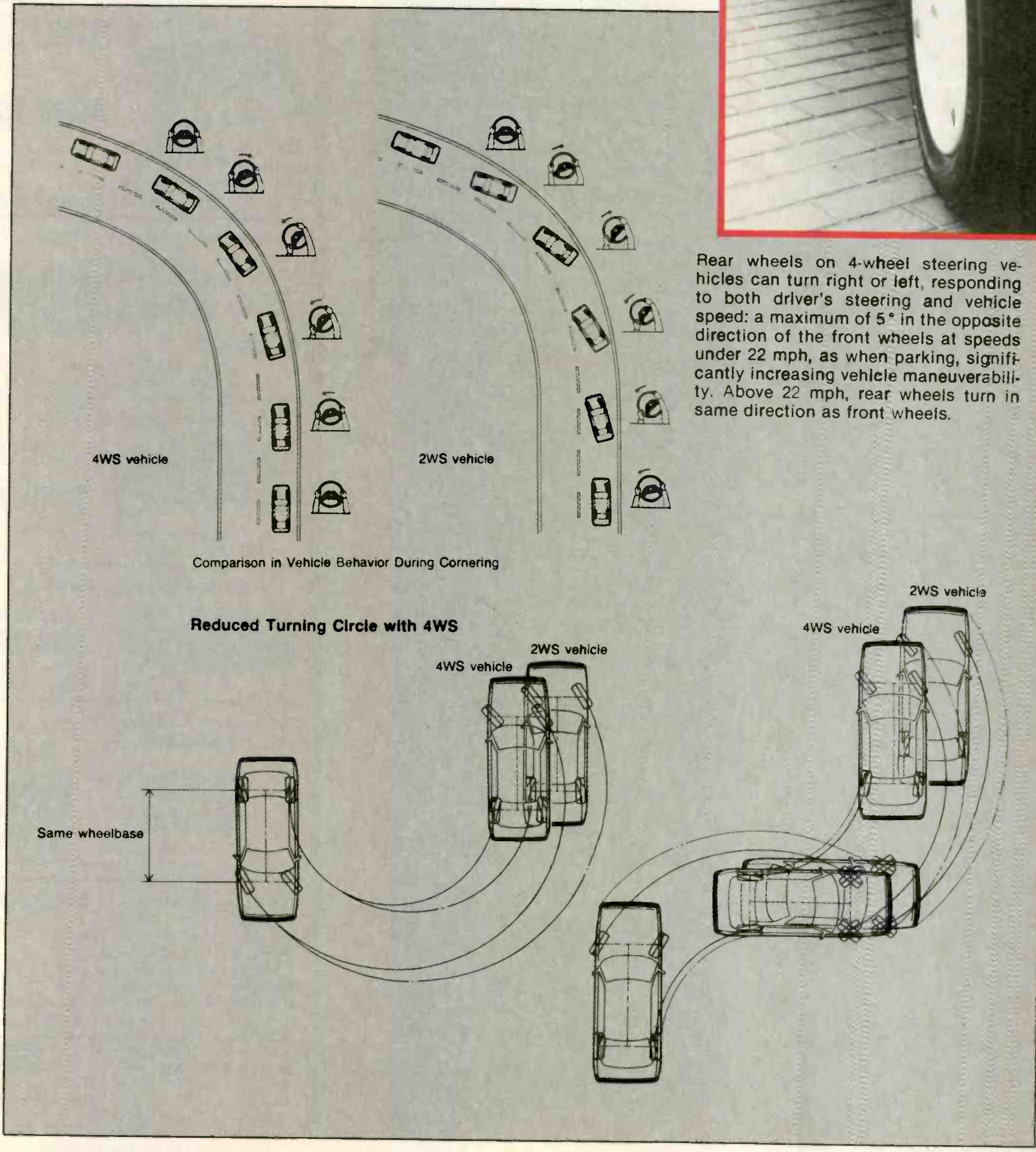
During cornering at speeds of more than 22 mph, the rear wheels are steered in the same direction as the front wheels to provide improved handling and stability compared with conventional 2-wheel-steering vehicles. When maneuvering at speeds lower than 22 mph – such as when parking the vehicle – the system steers the rear wheels in the direction opposite from the front wheels.

The electronic system with sensors regulates the steering ratio between the front and rear wheels according to the vehicle's speed to optimize the vehicle's dynamic characteristics at any speed.

This advanced 4WS system facilitates vehicle handling at high speed and, it is said, helps to reduce driver fatigue in sustained driving at highway speeds. ES&T



Rear wheels on 4-wheel steering vehicles can turn right or left, responding to both driver's steering and vehicle speed: a maximum of 5° in the opposite direction of the front wheels at speeds under 22 mph, as when parking, significantly increasing vehicle maneuverability. Above 22 mph, rear wheels turn in same direction as front wheels.



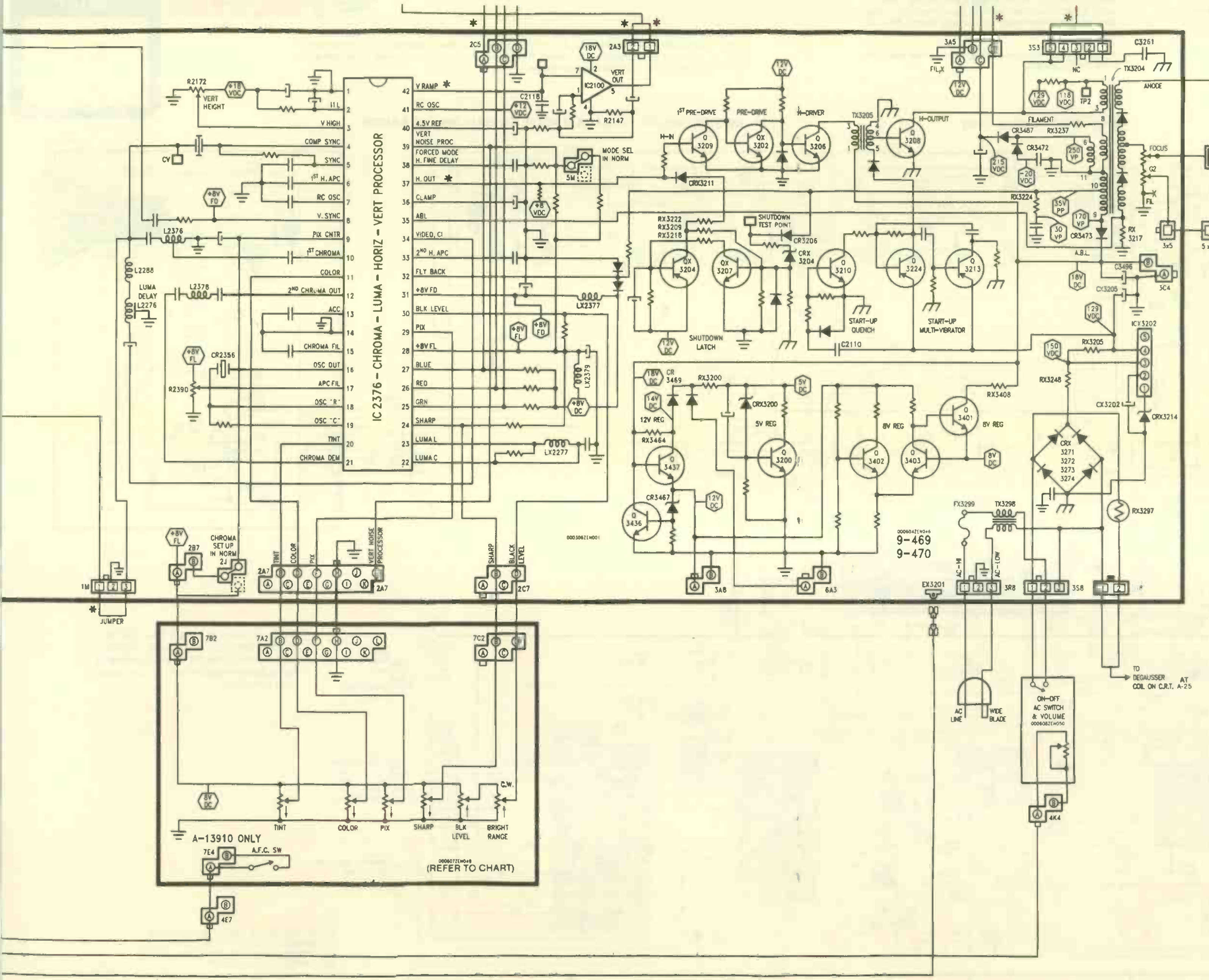
ESET Manufacturers' schematics

PROFAX

JULY 1987

3007

Zenith
D13085/
D1910B
chassis
Color TV



Product safety should be considered when component replacement is made in any area of a receiver. Components marked with a ⚠ and shaded areas of the schematic diagram designate sites where safety is of special significance. It is recommended that only exact cataloged parts be used for replacement of these components.

Use of substitute replacement parts do not have the same safety characteristics as recommended in factory service information may create shock, fire, excessive x-radiation or other hazards.

This schematic is for the use of qualified technicians only. This instrument contains no user-serviceable parts.

The other portions of this schematic may be found on other Profax pages.

SYSTEM SCHEMATIC

A system schematic is a hybrid troubleshooting aid consisting of a functional block diagram and simplified module schematics. It provides an overview for tracing major circuits and includes these features: key voltages, the makeup of individual cables, all connections between modules and assemblies, major components and the main lines of interaction related to these components.

The intention of the system schematic is to provide sufficient information to analyze the TV as a system for determining which major component is faulty. For complete module and assembly schematics, refer to the appropriate service manual.

I J K L M N O P Q R S T

3 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

Profax schematics are for the use of qualified technicians only.

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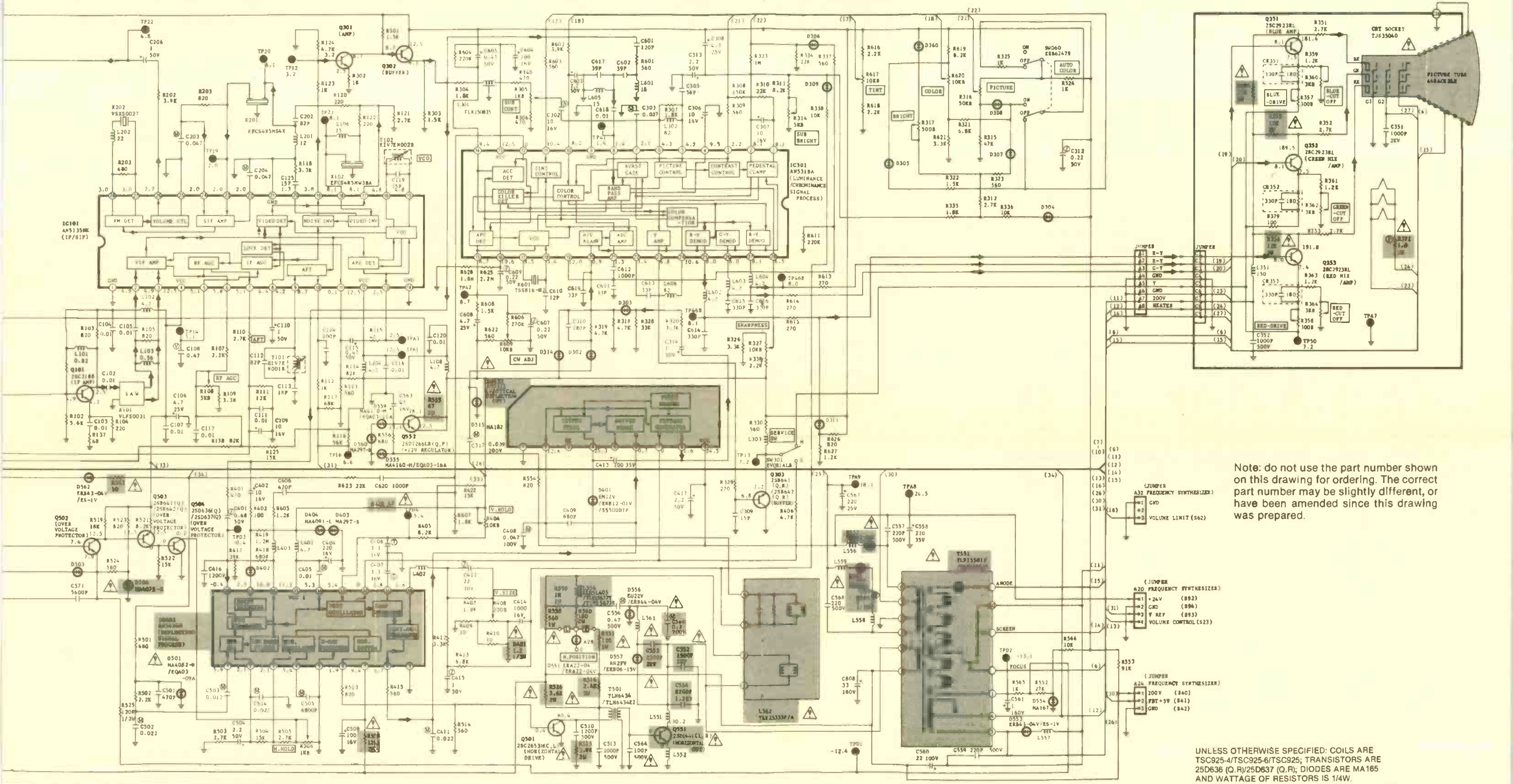
VIDEO SIGNAL LOOP

AUDIO SIGNAL LOOP

MAIN SCHEMATIC DIAGRAM MK-1 Chassis (model 8-1938)



Note: do not use the part number shown on this drawing for ordering. The correct part number may be slightly different, or have been amended since this drawing was prepared.

UNLESS OTHERWISE SPECIFIED: COILS ARE TSC925-4/TSC925-6/TSC925; TRANSISTORS ARE 25D636 (Q,R)/25D637 (Q,R); DIODES ARE MA165 AND WATTAGE OF RESISTORS IS 1/4W.

4 5 6 7 8 9 10 11 12

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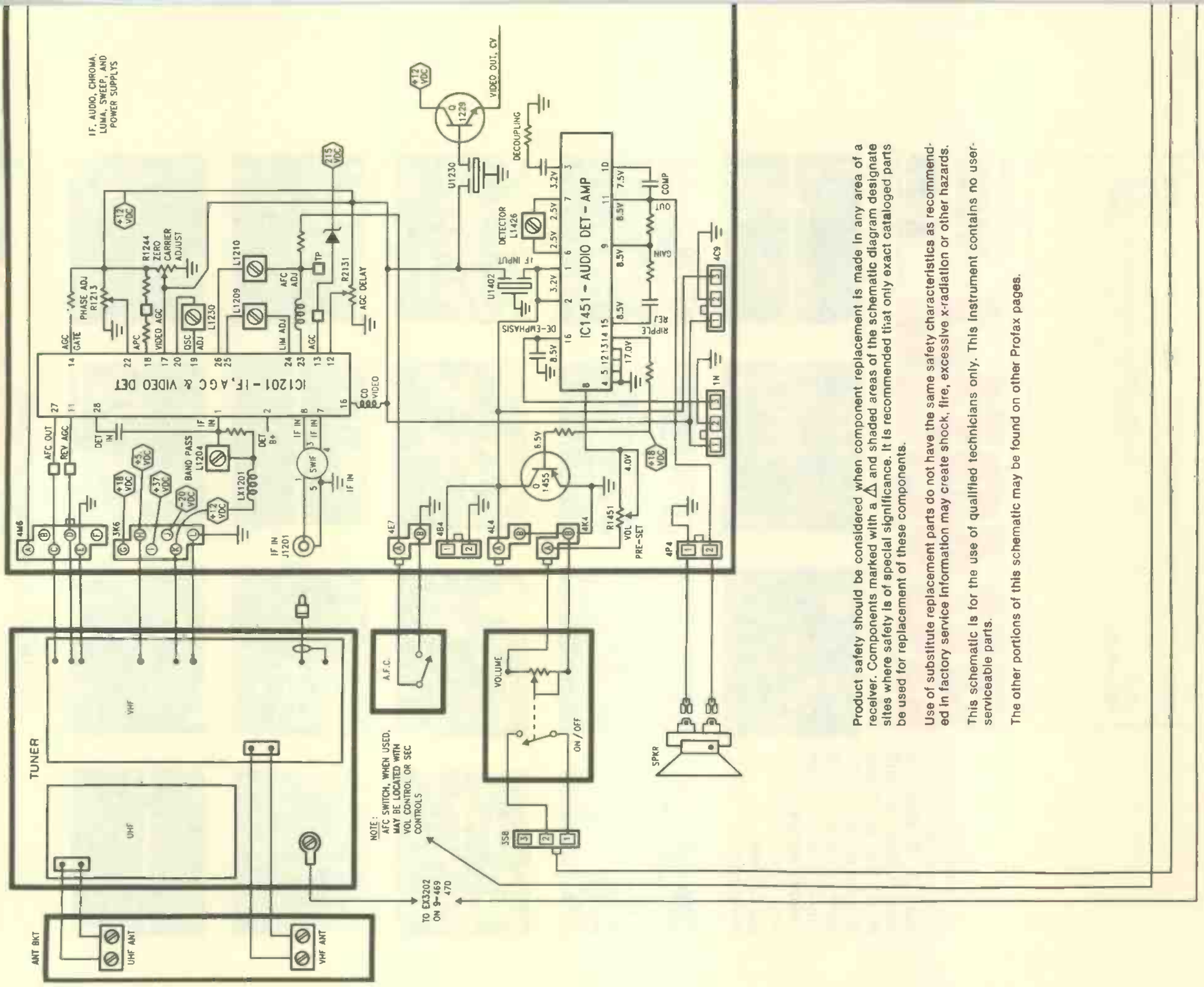

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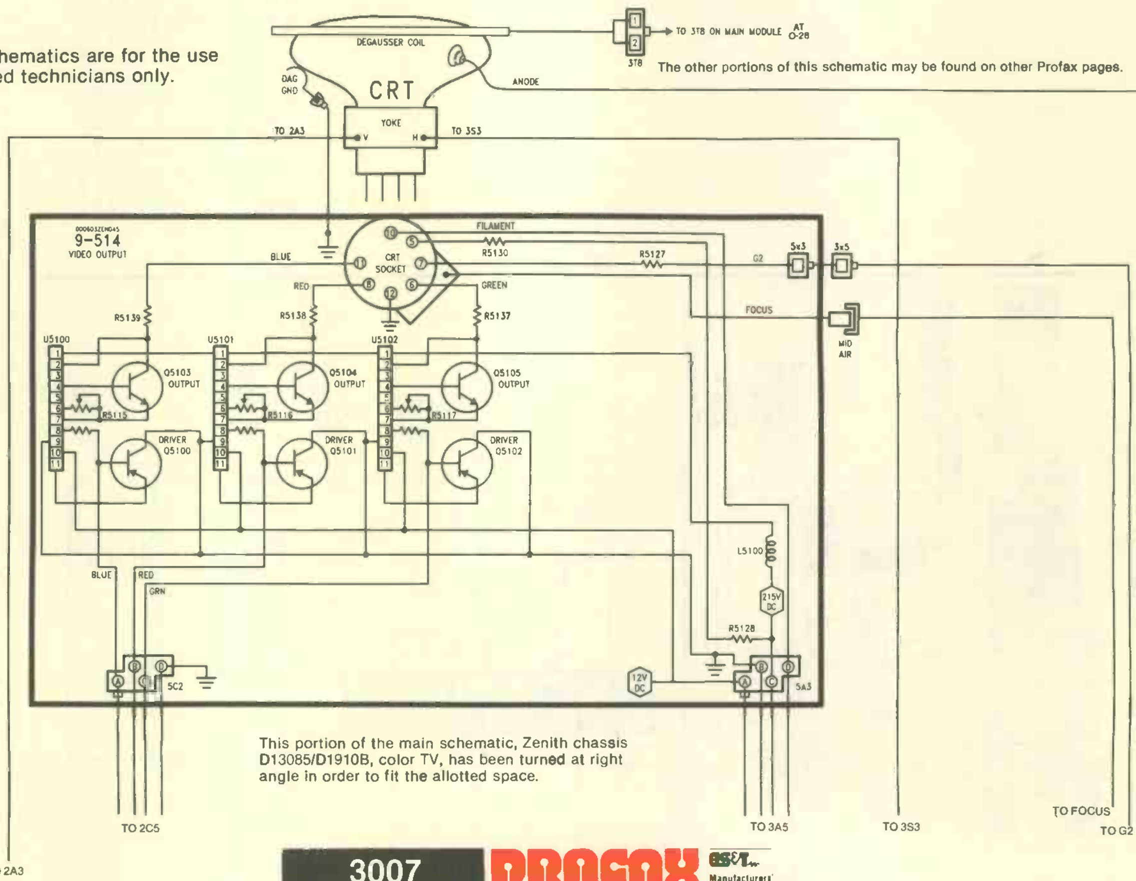
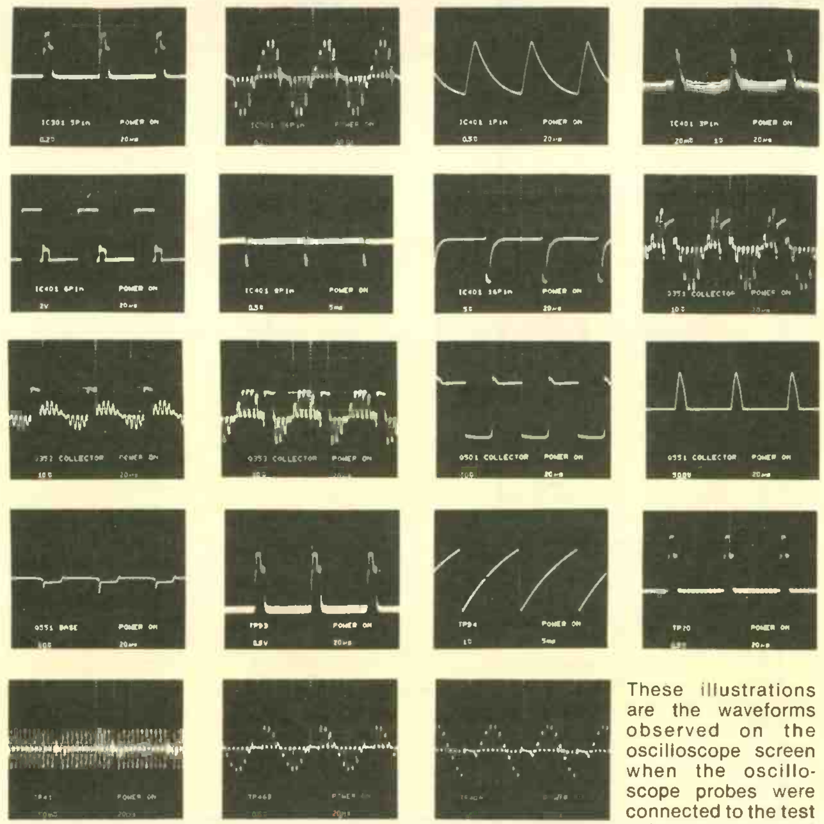


This portion of the main schematic, Zenith chassis D13085/D1910B, color TV, has been turned at right angle in order to fit the allotted space.

WAVEFORM PHOTOGRAPH



These illustrations are the waveforms observed on the oscilloscope screen when the oscilloscope probes were connected to the test points on the signal circuit board corresponding to the numbers on the schematic diagram.

ES&T Manufacturers' schematics PROFAX

Profax schematics are for the use of qualified technicians only.

The other portions of this schematic may be found on other Profax pages.

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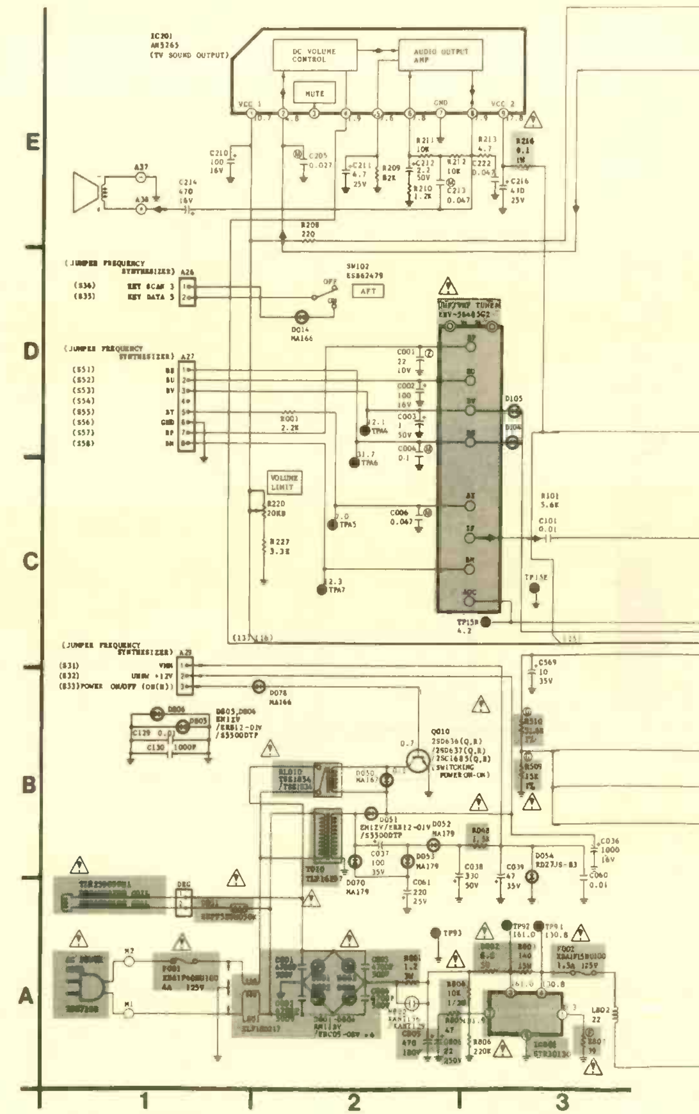


TROUBLESHOOTING low-voltage regulators

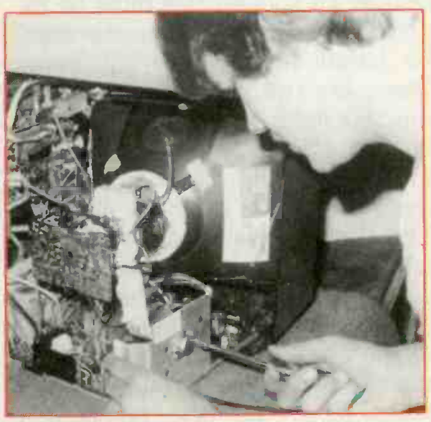
By Homer L. Davidson

All of the regulators discussed in this article have the same basic principle. A large power transistor is used as a variable series resistance between raw B+ and regulated B+. The resistance and conductivity of this power transistor is adjusted automatically by a control circuit that varies the transistor bias as needed to maintain a specific regulated output dc-voltage supply. Most of the models provide an adjustable control that can be rotated to obtain the desired output voltage. And then the circuit holds that voltage over a wide range of output current.

In addition, most regulators of this type have one or two large resistors that are connected in parallel with the collector and emitter of the power transistor. When the power transistor is biased to cut-off, these resistors continue to pass current, providing a minimum output voltage. The total power load (and its heat) is divided among three components (transistor and two resistors) in three locations, so elaborate heat sinks are unnecessary.

Symptoms of intermittent operation, HV shutdown, horizontal picture pulling, hum bars, insufficient width or height, weak locking, poor color and noisy sound might be caused by defects in the low-voltage regulator, and *not* in the horizontal deflection, vertical deflection, sync clipper or one of the other circuits that is *usually* the source of these problems. This can be very confusing. The conditions of power-supply voltages are easy to overlook during the initial stages of troubleshooting, but they are vitally important and *must be tested*.

Some important duties of the low-voltage regulator circuits are to regulate or stabilize the dc voltages applied to several stages or circuits of a TV receiver. And most important of these is the horizontal-output stage. If the horizontal-output transistor's supply voltage is permitted to rise as much as 10V, the dc high voltage might increase by several-thousand volts, causing arcs, or activating the HV shutdown circuit that stops all picture and sound.



One of the first tests during low-voltage regulator troubleshooting is to remove the horizontal-output transistor and compare the collector voltage with and without the transistor connected.

Of course, lower voltage at the output transistor's collector produces a smaller picture or a black screen without high voltage. Other symptoms and repairs will be described in the case histories.

Basic voltages and resistances

Some tests never change: The basic voltage and resistance measurements are two of them. Other essentials are in-circuit and out-of-circuit transistor tests.

The newer low-voltage regulator circuits (Figure 1) feature more integrated circuits (ICs), which can be tested in-circuit only for shorts and leakage. If you are certain a transistor or diode junction is inside the IC and connected between two pins, it can be tested with the diode voltage-drop test featured by some digital multimeters (DMMs).

Test the dc voltage at each terminal of the IC and (with power *off*) check the resistance from pin to ground of all terminals that had voltage (or should have had voltage according to the schematic). A low resistance reading might be caused by leakage in another component connected to the same terminal. Disconnect any paralleling capacitors, zeners or resistors while testing the IC pin's resistance to ground.

Power IC's, such as IC 901, have a high rate of failure. Also, an ohmmeter test is not sufficient. Sometimes the IC regulator breaks down under load, therefore, it must be replaced to actually locate the defective component.

No sound and no picture

Perhaps the first step should be measuring the dc voltage at the horizontal output transistor's collector (case) to determine if the low-voltage power supply is working. Very low voltage might indicate a defective output transistor or regulator. Remove the horizontal-output transistor (or the fuse for that stage) and notice what the dc voltage does. A higher voltage indicates a defect in the horizontal-deflection circuit, such as a shorted output transistor. Therefore, the attention should be directed there.

A low or no voltage at the collector might point to a defective regulator or low-voltage power supply. Rotate the B+ control and notice if the output voltage changes. If the B+ adjustment control has no effect on the B+ dc voltage, the regulator or power supply definitely is defective. Remove the horizontal-output transistor or the B+ fuse that supplies it and proceed to repair the regulator circuit first, using dc voltage and resistance methods. Diodes are prone to failure in regulator circuits.

An open principal filter capacitor can cause low voltage both into and out of the regulator. Check the individual diodes of the bridge, if the voltage is slightly low and has 60Hz hum that is difficult to filter. (Ripple from a true bridge should have a 120Hz frequency.)

Check the power-supply/regulator area visually looking for burned resistors, loose connections to the board or any other obvious signs.

In a Sharp SKC-1310A portable (Photofact 1851-2), I found fuse 4A F701 open and only +18V applied to the Q602 horizontal-output transistor. This voltage increased very little when the transistor was removed from the circuit, thus indicating power-supply/regulator problems.

Regulator transistor Q701 and diode D751 were tested in-circuit and appeared to be normal. I removed one end of D751 from the circuit and tested it for leakage. The diode was not leaky (Figure 2). At first, regulator Q701 was suspected of breaking down under load, but with the output transistor removed, the voltage remained too low. The principal (and only) filter capacitor (C705) was paralleled by a known-good capacitor with no improvement.

Finally, zener diode ZD751 was tested in-circuit and registered leakage. But when it was removed from the board, it was open in both directions and without leakage. Evidently, the zener had developed a *hot spot* in it that fragmented part of the solid-state element. I have seen the phenomenon of a traveling short, high leakage or open circuit before with power transistors and SCRs, but this was a first for zeners. The defective zener was reducing the Q701 base voltage.

Installation of a new 55V zener diode for ZD751 and minor adjustments brought normal operation with a full +120V from the regulator.

Fuse blows repeatedly

Although it is possible for a shorted component in the regulator circuit to repeatedly blow a fuse or trip a circuit breaker, the low-voltage circuits cause most fuse problems. If the B+ fuse continues to blow, remove the horizontal-output transistor to find if that stops the overload. If it does, the transistor probably is defective or has a very heavy collector load.

When the power-line fuse will not hold, check for a leaky or shorted diode rectifier perhaps in the bridge circuit where one or two diodes might be leaky. I use the DMM's diode test to check for such leakage. Some technicians prefer the high range of a VOM.

The overload often burns open a large high-wattage, current-limiting resistor that supplies the bridge. Of course, this must be replaced. And then the chassis must be handled safely during tests. There are two general ways of doing this (both have been discussed before). One is to connect a 100W incandescent light bulb in place of the fuse in the incoming ac line. The bulb resistance limits the amount of current that the TV can draw, while the bulb's brightness indicates approximately the amount of current. The other method is to use a variable-voltage transformer for the ac power. Operation with low voltage to prevent component failures during tests is an excellent procedure that has been described in detail in

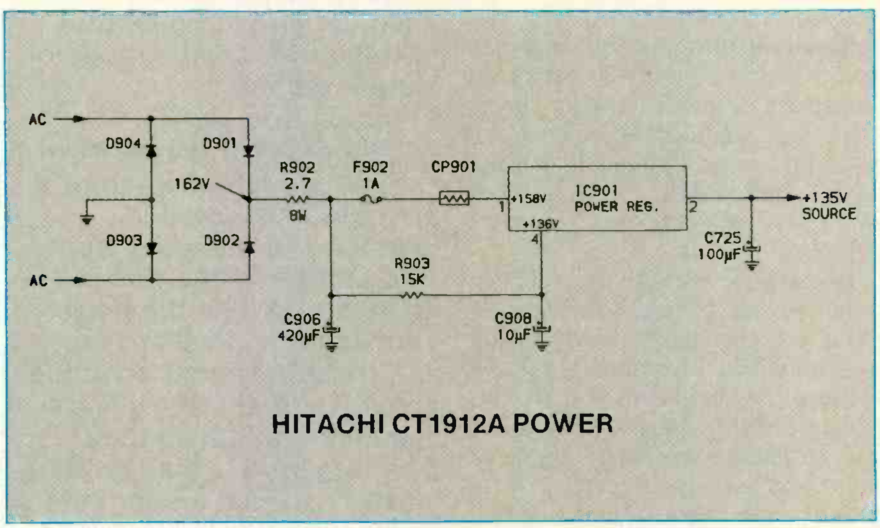


Figure 1. In the Hitachi CT1912A receiver (Photofact 2200-1), the functions of several transistors (including one power type) have been packed into one IC901 integrated circuit. Also, there is no adjustment control for the output voltage. The circuit is much more simple than the ones using discrete components.

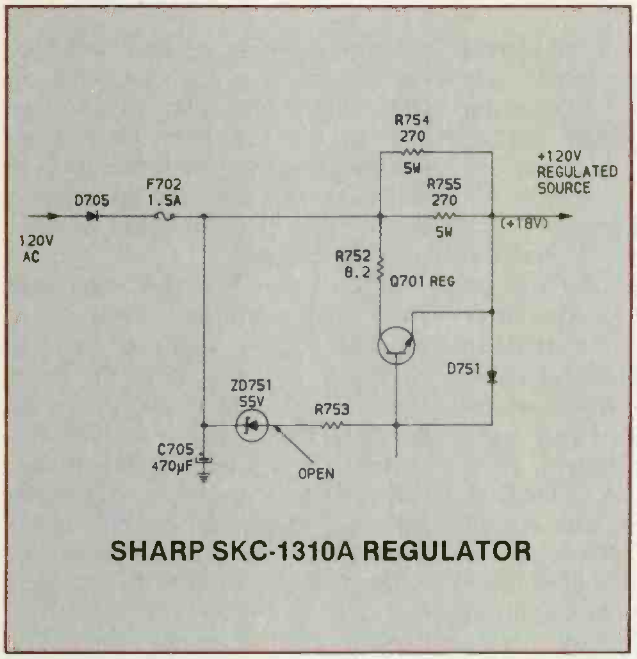


Figure 2. A leaky ZD751 zener diode produced a dead chassis in one Sharp SKC1310A color receiver. Only +18V were measured at the collector of the horizontal-output transistor, at the beginning. After the transistor was removed, the voltage increased a volt or so; nothing significant. Resistance tests finally determined that zener ZD751 was open. (In later tests it was shorted and in others it showed leakage. Obviously damaged by heat.)

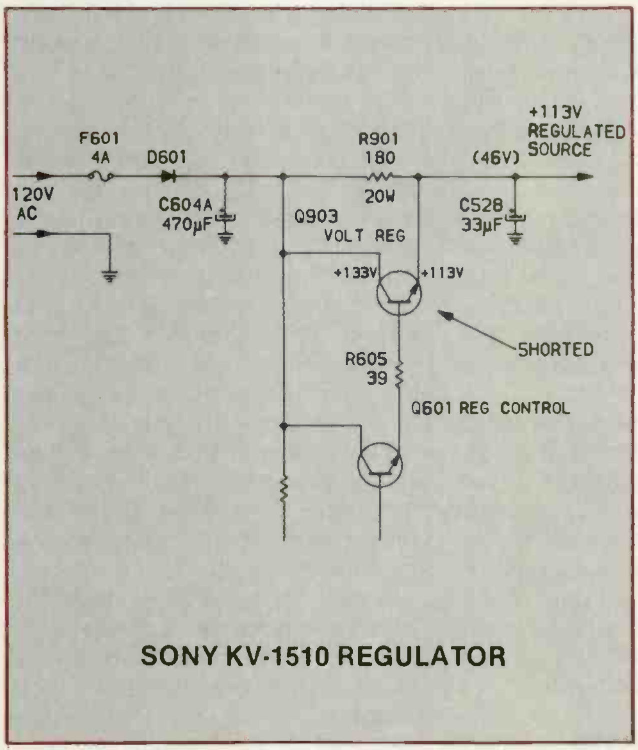
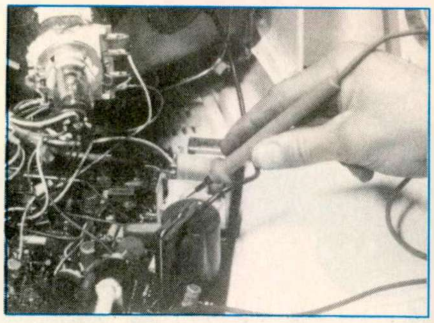


Figure 3. A shorted D903 voltage-regulator transistor in a Sony KV-1510 (Photofact 1322-2) produced hum bars. The first clue to this was the +146V at the collector of the Q903 voltage regulator where the voltage should have been +113V. In fact, the base, emitter and collector each measured +146V, obviously from internal leakage.



A convenient point to check the regulated LV supply is the collector of the horizontal-output transistor. This is one of the important points that must be monitored by meter as the variable-voltage transformer gradually increases the 60Hz voltage applied to the chassis. Other important voltages are the incoming variable ac voltage and the HVdc.

previous articles. When performed correctly, it is very satisfactory, allowing many tests while protecting the horizontal-output transistor from failure.

Hum bars

One or two hum bars moving upward in the picture usually are produced by a leaky regulator transistor or zener diode in the regulator circuit. First, try to adjust out the bars by correctly adjusting the B+ control. Sometimes a misadjustment of the B+ control will reduce the amount of regulation, causing the hum. Intermittent horizontal *pulling* of the picture might be a symptom, also, of the incorrect B+ control adjustment.

If the B+ voltage cannot be adjusted for the correct voltage, check each APF or regulator transistor for leakage. Remove the suspected transistor and perform another leakage test out-of-circuit. Sometimes the flat power transistors (TO-220 type) test leaky in-circuit but normal when removed. My advice is to replace them.

A high +146V from the low-voltage regulator and hum bars in the picture were the symptoms of a Sony KV-1510 portable (Photofact 1322-2). All three pins of the D903 voltage-regulator transistor tested the same voltage, and it was very high for the circuit (Figure 3). An in-circuit test showed D903 had leakage between all pins. We replaced D903 with a universal ECG277 transistor, which restored the picture and produced a normal +113V voltage source from D903.

Picture pulling

Usually, excessive horizontal tearing or pulling of the picture might be caused by defective filter capacitors or leaky components in the horizontal oscillator circuits. Also it is possible for leaky active-power-filter or AVR-regulator transistors to produce both faint hum bars and picture pulling. A leaky diode in the regulator circuit can cause the same symptoms.

Excessively high dc voltage was measured at the horizontal-output transistor's collector in a Panasonic CT-118 (Photofact 1858-1) that showed faint hum bars and erratic pulling of the picture. DMM tests of the Q801 AVR regulator transistor found excessive dc voltage at all terminals (Figure 4). When Q801 was removed from the chassis, it tested high leakage between collector and emitter.

Replacement of Q801 with a GE-35 universal replacement (and a small adjustment of R810, the +115V control) restored a normal picture.

HV shutdown

Many receivers have a shutdown circuit that can be triggered into stopping the horizontal deflection (and with it all receiver functions) by either of two general overloads.

Excessive HV–Usually, the most obvious trigger comes from a signal taken from the flyback. This pulse amplitude varies in step with the HV pulses (and the rectified dc HV). The circuit is designed to stop all receiver operation if the HV pulse exceeds a certain level. Therefore, the shutdown circuit primarily monitors *voltage*.

Excessive current–The second shutdown triggering signal comes from circuits that monitor the *current* (usually) at the *cold* end of the flyback's HV winding. (This is done by the current that flows through a series resistor, producing dc voltage. All variations of this voltage are sent to another part of the shutdown circuit, so shutdown is triggered (usually in a different way than for the pulses) by any abnormal increase of HV-winding current.

This increased current can come from many sources, such as a shorted picture tube. A shorted CRT gun or spark gap can force the CRT to conduct many times its normal current, which is sufficient to trip the shutdown. Therefore, the raster lights up, usually with just one bright color, then shutdown occurs after a second or so.

Shorted turns in a flyback winding or defective HV-rectifier diodes that increase the HV-winding current can activate the shutdown.

Low voltage vs. HV shutdown

Excessive output from the low-voltage regulator can cause shutdown by applying too much B+ voltage to the horizontal-output's collector. Of course, a higher horizontal transistor's voltage in turn produces a greater HVdc, forcing the circuit into shutdown. Good tests require a variable-voltage 60Hz transformer for ac power. Begin with the receiver's input voltage at about 30Vac (after you have dcV meters connected to the high voltage and to the collector of the horizontal-output transistor). Slowly increase the receiver's ac voltage and compare the two meter readings. If the dc high voltage reaches the rated value, but the ac line voltage is only 90V or 100V and the transistor collector has the full B+ voltage, it is certain a problem exists in the low-voltage regulator: The low-voltage supply is too high.

For excessive voltage look for defective regulator and reference amp and driver transistors, leaky diodes (also zeners) and open resistors.

Sanyo shutdown–When shutdown occurred, the low-voltage source increased to +149V in a Sanyo 31C40A (Photofact 1986-1). Of course, the regulator definitely is at fault when adjustment of the B+ control does not change the +149V. And the first components to be tested should be the VR001 B+ control and all other resistors, transistors, zeners and diodes in that vicinity (Figure 5).

All regulator transistors tested normal, with no opens or serious leakages. However, we replaced Q901 because many of these break down under load. The operation was no better after an ECG369 replaced the original Q901.

Incidentally, the large resistor that usually is connected between emitter and collector of power-regulator transistors is here in the Photofact 1986-1 schematic, but somewhat hidden. Follow this path from the +152V input on through the 0.4A F002 fuse to one end of R901, which is rated at 160Ω at 20W, and is the regulator-assist resistor. The other end of R901 connects to diodes D003 that produce their required voltage drop and connect to the +120V source, which connects to the Q901 emitter through R011, a 1Ω resistor. Except for the D003 voltage drop, this is merely a 160Ω resistor connected between collector and emitter of Q901. The method of drawing has made it appear complicated.

Each diode was tested for leakage after one lead was disconnected from the circuit, but no leakage was found. C005 was tested in-circuit and appeared to be normal. The resistors were checked after one lead of each was disconnected. All were within tolerance until R013 (a 49kΩ 1% precision resistor) was found to be open. Of course, 49kΩ at 1% tolerance is difficult to obtain. I solved the problem by assembling several 47kΩ and several 2kΩ resistors and (with a digital ohmmeter) trying several series combinations of individual 47kΩ and 2kΩ resistors until a pair was found that gave the desired 49kΩ at about 1%.

The open R013 resistor had reduced the positive voltage at the VR001 B+ adjustment control. The regulator circuit viewed this as a decrease of the +120V source, so it promptly attempted to increase the +120V supply voltage. And it did increase...and increase... until the output became +149V unregulated.

Replacement of R013 and an adjustment of VR001 B+ control solved the shutdown problem and gave good receiver performance.

Delayed shutdown

An intermittent or delayed shutdown can be very difficult to locate because it usually is caused by a defective component. Some component is shorting or opening after it becomes heated. Transistors and diodes sometimes become erratic when they reach a critical temperature. Terminals that have burned or poor-contact areas on high-wattage resistors might cause intermittents.

With a sharp 15B50A model

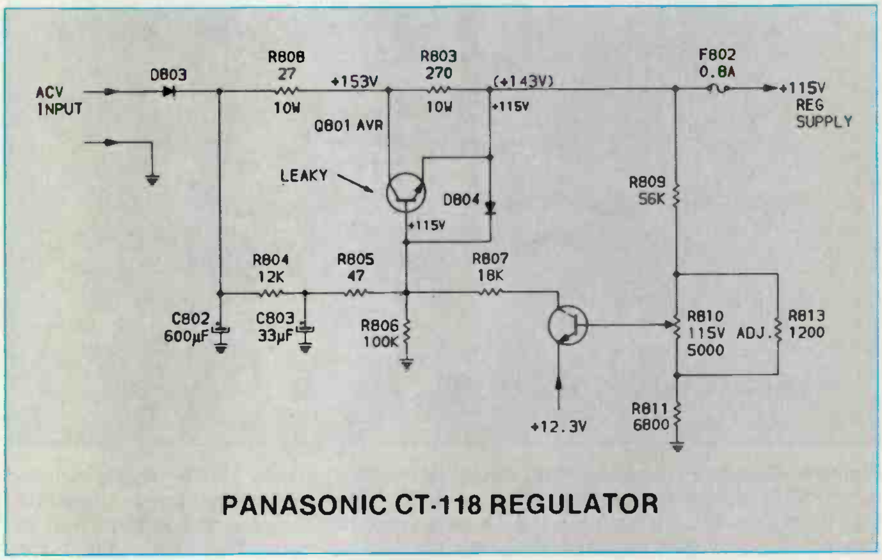


Figure 4. Excessive *picture pulling* was caused by a leaky D801 regulator transistor in a Panasonic CT-118 model (Photofact 1858-1). Voltage at the horizontal-output collector was a high +143, and it in turn was increasing the high voltage and many horizontal pulse voltages throughout the receiver.

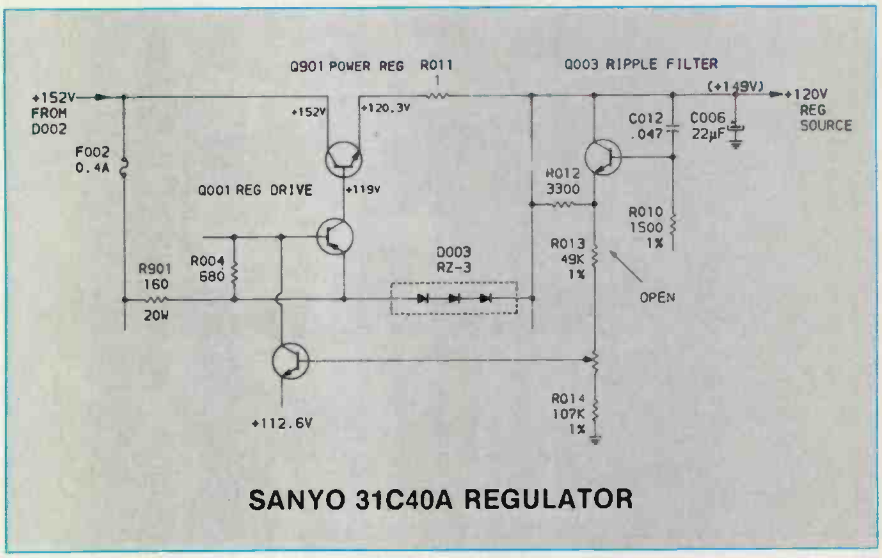


Figure 5. An open 49K R013 resistor in series with the B+ adjust control of a Sanyo 31C40A portable (Photofact 1986-1) forced the regulator to give out excessive voltage (+149V). This higher voltage caused the horizontal-output stage to produce more high voltage. Therefore, the receiver was dead from shutdown.

(Photofact 1817-2), the sound was heard and the raster appeared before shutdown occurred. A variable-voltage ac transformer was connected to supply the 60Hz power, and a DMM probe was attached to the collector (case) of the horizontal-output transistor. Then the ac voltage was increased from a low voltage up to 120Vac. The collector voltage reached +167V before the ac voltage reached 120V. It was a classic case of B+ regulator failure.

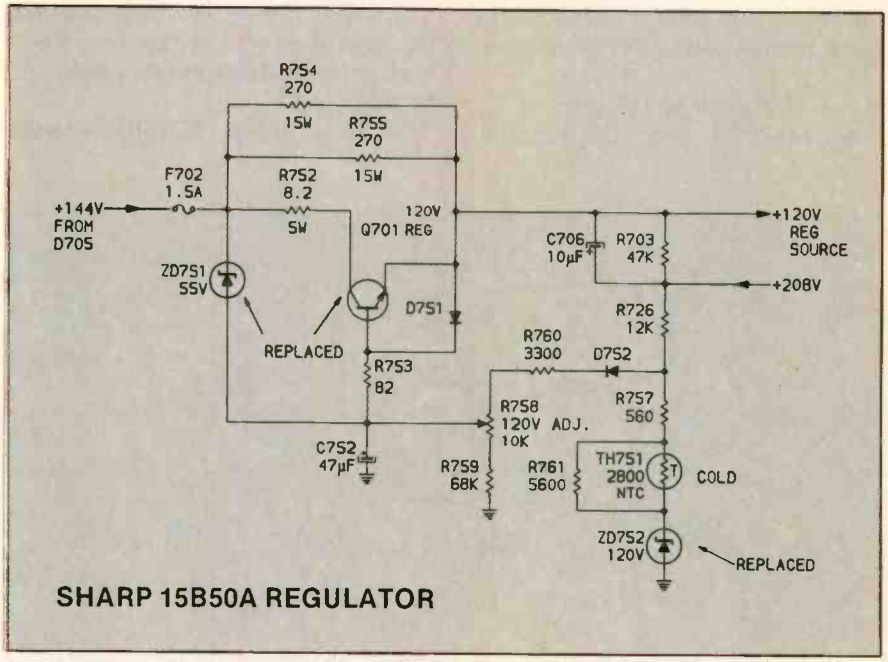


Figure 6. The low-voltage regulator circuit of the Sharp model 15B50A model (Photofact 1817-2) follows the general patterns of the others by having a power transistor that functions as a variable-resistance series resistance to vary the voltage drop as needed. But it is different in not having any smaller transistors or ICs. When the cause of the shutdown could not be found with the resistors, we replaced Q701 the power transistor, and two zeners, ZD752 and ZD751. These can't be tested adequately, except by replacement. The receiver operated properly.

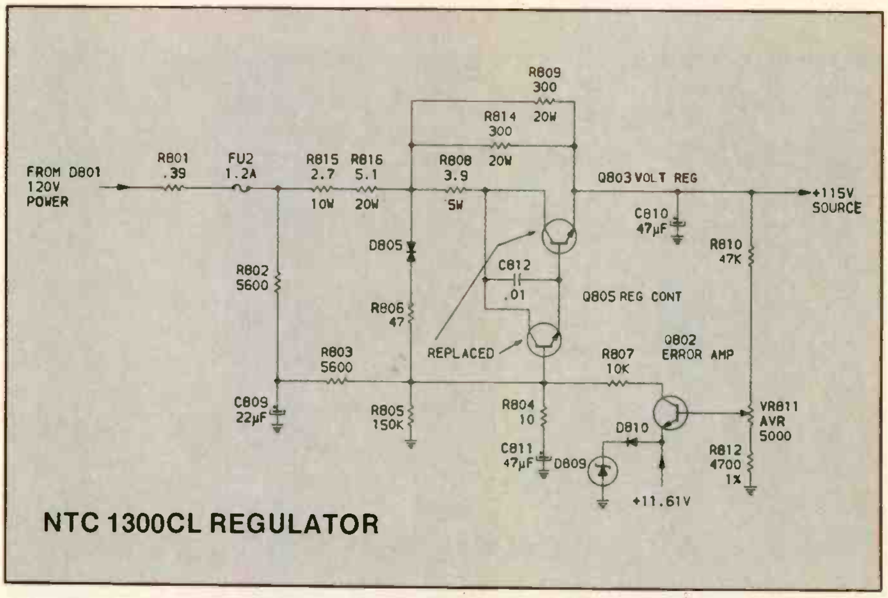


Figure 7. A pulsating +129V at the horizontal-output's collector gave a raster that would flash *on* and *off* rapidly with an NTC 1300-CL portable (Photofact 1777-2). Resistors, diodes, zeners and transistors were tested in-circuit without any defects being found. On a guess, Q803 regulator and Q805 regulator-control transistors were replaced, and the pulsating voltage with flashing raster returned to normal.

Because voltage-regulator transistors have a tendency to break down, we replaced Q701 with a GE-35 universal (Figure 6). Next, both zener diodes were replaced. ZD752 was replaced with a 120V zener and ZD751 was replaced with a 55V zener.

After the regulator transistor and the two zener diodes were replaced, the receiver operated for hours. Performance, good; intermittent shutdown, gone.

Flashing raster

Both sound and raster would flash *off* and *on* at a rapid rate in an NTC 1300-CL portable television (Photofact 1777-2). At the horizontal-output transistor's collector, the dc voltage was a high +129V and pulsating (Figure 7). Adjustments of VR811 changed the B+ output only slightly. When the line voltage was reduced to provide +115V at the output transistor's collector, the flashing disappeared. The diagnosis was definite: The regulator was not reducing the dc voltage properly.

Q803 voltage-regulator and Q805 regulator-control transistors were checked in-circuit, testing normal. Similarly, diode D810 and zener diode D809 both tested good in-circuit. All resistors around the critical area were tested and found to be within tolerance.

After we replaced Q803 and Q805 regulator transistors, the B+ control could be adjusted for the normal +115V, and none of the adjustments slightly above and below that point caused any flashing or other instability.

Intermittent raster

Intermittent-raster problems appear with many different symptoms. A raster with picture might light normally and then black out immediately, or the receiver might operate normally for several minutes before losing the raster. There are a number of defects that could cause such intermittent operation. These are some of the conditions, components or circuits that should be tested:

- Momentary loss or change of

CRT grid voltage, screen voltage, heater power and other CRT problems including socket defects;

- A video problem that biases the CRT into cut-off intermittently;
- Any overload that forces the receiver into shut-off.

In addition to defective electronic components, intermittent rasters can be caused by corroded circuit-board connectors, loose mounting or ground screws and loose connections to or inside resistors. There are many more similar problem sources.

With an older Admiral 4M10 color portable (Photofact 1591-1), the raster would go black for about a minute and then return. When the chassis was cold and functioning correctly, the R901 B+ adjustment varied the voltage source from +114V to +130V (Figure 8). But when the raster went black, the +120V source measured +135V.

We replaced the Q900 pass driver, but the conditions were unchanged. All the resistors, one diode and one zener (forward conduction) in the regulator circuit were tested in-circuit and none found defective. Finally, during a power-on test, I noticed zener D901 had +132V across it. This was incorrect, because D901 is included to stabilize the voltage there at +125V.

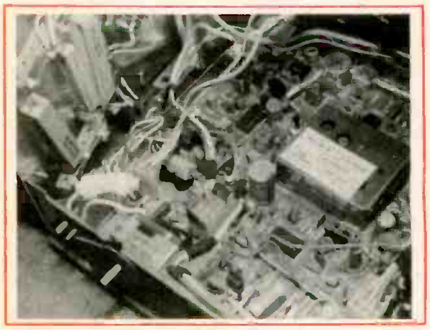
Installation of a new 125V zener to replace D901 stopped the intermittent raster, giving a good, dependable picture.

Lightning damage

Damage from lightning that comes in through the 60Hz-power wiring can be minor or extensive and all degrees in between. For the first step, give the chassis a thorough visual inspection, particularly around the power-supply area. In addition to burned resistors, insulation of wires and plastic connectors, look for damage to the circuit board. If large holes have been burned in the board, destroying much wiring, it might be wise to judge it beyond repair.

When the chassis shows no major visible signs of damage, the next steps are to test the line fuse, the line-rectifier diode (or diodes), the filter capacitor, any low-resistance current-limiting resistors, the *on-off* switch and the voltage regulator transistor (or SCR). It's possible for a minor lightning strike to ruin only those components just listed. But a stronger bolt can fuse conductors and burn components at many areas of the receiver, including some that have no direct connection with the 60Hz power or the antenna. Many of those receivers will be declared a total loss.

When a Sanyo 91C64 portable color receiver (Photofact 1929-3) was brought to the shop, we discovered it had been damaged by lightning. I replaced the F001 4A fuse, the RA2 low-voltage rectifier, the R002 2.2Ω current-limiter resistor, the R017 1.8Ω isolation resistor and the Q901 power-regulator transistor (Figure 9).



After lightning strikes (or affects) a TV chassis, always check each regulator transistor, all diodes and voltage-dropping resistors. Also, check the circuit board for burned or damaged wiring.

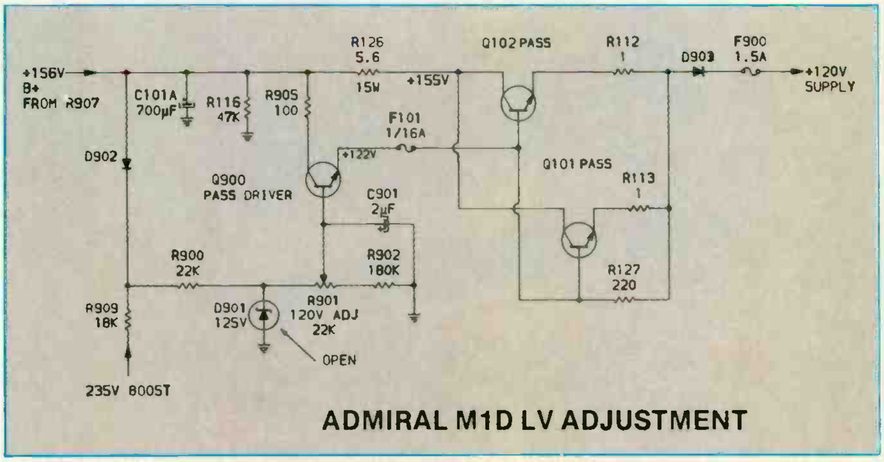


Figure 8. An older Admiral 4M10 color portable (Photofact 1591-1) developed an intermittent loss of raster. During the usual in-circuit testing of components, it was noticed that 125V zener D901 had +132V across it. The zener was there to hold that voltage to +125V, so the zener must be open. Installation of a new D901 stopped the intermittent.

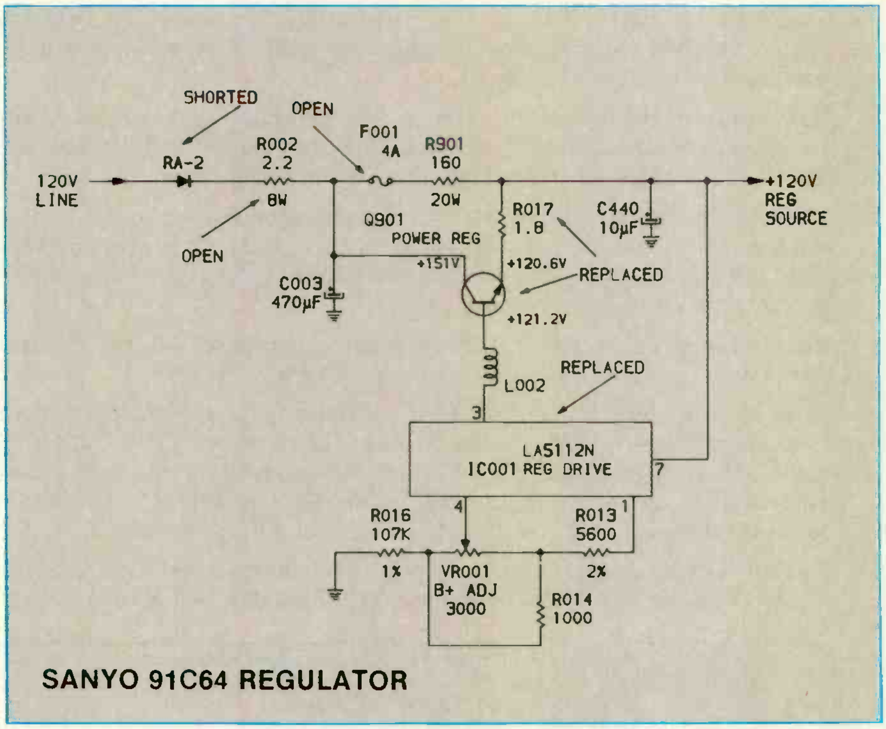


Figure 9. After a nearby lightning strike zapped a Sanyo 91C64 (Photofact 1929-3), we had to replace the F001 4A fuse, the RA2 rectifier, the R002 2.2Ω resistor, the R017 1.8Ω resistor and the Q901 power-regulator transistor. It was necessary also to replace IC001 before the performance was good.

With all these components installed, the receiver had a raster, but that raster had hum bars and the +120V source checked only +106.5V, also the B+ control had no effect on the regulator's output voltage.

Finally, replacing IC001 (LA5112N) with a universal SK9188 power regulator increased and adjusted the +120V source while it eliminated the hum bars. The portable color receiver was ready for the customer.

An unusual problem

Sometimes when the chassis of a Goldstar KMC1311 was moved or jarred, the raster and sound would disappear. Yet, the receiver might operate for three or four hours without any problems. Or, the circuit might shut down at turn-on. When the chassis was dead, no voltage was applied to the horizontal-output transistor's collector.

The low-voltage power supply and regulator circuit were checked for loose soldered connections and intermittent components, but we found none. When the receiver was dead, a touch with the DMM probe would bring the receiver to full activity. After several attempts, we found the ac voltage was missing from the silicon diodes when the set was dead. Then the ac voltage was traced back to the 3A fuse holder. Just a touch on the fuse, and the chassis began to operate.

Evidently, the fuse or holder was involved. All connections from the fuse holder to the board wiring were good, but one fuse-clip end was bright and the other was dark. *The fuse holder was defective!* Instead of replacing the fuse holder with a new one, we decided to solder a 3A slow-blow *pig-tail* fuse direct to the circuit board in parallel with the old fuse holder. And that solved the mystery of the intermittent power.

Comments

Here are a few suggestions that didn't find a place in the case histories. Because of the heavy wattage they must handle, power-regulator transistors cannot be checked adequately with the test equipment we have. Leakage that is very small when checked by a meter sometimes begins to multiply as the in-circuit voltage and current are increased. Therefore, the only certain test of a power transistor that has good junctions but is still questionable is to replace it and observe the results. A correctly operating transistor was defective, regardless of test results.

Remember, when the horizontal-output transistor is removed for tests, the B+ adjustment probably will not vary the B+ regulated voltage. The B+ will be too high or too low, but it's not likely to be the correct voltage until the horizontal transistor furnishes a normal load.

Make a habit of tightening all power-transistor mounting screws. Many intermittents originate from those loose screws.

For your safety and to protect your equipment, always use an isolation transformer for the 60Hz power. Also, a variable-voltage 60Hz-line transformer is essential for testing shutdown problems or cases of severe overload. *Both transformers are essential.* A variable transformer does *not* isolate, and an isolation transformer does not vary the voltage.

ES&T

What do you know about electronics?

A high-speed model

By Sam Wilson, CET

Figure 1 shows a model that often is used to describe the operation of a bipolar transistor. The arrows show the relative amounts of current flow in the base and collector when the transistor is properly biased for operation.

The general approach is to explain that a positive voltage on the base causes many charge carriers (electrons in this case) to move from the emitter to the base region. Once in the base, these charge carriers fall under the influence of the collector potential, and most pass into the collector.

I was talking to a friend about some very strange theories I've heard during my years of experience in electronics. He told me about a model for bipolar transistor operation that he was taught when he was a student at the university. The same illustration was used (Figure 1). Here is the way the explanation goes:

The electrons in the emitter are attracted by the positive base and collector voltages. By the time they cross over the emitter-base junction they are going so fast that only a few can make the turn and go out the base lead. Most of them just plow into the collector region.

I know this explanation will sound silly to you, but think about this: If you were trying to teach young people about transistors, you might sell them on that model. You could tell them that this is just a convenient way to look at the transistor.

I don't know what to say about

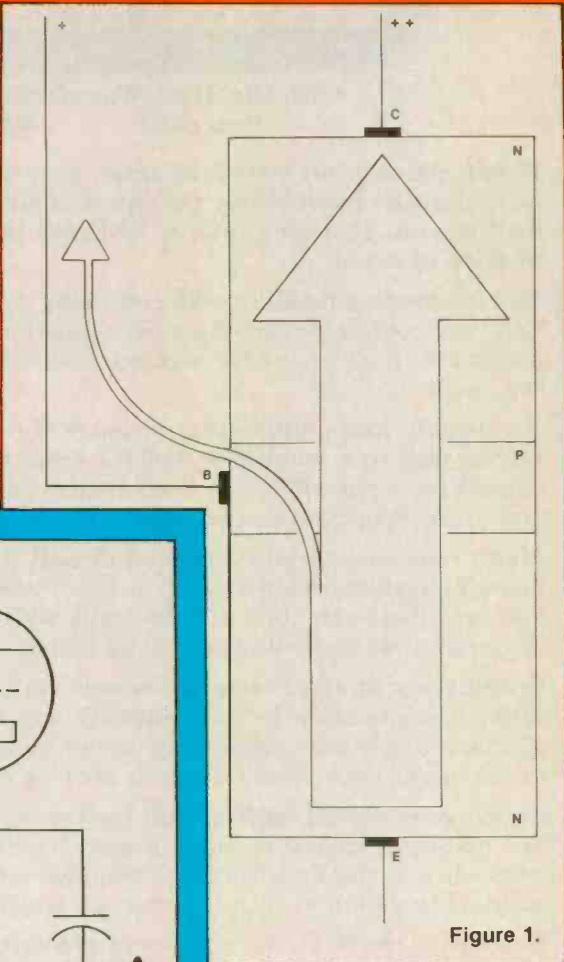


Figure 1.

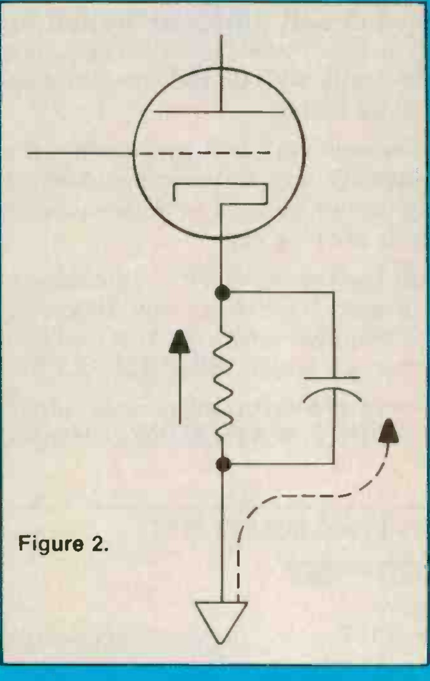


Figure 2.

the idea of telling this to university students.

Planned obsolescence

Whenever I'm with a group of technicians and the subject of strange theories comes up I find that everyone has a story to tell.

When I started my first full-time teaching job, I was required to sit in the class of the oldest and most venerated instructor on the campus. On the first day he was explaining the operation of the cathode bypass capacitor shown in Figure 2. Here is the way it went:

Instructor–On one half-cycle, the electrons flow through the resistor (solid arrow). On the next half-cycle, the electrons flow into the capacitor (broken arrow). This cycle repeats over.

Puzzled Student–"It seems to me that the capacitor would eventually get full of electrons."

Instructor (With his most feared "You are stupid" tone)–"Well, young man, that is why radios can't operate forever."

The 4-layer diode

For several years I have been writing about the characteristics of a 4-layer diode and some of its applications. However, it is next to impossible to buy such a diode without getting them in quantity, so there haven't been any good lab experiences with this component.

Sometime recently I ran across the solution to this problem. Unfortunately, I can't find that reference. The idea is that *an SCR*

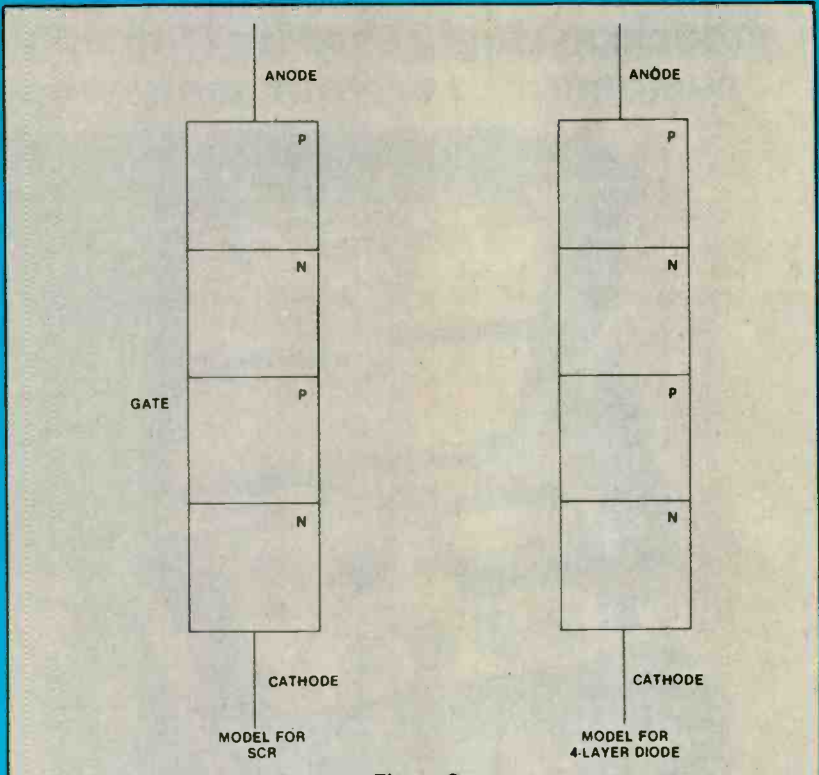


Figure 3.

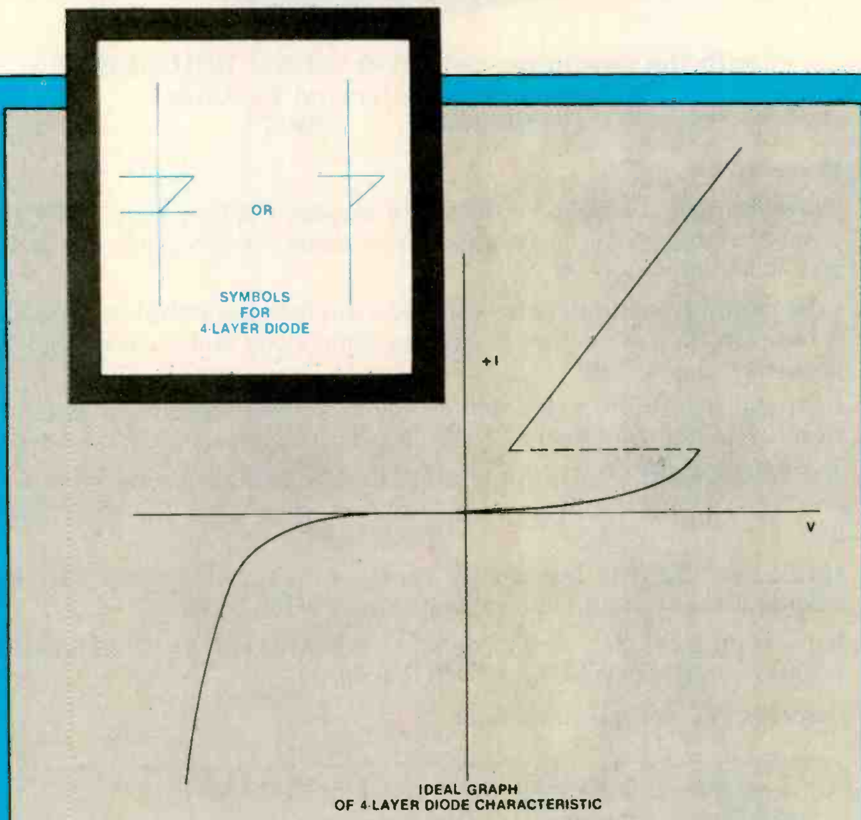


Figure 4.

can be used as a 4-layer diode if you leave the gate open.

Figure 3 shows the model most often used for an SCR. It shows why it can be used as a 4-layer diode (also shown).

By way of review, refer to Figure 4. The 4-layer diode is a breakover device in the forward direction. In other words, when it is forward biased, it behaves like a neon lamp.

When reverse-biased, it behaves like two identical reverse-biased diodes in series.

Four-layer diodes are also known as Shockley diodes.

I haven't had a chance to try the SCR idea. My next step is to try this in the lab. In a future issue, I'll tell you how well it works.

In the meantime, I will tell you what *hasn't* worked. That is to put two junction diodes in series to try to get the 4-layer characteristic.

Here we go again!

There are some problems and questions related to electronics that make the rounds every two or three years. I don't want to give them the dignity of calling them classical questions. I'm not sure whether any point is proven by being able to solve them (or, not being able to solve them). Printing those problems and giving the solutions does not, unfortunately, make them go away.

Figure 5 illustrates an example. It was given to me recently by a student at New England Institute of Technology. (This school is located in Palm Beach, Florida. I wonder if there is a Palm Beach Institute of Technology in Maine.)

The question is: What is the resistance between terminals A and B? All of the resistors on the cube have the same value.

Attempts to solve this problem with series and parallel resistances usually result in failure.

The best approach is to assume a voltage across the terminals. Current flowing into R1, R2 and R3 will divide evenly because each of these resistors looks into two identical parallel resistors. So, the three resistors are in parallel.

By similar reasoning, R3, R4 and R5 are also in parallel.

It follows that R1, R2 and R3

terminate at equal voltage points because they have identical currents and resistances. Likewise, R4, R5 and R6 also terminate in equal voltages.

Figure 6 shows the result of this reasoning.

Because the remaining six resistors are connected between these equal voltage points, they must be in parallel.

When three identical resistors are connected in parallel, the resistance of the combination is one-third the value of one resistor. Likewise, six identical parallel resistances will have a resistance that is one-sixth of a single value.

Figure 7 shows the result. The circuit resistance is:

$$\frac{1}{3}R + \frac{1}{6}R + \frac{1}{3}R$$

$$= \frac{2}{6}R + \frac{1}{6}R + \frac{2}{6}R$$

$$= \frac{5}{6}R$$

The resistance of the circuit between A and B is 5/6 the value of one of the resistors.

If you know of an example of one of these nonsense problems, you can do me a great favor by sending it to someone else.

A critical look at electron current

Until the invention of the bipolar transistor in 1948, there were two theories of current that were strong rivals. Electrical engineers, physicists and many other scientists used "conventional" current flow. In other words, they assumed that current flows from positive to negative.

People at all levels of electronic jobs used electron flow–that is, they assumed that current flows from negative to positive.

The argument for electron flow was based, in part, upon tube theory. If electrons flow from cathode to plate, it follows, supposedly, that current goes that way too. The opposing argument is that an electron wouldn't go to the plate unless there was a positive place (hole) for it to go to. That hole goes from the plate, where

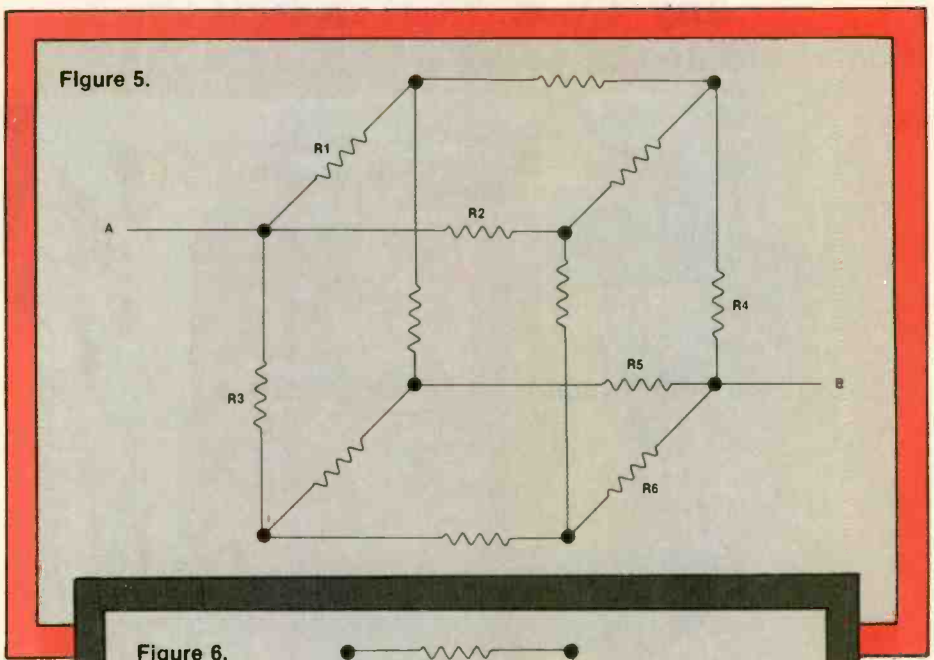


Figure 5.

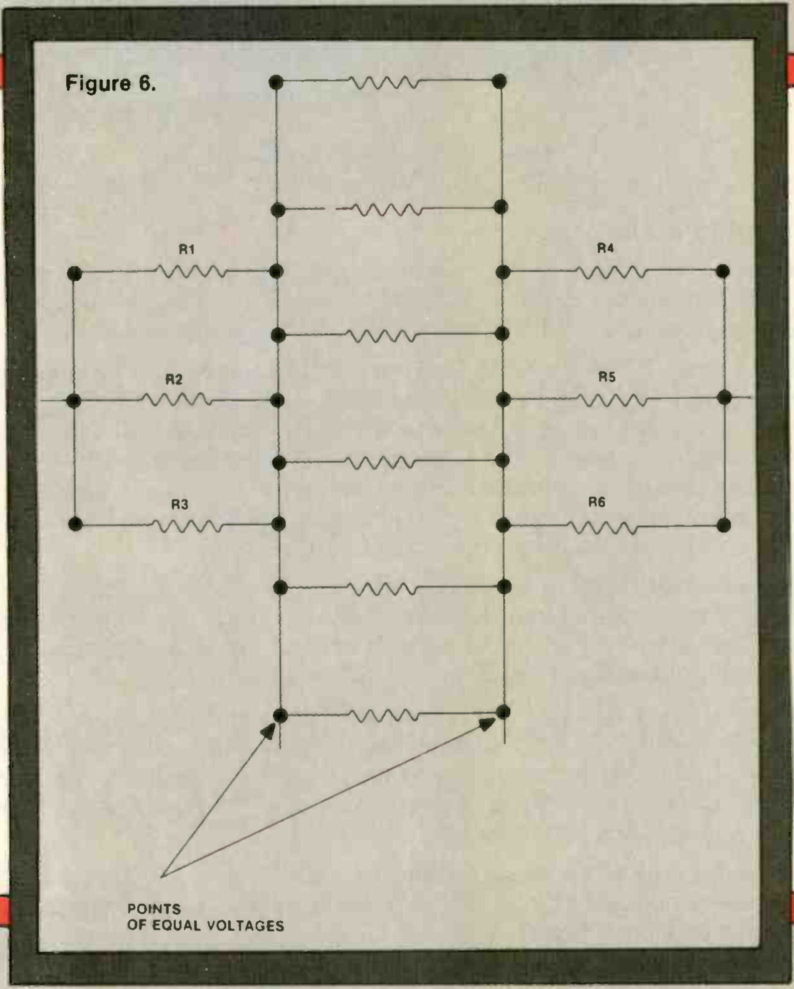


Figure 6.

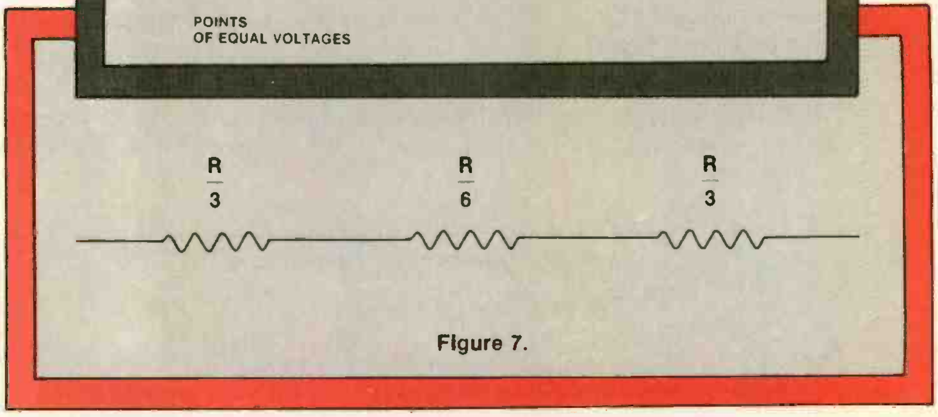


Figure 7.

the electron is, to the cathode, where the electron was.

Another argument for electron flow was the motion of electrons through a copper wire. It consists of a flow of *free electrons*. In fact, this is true for current flow in all metals. According to this argument, there can be no current flow unless there are free electrons to carry the current. So, current must be electron flow.

It can be argued that electrons can't go from one place to another unless a hole goes in the opposite direction.

Consider the following numbers.

A cubic centimeter of germanium at room temperature has about

44,000,000,000,000,000,000,000

atoms. The resistance between opposite faces is about 47Ω due to its

25,000,000,000,000

free electrons. It has an equal number of holes.

A cubic centimeter of lightly doped P-type material has a resistance of only about 10Ω. It has about

368,000,000,000,000

holes, and only about

1,700,000,000,000

free electrons. In other words, there are about 216 times more holes than electrons.

The low resistance of doped P-type germanium cannot be accounted for in terms of free electrons. So, current flow through the P-type material must be due to hole flow: *positive* to *negative*!

If you look at modern textbooks for electronics engineering or technology, you will find conventional current being used. However, if you look at textbooks for technicians, you see electron flow still being used.

The overall result is a mess. When technicians communicate with engineers, they have to sit on opposite sides of the table to get the current to flow in the same direction for both.

Question: Which way do the arrows in semiconductor symbols point?

Answer: In the direction of *conventional* current flow.

Question: Why can't we put this concept of electron current to sleep once and for always? **ES&T**

Literature

64-page Blue Book

Non-Linear Systems' 1987-88 full-line catalog describes the company's latests offerings that encompass over 2,000 models of digital panel meters and battery operated portable test instruments. Test instruments included in the catalog are digital multimeters, oscilloscopes, frequency meters and circuit/component analyzers.

Circle (128) on Reply Card

Interchangeability guide

Batt-Tronic Corporation has published a guide for watch/calculator battery interchangeablity. The guide features interchangeability information for both foreign and American watch and calculator batteries. Valuable tips are included on proper battery replacement along with a complete catalog of products and services.

Circle (129) on Reply Card

Test and measurement catalog

The latest edition of the *Philips Test and Measuring Instruments* catalog for 1987-88 is a 270-page document that provides details on Phillips' range of test instruments, with full information on all new products introduced in the last year. Product model number indexing enables fast location of any instrument. Full information is provided to allow ordering of any of the equipment from Philip's sales offices worldwide.

Circle (130) on Reply Card

Rental product guide

For those contemplating leasing rather than buying part of their equipment, *Leasametric* offers a 198-page rental product guide designed for easy reference. It incorporates an informative overview, product descriptions, specifications and selection guides. Indexes and cross-reference charts facilitate product comparisons.

Circle (131) on Reply Card

Multiple-outlet strips catalog

Sockets Plus Multiple-Outlet Strips catalog from *Perma Power Electronics* lists features and detailed specifications for 113 models, having as many as 12 outlets each. Special models for industrial/laboratory, hospital-grade and high-abuse environments are included, many with rack-mount options. Strips are available with a patented surge suppressor,master switch and indicator light. Photos and diagrams are included.

Circle (132) on Reply Card

Heat sink catalog

Thermalloy is offering its 1986/87 catalog that includes 20 new stamped heat sink designs.

Over 250 extruded heat sink profiles have been added. There are six pages of labor-saving options.

Circle (133) on Reply Card

Books

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

CD-I and Interactive Videodisc Technology, by Steve Lambert and Jane Sallis; Howard W. Sams, 224 pages, $24.95 softbound.

A source book for programmers and producers of interactive media, computer and audio-visual enthusiasts, this guide describes techniques and methods for creating interactive videodisc (IVD) and compact disc-interactive (CD-I) applications. There are chapters of a technical nature along with chapters delineating the user's role within the high-tech environment. Topics include:

- Interactive videodisc development and technical overview.
- Types of laser videodiscs.
- Videodisc formats.
- Levels of interaction.

With their work in industry and optical media journalism, the editors, Lambert and Sallis, have been following this emerging technology since its beginning.

Published by Howard W. Sams and Company, 4300 W. 62nd St., Indianapolis, IN 46268; 1-800-428-SAMS.

Elements of Electronic Instrumentation and Measurement, 2nd edition, by Joseph J. Carr; Prentice-Hall, 515 pages, $42.67 hardbound.

This updated edition relates to the many changes in instrumentation that have developed since the original text was published in 1978 – the present, widespread use of digital electronic control, for example. Electronic instruments for measuring have proliferated to such an extent that technicians and others in the field find themselves heavily involved with an array of electronic devices.

In this book, readers will study instrumentation techniques, be introduced to certain commercial products and will come to understand the what and why of measuring, and the instruments in use.

Published by Prentice Hall, Inc., Englewood Cliffs, NJ 07632; 1-800-223-2336.

Electronic Principles: Integrated and Discrete, by James F. Cox and S. Roger Everett; Prentice-Hall, 553 pages, $41.33 hardbound.

Here are authors who believe that some electronics instruction is as obsolete as teaching Model-T repair in today's Space Age. For readers who understand the basics, this easy-to-follow book provides concise yet thorough coverage of discrete circuitry, IC op-amps, combining integrated and discrete electronics, transducers and optoelectronics. There are troubleshooting sections at the ends of each of the 13 chapters.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 1-800-223-2336.

Solid-State Projects You Can Build, by Rudolf F. Graf and George J. Whalen; Howard W. Sams, 176 pages, $10.95 softbound.

These do-it-yourself building projects require only simple tools and a VOM. A sampling of the projects includes:

- Electronic dice.
- Television remote-sound system.
- Wireless video camera link.
- Computing thermometer.
- Proximity or touch alarm.
- Sing-along light controller.
- Rally-mate time-piece.

There are complete step-by-step construction procedures, illustrated with drawings and photographs.

Published by Howard W. Sams & Company, 4300 W. 62nd St., Indianapolis, IN 46268; 1-800-428-SAMS.

Troubleshooting Techniques for Microprocessor-controlled Video Equipment, by Robert L. Goodman; Tab Books, 352 pages, $16.50 paperback, $24.95 hardbound.

To facilitate servicing the *electronic brains* now used in everything from color televisions to VCRs and videodisc players, this book breaks down the intricacies of microprocessors and digital electronics with step-by-step demonstrations. Following a short course on digital electronics, there is an introduction to troubleshooting techniques for logic circuits, using digital logic probes, logic monitors and oscilloscopes. Finally, the highly sophisticated troubleshooting method, *signature analysis* developed by Hewlett-Packard, is detailed in one complete chapter.

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

ES&T

Photofact

These Photofact folders for TV receivers have been released by Howard W. Sams since ES&T's last report.

AOC
C9163MB 2507-1

EMERSON
ECT1900/A/B 2503-1

EMERSON
MS30R, MS30RA 2507-2

EMERSON
ECR222 2508-1

HITACHI
CT1365 2505-1

HITACHI
CT2066, CT2066J, CT2066WJ 2506-1

MAGNAVOX
25C201-AA/2-AA/3-AA/4-AA/5-AA/6-AA 2503-2

MITSUBISHI
CS-1453, CT-1454R 2506-2

PHILCO
Chassis 19C511, 19C529 2508-2

RCA
Chassis CTC120D SUB1 2502-1

RCA
Chassis CTC130C 2504-1

SEARS
564.42090550 2502-2

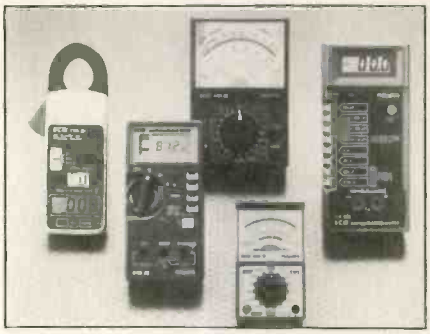
SHARP
20KP75 2504-2

SHARP
25KV785 2505-2

Products

Test equipment, accessories

Philips ECG has announced the addition of five multimeters to the company's Test Equipment & Accessories line.



The new products include the pocket-sized AM-14, a versatile yet economical analog multimeter, AM-20, a general purpose VOM analog multimeter; CM-30, clamp-on digital meter for reading ac current; CX-920, a digital capacitance meter; and DM-76, an autoranging digital multimeter.

Circle (75) on Reply Card

32-channel logic analyzer

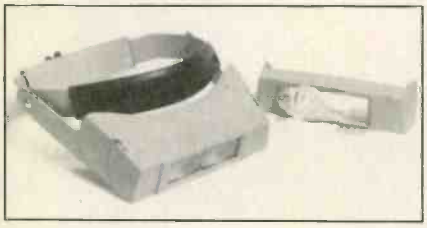
The *Advanced Microcomputer Systems* logic and data analyzer PC Logic 1 and PC Logic 2 from Advanced Microcomputer Systems is an analyzer that is compatible with the IBM PC bus with up to 32 channels of data-capture input at a sample rate of 50MHz. The analyzer includes a completely menu driven software package that displays logic diagrams as

well as data dumps in binary, octal, Hex, and ASCII format on the PC monitor. The expansion and compression of channels and samples provides for maximum data analyzing flexibility. The software also allows the user to save and load data onto the disk.

Circle (76) on Reply Card

Magnifier for work or hobby

The Mark II Magni-Focuser by Edroy Products is a binocular magnifier with a single, shatter-resistant, optical quality lens. The absence of a center post in the lens



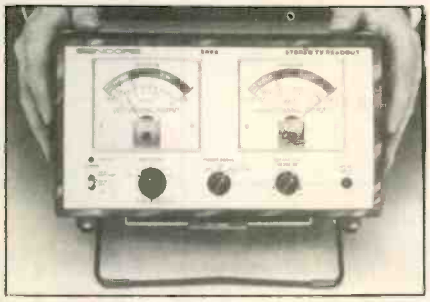
provides an unobstructed field of view. Weighing only 4½ ounces, the Magni-Focuser is comfortable throughout many hours of use. Its contoured, padded vinyl headband is adjustable, self-locking, fully washable and replaceable. Front lens plate units are interchangeable, snapping on and off to meet various distance and magnification requirements. The Magni-Focuser may be worn over regular or safety glasses and flips up, out of the way when not needed. The flip unit is constructed of high-impact ABS plastic, with nothing to wear out, corrode or stick.

Circle (77) on Reply Card

Stereo-TV readout

Sencore Electronics announces a method to accurately analyze stereo TV audio.

The SR68 Stereo-TV Readout is reported to allow the service technician to measure the output of audio amplifiers; either at the line or speaker outputs. It incorporates dummy loads that provide to 100W per channel of power dissipation to catch even elusive problems that may show only when components are stressed to their full potential.



This testing device provides dual meters to visually monitor the outputs, and measures the audio levels directly either in dB or watts. Audio separation of stereo circuits may be automatically measured to as low as -40dB by simply turning one knob.

Circle (78) on Reply Card

High resolution monitor tester introduced

Network Technologies has introduced the Montest-RGB5, a portable tester for high resolution CRT monitors. The tester is designed for use with monitors implementing scan rates of 50kHz and having 798 lines of resolution.

Most often used with CAD/CAM and desktop publishing software, these monitors must be maintained for proper resolution and clarity. The MONTEST-RGB5's battery-powered portable design allows it to be taken directly to the field rather than requiring that monitors be returned to a central depot for repair and alignment.

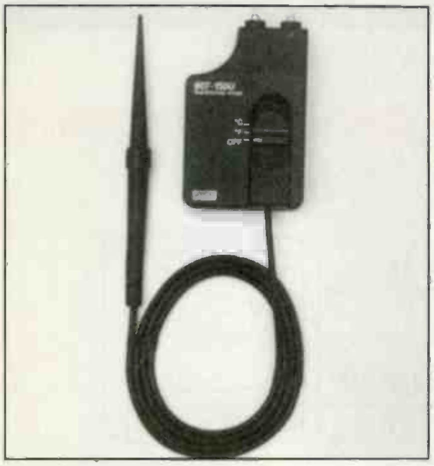
Circle (79) on Reply Card

Temperature probe converts DMM

John Fluke Manufacturing presents the 80T-150U Universal Temperature Probe, a measurement accessory that converts any digital multimeter into a thermometer. The 80T-150U uses a P-N junction temperature sensor housed in a low thermal-mass tip to provide fast responding, high accuracy readings.

The unit is switch-selectable for readouts in °F or °C. The 80T-150U can make temperature measurements of live circuits, with

350V peak ac standoff capability. Small components can be accurately measured without cooling due to mass of the probe tip.



The probe is suitable for surface, gas and non-corrosive liquid measurements. This includes most industrial solvents, water lubricants and fuels, as shallow as ½-inch.

Circle (80) on Reply Card

Surge suppressors

A line of high performance surge suppressors has been introduced by *General Electric* to protect home entertainment equipment from sudden impact voltages that could destroy or harm their delicate circuitry. The triple outlet VNS-21D incorporates a radio frequency interference (RFI) filter to guard against static-causing, TV interfering powerline noise.

Altogether, there are five different SurgePro devices designed for solid-state stereos, VCRs and TV sets, offering up to six connections through a single outlet.

Circle (81) on Reply Card

Videotape teaches VCR maintenance

Ucando VCR Educational Products has released a new video tape that shows how to perform many of the common repair jobs required on every VHS video cassette recorder.

This video tape brings expert advice about the inner workings of the VCR. After viewing the 2-hour program, viewers will be able to properly clean the heads, rollers and guides in a VCR, as well as to replace the belts.

There are no special skills or tools required for performing the maintenance and repair work shown in this video tape.

Circle (82) on Reply Card

Pattern generator

A portable audio-video pattern generator with four times the number of patterns and one-third the usual volume has been introduced by *NCM Electronics.*

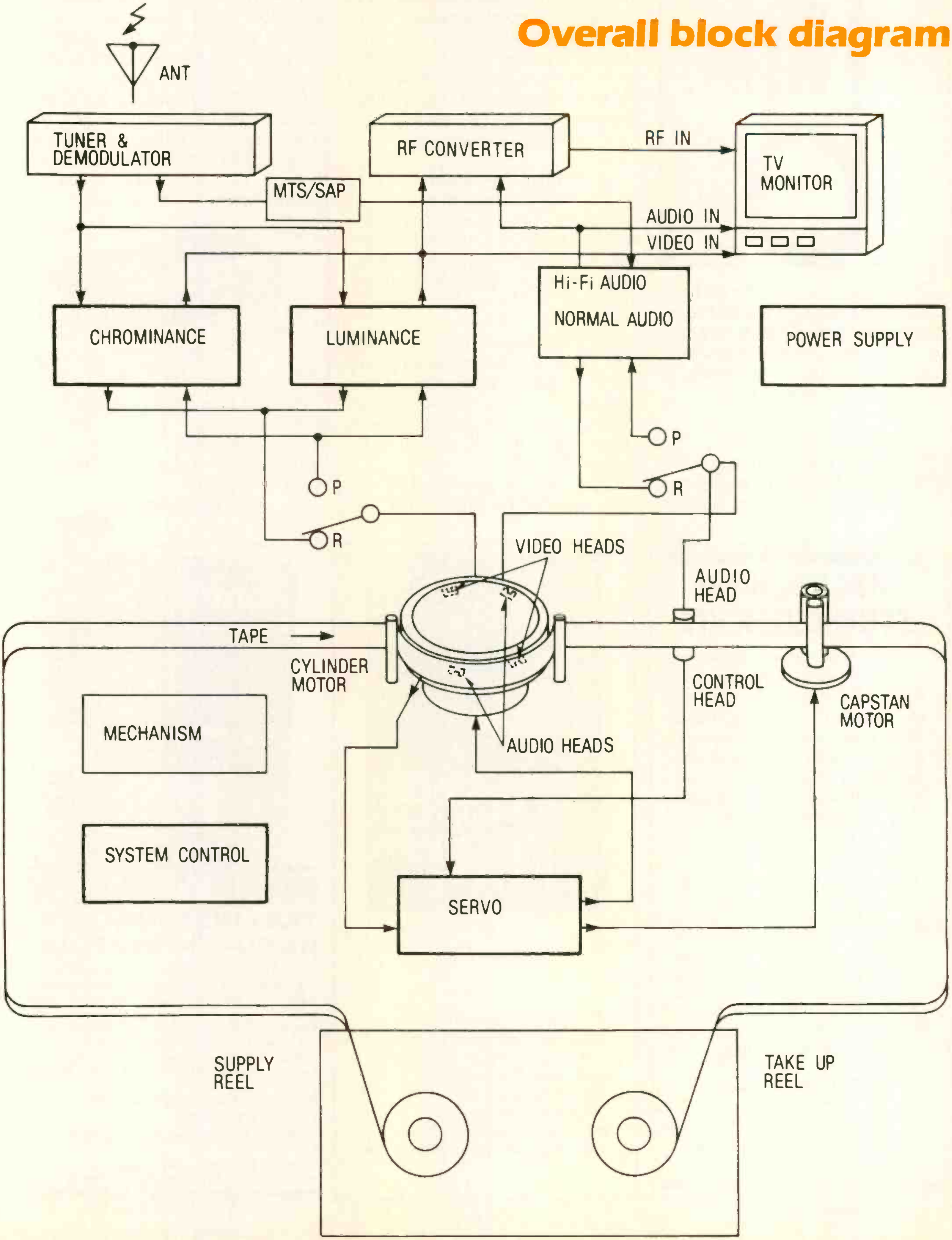
The Video Wonderbox features 32 standard B&W and color patterns, including NTSC color bars. Its portability has been achieved through the use of NCM's in-house custom-designed LSI circuits.

The unit is designed for testing, troubleshooting and aligning VCR's, computer monitors and monochrome, color and cable-ready televisions.

Circle (83) on Reply Card

ES&T

Overall block diagram



A lot has been made of the fact that VCRs are complex machines. They are. Servicing manuals on these units run over 100 pages. Many of those pages are multifold pages that contain the equivalent of three sheets worth of information. Block diagrams and schematic diagrams for VCRs can run for page after page.

This can't be helped, given the complexity of the products, but trying to understand basic principles of operation can be seriously impeded because of the sheer volume of information that has been waded through.

Given all of this complexity, when a piece of information comes along that makes it easy to grasp the general principles of the technology almost in a single glance, it's worth making interested people aware of it.

Take a look at the overall block diagram of a GE VCR on the opposite page. Of course it's highly simplified, but it provides you with an immediate grasp of what goes on in a VHS VCR.

In this case, the PLAY/RECORD switch is in the RECORD position. When the VCR is in this condition, using a local broadcast station for a source, it tunes the signal, demodulates it, processes the chrominance and luminance, and audio signals to apply them to the video and audio heads, respectively, where they are converted into magnetic information and impressed onto the tape.

The mechanical system controls the speed of rotation of the video head cylinder and the captan motor, based on signals from the control head and the head cylinder. Notice that the direction of the arrowheads indicates input or output, or, in some cases, both.

Again, this overall block diagram of a VCR can't give details of operation of a VCR. It's too simple. But a grasp of the principles it shows can give you a head start toward understanding the details later.

ES&T

Working with hexadecimal numbers

Hexadecimal. It's a word that strikes fear and loathing in the hearts of the stoutest men. It's as if the "hex" part puts a hex on people. It has something to do with computers and numbers, but what?

Hexadecimal (hex, for short) really isn't that hard to understand. It just takes a little reflection on the way we make numbers. Take decimal, for example. In decimal, we count using the digits 1, 2, 3, 4, 5, 6, 7, 8, 9.

It might have been possible to create a digit for every number, but that would have been cumbersome in the extreme, and would have made calculation exceedingly difficult. Instead, it was decided to use only nine digits, then when it was necessary to represent ten of whatever was being counted, the digit would be moved one place to the left to show that the 1 represented one *group of ten* rather than simply one (see Figure 1). Presumably, it was decided to do this at the number ten because humans have ten fingers. In forming the decimal number ten, the zero is placed to the right of the digit to show that, in fact, it has been shifted to the left. Then we can continue counting: 11 represents one group of ten plus one, 12 represents one group of ten plus two, and so forth.

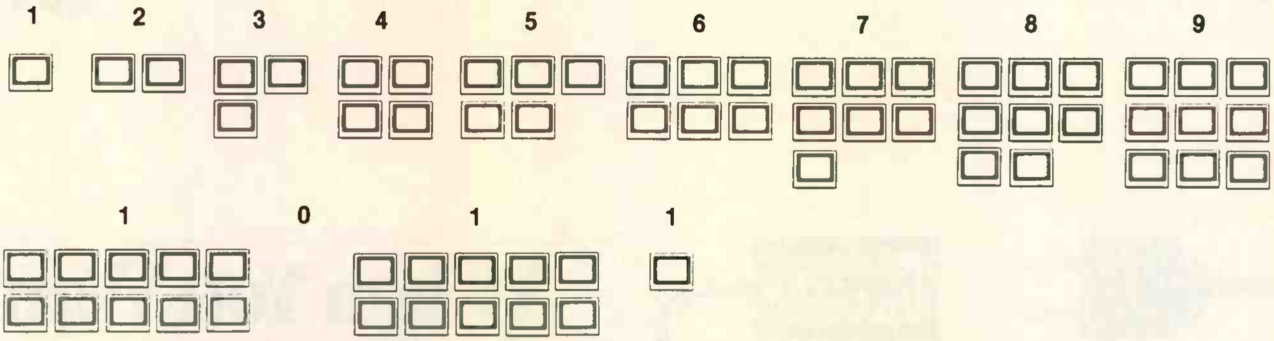


Figure 1. Decimal numbers are formed as shown here. Each individual digit represents a quantity. To form a number ten, we use positional notation (shift the 1 digit one place to the left) to show that the 1 represents a group of ten rather than one unit. The 0 in the number 10 shows that the 1 has been shifted. To form larger numbers, we use 11 as one group of ten plus one, 12 as one group of ten plus two, etc.

In hex, for reasons that will be presented in a moment, it was considered advantageous to create several more digits. In hex, counting proceeds: 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, 10, 11, etc. Thus in hex, the numbers ten, eleven, twelve, thirteen, fourteen and fifteen are represented by A, B, C, D, E and F respectively. Please note that it would have been possible, and might have been better, to create some new numeric digits for those hex numbers, but the letters A through F were already in existence, so what the heck!

What does all that have to do with computers? Well, nothing and everything. Some computers are said to operate in hex, but that is not, strictly speaking, correct. If we take a look at the correlation between hex and binary the whole thing becomes clear.

You might want to refer to the Computer Corner in last month's ***ES&T***, in which binary numbers were discussed. Counting in binary proceeds; 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111 (those are the numbers one through 15 in binary).

Now take a look at Figure 2. Notice how conveniently a single hex digit represents a binary number that takes four binary digits. That's essentially what is meant by a computer operating in hex. A computer, as we have emphasized many times, operates only in binary. Its 2-state devices can't operate any other way. But the computer operates such that its binary digits are taken four at a time (or some integral multiple of four at a time).

So the computer continues to operate in binary. The advantage to hex is to the operator or programmer. Let's say a human is trying to deal with the computer's operation and it includes a binary number like 10110101100010111111. That's twenty digits. I defy you to manipulate that many digits that are all alike without transposing digits or accidentally changing a 1 to a 0 or vice versa. But if you replace each group of four digits with its hex equivalent you have the hex equivalent of the binary number: B58BF (see Figure 3). You're a lot less likely to mess up *that* number when you're working with it.

Of course it's not especially easy to work with hex. It takes a couple of serious mental leaps to treat letters of the alphabet like numbers, and to treat numbers with a single digit that you're used to representing with two digits. But

Decimal	Binary	Hexadecimal
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10
17	10001	11
18	10010	12
19	10011	13
20	10100	14

Figure 2. The hexadecimal numbering system is a handy way to represent binary numbers (which quickly can get very long using four digits at a time) in a way in which they're more easily handled.

starting with a basic understanding of what hex is all about, you can play with the numbers until you have at least reached peaceful coexistence, even if you're never quite comfortable with them.

B	5	8	B	F
10011	0101	1000	1011	1111

Figure 3.

Figure 3. You can take a binary number four digits at a time and represent each group of four digits with its hex equivalent. The whole point of hex is to make it easier for us to deal with strings of binary digits.

Answers

Questions are on page 4

1. B. The logic levels at the inputs and output of each gate are shown in Figure A. Remember, the only way to get a logic 0 out of a NAND is to have all inputs at logic 1.
2. 1,555kHz. The radio will play if the local oscillator is dead. Remember: Oscillator frequency = RF frequency + IF frequency.
3. A. The circuit is a Wheatstone Bridge, balanced when there's no current thru the meter.
4. 12Ω. The equation for the balanced bridge is

$$R1/R2 = R3/\text{speaker } Z$$

If it is an 8Ω speaker:

$$R2 = R1 \times \text{speaker } Z/R3 = 12\Omega$$

5. IN4146. The IN prefix is understood. The colors represent the same numbers as for resistors.
6. A. The wide band indicates the cathode side.
7. C. Assume the radio is dead but the power supply is OK. When the radio is tuned through a strong station, the current meter should show a strong increase in deflection. With no audio input, the push-pull amplifiers are nearly cut off. The input audio drives the transistors into conduction.
8. B. With an emitter-base short, the transistor is cut off. No current flows in the collector resistor, so there is no voltage drop.
9. A. The input signal is at the base and the output signal is at the collector. The emitter is common to the input and output signals.
10. B. With R open, base has no forward bias.

By Kirk Vistain

Breaking the CLV servo loop

As mentioned in past columns, CD players are chock full of servos, and if you've ever encountered tough problems in them, you know the true meaning of the phrase *going around in circles*.

What is a servo? It's a circuit that uses part of its output as an input. This principle is familiar to anyone who has worked with audio amplifiers. A certain amount of the output is always *fed back* to the input in order to cancel distortion products. But servos are generally part of an electromechanical device, something with a motor in it. A servo system functions to maintain the correct operating position of a mechanical assembly by comparing a position signal (feedback) to a reference signal.

Specifically, a CD player has tracking/sled, focus and disc motor (CLV) servos. The tracking coil and sled motor are separate, but they share a good portion of the servo circuitry before going their own ways. Simply put, the sled takes care of the *coarse*, and tracking the *fine* control of the optical block.

Thanks to safety shutdown circuits, one of the more common symptoms encountered in home CD players is a dead disc motor. Many home units are designed so that focus must be achieved (FOK) in order for the motor to start. (Although, most of the portables I've seen run the motor up as soon as you push PLAY.) Sometimes, the disc will start to spin, then shut down if TOC is not read, perhaps due to RF PLL or tracking trouble. Because one of the first things we need to do on a defective player is check the RF (eye pattern), we're in trouble unless we can get the disc motor to run. *No* rotation equals *no eye pattern*.

It's times like these that make you appreciate manufacturers who build diagnostics into the set, at least something that allows you to defeat shutdown. Some units have a pin on the microprocessor that eliminates certain shutdown processes when grounded, but few are documented well enough to let you know what actually is being defeated. The pin may be marked TEST, ADJ, SERVICE, or something more arcane, such as BATT2, but, you usually can figure that activating it will, at the very least, prevent the player from coughing the disc out while you're trying to adjust or troubleshoot the machine.

Back to the original problem now; the CLV motor is dead and you need to check the laser. Most of the time, you're just going to have to get in and rewire a few circuits to do it. Take a look at Figure 1. Many CLV motors are of the brushless, slotless type, which among other things, means that speed control is probably effected by changing the bias on a Hall-effect device. Assuming the power supply to the motor is OK, you can disconnect the speed control input from the servo circuitry and substitute a variable external power supply. Bias voltages are usually in a 0Vdc to 2Vdc range, and quite often negative. Be sure to check the schematic for the unit you're fixing.

You'll need relatively precise control over motor speed, and thus, bias voltage. If your supply has a precision, multiturn pot that is quiet and effective down at the lower end of its range, you're all set. But if you have one like I use, the control is so erratic below 6V, that it's impossible to get stable control of the motor. You can go out and spend a few hundred dollars on a new supply, or you can dig through your bin of forgotten parts for a couple of resistors to make a 10:1 voltage divider. Something around 900kΩ and 100kΩ ought to do nicely. The Hall devices need

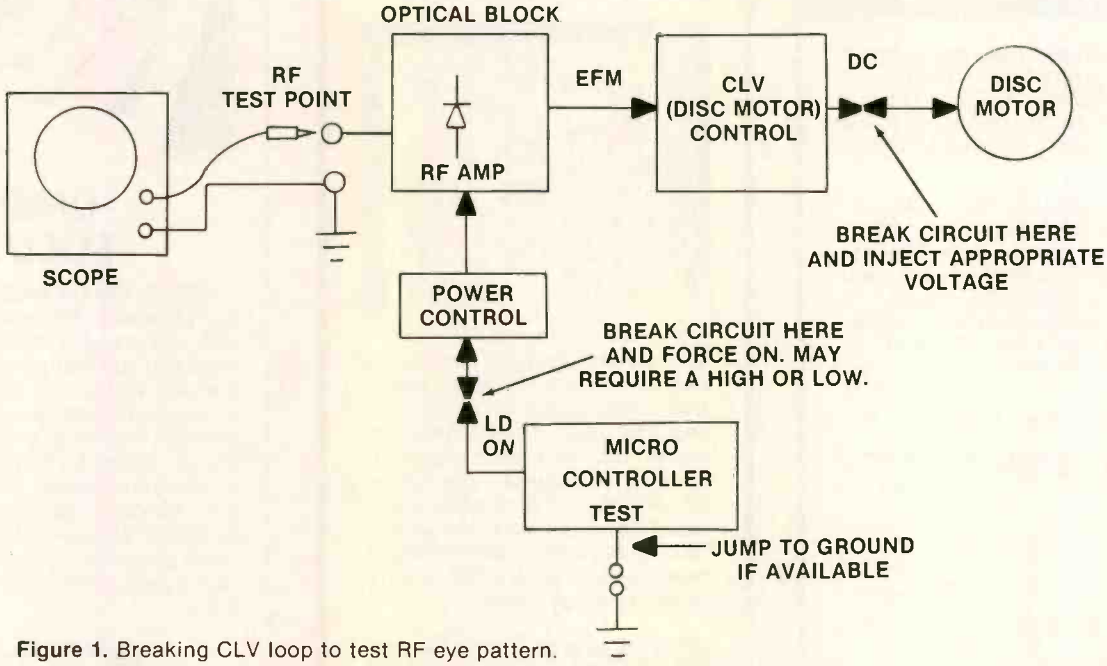


Figure 1. Breaking CLV loop to test RF eye pattern.

voltage, not current. Now your power supply can operate in a comfortable 10V to 20V range where the output level control works smoothly. In the field, a 1.5V battery (Oops! I mean "cell") works nicely, but you still have to rig up a potentiometer to vary the voltage.

Lately, I've noticed some portable players using the simpler, brush-and-commutator type of dc disc motor. These have only two wires. The servo provides both power and control, unlike circuits designed for BSL motors that only need to supply a control voltage.

Of course, making the motor turn is merely one step in the process. In order to see an eye pattern, the laser must be *on* and the focus servo operational. Once again, the microcontroller usually feeds some sort of enabling signal to the optical block. It might be termed LD, LDON, or something else, but you usually can figure it out by studying the schematic. Even with the test mode engaged, it is often necessary to force this signal to the proper level to get the laser to stay on long enough.

Now that we have the laser turned *on* and the disc motor spinning at around 300 rpm, you ought to get some sort of eye pattern, assuming a disc is in the machine, the RF amp is working and the focus servo is OK. But what if focus is bad? Sometimes, that will make the test impossible, but often, there is enough slop in the sled assembly that the nimble-fingered technician can move the optical block enough to find a good focus point, if only for just a moment. If the RF is OK, you can make the working assumption (one we can discard later if it gets us nowhere) that the laser is not the cause of the apparent motor problem. By the way, make sure the optical block is positioned into the disc where data density is normal. In the TOC (table of contents) and between tracks, you'll see an anemic pattern.

As with any troubleshooting procedure, practice makes perfect. You also need to understand the circuit well enough to make a good guess exactly where to break the loop and inject voltages. Top troubleshooters are also experimenters, unafraid to fail several times in the pursuit of improved technique.

Next time we'll break a few more loops, and maybe even find a way to test the RF PLL with a dead optical block.

By the way, a few columns back, I mistakenly claimed that ½-inch PCM audio and CDs use the same sampling frequency. Thanks to Dennis Machesky of Sony Corporation for setting me straight. PCM uses 44.056kHz; CD, 44.1kHz. To a guy like me, brought up on analog equipment, two frequencies are essentially identical if they are within 0.09% of one another. But to a digital circuit, the difference is significant. The standards committees set it up this way so direct digital copies of CDs could not be made on ½-inch PCM equipment. ES&T

Readers' Exchange

Beginning July 15...
No ad requests will be accepted for Readers' Exchange without a *full, verifiable name, address AND phone number*. This information is necessary for ***EST*** files. Phone numbers will not be published, if so requested. All ad requests received prior to the above date will be processed as received. **Editor.**

Wanted:

Schematic/information for old Shenendoah Five, Henry Field radio. Will make it worth your time. *Wayne Burmahl, 12607 E. McCoy St., Independence, MO 64055.*

Schematic/service manual for Farfisa Sabre Reverb-1 amplifier used with Farfisa Compact Duo. Will buy or copy and return at my expense. *Dan Graziadei, Stereo Service Center, 227 5th Ave., Pelham, NY 10803.*

Drive wheel for old Zenith stereo, EVG No. 1499-37. *William Blankinship, Blankinship TV, 1216 N. Main, Rusk, TX 75785; 214-683-5070.*

Sony No. 1-222-235 volume control W/switch for KV-1210U television. *Charles T. Huth, 229 Melmore St., Tiffin, OH 44883.*

Loan of manual for Heathkit oscillograph 10-104 so that I can copy needed information to repair my scope. Will return promptly. *Charlie Martel, 95 Bay State Road, Belmont, MA 02178.*

GE radio transformer, catalog No. RT-5958, for clock radio, GE model C-4390A. Will buy. *Frank Massi, 714 Walnut Drive, Apt. 310, Darien, IL 60559.*

Information about Seville model SC1382 color television. *Jorge Miranda, Miranda Repair Shop, 4911 Murphy Place, West New York, NJ 07093.*

Service manual for B&K model 1431 oscilloscope. Will buy or copy and return. *George Demaris, 7387 Pershing Ave., Orlando, FL 32822.*

Service information for the following—Unicom Electronics power supply, model PS11R; Tandy 64K Color Computer II, model 26-3127; EMP/GTS manual Mini Modem, model MM-101 (manufactured by Elec and Eltec Company, Hong Kong); Heathkit oscilloscope calibrator, model IG-4505; Leader RF signal generator, model LSG-11; Garrard turntable, model Lab 95B; Johnson Messenger CB, model 323; Apple IIe Pro System Duo-Disk Imagewriter Printer Monitor II; Icom model 735 ham transceiver. Will purchase or copy, my cost. *Mike Adams, Haney Vo-Tech Center, 3016 Hwy 77, Panama City, FL 32405; 904-769-2191.*

Please state price and/or condition in correspondence for the following—two transistors, MRF 455A; one antenna tuner, MFJ 962, 949C, 941D or 989; five tubes, No. 7868; ten lamps, No. 12 6V for Bogen PA amps; one each bandswitch for Panasonic RF 2800 receiver, No. RSR 98W or equivalent; one printer and disk drive for Tandy Color Computer II, model 26-3127; one each Z-80/CPM and modem board for Apple IIe ProSystem. *Mike Adams, Haney Vo-Tech Center, 3016 Hwy 77, Panama City, FL 32405; 904-769-2191.*

TV, VCR parts, modules, service manuals and test equipment—only new or excellent condition components; books, publications and troubleshooting guides for televisions and related electronics equipment. *Tim Rowell, 1200 Barton St., Johnson City, TN 37601.*

Two timing wheel support assemblies for Accutrax +6 (BSR) phono No. PN B114235. Will consider buying junker. Pay any fair price. *TV Central, 870 Pio Nono Ave., Macon, GA 31204; 912-743-1451.*

Flyback transformer for Zenith model No. T2585p, part No. 95-3243-02. Zenith says N.L.A. *Tektronics, 17 W. Granada Blvd., Ormand Beach, FL 32074; 904-672-1175.*

For Sale

Hickok Universal TV-FM alignment signal generator, model 610A, with manuals, good condition, $75; Philco wideband oscillator amplifier, model 8300, good condition, $10; Rider service manual, volume 16, $15; Supreme radio service manual (1926-1938), Supreme radio service manual (1941), $5 each; Sams Photofact sets No. 69 through No. 496, 75¢ each or all 275 sets for $150, or best offer; Sams record changer service manuals, CM-2 through CM-9, RC-11 and RC-12, $2 each or all 10 manuals for $15. All prices plus shipping. *John Brouzakis, 247 Valley Circle, Charleroi, PA 15022; 412-483-3072.*

Sams Photofact sets, No. 1224 through No. 1475, complete $250; Sylvania CK1500X Chek-A-Color test jig with over 75 adapters, already modified for up to 38kV testing, excellent condition, $250; Castle Mezzer FSM-V VHF field-strength meter, Sencore B124 battery eliminator and Sencore B156 7-in-1 dc bias supply, all three items in excellent condition, $90. Instructions with everything. All prices plus shipping. *Baros TV Service, 6113 Isleta Blvd. SW, Albuquerque, NM 87105; 505-877-5688.*

Sencore—VA62 video analyzer, VC63 VCR analyzer and NT64 NTSC pattern generator, $2,800 for all three; Diehl Mark VI, $350; CR70, $750; LC53, $750. Will sell package for $4,300. All equipment like new, with leads and manuals. VA62 and LC53 used once; all other units, unused. Illness forces sale. *J. Collins, 11 Michael St., Woodcliff Lake, NJ 07675; 201-391-8425.*

Hewlett-Packard model AR120 oscilloscope, with manual on fiche; Beckman/Berkley Eput meter, model 7150, 5A2 scope CRT in box. Best offers. Other equipment available. *Kenneth Morvant, Route 4, Box 1290, Abbeville, LA 70510; 318-643-6867.*

Sencore—SC61, VA62, VC63, NT64, CR70, LC53, PR57, TF46—with all accessories, one-half of *new* prices; Sams Photofact folders No. 1200 through No. 2172, $1,000; No. 2299 through No. 2480, $500. *C. Hugh Harrell, P.O. Box 6691, Newport News, VA 23606; 804-877-7915.*

TV parts from Admiral 1M30, RCA CTC40P, Sears 528.41940 and 528.41950, Zenith 25CC50 and MGA 19-inch console. Picture tube from RCA 19VLNP22, with yoke, used two months. Many other chassis on hand. *D.J. Aijala, 50 Fir Circle, Babbitt, MN 55706.*

Sencore SG165 AM-FM stereo analyzer, $545; Sencore VA62 video analyzer, with VC63 VCR test accessory, $2,095. Equipment in excellent condition, complete with manuals and probes. *John's TV, 34 Hillside Ave., Soudentown, PA 18964; 215-721-1563.*

Sencore SG165 AM-FM stereo analyzer, like-new condition, with test leads and service manual, $250, cashier's check only. *John Schultz, 3611 Orchard Road, Quincy, IL 62301; 217-224-8227.*

B&K 820 digital capacitance meter, $95; Precision E-200C signal generator, $55; B&K 666 Dynajet tube tester, $65. All mint condition, all prices plus shipping. *Ted Youngman, 2225 Vigo St., Lake Station, IN 46405.*

Heathkit IT-5230 CRT tester and rejuvenator, $50; Knight tube tester, model KG-600B, $35, Precision signal generator (two available), model E200, $40 each; B&K model 667 tube tester, $35; Sprague Jud Williams curve tracer, model A, $50; Roberts tape recorder, model 771X, $100. *Ralph Dorough, 117 Pecan St., Terrell, TX 75160; 214-563-7105.*

Argon discharge tubes, Sylvania type R-4410 and type S-501, used to discharge HV capacitors through magneto-striction sounding heads, $6 each; 100W ferrule-type resistors, 20kΩ, $3.50 each. Twelve each available; items no longer in production. Prices do not include shipping; send shipping instructions with M.O. *Unitronix, P.O. Box 247, Galveston, TX 77553-0247; 409-763-2207.*

Sony 13-inch monochrome monitor, model CVM131, $50; Conrac 8-inch monochrome monitor, $35; Texas Instruments model Silent 700 printer, with cable and paper, $35. Hewlett-Packard 130C oscilloscope, $200; 202A low frequency function generator, $60; 650A test oscillator, $60; 400H VTVM, $60; 2401B integrating digital voltmeter, $200; Tektronix RM529 TV waveform monitor, $150; 180A time mark generator, $85; 3B3 time base plug-in, $100; Fluke 8300A digital voltmeter, $400. All this test equipment works OK. Include $12 to help pay shipping. *Fred Jones, P.O. Box 702, Niceville, FL 32578; 904-678-1803.*

B&W picture tubes—19DUP4, 19CUP4, 19BLP4, 17DA/17DR/19AB/21EV, 21FDP4. All new, $10 each. Price does not include shipping. *Ray's TV, 4821 East View Drive, New Orleans, LA 70126; 504-246-6205.*

SAT-250 audio dummy load, 2-channel/250W per channel, 8Ω 500W, 4Ω. Excellent, $70, we ship. *Dan's Radio-TV, 866 Cy Ave, Casper, WY 82601.*

PF Reporter magazines, 50¢ each; Sams Photofacts, $1 each. Send s.a.s.e. for list. *George Otto, 1045 Magnolia Ave., Beaumont, TX 77701.*

Xerox copies on original factory-service manuals for Zenith, Admiral and Motorola color television. Literature on transistor radios, auto radios, 8-tracks, portable cassette players and turntables—too many to list. Send s.a.s.e. with your needs. *Kenneth L. Mixon, 401 E. San Pedro Ave., Perry, FL 32347; 904-584-2116.*

Panasonic parts, large quantity, older, also used for Bradford. Parts are for televisions, tape recorders and stereos; part numbers, model numbers and descriptions needed. Send s.a.s.e. with your needs; I will return prices. *T&T Electronics, 200 Main St., Williamstown, MA 01267.*

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PHOTOFACTS: Individual folders #1 to #1400 $3.00. Above #1400 $5.00. Sent same day first-class postpaid. Loeb, 414 Chestnut Lane, East Meadow, NY 11554. 4-87-6t

SERVICE MANUALS. Large Shop has 18 yr. collection of duplicates. All original manufacturer. All new. Audio $2.00, video $5.00. Send SASE for list. Tape Recorder Clinic; 4850 E. Speedway; Tucson, Arizona 85712. 11-86-tfn

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COMPLETE VCR TEST SHOP: Sencore SC61 Wave form analyzer, VA62 video analyzer, VC63 VCR head test acc, NTSC pattern generator, PR57 powerite isolation tranf. Tentelometer tape tension gauge, Tentel VHS spindle height gauge, Tentel head protrusion gauge, with S1 stand, Zenith torque gauge. Call (414) 835-1793. 7-87-1t

VCR REPAIR SOLUTIONS FOR VHS MODELS. Volume I – 150 Symptoms and cures – $11.95. Volume II – $11.95. All 300, $19.95. Eagle Electronics, 52053 Locks Lane, Granger, IN 46530. 7-87-6t

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VCR REPAIR, all makes and models. 72-hour turnaround, 90-day limited warranty. Contact: Electrodyn, 917 South Rogers St., Bloomington, IN 47401. Telephone: 812-334-1023. 6-87-2t

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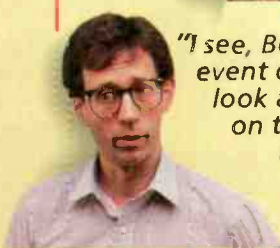

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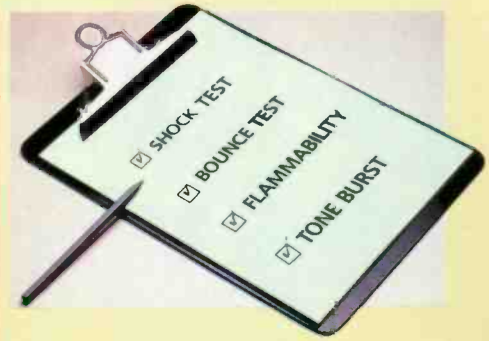

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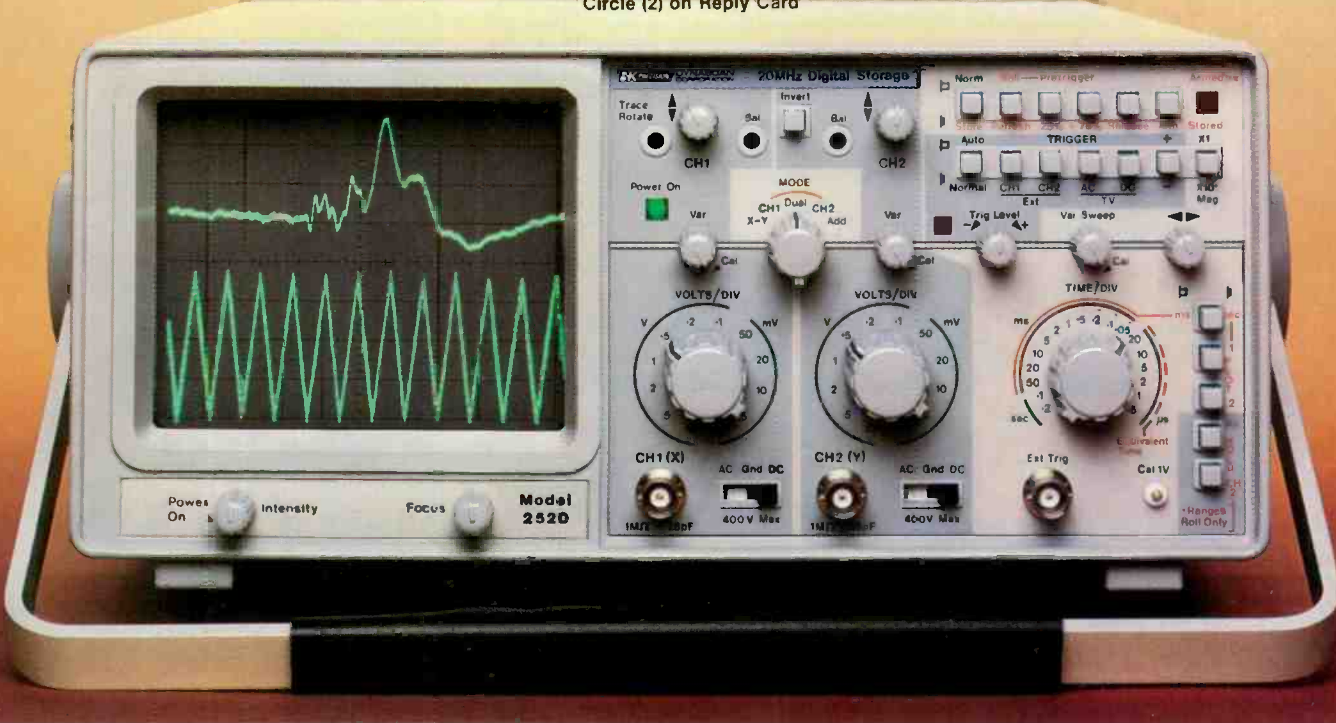

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