THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

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Servicing & Technology

July 1996

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

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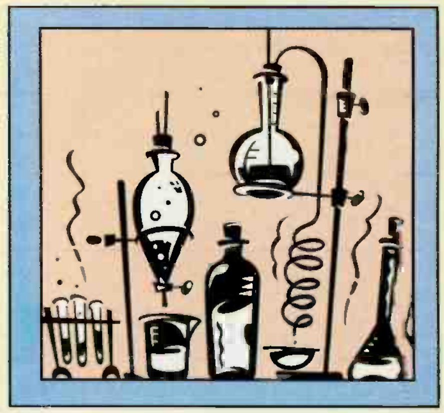
ON THE COVER

When they think of consumer electronics servicing, most people think of meters, oscilloscopes and soldering irons, but chemicals are also extremely important to the service technician. In many cases, a product that is exhibiting a problem can be restored to life by a thorough professional cleaning with the right chemicals, or lubrication of moving parts that restores smooth operation. (Photo courtesy Caig Labs)



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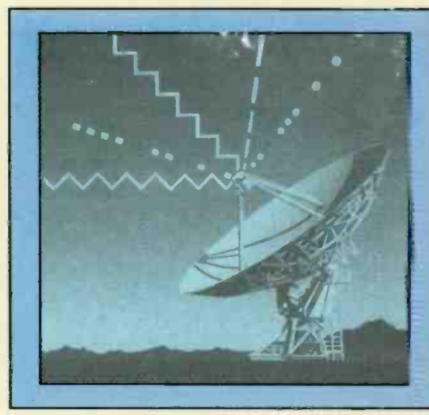

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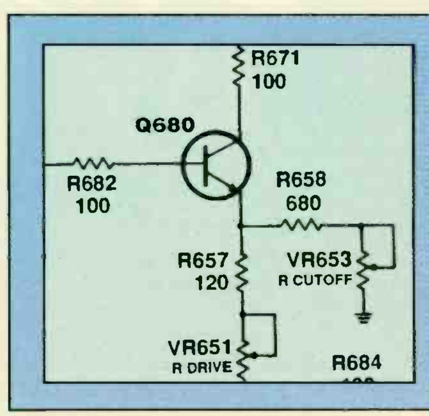

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

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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EDITORIAL

Aha!

As we have said before in the pages of this magazine, consumer electronics servicing is a demanding intellectual exercise. Consumer electronics products are extremely complex, and operate on principles that are only vaguely comprehended by most of us. When a TV, VCR or personal computer malfunctions, the cause of the problem may be quite obvious and simple to pinpoint, or it may be extremely difficult to solve.

As an example of a difficult problem, in the article in this issue "The mystery of the yellow-green bird," the author describes how he was led down the wrong path by some bad information. In other articles that we have published in past issues, authors have described how they worked on a problem on a television set long after they should have put it aside.

Most service procedures on consumer electronics products are relatively straightforward; the symptom points to a particular area of the circuit, a few measurements and the faulty components have been isolated, and then replacement of the faulty components restores the product to proper operation. Unfortunately, a few repairs don't work that way. In some cases the symptom is vague and the cause not easily pinpointed. In some cases it turns out that there were actually a number of faulty components in different circuits all of which contributed to the problem, making the repair exceedingly difficult. There are many other reasons that a repair may be difficult.

Many service technicians make a fundamental error in these cases and continue to work on the problem long after they should have set it aside to let the thought process incubate. Frequently the technician continues to bang away along the same track, certain that circuit area he's working in is the seat of the problem, only to find on further thought that it's actually somewhere else. Or he may find that he's shotgunning the problem, and none of the directions he heads in turns out to be of any help in solving the problem. In some cases, setting the problem aside for a while, or in other cases, turning the problem over to a technician to whom the problem is fresh leads to a solution.

I experience the same type of situation in a word game I play in the daily paper, The Jumble. The game consists of four words whose letters are jumbled up. The object is to unscramble each jumbled word. Some of the spaces in which the unscrambled words are placed are circled. The puzzle solver then tries to arrange these circled letters into a word or words that solve a cartoon puzzle.

Sometimes the solutions to the scrambled words just seem to leap out at you. In some cases all four words are easy to unscramble, and the word or words that solve the cartoon puzzle almost rearrange themselves. In other cases, it's difficult to find the solution.

On occasion I've put the puzzle aside, sometimes for just a minute and sometimes for hours, and then all of a sudden the solution pops into my head. Apparently my mind has been working on the problem while I've been busy doing something else. On other occasions I'll ask a family member if they can unscramble one of the words. On more than one occasion someone else has been able to unscramble at a glance a word on which I've worked at for a long time.

One of the most famous stories in scientific literature involves just such an application of letting the mind work on a problem that has resisted a solution. We've all heard about it.

It goes something like this. Archimedes had been given the task of trying to devise a way to determine the difference between objects that were made of gold, and counterfeit objects that were made of a less precious gold alloy. Both sets of objects looked alike.

Archimedes worked on the problem for a long time with no results. Then one day while he wasn't even thinking of the problem, he sat down in the tub. When the tub overflowed he shouted "eureka," because the solution had occurred to him. Measuring the weight of the volume of water displaced by a vessel in which the object would be placed would prove whether the object was pure gold or not.

That's just the nature of solving problems, either for a living or for fun. Sometimes the solution to the problem seems to just happen, with little or no effort, and sometimes the solution to the problem just will not come.

In the case of problems that are part of someone's job, the work ethic sometimes gets in the way. The technician simply wants to get the work done and get the product off of the bench. But every technician, or service manager, should set a time limit. If a job isn't done within a certain amount of time, quit. Get someone else on the problem, or just let it incubate in your mind.

In most cases, as you know, the solution to the problem will come. Unfortunately, in a few cases nothing will happen. The problem will continue to defy solution. In those cases, give up; give the product back to the owner without charge and an explanation that not all problems can be repaired. It simply doesn't make any sense to continue to waste time working on a product long after any possibility of making money on it has passed.

Nils Conrad Persson

Satellite installer classes

C.S.I. Certified Satellite Installer, classes are scheduled to begin on Spacenet 3, channel 4 starting August 23, 1996.

The NEB*SAT satellite network will be producing three separate technician training courses starting August 23rd and August 30th. The training is free to those who have C-Band reception satellite capability, or viewers can register with Nebraska's Community College System to obtain full semester hour credits.

In announcing the fall schedule, Dick Glass, President of the Satellite Dealers Association, and the Electronics Technicians Association International, said "This is the first time basic satellite installation and servicing training, with full college credit, has been brought to North American tvro technicians. Previous courses offered by Mid Plains Community College, and Central Community College, have been directed towards those already classified as electronics technicians or technicians students.

The C.S.I. Prep course will zero in on dish technology specifically. We expect a large number of viewers since the majority of tvro dealers and technicians do own C-Band systems. Previous technician courses on S3-04 have found hundreds of viewers unable to watch because they did not have access to a dish system."

"Big Friday" will start out on August 23 from the studios of Mid Plains Community College in North Platte, Nebraska. Gordon Koch, CETsr, and Dick Stephens, CET, will produce the classroom presentations from 7:30 PM CST to 10:30 CST for 16 weeks. Following that initial broadcast on August 30th, Central Community College will begin a 16 week series entitled "Applied Electronics Technology." Time for this Friday session is 1:00 PM until 2:30 PM. AET will be presented by Fred Roeser, CETsr, Dana Wert, and Tim Ziller, of Central Community College in Grand Island, Nebraska.

The presentations from Mid Plains will be broken into two separate courses: C.S.I. Prep, and FCC Commercial License Preparation. According to Mr. Glass, the three courses listed here: Applied Electronics Technology, C.S.I. Prep, and FCC Prep, along with the just completed C.E.T. Prep 16 week course, cover training most requested by technicians and installers, can gain college-level training at very little cost and in many cases, do it in their own home and also prepare for CET, FCC or CSI exams.

For those who wish to gain college credit for participation in the satellite courses, contact should be made during June and July with the two colleges:

Mid Plains Community College
Gordon Koch, CETsr
1101 Halligan Drive
North Platte, NE 69101

Central Community College
PO Box 4903
Grand Island, NE 68802-4904
308-389-6431
Attn: Fred Roeser, CETsr

The fee to register for course materials and college credits is $79 for attendees participating from outside Nebraska. C.E.T., C.S.I., and FCC Exams will be taken by a majority of those taking the courses. Exam fees are in addition to the course credit fees.

It should be noted:

The Friday 1PM classes on Spacenet 3-04 are very basic beginner concepts. People with absolutely no electronics training can receive entry-level technical training in electronics during these sessions. Subjects are: Safety and Basic Concepts of Electronics, Electrical Quantities and Components, The Math of Electronics, Ohm's Law, Series Circuits, Parallel Circuits, Series-Parallel Circuits, Cells and Batteries, Magnetism and Eltro-magnetism, DC Measuring Instruments, and Basic AC Quantities. (All coming from Central Community College).

The Preparation for Federal Communications Commission Commercial Licenses (From Mid Plains Community College) will cover all of the questions in the official FCC question pools for Elements 1, 3, 7, 8, and 9. Elements 1 and 3 must be passed in order to qualify for the General Radiotelephone Operators License. Element 8 is required for the RADAR endorsement and Elements 7 and 9 are required for the GMDSS, Global Maritime Distress and Safety System license. No Morse Code study is involved in the satellite course.

The C.S.I. course will include material such as is contained on the C.S.I, examinations sponsored by the Satellite Dealers Association (SDA) and the Electronics Technicians Association. (ETA). These are some of the materials included in the course: Satellite Technology, Dish Alignment, Polarity Principles, Tools and Test Equipment, Troubleshooting Knowledge, Decoder and Programming Concepts, Fixed Dish Concepts, Multiple Receiver Techniques, Actuator Principles, Sensors, Grounding and Safety, and Trenching and Building Entry.

Certification and Licensing examinations ordinarily taken at the conclusion of the courses can be set up at most of ETA's over 350 test sites, any U.S. Military Installation, and special temporary sites such as public libraries. For more information regarding the S3-04 broadcasts and the certification and licensing programs, contact ETA/SDA at: 602 N. Jackson, Greencastle, IN 46135, 317-653-4301, Prodigy: LTAL30A@PRODIGY.COM, or: TDSNETeta@indv.tdsnet.com.

Survey reveals growth of service centers

Are growth and profits in the consumer electronic service industry dependent on the youth of the owner? Probably not, but the results of a survey by the National Electronics Service Dealers (NESDA) indicate a possible correlation. A poll of attendees at the August 1995 National Professional Electronics Convention revealed that service centers with younger owners were generally more successful than those operated by owners who had passed their 50th birthday.

Statistics from that annual meeting revealed that the responding service dealers were equally divided between those over 50 and those under 50. Of the entire group, approximately one-fourth had service revenues of more than $1 million dollars. Yet, the younger group made up almost two-thirds of these million dollar service centers.

The same phenomenon showed in the

employment analysis of these same businesses. The average number of full-time technicians at the younger service centers was 11.5. The older group employed 6.2 full-time technicians per business.

There were other interesting numbers revealed in the survey. The median revenue for all service centers was less than $500,000 per year. This revenue comes primarily from the service of home entertainment products. However there is a significant number of service centers that service computers (42%), copiers (29%), auto sound systems (51%), microwave ovens (76%) and industrial electronics products (27%).

The median technician salary from this entire group was $17.73 per hour for experienced technicians. Beginner technician starting salary averaged $8.81 for all businesses. Benefits offered by more than 50% of the businesses included vacation, health insurance, and education. Life insurance was paid by 31%, 16% family health insurance, and 31% paid for uniforms. Only 11% have a retirement program, and 4% permit profit sharing in addition to salary.

In service operations, 78% require a deposit or charge for estimates. Of total service volume, warranty service accounted for 23% with an additional 15% coming from service contract providers. Of the group, 6% do perform some work for third-party service contract companies, and 89% do some in-warranty service. Warranty rates are generally low, with the best-paying manufacturers offering 84% of carry-in rates, while those at the bottom are paying 49% of carry-in rates.

Equipping a service business can be an expensive proposition. While the median value of their test equipment is $30,000, some ran as high as a $750,000 investment in test equipment.

The next survey of this group will be conducted during the National Professional Service Convention, August 5-10, 1996 at the Regency Union Station, St. Louis MO. Highlights of the week-long convention include management and technical seminars, face-to-face meetings with the National Service Managers of nearly two dozen manufacturers, and annual meetings of the National Electronics Service Dealers Association (NESDA), the International Society of Certified Electronics Technicians (ISCET), the National Independent Appliance Servicers (NIAS), and the Professional Service Association (PSA).

There will be a two-day trade show featuring appliance, computer, and consumer electronics products, service aids, service contract programs, service management software, and test equipment. For more information about the survey or the convention and trade show, contact NESDA, 2708 West Berry, Fort Worth, TX 76109, 817-921-9061, Fax 817-921-3741, or E-Mail iscetFW@aol.com.

Video equipment manufacturers start 1996 with positive sales

Video sales began 1996 with a two percent overall gain compared to the same period in 1995, according to the Consumer Electronics Manufacturers Association (CEMA). TV/VCR combination sets, projection TVs and VCR decks rose a combined 21 percent.

According to Roger Hackett, chief executive officer of Go-video, a CEMA member, the latest sales figures show optimism for 1996. "The industry has steep challenges ahead to surpass any 1995 figures, however with the upcoming summer Olympics and presidential elections, we should be able to reach our goals with new product innovations and high quality standards. As an industry we continue to deliver products at competitive prices. Video products add increasing value to consumers' home entertainment systems."

Sales of projection TVs picked up where they left off in 1995, rising 29 percent in January. Models 55 inches and larger rose 70 percent over January 1995 sales. CEMA expects dollar sales of projection TVs to top $1.7 billion this year, a 17 percent increase from 1995.

Shipments of VCR decks jumped 19 percent in January. Monaural models recorded sales of 540,000, up 20 percent from last year, while dealers purchased 18 percent more stereo VCRs.

Feeding off consistently strong 1995 sales of almost $730 million, TV/VCR shipments climbed 30 percent in January. In the mid- and large-screen segments, sales were up a robust 43 percent. CEMA expects TV/VCR sales to surpass the $800 million mark by the end of 1996.

The direct-view TV market fell nine percent. The 19-inch and 20-inch segments of the market dropped by more than one fourth compared to January 1995, however, sales of 25 inches and larger models were up a solid five percent, supporting the trend that bigger is better with American consumers. With the upcoming summer Olympics and presidential elections, historic boons for consumer electronics purchases, the direct-view color TV market could easily top $7 billion this year in sales. ■

ES&T Calendar

National Professional Service Convention and Professional Service Trade Show
August 5-10, 1996
St. Louis, MO
817-921-9061

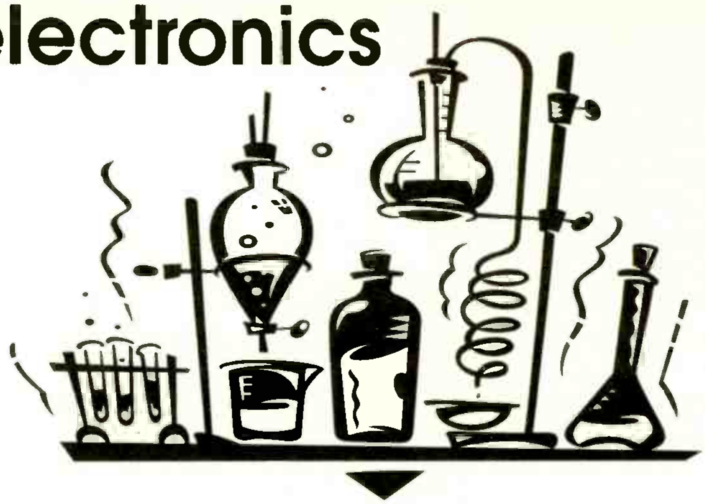
ServiceTech '96: Fourth Annual Conference of Innovation in Services Technology
September 9-12, 1996
Boston, MA
800-333-9786 or 941-275-7887

Eighth Annual Digital Audio & Video Workshop
October 1-4, 1996
Philadelphia, PA
703-907-7674

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

Chemicals in electronics



By The ES&T Staff

In addition to the oscilloscope, DMM, tools and soldering equipment electronics servicing is highly dependent on the use of chemicals. Some of the chemicals used in consumer electronics servicing are obvious: coolant spray, degreasers, cleaners. Some chemicals are less obvious, however.

For example, that stream of smoke that emanates from the tip of the soldering iron as you solder is caused by the melting and burning of the rosin core of the solder, a chemical that is used to remove the oxide from the two metals that are being soldered together.

"In large quantities or in enclosed unventilated spaces, chemicals can cause problems."

There are chemicals everywhere

We take for granted the existence of chemicals, and rarely think about how pervasive they are in our lives. Taking some time to give it some thought is not a bad idea.

Take a look at the service area. Chances are you'll see spray cans of cleaners, lubricants, coolants, flux removers and more. But that's only part of the chemicals you'll be exposed to during a given day. At home, look under the sink, in the basement, in the garage. Chances are there's detergent, bleach, household ammonia, alcohols, turpentine, paint thinner, insect sprays, furniture polishes, and a whole lot more.

Some of those chemicals are dangerous

We're exposed to chemicals every day. Don't forget, for example, the after shave or perfume worn by the individual next to you at work or on the bus. While most chemicals are relatively innocuous in small quantities, in large quantities or in enclosed unventilated spaces they can cause problems.

And while the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) have identified many of the more dangerous chemicals and either restricted their use or banned them outright, there are still many chemicals that can cause health or environmental problems.

What are some of the uses for chemicals in electronics servicing?

Because we tend to take those things that have become familiar for granted, we sometimes don't even realize the role that they play in our lives. Chemicals have a tendency to fall into that category. How often do you turn, grab a can of control cleaner/lubricant and squirt it into a noisy pot without even thinking about it. Here's a list of some of the common uses for chemicals in electronics servicing.

- Cleaners
- Coolant sprays
- Adhesives
- Conductive inks
- Insulating overlays
- Conductivity enhancers
- Deoxiders (soldering flux)
- Lubricants (oil and grease) oil rotating parts, grease sliding parts
- Clean/recondition typewriter/printer platens and rollers
- Clean/destaticize TV/monitor screens

Use the right form of the chemical

Electronics servicing chemicals are available in a variety of forms. You'll get the best results, spend less money, and cause the least adverse impact on the environment, both your immediate environment and the greater environment outside the walls of your service center, by using the best form for the particular job.

Here are a few of the forms in which you'll find servicing chemicals:

- sprays
- liquids
- saturated wipes
- magic marker type products

When the problem is a bit of dust or cat hair in the mouse of someone's personal computer, for example, it makes more sense to apply a little cleaner to a foam swab and wipe it over the moving parts rather than to spray the innards of the mouse, wipe off the excess and wait for it to dry.

Some of today's chemicals

Because of the negative impact on the environment or their danger to humans, a number of the chemicals that have been most effective in cleaning electronics products and cause the least amount of damage to any of the components in the product are no longer available because of laws that have been passed banning their use. Well-known examples of this are chlorinated fluorocarbons (CFCs) and trichloroethane.

However, chemical manufacturers have devised an arsenal of products that will do more or less the same job as the chemicals that have been banned, and with less harm to humans or the environment. Here are some examples of those replacement products.

- Perfluorocarbons. These solvents are ozone-safe, dry fast and are safe for use on plastics. They are expensive, however, and not the best of solvents. They are frequently blended with other chemicals, such as HCFCs or terpenes.
- Alcohols and alcohol blends. Alcohols are excellent cleaners. Isopropanol

and ethanol are the two alcohols that have good handling characteristics and are relatively non-toxic, so that they are useful in servicing. They are inexpensive and relatively safe for use on plastics.

Alcohols are flammable so care must be taken. Another problem with alcohols is that they are hygroscopic, that is, they absorb moisture from the air, so they must be kept tightly closed. By the way, that alcohol in the medicine cabinet is a very dilute mixture of water and alcohol, and so is not useful on the service bench.

• Hydrocarbon blends. These are products derived from petroleum. They provide good cleaning, especially of fluxes, grease and some inks.

• Terpenes. These are chemicals that are produced by all green plants. One of the sources of these chemicals is citrus. Some of these products have a pleasant aroma of orange. They can remove fluxes, oils, tape adhesives and some conformal coatings. Terpenes may leave residues, or have other drawbacks.

This is only a sampling of the many chemical products that are available for the consumer electronics service center today. See your distributor or chemical supplier for other choices and more details on their characteristics.

Exercise care

While most of today's chemicals are relatively safe in low concentrations, chemicals are still hazardous. Alcohol burns, and some types of hydrocarbons are flammable under certain conditions. Liberal use of chemicals, even those generally considered safe, in enclosed spaces without ventilation can lead to unhealthy concentrations.

If the ventilation in your service area doesn't seem to be up to snuff, check into some of the options for getting rid of noxious fumes. There are systems that can vent fumes outside, and systems that can remove materials from the air and recirculate them.

And just as important, for the health of everyone in the service center as well as for the environment, use the least toxic and aggressive chemicals you can get away with, use chemicals carefully and sparingly, and in the most efficient, effective, form for the particular use. ■

How to design and build a POST code reader—Part 2

By Harvey K. Schwertly, CET

Note from the editor: The POST code reader described in this second part of this three part article which first ran in the June issue, is a fairly rigorous project and we don't recommend that it be attempted except by those readers who are advanced circuit builders who are well-versed in computers and digital logic. We have published this article because it was felt that even if an individual does not choose to build the POST code reader circuit described, the material in the article provides an excellent introduction to POST codes and the devices that are used to read and display them, as well as an excellent introduction to programmable logic devices, which are frequently encountered during servicing of consumer electronics products.

This is the second part of a three part article that provides details on the function, design and construction of a POST code reader card. The first article covered the PC booting process, provided a list of some of the other POST readers that are on the market and described designing a different PAL for decoding all of the DIAGNOSTIC POST ports on the PCs.

This article segment covers programming a PAL (programmable array logic) chip to convert binary data from the personal computer data bus to hexadecimal numbers on a seven-segment display using the proLogic compiler from TI (Texas Instruments). This installment will cover the construction of the board and add features that would constantly monitor the four power signals on the board with LEDs and an LED to show the status of the reset pin.

TRUTH TABLE

Data	Segments	Display
D C B A	a b c d e f g	
0 0 0 0	H H H H H H L	0
0 0 0 1	L H H L L L L	1
0 0 1 0	H H L H H L H	2
0 0 1 1	H H H H L L H	3
0 1 0 0	L H H L L H H	4
0 1 0 1	H L H H L H H	5
0 1 1 0	H L H H H H H	6
0 1 1 1	H H H L L L L	7
1 0 0 0	H H H H H H H	8
1 0 0 1	H H H L L H H	9
1 0 1 0	H H H L H H H	A
1 0 1 1	L L H H H H H	b
1 1 0 0	H L L H H H L	C
1 1 0 1	L H H H H L H	d
1 1 1 0	H L L H H H H	E
1 1 1 1	H L L L H H H	F

Figure 1. This is the truth table for a binary to seven-segment display.

Programming the PAL

The object was to design a PC board to read and display the power on self test (POST) codes that the BIOS (basic input/output system) emits during the boot up process. Knowing what step in the boot-up process the computer was in when it failed is a great help when it comes to troubleshooting hard down computers and repairing them.

In building this circuit, the first problem that I ran into was that there was a shortage of hexadecimal displays, and the ones that I found lacked any documentation. Moreover, the cost was about ten dollars per chip. I decided to program my own chips for about two dollars a chip. This article details how I went about programming the chips.

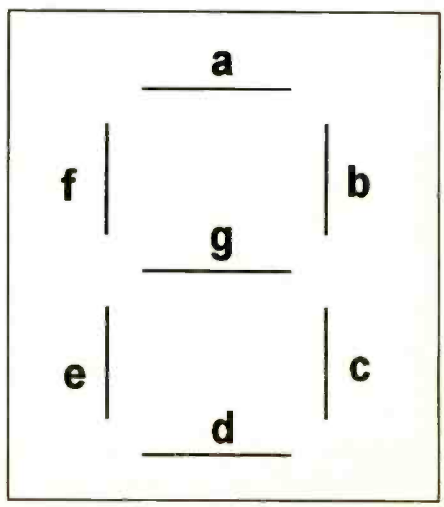


Figure 2. This is a representation of a seven-segment display.

Schwertly is a digital systems technician, designer and instructor.

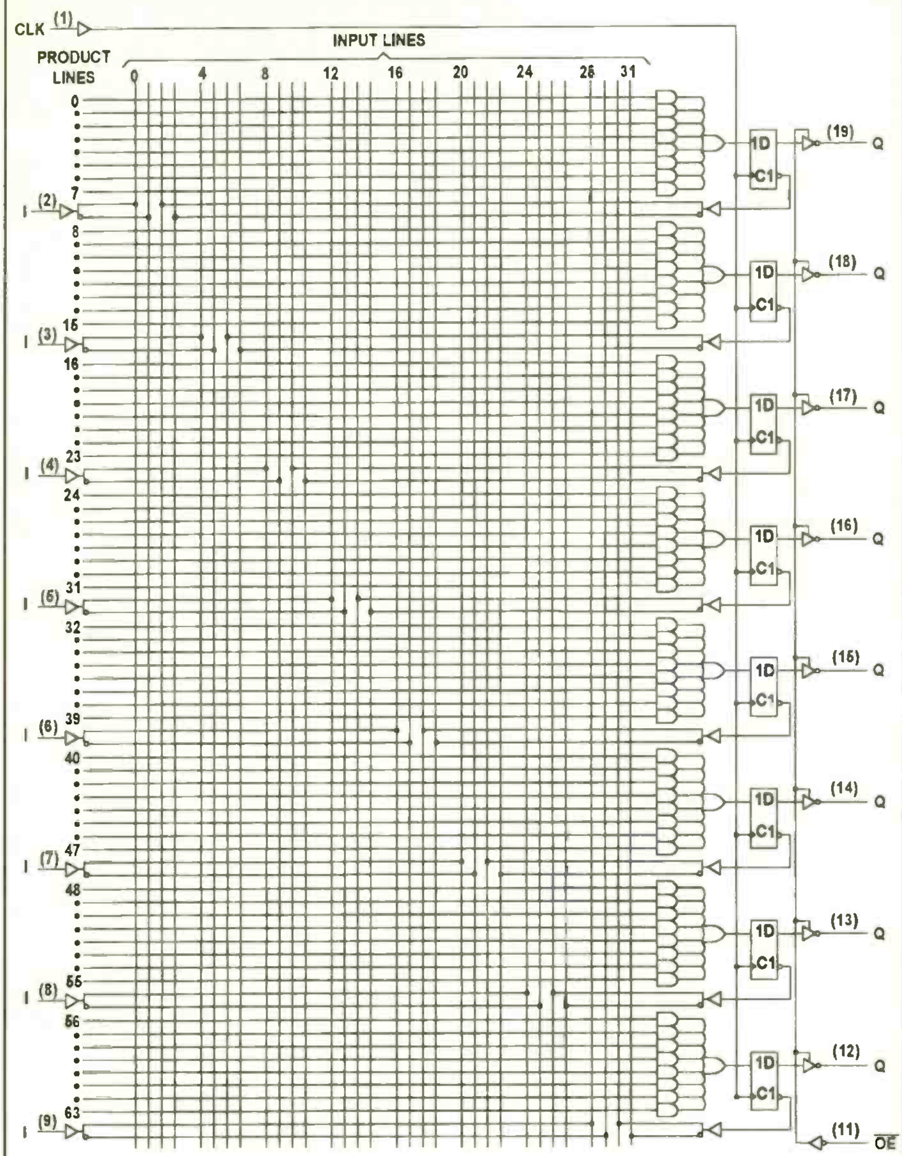


Figure 3. This is a logic diagram representing the PAL16R8. This device is a Programmable Array Logic with 16 inputs (each of which can be either a low or high making the 32 input AND gates) and 8 register outputs active low.

The first step was to set up a truth table and select the PAL chip that fits the table. The next step was to write the equations and put Xs on each connection that was not to be destroyed by the PAL programmer. This ensures that the chip fits the requirement. The next step is to write a program in ASCII (American Standard Code for Information Interchange). For this step, use a text editor so that the program does not imbed any of its code into the program. Finally, using a compiler, compile the code and perform a simulation to ensure that the code is correct.

Developing the truth table for hexadecimal display

The object of the following procedure is to develop the truth table for the seven-segment hexadecimal display, so that it will display digits 0 to 9 and letters A to F from the DATA BUS on a PC. This requires two chips: one for the LSD (Least Significant Digit) and one for the MSD

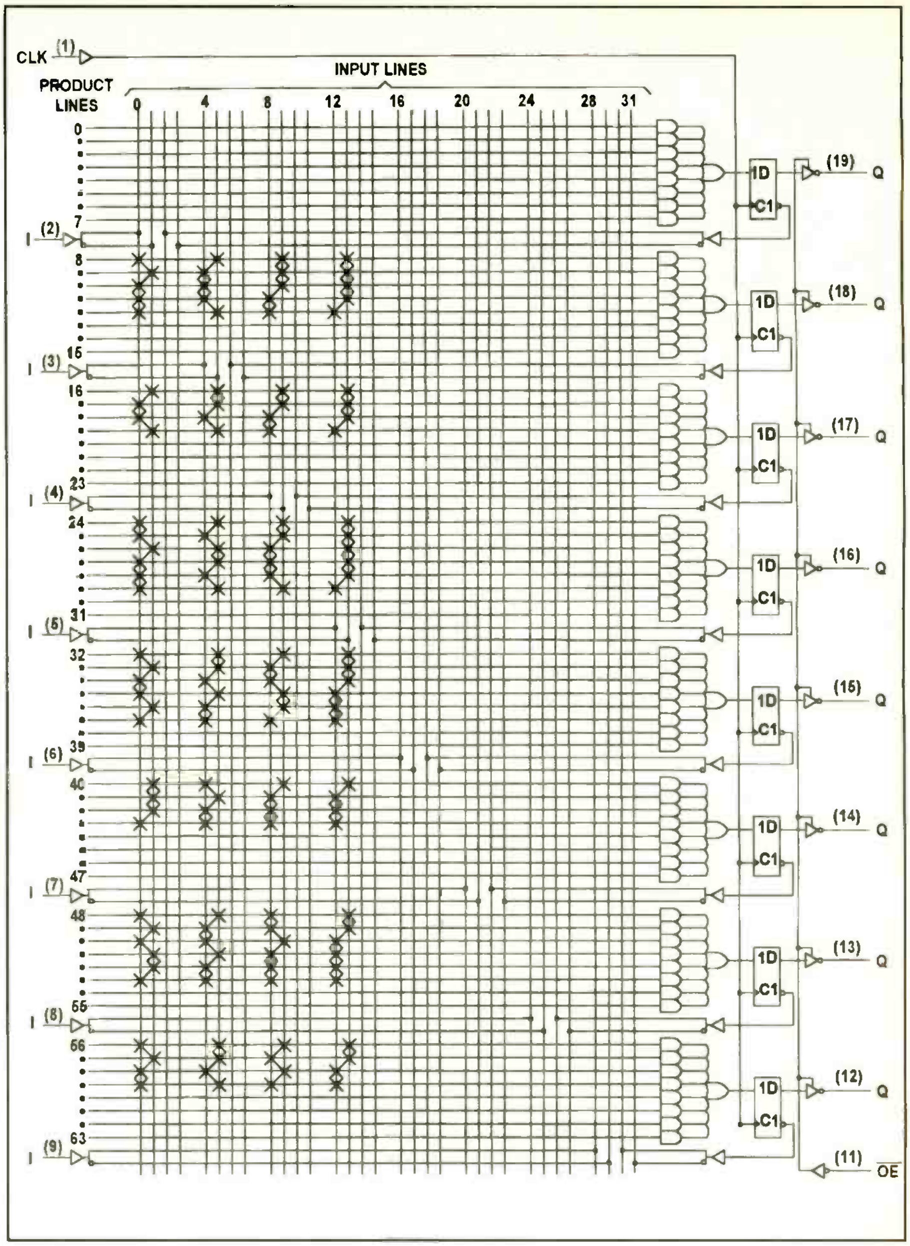


Figure 4. This is a logic diagram of the PAL16R8 which has the logic for a binary-to-seven-segment decoder X'ed out.

(Most Significant Digit), thus giving us from 00 hexadecimal to FF hexadecimal, or 256 combinations or tests.

The truth table for the binary to seven segment display is shown in Figure 1. Figure 2 is a representation of the seven-segment display. The data is binary from 0000 to 1111, and the segments display the number using the high values. I used a common-cathode display.

As an example, the seven-segment display will display the number 3 if the segments a, b, c, d and g are illuminated. Take a look at the column under the heading DISPLAY in Figure 1. To the left of the number 3, you can see that in order to display this numeral the segments a, b, c, d and g must receive a data high from the appropriate decoder.

Equations for programming the PAL

To write the equations that will be used to program the PAL, write down the data inputs for the low conditions for each segment. The reason for using the lows is that there are fewer lows than there are highs, so the formulas will be smaller. Another reason is that we are writing for the lows so

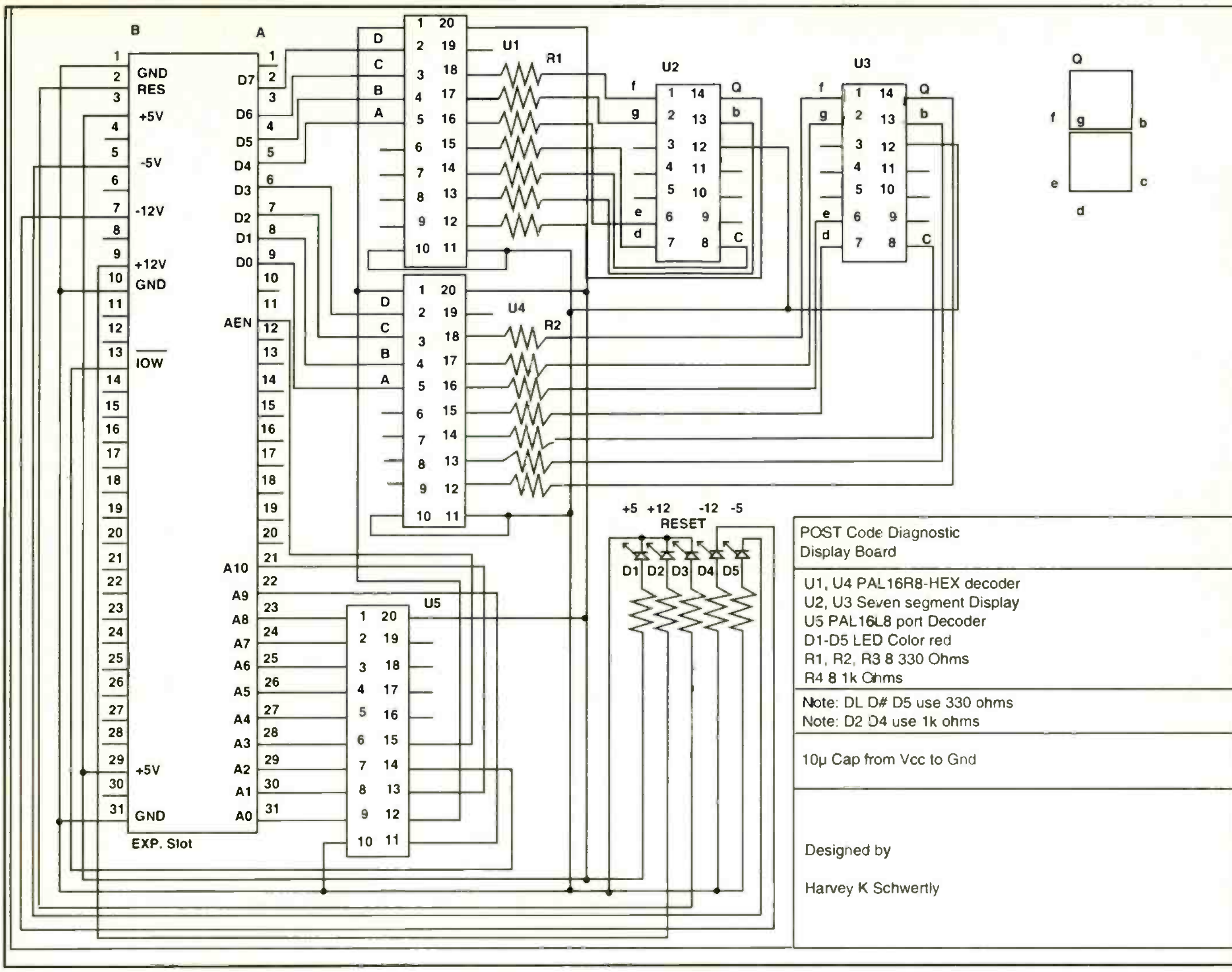


Figure 5. This is a schematic diagram of the POST code reader that I designed and fabricated. The layout of this diagram is similar to the physical layout of the board.

if that condition is a high it will light the LED, which is what we want.

If discrete chips were to be used we would need approximately 45 chips for each display. Using a PAL reduces chip count, cost, and board space.

Let's look at the process for segment "a" of the seven-segment display. Under the heading "SEGMENTS" in Figure 1, locate a. Read down that column and each time you encounter an L, read the digits under the "DATA" column. You'll find that:

a = 0001 + 0100 + 1011 + 1101

Now we will assign SEGMENT a of the seven-segment display to pin 12 of the PAL, DATA D to pin 5, DATA C to pin 4, DATA B to pin 3, and DATA A to pin 2. After that we will write the equation for a segment to use in the compiler and the Universal Programmer, we will do this for each segment.

We will do the first part of SEGMENT a:

a = 0 0 0 1

pin12.d = !D & !C & !B & A

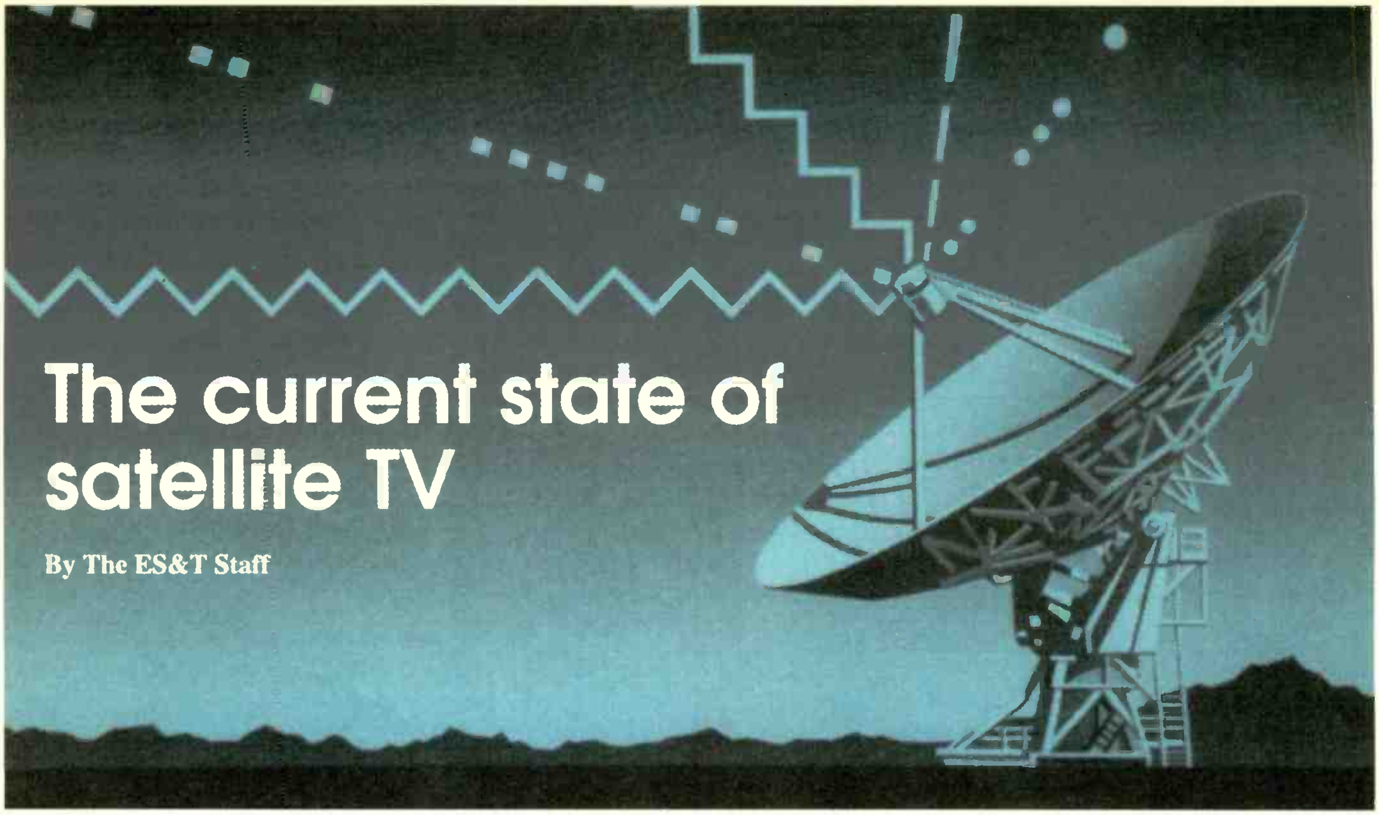
Here is the entire equation for segment a =

pin12.d = !D & !C & !B & A | !D & C & !B & !A | D & !C & B & A | D & C & !B & A.

Now write the equations for the remaining segments or compare them with the HEX.PLD file. I selected the PAL-16R8 (Figure 3), Programmable Array Logic with 16 inputs (each of which may be either a low or high making the 32 input AND gates) and 8 register outputs active low. Figure 3 is blank for your use. I suggest making extra copies to save you from erasing all the time.

First, we will take a copy of the logic diagram and put Xs where we want to keep those fuses intact. Moreover, we want to make sure that our truth table will fit on the selected PAL, otherwise if it did not fit we would have to select another PAL. Refer to Figure 4 which has the logic X'ed out on the diagram. The schematic for the completed POST reader card is shown in Figure 5.

The third part of this article will cover the details for writing the program for the PAL. ■



The current state of satellite TV

By The ES&T Staff

Satellite TV, which began with TVRO (TV receive only), is beginning to mature. Now, in addition to the "free" unscrambled signals available from a number of sources, as well as scrambled signals that TVRO offers, there are two systems that were designed for direct delivery of television signals from satellites to homes. These systems are called direct broadcast satellite systems, or DBS.

In the case of TVRO, originally, the signals intercepted were not really meant for consumption by individuals. They were signals such as network news feeds, sports feeds and things like cable TV movies. Many of the signals available at that time were intended for local free television broadcast, but some were intended to be delivered to a paying audience.

For a while, TVRO was an earthly video paradise. Then the skies "went dark." The providers of a great deal of the available programming scrambled their signals. Of course that left a lot of free programming still available on satellite, but the free movies came to an end.

Because of the nature of the signals, and the variety of satellites via which programming is provided, TVRO systems are characterized by large dish antennas, typically 6 to 12 feet across, and actuators that are required to move the dish so that it can be aimed at a number of different satellites.

A lot has changed

The frontier days of TVRO are over, but it still continues to do just fine. Many viewers are happily watching the free programming that is still available on those satellites. Many more are now somewhat less happily paying to watch their favorite movies and other premium programs that emanate from the same satellites. Many watch both.

Now there are satellites that carry only signals that are intended for a paying audience. These types of signals have been featured in the news and advertising recently. This article is intended to provide some basics of today's satellite TV to readers who may not be familiar with the newer systems.

DBS

Direct broadcast satellite (DBS) consists of television that is intended for broadcast directly to consumers. There are no news feeds, sports feeds or network TV feeds. All of the programs are intended for individual TV viewers. Moreover, the antennas are smaller and they are fixed. All of the DBS programming for a given system comes from a single satellite, or from multiple satellites located in the same area of the sky. All of the signals are scrambled so that a descrambler is required at the receiving location. There are two distinctly different types of DBS systems: the Primestar system and DSS (digital satellite system).

Primestar

The Primestar DBS system requires a parabolic dish at the receiving site of about three feet in diameter. The signals are broadcast in the frequency range known as the Ku band. Primestar signals are analog TV signals. There are currently about 70 channels available via Primestar, and more additions are planned.

The customer does not purchase the receiving equipment. It is leased as a part of the monthly cost of the system. There is, however, a one time installation charge to the customer.

DSS

The digital satellite system requires only an 18-inch dish at the customer location. In the case of DSS, the customer buys the reception equipment, and may install it himself, or have an installer do it for him. Unlike the other satellite technologies, DSS is digital.

The DSS system consists of the dish antenna, a digital integrated receiver/decoder (IRD), which separates each channel, and decompresses and alters the signal so that it can be used by a TV set, and a remote control.

The provider of the signals for DSS is DirecTV. Programming for this system is via three satellites built by Hughes Electronics. These satellites, designated DBS-1, DBS-2 and DBS-3, are located together in one area of the sky. Each of these satellites transmits television signals via 16 120W Ku-band transponders.

Providing the motion picture digitally

The DSS system uses a method of delivering the digital signal called MPEG-2 technology. MPEG stands for the motion picture experts group. The MPEG technology allows the broadcaster to compress the motion picture image so that is can occupy much less space than would the uncompressed image. The DBS-2 and DBS-3 satellites can transmit images at around 30Mbits/sec.

The DSS receiver systems

At present, RCA and Sony offer DSS systems to consumers. Other manufacturers are expected to introduce similar systems soon.

The new meaning of home entertainment electronics

At one time, not too long ago, home entertainment electronics meant little more than music coming from a radio that had little of the depth and quality of the original, and a monochrome TV that brought news and entertainment into the home through a cloudy window. Today, audio and video equipment bring that same news and entertainment into the home with almost complete fidelity to the original source.

Direct broadcast satellite, home theater and concert hall audio are a reality. High-definition TV is on the horizon. All of these products will provide new opportunities and challenges for consumer electronics service. ■

Switching power supply theory and troubleshooting

By Steven Jay Babbert

The use of the switching power supply, sometimes referred to as switched-mode power supply, or SMPS, is becoming very popular in the design of "high-end" television sets. Though the basic principles of operation aren't terribly complicated, typical designs generally utilize a host of support devices. The resulting complexity has been a source of frustration for more than one technician.

In this article we will look at the fundamentals of switching supplies. Some of the less familiar devices they often use such as MOSFETS and opto-isolators will be discussed. And finally, we will look at the switching power supply of a late model Magnavox TV.

The transformer

The heart of the switching power supply is the transformer. Transformers were used in older TVs to convert the ac line voltage into various higher or lower secondary ac voltages. These voltages were then rectified as needed before being applied to their respective circuits or "loads."

Transformer supplies worked well and were relatively efficient in terms of power transfer. In many cases this efficiency approached one hundred percent; almost no power was wasted by the transformer in the conversion of "primary" voltage to "secondary" voltage. Furthermore, since any number of secondary voltages can be obtained via taps at various points along the secondary winding, resistive voltage dividers weren't needed. These dividers, which are used to derive numerous voltages from a single dc source, waste power.

Many of the transformer designs were self-regulating. Based on the nonlinear properties of saturated cores, the transformer was designed so that the core would saturate at a voltage somewhat below the 120V line level. When the core becomes saturated it won't support additional magnetic flux, hence increasing the input voltage won't increase the output voltage. Consequently, the output voltage will remain fairly constant over a range of input voltages.

Power-line transformers were eventually eliminated from the power supplies of most TVs because of their size, weight and the cost of construction materials. Without the isolation provided by the insulation between the primary and secondary windings, the chassis of sets powered by bridge-rectifier type power supplies became "hot." These chassis present a potentially lethal hazard to service personnel and a potential cause of component damage if an external isolation transformer isn't used during servicing.

Semiconductor based voltage regulators were pressed into service with varying degrees of success. Designs were improved over the years and efficiency was increased, but the transformer continued to have certain advantages. The fusion of these two technological concepts has proven to be the key to overcoming the problems inherent in each.

Reducing transformer size

In theory, if the frequency of the input voltage is raised, the physical size of a transformer can be reduced while main-

Babbert is an independent consumer electronics servicing technician.

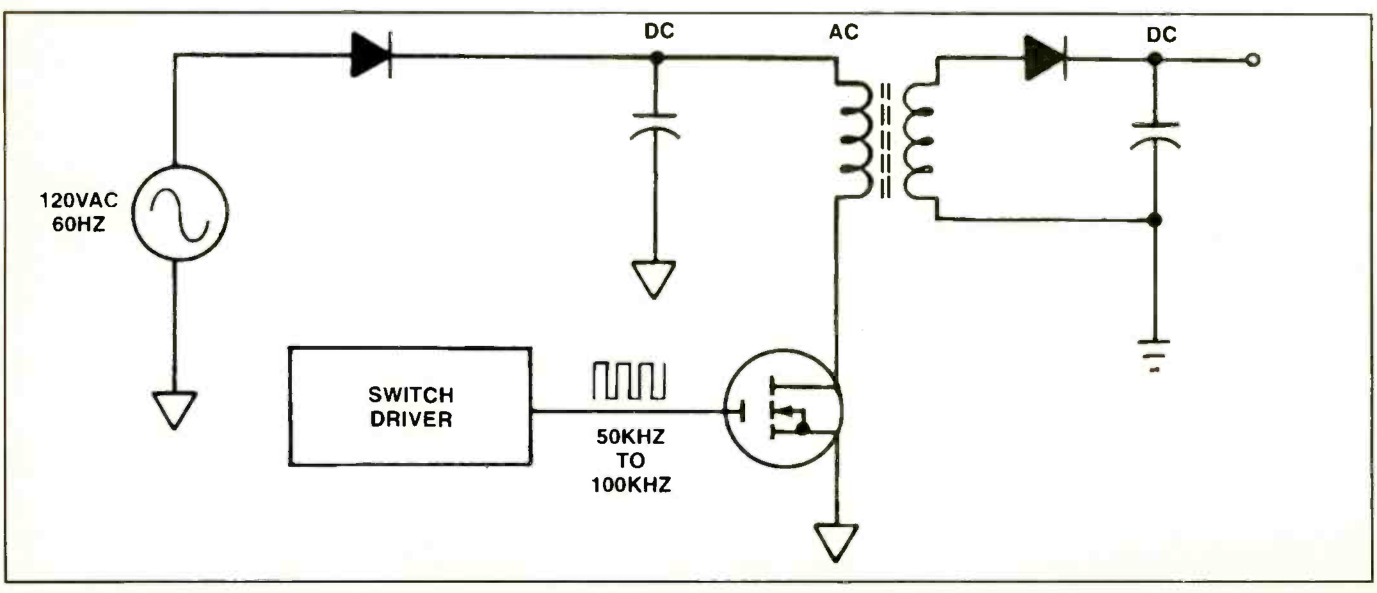


Figure 1. This figure shows the three-step conversion process used by switching power supplies: ac is converted to dc, then the dc is converted back to the ac of a higher frequency, then this ac is converted back to dc.

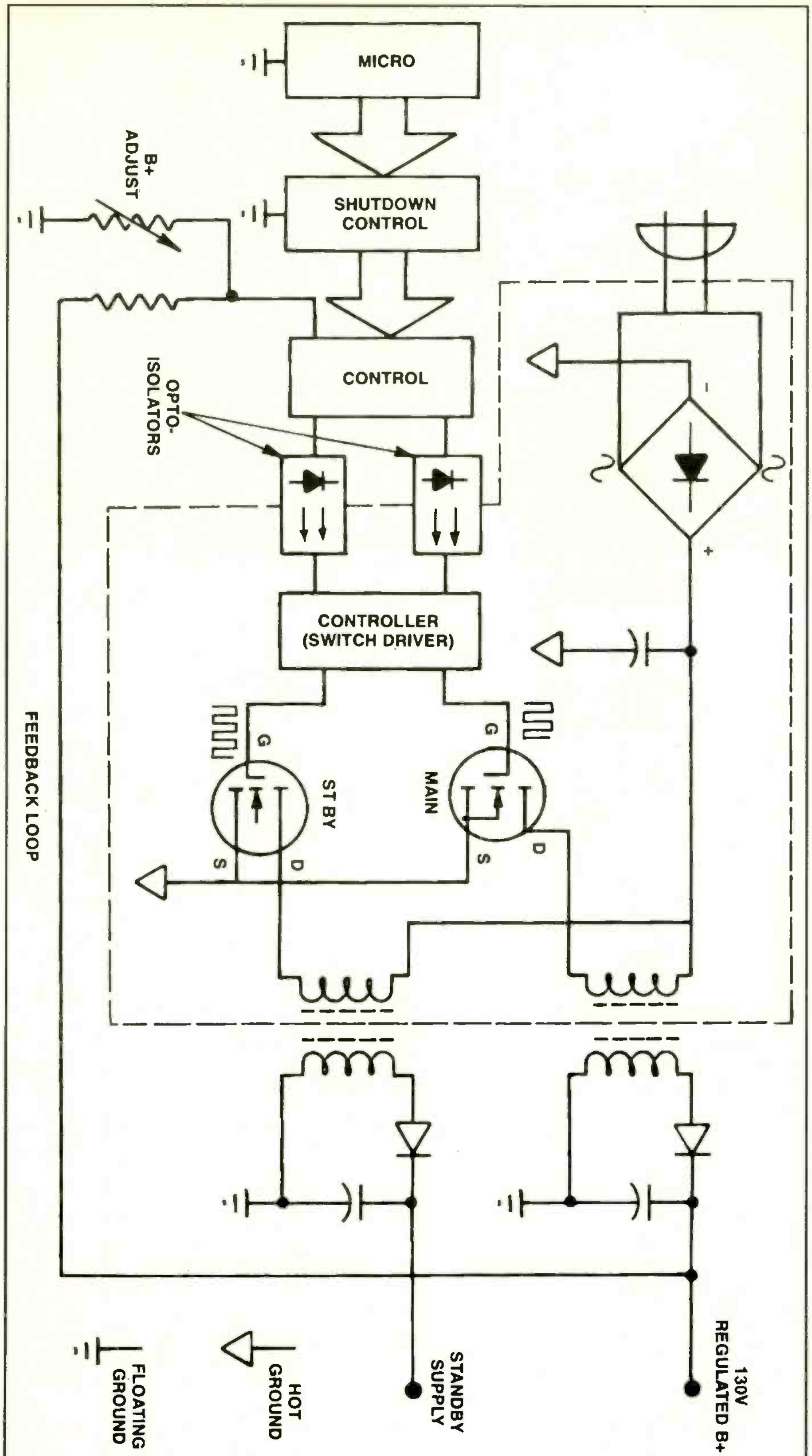


Figure 2. This block diagram shows how the chassis is isolated by the use of opto-isolators and transformers. Components within the boxed area have a "hot" ground.

taining the same power transfer. In practice, this creates problems such as core heating due to eddy currents (circulating current within the core material). This problem can be eliminated by using ferrite as the core material. Ferrite has the same magnetic properties as iron, but doesn't allow eddy currents to flow.

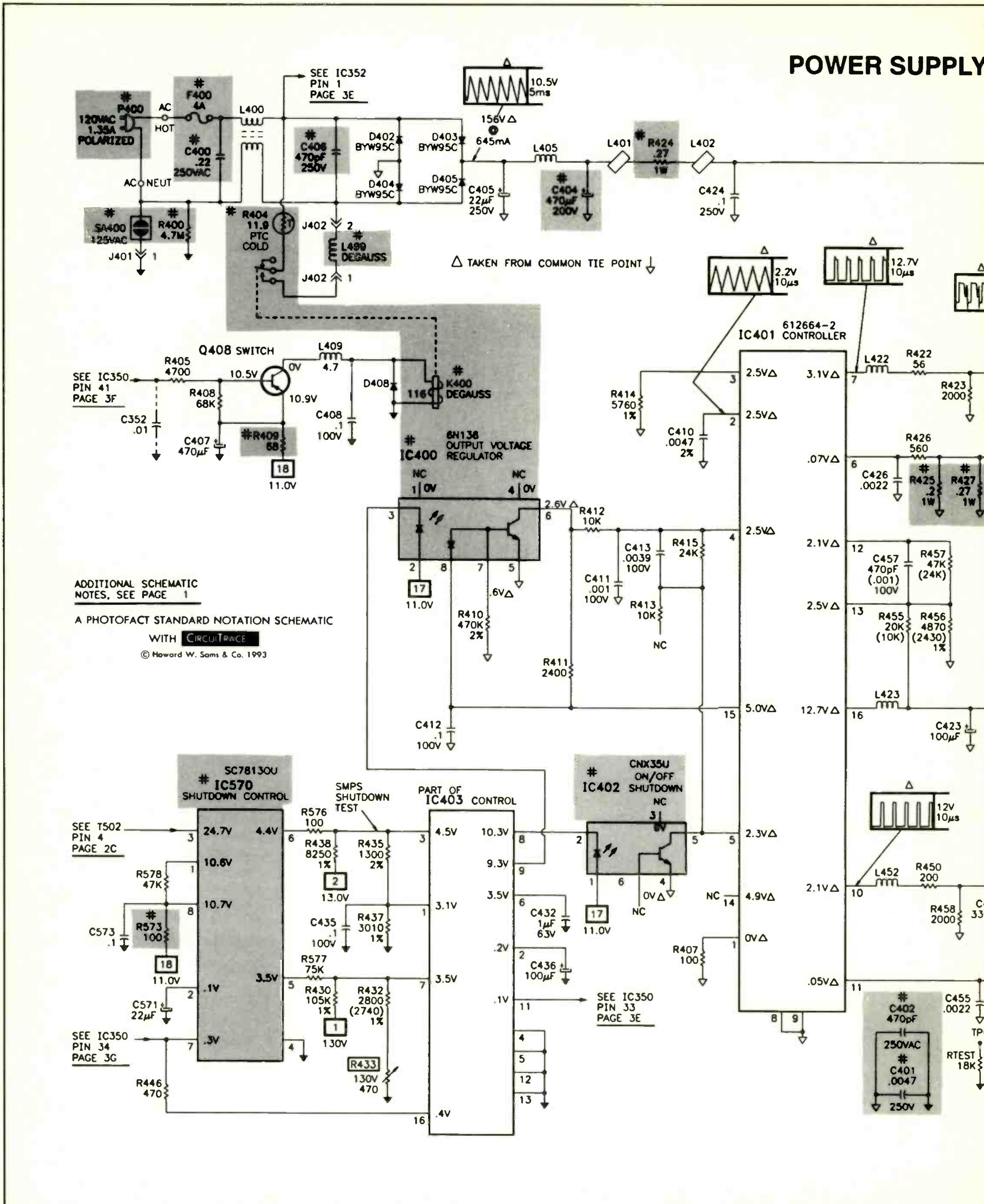
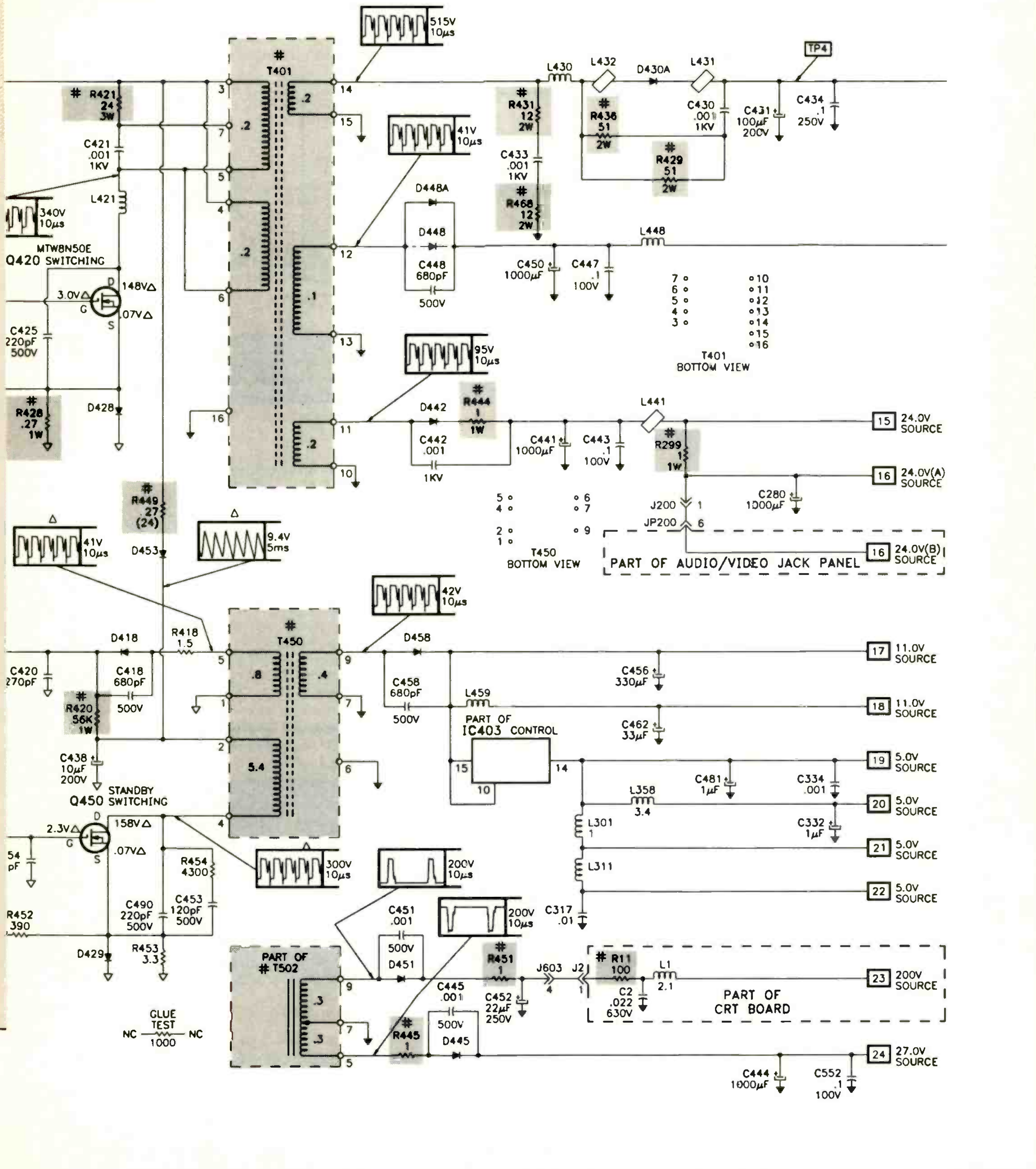


Figure 3. The switching supply used in Magnavox chassis 31X103, 31X303 is very complex compared to the non-switching supplies used by most television sets.

SCHEMATIC



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Opto-isolators

Opto-isolators are used in electronic equipment to interface control circuits to the circuit being controlled without using an electrical connection. In most cases, the circuit being controlled uses a higher voltage than the control circuit. If conventional interconnecting devices are used and become shorted, the higher voltage could be passed to the control circuit causing extensive damage.

A by-product of some types of semiconductor action is "photon" or light emission; conversely, semiconductor action can be produced when specially designed devices are exposed to light. Opto-isolator operation is based on this principle of light sensitivity.

The most basic opto-isolator has a single infrared LED on the input side and an NPN transistor on the output side. The transistor is specially designed so that the light from the LED will penetrate into the base region. The LED and transistor are separated by a clear resin with a very high breakdown voltage.

When the LED begins to emit light in response to an applied voltage, the transistor will begin to conduct. If the light intensity is increased enough, the transistor will saturate, in effect acting as a closed switch. In this example, the opto-isolator behaves essentially like a single junction transistor, but instead of applying the drive voltage directly to the base it applies it to the anode of the LED. By modulating the drive signal, the opto-isolator can be made to pass or even amplify an electronic signal.

If a shorted component in the output circuit passes a high voltage at the opto-isolator, the transistor might be destroyed but the LED and input circuitry will be unharmed. The opto-isolator will have to be replaced but the more expensive control circuit components will have been spared from any damage.

The most common opto-isolators come in DIP (dual in-line pin) packages having four to eight pins. Eight-pin packages often contain two input/output pairs. Opto-isolators are also available that use FETs, SCRs, DIACs (triac drivers) and more instead of, or in conjunction with, the output transistor.

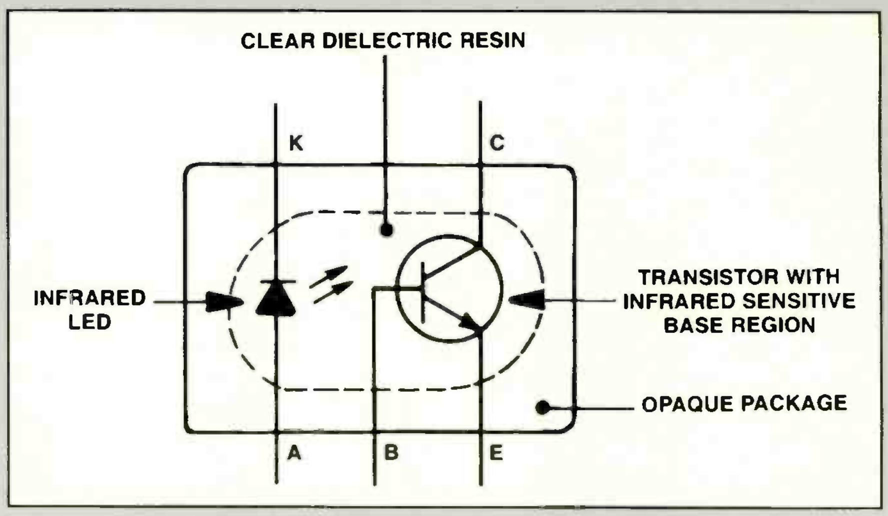


Figure 1. The clear resin isolated the input from the output. If the base lead is brought outside of the device, the transistor can be tested.

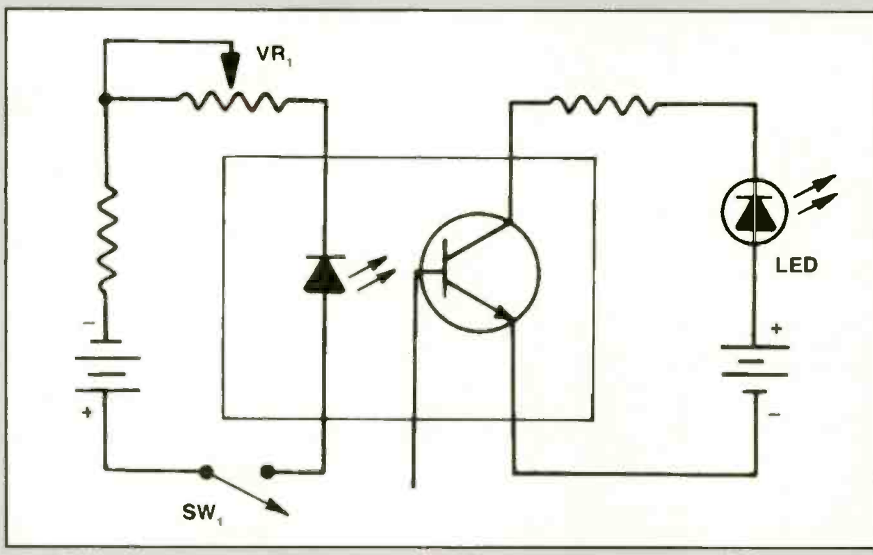


Figure 2. When SW1 is closed, LED1 will turn on. The brightness of LED1 can be controlled by adjusting VR1.

Transformers are more efficient when the power signal is a square wave than when it is a sine wave, because of the greater rate of change of square waves (many cable TV systems use square-wave ac to power line amplifiers, etc.). By converting 60Hz ac sine wave voltage to 50KHz ac square-wave voltage, the transformer needed to power a typical TV chassis can be reduced in size to about one cubic inch. In contrast, many techs will remember the "mammoth" transformers used in early solid-state chassis.

High frequency ac has an additional advantage when it comes to "ripple" filtering after rectification. Because the charge on the filter capacitor is refreshed more frequently, the capacitor doesn't need to store as much charge per cycle in order to maintain sufficient charge between cycles. In this case, smaller electrolytics can be used. This is the same reason small electrolytics are used to filter

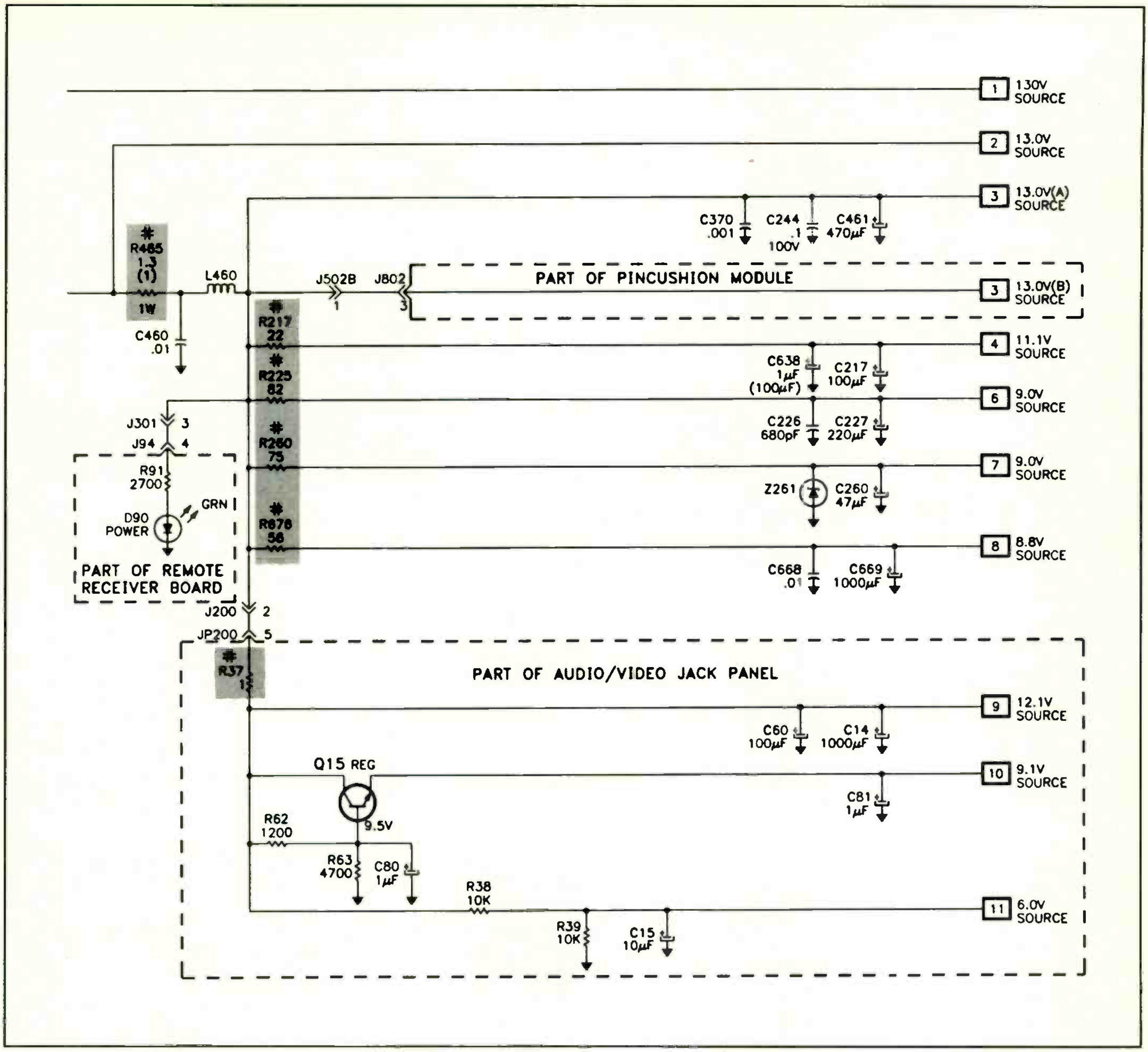


Figure 3. (Continued)

IHVT (integrated high-voltage transformer, or flyback) secondaries (over 15KHz).

Three-step conversion

Switching supplies use a three-step conversion process (Figure 1). The first step is to convert the ac line voltage to dc (raw B+) by using a full-wave bridge rectifier. This dc is then applied to one side of a transformer's primary winding. The other end is connected to a switching device; usually a MOSFET, (metal-oxide-semiconductor field-effect transistor).

When the "switch" is on, the dc current flows to ground. When it is off, current is interrupted. Since the inductance of the transformer opposes the change in current when the switch is switched on, it presents a high impedance path until the magnetic flux is fully established. At that point only the low resistance of the transformer winding will limit current flow. Since such a condition can't be allowed to exist, the switch must be turned off at the appropriate time.

If the switch is turned off before the flux is fully established, the output voltage won't reach maximum. Therefore, by adjusting the duty cycle, the output voltage can be varied. The switch is driven by a rectangular pulse train from a driver circuit. The switching of the switch caused by this pulse train results in rectangular ac pulses in the primary winding and, due to transformer action, similar pulses in the secondary winding.

As with any transformer, the output voltage will depend on the ratio of the number of turns in the secondary to the number of turns in the primary. This output voltage is then rectified into dc. Scan-derived voltages from the flyback (IHVT) are produced in a similar manner, but in this case, the horizontal output transistor acts as the switch.

Overview

Let's look at a block diagram of a switching supply in a Magnavox chassis 31X103, 31X303 (Figure 2). This supply uses two separate transformers; the main

MOSFETS

The MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) is used almost exclusively as the "current switch" in switching power supplies. Since MOSFETS are a form of transistor, they can be used to amplify a signal; however, they have features that make them especially suited to high-speed switching applications.

Like the JFET (Junction FET) from which they evolved, they rely on an electric field to control current flow. Bipolar junction transistors use current injected into the base region to control current flow. In FETs, an electric field alters the cross-sectional area of the conductive channel between the source and drain regions to control current flow.

The MOSFET differs from the JFET in that the gate is insulated from the channel by an oxide layer. Since no current flows through the oxide, MOSFETs present an extremely high impedance to the input circuit. This oxide layer is static sensitive and therefore handling precautions must be taken.

In MOSFETs, the oxide layer acts as the dielectric of a capacitor while the metal gate and the silicon substrate act as the two parallel plates of the capacitor. The electric field resulting from an applied gate-to-source voltage (the source being tied to the substrate) causes the charge type of the substrate to invert in the area near the oxide layer.

In an N-channel enhancement-mode MOSFET, application of a positive gate voltage will form an n-type channel between the source and drain n-type semiconductor regions. If this channel ismade wide enough, the device will be turned fully "on", allowing current to flow freely. Once the gate voltage is removed, the channel will revert to its former state (p-type).

P-channel devices are also made, though N-channel devices are faster. This is because the mobility of electrons, (the charge carriers in n-type material), is about three times that of holes (the charge carriers in P-type material). PMOS and NMOS are available in both enhancement-mode and depletion-mode types. In the former, the channel is formed by the application of the gate voltage; in the latter the channel exists without gate voltage and is eliminated when a gate voltage is applied.

The "on" resistance of the MOSFET is lower than that of the bipolar transistor. This translates to a lower voltage drop across the device and less heat generation for given current. Furthermore, MOSFETs don't have "recovery delays" which are an inherent problem in bipolar transistors. These delays limit switching speed.

Though MOSFETs don't draw current from the driver circuit, they do require a relatively high gate-to-source voltage for a "solid" turn-on. This voltage is about 12V. Bipolar transistors require only about 0.6V. This usually doesn't cause a problem unless the device is being used in a circuit using a supply of less than 12V.

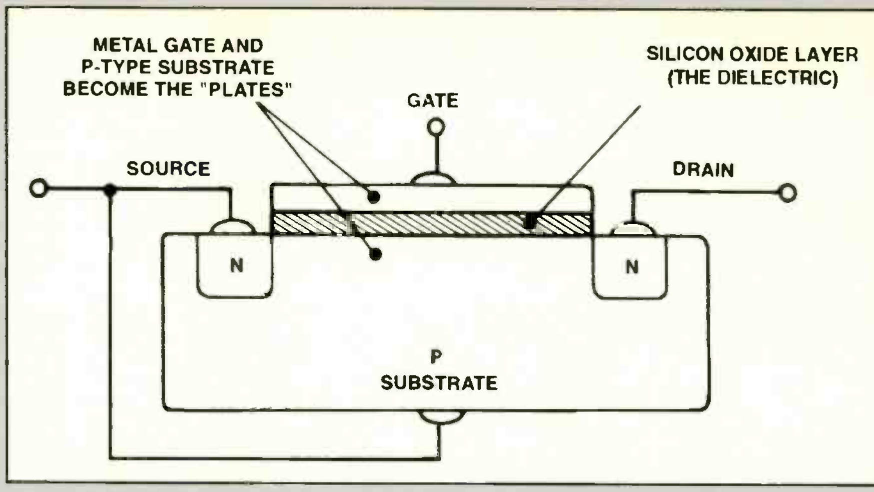


Figure 1. This is the basic N-Channel enhancement mode MOSFET without applied voltage. No current will flow between the source and drain under these conditions.

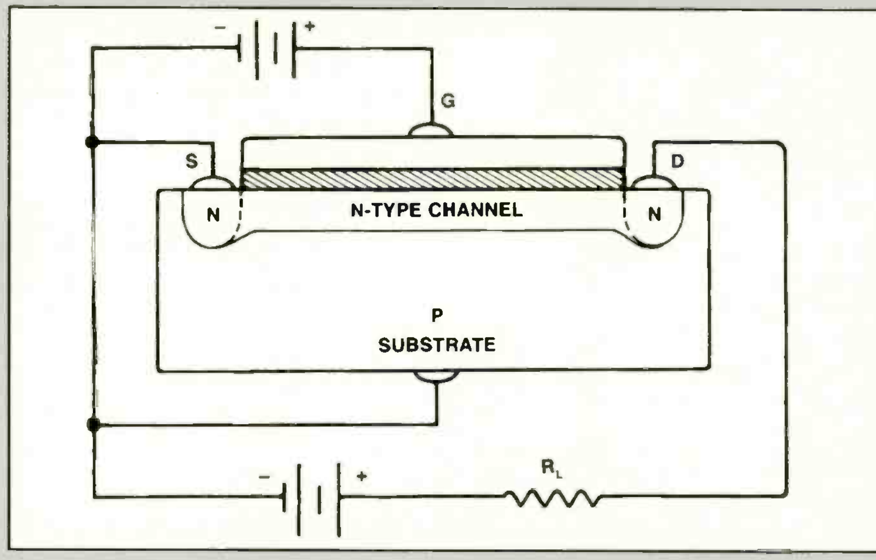


Figure 2. With applied voltage, the substrate material along the oxide layer is inverted to the N type, forming a conductive channel.

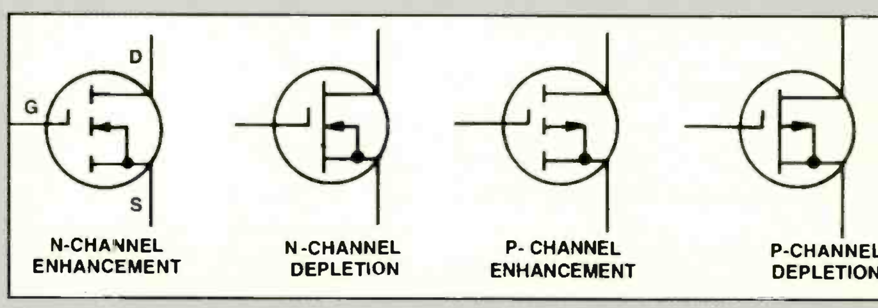


Figure 3. These are the schematic symbols for the four main MOSFET types. Of these, the N-Channel enhancement mode is the most commonly used.

transformer supplies the voltage for the horizontal output circuit and the standby transformer supplies any circuits which must be kept "alive" when the TV is off. Each of these transformers has the high side of its primary tied to the raw B+ line and its low side tied to the drain of an N-channel enhancement mode MOSFET.

These MOSFETs get their drive signals from the controller IC. These signals consist of pulses with a frequency of about 50KHz. The amplitude is about 12V and the duty cycle is about 25%.

So far, all of the devices covered have some electrical connection to the ac line via the bridge rectifier. The gates of the MOSFETs are insulated by the oxide layer, but the oxide is fragile and can't be relied on to provide isolation. Since the transformers provide isolation at the supply's output, all that's needed is some isolation on the input side to prevent the entire chassis from being "hot".

The control IC supplies the signals to the opto-isolators. The voltage regulation signal is basically an "error" voltage generated by the control IC. This signal will change the duty cycle of the main supply pulses as needed. The on/off (shutdown) signal is a two-state voltage (high or low) which enables or disables the pulses as needed. These signals don't affect the standby switch pulses.

The control IC receives the needed feedback from the output of the main supply to develop the error voltage. It also receives inputs from the shutdown control IC which monitors various parameters for fault detection. Finally, it receives a power on/off signal from the microcomputer.

The standby supply

Lets look at the complete schematic diagram. The standby supply switch Q450 "pulses" current through the primary winding of T450 (pins 2 and 4). These drive pulses are generated by the controller IC (IC401). These pulses should be present whenever the set is plugged in.

The voltage of one secondary winding of T450 at pin 9 is half-wave rectified by D458. After filtering it becomes sources 17 and 18. The dc voltage is also passed through a 5V regulator (part of IC403) and after additional filtering becomes sources 19 through 22. Some of these voltages are used by components in the switching supply itself.

The voltage from an additional winding on T450 exits at pin 5 and is rectified by D418. After filtering it is applied to pin 16 of the controller IC. This is the controller's supply voltage. However, since the controller IC must be running before T450 can supply its voltage, a start-up or keep-alive circuit is used.

R420, a 56K resistor is connected between the high side of T450's primary (raw B+) and the cathode of D418. When power is first applied to the chassis, the resistor bleeds just enough current into IC401's supply circuit to start the standby pulses. The principle is the same as is used in many TV "trickle-start" horizontal drive circuits.

The main supply

The main supply works essentially the same as the standby supply. Q420 gets its drive pulses from the controller IC, but only when the power is on. T401 uses two primary windings in parallel to increase current handling capability. The voltage from one secondary winding at pin 14 is rectified by D430A and after filtering becomes the 130V regulated B+ for the horizontal output section.

Another secondary voltage at pin 12 is rectified by D448A. After filtering and voltage division it becomes sources 2 through 11. Source 7 is zener regulated by Z261 and source 10 is regulated by transistor Q15. A third secondary voltage, at pin 11, is rectified by D442. This voltage becomes sources 15, 16A and 16B. The "power on" LED (D90) is connected to the main supply distribution network.

The scan-derived voltages from the IHVT (T502) are also shown on the power supply schematic. One voltage at pin 9 is rectified by D451 and becomes the 200V source number 23. Another voltage at pin 5 is rectified by D445, becoming the 27V source number 24.

Because the secondary windings of IHVTs provide a convenient place from which to obtain supply voltages, designers opted to obtain some supply voltages from the IHVT secondary rather than add more windings to the switching transformer. Since the horizontal output circuit converts dc to ac then back to dc, these voltages have undergone a five-step process in all.

The controller

The controller IC (IC401) generates the gate-drive pulses for the switches. Resistor R414 and capacitor C410, at pins 3 and 2 respectively, form the RC timing network which determines the frequency of the pulses. Crystal-control accuracy isn't needed because the precise frequency of the pulses isn't critical.

An on-board 5V regulator supplies the collector of the opto-isolator's output transistor via R411. This voltage must be stable for the error voltage to be stable. Since the emitter of the transistor is grounded, the collector-to-emitter resistance will form a voltage divider with R411. The voltage of this divider is tapped by R412 and applied to the control input of integrated circuit IC401.

The resistance of the transistor is modulated by the intensity of the light from the LED. The LED's voltage comes from IC403 pin 9. The anode is connected to source 17 (11V). The voltage drop across the LED is about 1.7V (LED's have a higher voltage drop than silicon diodes). This voltage drop will remain fairly constant even though the current (and brightness) varies with the error voltage.

Pin 5 of IC401 is the on/off (shutdown) input. It's connected to the collector of the output transistor in opto-isolator IC402. The collector is normally pulled up via R415 to about 2.3V. If the transistor is switched "on" by the input LED, pin 5 will be pulled near ground, signaling the controller IC to stop main switch pulses.

The anode of the LED is connected to the 11V supply (source 17). When the power is on, the voltage at the cathode is held at 10.3V. The difference (0.7V) which is dropped across the LED isn't enough for forward biasing. For the LED to turn on, pin 5 must drop to about 9.3V. Note that this opto-isolator acts as a

(Continued on page 39)

switch whereas the voltage regulator opto-isolator acts as a buffer amplifier.

The control IC (IC403) performs two main functions. First, it coordinates signals from the shutdown control IC (IC-570) and the microcomputer to facilitate the on/off (shutdown) function. Second, it contains the circuitry that generates the error voltage for voltage regulation.

When pin 16 is pulled low (0.4V) by the micro computer (IC350), the control IC will power-up the chassis. The chassis will power-down if pin 16 goes high (about 5V). If the voltage at pin 3 (normally 4.5V) is pulled down by pin 6 of IC570, the chassis will go into shutdown.

The SMPS shutdown test requires that R435 be momentarily shorted with a jumper. This pulls pin 3 of IC403 down to about 3.5V causing shutdown. The supply voltage for pin 3 comes from source 2 (13V) via R438. This source voltage is part of the main supply and will drop in the event that the supply becomes seriously loaded by a shorted component such as the HOT. In this case the chassis might shut down before the fuse blows.

In order to regulate the supply voltage, IC403 must have feedback. A sample of the 130V source is applied to a voltage divider consisting of R430, R432 and R433. It is then applied to pin 7. A comparator in the IC compares this voltage to a stable reference.

Any difference between the divided-down sample and the reference results in an error voltage (correction voltage) which is passed to the controller IC via the regulator opto-isolator. Adjusting R433 changes the voltage at pin 7. The control IC will then raise or lower the regulated B+ as needed to bring the voltage at pin 7 back to 3.5V.

Shutdown control

Unlike many TV designs in which the horizontal drive section is disabled in the event of a fault, TVs using switching supplies generally cause the supply itself to shut down. IC570 controls this function. Pin 3 monitors the high voltage indirectly via a scan-derived voltage from the IHVT (T502).

Instead of monitoring scan-derived sources 23 or 24 which are used to power various circuits, IC570 monitors the voltage from a separate winding on T502 used specifically for this purpose (Figure 4). The voltage at pin 4 is rectified by D530 and filtered by C530. A sample of this voltage is tapped from the junction of a voltage divider consisting of R580 and R579 and applied to pin 3 of IC570.

This voltage (normally 24.7V) is further scaled down within the shutdown IC before being applied to the comparator. If the high voltage increases, the voltage at pin 3 will rise signaling a fault. This results in pin 6 pulling low causing IC403 to disable the main supply pulses.

The high voltage shutdown test requires that a 920Ω resistor be momentarily placed across R580. This changes the division ratio of the voltage divider raising the voltage on pin 3. Immediate shutdown should result. This test should be made after any servicing of the high voltage circuits. Power must be removed from the chassis for at least five seconds to reset following shutdown.

Troubleshooting

Troubleshooting switching supplies is not too difficult once basic operating principles are understood. It is important to remember though that these supplies are very different from supplies using switching regulators and many of the troubleshooting tricks you may have developed for them will be of no use on switching supplies. There is no practical way to "force-feed" the chassis by using reduced line voltage and bypassing sections of the supply. Too many individual voltages would have to be substituted.

Even though most of the chassis is "cold", it is still wise to use an isolation transformer in case you come into contact with "hot" ground when making voltage or resistance measurements. The triangular symbol represents the hot ground.

If the supply in this set is blowing fuses as soon as the set is plugged in, the most likely cause is MOSFET Q420 or Q450. When either of these develops a source-to-drain short, the raw B+ line is pulled near ground. Electrolytic capacitors C404, C405 and C438 could also cause this symptom if they become shorted.

A severe secondary overload caused by a shorted component such as the horizontal output transistor can cause fuse blowing, but in some cases the chassis will shut down first. Overloads reflected from the secondary of the main switching transformer T401 won't blow fuses until the set is turned on.

In most chassis using this type of supply, the HOT can be removed during troubleshooting if you suspect a loading problem is being caused by the horizontal output circuit or an IHVT secondary load. If the supply operates normally with the HOT out of the circuit, then you've at least eliminated the possibility of a problem in the supply itself. An IHVT primary short to ground will still load the supply with the HOT removed.

The cause of this type of problem can be easily found by taking resistance measurements. Wick the solder from the supply side of the IHVT if you want to further isolate the problem. As long as you don't disable the 130V feedback path when unloading the supply, it should regulate properly.

Switching transformers are pretty reliable but they do fail occasionally. A primary-to-ground short will blow the fuse with the set off if it is a "hot" ground. Shorted turns in the primary or secondary will stress the switch and may blow the fuse—but only when the set is on. If the standby transformer develops shorted turns, it may cause the fuse to blow whether the set is on or off since it operates whenever the set is plugged in. Shorted turns usually require "ring" testing since they don't change the already very low dc resistance appreciably.

In cases where no shorts or excessive loading can be found but the fuse still blows, check the switch drive circuitry. If the gate of either MOSFET is held at 12V instead of being pulsed, the MOSFET will remain "on". It will act as if it is shorted but will test good.

A malfunctioning controller IC could hold the switch "on" only when the set is on, or whenever the set is plugged in. In either case if you open the gate circuit and the fuse holds, you've isolated the problem; the controller IC or some associated component must be defective.

Start-up problems

If the chassis won't start and the fuse is intact, a good place to start is the standby supply. It should be operating whenever power is applied to the chassis. If any of the sources 17 through 22 is up then it must be running.

If the standby supply is down, check for 158V at the drain of Q450. If this voltage is absent, then some series-connected component must be open such as D453 or R449 (assuming that there is B+ at the output of the bridge rectifier). If you find open components, be sure to check Q450 for shorts.

If Q450 has drain voltage, check the controller IC's supply pin. It should be 12.7V. If it is much higher than that, the IC probably isn't drawing current. This voltage is bled from the raw B+ supply by R420. If the voltage is correct, the controller should be pulsing the gate of Q4590.

Scope pin 10 for the drive pulses. If they're present the MOSFET must be defective (assuming the pulses are reaching the gate). If there are no pulses, the IC must be bad. Open the gate circuit and scope pin 10 once more to be sure the pulses aren't being shorted to ground. A MOSFET can develop a gate-to-source short which wouldn't affect drain supply.

If the standby supply is operating but the set won't start, first look at the power-on LED. This LED won't be on unless the main supply is running. If the LED is on but the chassis seems to be dead, the problem must be outside of the supply. If the LED comes on for a fraction of a second, suspect a shutdown problem.

Once you determine that the main supply is down, check for the raw B+ at the gate of Q450. If the voltage is there, measure pin 16 of IC403. It should be about 0.4V if the microcomputer (IC350) is sending the "on" signal. If it is around 5V the microcomputer might have a problem. If the voltage at pin 16 doesn't drop when the power button is pressed, try unplugging the set for at least five seconds and then try it again.

Troubleshooting the microcomputer is beyond the scope of this article; however, don't overlook the possibility that it isn't getting its supply voltage. 5V from source 22 is applied to pin 42 of IC350. This voltage is derived from a 5V regulator which is part of IC403. It is possible that this regulator could fail, disabling IC350. The standby supply will run even if the microcomputer is down.

Shutdown problems

If you suspect a legitimate shutdown problem (usually evidenced by a very brief period of operation after turn-on) the first step is to determine whether the problem is high-voltage related. To make this determination, disconnect one leg of R580, or one of the other series connected components in the feedback line from T502 (IHVT), to disable the high voltage shutdown function. Reconnect the set and turn it back on and then quickly measure the high voltage. Don't run the set any longer than necessary in this condition.

If the high voltage is excessive but the regulated B+ (130V) is normal, turn your attention to the horizontal output section. If the B+ is high and can't be adjusted to normal, the problem must be in the supply. If all components in the feedback voltage divider including the 130V adjust control are good, IC403 is probably bad. It is also possible that problems in IC400 or IC401 could cause high B+.

If the chassis goes into shutdown even with the high voltage feedback line disabled, the problem must be due to an overload. If the horizontal section is disabled using the method outlined earlier and the problem remains, try to find the source of the loading by making resistance measurements from the various sources to ground. When unloading the supply by disconnecting component legs or jumpers, bear in mind that you might disable a source needed for the supply to run. Check the schematic.

If you suspect a fault in the shutdown circuit, desolder one leg of R576. This resistor ties the shutdown control IC to the control IC. If the problem persists IC403 must be malfunctioning (though opto-isolator IC402 or the controller IC could develop a problem causing a shutdown-like symptom). If desoldering one leg of R576 eliminates the problem then IC570 is a suspect.

If pin 8 of IC403 is about 9.3V, the control IC is sending the "off" signal to the controller (pin 5). Looking at these voltages should help to pinpoint the source of any problem in this area.

On the bench

A customer brought one of these sets to me to service. It was totally dead. The fuse was intact so I checked the standby supply. All standby sources were down. I checked the voltage at the drain of MOSFET Q450 and found no B+. Tracing the B+ line led me to R449 which was open.

Since R449 was open, I suspected that Q450 was shorted. Testing with a DMM revealed a source-to-drain short. Apparently R449 had opened before the fuse had had sufficient time to blow. Diode D453 was okay.

Though the main switch is a "power" MOSFET in a TO-220 package, the standby switch was much smaller resembling a small-signal transistor. At the time I wasn't able to cross-reference this device so I opted to replace it with a larger but otherwise similar MOSFET (ECG-2393). This is the cross-reference for the main switch. All standby supply voltages came up to normal. I have not had a call-back on this set.

Summary

Switching power supply designs vary, but you will find many of them are very similar to the one described here. Some have most of the active components placed inside of a sealed module which can make troubleshooting to the component level impossible. In any event, a general understanding of how these supplies operate will be helpful when they come across the service bench. ■

Test Your Electronics Knowledge

We get letters

By Sam Wilson

I searched through some letters I have received in the past. The letters dealt with questions that were previously asked in "Test Your Electronics Knowledge". Are we moving ahead?

1. If you increase the bandwidth of an amplifier you automatically decrease its ______.

2. Name seven types of receivers.

3. What is the unit of measurement for gain-bandwidth product?
   A. Current.
   B. Time unit.
   C. Voltage.
   D. Frequency.

4. Which of the following is used to measure radiant energy?
   A. Goniometer.
   B. Bolometer.

5. For an unregulated power supply better regulation occurs with a
   A. choke-input filter.
   B. capacitor-input filter.

6. An SCR is turned on by a gate
   A. voltage.
   B. current.

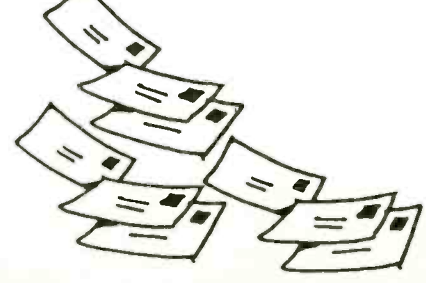
7. The input resistance of a VMOS transistor is
   A. high.
   B. low.

8. The phase angle between the voltage and current in a certain power circuit is 90-degrees. What is the power factor?

9. What is the decimal value of the binary-coded decimal number 0001 0011?

10. Is the following statement correct: "According to Watt's law: P = V x I?"
    A. Correct.
    B. Not correct.

(Answers on page 49)



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

The mystery of the yellow-green bird

By Roger D. Redden

In detective novels, the detective gathers evidence and evaluates suspects. From his list of suspects he crosses off those who have no access to the crime scene and thus an unassailable alibi. Then he clears or implicates those that are left until he finds the culprits.

As electronic technicians, we follow similar steps to ferret out the defective parts when an electronic device expires. First, we rule out those parts that are in circuits not related to the problem, that is, not at the scene of the crime. Then we test the parts in the remaining suspect circuits for abnormal values or actions, clearing or implicating them until we find the defective ones. It sounds straightforward, but in good detective novels, and much electronic troubleshooting, complications invariably arise.

A technical mystery

I invite you to try to solve this technical mystery that bedeviled me. I'll present evidence I discovered and conclusions I made, and at key points, ask you what you think. A set of brackets after each question contain my response to the question, but please decide what you think before reading them. As the original sleuth in this case, I'm afraid my astuteness resembled that of a bumbling Inspector Clouseau more than a brilliant Sherlock Holmes. That's a clue to bear in mind when answering the questions.

Pick any color, so long as it's yellow-green

The customer controls this Mitsubishi TV, a model CS-2720, through a microcontroller chip, using the menu, volume, and channel buttons to select a function and make changes. With the on-screen color level indicator set all the way down, the TV appeared to have a normal black and white picture.

Unfortunately, most of the picture remained nearly black and white when the color level indicator was raised to maximum. But some normally green or yellow hues shifted to a vivid yellow-green. An outstanding example of this was Sesame Street's Big Bird, which glowed yellowish green against an otherwise nearly monochrome background.

Varying the tint control throughout the indicated range scarcely changed the tint of Big Bird's feathers, and had less effect on the rest of the screen. The on-screen display (OSD) indicators and messages (tint, color, etc.), also appeared black and white except for some green letters on one of the on-screen functions.

A make-do map

There is no Sams diagram for this set, but the photo of the main board in a Sams 2669-1 looked almost identical. Though I found some minor variations between the circuits shown in this Sams schematic and the ones I checked on the main board of this set, for this problem the schematic I had available was a useful map of the main board.

At a quick glance, the picture of the CRT socket board also looked identical to the CRT board in this set, with the RGB output transistors in the same places. I assumed it was identical.

Question 1: Does this sound like a reasonable assumption?

[1. Ok, that was too easy. I wouldn't have mentioned it if the board wasn't different from the diagram.]

Tracing the paths

Parts of the schematic that were relevant to this problem were on four different pages of the Sams diagram. Often, by the time I found the area I was searching for, I had forgotten why I wanted it. I combined parts of those four pages into the simplified diagram shown here.

To make it easier to follow the signal paths, I added the dot-arrow symbols shown at the left of the schematic. Let's trace the signal paths as they appear on the schematic through the schematic, so you'll be familiar with the circuits.

The video path

Video from Q101 enters pin 4 of IC2AO, which switches between the internal video and an external video source under control of the microcontroller, IC701. The composite video output of IC2AO goes to pin 1 of DL201, the comb filter, which separates the luminance and the chroma. We'll follow the luminance signal through the set and come back to the chroma later.

The luminance exits the comb filter at pin 5, goes through Q204 to pin 12 of IC202, exits the IC at pin 11, goes through second video transistor Q203, and enters IC201 at pin 32. It exits IC201 at pin 19 (lower right), goes to Q201, and from there to a common connection on the CRT board to be mixed with the R-Y, G-Y, and B-Y signals. This mixture produces the RGB signals for the CRT.

The color path

Returning to the chroma signal where it exits the comb filter at pin 4, we can follow its path through BP601 to pin 5 of the y/c switch. It exits the y/c switch on pin 8 and goes to pin 34 of IC201. Inside IC201, the chroma bandpass signals are demodulated and output on pins 16, 17, and 18. These R-Y, B-Y, and G-Y signals go to the bases of Q651, Q652, and Q653 for mixing with the video signal.

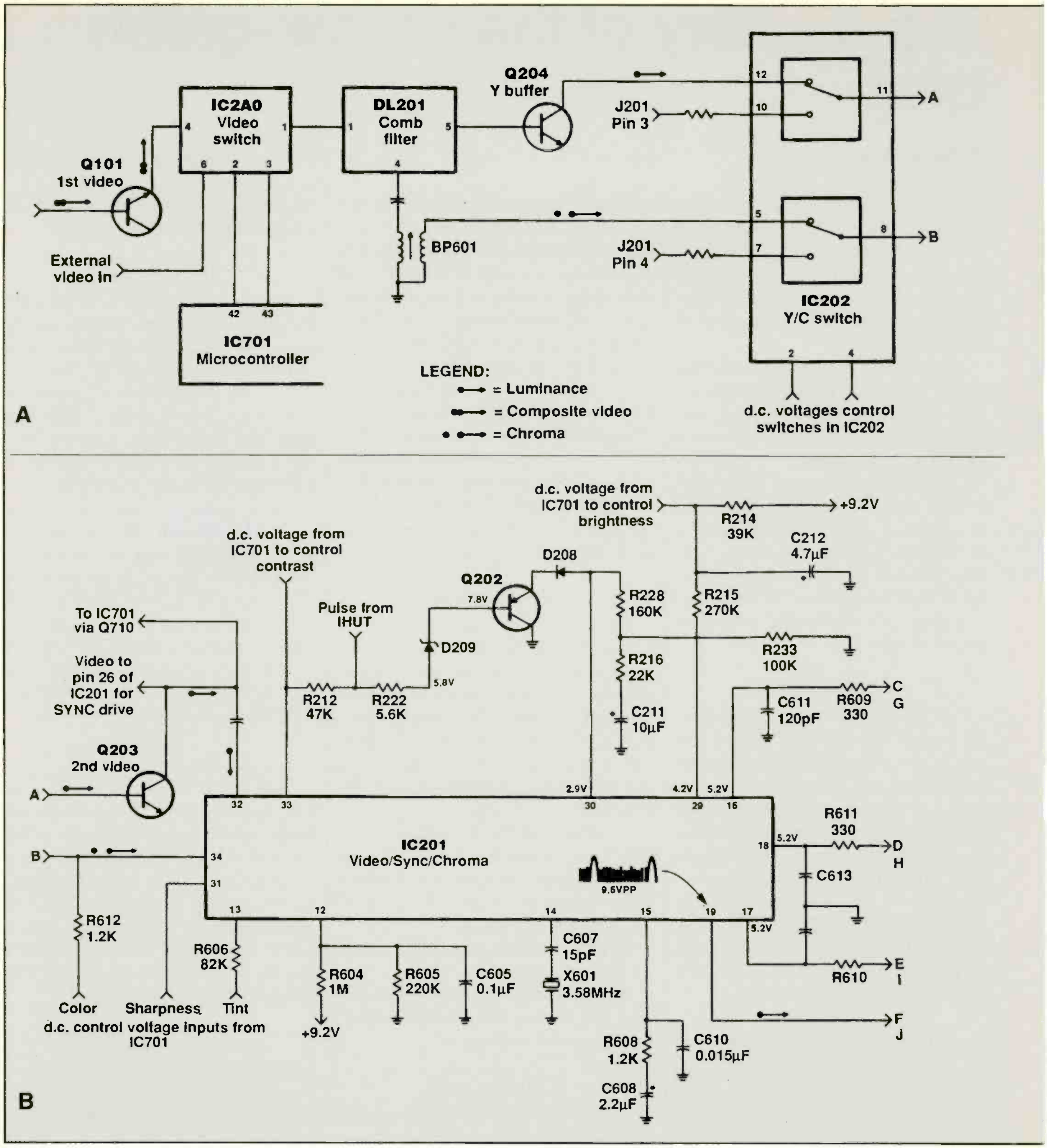
An assumption

I've found that defects in the RGB outputs usually change the color of the raster, and problems in the video output stages typically have drastic effects on the brightness. Since the set seemed to have a good black and white screen, I assumed that all of these output stages were working normally.

Question 2: Does this sound to you like a good assumption?

[2. This is probably a good assumption about 9 times out of 10. But telling you the answer for this case reveals too much

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



before you've had a chance to solve the mystery, so we'll withhold that evidence.]

Some conclusions

Even though the areas of color on the screen were the wrong tint, they were in color sync. This meant that while the 3.58Mhz oscillator might be the wrong phase, it was running, and it was at the right frequency. Areas of near black and white along with areas of fairly strong color in the same picture suggested that the color signals might be distorted, allowing only certain frequencies to pass through to the CRT. If that were true, the distortion could be occurring in the tuner, video IF's, comb filter circuit, or the chroma circuits inside IC201.

Testing the signal path

As a first step in troubleshooting, I connected a source of external video to the video jack that connects to pin 6 of IC2AO, and used the customer control to

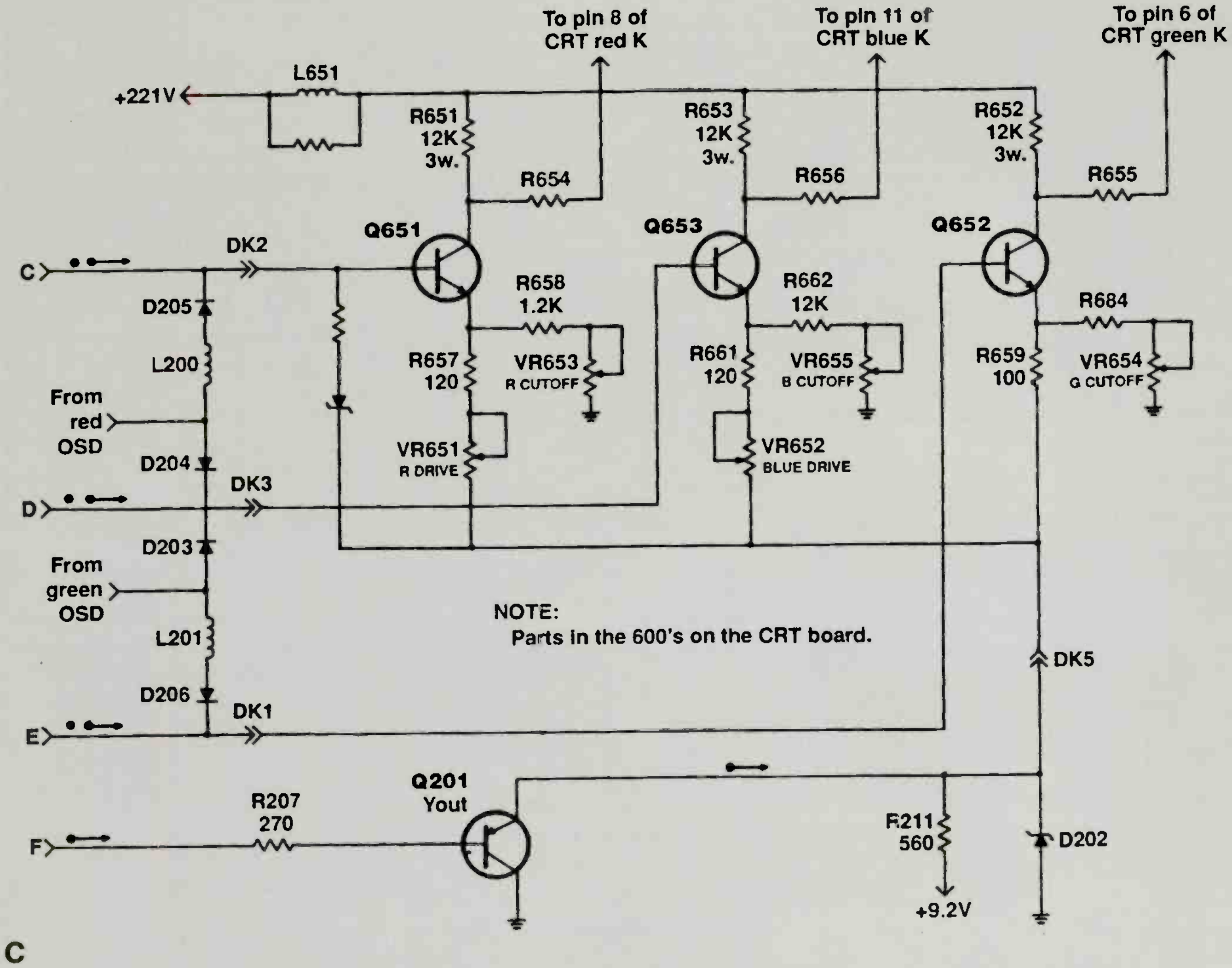


Figure 1. Four pages of the Sams diagram are combined in this simplified schematic showing the signal paths from the first video to the CRT.

switch to external video input. If the symptoms cleared using external video, it would implicate the tuner or IF's. If the symptoms remained, the tuner and IF's would be unlikely suspects.

Question 3: Was this a good idea?

[3. Yes. It was easy to do, and quickly checked a number of circuits.]

Connecting external video into pin 6 didn't improve the color. As a next step, I wanted to place external video and chroma signals at J201, pin 3 and 4 respectively. But I didn't have a plug or adapter to fit the socket, so I abandoned the idea. Instead, I used my scope to check the video at pin 32 of IC201, which appeared normal.

Next I checked the chroma signal at pin 34 of IC201. It also appeared normal, but I didn't trust it. I reasoned that if there were a phase or frequency problem with the color signal, it would be hard or impossible to see with the scope.

To double check that the problem was not before this point, I substituted a chro-

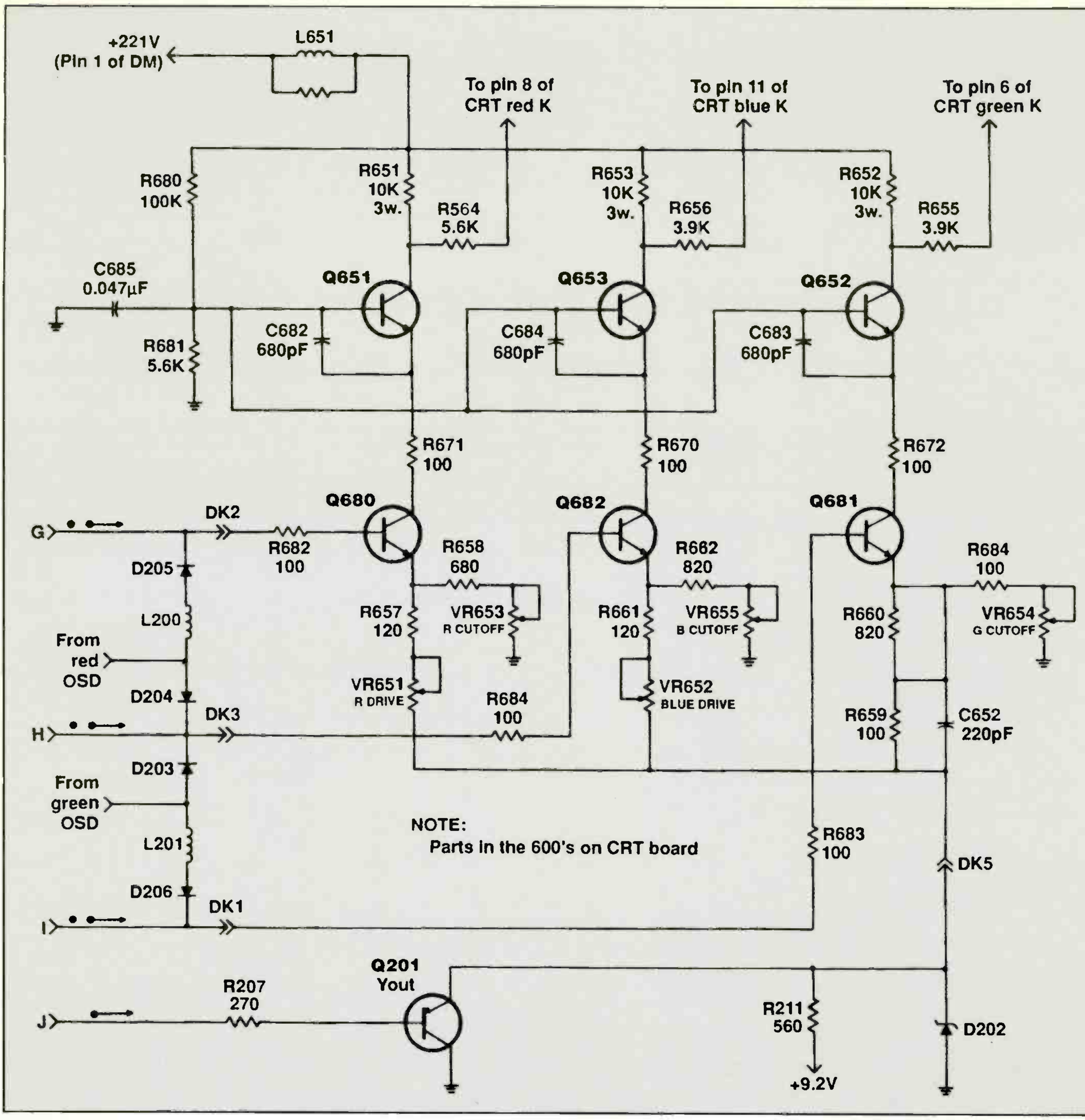


Figure 2. This schematic shows the circuitry found on the CRT board in this set.

ma signal (video frequency color bars from a Sencore VA48) into pin 34. The TV's screen showed only a few greenish bars, while the rest of the color bars were nearly black and white.

In short, there was no improvement when substituting a known good signal at this point. From this, and the normal appearing scope signals, I concluded that the video and chroma input signals to IC 201 had airtight alibis.

Question 4: Was that a reasonable conclusion based on the evidence?

[4. Yes. Viewing the video on the scope should be reliable enough, and checking the chroma by both signal tracing and signal injection should prove it was okay.]

Anything with that many legs could run amok

My suspicions now focused on IC201 and its surrounding circuits. After all, this is where most of the color processing takes place, and it seemed reasonable that a problem here could produce strange symptoms. I checked the dc voltages on the pins of IC201, especially the pins shown on this diagram. The fixed dc voltages all appeared normal.

The service literature didn't show the range of dc voltages that should occur on the pins controlling the tint, color, sharpness, brightness, and contrast. I connected the probe of a voltmeter to each of these pins in turn, and pushed the appropriate buttons on the set for each function and then proceeded to vary the indicators on the screen throughout their range.

The color control voltage at pin 34 varied from 2Vdc to 7Vdc; probably normal. The tint control voltage at pin 13 varied from 3.6Vdc to 5.7Vdc. I was less sure about that one, but inclined to think it was normal. The brightness control voltage at pin 29 moved from 3.55Vdc at minimum, to 3.69Vdc at maximum. That change of only 0.14V seemed suspicious, especially since I now noticed that this voltage variation caused little change in screen brightness. In my haste to condemn the color circuits, I had failed to do one of the first things that a good technical detective should do: namely, try to persuade the customer controls to become informants.

While I didn't see how the brightness problem could cause the color symptom, I thought it was a clue worth exploring.

Question 5: Do you agree that it was worth exploring?

[5. The brightness not changing was relevant to the problem, but indirectly enough that following that lead didn't help me. Perhaps if you are thinking a number of logical steps ahead, then yes would be the correct answer to this question. If you are only thinking one or two logical steps ahead, as I was, then no would be a better answer.]

Probing the brightness variation

Exploring why the brightness, and the voltage at pin 29, changed so little, I speculated that if capacitor C212 or C211 were leaky they might pull the voltage at pin 29 down and limit the amount it changed. My hopes high, I removed and tested them, but they checked good. The resistors around pin 29 also checked good, as did diode D208.

While checking R215, it slowly began to dawn on me that it was a relatively high value resistor. This led me to check the dc voltage at the junction of R215 and R214 while adjusting the brightness. It varied from 0.04V to 7.66V.

Question 6: Did this voltage change, and the value of resistor R215, mean that the small dc voltage variation at pin 29 was actually normal? (Hint: also note that the voltage at pin 30 of the IC was a normal 3V, and that the value of R228 is less than the value of R215.)

[6. Yes. These facts practically guaranteed that the voltage at pin 29 was normal. With R215 having a resistance of 270KΩ, even a small current going through it would cause a large voltage drop across it.

If pin 29 of IC201 were internally connected to either a resistance less than the resistance of R215, or to a relatively low impedance voltage source, then practically all of the 7.66V of control voltage would be dropped across R215. And R228, with a resistance less than that of R215, and going to a voltage of about 3V, would further reduce voltage variations on pin 29.

The fact that the voltage at pin 29 remained at 3.55V when the voltage at the junction of R214 and R215 was only 0.04V showed that the voltage through R215 was not the source of the voltage at pin 29, and indicated a low impedance voltage source inside IC201, probably a current controlled op amp. The voltage of such a low impedance (stiff) source would be little affected by changes in the control voltage.

Two short reviews

I reviewed the situation. I had con-

Test Your Electronics Knowledge

Answers to the Quiz *(from page 42)*

1. gain. Gain and bandwidth are tradeoffs in an amplifier.

2.
   1. Crystal (also called crystal input)
   2. Regenerative
   3. Superregenerative
   4. TRF
   5. Single conversion (also called homodyne)
   6. Superheterodyne
   7. Reflex

3. D - Gain has no units, and bandwidth is a frequency range. Gain-bandwidth is a frequency.

4. B - By definition - a bolometer is a device that measures radiant energy.

5. A - However, a capacitor-input filter gives a higher output voltage.

6. B - It is a gate current that operates an SCR even though that current is obtained with a gate voltage.

7. A - This is a very important advantage of a VMOS transistor.

8. Power factor equals COS(90) which is 1.0.

9. 13 - You would be surprised at the number of technicians who have never heard of BCD (binary-coded decimal) numbers.

10. B - It is Joule's law. Always give credit where credit is due.

Wolfram is another name for tungsten.

cluded that the RGB and video output stages were working, as shown by the normal black and white screen. I was satisfied that the video and chroma inputs to IC201 were okay.

Further, I believed that the control voltages for the brightness and tint were working correctly, but that they were not having the proper effect on the screen. Since the tint and brightness were clearly controlled by components inside IC201, it and the components around it were the best logical suspects.

Question 7: Do you agree that these were the best suspects?

[7: I hope you disagreed. Unlike a good detective, I neglected the obvious. Before jumping splat in the middle of a conclusion, I should have checked the outputs of IC201 to see if the video on pin 19, and the chroma drive signals on pins 16, 17, and 18, varied in a normal manner while I adjusted the tint and brightness.]

Having decided that there was something wrong in the IC201 circuit, I checked the dc voltages around it, the oscillator signal on pin 14, and the components shown around it in this diagram. Everything seemed normal, so I purchased and installed a new IC. As you may have guessed, that IC was not actually the cause of the trouble.

Again, I reviewed the situation: I was tired, frustrated, and my back hurt. I ended my review and quit for the day.

By the next day I was thinking clearly enough to check the outputs of IC201 with a scope. Pin 19 had normal looking video with a pedestal (rectangular pulse) that grew larger and smaller as the brightness indicator on the screen varied. With a color bar signal connected to the antenna, the chroma drive at pins 16, 17, and 18 showed normal looking bars that shifted when the tint control voltage was varied. Had I checked these points first, I wouldn't have replaced the IC.

I believe I just heard a distant voice say, "Elementary my dear Watson."

If it's visible, it must be possible

If the dc voltages of the IC were normal, and it produced normal output signals, and the screen had normal black and white except for the brightness and contrast not changing enough, what was left? Could there be a problem with the OSD circuits, supposedly one green and one red, but in fact black and white except for that one green word? I removed L200 and L201, which disconnected the outputs of the OSD circuits from the red and green chroma drives. Now the OSD circuits should not affect the picture. But the symptoms persisted. Scenes flashed through my mind of a rat nosing through a maze, finding every passage blocked.

There must be a way out! Uh, I mean, there must be a bad circuit or component somewhere. Maybe the chroma drive signals were being lost between the outputs of the IC and the bases of the RGB transistors. I connected my scope in turn to each of the bases of the RGB output transistors. Surprise! There was no signal on any of them. That was a puzzle. It seemed impossible that the screen could have green color on some objects without a signal on the green output transistor.

Question 8: How could that be?

[8: If it can't be true, it probably isn't. Remember the question about the CRT board that looked identical at a quick glance? I had just banged into a signpost that showed I was using the wrong map. Shades of Inspector Clouseau!]

Drawing practice

The emitters of the RGB outputs did have signals, but their tops were ruler flat. The collectors also sported flattopped signals. I suspected these flattened signals indicated a wrong dc bias somewhere. Searching for that wrong bias, I slowly discovered that this CRT board did not match the one in the Sams diagram.

In order to make sense of what was going on, I drew the diagram shown in Figure 2. From now on, refer to this diagram for the output stages instead of Figure 1. All components numbered in the 600's in this schematic are on the CRT board. This schematic is nearly complete, and should help anyone working on this set without the correct diagram.

Once I had the correct diagram of the output stages, it became clear why there was no signal on the bases of the RGB outputs, Q651, Q652, and Q653. These transistors were common-base amplifiers, with the base signals being grounded for ac by C685. In this revised circuit, the R-Y, G-Y, and B-Y signals go to the bases of the three added transistors, Q680, Q681, and Q682, and the video output goes to a common point in their emitter circuits. The resulting RGB signals pass through the RGB output transistors to the cathodes of the CRT.

A check of the chroma drive signals on the bases of Q680, Q681, and Q682 showed them to be virtually unchanged from those on pins 16, 17, and 18 of IC-201. The signals on the emitters of these transistors also looked normal, not flattened at the top. But their collector signals were flattened.

What's normal?

Of course, since I had drawn this schematic, there were no normal voltage readings on it. But it seemed reasonable that the dc voltages on the bases of Q680, Q681, and Q682 would be about the same as those on pins 16, 17, and 18 of IC201, and that their emitter voltages would be about 0.6Vdc less.

I knew that the dc voltages from the integrated circuit were normal, and the waveforms on the bases and emitters of these transistors looked good, implying that the bias was normal on them. Their collector voltages should be about the same as the emitter voltages of Q651, Q652, and Q653, since they are connected to them through 100Ω resistors.

The emitter voltages of these transistors, in turn, would be about 0.6Vdc less than the voltage set by the voltage divider of R680 and R681, particularly since capacitor C680 grounded any pulses that might affect the bias there.

Knowing that the waveforms appeared normal on the bases and emitters of Q680, Q681, and Q682, but were flattened on their collectors, which get their dc voltages from the emitters of Q651, Q652, and Q653, aroused my suspicion about the bias of these latter transistors.

Question 9: Do you think the base bias circuit of these transistors would be a good place to check?

[9: Yes. That's as reasonable as a hunch that Charlie Chan enjoyed food.]

Checking the R680/R681 bias circuit, I found the resistance across R681 to be a normal 5.6KΩ. R680, on the other hand, showed a resistance of about 900KΩ in circuit, instead of the proper 100KΩ. Often, when one end of a resistor goes to a high B+ voltage such as this +221V supply, resistance readings appear wrong because of residual charge left in the supply.

To drain any such charge, I grounded pin 1 of the DM socket (+221 volt supply) for about a minute, and then checked the resistance again. It remained about 900KΩ. The resistance of R680 still read 900KΩ after removal from the circuit. Replacing it restored normal color to the set, as well as an adequate range of control of brightness and contrast.

Would you believe tolerances?

Why were yellow-green colors more visible than other colors? My theory is that the tolerances of the parts, or possibly just the adjustments of the drive and cutoff controls, allowed the green output circuit to conduct more than the red and blue output circuits, even though the forward bias on all of them was reduced.

Are you a whiz? or psychic?

If sometime before you read that R680 was bad, you said: "I'll bet R680 is bad," then congratulations on your brilliance, technical experience, or superior intuition. If not, then like me, you might sometimes have to methodically check out every lead before you can point an accusing finger and say, "That's the villain! Get the heat!" ■

Oscilloscope/multimeter

Fluke Corporation introduces the new dual-channel 100MHz handheld ScopeMeter B test tool with a high contrast, cold-cathode, fluorescent backlit display, that is 10 times brighter than previous test tool displays. It offers handheld convenience, battery-powered portability, a rugged case, and is easy to operate and set up according to the manufacturer. It also fully integrates these scope capabilities with a full-featured 5MHz true-rms DMM that allows users to view waveforms and meter readings simultaneously.

The all-new, high-contrast display features a cold-cathode, fluorescent backlight that makes waveforms show up well whether users are working in a dark environment or in bright sunlight. The unit can run for four hours on a rechargeable NiC battery pack, even with the backlit display turned on. The unit also runs on common C size alkaline batteries. In addition, the entire unit is schockproof and resistant to water, dust and contaminants to survive your environments.

Circle (8) on Reply Card

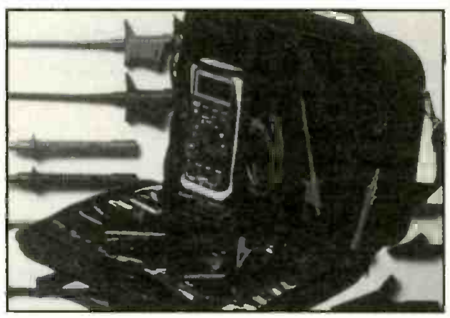
Fingertip soldering iron

A new "fingertip" soldering iron, recently introduced by *Wahl Clipper Corporation*, is designed to increase convenience and productivity in all types of soldering, including small production work.

Although miniature in size, (only 1 ounce in weight and 2 1/2 inches long) the iron still delivers 25W of soldering power at 900F. When attached to the finger, between the first and second knuckle with a self-gripping strip, the iron leaves both hands free to hold, position and reposition soldering elements.

The iron, which features an isolated tip design and grounded case, comes with three styles of long-life ISO-TIP soldering tips: fine tip; micro tip; and a half-mil pitch tip to solder half-mil pitch chips. The tips' small size concentrates the heat directly on the tip to increase efficiency; and the tips' nickel chrome plating withstands prolonged soldering times.

Circle (9) on Reply Card



Test equipment accessory kits

Outfitted with a complete set of test accessories specifically designed for use with either Fluke, Hewlett-Packard and Tektronix digital multimeters, graphical multimeters and oscilloscopes, *ITT Pomona's* new Test Companion accessory kits feature Cordura carrying cases to hold and protect instrument, test leads, probes and tools and provide zippered and Velcro pockets for manuals, service forms and miscellaneous items.

Also available among the company's all-new line of the brand- and model-specific accessory kits are smaller, shoulder-pack kits and tri-fold pouch styles. Most accessories in the kits are IEC1010-compliant, and each kit is expressly tailored to provide maximum test versatility and performance levels.

Circle (10) on Reply Card

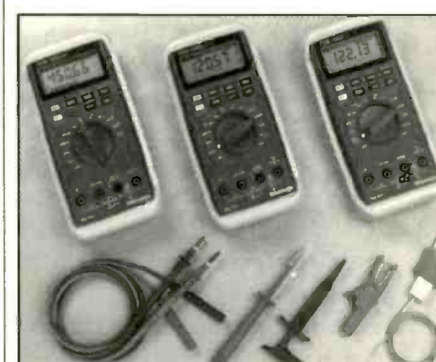
Analog/digital storage oscilloscope

Kenwood announces the arrival of their newest analog/digital storage oscilloscopes with real time bandwidth of 50-MHz and a maximum sampling rate of 40 MS/s (DCS-7020: 20 MS/s).

The series offers features such as Memory Function with 4K word acquisition memory plus 2K word reference memory (backed up by internal battery). The PST (persistance) mode helps measure variations in waveform width due to jitter, voltage variations, etc. The peak detector makes it possible to detect glitch noise with a pulse width of 25ns (DCS-7020: 50ns) or more. The external clock input terminal provided as standard allows sampling of noncontinuous signals by triggering using the clock signal input.

These Instruments are imported from Japan by PRINT Products.

Circle (11) on Reply Card



Handheld DMMs

The DMM800 series, announced by *Tektronix* is designed to meet the accuracy and resolution requirements of electronic design engineers and technicians.

The series consists of the entry-level DMM830, the mid-range DMM850, and the high-end DMM870.

The DMM850 and DMM870 let users read two measurements at once. For example, engineers can measure amplitude and frequency of current or voltage without switching between signal displays.

The DMM850 and DMM870 can measure temperature in both F and C.

The DMM850 and DMM870 can label when minimum and maximum values have occurred during testing.

The DMM870 allows engineers to set high/low tolerances. A beep sounds when values exceed user-set limits.

The DMM870's 1ms peak-hold function records the minimum and maximum readings for short-mode events, making it possible to detect anomalies that might otherwise go unnoticed.

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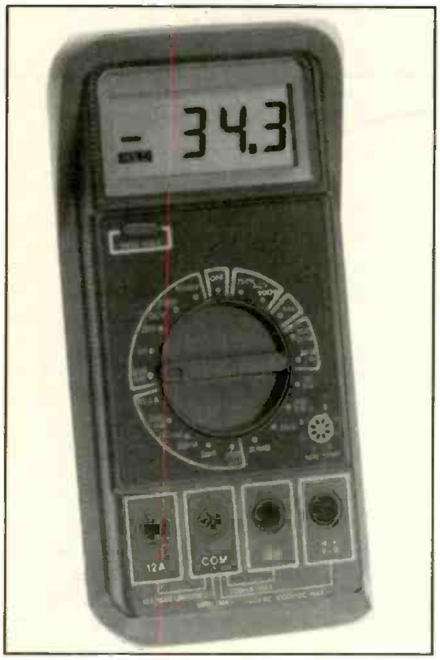


DMM

A new, holster protected, 3 1/2 digit multimeter with bright LCD readout, the Model D904 from *HC Protek* features more than 12 measurement capabilities.

This 2000 count, hand-held instrument tests transistor for Hfe (beta) from 0 to 1000, checks diodes, measures dc current to 12A and resistance to 20mΩ in 6 steps. It has a 10MΩ input impedance for both ac and dc, includes a continuity buzzer, data hold function, and a low battery indicator. It will measure dc voltage from 200mV to 1000V with 0.5%+/-2; D accuracy; resistance from 200Ω to 20MΩ; voltage from 200V to 1000V and dcA from 200μA to 12A.

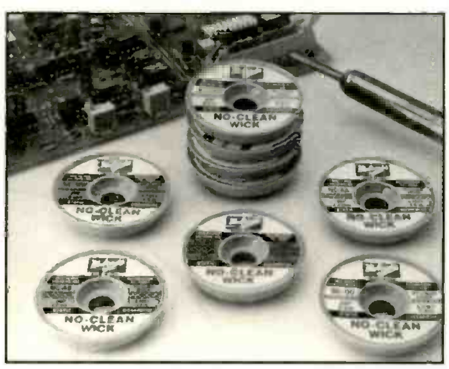
Circle (12) on Reply Card

Capacitance DMM

Extech's new capacitance multimeter is ideal for checking the value of motor run and start capacitors and for detecting shorted or open capacitors. In addition, the capacitance DMM performs all multimeter functions including ac/dc volts and current, resistance, diode test and continuity beeper. Wide ranges allow ca-

pacitance measurement to 20mF and resistance measurements to 2000 mΩ. A zero adjust knob for capacitance is featured along with a large 0.78" LCD display, and indicators for low battery, polarity, and overrange. A triggering LED lamp indicates live circuits when working in a poorly lit environment.

Circle (13) on Reply Card

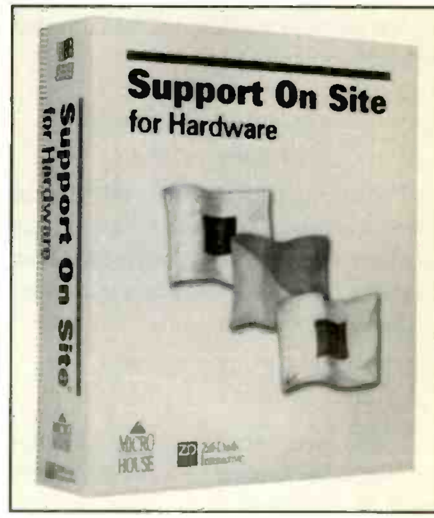


No-Clean Desoldering wick

A new no-clean solder wick designed for static-free desoldering and repair of printed circuit boards without the need for subsequent cleaning has been introduced by *Multicore Solders*. No-Clean Wick is supplied wound on static dissipative spools conforming to both DOD standard 1686 and DOD Handbook 263 for static discharge protection.

The product uses a special halide-free vacuumized, no-clean, flux-coated copper braid that improves wicking action with faster and increased solder absorption according to the manufacturer. It will not lose its efficiency even after prolonged storage in humid conditions. PC boards will meet MIL-P-28809A Cleanliness Test without cleaning after use.

Circle (14) on Reply Card



Hardware support tool

MicroHouse International and Ziff-Davis Logical Operations are jointly announcing the introduction of "Support On Site for Hardware," a comprehensive, first-level, PC and network hardware support tool. The new CD-ROM subscription service is targeted at PC technicians, network support professionals, help desks, network administrators, MIS Managers, and system integrators who need immediate answers to technical questions on maintenance, installation, upgrades and support for multivendor hardware.

The product is designed to help users instantly pinpoint hidden problems with the combined capacity of a comprehensive database and an authoritative knowledgebase right at their fingertips. It eliminates the time wasted hunting for misplaced technical manuals and researching back issues of archived magazines. Users will spend less time waiting in tech support queues of manufacturer's help hot lines trying to get answers to pressing support problems.

Circle (15) on Reply Card

What Do You Know About Electronics?

Graphical solutions to calculus problems

By Sam Wilson

I have always believed that applications of mathematics are more important than pure mathematics. Unfortunately, the pure mathematicians have a stranglehold on the teaching methods of math in many schools and colleges.

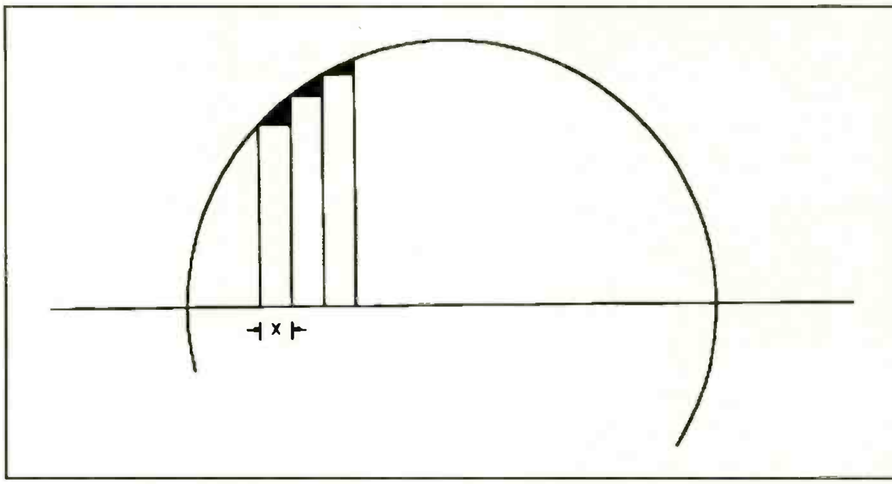


Figure 1. The area under a curve can be found approximately by graphic methods by dividing the area into a number of rectangles, finding the area of each of the rectangles, and adding them together. The larger the number of rectangles into which you divide the area, the greater the accuracy of the solution.

An example of a useless calculus exercise

For example, if you study integral calculus in college, you spend hours proving how integrals can be derived. An example is shown in the following exercise.

Show that:

$$\int \sqrt{a^2 - x^2}\, dx = \frac{x}{2}\sqrt{a^2 - x^2} + \frac{a^2}{2} \sin^{-1} \frac{x}{a} + C$$

Then, work the first 20 (very similar) problems in exercise 13-7 and prove each case by differentiation. Hand in your paper tomorrow.

After you do that exercise, just to prove you can do it, you put your graded paper in a notebook that you will throw away within two years.

If you ever run across a situation where you *do* need to know the value of any of the 20 integrals in that lesson you will, no doubt, look it up in a table of integrals.

Calculus books

I have a book inside me that could be used along with a standard calculus text. My book would be titled "Here is What You Can Actually Do With That Stuff!"

Actually, there was a book written by A.E. Richmond (Calculus for Electronics, published by McGraw-Hill). My copy has a copyright date of 1958. You may run across a copy in a library or a used book store. If you do find one, I think you should buy it. I am using that book as a reference in this WDYKAE?

Uses of calculus

In a previous article where I introduced integral calculus I noted that you can use it for finding an area under a curve. I used a crude graphical method and promised to show you a more accurate method in this issue. But, first, what can you do with that stuff? Here are a few examples.

- The open area in a hysteresis curve for a transformer is directly related to the transformer hysteresis loss.
- The effective value of a waveform is related to the area under the curve.
- If you divide the area under a half-wave of a pure sinewave into rectangles, then add the areas, and divide by the num-

Wilson is the electronics theory consultant for ES&T.

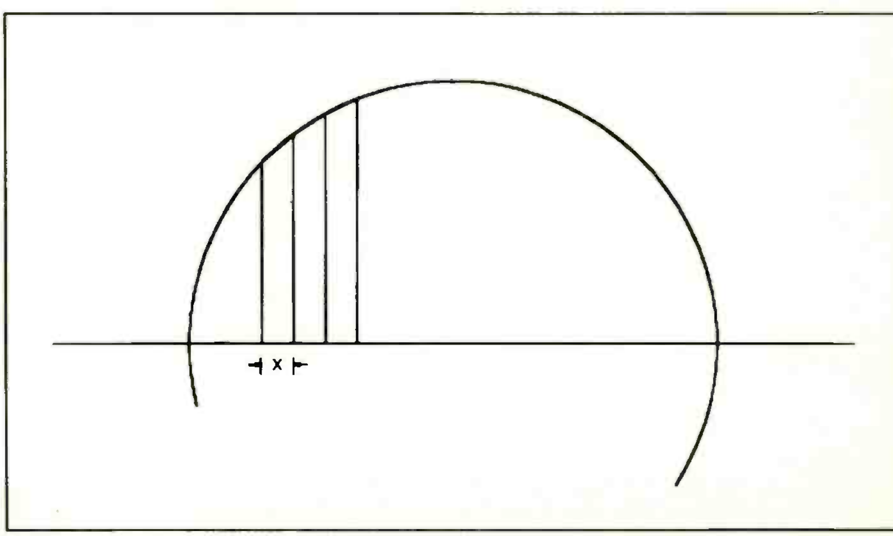


Figure 2. If you divide the area under the circle into a number of trapezoids, the area that is not included in the calculations becomes less, thus increasing the accuracy of the result.

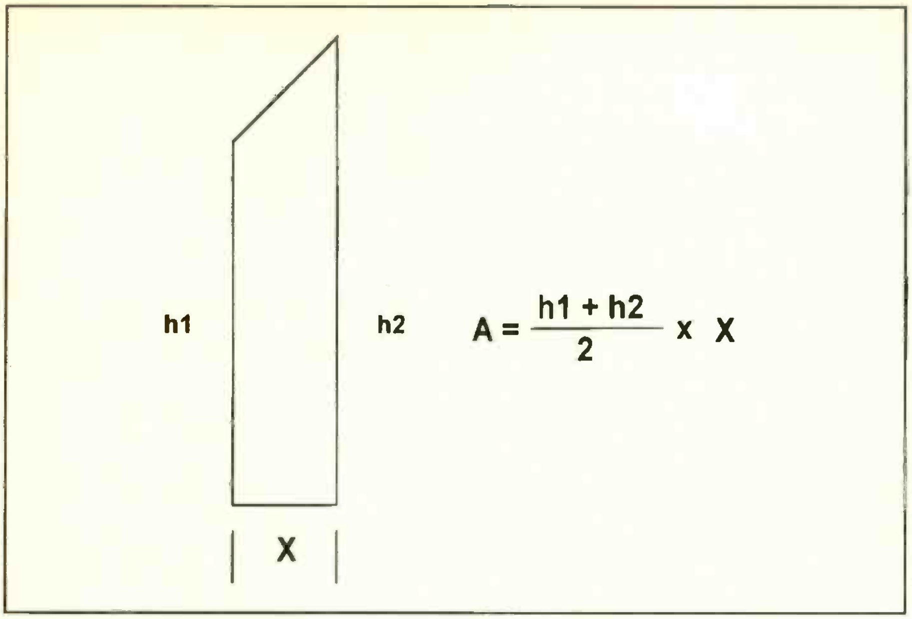


Figure 3. Here's the equation you use to find the area of a trapezoid.

ber of rectangles in the half cycle, you get the average value for a sine wave. (This technique can be used to find the average value of other waveforms.)

Calculating the area of a half-circle

One of the things you can do with integral calculus is to calculate the above-mentioned areas. That can be done mathematically or graphically. In this article I will show you some graphical methods.

An easy problem to solve is to find the area of a half circle by graphical integration. With that problem you know what the answer should be, so, you can check the accuracy of your method.

$$A(\text{of a half circle}) = \frac{\pi \times r^2}{2}$$

So, if your graphical solution for the area of a half circle or quarter circle is reasonably close to the value calculated with that equation your graphical solution is an acceptable approximation.

I should point out to you that there are some curves based upon mathematical equations where you *cannot* find the area by using a mathematical procedure. The only possible method in those cases is the graphical one. That is a good reason for learning graphical solutions.

The rectangular solution of areas

Important note: do not try to solve the graphical problems in this article by scaling the drawings. They are used for the purpose of showing you how to make your own drawings. Make larger drawings for greater accuracy.

As shown in Figure 1, the rectangular method involves dividing a half circle into very small rectangles. Each rectangle has the same width (x). By using only a 90-degree area in this solution you get improved accuracy.

In this procedure, the areas of the rectangles in the 90-degree range are added. [The area of each rectangle is determined by multiplying its measured height by its measured width (x)]. For best results use a sharp pencil to make your drawing.

By making accurate measurements you will get a good approximation of the area in the quarter of a circle. Multiply that area by 4 and you have a good approximation of the area of a circle.

The shaded areas in Figure 1 represent the errors in this method. Those areas are not included in the calculation. It should be obvious that increasing the number of rectangles, by decreasing the width (x) of the rectangles, will decrease the shaded area not covered by the rectangles, thus increasing the accuracy of your solution.

The trapezoid solution of areas

Instead of using rectangles, a more accurate solution is obtained by using trapezoids. That reduces the errors (dark-

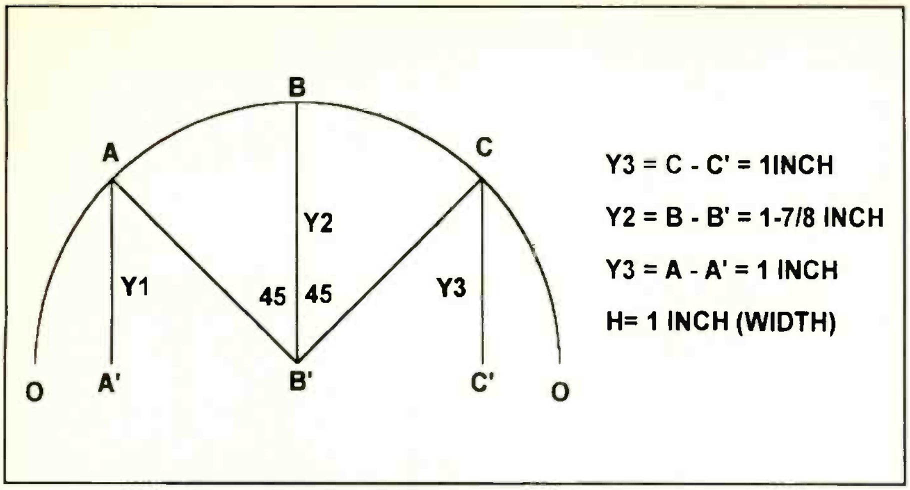


Figure 4. Simpson's rule, illustrated here, provides a moie accurate method for finding the area under a curve. It is based on the fact that a parabola can be drawn through any three points that are not in a straight line.

ened areas). See Figure 2. The method of finding the area of each trapezoid is shown in Figure 3.

The darkened area in Figure 2 shows that the error here is less than the error in the rectangular method (Figure 1). By adding the areas of the trapezoids in a quarter circle, and multiplying by 4, you will get a very good approximation of the circle area.

Finding the area of a circle by Simpson's Rule

Remember that greater accuracy for the graphical method of determining areas can be obtained by using a greater number of rectangles. This is also true when using Simpson's rule to perform the calculation. However, to demonstrate the greater accuracy of Simpson's method we will use only two areas.

Simpson's rule is based upon the fact that a parabola can be drawn through any three points that are not in a straight line. That is especially true if smaller areas are used for calculations.

The parabola will always come very close to tracking the curve. By determining the area under the parabola the area will be very nearly equal to the area under the actual curve. (In our case the actual curve is part of a circle.)

In Figure 4 the parabola is formed by OABCDO. I know, it looks like a circle. Use your imagination. The area under the parabola is divided into two equal areas. The section of the circle is not included in this drawing because it is so close to the parabola it would be difficult to distinguish between the curves.

Remember that a circle, like a parabola, can also be drawn through any three points that are not in a straight line. Our section of a circle would also pass through points ABC.

In the illustration Y_0, Y_1, and Y_2 are coordinates; that is, they are distances from the X axis.

There is an important restriction on this method: "There must always be an even number of areas under the curve." That is assured if you find areas that are butted together so that Y_2 becomes Y_0 in the next two areas.

The total area under a section of a parabola is given by the equation:

$$A = \frac{h}{3} (y_0 + 4y_1 + y_2)$$

Consider now the portion of a circle shown in Figure 3. Line A-A represents Y_0, and line C-C represents Y_2. Line B-B represents Y_1 in the equation.

By Simpson's rule:

$$A = h/3\ (Y_0 + 4y_1 + Y_1)$$

where the letters h and y represent measured lengths. A parabola, represented in Figure 3, was drawn and the following values were obtained:

$h = 1$ inch
$Y_0 = 1$ inch
$Y_1 = 2.1$ inch
$Y_2 = 1$ inch

Substituting these values into the equation gives an area of

$$A = \frac{1}{3}\ [1 + (4)(2.1) + 1]$$

That is the approximate area under the parabola which is the approximate area of 1/4 of the circle. Multiply that area by 4 to get the approximate area of the circle.

$4 \times 3.467 = 13.867$ (answer)
Using 2.1 for the radius of the circle:

$A = \pi r^2 = \pi \times (2.1)^2 = 13.85$ (Answer)

In both cases the area and the approximate area are given in square inches.

The solution is based upon the fact that the circle and parabola are drawn through the same three points, and, those three points are one-fourth circle apart.

That dreaded first day

Manfred Smedge was valedictorian of his class. His honored position was based upon getting all A's in ohm's law at the school where he graduated. He was immediately hired by Lockwary, Inc. He started in the THINK Department and was worried about how he would do on his first day.

His first assignment came almost immediately from the top dice-thrower in the department. "Smedge", he hollered, "we need a small amount of Wolfram, and, we need it NOW!" The big thinker disappeared into his office.

Smedge was terrified. Now he was sure he would mess up on his first assignment!

Carlotta Lotta sensed he was on the spot. She moved beside him and handed him a 100-watt light bulb. "Give him this" she said.

What was going on? If you know, write your answer here _______ and then check your answer at the end of the answers for "Test Your Electronics Knowledge" in this issue and give yourself 100 points if you are right. ■

CD-ROM instrumentation software catalog

National Instruments announces a multimedia CD-ROM for Windows 95/3.1 PCs and Macintosh/Power Macintosh computers that gives users extensive information and demonstration versions of the company's application software packages—LabVIEW, LabWindows/CVI, HiQ, Measure, and Signal Processing Suite. The software also includes information on real customer applications in a variety of industries.

The CD-ROM includes information on all the company's virtual instrumentation software packages, including: LabVIEW graphical instrumentation software, LabWindows/CVI visual development software, Component Works software for Visual Basic 4.0, Measure software for Microsoft Excel, and VirtualBench turnkey virtual instruments.

Also included is information on the company's data analysis and visualization tools—HiQ and the Signal Processing Suite; as well as on TestSuite and LabSuite, the company's software packages for automated testing and laboratory automation applications. In addition, the Software Showcase provides details on technical support, customer education courses, and products and services offered by third parties through the National Instruments Alliance Program.

Circle (37) on Reply Card

Electronics products website

Surplus Traders announces their website at http://www.73.com which offers ac/dc adapters, switching power supplies, solar materials, stepper motors, cable TV equipment, telephone parts and accessories and more, all linked by a powerful index, with quick "push button" access.

Circle (38) on Reply Card

Buyers' group website

SBS Direct announces its new Internet website at http://www.sbsdirect.com.

Initially, the site will serve members of the SBS Buyer's Group, and provide one-step access to over 20,000 service parts and accessories.

Circle (39) on Reply Card

Service information website

EURAS USA, Inc. announces a service at its World Wide Web site, http://www.euras.com, designed to assist consumers needing service on consumer electronics by directing them to the qualified service companies nearest them.

The website allows all consumers to use a database to identify those companies nearest them simply by typing in their zip code. By clicking on a name, consumers can learn more about a particular company. If the company has a home page, consumers will find a link here as well.

The information provided on the companies includes address and contact information, as well as specialized facts prepared by each company. For example, they can give their hours of operation, details of their terms and conditions, brands they are authorized to service, the numbers of years of experience they have, what types of equipment they prefer to repair, etc. Consumers can quickly judge which company to contact and avoid unnecessary phone calls or trips.

Circle (40) on Reply Card

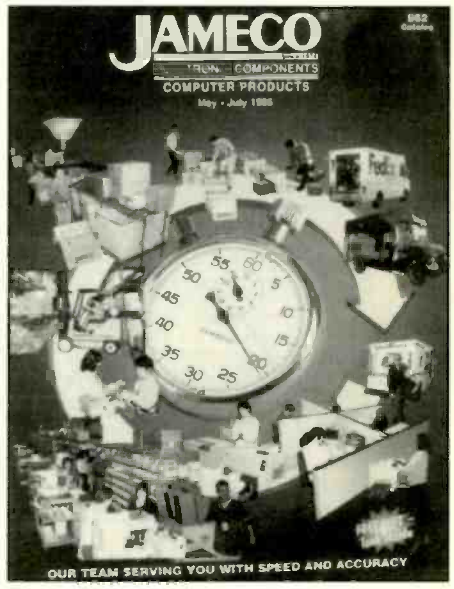
Test equipment web site gives advice on cutting test equipment costs

Reducing the cost of electronic test equipment is the goal of Test Equipment Central, a free interactive service launched on the Internet May 1st by Telogy, Inc. The site, accessible at http://www.tecentral.com, is designed to help professionals who acquire electronic test equipment lower their overall test equipment costs by recommending the most cost effective way to acquire individual instruments based on user input. The site also makes it easier for users to sell instruments they no longer need by giving users the market demand for equipment they wish to sell.

Often, equipment quotes fail to use many cost reducing options because of the time needed to analyze all of the options available to acquire an instrument. The web site performs the analysis a user needs to weigh these options. Recommendations can include new or refurbished equipment and whether to buy, lease, or rent based on how long the user will require the equipment. Users can build a "shopping list" of best recommendations which they can use to request quotes at equipment suppliers.

To further help users lower test equipment costs, the site displays the availability of refurbished instruments.

Circle (41) on Reply Card



Electronics/computer products catalog

Jameco Electronics has released their latest catalog, the Spring '96 edition, featuring over 250 new products, including: EDO SIMMs , Gentron relays, cellular phone accessories, networking products, ADAM remote data acquisition and control modules, high capacity Seagate hard drives and more. The company's now includes over 5,000 electronic and computer products.

Circle (42) on Reply Card

Correction for Ewert article

It was brought to our attention that in the May 1996 issue of **ES&T** on page 16 there were some errors in the artwork that accompanied the Jurgen Ewert article entitled " Testing audio power amplifiers." The following is the art as it appeared that month along with the corrected version. We apologize for any confusion that this may have caused.

$$P_{out}\,[Watt] = \frac{V_{out}\ [V\ rms]}{R_{load}\ [\Omega]}$$

$$P_{out}\,[Watt] = \frac{(0.125 \times V_{pp})\ [V]}{R_{load}\ [\Omega]}$$

▲ Equations in text

Corrected version ▼

$$P_{out}\,[Watt] = \frac{V_{out}^2\ [V\ rms]}{R_{load}\ [\Omega]}$$

$$P_{out}\,[Watt] = \frac{(0.125 \times V_{pp})^2\ [V]}{R_{load}\ [\Omega]}$$

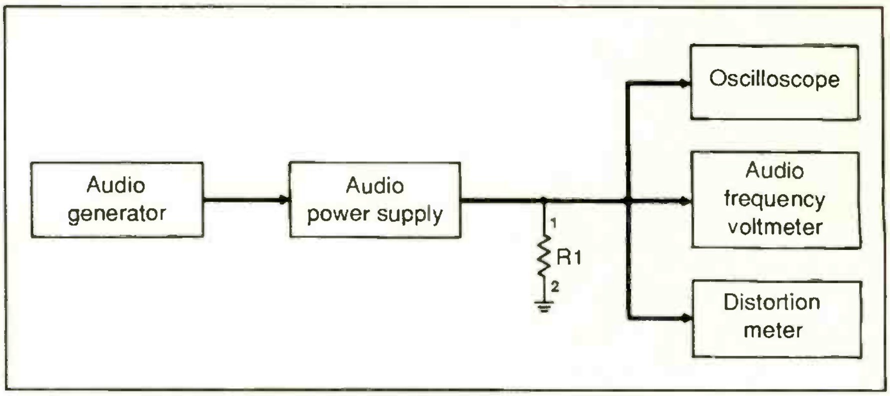
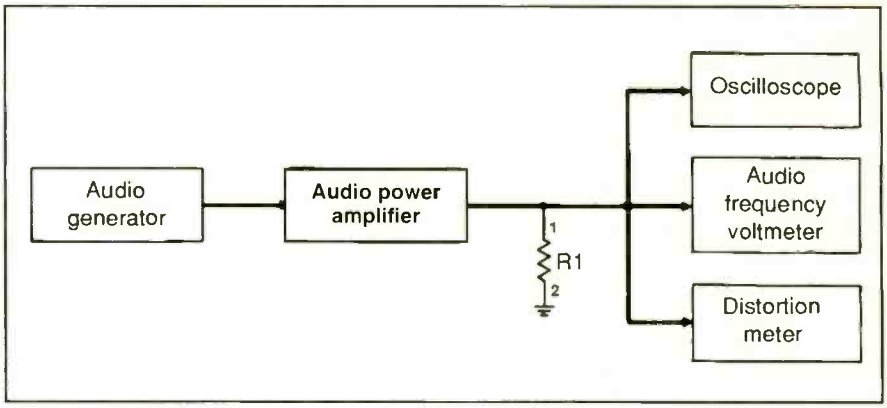


Figure 2. Test circuit for measuring audio power amplifiers.

Figure 2. Corrected version ▼



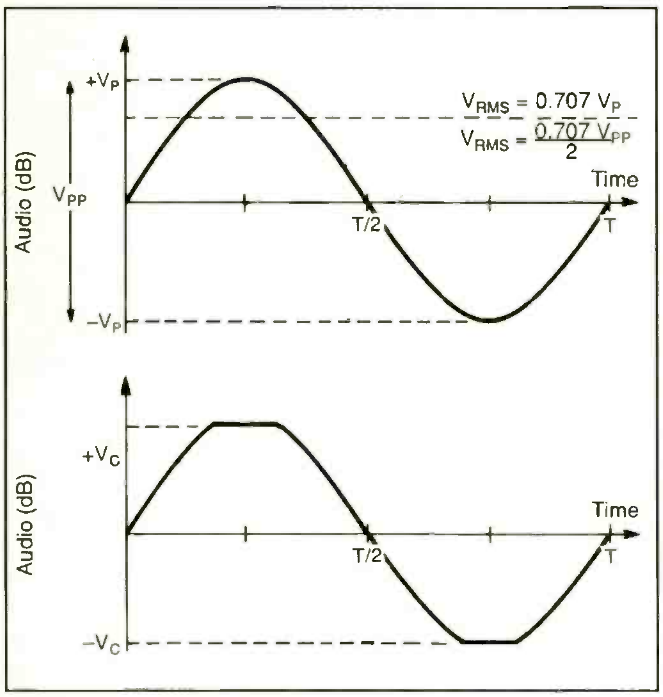


Figure 3. To measure the maximum output power, set the frequency of the generator to 1kHz and increase the input voltage starting from a very low value until the amplifier starts to clip the positive and the negative peak of the sine wave at the output. A good amplifier should start to clip the positive (+Vc) and negative (–Vc) peaks symmetrically.

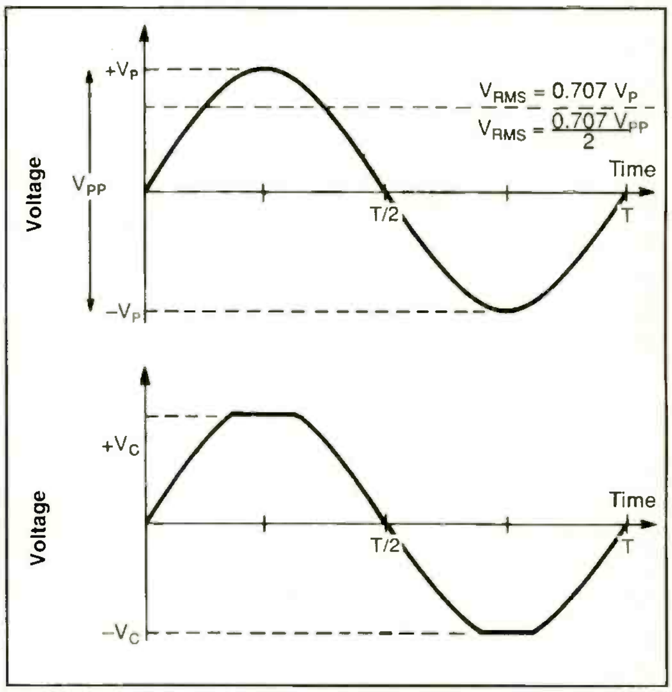


Figure 3. Corrected version.

Enough Rope to Shoot Yourself in the Foot: Rules for C and C++ Programming, By Allen I. Holub, McGraw-Hill Inc., 208 pages, paperback $24.95.

From a master in the field, Enough Rope to Shoot Yourself in the Foot: Rules for C and C++ Programming is a collection of more than 100 guidelines, tips, and techniques for writing flawless code in the C or C++ programming language.

Acknowledged expert Allen I. Holub provides programmers, engineers, scientists, students, and others who work with these powerful programming languages with straightforward advice and rules of thumb for exploiting the full potential of C and C++. He skips all the unnecessarily technical lingo, instead offering a concise, pithy desktop guide.

In readable, witty fashion, Holub discusses general rules, formatting, and proper code organization before dissecting central issues such as organizing and writing maintainable code, object-oriented programming, and data abstraction methods. Other chapter topics include both C and C++ specific problems and how to avoid them, project management, and debugging strategies.

Holub uses plenty of examples to illustrate the rules of thumb presented throughout the book. Readers also will find helpful design strategies and more.

About the author: Allen Holub (Berkeley, California) heads a Windows consulting and training from and teaches at the University of California at Berkeley. He originated the "C Chest" column in *Dr.Dobb's Journal* and regularly contributes articles to *Microsoft Systems Journal* and other publications. He has also written several successful books, including *C+C++: Programming with Objects in C and C++*.

McGraw-Hill, Inc. 11 West 19th Street, New York, NY 10011

The New Internet Business Book, By Jill H. Ellsworth and Matthew V. Ellsworth, John Wiley & Sons, Inc, $24.95 paperback, 512 pages

In 1995, it seemed that one couldn't watch a television commercial without a World Wide Web address flashing across the screen. Does a Web page automatically make a company cyber-savvy? Can only the big guys play? Will anybody visit, or even find, a Web site once it is up and running?

The New Internet Business Book by on-line masters Jill and Matthew Ellsworth, is the completely updated bible for people doing business in today's on-line marketplace.

With 70% new and revised information, this best-selling guide teaches businesses, large and small, how to get on-line in 1996! The New Internet Business Book covers:

- Step-by-step guidelines for putting a new business on the Internet.
- Guidelines for creating a company World Wide Web site.
- Integrating the Web and the Internet into a marketing plan.
- Security and on-line transactions.
- Rules and tools for creating an on-line business presence.
- New netiquette and Acceptable Use Practices for the Internet.
- Listings of vital business and professional resources on the 'Net'.
- The future of Internet business.

The Internet is constantly evolving, and the Ellsworths keep businesses current with the latest on Internet business trends, tools, and resources.

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

Programmer's Guide To Online Resources, By Bob Kochem, John Wiley 7 Sons, Inc., 368 pages,$24.95 paperback

With its rapid growth, the Internet is overflowing with a wealth of invaluable resources for programmers, and navigating through this information can be time-consuming and frustrating.

In *Programmer's Guide To Online Resources*, networking and communications expert Bob Kochem gives programmers a road map to all the technical data, programming utilities, software and other valuable material available on the World Wide Web. Written specifically for the programmer, this guide provides vital information on: sources of code and tools, vendor support sites, programmer question and answer groups, magazine archives and datatbases, multimedia and virtual reality, security, encryption and antivirus, networking and communications, and personal computer operating systems and environments.

Packed with advice and tips, *Programmer's Guide To Online Resources* is a valuable professional resource that will help programmers make the most of the fast-growing online world.

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

Easy Calculator Math For Electronics, By Larry R, Luchi, LimeLight Books, $17.95

Electronics instructor Larry R. Luchi teaches you to make quick work of math problems involving electronics with this new study guide. Luchi takes the reader through each required step in over 30 formulas used in electronics - from Ohm's Law to phase angles to component values for resonance to transistor characteristics.

Each one is carefully explained, with one or more step-by-step examples presented in an easy-to-view, easy-to-follow format. Terminology and theory explanations are included, along with diagrams to aid in understanding the material.

Luchi begins with sections on Using the Scientific Calculator in Electronics, explains the Algebraic Operating System, display formats, the keyboard and display, and coordinate systems.

Larry Luchi has used the techniques and examples in this book in the retraining courses he has taught to technicians at a number of companies in the field of electronics and electronic manufacturing processes, as well as his vocational and night school electronics classes and the classes he teaches in amateur radio (he holds amateur call sign W7KZE).

A Division of Tiare Publications, PO Box 493, Lake Geneva, WI 53147

Understanding and servicing CD players, By Ken Clement, Butterworth Heinemann, 256 pages, Hardcover $49.95

Written specifically with service technicians and engineers in mind, this book is designed as a bench-side companion and guide to principles involved in repairing and adjusting CD players. With a problem-solving approach and numerous examples, this is a helpful companion to the service manuals.

Butterworth Heinemann, 313 Washington Street, Newton, MA 02158-1626

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Per column Inch (classified Display): $235 per column inch, per insertion, with frequency discounts available, 1" minimum, billed at 1/4" increments after that 10" maximum per ad. Blind ads are $40 addition. Reader Service Number $25 additional to cover processing and handling costs. (Free to 4-inch or larger ads.) For more information regarding classified display advertising please call 516-681-2922. Optional color (determined by magazine) $150 additional per insertion.

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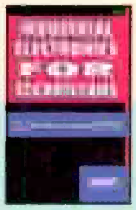

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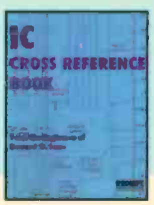

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* U.S. list price. Prices subject to change without notice.

(1) Approvals/Listing pending

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