THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

T.M.

September 1999

Test accessories update

Oscilloscope basics

PROFAX
Zenith Color TV Receiver Model SD1995W/SD3923W/ SD3961Y/SD3961YH

Multimeter update

U.S. $3.50

7 25274 86667 0

Sencore "Lite" High Quality General Instruments Compliment Existing Sencore Analyzers

The "Lite" Line instruments from Sencore enhance the capabilities of Sencore analyzers to round out your servicing bench. Check out these three great units and see how their capabilities can help increase your efficiency to brighten your bottom line.

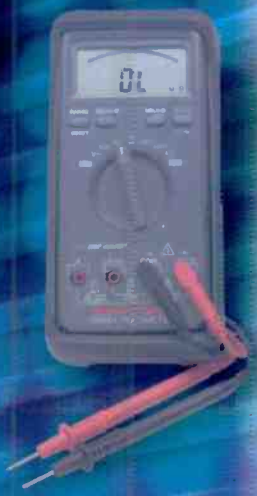
Turn On The Lite

$1,799
SC301 Oscilloscope

- 150 MHz CRT readout
- CRT readout of frequency, time, voltage
- 10 on-screen memory settings
- Dual channel
- Built-in component analyzer
- 3-year Limited Warranty

$99
DM500 Meter

- AC/DC voltage and current
- Resistance to 30MΩ
- Beep Guard™ Input Protection
- Continuity/Diode Test
- Shockproof
- 1-year Limited Warranty



$199
DM501 Meter

- True RMS
- AC/DC voltage and current
- Resistance to 30MΩ
- Data hold
- Water resistant
- Beep Guard™ Input Protection
- Current to 20A (limited)
- 1-year Limited Warranty

Call Today to Turn On The Lite

SENCORE

1-800-736-2673 • www.sencore.com

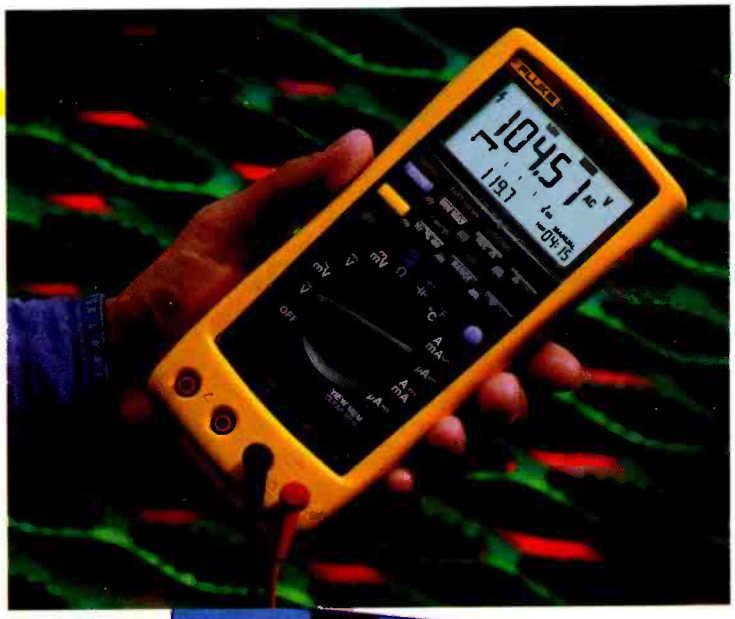
e-mail sales@sencore.com

Circle (1) on Reply Card

ELECTRONIC
Servicing & Technology

Volume 19, No. 9 September 1999

contents



9

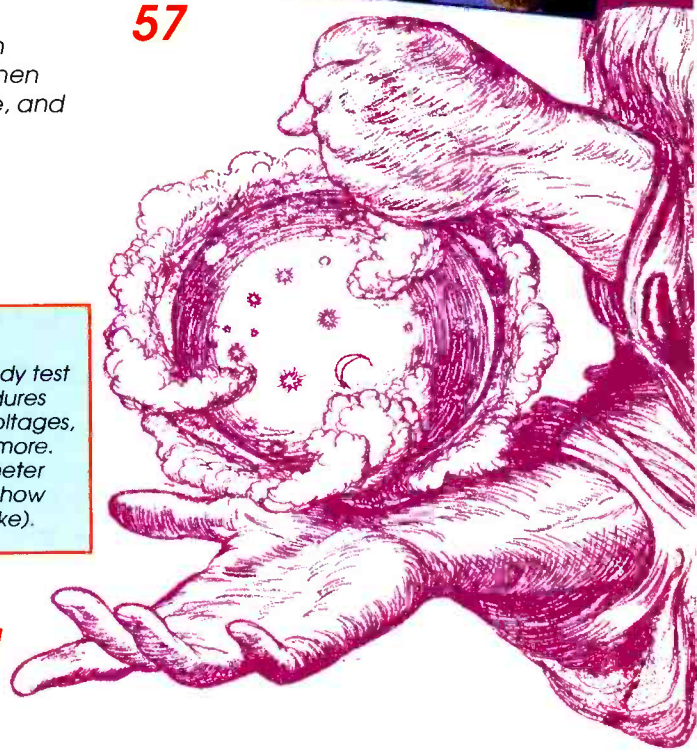
FEATURES

57

DEPARTMENTS

ON THE COVER

The multimeter is a compact, versatile, handy test instrument. Most electronics service procedures are begun using this instrument to check voltages, resistances, semiconductor junctions, and more. The specification sheet describing a multimeter will tell the technician what it will measure, how accurately, and safely. (Photo courtesy Fluke).



51

Editorial

by Nils Conrad Persson

Some encouraging words for independent service

In a time of upheaval, people are always looking for information that they can use to make sense of things, and perhaps at the same time, generate some hope for better days to come. The last couple of decades have been a period of prolonged upheaval for the consumer electronics service business.

It's a sad litany from the point of view of the independent service center. For a number of reasons, including the establishment of major discount electronics stores, prices of consumer electronics products have tumbled to the point where sometimes it makes better economic sense to replace a product rather than to have it serviced. During the same period of time, the products have become more and more reliable, thus drastically reducing the need for service.

But we're all used to these problems by now. However, now along come several more elements in the upheaval that we've been experiencing. High-definition television has been introduced. HDTV is a highly-complex product for which not a lot of service information has been provided. And we've been hearing so much about "convergence," and home networking, and more amazing new consumer electronics technology. Some independent service centers have begun to wonder if the manufacturers have them in mind to perform service on these products.

At a recent meeting of independent service center owners — the annual National Professional Service Convention (NPEC), put on by the National Electronics Service Dealers Association (NESDA) in Dallas August 2 through August 7 — representatives from many consumer electronics manufacturing companies held a round table discussion. The subject was "The future of independent consumer electronics service." From the first speaker to the last, these representatives said definitively, and resoundingly, that for the future, they are still looking to independent service centers to service their products, and that they are generating the service literature, and developing other programs to help independent servicers do just that.

The companies in attendance were: Hitachi, JVC, LG Electronics, Panasonic, Philips, Pioneer, Samsung, Sharp, Sony, Thomson Consumer Electronics (RCA/GE), and Toshiba. Here are some of the comments by these company representatives. I have chosen not to identify particular comments from particular individuals, but the general optimistic tenor of the meeting comes through. Also coming through loud and clear is the message that service centers will have to adapt to modern technology, such as personal computers and the internet, if they expect to stay in business and prosper in the future.

First manufacturer

Diversification is *necessary*. Consumer electronics service can't be the sole source of income for your business.

This company is instituting or improving the following to help service centers:

- Warranty rate structures
- Service parts availability and pricing
- Call center support
- Claims processing
- Partial payments
- Level of technical support
- Programs to help service centers complete service procedures on projection sets on the first call
- Internet-based training

Second company

Service centers need to be prepared to adapt quickly.

This representative is convinced of two things:

- The current service centers will be the service centers that service tomorrow's consumer electronics products.
- Products will continue to come and go; even faster than they are today.

Manufacturers need a single internet launch pad via which manufacturers can identify appropriate service centers, and via which service centers can access service information, order parts, look up warranty status, etc.

Third company

"I think that the future of the industry is good." He quoted a consultant: service centers need to change. They must improve their efficiency and capabilities at a rate of 7% per year.

Two related factors can help service centers do their jobs well:

- Manufacturers must do their business communications via the internet.
- Service centers must access information via the internet.

Trends, such as convergence, are happening in consumer homes, and service centers have to be prepared for that.

Fourth company

"There is a future, but where will it bring us? What are the business factors, and what control do we have over them? This has a great deal to do with who will survive."

(Continued on page 55)

News

AES presents "next generation internet" White Paper to White House

As the global forum for professional audio, the Audio Engineering Society (AES) is keenly aware of the importance of establishing the highest quality audio standards for Internet2 and Next-Generation Internet Systems. An AES Committee recently presented a technology White Paper to the White House officials representing the National Economic Council, the Office of Science and Technology Policy, and the Office of the Vice President, highlighting the technical and policy steps that will be necessary to assure improved audio quality over advanced networks.

AES President Dr. Marina Bosi, AES Past President Dr. Elizabeth Cohen, and AES Fellow Dr. John Strawn recently presented the AES White Paper "Networking Audio and Music Using Internet2 and Next-Generation Internet Capabilities." The AES Committee met with Senior Director to the National Economic Council, Tom Kalik, National Science and Technology Council Senior Policy Advisor Lori Perine, and Policy Advisor for the Office of the Vice President Audrey Choi at the White House. This historic meeting marked the first time the AES has presented a formal White Paper to Washington.

The Next-Generation Internet is a new initiative sponsored by the U.S. Government to connect universities and national labs to high-speed networks that are 100 to 1,000 times faster than today's Internet, and to invest in long-term research on networking technologies and the next generation of networked applications. The Administration's NGI initiative works in close partnership with the university-based Internet2 project.

"As a non-profit organization unaffiliated with any manufacturer, we represent an authoritative and unbiased voice," Dr. Bosi explained. "Our goal is to ensure the development and implementation of Next-Generation Internet systems, as that will carry significantly improved audio quality."

"The history of leaving scraps of bandwidth for audio should not be repeated," Dr. Cohen stated. "The AES believes that preserving and creating pathways for high-quality audio should be an essential part of all Next-Generation Internet initiatives. We are committed to helping establish full compatibility between the professional audio world and Internet technology."

During the presentation, Dr. John Strawn introduced elements of the AES Internet2 White Paper, which focused on improving audio and music, including long-distance performance, mixing at large distances, and remote master classes. Technical issues, such as jitter, latency, and the automatic identification of the content of musical recording, were also discussed.

"Our meeting with the National Economic Council was very encouraging," Dr. Strawn said. "We are in a position today to expedite the move to improve audio over the Internet2 and other NGI systems. And, the Administration is eager to move forward with this work. Since Internet2 already connects many U.S. universities, it is in our best interest to make University audio and music departments aware of the potential for research and collaboration. The AES Internet2 White Paper was very well received, and we are optimistic that this initial meeting will result in much good for the future of the professional audio community," Dr. Strawn concludes.

The National Economic Council enlisted the AES Committee to prepare a comprehensive list of potential university-based R&D-oriented music and audio departments. The White House intends to initiate a conference call with these laboratories, with the mandate of informing them about their Internet2 campus contacts, and encouraging them to initiate music and audio research over Internet2.

Formed in 1948 by a group of concerned audio engineers, the AES stands as the pivotal force in the exchange and dissemination of technical information for the industry. A truly international organization, the AES counts over 12,000 members throughout the U.S., Europe, Japan, and the Far East.

The AES Next Generation Internet White Paper is available on the AES website at <www.aes.org>. Information on Internet2 is available via the Internet at <www.Internet2.edu>.

Year-to-date DVD sales reach one million

CEMA expects explosive sales to continue, predicts 3 million in sales by year's end

Sales of the new video playback technology of choice, Digital Versatile Disc (DVD), reached 1 million units this week, according to numbers released by the Consumer Electronics Manufacturers Association (CEMA). CEMA also announced revised projections for total DVD unit sales in 1999, increasing previous predictions of 1.8 million to 3 million. "DVD sales continue to vastly outpace introductory sales of VCRs and CDs. It has quickly become a mass market product, demonstrating that consumers want the best possible picture and sound quality they can get. For this reason, DVD is a great harbinger for HDTV — people want theater quality video and sound," said Gary Shapiro, president of CEMA. "Typically, two thirds of industry sales are made in the second half of the year. If DVD stays on track, volume should reach 3 million before the end of 1999," added Shapiro.

Shapiro noted that CEMA doesn't expect the absence of Divx to have a negative impact on DVD player sales. "We saw Divx simply as a product feature."

With its vastly improved picture quality and six-channel surround sound, DVD provides a host of advantages over existing video playback systems. DVD technology uses as many as 500 lines of horizontal resolution, as compared with the VHS format's 240 lines, and can store up to 133 minutes of full-motion video on a single-layer, CD-size disc (and more than four hours on dual-layer discs).

In addition to its stunning digital images and surround sound, DVD gives consumers the ability to modify the aspect ratio from the squarish (4:3) measurements of today's TV sets to the widescreen (16:9) dimensions of a movie theater screen.

(Continued on page 56)

Products

Digital multimeters

Fluke has introduced the 87 and 89 Series IV DMMs.

The meters add dBm, 100 kHz ac bandwidth and true rms ac+dc voltage and current measuring capabilities. The meter offers 0.025% accuracy and over 50,000 counts of resolution on a multiple reading display that includes a secondary display and a real-time clock to time-stamp critical measurements. Another benefit is the fast startup sequence.

In addition to the ac capabilities, the meters measure V and mVdc, ohms, amps, capacitance, conductance, frequency, and temperature. The meters also provide troubleshooting aids such as diode test and continuity and open circuit test features with audible tone in addition to the visual display.

Capacitance measurement ranges include a 1 nF range and the ability to measure up to 50,000 µF. Min/Max/Average and Fast Min/Max (to register peaks as short as 250µs) take advantage of the real-time clock feature to identify the timing of events. And, Hold/AutoHOLD extends the Touch Hold® function introduced by the company several years ago.

The 89 Series IV can store up to 1000 measurements in stand alone operation, allowing a user to log data based on events, time or manually. All measurements are available for later viewing on the meter's display.

It provides additional functionality combining internal reading memories and isolated infrared (IF) serial communications capabilities with the optional FlukeView® Forms software to quickly document tests.

Fluke Corporation, P.O. Box 9090, Everett, WA 98206. Phone: 888-492-7550, Fax: 425-356-5116, E-mail: fluke-info@tc.fluke.com. Website: http://www.fluke.com

Circle (100) on Reply Card

ESD safe continuous vacuum handling system

Virtual Industries announces the SMD-VAC HP, a high-performance vacuum handling system with continuous airflow. This ESD safe tool will handle parts as small as ten thousandths of an inch square all the way up to large pin grid arrays.

The unit features a high-performance diaphragm pump that develops a vacuum of over 15 inches of mercury. An electric eye turns the pump off when the handle is not in use, which extends pump life and saves energy. An adjustable airflow control allows for fine-tuning in critical handling situations.

The product comes complete with a low-voltage wall transformer, 1/8-inch vacuum hose, handle, and seven vacuum tips in various sizes. Optional items include a foot switch and a variety of small parts handling tips.

2130 Victor Place, Colorado Springs, CO 80915, Phone: 800-530-8377, 719-572-5566, Fax: 719-572-5504, Website: www.virtual-ii.com

Circle (101) on Reply Card

Desoldering wick

Tech Spray introduces Pro Wick and No-Clean Wick desoldering braid on 25, 50, and 100 foot anti-static, individually vacuum packaged bobbins.

These desoldering braids offer advanced braid design with strong capillary action that quickly and completely pulls excess solder to help prevent damage to boards and sensitive components, according to the manufacturer.

Pro Wick is based on pure rosin, Type R Flux and No-Clean Wick is developed for no-clean environments and removes up to four times more solder than conventional wick. Both types of desoldering wick are available in standard widths on the new larger anti-static bobbins.

P.O. Box 949, Amarillo, TX 79105,
Phone: 800-858-4043, Fax: 806-372-8750,
Website: http://www.techspray.com

Circle (102) on Reply Card

Infrared thermometer

Fluke has introduced the Fluke 65 Infrared thermometer, a non-contact, laser sighted, stand-alone thermometer. Created to meet the needs of electrical, process, plant maintenance, facility maintenance, HVAC/R, and automotive professionals, the unit cuts measurement response time to less than one second.

This instrument features a laser beam for easy aiming and is useful for measuring rotating, electrically live, dangerously hot, or hard-to-reach objects. It is also an alternative to a contact thermometer. It provides an accurate response in 0.8 seconds with highly repeatable temperature readings from 40°C to 500°C (-40°F to 932°F).

Fluke Corporation, P.O. Box 9090, Everett, WA 98206, Phone: 888-492-7550, Fax: 425-356-5116, E-mail: fluke-info@tc.fluke.com, Website: http://www.fluke.com

Circle (103) on Reply Card

THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC
Servicing & Technology

Electronic Servicing & Technology is edited for servicing professionals 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.

EDITORIAL
Nils Conrad Persson, *Editor*
(Internet e-mail: cpersedit@aol.com)
Alycia Nicholsen, *Associate Editor*
(Internet e-mail: AlyciaEST@aol.com)
Richard S. Moseson, W2VU, *On-Line Coordinator*

CONSULTING EDITORS
Homer L.Davidson, *TV Servicing Consultant*
Victor Meeldijk, *Components Consultant*
John E. Shepler, *Audio Consultant*
Sam Wilson, *Electronics Theory Consultant*

PRODUCTION
Elizabeth Ryan, *Art Director*
Barbara McGowan, *Associate Art Director*
Edmond Pesonen, *Electronic Composition Mgr.*
Dorothy Kehrwieder, *Production Manager*
Emily Leary, *Assistant Production Manager*
Pat Le Blanc, *Phototypographer*

BUSINESS
Richard A. Ross, *Publisher*
Sal Del Grosso, *Accounting Manager*
Ann Marie DeMeo, *Accounting Department*
Judith Erickson, *Office Manager*
Catherine Ross, *Circulation Manager*
Melissa Gilligan, *Operations Manager*
Jean Sawchuk, *Data Processing*
Denise Kelis, *Customer Service*

ADVERTISING SALES OFFICE
Kaprelian & Company, Inc.
521 Illinois Avenue, St. Charles, IL 60174
Tel.: 630-584-5333 Ext. 10 • Fax: 630-584-9289

Bill Kaprelian, *Director of Advertising*
Emily Leary, *Sales Assistant*

EDITORIAL CORRESPONDENCE:
P.O. Box 12487
Overland Park, KS 66212
913-492-4857

ETA — Electronics Technician Association

National Electronics Service NESDA Dealers Association, Inc.
Member, Electronic Servicing Dealers Association

Electronic Servicing & Technology (ISSN 0278-9922) is published 12 times a year by CQ Communications, Inc. 25 Newbridge Road, Hicksville, NY 11801. Telephone (516) 681-2922. Periodical class postage paid at Hicksville, NY and additional offices. Subscription prices (payable in US dollars only): Domestic—one year $26.95, two years $49.95. Canadian—one year $36.95, two years $69.95. Foreign Air Post—one year $44.95, two years $85.95. Entire contents copyright 1999 by CQ Communications, Inc. Electronic Servicing & Technology or CQ Communications, Inc. assumes no responsibility for unsolicited manuscripts. Allow six weeks for delivery of first issue and for change of address.
Printed in the United States of America.

Postmaster: Please send change of address notice to Electronic Servicing & Technology, 25 Newbridge Road, Hicksville, NY 11801.

CQ Communications, Inc. is publisher of CQ The Radio Amateur's Journal, Popular Communications, CQ Radio Amateur (Spanish CQ), CQ VHF, CQ Contest, and Electronic Servicing & Technology.

Test accessories update

by the ES&T Staff

Troubleshooting a piece of consumer electronics equipment can be one of the toughest jobs in the world. But you knew that. A modern TV, for instance, is an extremely complex piece of equipment. When one of these beasts fails, determining what went wrong requires detailed knowledge of circuit operation, accurate and detailed service literature, and sophisticated test equipment.

But in many cases, even that is not enough. The compact and complex nature of today's consumer electronics products is such that many service procedures can't be completed without the use of some specialized test accessories.

Isolation transformer

Just one example of an indispensable test accessory that everyone reading this article should be aware of is the isolation transformer. Some years ago, the U.S. government decreed that consumer electronics manufacturers make their products more energy efficient. Considering the many millions of consumer electronics devices in use in the U.S., a savings of just a little energy by each TV set, computer monitor, etc., could reap huge energy savings in the aggregate.

Part of the reason that the efficiency of TV sets of that time was poor was the standard way of building the power supply: they used a half-wave rectifier for rectification, effectively throwing away one half of the power that the set used. For each set owner, it really wasn't a huge deal. The sets cost a little less because of the simple rectifier in the power supply, and energy was cheap, so the cost of the wasted energy wasn't significant.

For the nation as a whole, it was a large deal. A lot of energy was wasted in the aggregate. So the manufacturers replaced half-wave rectifiers with full-wave rectifiers that were more energy efficient. The only problem was that any portions of the chassis that are tied directly to the output of the power supply are at a potential equal to that of the power line voltage. That poses some danger to the servicer. If he isn't aware of the voltage level of those portions of the chassis, he could receive a nasty shock while servicing.

Moreover, if a technician uses any test equipment, such as an oscilloscope, that is also connected to the power line, to try to check waveforms produced by any of the circuits in one of these sets, the result will be damage to the power supply because of a shorted diode, and possibly damage to the oscilloscope as well.

Because of this fact, every service center needs an isolation transformer to isolate the power line connection of the unit under test from that of the test equipment. An isolation transformer is simply a one-to-one transformer that is constructed such that there is no electrical connection between the primary winding and the secondary winding. Thus, whatever device is plugged into the transformer is not connected to the primary winding, and thus is not connected to the power line ground.

Variable transformer

Have you ever encountered one of those sets that just seems unfixable? You know the type of product. You find the source of the problem, and you replace the faulty component. Confident that you've corrected the fault, you plug the set into the power outlet, and turn it on, only to watch smoke curling out of it, rather than being treated to picture and sound. A check of the components and circuits shows that the same component(s) failed again. But that means that there's something else wrong that is causing those components to fail. Further static checks with power not connected fail to reveal where the problem is. You really need to install good components to replace ones that

Plug anything but Pomona into me, and you'll get a signal you'll never forget.

Your Instruments Know. Some have called the portable DMM the test engineer's best friend. But feed it shaky input signals from a bad set of test leads, and its performance can suddenly turn on you. Of course, you can avoid such altercations by using Pomona test accessories. No matter what you're testing—from high density ICs to high speed motor drives—Pomona makes the connection secure. Plus, superb grip designs and ergonomics give you maximum flexibility and comfort. And Pomona also offers turnkey test kits for all leading DMMs—to completely satisfy their need to make fast, reliable measurements. So stick with the accessories preferred by savvy DMMs the world over. Contact Pomona Electronics at Tel: (909) 469-2900, Fax: (909) 629-3317. **www.pomonaelectronics.com.** And just tell them your instrument sent you.

Circle (116) on Reply Card

Pomona®

failed again, then turn on the power to make further tests, but that will just destroy the replacement components you've already installed in the chassis.

An experience such as that is disheartening. It's also costly. Now, you have to replace the replacements. And how do you find out where the problem might be without destroying a few more replacement components? That's where a variable transformer comes in. You can replace the destroyed components, then apply power *at reduced voltage*.

You can start by plugging the variable transformer into the power line, and then plug the television set into the variable transformer set at 0V. Depending on the nature of the problem, you might want to connect the oscilloscope, and/or the DMM to some critical point in the circuit. Then you *gradually* increase the voltage, constantly watching the voltage(s), current(s), and waveforms around the area where the failures occurred.

In most cases, careful observation will reveal that one or more of the components surrounding the problem area is drawing too much current. Then you can remove those components from the circuit and test them. With a lot of skill, and a little bit of luck, you will eventually find the component or components that are the cause of the problem.

Of course, each time you think you have corrected the problem, you will cautiously start the set using the variable transformer to be sure that you have in fact solved all the problems that may be lurking in the product.

Test clips

Another challenge these days to the diagnostic and servicing skills of consumer electronics servicing technicians is the IC with large numbers of closely-spaced leads. You think that one of those devices, or something connected to it, is the cause of the problem, so you decided to probe it. But further inspection shows that you really can't get a test probe onto the pin of interest. Or, actually, maybe you can apply a test probe, but the lead spacing is so tight that the tiniest of slips will cause the probe to short two pins together, possibly destroying the IC, if it's not already damaged. What to do?

Well, one approach has been reported in an article in a past issue of this magazine. You could turn the set off, solder a wire to the lead, or leads, of interest, and then connect the probe to the wire(s) to gather information. It worked for the author of that article. He used the information that he gathered in that fashion to complete his diagnosis.

But there is a quicker, easier way. Many manufacturers offer a variety of IC test clips that a technician can use to get a probe on an IC pin. One type of test clip has the same number of leads that the IC has, and clips right over the IC. The test points that are connected to the IC leads fan out as they get farther from the IC, so that the technician can attach a test probe without short-circuiting any pins.

This type of test clip can be very helpful in performing, but it has one drawback: cost. Each test clip may cost upwards of one hundred dollars or even more. Of course, if you're going to be servicing a lot of sets that have the same IC, and it's somehow involved in a lot of failures, it might still make sense to buy one. On the other hand, if your service center is like most, you won't find a lot of use for very many of these types of clips, if at all.

But all is not lost. The manufacturers of test accessories understand that many electronics companies don't encounter problems with the same configuration of IC over and over. In their wisdom, and being interested in selling product, they've come up with several ways to make probing of ICs more flexible. One approach is the tiny grabber.

One of these devices is, in essence, a tiny pincer that can grab around a single IC pin, and not touch any other pins. From the pincer, a lead brings out the connection to that IC pin out to a point where a technician can connect a probe to it. Manufacturers sell these grabbers individually, if the technician only needs to probe one pin at a time, or in kits that consist of a number of these tiny pincers in several different colors.

Using one of these kits, a technician turns off the set to be tested, then attaches one of these grabbers to each of the pins of the suspect IC and turns the set back on. Then the technician can probe and check to his heart's content, without any danger of shorting out two IC pins.

Other test equipment accessories

Mentioned above are only a few of the many test equipment accessories available to consumer electronics service technicians. Other accessories include: audio dummy loads; resistance, capacitance and inductance decade boxes; bench power supplies; test jigs and fixtures; VCR test jigs, and other assorted accessories. The March Buyers' Guide issue of this magazine carries a full listing of companies that manufacture or distribute test equipment accessories. ■

Multimeter update

by the ES&T Staff

Much of consumer electronics troubleshooting consists of measuring voltage, current, resistance, capacitance, checking semiconductor junctions, testing transistors, and checking continuity. The DMM can do all of these things, at least to some extent. And it's inexpensive, small and portable, and easy to use. That's why the DMM is usually the first piece of test equipment that a technician reaches for when he's trying to determine why that TV, VCR, stereo system, or other consumer electronics product doesn't work.

Just because a technician has bought many of a particular piece of equipment, and uses it every day, doesn't mean that he knows everything that he should about it. Most of us are often too busy getting our jobs done to have time to think about the products we use to do it. With that in mind, we present this article describing the DMM, detailing the specifications that describe a DMM, and describing how measurements are made.

Choosing your DMM

Buying a digital multimeter requires not only looking at basic specifications, but also looking at features, functions, and the overall value represented by a meter's design and the care taken in its production.

Reliability of test instruments, especially under tough conditions, is more important than ever today. It's a good idea to make sure that the DMM you buy has undergone a rigorous testing and evaluation program.

User safety is another important consideration in the choice of a DMM. Before buying a DMM for your work, check to see if it was independently tested by a certified testing lab and then listed by testing labs such as UL, CSA, VDE, etc.

Many DMMs are available with different combinations of features like Touch Hold, analog bar graphs, and enhanced resolution. Accessories for high current and temperature measurements are available to extend the capabilities of your DMM. Before you buy a DMM, you should check to see if the set of features on the DMM you're thinking of buying includes all the features you need, and if accessories you might need are available from the manufacturer or a third party.

Digital multimeters offer a wide selection of features. Choosing the right meter for the job can be challenging unless you know what the features do. This article explains some of the most common features of a DMM and details how those features can be used in actual applications.

Resolution, digits, and counts

Resolution refers to how fine a measurement a meter can make. By knowing the resolution of a meter, you can determine if it is possible to see a small change in the measured signal. For example, if the DMM specification says that the meter has a resolution of 1mV on the 4V range, it is possible to see a change of lmV (1/1000 of a volt) while reading lV.

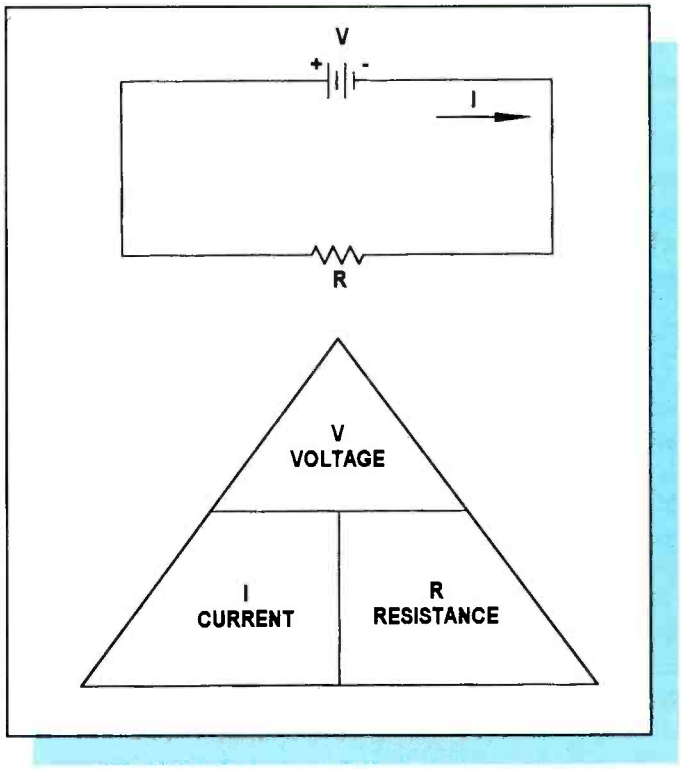


Figure 1. A DMM makes use of the principle of Ohm's law to directly measure and display either ohms, amps, or volts.

You wouldn't buy a ruler marked in one-inch (or one-centimeter) segments if you had to measure down to 1/4 inch (or one millimeter). A thermometer that measures only in whole degrees isn't much use when you want to see if your temperature is a normal 98.6°F. For this, you would need a thermometer with 0.10 degree resolution.

The terms *digits* and *counts* are used to describe a meter's resolution. DMMs are grouped by the number of counts or digits they display. The value of counts tells you how finely the measured parameter can be divided. Let's say the meter offers 4,000 counts. That means that the digital circuitry in the meter can resolve the value being measured into 4,000 parts.

Meter manufacturers use the term "1/2 digit" to describe a digit in the display, the *most significant digit* (MSD), that has only two segments, and therefore can only display the digit 1. Thus, for example, a 3-1/2-digit meter can display three full digits ranging from 0 to 9, and one half digit, which displays only a 1, or it may be left blank.

So what's the point of adding a half digit instead of a whole digit. The idea is that a half digit requires less circuitry than a full digit, and it significantly increases the resolution. A 3-1/2-digit meter will display up to 1999 counts of resolution. A 4-1/2-digit meter can display up to 19,999 counts of resolution.

While we're at it, let's talk about that term MSD. When looking at a number, lets say 1435, the 1 in the number represents

thousands, the 4 represents hundreds, the 3 represents tens, and the 5 represents ones. Thus 1435 means "one thousand, four hundreds, three tens, and 5 ones." Because the 1 represents thousands in this number, it is the most significant digit (MSD). Because the 5 represents ones, it is the least significant (LSD).

It is more appropriate to describe the resolution of a multimeter by counts of resolution than by the number of digits displayed. Today's 3-1/2-digit meters may have enhanced resolution of up to 3200 or 4000 counts.

3200-count meters offer better resolution for certain measurements. For example, a 1999-count meter won't be able to measure down to a tenth of a volt if you are measuring 200V or more. However, a 3200-count meter will display a tenth of a volt up to 320V. This is the same resolution as a more expensive 20,000-count meter until you exceed 320V.

Accuracy

Accuracy and resolution are sometimes used interchangeably, but that's not correct. As we just discussed, precision refers to the fineness with which the value of the parameter being measured can be divided. Your display on a 3-1/2-digit meter may show a voltage measurement of 1.015V. A very precise number. But if the voltage being measured by the meter is actually 0.9V, the measurement is not accurate.

The term "accuracy" designates the largest allowable error in the meter reading that will occur under specific operating conditions. In other words, it is an indication of how close the DMM's displayed measurement is to the actual value of the signal being measured by the meter.

Accuracy for a DMM is usually expressed as a percent of reading. An accuracy of 10% of reading means that for a displayed reading of 100.0V, the actual value of the voltage could be anywhere between 99.0V and 101.0V.

Specifications may also include a range of digits added to the basic accuracy specification. This indicates how many counts the digit to the extreme right of the display may vary. So the preceding accuracy example might be stated as +/-(1%+2). This means that for a display reading of 100.0V, the actual voltage could be between 98.8V and 101.2V.

In contrast, analog meter specifications are determined by the error at full scale, not at the displayed reading. Typical accuracy for an analog meter is +/-2% or +/-3% of full scale. Typical basic accuracy for a DMM is between + (0.700+1) and +/-(0.1%+1) of *reading*, or better.

Ohm's law

Voltage, current, and resistance in any electrical circuit can be calculated by using Ohm's law, which, as you know, states that voltage = (current) X (resistance). Thus, if any two values in the formula are known, the third can be determined.

A DMM makes use of the principle of Ohm's law to directly measure and display either ohms, amps, or volts. On the following pages, you will see just how easy it is to use a DMM to find the answers you need (see Figure 1).

Digital and analog displays

For high accuracy and resolution, the digital display excels, displaying three or more digits for each measurement.

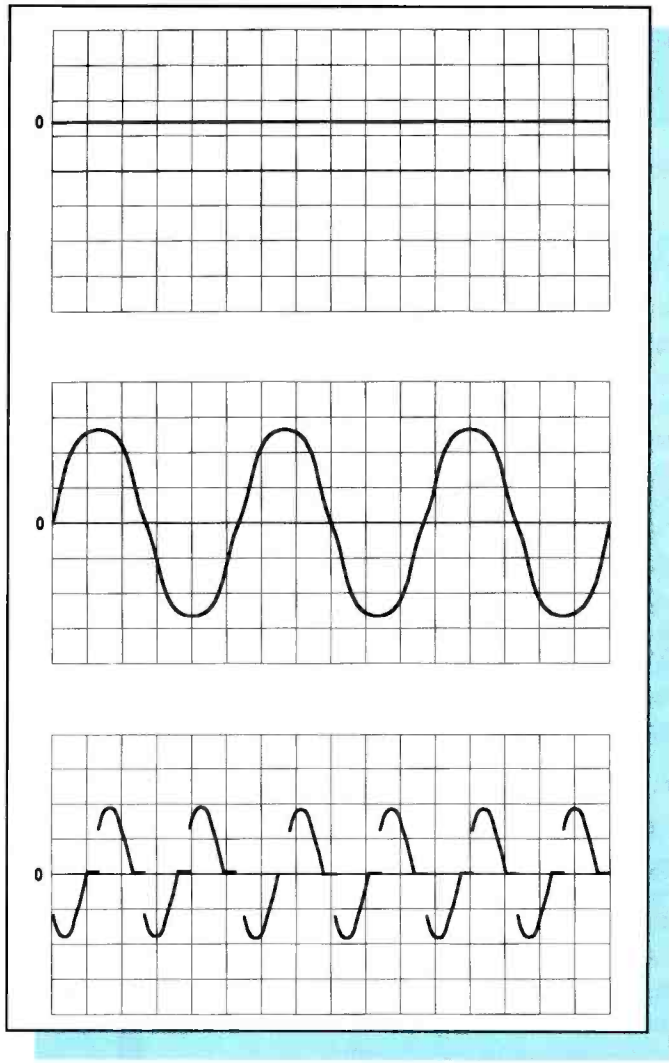


Figure 2. The bottom graph is of a non-sinusoidal waveform. Correct measurement of this waveform requires a DMM that can measure rms.

The needle display on an analog multimeter is less accurate and has lower effective resolution because the technician has to estimate values between the lines.

A bar graph shows changes and trends in a signal just like an analog needle, but is more durable and less prone to damage.

Measuring voltage

Some of the following may sound a little basic for many readers, but for the sake of completeness in covering the subject, we're going to include it here. As you know, one of the most basic tasks of a DMM is measuring voltage. A typical dc voltage source is a battery, like the one used in your car. AC voltage is usually created by a generator. The wall outlets in your home are common sources of ac voltage. Some devices convert ac to dc. For example, electronic equipment, such as TVs, stereos, VCRs, and computers, that you plug into an ac wall outlet use devices called rectifiers to convert the ac voltage to a dc voltage. This dc voltage is what powers the electronic circuits.

Testing for proper supply voltage is usually the first thing that a technician does when troubleshooting a circuit. If there is no

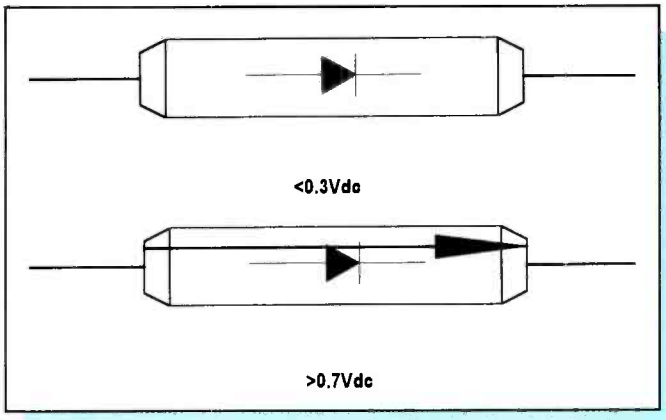


Figure 3. If the voltage at the probes is low enough during resistance, it will not forward bias semiconductor junctions.

voltage present, or if it is too high or too low, the voltage problem should be corrected before investigating further.

The waveforms associated with ac voltages are either sinusoidal (sine waves), or non-sinusoidal (sawtooth, square, ripple, etc.) (Figure 2). Higher quality DMMs display the "rms" (root-mean-square) value of these waveforms. The rms value is the effective or equivalent dc value of the ac voltage.

Most meters, called "average responding," give accurate rms readings if the ac voltage signal that they're being used to measure is a pure sine wave. Average-responding meters are not capable of measuring non-sinusoidal signals accurately. Non-sinusoidal signals are accurately measured using DMMs designated "true-rms" up to the DMMs specified *crest factor*. Crest factor is the ratio of a signal's peak to rms value.

A DMMs ability to measure ac voltage can be limited by the frequency of the signal. Most DMMs can accurately measure ac voltages with frequencies from 50Hz to 500Hz, but a DMMs ac measurement bandwidth may by hundreds of kHz wide. DMM accuracy specifications for ac voltage and ac current should state the frequency range along with accuracy.

How to make voltage measurements

1. Select Volts AC or Volts DC or 300 mV as desired.
2. Plug the black test probe into the COM input jack. Plug the red test probe into the V input jack.
3. Touch the probe tips to the circuit across a load or power source (in parallel to the circuit).
4. View the reading, being sure to note the unit of measurement.

Note: For dc readings of the correct polarity (+/-), touch the red test probe to the positive side of the circuit, and the black probe to the negative side or circuit ground. If you reverse the connections, a DMM with auto-polarity will merely display a minus sign indicating negative polarity. With an analog meter, you risk damaging the meter.

Note: 1/1000V = 1mV 1000V = 1kV

High-voltage probes are available for measuring voltages in television and CRT repair, where voltages can reach 40kV.

Caution: These high-voltage probes used for TV and CRT work are not intended for electrical utility applications in which high voltage is also accompanied by high energy. Rather, they are intended for use in low-energy applications.

Resistance

Resistance is measured in ohms. Resistance values can vary greatly, from a few Mohms for contact resistance, to billions of ohms for insulators. Most digital multimeters measure down to 0.1Ω, and some meters measure as high as 300MΩ. Infinite resistance is read as "OL" on meter displays. This means that the resistance is greater than the meter can measure. Open circuits will read "OL" on the meter's display

Resistance measurements must be made with the circuit power off, or the meter or circuit could be damaged. Some DMMs provide protection in the ohms mode in case of accidental contact with voltages. The level of this type of protection may vary greatly among different DMM models.

For accurate low-resistance measurements, any resistance in the test leads must be subtracted from the total resistance measured. Typical test lead resistance is between 0.2Ω and 0.5Ω. If you measure resistance in the test leads greater than 1Ω, the test leads are faulty and should be replaced.

If the DMM supplies less than 0.6Vdc test voltage for measuring resistance, it will be able to measure the values of resistors that are isolated in a circuit by diodes or semiconductor junctions. This often allows you to test resistors on a circuit board without unsoldering them.

Continuity

Continuity is a quick go/no-go resistance test that distinguishes between an open and a closed circuit.

A DMM with a continuity beeper allows you to complete many continuity tests easily and quickly. The meter beeps when it detects a closed circuit, so you don't have to look at the meter as you test. The level of resistance required to trigger the beeper varies from model to model of DMM.

Diode test

A diode is like an electronic switch. It can be turned on if the voltage is over a certain level, generally about 0.6V for a silicon diode, and it allows current to flow in one direction.

When checking the condition of a diode or transistor junction, a VOM (volt-ohm meter) not only gives widely varying readings, but can drive up to 50mA through the junction.

Some DMMs have a diode test mode. This mode measures and displays the actual voltage drop across a junction. A silicon junction should have a voltage drop less than 0.7V when the meter is applied to it in the forward direction, and be an open circuit when the meter is applied in the reverse direction.

How to make resistance measurements

1. Turn off power to the circuit.
2. Select resistance (Ω).
3. Plug the black test probe into the COM input jack. Plug the red test probe into the ohms input jack.
4. Connect the probe tips across the component or portion of the circuit for which you want to determine resistance.

Independent testing: the key to compliance

Look for a symbol and listing number of an independent testing lab such as UL, CSA, TUV, or other recognized testing organization. Beware of wording such as "Designed to meet specification." Designer's plans are never a substitute for an actual independent test.

How can you tell if you're getting a genuine CAT III or CAT II meter? Unfortunately, it's not always that easy. It is possible for a manufacturer to self-certify that its meter is CAT II or CAT III without any independent verification. The IEC (International Electrotechnical Commission) develops and proposes standards, but it is not responsible for enforcing the standards.

Look for the symbol and listing number of an independent testing lab such as UL, CSA, TUV, or other recognized approval agency. That symbol can only be used if the product successfully completed testing to the agency's standard, which is based on national/international standards. UL 3111, for example, is based on IEC 1010. In an imperfect world, that is the closest you can come to ensuring that the multimeter you choose was actually tested for safety.

5. View the reading, being sure to note the unit of measurement-ohms (Ω), kilohms (kΩ), or megohms (MΩ).

Make sure the power to the unit under test is off before making resistance measurements.

Measuring current

Current measurements are different from other measurements made with a DMM. Direct current measurements are taken by placing the meter directly in series with the circuit being measured, thus allowing all the circuit current to flow through the meter circuitry. An indirect method of measuring current can be employed that does not require the circuit to be opened and the meter placed in series. This indirect method employs the use of a current probe, which is essentially a transformer.

How to make direct current measurements

1. Turn off power to the circuit.
2. Cut or unsolder the circuit, creating a place where the meter probes can be inserted.
3. Select Amps AC or Amps DC as desired.
4. Plug the black test probe into the COM input jack. Plug the red test probe into the 10 amp (10A) or 300mA (300mA) input jack, depending on the expected value of the reading.
5. Connect the probe tips to the circuit across the break as shown so that all current will flow through the meter (a series connection).
6. Turn the circuit power back on.
7. View the reading, being sure to note the unit of measurement.

Note: If the test leads are reversed for a dc measurement, a "-" will show in the display to indicate polarity.

Input protection

A common mistake is to leave the test leads plugged into the current input jacks and then attempt a voltage measurement. This causes a direct short across the source voltage through a low-value resistor inside the DMM, called a current shunt. A high current flows through the DMM and, if the meter is not adequately protected, can cause extreme damage to the meter and to the circuit, and injury to the operator. Extremely high fault currents can occur if industrial high-voltage circuits are involved (voltage of 480V or higher).

A DMM should therefore have current input fuse protection of high enough capacity for the circuit being measured. Meters without fuse protection in the current inputs should not be used on high-energy electrical circuits (voltages greater than 240Vac). Those DMMs that do use fuses should have a fuse with sufficient capacity to clear a high-energy fault. The voltage rating of the meter's fuses should be greater than the maximum voltage you expect to measure.

For example, a 20A, 250V fuse may not be able to clear a fault inside the meter when the meter is inadvertently connected across a 480V circuit. A 20A, 600V fuse would be needed to clear the fault on a 480V circuit.

Current probe accessories

Sometimes, you may have to make a current measurement that exceeds the rating of your DMM or the situation does not allow you to open the circuit to measure the current. In these higher current applications (typically over 2A), where high accuracy is not needed, a current probe is very useful. A current probe clamps around the conductor carrying the current, and it converts the measured value to a level the meter can handle.

There are two basic types of current probes used with multimeters: current transformers, which are used to measure ac current only, and Hall-Effect probes, which are used to measure either ac or dc current.

The output of a current transformer is typically 1mA per amp. A 100A circuit current value is reduced to 100mA through the meter, which can be safely measured by most DMMs. The probe leads are connected to the "mA" and "Common" input jacks, and the meter function switch is set to mAac.

The output of a Hall-Effect probe is 1mV per amp, ac or dc. For example, 100Aac is converted to 100mVac. The probe leads are connected to the "V" and "Common" jacks. Set the meter function switch to the "V" or "mV" scale, selecting Vac for ac current or Vdc for dc current measurements. The meter displays 1mV for every amp measured.

Multimeter safety

Making measurements safely starts with choosing the proper meter for the application, as well as the environment in which the meter will be used. Once the proper meter has been chosen, you should use it by following good procedures.

The International Electrotechnical Commission (IEC) established new safety standards for working on electrical systems. Make sure you are using a meter that meets the IEC category and voltage rating approved for the environment where the measurement is to be made. For instance, if a voltage measurement needs to be made in an electrical panel with 480V, then a meter

rated Category III-600V should be used. This means the input circuitry of the meter has been designed to withstand voltage transients commonly found in this environment without harming the user. Choosing a meter with this rating, which also has a UL, CSA, VDE, or TUV certification, means the meter not only has been designed to IEC standards, but has been independently tested and found to meet those standards. (See Independent testing sidebar.)

Common situations that lead to DMM failure

If the user doesn't exercise caution, some DMMs can be damaged or destroyed. Here are some of the situations that can cause a DMM to be damaged.

1. Contact with ac power source while test leads are plugged into current jacks
2. Contact with ac power source while in resistance mode
3. Exposure to high voltage transients
4. Exceeding maximum input limitations (voltage and current)

Types of DMM protection circuits

Some DMM manufacturers have provided their multimeters with protection circuits that will minimize or eliminate damage to the DMM. Look for such features when buying a new DMM.

1. Protection with automatic recovery. Some meters have circuitry that detects an overload condition and protects the meter until the condition no longer exists. After the overload is removed, the DMM automatically returns to normal operation. This type of meter protection is usually used to protect the ohms function from voltage overloads.

2. Protection without automatic recovery. Some meters will detect an overload condition and protect the meter, but will not recover automatically until the operator performs an operation on the meter, such as replacing a fuse.

Look for these safety features when considering a DMM:

1. Fused current inputs
2. High-energy fuses (600V or more)
3. High-voltage protection in resistance mode (500V or more)
4. Protection against voltage transients (6 kV or more)
5. Safety-designed test leads with finger guards and shrouded test probe terminals
6. Independent safety organization approval/listing (organizations such as UL or CSA)

Safety checklist

- Use a meter that meets accepted safety standards for the environment in which it will be used.
- Use a meter with fused current inputs and be sure to check the fuses before making current measurements.
- Inspect test leads for physical damage before making a measurement.
- Use the meter to check continuity of the test leads.
- Use only test leads that have shrouded connectors and finger guards to prevent accidental contact.

• Use only meters that feature recessed input jacks.
• Select the proper function and range for your measurement.
• Be certain the meter is in good operating condition.
• Follow all equipment safety procedures when using the digital multimeter.
• Always disconnect the "hot" (red) test lead first after making measurements.
• Don't work alone.
• Use a digital multimeter that has overload protection on the ohms function.
• When measuring current without a current clamp, turn the power off before connecting into the circuit.
• Be aware of high-current and high-voltage situations and use the appropriate equipment, such as high-voltage probes and high-current clamps.

DMM accessories

One important requirement of a DMM is that it can be used with a variety of accessories. Accessories are available that can increase your DMM's measurement range and usefulness, while making your measurement tasks easier.

High-voltage probes and current probes scale down high voltages and currents to a level the DMM can safely measure. Temperature probes convert your DMM into a handy digital thermometer. These RF probes are another accessory that can be used to measure voltages at high frequencies.

Furthermore, a selection of test leads, test probes, and test clips can help you easily connect your DMM to the circuit. Soft and hard carrying cases protect your DMM and conveniently store your accessories with your DMM.

Glossary

Accuracy — How close the DMM's displayed measurement is to the actual value of the signal being measured. Expressed as a percentage of reading or as a percentage of full scale.

Analog meter — An instrument that uses a needle movement to display the value of a measured signal. The user judges the reading based on the position of the needle on a scale.

Annunciator — A symbol on the display that identifies a selected range or function.

Average Responding DMM — A DMM that accurately measures sinusoidal waveforms, while measuring non-sinusoidal waveforms with less accuracy.

Count — A number used to specify a DMM's resolution.

Current-shunt — A low-value resistor in a digital multimeter for measuring current. The DMM measures the voltage drop across the current shunt and, using Ohm's Law, calculates the value of the current.

DMM, Digital Multimeter — An instrument that uses a digital display to show the value of a measured signal. DMMs feature greater durability, resolution, and far higher accuracy than their analog meters counterparts.

Non-sinusoidal waveform —A distorted waveform, such as a pulse train, square waves, triangular waves, sawtooth waves, and spikes.

Resolution — The degree to which small changes in a measurement can be displayed. RMS. The equivalent dc value of an ac waveform.

Sinusoidal waveform — A pure sine wave without distortion. True-rms DMM. A DMM that can accurately measure both sinusoidal and non-sinusoidal waveforms.

Special features

The following special features and functions available on some DMMs may make it easier to use your DMM.

• Annunciators show at a glance what is being measured (volts, ohms, etc.).
• Touch Hold freezes the display on stable readings so you can use both hands to take a measurement and view results later. One-switch operation makes it easy to select measurement functions.
• Overload protection prevents damage to both the meter and the circuit, and protects the user from injury.
• Special high-energy fuses provide extra protection for user and meter during current measurements and overloads.
• Autoranging automatically selects proper measurement range. Manual ranging lets you lock into a specific range for repetitive measurements.
• Autopolarity indicates negative readings with a minus sign, so even if you connect the test leads in reverse, you won't damage the meter.
• Low-battery indicator. ■

This article was based, with permission, on the Application Note "ABCs of DMMs: Multimeter features and functions explained," published by Fluke Corporation, P.O. Box 9090, Everett, WA 98206. 800-443-5853. Http://www.fluke.com. If there are any errors in this article, they should be attributed to the ES&T editors, not to the document on which it is based.

Oscilloscope basics

by John A. Ross

An oscilloscope works as a useful, versatile addition to the test bench for any technician attempting to trace or monitor electrical signals. With an oscilloscope, a technician can check the display of a waveform and look for variations in amplitude and time, determine phase relationships between voltages and currents, or look at the frequency response of a circuit. When using an oscilloscope, waveforms display as a plot or graph of the variations. While the horizontal movement of the oscilloscope trace on the X axis is proportional to time, the vertical movement of the trace on the Y axis is proportional to voltage. The intensity or brightness of the display represents the Z axis of the graph.

Becoming familiar with the oscilloscope

Figure 1 shows the front panel of an analog oscilloscope and features a display, as well as a set of controls. In very basic terms, a signal feeding into the oscilloscope causes the device to display waveforms. Analog oscilloscopes apply a measured signal voltage directly to an electron beam moving across the oscilloscope display. The signal voltage deflects the beam up and down proportionally and traces a waveform on the CRT screen. Controls allow the user to set the intensity, focus, and horizontal and vertical centering of the displayed waveform.

Referring to Figure 1, the display of the oscilloscope is divided into a grid called a *graticule*. Each vertical and horizontal line represents a division used for measuring voltage and time. While the labels on the Volts/div and Time/div oscilloscope controls refer to major divisions, the marks on the center horizontal and vertical graticule lines refer to minor divisions.

Because the oscilloscope offers a linear display, the device can display the peak-to-peak value of any test signal. Those values are measured as volts per centimeter of vertical deflection. In addition, video waveform monitors and oscilloscopes that are designed for video work feature a dotted line across the display face that represents the same luminance setup level. In most cases, the setup level is referred to as the pedestal or picture black level and signifies the difference between video and sync signals.

Because of its functionality and versatility, you can use an oscilloscope to:

- determine the time and voltage values of a signal;
- calculate the frequency of an oscillating signal;

Ross is a technical writer and microcomputer consultant at Ft. Hays State University, Hays, KS.

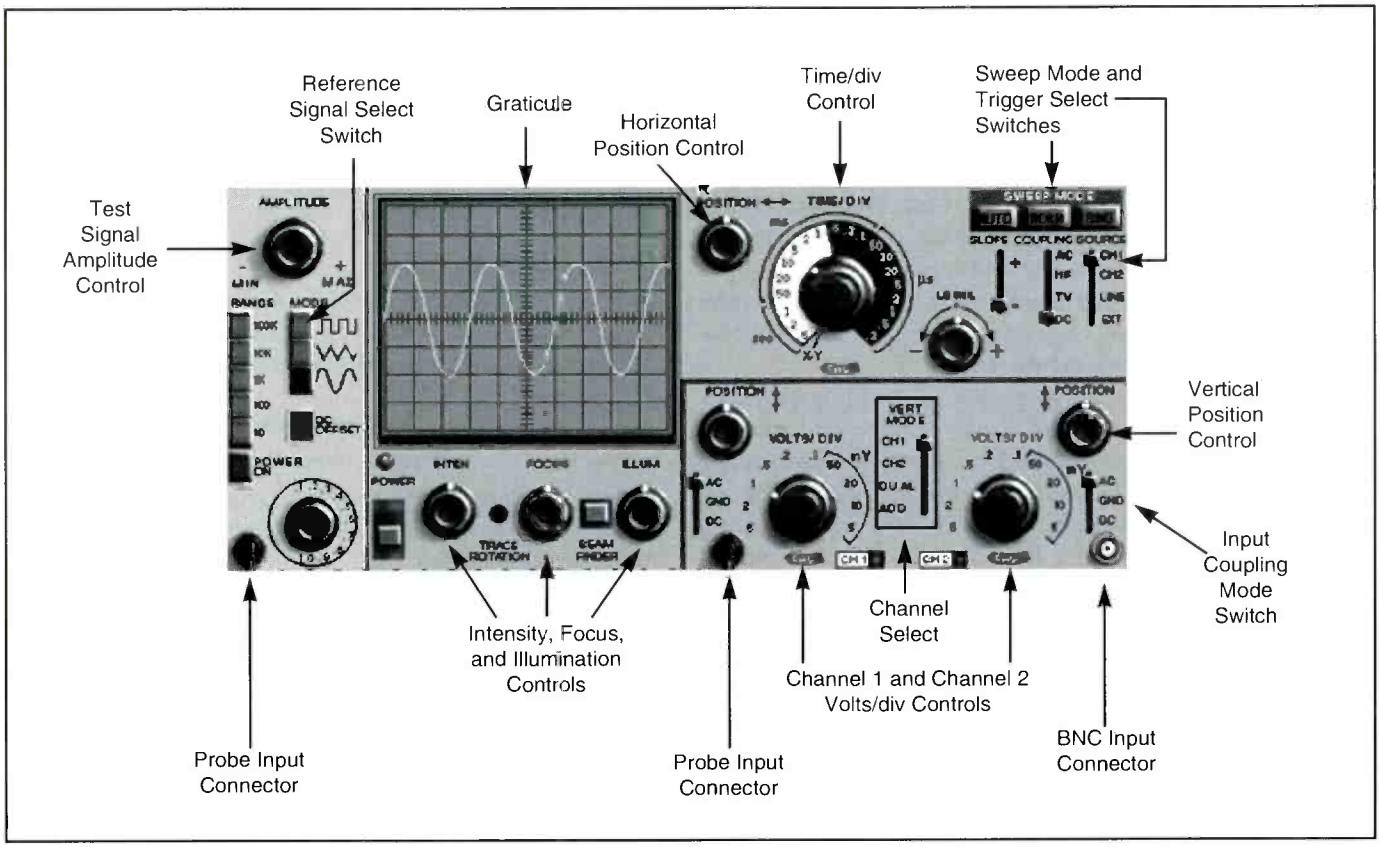


Figure 1. The front panel of an analog oscilloscope features a display, as well as a set of controls. The signal voltage deflects the beam up and down proportionally and traces a waveform on the CRT screen. Controls allow the user to set the intensity, focus, and horizontal and vertical centering of the displayed waveform.

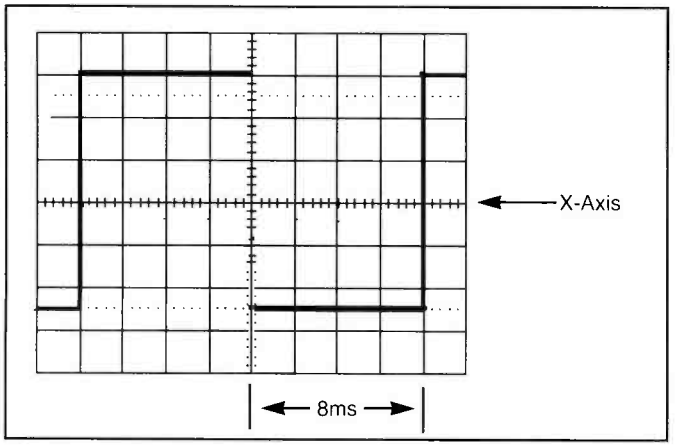


Figure 2. In this application, the oscilloscope is being used to measure pulse width in reference to time. In this case, the Time/div control is set at 2µsec and the entire display has a width of 20µsec. To measure the time duration of a waveform, multiply the distance by the setting of the Time/div control. The pulse has a width of 8µsec.

- monitor circuit action through the movement of the waveform;
- compare portions of a signal with the remainder of the signal;
- use the distortion in a signal as a problem-tracing tool;
- see the dc and ac voltage components of a signal;
- determine the amount of noise in a signal; and
- determine whether the noise in the signal changes over time.

Displaying a waveform

A picture of a waveform is displayed on the oscilloscope face as the electron beam moves across the screen of the CRT at a specific rate, deflected by the voltage at the point in the circuit under test to which the scope probes are connected. Positive voltages cause the beam to deflect upward, while negative voltages cause the beam to deflect downward. Limitations in CRT design also constrain the possible range of frequencies displayed by an analog oscilloscope to a maximum of 1GHz. More specifically, the trace has a maximum rate for writing to the phosphors on the inside of the CRT face. The measurement of low frequencies shows as a bright, slow moving dot, while the measurement of high frequencies results in a very dim display. In either case, it becomes difficult to see the waveform.

An oscilloscope requires some type of synchronization for the proper stabilization of the display. During operation, an internal sweep oscillator produces a sawtooth wave, which repeatedly sweeps the electron beam horizontally across the face of the CRT. The action of the sawtooth wave produces linear deflection and sets up a time base for the displayed signal. If the time base has one half the frequency of a measured sine-wave, the oscilloscope will show two cycles of the sine wave. Vertical deflection is controlled by the amplitude of the test signal. Vertical amplifiers allow the oscilloscope to have the capability to measure the bandwidth of a signal. Typical oscilloscopes have a vertical response ranging from 5Mhz to 200Mhz.

The test signal also triggers the horizontal sweep of the CRT beam and sets the horizontal time base so that the beam moves from left to right within a specific time interval. As the sweep rate increases, the beam traces a solid line rather than a single dot and — along with the vertical deflection circuitry — produces a graph of the test signal. In addition to setting the time base, the triggering action also ensures that the trace of the repeating signal consistently begins at the same point.

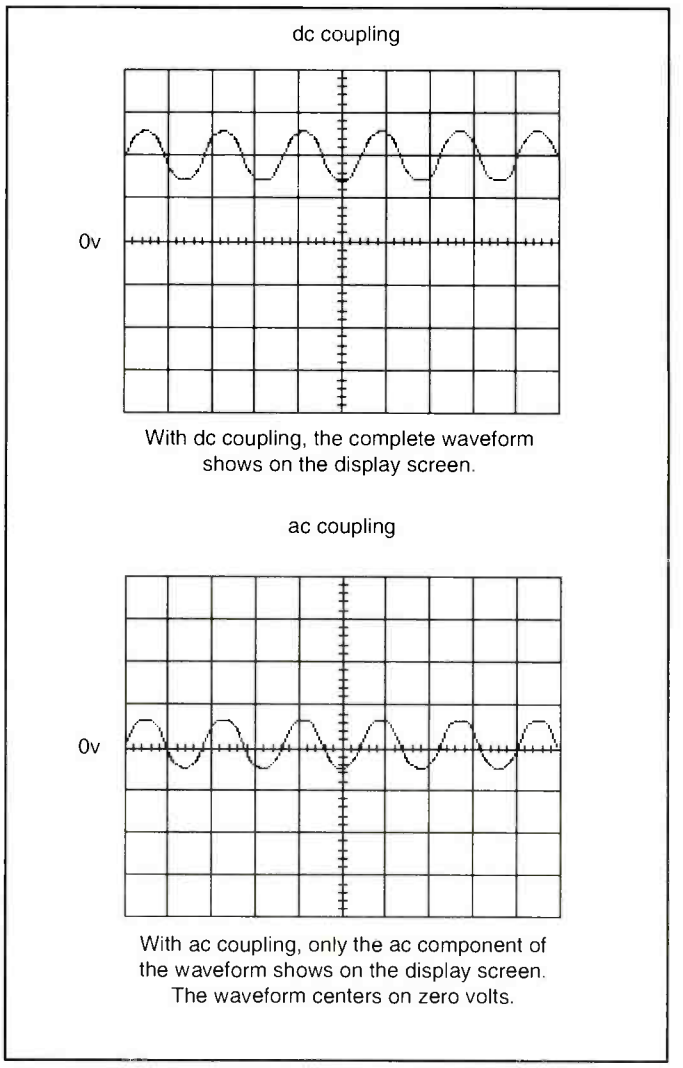


Figure 3. Setting the oscilloscope to dc coupling does not block either the dc or ac components of the test signal. As a result, the entire signal shows on the display. Setting the switch to ac coupling blocks the dc portion of the signal. As a result, the waveform centers on 0V and allows the display of large signals.

X-Y mode and alternate/chop displays

Many troubleshooting applications require the comparison of the waveform of a reference signal with the waveform of the test signal. One method used in most analog oscilloscopes for displaying a second channel is called the X-Y mode. With the X-Y mode, a second channel displays along the X-axis.

When the troubleshooting process requires the display of multiple channels, oscilloscopes employ either the alternate or the chop mode. With the alternate mode, the display alternately draws each channel. One completed sweep of the beam draws the first channel, while the next sweep draws the next channel. The alternate mode works well with medium- to high-frequency signals.

When operating in the chop mode, the oscilloscope draws small parts of each signal by switching back and forth between the signals. Because the chop mode utilizes extremely fast

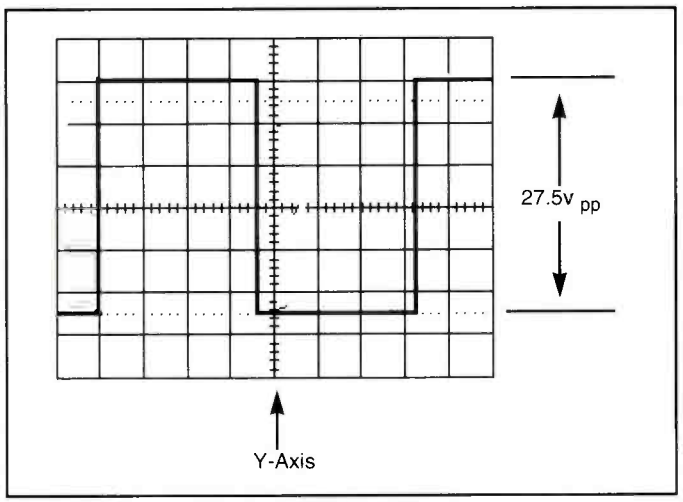


Figure 4. If you display a $2V_{PP}$ signal on a 1V/div screen, the signal will cover two vertical divisions. As shown here, setting the Volts/div control to 5V allows each of the vertical divisions to represent 5. At this setting, a 27.5 V_{PP} signal will cover five-and-one-half divisions.

switching, the waveform always appears complete. The chop mode works well with lower-frequency signals.

Oscilloscope controls

Any survey of the controls found on the front panel of an oscilloscope begins with the focus, contrast, and intensity controls. Referring to Figure 1, the display controls are directly beneath the graticule. As with television receivers, the focus control adjusts the sharpness of a reproduced image, while the intensity control works much like a contrast control and adjusts the brightness of the waveform. During the testing of a circuit, any increase in the sweep speed of the oscilloscope trace requires an increase of the intensity level. The trace rotation control allows the alignment of the waveform trace with the horizontal axis of the graticule.

Horizontal position and time base

Referring to the upper right corner of Figure 1, the horizontal controls position and scale the waveform horizontally. Positioning occurs through the adjustment of the horizontal position control. Every oscilloscope operates with a main time base. In addition, many oscilloscopes also feature a delayed time base, or a time base sweep that begins after a pre-determined time from the start of the main time base sweep. The use of a delayed time base sweep allows the clear viewing of activity in the test circuit.

The Time/div control

Using the characteristics and the capabilities of an oscilloscope, we can measure both the *rise time* and the *period* of a waveform. Rise time is defined as the amount of time required for a waveform to increase from 10% to 90% of its total amplitude. The period is defined as the amount of time during which a repetitive waveform goes through one complete cycle.

When we measure the length of a pulse; the width of a pulse; the timing of pulses; or the frequency of a signal with an oscilloscope, we use the Time/div control and X-axis of the graticule. The use of the Time/div control scales the waveform by allowing the technician to select the rate for drawing the waveform across the display graticule. Any measurement made with an oscilloscope is much more accurate if the measured portion of the test signal covers a large area of the display.

As an example of how horizontal scaling works, we can set the Time/div control to 1µsec. With that, each horizontal division of the graticule represents 1µsec and the entire screen has a width of 10µsec. If we change the control setting to a different scale, we can look at either shorter or longer time intervals of the input signal. Since we measure time along the X-axis, the smaller divisions allow greater measurement accuracy.

Figure 2 illustrates the measurement of pulse width in reference to time. In this figure, the Time/div control is set at 2µsec and the entire display has a width of 20µsec. To measure the time duration of a waveform, we multiply the distance by the setting of the Time/div control. The pulse has a width of 8µsec.

Horizontal frequency

Horizontal frequency adjustments allow the user to set a frequency range and phase for the oscillator in the oscilloscope that generates the horizontal sweep signal. Depending on the application, a technician can set the horizontal selector switch so that the horizontal trace is generated internally by that oscillator, or by some external signal source. For accurate display of a waveform, the user adjusts the frequency of the sweep oscillator so that it corresponds to the frequency of the test signal. The display signal will appear to become stationary if the sweep

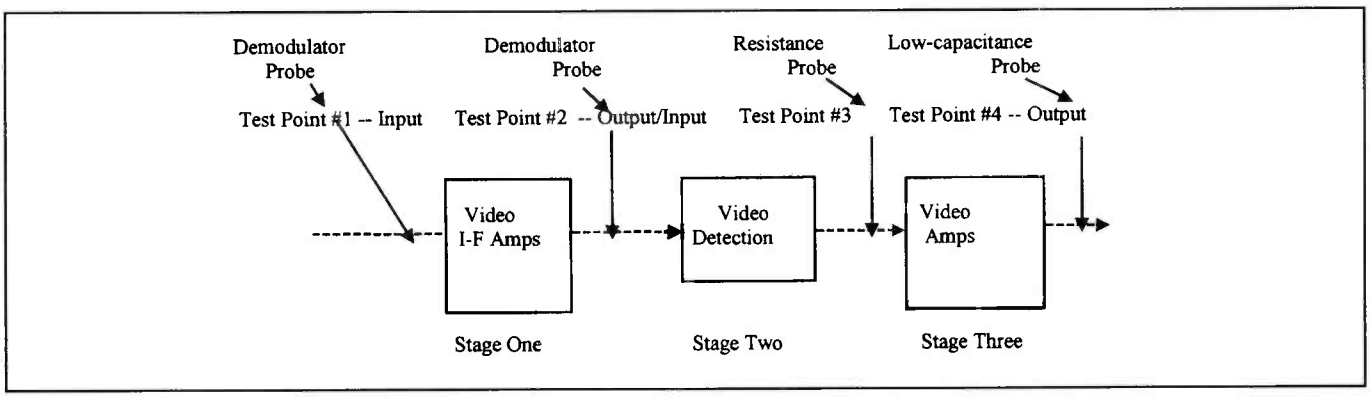


Figure 5. The demodulator probe is used to check for the presence of a signal at the first two test points. Because of the circuit loading and detuning caused by the demodulator probe, an amplitude measurement is nearly impossible. At the third test point, a resistance probe provides low-pass filtering and sharpens the display. The use of the low-capacitance probe at the video amplifier stage output minimizes circuit loading while allowing the technician to check for the proper amount of gain.

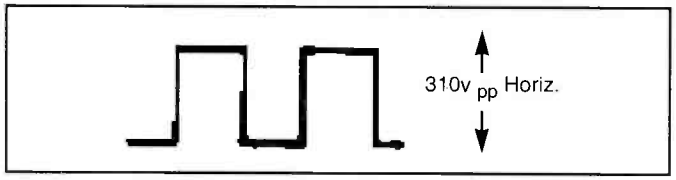


Figure 6. When checking the operating performance of the switching device in a switched-mode power supply, use the oscilloscope to evaluate the waveform at the base and collector of a switching transistor or the drain of a MOSFET. For scan-derived power supplies, the use of an oscilloscope to confirm that oscillation exists will save a large amount of repair time. The signal at the appropriate element of a switching device will resemble this square waveshape.

oscillator runs at either the same frequency, or a sub-multiple of the test signal frequency. Most oscilloscopes will offer the capability to simultaneously display and compare two or more traces.

Trigger controls

Referring to Figure 1, a trigger switch allows the user to select different sync sources for the control of the oscillator. An internal sync setting causes the oscillator to self-synchronize with a sample of the test signal. A line or 60Hz setting synchronizes the oscillator with the 60Hz cycle of the power line. An external sync setting provides the flexibility of connecting external sync sources directly to the oscillator.

Input coupling switches

The input coupling switches in the vertical control section of the oscilloscope front panel allow the selection of a coupling method from the test circuit to either input channel of the device. As Figure 1 shows, the coupling can be set to dc, ac, or ground. Setting the input coupling switch to the ground setting disconnects the signal from the oscilloscope's vertical circuit and displays the location of 0V on the screen.

Referring to Figure 3, setting the switch to dc coupling does not block either the dc or ac components of the test signal. As a result, the entire signal shows on the display. Setting the switch to ac coupling blocks the dc portion of the signal. As a result, the waveform centers on 0V and allows the display of large signals.

Vertical controls

The vertical controls allow the operator to vary the vertical position of the waveform, and to vary the size of the waveform on the display screen. As with the horizontal controls, the vertical controls scale the waveform to a viewable condition and size. General purpose oscilloscopes can accurately display signal levels from a few mV up to 40V. The vertical controls include the vertical position adjustment and the Volts/div control.

The Volts/div control

Sensitivity involves the capability of the oscilloscope to display the peak-to-peak amplitude of a waveform and is expressed as volts per division, or V/div. The voltage of any input signal can be determined by multiplying the number of vertical divisions along the Y-axis that are covered by the displayed signal by the V/div control setting.

If you display a $2V_{PP}$ signal on a 1V/div screen, the signal will cover two vertical divisions. Referring to Figure 4, setting the Volts/div control to 5V allows each of the vertical divisions to represent 5. As a result, 27.5 V_{PP} signal will cover five-and-one-half divisions.

Something else that must be considered, however, is the attenuation factor of the attached test probe. This factor influences the scale factor of the Volts/div control. To offset that influence, when making qualitative measurements, divide the Volts/div scale by the attenuation factor. In most cases, the oscilloscope will automatically adjust the scale factor to the attenuation factor.

Phase measurements with the oscilloscope

You can also measure phase of a signal with either a single-trace or a dual-trace oscilloscope. However, the dual-trace oscilloscope offers greater accuracy and the capability to measure the phase differences between complex signals that have different amplitude, frequency, and waveshape characteristics.

To measure the phase difference between two signals, measure the distance covered by one complete cycle of the reference signal. To find the phase factor, divide one cycle by the number of centimeters covered. If one 360° cycle equals 5cm, then 1cm equals 360°/5 or 72 degrees. In this case, the waveform as displayed on the screen has a phase factor of 72 degrees.

To find the phase difference of the two signals, measure the horizontal distance between two points on the waveform. For the reference signal and signal 1, the distance is approximately 0.33 cm. Then, multiply the distance by the phase factor to find the phase difference. In this case, the phase difference between the two signals equals: 0.33 x 72° or 23.76°.

Waveform analysis with the oscilloscope

The display characteristics of an oscilloscope allow the user to see the effects of circuit defects on signals. Many times, a technician can connect a square wave generator to a circuit, such as an amplifier, and check for different types of distortion. As an example, introduction of low-frequency hum combined with a phase shift will distort the shape of the square wave output of the circuit so that it resembles a trapezoid.

Oscilloscope probes

Because of the different types of signal and circuit conditions, oscilloscopes also utilize two different types of probes: passive and active. Regardless of the category, a probe acts as the interface between the oscilloscope and the signal source in the circuit being tested. Because the probe is an interface, it provides a good physical connection; a method for transferring an undisturbed signal to the oscilloscope; and a method for measuring without affecting the circuit conditions.

Passive probes act simply as a conductor to convey the signal of interest from the circuit being examined to the oscilloscope input. Active probes, on the other hand, provide their own amplification without loading the circuit or perform tests on a signal before applying it to the oscilloscope. These types of probes can solve problems, such as circuit loading or perform tests on signals, sending the results to the oscilloscope. The type of probe used depends on:

- the bandwidth and rise time of the oscilloscope;
- whether the test signal is a voltage, current, logic, optical, or mechanical signal;

• the type and amount of frequency content found within the signal;

• whether the impedance of the probe combines with the source impedance to create a new signal load impedance; and

• whether the impedance of the probe is greater than the impedance of the test signal.

All active probes require an external power supply. In addition, any measurement of a signal with an oscilloscope probe requires a connection to the probe tip and a connection to ground. Passive and active probes arrive with a ground clip that allows the grounding of the probe to the circuit under test. Because of this arrangement, the probe and oscilloscope share the same ground as the test circuit.

Attenuation factors

Generally, passive probes have some attenuation factor, such as 1X, 10X, or 100X, that balances the electrical properties of the probe against the electrical properties of the oscilloscope. A probe that includes an attenuation factor has improved measurement accuracy and minimizes the circuit loading that occurs at higher frequencies. The improved accuracy occurs through the addition of resistance to minimize the ringing caused by the capacitance of the test cable. As an example, an X10 probe has the effect of reducing capacitance by a factor of ten. However, any attenuation factor also reduces the amplitude of the signal seen on the screen by the listed factor.

As an example of the effect of the attenuation factor, a passive probe with 10X attenuation will hinder the display of signals that have a level of less than 10mV. Yet, a 1X probe that lacks the attenuation will allow the introduction of interference into the test circuit. Despite this problem, the probe with the lower attenuation factor works well for the measurement of weak signals. Many oscilloscopes have the capability for detecting the presence of a 1X or 10X probe and automatically adjust the display. Other oscilloscopes require the manual setting of the Volts/div control to accommodate the attenuation factor.

Probe types

A demodulator probe allows the observation of modulated RF signals by demodulating the signal before its application to the vertical input terminals. Rather than allow for the checking of the quality of the signal, demodulator probes show the presence of a signal. Other probes offer a built-in isolation resistor or a low-value capacitor to prevent the loading of the circuit under test. High- and low-impedance probes that contain various values of capacitors allow the testing of high- and low-frequency circuits. While attenuator probes include a range switch for the proper attenuation of an input signal, direct probes allow a straight-through connection to the test circuit.

Troubleshooting with an oscilloscope and probes

Each of these probes allows the technician to test circuit operation through signal tracing and the logical process of deduction. With this technique, a technician can follow the stage-by-stage progression of a signal and find the point where the signal weakens or disappears. Before attempting to troubleshoot a circuit using an oscilloscope and probes, always check the settings of the controls and compensate the probes.

Default settings for controls

Before using the oscilloscope for troubleshooting a circuit or component problem, always set the controls to standard positions. Some oscilloscopes have an AUTOSET or PRESET button that sets up the controls in one step to accommodate a signal. While the oscilloscope operator's manual will specify default settings, always:

- Set the volts/division scale to a mid-range position;
- Turn off all magnification settings;
- Set the input coupling to dc;
- Set the trigger mode to auto;
- Set the intensity control to a nominal viewing level; and
- Adjust the focus control for a sharp display.

Compensating the probe

The use of a passive probe during the troubleshooting process requires the compensation of the probe. When compensating a probe, you balance the electrical characteristics of the probe with the oscilloscope so that you receive accurate measurements. All this occurs through an adjustment of the probe and the use of a square wave reference signal. With the probe tip connected to the reference signal, you can adjust the probe until the displayed waveform is a square wave.

Troubleshooting examples

Schematic diagrams often show key test points for a circuit and the normal waveform and amplitude for the signal at that point. In addition, knowledge about the operation of particular stages also helps the technician to have an idea of what kind of signal he expects to find there. For example, a technician should know about the amount of gain expected from a stage. High-gain RF and video stages will have a higher amount of amplification than power output amplifiers.

Many times, the use of signal injection increases the chance for the accurate measurement of gain. While the changes in amplitude seen with normal operating signals may make the checking of a waveform difficult, an injected signal provides a steady signal source. With the signal injected at the input of the stage, a measurement can be taken at the stage output.

In the example shown in Figure 5, the demodulator probe is used to check for the presence of a signal at the first two test points. Because of the circuit loading and de-tuning caused by the demodulator probe, an amplitude measurement is nearly impossible. At the third test point, a resistance probe provides low-pass filtering and sharpens the display. The use of the low-capacitance probe at the video amplifier stage output minimizes circuit loading while allowing the technician to check for the proper amount of gain.

Using an oscilloscope to test the switched-mode power supply

Given the complexity of switched-mode power supplies, a wide-band oscilloscope becomes especially useful. When checking the operating performance of the switching device, use the oscilloscope to evaluate the waveform at the base and collector of a switching transistor or the drain of a MOSFET. For scan-derived power supplies, the use of an oscilloscope to confirm that oscillation exists will save a large amount of repair time.

The procedure for confirming the presence of oscillation requires that the TV set be connected to the power line through a variable transformer. Start by setting the transformer to 0V. In addition, remember that the repair procedure also involves working on the "hot" side of the iso-hot chassis. Always verify that the connections of the test equipment are attached to the proper ground. If you're using the oscilloscope to test a switching transistor, attach the oscilloscope test probe to the collector of the transistor. If testing a switching MOSFET, attach the oscilloscope test probe to the drain of the device.

Slowly increase the transformer output voltage while you monitor the shape of the waveform at the test point. The measured waveform should resemble the waveform shown in Figure 6. While increasing the transformer voltage, also listen for squealing noises. Any type of unusual noise indicates that other problems exist in the scan-derived power supply.

Purchasing an oscilloscope

Matching the correct oscilloscope to your service application is one of the more important test equipment decisions. Although all of us have concerns about costs, we should also recognize that the capabilities of equipment like an oscilloscope allow us to keep abreast of technological changes. Certainly, modern oscilloscopes offer a variety of features, such as built-in measurements, digital displays, and digital storage. However, the decision to purchase an oscilloscope should hinge on the capability of the equipment to perform fundamental tasks. In the case of oscilloscopes, the fundamental task is acquiring and displaying waveforms.

With that fundamental concept in mind, you can begin matching the waveform acquisition and display capabilities with your bandwidth, rise time, triggering, and capture needs. From there, you can consider specifications such as:

- Input impedance;
- The vertical-axis sensitivity;
- The horizontal sweep rate;
- Signal delay time;
- The ability to delay the sweep rate;
- The ability to display multiple traces;
- Multiple functions, and
- Warranty.

Each of these features adds to the cost of the oscilloscope and to the value the oscilloscope offers a service operation.

As soon as we mention digital circuitry and digital clock rates, the bandwidth and rise time needs of an oscilloscope begin to increase. A typical rule-of-thumb says that the oscilloscope bandwidth should exceed the highest expected frequency signal. As an example, an oscilloscope with a 150MHz bandwidth can accurately measure signal frequencies up to 150MHz. If higher frequencies exist in a test circuit, the measurements lose accuracy and become less predictable. Oscilloscope manufacturers recommend that technicians utilize oscilloscopes that have a bandwidth five times greater than the signal frequencies found in the circuit under test.

Moreover, the rise time of the oscilloscope should allow the precise measurement of the rise time of a waveform. For five percent accuracy, the oscilloscope should offer a rise time not more than three times faster than the rise time of often-measured waveforms. A need for two percent accuracy in rise time measurement changes the oscilloscope rise time requirement to not more than five times the waveform rise time.

It has been demonstrated mathematically that a digital pulse waveform, or any square wave, consists of an infinite number of sinewave components that have individual amplitudes and phases. Here, the importance of the relationship between oscilloscope bandwidth and rise time becomes most apparent. Using an oscilloscope with a large bandwidth and a precise rise time allows the clean display of the waveform and discloses any problems, such as ringing or overshoot. A low-bandwidth with a limited rise time oscilloscope will only show a clean pulse.

Along with vertical axis sensitivity, we also need to consider the horizontal sweep rate of the oscilloscope. Measured in seconds per division, the horizontal sweep rate is the amount of time required to move the oscilloscope CRT electron beam across the distance of one division. We can supplement the ability of the oscilloscope to acquire a waveform by adding the capabilities to magnify and delay the sweep. With sweep magnification, the oscilloscope magnifies the waveform by switching the horizontal amplifier gain. Delayed sweep, or triggering, allows the oscilloscope to capture and expand on the full rise time of a pulse. With this capability, a technician has the ability to magnify any portion of the waveform.

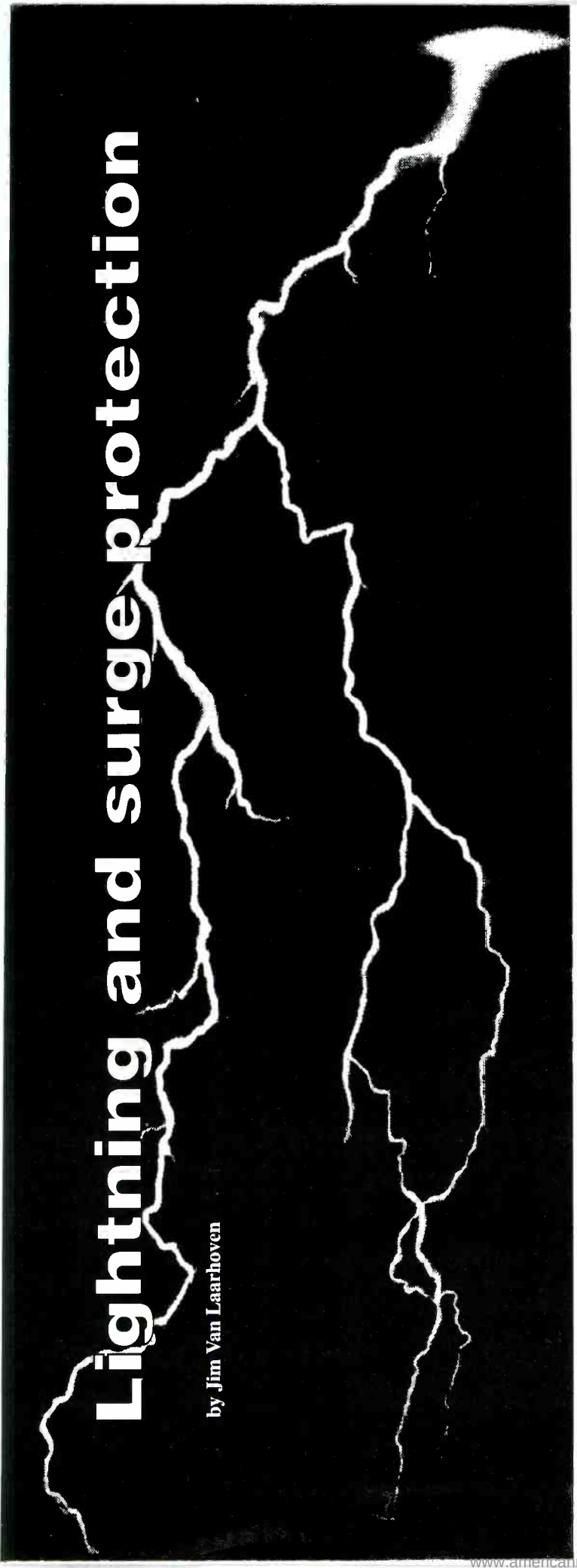
Along with the delayed sweep, another consideration when purchasing an oscilloscope is the number of acquisition channels needed for a particular task. For most service applications, a dual-trace oscilloscope provides a method for viewing and comparing the input and output signals at the same time. However, because most digital circuits have multiple inputs and outputs, four-channel oscilloscopes have become more popular.

The digital storage oscilloscope

The need to observe multiple signals may also lead to the purchase of a higher cost *digital storage oscilloscope* (DSO). With the DSO, a technician can store signals into digital memory and recall the signals later. This capability gives the advantage of viewing and comparing stored and real-time signals simultaneously. A feature once found only in digital storage oscilloscopes — peak detection — allows almost all analog, high-bandwidth oscilloscopes to capture and display fast moving noise spikes.

Along with those functions, other features such as automatic setup, store/ recall, and built-in measurement devices may make a higher-end oscilloscope a more attractive purchase. The automatic setup feature provides a method for the oscilloscope to automatically sense the characteristics of a waveform and adjust the display for the particular waveform. An integral part of the automatic setup feature called store/recall further automates the front panel setup by storing and recalling a large number of front-panel set-up adjustments for specific needs.

Measurement functions complement the waveform display by placing voltage and time measurements along the waveform. The voltage settings allow measurements of peak-to-peak values, negative peak values, and positive peak values. During operation, the voltmeter function automatically tracks the waveform and displays the needed readings. Along with the voltmeter, some oscilloscopes also offer a built-in counter/timer that shows measurements of frequency, period, width, rise time, and fall time. Like the voltage measurements, the counter/timer readings can match to any portion of the waveform. ■



Lightning and surge protection

by Jim Van Laarhoven

It is hard to imagine the amount of energy that relates to a billion watts; nevertheless, this is exactly the amount of power contained in a typical lightning strike. Three hundred million volts randomly seeking opposite polarity. The damage that lightning can do to a sturdy object in its path is devastating in itself, but the thought of that kind of power finding its way into delicate electronic equipment is more than alarming. It makes you wonder if it's even worth the effort to try to protect the equipment in the first place.

Fortunately, most surges are lower in magnitude than the one just described because the lightning strike occurred some distance away. In cases like this, when the magnitude of the surge is manageable, lightning and surge suppression is a very good idea and can save a TV or VCR from damage.

Researchers have been improving the technology of lightning and surge protection ever since the advent of the telephone and the supply of electricity to the general public. Early protection was crude, but the equipment it was safeguarding was not as complicated as the equipment of today. Lightning rods perched on high roofs with a simple cable leading to a grounding rod was about the extent of turn-of-the-century attempts at lightning protection (It is interesting that they still use this method today as partial protection from lightning damage).

The author, and the editors of **ES&T**, don't expect electronic servicing technicians to become experts on the subject of lightning and surge protection. And no one would expect a service technician to install a surge protective device in the power line ahead of the service entrance. But the potential for lightning damage to consumer electronics products is serious, and anyone who services them should be aware of the capabilities of these protective devices.

Characteristics of lightning

It may help to define a few characteristics of lightning before exploring how to protect your equipment from its harmful effects. Here is the course of events that must take place for lightning to be produced. A rain cloud will have a positively-charged top and a negatively-charged bottom. This negatively-charged bottom induces a positive charge on the earth below it. When the potential between the bottom of the cloud and the earth reaches a certain level, the air becomes ionized along a confined path and a lightning discharge occurs. The lightning really acts like the discharge of a giant capacitor: the bottom of the cloud being one plate and the induced positive charge of the earth being the other. There is still a lot of controversy over how clouds become charged in the first place. Some say that ice must be present in the top of the clouds before they can become charged and some say the opposite.

Studies show that a lightning bolt is really a combination of numerous discharges, each lasting about 0.0002 seconds. Since an average flash lasts about 0.25 seconds, it is figured that most of the flash is dead space between discharges. The human eye can not easily detect these dead spaces because it all happens in about a quarter of a second.

Lightning, for the most part, seems to be attracted to metal or tall objects. There are personal accounts that contradict this the-

Jim Van Laarhoven is an independent technician and consultant for computer based lighting.

ory, but one thing is for sure in our present understanding of lightning; it is nearly impossible to predict with any degree of accuracy where it will hit.

Lightning damage to electronics products

Technicians have seen many different types of damage that attest to what lightning can do to electronic circuitry. One shared observation is lightning's erratic behavior when it comes to selecting components to destroy. Entry and exit points of the overvoltage on a PC board are occasionally obvious, but the path of destruction frequently defies logic.

Bearing this random damage in mind, there are still some components that are more susceptible to harm than others. For instance, an IC chip can house over 100,000 memory bits and over 5,000 logic gates. Even if the lightning doesn't directly burn the chip, stray voltage from a spike can still damage it. Secondary damage from a lightning strike can also show up in the power supply. If components in the unit are shorted when the power is turned on, the power supply could be damaged as a result. Further damage to the printed circuit board may also occur at this time.

Protecting devices connected to the power line

Given that consumer electronics products are highly susceptible to lightning damage, it makes sense to consider spending a little money to try to prevent, or minimize, such damage. That means buying and installing surge suppression equipment somewhere between the electronics products and the power line.

When purchasing suppression equipment, redundancy can be a deciding factor. For example, you may have an uninterruptible power supply with transient suppression already built-in; however, you may consider adding more protection to the supply voltage starting at the electrical service entrance.

Units are available that can protect an entire electrical service to a house or business (Figure 1). These units are customarily rated in pulse transient energy; either in joules, or in wattage and will state response times along with peak protection. A standard response time is less than 1nsec. The closer you install the suppression equipment to the electrical panel, the better the protection. For added safety, you can also buy surge suppression outlets that plug into standard duplex receptacles.

Other conduits for power surges

Telephone, data, and coaxial cables are prime points of entry for lightning-induced surges. When a modem fails to respond or data is garbled, there's a good likelihood that a surge is the cause. All configurations for telephone and data surge protectors are available and relatively easy to install (Figures 2 and 3). Coaxial cables sometimes come with a separate grounding wire that runs along the outside of the outer sheathing. This grounding wire can be attached to a separate grounding rod where the cable enters the building. This is good protection in itself, however a separate surge suppressor at the splitter or at each termination may be a favorable addition (Figure 4). The damage that could happen to TVs, VCRs, satellite receivers, and cable interfaces without protection might justify this cost.

Gas tubes

Another component in surge suppression is the gas tube (Figure 5). These tubes incorporate a gas-filled gap that offers high resistance to regular operating voltages. When the voltage becomes high enough, it starts conducting and shunts the over-voltage safely to ground.

Gas tubes are slow, but can handle high voltages well. These tubes are commonly used to protect data lines, but the clamping voltages are usually too high for use on modem or computer ports. The electric company uses them on their distribution lines to shunt over-voltage to ground.

Early streamer emission

One more region of protection is early streamer emission (ESE). This technology owes its beginnings to the lightning rod. Many companies manufacture this product, but the principles are the same. The unit's electrodes start gathering energy from the surrounding electrical field that precedes a thunderstorm. This energy is stored and then released when the surrounding electrical field increases suddenly (this sudden increase means lightning is about to strike). The release of this stored energy causes lightning to be attracted to the ESE unit, making it the most likely target for a strike.

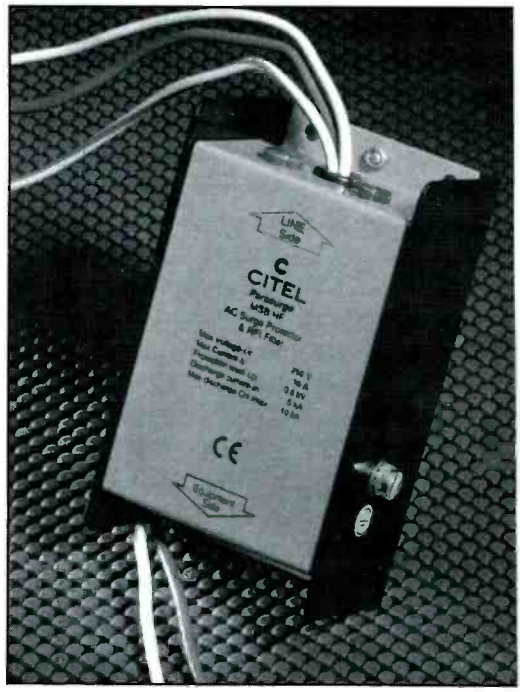


Figure 1. Surge suppression devices are available that can protect an entire electrical service to a house or business. The closer you install the suppression equipment to the electrical panel, the better the protection.

Grounding systems

Grounding systems play an important role in lightning and surge protection. They offer an excellent path of least resistance for stray current to reach the earth. These bare (generally they are bare, but sometimes are insulated green) copper conductors carry no current unless a fault occurs. This wiring is bonded in a continuous manner to all of the building's metal equipment and plumbing. If for any

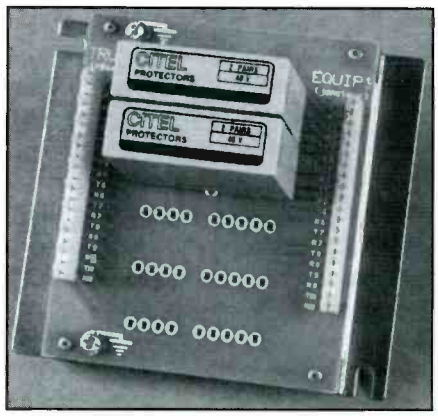


Figure 2. This type of surge protection device can provide protection for a number of telecommunications and data communications devices connected to telephone lines.

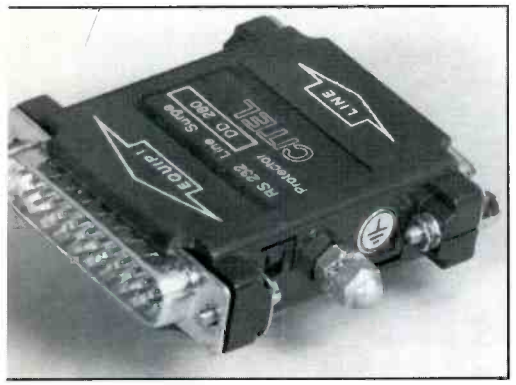


Figure 3. This RS-232 surge protector is designed to protect all lines of a parallel computer connection.

reason current is applied to these conductors, it will either travel to ground or trip an electrical breaker.

In a situation such as a lightning surge, the grounding system can be bad news and also good news. The bad news is that it is a common way for lightning to enter a building. The good news is (as mentioned earlier) it offers a good path to ground. This is provided that the grounding system has a low resistance connection to the earth. Standard grounding rods are usually made of galvanized steel. They are about eight feet long and about 5/8 inch in diameter. These rods normally are sufficient, but not optimum. Grounding rods can be purchased made of copper-coated steel, in lengths of ten feet, and in a diameter of about 3/4 inch. These rods are far superior to their galvanized counterparts. The resistance of the copper rod is lower because its copper-coating conducts better than the galvanized coating of the smaller rod. In addition, the increased surface area of the larger rod allows more earth to come into contact with it. The increased surface area of the rod, added to the copper's excellent conductive ability, will decrease the total resistance of the grounding system. In relation, lightning and surge faults will then find an easier path to the earth.

Figure 4. Coaxial surge protectors, such as these, provide protection to devices that are connected to coaxial cables entering the house, such as CATV cables, antenna cable, and cables from satellite receiving dishes.

A typical inspection/installation

Starting with the exterior of a house, let's take a look at what's involved, step-by-step, in the installation of a surge protection system. We will also examine the existing grounding system. For reference, this house has a personal computer, TV, VCR, satellite system, stereo, and telephone/answering machine.

Let's begin at the electrical meter. From the meter location, you should be able to look down and see the grounding rod. Using an ohmmeter, attach one end to the copper conductor exposed at the grounding clamp and the other end to the grounding rod. Your reading should be around 1Ω or less. If this resistance is higher, check to see that the grounding clamp is free of corrosion or damage. Replace the clamp if necessary. You may decide at this time to add another copper grounding rod to be on the safe side.

Next, find the telephone interface box. There should be a grounding wire coming from this box to either its own grounding rod or the rod you have just inspected. Examine it to make sure this wire is free of damage and corrosion.

The satellite dish will be the next stop. Make sure the grounding wire from the dish has a good grounding source as you did with the telephone. In addition, it wouldn't hurt to perform a resistance measurement from the dish to ground.

Check around the house to see if it has an antenna. If it has, installing an antennae surge protector would be wise. Be sure to inspect grounding sources there also.

Installation of a power-line surge protector

The next step will be installation of a surge protector at the main electrical panel. This procedure should be performed by a licensed electrician. For starters, most likely local and national electrical codes will require that this be done by an electrician. And it's just one of those things usually best left to someone trained and licensed to do it. Panel mounted surge protectors are generally

If you're planning a move in the near future, don't risk missing an issue of **Electronic Servicing & Technology.** Please give us 6-8 weeks notice if you're planning on changing your address. Just send us your new address WITH YOUR SUBSCRIPTION MAILING LABEL, to:

Electronic Servicing & Technology
25 Newbridge Road
Hicksville, New York 11801
Phone: 1-516-681-2922
For Faster Service
FAX: 1-516-681-2926

wired directly into a two-pole breaker inside the panel. The size of this breaker will be determined by the manufacturer's specs that come with the surge protector. Typically, the surge protector will have LED's to show that both legs of the single-phase system are being protected. If you do contract with an electrician to perform this work, they can cooperate with the power company to install a second surge protector that is incorporated into the outside meter. This is not a common installation, but it is available.

There is another lightning protector available that inserts into a half-inch knockout in the electrical panel. It is wired directly to a two-pole breaker and has a one-time use. It is easy to tell when you need to replace this type, because a black-tar substance ordinarily starts oozing from its plastic seams. This unit is probably familiar to you already; it has been available for many years.

The computer

Now, on to the home office, and the computer. An uninterruptible power supply (UPS) would be a good idea in this location, however money may be an issue. Just the same, a combination telephone/outlet wall mount suppressor would work well here.

The entertainment center

Our next install area is in the living room, where the entertainment center is. The TV, VCR, satellite system, and stereo are all placed closely together and there is plenty of room behind the center for you to hide the suppression equipment. This is another area that could use a combination suppression unit. The unit that I recommend has six outlets, two in/out coaxial fittings and two in/out telephone jacks. This should cover all of the equipment and leave a couple of outlets for future use. These combination units come in an amazing assortment of configurations to suit almost any need.

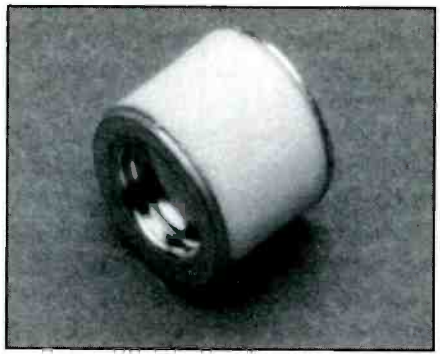


Figure 5. Gas tubes incorporate a gas-filled gap that offers high resistance to normal operating voltages. When the voltage becomes high enough, it starts conducting and shunts the over-voltage safely to ground.

Telephone answering machine protection

There is only one more room left to protect and that has a telephone/answering machine in it. Again, the use of a wall mount telephone/outlet combination might be a good idea here. That finishes the lightning and surge suppression install for this house.

Each installation is different

Each installation will be different, as with the suppression equipment used. The amount of lightning and surge suppression equipment available on the market is astounding. Some companies cater only to computer applications and others carry a full line of suppression products.

Devices that use technology, like that of early streamer emission, prove that the industry is evolving. However, concentrated research needs to be completed to find more ways to control the ill effects of lightning. It is an immense undertaking, but nevertheless, a worthy one. ■

New Consumer Electronics Technologies

by the ES&T Staff

Walk into any consumer electronics/appliance discount store these days and look around. The variety of products is truly amazing. The introduction of these products over the past couple of decades, starting with VCRs and CD players, has truly been a flood. And there doesn't seem to be any letup in the flow.

For instance, it seems that everyone these days has a cellular telephone to his ear. No one is talking to the people around them. They're on the phone to someone who may be many miles away.

Then there are computers, peripherals, and networks. These days, the computer literate consumer doesn't have one computer in her home; there are two or three. And where there are two or three computers gathered together, the urge to network is overwhelming. And the manufacturers have obliged. Today, it's possible to network several computers using cabling specially-designed for the purpose. It's a good way to go, and many consumers have opted to network in that traditional manner.

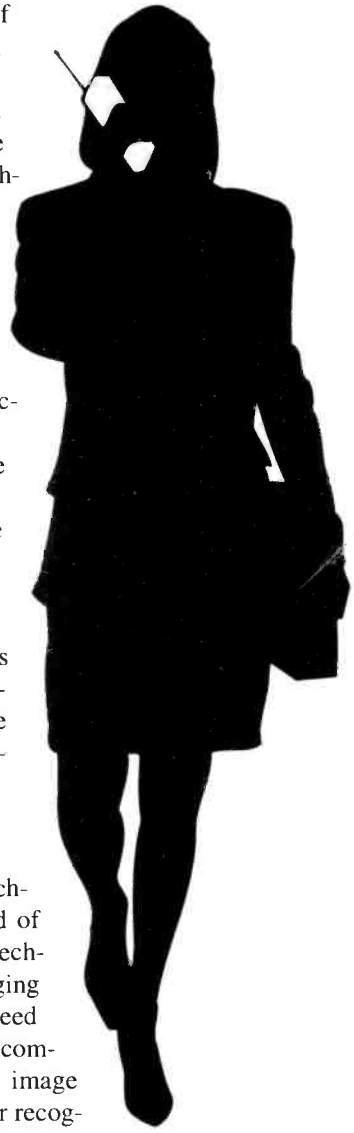
But networking computers in that way can be costly; you have an expert pull new wires. So innovators have come up with several other ways to establish computer networks: telephone line, power line, and rf. Yup, that's right, you can connect your main personal computer to an rf box, then do the same with your laptop, then go out on the patio, and while you're sitting by the pool drinking lemonade, you can be accessing files from the hard drive of your desktop computer that's sitting inside on your desk.

But so much innovation is going on in the area of consumer electronics, it's hard to keep track of it. This article will explore a number of new products/technologies that have been introduced in the last few years in an effort to help keep readers abreast of developments in their field.

A "highlighter" that grabs text

C Technologies AB (C Tech), a privately-held company based in Lund, Sweden, is a developer of handheld computers based on advanced imaging technology. Founded in 1996, C Tech's emphasis is on developing technologies that foster the resources available for improving the efficiency, cost, and intelligence of handheld computing devices.

The company is the brainchild of founder Christer Fahraeus. In 1995, while working on a Ph.D. in neurophysiology, Fahraeus first envisioned the idea for C Pen, the company's core product. While using an ordinary highlighter to spotlight important information, he realized that he could merge digital camera technology with a powerful processor using neural networks for image processing to create a radical new technology. In essence, he conceived of an electronic highlighter.



C Tech plans to establish C Pen in the global marketplace. Already with established market demand in Europe and Scandinavia, C Pen will soon be a recognized brand name around the world for pocket-sized computer-related devices. C Tech products will be available through an international network of distributors, with the manufacturing and logistics outsourced to specialists.

The technology

In their efforts to lead the way in technological innovations within the field of information gathering, C Tech's "See technology" provides the method of merging digital camera technology with high speed handheld computing. This technology combines powerful neural network-based image processing and OCR (optical character recognition) techniques.

"See technology" makes it possible to capture printed text, pictures, and data using a handheld computer small enough to fit in the palm of your hand. This technology also makes it possible to enter text into the application by hand, using the device as a normal pen.

For users, this means the end to having to highlight information and then retype it back into a PC. The C Pen will make gathering information and putting it to use faster than ever before, musts in the Internet age.

C Tech uses the latest technology, including the Intel StrongARM processor, in order to increase processing power, optimize memory utilization, and minimize power consumption, while still keeping the product very small. C Tech has developed an environment, using new technology, such as the Active X and COM standards, enabling users to access the contents of C Pen as if they were accessing a standard Windows file.

C Tech has developed a proprietary operating system for the C Pen, designed to optimally combine images and image processing. The operating system is compatible with Windows 95/98 and NT, and C Tech plans to open its operating system, making it possible for third parties to develop and run application software.

Products

The C Pen is a Personal Digital Assistant that reads, stores, processes, and transfers printed text cordlessly to any PC. By utilizing mobile computing and OCR technologies, C Pen changes the way we capture information.

This pen-shaped device functions as a mobile information collector. By simply moving the pen over printed text, as if highlighting, the information is scanned through an integrated digital camera. The scanned images are then transformed into computer-readable text by an OCR-system, which stores the information as an editable text file in the C Pen. The file can then be transferred to a Windows 95/98, or NT-based PC, mobile telephone via a built-in infrared (IrDA compatible) port.

The C Pen also can run specialized applications, such as an address book, and provide translation services, a must for the international business traveler. In addition, users can download files into the C Pen and then upload them to another.

Weighing just over 5 ounces, this pocket-size device is useful for gathering information from anywhere at anytime. Business professionals, researchers, lawyers, doctors, students, or average consumers will no longer need to put pen to paper, cut information from magazines, books, or papers, pay for copies and scanners, or carry a PC whenever they need to compute away from their place of work.

C Pen comes well-equipped with 2 MB of flash memory, allowing for storage of approximately 100 pages of text. C Pen reads and collects printed text (sizes 7 to 18 points) at approximately 100 characters per second. Indeed, the C Pen allows real-time image processing, which allows, for example, images to be processed into readable sentences, from overlapping originals. Address book functions comes free of any additional charge with the C Pen 200.

For more information on C Pen, visit the company's website at <www.cpen.com>.

Home networking technology

IBM has announced the introduction of its Home Director home networking solution. According to the manufacturer, this is the first effort of its kind by a major technology company to deliver a complete home network controlled from a PC or television screen. IBM and its partners in the home construction industry are now delivering this leading-edge technology to new homes throughout the United States.

Through implementation of the new Authorized Home Systems Integrator program, IBM has developed a unique distribution channel that provides local installation, service, and support for Home Director systems. Combined with the innovative design of the Home Director solution, the average home buyer is now able, for the first time, to purchase a home networking system that is customizable for their needs — yet does not require a special hardware configuration.

"In developing Home Director, we looked at how traditional home systems were being installed and identified the key aspects that deliver the greatest benefits to home owners," said Mary Walker, General Manager of IBM Home Networking. "Prior to Home Director, systems with similar capabilities were created on an individual basis with little standardization and often required significant technical knowledge to operate. IBM has not only created a system with improved reliability through a pre-fabricated solution, but also a system that is flexible and designed with the average home owner in mind."

Home Director integrates the functions of household systems, including security, lighting, heating and air conditioning, network-enabled PCs, and PC peripherals, such as printers, modems, and storage. This functionality enables a multitude of activities; from turning off a light left on by the children at the other end of the house to using the arming of the security system to activate a routine that will turn off lights and adjust the thermo-

stat. All controlled through a simple, easy-to-use interface on any television or PC in the home.

The Home Director system consists of two key components: the Home Network Controller and the Home Network Connection Center. The Home Director system is an intelligent home networking and control solution that uses the power of the Home Network Controller and the connectivity of the Home Network Connection Center to facilitate communication between the various systems that exist in the average home. Connecting these systems through the Home Network Connection Center gives the homeowner up to 16 separate video feeds, a local area network for up to four PCs, up to four separate telephone lines, lighting control through the existing power lines, video monitoring through up to four remote in-home cameras, and control of intelligent devices through low-voltage wiring.

In order to ensure consistent installation and service for Home Director home networking Systems, the manufacturer has developed the Authorized Home Systems Integrator Program. To become an Authorized Home Systems Integrator, companies and individuals must meet qualification requirements developed by IBM, receive training from them, and agree to act as a local installer, integrator, and service representative for Home Director. Presently, IBM has authorized integrators across the country and is in the process of broadening this base.

In addition, the company is working closely with many builders and developers across the United States to help develop communities that will use this system. As part of this endeavor, the company is helping to define the technology infrastructure that will connect Home Director homes to their surrounding communities. Complete communities of this nature are expected to start appearing in the near future.

Although initially targeted at the new home construction market, Home Director can be retrofitted into most existing homes. For more information, visit the Home Director website at www.ibm. com/homedirector or call 1-800-426-7144.

Key features

• Home Network Controller — Functioning as the "brains" of the home, the Home Network Controller takes data currently available from common home systems and makes the information meaningful. For example, the simple function of disarming your security system can trigger lights to go on in the house as the homeowner enters and adjust the thermostat to an energy-saving level.

• Home Network Connection Center — Integrates the home's data, voice, fax, and video wiring in one central location.

• Remote access through a modem-to-modem dial-up connection.

• Intelligent lighting with controllable Dimmer Switches that do not require additional wiring.

• Wireless Remote Control allows homeowners to interface with Home Director through their television to change routine settings, such as when to begin the morning wake-up scenario.

• Security interface which enables Home Director to communicate with the home's security system.

• Heating, ventilation, and air-conditioning (HVAC) control kit includes programmable thermostats and HVAC controllers to allow for increased energy management in the home.

Frequently asked questions

Q: What is Home Director?

A: Home Director is a home network solution that uses the power of a dedicated processor to connect and control the common systems that exist in the modern home, including security systems, lighting, HVAC, in-home cameras, communications, and PCs.

Q: What is the purpose behind Home Director?

A: To change the nature of home control and computing by transforming stand-alone systems into a network of valuable information appliances that add quality, convenience, and safety to consumers' everyday lives; ultimately the linking of intelligent communities. Home Director also brings technology previously reserved for the wealthy to a new category of home buyer.

Q: What is IBM's definition of home networking?

A: Home Networking is the linking of the various systems in a home in a way that adds connectivity, convenience, and security to a family's life. By linking these systems together, a home network allows each system to integrate with the others, eliminating stand-alone devices and creating a more powerful technology package. Reaching beyond the concept of home, home networking can be expanded to include such things as community Intranets and local services.

Q: What are the key benefits of a home network?

A: By creating a way for the various systems in a modern home to communicate, a home network provides connectivity, convenience, and security. A residence powered by Home Director provides homeowners with an intelligent link between commonly available home systems, such as security, lighting, and HVAC systems. For example, as you leave for the day, by simply arming the security system, you can activate a routine that will turn off lights and adjust the thermostats to an energy saving level.

Q: Many people in the industry are talking about home networks. What makes Home Director different/superior?

A: When people in the industry discuss home networks, they are often referring to PC to PC connectivity in the home. Home Director provides a true home network. It goes beyond limited functionality and allows many common systems in a home to interact with one another. Home Director's open architecture is designed to work with an almost unlimited number of disparate systems that are available today and for the foreseeable future.

Q: How is this product different from the Home Director product you introduced into retail stores last fall?

A: The Home Director retail product is targeted at the "do-it-yourself" homeowner who owns a personal computer and has a desire to automate their home. The retail product is a much less complex sys-

tem that allows consumers to control various home lights and appliances through their PC, using a combination of customized software, hardware modules, and existing X10 technology that communicates over a home's existing wiring.

Internet sharing device

IBM has introduced Internet Distribution Center, a home networking application that works with their Home Director system to provide simultaneous Internet access to multiple home personal computers easily and cost effectively.

"As the number of multiple-PC households grows, so does the frequency of instances where more than one family member wants to use the Internet at the same time," said Mike Braun, General Manager, IBM Consumer Division. "Our goal is to make it as easy as possible for consumers to enjoy the benefits of computing in the new connected world. Reflecting this focus, our new Internet sharing device eliminates the hassle and cost of getting multiple phone lines, and instantly resolves an increasingly common household conflict."

Web Point is the company's first Internet sharing product and is designed to work with any Home Networking infrastructure. By making it even easier to configure an Internet access account and share that data throughout the home, consumers no longer have to worry about continually updating their PCs with new ISP information. While initially available for a wiring platform that utilizes the Home Network Connection Center, the company intends to make the Web Point operational across other home networking infrastructures as they become reliable enough to meet the company's rigorous Home Networking standards. These include the emerging Home PNA technologies that use existing phone lines to transmit data and the new Home RF standard. In addition, Web Point has been designed to work with upcoming Internet appliances — such as Internet phones — making it possible to access the Internet without a personal computer.

Home networking via telephone wires

The leading computing and communications companies have announced the formation of an alliance to help deliver easy-to-use, affordable, high-speed home networking solutions over existing telephone wires. The group, called the Home Phoneline Networking Alliance (HomePNA), includes founding members 3Com, AMD, AT&T Wireless, Compaq, Epigram, Hewlett-Packard, IBM, Intel, Lucent Technologies, Rockwell Semiconductor Systems, and Tut Systems. HomePNA's immediate mission is to accelerate the development and marketplace introduction of a home networking specification. Member products should be available now.

"In the business world, the real power of the PC revolution was unleashed only when PCs were networked together. The goal of HomePNA is to extend that revolution into the home," said Rod Schrock, Vice President and General Manager Consumer Products Group, Compaq Computer Corporation. "But since most households don't have a system administrator, a successful home networking specification has to be simple, foolproof, and inexpensive. The members of HomePNA have stepped up to that challenge."

According to Dataquest, during the summer of 1998, more than 15 million homes in the U.S. had two or more PCs and analysts expected this number to double over the following two years. Jupiter Communications projects that in addition to PCs, more than 15 million information appliance products will be purchased in the next five years. The need to share Internet access, digital information, and computing resources among personal computers and other information appliances will spark consumer demand for a home networking solution.

"This Alliance has really done its homework, bringing together industry leaders representing all facets of the home PC and networking space," said John Coons, Director/Principal Analyst, Dataquest. "As a result, consumers can implement solutions quickly and with confidence that the solutions will still be around tomorrow."

Benefits of home phoneline-based networks

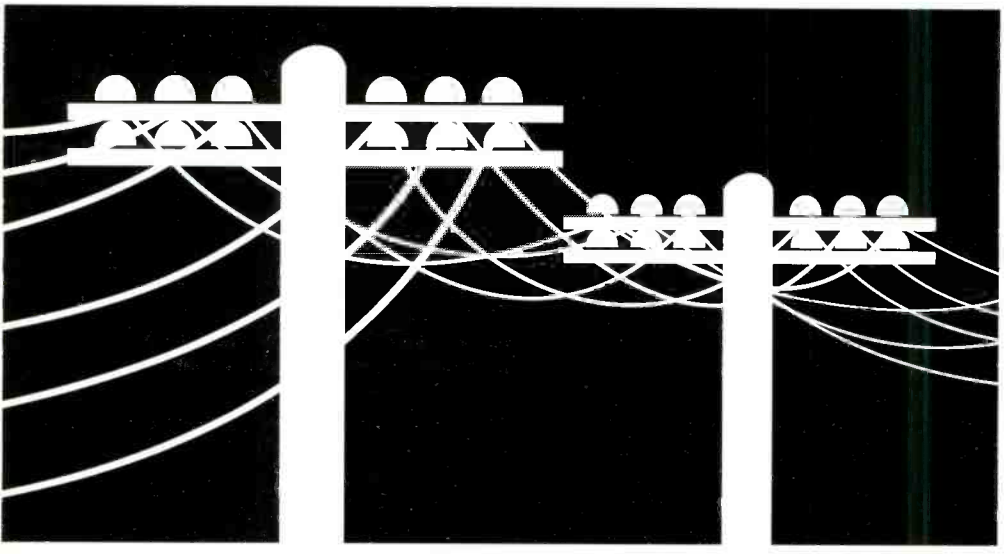
The benefit of home phoneline-based networks is a simple, cost-effective, and proven solution for consumers that requires no costly or disruptive rewiring of the home. The phoneline network utilizes existing telephone wiring to connect computers and devices without interrupting phone service.

Home phoneline networking will work with existing Internet access technologies, such as V.90, ADSL, or cable modems.

Key applications enabled by home networking include shared Internet access, shared data and applications, shared peripherals (printers, scanners, modems, digital cameras, storage devices, etc . . .), and multi-player gaming.

HomePNA will develop specifications for creation of industry-wide standards. The Home Phoneline Networking Alliance has adopted innovative and proven networking technology from Tut Systems that allows home networks to operate over telephone wires at 1Mbit/s.

The Home Phoneline Networking Alliance is also currently working together to develop future specifications — already under development — for even higher speed home phoneline networks. Building upon the 1Mbit/s network specification, the second generation of high



speed home networks is targeted at 10 Mbit/s and more and is expected to be available mid-999. It will be scalable and backward compatible, and will also be interoperable, allowing for simultaneous communication of voice, video, and data.

To promote the proliferation of these solutions, HomePNA will provide field certification and interoperability test suites and will serve as a forum for technological and consumer issues. Certified products will be eligible to use the HomePNA brand logo and marketing programs. HomePNA will work closely with industry standards committees, such as the Institute of Electrical and Electronics Engineers (IEEE) and the International Telecommunications Union (ITU) for submission and adoption of the specifications as the industry standard.

About the Home Phoneline Networking Alliance

The Home Phoneline Networking Alliance is an association of industry-leading companies working together to help ensure adoption of a single, unified phoneline networking industry standard and rapidly bring to market a range of interoperable home networking solutions.

Founding members of the organization include: 3Com, AMD, AT&T Wireless, Compaq, Epigram, Hewlett-Packard, IBM, Lucent Technologies, and Rockwell Semiconductor Systems.

Wireless communications specification for the home

Leading companies spanning the personal computer, communications, and consumer electronics industries have formed a working group that will develop a specification for wireless communications in the home. This specification will allow personal computers, peripherals, cordless telephones, and consumer electronic devices to communicate and interoperate with one another.

The Home Radio Frequency Working Group (HRFWG) has published the open specification for home wireless communications, called the Shared Wireless Access Protocol (SWAP).

The HRFWG is led by core members Compaq Computer Corporation, Ericsson Enterprise Networks, Hewlett-Packard, IBM, Intel, Microsoft, Motorola, Philips Consumer Communications L.P. (PCC), Proxim, and Symbionics, and supported by Butterfly Communications, Harris Semiconductor, Intellon, National Semiconductor, Rockwell Semiconductor Systems and Samsung Electronics America.

The HRFWG's goal is to provide the foundation for a broad range of interoperable consumer devices by establishing an open industry specification for wireless digital communication between PCs and consumer electronic devices anywhere in and around the home. The HRFWG believes that this specification will accelerate the development and adoption of wireless communications in the home. To date, the adoption of networking technologies in the home has been inhibited by the high cost and impracticality of installing new wiring, and multiple, incompatible wireless communication standards.

"We believe that by establishing a wireless communications specification for the home, a new industry will be created that results in unprecedented interoperability between intelligent devices in the home," said Ben Manny, chairman of the HRFWG and engineering manager for

residential networking at Intel's Architecture Labs. "For example, with Home RF technology, users will be able to spontaneously access their PCs from anywhere in the house or yard."

"The fact that these leading companies are driving a common specification for wireless communications in the home is extremely significant," said Brian Cotton, industry manager for Wireless Communication, Frost & Sullivan. "Ensuring interoperability will make it possible for companies across these industries to offer a broad range of high volume, cost-effective consumer products and solutions."

Shared Wireless Access Protocol (SWAP)

SWAP, the Shared Wireless Access Protocol, defines a new common interface specification that supports both wireless voice and data services in the home. Because of the numerous and diverse natures of companies and products within the PC, telecom, and consumer electronics industries, the SWAP specification is critical to ensure that the myriad of products are interoperable. Some examples of what users will be able to do with the availability of products that adhere to the SWAP specification include:

- Set up a wireless home network to share voice and data between peripherals, PCs, and new devices such as portable, remote display pads
- Review incoming voice, fax, and e-mail messages from a small cordless telephone handset
- Intelligently forward incoming telephone calls to multiple cordless handsets, fax machines, and voice mailboxes
- Access the Internet from anywhere in and around the home from portable display devices
- Activate other home electronic systems by simply speaking a command into a cordless handset

HOP technology brings wireless networking to the home

Alation Systems has announced the availability of HomeCast Open Protocol (HOP), an innovative wireless home networking technology that uses radiowaves to connect multiple computers to the Internet. Now shipping in Diamond Multimedia's HomeFree Wireless, HOP lets multiple home computer users simultaneously share an existing Internet connection — without any wires or additional phone lines for less than $100 per computer. Designed for ease-of-use, the Diamond HomeFree product allows users to connect computers within a range of 150 feet from each other.

With household second PCs costing less than $1,000 being set up for children, laptops coming home from work, and an increasing demand for Internet access by several family members at a time, many homes end up with two or three computers. Typically, only one PC is connected to the Internet and the printer. HOP technology allows households to simultaneously surf the Web — even sharing a single Internet account — as well as use a printer connected to a different PC, or even play multi-user computer games.

"Alation's goal was to use technology to bridge the gap between what people had and what they really wanted," said the company's CEO Geoff Zawolkow. "Then we had to make it simple, easy, and reliable, so that we were simplifying people's lives. With HOP, we have created consumer-level networking."

Easy to install

HOP technology lets consumers quickly and easily create a home network for Internet, printer, and file sharing without having to install new phonelines or buy additional Internet accounts. With Diamond's HomeFree Wireless home network product, powered by HOP technology, set up is as simple as inserting a card and running software. A single add-in card is used in each computer.

"HOP is a state-of-the-art consumer wireless technology that enables the sharing of Internet access, peripherals, and networking gaming," said Jim Cady, General Manager of Diamond Multimedia's Communications Division. "By integrating HOP technology into our home networking solution, the HomeFree Wireless, we can offer consumers a high-performance wireless product that is affordable and easy-to-use."

Around the home

Setting up a HOP network is extremely easy, and using one is even easier, says the company. HOP products use the networking capabilities already in Microsoft Windows 95 and Windows 98, which ensures users do not need to learn another piece of software for things like transferring files from one computer to another.

HOP allows HomeFree Wireless users to "see" each other over the network when they click on the "Network Neighborhood" icon on their Windows desktop. Each user creates a name for his computer, such as "Dad's Machine."

Household members can then see the other computers on the HOP network by the name selected; and they can trade files, send e-mail, or play online games. With the HOP network, everything is connected and shared. This way, if one computer is hooked up to the Internet, then everyone else on the network can share that same Internet connection and surf the Web — even at the same time.

Expensive computer peripherals, like printers, scanners, CD-ROM drives, and fax modems, can all be shared. For example, one user could print a document on a printer in a different room or connected to a different computer.

The future

Today, HOP solves the problem of multiple computers in a home needing to share a single Internet connection. In the future, other types of devices could become HOP-powered and could share in the HOP wireless information network — next-generation televisions, telephones, hand-held computers, electronic organizers, stereos, electronic books, and other devices. Internet radio stations, for example, could play on the stereo, or users could download movies and video clips from the Web and play them on the television.

At the heart of HOP technology is an advanced radiowave technology that passes through floors, walls, and ceilings, linking HOP-powered computers at distances of up to 150 feet from each other. HOP provides throughput speeds of up to 1 megabit per second (over thirty five times the speed of the average household Internet connection itself).

About HOP

Through its HomeCast Open Protocol (HOP), Alation Systems is leading the charge to establish an open method for networking computers and the Internet in the home without wires or extra phonelines. HOP-powered computers and consumer devices can connect with each other through radiowaves at a rate of 1Mbps — about 35 times faster than a 28.8 kbps modem. The innovative, cost-effective HOP technology was developed in 1998

as a method to bring the convenience and ease of wireless networking to consumers. HOP is currently available as part of Diamond Multimedia's HomeFree Wireless product. For more information about HOP and home networking, visit the Alation website at www.alation.com. The web site for Diamond Multimedia is www.diamondmm.com.

Telephone wire network for computers

Diamond Multimedia also offers a HomeFree Phoneline solution to its line of home networking products for PCs. The product uses existing home phonelines to link multiple PCs for the sharing of Internet access, printers, and other peripherals, as well as to support networked multi-player gaming. The new product incorporates AMD's PCnet Home networking controller. It is Home Phoneline Networking Alliance (HomePNA)-certified and carries the HomePNA logo to ensure full compatibility with other standardized phoneline networking products. The product is standards-based and utilizes the existing phonelines within the home to deliver

"The PCnet-Home controller incorporates the hardware and software functionality required to make cost-effective home networking a reality," said Dr. Laila Razouk, vice president of AMD's Network Products Division. "By utilizing AMD's HomePNA networking controller in the new HomeFree Phoneline product, Diamond Multimedia is well positioned to be one of the first to market with an affordable, high-performance, easy-to-setup networking solution which uses a home's pre-existing phone wiring."

Home PC networking is poised for growth

The advent of PCs that sell for less than $1,000 is expected to continue to drive the growth of multiple-PC homes as consumers purchase second and even third PCs. In fact, some market observers believe multiple-PC homes are growing faster than single-PC homes in North America. Home networking solutions, such as the HomeFree Phoneline product, enables consumers to share their PC resources, potentially saving hundreds of dollars per year through sharing PC peripherals and ISP accounts. The deployment of higher speed broadband Internet connections to the home, via cable or DSL modems, is expected to further drive home PC networking as consumers seek to share faster, but more expensive, Internet access.

Voice and data share existing phonelines

The HomeFree Phoneline product does not require the use of any new wires. The product simply plugs into a standard RJ-11 telephone jack so that it can use existing phonelines. The HomeFree Phoneline product enables the simultaneous operation of telephone service and home networking over the same phoneline system already installed in most North American homes. By using a unique frequency range, the product avoids conflicts with telephone calls and other phone services.

Share internet access, peripherals, and more

The HomeFree product includes WinGate Home 3.0 Internet sharing software from Deerfield.com that enables multiple users to simultaneously access the Internet by using a single phoneline and ISP (Internet Service Provider).

"WinGate software allows consumers to fully leverage a single connection to the Internet," said Mike Deerfield, CEO of Deerfield.com. "It's a perfect complement to the HomeFree Phoneline networking card and provides a tremendous value by consolidating Internet resources."

Additionally, HomeFree Phoneline can be used to transfer files and share peripherals, such as printers, modems, scanners, and Zip drives. Multiple-PC homes are increasingly expected to network their PCs over the coming years in order to save money by sharing peripherals and Internet access. Moreover, using this product, consumers can also enjoy networked multi-player gaming at home.

Mobile multimedia integrated system platform

Alpine Electronics of America, Inc., announces products for a system they call the Mobile Multimedia, which integrates the company's audio, security, and navigation products, as well as its new visual and communications tools.

The key to this platform is the flexibility and ease-of-use of the existing line of components. Consumers can build upon the core multimedia product, by expanding and adding compatible components to create a complete multimedia system in the vehicle. Should the consumer not want the multimedia fully integrated system in their vehicle, all of the products function and perform as stand-alone systems.

Navigation: The Navigation and Information System is an advanced in-vehicle GPS (Global Positioning Satellite)/CD-ROM computer with an LCD display that offers drivers "door-to-door, turn-by-turn" navigation and an extensive Points of Interests (POI) information database.

Mobile Mayday: Uses the U.S. government's OPS and wireless communications technology to provide enhanced personal security for consumers in conjunction with the OnGuard 24-hour Emergency Response Center operated by AIX Technologies, Inc. Mobile Mayday can be installed in any vehicle and includes a central control unit complete with a backup battery, a OPS antenna, and two in-car buttons to provide personal security, roadside assistance, convenient concierge services, and theft recovery.

According to a company spokesman, "Navigation and Mobile Mayday are only a part of this Mobile Multimedia concept. With the next generation of software that will be launched in the spring of 1999, the company can offer consumers integrated navigation, Mobile Mayday, security, and communications with on-demand traffic information, text messaging between the Mobile Mayday system, and navigation screen for vital information, as well as entertainment. Mobile Multimedia means safety and convenience for drivers."

Other product options for a complete Mobile Multimedia vehicle includes a newly launched DVD and Dolby Digital mobile theater product, Alpine's home theater experience for the car. The mobile theater entertainment system includes a television tuner, DVD video player, and a Dolby Digital processor designed specifically for the automotive environment.

The manufacturer also offers high performance MiniDisc head units with its exclusive Dynamic Harmonic Expander (DHE) technology, as well as the new M-DAC digital technology to support the engineering in all of their multimedia products. M-DAC technology incorporates 96kHz and 24-bit capability necessary for DVD and other products that fall under the Mobile Multimedia platform.■

Another look at a Zenith favorite

by Bob Rose

The Zenith favorite to which I am referring uses the 9-1130 module (in 25-inch sets) and belongs to a "family" of chassis that include the 9-1118 (in 20-inch sets) and 9-1132 (in 27-inch sets). These three modules are identical, except for those parts and circuits that permit them to be used with different sized picture tubes. They have been in service for something like six years and have proven to be highly reliable, which means there are a lot of Zenith TVs in consumer hands that still use them. As a matter of fact, it's rare that a week passes that I don't service at least one.

These modules, though reliable, do fail, which is good for us in the repair business. Moreover, almost all of their failures can be quickly and reliably repaired in your service center using just a few inexpensive "speciality" parts, in addition to parts you normally stock. I will cover problems and repairs in six areas and will reference my remarks to Sams Photofact number 3181, from which I take my illustrations.

The power supply

The first area is the power supply (Figure 1). I won't describe how it works here because I did that in an article published in the November 1997 issue of this magazine, to which I refer you. If you are an authorized Zenith service center or have some of Zenith's recent literature in your service center, then you will have easy access to a "blow-by-blow" description of its workings.

We are accustomed to changes in consumer electronics about every six months or so, which means change doesn't surprise us. Would you believe that this particular power supply and certain variations of it have been in use for over ten years? Now that certainly comes as a surprise. Moreover, some of the brand-new Zenith televisions use an updated version of it. That is, some of the components have been upgraded to handle more current, but the basic design really has changed very little. Therefore, my suggestions can be used to repair modules both older and newer than the 9-1118, the 9-1130, and the 9-1132.

Rose is an independent consumer electronics business owner and technician.

Dead power supply

When you face a dead power supply, begin by checking diodes CR3432 and CR3433 and replace them if they are shorted or leaky. Either one, or both, will check leaky and/or shorted if ICX3431 is shorted, which may be your first clue that the IC itself needs to be replaced. It's a good idea to check all of the resistors in the primary circuit, paying special attention to RX3433 (15Ω) and RX3434 (43Ω). Then, as a matter of course, replace ICX3431 (the switching IC) and Q3431 (the driver transistor). These components will almost always be defective. I suggest that you not even bother to check them; just replace them.

ICX3431 is a STR53041 and can be ordered by that part number from many suppliers, or it can be ordered from Zenith using the part number 223-0028. Q3431 can be ordered from Zenith using the part number 121-1264-01A. Even if you can find what looks like an acceptable substitute, I recommend that you use only an OEM part because this transistor is critical to the operation of the power supply. Incidentally, Q3431 costs less than $.75, so you are not looking at big bucks.

Electrolytics can cause problems

Three electrolytic capacitors also cause problems from time to time. C3425, the main filter capacitor, can cause the power supply to fail, especially if its capacitance becomes reduced. I routinely replace it if there is the least doubt about its reliability. If you don't replace it, I suggest you remove it from the circuit and check it for low capacitance and high ESR. I also recommend that you check and/or replace C3434 (22μF) and C3432 (100μF). Since capacitors are basically inexpensive these days, you might think about routine replacement of C3434 and C3432.

If you have had experience working on the 9-1118, 9-1130, and 9-1132, you know that a shorted picture tube will damage the power supply. I have repaired more modules than I care to remember, only to find out that after the set played for a while, the picture tube shorted (heater to cathode), placed a heavy current drain on the power supply, and caused the power supply to self-destruct. But that's the risk you take when you deal with these sets. After you complete the repair and turn the set on, watch the picture for the least sign of failure. If you see the raster shrink and/or turn white with retrace lines in it, turn the TV off immediately. You can at least salvage your new parts if your customer doesn't want the CRT replaced with a new or used one.

Horizontal deflection

Three components in the horizontal deflection circuit cause problems from time to time. The first is the flyback; the second, the horizontal output transistor; and the third, C2212 off pin 30 of IC1200. The part number for the flyback is 95-4203. I can't give you a price for it because I don't think I have ever bought a new one. You see, I very seldom return a dud if I have to buy a rebuilt module, and I don't sell those modules I salvage from discarded televisions. The reason is simple. Many duds are worth far more as a parts source than they are for the dud fee. Zenith typically offers something like $30.00 for a dud fee. If you use just one tuner or one flyback from one of these modules, you have made more money than if you returned it for dud credit or sold it to a repair depot, and there are

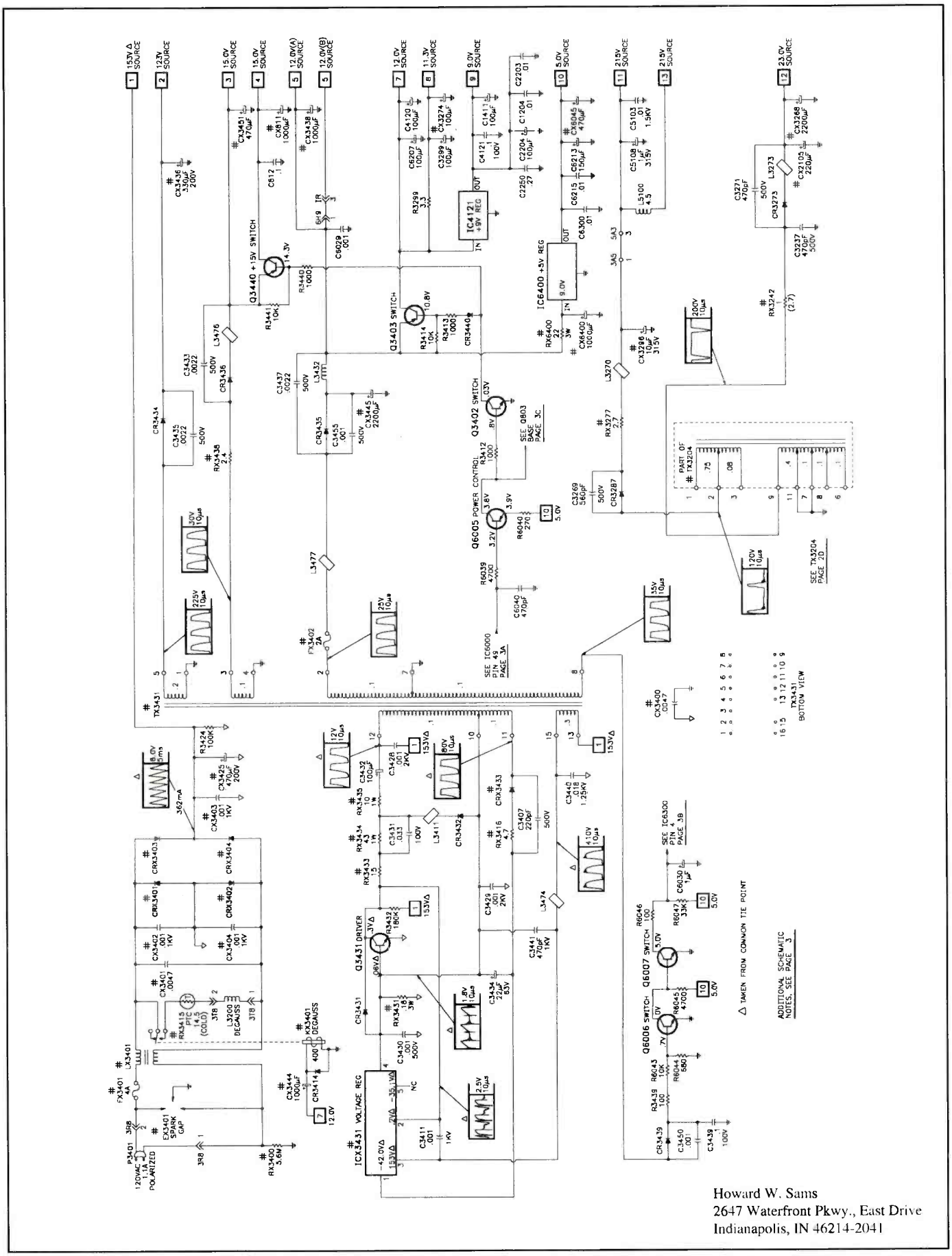


Figure 1. The basic design of this power supply has been around for over ten years. It has been updated and modified to accommodate changes and updates in the various chassis, but it does a good job and is reliable. So why make unnecessary changes?

Howard W. Sams
2647 Waterfront Pkwy.,
East Drive
Indianapolis, IN 46214-2041

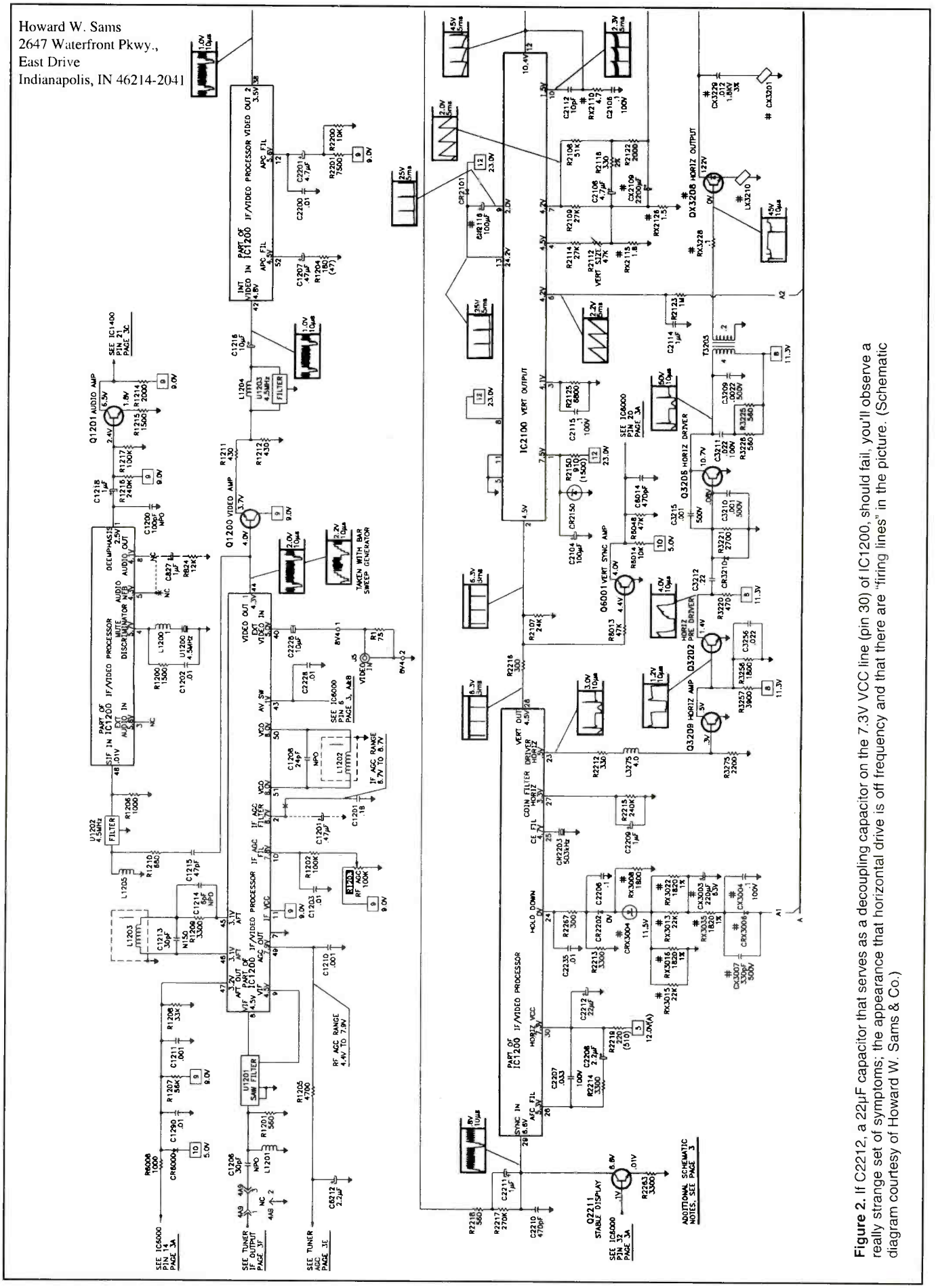


Figure 2. If C2212, a 22µF capacitor that serves as a decoupling capacitor on the 7.3V VCC line (pin 30) of IC1200, should fail, you'll observe a really strange set of symptoms; the appearance that horizontal drive is off frequency and that there are "firing lines" in the picture. (Schematic diagram courtesy of Howard W. Sams & Co.)

Howard W. Sams
2647 Waterfront Pkwy., East Drive
Indianapolis, IN 46214-2041

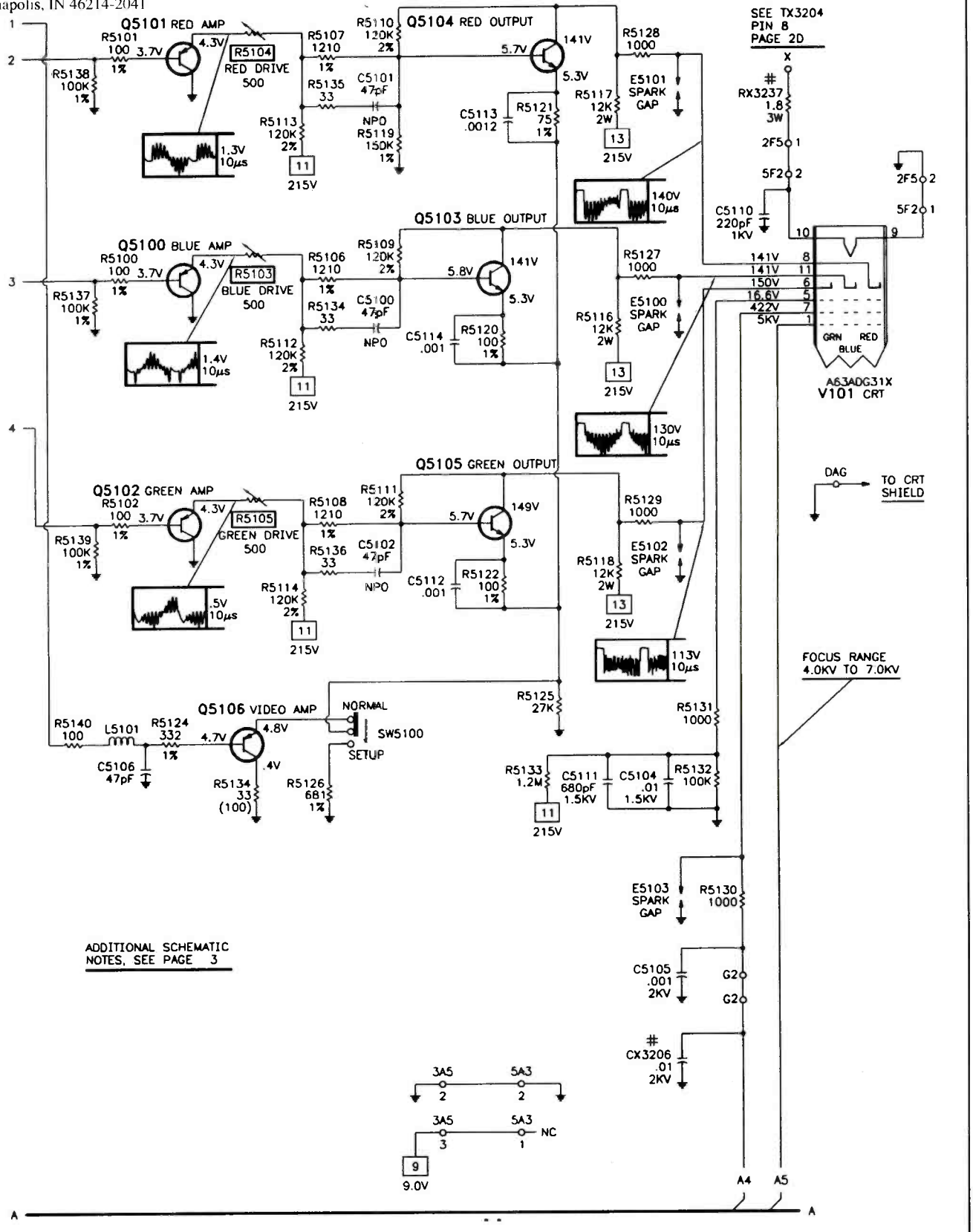


Figure 3. Two components cause most of the vertical deflection problems in these chassis: the vertical output IC (IC2100) and RX3242 (not shown in this view).

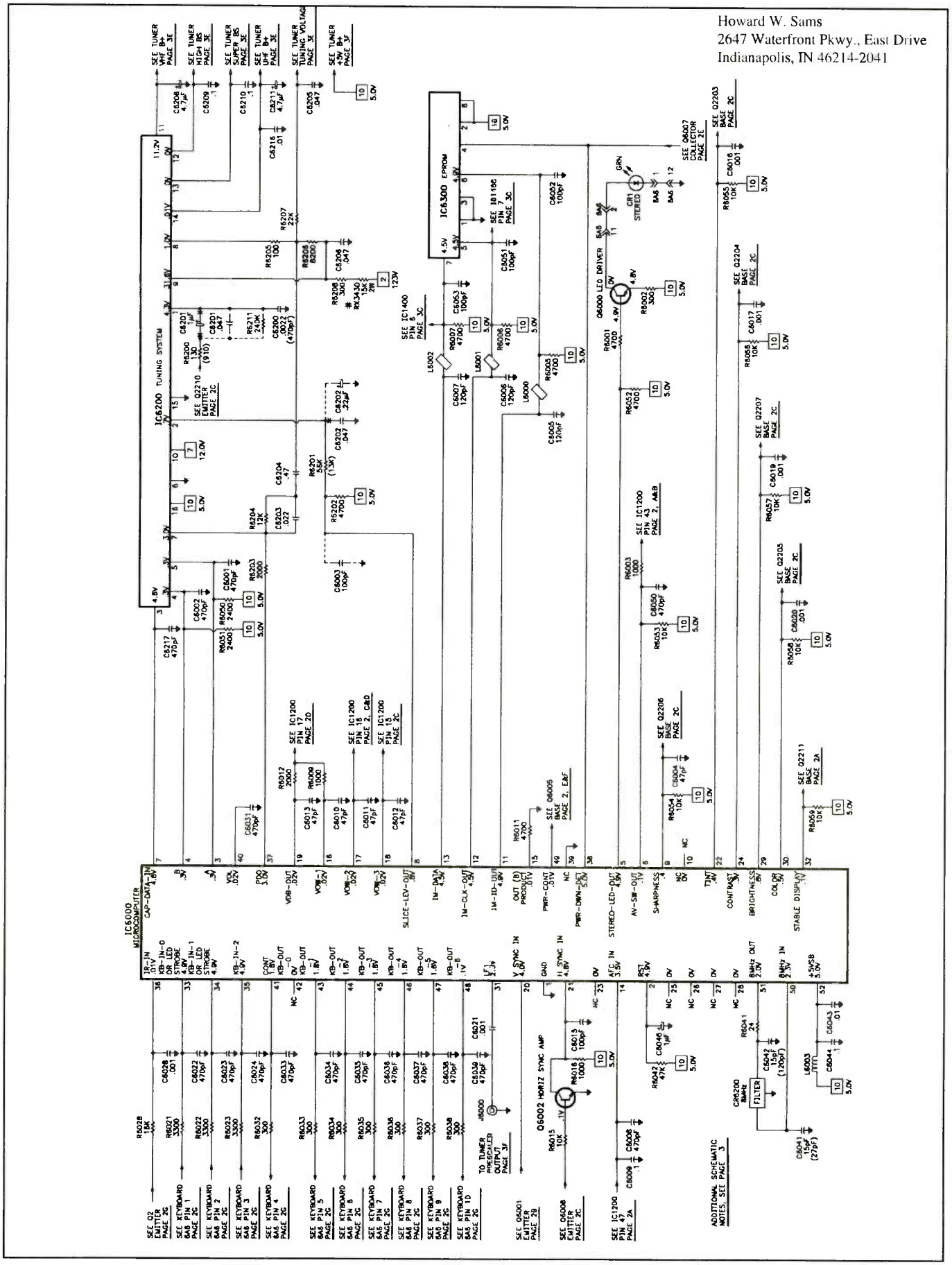


Figure 4. The last video problem I serviced in one of these sets was the classic set of symptoms: a bright screen with retrace lines and washed out picture. I traced the problem to a leaky Q5106.

Howard W. Sams
2647 Waterfront Pkwy., East Drive
Indianapolis, IN 46214-2041

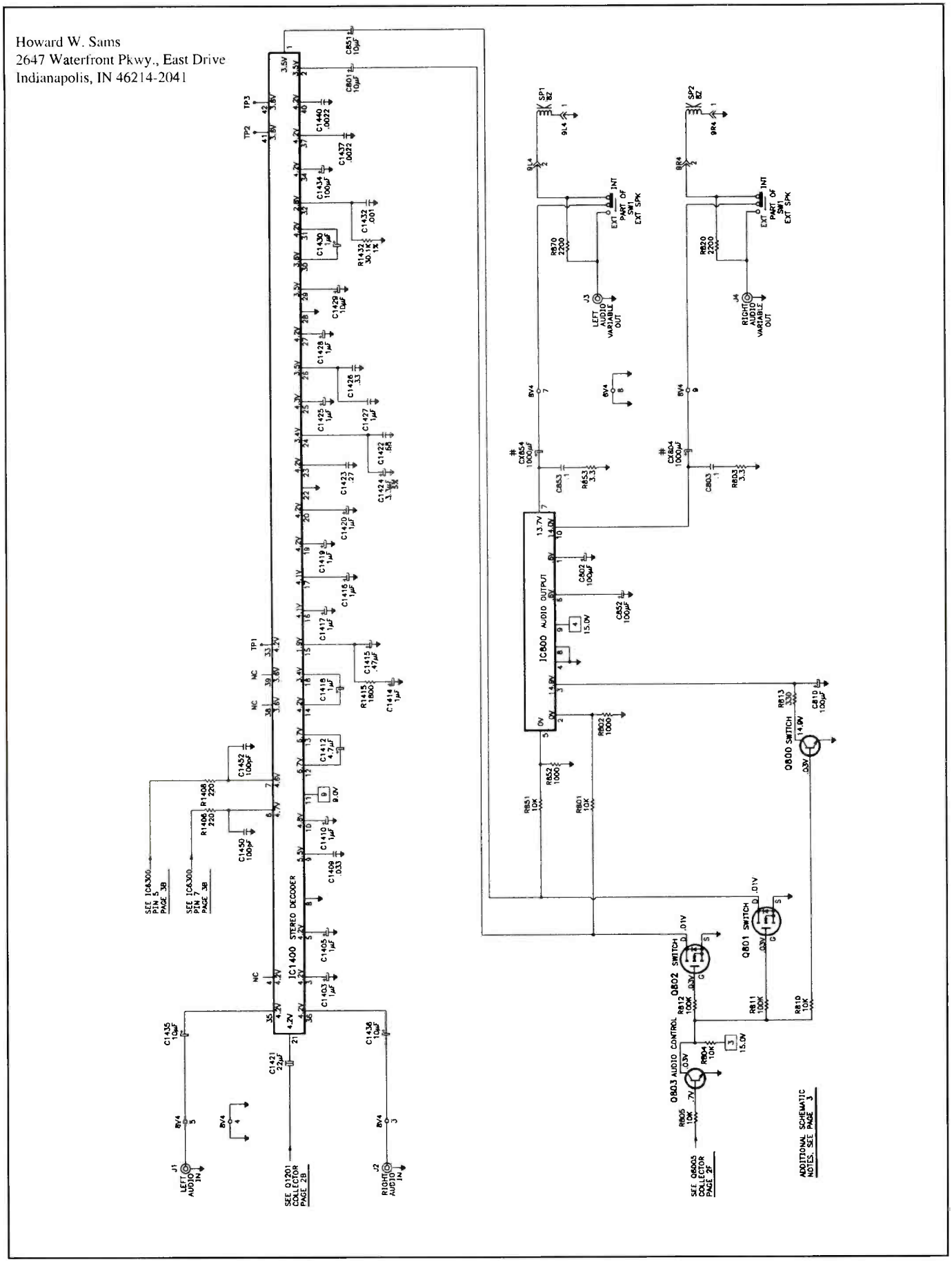


Figure 5. I have had to replace IC1200 on two occasions to solve the "no video" problem.

many other parts on the module that you may be able to use in future repairs.

The second of the two components is the horizontal output transistor. The Zenith part number is 121-1148. However, a generic works fine. Therefore, think about using an NTE2302, an ECG2302, or an SK9422.

The third component is C2212 (Figure 2), a 22µF capacitor that serves as a decoupling capacitor on the 7.3V VCC line (pin 30) of IC1200. When it fails, C2212 causes a really strange set of symptoms. You might think, for example, that horizontal drive is off frequency, but it won't be. Or you might think that the picture has "firing lines" in it, but it won't have. You will also hear a high-pitched squeal coming from the area of the flyback. Your customer might complain that "the picture is not clear" or that the picture has "a lot of distortion in it." The problem will almost always be C2212. If you check this capacitor, you will find that the capacitance checks okay, but that it has an extremely high equivalent series resistance (ESR). The last one of these capacitors that I checked had an ESR in excess of 900Ω.

Vertical deflection

Two components cause most of the vertical deflection problems in these chassis: the vertical output IC (IC2100 in Figure 3) and RX3242. The part number for the vertical output IC depends on the screen size, but it will belong to the popular "LAxxxx" series of vertical output integrated circuits. Speaking from experience, I seldom have to replace one of the capacitors because, in most cases, the "no vertical deflection" symptom is caused by cold solder joints at some of the pins of this IC. When I do replace the vertical output IC, I use the "LAxxxx" for which the chassis calls.

The other problem component is RX3242, a 2.7Ω resistor off pin 9 of the flyback. When it opens, RX3242 deprives IC2100 of B+, defeating vertical deflection. Note that the resistor often opens for no apparent reason, meaning replacing it solves the problem.

Video problems

Other than picture tube problems, I seldom see a genuine video problem. The last one I serviced was the classic set of symptoms: a bright screen with retrace lines and washed out picture. I traced the problem to a leaky Q5106 (Figure 4). If my records are correct, I have had to replace IC1200 (Figure 5) on two occasions to solve the "no video" problem. The Zenith part number for this IC is 221-679. However, NTE7054 and ECG7054 work just as well.

System control

The only component in system control that has ever given me trouble is the EEPROM, which Zenith calls EAROM (IC6300). It causes a variety of problems: no picture and no audio (just a very dim raster), bad picture and bad or no audio, and on one occasion a set that would worked perfectly but would not turn off. (no, the problem was not an incorrect setting in the service menu.)

You can order this IC from Zenith using part number 221-636, but you may have to find a way to program it yourself. Optionally, you can buy a rebuilt module. I confess that I have a problem buying a new module because I can't find a way to program a $3.00 part. Since I keep duds and salvaged modules, I have been fortunate enough to have had several used EAROMs in my parts bin and didn't have to bother with programming a new one.

Audio

I have to admit that the audio circuits used in the 9-1130 module are highly reliable. I have serviced just two components in the audio circuit since I've been repairing these modules. The first is IC1400. In one instance, lightning just blew it apart. In the other instance, it failed to process and output the right audio channel. The Zenith part number is 221-683 or 221-683A. I am not aware of a generic substitute for this device.

However, IC800, the audio output device, does occasionally fail. Replace it with Zenith part number 221-598. If there is a generic replacement, I am not aware of this integrated circuit.

There is one other audio problem I will mention because I have seen it more than half a dozen times. If you encounter difficulties with the audio output jacks or audio that comes and goes (intermittent), check the solder connections between the jack pack and the main circuit board. Chances are that resoldering the pins on the jack pack and/or the motherboard will take care of the problem.

You can repair some modules in the service center

Well, that about does it. As you can see, when they fail, the 9-1118, 9-1130, and 9-1132 (and related ones) modules can usually be quickly and reliably repaired. You don't even have to stock a lot of extra parts either, especially if you have a dud or two lying around. The extra money you make by repairing them, instead of replacing them, can go into your bank account instead of someone else's. A good idea, don't you think? ■

ES&T Calendar

PCS '99
September 22–24, 1999
New Orleans, LA
703-739-0300

AFSMI 29th World Conference & Exposition
October 17–19, 1999
Disney's Coronado Springs Resort
Convention Center
Orlando, FL

Association For Services Management International (AFSMI)
1342 Colonial Blvd., Suite 25
Fort Meyers, FL 33908
941-275-7887 Fax: 941-275-0794
Website: http://www.afsmi.org

Consumer Electronics Show (CES)
January 6–9, 2000
Las Vegas Convention Center
Las Vegas, NV

Consumer Electronics Manufacturers Association (CEMA)
2500 Wilson Blvd.
Arlington, VA 22201-3834
703-907-7600
Website: http://www.cemacity.org

Looking for a crystal ball

by Roger D. Redden

Smoke! It rose from the replacement for a resistor that had burned before. I quickly switched off the power, but it was too late. The IC that I had replaced because it was shorted, was again shorted. This led back to the same frustrating decision: should I abandon the repair, or struggle on?

Had I foreseen the difficulties when I started the repair, the choice would have been easy. The customer had said he would not pay more than $85.00 for the repair. This ruled out a rebuilt module, which cost about $80. But after my first evaluation of damage, I thought repair of the module would produce a reasonable hourly wage return for the effort I expended.

Now, spending another $13 for the IC would raise the cost of this repair effort to about $56. Yet, if I bought the IC, the remaining bad parts might be cheap, and identifying them might give me useful information that would let me make money on a future repair. Or, if my current luck continued, I might spend nearly the cost of a rebuilt module on parts and still not have a module that worked. Yet, if I abandoned the repair, the time and the $43 already spent was wasted.

On the other hand, my parts supplier had warned me the root problem might be a H-K (heater-cathode) short in the CRT. The CRT checked good, but the short could be intermittent. I kept thinking of the line from the song about the gambler that, "you gotta know when to fold them, know when to walk away . . ." But I didn't know which of these I should choose.

Hindsight tends to reveal faulty decisions. I could see a trail of them leading to this dilemma. What I wanted was a crystal ball so that I could pre-check the future result of a current decision. That would really simplify life.

A charred start

This indecision began with a Zenith TV, model SMS2504EW, that uses the 9-1407 main module (the 9-1406 and 9-1408 are very similar). A transistor near the middle of the board, Q3431, was badly burned. The diagram, a Sams 3439, labels that small transistor "switching," but, though it's part of the switch mode power supply (SMPS), it's not the main switching, or chopper, transistor. That function is inside IC3431. Some explanation of a similar supply is given in the October and November 1997 issues of this magazine. Figure 1 shows a partial diagram of the circuit.

Along with the burned Q3431, resistor RX3434 was burned, RX3433 was open, and R3499, a surface mount resistor on the bottom of the board that tied to the base of Q3431, was vaporized. Lastly, IX3431 was shorted between pins 2 and 3. In-circuit resistance checks of all resistors and diodes on the primary side of the SMPS circuit, rectifiers in the secondary side, and secondary sources to ground, revealed no further problems.

Descent into the technical tangle

I assumed that integrated circuit ICX3431 had shorted, which resulted in the destruction of the other parts. The cost of all bad parts would be under $20 at a local distributor, so repairing the module seemed to be a reasonable decision.

I saw that I could check the operation of the supply in standby mode while the module sat on my bench. (I realized later that this should only be done with extreme caution: if Q3402 or Q6004 were shorted, switching the module on, the anode lead laying on my bench could have a voltage of 25KV on it.)

After replacing the bad parts I had found, I plugged the module into a variable isolation transformer set at 45Vac. The ammeter in the isolation transformer up-ticked to about 0.25A, then settled back to nearly zero. Checking from hot ground to pin 1 of IC3431 showed -41V: normal. From cold ground to the 123V source showed 128V, which seemed o.k. with no load. As the input voltage was raised, all of the above measurements remained nearly constant until the input exceeded 100Vac. Then the input current jumped to over 0.5A, and the pin 1 voltage dropped to -28V. This should not occur on an idling power supply. Backing the input below 100Vac, then reapplying power, returned the current and voltage reading to normal.

Suspecting that the problem was caused by a fault in a secondary supply, I disconnected one end of RX3438, FX3402, CR3439, and C3450. This removed all secondary loads except the horizontal output transistor (HOT), which connects to the 123V source. But the problem remained.

Tracing the printed circuit foil from the 12123V source, I found a jumper, W5, that connects to RX3261, a 10Ω, 10W resistor from the IHVT winding connected to the HOT. I removed one end of W5, which disconnected the HOT load from the 123V source, but the symptom was unchanged.

My suspicion shifted back to the primary circuits. And since the problem only occurred at higher ac voltage levels, the bad part undoubtedly would check good when tested at low voltages.

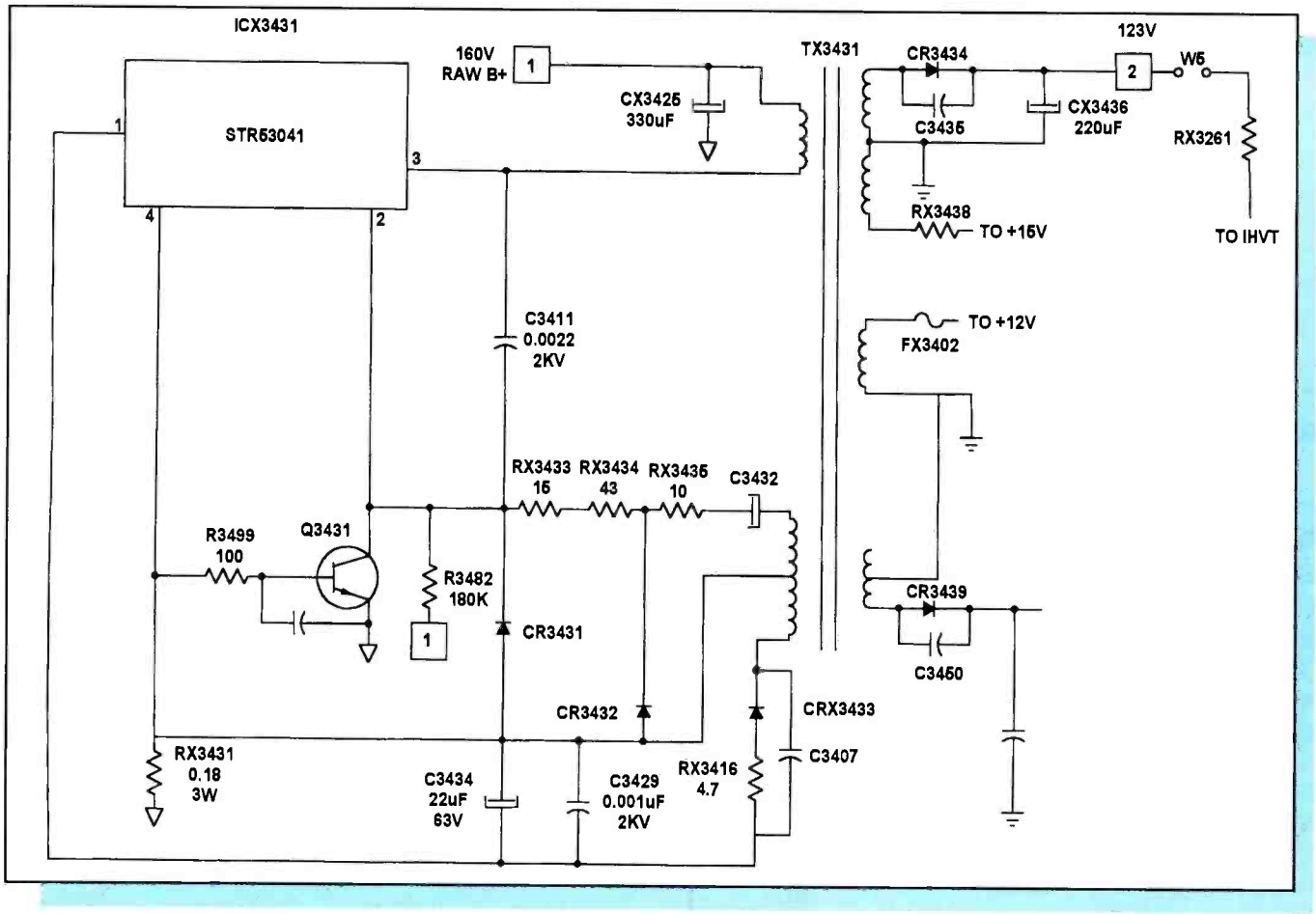


Figure 1. A partial schematic of the switching power supply of a Zenith 9-1407 module.

So, starting with the two diodes and the two electrolytics, I removed parts and checked them for leakage at their rated voltages, or at 600V, the highest voltage my capacitor checker produces, for those rated over 600V. All parts checked good. Still not convinced, I substituted the diodes, the electrolytics, and all capacitors rated over 500V. The symptom continued.

The dc voltage and the ripple of the raw 160V supply appeared normal. It seemed the only thing left was CR3434, CR3435, and CX3436 in the 123V source. When CX3436 was removed, the input current was normal when the voltage level was 120Vac. But when I substituted another capacitor, the symptom returned. Removing and substituting as a pair, CR3434 and C3435 produced the same effect: the symptom going away when they were disconnected, coming back when they were replaced.

The only explanation I could muster was that TX3431, the chopper transformer, must have leakage or some strange short between windings. It rang normally, but of course the trouble didn't appear below 100Vac input voltage.

At this point, the smart thing from a money standpoint would be to quit (or, had I passed the point for doing the smart thing hours before, after the first check of all primary components found no problem?). Adding $25 for a transformer to the $18.00 already spent increased the cost of parts to $43.00; slightly over halfway to the repair limit, a doubtful choice.

A step too far

On the other hand, since I had already substituted everything else, the trouble had to be the transformer, I reasoned. So the choice at this point was invest $25 more and hopefully make about $40.00 on the repair, or lose the time and the $18.00 already spent — and I'm frugal to a fault.

I received and installed the transformer (the original is hard to remove). When the ac input exceeded 100Vac, the input current went abnormally high: the same strange symptom as before. I could scarcely believe it!

After mulling it over a few days, I decided to go for broke (it felt that way) and try another ICX3431. A bad replacement IC seemed unlikely, but it was all I could imagine. I installed it, and apprehensively began raising the ac voltage. The current stayed normal, even at 120Vac. *The original replacement IC was bad.* After credit for the defective IC, I was back to $43.00, and uncounted hours in the set. But things were looking up.

I put the old chopper transformer back in so I would have a good, new spare. But then the high current symptom returned. Incredible! Reinstalling the new transformer again cleared the symptom. Surely the odds against a bad replacement integrated circuit and a bad transformer, both simultaneously causing this strange symptom, are astronomical.

Instant money burner

I installed the module in the set, and beginning at 45Vac, increased the voltage in 5V increments to 120Vac, turning the

set on a few seconds at each voltage level. Current seemed about normal, the -41V was right as well, and I heard high voltage hit when the set was turned on. Everything seemed o.k. At the 120Vac level, I left the power on to see how the picture looked.

I never found out. After about thirty seconds, there was a pop, and as mentioned at the beginning, smoke rose from RX3434, and I subsequently found ICX3431 shorted. I needed another IC to get back to where I was before the smoke rose, again increasing my total parts cost to $56.00, meaning I would make under $30.00 for the repair, even if the remaining problem turned out to be minor. But I was down $43.00, and spending $13 more for another IC might get that $43.00 back. Otherwise, it became my cost for the privilege of working. By now, you're familiar with the argument, and my tendency.

Eventually, I installed another IC and resistor, determined to take every precaution to prevent shorting the IC. I removed one end of W5 again, and, to limit the current, connected a 100W light bulb between it and the end of RX3261 that connects to it. I left the CRT board disconnected from the CRT in case an H-K short occurred as it warmed up.

I started at 45Vac again and checked all the source voltages, including the 210V and 22V sources developed by the IHVT, at each upward step in ac voltage. All voltages seemed normal, though the 210V and the 22V sources were lower (180V and 18V, respectively) because of the light bulb in series with the IHVT.

At 120V, the bulb still glowed dimly, though perhaps a trifle too bright, and about 0.5A of current was drawn, perhaps a trifle too high, but not that excessive. When I left the power on for a couple of minutes, nothing bad happened. The CRT became suspect number one.

To prevent the effects of a possible intermittent short, I installed an H-K isolation transformer on the CRT. With the CRT board connected to the CRT, and the input voltage at 45Vac, I hesitantly turned the set on. At first, everything seemed as before, but then the current climbed toward 1A, and the bulb burned brighter than normal. When the raster became visible, it had retrace lines, no video, and was too bright for a set that was powered through a current limiting light bulb. I shut the power off. The good news was that the power supply had not blown.

Uncovering the arsonist

With the CRT board removed from the CRT, I checked the voltages on the collectors of the RGB transistors. Normally 150V, they read 5V. This would turn the CRT fully on, essentially producing the effect of an H-K short. Finally, I was on the trail of the primary culprit. I found the video amp transistor, Q5106, which connects to the emitters of the RGB transistors, shorted. Replacing it restored normal operation of the set.

You may call me too cautious but I left the H-K isolation transformer installed, though I doubted the CRT was bad. I simply wanted to avoid the risk.

Hindsight, evaluation, and resolve

In hindsight, I should have quit after the first $18.00 spent on parts did not fix the set. But at each step along the way, the decision was muddied by my reluctance to lose the money and time already invested. I estimate I cleared about $25 for about 20 hours of work, or $1.25 per hour. Perhaps I should think of it as low cost technical education, and focus on the satisfaction of solving a puzzle and completing a tough job. But I'd rather make money, and if I could get that crystal ball from the flea market to work, I'd avoid getting involved in jobs like this.

To that end, I have resolved that, in the future, if the cost of parts appears as if it will exceed one third of the total approved for the repair, or the time involved threatens to be over 3 hours, I will quit the repair. It's a good resolution. The problem is, it approximates my unstated resolve when starting this repair. Then, step by subversive step. ■

Books

***Practical Acoustics* by Stephen Kamichik, PROMPT Publications, 192 pages, paperback, $29.95**

Acoustics is the physics of sound. As simple as that may sound, though, it is actually a complex multidisciplinary science — one that is not taught in most universities and technical schools. A full understanding of acoustics, then, demands that the student grasp the many concepts and practical applications of this fascinating subject. Because acoustics affects so many of our everyday experiences, we tend to take it for granted. This book is designed to help shed some light on the mysteries of how sound "works." *Practical Acoustics* is a two-part in-depth study of this science. Whether you are using this book as a beginning study, reference, or as a refresher course, *Practical Acoustics* will not disappoint.

Part One contains 11 chapters of theory, including test questions. Topics include acoustical waves, decibels, transmission through media, ultrasonics, human ear anatomy, underwater acoustics, microphones, and speakers.

Part Two contains eight chapters of projects along with problem solutions and a glossary of terms. Topics include speaker enclosure, graphic equalizer, crossover network, ultrasonic auto radar, preamplifier circuits, surround-sound, and tone control.

Stephen Kamichik is an electronics consultant who has developed dozens of electronics products and received patents in both the United States and Canada. He holds degrees in electrical engineering and was employed for several years as an electronics technician at SPAR in Montreal, where he worked on the initial prototyping of the Canadarm.

PROMPT Publications, 2647 Waterfront Parkway E. Drive, Indianapolis, IN 46214-2041

***Joe Carr's Circuit Toolkit* by Joe Carr, PROMPT Publications, 256 pages, paperback, $29.95**

Open the lid to *Joe Carr's Circuit Toolkit* and you'll find a collection of useful, easy-to-build circuits that promise to spark new ideas in your day-to-day use of circuits and help solve frustrating problems that may have been troubling you for some time. After decades of involvement in the electronics world, Joe Carr has amassed a list of his favorite analog electronics circuits for your perusal and enjoyment. Carr presents each circuit with basic theory and simple math, eliminating hours of exhaustive reading and allowing you to design each circuit with simple division on a handheld calculator.

Joe Carr's Circuit Toolkit contains RF & Wideband Amplifiers, RF Hybrids & Combiners, Waveform Generators, Attenuators and Pads, NE-602 Receiver Circuits, Constant Current Sources, Active Filters, Notch Filters, Construction Hints, Toroids, DC Power Supplies, RF Oscillators, and RF Filters for Interference Reduction.

Joe Carr has published more than 80 books and 600 magazine articles since 1968. He write monthly columns in Popular Electronics, 73, and Nuts 'n Volts, and a bi-monthly column in Popular Communications. Joe has also authored a series of technical guidebooks called the Electronic Circuit Guidebook, available from PROMPT Publications.

PROMPT Publications, 2647 Waterfront Parkway E. Drive, Indianapolis, IN 46214-2041

***The Digital IC Gallery* by Clement S. Pepper, PROMPT Publications, 608 pages, paperback, $39.95**

Experimenters or hobbyists, unless they have access to the multitudes of manufacturers' data books, find it difficult, if not impossible, to discover the full range of devices that may be available and appropriate for an intended application. Vendor catalogs often contain only a partial listing, and often only the best-selling devices are shown.

This book is intended to assist the reader in identifying digital devices in the TTL and CMOS logic families. Author Clement S. Pepper, with over 30 years of research and development and one-of-a-kind system development under his belt, has compiled a comprehensive study of the latest semiconductor technologies, complete with logic and connections diagrams, truth tables, functional descriptions, and performance data.

Along with chapters on digital integrated circuit basics and data logic, Pepper has included a glossary of definitions found herein, as well as revealing differing terminologies that competing manufacturers use for the same parameters. An appendix also lists numerous manufacturers' data books that are available. The main chapter include Monostable Multivibrators and Timers, Flip-Flops, Latches and Shift Registers, Counters and Dividers, Decoders and Encoders, Multiplexers and Demultiplexers, Arithmetic and Logical Functions, Bus Transceivers and Buffers, and Line Drivers/Receivers.

PROMPT Publications, 2647 Waterfront Parkway E. Drive, Indianapolis, IN 46214-2041

***Optoelectronics Volume 3* by Vaughn D. Martin, PROMPT Publications, 464 pages, paperback, $39.95**

Optoelectronics Volume 3 gives you the necessary instructions and training to design and assemble your own optoelectronic devices, including a laser optics lab, a sandbox holography lab, and a physical optics lab. It also offers you a review of the essentials of optoelectronics covered in the previous volumes. Topics covered include light's interaction with surfaces, laser sources, scope cameras, edge detection ICs, reflections and mirrors, and ambient light suppression.

Vaughn Martin is a senior electrical engineer with the Department of the Air Force. Previously, he worked at Magnavox and ITT Aerospace/Optics, where he acquired his fascination with optoelectronics. He has published numerous articles in trade, amateur radio, electronic hobbyist, troubleshooting and repair, and optoelectronics magazines.

PROMPT Publications, 2647 Waterfront Parkway E. Drive, Indianapolis, IN 46214-2041

Editorial *(from page 2)*

Factors that the service centers can't control:

- Product quality
- Retail price
- The Economy
- Large self-servicing dealers

Factors that the service centers can control

- Independent service centers will service this company's products
- There will be an increase in consumer electronics products in the home
- The products will be larger and more complicated
- The products will be introduced at a faster rate

What the service centers will have to do

- Become more efficient
- Hire and train good technical people
- Spend time on servicing
- Access information via the internet
- Use internet-based training materials. Servicers must be prepared to use this type of information.
- Be able to proper run a business
- Rely on electronic business techniques as much as possible. Cut paper.
- File warranty claims electronically, in batches

Who will survive

- Well run, well-organized businesses
- Business that have grown and diversified: home theater, home security, etc.

What can service centers do now?

- Diversify; look at every conceivable option regarding products to service
- Automate business
- Look at manual processes and try to automate them

What can/should manufacturers do?

- Automate their own internal systems
- Make large databases of information accessible to service centers so they can store them at the service center site.

Fifth company

This individual started with the observation that in today's consumer electronics environment additional factors than the manufacturer, the retailer, the current programming providers, and the service center have become part of the equation:

- Computer internet communication
- New companies interested in control of entertainment from the source

One of the very important factors in the success of a service center, as well as the manufacturer, is customer relationship management. It even has its own acronym: CRM. In his words, every positive customer experience becomes a new benchmark.

Some additional remarks:

- If we're organized correctly, we shouldn't have to talk to each other (manufacturer and service center)
- A new generation of people has resistance to traditional brand loyalty
- Many products are turning into razor/razor blades type of situation. For example, computers are available very inexpensively to anyone who will sign up for two years of internet service.
- This company has no factory service centers
- The company is working on putting more service information on the internet
- This company already has an extranet in place
- On-line training will be the only type of training for consumer electronic service technicians in the future.

Sixth company

This company sees independent servicers as partners working together with them. The mission of this company and service centers working together is:

- Customer retention
- Bringing business and value into the corporation

How can we be easy to do business with?

Other comments:

- Depot repair will continue to grow
- In-home service will continue to grow
- Carry-in service will decline
- Customers will continue to grow more demanding
- Service centers have value-added opportunities in home service and connectivity (connecting disparate components into, say, a home theater system)
- This company needs independents to be successful

Seventh company

"We need each other."

Currently, with existing analog products, the products are:

- Simple
- Standalone
- Prone to failure

Moreover, these products are redundant. Most homes have more than one TV, VCR, etc. Some downtime is acceptable. Customers don't want failure to happen, or they will lose confidence in the products. However, at this time, they will accept occasional failures, and will allow 5 to 7 days for service, but don't want repeat failures.

Future products include emerging PCs, digital cameras, integrated hardware/software products, networked products. These are not redundant. Customers expect help more quickly, want help with software, want help with upgrades, expect on-line support.

In this milieu, any downtime will be measured in hours, but in general, service becomes maintenance and downtime becomes unacceptable. Moreover, journeyman technicians will be few. It will be, for the most part, entry-level technicians and expert specialists.

Eighth company

This company thinks the future of consumer electronics service will be:

- Selling more high-end, large screen products. Service will be in the home.
- Products will be increasingly digital
- Service centers should look to antenna installation and component hookup business

Service centers should keep these ideas in mind:

- They will be servicing in the home
- They have to maintain good quality of service (QOS)
- They will be called on to provide connection service
- They will be called on to install antennas
- They should be prepared to sell accessories on service calls
- They need to become, or remain, technologically proficient
- The need to become computer and internet savvy
- They need to be team players.

There were many more comments, but we don't have room for them here. But there seemed to be no disagreement among the manufacturers: independent service of consumer electronics products is here to stay for the foreseeable future. Manufacturers need independent service and are doing what it takes to help them stay in business. ■

News *(from page 3)*

Capable of storing, on one side of a disc, more digital information than seven audio CDs, DVD's unequaled flexibility allows the consumer to select from as many as eight different soundtracks and 32 subtitle tracks, choose preferred camera angles, and access background information, for example, on the film's actors and director.

At a time of rising concern over whether certain movies are suitable for children, DVD gives parents the option to view a mature version of a particular film, while limiting their children to a version edited for younger audiences. Another compelling feature is that DVD players are fully compatible with music CDs. Today, nearly two dozen companies manufacture or market DVD players at prices ranging from as little as $199.

CEMA is a sector of the Electronic Industries Alliance (EIA), the 74-year-old Arlington, Virginia-based trade organization, representing all facets of electronics manufacturing. CEMA represents U.S. manufacturers of audio, video, accessories, mobile electronics, communication, information, and multimedia products, which are sold through consumer channels.

CEMA applauds Rio device court decision

Portable music player deemed not a digital audio recording device

The Consumer Electronics Manufacturers Association (CEMA) applauds the 21-page opinion issued recently by the U.S. Ninth Circuit Court of Appeals holding that Diamond Multimedia's Rio MP3 music player is not a digital audio recording device and is thus not subject to the restrictions of the Audio Home Recording Act of 1992 (AHRA). The Rio is a consumer electronics device with headphones that allows a user to download MP3 audio files from a computer and listen to them elsewhere. The Act, designed to facilitate private, non-commercial copying of audio material primarily for personal, time-shifted play purposes, imposes design restrictions and royalty requirements on manufacturers of certain consumer audio recording products. The decision in this case, Recording Industry Association of America (RIAA) v. Diamond Multimedia, frees the Rio device from these restrictions.

"We wholeheartedly agree with the court's decision, and are pleased that this affirmed the denial of the preliminary injunction against the Rio product when first tried in the district court," stated Gary Klein, Vice President for Government and Legal Affairs for CEMA. "Because this was the first time an appellate court had the opportunity to interpret the Audio Home Recording Act, CEMA filed an amicus brief in this appeal, which rose from the RIAA's efforts to prohibit the manufacture and distribution of the Rio music player."

Klein continued, "The opinion confirms that the Rio is entirely consistent with the intent of the Audio Home Recording Act, legislation which CEMA helped draft. This is a big win for consumers as it will allow them to add the convenience of portable audio to the PC and Internet audio experience. With the advances of digital technology in devices such as these, consumers no longer have to sit at their computer workstations to listen to audio from their computer, but can store audio that can be played where and when they choose." ■

Photofacts

GE
VG4062 ..... (sim to) VCR-313

HITACHI
M7LXU2 4190
NA6DM 4193
27FX48B501 4193
27FX48B511 4193
27FX48B521 4193
32FX48B 4190

ORION
TV1319A (Version E) 4189
TV1928 (Version W) 4192

PANASONIC
AP326 4187
AP327 4187
CT-20G4A 4187
CT-20G14A 4187
CT-20G14DA 4187
CT-20G24A 4187
CT-20G25DA 4187
CT-20G34A 4187
CT-2013SA 4187
DP326 4187
DP330 4187
XEP326 4187

RCA
CTC203AX 4183
F27664YX1 4183
F27665YX1 4183
VR346 ..... VCR-313
VR527 ..... VCR-313

SANSUI
TVM1302A (Version B) 4185
TVM1302A (Version C) 4185
TVM1302S (Version E) 4185

SANYO
AVM-2588C 4194
AVM-2588G 4194
G5V-2588CO 4194
G5V-2588C1 4194
G5V-2588GO 4194
G5V-2588G1 4194

SYMPHONIC
ST4919 4188

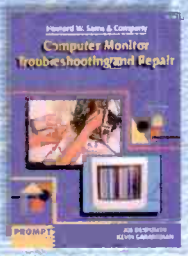
TOSHIBA
CE32H15 4184
CE36H15 4191
CF32H50 4184
CF36H50 4191
TAC9805 4184
TAC9809 4191
TAC9816 4191
TAC9817 4184

WHITE-WESTINGHOUSE
WTV-11901 4182

ZENITH
A27B33W 4186
LGA29B33WM 4186

ES&T BOOK SHOP

ES&T Presents Computer Troubleshooting & Repair
Features information on repairing Macintosh computers, a CD-ROM primer, and a color monitor. Also included are hard drive repair tips and computer diagnostic software.
61087 • $24.95

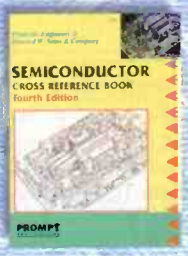


Computer Monitor Troubleshooting & Repair
Learn the basics of computer monitors with chapters on tools and test equipment, monitor types, special procedures, how to find a problem, and how to repair faults in the CRT.
61100 • $34.95

1999 Computer Monitor Troubleshooting Tips
Includes over 2,000 troubleshooting and repair tips listed by manufacturers name and model number featuring such major names as Apple, Gateway, Compaq, IBM, and Dell.
CD-ROM Included
61179 • $49.95

ES&T Presents the Test Equipment Guide
Includes the latest information on how to choose the best equipment, how to build test equipment and accessories, how to set up the ideal service bench, and how to put together a practical tool kit.
61089 • $24.95

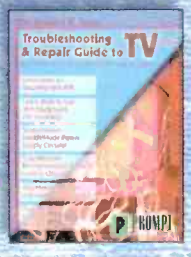
Complete VCR Troubleshooting & Repair
In addition to trouble-shooting procedures, this book contains nine detailed VCR case studies, each focusing on a particular model of VCR with a very specific and common problem.
61102 • $34.95



Semiconductor Cross Reference, 4th Edition
With more than 490,000 part numbers, type numbers, and other identifying numbers listed, technicians will have no problem locating the replacement or substitution information needed.
61080 • $29.95
Also available on CD-ROM,
61140 • $29.95

ES&T Presents TV Troubleshooting & Repair
Presents important and new information that will make it possible for technicians, students, and electronics hobbyists to service TVs faster, more efficiently, and more economically.
61086 • $24.95

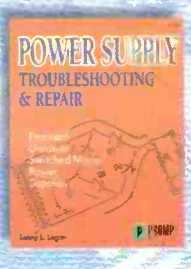
Complete Projection TV Troubleshooting & Repair
Covers everything from the basics of projection circuits, tools and test equipment, TV types, safety procedures and measurements, to the finely detailed repair techniques.
61134 • $34.95



Troubleshooting & Repair Guide to TV, Second Edition
The most comprehensive, complete, and up-to-date television repair book available, with tips on how to troubleshoot the newest circuits in today's TVs.
61146 • $34.95

ES&T Presents VCR Troubleshooting & Repair
This book provides in-depth and thorough information on a variety of VCR troubleshooting and repair areas.
61158 • $24.95

Howard W. Sams Servicing Series RCA/GE Televisions
From RCA component numbering systems to the infamous "tuner wrap" problem, this book gives you all you need to make more efficient repairs.
61171 • $34.95



Power Supply Troubleshooting & Repair
Designed to provide technicians with a better understanding of how switched-mode power supplies operate. It also provides practical, useful procedures to follow when troubleshooting power supplies.
61138 • $24.95

YES! I want to learn from the experts. Rush me my book(s) right away!
Please add $4 shipping & handling. **FREE shipping & handling for orders $50 and over.**
Please make your check or money order payable to: Electronic Servicing & Technology
U.S. and possessions - add $4 shipping/handling. FREE S/H on orders $50 and over. Foreign - shipping/handling charges are calculated by order weight & destination. A $4 credit will be applied for Foreign orders over $50.

To Order Call
800-853-9797

Qty	Order#	Description	Price	Total Price
			Shipping/Handling	
		New York Residents add applicable sales tax	Total	

Name_____
Address_____
City_____ State_____ Zip_____
MC/VISA/AMEX/Discover #_____ Expires_____
Form of payment: ☐ MC ☐ VISA ☐ AMEX ☐ Discover ☐ Check ☐ Money Order

Please mail your orders to: Electronic Servicing & Technology, 25 Newbridge Rd., Hicksville, NY 11801-9962 FAX: 516-681-2926

Classified

Classified advertising is available by the word or per column inch.
By-the word. $1.65 per word, per insertion, pre-paid Minimum charge is $35 per insertion. Initials and abbreviations count as full words. Indicate free category heading (For Sale, Business Opportunities, Miscellaneous, Wanted). Blind ads (replies sent to ES&T for forwarding) are $40 additional. No agency discounts are allowed for classified advertising by the word. Contact Alycia Nicholsen at 516-681-2922 to place your classified ad (by-the-word). Mastercard, VISA, American Express and Discover are accepted for FAX or mail orders.
Per column Inch (classified Display): $235 per column inch, per insertion, with frequency discounts available, 1" minimum, billed at 1/4" increments after that 10" maximum per ad. Blind ads are $40 addition. Reader Service Number $25 additional to cover processing and handling costs. (Free to 4-inch or larger ads.) For more information regarding classified display advertising please call 516-681-2922. Optional color (determined by magazine) $150 additional per insertion.

Electronic Servicing & Technology, 25 Newbridge Rd, Hicksville, NY 11801 Attn: Classified Department
Ph: 516-681-2922 FAX: 516-681-2926

FOR SALE

WinSTIPS! — over **116,000** Current tips from repair shops! All brands. Monitor and Consumer Electronics. Search any phrase. Vcrcross, Sams, Philips Ecg. One-button update Tips. Windows 95/98 **$149.95**.(CD or Web download). **http://www.kdtviwe.com.** KD TV 514 3rd St., Aurora, IN 47001. **1-888-KD-STIPS.** All c/cards. Ken Hull C.E.T. **WinSERV** Service software $299.95. **ServiceTalk** email repair group 30 day free trial on all 3.

IN-CIRCUIT ESR TESTER - Find bad caps FAST and RELIABLY with the new Capacitor Wizard in-circuit ESR Tester! Great for monitors switching power supplies, TVs, etc. ONly $179.95. MC/VISA. **Independence Electronics, Inc., 800-833-1094, www.awiz.com**

PRICE REDUCTION. Diehl Mark III $39, Diehl Mark V Horizontal circuit tester $159. Conductive coating for remote control keypads $9.99 ppd. **WEEC**, 2411 Nob Hill Road, Madison, Wi 53713. 608-238-4629.

VEHICLE MAGNETIC SIGNS (12" X 24") — Up to 3 lines of 1 color copy. Send $69.95/pair prepaid! AAamazing Electronics, OTB/ K-Mart Plaza, Rensselaer, NY 12144-3522.

SENCORE, TEKTRONIX, HEWLETT PACKARD (all models). We **BUY, SELL, & TRADE**. Please call **"CHOICE ELECTRONICS"** for all of your test equipment needs. Complete financing options available. Call 1-800-609-0677, 605-361-6386 ask for Lance Tople.

********60,000******** MULTIPLE SOLUTIONS FOR EACH SYMPTOM IN 1 CONCISE FORMAT has features no other tips program has. Covers more than 140 manufacturers on all types of consumer electronics. SERVICE TIPS THE ONLY NESDA APPROVED TECHNICAL TIPS PROGRAM **$199.95** (plus s & h).

*******ESD'S ALL NEW Computer Monitor SERVICE TIPS program over 10,000 tips on Computer Monitors*******Covers over 200 brands same easy simple format as our SERVICE TIPS program. All information at your fingertips. No need to be afraid to repair computer monitors any longer with our unique program. SPECIAL INTRODUCTORY PRICE $99.95 (plus s&h) **BOTH PROGRAMS WORK WITH WINDOWS 95, 98, & NT, AND ARE Y2K COMPLIANT. TO ORDER SERVICE TIPS or COMPUTER MONITOR TIPS CALL 1-800-621-8477**. Electronic Software Developers Inc., 826 S. Main St., Farmingdale, NY 11735 or e-mail us at esd@bccom.com or visit our web site at www.servicetips.com

TV CASE HISTORIES: Volume 7 with 3,045+ histories. Satisfaction assured. Only $59 (plus $3.25 shipping). Over 9,450 books and supplements sold with only 1 returned for a refund! **Mike's Repair Service,** P.O. Box 217, Aberdeen Proving Ground, MD 21005. Same mailing address 35+ years. Send SASE for samples. 410-272-4984,1-800-2-FIX-TVS 11a.m.-9 p.m. (http://mikesrs.webjump.com)

TEST EQUIPMENT BOUGHT & SOLD: OSCILLOSCOPES, ETC. 925-706-0177. FAX: 925-706-0156. www.oscilloscopesetc.com

*******NAP Tuner 340309******* RCA Tuner TCHRIA or TCCRIA and more. Snowy picture? **Will rebuild for $25.00**, Free Shipping!!! **Tip Top TV & VCR**, 18441 Sherman Way, Reseda, CA 91335, **818-345-1974.**

FOR SALE

SERVICE TIPS for **FREE!!!** ******** That's right it's **FREE!! PROFESSIONAL BOARD LEVEL & COMPONENT LEVEL REPAIRS for TV's, VCR's, Projection TV's, CAMCORDER's, CD Players, Audio** and other repairs on computer disk. **ADD** your own repair tips. **PRINT** out repair tips. **BACKUP** & save **Your** repairs. Want to share your own repair tips? If you do, we will send you **FREE** Updates!!! Ask about our **TIP EXCHANGE** policy. For IBM compatible computers with a hard drive and some Apple Macs. **Get your FREE Stage 1 SERVICE TIPS PROGRAM Now!!! ***** FREE CALL — CALL NOW!!! CALL 1-800-215-5081. *******

TEST EQUIPMENT FOR SALE: REASONABLE PRICES SENCORE, TEKTRONIX, HP and MUCH MORE. View complete list at: http://www.astglobal.com or contact: **AST GLOBAL ELECTRONICS**. Voice: 888-216-7159; Fax 814-398-1176; e-mail: sales@astglobal.com

SENCORE — VG91 Video Generator and TVA92 Video Analyzer. Both for $2,000. SC61 Waveform Analyzer, $1,000. SG165 AM/FM Stereo Analyzer, $325.00. VC93 VCR Analyzer, $800.00. PR57 Powerite, $200. CR70 CRT Restorer, $550. All in factory boxes with manuals and leads. **941-458-7632.**

BUSINESS OPPORTUNITIES

CENTRAL FLORIDA TV/ELECTRONICS Business/Building. Heart of the retirement area. 36 years (75K0. Owner retiring. **941-385-0359.**

NORTHWEST MONTANA CONSUMER ELECTRONICS/MOBILE RADIO BUSINESS. Shop plus house. Good one man operation. 13 years (150K). Owner retiring. 406-675-0618.

CONSUMER ELECTRONICS SERVICE AND SALES BUSINESS located in beautiful California central coast area. Inventory and equipment. Owner retiring. **805-927-1550.**

ELECTRONIC REPAIR CENTER — ATLANTIC CITY AREA. Excellent location on busy highway. Owner retiring. Steady year-round work from individuals, hotels, and casino work available. Call 609-641-1468.

HOME MANUFACTURING BUSINESS FOR SALE, Engineer and owner to sell stock products, tooling and plan rights of a computer monitor distribution amplifier. A high quality, high profile item for the related industries. All the foot work is done, easy enough to do at home. Product has great potential. Asking $50K, serious inquiries please. **516-395-5668.**

WANTED

WANTED:USED TEST EQUIPMENT. TURN IDLE OR EXCESS EQUIPMENT INTO CASH. AST GLOBAL ELECTRONICS. Voice: 888-216-7159; Fax 814-398-1176; e-mail: sales@astglobal.com.

Reader's Exchange

Readers' Exchange is a free service.

The following restrictions apply to Readers' Exchange:

- Only individual readers may use Readers' Exchange, and items must be restricted to those that are ordinarily associated with consumer electronics as a business or hobby. If you're in business to sell the item(s) you want to offer for sale, the appropriate place for your message is in a paid advertisement, not Readers' Exchange.
- Readers' Exchange items must be restricted to no more than three items each for wanted and for sale.
- All submissions must be typed or printed clearly!

Send your Readers' Exchange submissions to:
Readers' Exchange, Electronic Servicing & Technology, 25 Newbridge Road, Hicksville, NY 11801

FOR SALE

RCA modules and Sylvania IF panels & DEF panels and modules. Sams Photofact. *Contact: Ann Bichanich, 15 W. Lake St., Chisholm, MN 55719.*

Tentel complete gurge set, mint condition, VHS $1100.00. Cobra CB base station, $35.00, SWR RF meter w/CRB, 100W, $25.00, Bird rel. field meter, 10W, $30.00 and other CB accessories. Send an SASE. *Contact: Ralph Bianco, 1431 Robinson Ave., Havertown, PA 19083, 610-446-4519.*

Sharp VHS camcorder, Model VL-L80WA w/all accessories and manuals, $100.00. *Contact: Frank, 727-392-0230.*

Sencore VA62A universal video analyzer, like new, includes all manuals and accessories, $630.00. *Contact: Mike, 781-396-6023 after 5 p.m.*

Pace MBT220 desoldering station, includes PPS85, SX70/65, IR70/SP2, stands, manual, excellent condition, $700.00. Pace PPS85 base for MBT250, clean, excellent, $375.00, $275.00 (scratched front panel). Hot air reflow rework station, NU Concepts Systems Hart 200A, $600.00. Raychem super heater hot air jet pencil, $200.00. Plato digital readout solder pot, $200.00. Mesei hot tweezers, $50.00, hot plate, $100.00, Ungar 6966 heat gun, $55.00. Soldering stations: Weller EC2002M with 1201 pencil, brand new in box, $225.00 with 1 year factory guarantee. Weller WTCPN TC202 base with TC201 pencil with new Weller/Ungar heater modified, $55.00. *Contact: Jim Behar, 301-572-9056.*

Sencore SC-61 waveform analyzer, like new with probes and manuals, used 5 months, $1500.00 plus shipping. *Contact: Gene Buresh, 402-768-2504.*

Precision 910 tube tester, $50.00. Radio City products Model 802-AS-15, $40.00. Supreme Model 89 antique checker, $75.00. All with set-ups. Heathkit (small) scope, 3-inch screen, Model 10-17, $50.00. Used radio tubes (box of 100), $50.00. Box 37 1-volt old radio tubes, $40.00. Box of gas tubes OA3, OB3, OC3, O24, etc., $20.00. Shipping not included. *Contact: Maurer TV Sales and Service, 29 S. 4th St., Lebanon, PA 17042, 717-272-2481.*

ES&T magazines from 1984 to 1988 and 1996 to 1999 (current). All for m$35.00 plus shipping. *Contact: Dan Schultz, 218-643-9614 after 5:30 p.m. Central.*

WANTED

Symphonic TV ST131CC schematic (or copy) of the power supply. Sama 3727 or 3972. Will pay $10.00 for Xerox. *Contact: John Augutine, 610-929-8850, E-mail: jaugust@bellatlantic.net.*

Magnavox VCR Model VR9360 AT01 display P.C. board, front PWB assembly. *Contact: Don's TV and Repair, 131 So. Walnut St., Spalding, NE 68665, 308-497-2513.*

Emerson Model 850 radio and Hitachi PTV Model 46UX10BF schematic and parts information. Will buy or copy and return. *Contact: Harold Klotzle, 330-297-1155 (phone/fax).*

Hickok or Precise 111M tube tester, audio tubes (KT-88, 2A3, 6550, etc.); Nakamichi Dragon turntable, Technics tables/arms, record mastering equipment. *Contact: Kim Gutzke, 612-869-4963.*

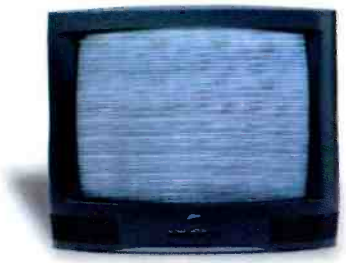
Navy impedance bridge wanted for parts, ZM-11U. *Contact: Sidney, 510-357-3788.*

RCA Model PVM035 (1986) microfiches and/or paper schematics, also focus/screen adjust assembly. *Contact: Rick Arlitt, 512-836-3889, E-mail, erserve@aol.com.*

GE Model CG-9805 camcorder parts. Panasonic assembly No. VEPSO2105 and VJBS02105, IC 2001 MN 67461VDNF, IC 6001 D75108GF718, head ref. board VJBW0779, need service manual, complete boards or assembly. *Contact: Video and VCR Repairs, 21 Lombardy Drive, Baltimore, MD 21222-2309, (fax) 410-282-4460.*

ADVERTISERS' INDEX

We'd like to see your company listed here too. Call Bill Kaprellian at 630-584-5333 Ext 10 or Fax him at 630-584-9289 to work out an advertising program tailored to suit your needs.



Product Breaks Down

repairnow.com℠
Get It Fixed Right. Now.

Customer Goes Online To Find Reliable Help

Customer Schedules Appointment With You

You've Got A New Cash Customer

Improve Your COD Referral Connections.

Connect to more potential cash customers faster and easier than ever before by joining RepairNow.com, a cost-effective online service network developed by *NEW,* the industry's leading provider of service contracts and consumer protection plans.

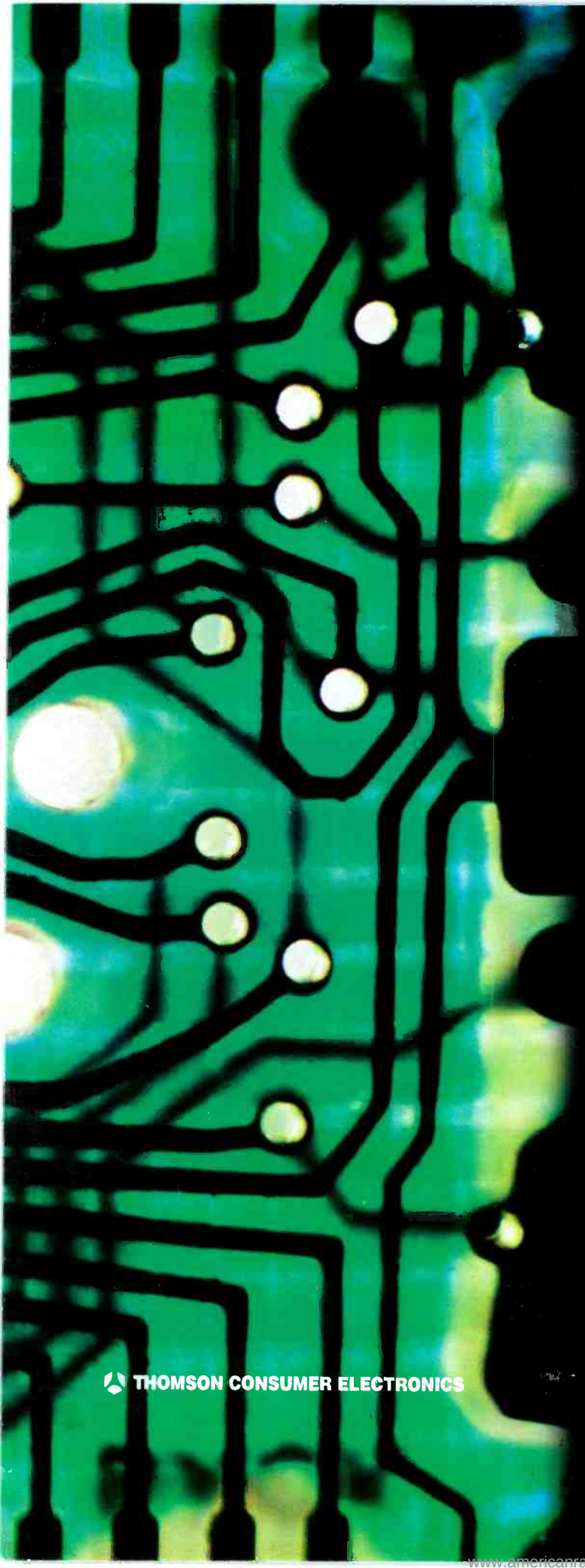
It's Never Been Easier to Reach Potential Cash Customers.

RepairNow.com makes it easy for potential customers to not only find you, but also to find out about you: The special services you offer, your reputation for quality, and other information they need to choose a service provider. And because RepairNow.com is being offered by *NEW,* the nation's largest independent third party administrator with more than 16 years' experience in the customer service field, a RepairNow.com referral will carry the added credibility so critical to consumers today.

Call 1-888-243-6089 today – *and connect to more cash customers for less money than you ever thought possible.*

repairnow.com℠
Get It Fixed Right. Now.

Circle (118) on Reply Card



Exact Semiconductors

The Right Parts For The Job

"Trust Me!"

How many times have you heard that!

You built your reputation on hard work and quality repairs. Why change now?

Put your reputation on the line with two names you *can* trust.

SK *Series* and Thomson Consumer Electronics.

With over 1,700 exacts in stock, you won't have to look anywhere else. And when you're in need of any video heads, belts, tires, flyback transformers or video replacement parts, we have them too.

But we don't stop there.

Our continuing quality assurance and accuracy goes into every SK *Series* product.

For more information on SK *Series* products, contact your nearest Thomson Distributor.

SK *Series*...The parts you need to do the job. "Trust me!"

THOMSON CONSUMER ELECTRONICS

SK *Series*

Circle (113) on Reply Card