THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

November 1996

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC

Servicing & Technology

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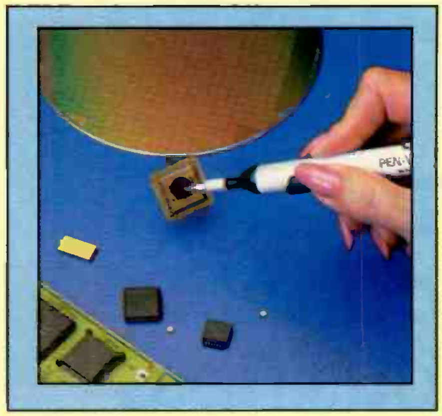
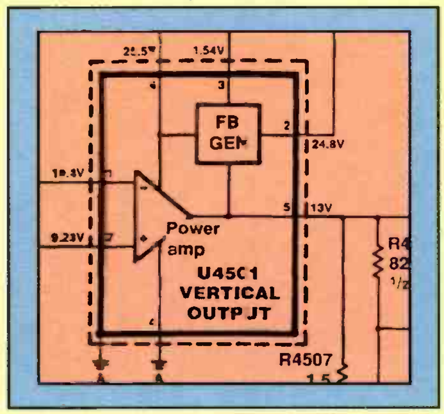
Contents

ON THE COVER

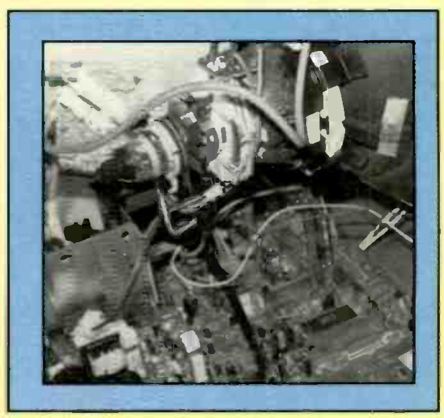
Consumer electronics products of today are marvels of circuit miniaturization and automated fabrication. One of the consequences of these characteristics is that in many cases it is absolutely impossible to complete a repair without using some kind of special handling devices and/or aid to vision. Special circuit board and parts handling products help to make servicing easier and more efficient. (Photo courtesy Virtual Industries)



page 8



page 11



page 24

EDITORIAL

Taking care of business

Ask business owners or technicians how they got started in the consumer electronics servicing business, and you'll hear a variety of stories. But a frequent thread of such a conversation is "electronics was my hobby."

Most people who entered electronics service did it because they love to work with electronics. They find electronics fascinating, and thrill at the intellectual challenge when faced with a malfunctioning product, or comparing the symptoms they observe with the knowledge of how electronics works, to come up with a diagnosis of what might be wrong.

I have never asked a manager or owner in electronics service how he got started in the business and heard him say "business was a hobby of mine, so I decided to get into business this way."

A number of consumer electronics service business owners or managers will say that they got into the business because they were business-oriented people looking for some kind of business to buy or manage, and the business they're now in represented a good opportunity. For most of these people, electronics is not in the blood as it is for the hobbyist or enthusiast who turned to servicing as a career.

Electronics is a fascinating pursuit, and with the rapid advances in consumer electronics, it becomes more fascinating every day. Anyone who shares the fascination with electronics understands how it captivates. There's something fascinating about a device that can capture signals out of the air and generate sounds and pictures. Amateur radio enthusiasts have an endless fascination with being able to communicate with other human beings half a world away by just using the signals generated and received by that magic box in front of them.

Today, a whole new generation of enthusiasts is being created; a generation fascinated by the personal computer. They have found that the computer can help them compose and format correspondence, organize and list their worldly possessions, keep track of their finances, access huge amounts of information from the world wide web, or communicate instantaneously (or nearly so) with another human anywhere in the world. Many of those enthusiasts are letting their computer hobbies lead them into careers in that area.

One of life's little ironies is that in many cases, individuals who are not enthusiasts, who are in consumer electronics, not because they are consumed by electronics and its uses, but because they have chosen this particular area of business in which to exercise their business skills, are more successful than their counterparts who get into service because of their love of electronics.

On reflection, it should not be surprising. The business expert who enters consumer electronics service invariably recognizes that he must employ people who have skills in servicing consumer electronics products. He understands markets and marketing. He knows how to read a balance sheet. He understands, in short, how to run a business.

Many individuals who are in consumer electronics service because they were fascinated with electronics are not good businessmen. Frequently they make decisions based on their interest in electronics, rather than hard business facts. That is not to say that it is not possible for an electronics enthusiast to become successful. Many, in fact, have. However, these are the ones who have made the commitment and spent the time and effort to become educated as businessmen, or to hire the services of someone who has that expertise, or both.

If you're a consumer electronics service business owner who is more oriented toward electronics than business, and you don't know how to price your service, or negotiate reasonable warranty rates with manufacturers, or whether your business is thriving or failing, you should take time to take a course in business, or attend a seminar, or join an association.

If you hope to remain in business into the next century, you will need to become every bit as skilled in business matters as you are in electronics.

Nils Conrad Persson

MECP announces new recertification tests and alters length and price of installer certification

Effective September 1, 1996 the length of certification for Mobile Electronics Certification Program (MECP) tests at the First Class, Master and Specialist levels has been increased to four years. The Installer level tests will remain at the current two-year length.

With recertification occurring every four years instead of every two, the fees for the tests will be slightly increased. For all tests taken January 1, 1997 or later, the registration fees will be $25 for the Installer level (currently $20) and $65 for the First Class, Specialist and Master levels (currently $55). As a result of doubling, the length of certification, installers will save approximately 40 percent on test fees, according to the Mobile Electronics Certification Committee of the Consumer Electronics Manufacturers Association (CEMA).

Recertification tests, composed of 50 questions, for the First Class, Master and Specialist levels, are being developed. The new tests will review current and new mobile electronics technology.

Initiated in 1991, MECP tests and certifies installers in the three primary sections of the 12-volt industry: autosound, vehicle security and cellular. It is the only nationally-recognized program of its kind for 12-volt installation. Consumers can call 1-800-767-MECP (1-800-767-6327) to find out the nearest retailer employing an MECP-certified installer. For more testing information, retailers and installers should call 703/907-7689 or write MECP/CEMA, 2500 Wilson Blvd., Arlington, VA 22201-3834.

EIA, *InvestorsEdge* Release EIA Stock Indices

The Electronic Industries Association (EIA), along with Ethos and *InvestorsEdge* have announced the creation of the EIA Member Stock Indices, a new feature of the Association's World Wide Web Site (http://www.eia.org/stock/).

The EIA Stock Indices will provide current stock price information (15 minute delay) of EIA's publicly traded member companies. The companies have been divided up into 7 indices representing different product segments of the industry. Member companies of EIA product sectors, such as the Consumer Electronic Manufacturers Association (CEMA) and the Telecommunications Industry Association (TIA), are also included in the indices. This site also includes a special EIA Member Stock Index which represents a cross-section of the entire electronics industry.

Within each index the companies are listed with their current stock price, daily change, and volume. All information is updated by the minute using Java enhanced technology. Each company's name is hyperlinked directly to their "At-a-Glance" summary on *InvestorsEdge*, which provides a more in-depth profile of the company. The EIA Stock Index is comprised of 30 companies selected by the Association's Senior Economist to represent the U.S. electronics industry.

"This exciting feature of the EIA World Wide Web Site is a first for electronics manufacturers and should lead to even more innovative methods of industry communication," commented EIA Chairman and Cobra Electronics CEO Jerry Kalov. "The EIA Member Company Stock Indices is just another one of the many benefits of EIA participation."

EIA President Peter F. McCloskey commented, "Our partnership with *InvestorsEdge* not only allows us to create and maintain these new features, but also allows the entire web community to access them. Once again, technology has made what was a difficult task just a couple of years ago a reality today."

EIA/EIF to develop pool of test questions for electronic skills certification program

The Electronic Industries Association (EIA)—including the Consumer Electronics Manufacturers Association (CEMA)—and EIA's philanthropic sector, the Electronic Industries Foundation (EIF) have announced their plans to develop a pool of test questions to be used in the certification of work-ready electronics technicians.

The groups have chosen Chauncey Group International, a subsidiary of Educational Testing Service (ETS), to develop and validate the test questions. ETS is best known as a long-time administrator of the SAT exams.

This work is the continuation of the National Skill Standards Development Project begun in 1992 to develop voluntary national skill standards for work-ready electronics technicians. Hundreds of individuals from companies representing all segments of the electronics industry and from industry associations like the Vocational Industrial Clubs of America (VICA) and the International Society of Certified Electronic Technicians (ISCET) participated in developing the 300 skill standards. Plus, experts from international companies measured the standards against international benchmarks to assure that US workers can meet standards set anywhere in the world. The standards now are widely accepted as the industry's definitive statement of its requirements for work-ready technicians.

Chauncey was selected because its experience encompasses the development of testing processes to measure effectively and fairly the competencies required for a variety of types of work. Chauncey's in-depth experience in developing certification tests safeguards both potential employers and employees by making sure the tests do not discriminate with regard to race, sex, ethnic origin or disability. Both will know that those who pass the test possess the skills, knowledge and abilities to succeed in the highly competitive international marketplace.

The pool of test questions should be ready for validation by the end of 1996. EIA/EIF has invited the industry organizations that participated in development of the standards and that conduct testing for electronic skills to become partners in the certification process when EIA/EIF decides how to implement a national testing program. Although other organizations conduct tests for electronics skills, theirs have not been developed with the breadth of industry input that has gone into the EIA/EIF program.

EIA/CEMA/EIF and their members have spent approximately $1 million on the national skill standards program, which was praised by the Department of Education as a model effort.

There is a fundamental need for skilled labor to assure that electronics equipment is manufactured in accordance with quality standards and at product levels that meet market demands, operate at full capacity and is serviced with a minimum of down time. By the year 2005, The U.S. electronics industry will represent nearly an $825 billion slice of the economy and will require an estimated 2,454,600 work-ready electronics technicians with world-class skills.

By clarifying the competencies needed for job performance, skills standards will enable educators to develop performance-based curricula so that graduates leave school with work-ready skills and are qualified to obtain jobs, to hold jobs successfully, to change jobs within broad occupational areas, and to adapt to changes brought about by emerging technologies.

The manual for the standard, "Raising the Standard—Electronics Technician Skills for Today and Tomorrow" is available in both paper and disk formats. Manuals can be ordered from CEMA's Product Services Department, phone: 703-907-7670, fax: 703-907-7968. For $25.00, buyers receive both a paper and disk manual.

Camcorder low light sensitivity standard certified by ANSI

The American National Standards Institute (ANSI) officially certified EIA-639, a standard that will help camcorder buyers compare low light sensitivity. Developed by the Consumer Electronics Manufacturers Association (CEMA), a sector of the Electronic Industries Association (EIA), this standard establishes a unified method of measurement for manufacturers to use in their literature.

The EIA standard applies to video cameras and camcorders of all types, including VHS, 8mm and the new digital products. Manufacturers who adopt EIA-639 are to indicate in their advertisements the low light performance as "measured by the EIA standard". Consumers should look for this wording when buying a new video camera or camcorder.

The task force assigned to developing this standard was created under the direction of the EIA/CEMA Video Systems Committee, composed of manufacturers, independent test laboratories, technical media representatives and consultants.

"Camcorder low light sensitivity or lux rating is an advertised feature for camcorders. A low lux rating, along with zoom range, automatic functions and a color viewfinder, are key features that influence camcorder sales," said John H. Stevens, task force chairman and manager of camera engineering for Thomson Consumer Electronics. "With this new standard, the industry can provide an accurate guide for consumers interested in buying camcorders."

During the course of the standard development, camcorder user tests were conducted to determine the level of picture performance a camcorder owner would accept when the lighting conditions were less than optimum. From these tests, information was gained on minimum acceptable quality levels for picture brightness and contrast and picture noise and color.

According to the standard, camcorders must equal or exceed the minimum acceptable level for the following five performance parameters:

- luminance level,
- black level,
- luminance signal-to-noise (S/N) ratio,
- chroma level, and
- resolution.

Manufacturers and other interested parties can order EIA-639 by calling Global Engineering Documents, phone: 800-854-7179.

Interconnect products catalog on CD-ROM

A CD-ROM version of the 650-page *Electronic Interconnection Systems Ordering Guide* is now available from the 3M Electronic Products Division. The new CD-ROM contains information on more than 5,000 electronic products.

Products described in the guide include: board and wiremount sockets, board stacking systems, "MIX" stacking connectors, D-Sub connectors, D-Ribbon connectors, DIN connectors, cables, assembly equipment, heat shrink tubing, tape and reel packaging, and wire marking products.

The CD-ROM requires Windows 3.1 or 3.11, a 386, 486, or 586 processor-based computer, a minimum of 4MB of RAM, and a CD-ROM drive. The electronic catalog includes product specifications, technical drawings and color photos as well as complete ordering information. Easy-to-use menus provide quick access to specific information.

Circle (74) on Reply Card

Product digest

Galco Industrial Electronics has just released its quarterly *In-Stock Product Digest*, a comprehensive 240-page catalog of electronic components, controls and supplies.

Industry resellers, end-users, service companies and machine/electronic OEMs will find the digest has been expanded and improved from previous versions. The digest features seventeen new product lines, an expanded alpha-numeric semiconductor index, an enlarged name brand replacement (NBR) component section and extensive technical reference data including cross reference charts. Newly listed products include: AMP and DDK connectors (a direct Amphenol replacement); Marinco NEMA receptacles (a drop-in Hubble replacement); F.W. Bell, Huntron, and ITT Pomona Electronics test instruments; switches from Idec and Joslyn Clark; Toshiba uninterruptible power supplies; and NTE universal semiconductor replacements.

Circle (75) on Reply Card

On-line parts ordering system

PC Service Source, Inc., announces the launch of PC service net a real-time Internet ordering and information retrieval system for PC spare parts.

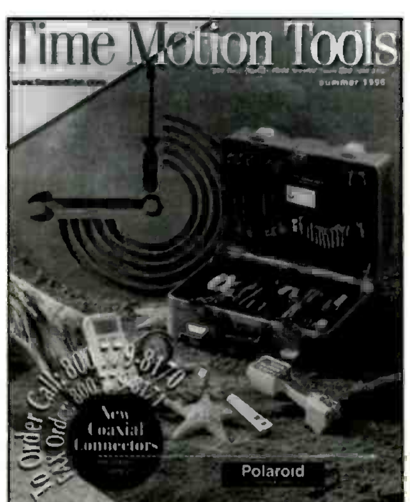
This new order-entry application gives service providers control over the entire transaction, including real-time access to pricing and availability, access to account and order status, advanced reporting and, in October, warranty claims processing. PC Service Net has a sophisticated keyword look-up capability, offering added convenience for users that do not know their part number.

With PC Service Net, the company's customers have three access options: online purchasing, ordering by phone, or ordering by fax.

Circle (76) on Reply Card

Tool, toolkit, test equipment catalog

Time Motion Tools catalog features over 150 new products including a large assortment of coax adapters, connectors, coax kits, new Dewalt cordless drills and



THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC
Servicing & Technology

Electronic Servicing & Technology is edited for servicing professionals who service consumer electronics equipment. This includes service technicians, field service personnel and avid servicing enthusiasts who repair and maintain audio, video, computer and other consumer electronics equipment.

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Polaroid Macro 5 and Micro Cam cameras.

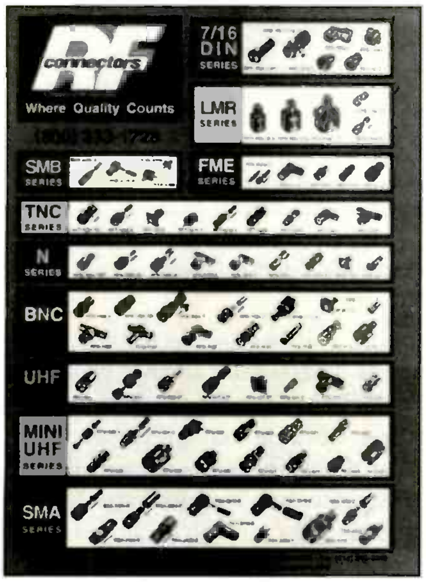
The catalog also offers a greater selection of tools, tool kits and test equipment plus many more hard-to-find products all contained in an easy-to-read format with prices and full-color photos.

Circle (77) on Reply Card

RF connector catalog

RF Connectors' new 100-page catalog features an expanded range of coaxial connectors, including 300 new items. Extensive coverage of BNC, TNC, N, UHF, MINI-UHF, MB, SMB, SMA, MCX, 7/16 DIN, FMR, LMR series, 1/2 inch and 7/8 inch cable connectors.

The catalog includes over 1500 coax



products, including cable assemblies, connector kits, Unidapt and Celludapt universal adapter products, cellular products and hand tools. Product specifications and photographs are included.

Circle (78) on Reply Card

Test equipment, tools, and supplies catalog

The fall 1996 48-page supplement catalog from Contact East comes packed with hundreds of new test instruments and tools for engineers, managers, technicians, and hobbyists. Featured are quality products from brand-name manufacturers for testing, repairing, and assembling electronic equipment. Product highlights include new DMMs and accessories, soldering tools, custom tool kits, EPROM programmers, power supplies,

"create your own" tool kits, ELF meters, milliammeters, megohmmeters, wavemeters, breadboards and helpful reference books.

Also included are the company's lines of: communication test equipment, scopemeters, datacom tools and testers, adhesives, measuring tools, precision hand tools, portable and bench top digital storage scopes, soldering/desoldering systems, static protection, ozone-safe cleaners, magnifiers, inspection equipment, tool bags, workbenches, cases and more. Brand names include: Tektronix, Fluke, BK Precision, Weller, Loctite, 3M, Pace, Extech, Microcare and many more.

Circle (79) on Reply Card

New web site

Bourns, Incorporated announces that the company's full line of products and technologies is now featured at http://www.bourns.com. Electronic engineering and purchasing professionals can easily access full-line product information about thousands products any time, anywhere, 24 hours a day.

The site showcases the company's full line of products and technologies and features hot products, news flashes, application notes, sales office listings and hot-links, product searches, printable data-sheets, shipment tracking, and company profile information. This site is updated regularly to ensure that customers can easily access the latest in products, technologies and news from the company.

Circle (80) on Reply Card

Circuit board and parts handling

By The ES&T Staff

In the early days of consumer electronics service, one of the biggest problems with handling parts was to be reasonably gentle with the vacuum tubes. If you dropped one, the glass envelope would break. If you subjected a vacuum tube to excessive shock or vibration, you might cause something inside to come loose.

And when it came to removing a tube from the circuit and replacing it, nothing could be simpler. Wiggle the tube a little while applying a little upward pressure and the old one comes out. Wiggle the replacement tube while applying downward pressure and the new one is in.

Replacement resistors, capacitors, inductors and other parts were usually quite large and physically robust, so that handling them and keeping them from being damaged was not much of a problem.

Photo 1. Tiny parts, such as surface mount components, may require special handling devices, such as this vacuum-operated handling tool. (Photo courtesy Virtual Industries)

Handling has become a challenge

Those good old days are gone forever. The printed circuit boards of modern consumer electronics products are populated with tiny components that are soldered in, or on, the board. Just seeing a chip transistor or resistor is a challenge. Removing one from the board and replacing it becomes an exercise that requires a magnifying light, tweezers, and a microwatt soldering iron. The chips that a technician can see easily usually has so many leads soldered to the board that just getting heat to all of the leads so that it can be removed can be quite a challenge.

Parts handling aids

When some of the components that have to be removed from the printed circuit board and replaced are comparable in size to a matchhead, it's going to present problems to a technician whose hands are at the normal human scale. Fortunately, however, there are a number of devices that can help a technician in handling these minuscule parts, some specially made for the purpose, some made for handling other tiny parts but adaptable to the parts handling task.

The vacuum handling tool

One of the handiest tools for parts handling is the vacuum operated pickup device. This device is essentially a small, soft, cup-shaped device with a small hole in its center that fits over a small-diameter tube that is connected to a vacuum source. When the technician presses the cup against the flat surface of a small component such as a chip transistor or resistor and applies a vacuum, the component is held against the cup by atmospheric pressure and can be moved with the tip of the tool and placed on the printed circuit board.

These tools come in many forms. For larger components, and primarily in manufacturing where production quantities of components are handled, the vacuum handling tool may be connected via a flexible tube to a motor operated vacuum pump. In some such devices, the barrel of the tool has a hole in it. When the hole is uncovered, air leaks through it and when the vacuum cup is placed over the component, nothing happens.

When the operator places his finger over the hole, there is no longer a leak of air, and the vacuum is applied to the vacuum cup, causing it to pick up the component. The operator can then manipulate the tool to place the component in its proper position on the circuit board. When the component is properly in place, the operator removes his finger from the hole, air leaks through again, there is no longer a vacuum and the component remains where it was placed.

A manual vacuum handling tool

For service centers, or low-volume production facilities, there are lower-cost manually operated vacuum handling tools that do not require an external source of vacuum. The tube that the vacuum cup is mounted on is connected to a rubber bladder that is contained in a small cylinder, much like the ink bladder of a fountain pen. A spring-mounted button rests against the bladder and protrudes through the cylinder. When the operator presses the button, the bladder is compressed, and air is expelled.

Then the operator presses the vacuum cup against the component to be moved and removes his finger from the button. As the bladder resumes its normal shape, it creates a vacuum, and the component is held against the vacuum cup by atmospheric pressure. Then the technician places the component in the same manner as with the more sophisticated vacuum system, then press the button again to release the component.

Some other handling tools

Technicians have shown a great degree of ingenuity and creativity in adapting other tools designed for handling small parts to the task of handling minuscule electronic components. Some of these tools are commonly used in consumer electronics service, but some are more commonly found in use in the medical/dental profession, and even the kitchen.

For example, if you're trying to pick up a tiny component and place it in a difficult to reach place, sometimes a pair of needle nose pliers, carefully manipulated, may be all it takes. Tweezers of various sizes can help in picking up a tiny component and placing it on the board.

Other devices that have been used by creative technicians in handling tiny components are; magnetic tools, hemostats and other various medical tools, wooden

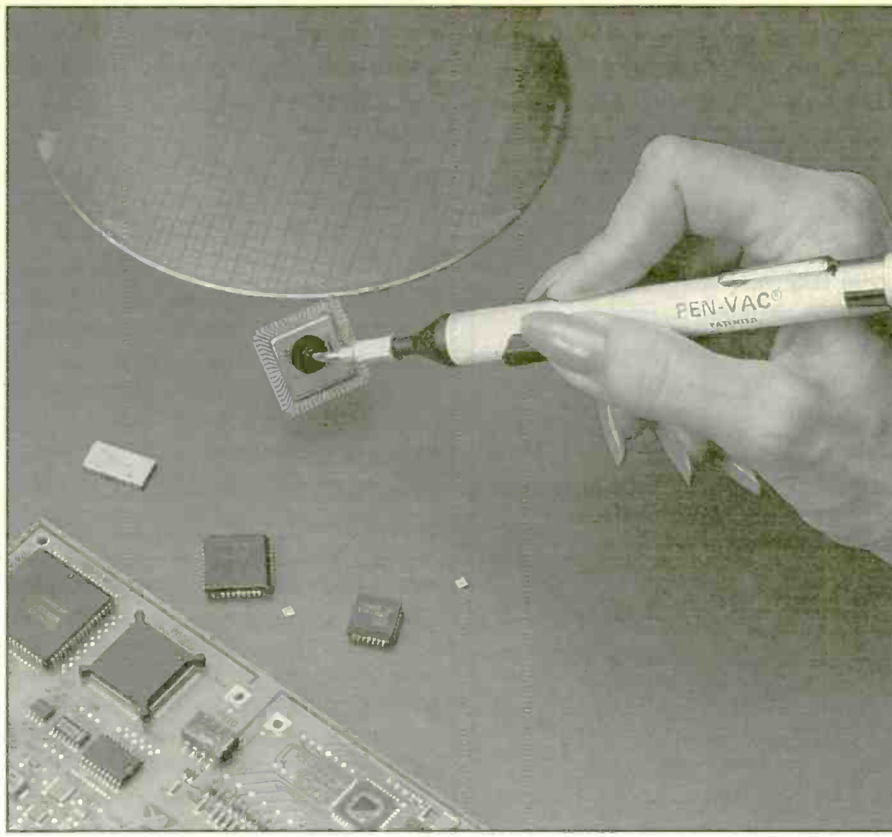


Photo 2. Vacuum-operated component handling devices come in a variety of shapes, sizes and handling capacities. (Photo courtesy Virtual Industries)

ES&T Calendar

EIA/CEMA
1996 Technical Workshop
Computer Monitor Servicing
November 6-8, 1996
Arlington, VA
703-907-7656

EIA/CEMA
1996 Technical Workshop
Color TV Technology & Servicing
November 12-14, 1996
Walnut, CA
703-907-7656

International Winter Consumer Electronics Show
January 9-12, 1997
Las Vegas, NV
703-907-7674

CES Mobile Electronics—The 12-Volt Educational Forum
April 4-6, 1997
Atlanta, GA
703-907-7674

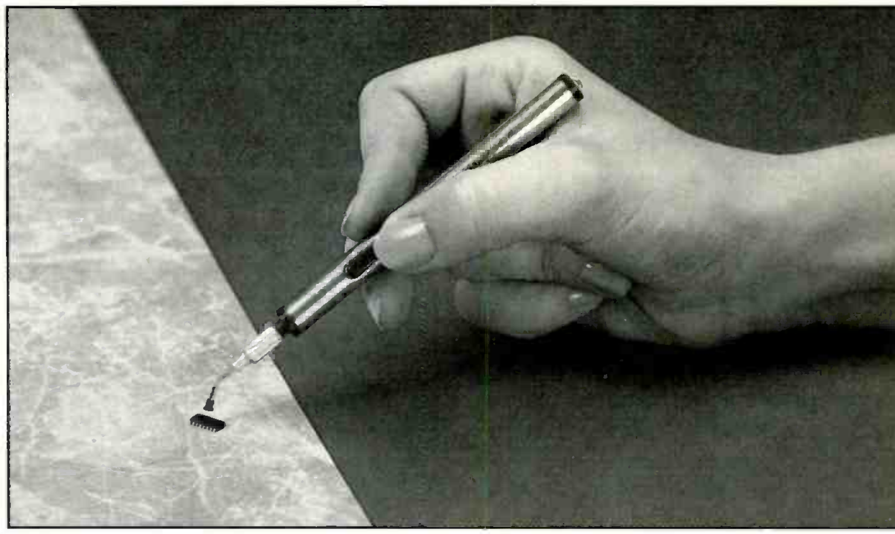


Photo 3. A manually operated vacuum parts handling tool needs no connection to an external source of vacuum. (Photo courtesy Virtual Industries)

sticks, dentists' picks and tools, homemade holding devices, the vacuum tool portion of a solder station, homemade vacuum tools, picks, scratch awls, ice cube tongs, IC inserters/extractors.

In order to handle a component, you have to see it

So many of the components found in today's consumer electronics products are so tiny that most service centers have magnifiers of some kind, as well as task lighting, to help the technicians see.

Here is a list of some of the magnification methods used by technicians: handheld magnifier, magnifier lamp, jeweler's loupe, microscope, camera imaging system, visor magnifier, magnifying spectacles attached to glasses. One clever way to achieve magnification is to use a video camera trained on the area of interest (the macro function on the lens provides a high degree of magnification), with the picture on a fairly large screen TV.

Some ideas that may help technicians in handling tiny components

•Use a video camera to view circuitry on a large-screen TV monitor during soldering and desoldering.

•Use thermal imaging for hot/cold spots on VLSI (very large scale integration) systems. A digital thermometer with a surface probe will provide some information, but a good infrared probe works even better. Hot and cold spots are areas for further checking.

•Gravity can be used to remove an unsoldered IC by attaching a weight to it.

•A knob puller can help to pull out ICs after desoldering. It also acts as a heat sink, protecting the IC.

•Sliding an 'E' steel guitar string under a surface mount IC and pulling it between the IC leads and solder lands can help to desolder an IC one whole side at a time.

Holding the circuit board while you work on it

Specially made PC board holders can provide a technician with an extra set of hands while he does soldering or desoldering. In some cases, even a vise, if used carefully, can help to hold the work at the right angle while the technician fixes it. Two other useful holding tools are "helping hands," the type of holder that consists of a weighted base with several alligator clips on universal joints, and a portable combination workbench and vise.

Save time and aggravation

Special holding fixtures and handling equipment have to be paid for, but the savings that they can provide may make it more than worthwhile to have them available in the service center. If holding a PC board in a holding fixture allows the technician to save a few minutes every time he has to do some soldering and desoldering, the fixture may pay for itself in a short time. Moreover, using a special handling tool or holding fixture could very well save a technician in the service center from damaging or destroying a costly printed circuit board. ■

Servicing the RCA CTC175/177 color television set

By Bob Rose

I first became acquainted with the RCA CTC175/177 family of television sets in 1993. Since then, I have seen between seven and twelveof these sets every week (sometimes more). When they appeared on the market, these sets represented the cutting edge of modern consumer electronics technology, because of the use of a special chip to store chassis parameters and the construction of the tuner as an integral part of the main chassis (a feature which I hope other manufacturers do not follow).

I have gleaned the information in this article from my service experience with these sets and from my reading and research. I recommend two publications by Thomson: The CTC175/176/177 Technical Training Manual, and the CTC177/87 Troubleshooting Guide. Sencore has published two articles that are also helpful service aids. These articles are found in Sencore News, Issues 170 and 171.

Power supply problems

I have found the power supplies in these sets to be among the most reliable on the market. The 175 chassis uses a traditional linear regulator supply to provide the operating voltages for the set and a transformer to provide the standby voltages. Aside from the usual damage caused by lightning or power surges, the only problem I have had has been with C4007. On two occasions, it has "blown its lid" and taken out the ac fuse. On two other occasions, I have had to replace the HOT (Q4401) and found that I also needed to replace the regulator (Q4150).

The CTC177 and 187 use a switching regulator to supply standby and run voltages (Figure 1). Integrated circuit U4101 is an extremely reliable chip. I have replaced it only two times in three years. I have, however, serviced several of these supplies that were dead. I traced the problem to an open R4104 off pin 4 of the chip. This resistor provides a startup voltage for the power supply.

If you replace a shorted U4101 and it immediately fails, check R4129 off pin 5. It is a good idea to check this resistor (100Ω) whenever you replace the chip. RCA states that a short in the secondary of T4101 will also cause the regulator to fail instantly, but I have never encountered that situation.

The only other difficulty I have had with this switching power supply has been cold solder joints around the pins of U4101 and the secondary pins of T4401. On at least two occasions I have had trouble with the solder connections at CR-4106, the diode in the 140V line. Whenever I get one of these sets in for service, I automatically check the connections at U4101, T4101, and CR4106.

When these sets first came out, I saw many that had high voltage but no raster and no audio. When I turned the G2 up, I noticed that there was no vertical deflection. It turned out that these diodes (installed at CR4704) became leaky and caused R4702 to fail (Figure 2). These two components provide the 12V run voltage for the set. These two components still occasionally fail. Always change this diode when you change the resistor.

Tuner and microprocessor shield problems

The big problem with these sets has been loose connections around the tuner and microprocessor shields (Figure 3). These loose shields produce a variety of problems: no startup, snowy picture, loss of vertical deflection, no audio, phantom front panel control operation, to name the most common ones. In one service bulletin, RCA stated that the problem was caused by improperly seating the shields during manufacture. It turns out that the problem is actually caused by the circuit board cooling at a different rate than the shields. RCA says it has developed an alloy that cools at the same rate as the circuit board and a solder that is more elastic than the "old solder." Will it work?

The recommended procedure is to remove (use desoldering braid to wick out) the old solder, carefully inspect the circuit board for cracks, and resolder. While you are at it, resolder the white wire at points E16 and E116 (Figure 4). Thomson's technical bulletin for this problem is TV 194-006A. This is a good bulletin to become familiar with.

The use of an EEPROM changes the troubleshooting procedure

The use of an electrically erasable programmable read only memory (EEPROM) chip to store operating parameters is new in the consumer electronics field, and it is here to stay. The result of this technology is that there are no pots, coils or capacitors to adjust. This IC stores everything from tuner data to horizontal frequency and everything in between. All adjustments are accomplished via the service menu and are written into and stored in this device and are used as the microprocessor calls for them.

This means that the servicer is presented with some new troubleshooting and repair challenges. Locating the problem may not be very difficult, but the repair may be time consuming because the EEPROM has to be programmed. The programming is divided into three segments: (1) instrument level adjustments such as color temperature, vertical height and linearity, (2) chassis level adjustments, such as RFAGC, PLL, 4.5MHz trap, etc., and (3) tuner alignment. The second and third level adjustments require the use of special equipment.

Remember this: never replace this chip without first resoldering the tuner shield. Ground faults here contribute to the failure of the EEPROM. I learned this the hard way. My mistake cost me time and money and customer inconvenience.

I won't go into alignment procedures

Rose is an independent consumer electronics business owner and technician.

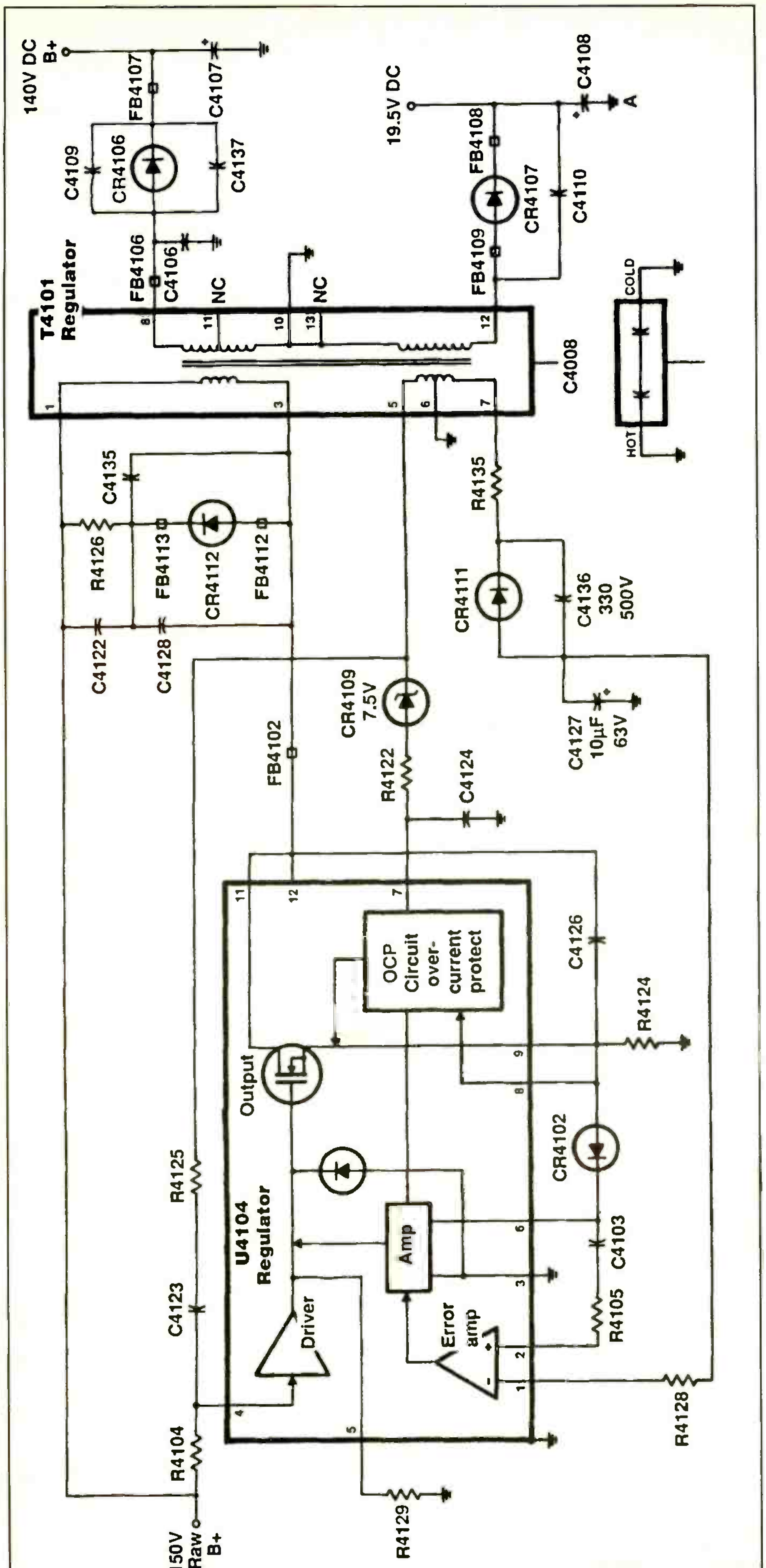


Figure 1. This is the switching regulator used by CTC177 and 187 television sets to supply standby and run voltages.

here, but if you think that you'll be servicing quite a few of these, I do recommend that you take at least one good working chassis, access the service menu, and make a copy of the values you find in each register. This information comes in very handy when you have to replace one of the little demons.

Problems caused by the EEPROM

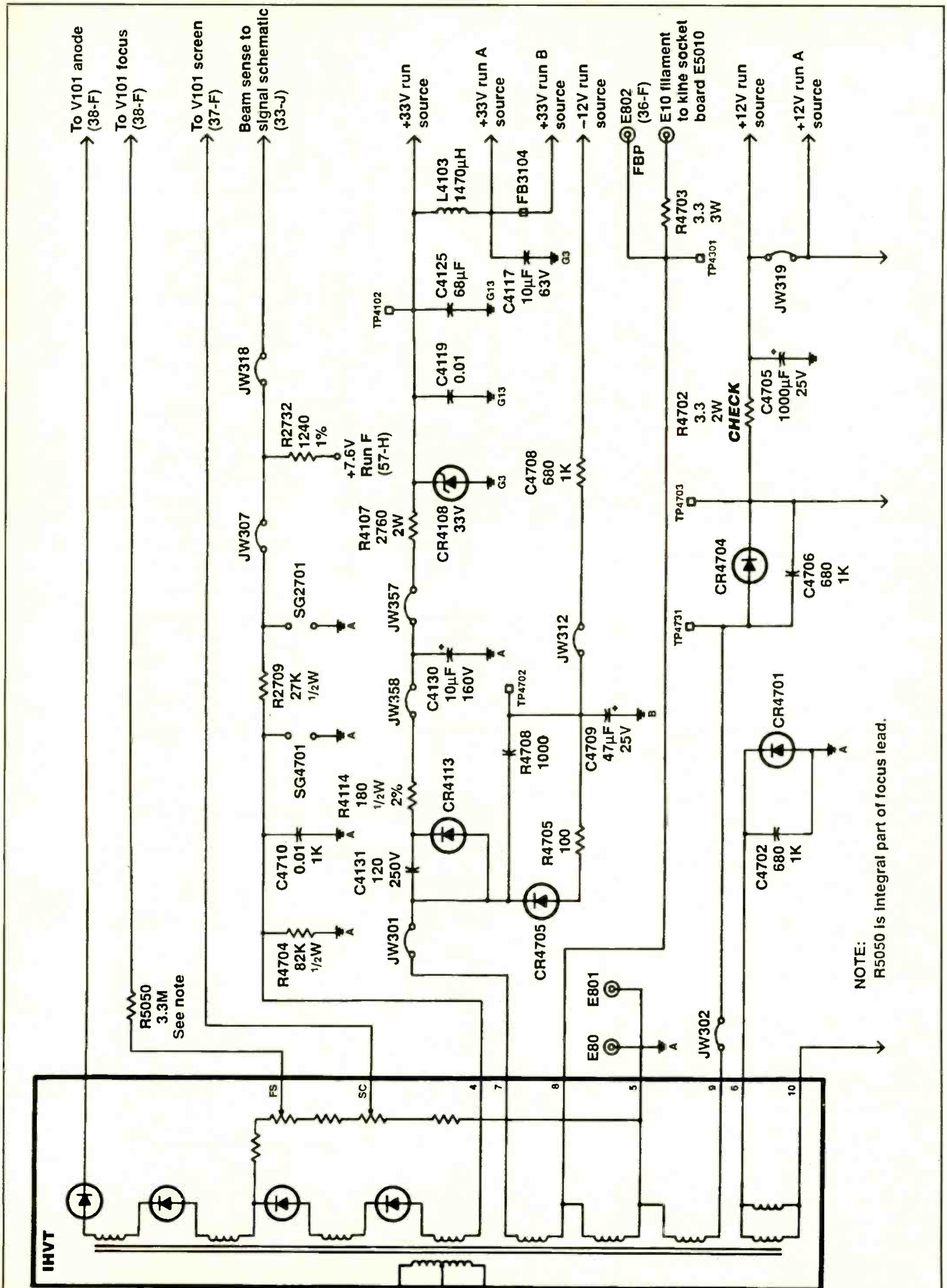
Now what problems can these little eight-pin DIPs cause? Figure 5 shows how they are configured in the circuit.

• *Very dim raster, no picture, no audio, and no on-screen display* (OSD). The set comes on, and it exhibits these symptoms. I admit that there are many things that can cause this problem, but, for me, it has always been that pesky little EEPROM.

• *No start-up*. You press the power button and you are greeted by stony silence. I disconnect ac power, wait a minute or two and reapply ac. I check for 5V on pin 8 of U3201. If it is there, I check for activity on pins 5 and 6 (clock and data pulses). Under normal operating conditions, when power is applied the microprocessor polls the EEPROM and the tuner PLL (U7401). If it receives a "handshake," clock and data activity cease. If the microprocessor does not receive a handshake, clock and data continue. Under these circumstances, either U3201 or U7401 could be defective. I have had U7401 fail just once. If I see activity on pins 5 and 6, I automatically replace the EEPROM. This usually cures the problem.

• *No audio*. I often encounter sets that have a no-audio condition. If you turn the volume fully on, you may hear very low, undistorted audio. Check U3101, pin 18 for a high. If this pin is high, the EEPROM is bad. The EEPROM has a program that causes the micro to mute the speakers at turn on and turn off. If it becomes corrupted because of faulty shield grounds, the EEPROM holds the mute line high, and the result is no sound.

Figure 2. When these sets were introduced, many developed the problem of high voltage but no raster and no audio. It turned out that diodes CR4704 became leaky and caused R4702 to fail. Always change this diode when you change the resistor.



IHVT
FS
SC
To V101 anode (38-F)
To V101 focus (38-F)
To V101 screen (37-F)
Beam sense to signal schematic (33-J)
+33V run source
+33V run A source
+33V run B source
-12V run source
E802 (36-F)
FBP
E10 filament to kine socket board E5010
+12V run source
+12V run A source
R5050 3.3M See note
R4704 82K 1/2W
C4710 0.01 1K
SG4701
R2709 27K 1/2W
SG2701
JW307
R2732 1240 1%
+7.6V Run F (57-H)
JW318
JW301
C4131 120 250V
CR4113
R4114 180 1/2W 2%
JW358
C4130 10µF 160V
JW357
R4107 2760 2W
CR4108 33V
C4119 0.01
TP4102
C4125 68µF
C4117 10µF 63V
L4103 1470µH
FB3104
CR4705
R4705 100
R4708 1000
TP4702
C4709 47µF 25V
JW312
C4708 680 1K
R4703 3.3 3W
TP4301
E80
E801
JW302
C4702 680 1K
CR4701
TP4731
CR4704
C4706 680 1K
TP4703
R4702 3.3 2W
CHECK
C4705 1000µF 25V
JW319
NOTE:
R5050 is integral part of focus lead.

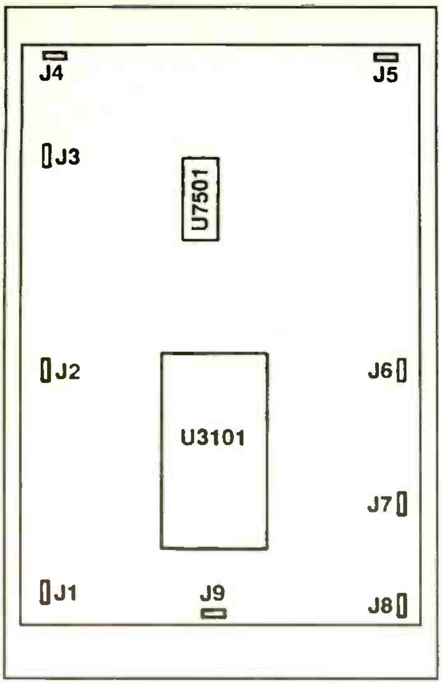


Figure 3. Loose connections between the tuner, microprocessor shields and the printed circuit board in the RCA CTC175/177 may cause no startup, snowy picture, loss of vertical deflection, no audio, and phantom front panel control operation, to name the most common problems. If you encounter any of these symptoms, remove the old solder, carefully inspect the circuit board for cracks, and resolder.

• *No vertical deflection* I received a CTC177 that had no vertical deflection. I found that the set had the necessary dc voltages, but very little drive coming out of the T chip. What to do? The easiest chip to change, and the most likely cause of this problem, was the EEPROM (it contains the vertical height and linearity adjustments). Sure enough, that fixed the no-vertical-deflection problem.

• *Will not tune all channels* This is a problem associated with a malfunctioning tuner, but in these televisions, the EEPROM can also be the culprit.

Vertical deflection problems

These television sets have vertical deflection problems caused by the same factors that afflict other sets. But, as you would suspect, they also have problems that are uniquely theirs. Use Figure 6 as a reference.

• *The raster is pulled in at the bottom, but fills out slowly within seconds of channel change.* Check resistor pack RN4501 for proper voltages. I found pin 4 to have no voltage on it because R4519 was open.

• *No vertical deflection and no audio.* Check R4702. If this resistor is open, remember to change CR4704 as well.

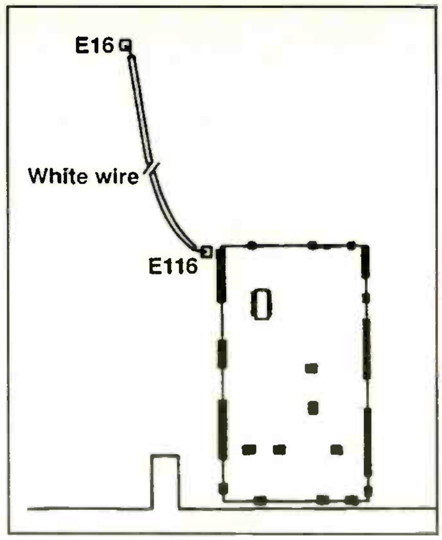


Figure 4. If you run across an RCA CTC175/177 on which you have to resolder the microprocessor and tuner shields, while you are at it, resolder the white wire at points E16 and E116 as well.

• *Non-linear vertical deflection.* Check for above normal voltages and/or noise on pin 18 of U1001, the T chip. If you find these conditions, check C4501 and C4503. Either one or both will be defective.

• *Intermittent vertical deflection.* On one of these sets, I found that I could cause the loss of deflection by flexing the chassis. I traced the problem to RN44501. On another set with this problem, I traced the problem to C4501.

• *Absence of vertical deflection.* On more than one occasion, I have found the absence of vertical deflection to be caused by poor solder connections at the pins of the switch-mode power supply (SMPS) chip. It is a good idea to check these pins when you get one of these sets in for repair, regardless of the problem you find.

Unusual problems

I use this category for a series of problems simply for lack of better terminology.

• *Buzz in the audio of a CTC176/77.* Check capacitor C4129. If it is marked 10µF, change it to a 100µF capacitor.

• *Black band at the top of the picture*

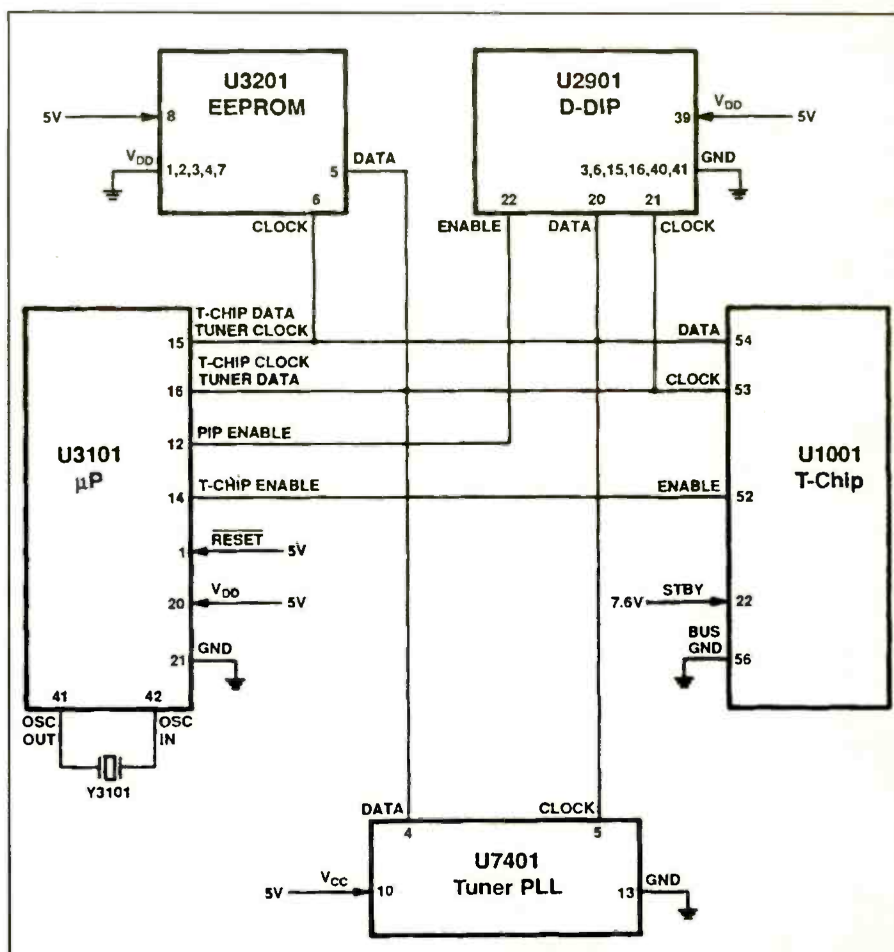


Figure 5. This drawing shows how the microprocessor, the EEPROM and the T-chip are connected in the RCA CTC175/177.

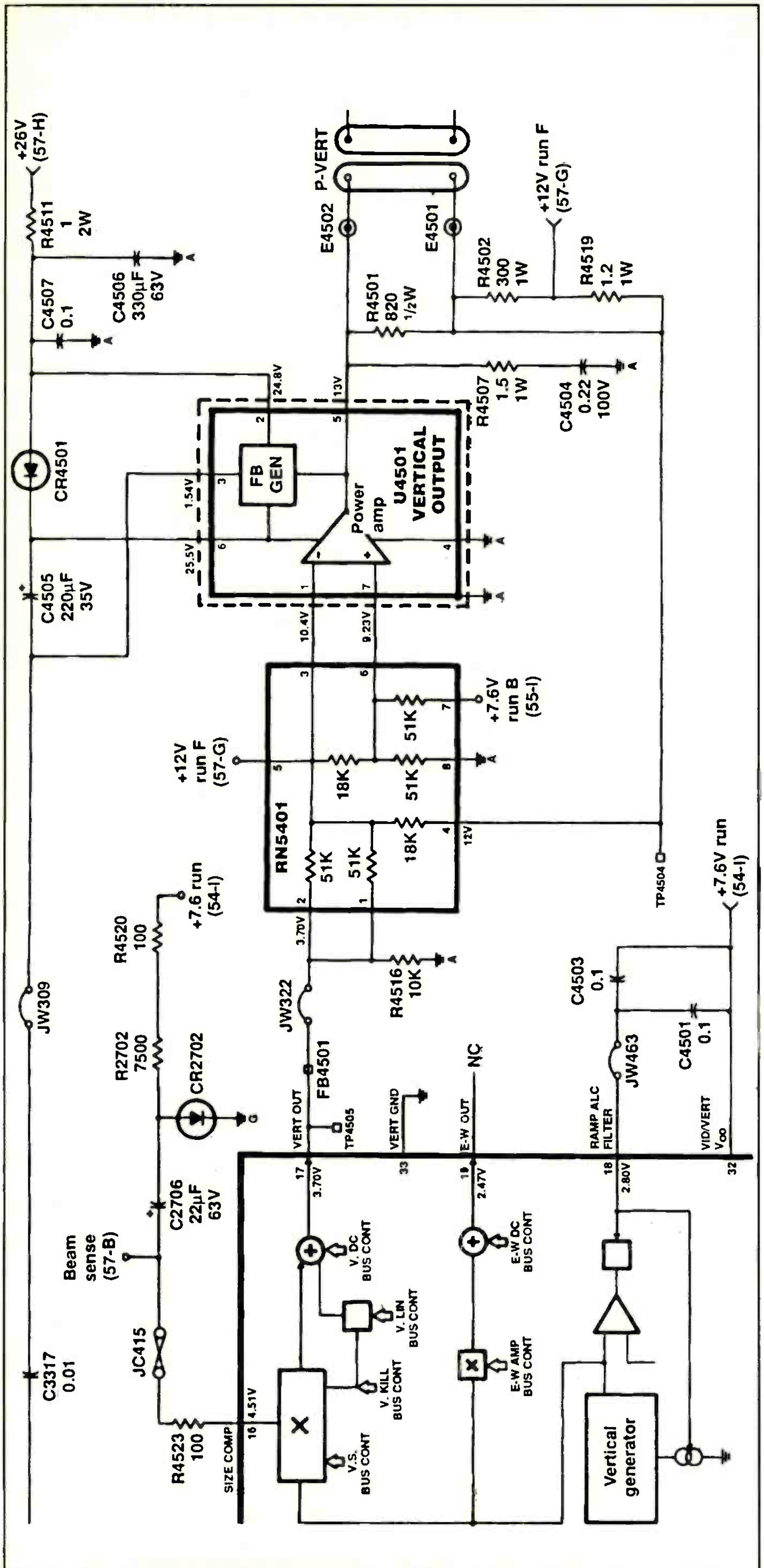


Figure 6. If you encounter vertical deflection problems in the RCA CTC175/177, they may be caused by the same factors that afflict any other set. But, as you would suspect, these sets also have problems that are uniquely theirs. Defective components in the portion of the circuitry shown in this drawing may cause vertical deflection problems.

after the set has warmed up. Resolder the tuner shield.

• *A green line running through the picture.* I had to call RCA on this one. Capacitor C2704 had been left out of the set during the manufacturing process. The problem had to do with horizontal blanking (if I recall correctly).

• *On-screen display (OSD) problems.* If the display is missing, check for 5V standby. If this voltage is low, check diode CR4104 in the bases of transistor Q4103 and Q4105. If the on-screen display is shifted to the left, the probable cause is the EEPROM. If the OSD is missing a parameter (such as "brightness" or "color") and all other parameters are present, replace the EEPROM.

• *No raster but good audio.* Check to see if the filaments in the CRT are lit. If they are, see if you have OSD. If you do not have OSD, turn up G2 and check again. The chances are that you now have dim video and dim OSD. The first time I saw this problem, I thought I had a major difficulty. It turned out that the customer had reduced the brightness and picture controls to absolute minimum. In these chassis, the OSD information is inserted before the picture and brightness information. If the picture and brightness are reduced to minimum, the result is not only no picture, but no OSD.

• *No autoprogram.* If the set will not autoprogram, Check C3301 in the base of Q3301. This may turn out to be a common problem.

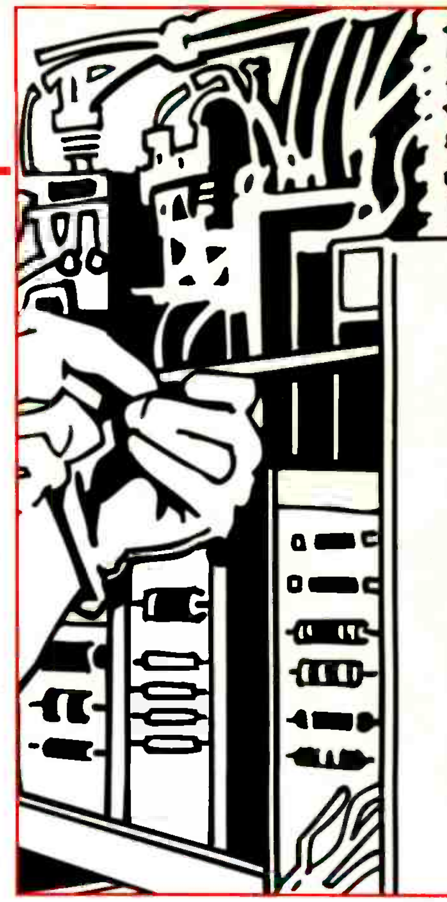
• *Intermittent tuner operation, especially after warmup.* If you encounter this problem, remove the top tuner shield and spray Y7401 with component coolant spray. If this restores tuner operation, replace this 4MHz crystal.

Conclusion

This article does not touch on several topics that may have been of interest to some readers, such as how to program the EEPROM. However, the purpose of the article has been to touch on some common problems that I have encountered and corrected. I hope these observation may be helpful to some other technicians ■

Power protection

By The ES&T Staff



Those of us who enjoy living in areas where the electric power is steady and reliable probably have a tendency to take this wonderful utility for granted. The power is just there, at all times. When we flip a switch, the light comes on, or the TV set springs to life bringing us information and entertainment from throughout the world, or the stereo comes on and soothes our troubled souls with a symphony. We're confident that while we're out of the house the power will be there to run the refrigerator, the air conditioning, the electric heat, keeping our homes comfortable, convenient, places to live.

Most of us never give a thought that somewhere, water is rushing through a turbine, or coal is being mined, transported and burned to make heat, to turn water into steam, to turn a turbine/generator, to make the electricity that provides us with such creature comforts.

And somewhere, someone is monitoring dials, gauges, and other instruments to make sure that power is constant, and making plans to put a peaking generator on line, or to make a purchase of a few megawatts from a system that has spare capacity, if the power consumption on the system servicing us becomes overtaxed.

Absence makes the heart grow fonder

But nothing's perfect. No matter how well managed a power system happens to be, there will be interruptions. These interruptions may consist of nothing more than a drop in voltage for a fraction of a second, caused by switching to a backup system when a generator is being shut down for maintenance, or it might be caused by a buildup of ice on the power lines throughout a wide area on a cold winter day that will leave homes without power for days.

When this happens, we suddenly become aware of the how much we depend on our electrical power system, and the inconveniences we face when we're without it. Of course, longer outages are generally worse. The refrigerator stops working and the food may spoil, the heating system probably doesn't work, and the toaster, the microwave oven and Mr. Coffee no longer do our bidding.

Brief outages may cause less of an inconvenience, but they may nevertheless be damaging to sensitive electronics equipment. For example, if your air conditioner is running when the power goes off, the compressor motor might send an inductive spike down the line that overstresses a sensitive component in the power supply of your TV or stereo. Or a power company self-closing breaker might try several times to restore power to the circuit from which you receive power, sending a spike down the line each time.

Silent problems

Many electrical problems aren't even that obvious. A spike or a surge comes down the line. You might notice a slight blink of the lights, nothing more. Still, some of the sensitive components in one of your electronics products was slightly overstressed, and will now fail in a year or two instead of in five or ten years. Or a bit in your computer got reset, and you're going to lose some data.

Some power problem definitions

Not everyone is familiar with power line problems, so here are some definitions:

Spike: A spike is a high-voltage transient, normally that lasts for a small fraction of a second. A spike may be caused by lightning that strikes near the power line and causes a brief but extremely high overvoltage to be induced onto the line. These spikes can do damage to unprotected sensitive electronic devices, even at considerable distances from the strike.

Spikes may also be caused by switching on or off of large electrical loads, such as a compressor motor, or switching of power sources by the utility. Spikes may cause damage to sensitive electronics equipment that may cause it to fail immediately, or it may simply weaken a component that will fail prematurely at some time in the future. Even if the spike doesn't damage or destroy anything, it could cause data corruption, printer errors, or other software type problems.

Surge: A surge is an increase of the voltage on the power line to an above-normal level that lasts longer than one cycle of the power-line voltage. Since in the U.S. that frequency is 60Hz, a surge would be an overvoltage lasting greater than 1/60th of a second. Surges may occur when a device on the line that has been drawing a large amount of power stops abruptly. The destructiveness of surges is due to their longer duration.

Sag: A power-line voltage sag is a condition in which the voltage is below normal for more than one cycle. A sag can cause a computer to lock up, or cause data errors or a disk crash because of incorrect voltage to the drive.

Noise: Power line noise consists of high-frequency impulses that accompany the sine wave. Noise may be in the millivolt range, or it may be as great in magnitude as several volts. Radio frequency (RF) noise, which may be caused by lightning strikes, radio transmissions, or even switching power supplies, can cause computer data problems.

Brownout: A brownout is an under-

POWER PROBLEM	ON-LINE UPS	OFF-LINE UPS	LINE CONDITIONER	SURGE SUPPRESSOR
BLACKOUTS	*	*		
BROWNOUTS	*	*	*	
SPIKES	*	*	*	*
SURGES	*	*	*	*
SAGS	*	*	*	

Figure 1. A number of options are available for power protection, depending on the severity of the power problem and the criticality of keeping the load operating and safe from electrical damage.

voltage that may last for minutes or hours. A brownout may cause hardware damage, such as through overheating of a motor because it's operating on a voltage lower than the voltage for which is was designed. It can also cause computer software problems because the computer circuits are operating at voltages lower than their design values.

Blackout: This is, as the name implies, a complete absence of line power for an extended period of time.

Solutions to the power problem

There is a range of choices available for dealing with power line problems. The one to be chosen depends on the severity of the problem, the sensitivity of the system being protected, and the degree to which it is critical that the system being protected continue operation without interruption. For example, if you were responsible for the operation of a critical data processing system, and located in an area where power quality and reliability were poor, you might want to connect your system to an on-line uninterruptible power system (UPS).

An on-line UPS is one in which the ac power is constantly fed to the load through the UPS. One such system consists of a motor-generator set with battery backup. The ac power is converted to dc, which turns the motor, which, in turn, turns the generator, which provides power to the load.

The power is also applied to a large battery system to keep it constantly charged. The battery terminals are connected in parallel on the same bus with the dc power derived from the ac line. With a system like this, if there's a power loss, the battery provides power to the motor-generator set and the load continues to be provided with clean power.

Conversely, if there's a spike or a surge, the electromechanical components essentially absorb them and, again, the load continues to receive clean power.

An *off-line* UPS or *standby* UPS, as the name implies, is essentially a battery operated system that remains in readiness to take over the power needs of the load should there be a loss of power. The load will also be provided with some kind of protection from surges and spikes, and possibly from sags and brownouts as well. An off-line UPS is not as reliable as an on-line UPS because of the switching that takes place when the power fails.

A *line conditioner* provides protection from overvoltage or undervoltage but doesn't provide continuity of power in the event of a blackout.

A *surge suppressor* provides protection from overvoltage conditions, but not against undervoltage or power loss.

See Figure 1 for a comparison of each of these types of power protection system.

Applying power protection

As with anything else, applying power protection includes making tradeoffs. Because electric power in most developed countries is reliable, and because electronic systems, including computers, in the home environment can be dispensed with for the brief periods of blackouts or brownouts that may occur, UPS systems and line conditioners are not required, and their expense is prohibitive.

But it has been documented that overvoltages such as spikes and surges can damage or destroy sensitive electronics equipment costing hundreds or thousands of dollars. Since surge/spike suppressors costing $100 or less can keep most overvoltages from reaching these products, and thus prevent such damage or destruction, it makes good sense to use them.

However, when you purchase or specify such a device make sure that it is UL listed as a surge/spike suppression device, not only as a wiring device. ■

Soldering and desoldering update

By The ES&T Staff

Many of today's modern consumer electronics products and personal computers contain printed circuit boards with very close conductor spacing and tiny, complex, devices soldered to the board. Since much of this technology is relatively new, some terms that technicians encounter in the manufacturers' literature with regard to soldering and desoldering may be unfamiliar.

The following glossary defines some of the new terms, and provides a review of the definitions of some of the older terms that may be familiar, but forgotten. You may also see some terms here that are more applicable to military spec products than to consumer products, but you never know when you may run into them.

Ag: Chemical symbol for silver.

Alloy: Mixture of two metals.

BGA: Ball Grid Array—a leadless package on which the connectors to the board have been placed in an array on the bottom of the package. They are attached to the board with tiny balls of solder placed on each contact.

Binary: Alloy consisting of two metals (e.g.tin/lead or tin/silver).

Blind Via: A via that does not go completely through the board, but is instead attached to an internal layer.

Bridging: Solder that crosses the gap between two conductors, such as two leads. Also known as a "short."

Buried Via: A via that does not show on either surface of the PCB, but runs between internal layers.

CBGA: Ceramic Ball Grid Array - A subset of ball grid arrays. CBGAs usually have a higher melting temperature solder between the component contact and the normal profile solder. A matching solder is placed on the pad so that during reflow the liquid solder is suspended between two unmelted bits of higher temperature solder.

Chip Component: A general term for leadless, passive surface mount devices such as capacitors ("chipcaps") and resistors. Also known as "discretes."

COB: Chip On Board. Refers to any attachment method where the unpackaged silicon die is mounted directly on the PCB. Connections to the board are commonly made by TAB, Flip Chip, or wire bonding methods.

Coplanarity: Maximum distance between lowest and highest pin when package rests on flat surface. Excessive coplanarity (over 0.004 inch) leads to solderability problems.

CTE: Coefficient of Thermal Expansion. The ratio of the change in dimensions to a unit change in temperature.

Delamination: Separation of joined layers in a PCB. This can be between plies in the substrate or between the substrate and the traces. This is caused by overheating the PCB.

Dewetting: A condition in which the solder has withdrawn from a surface giving the joint a lumpy, irregular look. Usually caused by over-oxidation of the attachment area.

Diffusion: Process by which an element mixes in another.

DIP: Dual In-line Package. A package for through-hole mounting with parallel rows of evenly spaced leads extending straight down below the package at right angles to the top and bottom surfaces.

DRAM: Dynamic Random Access Memory (referring to a type of chip).

EPROM: Electrically Programmable Read Only Memory chip.

Eutectic: Refers to an alloy which passes directly from a solid to liquid state during melt. The alloy will be one whose melting point is lower than that of either of its constituent elements.

Fatigue Resistance: Ability of a solder joint to resist vibration.

Fine Pitch: Component with lead pitch equal to or greater than 20mils and less than 50mils. Most common pitches are 20mils, 25mils, 33mils.

Fillet: Refers to the shape of the solder joint between the lead and the pad. Visual inspection criteria are largely based on the size and the shape of the fillet.

Flatpack: An IC package with gull wing or flat leads on two or four sides.

Flip Chip Technology: A type of component in which the silicon die is inverted and mounted directly to the PCB. A very frugal technology with respect to using board space.

Flux: A liquid or vapor material used to remove oxides which form on metal surfaces exposed to oxygen in the air.

Gull Wing: A surface mount attachment lead shaped like a gull wing. The lead extends horizontally out of the package for a short distance, then drops to the pad level, then extends horizontally again away from the component to make an attachment surface that rests on the pad.

Intermetallic Layer: Refers to the actual bond formed in soldering from the interdiffusion of two or more metals (e.g. copper/tin). The intermetallic layer is the most brittle part of the joint, and increases in depth in logarithmic proportion to both time and temperature during the soldering process. (Staying on the joint twice as long, or with an iron twice as hot, causes the intermetallic layer to become 10 times thicker.) The ideal intermetallic layer is continuous but thin.

J-Lead: A lead that drops down below

the component to the board level, and then curls back in under the component in the shape of the letter "J". This type of package conserves board space as compared to a gull wing design.

Leadless Ceramic Chip Carrier: A hermetically sealed ceramic package. Instead of metal prongs, LCCCs have metallic semicircles (called castellations) on their edges that solder to the pads. They're usually used in military applications.

Leaching: Ability of different metals to dissolve or diffuse into each other.

Lead: Metal attachment on a component used to mount the component to a printed circuit board and establish an electrical pathway.

Lead Pitch: Distance from the centerline of one lead to the centerline of the adjacent lead on an IC package.

Measeling: A condition of the PCB laminate material in which the internal weave becomes visible due to overheating the laminate. Usually has a white, spotty appearance and indicates a weakened and unreliable substrate.

MultiChip Module: A chip package within which more than one die is placed. Multichip modules can also contain sealed components and chip components. The most complex are really encapsulated printed circuit boards.

Metal Electrode Leadless Face: A leadless cylindrical component, usually a diode, resistor, or capacitor that is metallized on two ends.

Multilayer Board: A PCB that has more than two surfaces with conducting circuits. Internal layers are connected to each other and components on the outer layers of the board by plated vias.

Non-Eutectic: Refers to an alloy which passes from a solid to a pasty state before passing to a fully liquid state during melt.

Non-Wetting: A condition in which the attractive energy of the metal being soldered is insufficient to overcome the surface tension of the solder, resulting in the solder balling up rather than flowing out over and attaching to the metal's surface. A non-wetting condition is usually caused by oxidation and/or overheating of the solder, which causes the surface energies binding the solder to itself to overwhelm that available to the surface being soldered.

OMPAC: Overmolded Plastic Array Carrier (refers to BGA components).

Oxide: Glasslike material formed by the natural reaction of metal exposed to oxygen in the air. Interferes with proper wetting of the solder and is removed with flux before or during soldering.

Pad: Metallic attachment point on a printed circuit board, connects to the circuit trace or via that runs between the components, or is just a mechanical attachment point connecting to nothing. Sometimes referred to as a "land".

Pb: Chemical symbol for lead.

PCB: Printed circuit board.

PCBA: Printed circuit board assembly. A printed circuit board with all of the components soldered on to it.

PLCC: Plastic Leaded Chip Carrier: A component that has J-Leads on four sides.

PTH: Plated Through-Hole. Refers to either the technology of mounting components by inserting them through boards, or to the hole in which the components are inserted, known also as a via. A PTH, or via, is a plated barrel that can serve as an anchor to a component, as a conductive joint between the component and the circuits, or as a connection between layers on a board. Plated Through Hole Technology preceded Surface Mount Technology.

QFP: Quad Flat Pack. A flat component with leads on four sides.

RMA: Rosin Mildly Activated Flux. The most commonly used flux through 1995, but usually requires cleaning with chlorinated fluorocarbon (CFC) bearing materials, so it is being phased out.

Shear strength: Ability of a solder joint to resist a force applied parallel to the surface of the printed circuit board.

SMC: Surface Mount Component.

SMD: Surface Mount Device. A registered service mark of North American Philips Corporation to identify resistors, capacitors, SOIC, and SOT devices.

SMT: Surface Mount Technology. The technology by which components are mounted on the surfaces of PCBs rather than extending through them.

Sn: Chemical symbol for tin.

SOIC: Small Outline Integrated Circuit. A surface mount component with gull wing leads on two sides.

SOJ: Small Outline J-leaded. A surface mount component with parallel rows of j-leads on two sides.

Solder: Metal alloy used in soldering containing one of the metals used in the formation of an intermetallic bond.

Soldering: Process by which two or more metal surfaces are bonded together via an intermediary alloy.

Solder Balls: Small balls of solder that blow or roll across circuit boards during manufacturing, causing shorts and other mischief. Can be caused by outgassing of moisture or oxides during heating of solder paste or by hot air processes that blow solder off the joint.

SOT: Small Outline Transistor.

SRAM: Static Random Access Memory.

Surface Mount: A method by which components are attached to a printed circuit board by soldering to a pad on the surface of the board.

TAB: Tape Automated Bonding. The process of attaching the integrated circuit die directly to the PCB and using a lead frame to connect the two.

Tensile Strength: Ability of a solder joint to resist a force applied perpendicular (upward) from it.

Ternary: Alloy consisting of three metals (e.g. tin/lead/silver).

Tg: Glass transition temperature. Temperature at which substrate changes from hard to soft.

Tombstoning: When a resistor, capacitor or other chip component stands up and salutes as it's going through the solder process, causing only one end to be soldered and the rectangular components to take on the aspect of a tombstone. A classic rework condition.

TSOP: Thin Small Outline Package. An ultra fine pitch, rectangular, low profile package with the connecting leads on the narrow ends.

Ultra fine pitch: A component with lead pitch less than 20mil.

Via: A hole through a PCB connecting various layers or unattached but serving as a component anchor point. Vias are usually plated. See also Blind Via and Buried Via.

Wetting: Ability of a liquid to flow across a surface as opposed to sticking to itself. Wetting occurs when the attractive surface energy of the pad or lead is greater than the surface energy of the solder, drawing a molecularly thin layer of solder across itself. Heating solder adds to its surface energy, so the cooler the solder the better the wetting. Good wetting is indicated by a low contact angle between the fillet and the base metal.

Wicking: Ability of solder to travel towards a heat source or fill a through-hole. Caused by the same dynamic forces that control wetting. They are sister processes.

*This glossary is adapted, with permission, from the glossary presented by Metcal on their web site at http://www.metcal.com. ■

FUNAI
FT1951 3722

GE
TX826KB 3729
VG2030A ....(sim to) VCR-281
VG2032 ....(sim to) VCR-281
09GP110C24 3729
09GP110F24 3729

MAGNAVOX
TR2516C121 3724
25TR12C122 3724
25X601 3724
25X601-00AA 3724

PANASONIC
ALEDP269 3732
AMEDP246 3726
CT-20G31 3732
CT-27G30CT 3726
CT-27G30T 3726
CT-27G30UT 3726

QUASAR
AEDC271 3728
SP2018CU 3728
SP2018U 3728

RCA
VR327A VCR-281

SANYO
AVM-1906 3730
AVM-1936U 3730
G6B-19060 3730
G6B-1936U0 3730

SONY
KV-9PT60 3725
KV-13M20 3733
KV-14PM1 3733
KV-14R20 3733
KV-14RD1 3733
KV-20S30 3723
KV-27S25 3720
KV-29RS25 3720
KV-29RS25C 3720
SCC-J58B-A 3725
SCC-J59B-A 3725
SCC-J71B-A 3720
SCC-J73F-A 3720
SCC-J74B-A 3720
SCC-J74F-A 3720
SCC-J84C-A 3723
SCC-J84D-A 3733
SCC-J93A-A 3733
SCC-J93D-A 3723
SCC-J94A-A 3733
SCC-J95A-A 3733
SCC-J95B-A 3733

SYMPHONIC
ST131E 3727

ZENITH
SY2031S 3721
SY2031SM 3721
SY2049DT 3721
SY2049DTM 3721
SY2049X 3721
SY2504BW 3731
SY2518RK 3731

Solving TV vertical problems

By Homer Davidson

The many symptoms caused by problems in TV vertical and related circuits may include absence of vertical sweep, insufficient vertical sweep, black area at the top and bottom of the screen, intermittent vertical sweep, bouncing vertical, poor vertical linearity, and vertical foldover. The defective components that cause these symptoms may be found in the vertical input or output, pincushion, and low voltage power supply circuits. Unusual vertical symptoms may be caused by problems outside of the vertical circuits as well(Figure 1).

A leaky or open vertical output transistor or IC may cause absence of vertical sweep or intermittent or insufficient vertical sweep. Leaky or open electrolytic capacitors in the vertical output circuits can cause absence of vertical sweep, vertical lines at the top, black screen at the bottom, vertical bouncing, or poor vertical linearity.

An open or leaky vertical output yoke coupling capacitor or ground return capacitor may produce an absence of vertical sweep, insufficient sweep, poor vertical linearity, or vertical foldover. A dried-up or open filter capacitor in the vertical low voltage source can cause insufficient height, and a reduced source voltage applied to the vertical circuits.

Davidson is a TV servicing consultant for **ES&T**.

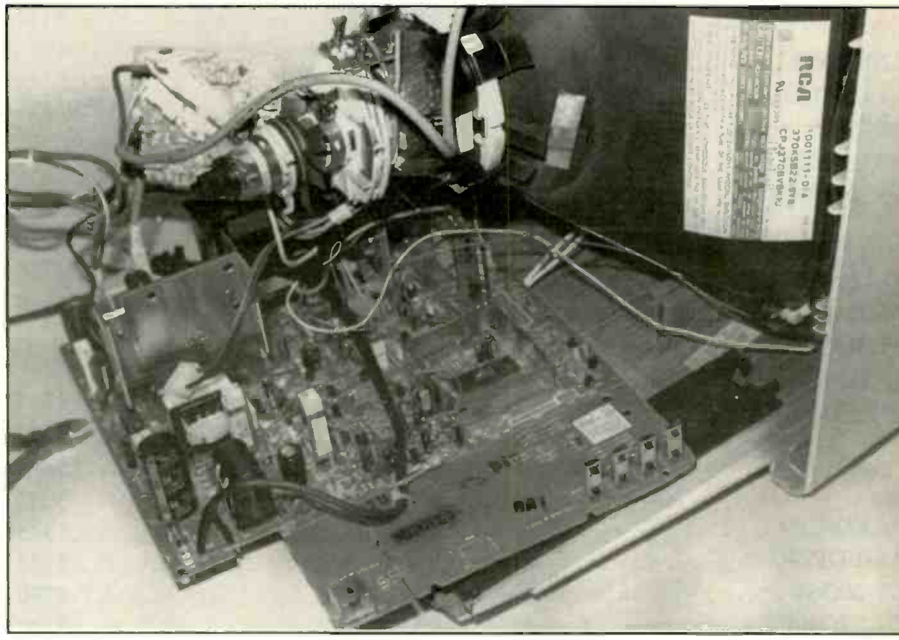


Figure 1. Always look outside the vertical circuits for unusual vertical symptoms.

No vertical sweep in the Sharp 19SB60R

A white horizontal line was the only thing that appeared on the screen when I turned on a Sharp portable TV. The cause of this problem might be in the vertical deflection IC or vertical output circuits. I located IC201 and IC531 and checked some waveforms. I observed a normal output waveform at pin 3 of IC201. This same waveform apeared normal as the input to pin 4 of IC531 (Figure 2). There was no vertical sawtooth waveform at pin

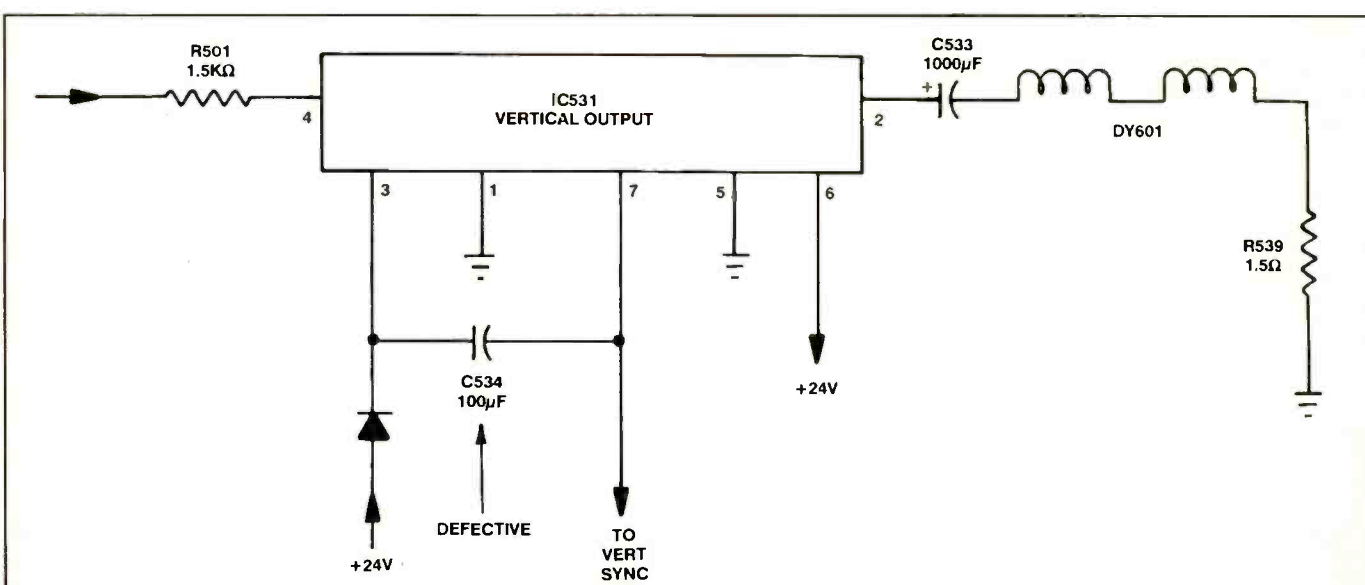


Figure 2. A defective C534 (100μF) capacitor between pins 3 and 7 caused a no vertical sweep in a Sharp portable.

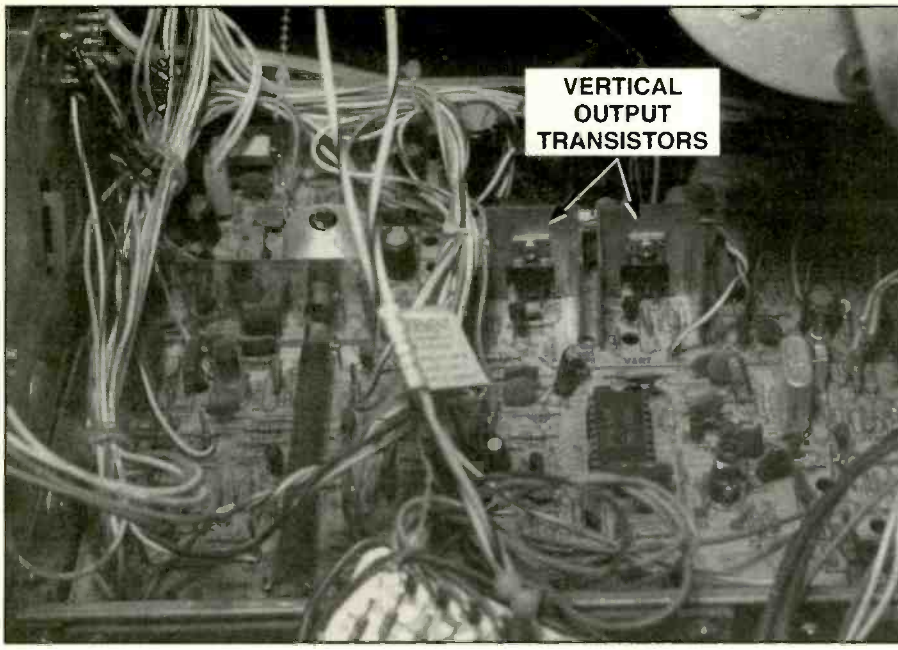


Figure 3. Locate the vertical output transistors by looking for separate heat sinks on the PCB.

2 of output IC feeding the vertical yoke winding.

These findings suggested that the defective vertical component was located in the output circuits of IC531, so I then measured voltages at terminals 2, 3 and 6. All of these voltages were fairly normal. I then observed waveforms at pins 3 and 7. They did not resemble the waveforms printed on the schematic. Vertical output waveforms are very unstable, even with the best oscilloscope.

Since the voltages were fairly normal, and the input waveform was normal, but there was no output waveform, I suspected IC351. Before ordering a replacement output IC, I checked all components tied to each pin of the IC. Diode D531 tested good, and connecting a known-good capacitor in parallel with C533 did not help. When I connected a known-good capacitor in parallel with capacitor C534 (100µF), the vertical sweep returned.

Bottoms up on a Sanyo 91C80

The bottom area of the picture was black and could not be adjusted out in a Sanyo 91C80 model. In this chassis, the vertical circuitry consists of separate vertical oscillator, 1st vertical drive, 2nd vertical drive, and two vertical output transistors. The vertical output transistors are located on separate heat sinks mounted on the pc board (Figure 3).

The voltage at the collector terminals at the heat sinks were within specification. Usually, in the case of vertical output transistors, the low voltage source is quite high (100V to 125V) compared to the value of supply voltage when the vertical output device is an IC (20V to 29V). The sawtooth output waveform at the emitter of Q903 and yoke terminal was fairly normal, suggesting that the problem was in the yoke circuits.

According to the schematic, the vertical yoke winding is coupled to the pincushion circuits. Diode D460 tested normal. The resistance at the primary winding of T403 was 85Ω (Figure 4). All low resistance resistors tested good. When I connected a known-good capacitor in parallel with C464 (100µF, 25V), the

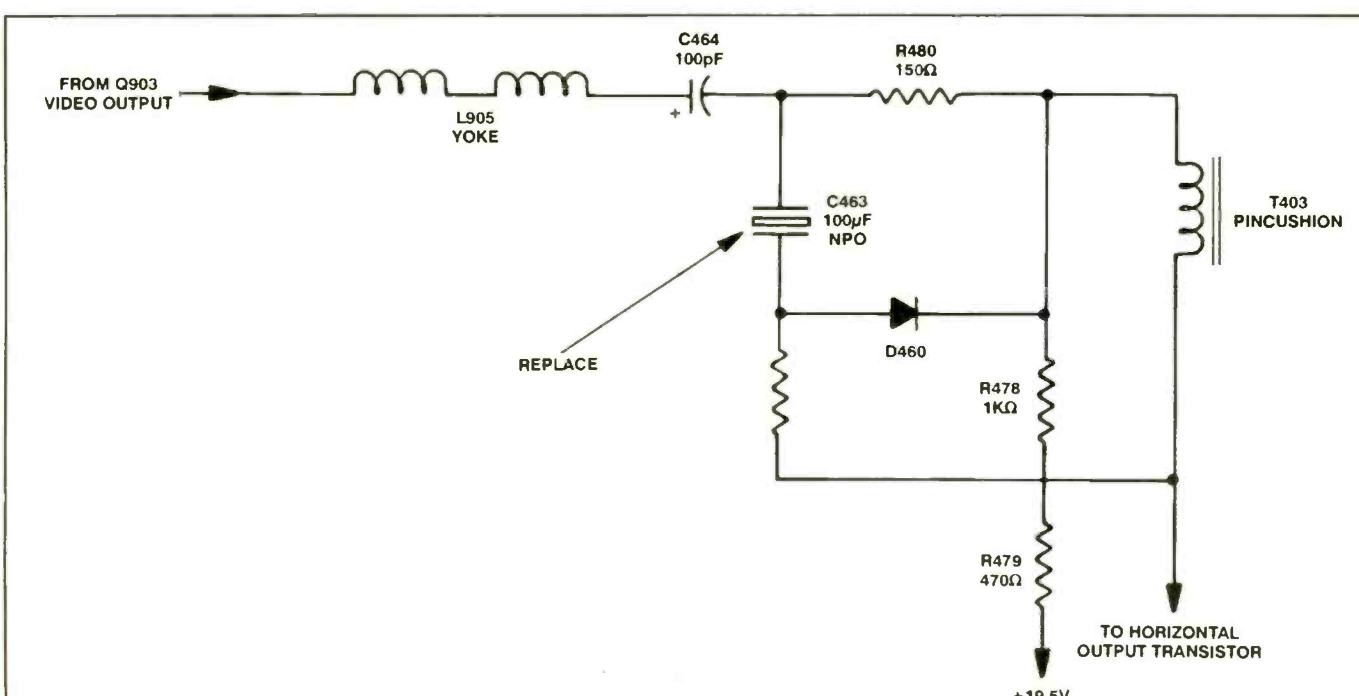


Figure 4. A defective NPO (C463) capacitor in a Sanyo 91C80 TV caused a black area at the bottom of raster.

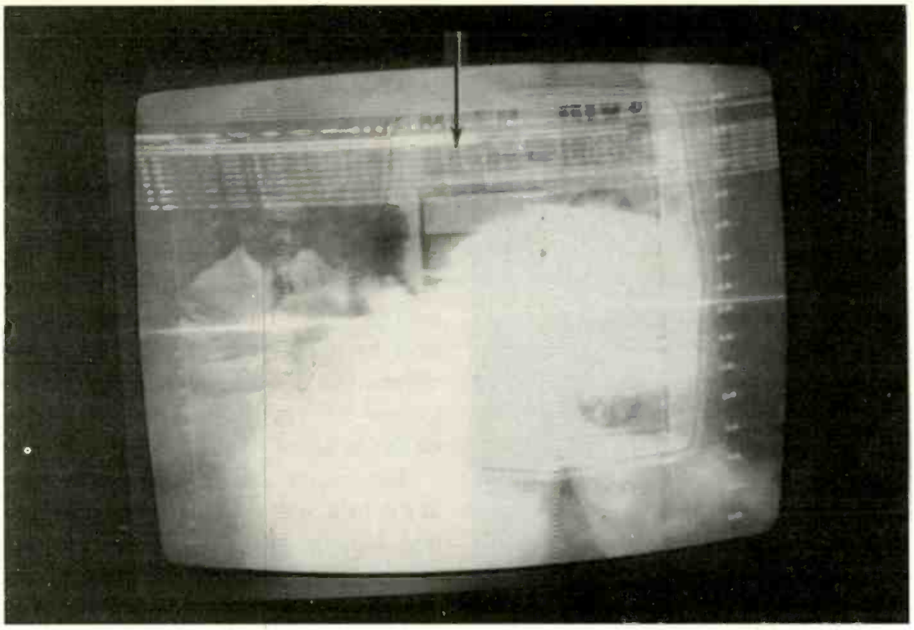


Figure 5. Bunched lines at the top of the raster can be caused by defective output transistors or a defective output IC.

lead from the PC board. I concluded that the problem must be caused by one or both of the vertical output transistors or defective electrolytic capacitors in the feedback circuits (Figure 6).

Before replacing the output transistors, always check all electrolytic capacitors first. I connected a known-good capacitor in parallel with each of the capacitors in turn, with the power turned off, then turned the set back on. When I shunted C308 (220μF) and C303 (100μF) there was no improvement in the symptom. When I shunted C305 (4.7μF), the lines at the top of the picture disappeared. This 4.7μF capacitor should be replaced with a 160V or 250V working voltage capacitor.

Intermittent vertical followed by collapse of vertical sweep

After a few hours of operation, a Goldstar CMT2612 TV became intermittent. On occasion, the picture would reduce to a horizontal white line. At other times the TV would operate normally for several days. At the times when the problem occurred, the amplitude of the waveform at the output, pin 4, of IC301 was low (Figure 7). The waveforms at pin 23 of the deflection IC, IC501, and the input pin, pin 8, of IC301, the output IC, were normal.

When the raster was collapsed, the voltage at pin 4 had increased above the

(Continued on page 39)

problem remained. When I connected a known-good capacitor in parallel with C463, a 100μF capacitor, the picture returned to normal. Replacement of C463 restored normal operation to this set.

Lines at the top

Several white lines appeared at the top of the raster, accompanied by a very poor picture in an Emerson MS250R TV. The white scanning lines could not be adjusted out of the picture (Figure 5). The raster was full and the input waveform at pin 26 of deflection IC201 was normal. The vertical output circuits in this set consist of a driver transistor and two vertical output transistors.

All three transistors tested normal in the circuit. Voltage measurements on all three transistors were near to the specified value. The vertical input and output waveforms to the yoke winding (DY100) were fairly good. Diodes D302 and D303 tested normal after I had disconnected one

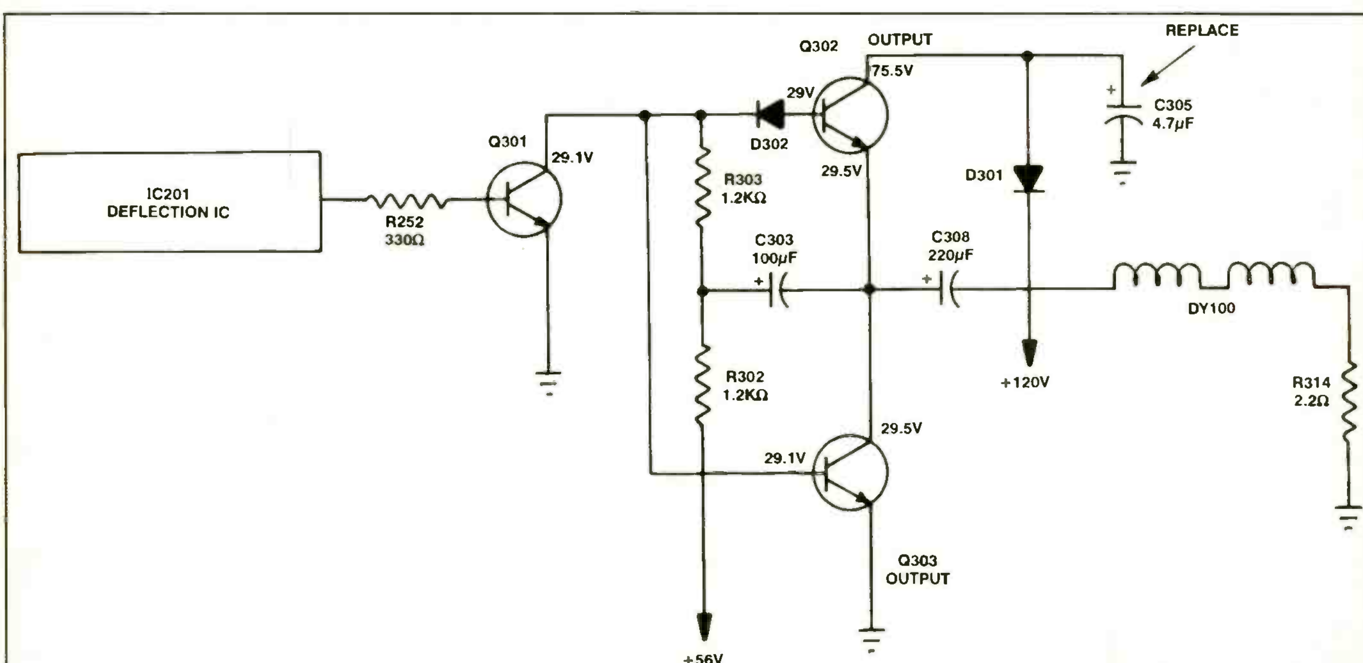


Figure 6. A defective capacitor, C305 (4.7μF, 160V), caused lines at the top of the screen in a Emerson MS250R.

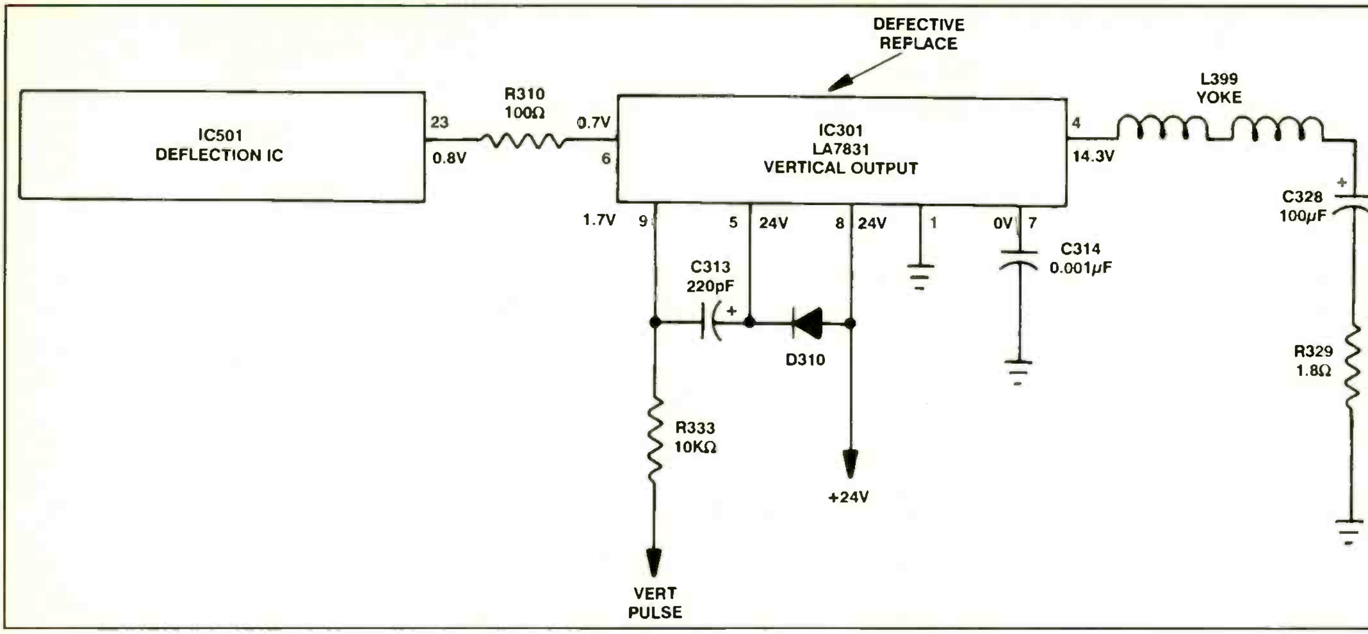


Figure 7. Intermittent and absent vertical sweep was caused by a defective output IC301 in a Goldstar CMT2612.

specified value. All other terminal voltages appeared to be within specification. I immediately suspected that the output IC301 was breaking down after several hours of operation. Since a defective C313 had been the cause of vertical problems in a number of other sets I've serviced, I first tried replacing the 220uF capacitor. The problem remained. Removing the yoke lead did not help.

I tested all components tied to IC301, but they appeared to be normal. I connected a known-good capacitor in parallel with C328 (1000μF) in the yoke return circuit with no improvement. I measured the resistance of R329 and found that it was right on the nose. That left LA7831, the vertical output IC. When I replaced that IC with an NTE1797 the set resumed normal operation and is still operating.

Intermittent with vertical bounce

In a Goldstar CMS9841T, the raster would collapse, and even when the raster was full the picture began to bounce. The picture might drop to a white line and then bounce right back up. Adjustment of the vertical size control did not help.

I measured all voltages in the vertical circuits when the vertical picture was collapsed. All voltages were fairly normal except the voltage at pin 3 of IC301. Since vertical raster problems are frequently caused by electrolytic capacitors, I connected known-good capacitors in parallel with C307 (47μF) and C303 (1000μF) in turn (Figure 8). The problem remained

The waveform at pin 2 of IC301 was absent when the raster collapsed down to a line. Waveforms on pin 7 and 3 were distorted. The only normal waveform was that of the input signal on pin 4.

Thinking that all of these problems must be caused by a bad IC301, I replaced it with an NTE1773 universal replace-

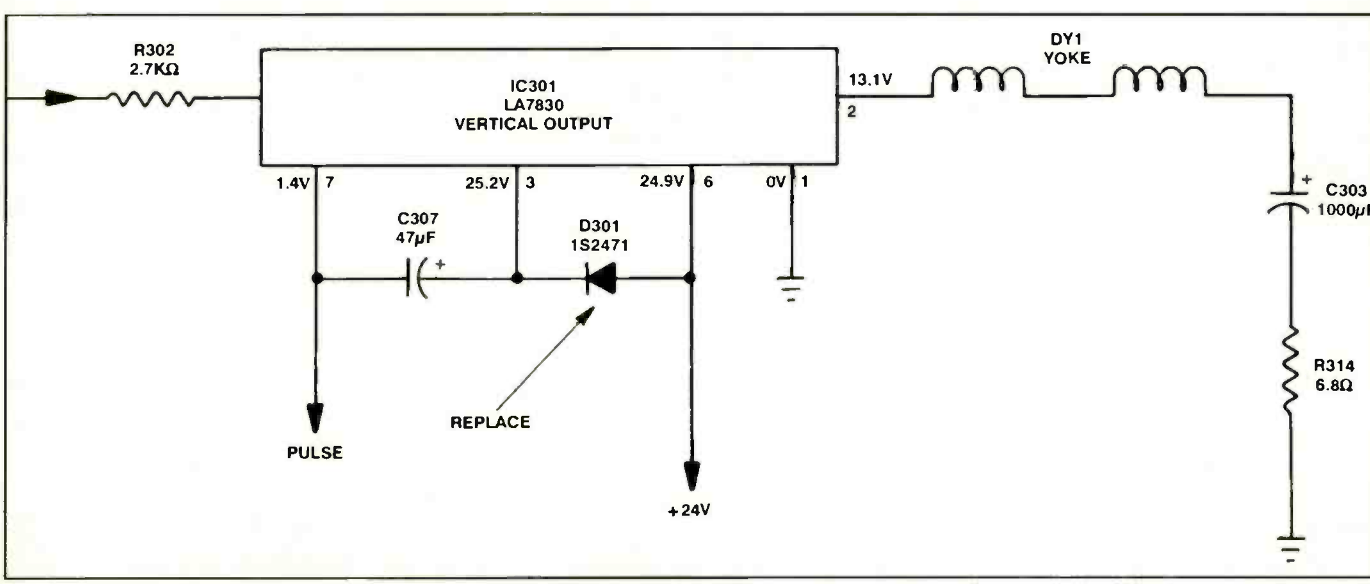


Figure 8. Intermittent vertical sweep and bounce were caused by a defective diode D301 in a Goldstar CMS9841T TV.

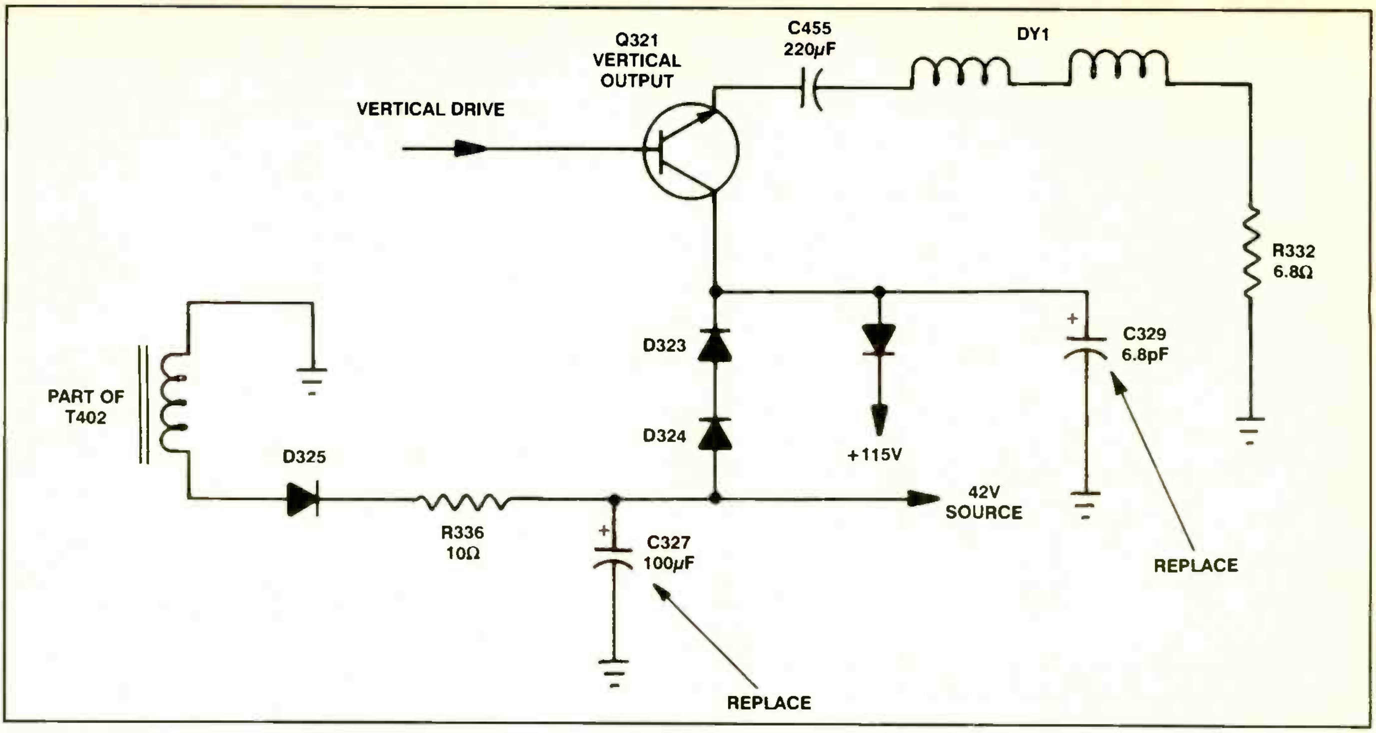


Figure 9. A black area at the top and bottom of the screen was caused by a defective C327 in the low voltage supply of a Goldstar CMR-4160 television set.

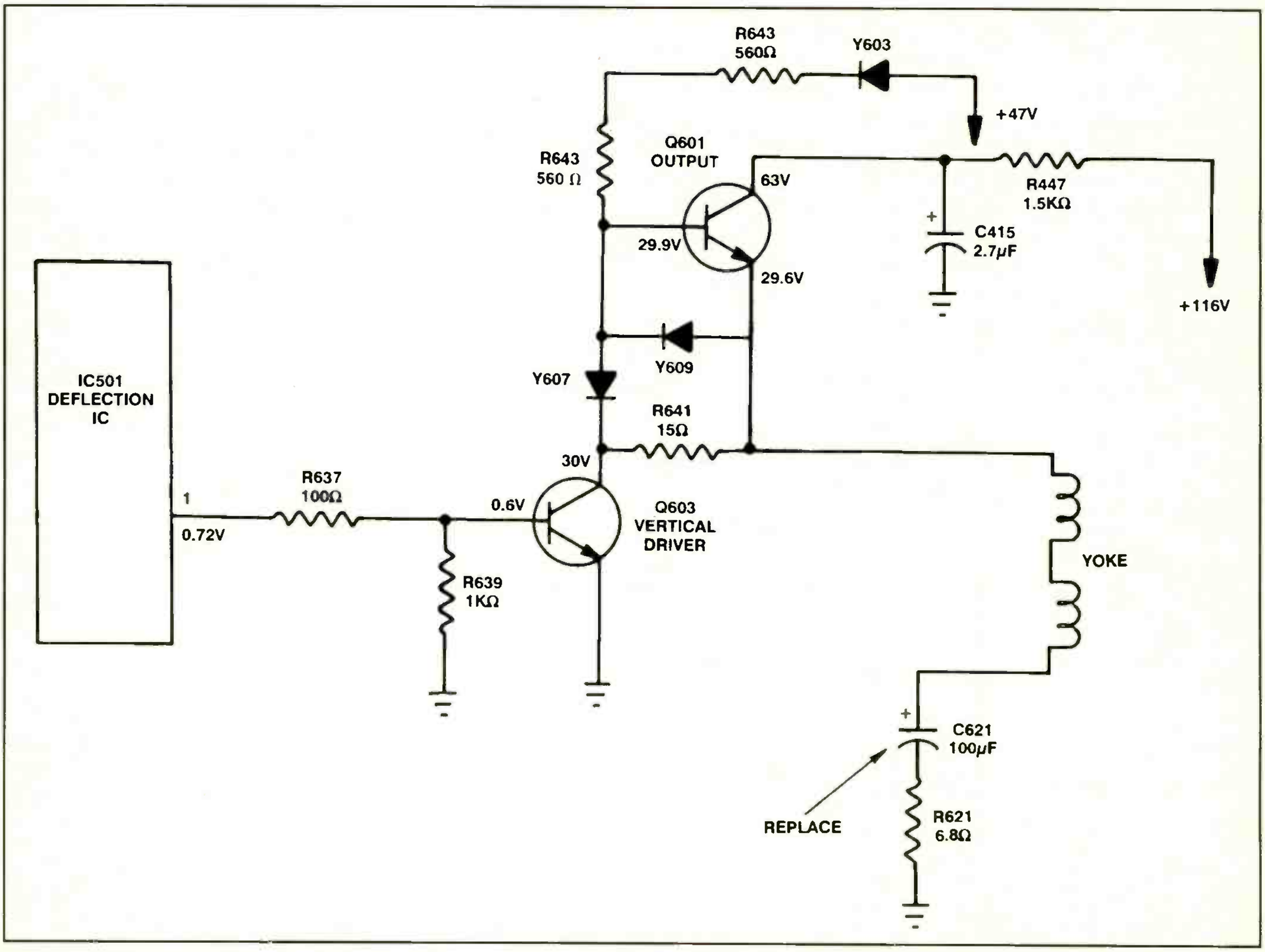


Figure 10. There was only one-half-inch of a folded over picture in the center of a GE 19PC-F chassis. The cause of this symptom was traced to a defective capacitor, C421.

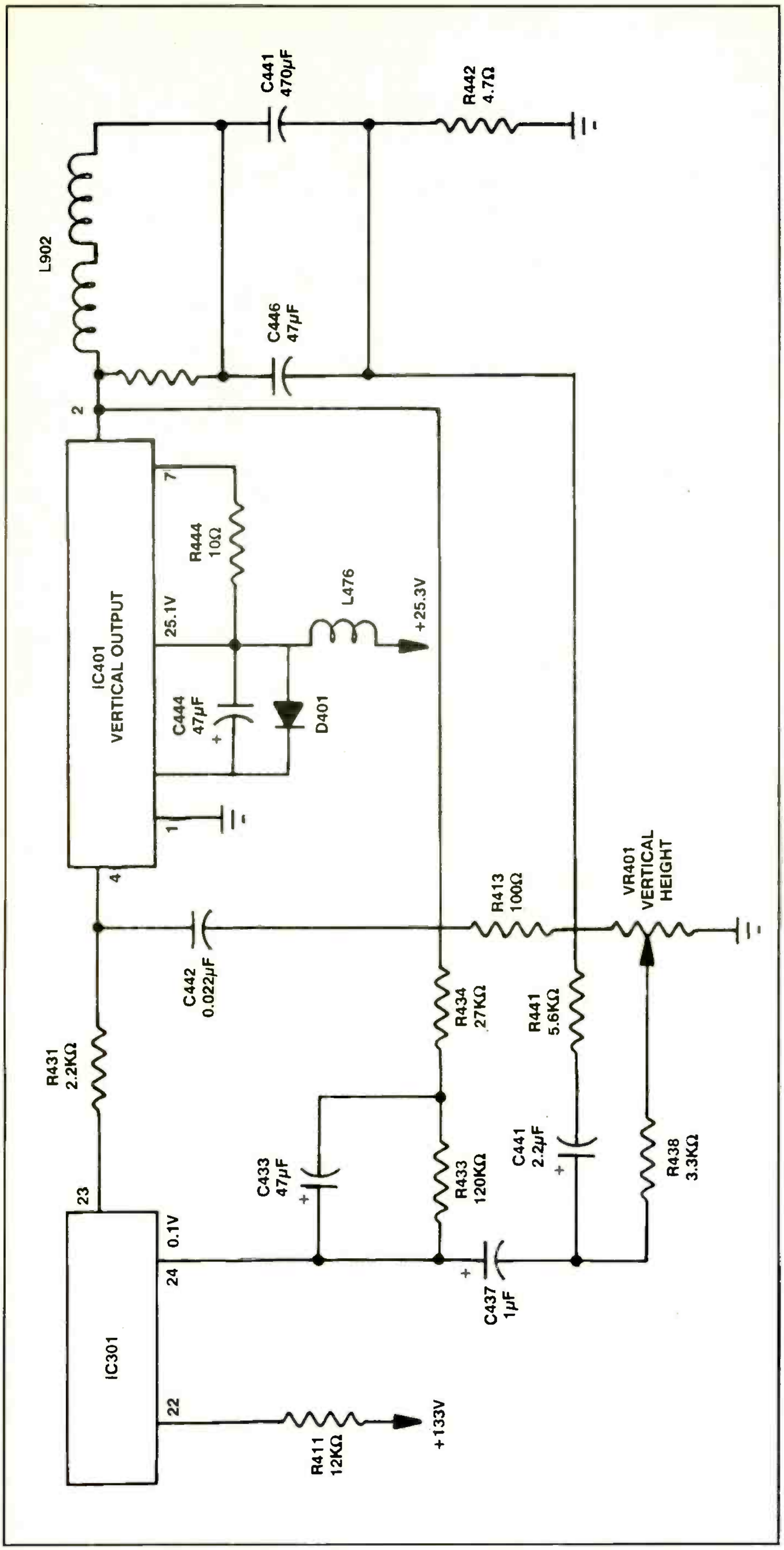


Figure 11. When the symptom is poor vertical linearity, check electrolytic capacitors in the vertical output and feedback circuits by connecting a known good capacitor in parallel with each one in turn.

ment. There was no change in the symptoms. I resoldered all soldered connections of IC301, thinking that perhaps one was not properly soldered. I now began to suspect that the replacement was defective. This can happen. However, I decided to try replacing diode D301 (1S2471) with an NTE519 switching diode. That cured the problem.

Black at top and bottom

In a Goldstar CMR-4160 TV set, the raster would not fill out the screen. There was a black area at both the top and the bottom of the picture. Adjusting the vertical height control had little effect on the picture height. Both vertical output transistors, Q321 and Q322, tested good in the circuit; however the voltages on both transistors were quite low compared to the specified values (Figure 9).

In this set, a +115V and a +42V source supply the vertical circuits. I traced the low voltage back to the scan-derived voltage source of flyback T402. Diode D325 and resistor R336 tested normal. All other voltages derived from the flyback circuits appeared normal.

Small filter capacitors in the various voltage sources sometimes become dried out and lose capacitance. When I connected a known-good capacitor in parallel with C327 (100uF, 50V), the top and bottom of the picture filled out the screen. Capacitor C329, connected to the collector terminal has caused vertical problems in the past. It should be replaced at the same time. Replace all small capacitors with a capacitance of less than 10µF in the vertical circuits. I replaced capacitor C329 with a 10µF, 160V working voltage electrolytic capacitor.

Half inch vertical foldover

A General Electric 19PC5734W had very little vertical sweep, with a vertical foldover in the center of the picture. When the vertical hold was adjusted you could barely see the small thin picture. The whole raster was collapsed down to a one-half-inch folded-over picture. There was no vertical sweep on this screen.

I immediately tested both vertical driver and output transistors in-circuit. Both transistors appeared normal. Voltages at the collector terminals had increased to +85V, compared to the +65V specified on the schematic (Figure 10). Of course this threw all voltages off on both transistors. The schematic showed that a +47V and +116V source fed the vertical circuits.

This situation convinced me that a bias diode was breaking down in the base circuits of Q401, so I disconnected one end of diodes Y609, Y607, Y603, and Y605 from the circuit and tested them. All of these diodes tested good. My next thought was that perhaps one of the output transistors was breaking down under load. I replaced both Q601 and Q603, but the raster remained narrow.

After losing a great deal of service time, I started to shunt the electrolytic capacitors in the vertical output circuits with known-good capacitors, one by one. Shunting capacitors C603, C614 and C615 in turn with a 47µF capacitor resulted in no improvement. When a known-good 100µF capacitor was connected in parallel with C621, the raster returned to normal and the voltage at the collector terminal had dropped to 63.5 V, very close to the specified value.

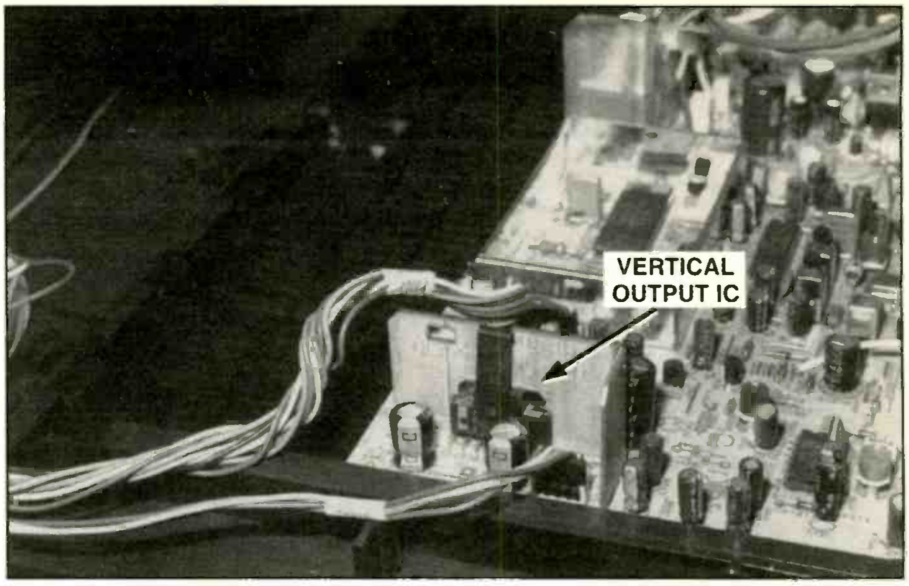


Figure 12. In modern sets, vertical output circuits are contained in a single IC. Look for this vertical output IC on a separate heat sink.

Poor vertical linearity

Poor vertical linearity in a Sanyo 91C515 TV was indicated by bunched lines at the top with uneven linearity at the bottom. Adjustment of the height control (VR401) did not help. Poor vertical linearity can be caused by a defective output transistor or IC, a change in value of bias resistors, or electrolytic capacitors. It is not difficult to replace vertical output transistors to determine if they are the cause of the problem. Some output ICs, on the other hand, are so difficult to remove that you should test all of the related components before you replace the IC.

Vertical linearity or foldover problems can be caused by vertical feedback and bias components. Check the input and output waveforms on the output transistors and IC. You cannot detect poor linearity by observing the output waveform because this waveform is not very stable. Next, measure voltages carefully. Shunt each electrolytic capacitor within the vertical output and feedback circuits with known-good components when the problem is poor linearity (Figure 11).

In this case, I shunted capacitors C447, C444, and C433, but the symptom did not improve. When C446 (470µF) was shunted, the linearity appeared normal after

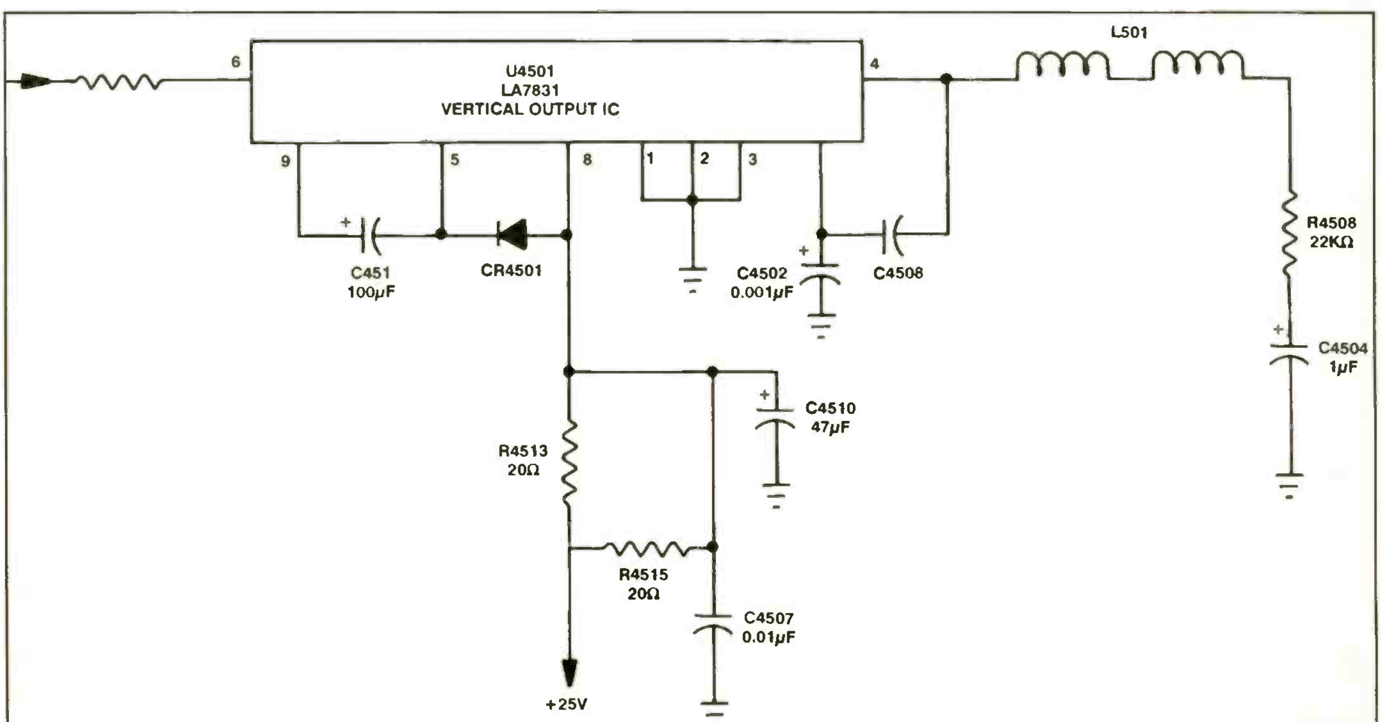


Figure 13. Failure of C4501, C4504, R4513, R4515 and CR4501 have all caused vertical problems in the RCA CTC146 chassis.

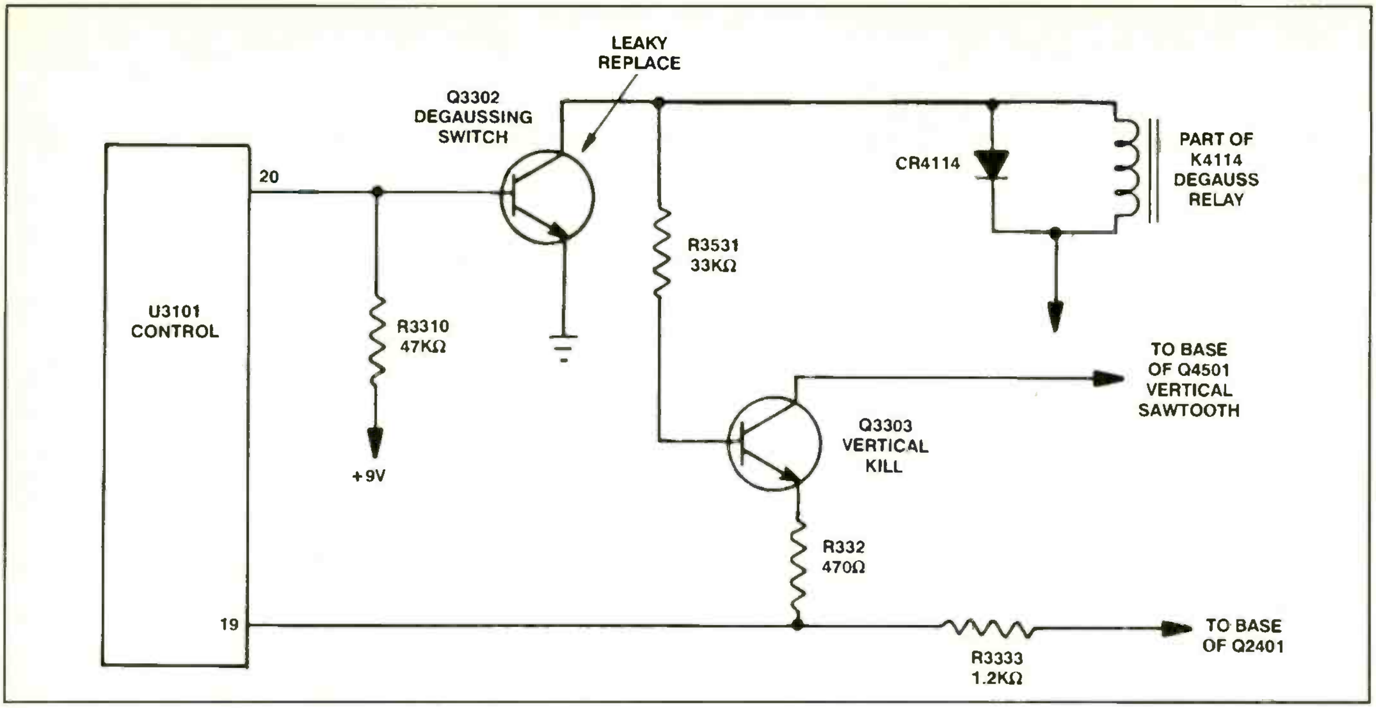


Figure 14. In one RCA CTC166 chassis, a defective degaussing switch transistor (Q3302) killed the vertical output at pin 20 of U3101.

touching up the height control. It is good practice to replace all small electrolytic capacitors in the vertical and output circuits in older sets, especially those of small capacitance such as C437 (1μF) and C441 (2.2μF) in this set.

Multiple vertical problems

Sometimes many different vertical problems will occur over the years in a given TV set. Many such problems are caused by vertical output transistors and IC components (Figure 12). These devices are easily located even when a schematic is not available. Look for devices mounted on a separate heat sink. Measurement of voltages on output components can help you to determine if the part is leaky or open.

Next connect a known-good capacitor in parallel with the voltage boost electrolytic capacitor between two terminals of the output IC. This capacitor has been known to cause intermittent or absent vertical sweep. If the vertical remains insufficient or absent, connect a known good capacitor in parallel with the output coupling or return electrolytic capacitor in the yoke circuits.

In one RCA CTC146 chassis that I serviced for absence of vertical sweep, I replaced the output IC, U4501, with an RCA SK9753 universal replacement. I did so because there was leakage between pins 3 and 4. Replacement of capacitors C4501 and C4504 has also cured insufficient vertical sweep in these sets. Check R4513 and R4515 for a change in resistance (Figure 13).

An unusual vertical sweep problem

One unusual case of reduced vertical sweep in an RCA CTC166 was not caused by defects in the vertical circuits. After spending several hours checking out the vertical circuits, the problem was traced to the control IC (U3101) circuits (Figure 14). A leaky degaussing switch transistor (Q3302) on pin 20 of U3101 killed the vertical circuits. The base of the vertical kill transistor (Q3303) is connected to the collector terminal of degaussing switch transistor Q3302. A leaky Q3302 killed the vertical sweep. Replacement of Q3302 cured the problem. ■

Understanding the bipolar transistor: Part I

By Steven Jay Babbert

Editor's note: The more detailed understanding of the characteristics of the basic electronics components that a technician possesses, the more effective his troubleshooting technique will be. For example, if a technician has a feel for the characteristics of a capacitor, he knows that when he places a DMM across the leads of a capacitor he will see the display increase gradually, as the capacitor charges to the voltage placed across it by the meter. If that doesn't happen, the capacitor has a problem.

Bipolar transistors are encountered in servicing of virtually every type of consumer electronics product. A good understanding of these ubiquitous devices will help any technician in tracking down and correcting problems caused by transistor malfunction. This series of articles on bipolar transistors is presented as an introduction for some, and a review for others, to help technicians hone their troubleshooting skills.

The transistor was invented at Bell Laboratories in 1947 by John Bardeen and Walter Brattain. The name is a contraction of the words "transfer" and "resistor" which are descriptive of its function. A transistor has three elements: the emitter, the base, and the collector. In many ways these elements are analogous to the vacuum tube triode's cathode, control grid and anode respectively.

The first production transistor was a point-contact device reminiscent of the cat's whisker detector used in some of the first crystal radios. The base consisted of a wafer of germanium. The emitter consisted of a beryllium-copper wire in contact with the base. Similarly, the collector consisted of a phosphor-bronze wire in contact with the base about 0.002 inches from the emitter. These point-contacts formed rectifying junctions which are the basis of many semiconductor devices. Connection to the base was made by an ohmic (non-rectifying) contact (Figure 1).

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These forerunners of the bipolar junction transistor were fragile and their characteristics were difficult to predict. Though various theories were proposed to explain their operation, none satisfactorily answered all questions.

The junction transistor

Fortunately in 1952 William Shockley, also of Bell Labs, invented a vastly improved version which didn't rely on point contacts. In this new device known as the junction transistor, rectifying junctions were formed by joining crystalline materials having different conductive properties. Though the junction transistor was of a different construction, the operating principles were essentially the same.

Both point-contact and junction transistors are further classified as bipolar transistors. The term bipolar arises from the fact that both polarities of charge carriers, holes and electrons, are involved in transistor action (charge carriers will be discussed later in this article). FETs (field effect transistors) on the other hand are classified as unipolar devices since the main conduction channel utilizes only one charge type.

The nature of semiconductors

In order to understand how transistors work we must first know what semiconductors are. Semiconductors, as the name implies, are materials whose electrical conductivity lies midway between that of an insulator and that of a conductor. An atom of any element consists of a nucleus surrounded by electrons. The electrons are thought to be orbiting the nucleus in layers, or "shells," depending on their energy levels. One important factor in determining the conductivity of a substance is the number of electrons in the outermost shell of its constituent atoms.

The maximum number of electrons that can occupy the outer shell of an atom is eight. This outer shell is also called the "valence" shell. Atoms having eight valence electrons are considered stable and tend to be insulators. The minimum number of electrons that can occupy the valence shell is one. Atoms having one val-

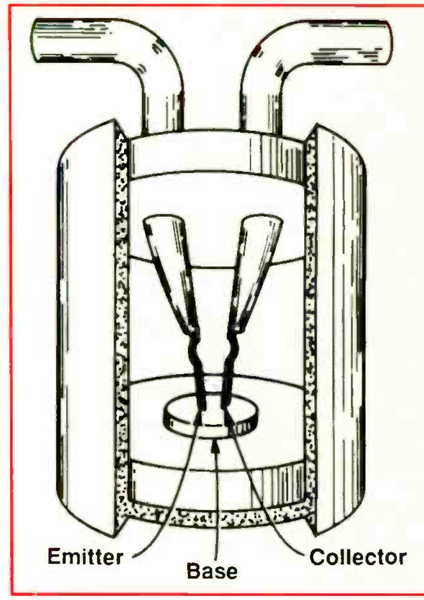


Figure 1. The first point-contact transistor was fragile and its characteristics were somewhat unpredictable. Nevertheless, it would turn out to be one of the major technological breakthroughs in the history of electronics.

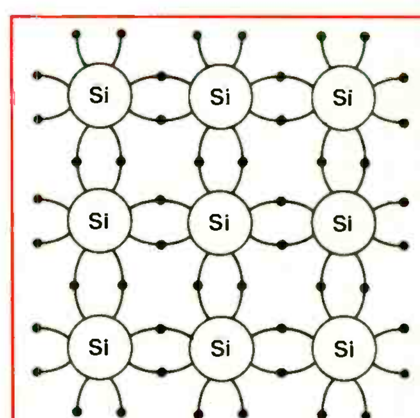


Figure 2. In an intrinsic (pure) silicon crystal, the atoms share their electrons in a condition known as covalent bonding. Intrinsic silicon is a poor conductor.

Period	Column III	Column IV	Column V
2	Boron B	Carbon C	Nitrogen N
3	Aluminum Al	Silicon Si	Phosphorous P
4	Gallium Ga	Germanium Ge	Arsenic As
5	Indium In	Tin Sn	Antimony Sb

Table 1. A portion of the periodic table of elements related to semiconductors. Elements in groups three and five are typically used as dopants for semiconductors.

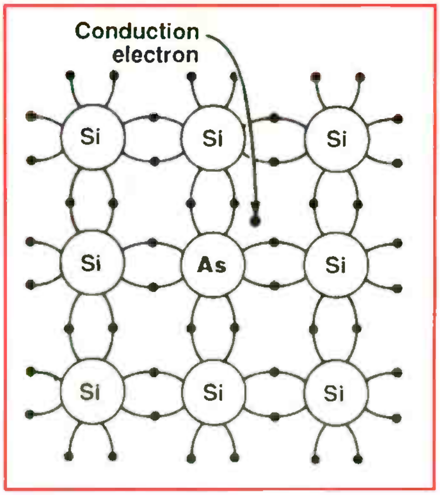


Figure 3. By adding "donor" impurities, the conduction characteristics of a silicon crystal can be improved. N-type silicon has an excess of free electrons.

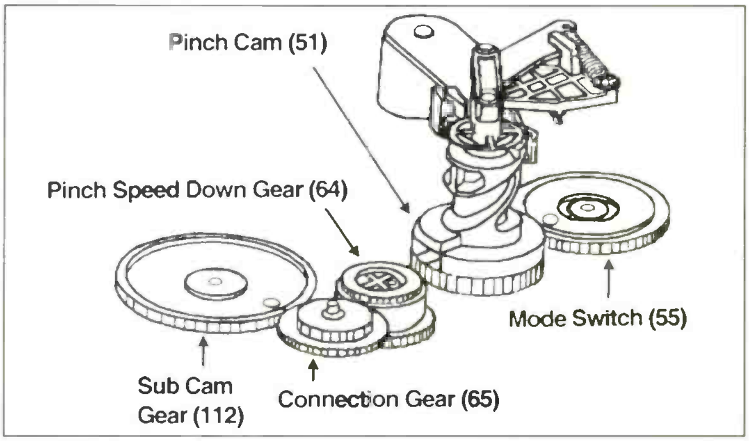
ence electron tend to promote conduction. Semiconductors are based on elements having four valence electrons such as germanium and silicon (see Table 1).

Germanium and silicon are crystalline materials having atoms arranged in a three-dimensional periodic fashion. The crystal is more easily described with a two-dimensional simplified diagram. Figure 2 represents intrinsic silicon, i.e. silicon without any added impurities. Though the electrons are shown as stationary objects they are actually orbiting the nucleus in an irregular path and at such a velocity that they can collectively be viewed as a shell, or spherical cloud.

Each atom has four electrons in its outer shell. Each atom also has four identical atoms in close proximity. These atoms share their electrons in a condition known as covalent bonding. Each electron pair comprises a covalent bond. The atoms are held together because each electron within a covalent bond is attracted to both nuclei. In effect, each atom now has eight electrons through sharing.

Electrons and "holes"

Electrons have a negative charge which is balanced by the positively charged nu-



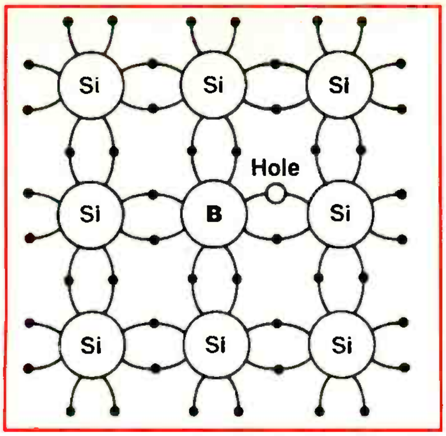


Figure 4. The addition of acceptor impurities renders a p-type crystal with an excess of holes, which improve conduction characteristics.

cleus which contains one proton for each electron, resulting in a net charge on the atom of zero. At low temperatures the electrons remain bound to the atoms within the crystal lattice. At higher temperatures, electrons become excited and may break a bond. This results in a "free" electron which will be available for conduction if an electric field is applied.

Once the electron leaves the bond, a "deficiency" exists in its place. This deficiency may be filled by a neighboring electron resulting in a shift of the deficiency from one location to another. These deficiencies, dubbed "holes", are generally regarded as particles similar to electrons but with a positive charge. Holes move under the influence of an applied electric field in a direction opposite to that of electrons.

The electrons in an isolated atom can only have discrete energy levels. In crystals consisting of many atoms, interaction between the individual atomic forces causes these discrete levels to spread into energy bands. When there is no thermal energy the electrons will fill a specific number of bands leaving the remaining bands empty.

The highest filled band is known as the valence band and the next higher band is known as the conduction band. These bands are separated by an energy gap known as a bandgap. The bandgap region corresponds to energy levels which electrons cannot possess. These bandgaps are measured in electron volts (eV). Silicon has a bandgap of 1.12eV.

At any given temperature, some bonds will be broken resulting in a free electron-hole pair. Since silicon has a relatively small bandgap, some electrons will move into the conduction band leaving holes in the valence band. In the presence of an electric field, both the holes and the electrons will gain kinetic energy and become charge carriers.

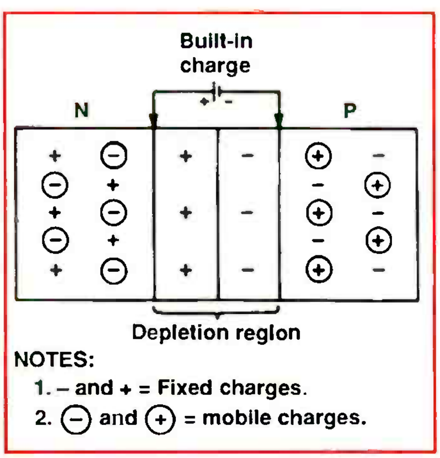


Figure 5. The joining of p-type and n-type crystals forms a p-n junction or diode.

Doping of semiconductors

Electrical conduction in intrinsic pure silicon is poor. This can be remedied by introducing impurities into the crystal in a process known as "doping". Usually dopants are elements having three or five valence electrons instead of four. Impurity concentration of "extrinsic" silicon usually ranges from one part in ten-thousand to one part in one billion. The most commonly used dopant materials are shown in Table 1.

In Figure 3, one silicon atom within the crystal lattice has been replaced with an arsenic atom which has five valence electrons. Four of the electrons form covalent bonds with the neighboring atoms. The fifth electron is said to be donated to the conduction band and hence the atom is referred to as a "donor". Due to the excess of free electrons, this type of silicon is referred to as n-type.

In Figure 4 the silicon has been doped with boron, which has three electrons in the valence shell. Covalent bonding can't be completed in this case because of the deficiency of electrons. Thus a positively charged hole exists within the valence band. An electron from a nearby covalent bond may jump over and be accepted by the hole in effect shifting the location of the hole. The addition of "acceptor" dopants to silicon creates p-type material.

In p-type silicon, holes constitute the main current carriers and are referred to as majority carriers. A small number of thermally generated electrons will exist and are referred to as minority carriers. In n-type silicon, electrons are the majority carriers whereas thermally generated holes are minority carriers. Both n-type and p-type crystals have a zero net charge and are said to be neutral. Note: Doping does not actually add or subtract charges but redistributes them due to the irregular bonding. If an n-type and a p-type crystal are atomically joined, a p-n junction or diode is formed.

The p-n junction

When a p-n junction is formed there is an initial burst of mobile carrier flow across the interface. Due to the attraction of unlike charges, electrons from the n-type side diffuse into the p-type side. Similarly, holes from the p-type side diffuse into the n-type side. As they cross the junction, these mobile carriers combine with their oppositely charged counterparts, mutually annihilating each other. This causes the area on either side of the junction to be devoid of mobile carriers. This area of the junction is referred to as the depletion region or SCL (space charge layer) (Figure 5).

Immobile or "fixed" charges which are uncovered while the depletion region is forming establish a built-in charge which opposes and eventually halts further diffusion. This charge effectively creates a "potential hill" or "barrier" which is what gives the diode the ability to block current flow in one direction while passing it in the other. The net charge of the entire crystal is still zero.

Diode action of a p-n junction

When the negative terminal of a voltage source is connected to the p-type side (anode) of a diode and the positive terminal is connected to the n-type side (cathode), the diode is said to be reverse biased. Under these conditions the holes are attracted to the negative source and the electrons are attracted to the positive source. This causes the depletion region to widen, increasing the potential hill. The diode is now "blocking" and the only current flow will be due to minority carriers. This is sometimes called intrinsic current.

If the polarity of the voltage is reversed, the diode will be forward biased. The positive voltage on the p-type side repels holes towards the junction. The negative voltage on the n-type side repels electrons towards the junction. The depletion region width is reduced and with it the potential hill. Both holes and electrons cross the junction enabling current to flow.

As forward bias is applied to a diode, the barrier potential must be overcome before conduction can begin. This accounts for the characteristic voltage drop of p-n junctions which is around 0.2V for germanium and about 0.6V for silicon. The lower atomic number of silicon (14 as opposed to 32 for germanium) allows greater atomic stability and hence the higher barrier voltage. Once the diode begins to conduct there is an approximate linear relationship between voltage and current (Figure 6).

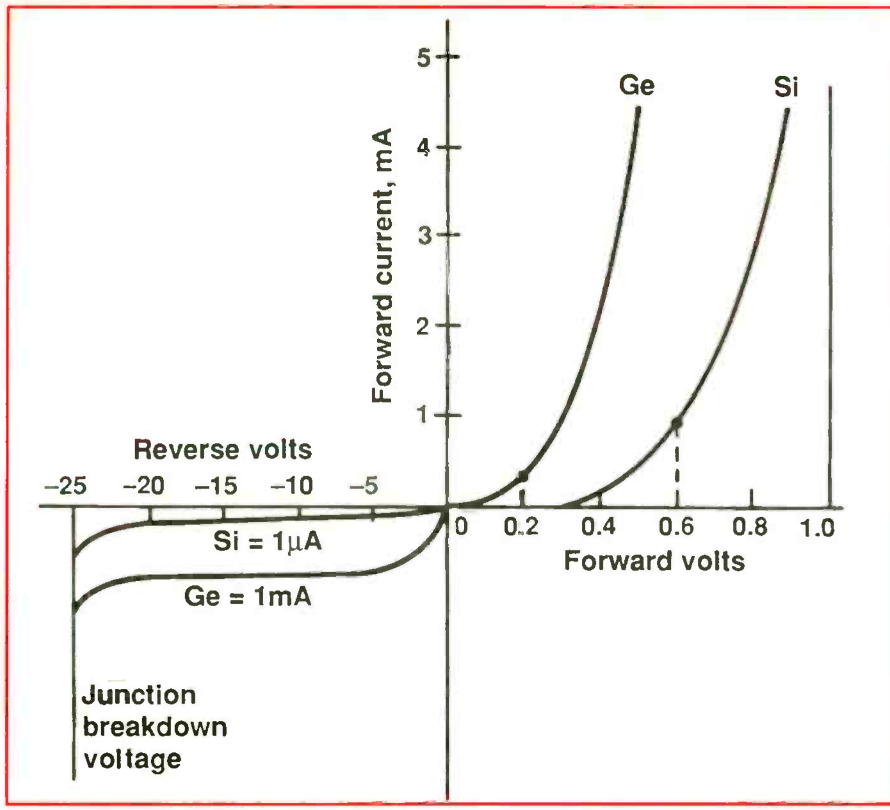


Figure 6. Typical current-voltage characteristic of a junction diode. Reverse "leakage" current is very small compared to forward current.

The bipolar junction transistor

The basic bipolar junction transistor or BJT is formed when a third piece of doped semiconductor material is joined to a p-n junction rendering an npn or a pnp device. In some ways this structure resembles two diodes sharing a common element. This can be useful in making some simple tests as will be shown later in this series.

Actually, BJTs are more complex than simple layers of p-type and n-type silicon. The base is made very thin in comparison to the emitter and collector. Emitters are doped more heavily (designated n+ or p+) while collectors are doped more lightly (designated n- or p-). This doping profile causes an asymmetrical spread of the depletion regions. Heavier dopant concentrations result in a more shallow penetration while lighter concentrations are penetrated more deeply (Figure 7).

Bipolar transistor operation

In the normal mode of operation, the emitter-base junction is forward biased while the collector-base junction is reverse biased. In an npn device, the depletion region at the emitter-base junction is overcome and electrons in the n-type emitter cross into the p-type base. Because the base is lightly doped with respect to the emitter, many of the electrons won't recombine with holes. The base ends up being flooded with electrons.

The collector-base junction is reverse biased and therefore it would seem that electrons would be repelled from the junction as in a normal diode. However, because the base is exceedingly thin, the spread of the depletion region from the collector penetrates into the region where the free electrons exist. The electrons that haven't combined with holes injected into the base from the base terminal are swept up or "collected" by the strong field created by the collector voltage. These electrons become collector current.

Typically, around 99% of the electrons "emitted" into the base region from the emitter are diverted into the collector. Even though the majority of the emitter current becomes collector current, the 1% that flows into the base circuit is in control because it puts the free electrons in position for the collector. This is what gives transistors the ability to amplify. The operation of pnp devices is the same with the exception that all polarities are reversed. This discussion of bipolar transistors will be continued in a future issue.

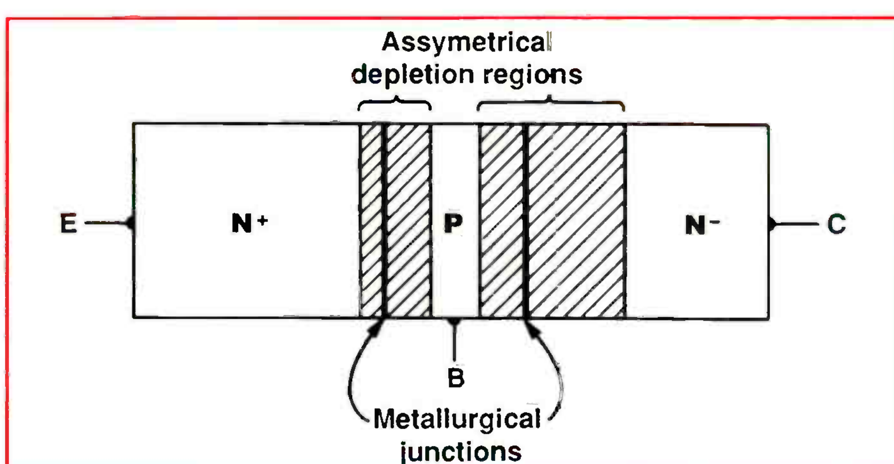


Figure 7. The asymmetrical doping profile and base thickness are important considerations in the design of BJTs.

Subminiature relays

NTE Electronics introduces the R73 series of subminiature relays. These high-performance relays, which have UL and CSA approvals, are designed for use in communications equipment, remote control systems, and instrument meters.

The 10A relays feature high sensitivity, compact design, epoxy-sealed construction, and low power consumption. DC operational, the R73 series is available in coil voltages of 3, 6, 12, and 24Vdc, and comes in both SPST-NO and SPDT contact configurations.

Weighing only 0.39 oz., the R73 series operates at a temperature of –55°C to +85° C. The relays have a minimum mechanical life of 100,000 operations, and a minimum electrical life of 10 million operations.

Circle (86) on Reply Card

Signal generators

Based on direct digital synthesis (DDS) technology, SG-100 signal generators from *Telulex* can generate a variety of complex waveforms at precise frequencies from dc to 20MHz with 0.1Hz resolution. A high speed DSP processor directly controls every aspect of the DDS system. Frequency, phase, level and I & Q rails are all controlled in the digital domain, resulting in clean, precisely controlled modulated waveforms.

The unit offers an extensive list of operating modes: linear/log sweep, AM, FM, PM, SSB, BPSK, FSK, burst, DTMF generation, DTMF detection and power level measurement. The product stores its operating software in Flash memory, making the unit field upgradeable.

Circle (87) on Reply Card

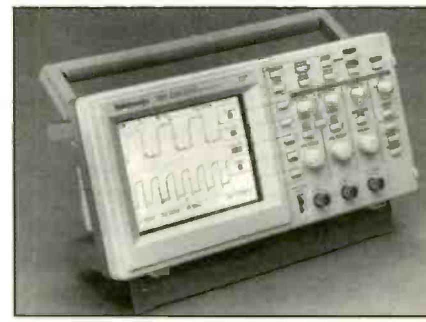
Autoranging DMM

Extech's new autoranging DMM, Model 380770 provides 29 ranges and 10 multimeter functions including dc/ac voltage, dc/ac current, resistance, capacitance, frequency, diode test, transistor test, and audible continuity test. The ranging mode may be auto or manual. Designed to meet IEC-1010 standards, this DMM provides ±0.3% basic dc voltage accuracy. A one-inch LCD display provides 3,200 counts with 2-3 updates per second and a 32 segment bargraph. Overrange, polarity, and low battery indications are featured along with overload protection on four input jacks. Complete with test leads, 9V battery, and protective holster with dual position tilt stand. Dimensions: 3.6 x 7.6 x 1.3 inch (90 x 189 x 31.5mm).

Circle (88) on Reply Card

Digital scopes

Tektronix announces its new Digital Real-Time (DRT) oscilloscopes, the TDS 200 Series. The new TDS 210 and TDS 220 are compact, well-equipped 60 and 100MHz units, respectively, designed for manufacturing, education, and service.



The new scopes rely on digital real-time (DRT) oversampling technology to provide high waveform quality, update rate, and stability. Both models sample at 1 GS/s, at least 10 times their bandwidth. This advanced high-speed technology enables users to capture signal details invisible on analog scopes.

The instruments are equipped with pre-programmed automatic measurements that allow users to quantify waveforms quickly: period, frequency, cycle RMS, mean, and peak-to-peak. Other productivity features include automatic setups (similar to autoranging on a digital multimeter), stored reference waveforms, and stored front panel setups which are not lost when the power is turned off.

Circle (89) on Reply Card

DMMs

Wavetek introduces six new handheld digital multimeters (DMMs)—five multimeters and one LCR component tester. The XT Series includes the 85XT, LCR55 and four newly-enhanced models: 23XT, 25XT, 27XT and 28XT.

Each XT model is optimized with a unique combination of measuring features; component checking functions such as capacitance, inductance, frequency and temperature are combined with standard DMM measurements. Additional features include easy-to-read oversized characters, auto-off, wide measuring ranges, fully-fused current inputs and input warning beepers.

Circle (90) on Reply Card

Circuit tracer

Pasar Amprobe announces the new circuit tracer, model AT-1000. The tracer enables tracing of both deenergized and energized circuits up to 300V ac/dc.

The transmitter can be directly connected to deenergized lines to search for opens or shorts or directly connected to energized lines to identify breakers and circuit paths. The receiver contains two user selected detectors for "Open" or "Current" tracing for a transmitter to receiver range of up to three feet. The circuit carrying the signal is confirmed when the receiver emits an audibly pulsed tome and displays the signal strength visually on the four LED signal strength indicator.

The unit can also; trace energized lines up to 300Vac or dc, trace deenergized and open conductors, identify breakers and fuses without powering down, locate shorts, identify wires in a bundle, identify control and alarm system wiring, and trace coaxial cable.

Circle (91) on Reply Card

DMM calibration kit

The SX-ASYC IIC Calibration Kit available from *Metrix Instruments* is a natural extension to its recently announced ASYC II series 50,000-count digital multimeters which can be re-calibrated without the need to open the meter.

ASYC II (Advanced Safety Concept) DMMs, were designed to eliminate opening the meters for any reason, including re-calibration. No mechnical adjustment

is needed, and re-calibration is performed digitally via an RS-232 serial port.

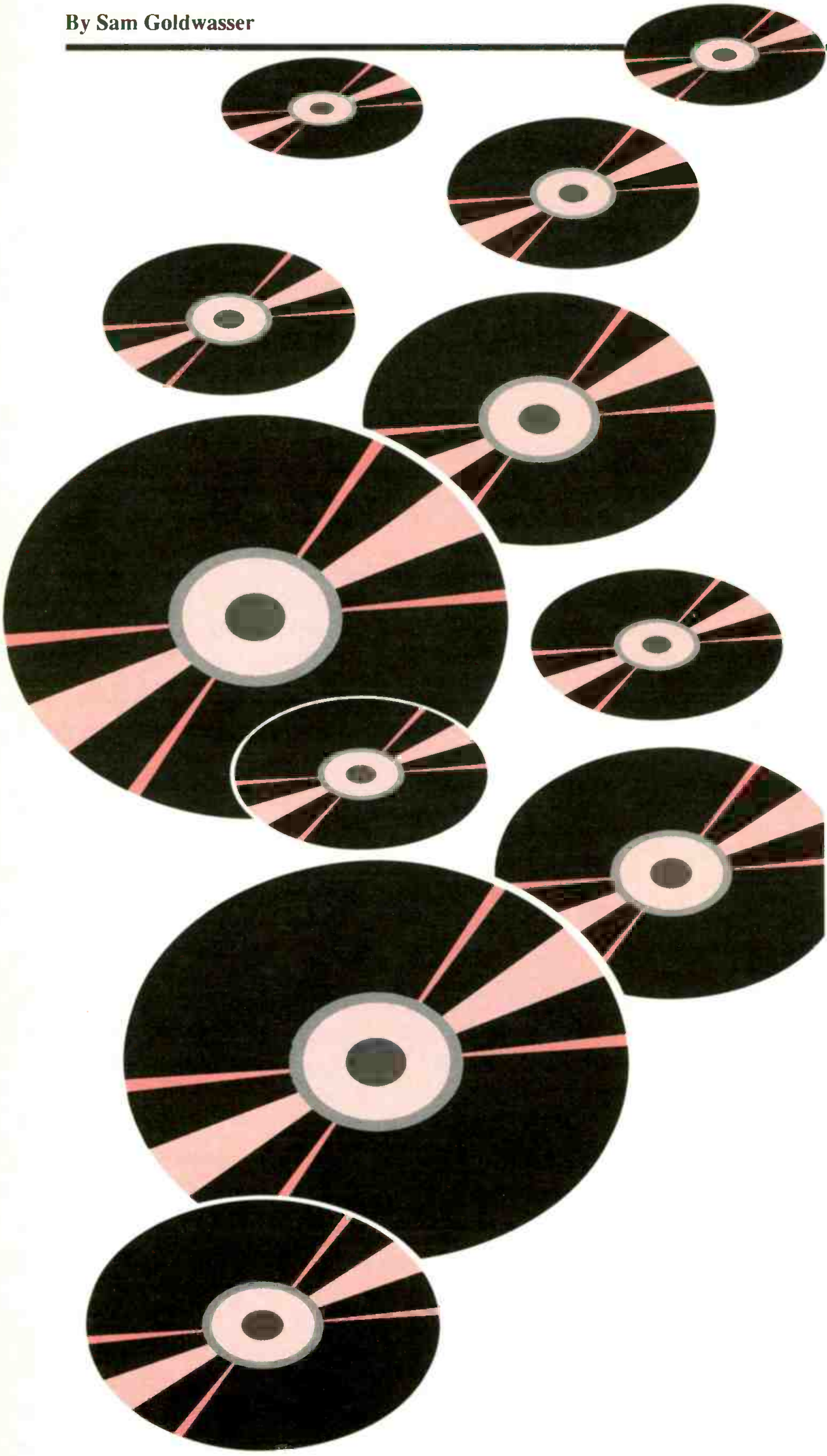
The new SX-ASYC IIC Calibration Kit comes with: An adapter used to isolate and format signals; interchangeable face plate labels keyed to the respective adapter/AYSC II meter; two 3-1/2 inch diskettes, one containing LabWindows drivers, the other containing the adjustment software itself; as 25/9-pin adapter for connection to any type of serial port; and an additional power supply needed for some types of PCs.

The ASYC II series meets IEC1010 safety standards.

Circle (92) on Reply Card

CD player fundamentals—Part II

By Sam Goldwasser



Part I of this article, which appeared in the October issue, provided a general overview of CD player operation, including some general comments on the types of problems that can occur. This segment includes a discussion of some specific problems that may cause a CD player to malfunction, or to fail to operate entirely, and provides specific suggestions for corrective action.

Where to start if the player is totally dead

If a CD player is totally dead, check input power, power cord, fuse, and power supply components. Locate the outputs of the power transformer and trace them to the rectifiers and associated filter capacitors and regulators. While the actual voltages will probably not be marked, most of the power in a CD player will be typically between +15Vdc and -15Vdc. Sometimes the voltage ratings of the filter capacitors and/or regulators will provide clues as to correct power supply outputs. Don't forget the obvious: the line cord, line fuse (if present), and power switch, or outlet. Most component CD players use linear power supplies so troubleshooting is straightforward. However, portables use dc-to-dc converters to generate the several voltages required. These are more difficult to troubleshoot. If an incorrect power adapter was used, then major damage can result despite the various types of protective measures taken in the design.

I inherited a Sony Discman from a guy who thought he would save a few bucks and make an adapter cord to use it in his car. Not only was the 12V to 15V from the car battery too high, but he got it backwards. This blew the dc-to-dc converter transistor in two despite the built-in re-

Goldwasser, Ph.D is an engineering consultant with extensive experience in both industry and academia. He has authored most of the comprehensive consumer electronics troubleshooting and repair manuals available on the Internet. These may be found at: http://www.paranoia.com/~filipg/HTML/REPAIR/ Repair.html.

verse voltage protection and fried the microcontroller. Needless to say, the player was a loss but the cigarette lighter fuse was happy as a clam.

The moral of this story is that those voltage, current, and polarity ratings marked on portable equipment are there for a reason. Voltage ratings should not be exceeded, though using a slightly lower voltage adapter will probably cause no harm, performance may suffer. The current rating of the adapter should be at least equal to the printed rating. The polarity, of course, must be correct.

If the power is connected backwards with a current limited adapter, there may be no immediate damage depending on the design of the protective circuits. But don't take chances; double check that the polarities match before you plug it in.

Note that even some identically marked adapters put out widely different open circuit voltages. If the unloaded voltage reading is more than 25% to 30% higher than the marked value, I would be cautious about using the adapter without confirmation that it is acceptable for your player. Needless to say, if the player behaves in any strange or unexpected manner with a new adapter, if any part gets unusually warm, or if there is any unusual odor, unplug it immediately and attempt to identify the cause of the problem.

CD player is operational but there is no display

If the CD player operates but the display is blank, the display may be one that requires backlighting, which uses miniature incandescent lamps. The lamp may be burned out. If you have to replace a burned-out lamp from a CD player display, check to see if you can find an alternative to the high-priced exact replacement bulbs. Test the bulbs with an ohmmeter. Measure the voltage across the light bulb connections and then replace the bulb with one that is specified at about 25% to 50% higher voltage. These may not be quite as bright but should last forever.

If the light bulbs are not at fault, or if there are no light bulbs, then check for power to the display including bad connections or connectors that need to be reseated. There could also be a power supply (e.g., missing voltage for a vacuum fluorescent display) or driver problem.

CD player ignores you

Symptoms like the display coming up normal when the power is turned on but all (or certain) commands are ignored could mean any of several things:

- Front panel problem—one or more buttons are not responding. Reseat internal cables, clean or replace offending push button switches. If your CD player has a remote control, see if it operates the player correctly.
- Reset failure—the player has failed to reset properly and is not ready for user input. Check power supply voltages, reseat internal connectors.
- Controller and/or driver electronics for the affected functions are defective. Check power supply voltages, reseat internal connectors.

For all but the first one, a service manual will probably be needed to proceed further if the problem is not caused by a bad power supply or bad connections.

Drawer does not open or close

If the drawer doesn't open when the front panel button is pressed, listen for the motor attempting to open the drawer. If you hear it whirring but nothing happens, check for an oily/loose belt or other mechanical failures. Cleaning of the belt may provide a temporary repair, but it should be replaced for a proper repair.

If you don't hear any activity from the loading drawer motor, the problem could be caused by the motor, the control chip, or the front panel pushbutton. Try operating the player by using the remote control to determine if the problem is caused by the pushbutton.

Drawer operation is erratic

You are about to remove your favorite CD but the player beats you to it, closes the drawer, and starts playing it over again. Or the drawer reverses course halfway out. Or it may be that the drawer motor continues to whir even after the door is fully open or closed and the front panel is then unresponsive.

This is usually due to dirty contacts on the door position sense switches. There are usually 3 sets of switch contacts associated with the drawer mechanism. If any of these get dirty, worn, or bent out of place, erratic operation can result:

- Drawer closed sense switch—dirty contacts may result in the drawer motor continuing to whir after the door closes and the front panel may then be unresponsive. Eventually, the drawer may open on its own.
- Drawer open sense switch—dirty contacts may result in the drawer motor continuing to whir after the door opens and the front panel may then be unresponsive. Eventually, the drawer may close on its own.
- Drawer pushed sense switch—most CD players allow the user to start play by gently pushing on the drawer which depresses a set of switch contacts. If these are dirty, the result may be that the drawer decides to close on its own or reverses direction in the middle of opening or closing operation.

The solution to all these problems is usually to simply locate the offending switches and clean their contacts. These switch contacts are usually not protected from dust, dirt, and grime so that these types of problems are quite common.

Drawer does not close completely

Failure of the drawer to close is a symptom that may not be obvious. The drawer may appear to close but a loose or oily belt may prevent the mechanism from completing the close cycle. This can result in erratic behavior because the disc clamping action is often controlled by the movement of the drawer.

The result of this problem is that sometimes the player will not recognize the disc, sometimes the drawer will open, or the problem may cause more subtle failures like tracking problems, etc. If you suspect that a CD player is experiencing this problem, clean the belt and see if there is any improvement. Belt replacement will be necessary eventually. Check for gummed up lubrication as well.

If the drawer goes through the motions of closing and then stops short without any further sounds, a gear may have jumped a tooth or broken some. The result is either that the mechanism is now incorrectly timed or not able to complete the operation. Examine the mechanism closely for broken parts. Cycle it manually by turning the appropriate motor pulley or gear to see if the drawer gets hung up or is much more difficult to move at some point.

If the player continues to make a whirring sound after the drawer stops, there might be some other kind of mechanical damage resulting in an obstruction or really gummed up lubrication not allowing the operation to complete.

Spindle table loose or sticks to clamper upon eject

When you remove the CD, you may have an added surprise—the platform upon which the CD sits pops off as well, possibly jamming everything. There may also be startup and spindown problems.

Various models use different techniques to fasten the spindle table to the motor shaft but this is strictly a mechanical problem. Either a set screw has worked loose, adhesive has weakened, or a press fit has come undone.

If there is no set screw, a drop of epoxy may be what is needed. However, correct height is important to guarantee proper focus range so some care will be needed if there is no definite stop. The disc and rotating clamper magnet must be clear of any fixed structures and at the correct distance from the optical pickup. Where something irreversible is involved like adhesive, check the service manual. The specification is usually 0.1mm accuracy.

A loose spindle table may also result in continued spinning upon eject or sluggish or noisy startup or seek, because if the spindle is loose, the motor will not be able to properly control disc speed during speed changes.

Intermittent operation

When a CD player appears to have a mood problem; playing fine sometimes or for only part of a disc or aborting at random times, there can be several possible causes including a dirty lens, dirty or worn interlock switch or bad connections to the interlock switch (mainly in portables and boomboxes), flexible cable with hairline cracks in one or more conductors, other bad connections, marginal power supply, or a defective disc.

- Dirty, scratched, or defective CD—confirm that the CD is not the problem. Clean the disc and/or try another one.
- Dirty lens—a player that accepts some discs and not others or accepts discs sporadically may simply need its eyeglasses cleaned.
- Mechanical—oily, flabby belts preventing full drawer closing or gummed up lubrication on the sled (may fail depending on ambient temperature. For example, if the music gets stuck at about the same time on every disc, then there may be gunk on the end of the sled track preventing the sled from moving any farther. This is especially likely if you just purchased a disc with an unusually long playing time—it has nothing to do with the musical tastes of the CD player!

Note: some players will simply not play discs which exceed about 74 minutes—the legal limit for CD playing time. Some discs may be as long as 78 minutes or more which means that some aspects of the CD specifications were compromised.

- Bad connections—there are often many little connectors used to get signals and power between the optical deck and main circuit board. These are usually cheaply made and prone to failure. Wiggling and reseating these may cure these problems. There may even be bad solder connections on the pins of connectors or board mounted switches. Slight flexing or just expansion and contraction may result in intermittent shutdown or other problems. These problems are more likely with portables and boomboxes which are subject to abuse.
- Cracks in ribbon cable—The moving and fixed parts of the optical pickup are often joined with a printed flexible cable. Constant flexing may cause one or more of the copper traces to crack. This may show up as an inability to get past a certain point on every disc—the player may shut down or start skipping at around 23 minutes into every CD.
- Dirty switches—oily film or oxidation may be preventing any of the limit or interlock switches from making reliable contact. If this is the case, the player may stop at random times, fail to accept a disc, close the drawer without your permission, etc. Use contact cleaner and typing paper to clean the contacts. Disassembly may be required for enclosed switches.
- Power supply or logic problems are also possible but rare. However, if you have a scope, check the power supply outputs for ripple; a filter capacitor may have dried up and lost most of its capacitance.

CD player overheats

A CD player which becomes noisy may have a component that is heating up and changing value.

In general, there should not be much change in behavior from the instant the power is applied until the next millennium. There is not much in a CD player that runs hot and might change characteristics. However, components do sometimes fail in this manner. Problems of this type need to be diagnosed in much the same way as one would find overheating components in a TV or computer monitor.

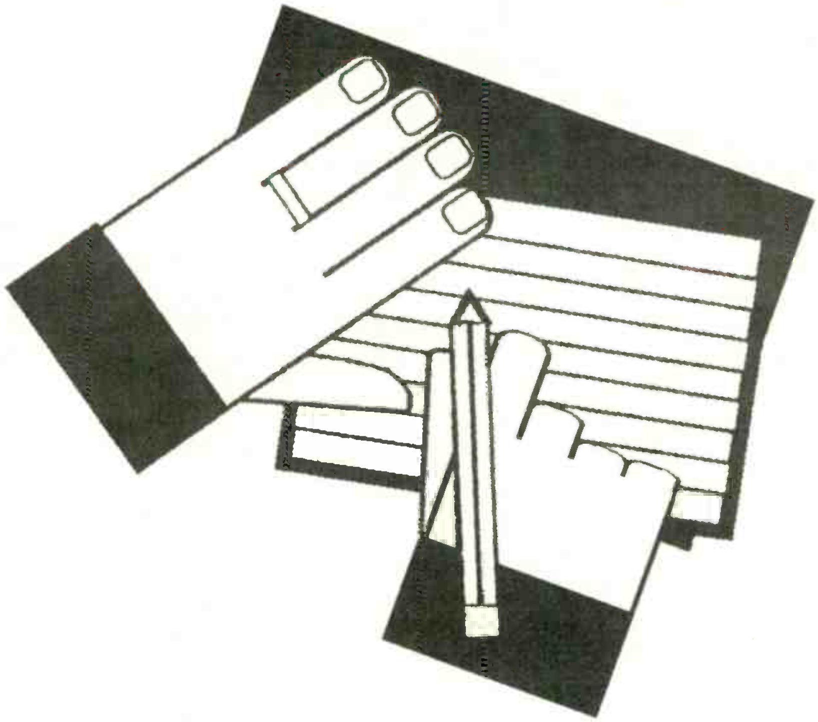
You will need a can of cold spray ('circuit chiller') and an oscilloscope, if available. Even a hair dryer on the no-heat setting will work in a pinch.

You are going to have to try cooling various components to try to determine which one is bad. However, on a unit that dies completely and suddenly after it warms this will not be much fun since you will not have ample opportunity to detect changes in behavior. On a CD player that will play but with tracking problems and/or audio noise, you should be able to monitor the playback quality by simply listening for improvement when you have cooled the flaky part.

First, I would recommend running with the covers removed and see if that has an effect confirming a thermal problem. Next, use the cold spray on individual components like the LSI chips—quick burst, wait a few seconds for something to change. If you are using the hairdryer, make a funnel out of paper to direct the air flow. You will need to be more patient with this approach.

Another way to determine if the problem is caused by heat is to use the scope to look at the RF "eye" pattern during this time and see if it decreases in amplitude and/or quality over the course of an hour. If it does, you may have an overheating problem in the laser diode or its power supply. ■

Test Your Electronics Knowledge



By J.A. Sam Wilson

1. The circuit in Figure 1 is
   A. a bridge full-wave rectifier.
   B. two 2-diode full-wave rectifiers.
   C. two discriminators.
   D. two ratio detectors.

2. As a class project Leon Smedge made a proposal to change all six transistors in his radio from NPN to PNP types. To get the required negative voltages he says he will reverse the half-wave rectifier diode. As his instructor, what do you tell him?

3. Conversion of electricity into light is called __________.

4. When you make a graph showing frequency vs. gain and phase shift you are making a ______ ______.

5. Is the following statement correct? "One side of the 2-line power in your house is (or, should be) earth grounded."
   A. Correct
   B. Not correct

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

6. Name four things that determine the resistance of a piece of wire.

______________, ______________,
______________, ______________.

7. What is the decimal value of Binary Coded Decimal (BCD) 0111 0001?

8. The voltage and current in a certain circuit are 60 degrees out of phase. Express the power factor as a percent value.

9. Given 6 = ln(X), X = ?

10. Refer to Figure 2. The circled RC combination is
   A. a low-frequency compensating circuit.
   B. a power supply decoupling filter.
   C. both of the above.
   D. neither of the above.

(Answers on page 60)

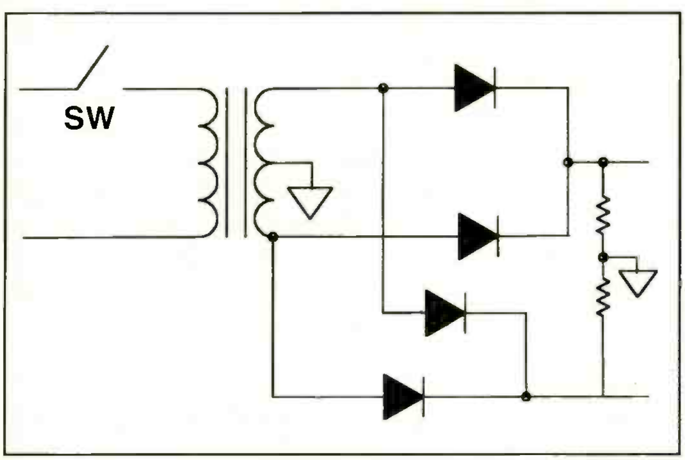
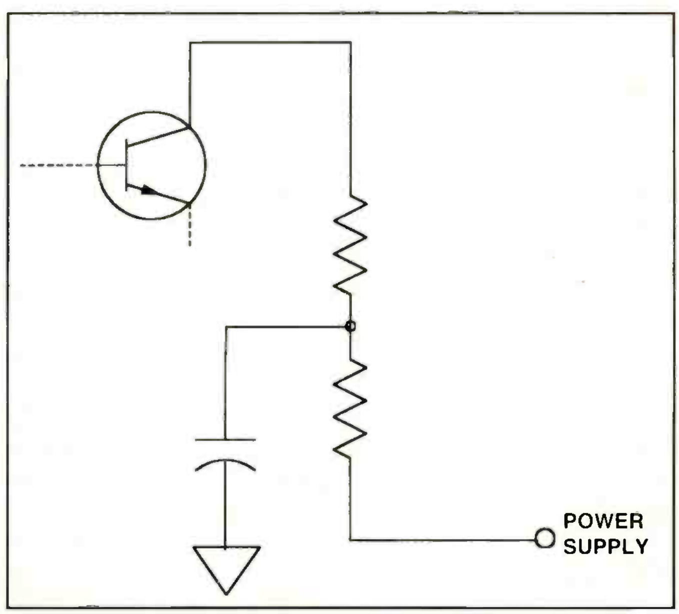


Figure 1. What is the function of this circuit?

Figure 2. What is the function of the RC combination in this circuit?



The Howard W. Sams Troubleshooting & Repair Guide to TV, The Engineers of Howard Sams, PROMPT Publications, 384 pages, paperback $29.95

Repairing and troubleshooting a television is very simple and economical with help from the information in this book. *The Howard Sams Troubleshooting & Repair Guide to TV* is a complete and up-to-date television repair book, with tips for all makes of TVs and timesaving features that even the pros don't know.

Written for novice and professional technicians alike, this useful guide contains comprehensive and easy-to-follow basic electronic information, in-depth coverage of television basics, and extensive coverage of common TV symptoms. Also included are tips on how to avoid electronic problems that interfere with TV performance and a question-and-answer section at the end of each chapter, a useful feature for instructors or anyone teaching themselves television repair.

The Howard W. Sams Troubleshooting & Repair Guide to TV was written, illustrated, and assembled by the engineers, editors, and technicians of Howard W. Sams & Company. With a combined 200 years of TV troubleshooting and repair experience, plus the expertise acquired in creating PHOTOFACT—the nation's bestselling after-market television service data—Howard Sams' technicians are uniquely qualified to produce a television book that presents information to anyone who wants to know how to repair a television.

PROMPT Books, 2647 Waterfront Parkway E. Dr., Idianapolis, IN 46214

Build a world Wide Web Commerce Center: Plan, Program, and manage Internet Commerce for Your Company, By Genesis, John Wiley & Sons, Inc, 464 pages, paperback $29.95

Build a World Wide Web Commerce Center: Plan, Program, and Manage Internet Commerce for Your Company (Wiley; $29.95 US/$39.95 CAN; June 28, 1996) is the book that teaches Webmasters and businesses of all sizes how to use Windows NT-based Web server software to establish a secure and sophisticated commerce site.

Integrating the technology and the business processes of conducting secure transactions on the Web, Build a World Wide Web Commerce Center is a blueprint for building and managing a state-of-the-art commerce center. Readers will learn how to: Devise an effective commerce strategy, create a web-based program that sell products through the Internet, sell a product or service on-line, provide customer support, and manage contact and track response.

Wiley books are available at your local bookstore or by calling 1-800-225-5945. In Canada, please call 1-800-567-4797.

John Wiley & Sons, Inc. 605 Third Avenue, New York, NY 10158-0012

Digital Electronics, By Stephen Kamichik, PROMPT Publications, 150 pages, paperback $16.95

PROMPT Publications announces the release of *Digital Electronics*, a book designed to supplement an introductory course in digital electronics, teach the electronics hobbyist about digital electronics, and serve as a review for practicing technicians and engineers.

Digital Electronics was written as a textbook for a first course in digital electronics, but its applications are varied. It can be used as a guide and handbook for independent study, while also serving as a review for technicians and engineers. And because the book does not assume a prior knowledge of the field, the hobbyist can also learn about digital electronics by using this book.

Some of the topics covered include analog circuits, logic gates, flip-flops, and counters. In addition, a problem set appears at the end of each chapter to test the reader's understanding and comprehension of the materials presented. To further drive home the concepts, detailed instructions are provided so that the reader can build the circuits described in this book to verify their operation.

Stephen Kamichik received his Electrical Engineering Technology diploma from Ryerson Polytechnical Institute in 1975. He received his bachelor and master of engineering from Concordia University in 1986 and 1989, respectively. Kamichik worked for several years as a professional technician, including a four-year stint at SPAR, where he was involved with prototyping the original Canadarm. He is a noted expert on custom electronic circuits and coded power control circuits, and has published two other books with PROMPT Publications entitled; *Advanced Electronic Projects for Your Home and Automobile* and *Semiconductor Essentials*.

PROMPT Publications, 2647 Waterfront Parkway East Drive, Indianapolis, IN 46314

Electronic Publishing Construction Kit, By Scott Johnson, John Wiley & Sons, Inc., 640 pages, paperback/CD-ROM $44.95,

The Electronic Publishing Construction Kit: Creating Multimedia for Disk, CD-ROM and the Internet is the complete book/CD-ROM toolkit for creating a wide range of multimedia applications. Scott Johnson, one of the creators of the award-winning HyperWriter software, reviews the basics of hypertext and multimedia and explains how to quickly master electronic publishing for CD-ROM and the Internet. Drawing on the powerful software included on the CD-ROM, Johnson leads readers through each step and provides hands-on instruction on every phase of digital publishing.

The CD-ROM includes: HyperWriter 4, HTML Converter, Hypertext versions of Electronic Construction Publishing Kit, and sample electronic products built with HyperWriter.

The Electronic Construction Publishing Kit provides all the information needed to create a wide variety of electronic publications, including books, magazines, promos, and more.

Note: Wiley books are available at your local bookstore or by calling 1-800-225-5945. In Canada, cal 1-800-567-4797.

John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012

TV Video Systems, By L.W. Pena and Brent A. Pena, PROMPT Publications, 128 pages, paperback $14.95

TV Video Systems is the hobbyist's and technician's how-to guide to the installation, operation, and troubleshooting of video programming sources.

With all of the sources of video programming available today, standard hard-wired cable, large-dish satellite systems, wireless cable, and digital satellite systems, knowing which one to choose and how to use it can seem overwhelming. *TV Video Systems* explains the different systems, how they are installed, their advantages and disadvantages, and how to detect problems and add accessories.

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L.W. Pena is an authorized independent certified cable technician with 14 years of experience. He has installed thousands of TV video systems in homes and businesses, and is an RCA certified DSS installer. Brent Pena has eight years of experience in computer science and telecommunications. In particular, he has worked as a cable installer, quality assurance specialist, and customer service professional. In this book, the two brothers offer their combined knowledge and experience.

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What do you know about electronics?

Percentages

By J.A. Sam Wilson

Before starting What Do You Know About Electronics? for this issue, here's a question based on an installment from April 1995 concerning a phenomenon called "Johnson Noise."

This was what I said in April 1995:

".....a carbon-composition resistor, sitting on a table with no connections, has a voltage across its terminals. It is called a noise voltage, or Johnson noise voltage, or thermal agitation noise voltage. Take your pick. That voltage is caused by the random motion of charge carriers (electrons) in the resistor. It occurs at any temperature above absolute zero (about -273C or -460F).

"Every resistor, semiconductor diode, bipolar transistor, FET and other component made with semiconductor material is guilty of generating the noise voltage.

"The temperature is given on the Kelvin scale for a good reason. At absolute zero it is assumed that all random motion of charge carriers stops. So the noise voltage must be 0V at that temperature. Well, that's the prevailing theory. No one has been able to produce that temperature up to now."

By way of review, the RMS value of Johnson Noise is:

$$V_{NOISE} = [4kTR(\Delta f)]^{\frac{1}{2}}$$

where k is Boltzman's constant, T is the temperature in degrees Kelvin, R is the resistance in Ohms, and f is the bandwidth in Hz. Johnson's noise is one of the noises created by a resistor.

Can you tell which of the following materials can be used to make a resistor with the least Johnson's Noise?

A. Carbon Composition
B. Silver
C. Ferrite
D. Lead Sulfite

*The answer is at the end of this article.

Wilson is the electronics theory consultant for ES&T.

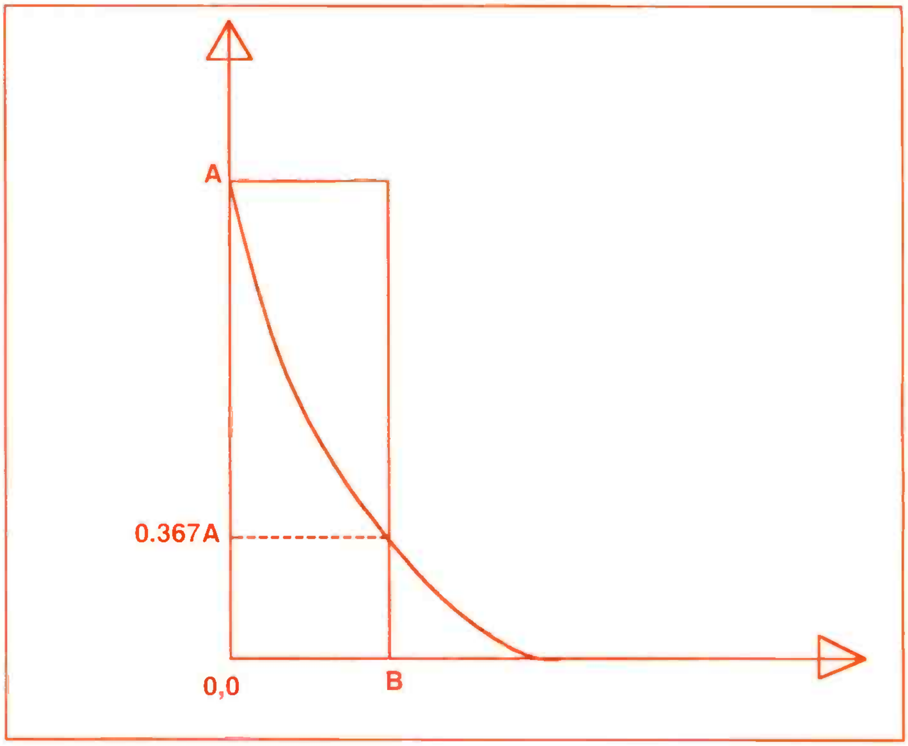

Figure 1. The solutions to difficult mathematical problems can often be closely approximated using graphical solutions. The method of determining the value of the solution is limited only by your imagination. One individual cut out an area that he had evaluated and weighed it to determine its magnitude.

Calculating percentages

I'm going to start this month's WDYKAE? with some material that doesn't, at first, seem like it has anything to do with electronics. However, if you stick with me I will tie it in.

It starts with a telephone call from my wife Norma.

Norma: "I need you to solve a math problem for me. We are giving an employee a raise due to increased responsibility on the job. The raise is from $6.78 per hour to $8.71 per hour. The paperwork requires that I express the raise in a percent value. What do I put down as the percent increase in pay?"

At this time I will advise readers who love to work math challenges to lay the magazine aside, temporarily, and work the problem.

My approach to the problem

Here is the way I worked the problem. I know that the percent regulation of a power supply is given by the equation:

$$\%\ REGULATION = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

where: V_{NL} is the no-load output voltage and V_{FL} is the full-load output voltage of the supply.

Remember that the "load" of a power supply is the current being delivered.

When you look at the equation for power supply regulation you can see that it tells the percent change in output voltage for a given change in the load. (Don't say "load current". That is a redundant expression. It's like saying "current current".)

Since we are looking for a percent change in hourly wage, we can use the

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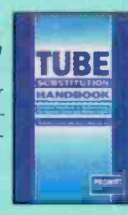

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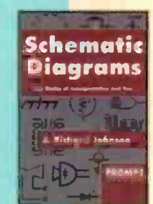

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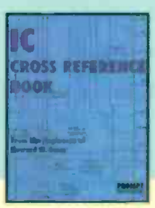

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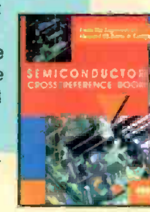

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Test Your Electronics Knowledge

Answers to the Quiz

(from page 55)

1. B

2. Probably something like "take it outside when you turn it ON, Smedge. You are going to destroy the electrolytic capacitors in the power supply!"

3. electroluminescence.

4. bode plot - (A reader advises me that this was not the original meaning of bode plot.)

5. A - But, check it out before you take a chance. There is home-owner wiring going on!

6. Length, Cross-sectional area, Type of material of which the wire is made, Temperature.

7. 71 - Each group of four digits represents one decimal number.

8. % Power factor
= cosine of the phase angle x 100
= cos(60) x 100 = 50%

9. 403.43 (rounded off)
ln is logarithm with a base e
$\ln^{-1}(6) = (\ln^{-1}) \ln X$
$X = \ln^{-1}(6) = 403.43$

10. C - You can't tell which it is unless you know the values of the components. For Figure 2, the resistor would be less than 100Ω and the capacitor could be an electrolytic. For A it would be high resistance and a relatively low value of capacitance.

same type of equation as used for percent regulation. However, we will change the meanings of the terms used.

We know that the old pay is 6.78 dollars per hour and the new pay is 8.71 dollars per hour. Our equation looks like this:

$$\text{PERCENT CHANGE} = \frac{\text{NEW PAY} - \text{OLD PAY}}{\text{OLD PAY}} \times 100$$

$= 28.4660767\%$

Note: I started with the larger value and subtracted the smaller value in order to get a positive percent change.

Proof: NEW PAY = OLD PAY + (PERCENT INCREASE OF OLD PAY)

Express 28.4660767% as a decimal: 0.284660767

NEW PAY = 6.78 + (0.284660767 X 6.78)
= $8.71 per hour

The trick here is to recognize that the percent increase (or decrease) in voltage is really no different than a percent increase (or decrease) in money, or, any other percent increase.

My point is this, your knowledge of electronics math can carry you over to math in other fields. My feeling is that there is only one math and it is the applications of math that get a little bit tricky.

A number you can bank on

Now I will turn to a story about banking in the 1700's. Bankers of that time already knew the equation for calculating an increase in money when they knew the percent interest. I have to make a guess here - but, it is well founded.

Someone in the banking business came up with a strange relationship. No doubt this was the result of fiddling with the above equations. Here is the strange relationship:

"There is a number that you can use to calculate the *increase* in money after there has been a *percent increase in the money*. (That is like the problems we just worked.) No matter how much money you start with you always get the same result if you use that strange number. I'm going to call that number e or ϵ or epsilon (for a very good reason). It is also called "Euler's number". His name is pronounced "oiler". He was one of the really great mathematicians of all time even though he wasn't very good at spelling.

Here are examples to demonstrate how it works.

If a banker pays simple interest and calculates it every year you do not get interest paid on interest. So, if your initial investment is $1000 and the banker pays 3% interest per year you have $1030 at the end of the first year.

When your interest is calculated for the second year it is not calculated on the basis of $1030. That would be paying interest on interest which is not done with simple interest.

If your banker pays compound interest and the rate is the same, you will have $1030 at the end of the first year and you will get paid 3% of $1030 at the end of the second year. That assumes your money is compounded annually.

In the years before Euler's time bankers had developed an equation for calculating money earned after y years:

$$\text{money on deposit} = X\left(1 + \frac{R}{Y}\right)^{Y}$$

where X is the initial deposit, R is the interest rate and Y is the number of years on deposit. By letting the original deposit be $1 and the rate be 1, the result is a very interesting equation:

$$M = X\left(1 - \frac{1}{Y}\right)^{Y}$$

Let's start with the number in parenthesis and let Y = 1000.

If you calculate that on your calculator you get: M = 2.7169.

Now let Y = 100,000 and you get M = 2.718268. Is that number starting to look familiar? Let's do it one more time with Y = 100,000,000. Then you get 2.7182818. Of course, that is the value of the familiar epsilon. The bankers didn't go any further with this equation.

In a previous issue I wrote an article based upon the question: "What Do the following things have in common: a bean sprout, a growing child and an exploding star." I could have added: and the increasing voltage across a capacitor in an RC time constant circuit, and the increasing current through an RL time constant circuit, and increasing money in a bank account.

The answer is that all natural growth is based upon the value of epsilon which is e on your calculator and the Greek letter epsilon in your arithmetic book.

When mathematicians, like Euler, started working with the number the bankers had discovered they found a lot of uses for e.

Here are a few examples: it is the base for natural logarithms (on your calculator), it is used to calculate impedance matching for four-terminal networks, as mentioned before it is the basis of the charging voltage and current in RC and RL circuits, it is the basis for hyperbolic functions used in some electronics problems (hyp or HYP on your calculator).

You have seen pictures of suspension bridges like the Golden Gate in California. The graceful arches of the main cable form a "catenary" curve based upon e.

Now we come back to my original idea: there is only one basic subject called mathematics. It can be applied to a wide range of subjects, especially to electronics.

Integration by cutouts.

Not long ago I received a letter from Joe Carr. You should recognize the name. He has written articles for **ES&T**. He is in agreement with me on the subject of graphical solutions. I am sure he will be glad to know that the University of Minnesota has added graphical solutions to their math work.

Joe Carr's graphical method of integrating is one of the most unusual I have heard of. You will remember that one of the jobs of integral calculus is to determine the area under a curve. I'll let him explain his method in his own words:

"I would like to share a technique I learned while working in a medical school. (It) is a geometrical solution to exponential decay curves (which are found in abundance in medical research).

Figure 1 shows the exponential decay curve. Electronics people are familiar with the curve as the resistor-capacitor discharge curve. One way to find the area under the curve is to plot it on fine mesh paper and then count the squares. (Reader note: That is the method I described in a recent article.)

The other (method) is to erect a rectangle with O,A on one side and O,B on the other side," (as in Figure 1). "The vertical line at O,B passes through the curve at the one time constant level, or, 0.367A. The area under the first five time constants is closely approximated by the area of the rectangle."

"I once used 20-to-the inch fine graph paper to test this method. The physical count of the tiny squares showed 2,944 squares, while the rectangle showed 2,960 squares. Pretty good, huh?"

Joe gave another example of a project where he cut out an area in question and pasted it onto 1/4-inch styrofoam, then, using a very precise method employing delicate beam balance he weighed the area, made a ratio, and calculated the weight per area.

His method is a precise way of calculating irregular areas using what amounts to a graphical technique.

Back to Johnson Noise

The answer to the question at the start of this article is NO. You can't select the material because Johnson Noise does not depend upon the material used to make the resistor. Look at the equation at the beginning of this article. Observe that the type of material is not in the equation.

Here is what that says: A 10Ω resistor produces the same amount of noise regardless of what material is used to manufacture the resistor. ■

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Leader LBO-516 scope, 3-channel 100MHz $550.00, Leader LBO-518 scope, 4-channel 100MHz $600.00. Keithley 179A true RMS bench multimeter, 4.5 LED digits, manual ranging $150.00. All in good condition. *Contact: Frank, 516-669-0283.*

Wanted

Tube tester Precise 111M or Hickok. Tektronix 570 oscilloscope, record cutting equipment (heads, lathes, amplifiers, limiters), SME-3012 tonearm. *Contact: 612-869-4963.*

Motorola ballast tube model VT73, part 17A485459. *Contact: Bob, Bob's Electronics, 156 HerseHeaven Road, East Nassau, NY 12062, 518-766-6270, Tues. - Fri.*

Panasonic VCR power supply for model PV4860. *Contact: Ken Cruise, Jr., 556 Terhune Drive, Wayne, NJ 07470, 201-616-0794.*Sylvania TV model CXZ0176W E53-1 chassis, need tuner synthesizer IC1410, NAO 6123950001 or tuner cluster control board assembly. *Contact: John Rosiak, 312 Mill Street, Elgin, IL 60123, 847-741-8405.*

TMK model 1933RC service manual or schematic. *Contact: Nancy Clar, She-Can-Too, 3322 Highridge, St. Las Cruces, NM 88012, 505-382-3422 (phone/fax).*

Sencore manuals for satellite receiver and down converter Satellite America, model SA-2000, Heathkit oscilloscope 10-4105. Panasonic fax Panafax 260. Radio college RCC databooks. *Contact: Mr. Rejean Mathieu, 819-874-1049 (phone), 819-874-0704 (fax).*

Sencore DVM56A Microranger. *Contact: Mike Sexton, 315-265-7528, after 6PM EST.*

Sharp 19 inch TV IHVT, ECG 390, Sharp MSH1FBA01. Sears VCR BEJ9QKA2760 remote control. *Contact: John's Repair Center, 142 Jackson Street, Philadelphia, PA 19148, 215-389-1147.*

Dynatech VCT model VR30 parts, cannot locate a supplier. *Contact: Richard Ryden, 731 Bloomfield Avenue, Nutley, NJ 07110, 201-667-3108.*

Zenith combo radio, cassette, phono - tuning display driver IC 905-297-14 Pin DIP. *Contact: Anthony Grasso, 100 Chenango Street #1207, Binghamton, NY 13901.*

RCA VCR models VKP900 and VLP900 copy or service manual for cassette deck section only. *Contact: Herman, 634 Grant Street, Sana Monica, CA 90405, 310-392-0102.*

New or used chips, flybacks, and other items for 1970s and 1980s TVs and VCRs. Ask for complete list. *Contact: W. Worley, 305 Hickory Bend Road, Enterprise, AL 36330, 334-347-5281.*

Panasonic VCR model AG-6200 top metal cover and bottom plate. *Contact: The VCR Workshop, Inc., 1044 S. Dupont Highway, Capitol Shopping Center, Dover, DE 19901, E-mail VCR.Workshop@InternetMCI.com.*

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