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AN INTERTEC PUBLICATION

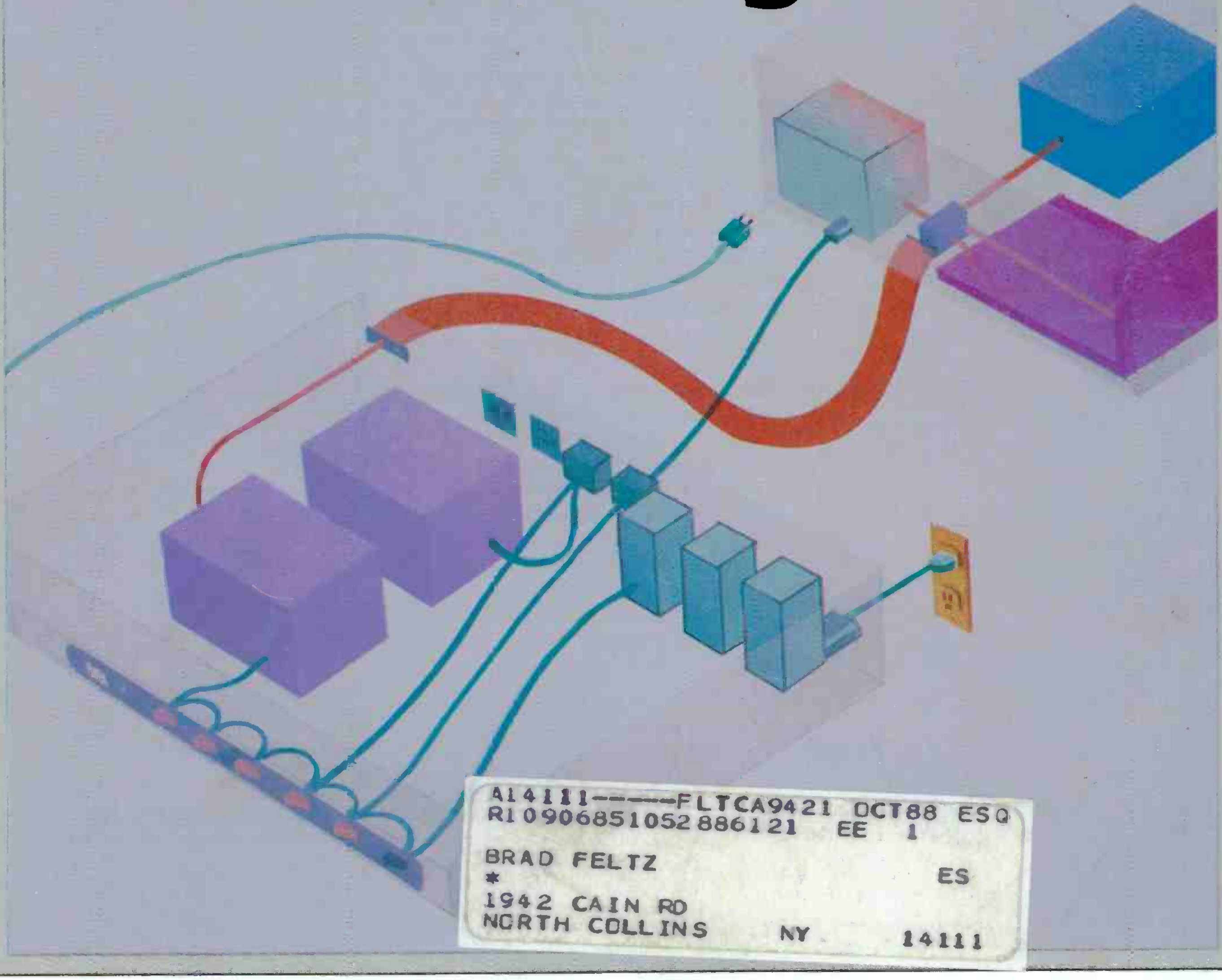
ELECTRONIC™ Servicing & Technology

NOVEMBER 1987/$2.25

Troubleshooting startup circuits

Servicing microwave oven panels • The meter said ...what?

Power conditioning



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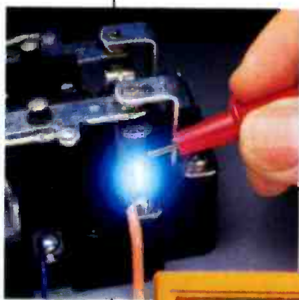

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The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

Volume 7, No. 11 November 1987

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Report from the test lab: the Semianalyzer transistor/junction tester
By Carl H. Babcoke, CET
The EDS Semianalyzer, intended primarily for testing diode and transistor junctions, uses a combination of passive testing and a breakdown mode with noise testing.

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Test your electronics knowledge
By Sam Wilson, CET
This month's quiz asks some basic questions about oscilloscopes and VCRs.

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Servicing microwave oven panels
By Homer L. Davidson
It's like magic—cooking without heat, with just the touch of a button. It doesn't take magic, however, to service the microwave's control panel, just some basic servicing skills.

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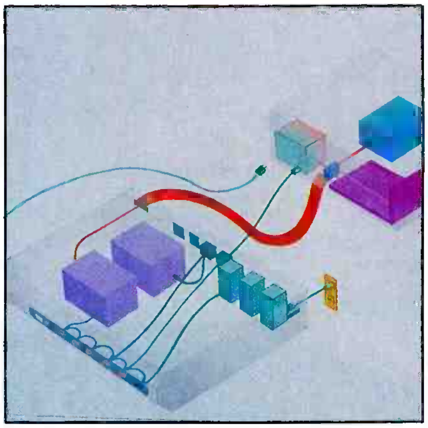
Power conditioning
By Conrad Persson
If you're like most modern consumers, you have a home full of electronic equipment—televisions, VCRs, computers, even devices you might not think of, like the water bed heater. Yet without power conditioning, you could find yourself back in the pre-electronic era with just one bolt of lightning.



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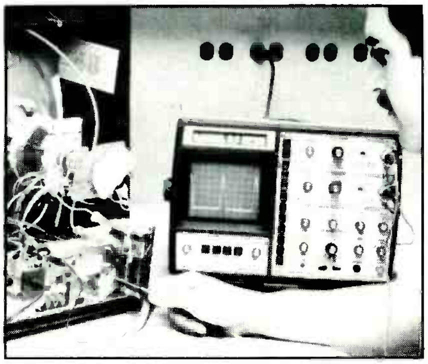
This uninterruptible power system provides emergency power to a personal computer when the ac-line power fails. (Photo courtesy of Applied Research and Technology)



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To see whether you've got a shutdown problem or a startup problem, monitor the collector of the horizontal output transistor. If you don't see pulses build up, you have a startup problem.

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Troubleshooting startup circuits
By Gregory D. Carey, CET
This second part in a three-part series on horizontal output circuits helps you differentiate between startup problems and shutdown problems.

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What do you know about electronics?—Model behavior
By Sam Wilson, CET
Sometimes you need to resort to a model to visualize how electronic components work. This month, take a fantastic journey into a semiconductor model to understand its behavior.

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The meter said ...what?
By Joseph J. Carr, CET
If you've ever done a double-take at a meter reading, you know that what the meter says isn't always the entire answer. This article shows four cases of misleading meter readings, and explains how the technicians found the correct answer.

On the cover...

This uninterruptible power system provides emergency power to a personal computer when the ac-line power fails or when the voltage drops below the required level. The unit provides dc directly to the computer, bypassing the computer's power supply, thus eliminating the inefficiencies of converting the UPS battery supply to ac, then converting it back to dc in the computer.

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Protecting your investment

Our society has become increasingly safety conscious. The use of seat belts in automobiles has been demonstrated to save many lives. In fact, seat belts have been shown to be so effective that many states have passed mandatory seat belt laws. The same is true of smoke detectors in the home. At first, just a few pioneering individuals were installing them. Then, as a result of the number of lives saved because of the beep of a smoke detector, more and more people saw the wisdom of having an alarm to alert them in the event of a fire.

This consciousness of safety has been carried over into other areas. Modern electronics products have become so sensitive to a number of environmental factors that efforts to eliminate, or at lease minimize, damage caused by these factors has increased. Two examples of these damaging factors are electrostatic discharge (ESD) damage and damage caused by power-line disturbances such as surges and spikes.

The electronics community, along with materials and packaging manufacturers, has come up with a number of answers to these problems. For example, the ESD problem has been attacked on a number of fronts: wrist straps, conductive bench tops, portable conductive work surfaces and other products alleviate the problem.

Likewise, manufacturers have come up with a number of ways to deal with the problem of power-line disturbances. These range from simple plug-in devices that feature minimal protection from spikes and surges, all the way up to uninterruptible power supplies that not only provide attenuation or elimination of spikes, but will provide from a few minutes to several hours of battery power in the event of a power outage.

All of this protection comes, of course, at a price. First, it costs money. Sometimes a lot of money. In some cases proper use of the protection is inconvenient. Who wants to be tied to a workbench by a length of conductor? What field technician wants to have to unwrap and lay out and find a ground for a complete ESD protective package? But if you want that protection, you have to use it every time.

But wait, there's a worse problem. Some of the products that are supposed to provide protection don't. Or at least they have never been *tested* to prove that they provide the protection they are claimed to have. As was pointed out in the static protection article in the October issue of ***ES&T***, some of the so-called static protective bags are least effective when protection is needed most. And when it comes to protection from power-line disturbances, it's definitely "Let the buyer beware."

For example, in talking to a source for this month's article on power conditioning, I learned that some manufacturer's sell "power conditioning" equipment that doesn't necessarily offer that protection. A little personal investigation with minimal effort confirmed this. I simply went into the personal computer department of a local discount store and lifted the first self-proclaimed spike suppressor off the rack. It was not only called a spike suppressor, it was UL listed.

However, after I opened the package and took a look at the disclaimer on the back of the unit, I found that the product had never been tested as a spike suppressor. The UL listing attested to the product's safety as an *electrical wiring device*, but said nothing about its ability to protect a device plugged into it from damage caused by power-line disturbances. The manufacturer's packaging was misleading at best. I'm sure that lots of people have their computers, VCRs and TVs plugged into similar devices, content that they have provided adequate protection for them.

Someone once said, "It's not what you don't know that will hurt you. It's what you know for sure that isn't so." Likewise, it's not so much the *unprotected* electronics products you own that will suffer damage – you can just unplug them during an electrical storm. It's the equipment you have "protected" using inadequate protection that will most likely be damaged or destroyed.

Don't leave protection of electronics equipment to chance. Study the market. Make sure that the protection you provide has been tested and found to be effective.

Nils Conrad Persson

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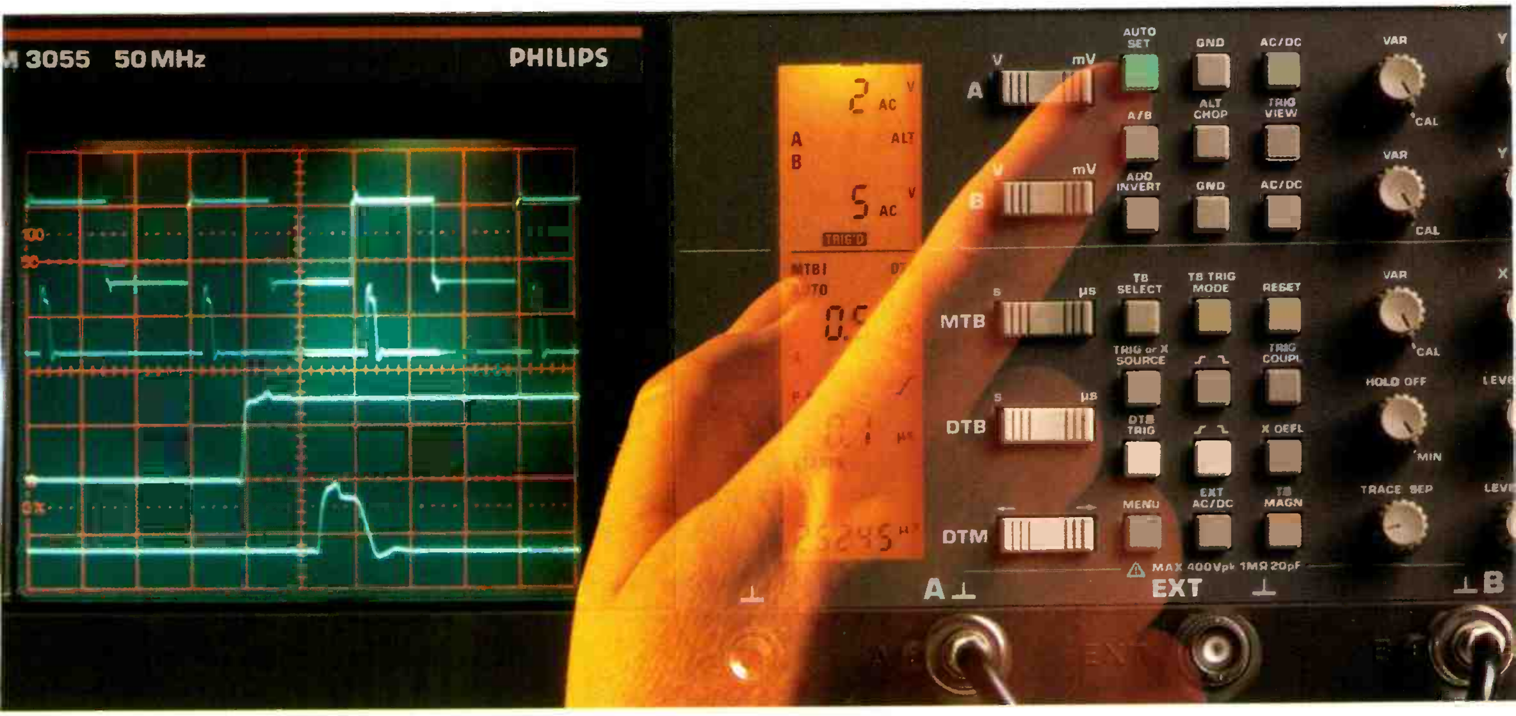

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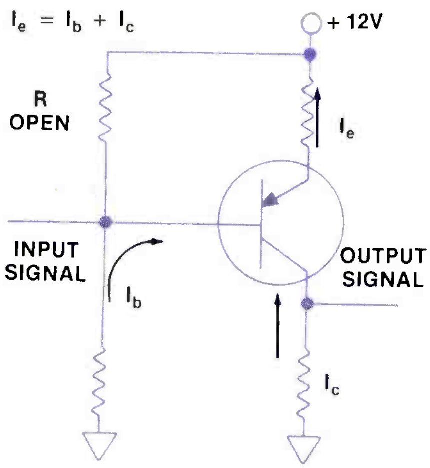
Feedback

Letter to Sam Wilson

In the "Test Your Electronic Knowledge" feature in the July 1987 issue of ***ES&T***, the correct answer to question 10 should be A. According to the schematic diagram, if the resistor marked R is open, the transistor will be saturated, because I_b and I_c still flow to ground through the transistor through V_{cc}. Therefore the formula $I_e = I_b + I_c$ still applies.

Moe Myint
Washington, DC



So many people have written about this error that I felt it necessary to give a detailed explanation of the correct answer.

As you know, the correct answer is that the resistor will be saturated. It is sometimes easier to visualize the purpose of R in a right-side-up NPN transistor circuit, so I am enclosing Figure A.

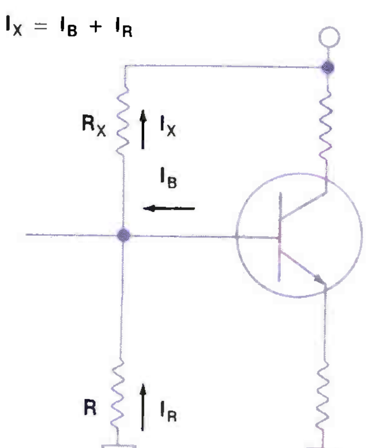


FIGURE A

The question states, "If the resistor marked 'R' is open, the transistor will be (saturated or cut off)." As shown by the arrows, the current through R_X is a combination I_B plus I_R. If R is open, only I_B flows through R_X. That greatly reduces the drop across R_X and causes the base voltage to go very high. The resulting increase in base current drives the transistor into heavy conduction (usually saturation). The same situation occurs in the PNP transistor circuit in Figure 5 in the July 1987 quiz.

Thanks again for writing. Your letters are very important to us.

Sam Wilson

Interest in electronic organ repair

In reference to the August 1987 Feedback letter about electronic organs, I would like to see a series concentrating on the theory and troubleshooting of these pieces of equipment, especially the smaller keyboards. I feel more people have these because of their inexpensiveness, and they tend to need servicing more often because of their portable nature, which makes them prone to disaster (from moisture, dust, fumble fingers, etc.)

Ray Tweedale, Jr., CET
Milwaukee, WI

From our readers' responses, it does seem that a series of articles on servicing electronic articles would be useful to ***ES&T*** *readers. If any of our readers would be interested in writing such an article, please contact the editor at Intertec Publishing, P.O. Box 12901, Overland Park, KS 66212.*

In the August feedback a reader requested an article on electronic organs. Perhaps this is a subject to be covered, perhaps not, as it is a rather specialized field and is slowly dying as companies, one by one, cease to produce product or have them designed and built overseas.

I have been servicing organs (or keyboards as they are called today) for almost 30 years. I have always tried to help techs from other locations who get themselves into an organ and find that it is a world of its own. (I get lost in a TV chassis.)

At one time the organ industry was very large, but at this time there appear to be only four companies left that are producing organs in this country. Many of the others are now just service organizations.

The modern-day organ or keyboard is actually a computer that plays music. Digital technology using PCM and MIDI interfacing is now the thing. While most instruments are similar on the outside and can do many of the same things, each company does it differently. If technicians have a good electronics background with some basic computer or digital training, along with some musical knowledge, they should be able to service the newer products. Most of the remaining companies will supply service information for a fee; however, one must usually be affiliated with a dealer in order to get parts or be willing to accept COD shipments with some sort of minimum order.

If you are not already aware, there is an organization for organ technicians that is growing every day. It is known as MITA International (Musical Instrument Technicians Association) and is based in St. Louis, MO. It puts out a montly newsletter to its members, and is running service seminars throughout the country, now that the companies do not. Membership is $25 a year for a tech, and it is fast becoming a clearinghouse for information as to what is happening in the industry. Contact Ken Gurler, Editor, MITA News, 8216 Audrain Drive, St. Louis, MO 63121-4504; 314-389-3290.

There have also been many super service companies springing up that are sources for parts for the older instruments that the individual companies no longer wish to keep in inventory. Keyboard Systems puts out a parts cross-reference for solid-state items used by the organ companies, and also lists all the present company service addresses. The company's address is 3637 East 7800 South, Salt Lake City, UT 84121. They are also a good source for older organ tubes.

Richard M. Johnson
Wakefield, MA

Photofact

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

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ES&T

News

NAPCEC expands education program

N.A.P. Consumer Electronics Corporation (NAPCEC) has announced an expanded format for its Successful Service Training (SST) program, a series of technically oriented educational programs aimed primarily at technicians, engineers and service professionals.

Program courses are continually updated. The current listing includes courses on VCRs, VCR product technology, wide-screen projection television, B1 and C9 television chassis, fundamentals of color cameras, and compact disc digital audio players.

NAPCEC also plans to introduce a basic digital technology program using a digital logic training system.

Individual SST courses range from two to five days and are offered at six NAPCEC training facilities and in major cities across the country. For more information, contact: Lisa Cole, N.A.P. Product Services, P.O. Box 555, Jefferson City, TN 37760; 615-475-0044.

Pace offers surface mount class

Pace has announced that its PCT-400 course on surface mount rework and repair will be conducted at its facilities on the following dates: Nov. 9-13 at both the Tustin, CA, and Laurel, MD, locations; and Dec. 7-11 at the Tustin, CA, location only. For more information, contact Pace at 9893 Brewers Court, Laurel, MD 20707; 301-490-9860.

VCR and camcorder sales increase

Sales of VCRs and camcorders advanced in July, according to the Washington-based Electronic Industries Association (EIA). Sales of camcorders topped 116,000 units, a 22% gain compared with July 1986. VCR sales expanded 10% to about 916,000 units.

Fluke services Philips products

John Fluke Manufacturing Company and N.V. Philips of the Netherlands have announced a new service arrangement in the United States and Canada. Factory authorized service for Philips Test & Measurement products will now be performed at Fluke Technical Centers throughout the United States and Canada. Products covered include oscilloscopes, logic analyzers, counters, function and pulse generators, multimeters and GPIB/IEEE-488 system components.

The agreement has produced several service enhancements for owners of Philips instruments:

- Automatic upgrades – Fluke service personnel will bring Philips instruments up to current specifications whenever they are serviced;
- 90-day warranty – On all repairs, Fluke will warrant the total performance of the instrument, not just the repair, for 90 days;
- Pick-up/delivery – Instrument pick-up and delivery and on-site calibration will be offered in many locations;
- Genuine parts – Only factory authorized Philips parts will be used in all repairs.

Fluke has also entered into a global alliance with N.V. Philips to market and support its test and measurement instruments in North America. ES&T

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INTERTEC PUBLISHING CORPORATION

Jumbo size plus sharp resolution --all in one

Matsushita Electric Industrial Company, Ltd, maker of National, Panasonic, Technics and Quasar products, has introduced the world's largest CRT color television featuring a 41-inch direct-view screen. The television combines the jumbo-size screen of a projection TV with the sharp picture resolution of a CRT television. A stand with built-in speakers will also be available.

The television offers three sets of stereo audio/video input jacks and two sets of audio/video output jacks. The set also has a special S-video input terminal for Super-VHS. Variable audio output jacks allow easy connection to an external hi-fi system.

The company used computer modeling and analysis techniques to reduce the weight inherent in large-size CRTs to 88.2lb, while virtually eliminating deflection distortion.

The TV tube's design, having a 30.6mm neck with a 110° deflection angle, represents a significant improvement over the 40-inch CRTs with 36.5mm neck and 90° deflection angle introduced several years ago.

The television has a flat hyperbolic screen with improved overlapping field lens, aberration-reducing triode and an impregnated cathode that allow the color CRT to accommodate 6mA of current and reduce dot size from 8mm to 5mm. The impregnated cathode can withstand high current without burning out. In addition, the back of the CRT's shadow mask has a special coating to increase electron reflectivity and thermal emission, which further reduces local doming.

The television has 560 lines of horizontal resolution and adopts the newly developed comb filters for greater detail by electronically processing the incoming color signals. Also added are newly developed black-level retention and dynamic aperture controls. The television features surround sound capability and Dolby surrounding circuit, and has a 2-way, 4-speaker sound system. Overall, output power is 30W (20W in the television and 10W in the surround rear speaker). ES&T

The Semianalyzer transistor/junction tester

This month, the report is about the model 59C Semianalyzer transistor/junction tester from Electronic Design Specialists. Model 59C is a combination of passive testing and breakdown voltages with noise testing. The two are not compatible, so they are not done together; instead, they are completely separated – an interesting concept that works fine.

The 59C is intended primarily for testing diode and transistor junctions, although tests can be made on a few other components. Physically, the unit is moderately small, except for the outside-type handle that functions as a tilt stand. Width and depth are 9 inches (plus the handle); depth is only 3 inches. Power is supplied by 120Vac only.

The digital readout appears to have 2½-digit operation with automatic range selection and ½-inch red LED digits. During the various tests, red LED words such as OPEN, PNP, SHORT or any of six others can be flashed on the screen to indicate the conditions.

There are only two basic test positions: JUNCT with the switch out (condition of the junction), or BRKDN (breakdown mode) when the switch is locked in. The breakdown mode measures leakage of the junction. That switch is next to the power switch.

At the right side of the panel above the two switches is a grille that resembles a giant salt shaker; the various sounds originate here. Two jacks for the test probes are located at the center bottom.

Testing silicon junctions

Here are the simple steps for testing the junctions of an average silicon transistor:

1. With the black lead at the base, touch the collector with the red lead. The screen should read: SINGLE JUNCT NPN. If it does, the first test has been passed. A defective junction might have read OPEN, LEAKY or SHORT. Any of these conditions reject that junction.
2. With the black lead on the base, touch the emitter with the red lead. The screen should read: SINGLE JUNCTION NPN (the same as for the collector test). This indicates a normal base/emitter junction.
3. Touch the red and black test leads to the emitter and collector. The reading should be OPEN JUNCTION. If so, reverse the test lead polarity and touch the emitter and collector again. This reading should also be OPEN JUNCTION. These open emitter/collector readings are normal, and any deviation probably indicates the transistor is defective.

Of course, these previous tests were all made with the mode switch in the junction position. Before using the breakdown voltage, you should know that this voltage can shock you, because it might be any dc voltage up to about 180Vdc. Of course, the current is limited to 10mA, but that much can really shock you. And any shock is worse when you are not expecting it. Use care when handling the test leads during the breakdown mode.

There are some problems. Do not leave the breakdown switch activated (switch locked in) but switch it off to the JUNCT position after each use. Otherwise, you might accidentally place the probes across a sensitive circuit, causing damage. But there is more. The dcv/dcv converter that supplies the breakdown voltage should not be operated for longer periods of time. Be on the safe side for both reasons and *turn off the breakdown voltage after each use*.

Testing voltage breakdown

With an NPN transistor, touch the red test lead to the collector and the black lead to the emitter. If the junction is good, the avalanche voltage will be less than 150V, and the speaker will have some faint hiss without popping or crackling. That is the *avalanche* or *breakdown voltage* of the collector/emitter junction. One test transistor showed 51.1V, which is the top voltage limit for its operation. The same test can be performed with the red probe touching the emitter and the black probe touching the base. Of course, this is reverse bias for the junction, which then acts as a zener to limit the voltage drop. With the test transistor that voltage was 5.6V.

Miscellaneous

Bias diode for a power transistor often has a box with two, three or four diodes in series. Any or all of these can fail. Use the basic transistor C/E method and the readout will show the number of junctions that are working.

Darlington or high-gain transistors show the usual single junction between base and collector, but usually will show dual junctions when measuring base to emitter.

In-circuit junction testing

The 59C is said to be very rapid and accurate when used for in-circuit tests. Of course, the breakdown test would not be used unless that transistor was disconnected temporarily from the circuit.

According to the instruction

By Carl H. Babcoke

manual, circuit loads as low as 10Ω will not affect the readings, although the LEAKY sign might be lighted at times. I tested a silicon base/emitter junction, obtaining SINGLE JUNCT NPN normal reading. A 96Ω resistor was connected between base and emitter, then the test was repeated. This time the readout was LEAKY SINGLE JUNCT NPN. No attempt was made to find the effects of lower resistances because transistor junctions that light the NPN or PNP legend usually are not defective (just obscured by circuit load). But if a transistor shows LEAKY JUNCT *without* the PNP or NPN flag, it probably is defective. Remove it from the circuit for more testing.

Testing zener diodes

When the diode is out of circuit, the 59C will show the correct zener dc voltage. Connect it the same as any diode breakdown test (red probe to the anode, black probe to the cathode) and read the zener voltage on the screen. The 10mA of regulated current makes this possible for zeners of all voltages.

Testing capacitor leakage

Out-of-circuit film and aluminum-electrolytic capacitors up to 1,000μF can be tested for leakage and the maximum voltage that each can endure, using the voltage-breakdown mode.

As the capacitor charges, the voltage reading races upward, slows down, levels off and then begins to go down. Because this is the voltage-breakdown point, notice what the voltage reads, then instantly disconnect the capacitor from the 59C test leads.

All capacitors produce noises when the voltage is near the breakdown point. Look for a capacitor that is breaking down at a lower voltage than the marked value (or the working peak voltage in the receiver). Thumping noises or wildly varying voltage readings are valid reasons to reject that capacitor.

Noise tests of transistors are performed exactly as leakage tests are, except attention is focussed on the volume and quality of the noise. Good semiconductor junctions will show a stable voltage and have a steady hissing sound (pink noise). Intermittent or noisy junctions produce an erratic voltage reading along with all varieties of popping noises. Leaky semiconductors often do not have excessive noise, but always will show a voltage lower than the rating.

Testing neon and LED lamps

With the instrument switched for the *breakdown* mode, touch the test leads to the LED or neon lamp (observing polarity when LEDs are tested) and the voltmeter will show the correct voltage for that LED or neon. In many cases the test can be made in-circuit with good accuracy. This is possible because of the regulated (constant-current) voltage supply.

Remember, for all these tests the machine being tested must be unplugged and without ac or dc power.

Note: Do *not* test the voltage breakdown of any tantalum capacitor. Tantalum capacitors have very low leakage but they have a tendency to short on any voltage beyond their rated limits. Do not test them.

Model 59C is not intended for testing germanium junctions. However, most germanium junctions can be tested with reduced accuracy. One germanium tested single junction with a breakdown voltage of 129V.

One red and one black test lead are furnished with the machine. They have no resistances, capacitances or inductances in series or parallel with the test leads, but the operating manual seems to indicate some important characteristics. The operating manual says: "The junction tester portion of the EDS-59C has been calibrated to sharp stainless-steel probes with exactly 36-inch long leads. If you use any test leads other than the ones recommended, the tester may give inaccurate circuit conditions." I have no comment.

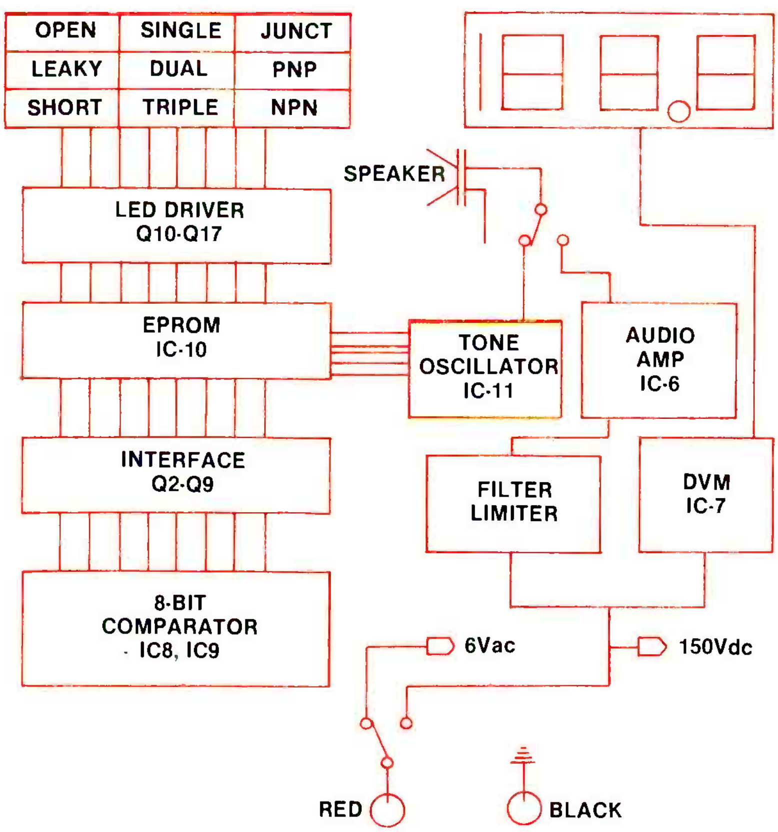


Figure 1. Block diagram of the unit. The first part of the unit probes semiconductors in circuit to indicate condition, type and number of junctions. The second part finds the component's breakdown voltage and amplifies junction noise.

Audible signals

Audio tones that accompany some transistor junction tests are not mentioned in the operating instructions and owner's manual that details all the other tests. Perhaps the manual I have was one of the early ones that was intended for revisions as needed. Anyway, the machine produces a pleasant low tone for normal junctions, a slightly higher tone for Darlington base readings or bias-diode junctions, a shrill high tone for shorted junctions, or a low buzz for leaky circuits. Of course, the audible signals cannot be used during breakdown tests because the audio channel is busy with noise analysis.

It has been said that after using the 59C instrument while noticing the various audio tones for each read-out, a technician should have no difficulty in using the junction analyzer by listening for the various tones, rather than by watching the read-outs. Of course, this can be a time-saver.

Comments

Every item of test equipment has limits on the things that safely can be done with or to it.

The junction mode of the 59C supplies all necessary signals for the tests; no outside power is needed or desired. Therefore, the machine being used for in-circuit tests *must* be unplugged from the 120Vac power. Further, all B+ lines near the test site should be grounded for a few seconds each to ensure that no B+ is stored there.

Do not switch to the breakdown mode and leave it there, even after the test has been made. One reason is the danger of shocks. The pointed test probes have up to 180Vdc between them (although limited to 10mA). I haven't been able to check out the following statement, so it is printed verbatim: "Besides, the DC/DC converter consumes a lot of power, and leaving the 59C in the VB mode for more than a few minutes at a time will shorten its life considerably." It is recommended, therefore, that you use the breakdown mode for the test or tests and then move the switch to *junction* position until the breakdown mode is again needed.

Incidentally, the only clue about how the instrument operates was found in a press release that said, in part: "sends out a special current-limited sine wave through its test leads to the circuit under test; the circuit and the component under test will distort the sine wave in a certain way. This distorted sine wave is converted by an 8-bit analog-to-digital converter, and the 8-bit word is presented to a 16K PROM, which has been programmed to recognize and display the results of just about any situation it may encounter."

Sample readings

The EDS-59C Semianalyzer is said to display up to 25 different combinations of circuit parameters. These will be self-explanatory.

Shorted junction – the reading is less than 0.6V (one junction) in both directions.

Leaky junction – readings under 0.6V in one direction, and one or more junctions in the other direction.

These will give you two samples of the screen readouts possible on the 59C.

Comments

During the time I have examined the EDS 59C, I have grown fond of it. At first, I was not enthusiastic because I had samples of almost every commercial transistor tester ever made and a few I had hand-built. But I particularly like the breakdown and noise tests, which are unique. Each technician will have a different preference. Another might like the panel readouts best; there is something for everyone.

The EDS 59C has several highly unusual features, and merits a thorough evaluation. After all, it is the equivalent of two testers in one with almost all functions automated. The only adjustment on the front panel is the junction/breakdown switch, and it is the one that changes from one type of testing to another. (EDS is located at 951 SW 82 Ave., North Lauderdale, FL 33068.)

ES&T

Test your electronics knowledge

By Sam Wilson, CET

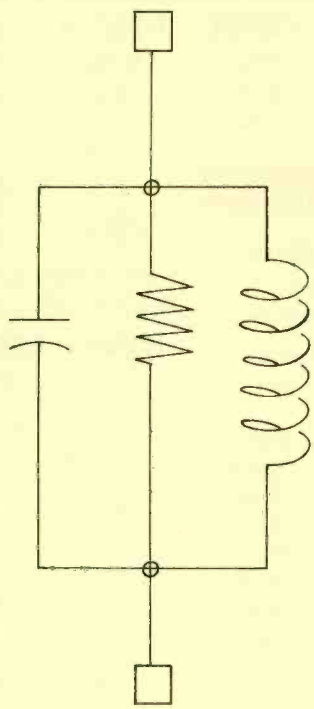


Figure A

1. Which of the following would you expect to find in a digital storage oscilloscope?
   A. A PIN diode
   B. A D/A converter
   C. A special CRT
   D. A video enhancement circuit
2. The Z-axis input terminal of any oscilloscope – including the digital storage oscilloscope – controls the
   A. angular movement of the CRT beam.
   B. vertical deflection of the beam.
   C. horizontal deflection of the beam.
   D. None of these choices is correct.
3. What type of diode is used to convert infrared remote signals into electrical impulses?
   A. Tunnel diode
   B. Hot carrier diode
   C. PIN diode
   D. Four-layer diode
4. The gap in a VCR head is about
   A. 14 thousandths of an inch wide.
   B. 1.4 thousandths of an inch wide.
   C. 25 millionths of an inch wide.
   D. 217 millionths of an inch wide.
5. In a VHS VCR the adjacent tracks overlap. To prevent signals from being affected by overlapping tracks,
   A. a different index of modulation is used for each head.
   B. the azimuth is different for each head.
   C. the elevation is different for each head.
   D. the direction of motion for each head, with respect to the tape, is reversed for each adjacent track.
6. The most common problem involving circuit board rework or repair is
   A. removing and replacing components.
   B. removing fungus protection.
   C. reconnecting cracked foil.
   D. re-applying fungus protection.
7. The resistor in Figure A is called a
   A. swamping resistor.
   B. equalizing resistor.
   C. temperature compensating resistor.
   D. bleeder resistor.
8. Should one of the heads in a VCR system become inoperative, the resulting picture will be a combination of ______ and ______.
9. Is the following statement correct? The recommended way to clean the video heads in a VCR is to use a lintless swab, a recommended solvent and a gentle up and down motion.
   A. Correct
   B. Not correct
10. An audio equalizer is really just
    A. a variable-frequency active filter.
    B. a bass boost tone control.
    C. an op-amp with a linear roll off.
    D. an elaborate set of tone controls.

Answers are on page 61.

Servicing microwave oven panels

By Homer Davidson

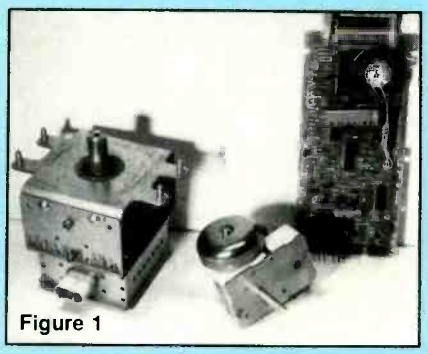


Figure 1

Figure 1. The heart of any microwave oven is the magnetron tube and control unit. Here an electronic control unit is contrasted with an older manual timer.

Figure 2. The touch pad or keyboard connects directly to the control board via a large, flat ribbon cable.

Figure 3. Here the control unit provides a controllable gate voltage applied to the triac switch assembly. If there is no gate voltage at the triac, suspect a defective control unit.

Modern microwave ovens may be operated by a touch of the finger – simply touch the buttons or pads of the control panel and the oven will automatically take over the cooking process. Like all other electronic devices, the control panel may break down and need repairs, but servicing the microwave oven control panel is not as difficult as it may seem at first. In fact, the defective control unit is rather easy to spot after making a few simple tests.

The touch-control panel

Many of the new microwave ovens have a front control panel that allows you to enter the cooking data with just a few buttons. Besides the number pads for cooking time, there are a number of other function keys used to control the cooking operation, such as the AUTO START CLOCK, TIMER, VARIABLE COOKING CONTROL, CLEAR, STOP and COOK pads. (See Figure 1.)

The keyboard assembly contains all the touch pads that control the microwave oven. (See Figure 2.) These touch pads are constructed somewhat like those of the calculator or computer system. When the touch pad is pressed, contact is made through a flexible cable to the control unit. This flat cable plugs into a large pin connector at the control board.

When an oven malfunctions, try operating the controls. If you press the proper sequence of keys and you don't hear audible signals, suspect a defective keyboard. Another symptom of a defective keyboard is the illumination of two or more figures on the display at the same time. Erratic oven operation and improper sign display may be caused by a corroded ribbon cable or dirty pin connector. A simple fix for this problem in some ovens is to cut off the corroded end of the cable, which will start a new set of contacts.

Testing the keyboard

Many microwave ovens feature a

set of test-mode connections that allow a servicing technician to bypass the keyboard and force the oven into the cook cycle. When the test points of an inoperative oven are shorted together and the oven goes into a normal cooking cycle, suspect a defective keyboard. If the oven does not start cooking with the test terminals shorted, use the high setting of an ohmmeter to check each wire connection of the cable between the keyboard and the control unit for broken wires.

The control unit

The control unit controls the entire cooking process when the cook key is pressed. As Figure 3 shows, a voltage from the unit energizes a cook relay or turns on a triac, which supplies power-line voltage to the primary winding of the high-voltage power transformer. The fan motor may be controlled by the control unit. In some of Sharp's touch-control circuits, the turntable motor also operates from the control board. If the oven features a temperature probe, it plugs directly into the control unit.

These symptoms suggest a defective control panel:

- Absence of signal when a key or a group of keys is pressed
- Failure of digit segments or indicator lights
- Appearance of incorrect figures on the display
- Flickering or erratic illumination of the display digits
- Erratic or improper clock operation
- Absence of sound from the annunciator, or continuous sound after cooking is complete
- Improper temperature control with the temperature probe in use
- Erratic cooking or no cooking at all

Digital display problems

A digital clock with LED display may be found in some microwave ovens. Other models have a lighted display panel with a display window of various function indicators. The digital display panel lights up when the power cord is plugged in. (See Figure 4.)

The digital display assembly may contain a fluorescent display tube that receives its filament voltage from a small power transformer mounted on the control unit. Suspect an open filament or no ac voltage (3V) if the filament of the tube

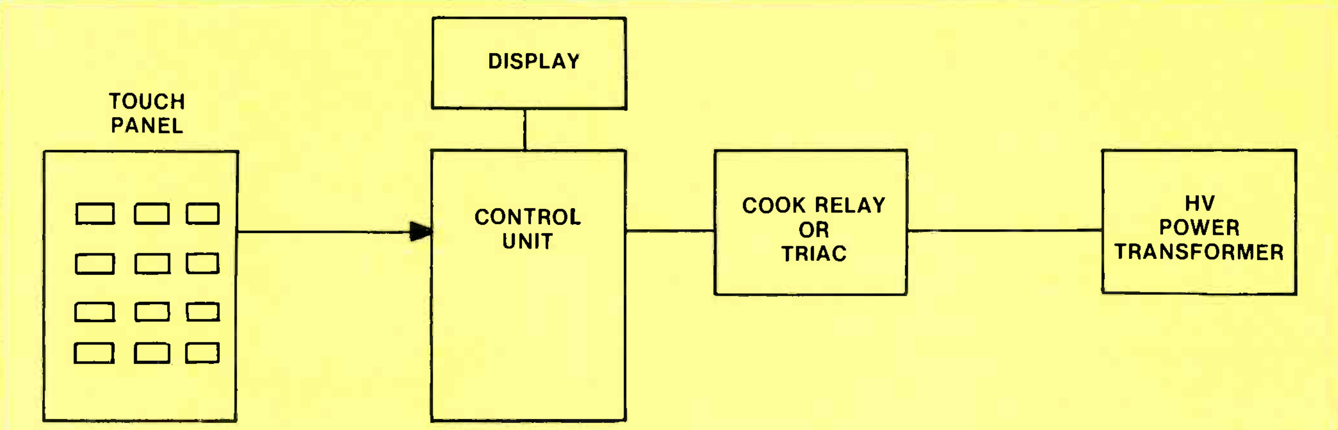


Figure 2

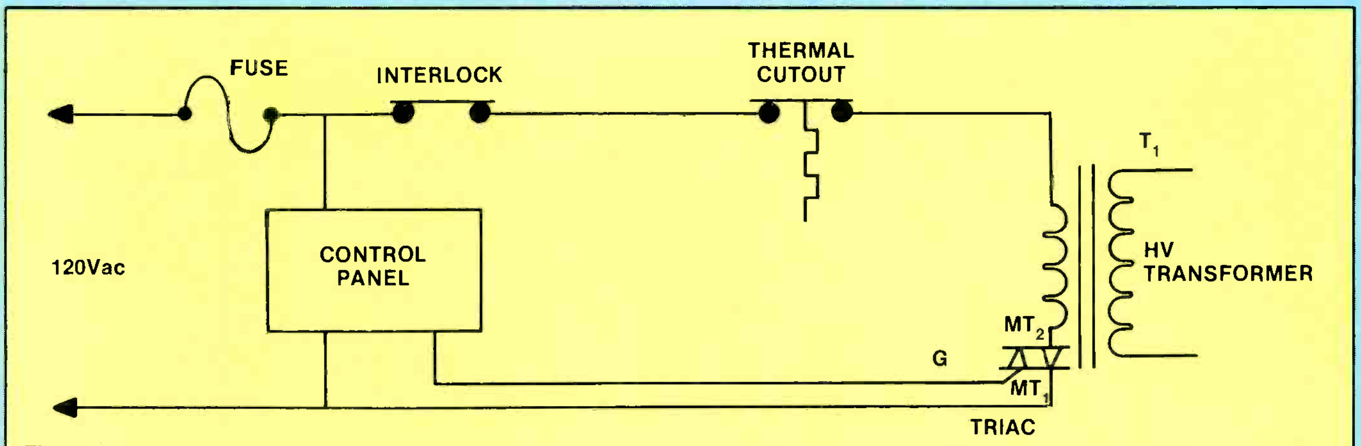


Figure 3

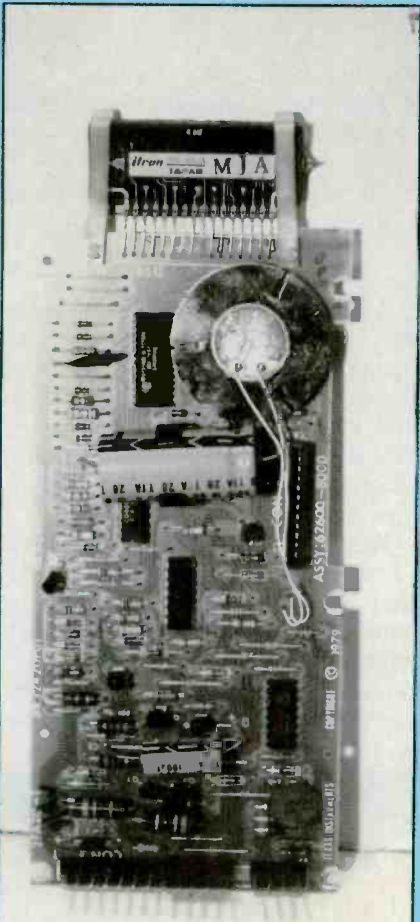


Figure 4

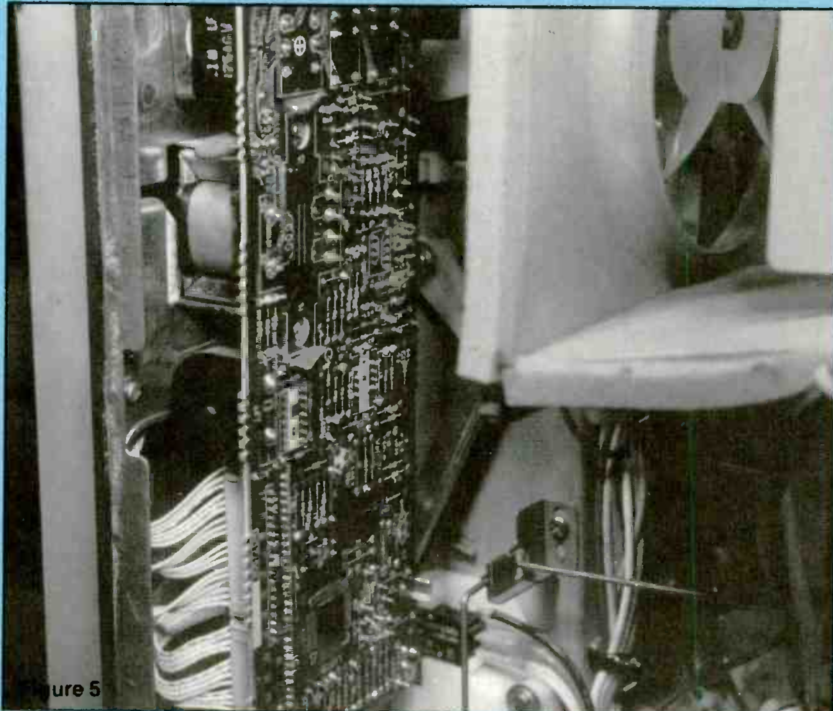


Figure 5

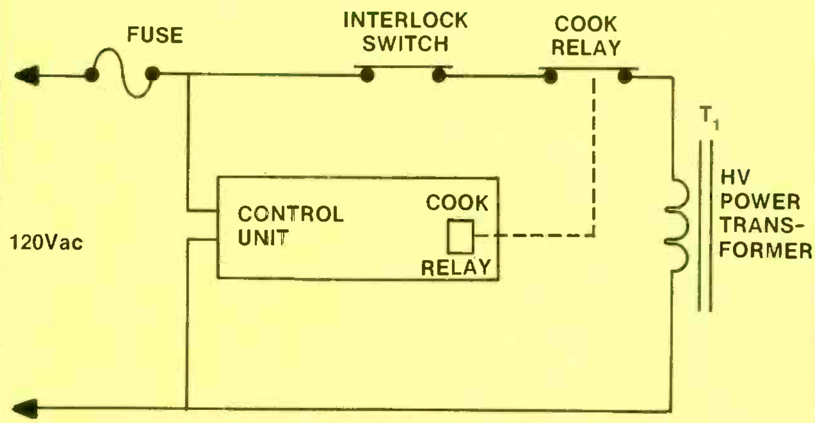


Figure 6

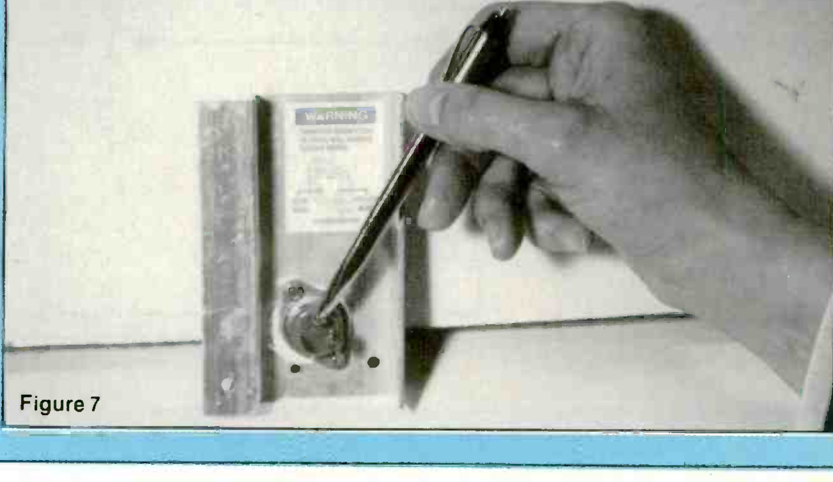


Figure 7

Figure 4. The digital display is found at the top of the control board. The round object below it is a ceramic annunciator for signalling.

Figure 5. In some ovens the small power transformer of the low-voltage supply is mounted on the control unit. If you suspect that oven failure is due to lightning damage or some other kind of power surge or spike, check this transformer.

Figure 6. In some models the control unit operates the cook relay assembly. The relay may be mounted on the control unit or separately in the oven.

Figure 7. Measure the gate voltage at the triac assembly to see if it is receiving a signal from the control unit. In this example the smallest space terminal is the gate connection.

does not light up. (See Figure 5.) The plate and grid voltage for the display tube are supplied by the control board. Check the oven fuse when the digital display does not light up and the oven doesn't operate. If you replace the fuse and the display still doesn't light, suspect a defective control unit.

The temperature probe

Some microwave ovens have a removable temperature probe, which is plugged into a jack found on the oven cavity wall. To use the temperature probe, you insert it into the food to be cooked, then press the appropriate buttons to input the final temperature that the cooked food is to reach. The oven will turn off automatically when the food reaches the programmed temperature.

When the temperature probe is plugged into the oven jack, it connects the probe directly to the control board. A probe sense switch may be activated at the same time in some ovens. This sense switch disables all regular cook operations and the oven will only operate on the sensing temperature probe. The probe sense switch is also connected to the control panel. The oven should never be operated with the temperature probe lying in the oven cavity. Most oven temperature probes are not interchangeable with other makes and models.

A defective temperature probe may cause improper program temperature operation: temperature does not update, final food temperature is wrong and the unit shuts off too soon. You can determine whether the problem is caused by the control board or by the probe by making the appropriate tests as discussed below.

For example, the temperature probe in a Norelco S7500 model can be checked with the ohmmeter. A thermistor in its tip has a resistance that decreases as its temperature increases. The probe shows a resistance of 55,000Ω at room temperature. Other temperature probes may have a resistance of 42,500Ω to 59,000Ω.

The temperature of a Sharp R-7350 model may be checked at 200°F. Here's how to do it. Put nine ounces of water in a 2-cup measuring cup and place the temperature probe in the water. Place the container and probe in the center of the oven and plug the probe into the oven receptacle.

Set the cooking temperature at 200°F and touch the COOK pad. In approximately 4 minutes the temperature of the water should be about 200°F and the oven should shut off. Disconnect the probe and measure the resistance at once, while the probe is still hot. The resistance should be 37,000Ω to 41,000Ω at 200°F. If the resistance differs greatly from this range of values, the probe is defective and should be replaced.

Servicing the control circuits

When you're faced with an oven that doesn't operate, the first step is to determine if it's caused by the power circuits or the control circuits. Determine if the oven relay or triac assembly is activated by the control unit. (See Figure 6.) Although the control panel selects time, temperature and clock operation, its main function is to turn the oven on and off. In ovens with the cook relay, you can hear and see the contacts close if the control panel is normal. Because the triac is silent in operation, you'll have to take a voltage reading to see if the gate voltage is present.

Before touching any of the circuits in the oven, carefully discharge the high-voltage capacitor. Clip the DMM test probe to the gate terminal of the triac. Clip the ground probe to the bottom or ground side of the high-voltage capacitor; sometimes just clipping the ground probe to the oven chassis may not make a good ground. Start the oven and measure the gate voltage. (See Figure 7.) A normal 5V is found at the Norelco triac assembly. No gate voltage indicates a defective control unit. A cook relay and triac assembly are both found in a Sharp SKR-9105 model.

Ovens with cook relays may be checked by measuring the voltage across the relay solenoid winding. Again, clip the leads of a DMM across the solenoid winding terminals after discharging the HV capacitor. Start the oven and measure the dc voltage across the relay terminals. No voltage here may in-

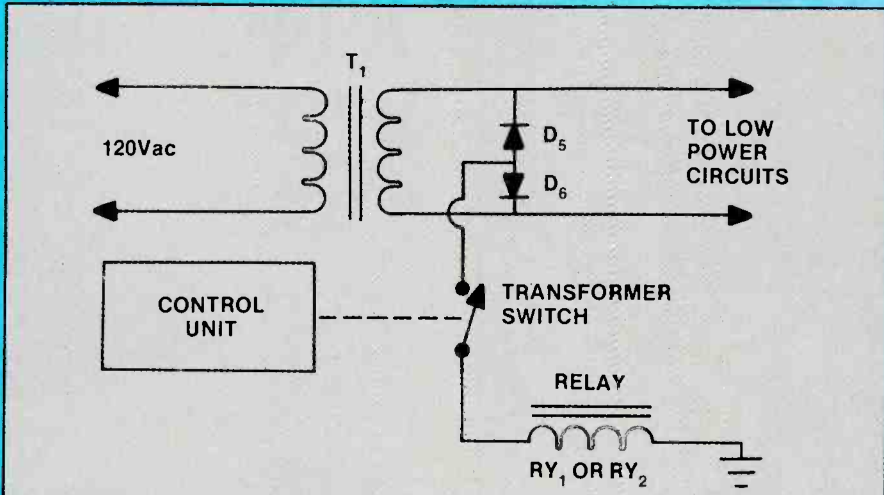


Figure 8

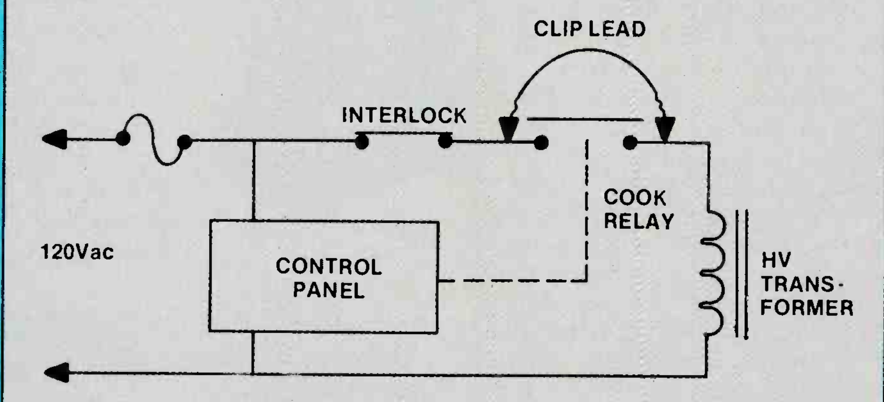


Figure 9

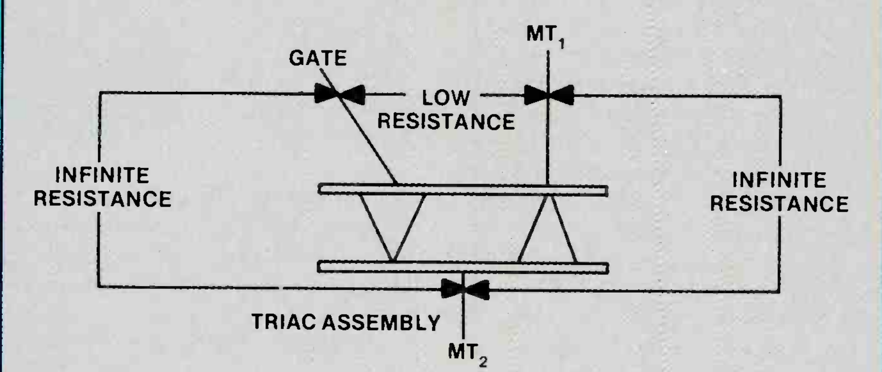


Figure 10

Figure 8. In a Sharp R-7350, a transistorized switch of the control unit controls the cook relay.

Figure 9. Placing a clip lead across the cook relay terminals will establish whether an inoperative oven is caused by the control circuits or if it's the power circuits. Always be sure that the HV capacitor is discharged before touching anything in the oven.

Figure 10. If you suspect that the triac is leaky, check it with the high ohms scale of the ohmmeter. You should measure infinite resistance in both directions between MT_1 and MT_2 if the triac is normal.

dicate a defective control unit.

If the proper control voltage appears at the relay terminals, the relay may be defective: for example, it may have an open solenoid winding. Check the continuity of the relay winding with the ohmmeter. The resistance should be somewhere between 100Ω and 150Ω.

In a Sharp R-7350 model, the cook relay is activated by a transistor switch located in the control unit. Actually, the solenoid winding of the cook relay is in series with the transistor turn-on switch and ground return of diodes D_5 and D_6 of power transformer T_1. (See Figure 8.) These components are all located on the control board.

To check out the relay in this case, disconnect wire lead terminals 3 and 5 and connect the ohmmeter leads to the relay terminals. The meter should read infinite with the power off, and display a low reading when the cook pad is touched. Replace the control unit if improper operation is found.

If the relay is energized and the oven still doesn't cook, suspect poor relay contacts. You may check the contacts with the ohmmeter, or simply shunt a clip wire across the solenoid terminals feeding ac to the primary winding of the high-voltage transformer. (See Figure 9.) The oven should come on at once if the high-voltage circuits and the magnetron tube are normal. Replace the oven relay if it is defective.

Oven starts when on/off pushed

A problem encountered in some microwave ovens is that the oven will begin to operate immediately when the on/off button is pressed, instead of remaining inoperative until you enter the desired cooking time and press the START or COOK button. In some cases this problem indicates a faulty control unit. In other cases, however, a leaky triac located in the primary winding of the high-voltage transformer may be at fault. To isolate the cause of this problem, simply discharge the high-voltage capacitor, pull the gate wire off the triac and start again. If the oven begins to cook, the triac is conducting with no gate voltage present, which suggests that the triac is leaky. In some ovens, you may find two different triac assemblies, one for the browner element and the other for the primary winding of the power transformer.

The suspected triac may be checked with the high-resistance range of a VOM or DMM. Resistance measurements between gate and T_2 on a good triac are infinite in both forward and reverse directions. (See Figure 10.) Likewise, the resistance measurement between MT_1 and MT_2 of a normal triac is infinite. A normal low-resistance measurement may be found in either direction between gate and MT_1. Suspect a leaky triac if the resistance measurements between gate and MT_2 or between MT_1 and MT_2 in any direction are low.

Blowing the fuse

In some ovens the fuse may blow when the on/off switch is pressed, indicating a short in the oven components. If the fuse blows when the cook pad is touched, do not change the control unit. Check for a shorted fan motor, magnetron or high-voltage rectifier.

Carefully discharge the HV capacitor and disconnect the high-voltage lead from the magnetron. Clip a 100W bulb across the primary winding of the transformer. Now, reset the control panel and touch the cook pad. If the light is bright and the oven fuse doesn't blow, the leaky component is in the high-voltage circuits. If the fuse blows at once, check the magnetron fan motor and stirrer motor for a short circuit.

Control unit power-supply

In cases where the control panel is found to be defective, most manufacturers would like to have the control unit replaced with a new one. This is especially true if the control panel is in warranty. Although replacing the control panel is quick and easy, a few voltage tests on the power supply of the control panel may reveal a few simple defective components; replacing just those will place the oven back into operation. Standard components in the power-supply circuits may be obtained locally or from the manufacturer.

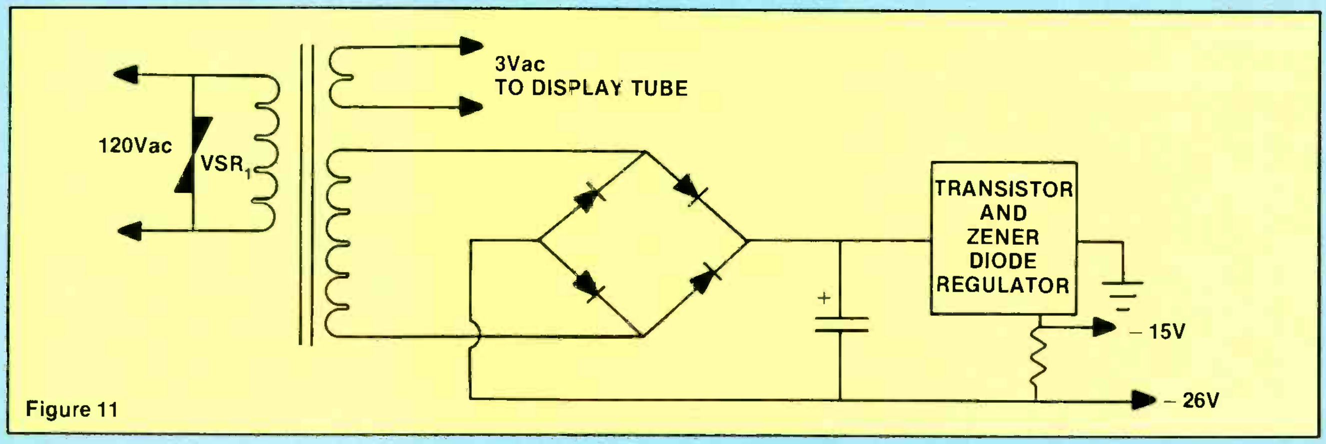


Figure 11

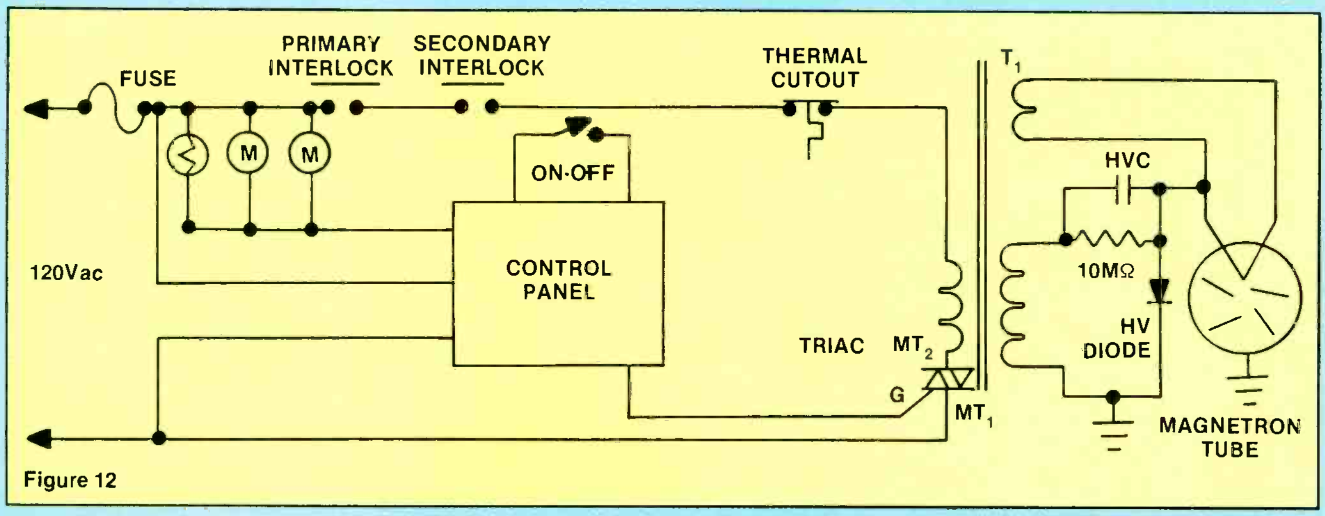


Figure 12

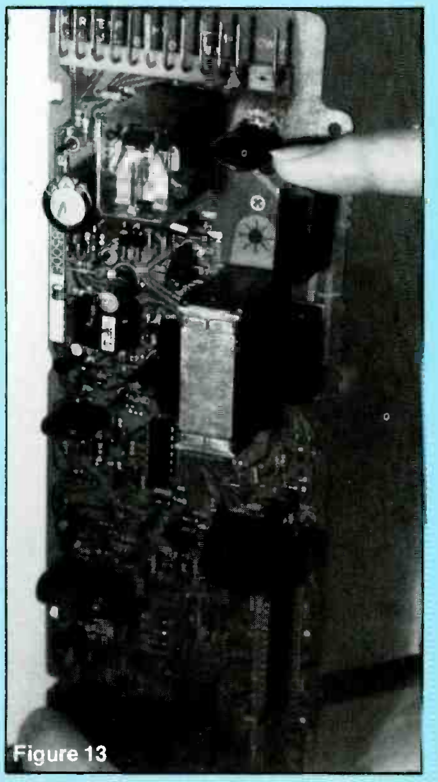


Figure 13

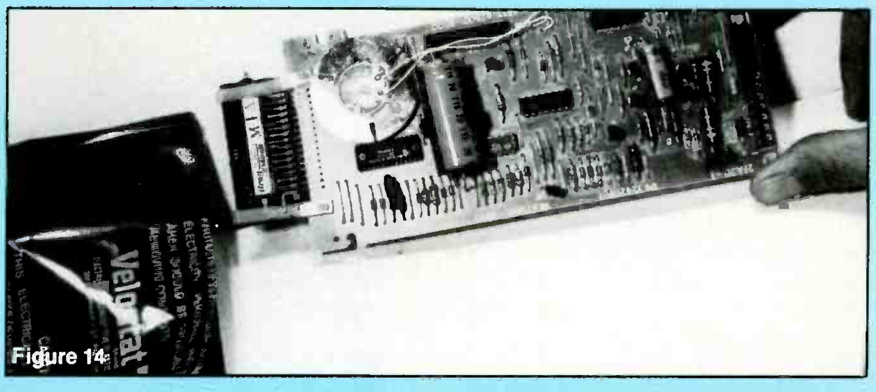


Figure 14

Figure 11. Check the low-voltage power supply of the control unit, just as you would do with a TV or audio system. Voltage measurements and leakage tests of diodes turn up most defective power supplies.

Figure 12. Before you take the drastic step of replacing the control unit, check other components. Poor interlock primary and secondary switches cause many oven problems.

Figure 13. A varistor across the incoming ac line protects the power transformer and other control components when lightning or power-line problems exist. Here the inside of the varistor was blown open after lightning struck the incoming ac line.

Figure 14. If the control board is susceptible to electrostatic discharge (ESD) damage, the replacement will come in a package that protects against static electricity. Be sure to take precautions against causing ESD damage, or you could destroy the new board before it's installed.

The power supply may be a full-wave bridge circuit with zener diodes, IC and transistor regulator circuits. (See Figure 11.) Check for correct voltage at the different voltage sources with the DMM. Improper voltage or absence of voltage may indicate a leaky or open component in the power supply. The control unit may be removed from the oven to check transistors, diodes and zener diodes for leakage. Check the transistors and diodes in the circuit with the diode test of a DMM. The windings of T_1 may be checked with the low ohms scale.

Last minute checks

Before replacing the front panel, make sure other components are not defective, or that problems elsewhere in the oven are not the cause of the trouble. Check for a good ground system at the receptacle the oven is plugged into. Make sure the ac operating voltage is between 110Vac and 120Vac. Sometimes, if the receptacle ground is defective, the panel may skip numbers, giving incorrect readings, or it may become difficult to program or erratic in operation.

Make sure all interlocks of the oven are operating properly. (See Figure 12.) Check each interlock action with the ohmmeter. Besides the primary and secondary interlock switches, check the door interlock sense switch found in some models. You may be able to program the control panel with a defective door interlock sense switch, but the unit will not start. This symptom may be confused with a defective control panel.

A defective on/off sense switch may prevent the fan blower, light and stirrer from operating. In this case the display will only show 88.88 on the display. When the oven comes on as the start or cook button is pressed, suspect a shorted triac rather than a defective control board. If the oven blows a fuse as soon as the start or cook button is pressed, check the oven for a leaky magnetron tube or high-voltage diode, not a defective control unit. Make sure the control panel is operated according to the manufacturer's directions, and check that other components are not defective before you replace the control panel.

Lightning damage

Often the control board is damaged by lightning strikes on the power line entering the house or by surges caused by power outages or shorting of high-powered ac lines during electrical storms. If you suspect damage as a result of power-line transients, check for burn marks near the control board. Notice that there is a varistor placed across the line to protect the control-board circuits. (See Figure 13.)

Replace the control board if it is excessively damaged by the lightning strike. If the damage doesn't appear to be excessive, you may find that other components are normal and only the varistor needs replacement. Clean off all burn marks and repair any damaged wiring. Re-install the repaired board in the oven and give the oven a test run. If everything is operating properly, replace the varistor across the ac input.

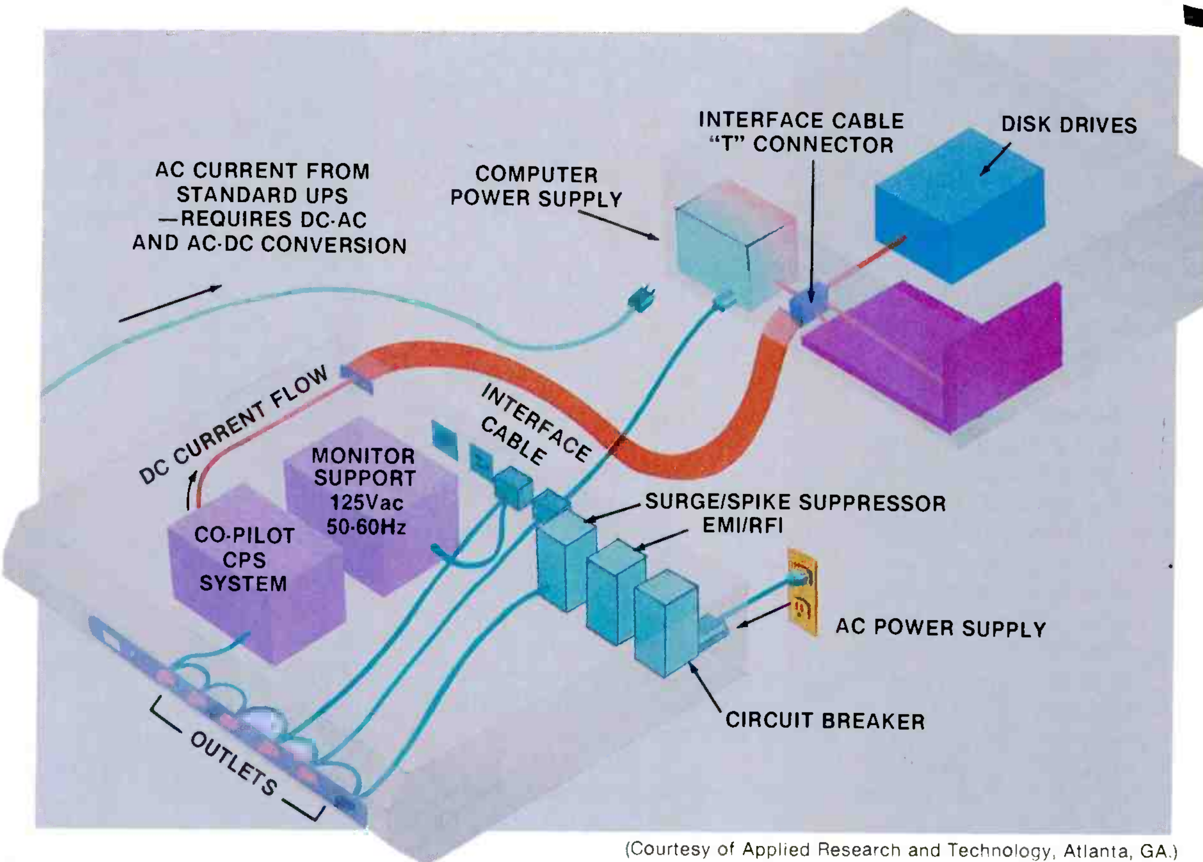
Some final precautions

Always discharge the HV capacitor before you touch any of the oven circuitry. Make sure that the control panel is defective before you replace it. Take precautions against electrostatic discharge damage when handling the control board. (You will probably find that it comes in an antistatic package for protection–see Figure 14.) Handle the control unit by the edges when you mount it in the oven. Once it is in place and the oven is back in operation, take gate or relay voltage readings to make sure everything is operating properly. Finally, making sure that you are familiar with the control panel, test the operation of the oven to ensure that it is completely restored to normal.

As was pointed out in the body of the article, there are some simple repairs that the technician in the field can make to the control board. In most cases it makes more sense to replace the entire board in order to eliminate lengthy diagnostic procedures to troubleshoot down to the component level.

ES&T

Power conditioning



(Courtesy of Applied Research and Technology, Atlanta, GA.)

By Conrad Persson

Late last winter, a relative asked me what I thought about the need for power conditioning. He had received a flyer from the local power company announcing a program of power conditioning for its customers. For a fee, the company would send an electrician to his house to install a lightning arrester, to protect the power line coming in, and a surge suppressor at the point where the most sensitive equipment is connected to the home's electrical wiring.

My response was that it's like buying insurance. His house might never be hit by lightning, making the investment worthless. On the other hand, if he didn't have it done and lightning hit the house, some equipment would be damaged.

About a month later he told me that the house had been hit by lightning, he had not had any of the power protection equipment installed, and the garage door opener, the TV and a cordless phone had been damaged.

Not long after that, a friend at work told me that her house had been hit by lightning and some of her consumer electronics equipment, notably her television, had been damaged.

These are, unquestionably, spectacular failures caused by disturbances on the power line. Whether or not it is economically feasible to protect the incoming power line of any one home against what is still an unlikely occurrence is still a moot point. However, it has been demonstrated that power lines inside and outside homes are subject to disturbances that can cause damage to delicate electronics equipment. The cumulative effect may be degradation of performance or outright failure of the product.

The nature of power-line disturbances

Much of the following information is excerpted from a paper titled "Power Line Problems – An Introduction," by Charles F. Kerchner, Jr., P.E., President of Kalglo Electronics Company of Bethlehem, PA.

To understand what power-line disturbances are all about, you need to understand some terms and definitions.

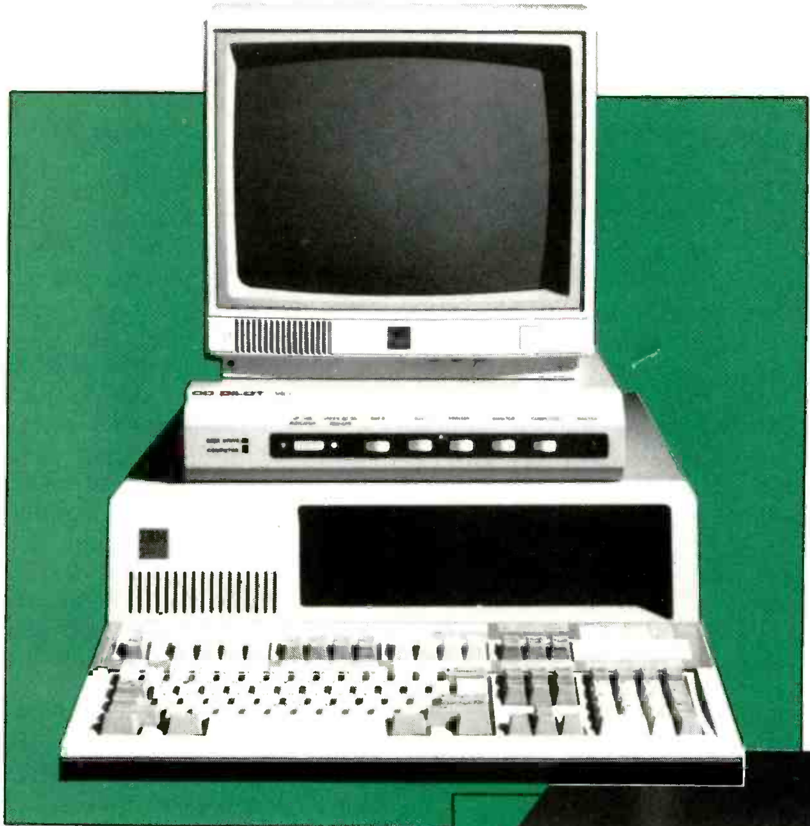
- Steady-state voltage – This term describes steady-state rms voltage values that stay constant for 10 seconds or longer.
- Nominal or normal voltage – The normal, planned voltage for a system. For most purposes in consumer electronics this is 110Vac to 125Vac.
- Power failure – A condition in which the power-line voltage drops to zero for more than one cycle (1/60 of a second) on any one of the three phases used to transmit the power.
- Blackout – A total power failure lasting from several seconds to hours or more.
- Brownout – A reduction in the steady-state utility power-line voltage below its nominal value.

The term *brownout* ordinarily means a low-voltage condition that is planned and announced beforehand to users, and is usually done to compensate for heavy electrical consumption.

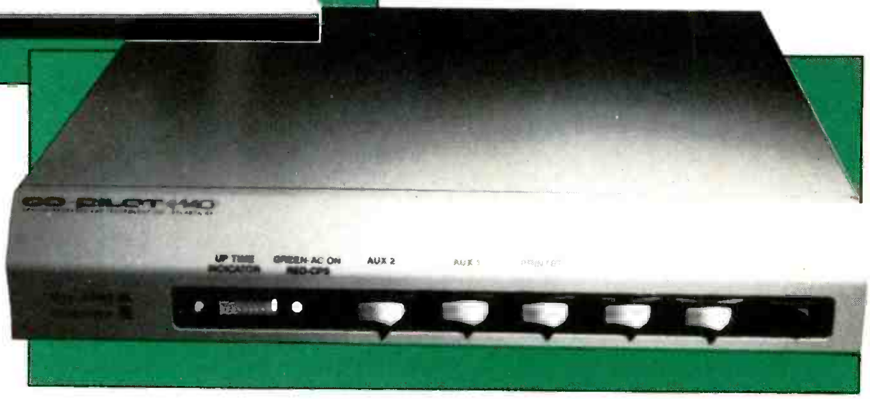
- Undervoltage – A continuous reduction in the steady-state voltage to below the nominal voltage. This condition is similar to brownout but ordinarily refers to unplanned reductions by the utility or a localized condition on a particular circuit.
- Overvoltage – A situation where the steady-state voltage of the power line exceeds the nominal voltage.
- Sag – A decrease in the power-line voltage for a number of cycles of the power waveform on any of the three phases. The duration of a sag is determined by the number of cycles of the 60Hz frequency that the disturbance lasts.
- Dip – A brief decrease in the power-line voltage. This is similar to a sag, but lasts a shorter amount of time.
- Surge – An increase in power-line voltage above normal that lasts for a number of cycles. A surge is the overvoltage equivalent of a sag.
- Impulse – A very short-term disturbance, increase or decrease, superimposed on the ac sine wave, that typically lasts between 0.5μs and 100μs. Impulses that increase the instantaneous voltage are called *spikes*, while those that decrease the instantaneous voltage are called *notches*.
- Spike – An overvoltage impulse ranging from 400V to 5,600V or more, superimposed onto the ac sine wave. Any spike of more than 600V can be highly damaging.
- Notch – An undervoltage impulse similar to a spike, but of opposite polarity to the instantaneous value of the ac sine wave. It is called a *notch* because the effect is to cause a notch in the sine wave. A notch typically lasts about as long as does a spike, but it may last up to several milliseconds. Spikes and notches ordinarily occur in pairs or in an oscillating series. For every notch there is usually a spike that follows because of power-line inductances and capacitances.
- Transient – Any short-term, abnormal event on the power line. All power-line disturbances are transient by definition.
- EMI – An abbreviation for *electromagnetic interference*. In terms of power-line problems, this is broad spectrum, electromagnetic noise that is either impressed on the power line directly from the source, or is radiated to the power line and then conducted to susceptible equipment.
- RFI – Electromagnetic noise in the radio frequency spectrum.
- TVI – Electromagnetic noise in the television spectrum.
- EMP – The abbreviation for *electromagnetic pulse*; EMP describes the powerful pulse of electromagnetic energy, generated by a thermonuclear explosion, that may damage or destroy sensitive electronic devices and interfere with electronic telecommunications.
- Differential mode – Power-line disturbances that occur across the normal current-carrying wires of the power line, from the hot wire to the neutral.
- Common mode – Power-line disturbances that occur between both of the current-carrying wires and ground.
- MOV – The abbreviation of the term *metal oxide varistor*. This is a 2-terminal device with a voltage-dependent resistance: When the voltage across the device increases above a specified value, its resistance decreases abruptly (1ns to 5ns). When connected from a line to ground, for example, if a large transient occurs, it switches from a very large value of resistance (essentially an open circuit) to a very low value and absorbs the potentially damaging voltage increase. MOVs are most effective when used in groups of three (line to ground, neutral to ground, line to neutral) to provide both common-mode and differential-mode protection.

This unit, the Mini-II, plugs directly into any properly grounded outlet, provides transient-voltage surge protection and is available with EMI/RFI filtering.

- Silicon avalanche zener diodes – A fast-acting, solid-state junction device, but with low energy-handling capacity. With switching speeds in the picosecond range, they operate by shunting the surge or spike to ground before it can enter the protected circuit.
- Gas discharge tube – A calibrated spark gap in a gas-filled chamber. These devices are relatively slow, operating in microseconds, but they can handle very large energy surges. They operate by shunting the surge or spike to ground before it reaches the protected unit. These devices are frequently placed at the service entrance and are used to provide protection for the wiring in an entire building.
- EMI/RFI filter – A circuit or device that contains series-inductive (load-bearing) and parallel-capacitive (non-load bearing) components that provide a low-impedance path around the protected circuit for high-frequency noise. Filters also attenuate impulses, because a Fourier analysis of a spike will reveal that a spike is composed of high-frequency sinusoidal components. Because of this, filters and surge suppressors used together act synergistically; that is, the two together provide better protection than the sum of the individual protection factors.
- UPS – Abbreviation for *uninterruptible power system*. Provides a steady source of power at or near the nominal line voltage to a piece of equipment, regardless of power-line disturbances such as sags, dips, brownouts or blackouts.
- Voltage-regulating transfor-



This unit, the Co-Pilot by Applied Research and Technology, is designed to be placed directly on the computer. The computer monitor is then placed on top of it. The unit provides surge and spike protection and EMI/RFI protection. In addition, according to the manufacturer, its internal battery will provide two hours of operating time for a fully loaded IBM PC AT in the event of a blackout or brownout.



mer – A continuous acting transformer, usually ferroresonant, that instantaneously regulates the output voltage to normal levels despite wide swings in the input voltage.

• Power-line conditioner – A combination of a voltage-regulating transformer with a super isolation transformer that provides smooth, regulated, noise-free ac voltage with no ohmic connection between input and output. This kind of unit will correct most power problems other than complete power failure.

How often do problems occur?

Mr. Kerchner's paper cites studies by three organizations that indicate that power-line problems occur regularly. For example, one study by members of the Institute of Electrical and Electronic Engineers (IEEE) shows that surges and impulse voltage spikes can occur as frequently as twice per hour in a typical residence, with peak values as high as 1,500V to 2,500V. During thunderstorms, peaks as high as 5,600V were observed.

A study by IBM in 29 different locations throughout the United States showed that an average of around 50 voltage spikes occur per month. This represented almost 40% of the total disturbances they observed.

A 2-year study by Bell Laboratories showed that most locations will experience approximately 25 power-line disturbances in a year, 87% of which were sags below 96V. Sags of this magnitude can cause the power supply in electronic equipment to malfunction.

While these studies don't agree completely on the nature of power-line disturbances, there is correlation that power-line disturbances are indeed a problem.

Solving the problem

Part of the solution is in the hands of the engineers who design the products. Where the quality of the product warrants, they must design or specify power supplies that will operate over a wider range of power-line voltages. They can include power-line disturbance suppression circuitry in the products they design.

For products that do not have adequate protection from power-line disturbances, which includes most if not all electronics products found in the average home (TVs, stereos, microwave ovens, VCRs, personal computers and so forth), the answer is to connect some kind of protection device in the power line to intercept spikes and surges before they enter the unit.

Mr. Kerchner makes an interesting point regarding external protection. Even in cases where internal protection is provided, it may make sense to use external protection. No matter how good a job the design engineer does of designing-in protection, those protection components usually take some finite, even if very short, time to turn on and provide their protection. And some kinds of faults can find their way around or through some kinds of power-line disturbance. If protection is provided external to the unit, the wiring between the protection device and the unit being protected provides a kind of delay line, giving the external protection device time to work fully before the disturbance reaches the equipment.

How power-protection devices work

Power protection comes in a number of shapes, sizes and degrees of effectiveness. One of the most familiar is the simple 6-outlet power strip with built-in components to intercept sags and spikes coming down the line *before* they get into your expensive and sensitive VCR or personal computer. Other power-protection devices are simply plugged directly into the wall outlet. Sensitive electronic equipment is then plugged into the power protection device.

There are some power-protection devices that are made for specific brands of computers. These include delayed turn-on of some of the outlets so that the computer will be turned on before the peripherals, such as the printer or external disk drive. Some manufacturers even provide a current sensor on one of the outlets in the box, so that all of the other outlets remain inoperative until current is drawn from one main receptacle. This gives the user the ability to use the on/off switch of one piece of equipment plugged into the device as a master switch to turn on all the equipment plugged into the device at once.

The sidebar accompanying this article shows schematic diagrams of some of the kinds of power-line conditioning products available and describes how they work.

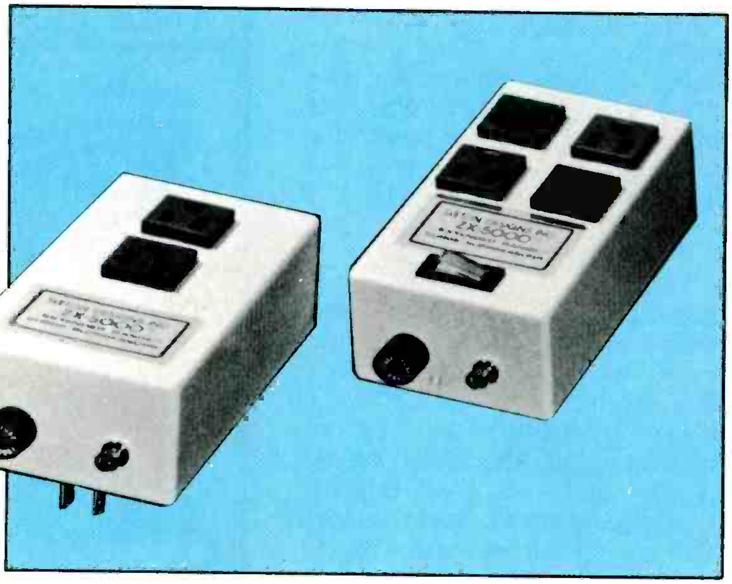
How good are they?

Power line conditioning products available for consumer electronics range from the almost worthless to the very effective. For starters, you can get some idea of the effectiveness of a given product by checking its UL listing. A good guide is to check to see if the device carries a label that says that it is UL Listed under Classification 1449 or 1283. UL classification 1449 is the classification for transient-voltage surge protection, and this listing indicates that the device has been tested and found to provide this type of protection.

UL classification 1283 indicates that the device has been tested and shown to provide transient-voltage surge suppression and also provides RFI/EMI noise protection.

If a device is listed under some other classification, it might have only been tested and found to be safe under the standard for an ex-

This device is designed to protect the entire building and all electric/electronic equipment in it from large, high-voltage surges coming from outside the building. Considered primarily a lightning surge arrester, this device would be installed by an electrician at the service entrance. It consists of a gas tube that dissipates larger surges to ground, then restores itself.



According to the manufacturer, this unit, the Sutton Designs ZX-5000 Extended Range series of surge-spike-noise suppressors, contains advanced protection circuitry designed for computer protection in military, space and heavy-duty commercial applications. Voltage withstand capability of the units is 25,000V, the dynamic short-term current rating is 20,000A, and clamping voltage is 195V.

tension outlet or multi-outlet plug, with no indication of whether it protects against transients.

I like to think transient-voltage surge suppressors are a little like seat belts: For the most part, you probably don't need one, but it's a

Continued on page 39

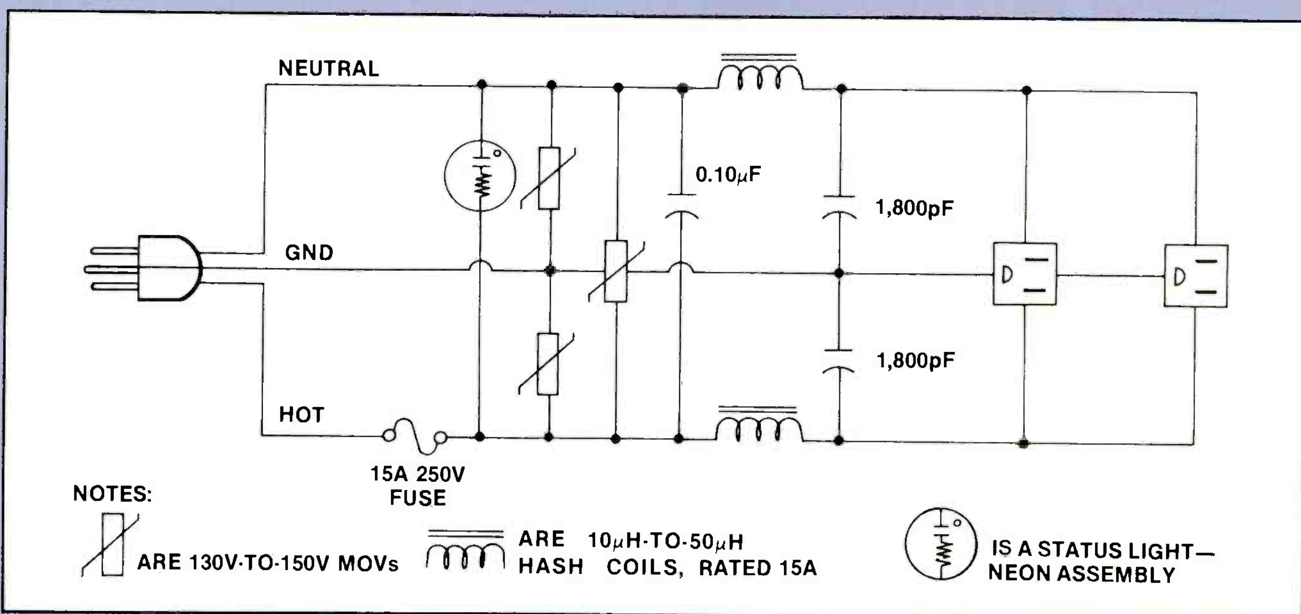
Here is a schematic diagram of a transient-voltage protection device with EMI/RFI noise protection. When the neon lamp is lit, it merely means that the device is connected to the line. It doesn't imply that the protection components are working.

The three MOVs provide transient-voltage surge suppression, and the capacitors and coils provide EMI/RFI noise supression. As discussed in the text, however, the transient protection and noise suppression act together synergistically so that the total protection offered by the combination is greater than the sum of the individual circuits.

The three MOVs are voltage-dependent resistors. The two MOVs connected from hot to ground and from neutral to ground protect against common-mode transients: those that are impressed on both the neutral and hot lines. The MOV connected from hot to neutral protects against differential-mode voltage transients.

Although the legend indicates that the MOVs used are rated between 130V and 150V, Kerchner says that 150V units are adequate to provide protection. Attempting to clamp the device's output too close to nominal line voltage might cause damage to the protection device in the event of a prolonged rise in line voltage to at or slightly above the rating of the MOVs.

The arrangement of capacitors and coils attenuates smaller-voltage anomalies that would not activate the MOVs, but would appear as noise at the input of the electronic product plugged into the line if they were not attenuated.



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good idea to have it on and working in case you ever do need it. And just as with seat belts, they will protect you up to a point. If you drive head-on at 65 miles per hour into a semi going 65 miles an hour in the opposite direction, no seat belt is going to save you. Just so with power protection devices: If your VCR is plugged into the ac line when a lightning bolt strikes the power line a few feet from your house, the spike coming through will probably destroy any power-protection device and the equipment it was installed to protect as well.

And if the unit it was designed to protect is your personal computer and you're sitting at the keyboard, you just might experience catastrophic failure as well.

Once again, caution is urged. If there are thunderstorms in the area, unplug any sensitive electronic products (do this well before the electrical activity gets too close, lest you have your hand on

Sources of power conditioning equipment

Acme Electric Corporation
125 S. Union St.
Olean, NY 14760
716-373-3255

Advanced Electronics Systems
2005 Lincoln Way East
Chambersburg, PA 17201
717-263-5681

Applied Research and Technology
The Pavilion, Suite 210
5770 Powers Ferry Road N.W.
Atlanta, GA 30327-4390
512-259-3403

BEHA Corporation
13191 56th Court, Unit 101
Clearwater, FL 33520
813-576-6074

CPS Electronics
4151-112th Terrace N.
P.O. Box 2460
Pinellas Park, FL 34290-2460
813-578-1600

Clary Corporation
320 W. Clary Ave.
San Gabriel, CA 91776
818-287-6111

Controlled Power
1955 Stephenson Hwy.
Troy, MI 48083
313-528-3700

Current Technology
1400 S. Sherman, Suite 202
Richardson, TX 75081
214-238-5300

Cuesta Systems
3440 Roberto Court
San Luis Obispo, CA 93401
805-541-4160

Dranetz
P.O. Box 4019
Edison, NJ 08818-4019
201-287-3680

Ecos Electronics Corporation
205 W. Harrison St.
Oak Park, IL 60304
312-383-2505

Electronic Specialists
171 South Main St.
Natick, MA 01760
617-655-1532

Elgar Corporation
9250 Brown Deer Road
San Diego, CA 92121
619-450-0085

General Power Systems
1400 N. Baxter St.
Anaheim, CA 92806
714-956-9321

Kalglo Electric
6584 Ruch Road
Bethlehem, PA 18017
800-524-0400

Lakontek
2385 South Clinton Ave.
South Plainfield, NJ 07080
201-755-7680

PMC Industries
9353 Activity Road
San Diego, CA 92126
619-695-3520

PTI Industries
320 River St.
Santa Cruz, CA 95060
408-429-6881

Panamax
150 Mitchell Road
San Rafael, CA 94903
415-499-3900

Para Systems
11425 Mathis St.
Suite 404
Dallas, TX 75234
214-869-1688

Perma Power Electronics
5615 West Howard Ave.
Chicago, IL 60648
312-647-9414

Philips ECG
100 First Ave.
Waltham, MA 02254
617-890-6107

Pilgram Electric Co.
105 Newtown Road
Plainview, NY 11803
516-420-8990

Power Integrity Corporation
1840 Pembroke Road
Greensboro, NC 27429-0682
919-379-9773

RCA Distributor and Special Products Division
200 Clements Bridge Road
Deptford, NJ 08096
609-853-2243

Safe Power Systems
528 W. 21st. St.
Tempe, AZ 85282
602-894-6864

Shape Magnetronics
901 Dupage Ave.
Lombard, IL 60148
312-620-8394

Sola
1717 Busse Road
Elk Grove Village, IL 60007
312-439-2800

Sun Research
Old Bay Road, Box 210
New Durham, NH 03855
800-443-1922

Superior Electric
383 Middle St.
Bristol, CT 06010
203-582-9561

Sutton Designs
Computer Security Division
300 N. Tioga St.
Ithaca, NY 14850
607-277-4301

Technipower
P.O. Box 222
Commerce Park
Danbury, CT 06810
203-748-7001

Tripp Lite
500 N. Orleans
Chicago, IL 60610
312-329-1777

Tycor Electronic Products Ltd.
6107 Sixth St.
SE Calgary, Alberta T2H 1L9
Canada
403-259-3200

Ultima Electronics
21 Central Drive
Farmingdale, NY 11735
516-752-0144

the plug when the surge comes down the line), and don't go near any wiring that comes into the house from outside: antenna, cable, telephone.

Which brings me to one final point: When you're thinking about transient-voltage surge suppressors, you might also give a thought to suppressors for the telephone line if there's a modem for the computer, and consider some kind of protection for any other wiring coming into the house from outside.

For a list of sources of power-conditioning equipment, see "Dealing with Power Line Problems" in the November 1986 issue of ES&T.

ES&T

Books

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

Standards Glossary; Underwriters Laboratories; $18.75.

Underwriters Laboratories' new Standards Glossary is a complete listing of terms and definitions taken from the glossary sections of more than 500 UL Standards for Safety.

The word "current" alone has more than a dozen listings, ranging from "breakaway current" to "threshold current." Distinctions are drawn between identical terms for different applications, such as rated current for products in general and rated current as it applies specifically to protectors. Each definition is followed by at least one UL standard to which the defined term applies.

Published by Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062; 312-272-8800 ext. 2612.

Product Index; Underwriters Laboratories; $8.

The new edition of Underwriters Laboratories' Product Index includes several new categories. The index has also been updated to include references to the latest published and proposed UL safety standards, now covering more than 12,000 products under more than 500 product categories.

Published by Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062; 312-272-8800 ext. 2612.

Communications Electronics: Systems, Circuits, and Devices, by Forest Barker; Prentice-Hall, 676 pages, $36.95, hardbound.

Written for new entrants into the field of electronic communications, this book provides basic information on the systems, circuits and devices used in communications systems. An opening discussion of modulation and a basic AM broadcast-band receiver (including troubleshooting and alignment) introduce the reader to a basic communication system. The more complex FM, 2-way radio, digital and light-wave carrier systems are also covered. The author discusses transmission lines and antennas, noise control, transmission and propagation and basic information on TV stations and receivers. Example calculations, tables and graphs enhance the physical, not mathematical explanations, and glossaries, reviews and quizzes are included after each chapter. Appendices explain the use of the decibel and government regulations.

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

ES&T

Troubleshooting startup circuits

By Gregory D. Carey, CET

This is the second of a three-part series dealing with the horizontal output circuits of modern TV receivers. Part I explained how shutdown circuits operate and the best way to find the cause of shutdown. This time, we will see what happens if the circuits never get started in the first place. Part III will explain how to isolate troubles related to the power supply and regulator circuits. Combining all three should help you isolate any problem related to the output stages.

We started this series by discussing shutdown problems because some technicians blame the safety shutdown circuits any time they are missing high voltage in a TV receiver. Let's start disarming this myth with a very simple axiom: *You cannot have a shutdown without startup*. This rule may be so important that you will want to hang it above your workbench.

The reason I am stressing this point so hard is that you use different methods to isolate *startup* problems than you use to isolate *shutdown* problems. For shutdown troubles, you want to reduce the voltage so that you can monitor the response of the safety sensors as you gradually increase the supply voltage. You isolate startup problems by helping some circuits along while monitoring a key test point. But you need to understand the startup circuits before the troubleshooting processes really make sense. For the most part, you need to remember that the circuits form a closed loop.

The closed startup loop

Figure 1 shows a general block diagram of a modern horizontal circuit. Raw ac voltage is applied directly to a rectifier – usually a full-wave bridge. The output is filtered with a large electrolytic capacitor and then fed to a regulator. (The different types of regulators will be covered in part III.) The regulator feeds one end of the primary of the flyback, which in turn feeds to the collector of the horizontal output transistor.

The output transistor receives its signal from a driver transistor feeding a step-down transformer. The transformer increases the current fed to the output stage to make up for the relatively low gain of the power-output transistor (beta generally runs under 10). The driver transistor gets its signal from the horizontal oscillator. The oscillator and driver, in turn, receive power from a scan-derived power supply connected to one of the secondary windings of the flyback transformer.

If you study this diagram for a moment, you'll soon discover it won't work. The horizontal oscillator cannot run without power from the flyback. But the flyback can't receive power unless the output transistor is being driven by the oscillator. Turning on the power switch gets everything ready, but the horizontal circuit can't get started without a push. That's why you need a startup circuit.

The startup circuit gives the horizontal oscillator and drive circuits the little push they need to start running. When the output transistor begins to conduct, a voltage begins to build in the secondary, feeding the scan-derived power supply. This, in turn, begins to power the oscillator and the driver to provide more drive for the output. After a few cycles everything has built to maximum, and the closed loop is ready to sustain its own operation.

Most receivers use one of two types of startup circuits. The type used generally depends on whether the entire chassis has a single *hot* ground (referenced directly to the ac line), or whether the chassis has a *hot* and a *cold* (isolated) ground. The two circuits are the *trickle* and the *kick* start circuits.

The trickle starter

The trickle starter, shown in Figure 2, is more common and less complicated than the kick starter. In its simplest form, the trickle starter uses a high-value resistor connected between the unregulated power-supply output and the horizontal oscillator and driver. This resistor lets enough current leak through from the raw B+ circuits to let the horizontal circuits start, but does not provide enough

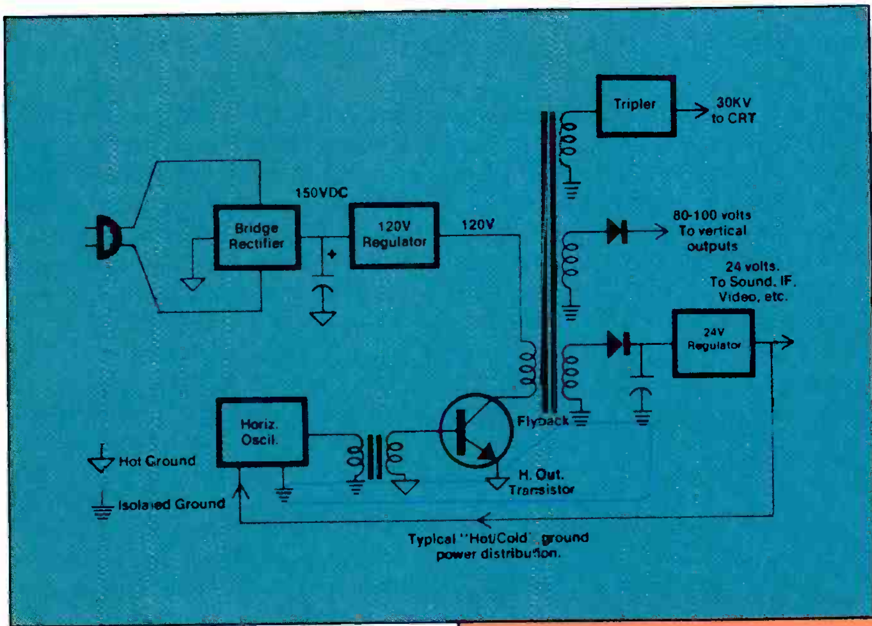


Figure 1. The scan-derived power supply and the horizontal oscillator form a closed loop; the flyback cannot generate power until the oscillator is running. (Courtesy of Sencore)

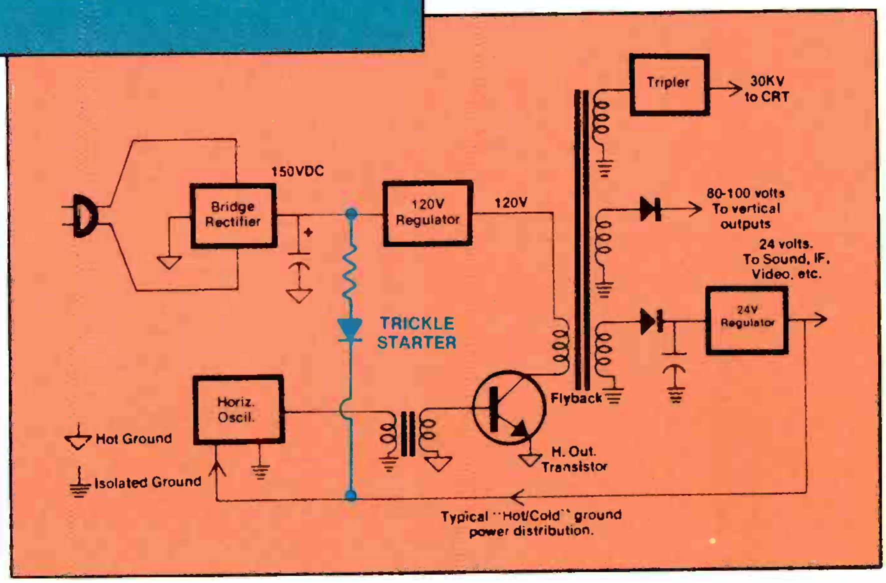


Figure 2. A trickle starter provides a small amount of unregulated voltage until the scan-derived power supply develops enough power to operate the horizontal circuits. (Courtesy of Sencore)

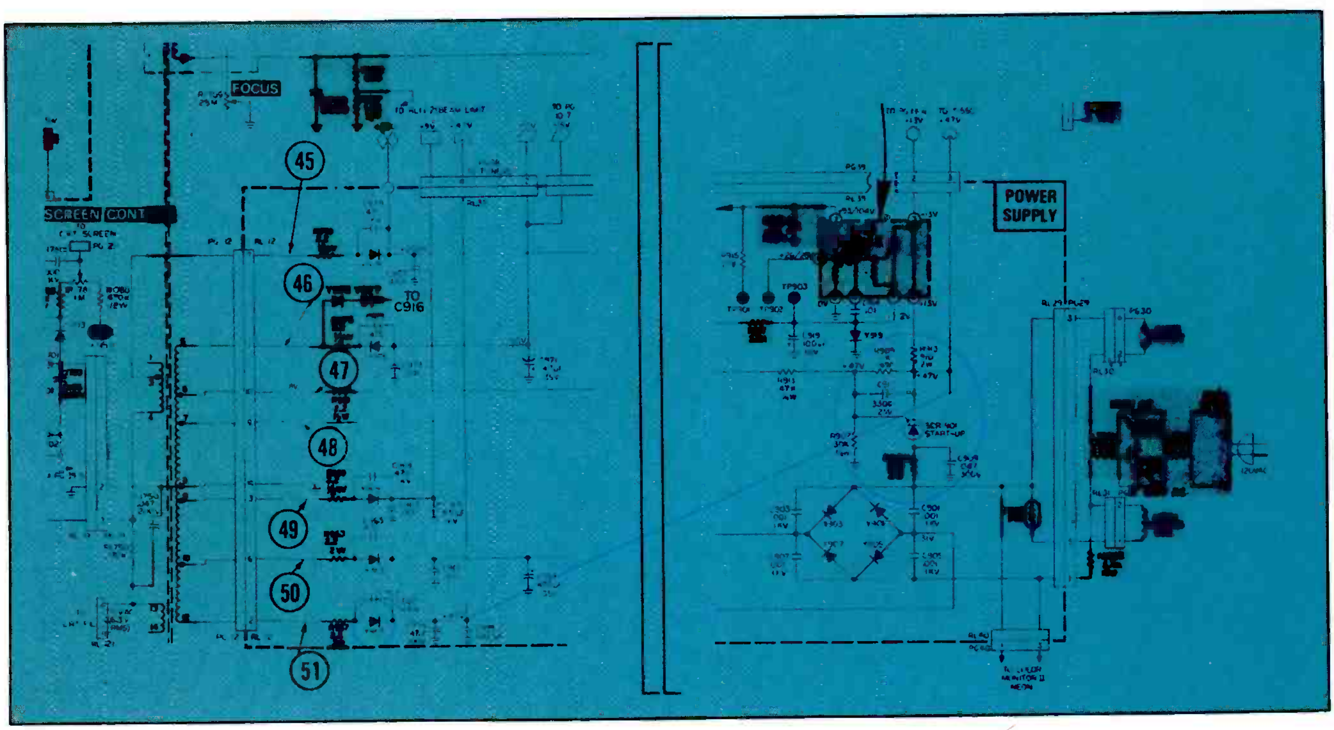


Figure 3. The current through the startup SCR (SCR-901) and the current-limiting resistor (R-905) provide power to the 47V line until the scan-derived voltage coming through the diode on the flyback (Y957) produces adequate power. (Courtesy of GE)

current to sustain operation. When the scan-derived power supply develops enough power, it takes over from the trickle circuit to operate the horizontal circuits.

You might wonder why the designer even bothers with the scan-derived feedback power. Why not reduce the value of the startup resistor and allow the oscillator and driver to be powered directly from the raw power supply? The answer is that this supply is not regulated. Line voltage fluctuations, perhaps caused by the refrigerator starting or by a motor kicking in at a factory down the road, could throw the horizontal oscillator off frequency. If flyback power is used, these surges are eliminated by the output stage regulator. Figure 3 shows an actual trickle startup circuit used in a General Electric set.

Figure 4. This simplified schematic of a circuit used by RCA shows how a kick starter develops an output. The start transformer produces an output, but only during the time that the main filter capacitor (C_1) is charging.

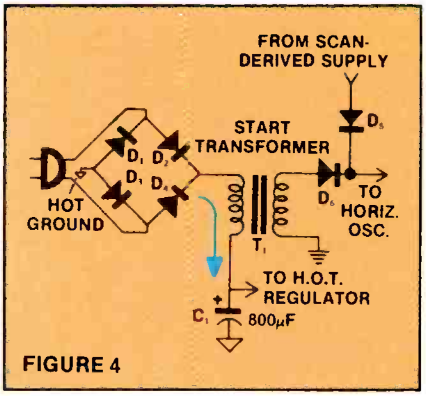
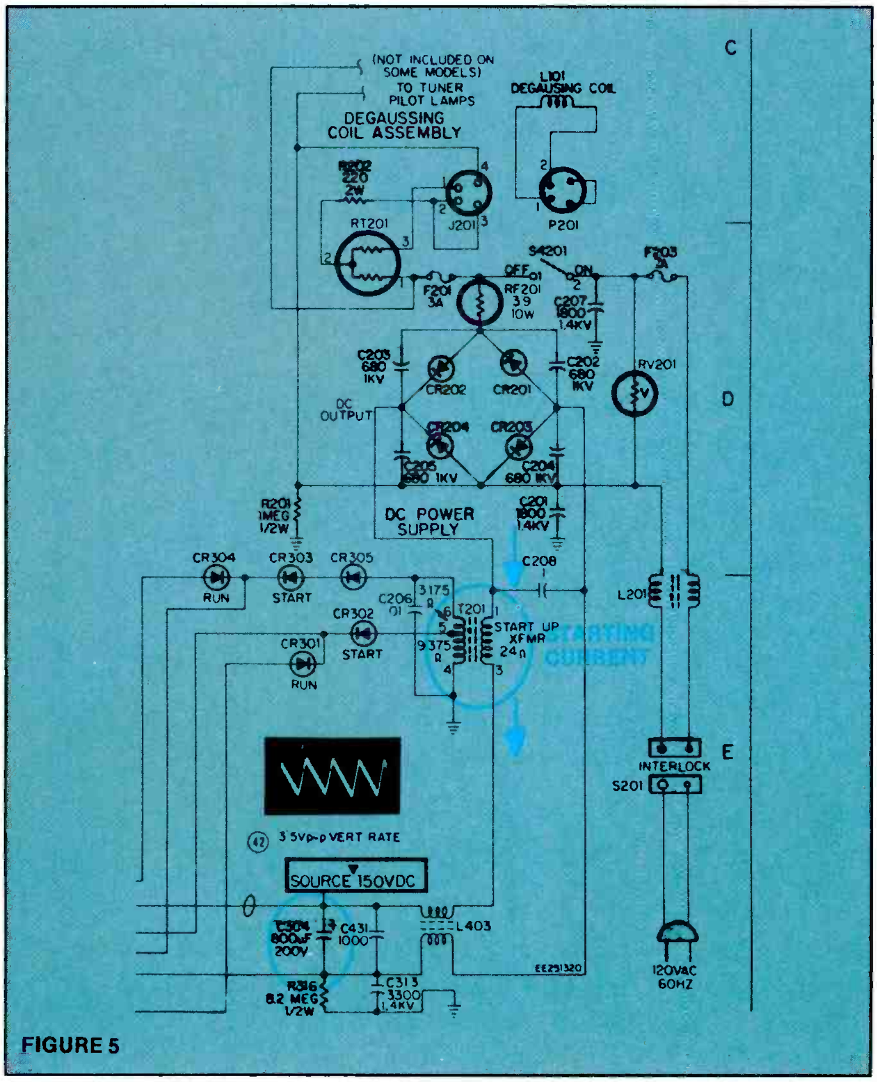


Figure 5. Here is the actual startup circuit used in RCA models from the CTC85 through the CTC101. The start diodes (CR302 and CR305) rectify the output during startup, and then block the flow backwards through the secondary when the output circuits are running. (Courtesy of RCA)



Kick starters

The startup voltage only needs to be present for the few milliseconds needed for the horizontal circuits to start. The kick starter provides these few milliseconds of power, and that's all.

The popularity of kick starters comes and goes, depending on circuit grounds. The circuit is usually found in receivers that have most of the circuits isolated from the ac line by the flyback transformer. These receivers still have a hot ground in the output stage. The trickle starter cannot be used in these receivers because the raw B+ is on the hot side and the horizontal oscillator is on the cold side of the flyback. The kick starter bridges between the hot and the cold sides of the flyback transformer without defeating the isolation.

A common example of the kick starter is found in RCA chassis from the CTC85 through the CTC101. These receivers have a startup transformer between the bridge rectifier and the main power-supply capacitor, as Figure 4 shows. This transformer mystifies some technicians because dc flows through its primary, and we all know that a transformer cannot be used with dc. Yet the transformer produces enough voltage to start the horizontal circuits. How is this possible?

To solve the mystery, you have to think of the circuit *before* the power is turned on, not after the set has run for a while. At this time the main filter capacitor will be discharged. The starting pulse forms as the capacitor is charging. The secondary voltage drops to zero when the capacitor is fully charged and dc current is flowing through the primary winding.

The diode at the output of the secondary serves two purposes. It acts as a rectifier while the starting pulse is formed. It then becomes reverse-biased as the scan-derived voltage builds, preventing the transformer from loading the scan-derived supply. (See Figure 5 for an actual kick-start circuit used in an RCA CTC85 chassis.)

The kick starter creates one particularly annoying problem for the servicer: It only fires one time. This gives you only one chance to determine what took place. And it must be reset by discharging the capacitor before it can fire again. The capacitor may take several seconds to discharge because a dead output stage does not draw normal current. It's a good idea to measure the dc voltage at the capacitor and wait until the voltage drops to about 20V before turning on the set again. That way you know the starting circuits can produce the starting pulse.

Circuits that prevent startup

It should be pretty clear that the receiver cannot start if the startup circuits are defective. However, the startup voltage can be present, but may not have enough energy to get the output circuits up and running. In still other cases the startup circuits work correctly, but a problem in some other circuit prevents the set from starting. These defects are also correctly labeled "startup" problems.

A defective horizontal oscillator, for example, prevents startup. The oscillator may be dead, or it may simply be too far off frequency. Sometimes a bad capacitor or misadjusted hold control can cause intermittent startup.

A set is more likely to have startup problems when it is connected to an isolation transformer. The core of the transformer softens the starting surge and shortens the time the kick starter circuit supplies voltage. The oscillator may be just far enough off frequency that it cannot get started during the shortened starting pulse.

A defect in any other part of the feedback loop also prevents startup. Common defects are in flyback transformers, output transistors or driver transformers. The receiver will also not start if the primary power supply is defective.

WARNING

Always use an isolation transformer when servicing startup problems to prevent death or injury to the servicer or damage to the circuits. TV receivers that use startup circuits almost always have hot chassis, in which some or all the circuits are referenced directly to the ac line. NEVER plug more than one unit into an isolation transformer simultaneously. Doing so may defeat the isolation.

Identifying the problems

The first step to fixing a problem is deciding whether the receiver has trouble in the startup or in the shutdown circuits. You need to know if the horizontal output circuit operated even for a few milliseconds. If some kind of signal appears, you know that the circuits started up and were then shut down. If there is no signal, you treat it as a startup problem.

Some technicians depend on the crackle of high voltage building on the CRT to make this decision. If you hear the high voltage come up, you know that the circuits ran for at least a moment. But the opposite does not always confirm a startup problem because there may be no crackle if the CRT cathodes don't conduct or if the CRT already has high voltage on it from a prior startup. (Note: The flybacks in many modern receivers do not have a high-voltage bleeder resistor, so high voltage may remain on the CRT for a long time.)

A better way to tell whether the circuits started is to monitor a test point when you first apply power. The collector of the horizontal output transistor gives the best information if you have an oscilloscope capable of measuring more than 1,000 volts. As an alternative, you can connect a high-voltage probe to the CRT high-voltage connector to see whether any high voltage develops. We will cover the test at the output transistor because it provides more information.

WARNING

Use extreme caution when making any measurements around high voltage. Remove the power before making connections. Make certain none of the test leads can come loose during a reading. Be especially careful to properly ground your test equipment to the circuit.

Turn off the set and connect your scope probe to the collector of the horizontal output transistor. *Be sure to securely attach the ground lead so it cannot come loose during the test.* Preset your scope to measure the flyback pulse from the output transistor. This pulse normally runs between $700V_{p-p}$ and $1,200V_{p-p}$, so set the input attenuator to its highest voltage level. Set the sweep to the horizontal video rate. Use your "horizontal preset" function if your scope has one, or else set the timebase switch to the 10 microsecond per division rate. (See Figure 6.)

Now, watch the scope's CRT as you turn on the set. If you see pulses build – even briefly – you know the circuits started and were then shut down. Follow the procedures in part I of this series to find the exact cause.

If you don't see pulses, switch your scope to measure dc (either by pressing a digital readout button or by going through the steps needed to make a dc measurement with the CRT). If the voltage shows zero, your "startup" problem is really a power-supply problem. Move back through the regulator and supply circuits to find its cause.

If dc is present, the rest of the circuits may be waiting for the startup pulse. You need to test the startup circuits next. One way to do this is to substitute for the startup voltage.

Give the set a little help

An effective way to check the startup circuits and scan-derived power supply is to substitute for the startup voltage with an external power supply. This is especially important when working with the more complicated kick starters. If the circuits start, you will disconnect the external voltage to see if the circuits continue to operate.

Monitor the collector of the output transistor (or the high voltage) to see if the circuits respond. Adjust your external power supply for the dc voltage normally found

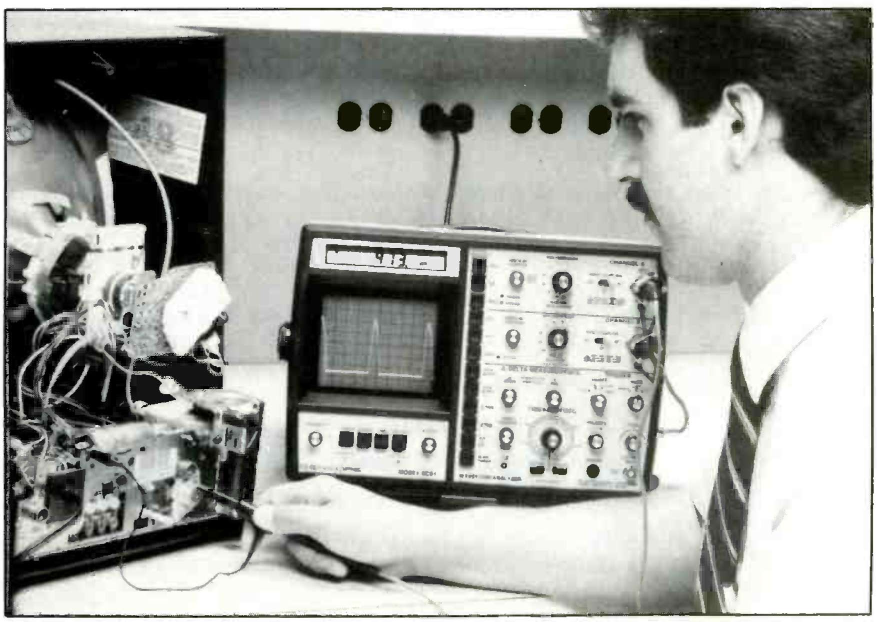


Figure 6. The best place to monitor, when confirming whether the set started, is the collector of the horizontal output transistor. If you see pulses build and then collapse, you know that the set started and was then shut down by a safety circuit.

at the scan-derived supply that feeds the horizontal oscillator. Connect the ground lead to the circuit ground. Turn on the power to the TV receiver and touch the positive lead of the external power supply to the test point in the receiver.

If nothing happens, the startup circuit is not the trouble. You will now need to track down the problem. The output stage is often damaged by power-line surges or nearby lightning strikes, so start there. Use a transistor tester to check the output transistor, and use a reliable yoke/flyback tester to test the flyback. If the output components test good, suspect a problem in the horizontal oscillator or the driver circuits.

If the receiver starts and runs with the external power supply connected, you're almost finished. But you still have to see if the set will continue to run. Disconnect the external power-supply lead. If the set still runs, you know that the closed loop functions correctly, but cannot get started. Test the items mentioned earlier: the startup circuits and the horizontal oscillator's free-running frequency. (Don't forget that you will have to wait for the filter capacitor to discharge to re-check the operation of a kick starter.)

If the set shuts down with the external supply disconnected, you have confirmed that the scan-derived power supply is not delivering enough power. Check the rectifier diode. If it is bad, be certain that you replace the diode with the correct type, because diodes designed for 60Hz supplies often don't work correctly when rectifying the 15kHz signals from the flyback. If the diode is good, suspect an open flyback winding or a component or connection between the flyback and the horizontal circuits.

Separating startup problems from shutdown problems will help you get to the real cause of a high-voltage problem faster. When you're certain you have a startup problem, the correct troubleshooting procedures help you quickly isolate its cause.

ES&T

What do you know about electronics?

Model behavior

By Sam Wilson, CET

Some time ago I wrote about the models that are used for teaching about capacitors. It is necessary to resort to models in order to give beginning students an idea about capacitors that they can visualize.

As far as I'm concerned, the hardest course to teach is beginning eletronics. You have to start everywhere at once. It is necessary to get the beginning student into the subject even though that student may have no background knowledge. Models make it possible to get the student into the subject in a short period of time.

There is the danger that students learning by models will get married to them. That gets in the way of their learning more advanced concepts as they come to the point where the model doesn't work. It can easily be avoided by letting the students know they are being given a concept that will have to be modified as they advance in their studies.

This month I'm going to start by reviewing the procedure for charging a capacitor when there is nothing connected to its leads. This procedure doesn't fit with the model that is usually used for teaching capacitors. I'm also going to talk about the voltage across resistors that have nothing connected to their leads. As with the capacitor discussion, this doesn't fit the model usually used for resistors. However, that voltage is very important for making certain types of measurements.

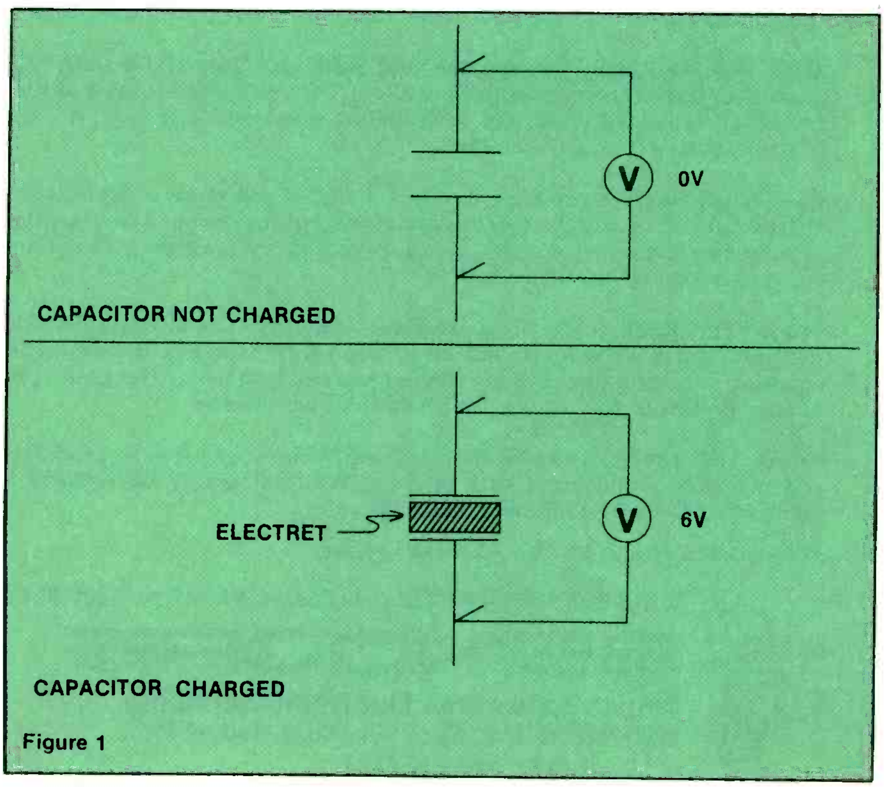


Figure 1

Charging capacitors without using their leads

A popular way of teaching about charging and discharging capacitors is actually a model for that operation. Students are told that capacitors become charged by forcing electrons into one plate of the capacitor and sucking them out of the other plate. The capacitor is supposed to be charged when the excess electrons are trapped on the negative plate and electrons are prevented from getting into the other plate.

That concept of charging a capacitor disregards the very important role played by the dielectric. As a matter of fact, a capacitor can be charged and discharged *without* using its leads, but not without using its dielectric. (See Figure 1.)

An *electret* is a permanently charged dielectric. At one time electrets were nothing more than a lab curiosity. Today they are used in speakers, microphones and other electronic devices. When used as a permanent (read-only) memory, they are guaranteed to hold their charge for 99 years.

You can make a simple electret by placing melted wax between two large plates that form a capacitor. Connect a very large voltage across the capacitor and keep it there while the wax cools and hardens. The wax will be an electret. (This experiment was described in a previous issue.)

The voltmeter in Figure 1 shows that there is no voltage across the capacitor at the start of the experiment. Placing the electret between the capacitor plates produces a voltmeter reading, showing that the capacitor is charged.

The idea of that experiment is to show that the *dielectric* actually stores the energy in the capacitor.

Before discussing the voltage across resistors that have no connections to their leads, it would be a good idea to take a fantastic voyage.

A semiconductor trip

I once saw a movie titled "Fantastic Voyage" (or something like that). People were put into a space ship and reduced in size. Then they were injected into the veins of a man. As I remember, they had to make their way to his brain. The plot may not be too solid, but the movie was a complete course in the operation of a human as a system.

We're going to borrow that space ship and travel inside a semiconductor material. That way, we can see for ourselves what Brownian motion and intrinsic currents are all about. It will help to review these things before we talk about that voltage across resistors. We're going inside a small block of germanium, but we would see the same thing in other semiconductor materials.

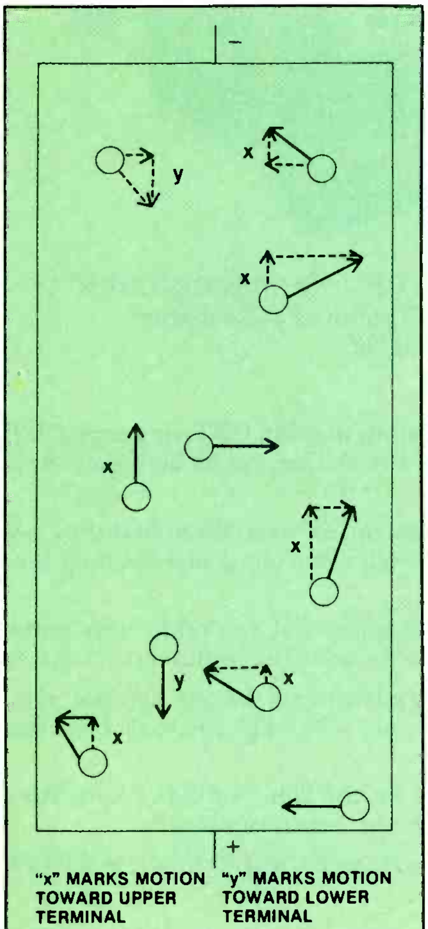
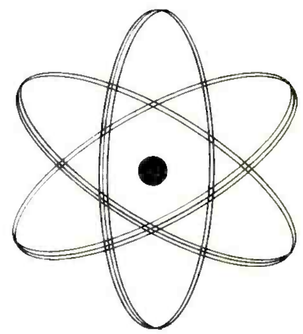


Figure 2



This time we will just journey to a point that is barely inside the surface. In the next issue, we will travel through the material and stop at such tourist attractions as grain boundaries, interstitial atoms and other deathnium traps.

Some of the people who are with us are not prepared for the first inside view of the material. They are not technically trained people. The geometric arrangement of the atoms is perfect and orderly. It looks like some kind of man-made work of modern art.

Every atom is perfectly positioned, and each atom is in a violent vibrating motion. We explain to the non-technical passengers that this is called *Brownian* motion. We would see this regardless of the type of material we had entered. At a special command, the people outside apply a small increase in heat and we see the motion increase.

Occasionally we see a small particle thrown off a vibrating atom. It looks like a tiny space ship as it moves between the atoms and lands at a distant atom. Those particles are electrons, and their motion through the material is actually a form of electric current, called *intrinsic current*.

When the temperature of the material is increased, the number of electrons traveling between atoms is also increased. It is this motion of electrons that we came to see, so we end the journey.

Noise voltage

You know that at room temperature there are electrons that gain enough energy to escape from an atom or molecule. The motion of those electrons – called *intrinsic* current – is in random directions.

Except for the few electrons moving at right angles to the resistor axis, the motion of electrons can be resolved into two vector motions. This is shown in Figure 2. One is the horizontal vector, which is of no interest here. The other is the vector in the direction of the leads.

At any one instant in time there will be more vector motions toward one terminal than toward the other terminal. *That terminal is very slightly negative with respect to the other terminal for the instant in time being considered.*

During the next instant in time there will be more vector motions in the opposite direction and the voltage across the resistor will reverse.

The overall result is that there is a very small amount of ac voltage across the resistor when it is lying on a bench with nothing connected to its terminals. That is called the *noise voltage* of the resistor. The noise is called *Johnson noise* or thermal agitation noise (sometimes just thermal noise).

If you like your theory laced with a little bit of math, the noise voltage can be calculated from the equation

$$V_{noise} = \sqrt{4kT\Delta fR}$$

where
k is Boltzman's constant (I'll discuss this later),
T is the temperature in Kelvin (that is, degrees C + 273°),
Δf is the band of frequencies of interest, and
R is the resistance of the resistor.

Applications

How does this affect the everyday work of a technician? Well, you can't do anything to change Boltzman's constant or the number four. However, you can see the advantage of cooling resistors in noise-sensitive circuits.

Also, the bandwidth of the circuit involved affects the noise, so it is important not to have a wider bandwidth than is needed for the job. Remember, *noise and bandwidth are tradeoffs.*

Actually, the noise equation doesn't tell the whole story. It is for use with copper wire. (It is a long time between times when we see copper-wire resistors.) For practical resistors the amount of noise is greater than indicated by the equation. Table 1 shows how practical resistors compare.

Table 1. Resistors and noise

Type of resistor	Noise problem
carbon	worst
film	better
wirewound	best

Use of noise in evaluating amplifiers

When you connect a resistance across the input terminals of an amplifier, you have injected noise into that amplifier. For example, connecting an antenna to the RF amplifier of a TV receiver injects noise because of the antenna resistance. As another example, a resistive transducer (such as a photoresistor) connected to an amplifier injects noise.

The semiconductor amplifying devices (bipolar transistors, JFETs and MOSFETs) are made with semiconductor materials, so they produce Johnson noise.

Manufacturers sometimes give a noise rating for a device or for amplifiers, stating its *equivalent noise resistance*. That is the resistance of an imaginary resistor that produces the same amount of noise as the device (or amplifier) being rated. A low value of equivalent noise resistance is preferred in most cases.

Equivalent noise temperature is another way of evaluating noise. It makes use of the noise *power* equation for resistance:

$$P_{noise} = kT\triangle f$$

where k, T and $\triangle f$ have the same meanings as in the equation for noise voltage.

ES&T

Products

Compressed gas dusters

Chemtronics has introduced a line of high-purity Ultrajet compressed gas dusters ultra-filtered to less than 0.2 microns. The dusters deliver a jet of microscopically pure, moisture-free inert gas that removes particulates from inaccessible areas without contaminating, scratching or leaving a residue.

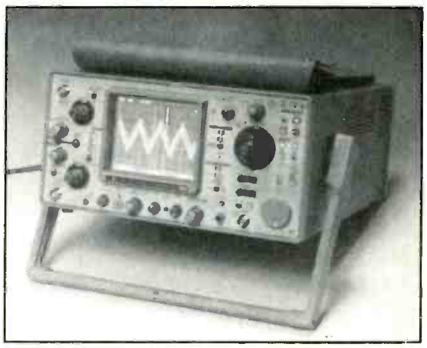
The dusters are available in 3-, 8- and 14-ounce cans, as well as in a reusable chrome valve assembly for high-volume users.

Circle (75) on Reply Card

Digital storage oscilloscopes

Iwatsu Instruments has introduced two new models to its line of digital storage oscilloscopes.

The DS-6612 offers a 60MHz analog bandwidth, a 60MHz digital storage bandwidth for repetitive signals, dual 20 megasamples/second analog-to-digital converters and deep 16K waveform memory. The DS-6411 has a 40MHz analog bandwidth plus dual 10 megasamples/second analog-to-digital converters.



Both scopes feature phase, peak-to-peak and ground reference, averaging, pre-trigger and post-trigger, GO/NO GO judgment modes and roll mode.

Circle (76) on Reply Card

Solder extraction systems

Automated Production Equipment Corporation has introduced three self-contained solder extraction systems, the models EX-500, EX-501 and EX-525. The systems feature zero voltage switching and localized grounding for CMOS safety, a finger switch/foot switch option, low-voltage heating elements and accessories, microprocessor-controlled temperature regulation, and locking DIN connectors.

Circle (77) on Reply Card

Telecommunications service tool kit

Contact East introduces its telecommunications service kit T27, specifically designed for the telecommunications specialist. A full selection of optional accessories and a choice of carrying case is available.

Circle (78) on Reply Card

ESD work station kits

Desco Industries has released several series of complete work station kits for proper grounding and usage in EOS/ESD-sensitive areas. Each series is available with five different standard benchtop soft mats in sizes from 18"x24" to 60"x24" Some series include complete work stations, including floor mats, wrist straps and all necessary ground cords. Others include only the benchtop mats or bench mats and wrist straps.

Circle (79) on Reply Card

Training materials

The "70 Series Solutions" training product from *John Fluke Manufacturing* is designed to maximize the usefulness and safety of the company's 70 Series of hand-held digital multimeters.

The product includes a 15-minute videotape, overhead transparencies, a 100-page instructors' guide and 25 student workbooks. Training emphasizes hands-on exercises rather than theory.

Among the subject matter covered is how to measure current, resistance, ac/dc voltages, sine wave, non-sine wave and composite voltage.

Circle (80) on Reply Card

Power regulators

The Datagard spike and noise suppressor from *SL Waber* is available in a wall plug-in unit, model DG315-P, or as a 16-inch strip for multiple plug-in, model DG315-S. Both feature maximum spike energy dissipation of 80J one time, 25J repeated usage, self-restoring. Maximum spike voltage is 7,000V, and clamping spike voltage is 55V above line.

The company's Linegard 600 uninterruptible power supply (UPS) protects against computer data loss in a power emergency. Engineered for multi-user PCs and mini-computers, the unit can provide up to two hours of power during an outage. The UPS features an internal battery, built-in voltage regulation, and overload capacity handling of up to a 200% load starting surge.

Circle (81) on Reply Card

Temperature controller

Hot Tools' Dial-Temp controller is compatible with any soldering iron, woodburning tool or other de-

vice that uses a heating element from 15W to 1,600W. The device is plugged into the controller and the controller plugs into any 110Vac outlet. The controller has a 15A capacity.

Circle (82) on Reply Card

Monitor tester

Network Technologies has introduced the MONTEST-VGA portable pattern generator, designed for operation with the new VGA monitors used with the PS/2 personal computer line. The tester verifies monitor operation in all modes as well as checks monitor alignment, convergence and color balance.

The unit generates four video patterns at eight scan formats. At 31.5kHz, it provides line formats of 350, 400 and 480. The 35.5kHz scan format is supported, exercising the full range of capabilities of the new display. The generator can also test TTL monitors compatible with the MD, CGD and EGD standards.

Circle (83) on Reply Card

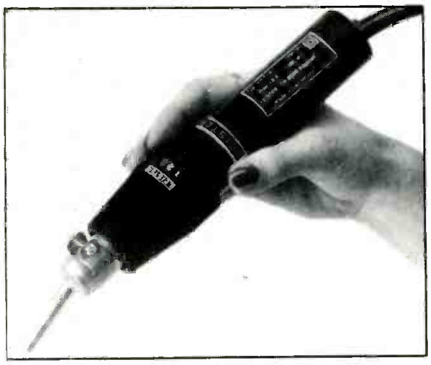
Electronic power conditioner

Sola has introduced a series of microprocessor-based electronic power conditioners (EPC) with output capacities of 500VA, 1,000VA and 2,000VA. The units' overload capacity ranges from 300% for 600 cycles to 1,400% for one cycle. Output voltage is measured continuously and corrected every 16ms. The EPC holds output voltage to ±5% for input voltage variations up to +15% and down to −25%. The 60Hz EPC is UL-listed, CSA-certified and conforms to FCC Class B requirements. The 50Hz models available are built to VDE and IEC requirements.

Circle (85) on Reply Card

Hot air tool

The *Brian R. White Company* has introduced the Leister Hot-Jet hot air tool, which provides contactless desoldering and soldering of surface-mount device (SMD) and dual-inline package (DIP) components between 20°C and 600°C using hot air. The electronically controlled air volume produced is 30 liters/minute and is adjustable in 3 steps.



The double-insulated tool is available in 100V, 120V and 220V 50Hz to 60Hz. A variety of nozzles and reflectors is available.

Circle (87) on Reply Card

The meter said ... what?

By Joseph J. Carr, CET

An English gentleman left his office in London and went to his club for an evening of convival fellowship with other gentlemen. When it came time to leave he went to the cloak room and found the porter standing there with his coat already in hand. The startled gentleman asked, "How did you know it was mine without the claim check?" The dignified porter retorted, "I didn't, sir. All I knew was that it's the coat you came in with...who *owns* it is another question entirely."

That dignified gentleman's club porter *refused to speculate on any fact not actually in evidence*. That advice is good not just for cloakroom porters, but electronic servicers as well. Sometimes, the meters and oscilloscopes give us a bum steer and thereby lead us unprofitably astray. Let's take a look at several situations where the evidence of our senses and instruments gives us false results.

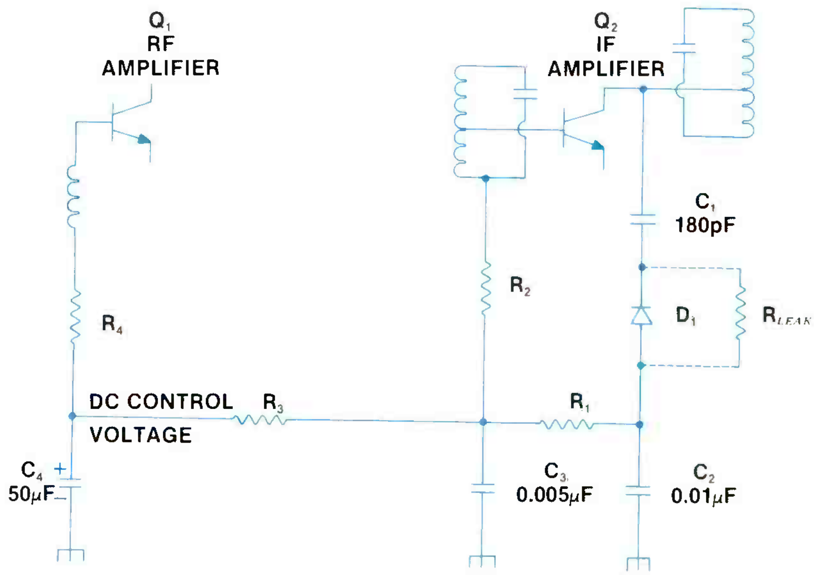


Figure 1

Case No. 1

A customer brought in an AM car radio. The complaint was that sometimes it whistled and sometimes it was distorted, but other times it played OK. The problem sounded at first like a classical intermittent–probably a loose connection or busted PC board. When the radio was turned on, the technician found that it worked and, in fact, on first blush appeared quite normal. He was about to assume it was just another NFF (no fault found), which happens quite often when customers work on their own sets without letting an expert check it out in the car.

But the technician was sharp, and he noted that the announcer tended to lisp a little on "S" and "P" sounds. Paying a little closer attention, he concluded that the lisping was due to the fact that the set was hyper-sensitive and was therefore on the verge of oscillation all the time.

The first place one might look in a radio with tunable oscillations (or lisping) is the automatic gain control (AGC) circuit. (See Figure 1.) The AGC samples the IF amplifier output signal, rectifies it and filters it to dc, and then uses the dc to control the gain of the IF and RF amplifier stages, so it forms a potential feedback loop if the decoupling is not working well. Hence, the AGC is always suspect in such cases.

Most AGC loops in AM radios contain a large-value electrolytic capacitor (C_4) that filters the dc control voltage, and if it is open oscillation will result. This capacitor is probably the classical cause of AGC oscillations. The technician bridged C_4 with a known good capacitor, but it produced no change. He next suspected the power supply decoupling capacitors. Again, bridging a known good electrolytic capacitor of the proper value across the set's capacitors did no good at all. Next the tech pulled one end of AGC-rectified D_1 loose and measured both the forward and reverse resistances. The ratio was 5:1, and the "conventional wisdom" told him that diode was OK, so he soldered it back in.

After a certain amount of head scratching and chin rubbing, he remembered that the customer claimed that the radio was sometimes distorted and at other times it was OK. Tapping the circuit board with an insulated probe didn't show any intermittents. Because the shop was too far from any AM station to receive a really strong signal, he connected the AM signal generator and tuned it to the radio dial frequency.

Sure enough, on strong AM signals (even though well within the normal permissible signal-strength range) the radio became distorted, while on weaker levels of RF input signal the distortion disappeared. It was also found that the radio tended to oscillate a little as the dial was rocked on and off the signal generator frequency. On a hunch he replaced the AGC rectifier diode (D_1), and the problem went away. The oscillation disappeared, the distortion disappeared, the announcer didn't lisp and the radio responded to the full dynamic range of input signals.

The root problem was leakage resistance across diode D_1 (R_{leak} in Figure 1). The confusion was twofold. First, diodes are normally open or shorted; only rarely do they exhibit leakage or a *partial* short. Second, the "conventional wisdom" misled the technician. It seems that 5:1 (or even 10:1, the alternate conventional wisdom) is bum advice for high-impedance circuits. An order of 100:1 or even greater is more reasonable for real diodes in real AGC circuits.

Another confusion was that the technician was in a single location where signal strengths did not reach the levels required to drive the set into trouble. Installed in a car, however, the situation was different because the driver frequently had to drive close to the station. The same scenario could conceivably result on table-model or portable radios that play OK in the basement (where signal levels are small), but distort in the second-floor bedroom where signal levels are higher. It also shows that the technician should not depend on a quick or cursory check of any equipment; the problem might be subtle.

Case No. 2

Fresh from spending 15 minutes too long on Case No. 1, the same technician picked up another car radio and tossed it on the bench. This model was an older, solid-state AM radio from the early 1970s. Turning it on, he found the same symptoms. "AHA!" he thought to himself, "Another bad AGC rectifier diode!" After replacing D_1, he found the problem persisted. In this case, collector-to-base leakage in the RF amplifier transistor caused a symptom similar to the symptom in Case No. 1. Although not a big problem today, it was common in the "olden days" when AM RF amplifier transistors were all germanium. (Note: The problem can exist on silicon transistors but it is a lot rarer than on Ge devices.)

Case No. 3

A Cable-TV/MATV maintenance repair installation organization (MRIO) had a technician who checked out equipment before giving it to field installers, and who

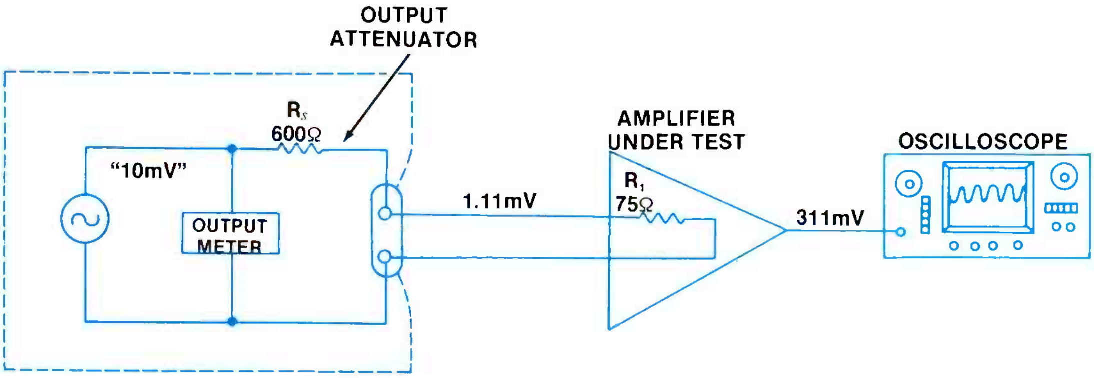


FIGURE 2

also repaired defective equipment. The technician was required to service both VHF/UHF channelized RF gear as well as baseband video amplifiers. Being frugal, the manager gave her a function generator to supplement the VHF/UHF TV generator, with the idea that the 0.01Hz to 11MHz function generator could service the 100Hz to 6MHz video baseband equipment. The function generator was a bright, gleaming new model that produced square waves, sine waves, triangular waves and variable duty-cycle pulses. It was truly a quality piece of test equipment.

The technician set up the function generator to make gain checks on the baseband video amplifiers prior to issuing them to field people. These amplifiers were specified to 40dB voltage gain (X100) and could accept high-level inputs to 25mV without overloading. Knowing these specs, she set the signal generator output frequency to about 1MHz and dialed up an output level of 10mV rms (well within overload spec). A 40dB voltage amplifier has a gain of X100, so she expected an output of 10mV x 100, or 1,000mV (1V). Because her output indicator was an ac-coupled wideband oscilloscope, which reads peak-to-peak (p-p) voltage, she expected to see about 2.82 x 1,000mV, or 2,820mV on the CRT screen. Unfortunately, the reading was only slightly more than 300mV. It was obviously a defective amplifier, so she put it aside for repair later. Because the impatient field crew needed an amplifier, she grabbed another and checked its gain. It too had an output voltage around 300mVp-p.

Two new amplifiers in a row with the same symptoms? Unlikely, for the brand was good quality and had a long record of working properly. So, being a bright young lady from a good technical school, she figured that something was wrong with the test setup. She first looked at the function generator operator's manual, and there she found the difficulty. Function generators, despite their wide frequency range, are *designed like audio generators* and thus have a 600Ω output impedance. Furthermore, the output level meter is *ahead* of the stepped output attenuator that sets both the level and the constant 600Ω output impedance. (See Figure 2.) As a result, the output level is accurate only when the signal generator output terminal is terminated in a 600Ω impedance. The video amplifier, on the other hand, has a 75Ω input impedance. In this circuit, the *actual* output voltage, V_o, as opposed to the meter reading, is:

$$V_o = \frac{(10\text{mV})(R_i)}{(R_i + R_s)}$$

$$V_o = \frac{(10\text{mV})(75)}{(75 + 600)}$$

$$V_o = 750\text{mV}/675 = 1.11\text{mV}$$

As a result of an incorrectly specified signal generator, despite the fact that it worked on the right frequency, the good 40dB amplifiers output 1.11mV × 100 = 111mV, or 313mVp-p...exactly what Brenda measured.

In past times, that type of error was unlikely because audio generators, with their 600Ω output impedances, rarely worked above either 20kHz or 100kHz at the highest. But today the technology finds it easy to provide multiwaveform function generators with low-end frequencies in the subhertz range and high-end frequencies in ranges that were clearly "RF" a decade ago. One expects RF generators to have a 50Ω output impedance unless specifically designed for TV/video applications, in which case it is 75Ω...not 600Ω!

Case No. 4

A building's cable system is designed around 75Ω equipment, which is standard for TV/video systems. By error, an installer uses 50Ω coaxial cable to wire a section of the building. When signal levels are measured, it is found that slight anomalies exist. Some gains are too high, and others are too low. Can we find the answer to the mystery? Consider Figure 3.

Whenever an RF or video amplifier is mismatched as regards input and/or output impedances, a *standing wave ratio* (SWR) exists. The SWR will cause a mismatch loss of:

$$ML = -10\ \text{LOG}\left(1 - \frac{\text{SWR} - 1}{\text{SWR} + 1}\right)^2$$

For example, when the SWR is 2:1, the gain mismatch loss is about 0.51dB. If there are two SWRs working with or against each other, the multiple reflected and incident waves bounce around

$SWR_1 = R_1/Z_0 = 75/50 = 1.5{:}1$

$SWR_2 = R_2/Z_0 = 75/50 = 1.5{:}1$

$$\text{MISMATCH LOSS} = 20 \text{ LOG} \left[1 \pm \left(\frac{SWR_1 - 1}{SWR_1 + 1} \right) \times \left(\frac{SWR_2 - 1}{SWR_2 + 1} \right) \right]$$

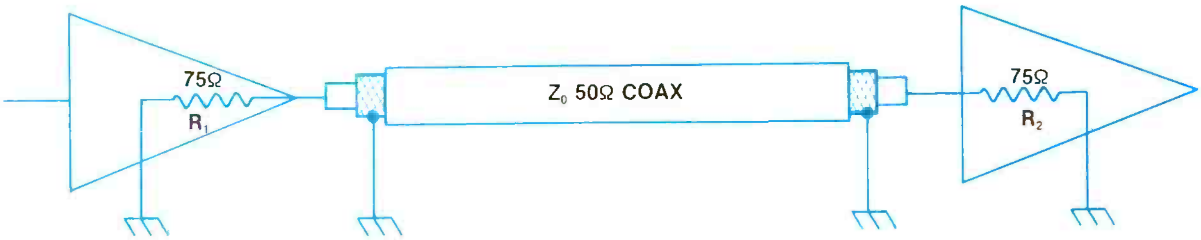


FIGURE 3

the coax, adding and subtracting to signal levels, and produce a mismatch loss of:

$$ML = -20 \text{ LOG} \left[1 \pm \left(\frac{SWR_1 - 1}{SWR_1 + 1} \right) \times \left(\frac{SWR_2 - 1}{SWR_2 + 1} \right) \right]$$

In the system of Figure 3, we have two SWRs involved:

$$R_1/Z_0 = 75/50 = 1.5{:}1$$
$$R_2/Z_0 = 75/50 = 1.5{:}1$$

In other words, we have a pair of 1.5:1 SWRs. When these SWRs are cranked through the formula, we have a pair of possible gain errors of +0.34dB or −0.35dB. In other words, a 10dB gain amplifier might ordinarily measure either 10.34dB or 9.65dB. While this variation might seem inconsequential (there are places where it is not!), it serves to illustrate a problem that becomes much worse with a larger mismatch.

Not everything is as it seems, a fact that points up the necessity for the technician to be more than a potted plant at the back of the shop. Some technicians I have known over the years always want a "cookbook" service guide that says, "When you see this, replace (or do) that." In real life it sometimes pays to think. ES&T

Audio Corner — By Kirk Vistain

Using a technical help line

The complexity of the products we service increases every year. Technological change is so rapid that what you knew just a few years ago is already obsolete. New home entertainment equipment is tougher than ever to fix, yet the selling prices are so low that many customers simply junk any defective unit that cost them less than $200. Among Japanese manufacturers, the plunging dollar has had a relatively minor effect on retail prices, but parts cost is turbo-thrusting into the stratosphere. There has never been a time when scoring a direct hit on the defective part has been more difficult or more essential.

Ten years ago, I would have said that calling a manufacturer's technical help line was about as useful as a 250W soldering gun in a microcassette recorder. Now that's changing. With all the large-scale integration (LSI) in equipment, much of the "circuit sense" we had with analog, discrete designs is missing, simply because we often don't know what's inside some $80, 80-pin chip. Add to this the fact that microprocessor control means that two otherwise identical units with different codes burned into their controllers may exhibit significantly different symptoms for the same failure.

Just to spray a little more gasoline on the fire, programmers are notorious perfectionists who may make several changes in a given model's program code throughout its production. These are, for the most part, not documented. So, sooner or later you'll probably need to call the manufacturer's tech help line, like it or not.

Be prepared

The varying commitment to support among companies means that the person on the other end of the help line could be anything from a glorified switchboard operator, with a prepared text on several broad product categories, to a technical help specialist, whose only job is to supply servicers with the information they need for effective servicing. Regardless of the type of help available, you can maximize the results by following a few simple rules.

First of all, you can probably avoid a call altogether by searching through all the updates, supplements and bulletins the major players provide. This is a basic requirement of intelligent servicing in the 1980s. Most techs I know would rather replace the tip on a hot soldering iron with their bare hands than keep a bulletin file updated, but the fact is that a 700° burn will cripple them less than shoddily maintained service information.

In the big shop, file maintenance should be considered a high priority, with the responsible individual reporting directly to the service manager. In a small shop, the technician may have to take care of it himself. You should need little coaxing if you're on commission or quota. Having that information organized and handy always pays off. The only thing I like less than filing service bulletins and supplements is not being able to find one when I need it.

Be sure you've done some troubleshooting first. Fishing expeditions shouldn't be necessary if your information is in order. In most instances, if you haven't used a scope, you're not prepared to call for help.

Next, have the manufacturer's service manual (schematic) in front of you. How can you and the technical adviser talk about circuitry over the phone if you're not both "singing off the same song sheet"? If you've had training on a unit, it would be smart to keep the training manual handy too. After all, you want to be on and off the phone as quickly as possible.

Make sure you have a clear understanding of the symptoms. You are going to be the eyes and ears of the tech adviser, and the more accurate your description, the better your chance of getting an answer. One of the fundamental drawbacks of telephone troubleshooting is that you're often missing a key symptom. That's why you're stuck. Of course, then you can't convey this symptom to the adviser because you're not aware of it. This is the cause of many "impossible" failures. The only remedy is more thorough troubleshooting.

Don't expect miracles. You're a trained, productive technician who works on the equipment every day. You have the defective unit in front of you, with all the visual and auditory clues available. If you can't fix the thing, how is somebody a few hundred miles away on the other end of a telephone line supposed to do it? The best you can expect is that the adviser has heard of the problem before, there's a late-breaking bulletin not yet in the shops, or perhaps just talking it over will trigger a solution in your mind.

Avoiding technical help

Most "dogs" are the result of either a mental block, inaccurate service information or physical inaccessibility of components. Of these, the mental block is the most common detriment to effective repair. If you ever want to be a class A technician, you'll have to deal with the problem daily. The answer is to be well informed. Study the current literature on the subject, attend manufacturers' training, and yes, you probably should even do some *homework* if you want to stay competitive. Information is what you need, and at the rate it's coming, it takes special effort just to avoid falling behind.

On the bench, if you haven't pinpointed the defective component in an hour, you better put the unit aside and get a few successful repairs logged out before continuing. Otherwise, you'll get "dog-headed," an unproductive state of mind in which you expect every simple problem to have a sinister, senseless, impossible cause. With that kind of attitude, you'll be lucky to fix anything.

When you finally put the pup back on the bench, reexamine the symptoms, assess the validity of the assumptions you're making, and repeat your test procedures. You'll probably get it this time.

Answers: to the quiz

Questions are on page 16.

1. B. Unlike the earlier storage oscilloscope, the digital storage oscilloscope does not require a special CRT. The waveform to be stored is converted into digits by an analog/digital converter, and those digits are stored in a memory. To retrieve the waveform, a digital/analog converter is used. (For more information, see "The Oscilloscope: The Eyes of the Technician" by Conrad Persson in the April 1987 issue.)
2. D. A signal at the Z-axis input terminal controls the beam intensity.
3. C. Does anyone remember when diodes were just used for detecting and rectifying? Tunnel diodes are used as fast switches and oscillators. Hot carrier diodes have a low forward breakover. Infrared diodes are used to generate infrared signals. The PIN (positive intrinsic negative) diodes convert the infrared signals into electric impulses. (See "What Do You Know About Electronics?" in the April 1987 issue.)
4. C. By comparison, the thickness of a human hair is about 250 times the width of a VHS VCR head gap. (See the April 1987 Video Corner.)
5. B. One video head is installed with an azimuth of +6°, and the other is installed with an azimuth of −6°. This ensures that alternate tracks are recorded at an angle of −12° to each other, so little signal is generated by overlapping tracks.
6. A. A vacuum desoldering system reduces this problem considerably. (See "Desoldering Components" by James K. Bausell in the May 1987 issue.)
7. A. The swamping resistor lowers the Q of the tuned circuit so the bandwidth is greater. See "Test Your Electronics Knowledge" in the May 1987 issue.)
8. Bad image and lots of snow. (See "Maintenance and Cleaning of VCRs" by Victor Meeldijk in the May 1987 issue.)
9. Absolutely NO! The swab and solvent parts of the statement are OK, but the up and down motion *may damage fragile heads*!
10. D. The equalizer divides the audio spectrum into a large number of bands – usually ten or so. (See the May 1987 Audio Corner.)

ES&T

By Bert Huneault, CET

Reading and writing with PROMs

This is the second part of a 4-part series on non-volatile memories. Part one covered the basic read-only memory (ROM), which is mask-programmed at the factory and cannot be erased.

Although the basic read-only memory is useful for purposes where you do not want any chance of the contents being erased, there are uses for which a *programmable* ROM is more convenient. For one thing, the ordinary mask-programmed ROM is very expensive, and is therefore not cost-effective in small production batches. In low-volume applications, it is more economical to use *fusible-link* ROMs that are user-programmable. These *programmable read-only memories* (PROMs) are not programmed during the IC manufacturing process, but are custom programmed by the user. Once programmed, however, the PROM is like an ordinary ROM – it can't be erased or reprogrammed. Thus, if the program in a PROM is faulty or the user decides to alter instructions or data, the PROM must be thrown away.

PROM ICs generally feature blown-junction transistor (BJT) technology, with transistor leads comprising fusible links. These links come intact from the manufacturer. By applying a suitably high voltage to specific addresses, the user can selectively blow any of these fuse links to produce the desired data storage. Connections left intact can represent a binary 1, while those burned open store a binary 0.

PROMs are field-programmable devices, and the equipment used to program them is called a *PROM programmer* (or *PROM burner*), a machine that permits keyboard entry of the desired program or data. During the programming process, the chip's address pins and data pins determine which memory cells will get their fuse links burned out.

As already mentioned, ROMs and PROMs are neither erasable nor reprogrammable. A more versatile category of read-only memories are both erasable and reprogrammable.

Erasable PROMs

The erasable programmable read-only memory, or EPROM, is a device that can not only be programmed by the user, but can also be erased and reprogrammed as often as desired. Once programmed, the EPROM is a non-volatile memory that can hold its stored data practically indefinitely.

The memory cells in an EPROM are field effect transistors (FETs) that feature a floating gate, an insulated gate with no electrical connections. By applying a relatively high-voltage programming pulse to the device (25V to 50V between source and drain for about 50ms per address location), electrons are injected into the insulated floating gate and remain trapped there once the pulse is removed because there is no discharge path. Thus, programming places a charge on the MOS transistor, and the MOSFET is such a good "capacitor" that is retains the charge for years.

Of course, there can be thousands of MOS transistors on the chip, each one representing a binary digit – bit 1 or bit 0, depending on whether it stores a charge or not. Naturally, during programming operations the IC's address and data pins are used to determine which memory cells get a charge and which don't.

The charge is erasable by means of ultraviolet (UV) light. A transparent quartz window is built into the top of the EPROM case (DIP package) for this purpose. High-intensity UV light is concentrated through this window onto the memory chip inside, causing a photocurrent to flow from the floating gate back to the silicon substrate; this neutralizes the trapped electrical charge. All the stored bit patterns are thus erased simultaneously.

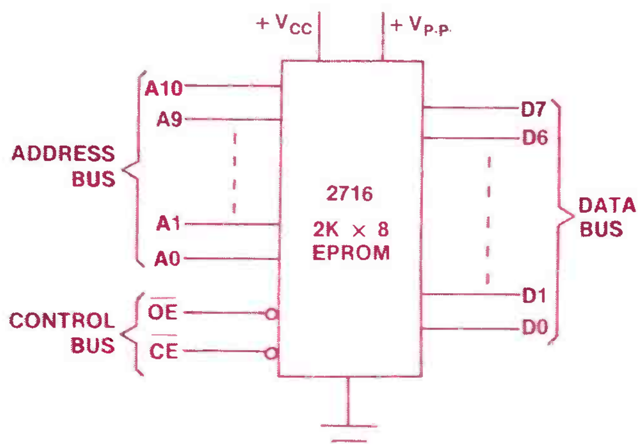


Figure 1. The EPROM can not only be custom programmed by the user, but can be erased and reprogrammed as often as desired. Like the ROM, the EPROM has eight data lines, but its eleven address lines (compared to 10 in the ROM) gives it a storage capacity of 2,048 eight-bit words, or 2Kbytes. Although both have a CE (chip enable) pin, the EPROM also has an OE (output enable) pin that allows it to write as well as read.

A main disadvantage of the EPROM is the long time (15 to 30 minutes) it takes to erase. Once the erasing operation is completed, an opaque label is placed over the clear window to prevent stray UV (from fluorescent lights or sunlight) from gradually erasing the new contents of the EPROM.

The EPROM can then be reprogrammed by means of a PROM programmer. Note that for both erasing and programming operations, the EPROM must be removed from the printed circuit board in which it is used.

EPROMs are very useful in design and development of computer systems. They allow the designer to try out a new program and debug it by erasing and reprogramming as often as necessary until it works perfectly. When the design is finalized, the data can be burned into PROMs for small production runs, or it can be sent to an IC manufacturer who produces a ROM mask for mass production.

Literature

Products catalog

The 52-page, full-color catalog from *Beckman Industrial* describes the company's line of digital multimeters, oscilloscopes, telecommunications test equipment, function generators and frequency counters. In addition to providing specifications and photographs on each product, the catalog also includes a section displaying the new line of temperature measuring instruments, consisting of hand-held thermometers and temperature calibrators.

Circle (125) on Reply Card

Battery size checker

Batt-tronic offers a 1988 universal battery size checker with a slot size for every popular watch and calculator battery. The sizer features silver oxide and mercury referencing, as well as lithium information.

Circle (126) on Reply Card

Products catalog

L-Com Data Products' 60-page interconnection products catalog contains over 2,000 line items, including RS232 devices and testers, multiplexers, rack panels, surge protection systems, cable and accessories. The catalog lists not only basic data communications products, but also hard-to-find and state-of-the-art devices. Information provided includes unit/quantity pricing, specifications, illustrations and photographs.

Circle (127) on Reply Card

Rental catalog

The 1987-88 rental catalog from *Genstar Rental Electronics* features electronic test equipment available from the company under rental terms. New equipment listings from major instrumentation manufacturers are included. Product categories include analyzers, meters, generators, oscilloscopes, desktop computers and telecommunications. Rental terms and conditions are listed, as are toll-free numbers of inventory centers.

Circle (128) on Reply Card

Electronic components catalog

Mouser Electronics is offering a 176-page catalog featuring 16,000 items stocked in depth. The catalog provides product data and pricing of standard stocked industrial electronic components, including capacitors, potentiometers, resistors, transformers, lamps, switches, batteries, holders, jacks, plugs, speakers, knobs, fuses, semiconductors, hardware, tools, test equipment and more.

Circle (129) on Reply Card

ES&T

Advanced electronics for remote control

One of the interesting–and frightening–things about taking a close look at today's TV sets is coming face to face with the incredible complexity you'll find there. But not only are today's televisions complex, the circuitry you'll find inside represents the state of the art in circuit design and construction.

For example, a look inside the model CTC 140, recently introduced by RCA and showcased in ES&T's Technology department in October, reveals a cornucopia of advanced electronics:

1. A digital control system that contains
   - a system control microprocessor (U3100),
   - an analog interface unit (U3300),
   - an EEPROM (U3200),
   - a keyboard matrix and indicators,
   - a band switching IC (U3600), and
   - the Dimensia microcomputer (U3501–in Dimensia models).
2. Surface-mounted devices (SMDs), many of which are electrostatically sensitive
3. A switching power supply

In other words, you don't have to get involved in computers or industrial electronics to be besieged by the latest electronic technology; it will come to you.

Why advanced electronics?

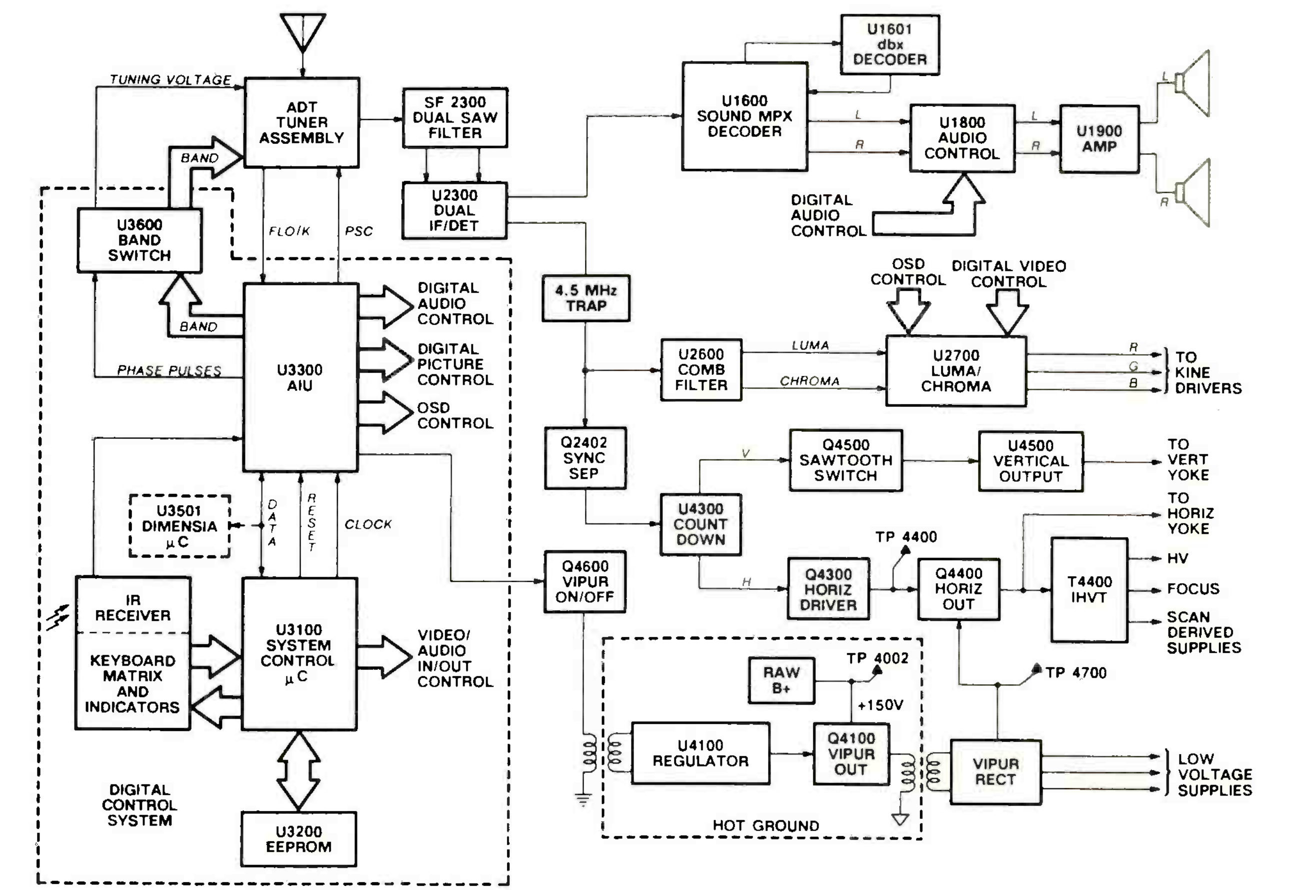
These advances have been introduced for a variety of reasons, including smaller size, lighter weight, lower production costs, greater efficiency and improved reliability.

The CTC 140 service manual has some interesting things to say about the reasons for using the circuitry that is found in the unit, and also about the servicing aspects of the set. "Some of the new and innovative CTC 140 features are made possible using a few unique and different circuits. Most CTC 140 circuit designs are derived from previous RCA color television chassis designs. These proven circuit designs help ensure a reliable product.

"The functional block diagram of the CTC 140 chassis contains a few blocks that are similar to those found in videocassette recorders and may be unfamiliar to some TV service technicians. Similar circuits have been used in high-end color television receivers for many years. These circuits often were designed to be modules and were rarely serviced. Because the CTC 140 chassis has most circuits unitized on one circuit board, it is necessary to service these circuits to the component level."

The digital control system

Systems control microcomputer U3100 scans the front-panel keys and monitors for a key press. When a key press is detected, U3100 checks to see which key has been pressed and initiates the appropriate program sequence. Scanning of the front-panel keys or buttons is also used to drive the front-panel indicators. The serial data bus carries



By Conrad Persson

communications to and from the analog interface unit (AIU), the system control microprocessor and the Dimensia microcomputer (only in Dimensia models).

A 4MHz crystal is used to generate a clock for timing the AIU and system control microcomputer. However, the serial data bus runs at 125kHz, this frequency generated by the system control microcomputer dividing down the 4MHz clock signal. The bus transmits local and remote-control function commands, along with Dimensia commands (only in Dimensia models).

The system control also communicates with the EEPROM via a separate serial data bus. EEPROM U3200 stores the channel tuning data for the scan list, the factory and customer picture/audio setup data (levels) and the menu data. A replacement part EEPROM comes preprogrammed with factory setup levels. The system control microcomputer stores and retrieves data in the EEPROM via the serial data bus.

The analog interface unit provides:

- power on/off control to the power supply via transistor Q4600,
- digital control of the picture and audio circuits,
- OSD control, and tuning control.

The set is turned on when the AIU supplies a 32kHz signal to transistor Q4600. When the 32kHz signal is removed from Q4600, the receiver is turned off.

Control of the picture and audio is provided by supplying pulses that are low-pass filtered to generate a dc control voltage. The dc control voltage is then applied to the video and audio circuits. As the number of pulses in a given time frame is varied, the dc control voltage is also varied and control of picture or audio is accomplished.

On-screen display is controlled by the AIU IC supplying control signals to the video processing circuits. The video processing circuits use these control signals turning off and on the picture guns to generate the OSD.

The AIU IC U3300 controls the tuning operation using the pulse-swallowing technique of most phase-locked loops. Band switching information is supplied to the band switch or band decoder U3600 from the AIU. Monitoring a divided-down version of the tuner's local oscillators frequency, known as FLO/K, the AIU generates the tuning voltage. The AIU also generates prescaler control (PSC) pulses to change the division ratio of the prescaler.

ES&T

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IC number 56A24-1 (or 56D24-1) used in Admiral model 25C631 color television. *Henry Sievers, 6819 Willamette Drive, Austin, TX 78723; 512-926-7479.*

Original factory service manuals for McMurdo Silver and E.H. Scott radios of the '30s; new or used parts—complete units; tubes 913 and 3KP4. *Wilford D. Wilkes, Box 103, Brisbin, PA 16620.*

High-voltage trippler (number on trippler is 561B026-1) for MGA color television model CS196, please send price. *John Augustine, 530 N. 9th St., Reading, PA 19604; 215-372-5438.*

Old RCA modules and service literature for classic CTC48-CTC92. Send asking price and module numbers. *Mike Shelton, 2708 May Drive, Burlington, NC 27215; 919-227-2908 after 8 p.m.*

B&K solid-state 3050 audio signal generator with manual; Heathkit model IM 4180 FM deviation meter with manual; Heathkit solid-state distortion meter. All items must be in excellent condition. *Lloyd Spivey, WLLS AM/FM, Highway 231 South, Hartford, KY 42347; 502-298-3268.*

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Diehl technician/shop owners newsletters, issues #4 to #14 (or higher). *J. Hillrich, 732 Queen St., Regina, Saskatchewan, Canada, S4T 4A3.*

K.L.H. model 7 speaker. *Frank Beckerle, 313 Woodcrest Drive, Buffalo 14220; NY 716-823-1571.*

Knight 83YX137 AF generator with manual; 83Y135 signal tracer manual only. *C.T. Huth, 229 Melmore St., Tiffin, OH 44883.*

Used scopes, generators, tube testers, Riders books. Will sell two pr sound powered phones, B&K 1076, Webster Tele-talk 2076. *Bob's Band Instrument, P.O. Box 92, Marion, MI 49665.*

Head drum assembly A-6050.009-A (or −066-A) for Sony SLP-300 player. *Don Hicke Video, 4642 Oregon St., #2, San Diego, CA 92116; 619-291-3932.*

Schematic/service data, original or copy, Tek oscilloscope model 545. *Scott Tanenbaum, 4 Jarvis Court, Erial, NJ 08081.*

For sale:

Sencore DVM 37 digital multimeter, $125; B&K Analyst 1077B, $225; Sencore LC53 Z-Meter. All equipment like new, with manuals and in original cartons. *Paul Cecil, Paul's TV, 260 Main Cross, Charlestown, IN 47111; 812-256-3119.*

Digital 11/34 computer with two RKO56J drives and 22 discs, $1,000. Simpson capacohmeter model 383-A, $40. Beltron CRT tester, $100. RCA oscilloscope, model W33A, $50. B&K Dyna Sweep 1070, $20. *Robert Blanchard, Pinehill Road, Warren, NH 03279.*

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

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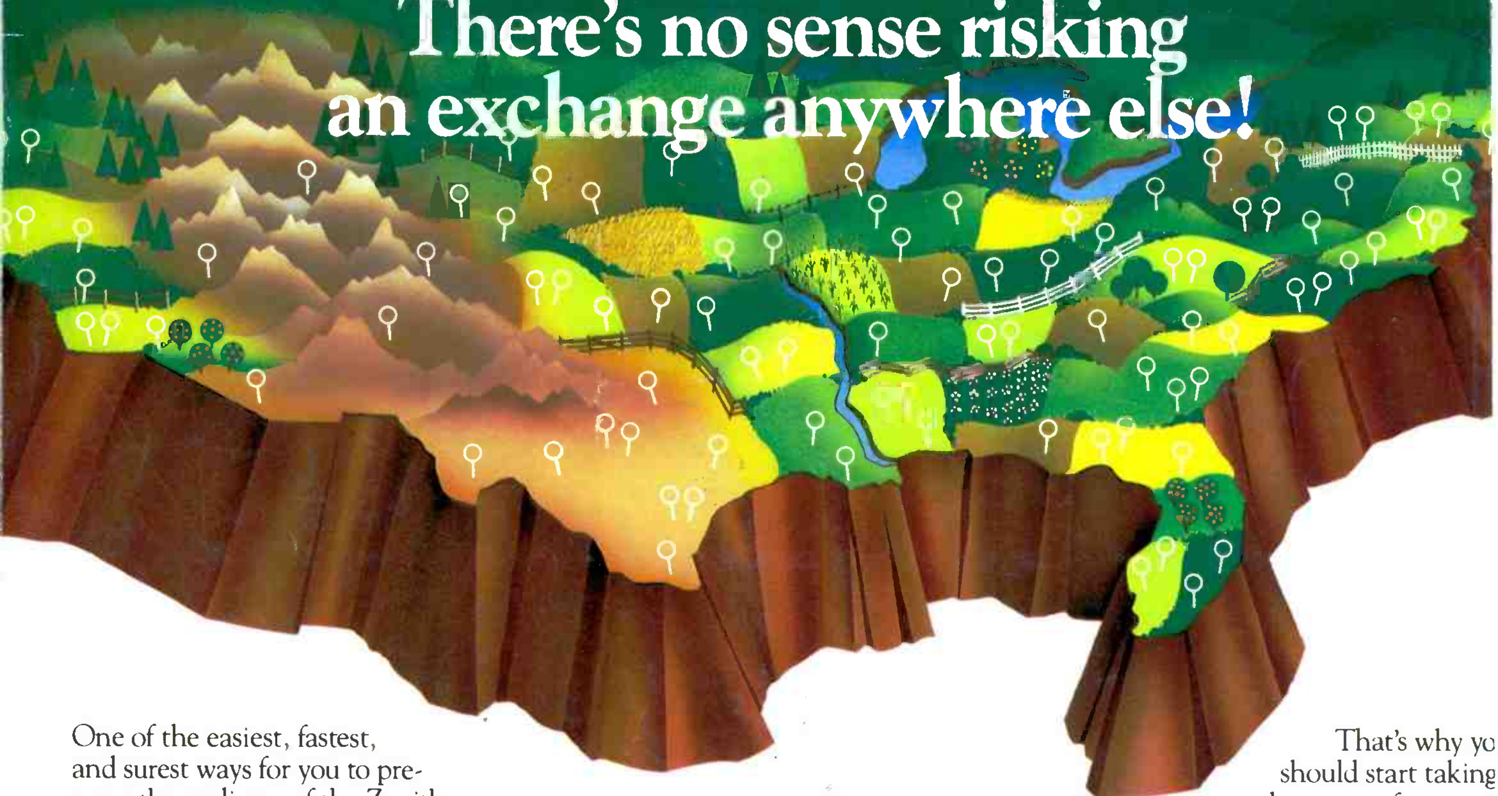

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