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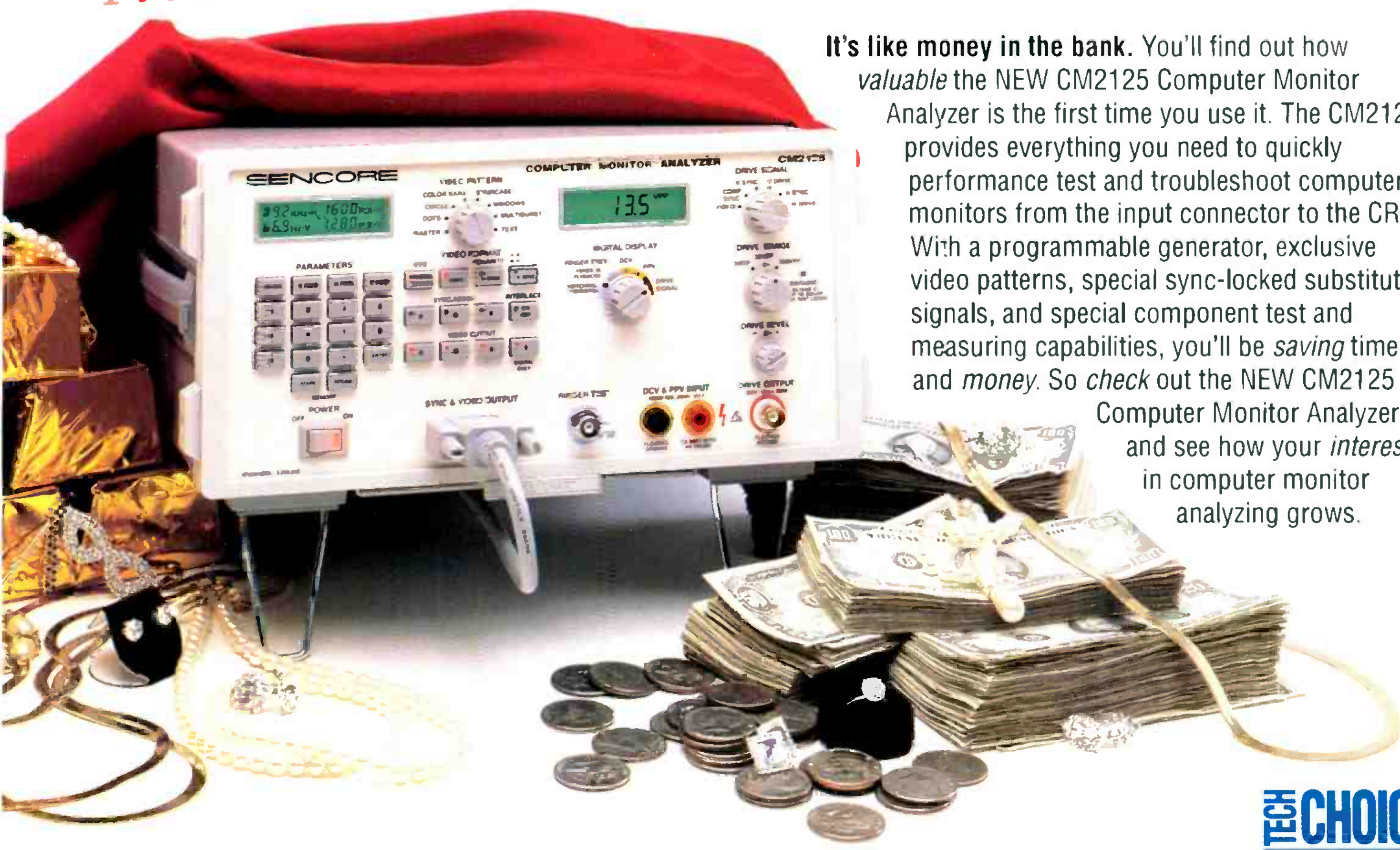

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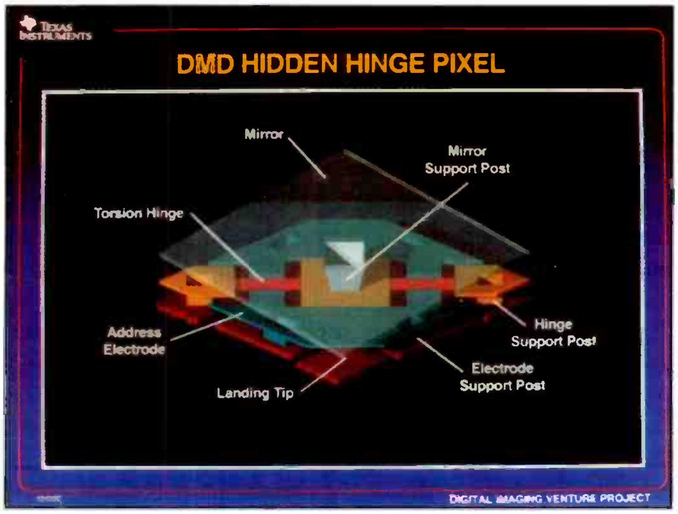

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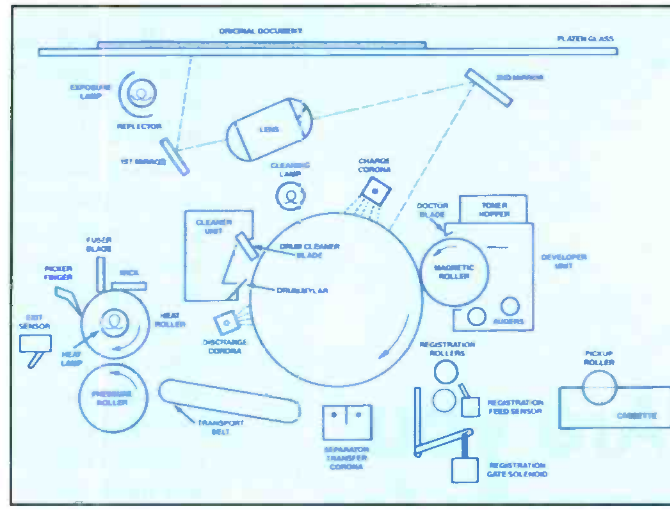

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING
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ON THE COVER

Most consumer projection television sets sold today are CRT rear-projection systems. The digital micromirror device (DMD) is a new television display technology currently under development. If this new technology is successfull, it could one day displace both CRTs and LCDs as the TV display of choice for projection systems. (Photo courtesy of Texas Instruments).

Are you ready for HDTV?

Television of today is really quite marvelous. When I sit across the room from my 19-inch set, the picture quality seems quite acceptable, the colors seem lifelike, and the stereo sound adds considerable realism to the program.

But compared to the large screen at the movie theater, with its surround sound, which presents a program that the viewer becomes a part of, that TV leaves something to be desired.

When we make an effort to improve the home television/theater experience by increasing the size of the picture, by using a television projection system, something undesirable happens. The horizontal lines that make up the picture become large enough so that we see them, and the picture looks "grainy."

People today are becoming used to high quality video images and superior quality audio, and are ready for improvements in the technical quality of the television programs delivered to their homes. And considering the amounts of money people are spending on large-screen TVs and VCRs and high quality stereo systems, they are willing to pay to have that kind of quality.

Enter HDTV

If some of the things that are happening in TV technology today come to fruition, it won't be long before TV programming with vastly improved picture and sound quality are available in homes. As detailed in the article "The status of HDTV," in this issue, a powerful alliance made up of AT&T and Zenith Electronics Corporation, General Instrument Corporation and the Massachusetts Institute of Technology, and a consortium of Philips Consumer Electronics, Thomson Consumer Electronics and the David Sarnoff Research Center—are all working together as the Digital HDTV "Grand Alliance" to develop HDTV.

If everything works out as hoped, it is expected that North America will be able to maintain the worldwide technological lead it has established. The adoption of an all-digital HDTV system in North America will promote the creation and maintenance of high-skilled jobs in the design and manufacture of HDTV receivers, displays, studio and transmission equipment, peripheral equipment, programming and software development, and semiconductor products.

Consumers will reap the benefits of the best technical minds collaborating to bring noise-free, theater-quality pictures and sound to American homes, as well as a host of new applications in home entertainment, education, computer and medical imaging, factory automation, publishing—all stimulated by the early adoption of this technology.

The implications for consumer electronics service are also great. The adoption of HDTV will no doubt create a host of opportunities for servicing. The receiving devices will be expensive, at first very expensive, and therefore consumers will not be throwing them away when they fail. They will have them serviced.

In addition, consumers will become used to the superior picture and sound quality, and will be willing to pay to correct relatively minor problems in sound and picture to keep their beautiful new TV sets in perfect order.

In addition, because the system is being designed so that it can interoperate with computers and communications systems, it will ultimately have more value to consumers than simply as an entertainment system, and it will therefore be far more important to keep it operating.

Of course all of this is still in the research, design and development stage. A lot of hurdles are still to be surmounted before HDTV comes to fruition. And there are no guarantees that it ever will.

But with the way consumer electronics technology has been advancing, it doesn't pay to ignore the possibility. If HDTV does happen, the people who will be performing the service on the consumer products will be the ones who are prepared.

And there can be no doubt that servicing of these new products, if they come, will require a substantial investment in education, new tools and test equipment.

Here at **ES&T**, we'll be keeping our ears to the ground to see how the technology is progressing so we can provide articles that help technicians get up to speed on the new technologies, test equipment and in general report on the progress of HDTV.

Nils Conrad Persson

ETA training program on Spacenet 3

Electronics technician training is now available on Spacenet 3, Channel 4. ETA's Greencastle, IN office announced that the first of a 20 week series was to have begun on January 14 at noon.

The series is an outgrowth of experimentation by ETA and SDA into teleconferencing as an extension of the association's regional technical and business management schools. These schools have been produced for several years by the not-for-profit associations and include the well-known SAM (Satellite, Antenna & MATV) classes.

The connection with Spacenet 3 is a result of ETA's close working relationship with Central Community College of Nebraska, which has campuses in Norfolk, Hastings and Grand Island. CCC also is the accrediting agency for the ETA regional technical and business seminars and the technical schools conducted as a continuing education opportunity for technicians, consumer and satellite sales and service dealers and installers, as well as the CET testing and registration program.

The National Satellite Trade Show conducted in August 1993 in Moline, IL, was the first teleconference leading up to this series. Live video was transmitted from Central Community College in Grand Island and from Nebraska Educational TV's studios in Lincoln to TVs on the floor of the trade show. An open phone connection from the SDA Show to Grand Island and Lincoln provided the interactivity.

On October 22nd, at the conclusion of ETA's 2-day Great Plains Technician Seminars, a two-hour live video conference was conducted from CCC's studios, with input from Roger Bartlett, NETV's chief engineer (from Lincoln). This show was M.C.ed by Dick Glass, President of both ETA and SDA. Each of these initial teleconferences provided the viewer with technical descriptions of how video signal compression is being utilized by the Nebraska Educational TV Network. Eighteen separate video and audio transmissions may be emanating to or from Spacenet 3 at any one moment. C-band TVRO viewers will be able to tune in on Spacenet 3, channel 2 or 4, to view the uncompressed portions of the network's various services including these classes.

Two additional 2-hour technical training sessions have been produced directly by the CCC faculty in Grand Island. One of these occurred on November 17, the last on December 17. These sessions experimented with high-tech electronics teaching aimed at manufacturing engineering technology.

On December 4th, ETA again teamed up with Central Community College, in yet another experiment into different methods of utilizing interactive videoconferencing: Four hours of technical training and teleconferencing were conducted. During the first hour, Fred Roeser, CET, of CCC, produced a live MATV training session, from Grand Island. The session was directed to the classroom students assembled at the Comfort Inn in Bloomington, IN. These students were part of the ETA/SDA two-day technical and licensing seminars taking place there. That live session allowed classroom questions and responses via direct phone to the Comfort Inn, and a live link-up to CCC's studios in Grand Island.

The second hour utilized previously recorded videos (produced by Dulca Scenes) of technical sessions conducted during the New Orleans SDA Convention in 1992. Ken Stewart's presentation regarding MATV Components, and Hans Rabong (of Winegard Co.) teaching about roof-top antennas, were transmitted. Attendees viewed each of the above sessions, looking at the quality of the video reproduction. This evaluation was requested because these programs were transmitted utilizing 384 kbits compression. Callers and classroom attendees concluded the compression did not detract from the technical content of the classes and would be suitable for the future series beginning in January.

More information and the class topics listing can be obtained by calling 317-653-4301, or by writing to: SDA, 602 N. Jackson, Greencastle, IN 46135.

New curriculum gives students principles of Total Quality Management

"The school that establishes a Total Quality Curriculum program is going to have a higher placement rate, and the students are going to have more success in business than those students who arrive without this training," says Pat R. Dalton, Manager, Business Operations Department, Caterpillar Inc.

Dalton and other business leaders agree that today's workers need new skills—creativity, problem solving and teamwork—to join the movement that's revitalizing U.S. industry: Total Quality Management (TQM). Entry-level employees trained in the principles of TQM have the skills business and industry leaders want and need to make their companies more competitive in the global marketplace.

Now education can respond to industry's needs and meet federal standards with the Total Quality Curriculum. Developed by the Vocational Industrial Clubs of America, the Total Quality Curriculum gives students TQM's tools before they enter the workforce. TQM empowers workers to increase the quality of their products and services, boost productivity and promote greater customer satisfaction. VICA's TQ Curriculum emphasizes the competencies and basic skills identified by the U.S. Secretary of Labor and the Secretary's Commission on Achieving Necessary Skills (SCANS): What Work Requires of Schools—A SCANS Report for America 2000.

The Total Quality Curriculum translates Dr. W. Edwards Deming's 14 principles, which produced the Japanese economic miracle, into terms that are meaningful to education. It also relates to quality programs in the United States, such as the Malcolm Baldrige National Quality Award.

"The Total Quality Curriculum has been a catalytic agent that has helped propel our school system's emphasis on teaching Total Quality Management. When properly applied, the principles of this curriculum have the potential to revolutionize education as we know it," says Patrick Konopnicki, Vocational Director, Virginia Beach City Public Schools, Virginia Beach, VA.

Developed by a partnership of educators with quality experts from business and industry, this 17-module curriculum was tested in classrooms nationwide and has proven to be effective in kindergarten through postsecondary school levels. The TQ Curriculum is designed to be integrated into the existing classroom setting, but can also be used as a separate curriculum. Modules begin with a discussion, followed by an activity to put quality concepts into practice. With a checklist of the school-to-work transition skills covered, students see how these skills apply to their general education, their occupational training and everyday life.

For more on Total Quality Management, see this month's Business Corner.

Safety standards

Underwriters Laboratories Inc. (UL) is proposing the Standard for Safety for Audio-Video Products and Accessories, UL 1492, for recognition as an American National Standard.

UL 1492 covers audio and video products intended for use on supply circuits in accordance with the National Electrical code, ANSI/NFPA 70.

These requirements, where applicable, cover:

A) Audio products and accessories intended for household use and involved with the reproduction or processing of audio signals. Examples of such products include amateur radio products, amplifiers, intercommunicating devices, phonographs,radio clocks, radio-phonographs, radio receivers, record players, tape players, tape recorders, transceivers, tuners, tuner-amplifiers, and similar products.

B) Video products that are intended for household or commercial use, and that receive signals off the air, through a CATV/MATV cable system, from a video-recorded medium, and from image-producing units. Examples of such products include video tape recorders, video-receiving, processing, recording, producing, and amplification products, television-antenna amplifiers, cable television (CATV) converters, television tuners, television receivers and monitors, television cameras, and similar products.

C) Auxiliary products and accessories intended for use with audio or video products wherein the auxiliary and accessory products are separate and do not perform the desired function, but are used in addition to or as a supplement to products according to the requirements in this standard. Examples of such products include character generators, editing controllers, video switches and encoders, CRT degaussers, video tape rewinders, head demagnetizers, tape erasers, and similar products.

D) Video products intended for entertainment purposes in ordinary locations of health-care facilities.

E) Cellular telephones and similar transceiving devices used on a vehicle, boat, or the like where the telephone interconnects to the telephone network through a radio transmitter and receiver.

F) Portable audio or video products of the types described in this standard that are intended for use with a vehicular, marine, or any other battery circuit as the power supply means.

Audio or video products intended for use by children are covered by these requirements, but shall also comply with the applicable requirements in the Standard for Electric Toys, UL 696.

Video products intended for use at mercantile and banking premises to provide a means of recording holdup attempts or similar activities in the area shall also comply with the applicable requirements in the Standard for Surveillance Cameras, UL 983.

Circuits in audio or video products intended to connect directly to a telecommunication network shall comply with the applicable requirements for telephone equipment, UL 1459.

A separately enclosed non-powered loudspeaker that is not intended for connection to a specific audio amplifying source shall comply with the requirements in the Electronic Industries Association (EIA) Interim Standard IS-33, Recommended Loudspeaker Safety Practices—An Industry Guideline, dated May 1987.

Battery chargers and power supplies, whether portable or for permanent installation and not packaged with or specifically referenced in literature packaged with a product but intended for use with audio or video products, are categorized as battery chargers or power supplies and are not covered by these requirements.

UL 1492 does not cover products that are covered by the Standard for Commercial Audio Equipment, UL 813.

UL is seeking review and comment from interested individuals and organizations to help develop a consensus upon which recognition of UL 1492 by the American National Standards Institute (ANSI) can be based. ANSI is a clearinghouse for information on standards and coordinates development of national consensus standards through voluntary action.

Anyone interested should contact Barbara Dorfman at UL, 1655 Scott Blvd., Santa Clara, CA 95050, 408-985-2400, ext. 2864, and request a free copy of UL 1492-NR. Participation will be by correspondence. Those interested should request their copy now so that all comments can be considered in time to meet the ANSI deadline for this standard.

National service center to be built

In a move designed to provide expanded support to its customers nationwide, Sharp Electronics Corporation announced plans to create a new national parts and service center on the site of an existing facility in Romeoville, IL, a suburb of Chicago. The company will invest $10 million to construct a 250,000 square foot addition to its midwest distribution center to house the operation, and will simultaneously restructure its Service and Parts Group, relocating most of the functions from corporate headquarters in Mahwah, NJ and several other locations to the new site.

"Sharp Electronics grew 12 percent in the last year despite a difficult economy, and we are projecting double digit annual sales growth through the rest of the decade," said Sueyuki Hirooka, the company's chairman. "Our service and parts operation must keep pace with the growth of our company, and at the same time, we must deliver continuous improvement in the level of service and support we provide to our dealers and retailers, as well as to the end users who buy our consumer and business electronics products. This new National Service Center will help us accomplish that goal."

Sharp said its overall employment in the United States would not be affected since employment reductions in New Jersey would be offset by additional hiring in Romeoville, IL and additions to the company's field service personnel. The move will affect approximately 125 permanent employees, about half of whom will be invited to relocate to the new facility in Illinois. The company hopes to absorb some of the employees not being asked to relocate as positions become vacant at corporate headquarters over the next 9-12 months.

Enhanced Regional Support. According to Arthur Sherman, group vice president of Sharp's Service and Parts Group, such functions as national parts supply, product refurbishment, product support and customer assistance will all be transferred to the new National Service Center when construction of the building is completed between July and September 1994. Certain executive staff members and the product safety team will remain at headquarters in New Jersey, while five regional service offices will be expanded and staffed to provide enhanced regional support to customers. In addition to Mahwah, NJ and Romeoville, IL, these offices will be located in Carson, CA, Lawrenceville, GA and Irvine, TX.

As part of the restructuring, Sharp will also cease providing direct repair services to end users, and will instead refocus its resources on supporting its dealers, retailers and independent servicers in providing these services.

"The primary driving force behind this decision was the need to expand our service and parts operation," stated Sherman. "When we began looking at options for expansion, we settled on the site in Illinois principally because its central location provides ease of transportation and telecommunications access to customers around the country."

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Electronic Servicing & Technology (ISSN 0278-9922) is published 13 times a year by CQ Communications, Inc. 76 N. Broadway, Hicksville, NY 11801. Telephone (516) 681-2922. Second class postage paid at Hicksville, NY and additional offices. Subscription prices (payable in US dollars only): Domestic—one year $24.75, two years $45. Foreign countries—one year $30.75, two years $57. Entire contents copyright 1994 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.

Statement of Ownership, Management and circulation Feb. 1 1994, Electronic Servicing & Technology, 76 North Broadway, Hicksville, NY 11801. Publication #02789922. Issued thirteen times a year, subscription price $24.75 per year (12 issues). Publisher: Richard A. Ross; Editor: Nils Conrad Persson, owned by CQ Communications, Inc. Stockholders: Richard A. Ross, Alan M. Dorhoffer, Thomas Kneitel, Arthur S. Salsberg. Circulation (Average of Preceding 12 Months): Net Press Run 27,568, Sales Through Dealers and News Agents 0, Mail Subscriptions 24,488, Total Paid 24,488, Free Distribution 2,080, Total Distribution 26,568, Copies Not Distributed 1,000, Returns from News Agents 0, Total 27,568. Circulation (Single issues nearest filing date): Net Press Run 26,396 Sales through Dealers and News Agents 0, Mail Subscriptions 23,381, Total Paid 23,381, Free distribution 2,015, Total Distribution 25,396, Copies Not distributed 1,000 Returns from News Agents 0, Total 26,396. /s/Richard A. Ross, Publisher.

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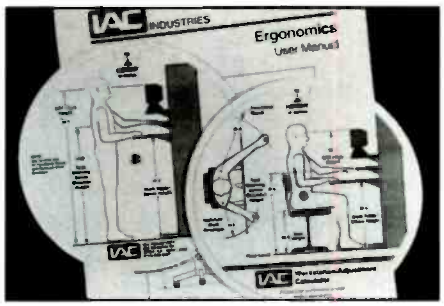
Literature

Workstation planning and training aids

IAC Industries is offering two ergonomic planning and training aids to assist industrial engineers, facility planners, manufacturing engineers, and plant safety managers with selecting ergonomic workstations and training employees how to use them.

One, a "workstation adjustment calculator," is an interactive wheel that shows correctly integrated body/workstation relationships based on a worker's height.



The other is an Ergonomics User Manual for workstations that explains the concepts of human engineering in layman's terms, with helpful hints for adjusting workstations and avoiding work-related injuries.

The company developed the new training tools in response to industry's growing interest in reducing ergonomic hazards to workers. Together, they inform users of correct adjustments for fitting a workstation to the body's dimensions.

To use the workstation adjustment calculator, you designate the worker's height, in inches, and windows line up on the wheel to show appropriate measurement ranges for body/workstation relationships. These include proper elbow height and seat height in terms of forearm-to-primary work table, corresponding work table height, task shelving below shoulder height, the "optimum work envelope" (i.e. the area in which a worker's tools and parts requiring constant usage are easily accessible), and for computer users, appropriate height for viewing monitors in terms of head and neck position.

One side of the wheel is for those whose work requires them to stand at a workstation; the other side is for seated tasks.

The calculator covers human body heights ranging from 60 inches (5 feet) to 72 inches (6 feet). This stature range represents the anthropometric dimensions of the 5th percentile female to the 95th percentile male—a widely accepted industry standard for classifying the human factor in ergonomic engineering.

The Ergonomics User Manual for workstations covers the basics of ergonomics, and describes common cumulative trauma disorders (CTDs) such as carpal tunnel syndrome, stiff neck, shoulder injuries, and elbow tendonitis. There are two sections of simple exercises, with illustrations, for preventing CTDs and relieving back pain.

The manual spells out the "Golden Rules of Ergonomics" with specific instructions for adjusting workstation shelves, work table, chair, overhead and task lighting, parts bins, tool platform, computer monitor, and footrest for comfort over a prolonged period of time.

Technical workstations are typically used for labor-intensive tasks such as precision assembly, testing, and other repetitive motion "hands-on" operations. Ergonomically-configured workstations equipped with good lighting allow users to work comfortably and more productively, without risking muscle strain or injury caused by cramped or over-extended movement.

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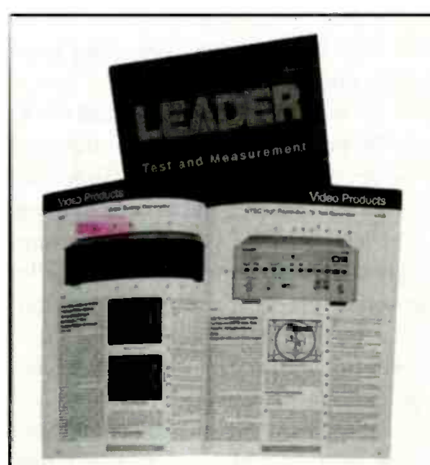
Full line catalog

Leader Instruments Corporation announces the release of its new 120-page, four-color, full-line Catalog No. 24. It features complete full-color product descriptions and technical specifications



(Continued on page 64)

Technology update: The status of HDTV

By The ES&T Staff

Based on publicity information furnished by the Grand Alliance.

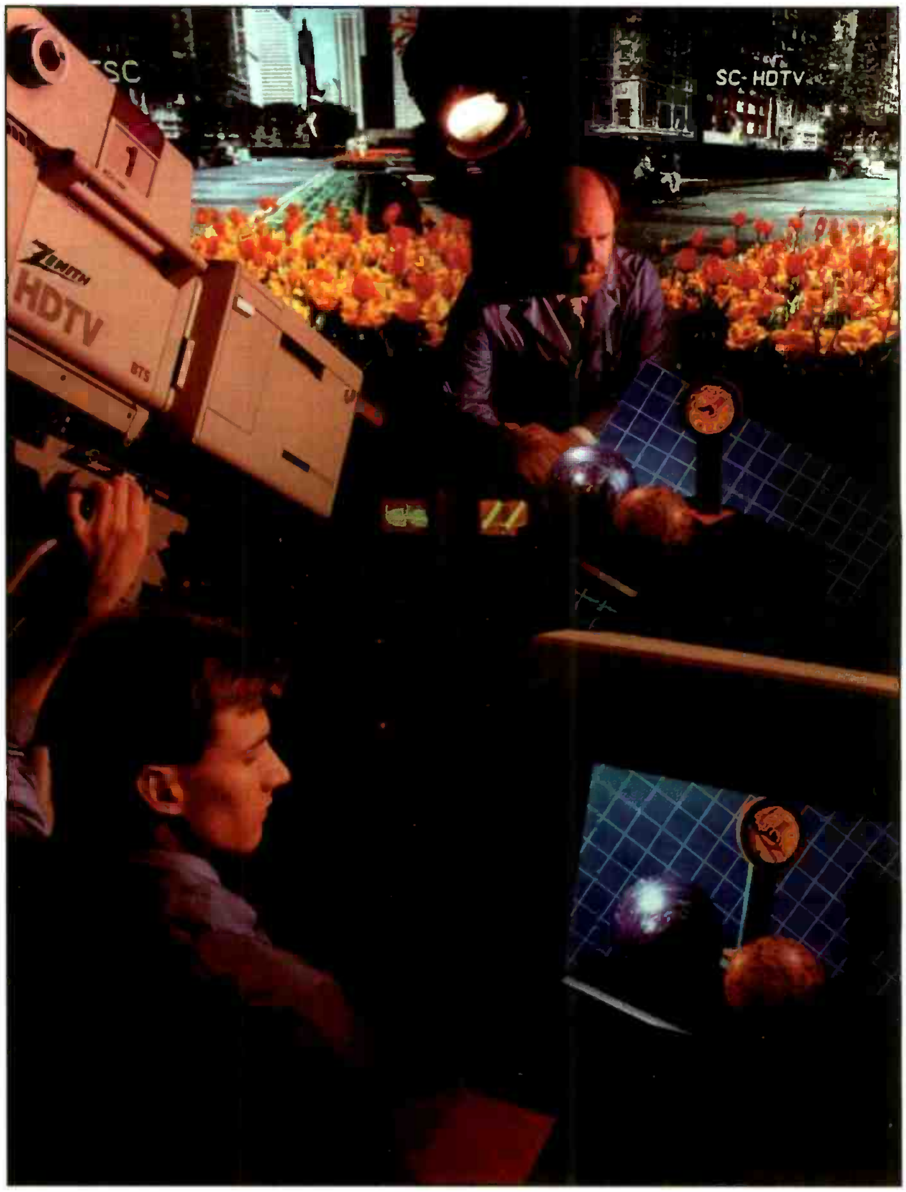
On May 24 of this year, the three groups that had developed world-leading digital high-definition television (HDTV) systems agreed to produce a single, best-of-the-best system to propose as the standard for the next generation of TV technology.

The three groups—AT&T and Zenith Electronics Corporation, General Instrument Corporation and the Massachusetts Institute of Technology, and a consortium of Philips Consumer Electronics, Thomson Consumer Electronics and the David Sarnoff Research Center—are now all working together as the Digital HDTV "Grand Alliance."

The Grand Alliance creates a collaborative effort with a pool of technical talent and financial resources that should assure that North America is the first to deploy and benefit from this new digital technology.

In the past, the process of formulating an HDTV standard had concentrated on selecting the best system from among those proposed. Under the Grand Alliance, the best features of all the systems can now be combined to produce a system superior to that of any one of the individual proponents.

The Grand Alliance approach is expected to be good news for everyone—consumers, broadcasters, cable operators, and the computer, consumer electronics and telecommunications industries, as well as for North American workers. The proposal addresses the needs of these key constituencies and incorporates capabilities that are vital to each of them.



Researchers in one of Zenith's laboratories evaluate the high-definition picture performance of digital HDTV technology that is displayed here on a "flat tension mask" high-definition monitor.

For instance, the system incorporates progressive scan transmission capability and square pixel capability: two attributes that are important for promoting interoperability with computers and telecommunications. Likewise, concerns expressed by many broadcasters have been addressed by including interlaced scan transmission in the initial deployment.

The proposal will allow North America to maintain the worldwide technological lead it has established. The rapid adoption of an all-digital HDTV system in the United States, Canada and the rest of North America, will promote the creation and maintenance of high-skilled jobs in the design and manufacture of HDTV receivers, displays, studio and transmission equipment, peripheral equipment, programming and software development, and semiconductor products.

Consumers will reap the benefits of the best technical minds collaborating to bring noise-free, theater-quality pictures and sound to American homes, as well as a host of new applications in home entertainment, education, computer and med-

Technology: The digital micromirror device

Based on information furnished by Texas Instruments.

While the Grand Alliance continues its development work on the HDTV system, other organizations continue to develop the technology that may one day be used to display an HDTV picture.

One such unit is the digital micromirror device (DMD), Figure 1, currently being developed at Texas Instruments.

The DMD

The DMD is a micromechanical, reflective spatial light modulator monolithically fabricated over a conventional CMOS SRAM address circuit. A 768 X 576 pixel array DMD (442,368 mirrors) has been developed for and demonstrated in one-DMD and three-DMD projection television systems that are capable of projecting pictures with diagonals ranging in size from 42 inches to 13 feet.

The DMD as a potential video display device

Most consumer projection television (PTV) sets sold today are CRT rear-projection systems. The display portion of these products consists of three CRTs, one for each of the primary colors. If other technologies such as the liquid crystal display (LCD) and the digital micromirror device (DMD) are to compete, they will have to have performance and reliability that meet the standards of the CRT, or be superior, and will have to cost about the same in order to be accepted in the PTV marketplace.

CRTs are the workhorse of display technology, and are constantly improved to meet higher performance standards of resolution, brightness, contrast ratio, and convergence in PTV applications. However, CRT performance is expected to soon reach its limit.

With the anticipated advent of digital, high-definition PTV in the late 1990s, with twice the resolution of standard-definition PTV, CRTs may not be able to meet the demanding standard of consumers for image quality that is comparable, or nearly so, to what they are used to seeing at the movie theaters.

Developers are therefore making large investments in LCD technology for PTV. LCD technology is currently faced with the challenges of improving its optical efficiency in order to achieve increased brightness, and with the development of high-yield active-matrix address circuits based on amorphous silicon or polysilicon technology.

According to Texas Instruments, the DMD provides a promising alternative to LCD technology in PTV applications, with performance equal to or better than that of a CRT, and with the potential for being cost competitive with the CRT. Currently, the DMD has more optical efficiency than conventional LCDs.

The DMD chip

The DMD was invented in 1987. It is the outgrowth of work that began a decade earlier at Texas Instruments on micromechanical, analog light modulators. These were called the deformable mirror device (also DMD). The DMD is a reflective spatial light modulator, consisting of an array of tiny aluminum mirrors that can rotate. The mirrors are monolithically fabricated over an address circuit consisting of conventional CMOS SRAM cells. The mirrors are 16µm wide on a pitch of 17µm and are capable of rotating

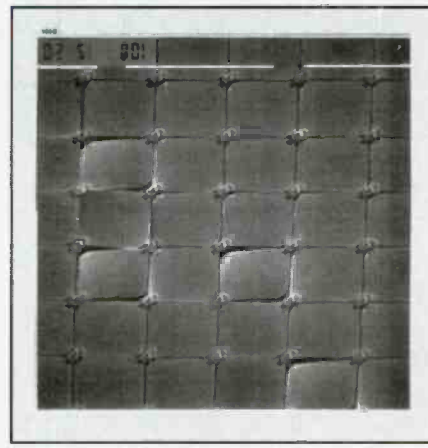


Figure 1. The digital mirror device (DMD), currently being developed by Texas Instruments, may one day compete with the LCD and the CRT as display elements for HDTV. In this early version of the DMD, the contrast ratio was degraded because of stray light diffracted from the hinges, hinge support posts, and the mirror edges at the landing tip which are not at right angles to the mirror surface. This stray light adds to the light that is projected by mirrors that are in the off state.

±10 degrees.

The mirror is suspended over an air gap by two thin torsion hinges supported by posts that are electrically connected to an underlying bias/reset bus. This bus interconnects all the mirrors directly to a bond pad so that a bias/reset voltage waveform

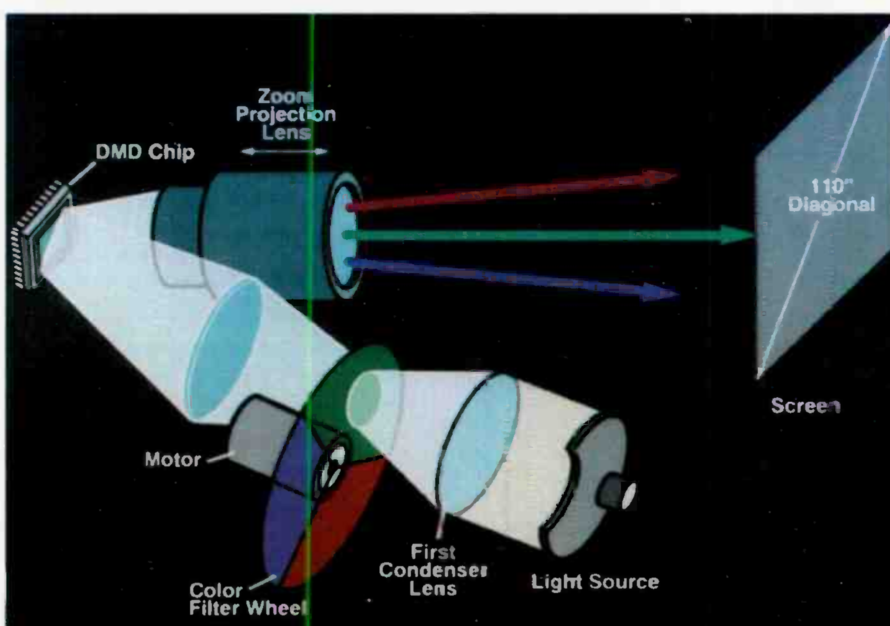


Figure 2. The DMD is used in a darkfield projection system. Projection of color TV using the DMD would be accomplished either by using three DMDs and three-color projectors, or by using a single DMD that would be time sequentially illuminated with different colored lights using a color wheel system.

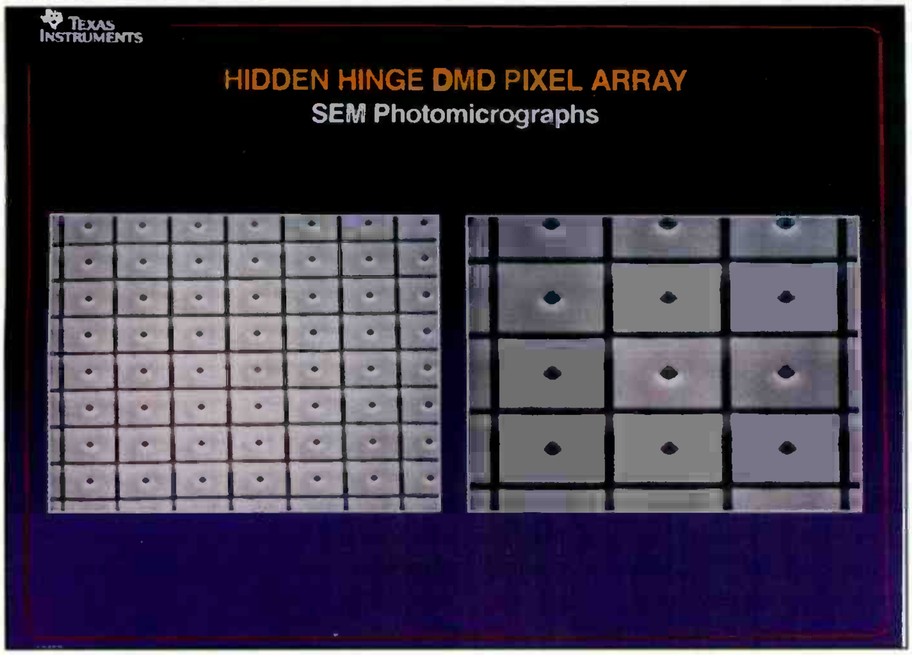


Figure 3. A new DMD superstructure is called the hidden hinge DMD. Viewed from the top, the pixel array looks like a set of closely packed square mirrors. This structure offers nearly ideal optical characteristics in terms of both contrast ratio and optical efficiency. The hinges and hinge supports in this system are hidden under the mirror.

can be applied to the mirrors by a circuit that is not on the same chip. Underlying the mirror are a pair of address electrodes that are connected to the complementary sides of an underlying SRAM cell.

Depending on the state of the SRAM cell, the mirror is electrostatically attracted by a combination of bias and address voltage to one or the other of the address electrodes. It rotates until its tip touches a landing electrode held at the same potential as the mirror.

A "1" in the memory cell causes the mirror to rotate +10 degrees. A "0" in the memory causes the mirror to rotate -10 degrees. Although the DMD can be operated in an analog mode, the mirrors are biased in such a way that only the digital landing states of ±10 degrees are possible. The digital mode of operation permits the use of low-voltage CMOS and ensures large, uniform deflection angles.

A 768 x 576 DMD pixel array (442,368 mirrors) has been developed for PTV applications. Such an array meets the European resolution standard, and exceeds the current United States resolution standard.

The DMD superstructure is formed on top of the CMOS, using four photolithography layers. The three metallization layers: the electrode, the hinge, and the mirror; are sputter-deposited aluminum structures that are plasma (dry) etched. During the fabrication process, a spacer made of an organic material is formed between the SRAM and the mirror structure. Later the spacer is destroyed, creating an air gap between the address electrodes and mirror.

The projection system

The ±10 degree mirror rotation angles are converted into high-contrast brightness variations by the use of a darkfield projection system. In a darkfield projection system, the light beam is aimed at an angle to the object whose image is to be projected. Only portions of the object that are at a certain angle to the incident light reflects light through the projection lens to form an image on the screen. All other light from the light source is reflected away from the projection lens.

DMD projection systems based on a single chip, and DMD projection systems based on three chips have been demonstrated. In the three-chip system, one chip is used for each of the primary colors (R, G, B). This is similar to most LCD projection displays. Because of the DMD's efficient use of light, it is also practical to use a single-chip system. The single-chip system is less costly and does not require convergence.

In the single-chip scheme, a single DMD is illuminated with the primary colors in time sequence using a color wheel (Figure 2). In either system, light from a metal-halide or xenon arc lamp, or similar source, is aimed through a condenser lens and directed at an angle of +20 degrees from the normal of the DMD and orthogonal to the rotation axes of the mirrors. A projection lens positioned above the chip (or chips) produces an enlarged image of each DMD mirror on a projection screen.

If one of the mirrors is rotated to +10

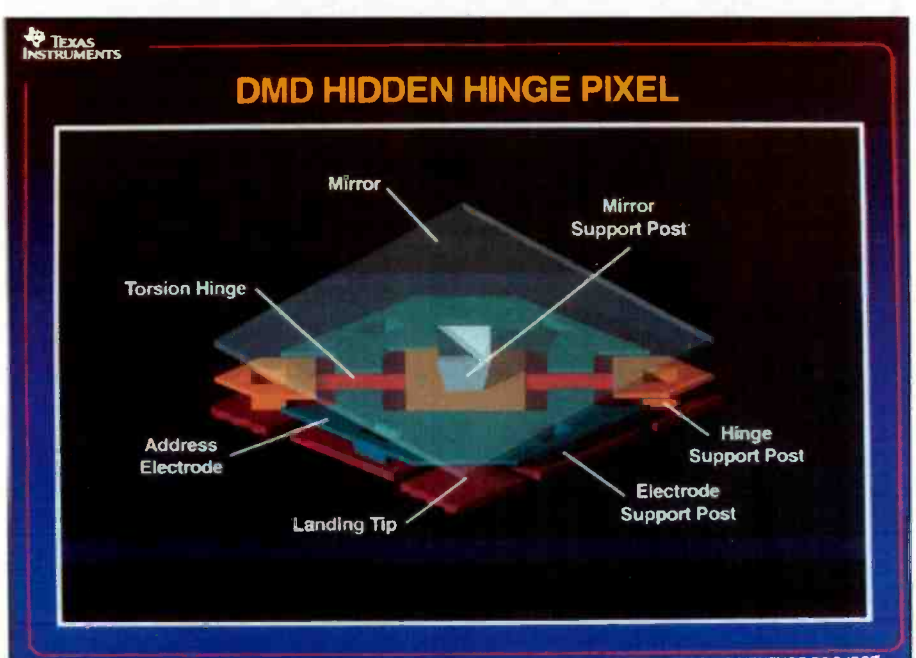


Figure 4. This view shows the detail of a single pixel in the DMD hidden hinge system.

degrees (memory address "1") it reflects the incoming light into the pupil of the projection lens and the mirror appears bright (on) at the projection screen. If a mirror is rotated to -10 degrees (memory address "0") it reflects light at an angle of -40 degrees with respect to the projection lens, so that the light from it does not arrive at the screen. This mirror appears dark (off) at the projection screen. The flat structures (post tops, hinges) reflect light at an angle of -20 degrees. This light also misses the pupil of the projection lens and is not projected onto the screen.

The mirrors can change position very quickly: in about 10μsec. The DMD can take advantage of this capability and vary the amount of time during which the mirror reflects light onto the screen versus the amount of time it appears dark on the screen, to achieve precise gray levels of brightness. This gray scale variation is accomplished by pulsewidth modulation of the mirrors.

Each video field is subdivided into time intervals, or bit times. Each interval is one-half as long as the preceding interval. During each of these bit times, the mirrors are addressed by the underlying SRAM array to be in either the on or off state. If an 8-bit modulation scheme is chosen, any one of 2^8 or 256 gray levels is possible.

Improved performance DMD

To be competitive with traditional CRT-based PTVs, the DMD projection system must have a contrast ratio (CR) of better than 100:1, and still maintain optical efficiency. The conventional DMD superstructure can only deliver a CR in the neighborhood of 50:1 with an f/2.8 projection lens. An f/2.8 lens is the fastest lens that preserves the darkfield imaging condition for mirror rotation angles of ±10 degrees.

Degradation in the contrast ratio of the conventional DMD superstructure is for the most part caused by stray light diffracted from the hinges, hinge support posts, and the mirror edges at the landing tip which are not at right angles to the mirror surface. This stray light adds to the light that is projected by mirrors that are in the off state. Together with other sources of stray light, including lens glare, the CR degrades to unacceptable levels.

A new DMD superstructure, Figure 3, is called the hidden hinge DMD. Viewed from the top, the pixel array looks like a set of closely packed square mirrors. This structure offers nearly ideal optical characteristics in terms of both contrast ratio and optical efficiency. The hinges and hinge supports in this system are hidden under the mirror (Figure 4). The mirror is connected by a mirror support post to an underlying yoke. The yoke is in turn connected by torsion hinges to hinge support posts. The address electrodes and landing electrodes are coplanar with the hinge. There are two air gaps, one between the mirror and the underlying hinges and address electrodes, and a second between the coplanar address electrodes and hinge and an underlying third level of metal of the CMOS SRAM structure.

The hinges and support posts are hidden under the mirror, and therefore cannot diffract light, and so do not degrade the CR. Because the mirror edges at the landing tip are perpendicular to the mirror surface, the landing tip diffracts less light, leading to less degradation in CR. The greater mirror area leads to greater optical efficiency.

A 768 x 576 hidden hinge DMD has been tested in an f/2.8 projector using a test pattern to properly take into account all sources of system CR degradation. System contrast ratios of 110:1 have been measured, meeting the contrast ratio requirement of better than 100:1 for PTVs with no sacrifice in optical efficiency. In fact, the efficiency increases because of the higher percentage of active mirror area.

Will this be the display of the future?

Service technicians are most familiar with CRTs as video displays. More recently, they have had to become familiar with LCDs. The deformable mirror device is an entirely new display system that could one day displace both CRTs and LCDs. We'll continue to track the progress and development of video displays as changes take place, and we'll keep the readers of **ES&T** posted.

ical imaging, factory automation, publishing—all stimulated by the early adoption of this technology.

The process

The HDTV standard-setting process has been and will continue to be a public, open process. At the same time, it must proceed as rapidly as possible if U.S. and Canadian consumers and the countries' economies are to capitalize on this critical new technology. These are the next steps in the process:

- The Advisory Committee has reconvened its Technical Subgroup to evaluate the Grand Alliance proposal in detail. If necessary, this group may negotiate changes to the proposal system with the alliance members. In the meantime, the alliance members are finalizing the specifications of the combined system in a few areas that are not yet fully resolved.
- Once the Advisory Committee's Technical Subgroup has approved the basic concepts of the combined system, the Alliance members will work together to construct the system. After that, the Advisory Committee will conduct extensive laboratory tests in the U.S. and Canada to verify that the system meets its expectations. The Advisory Committee could then recommend the system to the FCC and simultaneously begin field test verification of the system's performance.
- The FCC, in turn, would consider the Committee's recommendation in a rulemaking proceeding which members of the alliance hope could be concluded by the end of 1994. Whatever standard is adopted, the FCC requires that the applicable technology be licensed to anyone on reasonable terms.
- It is anticipated that Canada and Mexico will simultaneously initiate similar, appropriate procedures to assure rapid adoption throughout North America. Moreover, because of early North American implementation, it is hoped that the rest of the world will adopt many of the elements of the North American HDTV standard.

Speed is of the essence. The Grand Alliance system, if ultimately accepted by the Advisory Committee and the FCC, will maintain and enhance the North American leadership position in digital television technology and in HDTV in particular.

Digital high-definition television images (left) show the fine picture detail achieved by quadrupling the video information transmitted on current TV broadcasts (right).

Historical perspective

The television we watch today uses the NTSC (National Television Systems Committee) standard, finalized in the late 1940s. While that standard has been improved, most notably by the incorporation of color in the 1950's, today's television is based on the same fundamental resolution parameters as the original service, including 525 horizontal lines and interlace scanning. The introduction of color television approximately 40 years ago, was the last major advancement in the NTSC standard. The North American standardization activities were subsequently emulated throughout the world.

In the early 1980's, Japan's NHK proposed its MUSE HDTV interlaced system, based on 1,125 horizontal scan lines, and proposed its worldwide adoption. MUSE made the world aware of the goal of "high definition television," with quality equivalent to motion pictures, including a wide-screen format. The MUSE system renewed concerns in the United States about the capabilities of American technology. Many feared that American companies and employees would be shut out of a fundamental new technology.

In 1987, at the request of U.S. broadcasters, the FCC initiated its rulemaking on advanced television service and established its blue ribbon advisory committee for the purpose of recommending a broadcast standard. Former FCC Chairman, Richard E. Wiley was appointed to chair this effort. Hundreds of companies and organizations from the U.S., Canada and Mexico have worked together within the numerous subcommittees, working parties, advisory groups and special panels of the Advisory Committee on Advanced Television Service (ACATS) during the past six years.

Several important steps followed:

• ACATS developed a competitive process by which proponents of systems were required to build prototype hardware which would then be thoroughly tested. This process sparked innovation and an entrepreneurial response: initially there were 23 proposals for systems submitted to ACATS in September 1988. (Hardware was actually built and tested for six systems.)

• The FCC made several key spectrum decisions that also helped spark innovation. The Commission decided in early 1990 that new ATV systems would share television bands with existing services and would utilize TV channels as presently defined. The Commission also decided that a simulcast approach, as first proposed by Zenith would be followed. This meant that a new standard could provide a quantum leap forward from the current NTSC standard and would not be hindered by the requirements of the current standard, except to protect existing broadcast service during a period of transition.

• The FCC anticipated the need for interoperability of the standard with other media. Initially, the focus was on interoperability with cable television and satellite delivery; both were crucial to any broadcast standard. But the value of interoperability with computer and telecommunications applications became increasingly apparent, when the next technical advance came in the form of all-digital compression and transmission systems.

• Although the FCC had said in the Spring of 1990 that it would determine if all-digital technology was yet feasible, most observers viewed it as at least 10 years in the future. That same year, General Instrument became the first to announce an all-digital system, followed by the Philips-Thomson-Sarnoff consortium and by Zenith-AT&T. (Until then, there had been proposals for utilizing digital compression with analog transmission and proposals for hybrid digital/analog transmission.)

• Proponents later announced the use of packetized transmission, headers and descriptors, and composite-coded surround sound. (The Consortium and, to a lesser extent, Zenith-AT&T had previously adopted packetized transmission.) These features increase even further the interoperability of HDTV with computer and telecommunications systems. The introduction of all-digital systems had made such interoperability a reality.

• All-digital systems set the stage for another important step, which was taken in February 1992, when the Advanced Television Systems Committee (ATSC) recommended that the new standard include a flexible adaptive data allocation capability (and that the audio also be upgraded from stereo to surround sound).

Six systems (four of which were all-digital) underwent extensive testing in 1991 and 1992 at the Advanced Television Test Center (ATTC) in Alexandria, VA. Also participating in testing were CableLabs, which tested systems over a cable television test bed, and the Advanced Television Evaluation Laboratory (ATEL) in Ottawa, Canada. Canadian participation has been active and very important to the goal of creating a unified North American standard. The ACATS process has been critically dependent upon the unique, subjective picture-quality evaluations of the ATEL to ascertain if proponent systems truly result in "high definition" pictures. Canadian participation has also been an invaluable part of the complex simulcast spectrum issues because of the thousands of miles of shared borders between Canada and the United States.

Following testing, the Advisory Committee decided to limit further consideration to those that had built the four all-digital systems: two systems proposed by GI and MIT, one proposed by Zenith and AT&T, and one proposed by Sarnoff, Philips and Thomson. The advisory Committee decided that while all of the digital systems provided impressive results, no winner could then be proposed to the FCC as the U.S. standard. The Committee ordered a round of supplementary tests to evaluate improvements that had been made to the individual systems.

Speeding HDTV implementation

The formation of the Grand Alliance has eliminated the need for another round of testing on the individual systems, the results of which could have been inconclusive. Thus, the formation of the Grand Alliance could save a year or more in the implementation of HDTV and by reducing the risk of inconclusive test results and the possibility of legal or other challenges.

If accepted by ACATS and by the FCC, the system will speed the implementation of HDTV in the United States. That, in turn, should set the stage for adoption in Canada, enabling North America to maintain and enhance its worldwide lead in the development of this vital technology.

Interoperability

Representatives of the computer industry have made significant contributions to the HDTV standards process and to the Grand Alliance systems. They participated in the work of ACATS and helped to articulate the need for features that could enhance the interoperability of an all-digital system. The standard will be better than it would have been thanks to their participation.

It is important to recognize the extent of the commitment being made to increase interoperability of HDTV with computers and television. Participants from non-broadcast industries suggested a number of significant features for the standard which have been incorporated into the Grand Alliance proposal:

- They sought an all-digital advanced television standard. The proposal is for an all-digital system.
- They said that the digital data stream should have a prioritized and packetized data support structure. The alliance proposal incorporates such a structure.
- They maintained that the standard should include source adaptive coding. The Alliance proposal does.
- They requested that the standard provide for square pixels to facilitate computer graphics. The Alliance proposal provides for square pixels.
- They requested that the standard utilize a progressive scanning format. The Grand Alliance proposal includes progressive scanning from the outset and promises a migration plan to the eventual exclusive use of progressive scanning.

Other aspects of the Grand Alliance system enhance interoperability with computers and telecommunications. The Grand Alliance system is very similar to the evolving MPEG-2 compression approach, which is currently in working draft status in the MPEG Committee of the International Standards Organization.

The Alliance compression system may also include additional capabilities in order to assure the highest picture quality possible. If so, the Grand Alliance will endeavor to get these capabilities incorporated in the MPEG standard.

Another aspect of the Grand Alliance system which enhances interoperability is the fixed-length packet format that provides for flexible delivery of video, audio, text, graphics and other data by broadcast, cable, satellite and fiber. This packet data format provides flexibility and a high degree of interoperability with other emerging telecommunications and data networks that use similar technology, such as Asynchronous Transfer Mode (ATM), the emerging standard for broadband telecommunications networks. Finally, the proposal's packetized data transport structure utilizes universal headers and descriptors to provide flexibility and extensibility, i.e. headroom, for future growth of system capabilities.

More to come

The introduction of a completely new television broadcast system will mean a whole new technology for consumer electronics servicing technicians to learn. As the HDTV system evolves toward fruition, **ES&T** will continue to provide technical detail on the circuitry ■

Recommended system and servo control circuit diagnostic procedures for VCRs

By The ES&T Staff

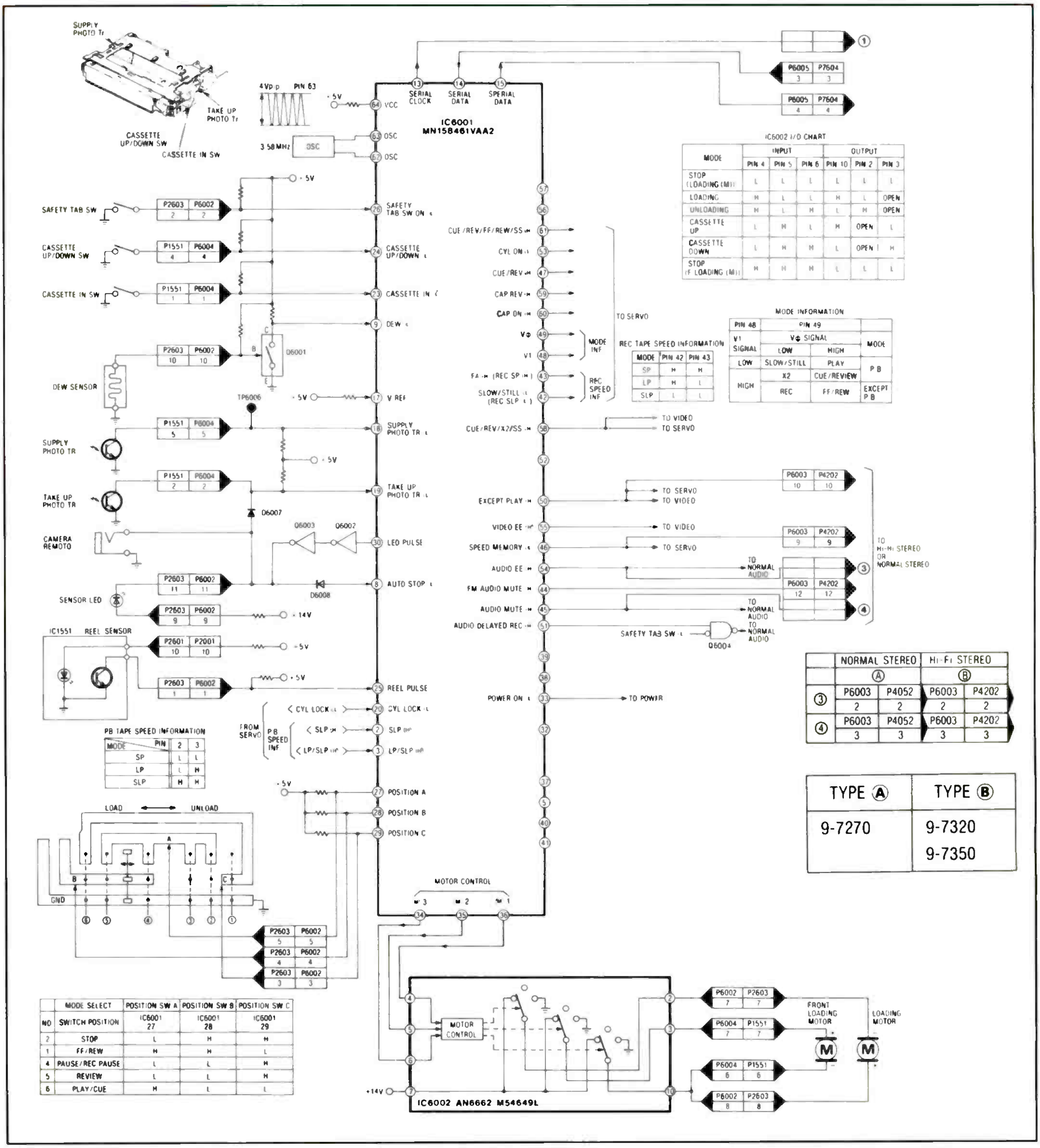


Figure 1

Adapted from a Diagnostics and Troubleshooting Techniques paper published by General Electric.

System and servo control failures account for more than half of all service performed on the electronic circuits of VCRs. Unfortunately, a great deal of time is wasted in determining the defective stage and components. Add to this the pressure of the customer or the manufacturer demanding quick service, and it becomes difficult for the technician to take the time to think the diagnosis through logically.

The purpose of this article is to reinforce some basic theory, and to suggest some logical steps in troubleshooting and diagnostic procedures. The way in which these circuits process information may differ from model to model. The results, however, are the same.

When thinking of where it makes sense to begin a diagnosis, a good approach is to think in terms of inputs and outputs.

The inputs to a device, whether a transistor or microprocessor generally are designed to make something happen, usually to an output. Assume, for example, that you suspect that the problem is a transistor switch whose function is to turn something on and off.

You push the play button and nothing happens. According to the schematic diagram, the loading motor requires 12Vdc. A multimeter measurement confirms that the 12Vdc source is supplying the proper voltage. When you measure the collector of the motor drive transistor you determine that the 12Vdc is present there. Still, pushing the play button causes no changes in the circuit.

A recommended diagnostic procedure

To track down the cause of this problem, monitor the base of the transistor with a meter. When the button is pushed, look for a change to occur. For a transistor to turn on it must be forward biased. In the case of an NPN transistor, the base must be positive relative to the emitter. For a PNP transistor, the emitter must be more positive than the base. A difference of approximately 0.6V between the emitter and base is normal for a silicon transistor and 0.3V for a germanium transistor.

If a change does occur at the base, but no change occurs at the collector, the transistor is suspect. If no change occurs at the base, check the preceding stage.

If the transistor checks good, you may want to verify the following stage and or stages by changing the input to the transistor (base), by forcing a change of state (base to ground through a low value resistor, or applying an external voltage to the base and monitoring the output: collector or emitter).

This procedure is similar to signal injection. In this case, by forcing a change of state, you cause the device to respond. This allows you to focus only on that device, and should lead to more clearly defined thinking. Failure to think logically results in incorrect diagnosis. Microprocessors have been destroyed by unnecessary desoldering. Always check the discrete components before concluding that the microprocessor is faulty. Failure to perform these checks can be costly and time consuming, and can result in PC board and component damage.

Some diagnostic hints

The following are diagnostic hints in troubleshooting two circuits found in all VCRs: the system control circuit and the servo circuit. Circuitry will differ from model to model. However, using a logical troubleshooting process to eliminate circuit components from suspicion will apply to all units.

Assume that you have already made the necessary checks to determine that the power supply and mechanical functions are all operating normally.

System control circuit diagnosis

The symptom in one VCR is that nothing happens when the play button is pushed, and the cylinder motor starts then stops (in some models).

A good approach to diagnosis in this case is to check the block diagram to determine the proper signal path (see Figure 1). Locate pins 34 and 36 on the system control IC (IC6001). These are the loading motor forward, loading motor reverse control lines.

Check the flow paths on the output ports. In this case, the outputs from pins 34 and 36 of IC6001 arrive on pins 4 and 6 of IC6002. These are input ports that turn electronic switches within the IC on and off. First confirm the V_{CC} voltage on pin 7 of IC6002. Next, look for a change to occur on pins 2 and 10 of IC6002 when

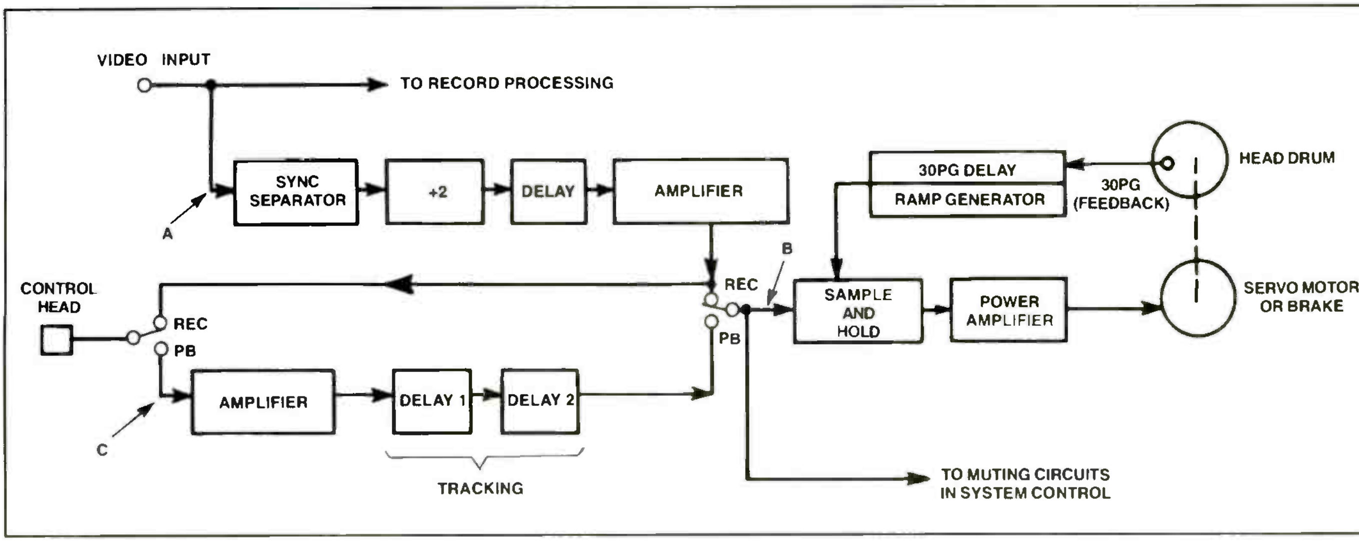


Figure 2

the play button is pushed. You determine that for the motor to load the tape, pin 10 must be high and pin 2 low. The reverse is true for unloading. If no change occurs, you recheck pins 4 and 6 while pushing the play button, remembering that the output of IC6002 will control the loading motor. To load, pin 6 will be high, and pin 4 low. If you confirm the proper change on these pins but none on pins 2 and 10, then the probability is that IC6002 is defective. In most cases, operation of the unit can be accomplished by applying 12Vdc from an external power supply to pin 8 of Plug P6009. The tape should load and the VCR should enter the play mode. Remember to remove the 12Vdc, or the loading motor will continue to run.

Now, let's assume there was no change at pins 4 and 6 of IC6002. Using an external dc supply, apply 5Vdc to pin 6 of IC6002. If the tape loads, you've determined that IC6002 is working properly. Work back on this line toward the microprocessor, checking the associated components for defects. If none appear, you might suspect the microprocessor.

Before condemning the microprocessor, you should make a few more checks. Are the inputs to other pins of IC6001 correct? Is the mode select switch functioning properly? Ask yourself these questions before you condemn a perfectly good microprocessor.

Servo control circuits

Servo circuitry could be thought of as the secondary operation that occurs within a VCR after the system control performs its function. Once the tape is loaded, the record and playback functions are taken over by the servo circuits. The recording of both the video and audio tracks in the record mode, and, conversely, the tracking of this information in the playback mode, must be precisely controlled for playback to be normal.

This is accomplished by two components: the cylinder motor and the capstan motor. Servo circuits can be troublesome to service since most of the circuitry contains feedback loops (information is fed back to other related circuits where it is stripped and, in some cases, reformatted and sent out again to be compared).

Before troubleshooting the following hypothetical problem, here is a good rule of thumb:

- If the picture produced by the VCR tends to break up horizontally, a likely cause is incorrect cylinder motor speed.
- If the video pulsates in and out at a more or less steady rate, a likely cause is erratic capstan motor speed. Most VCRs are designed to mute the audio when the servos are not locked.

There are many exceptions to these rules, but they may save you precious time and initially steer you to the correct circuitry.

Diagnosing a servo control circuit problem

The customer complained about a noise band that periodically ran up the picture when he played back a tape recorded on that machine. All other tapes, recorded on other VCRs, played back fine. When playing a tape recorded on this machine on another machine, it exhibits the same symptom.

The most likely cause of this type of symptom is a servo problem in the record mode. A quick way to confirm this would be to put a mark on the upper surface of the video head using a grease pencil. Place the machine under a fluorescent light and run it in the record mode.

Examine the spinning video head assembly. You should see a blurry, barely moving pattern of the mark you made. If you do not see this pattern, the servo is not locked. Assume that in this case you do not see this pattern, only a blur.

Let's say you also notice the following additional symptom: the video head switching point appears to move vertically through the picture. The switching point from head A to head B is turned on and off by an electronic switch. This point is chosen to be 5 to 8 lines ahead of vertical sync. It is precisely controlled by a 30Hz square wave produced in the servo system.

Take a look at the block diagram of Figure 2. Where would you suspect that the problem exists? A little reflection suggests that the problem is somewhere between points A and B.

The 60Hz vertical sync pulses from the composite video signal are separated and divided by 2. They are then amplified and sent to the control head to be used for the servo circuit. If you attempt to observe these pulses at the output of the amplifier, you will see that they are not there.

If the problem was that the servo locks in record but not in playback, this would indicate that the timing reference was lost. This would point to a failure between points C and B.

If the VCR fails to lock in both playback and record, the problem may lie with the 30PG feedback pulse generated by the video cylinder motor. Use a scope to confirm that the 30PG pulses are developed, that they have sufficient amplitude, and that they are triggering the ramp that drives the sample and hold gate. Usually, most of this circuitry is inside one IC. You can, however, trace both reference and feedback signals to points as close to the sample-and-hold gate as possible. ■

Understanding and servicing microwave ovens

By David T. Miga, CET

For the average consumer electronics servicing technician, servicing a microwave oven should be a relatively simple project. Compared to the circuits of such other consumer electronics products as TVs, VCRs and computers, the circuitry of microwave ovens is simple.

The basic concept of the microwave oven is to generate electromagnetic radiation at a frequency such that it causes the molecules in the food in the oven to vibrate, and thus to generate heat within the food itself, which cooks it.

The basic microwave oven circuit consists of a magnetron: a vacuum tube which generates the microwave radiation, and the circuitry that applies power to the magnetron. There is, of course, quite a bit of other circuitry, but that's there to control the operation of the microwave circuit, and to make sure the oven won't operate unless the door is closed.

The magnetron

The magnetron is the heart of the microwave oven. In reality, it is only a tube, something like the glass tubes you may remember in old TVs and radios. In the magnetron there is a filament, which is a wire heated with a large current which causes the wire to glow white-hot, like a light bulb. The wire releases not only heat, but a large number of electrons which do their best to get away. The tube is at a high vacuum so that the electrons are not slowed by air molecules.

To collect these electrons, a large positive voltage could be used on a plate inside the magnetron to attract them. In another scheme, the plate is grounded to the chassis ground, and a large negative voltage is placed on the filament to repel the electrons. Either system will work, but for safety's sake and to make the engineering easier, the grounded-plate system is used.

But what have we accomplished by collecting all these electrons? Actually, nothing yet. But what would happen if we put a powerful magnet inside the magnetron? Those poor electrons would be so confused by the magnetic poles that they would swirl and rotate on their way to the grounded plate. The swirl and rotation is controlled by machining the inside of the magnetron in such a way as to leave "pockets" for the electrons to resonate in, just like the pellets in a police whistle. The frequency of the rotation, or oscillation, in a typical magnetron is such that the output is in the microwave radio frequency known as the "X" band, or 2450MHz.

Figure 1 shows the symbol for the magnetron, and Figure 2 is a photo of a typical magnetron tube. The two connections at the base of the magnetron are the filament connections. The high negative voltage that is used to repel the electrons can be connected to either of these terminals.

The plate of the magnetron is attached to the metal mounting brackets of the tube, and will be grounded as long as the tube is properly mounted. The electrons are collected at the top of the tube, and the electrons are converted to high-frequency magnetic radio waves by the antenna stub at the top of the magnetron. It is important to understand that the electrons do not cook the food, the electromagnetic radio waves do.

The power that operates the magnetron is supplied by a circuit that consists of an electronic switching circuit and a high voltage transformer, as described below.

Applying power to the magnetron

In operation, a mechanical timer or an electronic control unit causes a relay or more usually a triac to pass 120Vac to the

Miga is president of Southgate Electronics.

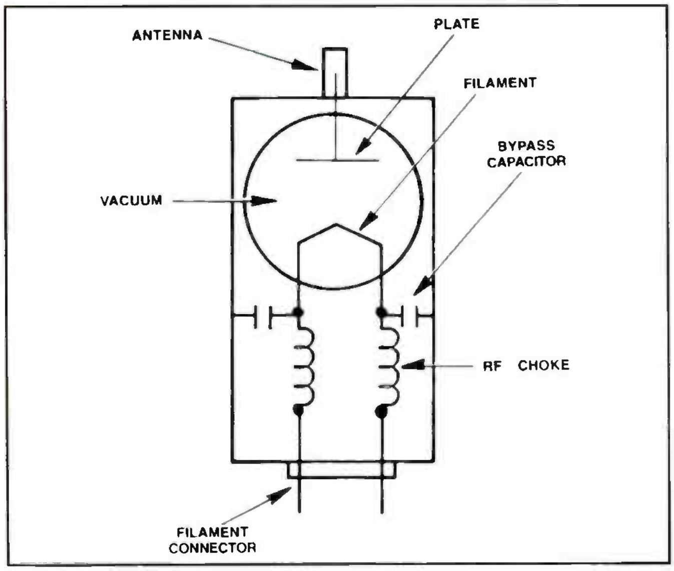


Figure 1. This drawing shows what the magnetron consists of.

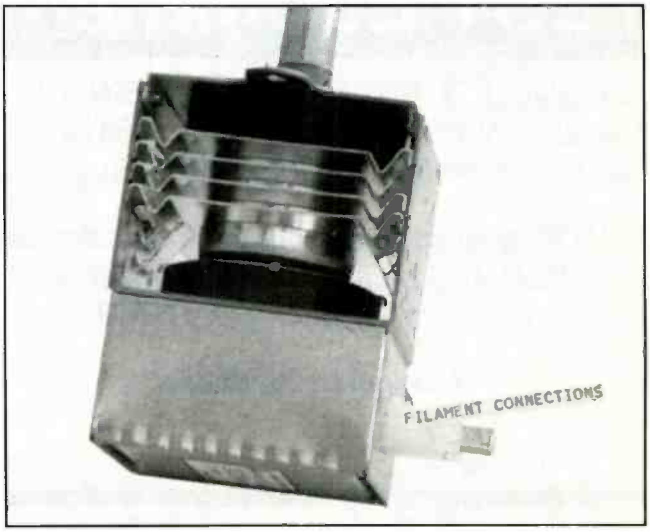


Figure 2. When you open up a microwave oven to service it, you'll find something that looks like this: the magnetron tube.

primary of the power transformer. The transformer has two secondary windings: a 3V secondary for heating the magnetron's filament, and a 1500V to 2500V secondary for the high-voltage power supply. To keep the windings count low, a voltage doubler circuit is used.

During one half of the 60Hz current, the transformer charges the high-voltage capacitor to ground through the high-voltage diode, but power is not delivered to the magnetron tube. When the polarity reverses, the capacitor is free to discharge through the high-voltage winding of the transformer.

The voltage of the capacitor is now in series with, or added to the voltage now produced by the winding of the transformer, thus the voltage is doubled, although the current is reduced to the amount that the capacitor can supply during its discharge. Therefore, the size of the capacitor controls the wattage of the oven, and the magnetron actually transmits energy in 60Hz pulses.

An important fact is that the capacitor may remain charged for hours after using the oven, so it must be discharged before any components in the oven are checked.

When a microwave oven is operated, the magnetron usually takes about three seconds to fire up, because the filament must come up to temperature. If you listen, you will be able to hear the firing up: the magnetron emits a one second buzz immediately after the filament heats up.

Controlling the power

In ovens with several power settings, the power delivered to the magnetron does not vary, but instead is cycled on and off by the controlling circuitry. The fan and light stay on, but the primary of the power transformer is energized or de-energized by a relay or triac.

More sophisticated ovens may use a temperature probe, or even a heated tin oxide gas vapor sensor to determine when the food is cooked. The resistance of a thermistor in the probe, or the voltage output of the gas sensor, is routed to a microprocessor, which has been programmed with the proper values to turn off power when the food has reached the correct temperature, or "smells" done.

The relay and the triac

Most technicians know about the relay; it is a simple electromechanical device. A coil of wire is energized so it'll pull an iron plate onto a set of contacts to make a connection. In this manner, a small voltage can easily control a large current.

You can think of a triac as a solid-state relay. With no control signal, the triac is an unconnected, or open circuit. Provide a tiny signal into the gate terminal of a triac, and it will allow a large current to flow across the MT1 and MT2 contacts.

But there are a couple of peculiarities when the triac is used. A relay would use two connections for the coil, and at least two more connections for the switch, making a minimum of four connections. But a triac has only three connections, gate, main terminal 1 and main terminal 2. Simply put, the MT1 connection is the joining of one coil connection and one switch connection.

Because this joins the low voltage of the coil to the high voltage of the switch, the engineer must take special care when designing any circuit using a triac. In other words, you cannot replace a relay with a triac; leave that to the design engineers.

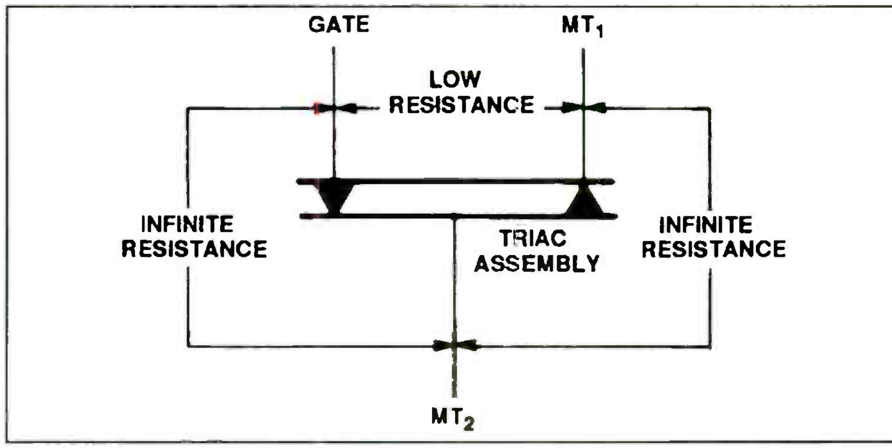


Figure 3. This schematic idea of the construction of a triac shows the resistance values you should expect to read when you measure resistances between the various electrodes of the triac.

Figure 3 is the schematic symbol of the triac, and Figure 4 shows the types of triacs that a typical microwave oven might use. The large square or round style are the most popular. The two larger terminals are MT1 and MT2, with the center terminal always MT2. The only small terminal is always the GATE, or control.

Some other components

In a typical microwave oven the magnetron tube is bolted on one side of the oven chamber, also called the cavity. A fan blows across the tube fins to cool the tube. The microwave energy is directed from the top of the tube through a square metal duct called a waveguide, through a plastic or mica plate called a waveguide cover. The purpose of the waveguide cover is to allow the waves to pass but keep water vapor or food particles out of the waveguide.

Most microwave ovens have a microwave stirrer in the top of the oven to reflect the microwaves all around the cavity. This stirrer may be driven by an

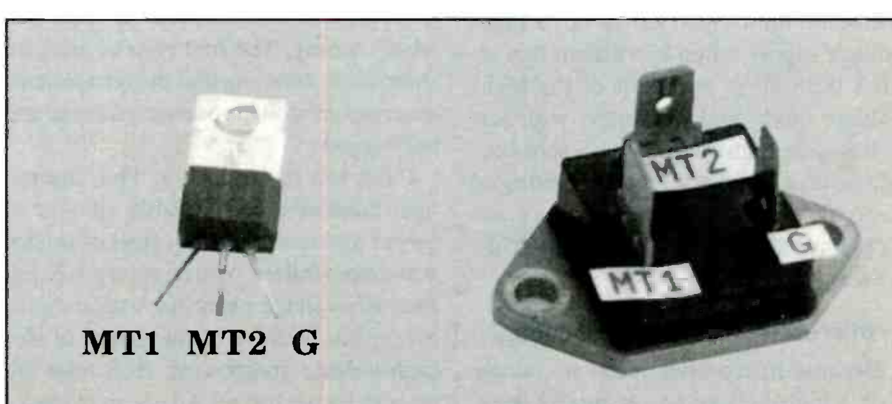


Figure 4. Triacs in microwave ovens come in a variety of shapes and sizes. Here are a few you may encounter.

electric motor, or, as in many ovens, it may be blown propeller-style by the air that is forced through the cooling fins of the magnetron.

Safety features

All microwave ovens have safety features to keep their users from being exposed to microwave radiation. A series of microswitches operate in a certain sequence, and are in series with one or more thermal switches, so as to assure that the power supply will operate only when all of the switches are in their correct positions. There is even a switch designed to short out the ac line, blowing the fuse, if any of the switches malfunction.

Testing the microwave components

When you encounter a microwave oven that has malfunctioned, the components that you may have to test include the diodes, capacitors, fuses, magnetrons, transformers and triacs to determine if they are either shorted or open. You may also be required to measure the high ac and dc voltages found inside the oven.

In order to perform these tests, you will need transistor checkers, ohmmeters, continuity testers and multimeters. It may be difficult to find a meter that will measure such high voltages. There are available combination test equipment that will measure and test all active components in a microwave oven, and is capable of measuring the high voltages encountered in a microwave oven.

One such combination test device is the Microanalyzer 76 (Figure 5) from Southgate Electronics. It contains several test devices that allow a technician to test all components in a microwave oven: a DVM that can measure up to 500Vac or dc, with a high-voltage input that will withstand up to 5000Vac or dc, a high-voltage supply wired to a circuit that allows the testing in-circuit of the high-voltage diode and capacitor, with test voltages as high as $700V_{PP}$, a semiconductor checker that allows the testing of semiconductor devices such as triacs, silicon controlled rectifiers, transistors, diodes and MOSFETS.

Microwave oven troubleshooting

Because microwave ovens are simple with a high-voltage power supply, magnetron tube and some type of control circuit, troubleshooting is usually straightforward unless the oven has an intermittent problem. If you encounter a dead microwave oven, the first step in servicing is to check and replace, if necessary, the fuse with the correct type. Most ovens use a ceramic self-quenching type fuse.

To check the operation of the oven, put a cup of water in the oven and turn it on. If there is still no function, or if it lights but doesn't heat, unplug the oven and discharge the capacitor.

The proper method of discharging the capacitor is by connecting a test clip to ground, then touching one, then the other capacitor terminal to ground, then using the clip to short across the terminals. Since this method discharges the capacitor through the transformer first, the discharge will be less violent.

Figure 5. This unit contains several test devices that allow a service technician to perform a complete series of tests on a microwave oven.

Making the tests

Once you've confirmed that the oven is not working, you'll have to check the components and circuits to pinpoint what's wrong. The first type of tests are static tests, meaning that the components are checked with the oven unpowered and unplugged.

First, test the capacitor. This component handles a considerable amount of power and is a frequent cause of microwave oven failure. You might try to check the high-voltage capacitor with a multimeter, but because of the nature of this high-voltage component, such tests are usually inconclusive. An accurate test of this component requires that you place a high voltage across it. This test really requires a tester such as the Sencore Z-Meter or the Southgate Electronics Microanalyzer, or other tester capable of accurately performing this test.

Another cause of microwave oven failure is a defective high-voltage diode. This diode may become either open or leaky. If you suspect a faulty high-voltage diode, unplug the oven, discharge the high-voltage capacitor, then check the diode.

Again, you may try this test using a multimeter, but a typical multimeter is not capable of producing a high enough voltage to properly check this diode. As with the high-voltage capacitor, the high-voltage diode requires a tester capable of applying a high enough voltage to properly test this device.

If the diode and capacitor check good, check the magnetron. The magnetron operates at high voltage and high current, which is a very hostile environment under which to work. The magnetron may cause problems in a number or ways.

If the oven does not seem to be cooking fast enough, or if operation seems to be intermittent, the filament connections may be burned or oxidized, or otherwise faulty. Check those connections and if they look bad, clean them up.

If the magnetron seems to be faulty and the problem isn't faulty connections, check to see if the magnetron is open or shorted. To check the magnetron, again unplug the oven and discharge the high-voltage capacitor. Disconnect the wires from the high voltage side of the transformer to the magnetron. Set the ohmmeter to the R X 1 scale. Connect the meter probes across the filament. The meter reading should be less than 1Ω.

After checking the magnetron, set the meter to R X 10,000 and measure the resistance between each end of the filament and common ground. The reading at each terminal should be infinite. If the resistance is low enough to be read, the magnetron or the high-voltage diode may be leaky. Disconnect one end of the diode and test again. If the readings remain the same, the problem is in the magnetron. If the readings now appear normal, the magnetron is probably good. Check the high-voltage diode.

Check the switches

If all tests so far have not found the defective component, and the oven still blows fuses when operated, the most likely cause will be a misadjusted or defective microswitch. With the oven unplugged, perform a continuity test of each microswitch and operate the door mechanism slowly, observing that the meter shows open and short as each switch goes through its motions.

A sticky or misadjusted switch in the wrong position may cause a short when another switch is cycled by opening the oven door. You should also check continuity of thermal switches mounted to the magnetron or oven cavity, if the oven remains dead. As a general rule, if the micro switch does not have a positive click as you operate it, it is bad. However, a bad switch could still click, so be sure to test them thoroughly.

If you suspect the power transformer, check its three windings.

Dynamic tests

Assuming that you have checked all components mentioned so far and still have not found any defective components using the static test method, dynamic tests must now be performed. If the oven seems to be working, such as the lamp lights and the fan blows, but there is no heat, tests must be done to be sure power is getting to the magnetron.

If there is any corrosion on the terminal connectors at the base of the magnetron, the low-voltage filament current will have trouble lighting the tube. Clean all connections with contact cleaner and squeeze all connectors so they push tight.

Plug in and turn on the oven; listen for the three-second delay, then the one-second buzz that all magnetrons emit when they fire up. If you do not hear the magnetron fire, unplug the oven and discharge the capacitor, then connect a multimeter across the primary of the transformer and power the oven.

If there is no voltage reading, there may be a problem with the triac, relay or whatever power switching system is used. If the 120Vac is there, the high ac and dc voltages should be measured next.

WARNING: This part of the test involves the measuring of potentially lethal voltages and extreme care must be exercised. Make sure that whatever meter you use is rated to handle the voltages (nearly 5KVdc) that you will encounter.

With the oven unplugged and capacitor discharged, connect the black test lead to ground, move the red test lead plug to the HV jack and connect the red test lead clip to the high-voltage winding of the power transformer connected to the high-voltage capacitor. Double check all connections, stand back and fire up the oven. The ac voltage should be in the area of 1500Vac to 2500Vac.

If this voltage is correct, turn the oven off, discharge the cap, move the red test clip to the other side of the capacitor and switch the meter to dc. Again, double check connections and fire up the oven.

A normally operating oven will cause the dc reading to initially show as high as 4.5 KVdc, then as the magnetron fires up and current is drawn from the power supply, the reading will decrease to somewhere between 2 and 2.5 KVdc and hold steady. Poor connections to the magnetron will usually show no voltage change, or a changing voltage as the connections make and break.

A defective magnetron will either not fire and the high voltage reading will remain high, or an intermittently shorting tube will cause the readings to be much lower than expected. Shorted magnetron tubes usually cause the power supply to hum louder than normal, but may not necessarily blow the fuse.

Testing the relay or triac

If previous testing of the primary voltage showed no reading and you suspect a relay or triac switching problem, these parts should be checked next. Most better quality ovens use a triac to power the transformer because they are much more reliable than a relay, but most technicians do not have a quick and positive way to test this device.

The triac used in the typical microwave oven is usually either a one inch square or round package about a half-inch thick with three terminals, although some ovens use the smaller plastic-metal tab style triacs. On the large triacs, the smallest terminal is the GATE, or control pin, with the MAIN TERMINAL 2 usually in the center, and the common, or MAIN TERMINAL 1 opposite the gate. On the smaller types, the pinout is MT1, MT2, GATE, viewed left-to-right as viewed from the front of the triac.

To test the triac with a multimeter, start by disconnecting the wires from the triac. Set the meter to the high ohms scale. Measure the resistance between MT1 and MT2 in both directions. These resistances should be infinite. If either of these resistances is measurable, the triac is leaky.

Then measure the resistance between the gate and MT2 in both directions. These resistances should also be infinite. A measurable resistance here points to a defective triac. A low resistance reading between the gate and MT1 in either direction is normal.

If the oven uses a relay, open it and check for pitted or heat-damaged contacts, and burnish them, or replace the relay. If you believe the problem to be a relay drive transistor, test the transistor with whatever type of transistor test you normally use.

The waveguide and stirrer

If all components have been checked and your microwave oven has the symptom of low heating, but otherwise seems to be working normally, check the waveguide cover at the top of the oven cavity at the exit of the waveguide. If it is coated with grease or food residues, it can absorb a large amount of power and even flash and arc. Clean it with ammonia and water, or if it is burned, replace it with the same type of plastic or mica material.

A malfunctioning stirrer can also cause problems; this can be checked without even removing the oven cover. Stick several NE-2 neon bulbs in the top of a styrofoam cup with a cup of water in the cup, and turn on the oven. A properly operating oven will ionize the neon gas and the neon bulbs will flash on and off as the stirrer rotates. If some lamps remain on while others stay off, the magnetron is operating; the stirrer is inoperative. Check for a broken belt or a seized bearing.

A quick and dirty method of measuring microwave power is to run the oven for one minute at full power with eight ounces of water in a styrofoam cup; a 500 watt cheapie will make the water almost too hot to stick a finger in, while a 750 watt monster will cause the water to steam.

The final check should be a test of the door seal with a properly calibrated microwave leakage tester. Although the FCC allows a maximum of five milliwatts per square centimeter, most ovens will show almost unmeasurable. Any reading over one milliwatt should be cause for alarm and the door seal and interlock should be repaired and rechecked. ■

Test Your Electronics Knowledge

Questions on resistance, impedance and voltage

By J.A. Sam Wilson

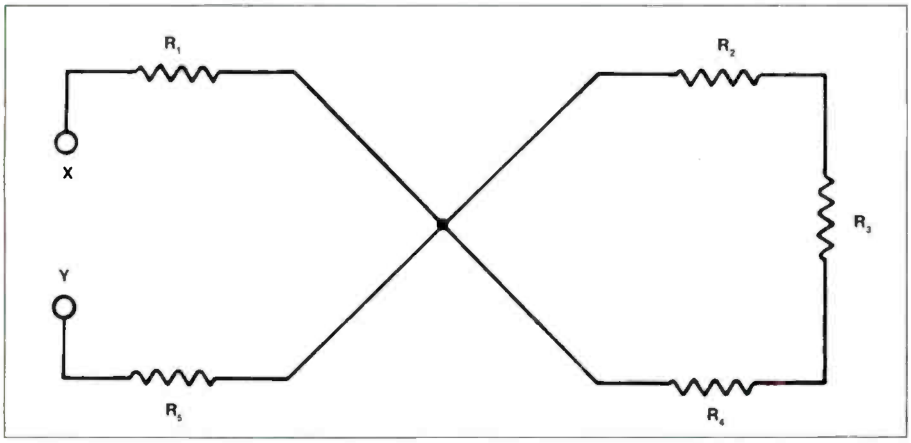


Figure 1. What is the voltage between 'x' and 'y'?

1. You have a dozen 10Ω resistors with a ±1% tolerance. You need 11Ω with a ±10% tolerance. Use as many of the resistors as you want. Show how you would connect them to get the required 11Ω.

2. Write the impedance $25\angle 90^\circ$ in rectangular form.

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

3. Assuming that each of the resistors in the circuit of Figure 1 is 25Ω, what is the resistance between terminals 'x' and 'y'?

4. What is the applied voltage in the circuit of Figure 2?

5. You deliver 600 pulses per second to a stepping motor. Assuming that each pulse is strong enough to advance the motor 7.5°, what will be the speed of the motor in RPM?

6. Can you find the voltage drop across R_2 in the circuit of Figure 3?

7. What determines the speed of a synchronous motor?

8. How much voltage would you expect to measure across an LED when it is operating at its normal brightness?

9. A 29.9mH coil is connected in series with a 100Ω resistor across a 400Hz generator. How much capacitive reactance is needed in series with the combination to get a phase angle of zero degrees?

10. At what frequency will an inductive reactance of a 27mH coil equal a capacitive reactance of a 27mF capacitor?

BONUS QUESTION—20 Points

You have an ordinary glass prism. You shine an ultraviolet light through one face of the prism. Will the longest UV waves or the shortest UV waves be bent to a greater degree by the prism? ■

(Answers on page 55)

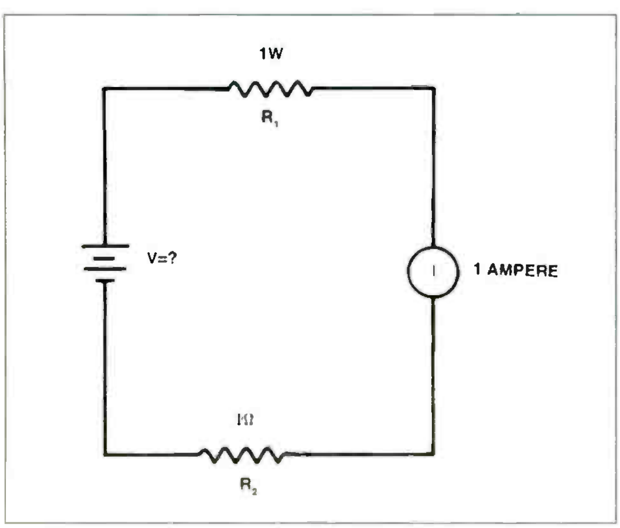


Figure 2. What is the value of voltage 'V'?

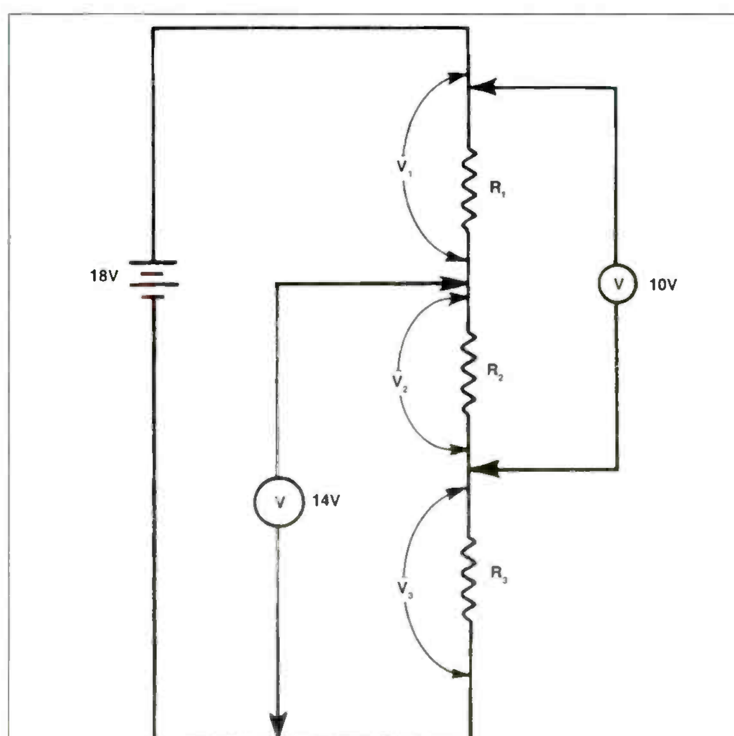


Figure 3. What is the voltage across R_2?

Computer software for service center management

By Conrad Persson

Personal computers have evolved from mere curiosities of a few years ago that entertained a handful of computer enthusiasts, to the powerful workhorses that they are today, capable of performing virtually all of the filing and retrieving, accounting, billing and bill paying, inventory and payroll of a small business.

Today, for a few thousand dollars, a small business can purchase all of the computer hardware and software to perform all of the administrative and accounting functions it will ever need.

Service center software

Many consumer electronics service centers have found computers to be helpful in just about every phase of the operation. For starters, there's service center management software. This type of software can assist the center in every task associated with the core business of the service center: keeping track of all of the products in the service center, from receiving the defective product to returning the repaired product to the customer and doing the billing. An advantage of using a computer for these functions is that the status of every unit in the service center is instantly available at any time.

Beyond service center management

Because of its ability to store and retrieve any type of information that can be converted into a form that a computer can handle, tasks other than service center management are being turned over to the computer. For example, an important resource for any service center is the mass of troubleshooting/diagnostic tips that it has available for the technicians to refer to when they encounter a problem that's difficult to solve.

This information takes many forms. In some cases, it's a few scribbles on a schematic diagram or a page of a service manual that describes a problem that was encountered on that product, and the corrective action that eliminated the problem. In some other cases, it's a more formal description of the problem and solution, filed away in a filing cabinet.

Troubleshooting/diagnostic tips may also take the form of bulletins published by the manufacturer to make all of its authorized service centers aware of common problems that have been encountered on certain products. Of course, another form of troubleshooting tips file is the memory of old Joe, who has been servicing for so long, and is so sharp that when someone has a problem they can't solve they go to him.

Each of these types of data files has its own unique disadvantages. For one thing, there are several databases that a technician must search, and, depending on the filing system used, the data might be easily accessible, or it might be almost impossible to locate. And, of course, paper can easily be lost or torn, or coffee stained beyond use. Old Joe might be out sick, or he might have forgotten some of the information he once knew. And one day he's going to retire.

These days, many service centers are turning to the computer for storage and retrieval of troubleshooting tips. Computerizing this information has many advantages. All of the data is in one place. If it's properly backed up and safeguarded it won't be lost. Every technician has easy access to all of the information. Tips from manufacturers and other outside sources that are on disk may be entered directly without writing or keying anything.

Computer diagnostic software

Because of the declining cost of both hardware and software, and easy-to-use software for almost any conceivable consumer application; household accounts, recipe file and retrieval, games, communication, inventory; computers have become firmly ensconced in the category of a consumer electronics product. That means that, increasingly, consumer electronic service centers are being called upon to service personal computers.

Computer diagnostics

The traditional servicing test equipment, such as oscilloscopes and DMMs, are useful in isolating the cause of many of the problems that afflict computers. But a computer is considerably different in a number of ways from other consumer electronics equipment. For one thing, computer operation depends on the software that's running at any particular moment. For another, because of the nature of a computer, with the right software it can be used to perform diagnostic operations on itself.

Because of this self-diagnostic ability, and because of the creativity of programmers to exploit this ability, many diagnostic software programs are now available to service centers that allow them to perform a wide range of diagnostic routines on computers to determine what's causing the problem.

Service center software

There is now available so much software for service centers; management, diagnosis, tips, that it becomes difficult to be aware of it all or to keep track of it all. This article is intended to help service center owners sort out the software situation and provide names, addresses and telephone numbers of software providers.

Service center management

The use of service center management software allows the service center to automate every aspect of the business. When a product is brought in for service you enter the customer's information and the nature of the complaint. If this is a repeat customer you may just have to type in the phone number: the rest of the information is retrieved from the computer database.

Here's a rundown of some of the features of a software product that provides a broad range of service center management support. Software such as this can vary considerably in its usefulness, depending on the particular needs and management style of the managers, so before

Persson is editor of ES&T

making a commitment to purchase such a system the buyer should compare the features and ease of operation of several packages.

Cost is another important consideration. The least expensive of these programs cost a few hundred dollars. The most expensive may cost several thousand dollars. As with any other product, the purchaser must weigh the product's features against the cost.

Many of the companies listed here offer a demonstration program that you can try out before you buy. Most of these demos contain all the features of the software product so you can determine if it will meet your needs. The only limitation of a demo package is in the record storage feature. Typically, a demo will only let you store 10 or so transactions.

One manufacturer, BGI, will send a fully featured package as a demonstration for $14.50, on the understanding that the person who orders it will pay the remainder of the full list price if the product is satisfactory.

Tracking/scheduling

As information is entered into the computer, the computer creates a job ticket and stores the information. Now you can do several things:

- Easily handle customer phone inquiries. Just enter the customer's phone number or name and the job information appears on the screen.
- Instantly access a job's current status just by supplying the appropriate code number.
- Get detailed job status information.
- Maintain a complete history of each unit by serial number or by customer number.
- Call up a summary schedule that allows you to see the whole day's schedule at a glance.
- Schedule on-site service by territory.
- Obtain a printout of both technician routing sheets and a management summary sheet.

Inventory management

The inventory program gives you the individual parts movement by the month, cross reference data, prices, quantity and a reorder report. By checking the movement record, you can adjust quantities ordered to make sure you have adequate inventory of parts without accumulating a large inventory of slow-moving parts. By coupling this information with manufacturer's shipping time, a service center can order replacement parts early enough to cut down on back orders.

Invoicing

With some programs, you may enter repair descriptions and labor pricing ahead of time. The information is then on record allowing the operator to automatically invoice by making number selections for repair descriptions and labor prices. In addition, this program segment allows you to print both customer and standard NESDA or NARDA invoices and to print post cards informing customers of the status of their unit.

Codes and tables

User-defined codes and part-pricing tables let you customize your system and speed up data entry. All the technician needs to do is to press a special key to see the list of possible code entries. They include codes for unit types, brands, manufacturers, technicians, status of jobs: e.g., parts on order or estimate, customer approval, return shipping method, sales taxes, vendors.

Forms and reports

A service management software system can save time and money in several ways by doing much of the paperwork. First, a valuable technician will have to take less time away from repair work to do paperwork. Second, the customer data only has to be entered once. After that, the computer will automatically generate the information in the proper format to match the different forms. Finally, the various computer generated reports allow service center management to see where the money is going and how fast.

Some of the forms and reports that are available are: management reports, such as daily work in process report, work completed not picked up, technician unit report, technician productivity report, production detailing report, job tracking/scheduling. Also available are invoicing reports, warranty and service literature information and inventory management.

Integrated software

Some service center software packages include more than one of these functions. For example, at least one software package includes modules for service center management, a symptom/cure module, a daily cash drawer module, and a time card module to keep track of technicians' time.

A caveat

A service management system won't make your business run any smoother all by itself, any more than an oscilloscope will diagnose a problem in a product. It's a tool. You have to learn how to use it and teach other people in your business how to use it. And you have to use it consistently and correctly.

One other comment: these systems are probably not for every servicing facility. A low-end system, software only to run on your own PC may cost several hundred to over a thousand dollars. A high-end system for a large shop, software or software and hardware, may cost several thousand dollars. On the other hand, if a shop is large enough to use one of these systems, and the people who will use it are dedicated enough to making it work, the benefits may well far outweigh the cost of the system.

Service management software companies

AVS Services
4893 Clarendon Drive
San Jose, CA 95129
408-257-6100

Advanced Technology Group
205 Regency Executive Park Dr., Ste. 306
Charlotte, NC 28217
704-521-8113
Fax: 704-521-9711

America West C&E
Sage Data Systems
1900 Elk Street
Rock Springs, WY 82901
307-382-5663
800-542-9378
Fax: 307-382-7323

Astea International Inc.
55 Middlesex Turnpike
Bedford, MA 01730
617-275-5440
Fax: 617-275-1910

Automated Systems, Inc.
4827 Pioneer Blvd.
Lincoln, NE 68506
402-489-2717
Fax: 402-489-2370

BGI Co.
50509 Hollyhock Rd.
South Bend, IN 46637
Phone/Fax: 219-277-8762

Cahill Electronics
160 Main Street, PO Box 568
Kingston, NH 03848
603-642-4292
Fax: 603-642-7941

Computer Transaction Systems
RepairWare
PO Box 56
North Weymouth, MA 02191
617-331-6968
800-332-6968
Fax: 617-331-6969

Core Software, Inc.
26303 Oak Ridge Drive
Spring, TX 77380
713-292-2177
Fax: 713-298-1492
713-298-1492

Custom Data Associates
PO Box 10903
Baltimore, MD 21234
410-668-9594
Fax: 410-661-3942

Ideal Computer Systems
1320 Second Ave., SE
Cedar Rapids, IA 52403
319-362-2662
Fax: 319-362-4305

Magic Solutions, Inc.
180 Franklin Turnpike, 2nd Floor
Mahwah, NJ 07430
201-529-5533
Fax: 201-529-2955

Metrix, Inc.
20975 Swenson Drive
Waukesha, WI 53186
414-798-8560
Fax: 414-798-8573

Ogment Group
PO Box 781
Lafayette, CA 94549
510-284-7372
Message or Fax: 510-284-4142

Plaza Distributing
RUSH Software
8800 Merrimoor Blvd.
Largo, FL 34647
813-392-9168

Premium Parts +
PO Box 28
Whitewater, WI 53190
800-558-9572
Fax: 414-473-4727

RAM Software Enterprises
3434 Bren Lee Court
Indianapolis, IN 46227-7905
317-881-0690

Sencore
Service Center Manager
3200 Sencore Drive
Sioux Falls, SD 57107
800-736-2673 Ext. 238
Fax: 605-339-9374

Service Control System II
National Electronic Servicing Dealers Association
2708 W. Berry Street
Ft. Worth, TX 76109
817-921-9061
Fax: 817-921-3741

Service Management Software
931 Sunset Blvd.
West Columbia, SC 29169
800-756-7035
Fax: 803-791-8521

Service Systems International, Ltd.
8717 West 110th Street, Suite 600
Overland Park, KS 66210
913-661-0190
800-826-4351
Fax: 913-661-0220

Sidon Data Systems
2030 Main St., 11th Floor
Irvine, CA 92714
714-553-1131
Fax: 714-553-1133

Dayta-Co
(Soft-Serve software)
757 North 22nd St.
Mesa, AZ 85213
Phone/Fax: 602-835-2243

Foothill TV & Electronics
(SyncPulse II)
7730 Foothill Blvd.
Tujunga, CA 91042
818-353-9595
Fax: 818-353-7016

Service tips programs

AnaTek Corporation
(Computer monitors)
PO Box 1200
4 Limbo Lane
Amherst, NH 03031
800-999-0304
603-673-4342
Fax: 603-673-5374

FixFinder
TCE Publications
10003 Bunsen Way
Louisville, KY 40299
502-491-8110

High Tech Electronics
1623 Aviation Blvd.
Redondo Beach, CA 90278
310-379-2026
Fax: 310-379-9608

Higher Intelligence Software, Inc.
60 Farmington Lane
Melville, NY 11747
516-643-7740
This company also offers custom software for the service industry.

Technical Information Procurement System
Techfix Software
PO Box 1681
Forest Park, GA 30051-1681
Phone/Fax: 404-968-3715

Diagnostics/utilities

Accurite Technologies Inc.
231 Charcot Avenue
San Jose, CA 951311
408-433-1980

All Micro Inc.
1250 Rogers Street. Suite D
Clearwater FL, 34616
813-446-6660

American Megatrends, Inc.
6145-F Northbelt Parkway
Norcross, GA 30071
404-263-8181

Central Point Software Inc.
15220 NW Greenbrier Parkway, Suite 200
Beaverton, OR 97006
800-445-4064

Dariana Software
5241 Lincoln Avenue, Suite B5
Cypress, CA 90630
714-236-1380

Data Depot
1710 Drew Street, Suite 5
Clearwater, FL 34615
813-446-3402

Diagsoft Inc.
5615 Scotts Valley Drive, Suite 140
Scotts Valley, CA 95066
408-438-8247

Disk Technician Corp.
1940 Garnet Avenue
San Diego, CA 92109
619-274-5000

Fifth Generation Systems
10049 N Reiger Road
Baton Rouge, LA 70809-4562
504-291-7221

Gibson Research Corp.
35 Journey Avenue
Aliso Viejo, CA 92656
714-362-8800
Fax: 714-362-8808

Landmark Research International Corp
703 Grand Central Street
Clearwater, FL 34616
800-683-6696

McAfee Associates Inc.
2710 Walsh Avenue, Suite 200
Santa Clara, CA 95051
408-988-3832

Micro 2000
1100 E Broadway, Suite 301
Glendale, CA 91205
818-547-0125
Fax: 818-547-0397

Renasonce
5173 Waring Road, Suite 115
San Diego, CA 92120
619-287-3348

RG Software Inc.
6900 E. Camelback Road, Suite 630
Scottsdale, AZ 85251
602-423-8000

Symantec Corp.
10201 Torre Avenue
Cupertino, CA 95014-2132
800-554-4403

Tech Assist Inc.
5590 Ulmerton Road
Clearwater, FL 34620
800-274-3785

Touchstone Software Corp.
2130 Main Street, Suite 250
Huntington Beach, CA 92648
714-969-7746

Trackmate
Diagnostics and disk drive maintenance
5305 E. Shore Drive
Conyers, GA 30208
800-486-5707
Fax: 404-922-8044

Ultra X Inc.
2005 De La Cruz Boulevard, Suite 115
Santa Clara, CA 95050
800-722-3789

Windsor Technologies
130 Alto Street
San Raphael, CA 94901
915-456-2200
Fax: 415-456-2244

On-line systems

Technical Information Procurement System
Online computer system for tech tips
PO Box 1681
Forest Park, GA 30051-1681
Phone/Fax: 404-968-3715
System Phone: 404-968-6600 E-7-1

Help desk/telephone support systems

Intellisystems
5250 Neil Road, Suite 110
Reno, NV 89502-6546
800-637-8400

This company manufactures a software product that doesn't fit into any of the categories discussed in the article, but that may be of interest to some service centers. It's a computerized system that allows a service center to set up a computer system such that callers may get answers to many of their questions directly from a computer without tying up a human operator.

Claims filing help system

Key Prestige
11065 Knott Avenue, Suite B
Cypress, CA 90630
714-893-1111
Fax: 714-893-7997

This company doesn't fit any of the categories in this article, either. It acts as a front end for many manufacturers for a number of functions. Once subscribed to this system, a manufacturer's specific data baseis created and continually maintained. Service centers can access this data and obtain information on claims, parts availability and pricing, technical bulletins and more, as authorized by the subscribing manufacturer. A center that wishes to access this system only needs a PC and the appropriate communications software.

When the user connects with the central source mainframe, they instantly have access to all authorized information. According to the company, the screens are all menu-driven and easy-to-use, and on-line help is available. ■

Copier basics

By James Intravia

Copier manufacturers generally describe their equipment as "state-of-the-art", and to them and the end users, it is. But, interestingly enough, from a service point of view, copiers have hardly changed at all in 20 years. I have been doing basic copier training for technicians since 1980 and other than idiosyncrasies of certain machines and explanations of new "bells and whistles", what technicians need to know hasn't changed at all!

The word xerography comes from a pair of Greek words. "Xeros" is Greek for "dry," and "graph" is the combining form of the Greek meaning to carve, or write. The combination of these translates to "dry writing". It is this word that the Haloid company used to come up with the name "Xerox," after the xerographic process was invented and perfected by a man named Chester Carlson in Astoria, New York in 1939. I am pleased to report that Mr. Carlson was handsomely rewarded for his invention and lived a full and happy life which included many contributions to worthy causes.

An explanation of copier operation is generally divided into two sections:

- The xerographic process, also known as the copy process, and,
- The paper path.

This explanation will start with the five steps of xerography. See Figure 1, a general drawing showing the essential components of a copying machine.

Charge

A key component in a xerographic copier is a rotating cylinder, usually called the drum (also known as photoconductor or photoreceptor). The surface of this drum is coated with a light sensitive semiconductive material, such as selenium. If a strong static charge is applied to this surface, the charge will remain there, as long as the surface is kept in darkness.

If light strikes this surface, the charge will flow to ground through the aluminum base beneath the light sensitive surface. If a single point of light strikes the surface, only that point will lose charge. The rest of the surface will remain charged. The drum rotates on a shaft.

Parallel to the drum will be a unit generally known as the "charge corona" (other names include primary corona, main corona, number one corona, and corotron). The corona consists of a pair of insulators with a very fine wire (about 60 microns) stretched between them. Each insulator (corona block) is at one end of the drum. They are isolated from ground.

At one end of the corona wire is a connector, connecting the 60 micron wire to a power supply of about 5000Vdc. This voltage is applied to the wire, with no path to ground. The result is what is known as a corona field. If you look closely at the charged wire, you can usually see a faint blue glow around it.

The field will cause the photoconductive surface of the rotating drum to be electrically charged. You can't measure it, but the actual voltage on the surface of the drum is about 700Vdc. After the drum has rotated past the electrostatic corona field it is completely charged with a static electric charge.

Exposure

When the operator places a document on the copier's platen glass and presses the copy button, a bright light under the glass is turned on and moves under the glass, illuminating the document. In the case of moving-top machines, the light stands still and the glass moves. The image of the document is reflected through a set of mirrors and a lens.

The image of the document strikes the rotating drum, moving at the same surface speed as the drum. Everywhere that light strikes the drum, the surface of the drum is discharged. Where there is no light, the surface remains charged. This gives an effect called the "latent image."

The surface of the drum now has an electrical pattern exactly corresponding to the document, except that it is a mirror image. Wherever the document was white, the drum has been discharged. Wherever there was printing on the original document the drum retains a charge.

Development

The drum, with its latent image, now rotates past the developer unit. The developer unit consists of an aluminum roller, parallel to the drum, with magnets inside of it. This roller is spinning and is nearly in contact with the drum. It spins in a trough-like area filled with developer: iron filings coated with plastic.

Another substance, the toner, is introduced into the developer unit. Toner particles are fine particles of black plastic. The irregular shape of the developer material (like a grain of sand under a microscope) and the plastic coating causes the much smaller toner particles to stick to the developer.

The static caused by the two non-metallic items and the nooks and crannies in the developer particles cause the toner to adhere to the developer particles. As the developer roller rotates, the magnets inside cause the developer particles, with the attached toner particles, to cling to the roller. As the roller comes close to the drum surface, the charged areas of the drum surface overcome the static charge that is holding the toner particles to the developer particles. This causes the toner particles to migrate to the drum surface.

The force of the magnetic field on the developer roller attracts the developer particles more powerfully than does the static charge on the drum, and continues to hold on to the developer particles. As the roller passes the drum, it then rotates back to the trough and the developer mixes with more toner and is replenished for its next rotation.

At this point, if you were to stop the process and remove the drum from the machine, you would find a mirror image of the document on the drum. This is not an invisible latent image This is for real. You can actually see the letters, and so on, right on the drum surface.

Intravia is owner/chief technician of Knight Business Systems Ltd., an office equipment servicing company, and publisher of a line of office equipment service manuals.

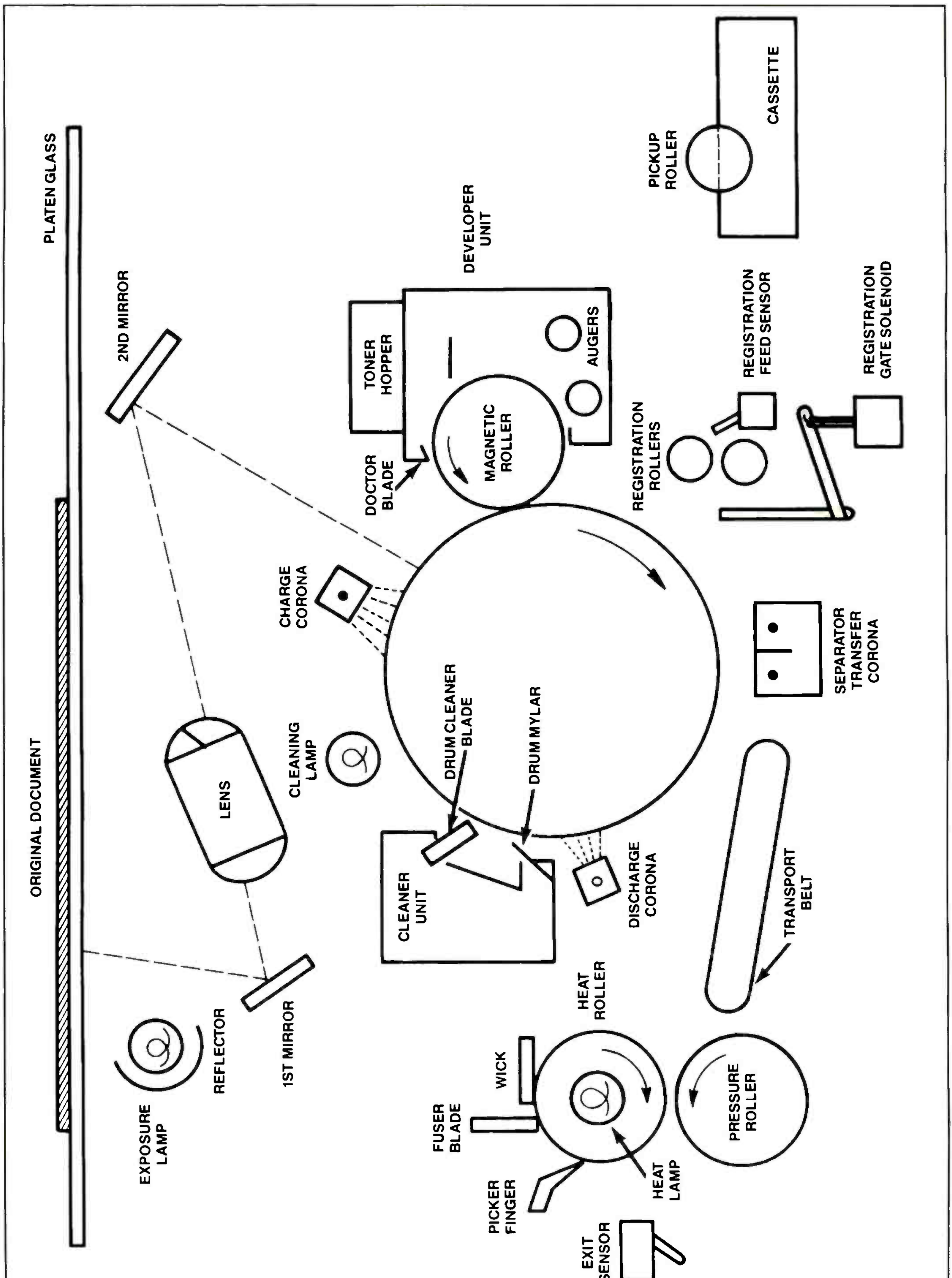


Figure 1. The essential components of a copying machine.

Transfer

The next step is to apply that image to the piece of paper. The paper has been fed into the machine. The electronics of the copier tells the paper exactly when to feed so as to meet the drum at the precise time. That will be discussed at a later time.

As the paper meets the drum, it passes over another corona unit. This is called the "transfer corona" and is pretty much identical to the charge corona. It is usually located beneath the drum. The paper will pass between the corona and the drum. This corona will charge the paper.

The charge on the paper will now be stronger than the charge that is holding the toner particles to the drum. Consequently, the toner will now leave the drum surface and adhere to the paper. Transfer is now complete. However the copy is not finished yet.

If you were to stop the machine and remove this piece of paper here is what you would find. The copy would look perfect. The image of the original document would be exactly copied onto the paper. You can read it. It is no longer a mirror image, but a perfect reproduction.

However, if you touched the paper at this time, the toner would rub right off onto your fingers. The toner particles are still particles. They are just laying on the paper, held there lightly by an electrostatic charge. This brings us to the final step.

Fusing

Fusing has nothing to do with fuses. Fusing is the term applied to the act of permanently bonding the toner particles to the paper. There are several methods of doing this, but nearly all modern copiers (and laser printers) use the following method of heat and pressure fusing.

The paper, with the image on it, passes between a set of rollers, which look similar to an old-fashioned washing machine clothes wringer. There are two very different rollers. The upper roller is hollow aluminum with a non-stick surface such as Teflon, and has an 800W quartz heater lamp inside of it. The lamp maintains a surface temperature on the roller of approximately 350F to 390F. The lower roller is a solid roller of silicone rubber.

The two rollers are pressed tightly together by springs. As the paper passes through them, the heat causes the toner particles to liquefy and flow into the grain of the paper. The pressure bonds the liquid into the grain of the paper. As the paper exits these rollers, you have a completed copy, which also happens to be quite hot for a second or two. That is the end of the basic xerographic process.

Diagnosing copy quality problems

Charge, exposure, development, transfer, fusing: these are the basic steps for the process and the cause and solution of all copy quality problems in a copier. No matter how experienced the technician, whenever he or she runs into a problem that is not instantly obvious, these steps must be mentally reviewed to eliminate the unlikely causes of the problem and to narrow down the troubleshooting steps.

For example if the copy is black, it can only be caused by a lack of exposure. If the copy is blank (white), it could be caused by lack of charge, lack of development or lack of transfer, but it could not be caused by lack of exposure or by problems in the fusing step.

The paper path

The stack of paper is usually sitting in a tray, known as a cassette. There is a set of rubber tires in contact with the top sheet. These tires (known as paper feed tires or primary feed tires) are mounted to a shaft which is driven by a small electric motor or a wrap spring or an electromagnetic clutch.

At the signal from the copier's main circuit board, this shaft will be driven, causing the tires to rotate, driving the paper forward to another set of rollers. At these rollers, the paper will stop and wait (the paper may actuate a switch which shuts off the primary feed paper feed tires or the primary feed may be designed so that one rotation puts the paper at this precise point). These rollers are called the registration rollers or secondary feed rollers.

At about this time, the scanner, the optical section of the machine which is illuminating and scanning the original document, will signal to the main circuit board that the latent image is being rotated toward the transfer corona. The registration rollers will now be engaged to drive the paper toward the drum so as to just meet the latent image. This point of contact, with the piece of paper meeting the latent image, between the transfer corona and the drum, is known as "registration." The paper will contact the drum, and the image will be transferred.

However, the same static charge that caused the toner to transfer to the paper also causes the paper to stick to the drum. Some mechanism must be in place to separate the paper from the drum. This is accomplished in any of several ways. There may be a "separator corona," a dc corona with an ac ripple, which magically causes the paper to fall off the drum without disturbing the image. Or there may be a small piece of mylar that peels the paper off the drum, like a fingernail removing wallpaper. In some cases, the stiffness of the paper causes it to go straight rather than wrapping around the drum, thus eliminating the need for separation.

After the paper leaves the drum, it is on its way to the fuser section. At this point the trailing edge of the paper might still be being carried by the registration rollers. Also, the portion of the paper not yet separated from the drum is helping to push it along. In some cases, this may carry the paper until the lead edge reaches the fuser rollers, at which point the fuser rollers will carry the paper.

In some cases, there may be a set of belts immediately after the transfer corona. These belts, often combined with a slight suction provided by a fan mounted below them, will help carry the paper to the fuser. The fuser is part of the paper path but was already described in the section on the xerographic process.

Copier problems

What goes wrong with copiers? Everything! But the most common problems have to do with copy quality. Approximately 95% of all copier problems are solved with common sense, logic, a Phillips screwdriver and some cleaning materials. An inexpensive digital meter is the most sophisticated item in a copier technician's tool case and is frequently not used for a week or more at a time.

Most copier troubleshooting is not done by measurements and comparisons, but by using your senses, by logically eliminating blind alleys, by trial and error. It has been said that a technician is his own worst enemy. Copiers are very unforgiving. Callbacks are the measure of competency. Good technicians recognize the tendency to make mistakes and retrace their own steps constantly to eliminate this.

Salvaging flooded electronic products

By Dale C. Shackelford

As flood waters recede back into the Mississippi river basin, servicing technicians throughout the Midwest have, no doubt, been flooded with calls to repair a variety of products that have been either partially or completely submerged in brackish water for an indeterminate amount of time. In many cases the replacement cost of the product will be less than the repair cost estimate, and the repairs will not be justified.

In cases where owners of specialty equipment, one of a kind units, or devices with sentimental value come to call, repair costs are of little concern. Additionally, technicians and hobbyists who frequent insurance auctions will often find salvageable products for pennies on the dollar. For those who are up to the challenge of restoring flood-damaged equipment, here are a few hints.

The same techniques discussed here, apply, of course, to restoring any kind of water damaged equipment, whether it's caused by rivers flooding, rain soaking, water damage during firefighting or plumbing leaks.

Shackelford is an independent electronic servicing technician.

Evaluating the condition

Upon receiving a product that has been completely or partially submerged, inspect the cabinet for damage which would preclude the unit from repair. Solid wood cabinets may sometimes be refinished, while cabinets constructed of wood laminate over plywood or chipboard should be discarded. If another cabinet is available that will accommodate the chassis, it should be used. Otherwise there may be no use for the chassis other than for parts. Plastic cabinets will obviously withstand most immersions, and will not sustain permanent damage from fresh, cool water.

Regardless of the type of product (television, VCR, stereo. etc.), closely inspect the entire chassis for any debris which may have accumulated inside the cabinet, by dismantling the entire unit. Be sure to mark all connections that are not otherwise clearly marked (wiring harnesses, pin connections, etc.). If necessary, write directly on the PC board with an indelible marking pen, and make your own drawings of the circuits. Depending on how much dirt and debris is inside, you may want to gently run a hose over everything to clean it out.

Reshaping warped PC boards

Often, pc boards that have been wet tend to warp out of shape. Severely warped boards should be removed from the chassis and immersed in warm water for several hours to make them pliable (what can it hurt, it's already been under water). Never use hot water, though, as this could cause further deformation. Also, if the boards are really dirty, a little mild detergent might help clean them up.

Once the board is completely saturated, rinse it if you used any detergent, then gently blow off any excess water with compressed air and lay the pc board on a piece of scrap, untreated plywood. By fashioning small clips to hold the pc board flat against the plywood, the board will dry, while the clamps will allow for expansion/contraction (Figure 1).

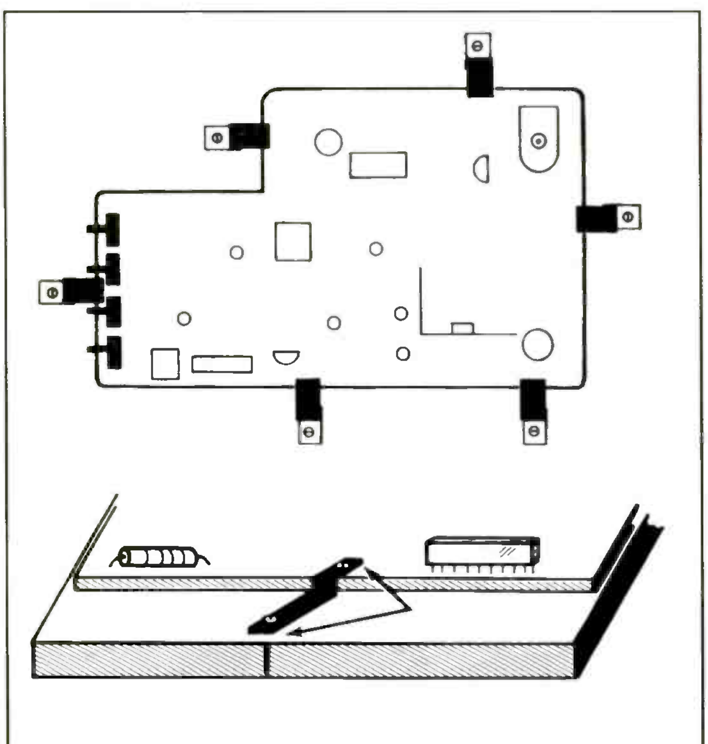
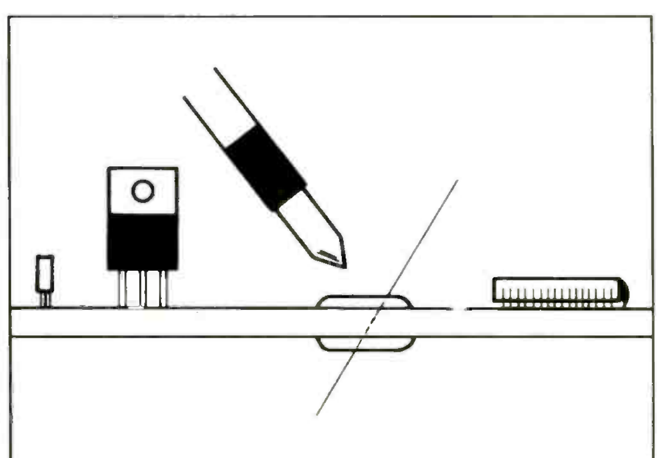


Figure 1. A few simple clips will allow you to fasten the pc board against a piece of plywood, so that it will be able to dry without warping, but will also be able to expand or contract as it dries.

Figure 2. If poor connections at griplets are a problem, resolder them. Passing a piece of wire through the griplet while soldering will help ensure the integrity of the joint.



If this is a fairly new set and the components look as though they might be susceptible to ESD (electrostatic discharge) damage, observe all ESD precautions.

Complete the drying process

Once all boards are completely dry and (relatively) flat, remove all of the larger IC packages, transformers, relays and other components that may trap or otherwise conceal moisture. Additionally, RF shields should be completely removed during the drying process to allow air to circulate evenly over all circuitry. A few blasts of compressed air will help to disperse moisture and aid in evaporation.

On some pc boards, circuit traces can begin on one side of the board (top), then pass through the board and continue on the other side (bottom). When a board with these types of traces, with metal rings connecting top and bottom traces (often called griplets) has been warped, the griplets can separate inside the board, causing an open circuit which is virtually impossible to detect visually.

Simply heating the solder on each of the griplets will usually be enough to establish the connections as the solder reflows, though passing a small piece of solid wire completely through the griplets as the solder is heated is recommended (Figure 2). In stubborn cases, jumper wires may be used to establish the connections.

Tuners

As tuners are such sensitive devices, they are often automatically replaced or rebuilt prior to being returned to service, but there is really no harm in trying to clean the original. Analog tuners should be cleaned as thoroughly as possible with compressed air or immersion in clean, warm water.

Extreme care should be taken not to bend or break any of the fine wires or coils with compressed air, as even the slightest bend may change the inductance enough to render the tuner useless. Once the tuner is apparently completely dry, a liberal dose of WD40 will displace any remaining, though unseen, moisture.

Apply small dabs of tuner lubricant to all contact points within the tuner then spray exposed coils and other components with a high resistance clear coat spray. These clear coats are typically used to reduce high voltage coronas around the second anode connections at picture tubes, and are very useful as a protective coating for other components.

Several light coats of this spray will be more effective than one heavy coat. Digital tuners rarely need more attention than other printed circuits, but will require special servicing more often than analog units will require it.

Other controls and components

Volume controls and other potentiometers should be cleaned with any one of the commercially available cleaners which leave a lubricating residue, and can be applied under high pressure. If possible, pots should be dismantled before cleaning to check for debris which may have accumulated within the case.

Finally, remove all components (brackets, housings, etc.) from the cabinet, and wash the cabinet thoroughly, both inside and out. Warm water under high pressure will dislodge most accumulated debris which may someday jar loose if not removed now, and cause a short circuit. Speakers that have been exposed to flood waters will obviously have to be replaced, and input/output jacks should be cleaned and dried.

Change any and all belts and tires within the unit, regardless of their outward appearance. Tape heads, tape guides and similar mechanisms should receive special consideration while cleaning, making certain that all soldered connections are secure. Mechanisms that normally require lubrication should be wiped clean before the new oil/grease is applied.

Before you turn it back on

After reassembling the unit, begin diagnostic procedures used with any other set. Before applying any power, it would be a good idea to perform resistance checks to make sure that there aren't any water induced short circuits lurking inside. Then, rather than simply plugging the unit into the wall and turning it on, use a variable isolated transformer and gradually increase the supply voltage. Check for the presence of horizontal pulses, waveforms, etc. at the lower voltages to prevent destruction of components.

While the process for salvaging each product will depend on the type of device, the amount of damage sustained and resources available, the main objective is to minimize the effects that the water had, or will have upon the electronic and mechanical components. The general rule in these cases is to clean and dry everything, but take it slowly. Do not place pc boards in direct sunlight to dry, as a normally lit room with good air circulation will allow the board to dry slowly and evenly. Take your time. The satisfaction and profits that can be realized are well worth the efforts.

Taking care of business

Many waterlogged consumer electronics products can be restored to perfect operating condition, but there are no guarantees. It would be unfortunate if you did all the work described above and then the set just refused to work, and the customer just refused to pay.

You should make it clear up front that you don't claim to work miracles, and if a particular waterlogged set works again it could be considered a miracle. And you should be sure to be paid up front. ■

Regulator burnouts

By Homer Davidson

In many of the newer TV chassis, the fixed low voltage is found damaged. A leaky horizontal output transistor, flyback, or secondary overloaded circuit may damage the low-voltage regulator in the low-voltage power supply. Often, the symptom is a dead set: no raster, or sound. The low-voltage regulator may be destroyed, leaky or open, causing no or improper low voltage, higher than normal low voltage, and blown fuses.

The low voltage regulator component may look like another output transistor or appear as an IC part on the heat sink (Figure 1). In the latest TV chassis, the low-voltage regulator may be a very large IC on a large heat sink. These voltage regulators may have three or more terminals.

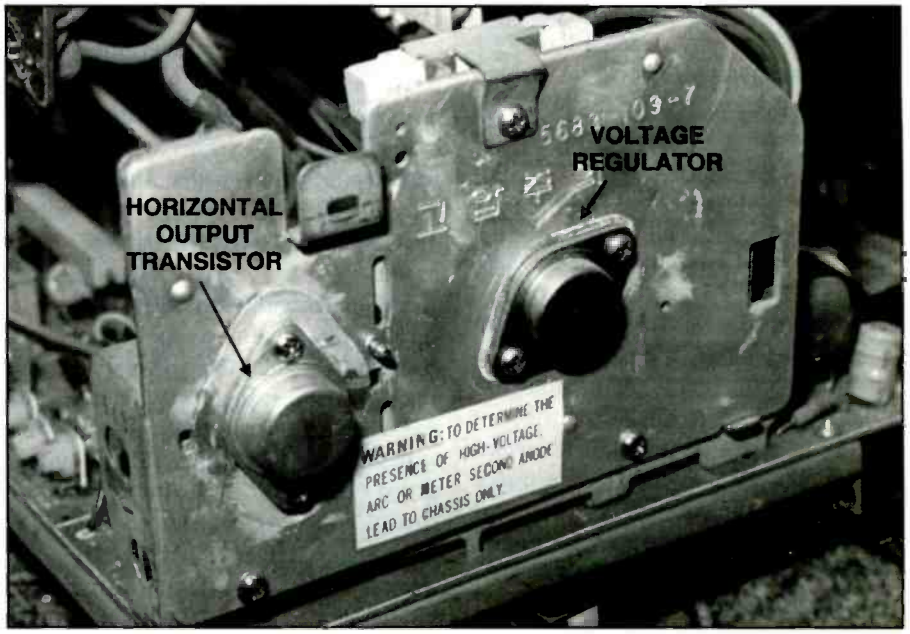


Figure 1. The low-voltage regulator and horizontal output transistor may look alike in some early voltage regulator circuits.

Basic low-voltage regulators

The flat four-terminal IC regulator may have several regulator transistors within one component (Figure 2). Here the input terminal is 1, the output terminal is pin 4, and pin 3 is grounded. These low-voltage regulators may have a fixed dc output voltage from +115Vdc to +135Vdc. The input voltage may vary from 150Vdc to 175Vdc.

The fixed regulator output voltage is fed to the horizontal output transistor, flyback and horizontal driver circuits. The fixed regulated dc voltage goes through the primary winding of the horizontal output transformer to the horizontal output transistor. Besides feeding the output circuits, the same regulated voltage may be applied to the horizontal driver primary transformer winding to the collector terminal of the horizontal driver transistor.

Basic fixed regulator circuits

The switched power line voltage is applied to the degaussing coil (L805), through thermistor R805 to degauss the picture tube each time the chassis is turned on (Figure 3). F801 will open if there is a leaky component in the low-voltage or horizontal output circuits. Resistor R801, 18Ω, dampens the inrush of ac current at power turn-on to prevent damage to the rectifiers.

Power is also applied to the bridge rectifiers to develop approximately 165Vdc for the regulator IC801. A leaky horizontal output component or voltage regulator may destroy the 4A fuse, R801 and one or two silicon diodes in the bridge rectifier circuits.

This +165V may be checked at test point TP9. Of course, in some TV chassis, you may find input and output test points in the low-voltage fixed circuits. If no test points are found, this dc voltage supply can be checked at the horizontal output transistor.

Capacitor C806 (470µF) stores and filters the raw dc voltage. The bridge rectifiers are protected by a 1.5A fast-blow fuse, F802, which will open in the event that IC801 or horizontal output circuits become leaky. If both F801 and F802 are blown, you may assume IC801, horizontal output transistor, flyback and over-

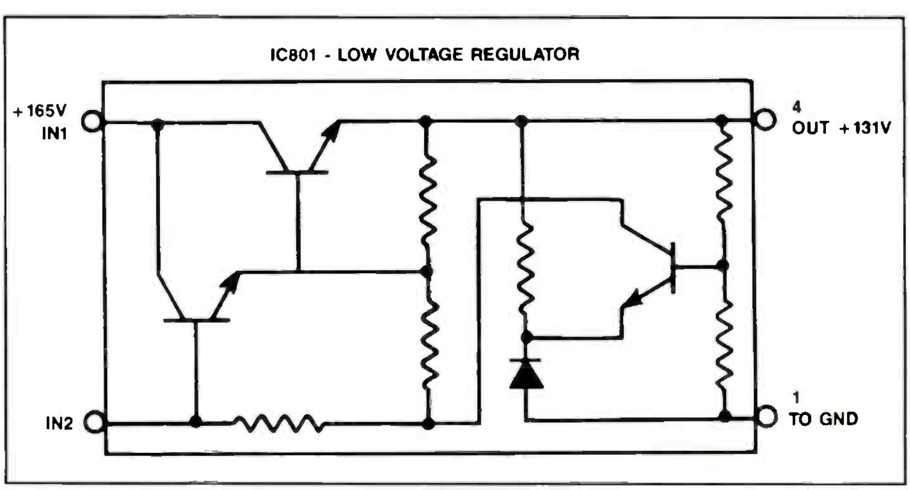


Figure 2. The internal wiring of a basic regulator IC component.

Davidson is a TV servicing consultant for ES&T.

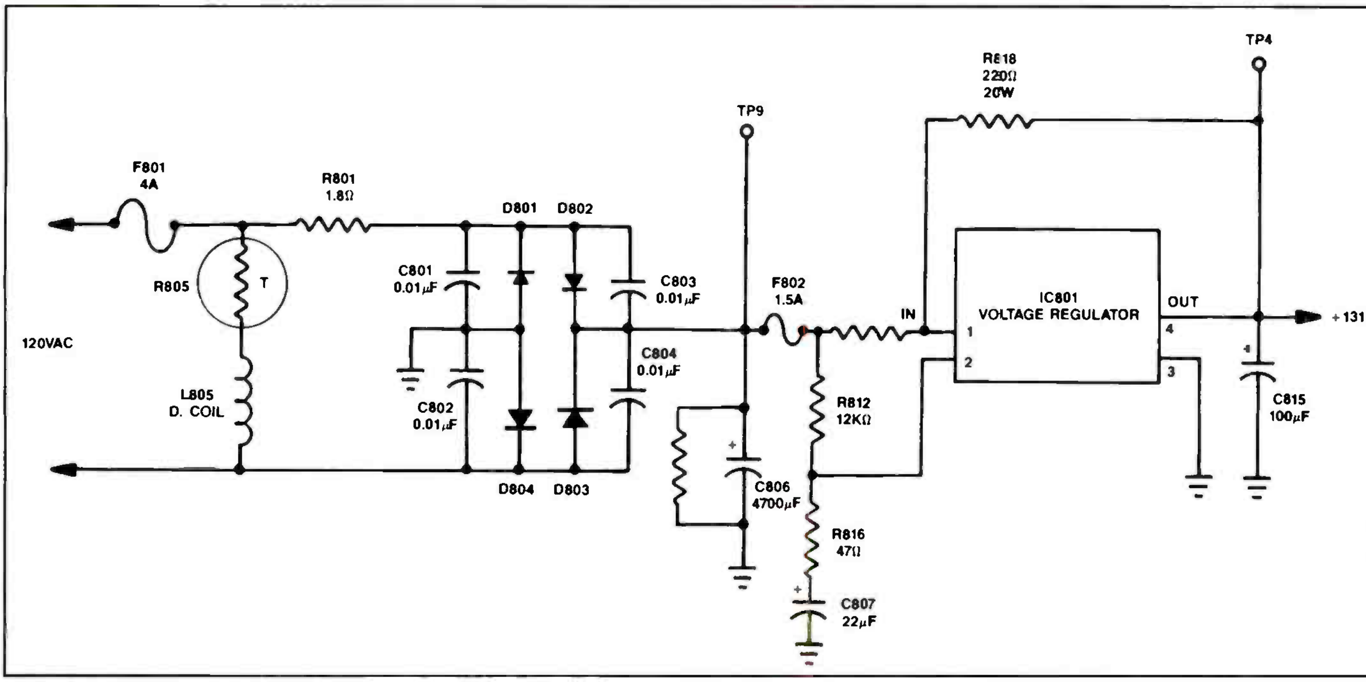


Figure 3. A basic fixed low-voltage regulator circuit with output voltage applied to the horizontal output and driver transistors.

loaded scan derived circuits may be leaky.

R818, 220Ω, 20W resistor in parallel with IC801, increases the current capacity of voltage regulator IC801. The output voltage can be checked at TP4. Capacitor C815 (100μF) provides filtering for the 131V source at pin 4 of IC801.

Defective regulator circuit

The symptom of a defective regulator is a dead chassis. The low-voltage regulator may fail as a result of internal leakage, power line spikes or surges, or lightning damage. Leaky components in the horizontal output and flyback circuits

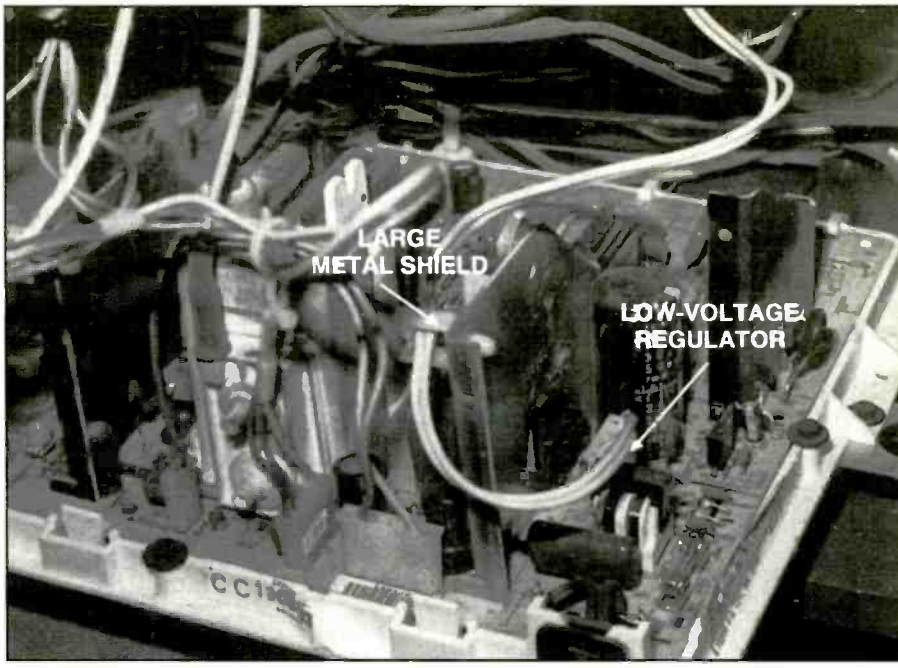


Figure 4. The low-voltage regulator IC or transistor is mounted on a large heat sink.

may result in a damaged regulator. Often when both fuses are blown, R801 may open up.

Inspect both fuses whenever the regulator circuit is defective. Take a voltage measurement at TP4 or the output terminal of regulator IC801 (Figure 4). Suspect a leaky regulator if both fuses blow after replacement. Of course, in the case of a dead set, a voltage test at the collector terminal of the horizontal output transistor may point directly to a defective regulator circuit.

If the regulator transistor becomes open, higher than normal voltage will be found on the horizontal output transistor and flyback. The chassis may shut down automatically as a result of high-voltage shutdown. Since +165V is found at input terminal 1, with only R818 (220Ω) in the circuit, higher applied voltage may shut down the chassis.

A leaky voltage regulator will repeatedly blow F802 and in some cases F801. Check for burned or open R810 (5.5Ω) and excessively warm R818. When light-

Figure 5. Try to replace the low-voltage regulators with the exact replacement if possible.

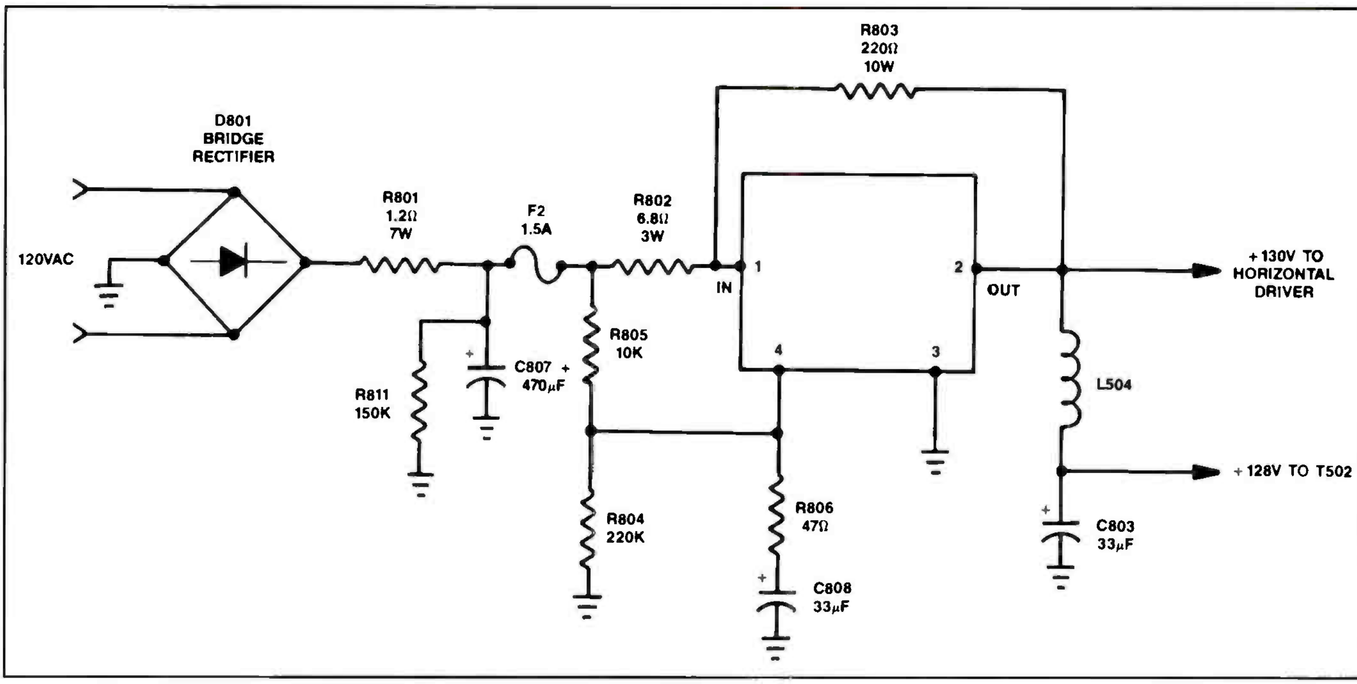


Figure 6. IC801 was destroyed by a shorted horizontal output transistor Q551 in a General Electric 13BC-4 chassis.

ning strikes the low voltage circuits, all small resistors should be checked and replaced if necessary.

Troubleshooting the low-voltage power supply

Before troubleshooting the regulator and horizontal output circuits, connect the set to the power line via a variable isolation transformer. With ac line voltage applied to the bridge rectifiers, measure the voltage at TP4 (+165V). The +165V is fed through fuse F802 (1.5A fast-blow type). Check the output voltage at F802 and test point TP4. In this circuit the output regulated voltage should be +131V.

If you measure low output voltage, or zero volts, suspect IC801 if F802 is normal. A higher voltage may indicate an open IC801 regulator. Low voltage at TP4 or horizontal output collector terminal may indicate a leaky regulator, flyback or horizontal output transistor.

Keeps blowing the B+ fuse

Suspect a leaky voltage regulator, horizontal output transistor or flyback if the B+ fuse keeps opening. A quick resistance or diode measurement from the collector terminal of the horizontal output transistor may indicate a leaky output transistor. A resistance measurement of less than one ohm indicates a shorted output transistor. Simply remove the output transistor and notice if voltage returns to normal or the fuse holds and does not blow at once.

Test the suspected leaky horizontal output transistor while out of circuit. Before replacing the transistor, check for a leaky damper diode or yoke circuit. A resistance measurement from collector terminal or damper diode will indicate leakage in the output circuits. Remember, in some output transistors, the damper diode is in the same package with the transistor.

Slowly raise the output voltage of the variable transformer after replacing the leaky output transistor. If the new transistor becomes warm, or the fuse blows at around 65Vac, suspect an overloaded secondary circuit, such as silicon diodes or leaky components within the secondary derived circuits. Do not overlook the possibility that the problem is caused by a leaky bypass capacitor within the pincushion circuits.

The defective flyback transformer

A leaky flyback may destroy the horizontal output transistor and low-voltage regulator IC. Check both fuses to see if they're open. After replacing a leaky output transistor, slowly raise the variable line transformer voltage. If the flyback is leaky, the output transistor will become warm before the transformer output voltage reaches 65Vac. Monitor the low voltage at the same time.

If the flyback winding opens, the voltage at the collector terminal of the horizontal output transistor will be zero. The dc voltage found at the isolation resistor or primary winding should be higher than normal if the flyback has an open winding. In most chassis that have a +120V adjustment control, this control cannot adjust the low voltage when the horizontal transistor is out of the circuit.

The leaky voltage regulator IC may produce higher than normal voltage to the horizontal output transformer (Figure 5). The leaky internal resistance would be in parallel with the 20W resistor, producing higher output voltage. Often, the low-voltage regulator becomes leaky to common ground, opening the B+ fuse. If the low voltage is higher, the high voltage is higher and may shut down the chassis.

After locating a defective output transistor or IC voltage regulator, remove it from the circuit, and check resistors, diodes and capacitors tied to each terminal.

Shorted General Electric 13BC-4 chassis

No sound, no raster, no picture, was the symptom in this GE portable chassis. Fuse F2 was burned black inside the glass area, indicating a short circuit. Before I replaced both fuses, I checked the horizontal output transistor from collector terminal to common ground. It showed a leakage resistance of 0.11Ω.

After replacing Q551 with an ECG389

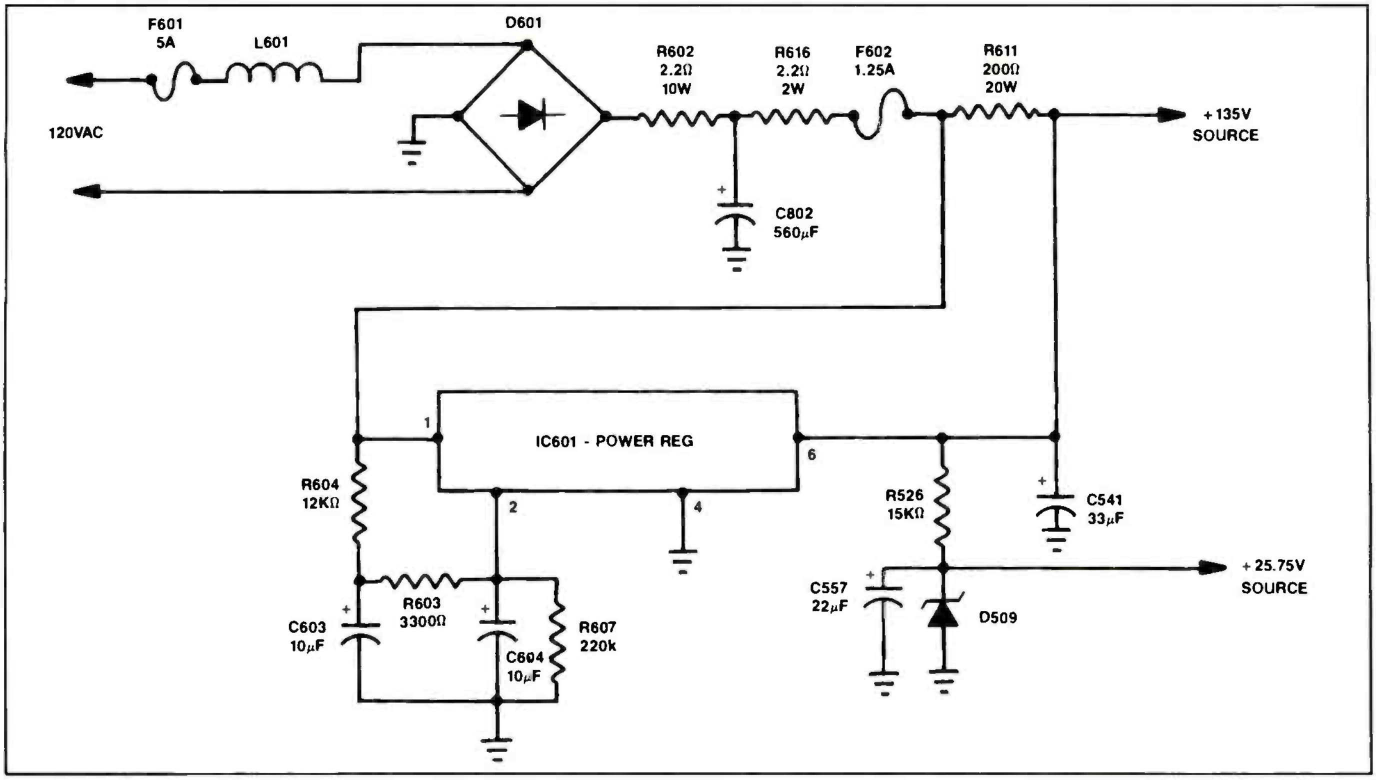


Figure 7. Lightning striking the power line destroyed several components within the low-voltage regulator circuits of this set.

output transistor, I connected the variable isolation transformer and slowly raised the ac voltage. Nothing occurred, no raster or picture. Both new fuses were normal. A quick voltage measurement at F2 indicated +168V, which was quite high. The voltage on the input terminal of the low-voltage regulator (IC801) measured zero volts (Figure 6).

I pulled the plug and tried to locate R802. 6.8Ω, 3W power resistor. After blowing out some dust and dirt, I located R802 near the low-voltage regulator. A low resistance measurement between TP05 and F2 indicated that R802 was faulty. I replaced this isolation resistor and applied power to the set. F2 opened immediately.

The resistance at the collector terminal of the horizontal output transistor to chassis ground was normal. The resistance from pin 2 of IC801 to ground was about the same. R802 tested good.

I removed the horizontal output transistor from the chassis and applied power to the chassis. Again, F2 blew. This left no doubt that the low-voltage regulator

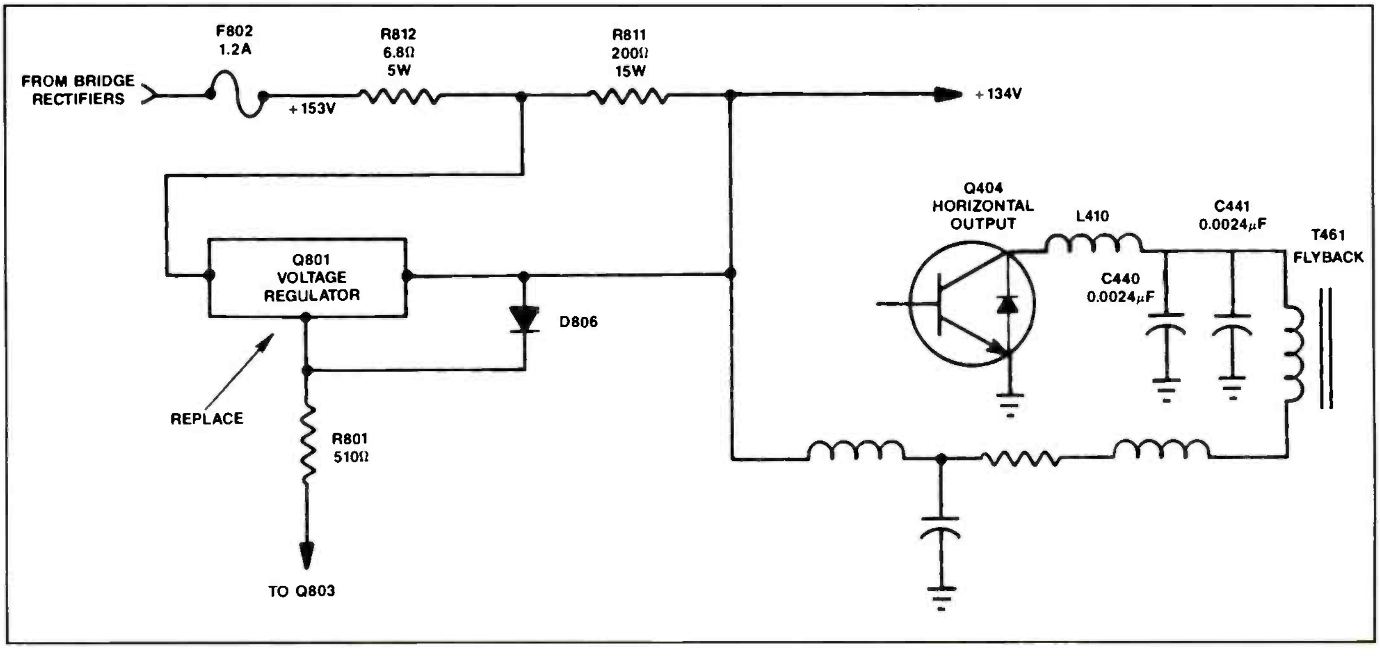


Figure 8. A defective flyback transformer, T461, destroyed both Q404 and the low-voltage regulator (Q801) in a Toshiba CX2035 TV set.

was defective. Replacing IC801 with an ECG1546 universal replacement returned this set to normal operation. Perhaps the horizontal output transistor (Q551) became shorted, taking out IC801, R802 and both fuses in its path.

Sony SCC-5480A with lightning damage

A Sony table model came in with lightning damage. The lightning had blown out fuses in the house and destroyed several appliances, torched a radio and silenced the TV set. In many cases a TV chassis struck by lightning or damaged by spikes or surges on the power line may be so seriously damaged that it is not economical to repair it. To evaluate whether it would be worthwhile to service this set I began by replacing both fuses: F801 and F802. Once I had replaced these fuses, I measured the resistance from the collector terminal of the output transistor (Q502) to common ground. It seemed to be normal.

I inspected the bridge rectifiers (D601) and found that two diodes were shorted (Figure 7). Since I did not have the right bridge rectifier on hand, I wired four 2.5A silicon diodes together and tacked them into the circuit to provide temporary power for an estimate. R602 and R616 were open, so I replaced them. R616 was replaced with a 2.5Ω, 5W resistor, and R602 with a 2.5Ω 10W resistor.

When I slowly raised the voltage, the power regulator IC began to smoke, and fuse F602 (1.25A) opened. A closer examination of resistors tied to the low-voltage regulator indicated a burned R604 (12K), R603 (3300Ω), R607 (220K), R526 (15K), and D504 was cracked open.

I removed IC601 from the back side of the chassis. This IC, mounted on a metal heat sink, also showed signs of lightning damage. The remainder of the chassis looked fairly clean, without any additional damage. I ordered a replacement for the low-voltage regulator from a Sony distributor. Now the evaluation of the extent of the lightning damage was complete. Replacement of IC601, D601, R602, R616, F601, F602, R604, R603, R607, R506 and zener diode D504 would restore the lightning damaged TV chassis to operation.

Toshiba CX2035 leaky flyback circuits

After replacing F801 and F802 in a dead Toshiba CX2035 TV chassis, I checked the horizontal output transistor for leakage. Q404 was definitely shorted (0.13Ω). I replaced it with an SK9022 universal replacement.

When I connected the set to the power line via a variable isolation transformer and increased the voltage, Q404 became warm. The low-voltage supply voltage was abnormally low. I checked the replacement Q404 for leakage, and this time measured 77Ω. I removed the transistor and checked it out of circuit. Q404 tested good.

I measured the resistance at F802 to common ground and the meter charged up and down, indicating no leakage. A resistance measurement at the output terminal of the low-voltage regulator (Q801) indicated around 79Ω (Figure 8). I concluded that Q801 was leaky, so I replaced it with a universal ECG270 replacement regulator.

I again slowly raised the ac voltage with the same results. Now Q801 had an extremely low output voltage. The resistance at the collector of Q404 was normal. I disconnected the red yoke lead, but nothing changed. Since Q404 and Q801 were damaged, I suspected a defective flyback transformer.

After injecting a horizontal signal at the base of the output transistor (Q404) and finding no output from T461, I ordered a replacement flyback transformer. No doubt the defective flyback had also knocked out the low-voltage regulator and output transistor Q404. The new flyback completed the correction of the low-voltage problem.

Conclusion

Always use a variable isolation transformer when servicing an ac-powered TV chassis. When the low voltage cannot be varied, suspect the low-voltage regulator circuits. Check the low-voltage circuits when low or no voltage is found at the horizontal output transistor. Closely inspect the low-voltage regulator for overheated conditions. Remember, with capacitor replacement in the fixed low-voltage circuits (+115V to +135V) choose an electrolytic capacitor with a working voltage of 200V. ■

Simple power supply and probe adapter aid testing

By Roger D. Redden

You know the symptom. When you turn on the TV you hear a brief rustle of high voltage, a short squeal, and then total silence as the set shuts down. It sounds as if the integrated high voltage transformer (IHVT) is arcing. But experience reminds you that the sound could also be caused by a load on the IHVT that draws too much current, a B+ regulator problem, a horizontal drive problem, or a shutdown circuit problem.

The collector of the horizontal output transistor (HOT) is a valuable test point for this kind of problem, and the adapter I'll describe makes it safer to hook a scope to this test point. Checking this test point while you use the power supply described here can help reveal if a load on the IHVT draws too much current, or if the IHVT arcs near its normal level of high voltage. In addition, you can use the power supply to check zener diodes with voltage ratings up to about 150V. First, I'll describe the adapter, and then the power supply.

A X2 adapter for a scope probe

For years I connected the X10 probe that came with my scope directly to the collector of the HOT to measure retrace waveforms. I never had a problem, even though my 10X probe was rated at 600Vdc while some collectors had 1100V retrace pulses riding on top of more than 100Vdc. My probe probably survived because probes often have a peak pulse voltage rating for low frequencies that is double their dc voltage rating. I also made the collector measurements fairly quickly, which prevented heat from building up in the probe.

Not long ago, my old probe became intermittent, and it was replaced with a probe rated at 500Vdc. That increased my concern about hooking the probe directly to the HOT collector. To reduce the possibility of damaging the oscilloscope probe while observing the waveform at the HOT collector, I soldered together the simple adapter shown in Figure 1.

Redden is owner and operator of a consumer electronics service center.

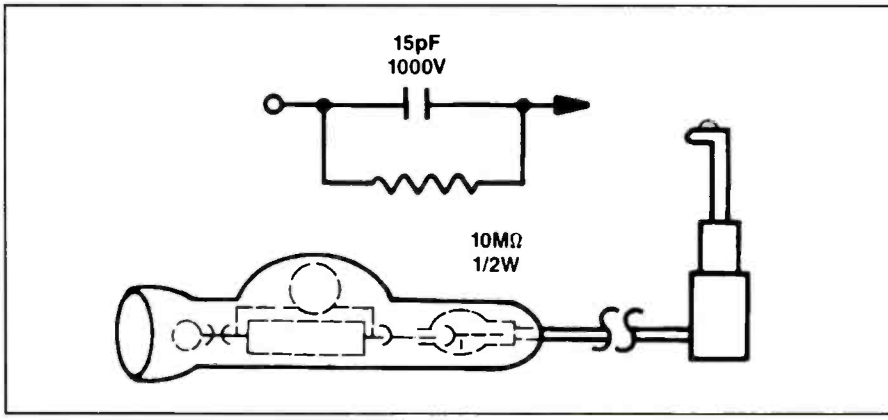


Figure 1. The X2 adapter is enclosed in heat-shrink tubing.

The adapter is just a 15pF, 1000V capacitor in parallel with a 10MΩ, 1/2W resistor. One end of the resistor is connected to a grabber through a short length of insulated wire. The other end is formed into a small loop to receive the hook of the 10X probe. I insulated the wire connection with a small diameter piece of heat shrink tubing, then shrunk a larger diameter piece of tubing over the capacitor and resistor, leaving the end that receives the probe unshrunk.

The capacitance of the adapter, in series with the capacitance of the probe and the scope's input, cuts a horizontal pulse almost exactly in half with practically no distortion of a horizontal, vertical or video waveform. Since the exact amount of voltage dropped across this adapter depends on the capacitance of the scope/X10 probe combination connected to it, you should test to see if the capacitor value given here cuts a small pulse acceptably close to half its actual size when used with your scope. If the pulse on your scope is too large, try a smaller value of capacitor. If the pulse is too small, try a larger capacitor.

Although this adapter decreases the risk of damage when measuring HOT retrace pulses, you must judge the risk yourself. You should check the rating of your probe and then decide if half the pulse you want to measure exceeds your probe's voltage rating, keeping in mind that the probe's pulse voltage rating probably is greater than its dc rating.

If your X10 probe is switchable, be sure it's in the X10 position while you use it with the adapter.

Since the adapter cuts a signal in half when used with a X10 probe, the combined effect is that of a X20 probe. For example, if the scope's vertical attenuator is set on 1V/Div, and the signal deflects the scope's beam 4 divisions, the voltage being tested would be equal to 4 volts (1 volt per division times 4 divisions) X 10 (X10 probe) X2 (adapter) = 80V; or figured more simply, 4 (divisions) X 20 (X10 probe X adapter) = 80V.

A simple variable power supply

The power supply, Figure 2, becomes useful when plugged into an isolated, variable ac source, such as an isolation transformer followed by a variable transformer. When plugged into such a source, this power supply can provide from 0Vdc to more than 150Vdc, depending on the amount of current drawn and the maximum voltage of the variable transformer used. This makes it useful to test a sus-

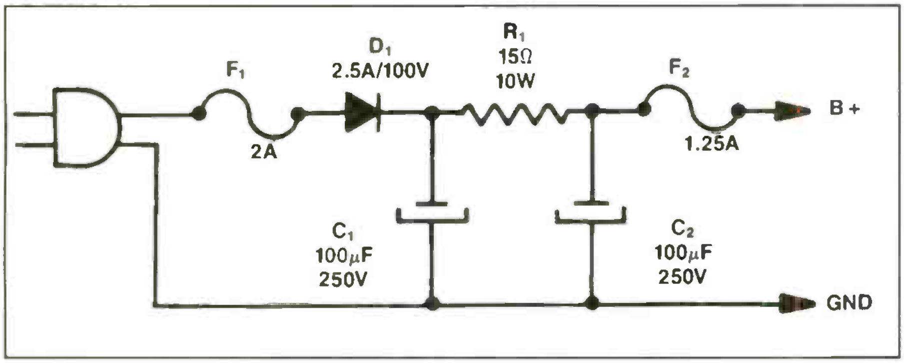


Figure 2. A half-wave power supply to be used with an isolated, variable source of ac power.

pected IHVT at its operating voltage level, or to check a zener diode with a voltage rating up to about 150Vdc.

Caution! This power supply is capable of supplying an output that could be lethal! Do not plug it directly into an ac outlet. You must use it with an isolation transformer. To remind myself, I attached a label near the plug with the printed warning, "Isolated Only."

Never plug the set into the ac outlet when you're using this supply for troubleshooting. After switching off the power to the supply, allow time for the capacitors to discharge before touching the B+ lead. With no load attached, the bleeder resistor needs almost a minute to discharge the capacitors.

Building the supply

There is nothing critical in the wiring of this circuit. I just taped the bodies of C1 and C2 together, soldered R1 between their positive terminals, soldered their negative terminals together for a ground bus, and then soldered D1, R2, and the fuses to the proper points on the leads of R1. I used heat shrink tubing around the fuses and D1 to prevent any shorts. To finish, I soldered an ac cord and some output leads to the assembly and put it all in a box. You can make it look better by mounting the parts on some perf board.

To make R1 short enough to fit into a box I had on hand, I actually used two 33Ω, 5W resistors in parallel. R1 will overheat if more than 0.7A is drawn for more than a few minutes. Even at lower currents, R1 becomes warm, so be sure your enclosure is fireproof and ventilated, and R1 is mounted away from anything flammable.

The function of F1 is to protect the isolation transformer if D1, C1 or C2 shorts. If your transformer is fused, you might not need F1.

Finally, be sure to put a caution on the cord, as mentioned above, and label the output leads as ground and B+.

Checking a zener diode

To check a zener diode with the power supply, connect the cathode through a series resistor to the positive terminal of the supply, as shown in Figure 3.

To find the value of the series resistor, assume a supply voltage 10V higher than the voltage rating of the zener diode and a current that will produce 0.1W. Using these assumptions, you can find the current (I) through the zener diode by dividing 0.1W by the zener diode's voltage rating (E), based on the formula P=IE. Then, since the difference between the supply voltage and the zener voltage is assumed to equal 10, divide 10 by the current to produce 0.1W. Here are two examples.

for a 5V zener:

0.1W/5V = 0.2A;
10V/0.2A = 500Ω

for a 25V zener:

0.1W/25V = 0.004A;
10V/0.004A = 2500Ω

Did you notice how neatly that works out? For the 5V zener, the resistor is 500Ω. For the 25V zener, the resistor is 2500Ω. If you just add two zeros to the right of the zener's voltage rating, you

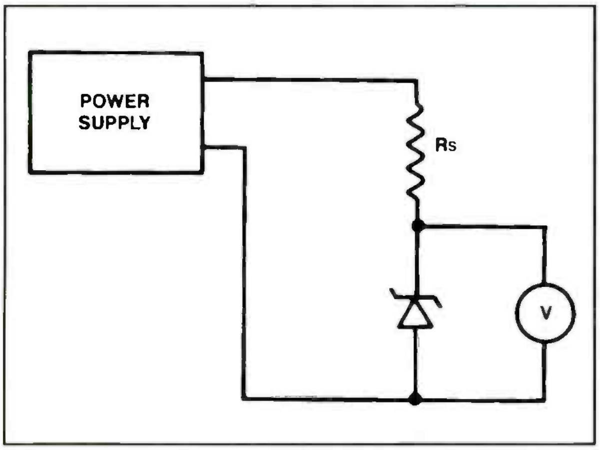


Figure 3. Using the power supply with a series resistor and a voltmeter to test zener diodes.

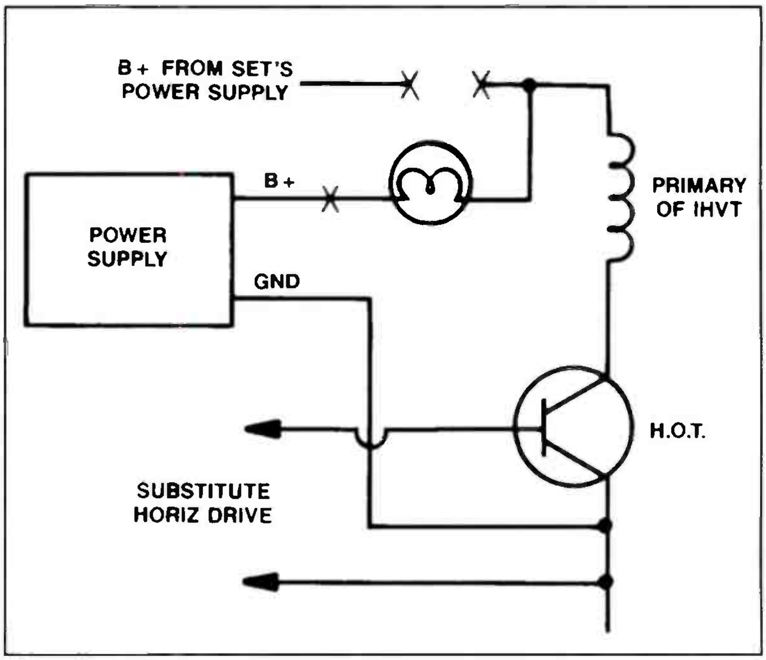


Figure 4. Connecting the power supply and an external horizontal drive to test the IHVT.

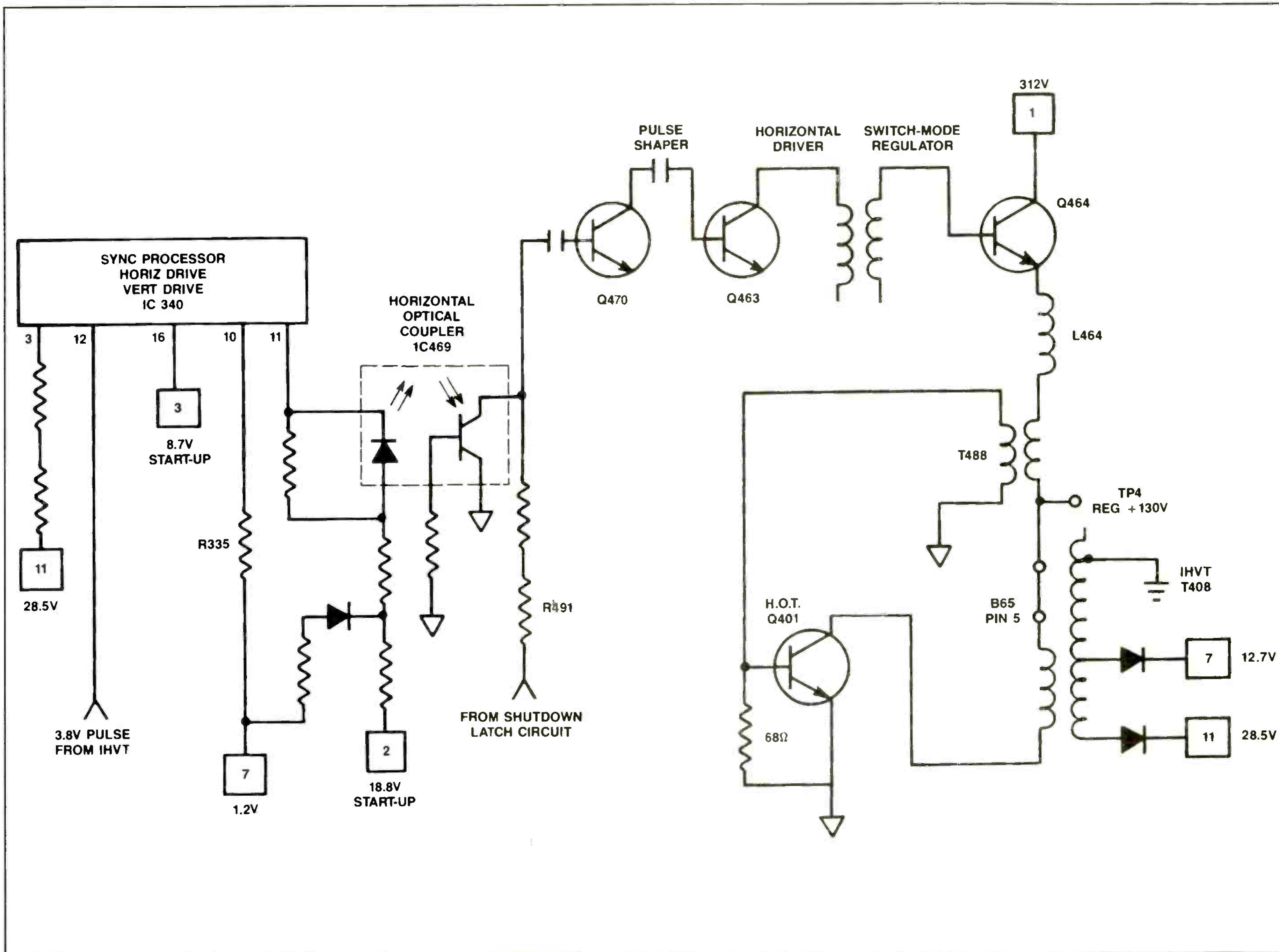


Figure 5. Simplified circuit of the Philco chassis with a symptom of squeal and hum. The IHVT and its loads were proved normal using the X2 adapter and the power supply.

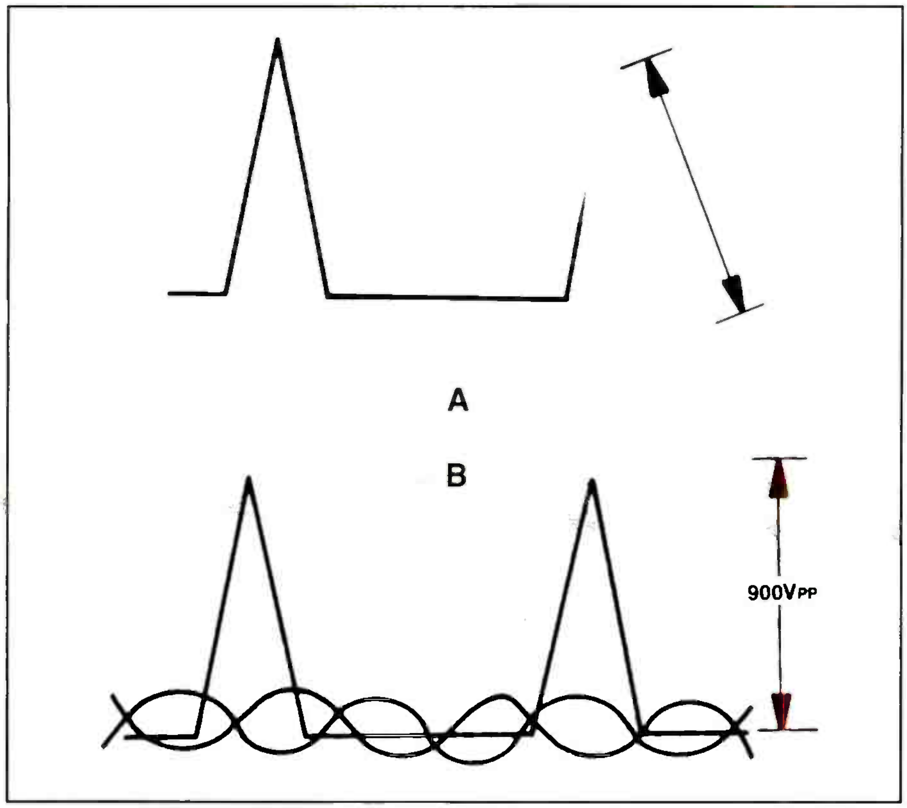


Figure 6a. Normal HOT collector waveform with 45Vac applied to the set, scope set at the horizontal rate.

Figure 6b. Abnormal HOT collector waveform with 68Vac applied to the set, scope rate set at horizontal rate.

have the needed series resistor value for 0.1W of power in the zener. Happily, any example works out the same.

If you increase the voltage of the supply to 20V over the zener's rating, the wattage becomes 0.2W. At 30V over, it becomes 0.3W, etc. The resistor chosen allows a broad tolerance for voltage.

Conversely, a voltage 10V higher than the zener's voltage rating gives a broad tolerance for resistor value. A resistor value 1/2 that of the value you got by adding the two zeros to the right of the zener's rating would cause the zener to dissipate just 0.2W. So you could safely use any value between those two resistor values and still check the zener with enough current to show any likely defect.

Once the zener is connected as shown in Figure 3, vary the supply from about 5V to about 15V over the zener's voltage rating using an acceptable value of series resistor. If the zener's voltage stays within tolerance of its rated value, then it is working normally. To avoid exceeding the wattage rating of zeners rated at under 0.5W, don't use a resistor value less than that found by adding two zeros to the zener's voltage rating.

Testing the IHVT and its loads

To check the IHVT, connect the supply as shown in Figure 4, with the ground of the supply to the ground for the emitter of the HOT. Disconnect the set's B+ from the primary of the IHVT, generally by removing a series connected fuse, resistor, jumper or coil. Connect a 100W light bulb in series between the B+ lead of my power supply and the primary of the IHVT. The bulb gives an indication of the amount of current drawn and helps protect components in the set. Remove the bulb only if the circuit seems normal and if you need more voltage than you can get with the bulb connected.

Using the X2 adapter and X10 probe, connect the scope to the collector of the horizontal output transistor.

Since the set is unplugged, supply external horizontal drive or external dc startup voltage to make the HOT operate. After you have drive to the HOT, increase the B+ from the supply to the IHVT primary while you watch both the light bulb and the waveform on the scope.

If you think too much current is being drawn (the light bulb seems too bright), or the waveshape starts to distort as you increase the B+ voltage from the power supply, reduce the B+ level a little and measure the voltage of any B+ supplies powered by the secondary of the IHVT.

Normally, if the dc voltage on the collector of the HOT is reduced, then the voltages of the secondary supplies are reduced by the same ratio. For example, if the HOT collector B+ is normally 100Vdc, but you're testing with it at 20Vdc, that's a ratio of 20/100, or 1/5. If the voltages supplied by the IHVT secondaries are normally 10V, 20V and 200V, then expect to find 1/5 X 10 = 2V, 1/5 X 20 = 4V and 1/5 X 200 = 40V on the secondary supplies when the HOT collector is operated at 20Vdc.

If a secondary B+ supply is less than about 90% of the value calculated with the ratio, disconnect its rectifier or protection resistor and then increase the voltage from the supply to the primary of the IHVT. If the bulb is no longer too bright, or the waveform is no longer distorted, then there is a problem in the disconnected supply or its loads.

If you have removed all the connections to the IHVT except the primary winding between the HOT and power supply, and still the light bulb burns too brightly or the HOT collector waveform is distorted, then the problem must be the IHVT. (It's normal for the retrace pulse to be wider and have lower amplitude when the yoke is disconnected, which lowers the high voltage).

If there are no signs of a problem in the IHVT when the collector is around half its normal B+ level, monitor the high voltage as you increase the B+ voltage from the power supply. If the high voltage reaches about normal without any sound of arcing and the HOT waveform remains good, the IHVT is not the problem.

An example using the supply and the adaptor

Here is how I found the cause of a confusing symptom in a Philco 25C547 chassis that I worked on recently. The schematic is found in Sams 2710.

When I turned this set on it sounded like arcing, combined with a slow motorboating sound, as if the high voltage were repeatedly starting up and shutting down. The high voltage was about 15kV.

I immediately assumed that the set was going into shutdown and then starting up again. This was a poor guess, since the shutdown circuit has two "error latch" transistors. If this were not clue enough that the set would not start up again after shutdown, the troubleshooting information lists the voltages present during shutdown. But because this information didn't fit my assumption, I didn't grasp it.

Changing my assumption, I removed R491 (see Figure 5), to defeat the shutdown circuit. Because the shutdown circuit was disabled, I wanted to protect the set by powering it with isolated low voltage, but it refused to start up. To get the set to work with low-voltage ac, I had to supply an external start-up voltage of 18V to point 2. This voltage is divided down by the set to give the other start-up voltage of 8.7V. After completing the repair, I found the set needed about 90Vac to start.

With 18V applied to point 2, and the set plugged into 45Vac, the squeal was gone, the dc voltage at TP4 was 71V, and the high voltage was 22kV. But when the ac voltage was increased to 68Vac, the symptom was back. And though the dc voltage at TP4 went up to 116V, a 45-volt increase, the high voltage only went up to 23kV, a 1kV increase. This seemed to imply excess current to the IHVT.

I hooked my probe adapter to the collector of the HOT and checked the waveform with the scope set at the horizontal rate, while I applied first 45Vac and then 68Vac to the set. A drawing of each waveform I found is shown in Figure 6. The waveform with 45Vac applied was a normal-looking 600Vpp, but the one with 68Vac applied had additional waveforms along the baseline (Figure 6B).

I wondered if this might be caused by a shorted IHVT, but the retrace pulses had increased to 900Vpp, which was not what I would expect with a shorted IHVT. Yet if there was no short, why was a 300Vpp increase in the retrace pulse increasing the high voltage only 1kV?

Checking the switch-mode regulator

I wondered if the switch-mode regulator, which not only regulates the B+ to the IHVT primary but also acts like a driver to the HOT base through T488, might be causing the problem. On the circuit board I found a jumper, B65, between TP4 and pin 5 of the IHVT (this jumper is not shown on the Sams schematic). I removed one end of it and connected a 60W light bulb from TP4 to hot ground. With 45Vac applied to the set, the light bulb lit brightly, TP4 measured 123Vdc, and the waveform at the base of the switch-mode regulator was a normal looking square wave.

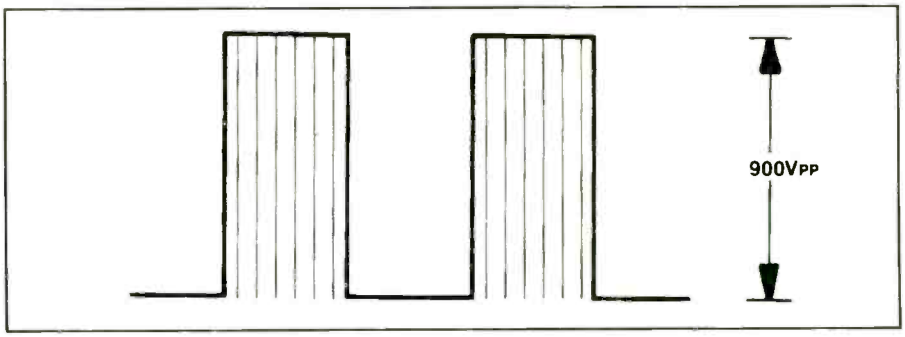


Figure 7. Abnormal HOT collector waveform with 68Vac applied to the set, and the scope set at 5mS.

With 68Vac applied to the set, TP4 was still 123V, the square wave on the base of the regulator still looked normal, and there was no squeal or hum. I decided the regulator was ok.

Could the problem be an IHVT diode?

You may be thinking at this point, as I did, that if the problem occurs when the high voltage increases, then it's likely to be a leaky diode in the IHVT. To find out, I left B65 disconnected and hooked my power supply to pin 5 of the IHVT. I removed the 18V external start-up voltage and injected a horizontal drive signal at the base of Q401 (I was lucky I didn't use the set's horizontal drive, since the result would have confused things).

While applying low dc voltage to pin 5 and looking at the Q401 collector waveform, I saw a small pulse between the two retrace pulses on the scope. This pulse disappeared when I increased the horizontal drive to the base of Q401 by an additional 2V. This HOT circuit, with a 68Ω resistor in parallel with the built-in resistor from emitter to base in the output transistor, seems to need more than the usual amount of drive to work correctly.

I increased the dc voltage on pin 5 of the IHVT while I watched the waveform on the collector of Q401 and monitored the high voltage. At some point, which I failed to record, I heard a hum that built slowly, faded, and then built again. Disconnecting L464 stopped this hum. Apparently, the drive signal injected in the base of Q401 was stepped up by T488 and caused parts of the regulator circuit to conduct.

Eventually, I had increased the dc voltage on pin 5 of the IHVT to 125V, and there was no arcing. This ruled out the yoke, the IHVT, and the loads on the IHVT.

I had two circuits, the regulator and the horizontal output, that seemed to work perfectly alone, but that failed when put together. I was puzzled.

Reconsidering the evidence

Reviewing what I had done, I realized that I had concentrated exclusively on the symptom of the squeal and ignored the motorboating sound. I had checked the waveforms at the scope's horizontal sweep rate because they were horizontal waveforms. But maybe I should use a slower sweep rate to see if I could discern the cause of the motorboat-like hum.

I removed my power supply from pin 5 of the IHVT, removed the external horizontal drive from Q401, reconnected B65 and L464, applied an external 18V start-up voltage to point 2, hooked the scope to the HOT collector, and applied 68Vac to the set. With the scope's sweep rate set at 5mS/Div, the mystery began to clear up. I found a waveform similar to the drawing in Figure 7.

There were bursts of retrace pulses followed by periods of absolutely no pulses. That explained both the squeal and the hum. I followed the horizontal drive, also coming in bursts, back through the horizontal circuits to pin 11 of IC340. With 68Vac applied, the drive at pin 11 came in bursts; but with 45Vac applied, the drive was continuous. All I had to do now was find out why.

The symptom occurred only when the IHVT operated above a certain level, which implied some kind of feedback. The connections I saw from the IHVT to

IC340 were a pulse to pin 12 of the IC, and the B+ voltages to point 11 and point 7. Disconnecting the 28.5V supply to point 11 made no difference, but when I disconnected the 12.7V supply to point 7, the drive became normal. I put the two supplies back and disconnected R335 to pin 10 of the IC. With R335 disconnected, the IC produced normal drive.

Isolating the problem

Trying to find the exact problem, I put R335 back and checked the voltage at point 7 while I increased the ac voltage to the set. Any time the voltage at point 7 rose above 8V, the drive came in bursts.

With the set unplugged, but with the external 18V start-up voltage hooked to point 2, I connected a second external power supply to point 7. As soon as this supply was increased to just above 8V, the drive from pin 11 of IC340 disappeared. The strange symptom now made sense.

When the 12.7V supply, powered from the IHVT, got above 8V, IC340 would stop producing a drive signal. Without horizontal drive, the 12.7V supply, powered by the IHVT, would drop below 8V. Then IC340, powered by the start-up voltage, would produce drive again, and the cycle would repeat.

IC340 was now the prime suspect, but I checked the resistors and capacitors around it anyway. They all seemed OK. Installing an ECG1632 replacement for IC340 caused the set to operate properly.

Looking back, I could have saved time by checking the HOT collector waveform sooner at the scope's slower sweep rate, instead of following my habit of checking it at the horizontal sweep rate.

But even with the scope set at the horizontal sweep rate, why couldn't I see the periods when horizontal drive was missing completely? I couldn't see what was missing because a triggered scope produces a sweep only in response to a waveform. Each burst of drive produced about 6 retrace pulses. My scope, set to display two retrace pulses at the horizontal sweep rate, showed those two pulses each time a burst of drive occurred.

It's as though I never looked out my window unless I heard a bell, and every time I heard the bell and looked out my window, I saw a camel walking past. I might think that camels were always walking past my window. ■

Test Your Electronics Knowledge

Answers to the quiz

(from page 21)

1. You only need to use one of the 10Ω resistors. Even if it is at the lowest end of its 1% tolerance it will still be within 10% of 11Ω.

2. You don't need a calculator for this one:
$25\underline{/90°}\Omega = 0 + j25\Omega$

3. 50Ω. R_2, R_3, and R_4 are shorted out of the circuit.

4. 2V. For the voltage across R_1:
$P = V \times I$. Therefore, $V_1 = {}^{P}/_{I} = {}^{1W}/_{1A} = 1V$

For the voltage across R_2:
$V_2 = IR_2 = 1 \times 1 = 1V$

The total (applied) voltage $= V_1 + V_2 = 2V$

5. 750RPM

$$7.5\ \frac{\text{DEGREES}}{\text{PULSE}} \times 600\ \frac{\text{PULSES}}{\text{SECOND}} = 4500\ \frac{\text{DEGREES}}{\text{SECOND}}$$

$$4500\ \frac{\text{DEGREES}}{\text{SECOND}} \times 1\ \frac{\text{REVOLUTION}}{360\ \text{DEGREES}} \times 60\ \frac{\text{SECONDS}}{\text{MINUTE}} = 750\ \text{RPM}$$

6. $V_2 = 6V$.
There are several ways to work this problem. Using Kirchhoff's voltage law:
$18V = V_1 + V_2 + V_3$

But, $V_1 + V_2 = 10V$ (from Figure 3)
By substitution

$18 = 10 + V_3$
$V_3 = 8V$

Since $V_2 + V_3 = 14V$ (from Figure 3)

$V_2 + 8V = 14V$
$V_2 = 6V$.

7. The frequency of the applied ac determines its speed.

8. The voltage across an LED is usually about 1.5V.

9. You only need to calculate X_L.
$X_L = 2\pi fL$
$= 6.28 \times 400 \times 29.9 \times 10^{-3}$
$= 75.1\Omega$

Therefore, $X_c = 75.1\Omega$ to make the circuit resonant and the phase angle = 0.

10. The reactances will be equal at the resonant frequency.
$fr = 1/2\pi\sqrt{LC}$
$= 1/2\pi\sqrt{27 \times 10^{-3} \times 27 \times 10^{-6}}$

$f_r = 186Hz$

ANSWER TO THE BONUS QUESTION

I have been accused at times of asking trick questions. I suspect that is because some readers are not sure what a trick question looks like, so the bonus question is an example.

Ultraviolet light will not pass through an ordinary glass prism.

Oh, what the heck! Give yourself five points anyway.

What Do You Know About Electronics?

Capacitors, color codes, aluminums, tantalums, etc.

By J.A. Sam Wilson

I have had a number of questions about capacitor color codes. There have also been some questions about electrolytic capacitors.

I am going to repeat an offer that I have made before. If the color code confusion is getting to you—take me up on this offer. I have some charts that decode most of the capacitor color codes in use.

Just send two 29 cent stamps along with your name and address. Stuff in a card that says "color codes" so we don't send you a new Buick or paper clip by mistake.

One of the stamps is for postage. The other is to help defray the cost of the envelope, addressing, photocopying, and, going to the mailbox in this 82° weather in Florida. With all the money that is left over I'm going to get me one of those Buicks. Send your request in care of this magazine.

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

Now, about the aluminum vs. tantalum electrolytic capacitors. The most important feature of electrolytic capacitors is their high capacitance (not capacity) in a relatively small package. They are not color coded. Instead, their values are printed on their cases.

The equation for the capacitance of a capacitor explains how the electrolytics get high capacitance:

$$C = [k]\,[A/d]$$

where C represents the capacitance, k is the dielectric constant of the material between the plates, A represents the area of the plates, and d is the distance between the plates. From that equation it is obvious that in order to get a high capacitance value you need to select a material with a high dielectric constant.

You can think of dielectric constant as being a multiplier. It tells how much more effective a dielectric is than a vacuum would be if it was used as a dielectric in the same capacitor.

But that doesn't tell the complete story about the dielectric. It must also be able to withstand a high breakdown voltage. Breakdown voltage is the voltage the dielectric must be able to withstand without conducting current. That is something that is not indicated by the equation. The aluminum oxide and tantalum dioxide choices do the job. In both cases they can be made very thin and still have a high breakdown voltage rating.

Saying that the dielectric is very thin is another way of saying that the distance (d) between the plates is very small. According to the equation, the smaller the d is the larger the capacitance is, therefore, the thin dielectric means that the capacitance of these capacitors can be quite high.

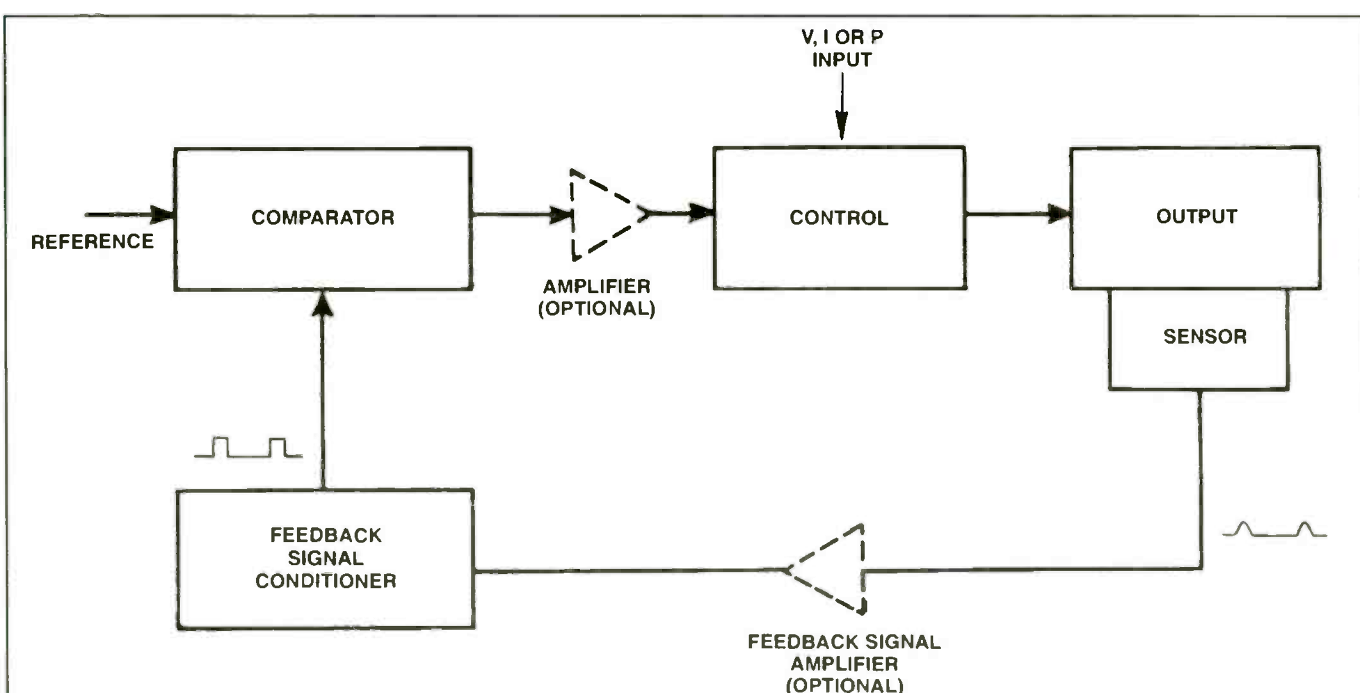


Figure 1. A negative feedback Servo System.

Aluminum oxide is a corrosion that is formed on one of the plates when it is manufactured. It can be "formed" by passing a current through the plates and through the liquid or paste used as an interface. The tantalum material can be sprayed on or applied in a number of different ways.

After the aluminum type has been on the shelf for a long period of time (one year or so) the aluminum oxide starts to deteriorate. That is why you shouldn't just connect an aluminum type into a circuit without re-forming the plates. When the aluminum dielectric deteriorates there is a lot of leakage current. It can be enough to destroy a component in your power supply!

This is one place where the tantalums have the edge. Their dielectric doesn't deteriorate very much (compared to aluminums) when they are not being used.

Re-forming the aluminum electrolytic is just a matter of connecting a dc or pulsating dc voltage across the capacitor with the correct polarity. You start with a low voltage and build it up to the working voltage rating. I have never been able to get an authoritative definition of what amount of time is needed. I use an hour with periodic increases over that time.

Maybe some super techs will drop me a line and tell me what they do (?)

To increase the area of the capacitor plates (A in the above equation) without making very large capacitors, the manufacturer uses aluminum foil that is "quilted." That is not the kind of quilting used to make blankets. It simply means that the foil is etched or matressed to give it more area per square inch.

Here is a short summary of both the advantages and the disadvantages of tantalum electrolytics.

Tantalums are made with a wider capacitance range (but the highest values are made as aluminum types). Tantalums have a longer shelf life (but they cost more). Tantalum capacitance values have a closer tolerance (but that isn't important in many filter applications). They have a lower leakage current (but the aluminums are made with a higher voltage rating).

The dc working voltage (WVDC) rating of electrolytic capacitors tells the dc voltage plus the peak of the ripple voltage that the capacitor must be able to withstand. The WVDC rating of a capacitor should be higher than the actual voltage expected across the capacitor.

WARNING!!! Tantalum is highly poisonous! Tantalum capacitors should never be discarded in a way that will allow tantalum to get into the environment!

Servos—Theory and applications

I have had a request to review servo theory and applications. Complete books have been written on this subject. Obviously, we can't give it a very broad treatment in one issue, so this will be the start of a series.

It is always a good idea to start a review by defining terms. My IEEE dictionary of Electrical and Electronic Terms defines *servomechanism* three different ways:

- A feedback control system in which at least one of the system signals represents mechanical motion.
- *Any feedback control system.*
- An automatic control system in which the controlled variable is mechanical position or any of its time derivatives.

Pay special attention to that second definition. It says that a servomechanism is *any* feedback control system. By that definition all of the following subjects fall into that category—regulated power supplies, automatic frequency controls, AGC and AVC circuits, motor speed controls including those used in VCR's and compact disk speed controls, phase-locked loops, temperature control, automatic brightness limiters, etc.

I am not totally comfortable with the second definition given above. To me, a servomechanism controls mechanical things like motor speed and antenna positioning. So, I'm calling the subject of this series "servos." That includes the mechanical and electro-mechanical types as well as the electrical/electronic types that have no moving parts.

One important characteristic of servo systems is that they present a special (sometimes very difficult) troubleshooting problem. The output depends upon the input, and, the input depends upon the output. Troubleshooting will be given special attention in this series.

Figure 1 shows a general block diagram of a servo system. This is a *negative feedback servo system*. Its automatic control is accomplished by placing a variable limitation on the output. By way of contrast, a positive feedback control reinforces the input to the controlled output. An oscillator is an example of a circuit with positive feedback and there may be some control of the feedback.

The place to start with the block diagram is the upper-right corner where it is marked "V, I, or P input." That is the place where the output of the system gets its energy. For example, it may be the power for running a motor. It could be the signal input for an automatic frequency control system. It is the input that will be controlled in some way before it is delivered to the output.

There must be some kind of sensor to determine the condition of the output. It isn't possible to automatically control the speed of a motor unless the system knows what speed the motor already has. Without the sensed speed signal the system wouldn't know whether to increase or decrease the speed, or, to leave it alone.

Sensors are sometimes called *transducers*. The correct technical definition of a transducer is that it is a device which permits the energy of one system to control the energy of another system. It is *not* technically accurate to say that a transducer "converts" one type of energy into another type of energy. However, it is O.K. for a model when you are teaching beginning students. (Speakers and microphones are examples of transducers.)

In Figure 1 the input to the sensor is taken from the output of the servo system. In the example of motor speed control the sensor would have to be some kind of device that can take speed as an input and deliver V, I, or P to the electrical/electronic servo system.

The output of the sensor is sometimes amplified before it is applied to a signal conditioner.

The signal conditioner is a very important part of the closed-loop system. The output signal of a sensor may not be useful to the comparator. Figure 1 shows an example of a typical sensor output from an optoelectronic tachometer. Note that the output of the signal conditioner is a more usable pulse waveform.

If the tachometer is a dc generator, the signal conditioner must employ a dc-to-frequency converter to make the signal useful for the comparator. A voltage-controlled oscillator (VCO) could be used in that case.

The comparator takes the signal from the signal conditioner and compares it with a reference signal. Continuing with the example of motor speed control, the reference could be from a crystal-controlled oscillator that has a pulse output.

If the comparator and reference signals match, there is no correction sent to the control circuit. If they do not match, the control circuit gets an input from the comparator that causes the output to get back in step. After the correction the input signals to the comparator match and no further correction takes place.

The control circuit may be nothing more complicated than a power amplifier. That is what is used in a linear voltage regulator. The signal from the control section goes to the grid or base of a power amplifier. The output of the power amplifier is the system output.

In another example the output of the comparator might be a frequency in the form of pulses and the frequency of those pulses used to determine the speed of a stepping motor. In one case each pulse advances the motor 15°. Therefore, every 24 pulses advances the motor shaft one complete revolution. If the steps for the stepping motor are in small angles and the frequency of the pulses is high, the motor will run as smooth as a Tonka truck. ■

Will Total Quality Management work for you?—Part 7

By John A. Ross

In Business Corner, for the past six months, we have been looking at the management theory called Total Quality Management. In this installment, we'll talk further about Point 6—Institute training on the job—of the TQM concept propounded by W. Edwards Deming.

Another look at TQM point 6—Institute training on the job

In the last Business Corner, we found that proper employee training is a link to quality, improved production, and enhanced service. Because the consumer electronics service industry involves having the best technical knowledge at our fingertips, the prior issue only considered how formal training, rather than self-training, can improve the performance of technicians. One of Deming's goals, however, is to improve the overall performance of the entire organization. Therefore, we also should consider how to improve the leadership, personal communications, and decision-making skills of employees. To managers who survive by using traditional "old-school" methods, any suggestion that employees should have leadership and decision-making skills may seem threatening.

Nevertheless, there are dividends when employees are trained to have such skills.

In a scene from the movie *Stripes*, an exhausted Bill Murray and others answered the question "What kind of training, soldier?" with the reply "Army training, sir." While "Army training" is not on this agenda, two different categories of training are. As you probably suspect, providing the best technical training for your employees is a primary responsibility for management. However, training in personal and management skills also should rank as a top priority.

Part of the Deming philosophy about quality and the workplace involves giving more responsibility to all employees. Responsibility has many meanings. From this perspective, we can define responsibility as having the capability to make independent decisions and having the ability to maintain good relationships with customers and other employees. In some ways, independent decision-making is not a learned process—some employees actually shy away from making any type of decision. Yet, training about how organizations function, why organizations can develop a particular culture, or how different personality types can mesh or clash can lead to greater employee leadership and can pay large dividends for both the employee and management.

As mentioned in other articles, many universities and third-party groups offer course work about organizations and leadership. Also, many institutes offer specific training about leadership and decision-making. Some of the topics to consider when looking for training include personnel management, organizational culture, and interpersonal communications. As an example of the emphasis that an organization can place on decision-making and interpersonal communications, one service organization hired a consultant to provide on-site training.

The training involved having each employee take Meyers-Briggs personality tests and addressing employees and managers as a complete group. Meyers-Briggs tests look at characteristics such as introversion, extroversion, value-based decision-making, and judgmental decision-making. The consultation also involved recognizing personality types and a look at why some personality types clash with other personality types. When the main group broke into two groups of extroverts and introverts, many employees (and managers) were surprised to learn that unconscious actions can provoke negative reactions among customers or fellow employees.

Whether we consider technical training or organizational training, only a formalized approach will provide the best results. Attempting to save money and time by providing the informal, "in-house" training can produce good results. However, a formalized, external approach to training will gain more attention and produce greater long-term benefits. Rather than look at the monetary and time costs for training as avoidable, unnecessary spending, consider the money and time as a wise investment. The technical training gained by your employees will carry the organization to new heights and will produce more profits. The organizational training given to your employees will not only instill greater decision-making skills but will also lighten the load for the ownership and managers by spreading responsibilities and building greater employee self-esteem. ■

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

Digital display dc power supplies

Leader Instruments has added nine new bench-type dc power supplies, Model 700 Series, to its product line. These single-output units cover maximum output voltages from 18Vdc to 110Vdc, and maximum currents ranging from 3A to 20A.

All feature constant voltage or constant current operation and provide $3^1/_2$ digit LED digital readout of both voltage and load current. Ripple as well as line and load regulation are kept low, and reverse polarity protection coupled with fast overload recovery are standard.

Circle (50) on Reply Card

Tech tips by modem or on disk

Technical Information Procurement Systems, Inc. is releasing its TechFix tech tip software which is based on its online tech tip service.

TechFix provides the user with online tech tip search options, and lets users develop a database on their computer.

Updates will be made available by mail, or by calling the online computer system by modem and downloading the new tech tip data file.

Version 2 comes with over 5,500 tech tips covering TVs, VCRs, and camcorders for major manufacturers. The software allows database searches based on make, model, chassis, symptoms, EIA codes, word searches, similar models, similar chassis, as well as wildcard model number searches.

All registered TechFix users receive a trial access period to the TIPS online system, which currently contains over 7,650 tech tips.

Circle (51) on Reply Card

Digital signal to NTSC converter

JVC Service and Engineering Company of America announces the availability of the DS-B525U Digital Scope, a device that takes a digital signal and converts it to an NTSC video signal that can be viewed on a TV monitor. In digitized video circuits, the digital signals that process the video have a direct relationship to some component of the original video signal. This test device can be used to examine the image at each line (address or data). If there is any variation in the data stream, it is noticeable on the TV monitor. As each line is tested, a quick comparison to the original video signal can be made by switching between the video signal and the digital signal being tested. In cases of testing address lines, the information may be visible only during the video blanking period. Therefore, an internal/external sync switch is provided to allow the signal to roll across the screen so the information can be seen. There is a wide band video switch which allows viewing of digital signals with a bandwidth greater than 4MHz on the TV monitor. The switch ranges are 0 to 4MHz and 0 to 10MHz.

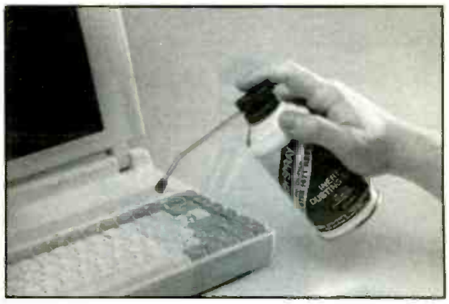
Circle (52) on Reply Card

TopLine solder practice kits

TopLine debuts its line of 20 solder practice kits for SMD machine run. Each kit includes a specific PC board and all components necessary for assembly. Most kits are available in quantities to build 10 to 100 assemblies. Kits are available for all skill levels from beginner to the most advanced. The company has engineered each kit to address a variety of applications including; training, machine diagnostics, stencil evaluation, solder practice, speed checks, demonstrations and experimentation.

For hand soldering, the company has a Rework Kit which is compatible with most rework stations including, PACE, Weller and OK Industries.

Circle (53) on Reply Card



Multi-directional spray attachment

Tech Spray, Inc. is introducing the new Multi-Directional Spray Attachment (#1990) which allows precise control over the flow and direction of spray.

The attachment fits the company's products as well as other Envi-Ro-Tech products. The unit easily attaches to the top of the aerosol cans using special threaded valves.

The attachment nozzle rotates 360 degrees allowing user to direct spray in all directions without inverting the aerosol can.

Circle (54) on Reply Card

Fiber optic tool kit

Metrotek Industries, Inc. now offers a Deluxe Fiber Optic Tool Kit, Model KY26. The kit contains 25 individual tools necessary to work with fiber optic cable. The tools are provided by major manufacturers. The case is a distinctive "fiber optic" yellow, made of high-quality materials including locking latches for maximum protection and durability.

Circle (55) on Reply Card

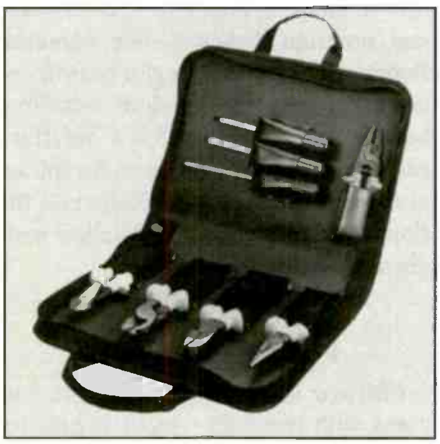
Expanded DMM line

Tektronix Inc. introduces three products in its handheld DMM product line.

The new DMM's will be useful for applications ranging from industrial design and service to education and general hobbyists. The meters are ruggedly designed and comply with industry safety standards. Each is designed and manufactured to comply with safety standards established by UL and IEC and conform to Mil-T-28800, Class 2 standard for shock and vibration.

The DM255 features a $3^1/_2$ digit display, 0.7% accuracy, autoranging or manual selection, data hold and current measurments. Where current measurements are not needed, the DM256 offers testing of voltage, capacitance, resistance and diodes with 0.5% accuracy, a fast continuity beeper and memory offset. The DM257 offers current and capacitance measurements with 0.5% accuracy, autoranging and manual selection, and a low battery indicator.

Circle (56) on Reply Card



Insulated-tool kit

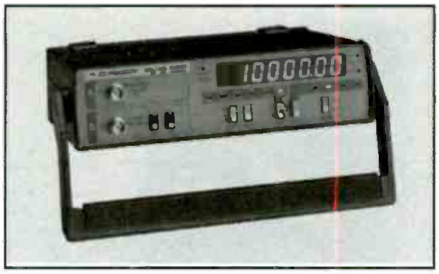
A kit containing an assortment of eight basic insulated tools that comply with the IEC 900 standard is available from *Klein Tools, Inc.* All of the tools in the kit will protect against electrical shock if they make contact with energized lines or equipment with voltages up to 1000V, when the tools are used correctly under proper conditions.

Included are three types of cutting pliers, three types of screwdrivers, a cable cutter, and a wire stripper/cutter.

Circle (57) on Reply Card

Multifunction counter

B&K Precision has improved their microwave multifunction counter. Model 1856A now has almost double the bandwidth (5Hz to 2.4GHz). Its temperature compensated crystal oscillator (TCXO) timebase has 0.5PPM stability from 18C to 28C, and 1 PPM stability from 1C to



50C. Sensitivity at 2.4GHz is 50mV.

The counter is useful for making accurate and repeatable measurements of radio transmitter frequency up to the microwave range. It is well suited for the communications industry. It exceeds the accuracy requirements for adjusting transmitter frequency to FCC standards, as required for radio stations or land mobile, radio telephone transceivers.

Because the unit extends to 2.4 GHz, it even covers emerging worldwide Personal Communication Services (PCS). Applications in the 2GHz band include military aeronautical systems, nuclear test facilities communications, railroad communications, broadcast auxiliary systems, wireless cable, and cellular phone companies' point-to-point microwave service.

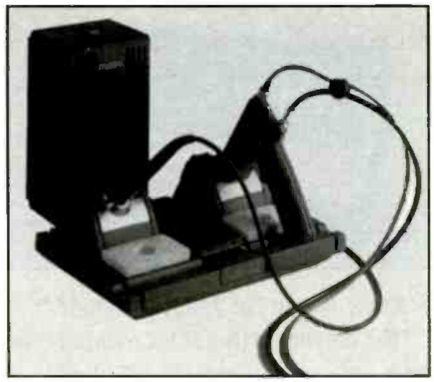
Period measurement capability is provided for accurate readings at very low frequencies. This facilitates measurement of tone frequencies used in many types of communications systems. The period function's range extends from 0.28µs to 0.2 seconds.

In the totalize mode, pulses from 5Hz to 10MHz are counted up to 99,999,999. This mode is useful in counting the number of operations performed by production machines or in quality control tests. Reset and hold can be performed using a front panel switch, or using a remote start/stop input.

Circle (58) on Reply Card

Rework station

Metcal, Inc. announces the addition of twelve new SMT tips to its combination through-hole/SMT rework solution. With the addition of these twelve tips, the SmartHeat STSS-005E Rework System grows to over 200 available tip geometries—enabling users to rework everything from the heaviest jobs to the most delicate components.



These systems contain a tip cartridge which self-regulates heat generation. This reduces the risk of thermal damage and eliminates the need for calibration and allows fast temperature recovery.

The soldering unit has a short tip-to-grip distance, while the desoldering unit features an ergonomic pistol grip design and a vacuum capable of clearing through-holes quickly and completely.

Circle (59) on Reply Card

Drive diagnostic package

Accurite Technologies Inc. announces the availability of a disk drive diagnostic package, the Drive Probe Advanced Edition. Using a combination of hardware and software, the product harnesses the power of an IBM PC compatible computer to provide computer dealers and service professionals with a comprehensive diagnostics package for testing 3.5 Macintosh drives, in addition to other

drives found in PC compatibles, including 4MB drives.

The diagnostic package also offers software publishers and duplicators a means of ensuring the integrity of their manufacturing equipment, with support for the most comprehensive list of non-standard duplicator drives available.

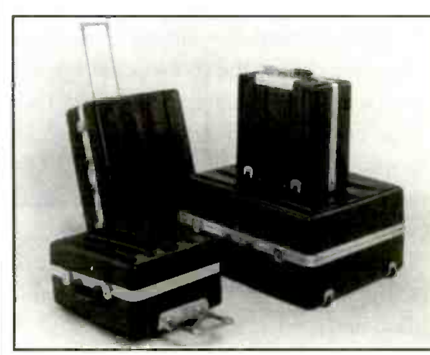
Using state of the art HRD (high resolution diagnostic) diskettes, and a proprietary design floppy controller installed in a PC, the product allows users to thoroughly evaluate the performance and check the condition of 5.25 inch (360Kb, 1.2Mb) and 3.5 inch (720Kb, 1.44Mb, 2.88Mb) standard or dual speed floppy drives, 800Kb and 1.4Mb Macintosh drives, as well as popular software duplication autoloader drives and their electromechanical diskette loading systems. It can also be used to assist in making adjustments and repairs to floppy drives which need servicing. The product eliminates the need to use an oscilloscope or other bench test equipment when testing or aligning drives.

The base package comes complete with three HRD test diskettes for testing the various models of 3.5 inch and 5.25 inch drives, both 3.5 inch and 5.25 inch format program diskettes, one universal floppy controller (single slot board), one drive personality module (external board) and assorted drive interface cables, power plugs and fuses. An optional bit shift module card plugs into the floppy controller board for window margin and asymmetry testing.

Circle (6) on Reply Card

Foam-filled cart cases

Chicago Case offers high-tech, cart cases with two-inch rugged wheels for easy mobility and a five-inch telescoping handle. All aluminum parts of the case



are made of a high-strength alloy of titanium, magnesium and aluminum. The foam-filled case is of high density Indestructo polyethylene in a variety of standard sizes and styles. The manufacturer will custom design cases for specific needs. Foam is cut to fit, hold, protect all products.

Circle (61) on Reply Card

Degaussing color monitors

By John Bachman

Just as with TV sets, a color monitor may develop a discoloration or color purity problem on part or all of the screen. Typically, the discoloration follows a semicircular pattern around one side or corner with several bands of different color distortions, like a rainbow. Sometimes the discoloration involves the entire screen, but that is rare.

This discoloration may be caused by an externally induced magnetic field that has permanently magnetized some material in the monitor. The three CRT electron beams are guided to their appropriate phosphor dots by a magnetic deflection system. The beams pass through a shadow mask near the phosphor surface assuring that the red beam hits the red phosphor, the blue beam hits the blue phosphor, and the green beam hits the green phosphor. If some nearby component (frequently, it is the shadow mask itself) has become sufficiently magnetized then the beams receive an undesired deflection, and will not land on the appropriate phosphor, or will land partly on one color and partly on another. The result is an impure color that arcs around the magnetized component.

Motion is an important clue to this problem. If the rainbow moves it is not being caused by a permanent magnetization but by some alternating magnetic interference in or near the monitor. If the rainbow does not move then it may be caused by permanent magnetization and degaussing is necessary. Moving the monitor to another location will determine if the interference source is internal or external. Does the rainbow disappear when the monitor is moved? If so, the magnetic interference is coming from something near the monitor's normal location. If the rainbow travels with the monitor the problem is in the monitor and degaussing may be required.

Bachman is president of Anatek Corp. in Amherst, NH.

Degaussing is the solution

Degaussing removes permanent magnetization by introducing an alternating magnetic field that is stronger than the offending permanent magnetization. This field will energize the magnetic domains of the material and induce an alternating magnetic field. Then, if the amplitude of the alternating magnetic field is gradually reduced to zero, the material will be demagnetized.

The easiest way to degauss a monitor is often to let the monitor do it. All modern color monitors have built in degaussing coils and circuits. Take a close look the next time you open one. There will be a coil of wire wrapped in tape or other insulation surrounding the CRT faceplate. Usually, it is coiled around the CRT behind the mounting ears. That is the internal degaussing coil. It is a coil of wire connected to the ac line through a thermistor current limiting circuit.

The thermistor has a low resistance when cold and a higher resistance when warm (typically a 10:1 ratio). It is in series with the degaussing coil so that when started cold a large current will flow through the coil and then will decrease to a low value. The internal degaussing coil thus automatically degausses the monitor every time it is turned on. This degaussing takes place while the monitor screen is blank so that the resulting discoloration is not visible during the degaussing.

Unfortunately, design limitations reduce the magnetic field strength available from internal degaussing coils. That limits the amount of permanent magnetization that can be neutralized by the internal degaussing. If a monitor has been strongly magnetized internal degaussing may not be enough, resulting in color purity problems.

Manual degaussing

Manual degaussing requires a degaussing coil. You may have to search a bit to find one, but they are available. One source is Apollo Wholesale in Irving, Texas, 800-488-2782. Many homemade coils exist, but be careful with them. There are line voltages involved; isolation, insulation ratings, spacings and fusing must be considered in any degaussing coil design. Manufactured degaussing coils cost less than $50. Why take a chance?

The basic principle involved in operating a manual degaussing coil is the same: introduce a strong alternating magnetic field and then slowly reduce its amplitude to zero. This is accomplished by holding the degaussing coil near the monitor (it can be on or off) turn the degaussing coil on and slowly move the coil away from the monitor as smoothly as you can. When the coil is at arms length from the monitor, turn the coil off.

When you hold the degaussing coil close to the monitor and turn it on you have introduced a strong magnetic field. Then, as you move the coil away the magnitude of the field at the monitor decreases. When you have the coil at arms length from the monitor there is no perceptible magnetic field at the monitor and you turn the coil off. ■

Books

Novell Certification Handbook, By John Mueller, CNE and Robert A. Williams, CNE, CNI, Windcrest/TAB Books, 224 pages, 25 illus., $24.95 paper, $40.00 hardcover.

Novell certification is the most coveted license sought by network specialists, and the *Novell Certification Handbook* is an all-in-one guide to acquiring and making the most of Novell credentials. When you consider that almost 60 percent of aspiring certified engineers fail the Novell exam, this volume becomes vital to the continued market growth of network technology.

Certified NetWare Engineers John Mueller and Robert A. Williams have compiled a one-stop source of essential information for network administrators, engineers, and instructors who want to obtain Novell certification or, having already acquired it, use it to their best advantage in an increasingly competitive job market. They answer all the most commonly asked questions: What are the certification requirements?, How do I register for the exam?, What should I look for on the test?, How can I speed up the certification paperwork?, What's the best way to present my certification to prospective employers or clients?, What are the continuing education requirements of CNEs, CNIs, and ECNEs?, and How do I set up a consulting business once I've received certification?

Windcrest/TAB Books, McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850.

Analog Electronics with Op Amps: A Source Book of Practical Circuits, By A.J. Peyton and V. Walsh, Cambridge University Press, $34.95 paper, $89.95 hardcover.

Analog Electronics presents a collection of analog electronic circuits based on the op amp, supported by a wealth of practical and technical detail which will enable the reader to select, build and test a desired circuit.

The book is primarily intended to be a practical reference volume rather than a teaching text. Both students and professional engineers will discover in its pages an extensive source of functional and established analog circuits, from integrators and differentiators to logarithmic amplifiers; from instrumentation amplifiers to filters. The circuits are conveniently grouped according to function, and the approach followed is to build-up slowly from the basic text book examples toward a series of practical, workable circuits.

Students who need to build and test particular types of analog circuitry as part of an assignment or project based activities will find this book useful. Professional engineers will also find the book useful for design and development work. The coverage is extensive and up-to-date, and provides expert, technical advice on the selected circuits.

Cambridge University Press, New York, NY 10011-4211

Master Frequency File, By James E. Tunnell and Robert Kelty, TAB Books, 544 pages, 40 illus., $29.95 paper, $40.00 hardcover.

For anyone using a scanner or shortwave receiver, *Master Frequency File* will unlock a world of listening possibilities. Packed with services, frequencies, call-signs, and user IDs on the 25MHz-to-2110MHz radio spectrum, this reference makes it easy for radio professionals and hobbyists alike to tune in and listen to communications from hundreds of sources, including the Federal Bureau of Investigation, Secret Service, Internal Revenue Service, Marshal Service, Commerce NOAA Weather, Drug Enforcement Administration, Customs Service, Immigration-Border Patrol, Prisons Bureau, and National Park Service. Also included is a list of publications, organizations, institutions, and facilities that can assist in expanding radio monitoring skills.

TAB Books, McGraw-Hill, Inc., Blue Ridge Summit, PA 17294-0850

Principles of Electronic Devices and Circuits, By David E. LaLond and John A. Ross, Delmar Publishers, Inc., 960 pages, $40.95 hardcover.

Principles of Electronic Devices and Circuits provides practical, technical-oriented coverage of transistor theory and operation. The highly visual approach used to describe how to analyze, solve and predict circuit operation—with a special emphasis on critical thinking—helps students focus on circuits and not just memorization. Step-by-step explanations show how to reduce circuit calculations to variations of Ohm's Law and voltage divider applications, enabling students to apply basic knowledge of dc/ac fundamentals to circuits and devices.

Delmar Publishers, Inc., Albany NY 12212-5015

Literature

(from page 5)

for 81 instruments including 10 new products. These range from general purpose test instruments such as analog and digital storage oscilloscopes to audio, function and RF generators, audio analyzers, video generators and monitoring equipment, programmable RGB generators, meters and bridges, frequency counters and bench power supplies.

Circle (11) on Reply Card

Tool catalog

The colorful 1994 Master Catalog from Jensen Tools offers 288 pages of electrical and electronic service products. This catalog is the company's 30th Anniversary issue. It features the best of the company's products (specialty tools, tool kits, and cases), and presents state-of-the-art test equipment from Fluke, Tektronix, Microtest, B&K, Extech, and many other leading manufacturers. The catalog also provides a complete source of hardware and accessories for network installation and service.

Major sections include: Tool kits, cases and carts, PC/computer service, Telecom, LAN & Fiber Optics, wire & cable, hand tools, power tools, metal working, soldering, static control, circuit boards, lighting, optical aids, test & measurement, and cleaning equipment.

Circle (1) on Reply Card

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WANTED

Schematic needed for stereo amplifier NAD model 3150, copy ok. *Clinton Skalsky, 101 Greenstone Lane, Waite Park, MN 56387. 612-252-2985.*

Schematic for Action TV/VCR Combo. If not available, IC208 and transistor connected to J206 on board. Both burned, unable to cross part numbers. Unable to locate company. *Write or send to Ed or Pete at Tektronics, 17 W. Granada Blvd., Ormond Beach, FL 32174. 904-672-1175.*

Looking for six transistors, FET 2SK7II. *The Music Shop, 548 Main St., Torrington, CT 06790-3796.*

Sams S.D.15 or schematic for Bearcat-250 scanner or source for 250. *Jos. Ososky, 722 Kimball Ave., New Kensington, PA 15068. 412-335-4624.*

Sencore CB42 CB analyzer and any CB related equipment, service manuals and books. *George Kozykowski, 96 Beaver Dam Rd. Montgomery, NY 12549. 914-457-5920.*

Yoke, JVC PN CE20006-00B for model #AV-2600US. (good used part OK): View finder for Sony camera HVC2200 (EVF PN HVF2000). *Contact Dennis DeKnikker at D&D Video Repair, 4861 E. Elliot Rd., Phoenix, AZ 85044. 602-598-0158.*

Volume control for a Bradford Model 89193 stereo player. *Paul Capito, 637 West 21 St., Erie, PA 16502*

LCD screen for Laptop CGA computer (81/4 inch width x 61/4 inch high). Need backlit pad only. *Richard S. Salazar. 5090 Palm Ave., Hialeah, FL 33012. 305-556-5724.*

Operating and service literature for a General Radio GR-1192-B frequency counter. *Call 805-733-0618 (after 4:30 p.m. PST).*

CRT sockets or adapters for RCA CTC-96A and CTC-120, and N.A.P. TV chassis: Hitachi flyback #2432091 or equivalent, ECG 866, 865 or equivalent; used O.K. *W. Worley, 305 Hickory Bend, Enterprise, AL 36330. 205-347-5281.*

Starting a service shop, looking for late model equipment. Service manuals and any service aids for VCRs and TVs. *604-485-4854*

RCA transformer, IHVT part #156364 or 150043. This unit is no longer available from RCA. *Herb's TV Servicing, 510-785-7783.*

Panasonic portable VCR model NV-8420. Need service and operators manual. *Robert Miller, Rt. 1 Box 223 Anadarko, OK 73005.*

Schematic for GE model 7-4950A showing disassembly and part #. Power transformer. Also, part # for GE P4930A power transformer. Will pay for any info. *Al Rosenstein, 326 E. 64th St., Savannah, GA 31405. 912-354-6350.*

Epson FX80 and Citizen LSP 100 printers. Service information wanted and details of regulator STK 7554. Photocopies acceptable. Offers to: *Norman, 7 Gloucester close, Four Marks, Alton, Hants, England, GU34 5HX.*

Safety glass (plastic) for 1958 Philco TV model G4242L. Part Number 54-6691. *Robert Snow, 2164 Catalina Dr., Clearwater, FL 34624.*

Wanted for Mark brand console color television, 1 power transformer identified as T-100 on chassis M9CZ-5K8, model: AMR 1960K. Also, Magnavox power supply high voltage circuit board, Type APW-005 or information to locate a replacement flyback transformer. *Wayne Turner, 2801 County Line Rd., Signal MTN., TN 37377. 615-886-3042.*

Looking for J.C. Penney audio/video module MVS001A (RCA part #153960) TV model #685-2501G. New or used if it is in working condition. *Boyd Hawks, Rt. 8, Box 406, Galax, Va 24333. 703-236-4210.*

Cassette deck mechanism from Aiwa AD1250, AD6300 or similar late 1970s model. Any condition. Also, replacement phonograph cartridge, Pfhansteil P-324 (Ronette DC400-OV) or similar. *Johnson Electronic Tech., 5 Kane Industrial Dr., Hudson, MA 01749. 508-562-1157.*

Sencore SC3080 Waveform analyzer. Like new. $2500/best offer. *314-243-4848.*

Schematic for Apple monitor model A2M2056 and same for other Apple monitors. Meter for Sencore CR168 CRT Tester. *Steven Baker, 164 River Road Hackettstown, N.J. 201-327-0349.*

Service manuals/schematics for Project One. Mark XXI audio amplifier/Panasonic color TV model CT-3003.*Michael M. Putz, 1210 Scott Ave., Chicago Hts., IL 60411. 708-755-6495.*

Service manual or schematic for Zenith color TV, Model SS2713 (7 years old). Will purchase or copy. *William J. Ryan Sr., 726 Berry Rd., Wilmington, DE 19810.*

Deflection yoke for Future Tech TV model 1918 GP. *John Phipps, 1412 Navaho Trail, St. Charles, MO 63304.*

Hitachi flyback #2432091 new/used; Touch pads & chips for G.E. and Magic Chef ovens; and source for metric screws down to 1.0mm dia. *W. Worley, 305 Hickory Bend, Enterprise, AL 36330. 205-347-5281.*

Need instruction manuals for RCA WR99A crystal calibrated marker generator, RCA WR52A stereo Sig. FM simulator, RCA WR538A Super Chro Bar Gen.. Will copy or pay for copies. *Harry Dillon, 204 E. Chapel Ave.. Cherry Hill, NJ 08034. 609-667-6617.*

B&K 470 CRT checker adapter socket #CR-42, Sams annual index around 1980. *Ed Herbert, 410 N. Third St., Minersville, PA 17954.*

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Sencore VC93 in original carton. Never used. $1200.00 619-948-0937 or write to *Terry Gibson, PO Box 400729, Hesperia, CA 92340.*

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Sencore SC61 Waveform Analyzer, $1990.00; plus shipping. *Sal Cribari, 1312 Well Dr., Camp Hill, PA 17011. 717-763-1855.*

Sencore VA62 with VC63 VCR accessory, $1200.00; Sencore CR70, $500.00; Sams Photofacts, mixed, from 700 to 2000, $200.00. Write to: *Joe Dinger RR1, Box 87-DD, Bringhurst, IN 46913 or call 317-566-3269 after 4 PM E.S.T.*

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Sams Photofacts, 1 through 1079. Sams Auto Service Manuals-$50.00 and up. *Ann Bickanick, 15 1/2 W. Lake St., Chisholm, MN 55719. 1-218-254-4421.*

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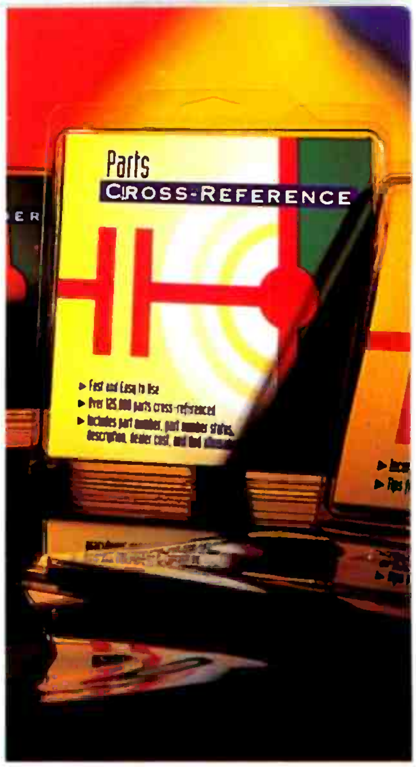

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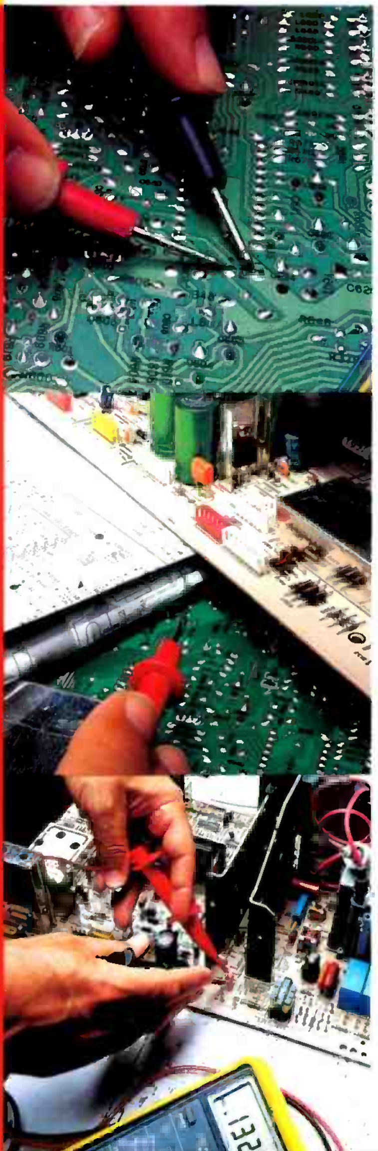

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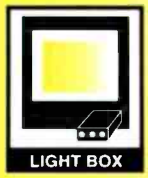

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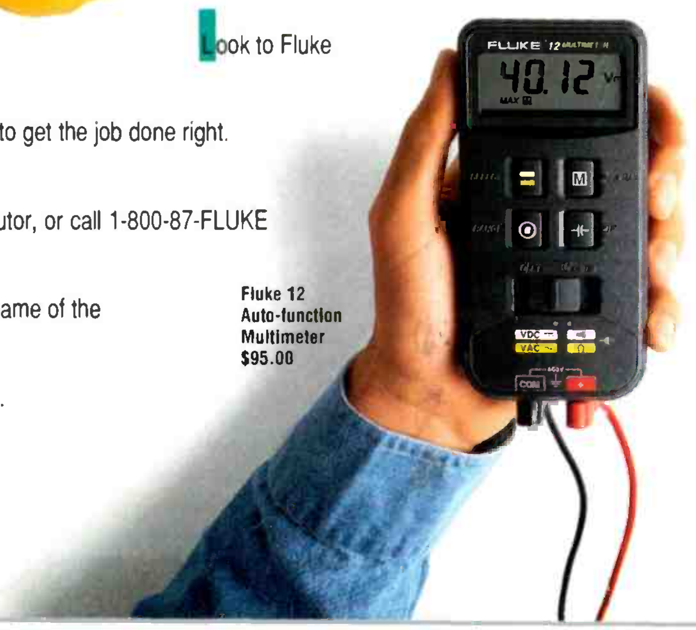

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