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September 1988/$2.50

Unusual lines in the picture • Electronics and automobiles

What do you know about...Four-terminal networks

Intermittents. We Hear You.

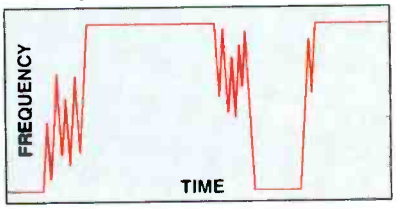
Introducing The Heavy-Duty DMM With An Audible Readout That Lets You Keep Both Eyes On The Job.

Intelligent design and solid construction make the new HD 150 Series the best DMMs in their class.

They're the latest in a distinguished line that began when Beckman Industrial pioneered heavy-duty DMMs with their distinctive yellow color. Many competitors have since imitated that color. As for imitating their performance, no one comes close.

The HD 150 Series attains new levels of excellence with a range of advanced features. They're waterproof. Drop proof. Auto-ranging. Slim-styled for one-hand comfort and convenience. With auto-off to prolong battery life. Plus 2 fuses, PTC resistor *and* MOV for unsurpassed overload protection.

Audible readout. A "sound" reason to go with the HD 150 Series. With this unique feature on the HD 153, you measure parameters by listening to a continuous variable tone. As the parameter you measure rises or falls, the tone's frequency increases or decreases, accordingly. Use it for volts, amps, or ohms. It's ideal for peaking and nulling, too.



Intermittent alert. A key application of audible readout. The HD 153 pinpoints intermittents by emitting a "crackling" sound when they're detected. The response sounds in about 1 msec—far faster than the information appears on any DMM display.

Logic function. The HD 153 detects TTL or CMOS logic pulses using standard test leads.

Easy to use. The HD 150 Series lets you read the LCD even at wide angles. With the large rotary dial you select functions with one-handed (right or left) convenience. Auto-ranging speeds you to the right range. A tilt-stand and Skyhook let you set or hang the DMM almost anywhere.

Built tough to work hard. The HD 150 Series DMMs are so tightly sealed against water and grime that they're *guaranteed for five years* against contamination. And, because they're built so tough, they're guaranteed for two years against *any* damage (except abuse). Crashes, overloads, moisture, dust…you name it. The HD 150 Series can handle it all!

Listening is believing. For a hands-on demo, see your distributor now. Learn why the HD 150 Series is the soundest DMM value you'll see. Or hear.

Key Specifications

	HD 151	HD 152	HD 153
Auto-ranging	✓	✓	✓
Range Lock		✓	✓
Audible readout			✓
Tilt Stand and Skyhook™	Optional	Optional	Included
Logic pulse detector			✓
DC voltage accuracy	0.7%	0.5%	0.25%
10A range		✓	✓
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Circle (1) on Reply Card

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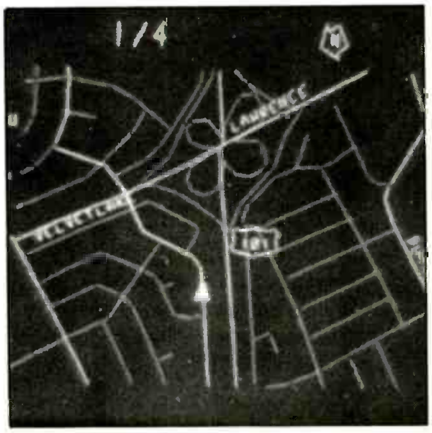

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ON THE COVER

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Editorial

Electronics without math?

As I write this, it's the day of the 1988 Major League Baseball Allstar Game. Tonight, as pitchers come up to the mound, the announcers will be throwing around such statistics as the number of games won and lost, the earned-run averages and other important pitching statistics.

At the same time, when Dave Winfield or George Brett or Wade Boggs steps up to the plate, the announcers will be spouting about the batting average, slugging percentage, number and percent of extra-base hits, and on and on about this particular batter. There will probably even be statistics about what this batter's average is against right-handed pitchers or southpaws.

And savvy baseball fans will sit in the stands or in their living rooms eating hot dogs, drinking beer and nodding knowingly about the importance of these statistics.

A lot of these same fans, who might be consumer electronics servicing technicians, will ask, when faced with an exposition on electronics, "Well, couldn't you explain it without the math?"

Starting in our August issue, Sam Wilson is writing a year-long series of articles on network theory, and, in answer to the requests from many people he's had as students in his various classes, he's trying to do it *without the math*. You have to watch out for Sam, though—he's sneaky, and he keeps slipping in the math.

The fact is, you can't explain electronics without the numbers any more than you can describe a game of baseball without the numbers. In baseball, besides the hitting, pitching and fielding statistics, there are the dimensions of the tools of the baseball player: the ball, bats and gloves must be very specific sizes. The dimensions of the playing field are precisely defined.

Or how about your relationship with your employer or employee? In most cases, such a relationship is defined in very precise mathematical terms. The employee works for a specified number of hours per day, for a specific number of days during the week. For each of these hours, the employee usually earns a specified number of dollars, and a specified percentage of his pay is withheld for social security and for federal, state and perhaps local income taxes.

Mathematics is involved in almost everything we do: buying a house or a car and paying the phone, gas, electric or water bills are all based on some kind of mathematical calculations. Planning a trip will ordinarily involve many calculations, including the miles you plan to travel, the gas mileage of the car, the cost per gallon of gasoline at the time, anticipated tolls, the cost of hotels/motels/meals, the cost of activities and so on.

And some techs want to learn about electronics without the math.

Sam, I salute your attempt to describe electronics without math, and I hope you're able to do it. But I think those students of yours who have asked you to do the job without math have given you an impossible task.

The most fundamental relationship in electronics is V = IR, and that's a mathematical relationship. And the math gets more involved as you go along. I think we need to admit that math is fundamental to the business of electronics. We can try to make the math as understandable as possible, but electronics without math is just not possible.

(Oh, and Sam, I know that your occasional slips into using math in your exposition are your subtle way of telling the readers that understanding electronics without the math doesn't really make sense to you either, but I won't let anyone else in on your little secret.)

Nils Conrad Persson

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Troubleshooting tips

Symptom: Incomplete vertical deflection, unstable horizontal hold, low-volume audio
Set ID: GE model 8-1304 (NF chassis)

This 13-inch General Electric color set had three problems: the picture (which was reasonably good with adequate color) did not fill the screen vertically, the horizontal hold was very unstable and the audio level was low even with the volume control turned all the way up.

Because no Photofact listing existed for this set, I ordered the service information package from the GE (now RCA) publications department in Louisville, KY. When this package arrived, I began troubleshooting. I assumed (quite wrongly as I found out later) that each problem had its own cause. I started by completely checking out the vertical sweep circuitry. I installed new output transistors, but they had no effect on the height of the picture. I then replaced several key electrolytic capacitors, but there was still no change.

Next, I reasoned (because the horizontal was unstable) that the vertical/horizontal IC could be defective. Installation of a new one had no effect on the problem.

Feeling very disgusted, I turned my attention to the low level of audio. I installed new output transistors and replaced key electrolytic capacitors and an IC, but there was no effect in the audio circuitry either. The volume remained low.

Having spent about three hours without any progress, I put the set aside until the next day. The following morning, I sat down and went over the schematic diagram again. What was I overlooking? Could all of these symptoms have a common cause? Once I started looking at the problem from this perspective, the light dawned as I was studying the schematic area showing the flyback circuitry, in particular the 12V and 15.5V supply voltages developed by sweep rectification. For some reason, I had completely overlooked this circuitry. A quick measurement of these voltages showed 5V and 8V, respectively. I turned the set off and did some resistance checks. The reading I got for R_{443} (connected directly to flyback pin 2) was 25Ω. This resistor should have read 5.1Ω.

A new R_{443} eliminated all three problems and restored the set to normal working condition. I was so upset with myself for having overlooked this circuitry that I made up a small sign and taped it to my bench: "Don't forget to check *all* voltages, especially those developed by sweep rectification."

George Marechek
Cheverly, MD

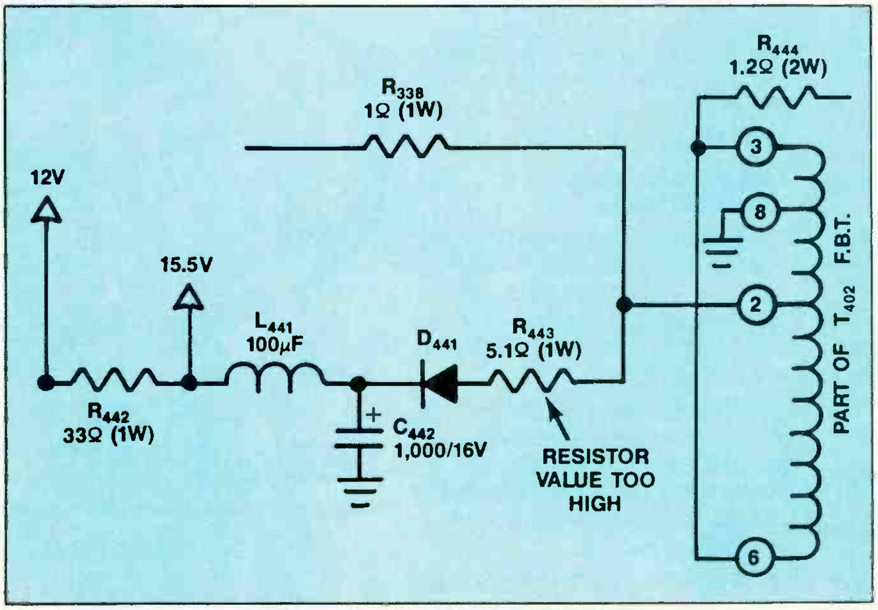

Figure 1. A new R443 eliminated three problems that appeared to be separate: incomplete vertical deflection, unstable horizontal hold and low-volume audio.

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Servicing & Technology

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

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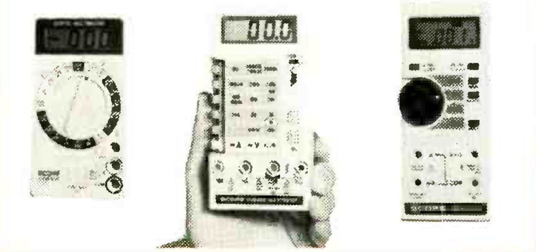

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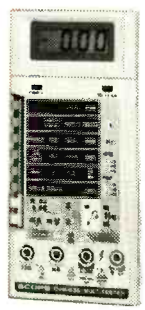

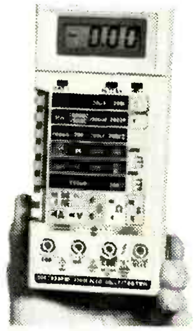

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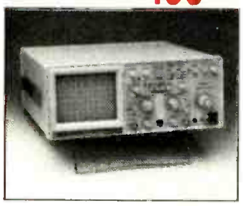

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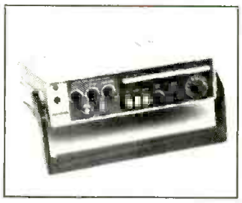

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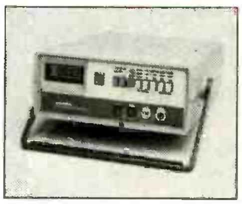

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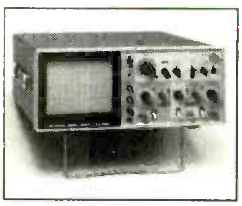

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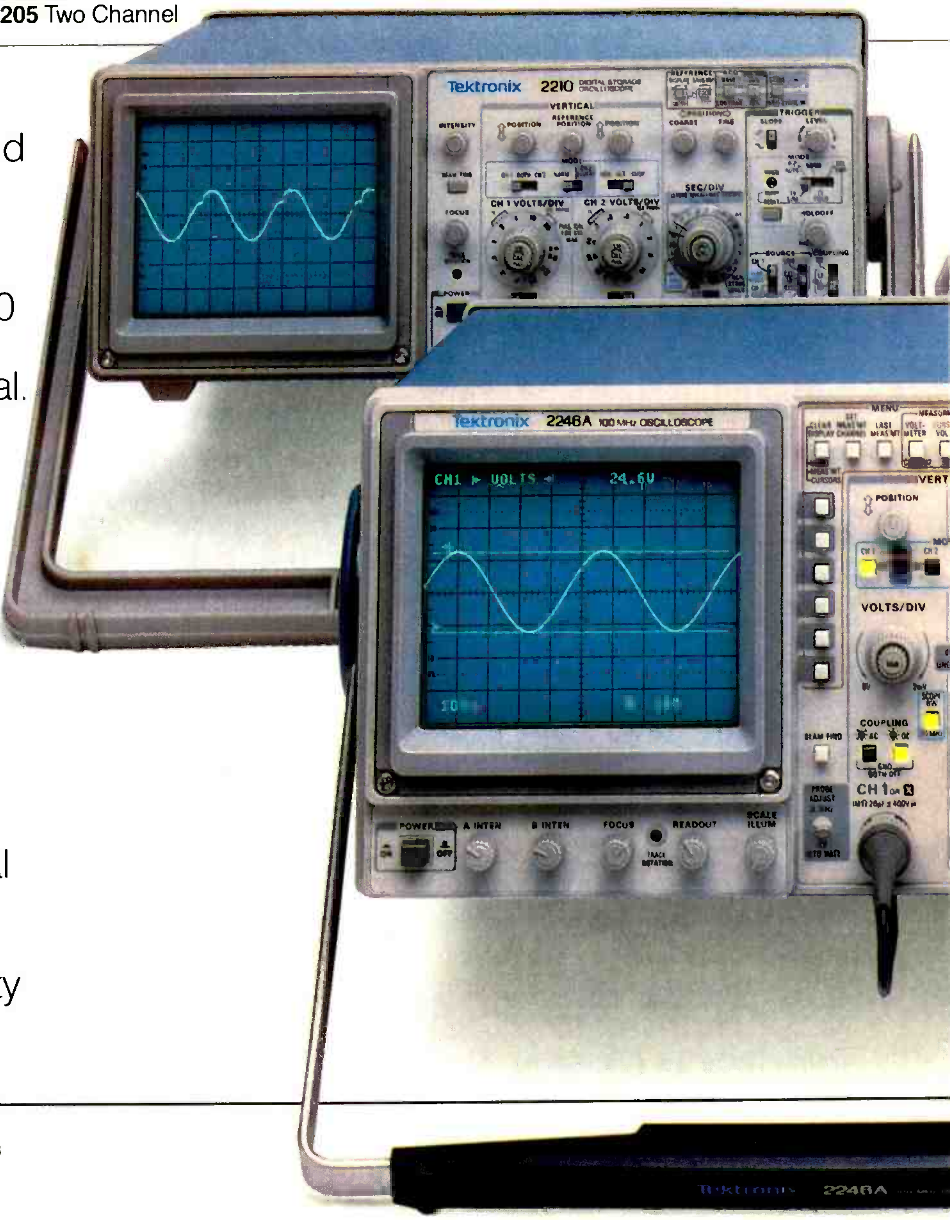
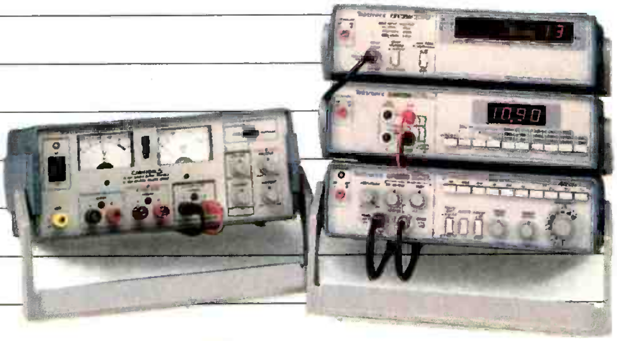


right within your range.



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Test your electronics knowledge

By Sam Wilson, CET

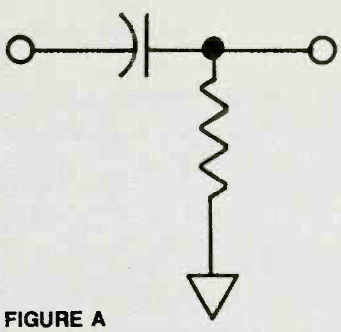
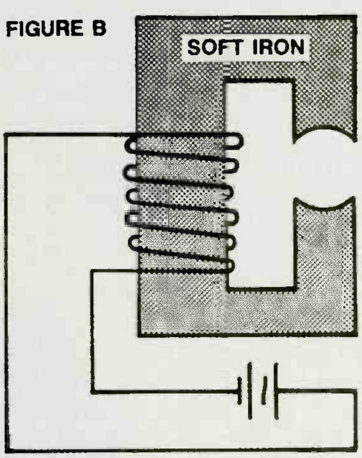


FIGURE A

FIGURE B



Only super techs can expect to get a grade better than 40% on this test!

1. In computer language, what do the letters in the word BASIC stand for?

2. Both attenuators and pads are used for matching impedances. Which of these is variable?
A. pads
B. attenuators
C. either or both
D. neither is ever variable

3. Now that we're on the subject of pads, what is the attenuation of two pads—each providing a 6dB loss—connected in tandem?

4. Which of the following bridge circuits is best for measuring a high value of inductance?
A. Hay bridge
B. Wein bridge
C. Maxwell bridge
D. Schering bridge

Wilson is the electronics theory consultant for **ES&T.**

5. Call up your knowledge of constant-k low-pass filters. How is the value of k determined?

6. Figure A shows
A. a differentiating circuit.
B. an FM de-emphasis circuit.
C. Both choices are correct.
D. Neither choice is correct.

7. In Figure B, the north pole of the electromagnet is
A. at the top.
B. at the bottom.

8. Three signals recorded on a VCR tape are: audio, video and ______.

9. In the TTL logic family, a logic high is a voltage above __________ and a logic low is a voltage below __________.

10. A very useful test instrument has the initials DSO. What do these initials stand for?

Answers are on page 67.

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The new breed of multimeters

By Conrad Persson

E = IR. That more or less sums up the idea of electricity and electronics. Of course, there's a lot more to it than that, but that relationship covers the first several chapters in most texts. It seems appropriate, then, that the most basic electrical/electronics tester, the multimeter, will test for E, I and R.

Of course, the multimeter is by no means the only piece of test equipment a technician needs to troubleshoot a defective piece of consumer electronics equipment, as evidenced by the shelves full of test equipment used every day by competent technicians: oscilloscopes, frequency counters, signal generators and more. But used correctly, a multimeter, especially one of today's sophisticated units, can isolate many faults in electronic circuitry.

Persson is editor of **ES&T**.

The basics

The most basic multimeter in today's arsenal of electrical/electronic test meters is the volt-ohm-milliammeter (VOM). These units cost well under $100, yet they let you check ac and dc voltages, resistances and currents in the milliampere range. To some degree, you also can check for semiconductor junctions, and VOMs make dandy circuit continuity checkers, especially when they have audible output.

But you have to be sure to learn the capabilities and limitations of one of these basic instruments. For example, unless the meter is specified otherwise, its frequency response is probably limited. If you're trying to measure the value of a signal at several kilohertz, the signal will be attenuated by the input circuitry of the meter, and your measurement will not be accurate.

Another limitation of the typical low-cost multimeter is that most do not give a true rms indication of an ac waveform being measured, so if the signal you're measuring is not a pure sinusoid, the measured value will not be the true rms value. There are true rms meters, but they are generally considerably more expensive than other multimeters.

A bell here, a whistle there

Beyond the basic volt-ohm-milliammeter functions, one of today's sophisticated digital multimeters may contain a number of functions that have evolved over the years. The units with the most capabilities offer an array of measurement functions that technicians of a few years ago couldn't have even dreamed of.

Figure 1 is a generalized block diagram of a DMM. One of today's popular multimeter capabilities is a diode test. Not only does this function test diodes, but it also tests other semiconductor junctions, and so acts as a quick test of whether a diode or transistor junction is OK, open or leaky.

When a meter is used in the resistance-testing mode, it places a low volt-

age with a constant-current characteristic across the test leads so that, once the leads are connected, the voltage across the test leads is determined by the product of the resistance being read and the known-constant current. The meter then measures that voltage and converts it into resistance.

The diode test is accomplished by placing a higher voltage across the meter's test leads than is available for most resistance ranges, but limiting the current to a smaller value than is allowed for the resistance measurements. This combination ensures that the semiconductor junction will be turned on when the meter is connected in the forward direction, but the current is limited to a safe amount that will not damage the junction.

Converting voltage into a digital signal

One of the more popular methods of converting a voltage into a digital signal is called the *dual-slope conversion method*, or the *double integration method*. (See Figure 2 for an idea of how it works.)

V_{in} is the input voltage—the voltage to be measured. V_{REF} is a reference voltage of polarity opposite that of the measured voltage, supplied by the meter. Capacitor C and operational amplifier A constitute an integrator circuit. Switch S_1 is an electronic switch that is initially in the position shown.

When the meter probes are first connected to the voltage of interest, that voltage is applied to the input of the integrator for a period of time (called the *integration period*) that was determined by the designers of the meter. (Integration periods are ordinarily selected to be related to the 60Hz line frequency, so integration periods of 1/60th of a second and 1/10th of a second are common). The output of the integrator is a voltage that is determined by the RC time constant of R and C. Because of the nature of the integrator circuit, the maximum voltage (the voltage at the end of the integration period) is proportional to the voltage being measured.

At the end of the integration period, switch S_1 is moved to the other position and a voltage of polarity opposite to the polarity of the measured voltage is applied. In this configuration, the capacitor is discharged until its voltage reaches zero.

Take a look at Figure 2b. Note that the discharge interval will be directly proportional to the maximum voltage, which in turn is proportional to the applied voltage. As a specific case, if the input voltage is doubled, the discharge interval will double.

At the same time that the integration interval ends and the discharge interval begins, a counter that is part of the meter circuitry begins counting pulses generated by a clock circuit. When the voltage reaches zero, the counter stops counting. The number of pulses counted is, therefore, proportional to the discharge period, which, as we already pointed out, was proportional to the input voltage. This count is converted to

Main article continued on page 20.

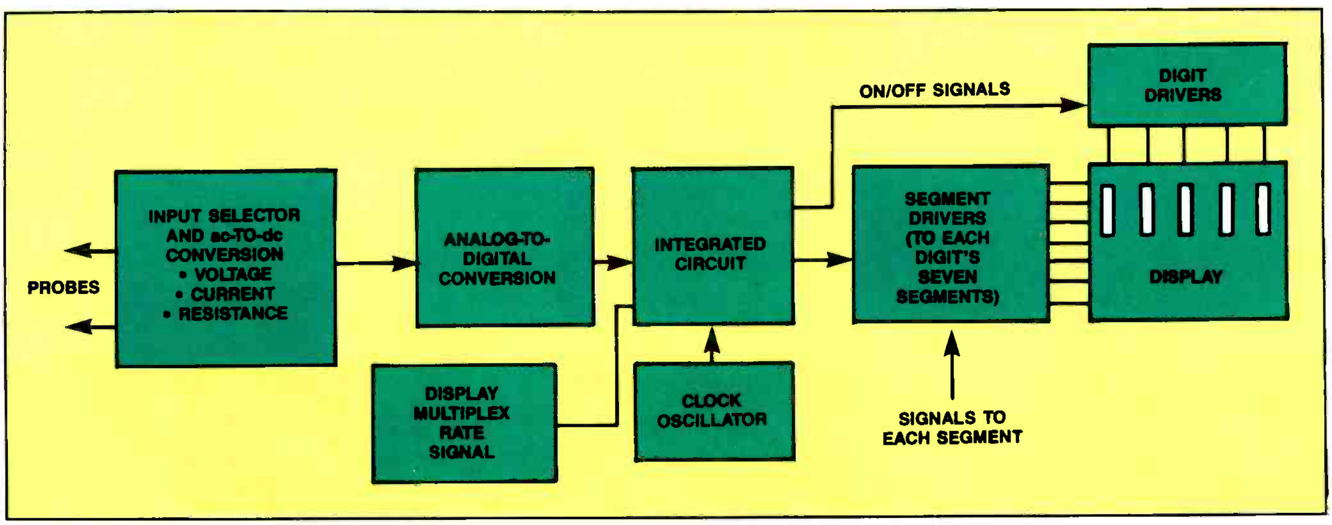

Figure 1. Because of the increasing sophistication in the fabrication of ICs, the construction of DMMs is evolving rapidly. However, this block diagram gives an idea of the general principles on which DMMs are based.

The new DMMs—heavy-duty and hands-free

By Rey Harju

Imagine this for trouble-free troubleshooting: You take out a heavy-duty DMM, hold it in one hand and flip the rotary selector switch to the function needed—say, volts. You don't worry about the range because the meter can set itself faster than you can. Using its built-in hanger, you hang the meter on the edge of a nearby equipment cabinet or wherever is handy. With both hands on the probes, you don't touch the DMM again throughout the entire service procedure. You don't even look at it again. Instead, it plays the reading audibly. With the new generation of smaller, heavy-duty DMMs that are just hitting the market, this scenario isn't the least bit fanciful.

Multimeters are general-purpose test instruments for measuring continuity, voltage, resistance and current. Depending on the model, other functions can include capacitance, digital logic, transistor gain, frequency and temperature.

Figure 1. Integrated circuit techniques allow meter manufacturers to pack a lot of circuitry into a small package, which allows designers to create a small, heavy-duty meter.

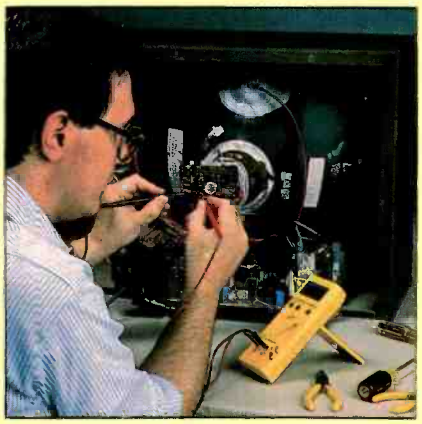

Figure 2. Some of the newer features such as autoranging and audible readout make it easier to concentrate on the work, not the tool.

DMMs incorporate digital measurement circuitry and typically display numeric results as digits, or *counts*, on the face of an LCD. With some new DMMs, many types of service procedures only require you to listen as readings generate continuous, audible tones. This audible-readout feature has become possible as new A/D conversion technologies have been incorporated in advanced DMMs. Within these circuits, DMM inputs are converted to frequencies. These frequencies not only provide very fast auto-ranging but also are converted readily into continuous, audible tones.

Keeping attention on the probes is also a safer way to work. However, even if test leads do accidentally make contact with dangerous voltages, the meter will sound a warning. Besides having extensive overload protection, these new meters sense dangerous voltages in the 200V and 1,000V ranges. When they're in autoranging mode, they will warn you with a loud beep and display a lightning-bolt symbol. As the meter enters either the 200V or the 1,000V range, it emits the warning.

Why heavy-duty?

Other than the fact that you can only get certain advanced features in the more expensive heavy-duty models, why else might a technician consider a heavy-duty, or *ruggedized*, DMM? Although standard professional-grade multimeters may have much the same internal circuitry and overall accuracy, these instruments are subject to breakdown from any number of everyday occurrences, including getting zapped by electrical overloads, falling off a bench or accidentally getting wet. Major differences with heavy-duty DMMs are found in the casing and in electric protection devices. The major advantage of relying on a heavy-duty DMM ultimately is that you know it will work when you get to the job, regardless of the location or conditions.

Ruggedized casing

A DMM that is designed to withstand rugged use, particularly in industrial applications, must be both shock-resistant and tightly sealed against contamination. The case provides this protection, but it generally adds bulk to the meter. Recent advances in VLSI circuit design have made it possible to shrink the size of the internal electronics. Those advances provided an opportunity to redesign the casing for a much more compact instrument, and the new heavy-duty DMMs are the result.

The new case is about the same size as two packs of cigarettes stacked on end, comparable to a typical telephone handset. Earlier ruggedized models are bigger and bulkier, about the size of a thick paperback book. The cases of heavy-duty DMMs are extremely strong and resilient; gaskets and O-rings seal the case against contaminants.

Your meters may need this protection even if they aren't used under particularly hazardous conditions. For example, a DMM could be knocked off a table or dropped as it is being slipped onto a belt. Dropping it from an antenna tower, telephone pole or scaffold is another common accident. There could come a time when you might get caught in the rain. Even indoors, a coffee spill at the bench could be costly—and aggravating—if a meter's in the way.

For rugged use, the meter (and its use) must be protected against electrical as well as mechanical hazards. Electronic protection devices inside the new DMMs meet or surpass those found in the best of the older, bulkier heavy-duty models. For example, fuses and resistors with positive temperature coefficients provide internal overload protection. The new, heavy-duty DMMs also incorporate metal-oxide varistors (MOVs), which are relatively expensive, solid-state devices that protect against high-voltage transients.

Hands-free, attention-free DMM operation

The compact size of the new DMMs means more than just being able to carry the meter conveniently into the field. Perhaps more important, compactness contributes to ease of use. With the new, slim designs, these meters can be held in one hand and operated with a flick of the thumb.

When the meter is in an auto-ranging mode, once the function is set, you can keep both hands and eyes on the work. This capability has become possible through fast auto-ranging combined with audible readout. The combination of fast, responsive auto-ranging with continuously variable tone generation has only recently become possible through an innovative approach to DMM circuit design.

Harju is the digital multimeter marketing manager for Beckman Industrial, Instrumentation Products division.

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The new DMMs—continued

From the viewpoint of a DMM user, the practical benefits are that the continuous, audible readout varies instantly and precisely to correspond to the signal.

Audible readout, of course, is the major breakthrough that completes the hands-free, attention-free concept. When you think about it, many types of service procedures do not require a numeric result. In peaking or nulling adjustments, for example, you only need to know whether the input is at maximum or minimum. When looking for intermittents, all you need to know is whether the signal is breaking up. Examples of service procedures that can be performed in this new, hands-free manner are given later in this article.

Working with digital circuitry

Transient digital pulses typically are too brief to be measured by analog detection circuits. In the past, a separate logic probe was needed for these measurements. When working with one of the new DMMs, however, all you do is switch to logic-detection mode, using standard probes. If a data signal is present, the meter emits an audible beep, thus eliminating the hassle of having to change instruments right in the middle of a job.

Automatic shutoff

Also new to the test-instrument marketplace is true automatic shutoff, which eases the annoyance of changing batteries. On some DMMs with this feature, the device switches to a low-drain condition. The new DMMs, however, will turn themselves off completely after an hour of unattended operation.

If your DMMs are used in the field, you know that it is annoying to have to change batteries frequently. This is a common complaint about low-cost DMMs, for which typical battery life can be as short as 75 hours. Longer battery-change intervals provide less of a chance for your technicians to get stuck somewhere with a dead meter and no spare battery. Changing the batteries less often also reduces the number of times your meters might be exposed to contamination while the case is open.

Cost/benefit evaluation

Because the new DMMs cost a little more, a cost/benefit evaluation might be helpful. To many servicing technicians, the new DMMs will represent a better value over lower-cost meters. Besides incorporating features such as auto-ranging and audible readout, which promote hands-free operation, the new heavy-duty DMMs offer the added value of ruggedness and dependability.

The advances in DMM technology pay dividends in the area of dependability: The new DMMs are engineered to include a minimum of moving parts. Autoranging eliminates much of the need for mechanical switch movement and reduces the number of electrical contacts in the meter. This can *design out* some of the potential sources of failure, such as corrosion and resistance of the contacts, which can contribute to poor per-

The new DMMs—continued

formance and ultimately to failure of the meter itself. Gold plating other contacts can further reduce the chance of failure.

With non-ruggedized DMMs, the possibility of malfunction is a hidden cost that should be taken into account. At today's repair costs, it can be less expensive to scrap a defective low-cost DMM and merely replace it. After you've done this a few times, you might well have exceeded the cost of the higher-priced, heavy-duty DMM. Of course, if your meter fails in the field, the cost in customer downtime or lost goodwill might greatly exceed the instrument repair costs.

Servicing applications

Applications for audible-readout DMMs extend to most types of diagnostic and repair work in which the objective is to sense maximum or minimum signal. Examples would include adjusting an amplifier for peak output or a damper for low noise. For such peaking and nulling tests, you can keep your hands (and eyes) on the test leads and potentiometer while you listen for the highest or lowest tone the meter will produce.

It's common to suspect an intermittent connection, especially in diagnostic work. Problems may come down to a broken trace on a PCB, a defective connector or IC pin or a cracked solder pad. Just identifying the problem can be difficult—you've got to be able to induce the failure. It's important to be able to know exactly what you are doing at the precise moment the failure occurred.

One of the most straightforward ways to induce failure is to try the *wiggle test*. Connect a DMM to either side of the circuit and test for changes in output as you stress selected components. On a conventional analog meter, the intermittent connection shows up as a fluctuation of the needle. On a DMM, the digital readout will shift numerically up and down in an apparently random fashion. The difficulty in either case, of course, is that you have to look at the meter to see this change.

With either of these techniques, you could easily miss something as you shift your attention between the meter, the test leads and the device. With audible readout, you connect the DMM, wiggle the board or connector and simply listen. If there's an intermittent connection there, you'll hear a characteristic crackling noise as the tone breaks up. You can measure voltage, current or resistance, and you don't have to be directly across the potentially offending component. The leads only have to be somewhere between the test points, because all you are listening for is a discontinuity in the frequency of the tone. Because you don't have to look at the meter at all, you'll have a better chance of seeing exactly what you were doing when the elusive bad connection revealed itself. Again, you can do this in volts, amps or ohms, whichever is most convenient.

In short, greater convenience, ease of handling and advanced features allow many of the new DMMs to dramatically improve troubleshooting.

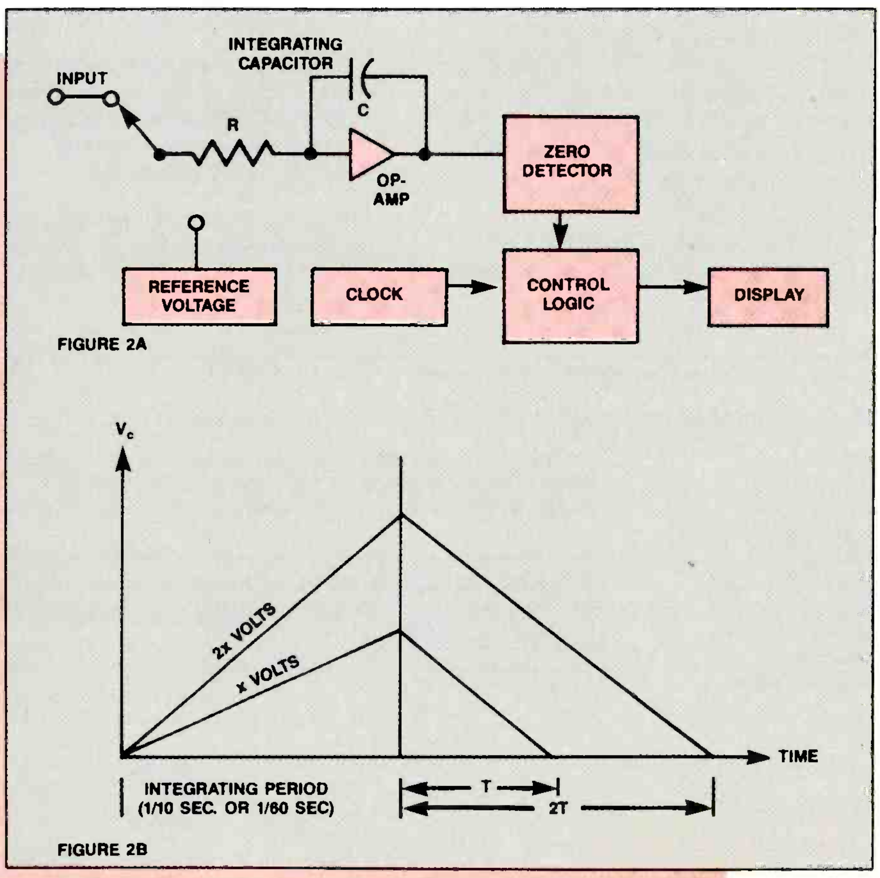

Figure 2. The block diagram in Figure 2a gives a basic idea of how analog-to-digital conversion is accomplished using the dual-slope technique. Figure 2b shows a graph of V_c vs. time. Because the slope of the discharge curve is identical regardless of the ultimate voltage reached by the integrator, the discharge period and, therefore, the number of counts recorded by the logic circuitry is proportional to that voltage.

Main article continued from page 15.

a digital number and displayed as the measured voltage. Although this method works well, it is somewhat slow, so many microcomputer-based meters use a variation called *multislope integration*, which we won't go into here.

Multimeters offer more possibilities today than they ever have before. Large-scale integration (LSI) is making it possible to pack more and more functions into the relatively limited space inside a DMM, and to do so without significantly increasing the cost of the device. In addition, because of competition among manufacturers, the functionality of DMMs is improving. The result: increasingly sophisticated products.

Master Handbook of 1,001 Practical Electronic Circuits—Solid-state Edition, edited by Kendall Webster Sessions; 420 pages; $19.60 paperback $28.95 hardbound.

This reference to solid-state circuits allows professionals and hobbyists to build fire alarms, moisture detectors, 4-channel stereo decoders, repeaters, audio filters, burglar alarms and other devices for the home, shop or car.

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

Electronic Servicing Data and Procedures, by Robert C. Genn, Jr.; Prentice-Hall; 373 pages; $16.95, paperback.

This workbench manual provides almost 200 step-by-step servicing tests and measurements for servicing electronics equipment. The handbook includes servicing tests for analog and digital equipment, including solid-state circuit tests and measurements and coverage of microprocessing units, optoisolators and phototransistors. The guide also contains figures and tables that reflect actual circuits, plus examples, diagrams and checklists that simplify diagnosis and speed servicing.

Prentice-Hall, Business and Professional Division, Englewood Cliffs, NJ 07632.

Complete Guide to VHS Camcorder Troubleshooting and Repair, by John D. Lenk; Prentice Hall; 317 pages; $38, hardbound.

This guide presents a simplified, practical system of repairing VHS camcorders for technicians familiar with the basics of television, magnetic recording and VHS VCRs. The guide concentrates on how the circuits work to help readers reason out a logical troubleshooting approach. A troubleshooting chapter includes service notes for a cross-section of camcorders, describing the most common trouble symptoms reported to manufacturers' service personnel.

Prentice-Hall, Englewood Cliffs, NJ 07632; 800-223-1360.

Cable Television Technology, by Kenneth T. Deschler; McGraw-Hill; 262 pages; $18.95, paperback.

Written with the technical assistance and endorsement of the Electronic Industries Association (EIA), this book prepares students to work as technicians in the cable TV (CATV) industry. Topics covered include traditional "lineman"-oriented topics—an overview of CATV history, franchising, job classifications and operational units, and a review of TV broadcast electronics and equipment—as well as high-technology subjects associated with satellite antennas and fiber-optic links. Each chapter includes learning objectives, a summary and review questions and, where appropriate, numerical problems. Appendices cover map symbols, troubleshooting and test procedures.

McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020; 212-512-4085.

Continued on page 25.

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The Hargis Company
Waco, TX 76701
817-754-5667

Nunn Electric Supply
Wichita Falls, TX 76301
817-766-4203

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*Ballard Supply
Salt Lake City, UT 84119
801-972-2430

VIRGINIA

Harco Electronics
Alexandria, VA 22314
703-548-5115

Cain Electronics
Norfolk, VA 23502
804-855-3394

*Fairway Electronics
Richmond, VA 23222
804-321-7255

Goldberg
Richmond, VA 23222
804-771-5762

Southeastern Elec.
Roanoke, VA 24012
703-344-6611

WASHINGTON

J W Electronics
Everett, WA 98201
206-258-4339

*D & H Dist.
Seattle, WA 98188
206-575-0604

J W Electronics
Spokane, WA 99202
509-535-5800

*Prudential Dist.
Spokane, WA 99202
509-535-9777

J W Electronics
Tumwater, WA 98502
206-943-1071

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509-575-1234

WEST VIRGINIA

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Huntington, WV 27501
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WISCONSIN

*Taylor Electric
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414-241-4321

G M Popkey
New Berlin, WI 53151
414-786-5887

WYOMING

Houge Radio & Supply
Cheyenne, WY 82001
307-632-6474

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Circle (12) on Reply Card

Computer-aided design tool for microchips

Scientists at the GE Research and Development Center have developed an advanced *silicon compiler* geared to the design of algorithm-specific chips for high-technology applications requiring high-speed digital signal processing.

With this second-generation chip-design software, known as PARSIFAL, it is possible to create algorithm-specific integrated circuits (ASICs) that perform their functions in a fraction of the time required by comparable devices designed by existing compilers. Speeds of 500 million operations per second are possible with chips compiled with the new software.

The speed is in the architecture

The faster number-crunching speed of ICs compiled with PARSIFAL is a result of the new compiler's ability to create chip designs having *digit-serial* architectures. This architecture enables the chips to add, multiply and perform other arithmetic operations on "words" composed of digits up to 16 bits wide. This approach replaces the method employed in first-generation, pipelined digital signal-processing (DSP) compilers, which are limited to the design of chips with *bit-serial* architectures (those that can deal with only 1-bit-wide digits).

The differences between the two chip architectures can be visualized by thinking of them in terms of factory assembly lines. In the bit-serial configuration, one "part" (bit of information) comes down the assembly line at a time and is subjected to a series of "machining" (arithmetic operations), one after another, as it travels along.

In the digit-serial architecture, on the other hand, there could be as many as 16 "parts" (16-bit-wide digits) going down the assembly line in tandem. Sixteen "tools" would be at each of the "work stations," and 16 finished parts would arrive at the end of the assembly line in the same time as it took the bit-serial "assembly line" to make one.

Choosing digit sizes for flexibility

In addition to the design of higher throughput chips, the new compiler boasts a flexibility that did not exist before. With PARSIFAL, a chip designer can evaluate tradeoffs between operating speed and chip area/cost by experimenting with different digit sizes.

For maximum speed, the designer would select the biggest digit size possible. However, this would require the largest—and, thus, most costly—chip. Choosing an intermediate value of digit size usually yields the most efficient chips in terms of information throughput per given area.

Several chips have been successfully compiled employing PARSIFAL. Among them is a 60,000-transistor arctangent chip designed to change Cartesian coordinates to their polar forms. This chip, developed for a medical application, computes 10 million operations per second at a sample update rate of 10MHz.

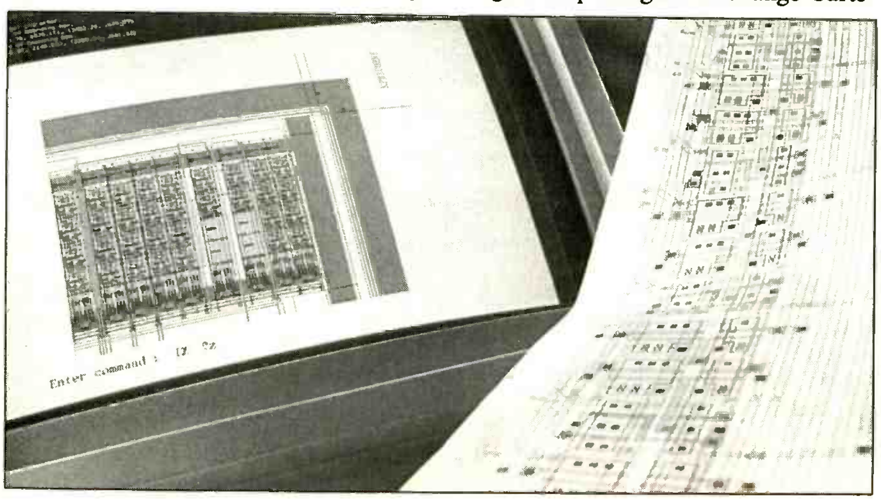
Once the algorithms or mathematical equations describing the arctangent chip's functional requirements had been finalized, it took a designer one day to generate an initial layout using PARSIFAL. It is estimated that this process could have taken up to five person-years employing conventional design methods. The complete design/optimization cycle involved ten iterations of the chip and took two weeks.

How it works

With the compiler (which is implemented on a Sun work station), the designer begins by entering the algorithms describing the chip's function, employing a programming language similar to C. In the case of the arctangent chip, this step required about 150 lines of code. The compiler then simulates the algorithms to confirm that they do what the designer wants.

Next, the compiler draws on its family of basic ASIC building blocks (called *leaf functions*), each of which is designed to do a single function such as addition or multiplication. It automatically picks out the leaf functions needed, lays them out following design rules, and "draws in" conducting wires that hook the building blocks together. The compiler has built-in optimization routines that serve to maximize layout density and minimize the length of the interconnect wires.

The compiler then simulates the operation of the circuit design, again to make sure it does what the algorithm asks. If it does, the compiler is then turned loose to convert the computerized chip representation (the array of interconnected building blocks) into a layout of transistors and other actual circuit elements. The file that results from this process is then fed into a system that creates the mask set needed for fabricating the chip. ES&T



Continued from page 21.

Bob Middleton's Handbook of Electronic Time-savers and Shortcuts, by Robert G. Middleton; Prentice-Hall; 378 pages; $16.95, paperback.

The little-known tricks of the trade, quick tests, tips and shortcuts explained in this handbook help in troubleshooting radio, TV, audio, CB, tape-recorder, intercom, CCTV, telephone and digitally controlled equipment. Instructions and illustrations show new servicing techniques, methods for getting the most from testers and new ways to use conventional test instruments. The book, written for beginning to advanced troubleshooters and hobbyists, contains complete plans for building test instruments, plus BASIC computer programs that simplify circuit analysis.

Prentice-Hall, Business and Professional Division, Englewood Cliffs, NJ 07632.

Digital IC Digest; D.A.T.A.; 850 pages; $110. (Quarterly updates: $60.)

The new *Digital IC Digest* reference source from D.A.T.A. lists and cross-references major electrical characteristics for more than 46,000 devices available from approximately 175 manufacturers of digital ICs. The reference shows device pinouts, critical specifications and packaging information. Other sections list discontinued devices and replacement device information.

D.A.T.A. Business Publishing, 9889 Willow Creek Road, P.O. Box 26875, San Diego, CA 92126; 800-854-7030, ext. 570 (in California, 800-421-0159, ext. 570).

Alarms: 55 Electronic Projects and Circuits, by Charles D. Rakes; 160 pages; $12.60 paperback, $19.95 hardbound.

The projects in this book are designed to show the variety of alarms that are available and to provide readers with step-by-step instructions for actually building their own alarms. The book shows how to build light alarm sensors, ultrasonic sensors, normally closed and normally open alarm systems, temperature sensors, multi-input alarm systems and more. The author also describes how to install systems in homes and cars.

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

Interface ICs Digest, Edition 24; D.A.T.A. Business Publishing; 780 pages; $110 (with quarterly updates, $170).

This reference, which provides data on 21,840 devices from 165 manufacturers, presents device pinout information; identifies devices by function, generic part number and manufacturers' part numbers; lists electrical characteristics; identifies more than 900 discontinued devices; and includes alternate sources. The cross-referenced guide now includes interface ICs for consumer equipment and modular and hybrid device information.

D.A.T.A. Business Publishing, 9889 Willow Creek Road, P.O. Box 26875, San Diego, CA 92126; 619-578-7600.

ES&T

Electronics and automobiles: A revolution in the making

By Mike Ergo

You may not be able to hear it, but a revolution is taking place. It's an electronics revolution, and it's taking place in the automobile industry. Cars of every make and model are being bombarded with electronics. Some of the electronics are integral parts of the automobile; still other devices fall under the category of gadgetry or creature comforts. In fact, it is estimated that the average car leaving the assembly plant today contains between $400 and $600 worth of electronics; that number will be close to $2,500 by the year 1990.

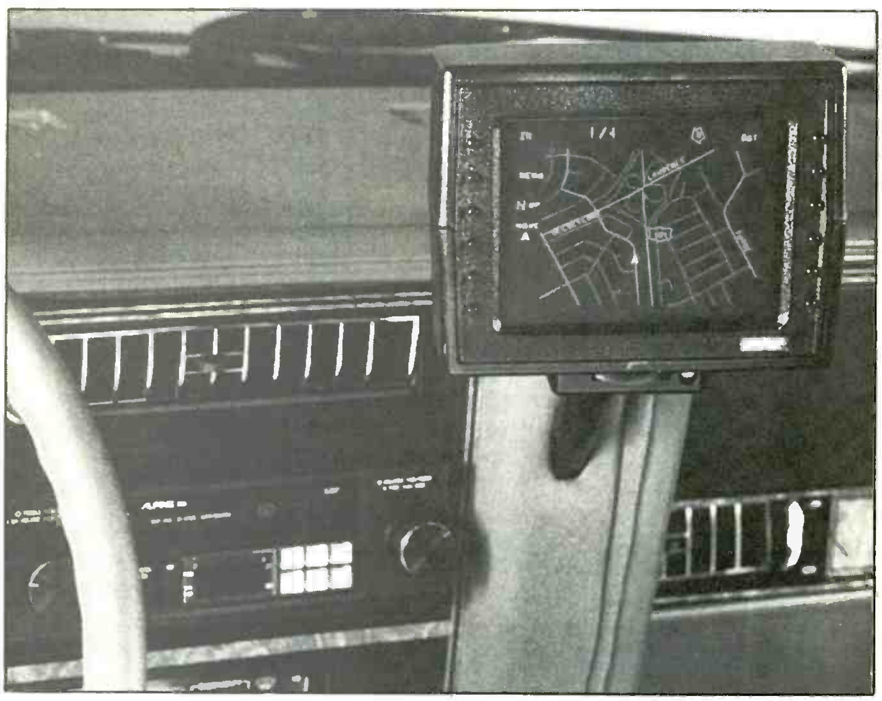
How are electronics being used on the automobile? Where are they located, and how are they being serviced? In order to answer these and other questions about automotive electronics, let's first take a quick look at the history of automotive electronics.

Ergo is president of Ergo & Associates, consultants to the automotive industry.

In the beginning

In 1839, Robert Anderson of Scotland drove the first carriage powered by a primitive electric motor. In 1851, W.M. Storm patented an engine in which gas was compressed before being ignited by an electric jump spark. The use of electricity was becoming so popular on the automobile that, in 1906, Buick included a storage battery as standard equipment. The year 1911 saw a major breakthrough in starting systems with the installation of the first successful self-starter on Cadillacs. This major achievement was the work of C.F. Kettering. Next came lighting changes, turn signals, gauges and, of course, radios. Cruise controls showed up on Chryslers and Cadillacs in 1957. In 1962, Pontiac offered the first fully transistorized ignition system. As they say, the rest is history.

By now we're all pretty familiar with the many electrical/electronic options on today's automobiles. For example, power seats, windows and door locks are very common. Automotive sound systems are as elaborate as you can afford, and it doesn't take an electronics whiz to notice the difference under the hood of a new car, or the cockpit-like appearance of the dash.



Electronic navigation systems will help drivers find their way around without consulting maps or stopping to ask for directions.

Under the hood today

What does all this mean to the future electronics servicer, and where is the automotive electronics revolution headed? Let's take a closer look at the sophistication of the electronics currently used on today's automobiles. For the past several years, every gasoline-powered car sold in the United States has had an on-board computer that controls engine performance. The primary purpose of this computer is to control exhaust emissions and maximize fuel economy. Started in the mid-1970s, this electronics evolution began as a direct result of tough government regulations from the EPA (Environmental Protection Agency) dealing with harmful exhaust emissions and fuel economy.

Today's exhaust emissions are controlled by a 16-bit, microprocessor-based computer using several sensors for information sources. The main source of information, in this direct feedback system, is the oxygen (O_2) sensor. (See Figure 1 for a basic understanding of how the system works.) Because carburetors are quickly becoming extinct, this same computer system has been adapted for fuel-injected engines. This innovation promises to be the way of the future.

Other familiar components also are disappearing. For instance, several GM engines use C^3I, which stands for com-

puter-controlled coil ignition system. This ignition system uses Hall-effect sensors to sense both crankshaft and camshaft positioning, eliminating the need for a distributor. Also used on some cars is a direct ignition system that eliminates high-voltage spark-plug wires, which can generate unwanted noise in a computer system. Instead, primary voltage is dispersed to each spark plug, which contains a mini-ignition coil mounted on the end of the plug itself.

And in the passenger compartment...

Aside from changes under the hood, major changes have taken place in the passenger compartment as well. The biggest changes have come in the form of electronic instrumentation, electronic heater/air-conditioning controls and sophisticated entertainment systems. Many cars, both domestic and foreign, now use digital instrument clusters. Basic clusters have a digital speedometer in either a back-lit LCD format or a vacuum fluorescent format.

More elaborate clusters, such as those found in a Cadillac or Corvette, include digital displays of oil pressure, fuel level, water temperature, engine RPM and even odometer readings. These clusters also are microprocessor-based and use PROMS to store important odometer information. Some clusters incorporate separate circuitry to perform trip computations. These computations include instantaneous and average miles-per-gallon readings, estimated time of arrival, estimated fuel consumption and instantaneous mileage range based on existing fuel levels.

Heater/air-conditioning controls also are microprocessor-based. Using driver information inputs and information from sensors that measure both inside and outside temperature, the passenger compartment temperature is maintained within ±1 degree. This feat is accomplished by continually adjusting the blower-fan speed, heater control-valve settings and plenum door positioning.

The sound systems

Regardless of whether you listen to the radio when you're driving, it's pretty hard to ignore the sophisticated sound/entertainment systems that are available on today's cars. Elaborate sound systems that can cost several thousands of dollars are being installed in today's vehicles. These systems not only include electronically tuned

AM/FM receivers, they also incorporate cassette players and compact disc players; they also should include digital audiotape (DAT) players one day soon. Almost all of these units are microprocessor-based, using the latest LSI (large-scale integration) techniques. Most offer features such as digital readout, infrared remote controls, music search on tape and built-in anti-theft circuitry.

One of the most sophisticated displays of creature comforts is a standard feature on GM's Buick Riviera. It is a touch-sensitive CRT (cathode ray tube) that contains the controls for the heater/air conditioner and the radio. To control the radio functions, you simply touch the screen and a picture of a radio appears. Touching the appropriate part of the picture gives the desired results. Also included in the Buick CRT system is an extensive set of self-diagnostics to aid mechanics in troubleshooting engine-related problems.

Other electronic features found on today's cars include anti-lock braking systems (ABS), electrically powered and heated rear-view mirrors, electric seats with memories, synthesized-voice warning systems that monitor vital engine/car parameters, and a myriad of other options.

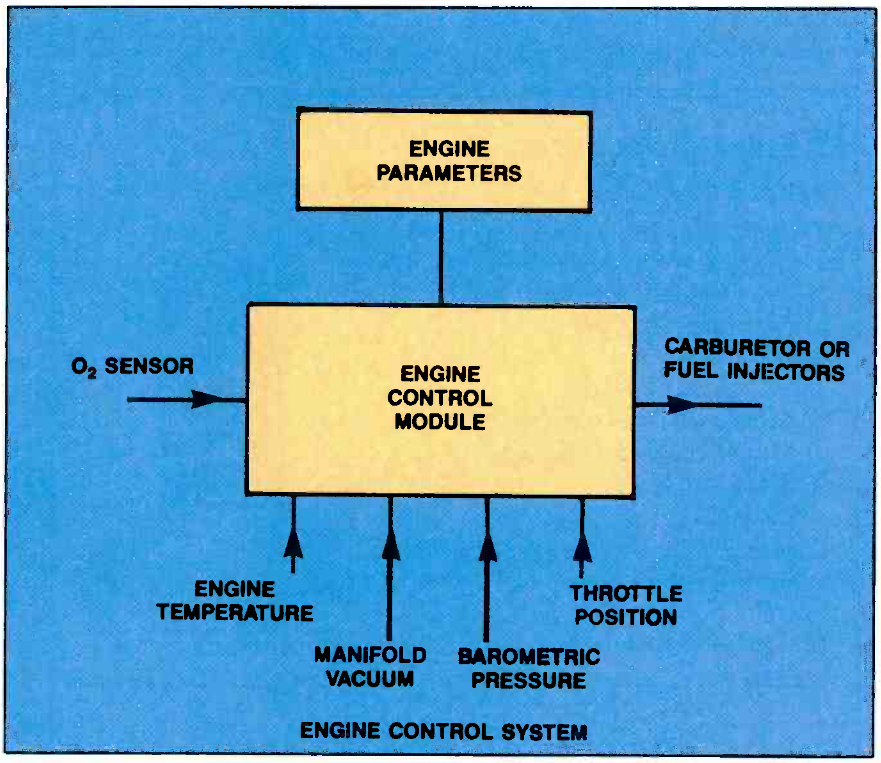


Figure 1. Today's cars already include electronic engine control. As shown in this block diagram, the electronic controls sense engine conditions and driver input, then operate the car accordingly.

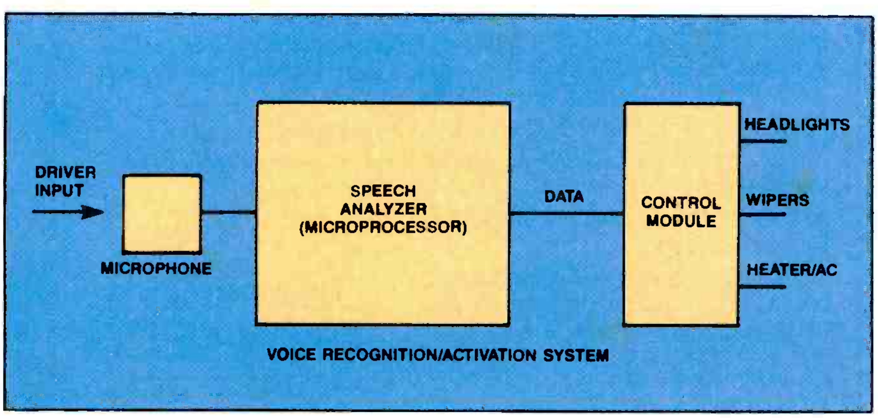


Figure 2. Voice-activated devices will allow drivers to operate such things as headlights and windshield wipers without taking their attention off of their driving.

If today's innovations aren't enough to make the mind wonder, let's take a look at what's coming in the future. Looking first at the drive train, in the future we should find a camless engine, where valves are activated by computer-controlled solenoids. Couple this modernistic engine with electronic power steering, electronically controlled 4-wheel drive and 4-wheel steering, add a computer-controlled suspension system, and you have a futuristic drive train.

What about safety? For a start, many of the basic functions such as headlights, wipers and heater/air-conditioner controls should be controlled directly by voice—voice activation and recognition. (See Figure 2.) Add a radar-type collision-avoidance system mounted in the front and rear bumpers—that should keep you from engaging in head-on and rear-end collisions. Now, to make sure you get where you are going, you will have to have a navigation system. Don't laugh—this CRT system will show you detailed maps of any city, down to the side streets. It will also show your position relative to the streets and highways and is accurate within 40 feet. A system will soon be available from the factory on an OEM (original equipment manufacturer) level. A picture of such a system, manufactured by ETAK, is shown on page 26. The ETAK system uses a built-in electronic gyroscope and speed sensors on the wheels to monitor positioning. Of course, a microprocessor does the calculations.

To make it easier for the driver to monitor vital engine information such as temperature, oil pressure, rpms and car speed, future cars may have a projection-type instrument cluster that will use 3D holography to project images in front of you so you don't have to move your head and refocus to check your car's vitals. At the same time, you will be able to see the road because the holographic images are see-through.

All of these wonderful devices will be connected together with only one pair of wires. Everything will be controlled by a multiplexed signal originating from a central body computer. In other words, all the devices including lighting will be smart devices, capable of decoding computer commands.

Are you convinced that an electronics revolution is taking place in the automotive industry? If you are involved in electronics at any level, you stand to be right in the path of the revolution.

ES&T

Unusual lines in the picture

By Homer Davidson, CET

The side effects of many failures show up in the TV picture. Learning to read the often distinctive lines they create can help you diagnose the defect.

Although the key word in the phrase *unwanted lines in the picture* is *unwanted,* there is one consolation: They often provide visible side effects of the defect. If they're visible, they may be identifiable, which would provide the servicer with a road map to troubleshooting the problem. Indeed, unwanted lines and dots on the screen often arrange themselves into recognizable families whose patterns can help you diagnose the sources of the problems.

During the years before color TV, only two types of unwanted lines ordinarily appeared on the CRT screen: one black Barkhausen and one white drive line, both vertical. These lines usually were not difficult to remove. With transistorized TVs, however, you often run into unusual lines.

Reading between the lines

Unusual lines, which might be vertical, horizontal, diagonal or a combination of the three, might appear almost anywhere on the raster. Some are stable; others vary constantly.

These lines are unusual also because of the variety of their appearances and the circuit problems that cause them:

- Retrace lines at the top of the picture often occur as a result of sync or vertical problems.
- Horizontal firing lines might be produced by strong arcs in the yoke, focus control or CRT socket. They also can be caused by HV arcs.
- HV arcing spots are displayed as a result of problems with a tripler, flyback or CRT-anode lead.
- Horizontal hum bars usually indicate poor filtering in the boost supply.
- Shaded vertical bars at the left hint of poor filtering in the boost supply.
- Several vertical "jail bars" on the left side of the screen usually indicate defective electrolytic capacitors in the AGC, sync and horizontal-output circuits.

Many other lines come from signals outside the television receiver. Therefore, before starting the testing analysis, determine if the lines are caused by a defect in the TV or by a signal picked up by the antenna from some outside source.

To determine if the problem is internal or external, disconnect the antenna lead wire and short between the receiver's antenna terminals. This maneuver usually eliminates noises from motors, neon lights and high-line arcs. If the noise on the screen is reduced or eliminated, the noise is coming from the antenna. If the lines or spots don't change, the problem is in the chassis.

Lines and spots

The focus control is sometimes the source of small lines and spots in the picture. To determine whether the focus control is the problem, rotate it in both directions and notice if the lines increase in intensity or disappear as the picture focus changes. If the control is good, the focus should change smoothly with little or no effect on the lines. A defective focus control might also emit a high-frequency squeal as the control is rotated. A corroded focus control might produce noise dots or lines on the screen of another TV nearby. If symptoms point to a problem with the focus control, replace it. If a new focus control

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Glossary

Barkhausen lines: Barkhausen-Kurz oscillation or Barkhausen oscillation, named after H. Barkhausen and K. Kurz, 20th century German scientists, is ultra-high-frequency oscillation produced in a triode oscillator by means of a positively biased grid. This oscillation causes the cathode electrons passing through it to oscillate at a frequency characteristic of the tube and applied voltages.

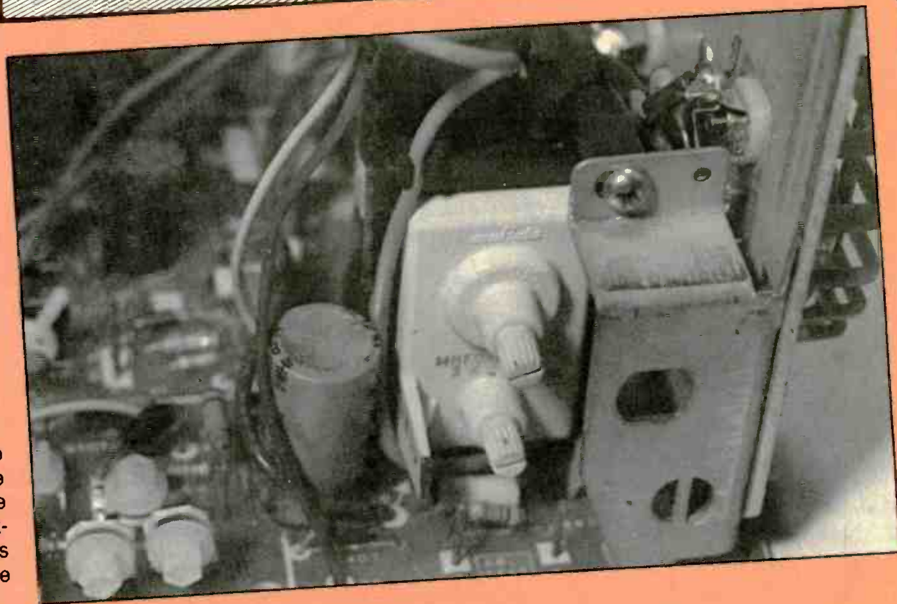
Firing lines: Firing lines are caused by amplitude-modulated noise such as arcing, similar to that caused by firing automobile spark plugs that are not properly suppressed.

Retrace lines: The signal voltage during the interval in which the electron beam is pulled back to the top of the screen to begin tracing out the next field of the picture is at a level that is designed to turn off the electron beam and, therefore, blank the screen. Theoretically, then, the screen should be dark during the vertical retrace interval. In the case when the received signal is weak or the brightness is turned up high, the retrace action may be seen as a series of widely-spaced, bright lines sloping diagonally upward to the right. Modern televisions have retrace blanking circuits to overcome this problem.

Davidson is the TV servicing consultant for ES&T.

Arcing horizontal lines JCPenney CTC90JL chassis

In this chassis, I could hear a faint, irregular but rapid arcing when the focus control was rotated. At the same time, several arcing lines flashed across the raster. I suspected either the focus control, the tripler or the CRT harness and socket. The sound was loudest at the CRT socket. Replacing the entire CRT socket and harness assembly solved the horizontal arcing lines.



Horizontal lines caused by arcing might be produced by a defective focus control. The two controls mounted on ceramic are the focus control, on top, and the screen-adjustment control, on the bottom. Rotate the focus control and notice on the picture tube if the arcing stops.

Retrace lines at the top Gold Star model CR-401 portable

In this set, I could not reduce the brightness enough to eliminate the retrace lines at the top. About +32V was measured at the collectors of the three color video-output transistors. Tracing the +162V source back to its beginning as a flyback-powered supply, I found the D_{510} diode (see Figure 1) virtually shorted. Also, protective resistor R_{521} was open. Replacing the diode and R_{521} fuse/resistor plus doing the usual adjustments brought a good picture to a normal screen, without retrace lines.

Perhaps a few words of explanation are needed here. Each color video-output collector is connected to its matching CRT cathode by a 4,700Ω resistor. Therefore, the collector and the CRT cathode have about the same +130Vdc voltage. Loss of the +162V supply reduces the CRT cathode voltages and forces the CRT to operate with far less than normal bias, thus producing excessive brightness.

Retrace lines at the top of the picture might result from defective components in the luminance, picture tube or vertical circuits.

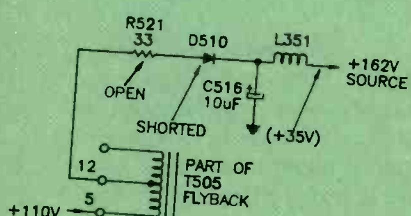


Figure 1. Retrace lines at the top of the screen in a CR-401 Gold Star portable were caused by an open R_{521} surge resistor and a very leaky D_{510}. Replacing D_{510} and 33Ω protective resistor R_{521} eliminated the retrace lines by reducing the excessive brightness. The defective components had reduced the +162V supply, which reduced the CRT cathode voltages and operated the CRT at near zero grid bias. Check the 1870-1 Photofact.

removes all noise lines and spots, the analysis is finished.

Horizontal firing lines can be caused by an erratic yoke socket or loose connections. Some firing lines are similar to the picture symptoms caused by arcs: round and oval in shape and one line high. But others are much wider (horizontally) and brighter, appearing as bright flashes. Occasionally, firing lines remove a sizable part of the raster. Inspect the yoke socket, looking for burned marks or signs of arcing.

Arcing horizontal lines in the picture sometimes are caused by a defective CRT socket and wiring harness. Place your ear near the focus control while you rotate it. Then repeat by listening to the CRT socket while rotating the focus control. To determine whether arcing occurs in the CRT socket and harness, turn off the power and remove the CRT socket. Turn the power on, and keep away from the CRT and its harness while you rotate the focus control. (Some defective focus controls will arc when the CRT socket has been removed, but they seldom arc with the socket on the tube.)

Incidentally, many color receivers have the screen-grid and focus variable controls in the same package. If one control is defective, both are replaced together.

Retrace lines at the top

Several diagonal retrace lines are visible at the top of a normal-brightness picture when certain defects occur in the luminance, vertical or picture-tube circuits. Usually these retrace lines are blacked into invisibility. If the picture is too bright, the brightness cannot be turned down and retrace lines appear at the top of the raster, you should suspect incorrect dc voltages on the CRT, either grid or cathodes. A leaky video output transistor can cause the same symptoms, except the raster and retrace lines are all the same color: red, blue or green.

High-voltage arcs

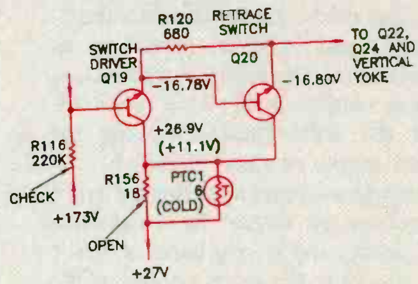
Although high-voltage arc-over can occur anywhere in the high-voltage circuitry, when this symptom occurs, suspect a defective tripler, flyback transformer, picture tube or CRT anode cable. And don't overlook the possibility of arcing at the spark gap across the tripler unit. The arcing tripler or flyback sometimes might produce a dark screen with horizontal arcing lines in the raster. With the power off, take a look at the

Folded-over retrace lines RCA CTC97H television

Seven very bright, folded-over retrace lines were located at the top of the picture. Below these were several less-bright lines that were visible after I increased the brightness.

I checked all CRT circuits and voltages (including the grids and cathodes of the CRT, and the collectors of the color-video outputs) without finding anything out of tolerance. I concluded, therefore, that the problem might be in the vertical circuit. This is one of the few models that has a switch driver and switch resistors. These components add vertical sweep power only during the latter part of retrace and the beginning of trace when special power is needed to provide good linearity. At Q_{19} switch transistor and Q_{20} retrace switch transistor, the common collector dc voltage was low. DMM tests proved that 18Ω R_{156} was open. (See Figure 2.) I replaced R_{156}, which returned the set to good vertical linearity without retrace lines. I also replaced Q_{19} and Q_{20} because experience has shown that these have a tendency toward failure later.

Figure 2. All dc voltages of the CRT were tested and found to be within tolerance. At second thought, those retrace lines appeared to be the result of a vertical system problem. A routine test of voltages revealed low voltage at the common collector of Q_{18} (switch driver) and Q_{20} (retrace switch). Of course, a serious defect in that 2-transistor circuit usually generates retrace lines at the top. Operation was normal after 18Ω R_{156} was replaced.



Intermittently arcing lines Sanyo 91C530 portable

Intermittently arcing lines were easy to see on the raster of this set. Sometimes the arcing lines were visible when the focus control was rotated. At other times, rotating the screen control apparently caused the arcing lines. And then, to make accurate analysis questionable, moving the T_{302} flyback either started or stopped the arc lines. A F1177 component contains the focus control, screen control and flyback. I installed a new F1177, which stopped all arcing lines.

Rolling hum bars Zenith 25D56 color receiver

Replacing the Q_{212} regulator transistor and the CR_{211} zener diode in this set corrected the audio hum and the black bars in the picture. (See Figure 3.)

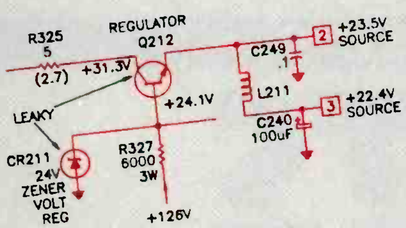
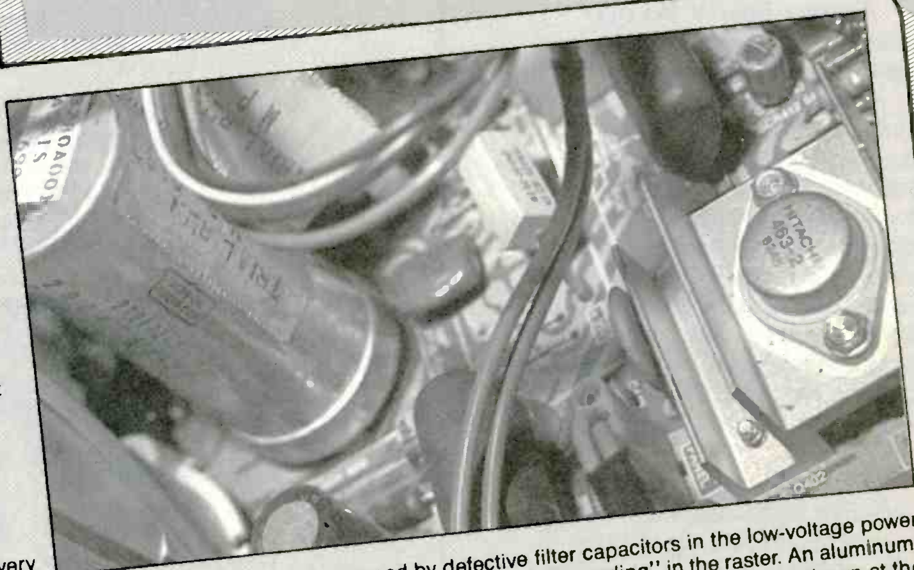


Figure 3. Four large black bars moving very slowly up the screen showed 120Hz ripple that was not being reduced enough by the Q_{212} regulator in this Zenith 25DC56. Transistor and diode tests showed Q_{212} and CR_{211} zener diode were leaky. Replacing them removed the black bars and the audio hum.



Rolling hum bars usually are caused by defective filter capacitors in the low-voltage power supply. Extremely poor filtering can produce "vertical crawling" in the raster. An aluminum-can electrolytic capacitor (probably with several internal capacitance units) is shown at the left in the photograph.

CRT anode lead. It might not be hooked properly in the hole, causing arcing between the male connection and the CRT anode button. This defect can easily happen after the TV chassis has been replaced.

Arcs that are causing picture noise and lines are difficult to locate in a molded flyback transformer. Turn the brightness up and down, listen near the flyback and notice whether the noise disappears or becomes stronger. Arcing usually occurs internally between high-voltage windings and diodes.

Rolling hum bars

Most dark bars that move slowly up the screen are the result of dried-out, low-capacitance filter capacitors or problems with the low-voltage regulators. Many different symptoms can be caused by defective electrolytic filter capacitors. When symptoms occur that make you suspect a filter capacitor problem, parallel in turn each filter capacitor of the low-voltage power supplies. For testing, use about the same capacitance as that of the capacitor in the chassis. Always turn off the ac power and discharge other capacitors before adding the paralleling capacitors. Incidentally, excessive vertical "crawling" might result from poor filtering of the low-voltage power supply.

A leaky voltage-regulator transistor or incorrect B+ adjustment (usually too high) in the low-voltage power supply might allow excessive 120Hz in the B+ output (four horizontal bars floating slowly upward on the screen). Also, check the regulator and AFP transistors for leakages or shorts. Likewise, a shorted diode in the base circuit of the regulator transistor can produce dark bars in the raster because the defect interferes with voltage regulation.

Two black bars rolling up the screen of an RCA CTC89 television CRT probably are not caused by a defective electrolytic capacitor. (See Figure 4.) One reason is that a defective capacitor usually causes four black bars for 120Hz and not two bars (60Hz). Instead, the diodes are the prime suspects; one can open or nearly short and change the 120Hz to 60Hz. Using the DMM diode test, check all the diodes including the bridge diodes, regulator diodes and start/run switching diodes. If necessary, switch to the resistance ranges during leakage tests, or disconnect one lead of each questionable diode for a more accurate leakage test.

Start-up in the RCA CTC89 uses diodes as switches to change two power loads from start-up to run power flows. These power loads are the +26.5V and +20.5V supplies for the horizontal-oscillator and driver stages. During each power-on, two temporary dc voltages are produced for the start-up procedure. These voltages are sufficient to start the horizontal oscillator and driver (the output transistor already has steady B+). Therefore, the horizontal and all receiver functions begin to operate. The start-up circuit must then be disconnected because it is not powerful enough to support the entire load. This is the end of start-up. Five start-run diodes switch from conductive to non-conductive states according to the polarity of voltages across them. (More about this later.) Also, CR_{305} and CR_{303} are in series for reasons not explained. In this article they are listed as CR_{305}/CR_{303} and treated as one diode.

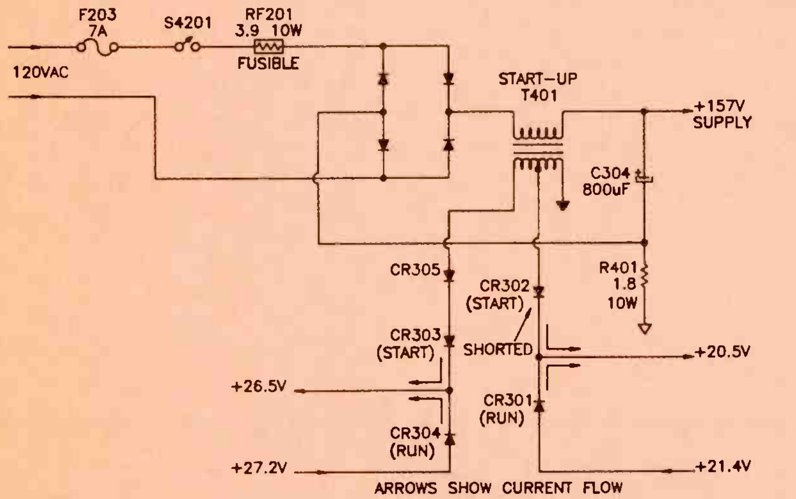


Figure 4. In an RCA CTC89E that had four black bars moving slowly upward on the screen, tests finally located CR_{302}, which was nearly shorted. Arrows show where the diode current flows, but not when it flows. First, current must flow from the start-up circuit to the +20.5V and +26.5V supplies that power the oscillator and driver. After start-up is over (and until the receiver is turned off), the current must flow from the +21.4V source to the +20.5V supply, and from the +27.2V source to the +26.5V supply. Notice that only the +20.5V and +26.5V supplies are receiving current (power) at all times (after power-on).

Lines in the center Sylvania E202 chassis

A band of horizontal lines appeared after I replaced the vertical IC_{302}. The complaint originally was about insufficient vertical height. An ECG794 universal transistor was installed as a replacement. Both vertical-output transistors were tested and no defects were found; they were then replaced without any change in the symptoms.

Because the lines were not in the narrow vertical area of the picture at the beginning, I installed another ECG794 IC. Those extra lines down the center were gone. Always watch for defective replacement ICs and transistors used in the video, IF and vertical circuits.

Wavy, pie-crust lines RCA CTC68 chassis

Picture lines on the left side of the screen showed wavy, pie-crust shapes. After testing many capacitors and resistors, I found 27Ω R_{125} burned open and CR_{403} operating quite warm. (See Figure 5.) Replacing those two HV-regulator components removed the wavy, pie-crust effect from the picture.

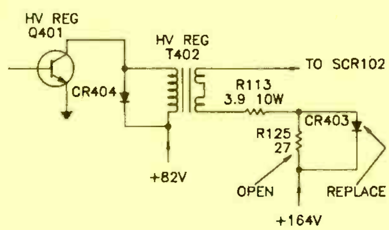


Figure 5. Picture lines at the left side of the screen showed wavy, pie-crust shapes on one RCA CTC68 CRT. Such problems often are in the horizontal circuit. Tests of capacitors and resistors in the horizontal circuit revealed that diode CR_{403} was operating very warm and R_{125} was burned open. Replacing CR_{403} and 27Ω R_{125} removed all unwanted wavy lines.

Dark bars on the left Panasonic TR-562A

This set had a dark picture on the left side of the screen, and the B+ boost voltage measured only +70.1V, although it should test at +113V. A very small electrolytic capacitor is used to filter the boost circuits. In several cases of this symptom on this model of TV set, replacing the original 1μF C_{420} with a 10μF 160V electrolytic removed all picture shading.

Equal in importance to the switching diodes are the voltage sources and current paths at the beginning. First, 120Vac power is rectified by the 4-diode bridge, producing 120Hz dcV pulses that are filtered and made peak-reading by 800μF C_{304}. The primary winding of T_{201} transformer is between the bridge and C_{304}.

The "kick-start" function of the start-up system operates by the charging surge of C_{304} current. At power-on, the current is very high, then it drops rapidly (as the capacitor charges) to a low, steady current. This powerful, short burst of dc primary current at each power-on produces, by induction, a narrow ac pulse across the T_{201} secondary winding, which has two outputs. The pulse from the T_{201} tap is rectified by series rectifier CR_{302}, and the output is filtered by capacitors of the +20.5V supply. (At the same time, diode CR_{305}/CR_{303} rectifies the T_{201} pulse, which is filtered by capacitors in the +26.5V supply. Note: we will continue to keep the two supplies separate by enclosing in parentheses the data from this supply.) Both voltage supplies are necessary to activate the oscillator and driver stages.

Horizontal-sweep operations produce diode switching. The +21.4V (rectified from flyback pulses) exceeded the +20.5V supply by enough to switch CR_{301}, the run diode, into its conducting mode, thus passing current. (In the same way, +27.2V from the flyback was higher than the +26.5V supply.)

One more step remains. Power is flowing from horizontal-rectified dc voltages to their normal TV loads. However, the start-up circuit also is connected, and it might be damaged if allowed to continue. Therefore, the start-up circuit must be disconnected from the two power supplies. Switching diodes also do that job. CR_{302} (and CR_{305}/CR_{303}) have become reverse-biased, promptly becoming an open circuit because of the higher +20.5V supply versus the disappearance of dc voltages from the kick-start circuit. Now the two power supplies have the correct voltages and the start-up circuit is disconnected and inactive. Start-up is finished, and the TV receiver is operating normally with full power.

Lines in the center

Horizontal lines often appear through the center of the picture; these lines are caused by a defect in the video stages. The lines are visible only when a picture is being received; they are not visible on a raster without a picture. Sometimes firing lines appear, causing oscillation in the picture or tearing of sync lock. When those problems appear, check the capacitances of all electrolytic capacitors in the AGC circuit, look for burned collector resistors in video-amplifier circuits and examine the transistors for improper replacements.

Wavy, "pie-crust" lines

Defective components in both the horizontal and the vertical circuits can cause wavy, "pie-crust" lines. Keep in mind that pie-crusting caused by defective components in the horizontal or vertical circuit tend to appear on the left side of the picture, while pie-crusting that results from a horizontal-sweep de-

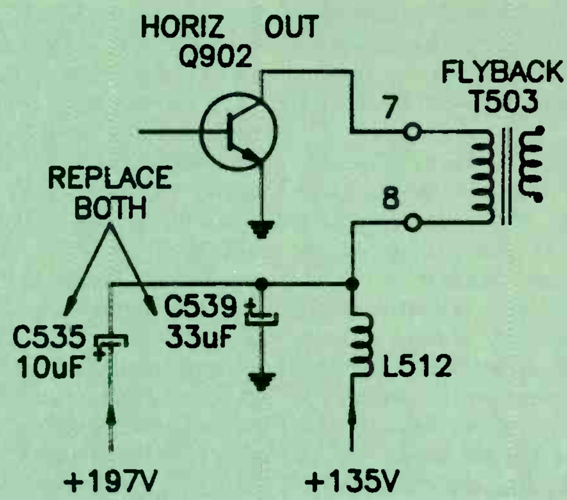


Figure 6. Vertical jail bars in the picture of a Sony KV-2644R were banished easily by replacing two electrolytic capacitors. C_{539} (33μF) bypassed the +135V source to ground, and C_{535} (10μF) bypassed the +197V supply to the +135V supply.

Green picture with retrace lines, followed by shutdown Zenith M1938W

This set showed rapid shut-down. After the back was removed, it was easy to see that the E5105 spark-gap was arcing. These picture-tube spark-gaps are located on the CRT board, near the prongs. Always replace burned or arcing spark-gaps with others of the 52-2240-06 original part numbers. One CRT element has one spark-gap inside the socket and another one separate from the socket. An arcing spark-gap inside the tube socket causes arcing lines in the raster. An arcing inside spark-gap also can force the horizontal circuit into shut-down.

Vertical bars RCA CTC-107C chassis

In this set, vertical bars at the left of the screen were caused by an open collector resistor on Q_{702}. This 56kΩ R_{712} resistor (see Figure 7) was open, thus changing to +0.97V the normal −2.53V at the Q_{702} collector. This voltage, along with the vertical pulses, is sent with vertical blanking to pin 7 of U_{701}.

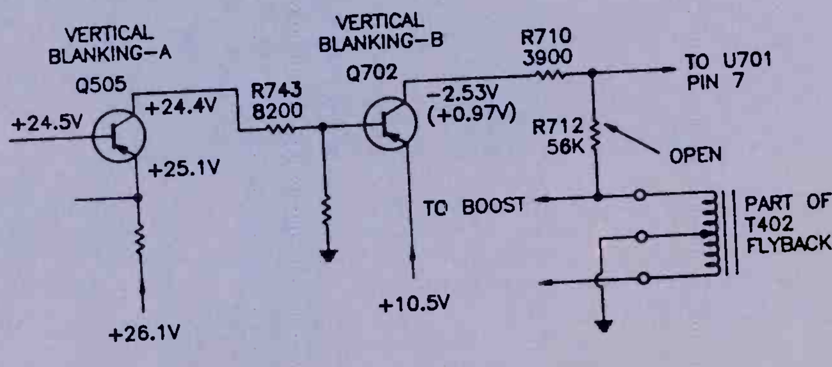


Figure 7. An RCA CTC107C showed vertical jail bars on the left side of the screen. A scope showed the jail-bar pulses at pin 7 of U_{701} where vertical blanking should be. Checking back with a DMM and an ohmmeter located an open R_{712} (56kΩ).

fect usually appears over the entire screen. In the vertical sync-separator stages, check for increased-value resistances, especially in the base and collector circuits. In the horizontal circuit, check for open electrolytic capacitors around the base circuit of the horizontal oscillator, perhaps in the phase detector. Also, look for burned resistors in the horizontal-output circuits.

Dark bars on the left

When vertical dark bars or a larger shaded area appear at the left side of the picture, one possible cause is poor filtering of the boost power-supply circuits. This boost voltage supplies the video-output transistors that usually drive the CRT cathodes. When this symptom appears, test the boost supply B+ output voltage. In many cases of dark shading or dark bars, the boost voltage will measure much lower than the schematic specifies. Perhaps the diode is defective, or the electrolytic filter is open.

Green picture with retrace lines

Another common set of symptoms are a green (or red or blue) picture with retrace lines quickly followed by shutdown. Sometimes the picture goes out of focus with arcing or firing lines in the picture. If these CRT symptoms are produced by an arcing focus control, shutdown probably will not occur (focus-control arcs seldom produce shutdown). When arcs are not visible or are otherwise easily located, it probably is faster to connect a 120Vac variable-voltage transformer. Start at some low line voltage, perhaps 50Vac, and increase it slowly until the picture is visible but does not have the problem. Then increase the line voltage until the problem occurs, but before shutdown, and make appropriate tests.

The first few instrument readings and visual observations should allow a good technician to identify the major system that is involved.

You often can see or hear the arc-over in a spark-gap assembly. These spark-gaps are connected from several picture-tube elements to ground to protect the CRT from high-voltage arc-over.

When one color is dominant, go directly to the spark-gap for the CRT grid of that color. But when arcing occurs and the picture goes out of focus, check for arcing of the spark-gap that's across the focus control. Suspect a leaky tripler rectifier when the spark-gap across the high-voltage tripler is arcing.

Vertical bars

A likely cause of several vertical "jail bars" on the left side of the picture is an open electrolytic capacitor in the AGC circuit or in the horizontal-output circuits. Similar bars over the entire picture might originate from defective vertical blanking.

First, determine if the bars are in the raster alone, in the picture or in both. Change the selector to a channel without a station signal. Turn down the color control. If the bars remain, the problem almost certainly is in the sweep circuits. Next, fine-tune a station picture and notice whether the bars become brighter or lose intensity with the tuning.

Vertical lines that are varied by the signal usually originate in the AGC or video-amplifier circuits. Dark vertical bars at the left side often are caused by open electrolytic capacitors in the B+ voltage supply for the horizontal-output transistor. (See Figure 6.) Either temporarily replace any suspected capacitors or parallel them with known-good electrolytic capacitors for a test. Install new ones if these old capacitors are defective.

When dark vertical bars cover all the picture, check the vertical-blanking circuits. Look for leaky blanking diodes in video-amplifier circuits. Then test all components of the vertical-blanking, especially diodes, transistors and resistors.

Although TV malfunctions and problems occur in many dozens of ways with different symptoms, the first few instrument readings and visual observations should allow a good technician to identify the major system that is involved. If his previous experience has been extensive, the technician might have the ability to go further and identify the components that have failed.

Remember that some of the unusual lines described in this article might appear on the picture tube of almost any brand or model TV receiver. ES&T

What do you know about electronics—

Four-terminal networks

By Sam Wilson, CET

The first part of this installment of "What do you know about electronics?" is a continuation of the series that began last month, which deals with the network theorems and laws that have applications in electronic circuits. The theorems and laws are presented here as theory, without relying heavily on math. The objective is to show how the theorems and laws are applied.

Figure 1 shows a black box with input and output terminals. It is often called a 4-terminal network or 2-terminal pair. In order to work with this concept, you have to play by the rules. Terminals A and B are one pair of terminals; C and D are another pair of terminals. The rules are that you can make measurements or connections across either pair. However, you are not allowed to make measurements or connections between the pairs. For example, you can measure the resistance between A and B, but not between A and C or A and D.

Wilson is the electronics theory consultant for **ES&T**.

To begin the study of black box problems, we will consider only resistor circuits. This approach will give us some important applications without having to consider reactive components. Also, we can make all of the necessary measurements with an ohmmeter.

There are four—and only four—possible measurements that can be made with an ohmmeter. These measurements are called *resistive parameters.*

As you will see, if you want to make a circuit that is equivalent to the black box, you would choose resistive parameters. The four parameters that define the black box are:

- the input resistance with the output terminals open.
- the input resistance with the output terminals shorted.
- the output resistance with the input terminals open.
- the output resistance with the input terminals shorted.

It doesn't make any difference how many resistors you have in the box or how the resistors are connected. You can represent the box with the simple circuit shown in Figure 2. This circuit is sometimes called a delta or pi (π) because it is in roughly the shape of the Greek letter π. Likewise, you can use the T-circuit in Figure 3 to represent the black box. This circuit is sometimes called a Y or wye, again because of its characteristic shape.

It should be immediately obvious that if either the delta or the wye-circuit can be used to represent the black box, then for every delta-circuit there is an equivalent wye. Also, for every wye there is an equivalent delta.

Let's stop here and look at a practical application. The delta-to-wye and wye-to-delta conversions can be used to simplify circuits. Suppose you are asked to calculate the resistance between X and Y in the circuit shown in Figure 4. You cannot solve that problem by determining series and parallel resistance. You can, however, replace delta-circuit ABC with wye-circuit LMN as shown. Now the circuit is a simple series-parallel network, and you can find the

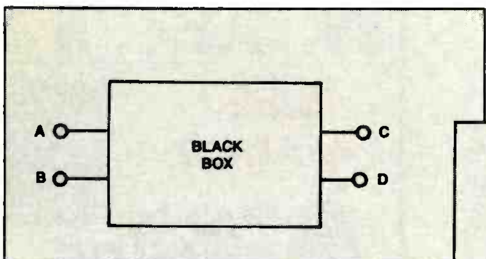


Figure 1. This black box with input and output terminals is often called a 4-terminal network or 2-terminal pair. Terminals A and B are one pair of terminals; C and D are another pair of terminals. You can make measurements or connections across either pair.

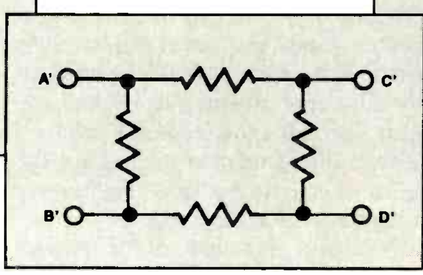


Figure 2. This circuit is sometimes called a delta or pi (π) because it is in roughly the shape of the Greek letter π.

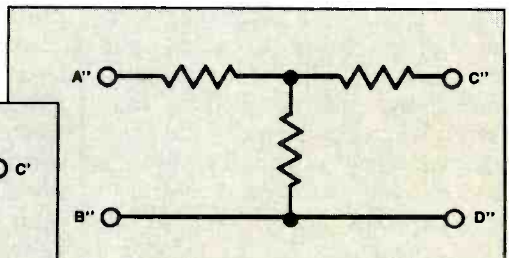


Figure 3. This circuit is sometimes called a Y or wye because of its characteristic shape.

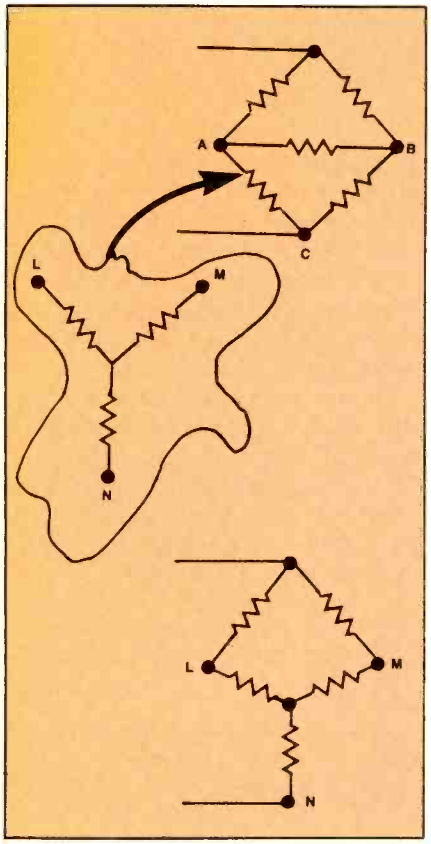


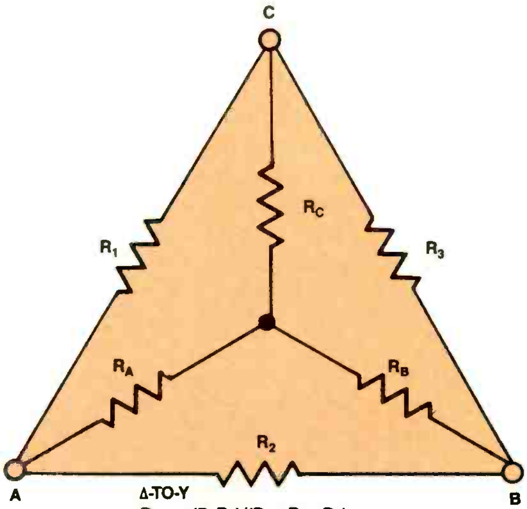
Figure 4. The delta-to-wye and wye-to-delta conversions can be used to simplify circuits. Although you cannot determine series and parallel resistance to calculate the resistance between X and Y, you can replace delta-circuit ABC with wye-circuit LMN as shown. Now the circuit is a simple series-parallel network, and you can find the resistance with series and parallel calculations.

resistance with series and parallel calculations.

Remember that we're only interested in what you can do with these theorems and laws. The mathematics are not of interest here. However, if you're one of those people who can't keep your fingers off your calculator, I've included the delta-wye and wye-delta transform equations in Figure 5. People who work with complicated networks often find it to their advantage to transform configurations in order to simplify the circuit.

Impedance matching

One method of matching impedances is to use a transformer. Of course, that won't work for the dc circuits under consideration here. However, the wye- or



Δ-TO-Y

$R_A = (R_1R_2)/(R_1+R_2+R_3)$

$R_B = (R_2R_3)/(R_1+R_2+R_3)$

$R_C = (R_1R_3)/(R_1+R_2+R_3)$

Y-TO-Δ

$R_1 = (R_AR_B+R_AR_C+R_BR_C)/R_B$

$R_2 = (R_AR_B+R_AR_C+R_BR_C)/R_C$

$R_3 = (R_AR_B+R_AR_C+R_BR_C)/R_A$

Figure 5. With complicated networks, the delta-wye and wye-delta transform equations can be used to transform configurations and simplify the circuit.

T-circuit can be used with dc circuits. Impedance is an ac-circuit term, but many ac circuits have a pure resistance under certain conditions. One example is a resonant circuit that has only resistance at the resonant frequency. Another is a transmission line that can be terminated in a pure resistance.

Suppose the black box in Figure 1 is the circuit that connects a 300Ω transmission line to a 150Ω line. The 300Ω line must "see" 300Ω looking into terminals A and B. Likewise, the 150Ω line must "see" 150Ω when looking into terminals C and D.

The black box can be used to match the two transmission lines. Assuming the lines are both unbalanced, as in the case of coaxial cable, either of the equivalent circuits in Figures 2 and 3 can be used to match the impedances.

There are several ways to determine the resistance values. They require a little bit of fancy mathematical footwork, which we can skip over for now. The important thing to know at this point is that by using only three resistors and either of the circuits in Figure 2 or 3, the unbalanced transmission lines can be hooked together. For balanced transmission lines, the configurations in Figure 6 can be used. They can be obtained directly from the delta- and wye-circuits.

Attenuators

There has been some mixing of terms in this business. However, the words *pad* and *attenuator* are used to mean the same thing. They both reduce signal amplitude and, at the same time, match impedances. An attenuator (or pad) can produce either a fixed or variable attenuation of the signal.

You can control the amplitude of a signal with a single resistor as shown in Figure 7. This simple procedure has a disadvantage, however: Every time the variable resistor is adjusted to change the amplitude, the impedance between the input and output circuit changes.

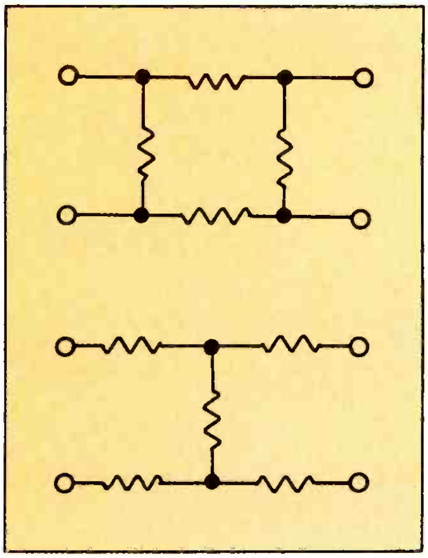


Figure 6. These configurations can be used for impedance matching when you are connecting to balanced transmission lines. They can be obtained directly from the delta- and wye-circuits.

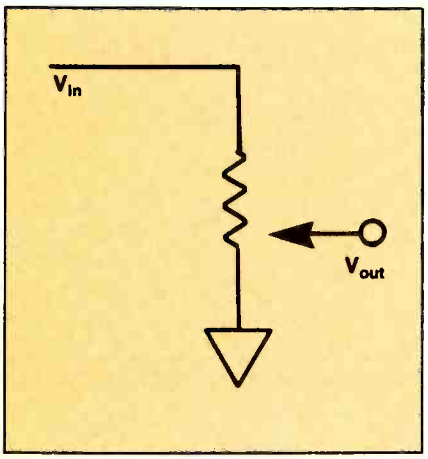


Figure 7. You can control the amplitude of a signal with a single resistor. The disadvantage is that, every time the variable resistor is adjusted to change the amplitude, the impedance between the input and output circuit changes.

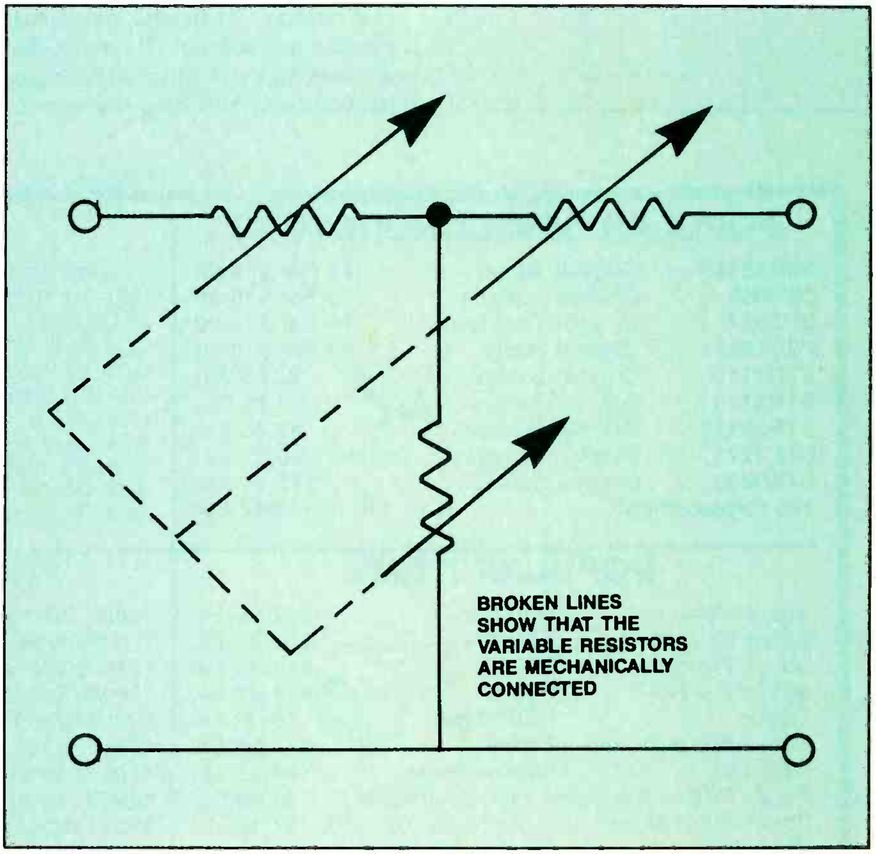


Figure 8. A signal's amplitude can be controlled with an attenuator to avoid the problem described in Figure 7. The variable resistors are ganged so that they are all adjusted at the same time. The attenuator makes it possible to control the amplitude of the signal delivered from one point to another. At the same time, it matches the impedances of the input and output circuits.

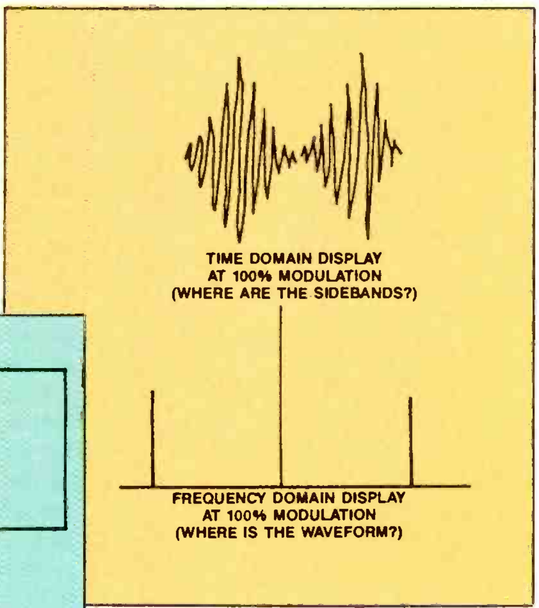


Figure 10. The usual methods of representing amplitude-modulated signals are shown here. These representations leave something to be desired because the time-domain display doesn't show the sidebands, and the frequency-domain display doesn't show the change in amplitude.

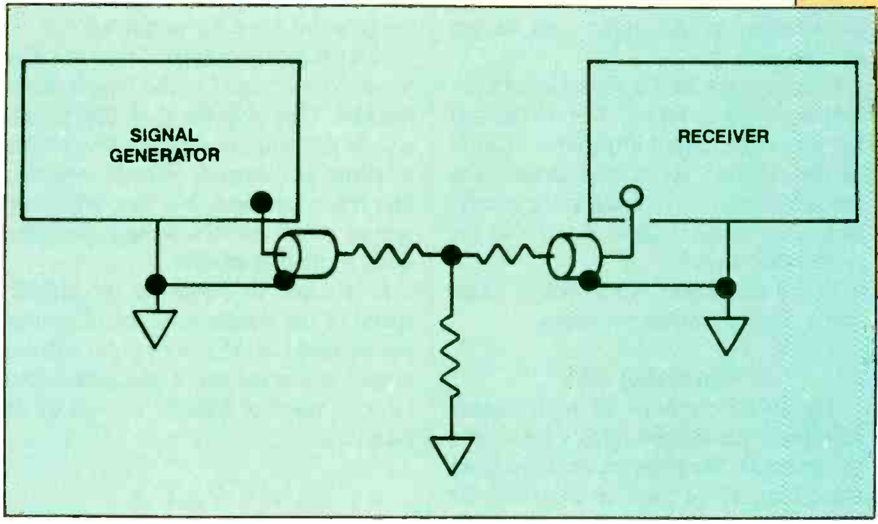


Figure 9. In this example of the use of an attenuator, the signal generator output impedance matches the receiver input impedance. The amount of signal delivered to the receiver can be varied without disturbing the impedance match.

That problem can be eliminated by using an attenuator like the one shown in Figure 8. The variable resistors are ganged so that they are all adjusted at the same time. The attenuator makes it possible to control the amplitude of the signal delivered from one point to another. At the same time, it matches the impedances of the input and output circuits.

One example of the use of an attenuator is shown in Figure 9. Here the signal generator output impedance matches the receiver input impedance. The amount of signal delivered to the receiver can be varied without disturbing the impedance match.

In the next issue, we'll look at some active four-terminal networks.

Visualizing AM

The usual methods of representing amplitude-modulated signals are shown in Figure 10. These representations leave something to be desired because the time-domain display doesn't show the sidebands, and the frequency-domain display doesn't show the change in amplitude.

There is a third way of representing amplitude modulation (see Figures 11a through 11d), but you have to reach for it. It is not usually given in basic textbooks. It involves the use of rotating phasors. Phasors are arrows that represent magnitude and phase angles.

As shown in Figure 11a, when the tip of a rotating phasor is projected on a time axis, the result is a pure sine wave. This assumes that the phasor is rotating at a constant speed. Only four points are marked, but in a total representation every point must be projected.

Note that the amplitude of the sine wave (V_M) is equal to the length of the phasor. The frequency of the phasor equals the number of complete phasor rotations per second. Voltage is used in this representation, but sine-wave current or power could also be represented with a rotating phasor.

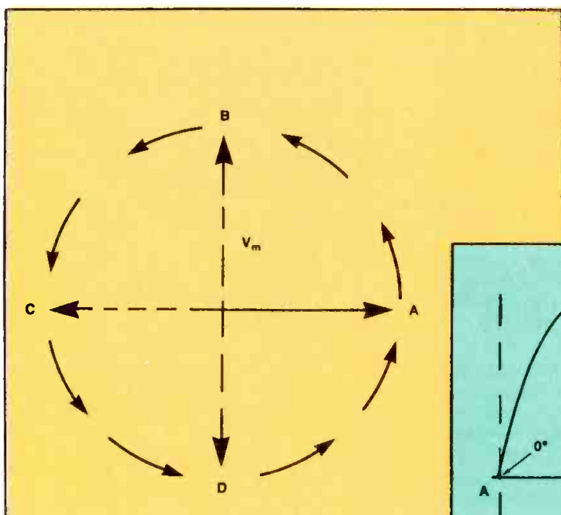
It is usual to represent the angular speed of the rotating phasor in radians per second (ω). If you stop the rotating phasor at any instant of time, the instantaneous value of voltage is given by the equation

$$v = V_m \sin \omega t$$

where ωt = the angle in radians.

A phasor, rotating at a constant speed, can be used to represent the carrier of an AM signal.

Now, visualize the rotating carrier phasor with two counter-rotating (rotating in opposite directions) phasors at the tip. (See Figure 11b.) This discussion



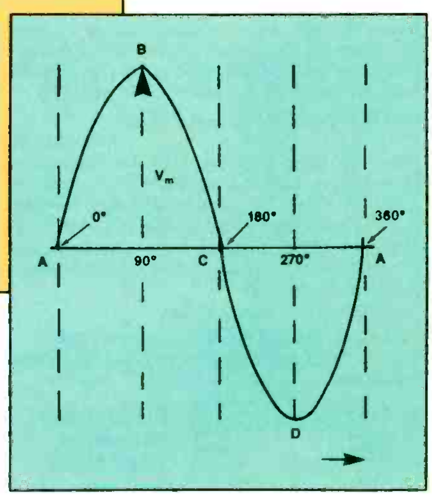


Figure 11a. One way of representing amplitude modulation involves the use of rotating phasors. When the tip of a rotating phasor is projected on a time axis, the result is a pure sine wave. This assumes that the phasor is rotating at a constant speed. Only four points are marked, but in a total representation, every point must be projected.

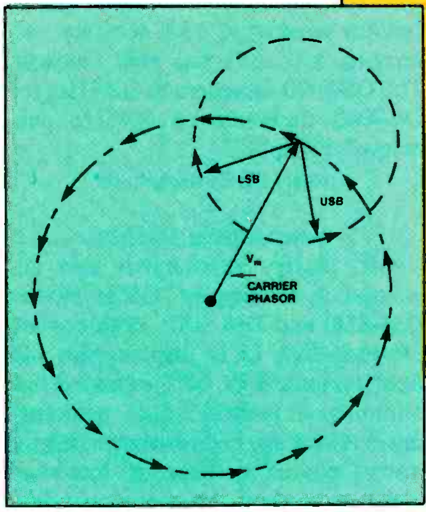


Figure 11b. Visualize the rotating carrier phasor with two counter-rotating (rotating in opposite directions) phasors at the tip. At the tip, each of the counter-rotating phasors has a length that is half the length of the carrier phasor. The counter-rotating phasors represent the upper sideband (USB) and lower sideband (LSB). When they are both pointing along the carrier phasor toward the origin (center of rotation), the resultant is zero. When they are pointing along the carrier phasor away from the origin, the resultant is twice the amplitude of the carrier. The LSB and USB rotating phasors, turning in opposite directions, change the length of the resultant.

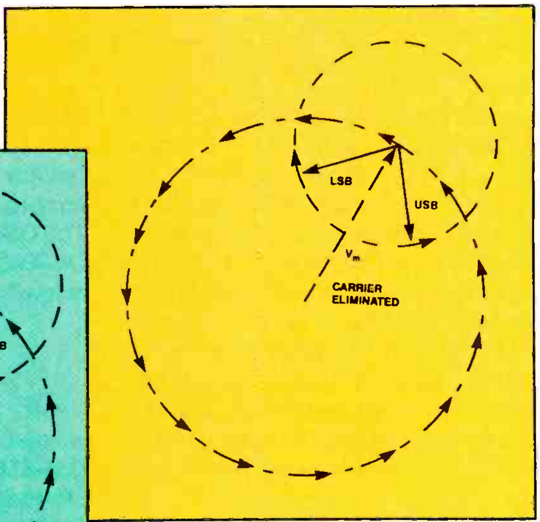


Figure 11c. Now, imagine the two counter-rotating phasors following the same circular path but without the carrier phasor. Project their resultant on a time axis. What you have is a double-sideband, suppressed-carrier signal.

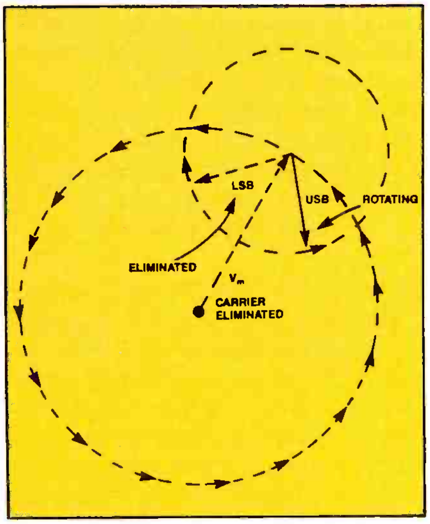


Figure 11d. Eliminate one of the sidebands. The other one is turning as it is moving around the circle. The projection of that side-band phasor is the signal waveform for a single-sideband, suppressed-carrier signal.

will concern the condition for 100% modulation. At the tip, each of the counter-rotating phasors has a length that is half the length of the carrier phasor. (This is the point where the faint-hearted will drop out of the discussion.)

The counter-rotating phasors represent the upper sideband (USB) and lower sideband (LSB). When they are both pointing along the carrier phasor toward the origin (center of rotation), the resultant is zero.

When they are pointing along the carrier phasor away from the origin, the resultant is twice the amplitude of the carrier. The LSB and USB rotating phasors, turning in opposite directions, change the length of the resultant. The projection of the resultant on a time axis produces the familiar time domain waveform shown in Figure 10.

Now, imagine the two counter-rotating phasors following the same circular path but without the carrier phasor. This condition is shown in Figure 11c. Project their resultant on a time axis. What you have is a double-sideband, suppressed-carrier signal.

Having done that, eliminate one of the sidebands as shown in Figure 11d. The other one is turning as it is moving around the circle. The projection of that sideband phasor is the signal waveform for a single-sideband, suppressed-carrier signal. ES&T

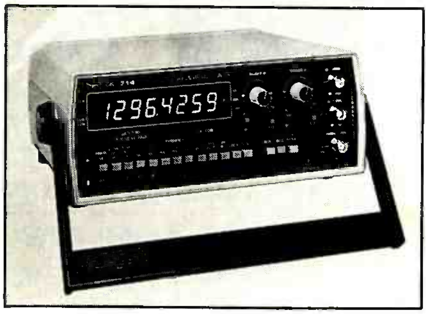
Software packages

Designer Technology has introduced two software packages. The Part Substitution software helps technicians keep up-to-date on cross reference and substitution of parts. The menu-driven software handles more than 5,000 parts and substitutions. The Tech Bulletins software package provides technicians with modifications and answers to technical problems from more than 3,500 bulletins from 60 manufacturers and 20 service centers. Quarterly updates are available for both packages, which operate on IBM PC, XT, AT or other compatibles.

Circle (75) on Reply Card

Frequency counter

The model 714 1.3GHz universal frequency counter from *Simpson* is designed for R&D, breadboarding and testing applications. The counter



features three input ranges, X1 and X10 attenuation, a 150kHz low-pass filter and adjustable triggering on channels A and B. Accuracy for all functions is ±1 count over a 0°C to 40°C operating range, with 1ppm stability and aging.

Circle (76) on Reply Card

Logic analysis kit

O.K. Industries has introduced the LK-680, a logic troubleshooting kit that combines three circuit-powered logic troubleshooting instruments into one kit. The kit includes a multipin IC logic monitor, a 20MHz logic probe, a 0.5Hz/500Hz switchable digital pulser and a probe-tip adapter with Micro-hook. The logic monitor adapts to ICs with up to 16 pins and has IC leg-extension pins for individual leg probing.

Circle (77) on Reply Card

Video alignment tape

Celebrity Research and Development Group has introduced the CAT2 professional ½-inch alignment tape system, a 2-cassette package that has 60 minutes of eight multipurpose test signals. The system features complete RF stability in playback, and the hi-fi audio track provides an accurate means of HD RF level and shape adjustment. Height and azimuth alignment of the stationary head is also allowed using the stereo and linear audio tracks. Audio tone segments provide visual confirmation of the frequency of the recorded material.

Circle (78) on Reply Card

Digital soldering/desoldering station

The MBT-210 soldering/desoldering station from *PACE* features a digital read-out display that indicates temperature selection and the actual tip temperature, which is settable within 1°. A heat-boost circuit compensates for heat sinks, and a temperature controller sustains tip temperature. The SnapVac vacuum generation system's rise time is 300% faster than electrically operated systems and eliminates lead resweat. The system features a static-dissipative desoldering handpiece.

Circle (79) on Reply Card

Software for IBM-PC compatibles

DatabasE DimensionS has developed a software package for IMB-PC-compatible computers. The package allows service centers to track the progress and location of items through the repair cycle. Features include automatic repair assignments to technicians, status tracking, parts orders and arrivals, and printing of warranty forms. Customers may call the computers by touch-tone phones.

Circle (80) on Reply Card

Soldering and brazing tool

The *McCormick* Mini-Torch, a soldering and brazing tool, has a 2,500° output from its torch head. Accessories include four sizes of replacement solder tips, 5-ounce Butane refills, and torch and solder heads. The tool will burn approximately one hour at a cost of 8 cents per refill.

Circle (81) on Reply Card

Oscilloscopes

Goldstar Precision has introduced the 7000 series oscilloscopes, which have 6-inch rectangular CRT displays with internal graticule, scale illumination and photographic bezel. The scopes feature a TV-sync separation circuit, X-Y mode, 1mV/div sensitivity, ±3% accuracy, calibration indicators and gold contacts. The OS-7020 measures to 20MHz; the OS-7040 measures to 40MHz with delayed sweep.

Circle (82) on Reply Card

Autoranging DMMs

A.W. Sperry Instruments has announced its autoranging DMMs, models DM-6510 and DM-6910. Both contain 3½-inch-digit LCD display with full function indicators, 50% extended resolution in all manual ranges, autoranging in all voltage and resistance ranges, instant continuity buzzers, low- and high-power ohms, electronic and fuse overload protection and recessed safety-designed input terminals.

Circle (83) on Reply Card

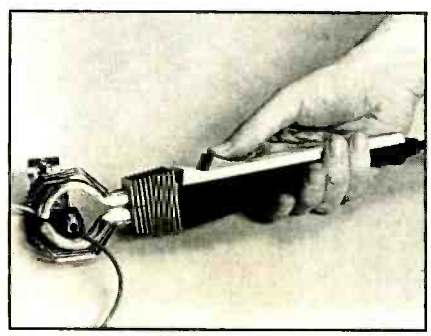
Current probe

The *AEMC* model MN103 current probe is designed to measure low ac currents. It outputs an ac voltage directly scaled to the current being measured and may be used with any DMM or other instrument having mV or Vac ranges. The 10A range covers 1mA to 12A, while the 100A range is used for currents between 1A and 120A. The frequency range is 50Hz to 500Hz.

Circle (84) on Reply Card

Heat tool elements

The *Eraser Company* has introduced ½-inch diameter elements for use with the Glo-Ring infrared heat tools. With

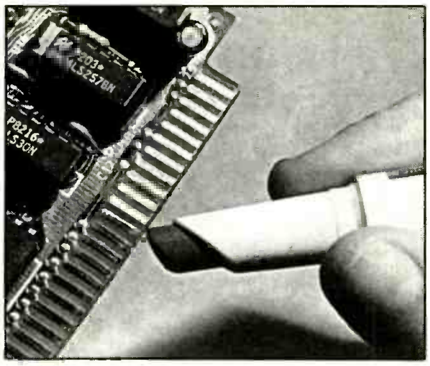


these elements, infrared heat is concentrated in a small area, allowing the unit to be used on small work pieces. Elements are available for either intermittent or continuous use and operate with the tool either on a 115V, 60Hz or 220/240V, 50Hz electrical supply.

Circle (85) on Reply Card

Field service kit

The No. 4c3k field service kit from *Micro-Circuits* allows technicians to open and close all connectors in a



malfunctioning circuit to permanently clean up the one or two marginally defective connections that may be causing problems. The technician uses the applicator to rub on a thin layer of 4c3m gold replacement.

Circle (86) on Reply Card

Epoxy, cleanser

Formula 04001 epoxy from *HMC* is a 2-part structural adhesive that sets in 3 to 5 minutes, doesn't shrink and cures at room temperature. The epoxy contains no solvents and works on plastic, wood, metal, glass, stone or concrete. Formula 04040 hand cleanser removes resins, adhesives, epoxies, inks, putty and grease. Both come in job-sized packages.

Circle (87) on Reply Card

Logic analysis systems

BitWise has introduced two logic analysis systems that feature up to 320 channels, 64K depth, 16 trigger levels, 1ns resolution and full IBM XT/AT compatibility. The System-40 provides state and timing analysis on 40 channels at 25MHz and timing analysis on eight channels at 125MHz. The System-80 has 80 channels that can be used for single or dual timebase state or timing analysis; one or both groups of 40 channels can be used as eight channels of 125MHz timing analysis.

Circle (88) on Reply Card

RS-232 dataline monitor

B&B Electronics has introduced the model 232BOII Breakout-II version 2.1 software, which turns an IBM PC or compatible into an RS-232 dataline monitor. The unit features two troubleshooting modes: interactive, for testing a single communications device; and monitor, for piggybacking onto an existing circuit to monitor two devices.

Circle (89) on Reply Card

TTL logic comparator

3M has introduced a full-spectrum TTL logic comparator that tests ICs in circuit at system speed. The unit tests tri-state, bi-directional, open collector ICs, PALs and bipolar ROMs. The comparator accommodates 8-, 14-, 18- and 20-pin DIPs, TTL and TTL compatible. A memory feature allows the unit to be left unattended until testing is complete.

Circle (90) on Reply Card

Digital storage scopes

Tektronix has introduced two hand-held digital storage oscilloscopes that offer two channels, dual time base, 5MHz bandwidth for repetitive signals (2MHz

for single-shot) and a 20MS/s sampling rate with 20ns resolution. Features include signal processing, auto setup and storage of up to nine waveforms and nine front-panel settings in non-volatile memory. The T202 offers a traditional oscilloscope interface; the T201 has a calculator-like interface for left-to-right logical manipulations. The scopes weigh less than 2 pounds and come with a battery pack, a carrying case and probes.

Circle (91) on Reply Card

Battery replacement tool kit

Batt-Tronic has introduced a kit for replacing watch batteries. The kit contains a battery tester, a 7-piece

Continued on page 66.

Products (continued from page 65).

screwdriver set, a flat knife case opener, a spring bar tool, pliers, two tweezers, a protection cloth, a 1988 Interchangeability Guide, a battery sizer and a magnifier.

Circle (92) on Reply Card

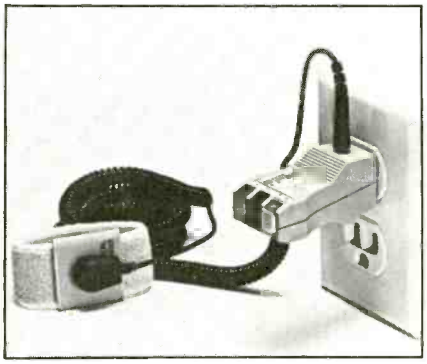
Hand lotion for technicians

Electro Lotion from *Start Manufacturing* is a hand and body lotion formulated for the electronics servicer. The lotion is non-contaminating and nontarnishing to materials being processed and will not hamper the solderability of printed circuits or components. The lotion is water- and solvent-soluable and contains no lanolins, mineral oils or silicones.

Circle (93) on Reply Card

ESD grounding system

The Stat-Gard ESD grounding system from *Ideal Industries* uses a grounding plug, wrist strap and lead set to continually drain static charges from the technician's body. The grounding plug inserts into any 3-prong, 120V receptacle and checks the 3-wire circuitry for wiring faults.



Circle (94) on Reply Card

Facsimile cleaning kit

The FAX Cleaning Kit from *Perfect-Data* is a printhead cleaning solution that cleans the printhead in facsimile machines and dries immediately. The kit contains the cleaning solution, ten cleaning wands, canned air, a case and cabinet cleaner and 25 non-residual wipes.

Circle (95) on Reply Card

Wrist-strap tester

The model 250 wrist-strap tester from *Electro-Tech Systems* measures the electrical integrity of a wrist-strap grounding system. The tester has visual and audible indicators, a fail-safe design with automatic self-check, and two switch-selectable upper limits. A 9V alkaline battery powers the unit.

Circle (96) on Reply Card

RF signal generator

B&K-Precision has introduced the model 2005 RF signal generator, which covers 100kHz to 150MHz in six fundamental bands, and to 450MHz on harmonics. The output may be AM-modulated by an internal 1kHz source or externally by any audio frequency. Features include step and variable fine-output attenuation to 40dB, variable AM modulation from zero to 100%, an auxiliary output for the internal 1kHz audio source and separate outputs for the RF connection and an external frequency counter.

Circle (97) on Reply Card

Logic analyzer

The ML4400 logic analyzer from *Arium* has 400MHz timing (100MHz sync) and user-selectable input cards for simultaneous analysis of up to four 8-, 16- and 32-bit microprocessors. The analyzer accommodates up to four standard or high-speed capture modules. The high-speed module has transitional timing and a memory depth of 8,192 to 32,667 cycles. Non-volatile memory and mono and color video outputs are standard.

Circle (98) on Reply Card

Static-dissipative field-service kit

Simco's static dissipative field service kit is a 24"x24" static-dissipative grounded work surface mat and a conductive wrist strap. The mat has two 11"x11" pockets for storing static-sensitive boards during transportation.

Circle (99) on Reply Card

Solvent sprayer

The Solvent Miser trigger-grip remote sprayer from *Micro Care Chemical Corp.* minimizes ESD damage when used with the company's MCC-ESD bench-top cleaning system for printed circuit boards and electronic assemblies. The 100% conductive sprayer, which also reduces solvent consumption, carries pictograms that illustrate proper assembly and disassembly procedures.

Circle (100) on Reply Card

ES&T

Quiz answers

Questions are on page 10.

1. Beginner's all-purpose symbolic instruction code.

2. C. According to the Audio Cyclopedia published by Howard W. Sams, "attenuators may be fixed in value or they may be variable." The word pad is defined as "another name for attenuator."

3. 12dB. This question was easy if you knew that *connected in tandem* means *connected in series.*

4. A—A Hay bridge. The bridge circuits are shown in Figure C. The Maxwell bridge is easy to construct, and with a little care you can get a reasonably accurate method of measuring inductance. A Schering bridge measures capacity using a high voltage. A Wein bridge measures frequency.

5. In a constant-k filter, the product of the series impedance (Z_1) and the shunt impedance (Z_2) is a constant value for all input frequencies, so

$$Z_1 Z_2 = k^2 \text{ or}$$

$$k = \sqrt{Z_1 Z_2}$$

6. A—a differentiating circuit. The circuit is also a pre-emphasis circuit used in FM transmitters.

7. A—at the top. Using conventional current flow, grasp the coil (mentally) with your right hand so that your fingers circle the coil in the direction of current flow. Your thumb will then point to the north pole.

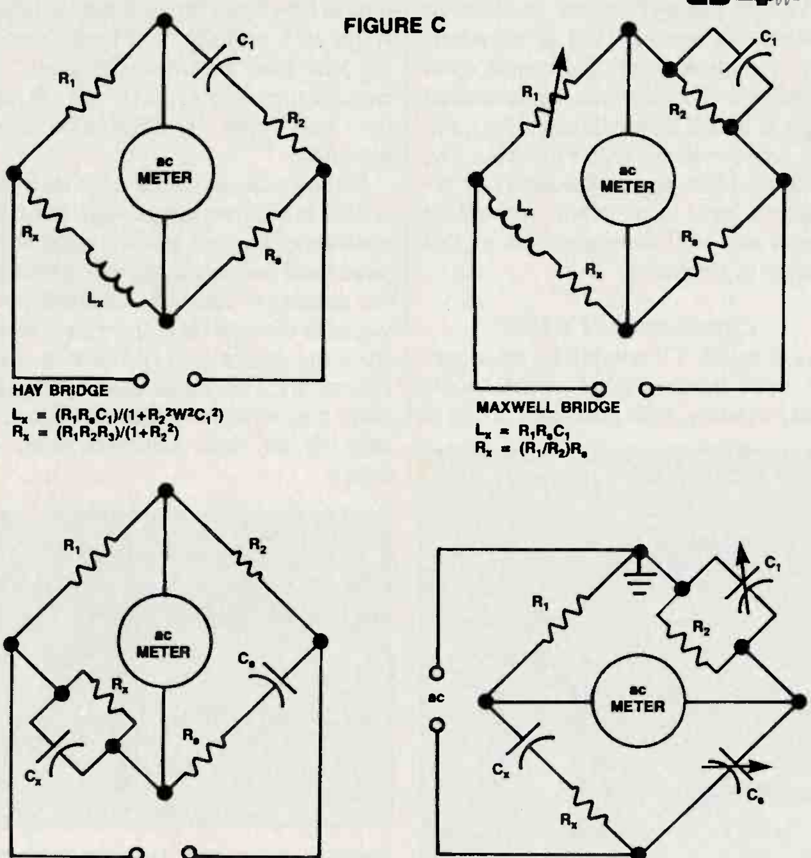
8. Control. The control signal regulates the speed of the tape through the VCR tape path.

9. 2.4V and 0.8V. These are the generally accepted voltage limits for TTL logic.

10. Digital storage oscilloscope. This type of oscilloscope was discussed in detail in the June 1988 issue.

ES&T

FIGURE C



HAY BRIDGE
$L_x = (R_1R_sC_1)/(1+R_2^2W^2C_1^2)$
$R_x = (R_1R_2R_3)/(1+R_2^2)$

MAXWELL BRIDGE
$L_x = R_1R_sC_1$
$R_x = (R_1/R_2)R_s$

WEIN BRIDGE
$f = 1/(2\pi R_xC_x)$

SCHERING BRIDGE
$C_x = (C_s/R_1)R_2$

Elements of video optics—Part II

By Carl Bentz

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

Optical systems for TV cameras consist of combinations of lenses and prisms. The optical system concentrates light from a scene, separates it into red, green and blue components, and focuses the three color images on the light-sensitive faceplates of the pickup devices. The shapes, placements and specific glasses in optical elements of the camera all play a role in making this possible.

The index of refraction

As light passes through a medium, a characteristic *index of refraction* can be determined for that material. The index is a ratio between the speeds of light in free space and in the material. Unless a specific wavelength is stated, the index is determined from the primary wavelength (589mμ) of a yellow sodium flame.

The index for air at standard conditions (temperature of 20°C and barometric pressure of 760mm of mercury) is often stated as *unity* (1) for simplicity, but that simplification is far from true. Violet (436mμ) and red (656mμ) lights produce indices of 1.0002957 and 1.0002914, respectively. The difference, although it may appear to be small, is sufficient that astronomers must make corrections in star-position calculations. Their job is more complex because the refractive index of air varies with the depth and density of the atmosphere.

The red-to-violet variance in the index for a medium (the *dispersion*) explains how an equilateral prism breaks white light into a rainbow spectrum. Each wavelength is affected linearly. For less energetic light of longer wavelengths, less bending occurs. (See Figure 1.)

As light passes from one medium to another, the rays are bent or refracted. The amount of bending depends upon the refractive index of the media and the angle at which light falls upon the junction between them. (See Figure 2.) The thickness of the second medium (for example, a lens) through which the light passes also will determine the overall change in direction.

Components of a lens

A complex TV zoom lens must pass the wide bandwidth of visible white light, bending it as necessary to form an image on the pickup devices. Ideally, all elements in the lens will provide frequency-independent refraction of the light. Any deviation (dispersion) causes *chromatic aberration*. In TV optics, a result is an undesirable separation of colors, which appears as fringes around objects. (See Figure 3.)

The greater the bending power of the lens (that is, the greater the surface curvature), the greater the effect dispersion will have on the image formed by the lens. This fact creates a problem in the manufacture of high-magnification lenses.

A simple convex lens (see Figure 4) has two focal lengths. One (F) is the distance from the lens to the image for which an object exists at infinity (as in a camera). F′ is the distance from the lens to the object for an image at infinity (as in a projector). If both faces of the lens have the same curvature, the two distances are equal (F=F′=f), and the lens may be oriented either direction.

If the entire diameter of a lens disk is used to form an image, light refracted near the edges may not converge at the same focal point as light passing through the center. A resulting distortion is a variance of magnification with distance from the center axis of the lens. (See Figure 5.) The image appears sharp, with pincushion or barrel distortion showing in lines removed from its center.

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

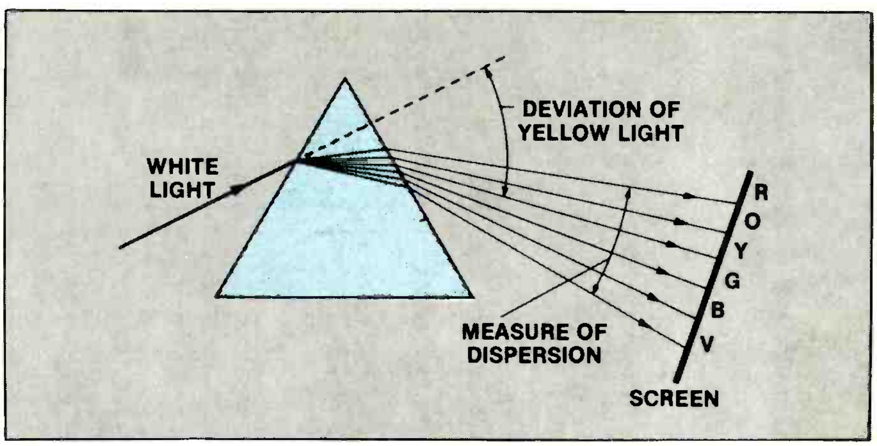


Figure 1. A prism may be used to break light into component colors because the index of refraction varies somewhat for each color's frequency.

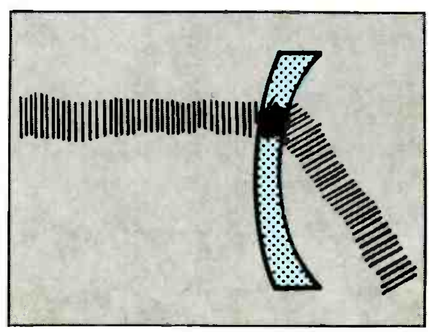


Figure 2. The amount of bending as the light ray enters the lens is determined by the index of refraction of the air and glass. As the ray passes back into air, it is bent again.

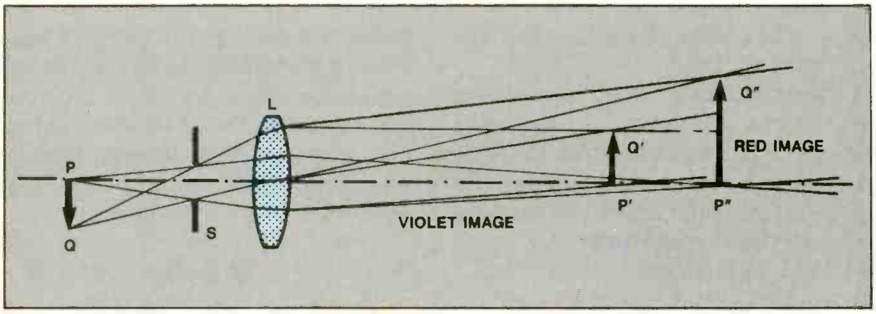
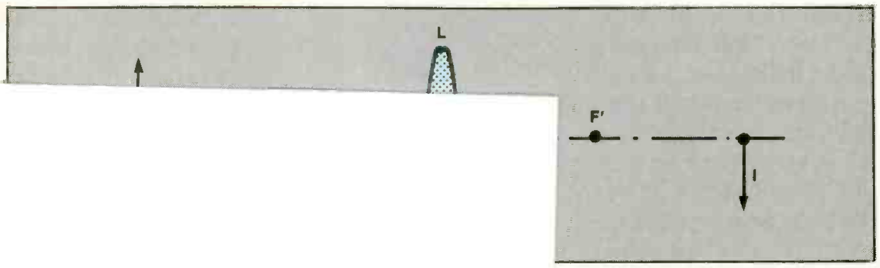


Figure 3. Different refractive indices can result in various colors focusing at different points.



wo focal points. In the TV camera, important. Between the lens and

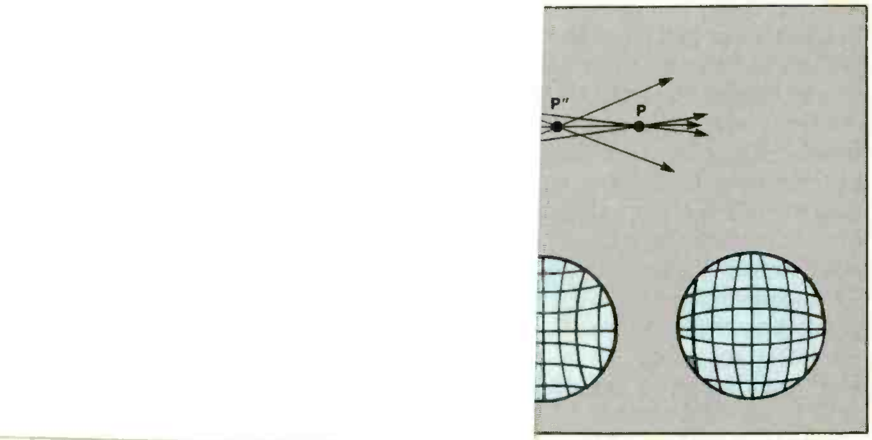


Figure 5. Pincushion and barrel distortion occur because of incorrect focusing through areas of the lens near the edges.

Convex lenses cause light rays to converge or meet at a focal point; concave lenses cause the rays to spread or diverge. Combinations of convex and concave shapes with each other and with flat or plane surfaces may be used to correct optical distortions.

Next month, Video Corner will continue the "Elements of Video Optics" series with a discussion of apertures and f/stops.

ES&T

More about decibels

By Conrad Persson

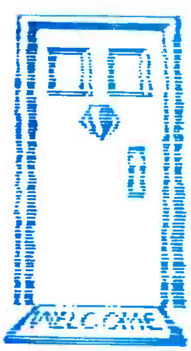
The concept of the decibel is so crucial to dealing easily with electronics and audio that we're going to be talking about it here in some detail. (For more about decibels, see "Audio Corner" in the July 1988 issue.)

Let's take a look again at the definition of the decibel:

$$dB = 10 \log P_{out}/P_{in}$$

Okay, I agree, it looks like a pretty dumb concept. Why wasn't the decibel defined as just log P_{out}/P_{in}? Or for that matter, do we really need to use decibels at all?

The key to understanding decibels is to recognize that, just as it is the case with a lot of other mathematics, the decibel was invented, made up out of whole cloth, just to make understanding and calculation of certain phenomena easier. The problem is that, although it makes things easier for the mathematician and the physicist, it makes things more confusing for the rest of us. However, if we spend a little time getting used to the idea, maybe some of the confusion will dissipate and we'll begin to see the usefulness of the concept.



50dB

Why use decibels anyway?

The sound of a jet engine is so loud that it creates not only the sensation of sound, but the sensation of pain as well. The ratio of such a loud sound to the softest sound that the human ear can detect is one trillion to one. (See the table in the July Audio Corner for more decibel readings.) That's a lot of zeros. And that's one of the reasons why decibels are used.

Using decibels, that ratio can be represented by saying that the sound level of a jet engine is 120dB above the level of a barely discernible sound. The unit just gives the technician, engineer or scientist an easier way of handling numbers.

Another reason that decibels are used is that the user can add gains and subtract losses instead of multiplying and dividing.

Part of the confusion about the concept is simply that methods of mathematical prestidigitation such as logs and decibels are presented in texts and courses in line with the rest of the technical material, and the student or reader gets the impression that those things are an essential part of the technology when they actually have nothing to do with the technology. Let's face it, magazines do the same thing, too, also with no intent to confuse—it just happens.

It seems, therefore, as though the concept of the decibel is part and parcel of the electronics technology, as much as E=IR. It's not. The decibel is a mathematical construct that just happens to make it easier to handle certain aspects of math in conjunction with electronics. An analogy (I leave it to you to comment on how apt it is) is that you can get from your house to the store in any of a number of ways, walking being the most basic. But you probably drive a car because it's easier—that is, once you go through all the trouble of learning to drive, getting a license, buying a car and getting it insured, inspected and licensed. After a while it seems that the car is part and parcel of getting to the store, but it's not. You could still get to the store without the car, even if cars had never been invented. It's kind of like that with decibels.

120dB

10dB

It's all a matter of relativity

Now that we've beat that thought to death, let's talk about some of the other things that are done with decibels. To go back to the definition, a decibel expresses a ratio. If one sound, S_2, is twice as loud as another, S_1, then their ratio, expressed in this mathematical fiction, decibels, is:

$$\begin{aligned} dB &= 10 \log S_1/S_2 \\ &= 10 \log 2 \\ &= 10(0.30103) \\ &= 3 \end{aligned}$$

So if one sound is twice as loud as another, it is about 3dB greater. That gives us some good information, but it's still relative. To know the loudness of sound S_2, we need to know how loud sound S_1 is and vice versa. The same bright guys who gave us decibels came up with a way to express decibel ratios so you know exactly the reference level and, therefore, the value of the phenomenon of interest.

Persson is editor of **ES&T.**

For example, a commonly used reference level in the telephone industry is 1mW. The abbreviation for the ratio of the power level of signals either above or below 1mW is dBm. Thus, a signal described as being at 9dBm would be approximately at 8mW. A simple, rough way to arrive at that number is to figure that for each 3dB the power approximately doubles, so at 9dBm, the signal is about (((1mW × 2)×2)×2), or approximately 8mW.

40dB

Here are a few other commonly used decibel gain expressions referred to specific levels:

dBj—1mV
dBk—1kW
dBw—1W

There are books of tables (for example, *The Handbook of Electronic Tables and Formulas, Fifth Edition*, compiled and published by Howard W. Sams) that include tables of equivalences between decibels and ratios. If you're stymied by log tables and you're faced with a decibel problem a little tougher than the nice, round 9dBm that I chose, you can still convert.

As an example, taking two rows from the table in the Sams book, 1dB converts to a numerical gain ratio of 1.259, and 2dB converts to a numerical gain ratio of 1.585. So let's say that in the example above, the power had been 10dBm instead of 9dBm. The signal of interest would then have been approximately ((((1mW×2)×2)×2)×1.259) or 10.1. In other words, for each 3dB gain, double the reference number. Do that three times and there's 1dB left over, which represents another 1.259 times the total.

100dB

Working with decibels can be confusing and frustrating, but with a little reflection to get them into perspective, you can feel comfortable with the concept. ES&T

Interfacing computers to the analog world—Part IV

By Joseph J. Carr, CET

The first few parts in this series have described analog-to-digital (A/D) and digital-to-analog (D/A) converters. Last month we looked at two techniques for performing an A/D conversion: single- and dual-slope integrators. This month we'll cover counters (or servos) and successive approximation methods.

Counter-type A/D converters

A counter-type A/D converter (also called a *servo* or *ramp* A/D converter) consists of a comparator, a voltage-output D/A converter (DAC) binary counter and the necessary control logic. (See Figure 1.) When the start command is received, the control logic resets the binary counter to 00000000, enables the clock and begins counting.

The counter outputs control the DAC inputs, so the DAC output voltage will begin to rise when the counter begins to increment. As long as analog input voltage V_{in} is less than V_{ref}, the DAC and comparator outputs are HIGH. When V_{in} and V_{ref} are equal, however, the comparator output goes LOW, which turns off the clock and stops the counter. The digital word appearing on the counter output at this time represents the value of V_{in}.

Both slope and counter-type A/D converters take too long for many applications—about 2^N clock cycles (where N equals the number of bits). Conversion times become critical if the high-frequency component of the input waveform is to be faithfully reproduced. The sampling rate (that is, conversions per second) must be at least twice the highest frequency to be recognized.

Successive approximation A/D converters

Successive approximation A/D converters are best suited to applications where speed is important. This type of converter requires only N+1 clock cycles to make the conversion, and some designs allow truncation of the conversion process after fewer cycles if the final value is found prior to N+1 cycles.

The successive approximation converter operates by making several successive trials comparing the analog input voltage with a reference generated by a DAC. An example is shown in

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

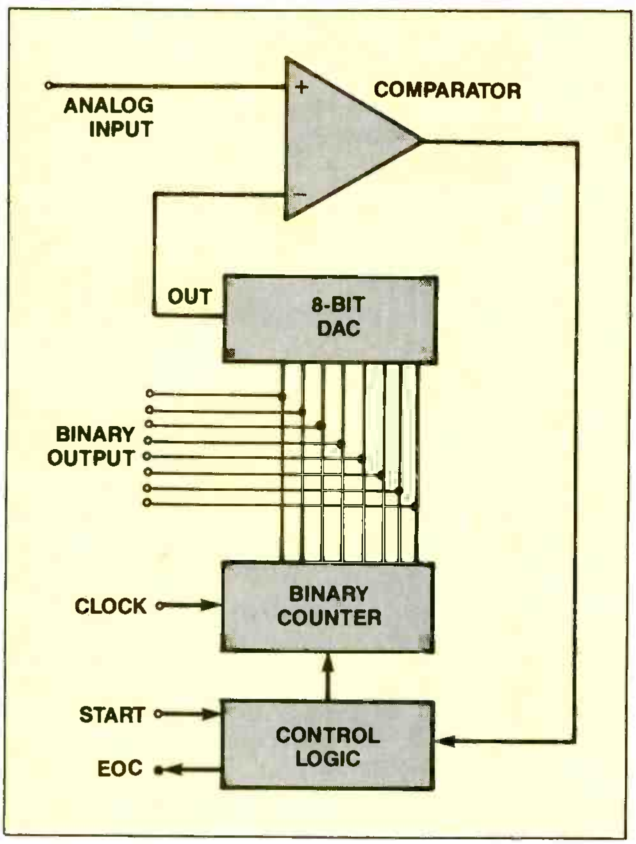


Figure 1. A counter-type A/D converter consists of a comparator, a voltage-output DAC binary counter and the necessary control logic. When the start command is received, the control logic resets the binary counter to 00000000, enables the clock and begins counting.

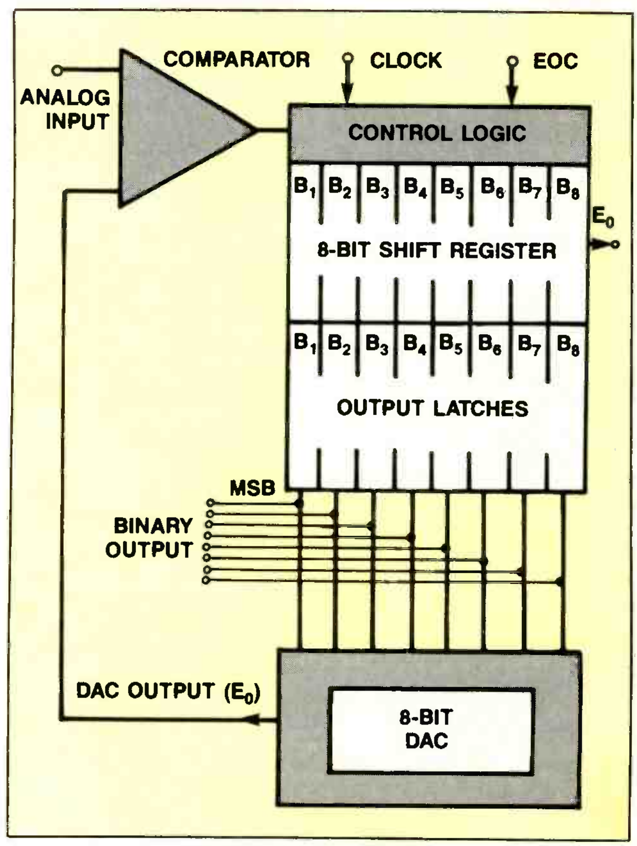


Figure 2. The successive approximation converter makes several successive trials comparing the analog input voltage with a reference generated by a DAC. This circuit consists of a comparator, a control logic section, a shift register, output latches and a DAC.

Figure 2. This circuit consists of a comparator, a control logic section, a shift register, output latches and a voltage output DAC.

When a start command is received, a HIGH is loaded into the most significant bit (MSB) of the shift register, which sets the output of the MSB latch HIGH. A HIGH in the MSB of a DAC will set the output voltage (V_{ref}) to half-scale. If the input voltage (V_{in}) is greater than V_{ref}, the comparator output stays HIGH and the HIGH in the shift register MSB position moves one bit to the right to occupy the next MSB (bit 2). Again, the comparator compares V_{in} with V_{ref}. If the reference voltage from the DAC is still less than the analog input voltage, the process will be repeated with successively fewer significant bits until either a voltage is found that is equal to V_{in} (in which case the comparator output drops LOW) or the shift register overflows.

If, on the other hand, the first trial with the MSB indicates that V_{in} is less than the half-scale value of V_{ref}, the circuit makes trials below V_{ref}. The MSB latch is reset to LOW and the HIGH in the MSB shift register position shifts one bit to the right to the next MSB (bit 2). The trial is repeated again. This process will continue as before until the correct level is found or overflow occurs. At the end of the last trial (bit 8 in this case), the shift register overflows and becomes an *end of conversion* (EOC) pulse to tell the rest of the world that the conversion is complete.

This type and most other types of A/D converters require a starting pulse and signal completion with an EOC pulse. This requires the computer or other digital instrument to engage in bookkeeping to repeatedly send the start command and look for the EOC pulse. If the start input is tied to the EOC output, conversion is continuous and the computer need only look for the raising of the EOC flag.

Now that you understand how A/D and D/A converters work, we're ready to tackle some practical data converters. Next month we'll begin looking at popular A/D circuits. ES&T

Readers' Exchange

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WANTED

Power transformer for a Sylvania D-12 chassis, part number 55-27416-2. Prefer new, but will consider used. *Robinson Electronics, 525 Airport Road, Santa Fe, NM 87501; 505-471-7892.*

CRT 520SB22A for Sony model KV1952R TV; Sencore VA48 for $500, must be in excellent condition. *James D. Lokken, 18402 Avolinda, Yorba Linda, CA 92686; 714-777-2345.*

Schematic diagram and service manual for Sound Creation AM/FM/cassette auto radio (FCC ID: BMM883SCR901), made in Korea. Will pay for copy of literature. Would also appreciate mailing address for the USA office of this company. *H. Fuqua, 1423 Jordan Drive S., Salem, OR 97302; 503-399-1423.*

Schematic or service manual for Hallicrafters models S-40 and S-40B radios. Photocopy will do. Will pay. *RAM TV Service, San Vicente 4E, Mayaguez, PR 00708.*

Jukebox service manuals and parts, particularly a mechanism cover for a Seeburg HF-100G, a high-frequency horn for an AMI model F-120 and a manual for a Seeburg model AY-160. Also need a service manual for any Scopitone machines. *Mike Zuccaro, Voice & Video, 5038 Ruffner St., San Diego, CA 92111; 619-560-1166 days, 619-271-8294 evenings and weekends.*

Power xfmr for a B&K #1076, part number 065-007-9-001. *Koleske TV Sales and Service, 1124 N. Mason St., Appleton, WI 54914; 414-734-5340.*

Zenith deflection yoke, part number 95-3357, for a model S1984W6, chassis 19KC542. Zenith no longer makes this part. Could use two. Please state price and condition. *Hawaiian TV, 1250 S. King St., Honolulu, HI 96814; 808-521-3838.*

Schematic, layout and alignment info for a Eico 2536 stereo receiver; operators and service info for a Precision Apparatus tube tester, series 10-54, Test Master; power transformer for a Mcintosh MI-3 stereo indicator. Will pay any costs. *Randy Garbiel, 1955 McEachern Manor Drive, Marietta, GA 30064; 404-424-9962.*

Flyback transformer (part number RTRNF1214CEZZ) for a Sharp model 19F72 19-inch color TV; schematic for an RCA model BWT122W B&W portable TV. *John Brouzakis, 247 Valley Circle, Charlerol, PA 15022; 412-483-3072.*

Service information and schematic for a VARO model FL-3D flutter meter; Hammarlund HQ-180 receiver. *William Zukowski, 12 Lark Place, Old Bridge, NJ 08857; 201-679-4749.*

Fluke model 77 or 23 multimeter; Heathkit model 5283 signal tracer; service manual for a Hitachi model V422 oscilloscope. *George John Demaris, 7387 Pershing Ave., Orlando, FL 32822-5743; 407-277-3746.*

For J.C. Penney color TV, model 685-2012, chassis number NMXP3A (tripler part number: ECX-B0083). State price. *Joe LaGuardia, 1521 Flamingo Court, Homstead, FL 33035; 305-257-7841.*

Deflection yoke for an Emerson model ECT1900 color TV. The number of the yoke is KY10030SD11. Please send price. *Augustine's TV • Radio Service; 530 N. Ninth St., Reading, PA 19604; 215-372-5438.*

Diagram for an RCA model RE-45 radio; a horizontal output transformer for a Sears model 564-416-92-804—I don't have the part number; a Simpson 260 voltmeter. *Ralph Dorough, 117 Pecan St., Terrell, TX 75160; 214-563-7105.*

Schematic and operators manual for a Robyn model 2000B Hi-Low Bander FM scanning receiver. *Don Wells, Kewaunee Engineering Corp., N. Main St., Kewaunee, WI 54216.*

Heathkit TTL/CMOS circuit course. Will pay the original price. *Ron Grega, 107 Ridgeview Drive, Dunmore, PA 18512; 717-347-6842.*

I have purchased a set of RCA home-study courses dated 1966-1967. I'm trying to learn radio and TV servicing in the course, and in between books 1011E and 1015E, the student built a test oscillator and radio and used them to get practical experience. If you have the items and would like to sell, please write. *E.A. Jenkinson, 1415 Poplar, Pine Bluff, AR 71601.*

Late TV servicing course by NRI, etc.; Sencore or B&K test instruments, for example, an adjustable ac isolated power supply, an FM signal generator, etc. *Ed Herbert, 410 N. Third St., Minersville, PA 17954.*

FOR SALE

Eico 460 oscilloscope, $40; Dupont 3-inch oscilloscope, $20; Dupont battery frequency meter, $20; 45 record player, $30; antique oak wall S.C. telephone, $200. Add UPS charges. *Clark Trissell, 3530 Pawnee St., Lincoln, NE 68506; 402-488-5263.*

Simpson Electric model 467 DMM, measures up to 1,000Vdc, 750Vac, 2A ac-dc, 20MΩ, includes leads and manuals, $100; Dumont model 1062 oscilloscope, 50MHz bandpass, dual vertical inputs, main and delay sweeps, 100% solid state, $495; Deihl model MARK III scanner, new, turn on any shut-down TV, $250. Add $10 for insured UPS shipping; COD is OK, too. *Fred Jones, 407 Morningbird Court, Niceville, FL 32578; 904-678-1803.*

Sencore LC75 Z meter capacitor and inductor analyzer, like new, original packaging, $595 or will trade for a Sencore SG165 AM/FM stereo analyzer. *Jim Patrick, 69 Main St., Greenwich, NY 12834; 518-692-9366 days, 518-692-2855 evenings.*

Heath IO-101 vector scope/color dot bar generator, $75; Heath RCL bridge, $50; Diehl Supertech MKIV, $350; 25A isolation xformer, $200 (new). *Cahill Electronics, P.O. Box 568, Kingston, NH 03848; 603-642-4292.*

Heathkit ET-3100 Design Console, $120; CIE single-trace, 10MHz oscilloscope, $150. Both in excellent condition. *J. Kostalek, 3141 Lodwick Drive, Warren, OH 44485.*

Two Ampex VR-660B 2-inch video recorders with many spare parts; two Sony CLR-1 color decoders. These pieces of equipment are located on Long Island, NY. *Robert Carlough, 8122A Thames Blvd., Boca Raton, FL 33433; 407-488-3467.*

Sencore CRT rejuvenator testers: model CR161, $85; model CR143, $50. Both in excellent shape. Add shipping. *James D. Lokken, 18402 Avolinda, Yorba Linda, CA 92686; 714-777-2345.*

Assorted Sams sets, #1 to #2000, $4 each, includes postage. Send SASE and $4 for each set you want. *Gordon F. Williams, P.O. Box 578, Arlington, GA 31713.*

McMurdo-Sliver model 15-17 radio, 15 tubes, 4-band, push-pull 6L6 output with a 15-inch Jensen Electro Dynamic speaker, chromium-plated chassis, tube and coil shields. Perfect working order. Chassis and speaker only—no cabinet. Best offer. Also for sale: new tubes at 90% off list price; text books; service manuals; magazines—send large SASE for list. *M. Seligsohn, 1455 55th St., Brooklyn, NY 11219.*

TSM #24-159—all for $125, shipping included. *Koleske TV Sales and Service, 1124 N. Mason St., Appleton, WI 54914; 414-734-5340.*

New, used only once Philips ECG model FET-43 analog meter—10MHz, 2-input, includes warranty card and instruction booklet, $35 plus shipping. *Stanley Todorow, G8468 Belle Bluff Drive, Grand Blanc, MI 48439; 313-695-0271.*

Sencore CR-143, like new, $150; Sencore TRC4, like new, $40; HP universal bridge, $150; B&K model 606 tube tester, $75. *Harley W. Jansen, 1600 First Ave., Marion, IA 52302; 319-377-3141.*

Sencore equipment: 1-year old, like new, SC-61, VA-62, VC-63, NT-64, EX-231, $5,250; SG-165, $895. *Angelo Russo, Tes Marketing, 3800 Lucius Road, Columbia, SC 29201; 800-553-5332.*

Heathkit model 3100B circuit trainer; "Concepts of Electronics" course with 2-binder set and parts—$110 for both. *Ron Grega, 107 Ridgeview Drive, Dunmore, PA 18512; 717-347-6842.*

Cushman CE-5 w/302, 313 and 314; Helper Sinadder S101; B&K 80MHz multifunction counter. *Perry Nolan, 1509 N. Lorraine, Hutchinson, KS 67501; 316-663-4748.*

Set of GE manuals for GE business band radios, $275; Johnson Radio LTR system select kit, $15. Add shipping. *Fred Allen 327 Polk St., Grand Forks, ND 58201; 701-746-0073.*

Sony model 0005-18 SQ-checker, $50; RCA model WR-99A crystal-calibrated marker generator, $50; Tohnichi torque gauges, 0 to 2mm/kg, $20; Sony torque gauges—SL-0004 measures 0 to 1,200g/cm, SL-0003-C measures 0 to 150g/cm, $20 each or both for $35. All works. Add postage. *J. Cruz, Box 3974, Langley Park, MD 20787.*

Sams sets, #11 through #2515, all offers considered; Sencore equipment: SG165, $500; PR57, $300; UPS164, $200. All like new, in original cartons, with manuals. *Leo B. Heinz, Heinz Radio and TV Service, 730 N. 81st St., Lincoln, NE 68505.*

Three Heathkit courses: electronic communications, semiconductor and electronic test equipment, all with parts and trainer, never used, $250; Beckman model DM45 digital VOM, $60; B&K model 2845 digital VOM with manuals and leads, brand new condition, $40. *Daniel Seidler, 3721 W. 80th St., Chicago, IL 60652; 312-284-8221.*

Sams Photofacts from #1010 to #2382. Folders below #1500, $2.50 each; between #1500 and #1999, $3.50 each; above #1999, $4 each. Also for sale, Sams VCR manuals #1 to #46, $7 each. Send SASE for updated list of items still available. *T. Conde, 513 Troy St., Dayton, OH 45404; 513-461-0451.*

Sencore VA48 video analyzer, $550/offer; Diehl Mark V scanner, new, $395/offer; Diehl Mark III scanner, New, $195/offer. *Duane Conger, 4321 Herrick Lane, Madison, WI 53711; 608-238-4629.*

B&K model 510 transistor and SCR tester, $65; Sencore sweep circuit analyzer, $65; Grundig 9-band short-wave radio, solid-state, $70. *F. Lurry, 4924 69th St., San Diego, CA 92115; 619-462-7445.*

RCA tuner modules, $15 to $30. Send SASE for info. *M.E. Andrews Jr., P.O. Box 91, Exeter, RI 02822.*

Radio Electronics magazines: Nov.-Dec. 1972, Jan. through Oct. 1973, Feb. through Dec. 1984, Jan. through March 1985—$0.25 each or all 25 magazines for $5; Popular Electronics magazines: May 1960 through April 1978—$0.25 each or all 48 magazines for $10. Add shipping. *John Brouzakis, 247 Valley Circle, Charlerol, PA 15022; 412-483-3072.*

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COMPUTER TV/VCR SERVICE TIPS DATABASE PROGRAM (IBM Compatible). Scan symptoms and cures in seconds by model or chassis. Add, change, delete, print out hard copy. An excellent aid for the technician. $49.95 for program. $69.95 includes up-to-date database with 1,000 plus ServiceTips. Add $2.50 postage and handling. Computer Assistance, Box 232026, Anchorage, AK 99523. 8-88-3t

FOR SALE SENCORE TEST equipment. VCR test acc., pattern gen., video analyzer, manuals, probes, and accessories. $3200.00. Call 614-947-2827 or 614-289-2565. 9-88-1t

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