THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

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October 1998

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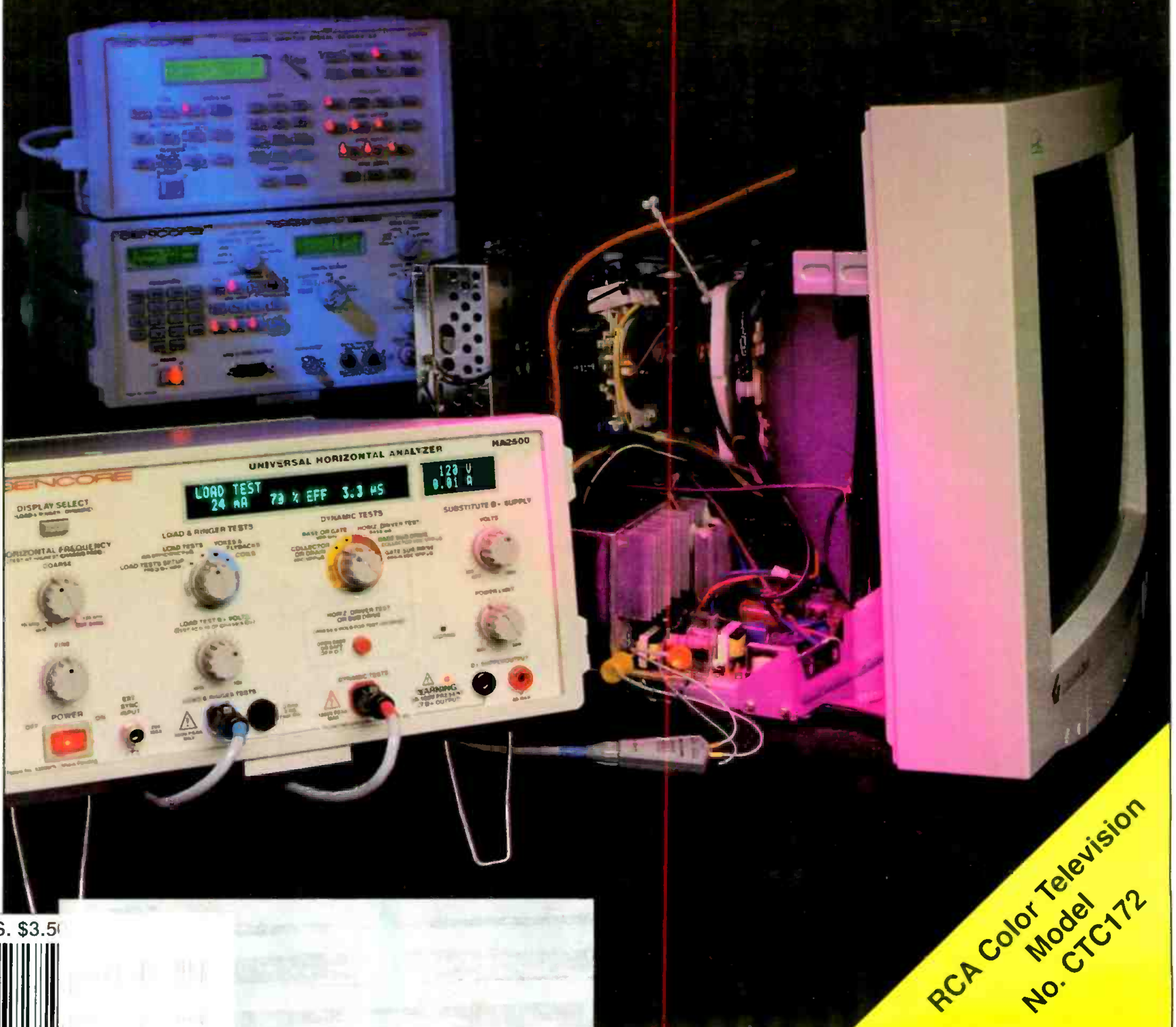

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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

Volume 18, No.10 October, 1998

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ON THE COVER

If a technician can service television sets, then a little additional training, and an investment in a few pieces of test equipment and software can prepare him for servicing personal computer monitors. (Photograph courtesy of Sencore)

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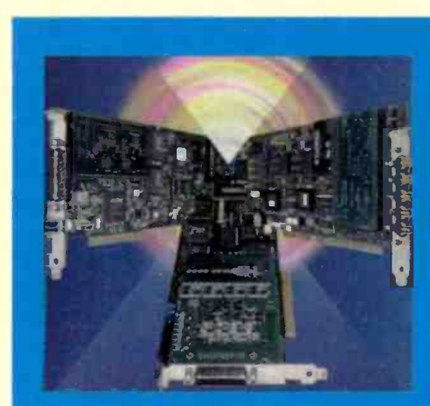

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EDITORIAL

Now that's a switch

Consumer electronics products of today are marvels of complex technology. There are things going on in modern TVs that even the engineers of sets made 30 years ago couldn't have even thought of. Just take a look: today's sets offer remote control, electronic tuners, picture in picture, comb filters, scan-derived power supplies, and more.

Add to that, the fact that we take for granted today, products that would have been hard to dream of just a few decades ago: VCRs, CD players, and now DVD players. Take a hard look at the mechanisms that make these products work. When you really give it some thought, it's hard to believe that it's possible to incorporate the precision that the mechanisms in these products require into mass-produced consumer products.

And that's just the mechanical aspects of these products. The electronic circuitry is equally marvelous. Most consumer electronics products sold today have what is essentially a computer at the heart of the system, and some type of read-only memory that contains the instructions that the computer is to follow. It's all very complex. Sometimes it makes us yearn for the old days when everything was relatively simple.

On the other hand, these modern, complicated, circuits have improved the picture and sound of the sets, or improved the way they function (does anyone get up to change channels anymore), or in some instances, made them more efficient, smaller, lighter in weight, or some combination of all of these.

The switched-mode power supply, found in most modern consumer electronics products, has provided a number of benefits, including most of those just named. Actually, some years ago, the government mandated to the consumer electronics industry that they make their TV sets more efficient. After all, there were millions of sets in millions of homes, and in every set there was a power supply that had a large transformer that was wasting quite a bit of electrical energy, and beyond that, a half-wave rectifier that converted the transformed ac to dc, but in essence threw half of it away.

The answer to that problem has developed into the power supplies that are found in consumer electronics products today: the switched-mode power supply. In fact, there's a switched-mode power supply in the monitor discussed in the article "Servicing computer monitors," in this issue.

Switched-mode power supplies use a full-wave rectifier to convert the entire ac line voltage to dc, and then use a switching circuit to adjust the duty cycle of the circuit to provide more or less power, depending on what's going on in the set. The output of the switched rectified dc, which varies at high frequency, is applied to the transformer, which provides isolation from the input circuit, and voltage transformation. This transformer does not, however, provide isolation of the circuits from the power line, thus, portions of any product using a switched-mode power supply will be "hot."

Because the frequency of the signal being applied to the transformer is so high, the transformer can be made much smaller than a transformer that operates at ac line frequency, so the entire product can be smaller and much lighter than one that operates on a linear power supply.

Of course, one of the biggest problems with switched-mode power supplies, as with so much of the circuitry used in current consumer electronics products, is that it is more complex, and therefore more difficult to troubleshoot. On the other hand, the more experience that a technician gets with any of these circuits, the more able he will be to service them. This magazine has published many articles on switched-mode power supplies, as well as on some of the other increasingly complex circuits. Look for more coverage of them in future issues.

Vacuum tubes

If you take the talk of the changes that have been wrought in consumer electronics back to its logical beginning, you wind up back at the vacuum tube. Now that's going back a long way. Interestingly, though, while vacuum tubes are very little used these days, they haven't disappeared completely. There are still a lot of "antique" radios and television sets out there that boast vacuum tubes as the active components.

Unfortunately, vacuum-tube technology is quite far removed from the world of solid state, and many technicians who have received their educations in the last couple of decades have not had any exposure to vacuum tubes at all. Moreover, many older technicians have been concentrating on solid state for so long that they've forgotten all about tubes.

Okay, it's unlikely that any of the HDTV sets that are going to be introduced in the coming months will be vacuum-tube based. And yeah, a couple of vacuum tubes taken together are possibly larger than a typical walkman type audio product. Still, vacuum tubes are not only found in antique products, they're being built into some of today's high-end audio equipment. That still doesn't really make any sense to me, but the fact remains that technicians who read this magazine might encounter a vacuum-tube-based TV or radio. Accordingly, we're going to run a few articles that deal with that technology as a primer and refresher. There's one in this issue.

Nils Conrad Persson

Preliminary first half 1998 U.S. electronics sales reach more than $241.5 billion: up 9.6% over 1997

U.S. factory sales of electronics equipment, components, and related products totaled more than $241.5 billion for the first half of 1998, representing a 9.6% increase over last year's figures for the same time period, according to preliminary data released by the Electronic Industries Alliance (EIA).

In announcing the first half sales figures, EIA President Peter F. McCloskey stated, "Despite the uncertainty in Asian markets, the U.S. industry sales continue to show a resilience and strength particularly in a number of key industry sectors."

The following is a breakdown of the first half product sales numbers according to product sector:

- Electronic Components sales rose to $74.1 billion, an increase of 5%, over last year's $70.4 billion.
- Consumer Electronics* saw an increase of 6% to $4.8 billion, compared to $4.5 billion in 1997.
- The Telecommunications sector continues to increase nicely with $36.9 billion, up 14% over last year's sales of $32.2 billion.
- Defense Communications** rose 11%, from last year's $14.1 billion to $15.7 billion.
- The Computers and Peripherals sector, with the highest percentage growth, hit $49.4 billion up 21% over the 1997 first half figure of $40.7 billion.
- The sales of Electromedical Equipment enjoyed an 8% rise, from $5.7 billion in 1997 to $6.1 billion this year.
- Industrial Electronics sales were flat, showing only a 1% increase, from $18.4 billion, to $18.6 billion.
- The Other Related Products category rose from $34 billion in 1997 to $36.4 billion in the first half of 1998, showing a 7% increase.

For nearly three quarters of a century, the Electronic Industries Alliance (EIA) has been representing U.S. electronics manufacturers. Committed to the competitiveness of the American producer, EIA represents the entire spectrum of companies involved in the design and manufacture of electronic components, parts, systems, and equipment for communications, industrial, government, and consumer uses.

CEMA asks FCC to move forward on must-carry. *Existing law requires cable systems to carry DTV*

CEMA has encouraged the Federal Communications Commission (FCC) to adopt pro-competitive, pro-consumer rules guaranteeing cable viewers' access to broadcasters' DTV signals. "We are pleased that the Commission is addressing the must-carry issue," said CEMA President Gary Shapiro. "The existing must-carry law requires the Commission to ensure that cable systems act as a conduit for digital television services, not a gatekeeper or filter."

"We urge the Commission to adopt pro-consumer rules to ensure that all cable viewers, by a certain date, will have access to broadcasters' DTV and HDTV transmissions," Shapiro added. "The law requires that the Commission issue rules so that cable viewers can enjoy HDTV as originally broadcast."

"The consumer electronics industry is heartened by recent positive statements by the cable industry on digital television," Shapiro also said. "We look forward to working closely and cooperatively with cable providers to ensure a rapid and consumer-friendly introduction of this new technology."

CEMA is a sector of the Electronic Industries Alliance (EIA), the 74-year-old Arlington, Virginia-based trade organization representing all facets of electronics manufacturing. CEMA represents U.S. manufacturers of audio, video, accessories, mobile electronics, communication, information, and multimedia products, which are sold through consumer channels. CEMA also sponsors and manages the International Consumer Electronics Show (CES), the world's largest annual trade event showcasing consumer electronics products. ■

Preliminary First Half U.S. Factory Sales of Electronics, June YTD 1998 (millions of dollars, not seasonally adjusted)

Preliminary First Half	YTD 1998	YTD 1997	% change
Electronic Components	74,156	70,418	5%
Consumer Electronics*	4,808	4,546	6%
Telecommunications	36,902	32,287	14%
Defense Communications**	15,792	14,183	11%
Computers and Peripherals	49,423	40,742	21%
Industrial Electronics	18,607	18,460	1%
Electromedical Equipment	6,169	5,701	8%
Other Related Products	36,400	34,095	7%
Total	241,584	220,432	9.6%

Source: U.S. Department of Commerce, compiled by EIA Market Research

***Includes domestically manufactured audio, video, and blank media products. Substantial amounts of products included in the Telecommunications and Computers/Peripherals categories are sold through consumer channels but are not separately identified in these data.**

****Includes specialized and defense related communications and tracking devices.**

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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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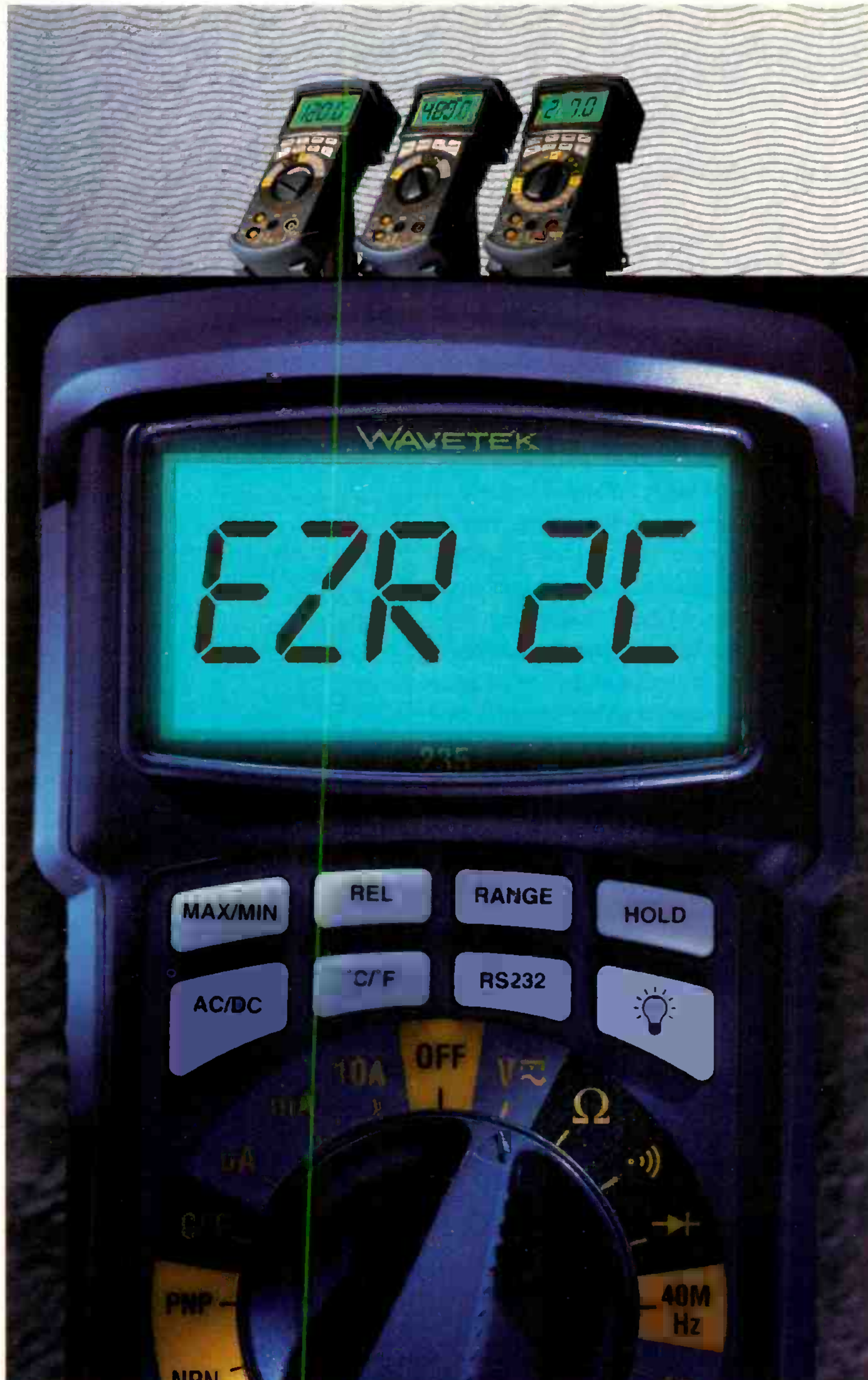


Servicing computer monitors

by John A. Ross

As technology changes, all the experience and expertise that we have gained helps us to adapt to the change. In many cases, our ability to adapt makes the difference between surviving in the electronics servicing profession, and finding some other line of work. Over the years of servicing consumer electronics products, we have gained experience with video display technology. Terms such as cathode ray tube, yoke, video signals, and deflection have become an almost natural part of our vocabularies. Given this ability to adapt, we can move from servicing televisions to a slightly different product: computer monitors. While moving into this area of electronics servicing may seem challenging, do not let the technology intimidate you. For most monitor service problems, you can utilize the same test equipment and the same reliable, professional knowledge that you have acquired for servicing television receivers.

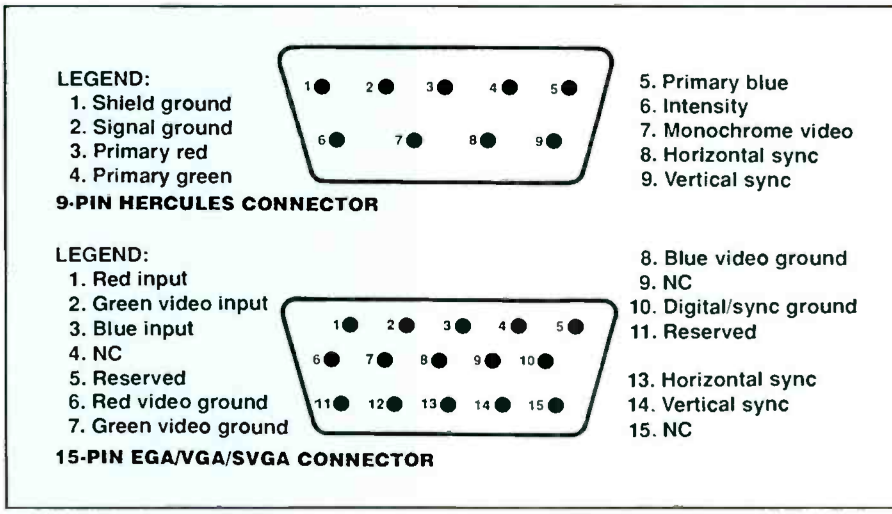


Figure 1. Video input connector of a text-only monitor, as well as the connector for EGA, VGA, and SVGA monitors.

Comparing display technologies

Along with the obvious similarities, computer monitors and television receivers also have obvious differences. Instead of receiving signals through antenna connections, video monitors receive signals from a either a PC card or set of integrated circuits within a microcomputer. We could think of the monitor and the system graphics adapter card as a video subsystem. When servicing the video display, you will need to provide a signal source, such as the microcomputer equipped with the appropriate video card or a generator and the correct video input cable. A variety of cable types have been used to connect monitors to microcomputer systems.

Because the video display works off the signals developed within the microcomputer, the monitor does not feature any audio circuitry. All audio for the microcomputer system develops internally through the microprocessor and a small speaker. More recent audio adaptations include the upgrading of the microcomputer system with an add-on sound card. Information video displays show text, as well as graphical data at a much higher resolution than television receivers are capable of. Indeed, rating video monitors on the number of individual dots displayed and the dot pitch has become common practice.

Video display modes

Video displays or monitors have progressed from the fairly simple monochrome displays to multi-sync displays. Depending on the type, monitors use input signals called TTL, RGB, and composite. In addition, displays are not only classified as monochrome and color, but also as enhanced color displays, video graphics array displays ,and as multi-sync displays. Finally, the adapter cards that drive the monitors have designations such as Hercules Graphics Card, Color Graphics Adapter, Monochrome Display Adapter, Extended Graphics Adapter, Super VGA, 8514 /A, and 34020.

Computer video adapters

Every personal computer system has some type of adapter for allowing the monitor to interface with processor. While earlier computers relied on a separate adapter card, all new personal computers directly integrate the interface into the main computer PC board (motherboard). Just as processors have gone through a steady evolution and have produced more computing power and speed, the video interface for a computer has also gone through steady improvements.

Again looking at the first adapters, early personal computers had adapters that provided monochrome-only text, a combination of monochrome-only text and graphics, and television-like color. In some cases, schools and other institutions continue to utilize the early color adapters and displays. For the most part, though, those displays and adapters have given way to Super VGA, multi-sync and 3-D video interfaces and adapters. Despite the changes, the principles of the video interface remain relatively constant.

For example, the video interface relies on a CRT controller, video RAM, and a character generator circuit. The CRT controller is a processor that receives input signals from the computer system's main processor through the address bus and data bus. Inputs for the controller include clock signals, data information, and addressing information. In addition to sending and receiving information, the CRT controller also controls the horizontal and vertical synchronization of the

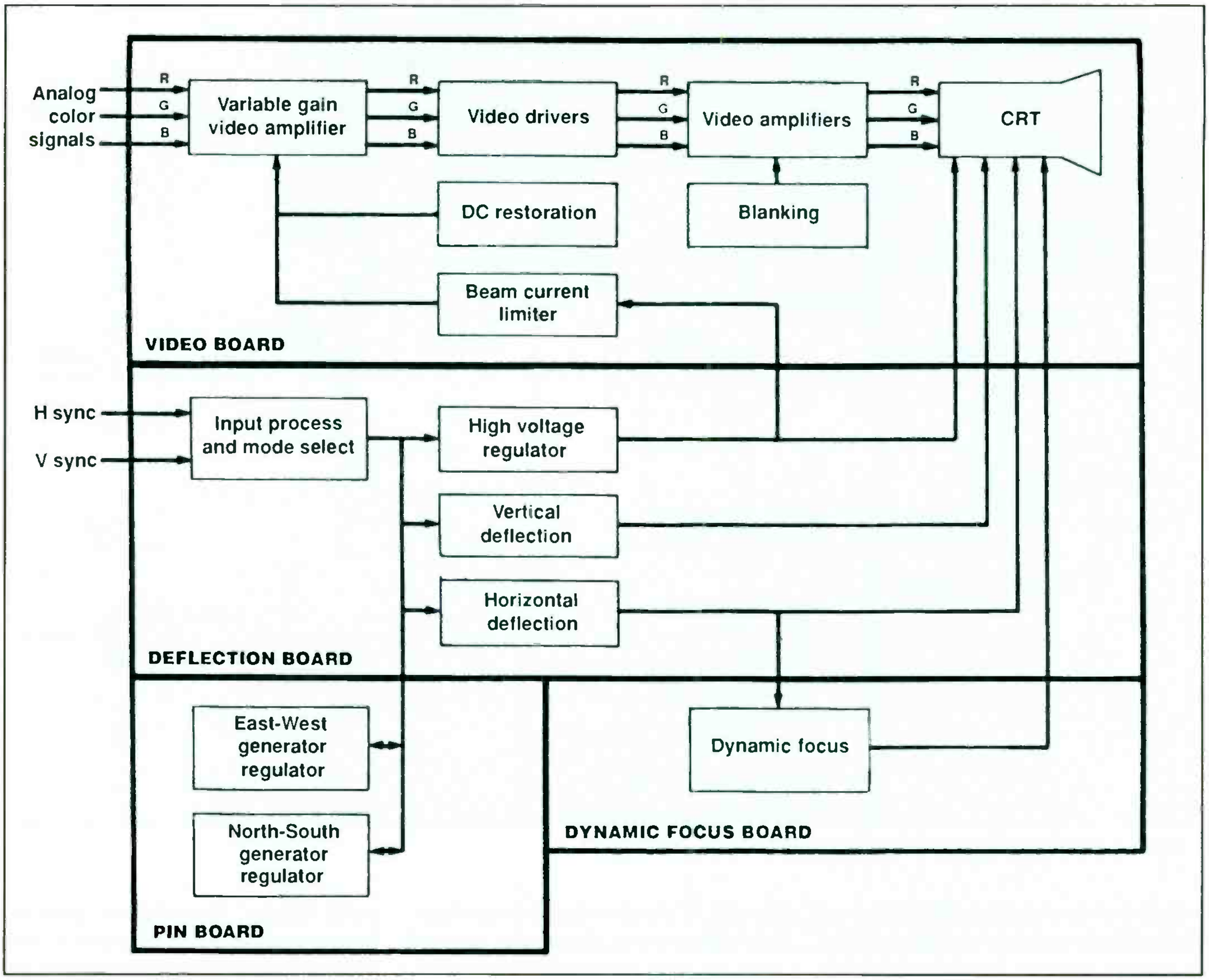


Figure 2. Block diagram of a sample monitor. As the diagram shows, the monitor consists of four circuit sections and the CRT. The four sections include the video modules, deflection module, dynamic focus, and pincushion module.

computer monitor through an interface with the system clock.

The CRT controller also works with video RAM that is either placed on the adapter or in separate slots on the mother board. While the early systems operated with a maximum of 4kBytes of video RAM, newer systems have progressed from 1MByte of VRAM to a maximum of 8MBytes. Newer 2D and 3D video accelerator cards use the large amount of VRAM to produce studio quality video effects at the desktop.

Video RAM stores the characters on display. In the RAM, one byte of information contains a code for the character, while a second byte contains the control information, so that a specific character will have a certain color or a certain effect. The CRT controller constantly scans the video RAM and, along with associated circuitry, encodes the contents of each byte. With this action, the adapter controls the operation of the electron guns in the monitor. As with television systems, the horizontal and sync signals lock the transmitted signals in sync with the monitor scanning circuits.

Character ROM within the video interface card codes each byte into a character set. From there, the video information travels to a shift register, which translates the data into a usable format. Then, the information goes through a number of logic circuits and becomes an output signal for the monitor. While this occurs, the CRT controller sends horizontal and vertical information through logic and shift registers, and outputs those signals and a brightness signal to the monitor. The three color output signals, color burst, and clock signals combine within a multiplexer, travel into a buffer, and appear as output signals for the monitor. Table 1 provides a listing of the signals produced by video adapter cards.

Of the listed types, only the VGA, SVGA, and multi-sync modes have any current use with SVGA and multi-sync monitors, gradually replacing the older VGA standards. However, as with all electronic systems, many institutions continue to use the older video standards for many purposes. When considering Table 1, pay special attention to the horizontal and vertical scan rates, as well as the resolution. Increasing the horizontal frequency produces many more lines in a 60Hz raster. With more lines, less of the raster line structure is visible.

Given our knowledge of television, we know that the NTSC system relied on a viewing distance of 8 to 10 feet. With a

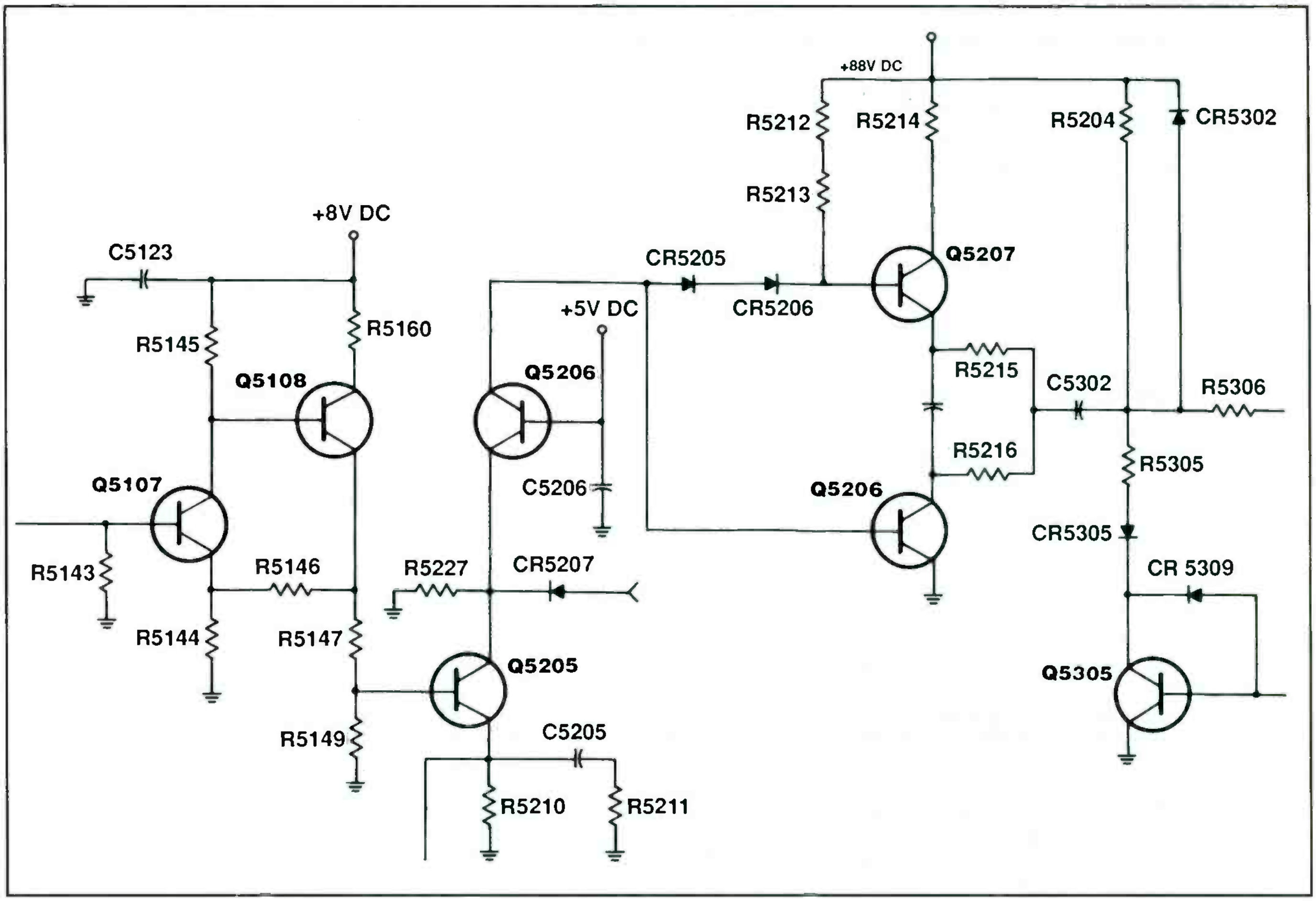


Figure 3. Schematic diagram for the video signal board.

longer viewing distance, the human eye did not pick up any screen flicker. With computer monitors, the viewing distance obviously reduces to 1 to 3 feet. Because of this, the vertical frequency, or refresh rate, becomes extremely important. If the vertical refresh rate has a high enough frequency, the eye is fooled into thinking that it has seen a full raster of light. If the number of frames per second drops below 24, the picture will have a disturbing flicker. If the number of frames rises above 24 per second, the flicker becomes less noticeable. Computer monitors use a refresh rate of 60–70 frames per second and a high horizontal scan rate to eliminate flicker and to make the human eye and brain think that a steady raster exists.

MDA

Early microcomputers relied on a display that would show only text or pixel-based graphics. These displays used either a *monochrome display adapter* or a *Hercules* graphics adapter as a source for video signals. As software designers pushed for higher quality video displays, this type of monitor often became inadequate. Many times, the adapter and card could not show the graphical images created through the software application.

Early microcomputer displays could not display colors or graphics. Using an adapter called the monochrome display adapter or MDA, these early displays worked well to display twenty-five rows of eighty characters. Figure 1 shows a video input connector of a text-only monitor, as well as the connector for EGA, VGA, and SVGA monitors. While looking at the connector pin-out diagram, note that the MDA adapter has a vertical frequency of 50Hz, and a horizontal frequency of 18,432Hz.

Using these synchronizing frequencies allows the monitor to display the 350 vertical and 720 horizontal raster lines required for good text reproduction. Since the original monochrome monitors could not support graphics, another type of video adapter card came into use. The Hercules graphics adapter card could attach to the older monochrome monitors, but could also attach to monitors that could display monochrome graphics. Since the adapter card attached to both kinds of monitors and produced 350 vertical and 720 horizontal lines, the Hercules adapter retained the unusual vertical and horizontal sync frequencies seen with the MDA video card.

CGA

IBM answered the need for better quality computer graphics with *the color graphics adapter* and the color display. The early CGA monitors could show sixteen-colors of text or graphics. Only a color graphics adapter or extended graphics adapter could drive the color monitor. Because CGA provides a vertical refresh rate of 60Hz and a horizontal scan rate of 18.43kHz, it has only a limited ability to reproduce text.

EGA

As a follow-up to the CGA card, IBM introduced the *extended graphics adapter* (*EGA*), and the enhanced color display. With the extended graphics adapter, a user could replace his monochrome Hercules,

Table 1 – Listing of Adapter Card Specifications

Video System	Horizontal Resolution	Vertical Resolution	# of Color	Horizontal Scan Rate	Vertical Scan Rate	Type
MDA	720	350	Mono	18,432Hz	50Hz	Digital
HGA	720	348	Mono	8,432Hz	50Hz	Digital
RGB	640	480	Infinite	15,734Hz	60Hz	Analog
CGA	300	200	4 of 16	15,750Hz	60Hz	Digital
	640	200				
EGA	640	200	16 of 64	21,800Hz	60Hz	Digital
		350				
VGA	640	350	256 of 256,000	31,500Hz	60-70Hz	Analog
		400				
		480				
SVGA	800	600	256 of 256,000	35,200Hz	56-72Hz	Analog
	1024	768				
	1280	1024				
8514/A	1024	768	256	31,500Hz	60-70Hz	Analog
XGA	640	480	65,536	31,500Hz	60-70Hz	Analog
	1024	768	256			
TI34010	1024	768	256	31,500Hz	60-70Hz	Analog

or color graphics adapter and monitor with a standardized design. The extended graphics adapter/enhanced color display also gave the additional bonuses of higher resolution and sixty-four displayable colors.

EGA monitors have eight video input signals and use a horizontal sweep frequency of 21.50 kHz. Along with the primary red, blue, and green video signals, secondary RGB signals intensify individual color signals. With the analog RGBI

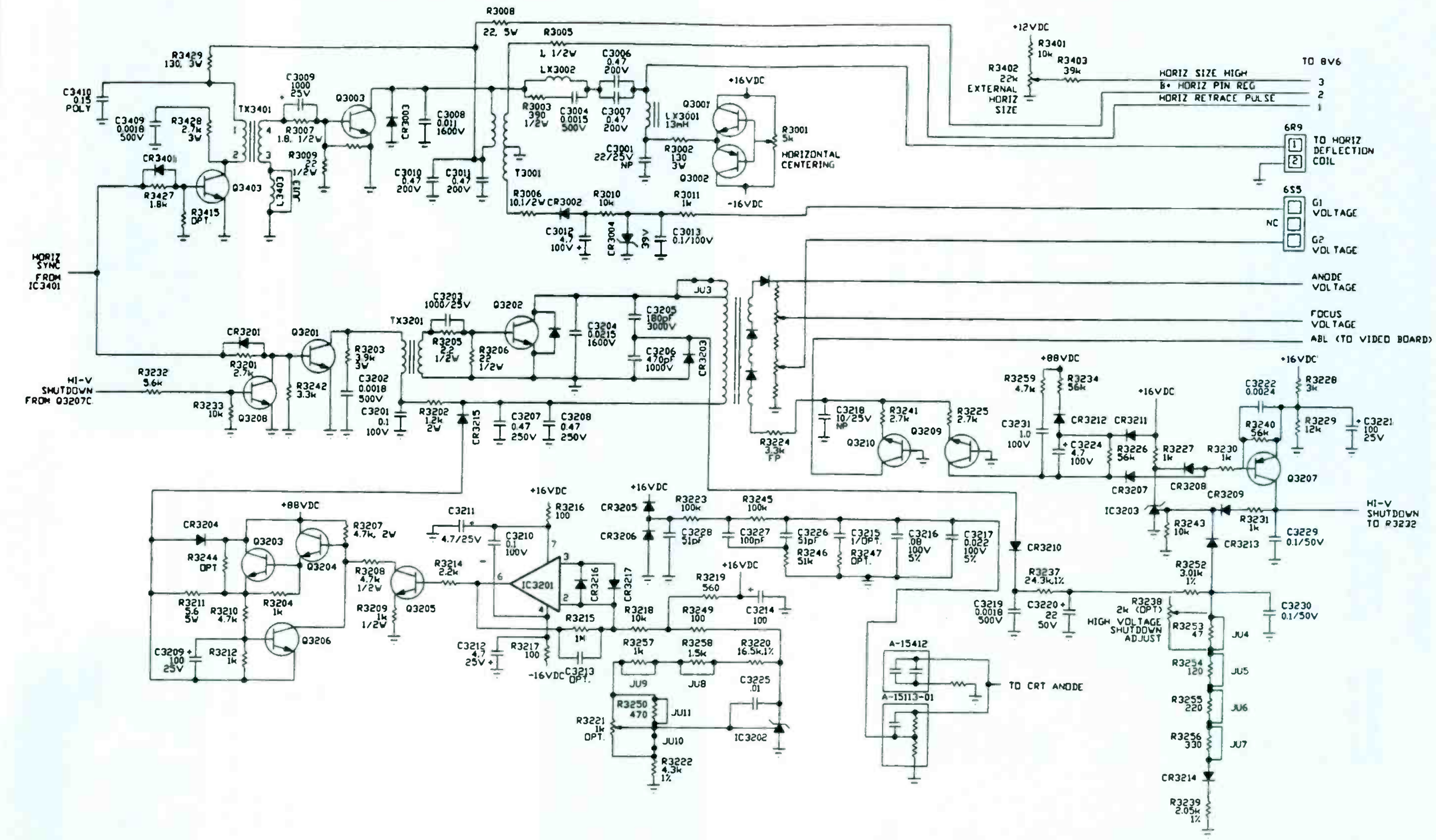


Figure 4. Schematic of the horizontal deflection circuit.

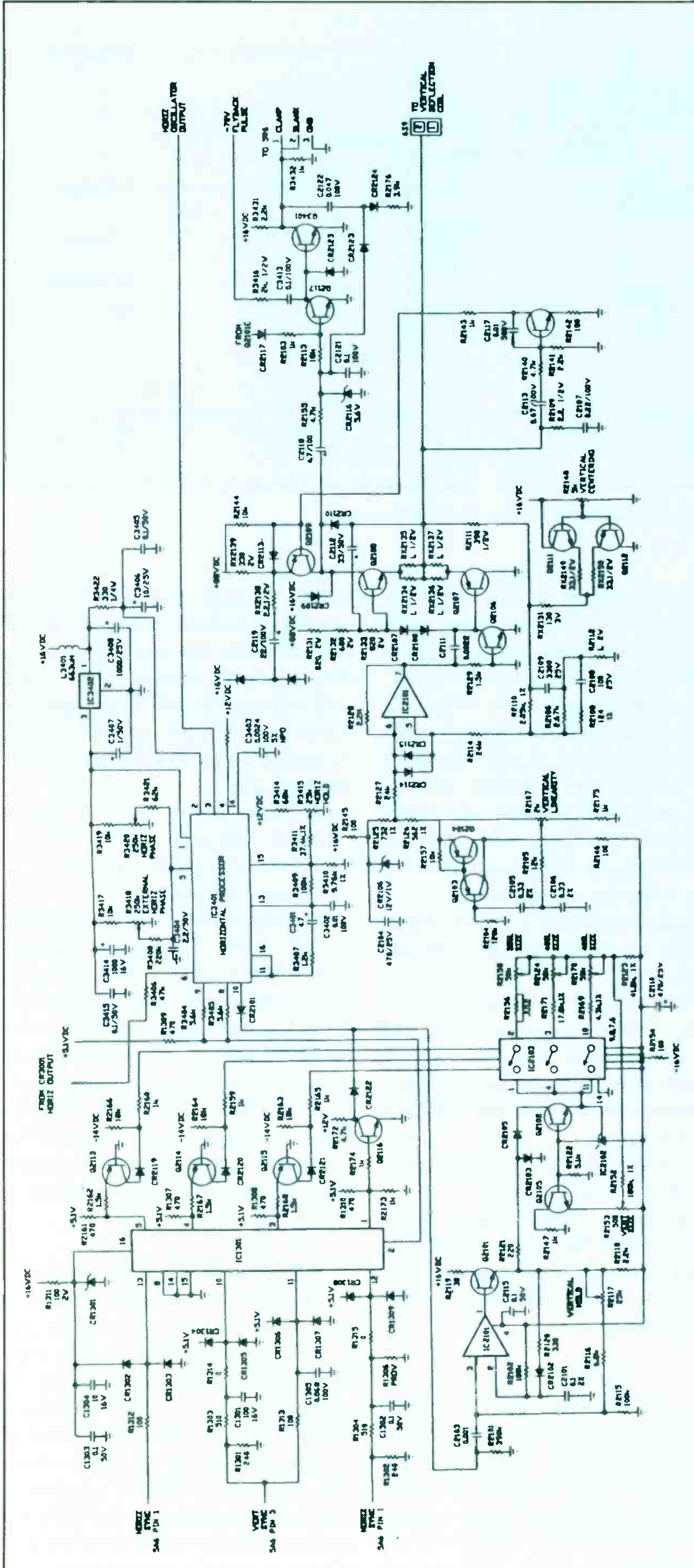


Figure 5. Schematic diagram of the vertical deflection module; the module contains circuitry for vertical signal processing and vertical deflection.

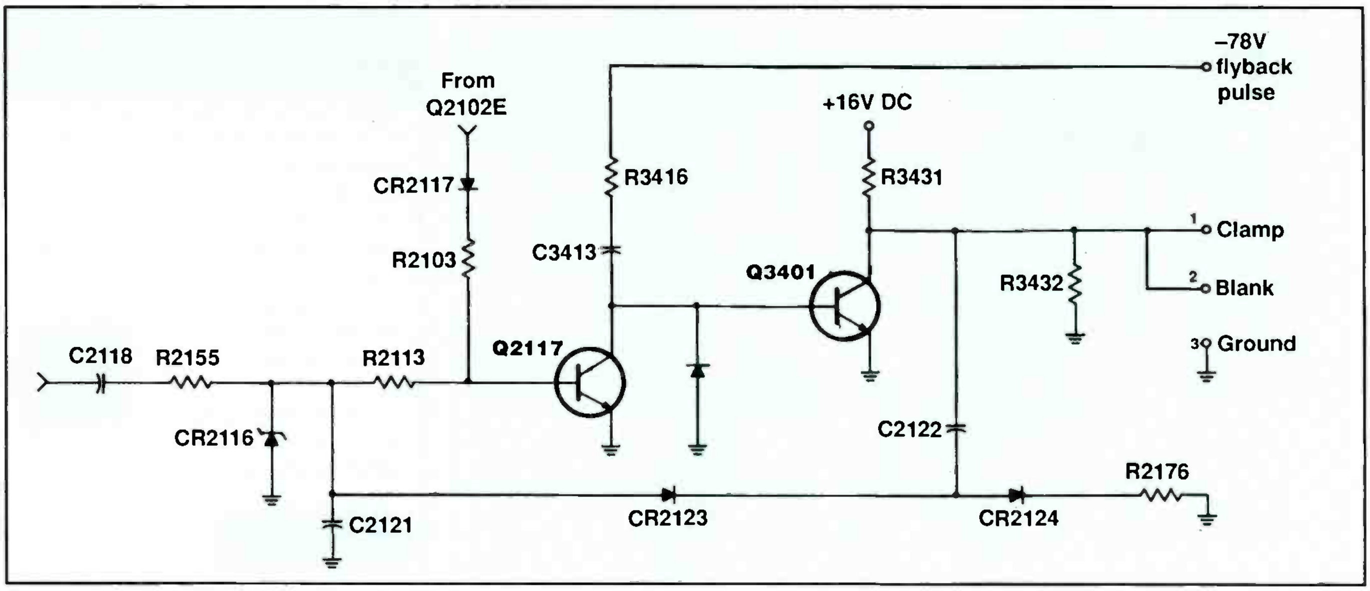


Figure 6. This circuit provides for blanking of the computer monitor screen during the blanking interval.

monitors, the intensity bit intensified all three colors at the same time. With the EGA monitor, the secondary video signals will intensify only the corresponding primary color. Because the secondary signals will intensify either the individual primary signals or combinations of the signals, the number of possible displayable colors rises from sixteen to sixty-four.

Sync signals also combine with the video signals. The vertical sync signal locks in the vertical oscillator, while the horizontal sync signal locks in the horizontal oscillator. As with television receivers, the monitor's sync signals also blank the CRT electron beams between lines, fields, and frames. EGA monitors use a fifteen-pin, D style connector called a DB-15 connector. Again, each pin carries an individual video signal. Table 2 lists the signals found at the pins of the video connector.

VGA

Advances in technology and user demands for better quality video, pushed manufacturers to produce a video system that gave microcomputer owners even more color choices, and even higher video resolutions. Early VGA monitors could display sixteen colors at a resolution of 640 x 480 and 256 colors at lower resolutions. With the introduction of the *video graphics array* (*VGA*) adapter, information display video technology also moved completely away from digital signal transmission to analog signal transmission.

Before the entrance of VGA technology, RGB monitors used an analog video signal. While the digital video signals are limited to on or off states, the analog signal causes the electron beam of the CRT to move in smaller increments. Because of this, more shades of color result. A VGA controller and monitor provide higher pixel addressability and better color graphics than the previous controller and monitor types. VGA controllers contain the following major sections:

• Graphics controller — Performs logical functions on data written to display memory;

• Display memory — Includes banks of dynamic random-access memory and stores screen display data;

• Serializer — Moves data from the display memory and converts the data into a serial bitstream;

• Attribute Controller — Determines which color will be displayed;

• Sequencer — Controls the timing of circuits found on the video controller;

• CRT Controller — Generates sync and blanking signals for the control of the monitor display.

Super VGA

Super VGA (SVGA) offers even higher video resolution specifications of 800 x 600 and 1024 x 768. Along with those higher resolution specifications, the combination of monitor and video adapter card could also produce more shades of color at a higher resolution. The increased number of high resolution colors has become a product of the monitor, the video circuitry, and the amount of video random-access memory on the adapter card. Although four different Super VGA standards exist, each supports a palette of 16 million colors. The SVGA resolution standards are:

• 800 x 600 pixels,
• 1024 x 768 pixels,
• 1280 x 1024 pixels, and
• 1600 x 1200 pixels.

The VESA SVGA standard produced by the Video Electronics Standards Association (VESA) covers the capability of a SVGA card to address video RAM as one block. Moreover, the VESA SGA standard improves the speed and efficiency of transfers between the system RAM and the video RAM. Most new video cards implement the VESA SVGA standard as part of the hardware system. Table 3 shows the pin-out sequence for SVGA signals.

8514/A and XGA standards

The **8514/A standard** produced by IBM extends the resolution of the VGA standard from 640 x 480 pixels to 1024 x 768 pixels. In addition, the 8514/A provides 262,00 colors and 64 shades of gray. When originally produced by IBM, the 8514/A standard relied on interlaced scanning. More recent 8514/A monitors use non-interlaced scanning. The EGA standard provides the same resolution as the 8514/A standard at a higher efficiency.

Multi-sync

Additionally, *Multi-sync* monitors automatically synchronize to a given scan rate. This allows the monitors to be used with any MDA, Hercules, RGB, CGA, EGA, VGA, or SVGA video input signal. Circuits within a multisync monitor scan the incoming signals and set to the received frequency range. Although multisync monitors offer flexibility, fixed-frequency monitors offer lower cost.

Video accelerators

Although standard video cards feature a CRT controller and digital-to-analog converters, actual processing is always handled by the microprocessor housed in the central processing unit. Because of this, a large amount of data must move from the video adapter card, along the computer bus, into the CPU, and into memory. *Video accelerators* contain a processor and can perform video operations without the aid of the CPU. As a result, the computer bus and CPU are freed to complete other tasks and the computer performs faster operations.

As a result, video accelerator cards can provide a large performance gain for common graphics operations and can provide speed improvements when working with graphics-based software. New video accelerator cards include highly-complex 3-D graphics rendering functions, such as polygon shading and texture mapping, and allowing the on-the-fly magnification of video clips. In addition, the accelerator provides the compression and decompression of video images so that video productions shown on a monitor screen will not have a jerky motion.

Table 2 — Connector Pin-out for EGA Video Signals

Pin #	Signal
1	Ground
2	Secondary Red
3	Primary Red
4	Primary Green
5	Primary Blue
6	Secondary Green
7	Secondary Blue
8	Horizontal Sync
9	Vertical Sync

Most 3-D accelerated video cards can deliver up to 16.7 million colors at 1280 x 1024 and a still-respectable 64,000 colors (high color) at 1600 x 1200. The latter resolution is useful for computer-aided drafting and computer-aided manufacturing applications. In addition to the capability for showing increased resolution and millions of colors, video cards contain anywhere from 2Mb to 8Mb of video RAM. The large quantity of VRAM speeds the performance of the system and ensures that the computer system will produce a high quality video image regardless of the display size.

Although the benefits of 3-D acceleration are not currently seen with business applications, graphics once seen only in games will migrate into the those applications. Many presentation programs and spreadsheet packages will take advantage of image quality offered by 3-D acceleration. In addition to applications, individual and business video conferencing also has begun to take advantage of the enhanced quality and speed given by the

(Continued on page 56)

Safety in the service center

by the ES&T staff

The consumer electronics service center is not the most dangerous place on earth. As I understand it, that distinction is reserved for the flight deck of an aircraft carrier, with its fighter jets spewing flames from the engines, bombs and rockets under the wings, and confusion as they launch the aircraft.

Compared to that, the service center is a safe, sedate place. But just look around. There are dangers: TV sets and computer monitors with several tens of thousands of volts on the CRTs, microwave ovens with their lethal combination of high voltage and high current, burning hot soldering irons, chemicals that pose dangers because they're flammable, and/or because they're dangerous if breathed in or swallowed.

And that's just part of the danger. Every place of business has its own set of safety hazards that have to be considered. Have you ever watched someone forget what they were doing and open the top two drawers of a filing cabinet? Or done it yourself? People have been injured when they did that and the cabinet tipped over on them. Those nice shiny floors of which the owner is so proud may be dangerously slippery if something gets spilled on it. And clutter can mean trip hazards.

That's just the personal safety problems. Equipment and product safety also need to be considered. Just about every consumer electronics product of today contains components that are sensitive to electrostatic discharge. Most of them also contain a full-bridge rectifier that will be damaged if a piece of line-voltage powered test equipment is used to test them unless an isolation transformer is used. And just what happens if you forget to switch the DMM from ohms to volts and try to measure voltages?

It pays to be safety minded

Accidents happen. There's no way we can prevent all accidents. But by making safety a priority in the business, we can minimize them. One way to do this is through the use of reminders; things such as posters in the service center that remind workers of safety hazards, or coach them in the correct way to pick up heavy items.

Did you know that floors that are cluttered, slippery, or damaged cause a substantial number of falls every year, with their attendant bumps, bruises, and even broken bones?

Seven steps to safe floors

The following information was taken, with permission, from the "New Pig Tech News and Views," a publication of the company New Pig, which manufactures floor safety products.

According to the National Safety Council, more than 565,000 people are injured each year from slips, trips, and falls. The only good news is that many of these accidents can be prevented.

One solution is for companies to develop and practice regular floor safety programs that incorporate the seven common sense practices below. And while these steps may at first seem basic and obvious, they can be huge in terms of prevention.

Inspect workplace floors regularly. Check for problem areas where liquid may accumulate or be spilled. Once noted, the following six practices will help correct troublesome areas.

• Prevent slip and fall hazards. Absorbent traffic runners are ideal for heavily used walkways around overspraying or leaking machines. Anti-slip runners and tapes can give employees sure footing in special areas, such as aisles, shower stalls, stairs, etc. Pay special attention to entrances and exits; that's where most dirt and moisture are tracked into your facility. Non-slip runners or carpets also will help provide traction and prevent liquid and dirt from building up.

• Alert workers to hazards. Always use warning signs and/or safety cones to notify workers of potentially dangerous areas — even during routine washdowns or other activities.

• Keep floors clutter-free. Sweep and mop floors to keep them free of slippery liquid and troublesome debris.

• Repair and coat floors. Fill cracks and crevices that may cause a worker to trip. Then, apply an anti-slip paint or coating, which will increase the usable life of your flooring and create a safer working and walking surface.

• Stop liquids from entering walkways. You can block liquid with absorbent socks or similar material, or contain and reclaim it with non-absorbent barriers and a vacuum cleaner.

• Reward employees. Encourage employees by rewarding those who practice safe working habits and maintain a clean environment. A simple "Well done," or small reward goes a long way to encourage good housekeeping practices.

A safety checklist

We won't claim that the following is a comprehensive list of safety items in the service center, but it does provide some food for thought:

- Are chemicals stored and used with care? Have technicians been made familiar with the chemicals' material safety data sheets?
- Are shelves for the storage of products to be serviced safe, and are the products on the shelves carefully placed so that they will not fall off?
- Are procedures in place for the safe handling of ESD-sensitive components?
- Are isolation transformers provided as needed?
- Are work station areas clean and free of clutter?
- Are work areas well lit?
- Are walkways well lit?
- Is stock and material neatly stored and clearly identified?
- Are all tools neatly stored and clearly identified?
- Are aisles and stairways clearly marked and unobstructed?
- Are there handrails where required for safety?
- Are floor surfaces clean, dry, level, and unbroken?
- Is trash and scrap material stored in appropriate containers?
- Are hazardous materials properly stored and clearly identified?
- Is emergency equipment accessible, clean, and clearly identified? Does this equipment work? ■

ES&T Calendar

43rd National Association of Service Managers
(NASM) Educational Congress
October 1-3, 1998
San Diego Princess
San Diego, CA
Caryn Worcester (CA)
619-562-7004: Fax 619-562-7153
NASM@NASM.COM

EIA/CEMA Spring Conference
(Electronic Industries Ass'n/ Cons. Electronics Mfrs. Ass'n.)
October 11-15, 1998
The Phoenician
Phoenix, AZ
CEMA (VA): 703-907-7600
www.cemacity.org

ASEA (AZ) State Convention
Oct. 14-18, 1998
Francisco Grande Resort
Casa Grande, AZ
Bob Lunn (AZ)
Work: 602-937-3241;
Home:602-937-3241;
Lunncet@aol.com

Personal Computer & Electronics Expo (Expositions Inc.)
October 15-18, 1998
Nassau Veterans Memorial Coliseum
Uniondale, L.I., NY
Expo Inc. (NY)
800-886-8000; 516-889-6000

WIRED Technology Expo
(WIRED Magazine)
November 7-8, 1998
Tarrant County Conv. Center
Fort Worth, TX
Julie Garinger/Bruce Rabin (TX):
817-263-4041

COMDEX/Fall '98
November 16-20, 1998
Las Vegas Conv. Center and Hotels
Las Vegas, NV
http://www.Comdex.com

Int'l. Cons.Electronics Show (CEMA)
January 7-10, 1999
Las Vegas Conv. Center and Hotels
Las Vegas, NV
CEMA (VA): 703-907-7600
www.cemacity.org

Western States Conference
(Regional Associations Conference)
Feb. 18-20, 1999
Queen Mary
Long Beach, CA
Bob Lunn (AZ)
Phone/Fax: 602-943-0596
Lunncet@aol.com

Tri-States Annual State Convention '99
March 11-14, 1999
Hood River Inn
Hood River, OR
Mike McCray (OR)
503-288-5356; Fax 503.288.0359
mmccray @cowboyz.com

Disk servicing

by the ES&T staff

Unless and until something more compact, rugged, and permitting of denser recording comes along, the optically encoded digital disk would seem to be well on its way to becoming the standard recording medium for prerecorded material. At the moment, the compact disk is already the standard for audio recording, and the CD-ROM is a very popular way to deliver software for personal computers. VHS tape is still the standard for delivering movies and other video programs to consumers, but with the recent introduction of DVD (digital video disk, or digital versatile disk) can it be long before the shelves at Blockbuster are filled with disks instead of tapes?

In any event, optical disks, and the machines that play them, are popular and becoming even more popular. Consumer electronics service technicians can expect to see a lot of these units. This article on the construction and encoding of the DVD is presented with the hope that it will be useful to technicians when they're called on to service a system that contains one of these units.

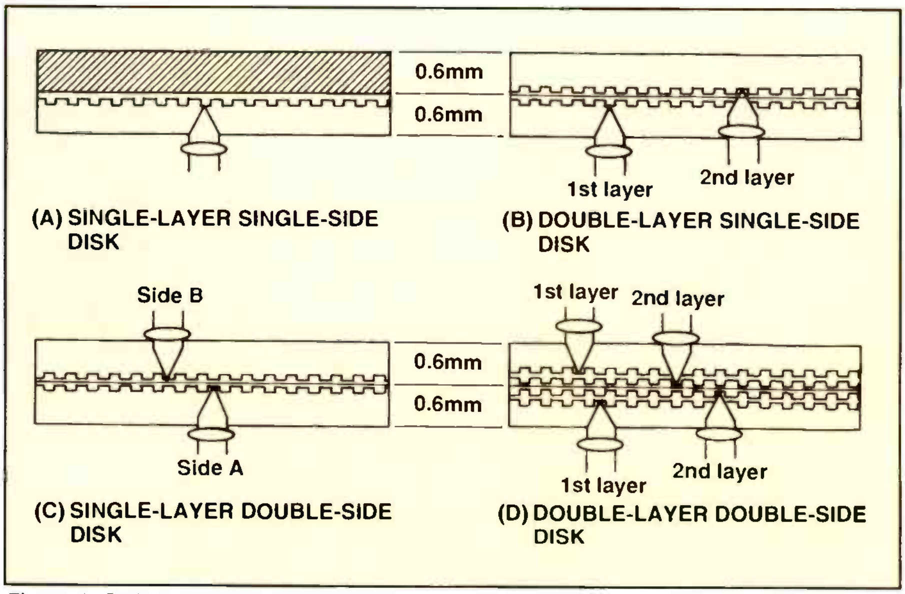


Figure 1. Optical disks can, at the moment, be made in one of four ways, as shown above.

Types of optical disk

For audio recordings, a simple disk with one side and one layer of recorded material provided more than sufficient recording density for the typical audio "album." Video programs present a far more difficult challenge. The combination of visual and high-fidelity, multichannel audio information that makes up one of today's movies would require the use of many disks recorded in the manner of today's compact disks. The challenge was to find a way to record all of that information on a single 120-mm (the same diameter as a CD) optical disk.

One factor in increasing information density was making the pits that represent information in digital form smaller, and making the laser pickup beam spot correspondingly smaller. The information density of optical disks can be further increased by recording on both sides of the disk, and upped even more by recording in more than one layer on one or both sides of the disk.

Optical disks can, presently, be made in one of the following ways (Figure 1).

Single-layer, single-sided

The single-layer, single-sided disk is the method of construction of the original compact disk. The pits that represent the audio information in digital form are formed on one side of the disk, then coated with a reflective material, and encased in plastic. The information is retrieved by a laser pickup device that is focused on the reflective layer.

The disk is placed in the compact disk player with the information-side of the disk facing downward. The laser is aimed up at the disk.

Using the increased recording density used with video disks, 4.7GB of information (about the amount of information that can be recorded on seven CDs) can be recorded on a single-sided, single-layer disk. Using current data compression techniques, a complete movie of over two hours in length, with high-quality picture and sound, can be recorded on one of these disks.

Single-layer, double-sided

In the single-layer, double-sided disk, two sets of pits representing analog information in digital form are formed in the disk, one facing each side of the disk. When the disk is played, two laser pickups, one on each side of the disk, retrieve the data. One of these disks can record 9.4GB of information.

Double-layer, single-sided

In this recording scheme, two layers of recorded information are recorded on the disk, one above the other. Two laser pickups on the same side of the disk are used to retrieve the recorded information. The layer of recorded material closest to the surface of the disk is coated with a semi-reflective coating. The coating allows a laser that is focused more deeply in the disk, to penetrate the coating and read information from the deeper layer. Another laser pickup, focused on the upper layer, is reflected from the semi-reflective coating, thus retrieving the information recorded in that layer. One of these disks can record 8.5GB of information.

Double-layer, double-sided

The recording scheme used on these disks is similar to that of the double-layer, single-sided recording, except that there is information beneath both surfaces of

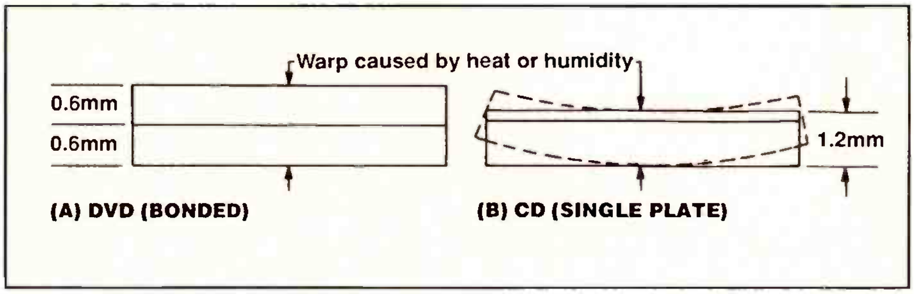


Figure 2. Because of the larger numerical aperture of the objective lens of a DVD, reading the data can be difficult if the surface of the disk is not perpendicular to the direction of the laser beam. The thinness of the disk used in manufacture of DVDs reduces these effects.

the disk are used to retrieve the information. One of these disks can contain a huge amount of information: 17GB.

DVD construction

DVD disks actually consist of two thin disks bonded together into a single unit. Each of the two disks is 0.6mm thick. The information density recorded in a layer of a DVD is considerably greater than the information density of a CD. This greater density is achieved by making the pits smaller, so that more of them can be placed on the disk. The smaller pits necessitate a smaller beam spot from the lens that focuses the laser on the pits. The decreased thickness of each disk in the bonded-disk scheme allows the smaller pits to be read more accurately by the smaller beam spot.

Another benefit realized by bonding two disks of the same material back to back is that any tendency of one disk to warp because of heat and humidity is offset by the tendency of the other disk bonded to it to warp in the opposite direction. Thus the disk remains flatter, and the information is retrieved more reliably in harsh environmental conditions.

Achieving large information densities

As was alluded to earlier in this article, the greater information density of which a DVD is capable, as compared to that of a CD, is achieved by making the pits in which the data is stored smaller. Specifically, the pits on a DVD are about one half the size of those on a CD.

It might seem that just reducing the pit size by one half would seem to no more than double the capacity of the disk. However, in addition to being able to pack the smaller pits closer together linearly in the information track, the *track pitch* (the distance between adjacent rows of pits) is also decreased, thus allowing the total length of the track to be greatly increased.

The smaller laser beam spot size required to read these pits is achieved by using a laser with a shorter wavelength, and using an objective lens that has a greater numerical aperture (NA).

Because of this larger numerical aperture of the objective lens, if the surface of the disk is at any angle other than perpendicular to the direction of the laser beam (inclination), the beam either becomes blurred, and therefore increased in diameter as it goes through the disk material, or might even strike the reflective material at a point that is displaced from the desired information pit. The thinness of the disk used in manufacture of DVDs reduces these effects (Figure 2).

Making the laser pickup beam spot smaller

The diameter of the beam spot is expressed by this equation:

$$\phi = \lambda/NA,$$

where the ϕ is the diameter of the beam spot, λ is the wavelength of the laser, and NA is the numerical aperture of the objective lens.

For a DVD in CD mode, the NA is 0.35, while in a DVD, the NA is 0.6. The wavelength of the laser is 650nm. Therefore,

$$\phi\ (DVD) = 650nm/0.6 = (approx)\ 1m$$

$$\phi\ (DVDCD) = 650nm/0.35 = (approx)\ 1.8m$$

The numerical aperture, NA, of the lens is equal to the ratio of the diameter of the lens, a, to the focal distance, f, from the

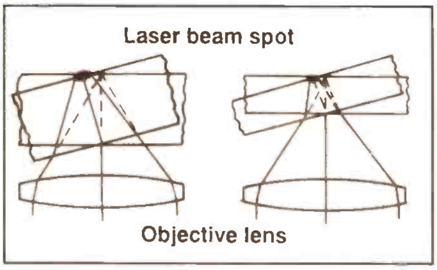


Figure 3. The numerical aperture, NA, of the lens is equal to the ratio of the diameter of the lens, a, to the focal distance, f, from the lens to the information being retrieved.

lens to the information being retrieved (Figure 3):

$$NA = a/f$$

Video compression

Even though a single-sided, single-layer DVD has seven times the storage capacity of a CD, if an NTSC TV signal were directly converted to digital information on the disk, the disk would hold only about four minutes worth of video data. It doesn't take a genius to get an idea of how many CDs it would take to store and play back a movie. A lot. Obviously, some technique had to be developed that would allow the data to be compressed.

In the 1960s, a group was formed to begin study of the problem and to come up with a solution. This *moving picture experts group* was a working group belonging to the ISO/IEC joint technical committee, a sub-organization of the International Standardization Organization and International Electric Standards Conference. The first application that the MPEG worked on was to produce karaoke disks, compact disk size disks that contained music, video, and words to accompany a live singer. This compression scheme, known as MPEG1, was a fixed bit rate system. That is, no matter how much action is taking place, the data compression stays the same.

MPEG1 compresses data at a ratio of 100 to 1. The maximum amount of time that can be recorded on a single-sided, single-layer disk using this scheme is 74 minutes. The picture quality of one of these disks is not as good as the quality of a picture produced by a laser disk (LD).

MPEG2

MPEG2, the currently used video compression scheme, is a compression technique in which the rate of data transfer needed to produce a moving picture depends on the amount of motion in the picture. If there is a lot of motion in the picture, it may require a data rate of 10 million bits per second (10Mbps), while for a picture with little motion, the data rate might be close to 1Mbps. The average data transfer rate would be in the range of 3.5Mbps. The data compression ratio for MPEG2 is around 40 to 1. Figure 4 provides a comparison of the MPEG1 and MPEG2 compression schemes.

Compression of a moving picture

As with a motion picture film, a moving picture on the TV screen is actually a series of still pictures. It's the image retention of the eye, along with interpretation of the series of images by the brain, that causes the effect of continuous motion. During some portions of a typical moving picture, large and rapid changes are taking place on the screen; for example, when there's a car chase, or fast-paced sporting event. In other portions of the moving picture, the camera is standing still, perhaps showing a deserted street, or showing the front of a building out of which we expect to see an actor come.

In the first case, when the action is hot and heavy, a great deal of data has to be transferred to constantly update the screen. In the second case, however, very little data has to be transferred.

In creating a moving picture using data compression, the current screen is compared with the most recent screen that was captured and stored. Only the information that is needed to update the previous image is recorded.

More on MPEG later

MPEG data compression is a pretty complex subject involving some abstruse mathematical operations, so we won't deal with it here. It is an interesting subject, and technicians should be aware of it in at least general terms, so it will be treated in a later issue.

Cleaning the objective lens and the laser pickup

Because of the microscopically small size of the data pits on a DVD disk, proper operation of a DVD player requires that both the source of the laser beam and the pickup that receives the modulated beam be very clean. Over time, dust and/or

VIDEO COMPRESSION SYSTEM (APPARATUS ADOPTING SYSTEM)	MPEG2 (DVD)	MPEG1 (VIDEO CD)
MAIN VIDEO RESOLUTION	720 X 480 PIXEL	352 X 240 PIXEL
FRAME RATE	60 IMAGES PER SECOND	30 IMAGES PER SEC
DATA TRANSMISSION RATE	1 TO 10 MBIT/SEC (VARIABLE)	1.15 MBIT/SEC (FIXED)
AVERAGE COMPRESSION RATE	APPROX 1/40	APPROX 1/100
PICTURE QUALITY	HIGHER THAN LD	EQUIVALENT TO VHS

Figure 4. A comparison of the MPEG1 and MPEG2 compression schemes.

smoke in the air in the room where the player is used can cause these critical portions of the unit to become dirty, thus interfering with the proper operation of the unit. If a technician encounters one of these units that seems to be erratic in tracking, or exhibiting noise in the audio or picture, a good thorough cleaning of the optics may be all the unit needs.

The first step in dealing with this type of problem is to ascertain whether it is occurring only on one or a few disks, or if it's a problem on all disks. If it only occurs on a few disks, the problem is probably with those disks. They may be dirty or scratched. If the problem occurs with all disks played on the unit, then it's probably a dirty lens or pickup, or both. It is also possible, however, that a lens/pickup system that is becoming dirty may be combining with defects in certain disks to cause problems.

The problem is that if the lens surface becomes dirty, the laser beam becomes blurred so that its intensity decreases. This causes the level of rf created by the pickup to become reduced in amplitude, thus causing playability problems on one, a few, or all disks.

Cleaning the objective lens

To clean the objective, moisten a cotton swab with alcohol, or the chemical recommended by the manufacturer, and wipe the lens outward a few times, using a motion just as if you were drawing a circle. Then two more times, moisten a fresh cotton swab and repeat the same cleaning procedure. Always clean the lens at least three times, each time with a clean swab.

For now, anyway, it's DVD

In recent years, there has been a great deal of change and innovation in recording materials for pre-recorded programs. Not too many years ago, vinyl was effectively replaced by the compact disk for audio recording. Now videotape seems to be threatened with replacement for pre-recorded movies, and, if re-recordable optical media become feasible, videotape might be replaced altogether. Whatever else happens, some other recording scheme may one day come along and replace everything we now use.

Whether or not that happens, for the time being, DVD will probably be the standard for pre-recorded movie disks for some time to come. It, therefore, wouldn't be a bad idea for technicians to learn what makes them tick. ■

Test Your Electronics Knowledge

by J. A. Sam Wilson

1. The approximate speed of sound in air is ________ feet per second.

2. Sound travels
A. faster in ocean water than in air.
B. slower in ocean water than in air.

3. Regarding narrow-band FM, the upper limit of sound frequencies transmitted is ________Hz.

4. A measurement loudness that is based upon sound power calibrated in equal steps is called a ________.

5. For a push-button telephone that has 12 buttons, how many tones are transmitted when one button is pushed?

____

6. A pure sinewave displayed on an oscilloscope shows the time between two successive peaks is 12.5 milliseconds. What is the frequency of the displayed sine wave? ________

7. The square root of 35 divided by the square root of 7 = ________.

8. The conductance of a 3MΩ resistor is ________ siemens.

9. All pure metals have a
A. positive temperature coefficient.
B. negative temperature coefficient.
C. no rule can be given

10. You have won 300 million dollars in a ball lottery. You have decided you would buy everyone in Cuyahoga Falls, Ohio, a new car. You have picked out a $20,000 car and decided to give one car a day to a different person each day. How long will it take you to go through the 300 million dollar jackpot? (Disregard interest on your money—since you keep your money in jars!).

(Answers on page 61)

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

Dual display multimeter

Extech's new dual display multimeter provides a 40,000 and 4,000 count dual display with 1μ or 10nA resolution and 0.06% basic dcV accuracy. Bar graph, range, and function are displayed in addition to primary and secondary measurement values. Measuring capabilities: ac voltage and current with a 45Hz to 1kHz acV frequency range, dc voltage and current, resistance, capacitance, and frequency. The dual display includes a combination of volts or amps with frequency. Additional features include relative time stamp for min/max recall and average functions, plus auto power off. Optional RS-232 interface and PC-DOS data acquisition software are available.

Circle (94) on Reply Card

Service information

AnaTek Corporation announces AnaTek Data Direct on CD. The CD contains information and data needed to repair or service any electronic equipment, according to the manufacturer.

The first of the three chapters on the CD consists of articles by Sam Goldwasser on how to repair anything electronic. The articles include Goldwasser's "Notes on the Repair and Troubleshooting of..." series on audio equipment, TVs, VCRs, camcorders, microwave ovens, computer monitors, printers, compact disk players, switched mode power supplies, electronic flash units, optical disk players and storage devices, small appliances, power tools, and photocopiers. Other articles cover basic electronics, troubleshooting techniques, deflection circuitry, flyback transformer testing, semiconductor testing, and capacitor testing, as well as safety procedures.

The second chapter includes all of the questions and answers posted to the ELREPAIR-L e-mail discussion group from May 1997 through May 1998. Users can "listen in" as the super technicians discuss technical and business issues on everything electronic.

The final chapter includes all of the questions and answers posted to the Electronic Repair Center internet site operated by the company. Questions on monitors, printers, TVs, VCRs, audio equipment, test equipment, camcorders, and components are all answered.

A powerful and efficient search engine created by Adobe Systems is included to speedily search the CD.

Circle (95) on Reply Card

Soldering system

The Sensa Temp ST 20A-SP is useful for most thru-hole and surface mount soldering applications. The unit also lets the user change hand pieces or tips instantly without re-calibration. An adjustable display dial with a locking mechanism prevents unauthorized tampering of temperature settings. Other features include the multi-colored LED indicator, a multi-unit stacking capability and feed-throughs for desoldering air lines, fume extraction, or other optional accessories. The product comes equipped with an Auto-Off safety system, which increases the life of tips and heaters while conserving energy.

Circle (96) on Reply Card

Computer monitor analyzer

The CM2250-PC "PRO" from Sencore is used for troubleshooting personal computer monitors. Now, all the technician has to do is select the make and model of the monitor, and the CM2250-PC "PRO" automatically configures to its setup, says the manufacturer. The analyzer has integrated the ability to store over 2,000 monitor setups and makes them available through a convenient charting system. Or, the user can simply scroll through the monitors and press enter. There is no need to refer to service literature and spend valuable time entering.

The analyzer integrates a "Process Generator" that does all the above and more, says the company. This system allows the user to control the testing and alignment process. The unit will automatically change the video patterns and signal parameters, wait for the user to make a test or adjustment, and then take him through the next step.

The analyzer offers a complete listing of features including color output analysis with the CP288 Auto "ColorPro II."

Circle (97) on Reply Card

Function generator

Global Specialties introduces the "PURE WAVE" function generator line. Available in four models, 2MHz, 5MHz, 10MHz, and 20MHz, the generators are microprocessor controlled to deliver a stable and accurate output with frequency stability of 0.1% and a total harmonic distortion of less than 1%. All models except the 2MHz version come standard with RS232 interface. Each model comes with variable duty cycle and dc offset controls.

The PW2120 (20MHz) and PW2110 (10MHz) each feature a 40MHz, 5-digit led external frequency counter. The PW2105 (5MHz) and the PW2102 (2MHz) each feature a 40MHz 4 digit led frequency counter.

Three models, PW2120, PW2110, and PW2105, in addition, have linear and log sweep operation facility.

The 20MHz model also features AM/FM modulation and burst mode.

Circle (104) on Reply Card

Oscilloscopes

Products Intl. Inc. introduces the new CS-5300 series of analog oscilloscopes from Kenwood. These oscilloscopes are available in either 50MHz or 100MHz, with or without cursors and readouts. The CS-5300 series does not use multi-function knobs, making it easier to use by an inexperienced person. Straightforward switch layout on the panel eliminates errors even on complicated operations, says the distributor. Moreover, the CS-5370 and CS-5350 employ electronic control knobs with light-touch tact switches for smooth switch operation. The CS-5370 and CS-5350 operation panel also features LEDs that indicate the major oscilloscope functions, in addition to the readout indicators.

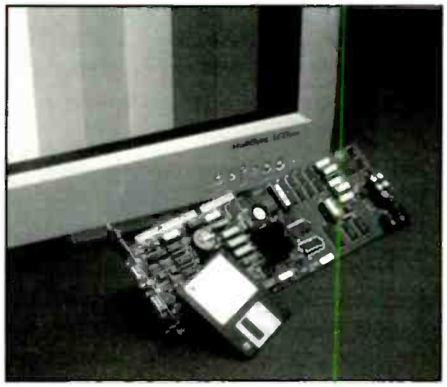
The CS-5300 series of oscilloscopes also features: automatic setup of both horizontal and vertical axes, automatic measurements of voltage and frequency, +/-2% accuracy with both horizontal and vertical axes, multi-trace display of any desired channel, and relay attenuator with improved reliability.

Circle (99) on Reply Card

Video test generator for production and service

Quantum Data announces the addition of the Model 801 GG-ISA Video Test Generator to its line. The unit features a programmable video clock rate of up to 360MHz, allowing high resolution display monitors to be tested. This generator produces output to measure linearity, convergence, brightness, and other features of monitors and video displays.

The generator is a self-calibrating, pixel resolution sync source which allows precision settings. Over 150 standard test images and over 130 popular formats come pre-programmed inside the unit, including 14 HDTV formats and Y, Pr, Pb color difference. Custom formats, images and sequences can be stored using the built-in interface, or by using a PC and a Windows 9X, NT based software program that comes with the genarator.



A new VGM (Video Generator Manager) user interface is standard with the unit and makes the generator's full potential available to even a relatively inexperienced operator. A version of this software is available on the company's website (www.quantumdata.com).

Circle (100) on Reply Card

Contact cleaner

LPS Laboratories announces the introduction of its new Electro Contact Cleaner, a solvent that replaces CFC-113 (Freon) with a new formula. The performance of the product remains unchanged. The product is a fast-penetrating, quick-evaporating, no rinsing, non-residue contact cleaner for electrical and electronic parts. The manufacturer claims that is has these qualities: no ozone depletion potential, nonconductive, nonflammable, safe to use on most surfaces, low odor.

Circle (101) on Reply Card

Universal cable connector adapter kit

The PT-4000-150, Unidapt female to female barrel adapter has joined the RF Industries Universal Adapter series. This connector can be used to couple Universal male terminations on RFA-4070 series cable assemblies, as well as the RFA-4059-A1 RF sampler and injector, or the right-angle and tee Unidapt adapter. These new accessories are an important way to expand the use and effectiveness of the Unidapt Kit, RFA-4024. This kit comes complete with two (2) male and two (2) female each of: BNC; Mini-UHF; N; TNC; SMA and UHF coaxial adapters. Each of these adapters, when joined using the Universal Center Adapter, create many adapter combinations of coaxial interfaces. Any Male to Male, Female to Female, or Male to Female adapter you need is produced quickly and easily, says the manufacturer: simply mix or match the pieces to make your adapter.

Circle (102) on Reply Card

Surface mount component placement system

Automated Production Equipment's Sniper is a solution to the manual alignment and placement of reworking CSP, Micro BGA, Ceramic BGA, and other SMT components in rework, prototyping, and low-volume builds. The manufacturer calls its placement capability "dead accurate," and says that the unit is designed to provide a high degree of process repeatability in what is traditionally a variable process highly dependent upon operator skill.

A split image of the component and PCB component pattern is viewed on a 21 inch monitor supplied with the system and all axes are easily adjustable within a vacuum-locked PCB work table. Once the component is aligned, the device is automatically placed by the press of a button. The product does not require any computer training and all temperature profiles for component removal or replacement are stored within the machine.

Circle (103) on Reply Card

Servicing a "dead set" RCA CTC185 chassis

by Bob Rose

The RCA CTC 185 chassis has been in consumer hands for more than two years, and it has performed quite well. Certain aspects of its technology like the "tuner-on-board" and use of memory devices to store alignment and operating parameters have been around for several years. Other aspects are new. Some of the newer technology makes servicing difficult, and nowhere is this more profoundly true then when the problem is a dead set.

This presentation will be as systematic and compact as possible, even at the risk of oversimplifying, because I believe such an approach makes servicing a little easier. If it won't let you "put your finger" on the problem, it will at least get you close enough to find it.

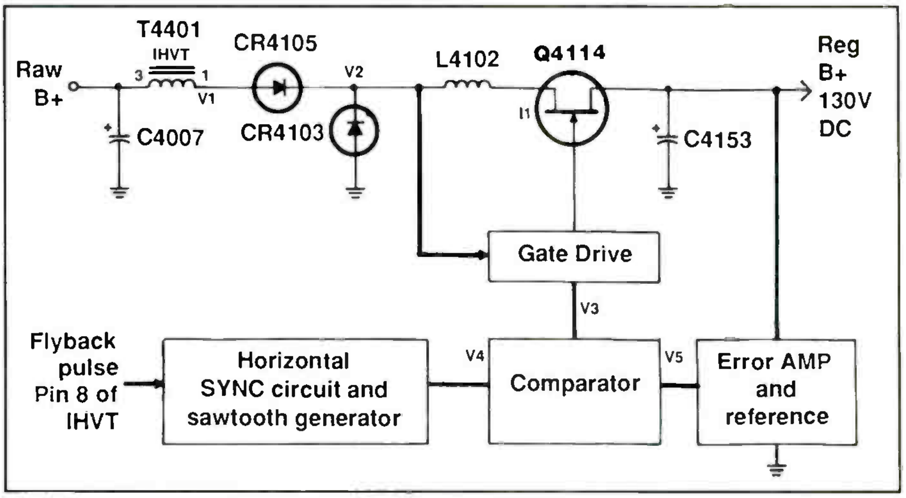


Figure 1. A dead-set condition in an RCA CTC185 might be caused by a problem in the power supply.

The four systems that can cause a dead-set

Any one of four systems in this set can cause the dead-set symptom.

The power supply

At the head of the list of systems that can cause a dead set is the power supply. Thompson describes this power supply as "a non-isolated switching power supply that uses a MOSFET as the switching device." It is somewhat complicated and seems to have a relatively high component count, but it works quite well.

Let's look at Figure 1. Raw B+ is fed through windings 1 and 3 of the IHVT (integrated high-voltage transformer) into the regulator circuit. The winding of the IHVT sums an inverting trace onto the B+ to provide "a pre-boost," so the supply will regulate even when the raw B+ falls below 130V. The number of turns on the winding determines the lowest voltage at which the supply will regulate, which means that the 19-inch and 20-inch sets will operate with as little at 90Vac.

After the pre-boost, the supply acts like a buck converter (output voltage equals input times the duty cycle). When Q4114 turns on, current flows through CR4105, L4102, and Q4114 to charge C4153. When retrace begins, the voltage on the anode of CR4105 begins to drop, but current continues to flow because of L4102. When voltage at the junction of the cathodes of CR4105 and CR4103 decreases to about -0.7V, CR4105 turns off, and CR4103 conducts until current drops to zero. Q4114 remains on until the current flow drops to zero. Its turn-off time is fixed, but its turn-on time varies in response to the PWM (pulse-width modulation) control circuit. It is helpful to remember that the retrace pulse supplied by windings 1 and 3 of the IHVT is negative going (Figure 3). If you want additional information plus waveform analysis, I suggest you consult CTC 185 Technical Training Manual published by Thompson Consumer Electronics (PO Box 1976, Indianapolis, IN 46206). I usually order such literature through my local RCA distributor, at least in part to keep what business I can in my area.

Power supply regulation

Now what about the regulation? Figure 1 is the block diagram. Figure 2 is a relatively complete schematic. The horizontal sync and sawtooth block generates a sawtooth voltage, which is combined in the comparator with a reference voltage to generate gate drive voltage. The gate drive block generates a 9V supply which floats above the regulated B+, and it is used to turn Q4114 on. I will spare you a description of how this circuit works, but I will try to place most of the components in their appropriate block. If you insist on a complete analysis, I suggest you read the booklet I just mentioned!

The horizontal sync and sawtooth generator is composed of Q4104 and Q4108 and associated components (C4109, R4118, R4120, for example). Q4102 and Q4103 and associated components form the comparator block. The error amp and reference block is made up of U4103 and voltage sense resistors R4137, R4111, and R4112. Please note that these are *precision* resistors. The gate supply consists of CR4106 and CR4111. Q4114 is switched on through R4138 and turned off by Q4113 turning on and bleeding the gate charge off through R4114.

Let me make one other comment about the components in this supply. R4108 is a gate-to-drain resistor which provides gate drive for the supply when the TV is

Rose is an independent consumer electronics business owner and technician.

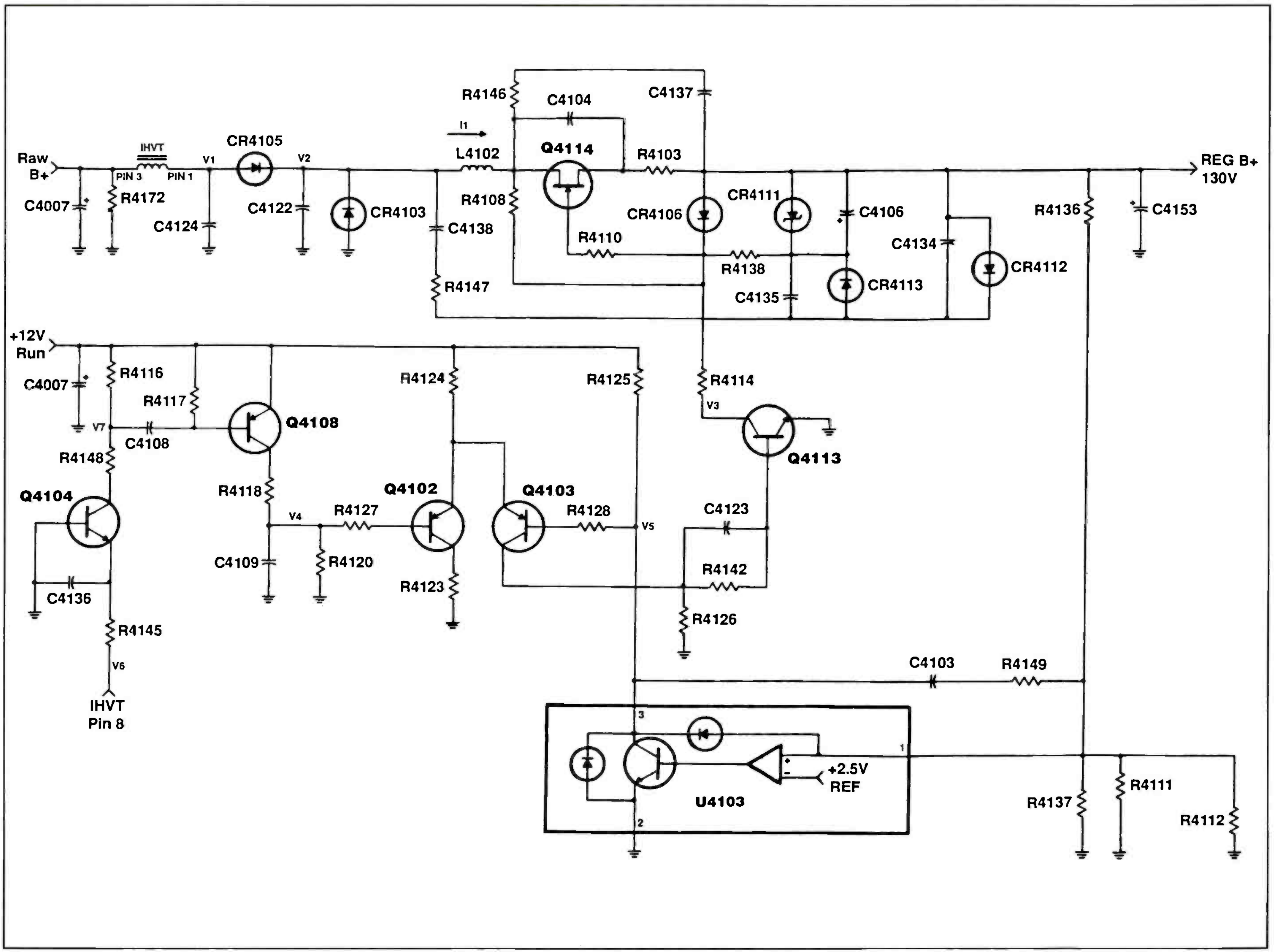


Figure 2. This relatively complete schematic diagram shows some of the details of the power supply shown in block diagram form in Figure 1.

(Continued on page 39)

(from page 26)

in standby mode. (In standby, the output voltage is equal to the raw B+ voltage.)

Now, that is a very simple and very quick preview of a somewhat complicated power supply. I think it will suffice for our purpose, though. Troubleshooting this supply is difficult because the supply will not operate unless the horizontal deflection is working, and horizontal deflection won't work unless this supply works. Chicken or egg? Not necessarily.

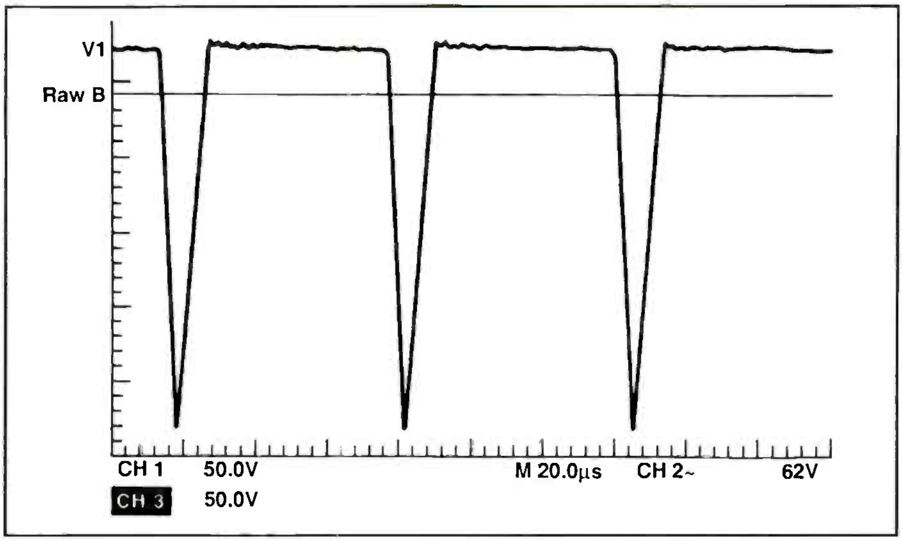


Figure 3. In this set, the retrace pulse supplied by windings 1 and 3 of the IHVT is negative going.

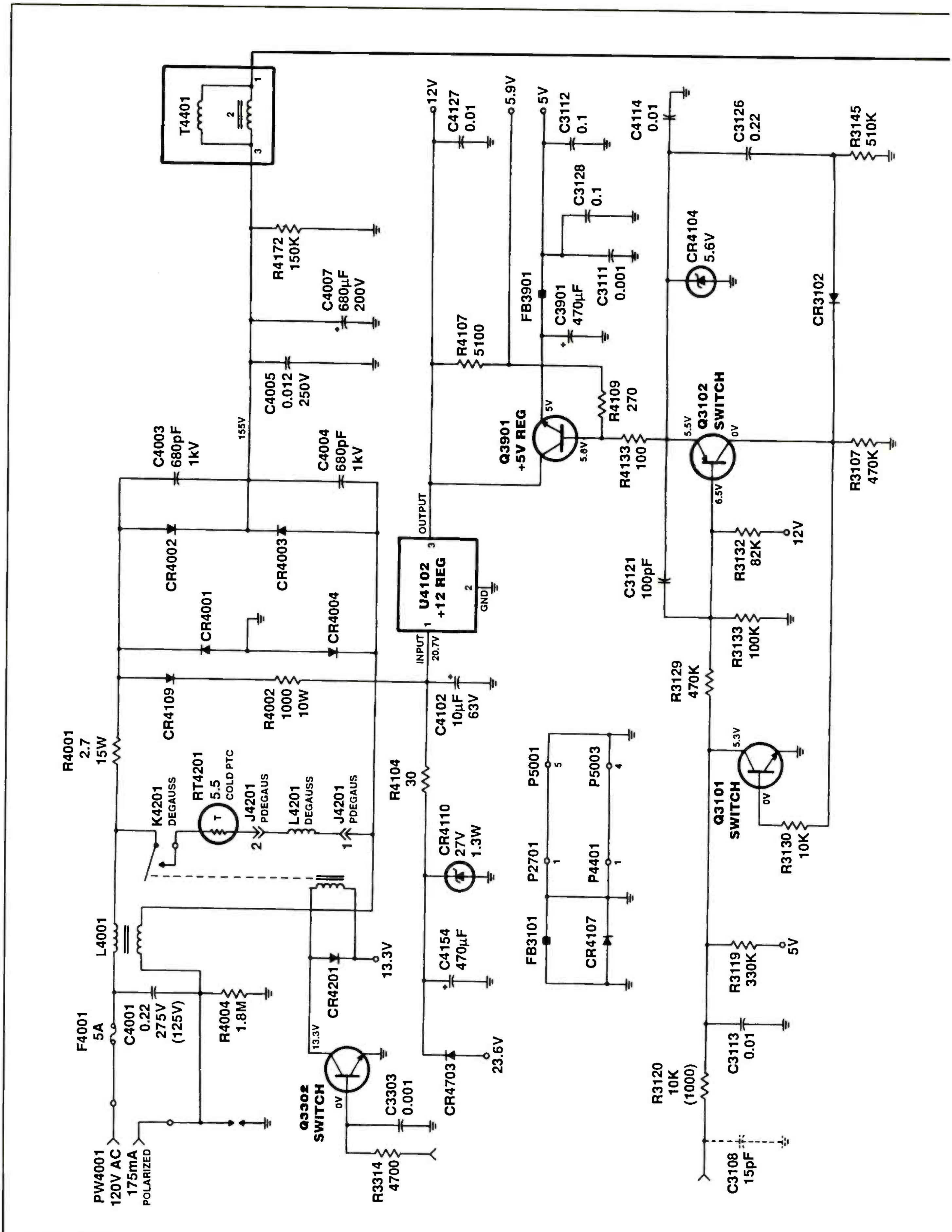
Troubleshooting the power supply

You can bypass the regulator by placing a short between source and drain of Q4114, but you *must* use an isolation transformer in conjunction with a variable transformer. If you do not use a variable transformer, the protection circuit will shut the TV down almost before you can blink an eye! So to get it set up and running, set the variable transformer at about 90V to 95V. When (and if) the set comes up, adjust the variable transformer so that the voltage on the collector of the horizontal output transistor (HOT; source of Q4114) is as close to 130Vdc as possible. You can then refer to the voltages and waveforms in the service literature to locate the problem.

A couple of service notes before I move on. Never, repeat never, de-energize any power supply or yoke lead by directly shorting it to ground. In other words, don't use a screwdriver to bleed a capacitor. If you must de-energize the component, use a 1kΩ resistor. You might get away with creating a direct short once, or even twice, but you will eventually damage Q4114. This does not apply to discharging the CRT. You may do so by using the ground braid around it.

Failure-prone components

Two components in this supply are more likely to fail than others: Q4114 and



T4401
PW4001
120V AC
175mA
POLARIZED
F4001
5A
C4001
0.22
275V
(125V)
R4004
1.8M
L4001
R4001
2.7
15W
K4201
DEGAUSS
RT4201
5.5
COLD PTC
J4201
PDEGAUS
L4201
DEGAUSS
CR4109
R4002
1000
10W
CR4001
CR4004
CR4002
CR4003
C4003
680pF
1kV
C4004
680pF
1kV
C4005
0.012
250V
155V
C4007
680µF
200V
R4172
150K
Q3302
SWITCH
13.3V
C3303
0.001
R3314
4700
CR4201
CR4703
23.6V
C4154
470µF
CR4110
27V
1.3W
R4104
30
C4102
10µF
63V
U4102
+12 REG
INPUT
20.7V
OUTPUT
GND
12V
C4127
0.01
R4107
5100
5.9V
Q3901
+5V REG
5.8V
5V
R4109
270
C3901
470µF
FB3901
C3111
0.001
C3128
0.1
C3112
0.1
R4133
100
FB3101
CR4107
P2701
P4401
P5001
P5003
C4114
0.01
C3126
0.22
R3145
510K
CR4104
5.6V
CR3102
Q3102
SWITCH
5.5V
6.5V
0V
R3107
470K
R3132
82K
C3121
100pF
R3133
100K
R3129
470K
Q3101
SWITCH
5.3V
R3130
10K
R3119
330K
C3113
0.01
R3120
10K
(1000)
C3108
15pF

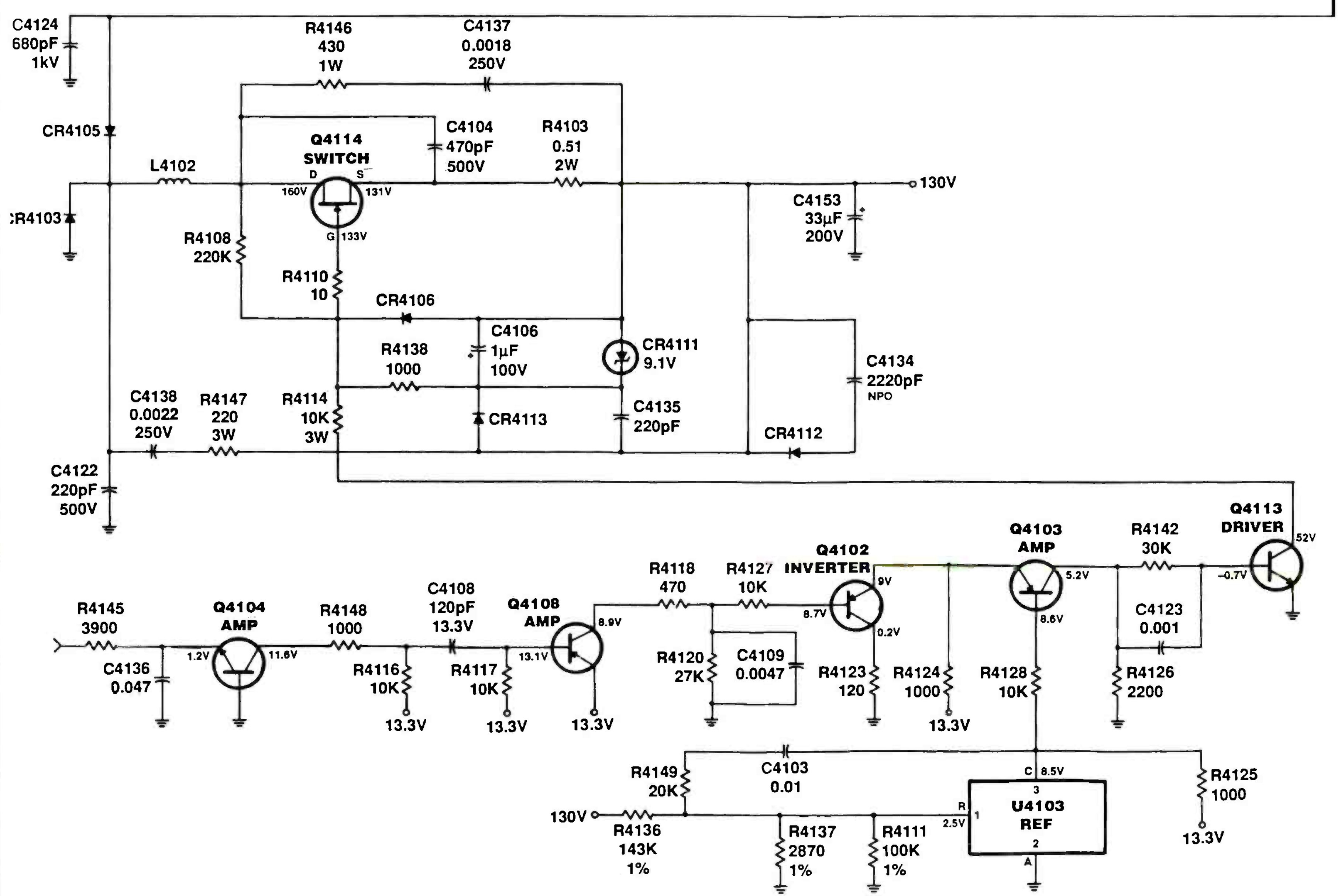


Figure 4. The full-power regulator and the standby supply of the CTC185. The standby supply is so straightforward that it needs little comment, but it does have a quirk or two.

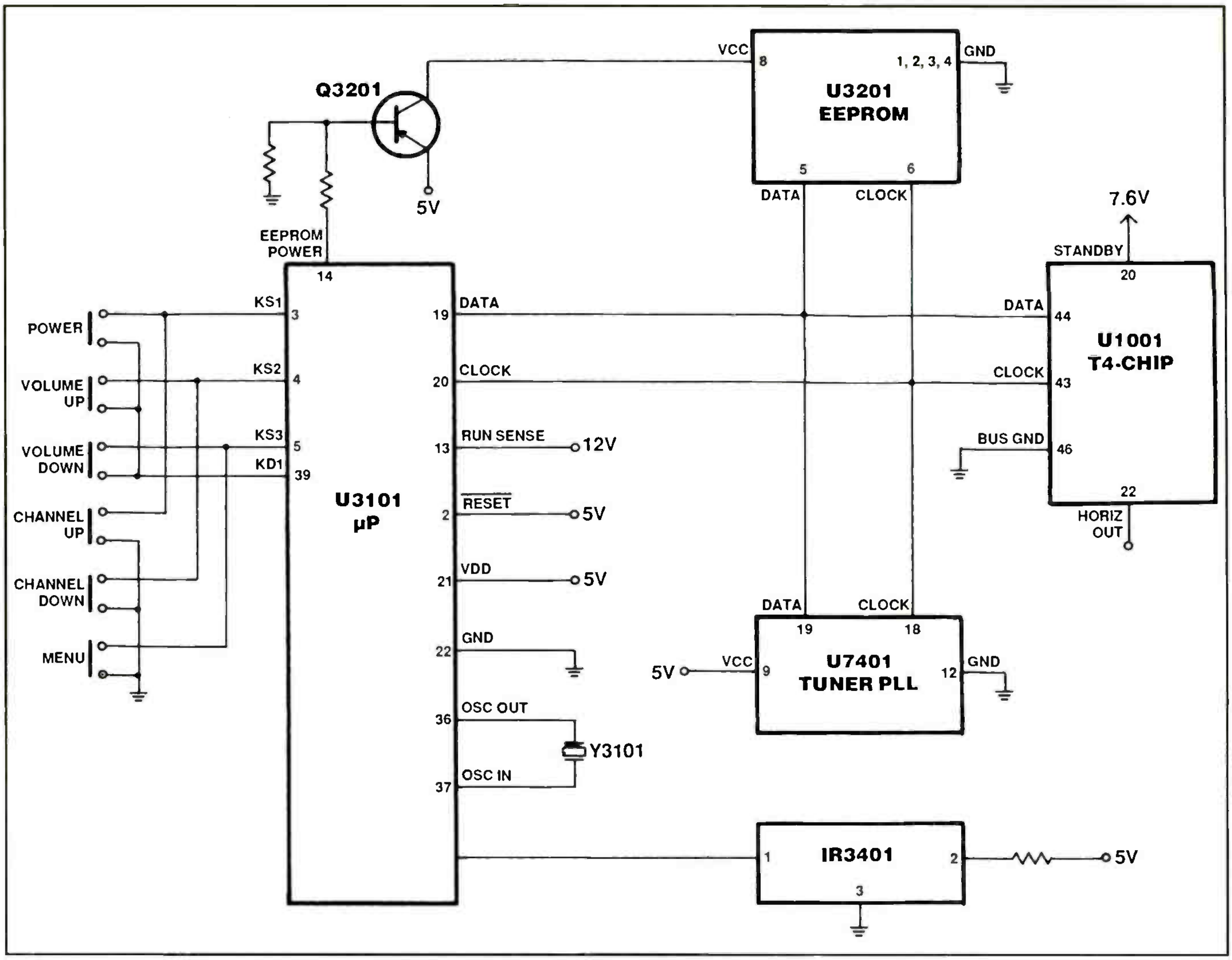


Figure 5. A block diagram of the configuration of this chassis' system control.

U4103. Q4114 most often fails due to an excess load, like a shorted HOT. The most frequent cause of failure of U4103 is excess voltage on one of its pins. If Q4114 runs hot, it probably will fail. Early production chassis used a 1μF cap for C4106 that could and often did decrease in value. That capacitor has since been replaced with a 0.47μF polyester capacitor. If you need to order this capacitor, use part number 226431. This capacitor is automatically packaged as a part of the new regulator kit which you can get by ordering part number 231523. When you replace Q4114, please be sure to bend its leads so that it fits snugly against the heat sink. Use heat sink compound on both sides of its insulator, and replace the insulator (part number 237641) if it shows any sign of damage. RCA suggests that you replace the heat sink clip before you solder in the new part. This is to make sure the transistor stays firmly seated against its heat sink. If you do not follow these procedures, you could cause the new component to fail because of inadequate heat transfer! I speak from experience.

The standby power supply

Figure 4 shows the full-power regulator and the standby supply. The standby supply is so straightforward that it needs little comment, but it does have a quirk or two. Obviously, it cannot supply much current because standby current to operate the chassis is stored only in C4154. The microprocessor even turns off the T4 chip (U1001: Figures 5, 7) to lessen current demands. In the full power mode, the 26V run supply takes over to supply 5V to system control and 12V to other parts of the chassis. The chassis has to have both of these voltages to operate.

When you have a dead set, check to see if you have 12V at the collector of Q3901. If this voltage is correct, proceed to check the 5.9V source and the 5.0V source. If the 12V is not there, make sure the T4 chip (U1001) is not turned on by checking for *any* voltage greater than zero on pin 20 of U1001. If there is voltage on pin 20, then U1001 is turned on, pulling the standby source low. Q4115, the T4 chip power control switch, could be defective, or the 12V supply could be missing. You can supplement the standby power source by using an external 26V supply connected to the cathode of CR 4703. This provides a constant supply so the T4 chip can run, and you can proceed with your troubleshooting.

System control

System control consists of the microprocessor (U3101), the T4 chip (U1001), the EEPROM (U3101), and the tuner PLL

IC (U7401). We are familiar with each of these chips, and I do not need to describe their functions. If you need such data, I suggest you consult the booklet I mentioned earlier or one of several publications Thompson has issued on their CTC 175-177 products. Figure 5 is a block diagram of the configuration of this chassis' system control.

These chips communicate via the "I Squared C" bus (inter-integrated chip), a two-wire arrangement that carries clock (SCL) and data (SCD) information to and from these devices (see Figure 5). When the microprocessor resets, it loads initial configuration information from the EEPROM. If you scope the clock and data lines of the EEPROM (pins 5 and 6), you will see a flurry of activity as the chassis is initialized (that is, immediately after the microprocessor resets).

Once the EEPROM has shaken hands with the microprocessor, clock and data activity cease until the chassis receives an ON command. If clock and data activity continue, the microprocessor and EEPROM have not successfully communicated, and this will lead to a dead set. Which is to say you have an important clue here. But, then, we are accustomed to seeing that, thanks to the CTC 175, 176, 177, and 187 chassis! There is a little difference here.

Look at Figure 5. Q3201 is a switch that the microprocessor uses on initialization to turn the EEPROM off for about 50ms and then back on to start it in a known position in its program. If the microprocessor does not receive an acknowledgment from the EEPROM, it will switch the power on and off in an effort to initialize it.

If you do not see clock and data information when the chassis is plugged in, or when the chassis receives an ON command, unsolder pins 19 and 20 of U3101 to make sure nothing is loading them down. If you still don't see these pulses, then you most likely have a defective chip. I have seen this condition just once, and a new microprocessor cured it.

There is one other peculiarity about the CTC 185 that you need to be aware of. If the tuner PLL IC fails to acknowledge when the set is turned on, the microprocessor will turn the set off and back on in an effort to clear the fault on the bus. This on/off cycle will continue indefinitely causing the degauss relay to click about twice a second.

Troubleshooting system control

Let us suppose you have a dead set and you think the problem lies with system control. How do you troubleshoot? I suggest you answer five questions:

(1) Does the microprocessor have its 5V, and is the 5V "clean"? Remember that the standby supply has just enough current to hold the chassis in standby. Use your external supply to hold the voltage up if you need it.

(2) Is there reset? Don't overlook the reset circuit. Pin 2 of U3101 has to have its reset, or the chip will not work (Figure 6). You might also note that the reset circuit monitors the state of the 12V standby supply. If that voltage drops below 10V, the reset circuit will activate and hold the microprocessor in a reset state.

(3) Is the oscillator working? Check pins 36 and 37 for a $5V_{PP}$, 8Mhz signal. If that signal is absent either the crystal or the IC, or both, are suspect.

(4) Is there something holding the data-in lines low? A stuck or leaky front panel control can cause you problems.

(5) I usually suggest as the fifth item that you take a scope and check data-out lines to make sure nothing is holding one or more of them low. But in this instance, I suggest that you monitor pin 22 of U1001 when the power button is pressed (Figure 7). If horizontal pulses are pre-

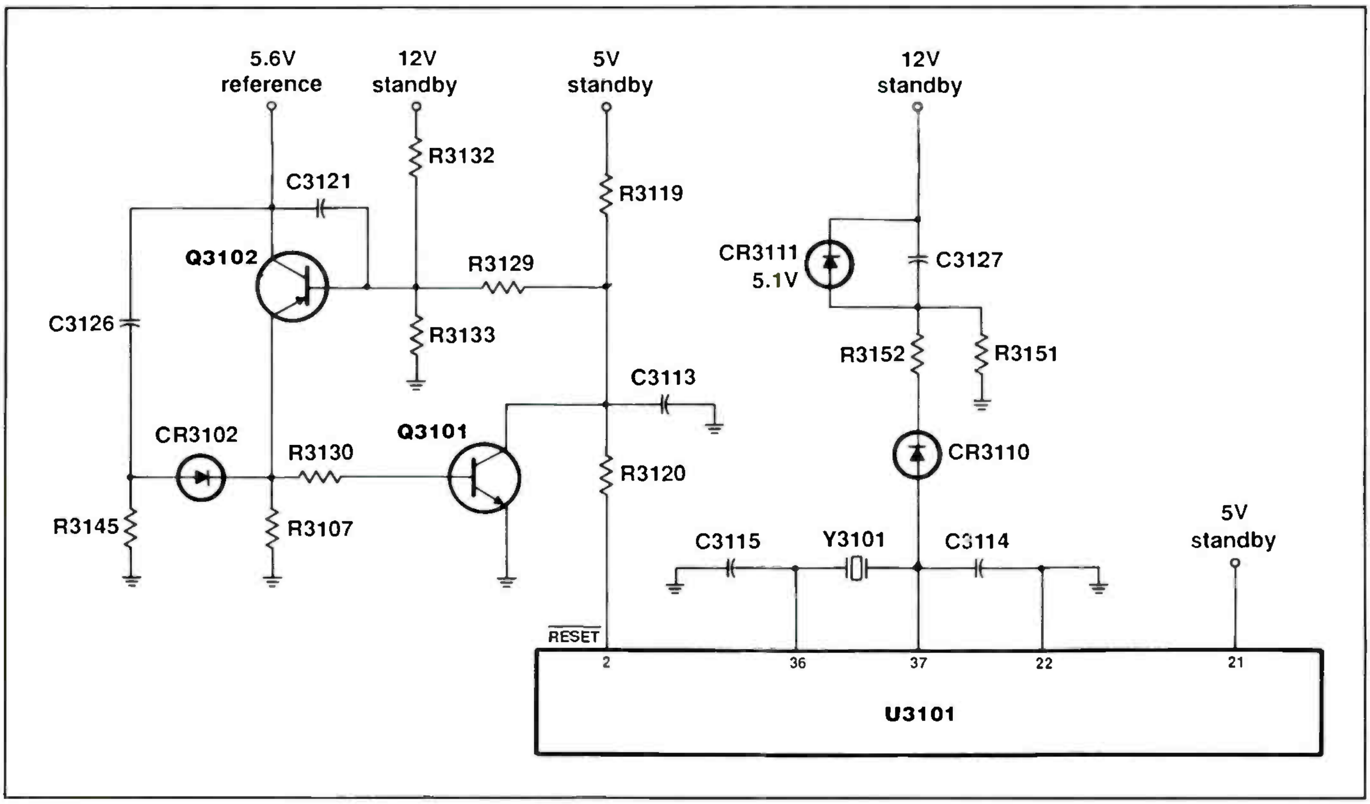


Figure 6. Don't overlook the reset circuit. Pin 2 of U3101 has to have its reset, or the chip will not work.

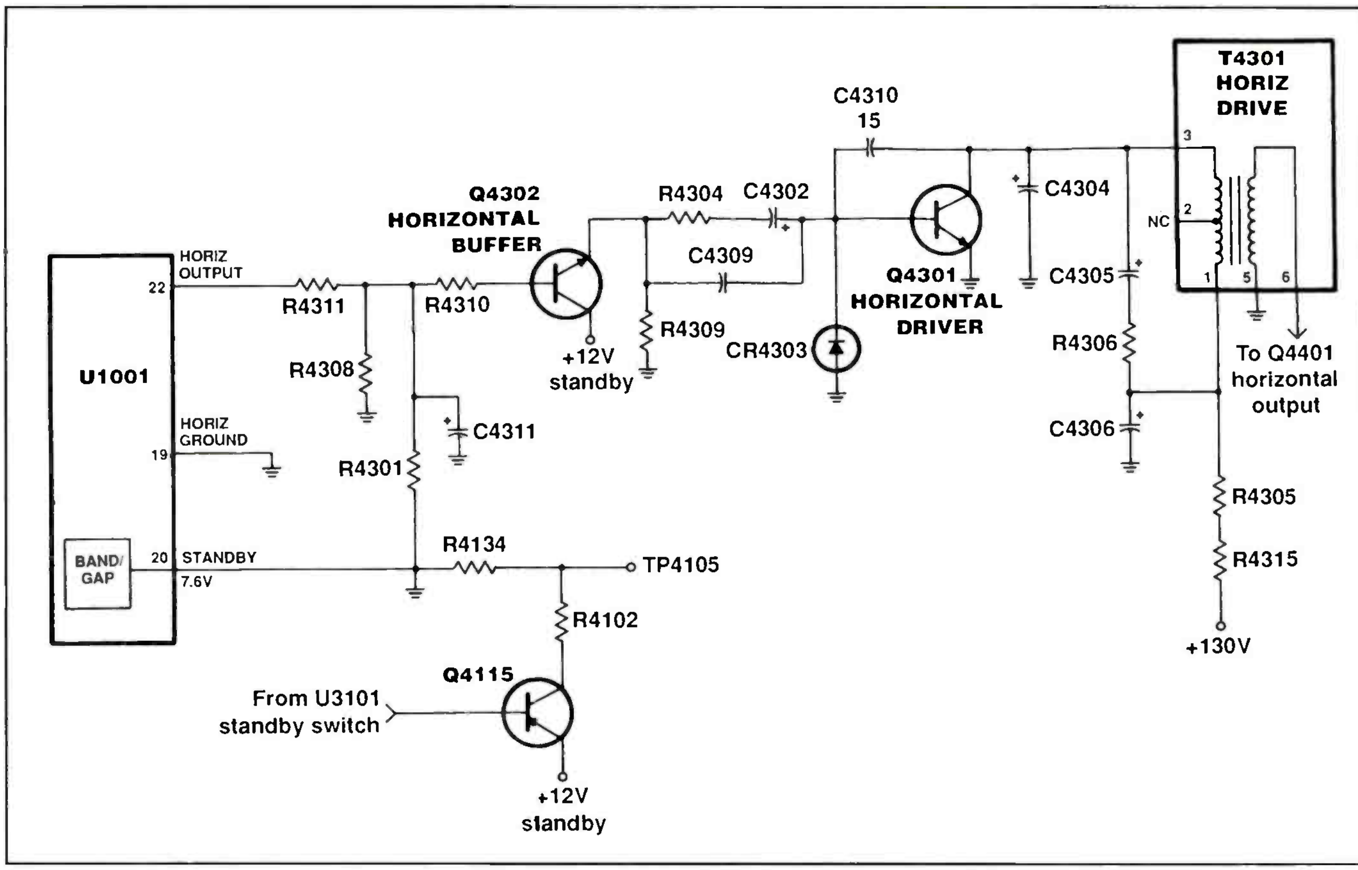


Figure 7. Monitor pin 22 of U1001 when the power button is pressed. If horizontal pulses are present even momentarily, then system control is working and your problem lies either in the deflection circuits or the 12V run supply. If the pulses are not there, check the 7.6V standby voltage on pin 20 of U1001.

sent even momentarily, then system control is working and your problem lies either in the deflection circuits or the 12V run supply. If the pulses are not there, check the 7.6V standby voltage on pin 20 of U1001. Use an external dc supply on the cathode of CR4703. If the supply voltage is still not present on pin 20, unsolder the pin to see if it comes up. If it still is not there, trace the missing voltage back to its source.

Horizontal deflection circuit

Obviously, a failure in the horizontal deflection circuit results in a dead set. Fortunately, this circuit is not as onerous to deal with as the others. Let us say you have narrowed your search to this circuit. How do you troubleshoot it?

First, do you have B+ on the collector of Q4401 (Figure 7)? If not, is the transistor shorted? If the transistor is shorted, be sure to check for a shorted Q4414. In every chassis I have serviced, a shorted HOT resulted in a damaged regulator. I should also say that these HOT's rarely fail in and of themselves. I have seen three defective HOT's this year. In two instances, I replaced defective IHVT's, and in one instance I replaced a defective cathode ray tube.

Second, as I have indicated, check for 7.6V on pin 20 of U1001. If it is missing, go to the 12V standby circuit.

Third, check for drive pulses out of pin 22 of U1001 when the power button is depressed. If no pulses are there, you probably have a system control problem. If the pulses are there but not present on the base of the horizontal output transistor, then there are several stages to check between U1001 and Q4401.

The x-ray protection circuit

Let me conclude with a brief statement about the x-ray protection circuit. I have had just one problem with this circuit in the last two years. Which is to say it is relatively trouble free. But it can throw you a curve. If the set tries to start three times and then stays off (you don't hear the degauss relay click), the set is probably in x-ray shutdown. How can you tell?

Monitor pin 24 of U1001 with a scope while you depress the power button. If dc voltage greater than 0.6V appears momentarily as the chassis shuts down, the x-ray protection circuit is active and will need to be repaired. If you detect no voltage on pin 24, then x-ray protection shutdown is not your problem. Be advised: If you elect to defeat this circuit, you had better know what you are doing, or you will cause more problems than you care to imagine.

Good troubleshooting

Well, good troubleshooting. I suggest that you have on hand good literature, a good DMM and a good scope. I do not suggest that you take my steps in the order in which I presented them. I usually begin with a quick look at the horizontal section because it will give me a clue about where to look next. Work out the procedure that lends itself to you. With good equipment, good literature, and a little knowledge, you will find the problem. ■

How to get started in vacuum tube amplifier and radio repairing

by Alvin G. Sydnor

Old, as well as new, vacuum tube amplifiers and radios are now in demand and many are being sold in as-is condition, which means they need to be repaired and restored. As an example, at a recent auction over 200 vintage electronic items were sold with prices ranging from $60 up to $300. A 1938 Airline radio went for $290 and a Crosley car radio went for $120. And I know of some old table models that are in demand and collectors are willing to pay as much as $3,000 for a specific model.

Another example worth noting is that a 1954 Fender "Super" Guitar tube amplifier in working condition is selling for $1,595. Any tube amplifier that has been around for over 40 years and is still selling for over $1,000 deserves good quality repair. The price of this same amplifier, if not in good working order, would drop well below $400.

Within the past several years the electron tube has re-surfaced as an acceptable, quality component in audio amplification. The demand for tube amplifiers for the guitar player and home stereo systems have provoked a number of manufacturers to introduce and re-issue some of their original vacuum-tube-based designs.

This trend toward tube amplifiers has driven prices of most old amplifiers sky high. Today electron tubes are available as "New," "New-Old-Stock" (N.O.S.), and "Used-Tested Good."

This area of electronics has become very profitable for antique dealers and collectors who buy, sell, and trade. It has also created a need for electronic servicing technicians who can restore and repair the old and the new tube radios and amplifiers.

Two areas of vacuum-tube product service required

What does it take to get into this as a hobby or business? First, we must point out that there are two areas that require being a specialist:

1. *Restoration* means that a set must be brought back to its original condition in every respect.

Those who specialize in restoration put new transformer windings into old transformer cans and put new electrolytic capacitors in old cans. The job of restoration involves the skill of repairing plastic, as well as cabinetry and metalworking. There are many specialists doing restorations and many electronic technicians farm their work out to them. This also includes speaker reconing.

2. *Repair* means the process of getting the set in good working order, which includes using short-cuts, such as substituting RC networks for those that are hard to find, and modifying power supplies using today's solid state rectifiers, etc.

Getting started

How do you get started? First we assume that you are competent in basic electronics and if you are now servicing any of today's electronic equipment you have the tools and test equipment that can be used to troubleshoot vacuum-tube equipment.

It is necessary to become familiar with sources of parts such as tubes, capacitors, transformers, knobs, schematics, and other services ,such as restoration, cabinet repair, and speaker reconing.

The first and most important thing to do is to start building up a library of parts suppliers catalogs and books that will be very helpful. As you collect these, you will soon notice that not all suppliers can provide the broad range of parts you will need. It is important to know who to contact for a particular part. Keep in mind that there are some parts that are very difficult to get, so when you find a part you need, order it immediately. I have seen some suppliers stock go to zero within minutes.

To start collecting the information you will need, I suggest you request a sample copy of a monthly publication called Antique Radio Classified (ARC). Their address is: P.O. Box 2 Carlisle, MA. 01741. This is a must if you are serious about getting into this type of service.

The following is a list of a few suppliers that stock parts for older products and that will provide catalogs. As you scan the advertisers in the current issues of **ES&T** and ARC, you will be able to add many more to the list.

Antique Electronic Supply
6221 South Maple Ave
Tempe, AZ 85283
602-820-5411

A.G. Tannenbaum
P.O. Box 386
Ambler, PA 19002
215-540-8055

Antique Triode
653 Commercial Street
Farmington, NY 14061
716-549-3823

International Components Corp.
102 Maxess Road
Melville, NY 11747
800-645-9154

Also from the ARC publication you will see many clubs listed that hold regular swap meets and seminars. If you plan to get into this area of service, it is a good idea to join a club in your area where you will have an opportunity to get business and meet other technicians who are willing to to share their experiences.

Specialists

Some technicians specialize in a particular area, as an example, audio amplifiers which include guitar and other musical equipment, and there are those who repair car radios for antique car owners and dealers. As you can see there are many areas in which you could branch out as a specialist. Put your imagination to work.

Future articles in **ES&T** will deal with vacuum tube circuits, old power supplies, tube detector circuits, trouble shooting techniques, and guitar amplifiers. ■

Sydnor is a retired consumer electronics servicing technician.

Understanding and specifying LCDs

by Simon P. Wyre, Lascar Electronics Ltd.

Liquid crystal displays (LCDs) have many advantages over other display methods such as cathode ray tubes (CRTs) or light emitting diodes (LEDs). Over the last two decades their performance and reliability have improved dramatically with longer life, higher contrast and of course, color. Developments such as flexible LCDs or those with irregular outlines are now possible. Their cost has fallen to the point that they can be included in marketing giveaways, such as wristwatches and credit card sized calculators. However, the specifier who plans to use LCDs in industrial applications, or indeed any application where they may be subjected to a harsh environment, must be aware of their limitations and take care accordingly.

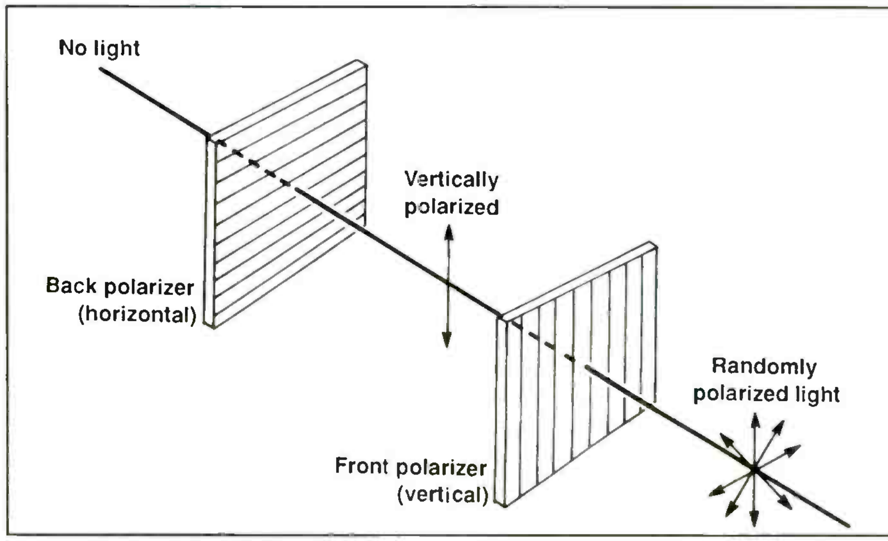


Figure 1. Two polarizing filters can block all light when aligned perpendicularly to each other.

Operation

LCDs work with polarized light (Figure 1). If randomly polarized light enters a polarizing filter, only light of a particular polarization will exit. If this light then meets another polarizer, it will only pass if the direction of its polarization matches that of the second filter.

If you have two pairs of sunglasses which have polarizing lenses, it would be informative to experiment by placing one lens in front of another and observe the light passing through while turning one lens. (But do not look at the sun.) When the two are perpendicular, almost all the light will be blocked out. Some airplane port hole blinds work on this principle.

Some crystals have the property that when light passes through them, they 'twist' the light. That is, they alter the angle of the polarization rather than cut out all elements of the light that are not polarized in the same direction. If a crystal with these properties is placed between perpendicular filters, some light will now pass. This effect can be observed with many everyday materials, such as molded clear polystyrene or acrylic.

Liquid crystal is a material that is exactly as its name implies: a liquid having the light refracting properties of a crystal. These properties, however, only exist over a limited range of temperature known as the *nematic* range. This range will be specific to the material and is illustrated in Figure 2.

Liquid crystals are influenced by electric and magnetic fields, which will alter the crystal alignment. Liquid crystal will also align to structures formed on the surface of the liquid crystal cell (Figure 3). Because the liquid crystal can be changed by electric fields, we can control the polarization of the light. With no field

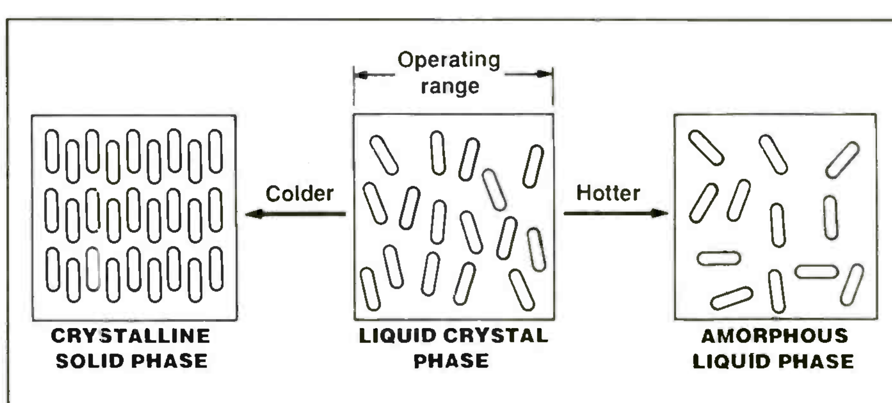


Figure 2. These are the three states of a liquid crystal. Too cold, and the crystal solidifies. Too hot, and the material loses its crystalline properties and becomes a pure (isotropic) liquid. This is why LCDs have a limited range of operating temperatures.

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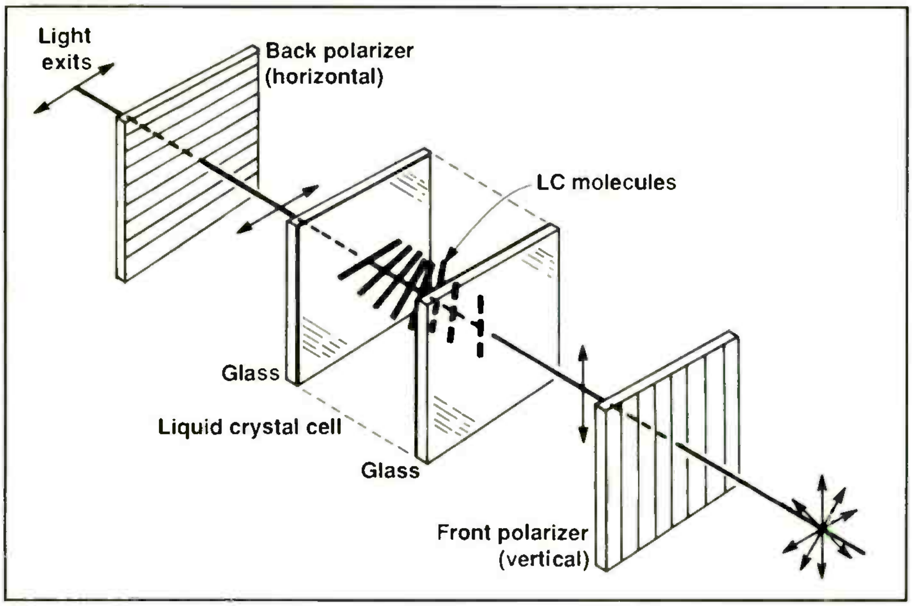


Figure 3. Placing a liquid crystal between the two polarizers, as shown here, allows light to pass. Note that the liquid is contained by glass. Glass is a supercooled liquid and is amorphous. Thus, it has little or no effect on the polarized light.

applied (Figure 3), the light passes. If, however, a field is applied, the crystal will not alter the light and therefore no light passes (Figure 4).

Having the whole of the inside of the cell coated with conductor will be of no use, unless we want to make a light shutter (which is a valid application of LCDs). In order to make a liquid crystal show numbers or something else, such as graphic pixels or a bell shaped symbol on an alarm clock, the conductive layer must be shaped accordingly. Figure 5 shows the construction of a practical LCD. There is a common backplane layer, which is the ground for all the segments. Above this on the other glass are the individual segments.

Multiplexing

For simple displays, it is satisfactory to have one connector for each segment. A typical watch display would have between 25 and 30 segments. As the complexity of the display increases, however, this is not possible. Consider a 640x480 monochrome laptop display. If each segment were connected to the outside there would be 307,200 connections. Furthermore, it would simply be impossible to run links from the glass edge up to the pixels in the center of the display.

The answer is multiplexing. Multiplexing means creating a matrix of backplanes and segments, whereby a number of segments will be joined together to one edge connector, but each segment will be placed above a different backplane. By shaping the drive waveforms accordingly, it is possible to have some segments on and others off even though they connected together. The disadvantage of multiplexing is that it will result in reduced contrast and a more critical viewing angle.

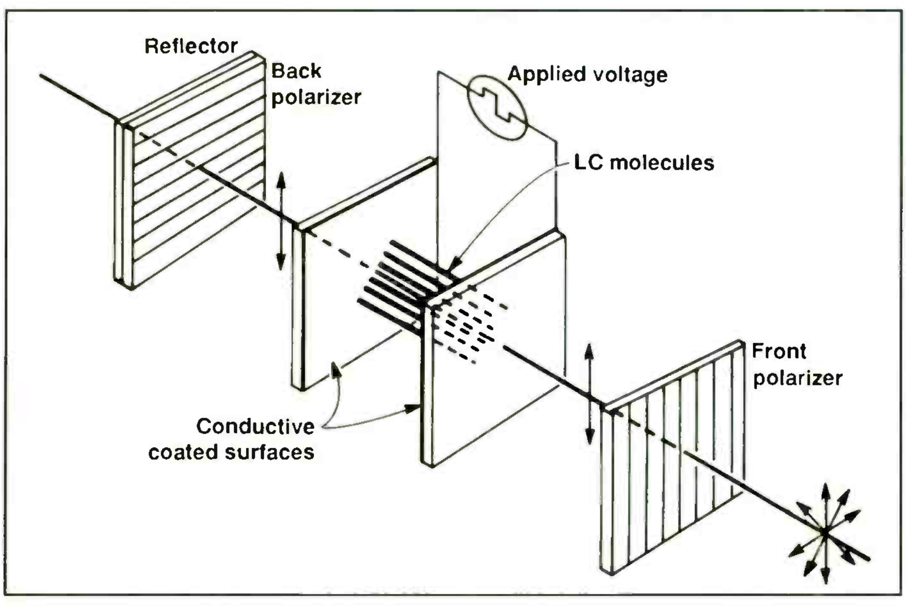


Figure 4. This is a standard reflective mode LCD. If the inner surfaces of the cell are coated in a transparent conductive layer, it is possible to control the alignment of the liquid crystal by applying an electric field.

Viewing angle and contrast

A dark (on) segment is never wholly dark and a light (off) segment is not purely transparent. So the contrast between dark and clear segments will not be absolute. The difference between the two is known as the contrast ratio, K, and is the brightness of the off segment divided by the brightness of the on segment. Several factors affect the contrast.

- The angle at which the display is viewed.
- The fluid and polarizer type. (Wide temperature range types have less contrast.)
- The reflector type, e.g. reflective or transflective.
- The drive voltage.
- The temperature.
- The level of multiplexing.

Because of the crystalline nature of the display media, the angle at which the display is viewed is important and becomes increasingly so as the level of multiplexing increases. The LCD is optimized for upwards viewing ('6 o'clock') or downwards viewing ('12 o'clock'). See Figure 6b. The viewing angle and the contrast can be varied by changing the drive voltage to the display. Equipment incorporating displays with high levels of multiplexing usually give the user some means of altering the viewing angle. Laptop PC users will be familiar with the contrast control on their screens.

Referring to Figure 6a, it will be apparent that as the multiplexing level increas-

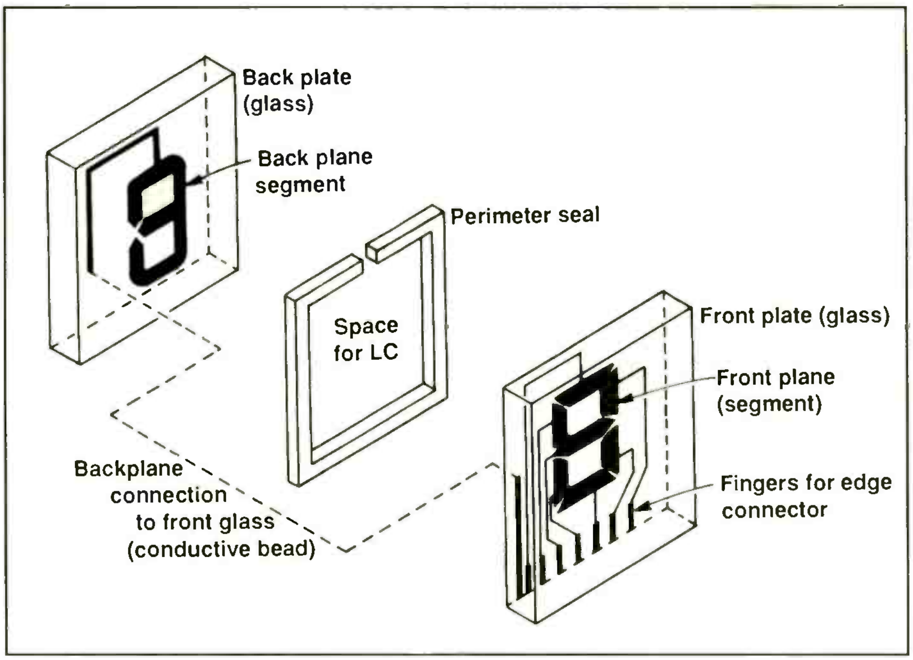


Figure 5. This is an example of a display LCD. The front and back plates are assembled to provide the cavity for the liquid crystal. The cavity is very thin (only about 0.0005") and is formed from an epoxy-resin seal that is compressed until the required thickness is achieved before being allowed to set.

es, so the point at which to set B1 and B2 becomes more critical. Eventually B2 and B1, even at their optimum positions, will start to move towards each other and the contrast ratio will reduce accordingly.

Backlighting

Most LCDs are used in daylight, but in many applications this will not be possible. Most laptop PCs, especially color types, need lighting to provide the correct viewing conditions. The light is usually passed through the LCD from behind and is thus referred to as 'backlighting.' Figures 7b and 7c show the construction of backlit LCDs. Backlights can be derived from incandescent lamps, light emitting diodes (LEDs), fluorescent tubes (cold cathode), or electroluminescent panels.

Sometimes the user will only want backlighting when it is dark, for example on a wrist watch. Here the display may have a partially reflective film on the back of the LCD behind which is some form of illuminating panel. (Figure 7b.) It is possible that the LCD is fully reflective with a lamp shining along the body of the glass. Such displays, however, are not evenly lit and are usually reserved to small non-critical applications, such as wristwatches.

LCDs can have their front and back polarizers aligned the same way. This will result in a display with a dark background and clear segments. They are referred to as 'reversed' or 'negative' mode and are used almost exclusively with transmissive displays (Figure 8). These types of display are popular with automobile entertainment systems and clocks where they are permanently back-lit with no reflective backing. In these applications low power operation is not of the utmost importance.

Electromagnetic compatibility (EMC)

LCDs do not radiate much electromagnetic interference (EMI) because the drive waveforms are 'soft' (low current and low rates of change). Consideration, however, should be given to the type of backlighting used. Cold cathode tubes and electroluminescent panels need high voltages and the circuits used to generate these voltages can be noisy.

Attention should be given to immunity. A large display will act like an antenna and incident EMI can get into a circuit via the LCD. Furthermore, an unprotected LCD will be vulnerable to electrostatic discharge (ESD), especially if it has a metal frame holding the LCD to the display PCB. A plastic window provides excellent protection to ESD and in severe cases a conductive window may be needed to protect the unit from EMI. Military type applications may have a fine wire mesh over the LCD.

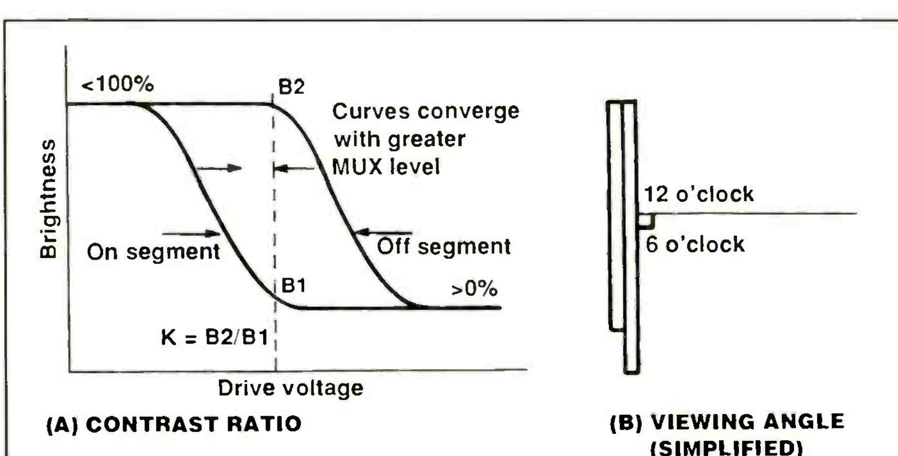


Figure 6. These are the factors that affect the contrast ratio of LCDs.

Summary: design pointers for specifying LCDs

If you will be purchasing an LCD display, or a product that utilizes an LCD display, and it may be used in a harsh or sensitive environment, you should consider the following questions.

Physical

Will the unit be subjected to severe shock or vibration?

Will it be vulnerable to impact?

Extreme temperature? Do not forget that a high internal enclosure temperature will affect the LCD temperature and direct sunlight will cause high temperatures in the LCD. Typically, normal temperature LCDs operate between 0 and

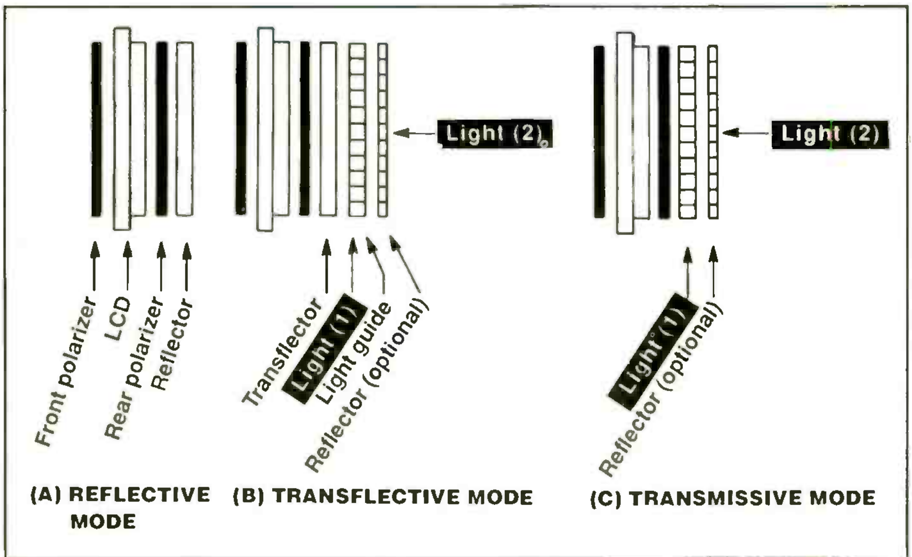


Figure 7. Reflective, transreflective, and transmissive are the three most used modes of LCD operation.

+55°C, low temperature -20 to +60°C ,and wide temperature -20 to +80°C.

Viewing angle: Will the user be looking down on the display? (select a 12 o'clock option) or up at it? (6 o'clock).

Lighting

Will the unit have to operate in poor light levels?

Select reflective for high contrast and good ambient light levels. Select transflective/transmissive plus backlighting for low light.

Consider the backlighting technology. Incandescent lamps are cheap but give poor illumination, use high power, and will not be suitable in dangerous environments, such as mining. Electroluminescent panels are efficient but are noisy and have a short life. This may not be significant for short intermittent use, such as wrist watch illumination but they are not suitable for prolonged use. LEDs are the most robust, but can deliver a lot of heat to the LCD, reducing the operating temperature range. Cold cathode is more expensive ,but gives good illumination and because of its white light, is good for color displays. As with electroluminescent displays, cold cathodes need high voltage and this may be problem in safety critical environments.

Will the user need a contrast control?

EMC

Will the unit need to comply with statutory requirements? Consider the following:

• Can electrostatic discharge (ESD) enter the unit via the LCD?

• Will the unit radiate or have poor immunity because of a noisy backlighting system or a large, unprotected LCD surface? ■

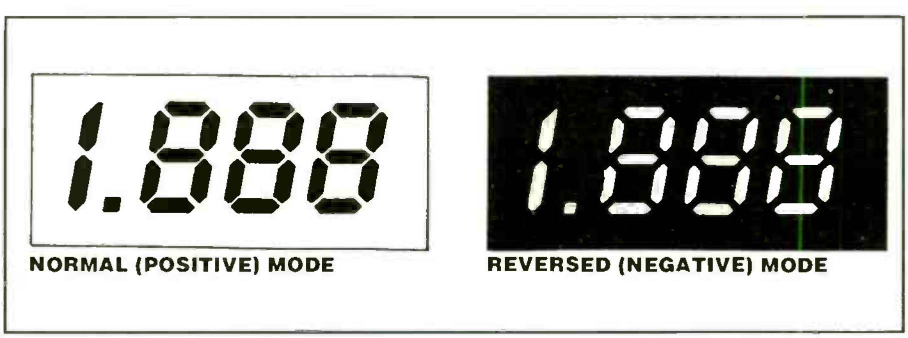


Figure 8. This graphic provides a comparison between conventional and reversed LCDs. Reversed displays need backlighting. Backlighting can be from one of several technologies and it is important for specifiers to understand the advantages and limitations of each type.

What Do You Know About Electronics?

by Sam Wilson

Sam's opinions expressed here do not necessarily reflect the official position of **ES&T**.

For newer readers who missed the Phrone Smedge story in the previous issue, here is a brief review. Phrone has only a 6.3V power supply on his workbench. He needs to test a load resistance rated at 500W and 120V.

Phrone decides to apply 6.3V to the secondary of a filament transformer to get the 120V across the primary to use for his test. His circuit is shown in Figure 1. He neglects to calculate the current required by the load resistance. The rugged little transformer dies in a smoke and fire situation. Show the calculation Phrone should have made.

Resistance

I think the story of Phrone Smedge deserves some additional thought. For the 500W, 120V resistance, I had in mind a bank of five parallel 100W light bulbs with special carbon filaments. (Don't grab a 100W light bulb and measure its resistance. The light bulbs in the Smedge story are not an "off-the-shelf" type.)

For my calculation of the resistance of the bank, I used the equation $P = V^2/R$ and solved for R:

$$\text{so, } R = \frac{V^2}{P} = \frac{120^2}{500} = 28.8\Omega$$

That is the bank resistance.

Now, this is very important. The resistance of the bank is a property of that bank. It is the resistance of the bank — even if it is lying on the bench not connected to anything. (Readers of WDYKAE? will remember that at room temperature there is a noise voltage across the bank's terminals, even though it is lying on the bench with nothing connected to its terminals.)

I purposely omitted any reference to temperature coefficient. It was not part of the story. Surely the resistance of the bank will change when the filaments are heated.

The filaments are made of carbon. Remember: carbon has a negative temperature coefficient. So, the resistance of the bank will *decrease* as its temperature rises. That makes the situation worse because the transformer current will increase with the bank heat. When the resistance decreases, the current supplied by the transformer circuit increases. So, the transformer winding will be further loaded and the temperature will increase.

Therefore, while making Phrone's situation worse, it was an overheat condition in the transformer even without considering the temperature coefficient.

Let me repeat what I have said about the resistance of the bank. That resistance (28.8Ω) is a property of the bank. The bank's resistance is the same even if no current flows through it. Incorporating temperature into the problem introduces a worse case situation and ensures a destructive transformer current.

I know that Phrone could have added a fuse or circuit breaker to prevent the burnout. (Thanks to readers who reminded me!) However, Phrone does not yet have a good grasp of fuse theory. When Phrone's circuit is first connected, the inrush current is:

$$I = \frac{V}{R} = \frac{120}{28.8} = 4.167\text{A!!}$$

The transformer secondary — now used as a power source for the bank — cannot supply that inrush current. Then, as the carbon load heats, its resistance decreases and the current increases even more.

How much?

I know that the top-level technicians who read **ES&T** are not going to be satisfied by knowing carbon has a negative temperature coefficient. They will want to know *how much* will the resistance of the bank change with an increase in heat.

Since we don't have the bank of resistors (carbon filaments) on our work bench, we will have to assume a temperature rise. The current and temperature rise in the bank will stop when the transformer starts to smoke and burn.

We will assume the temperature of the bank of carbon filaments at the start is 25°C. That's room temperature. Let's assume the temperature of the bank rises to 50°C when the transformer meets its untimely death.

Remember that the proportional change in resistance with a unit, or standard, rise in temperature is called the temperature coefficient. Table I shows some typical temperature coefficients for various materials.

Here is how you calculate the amount of change in resistance for a given amount of temperature change:

$$DR = R_1 \times a \times Dt$$

where DR is the change in resistance (That's what we want.)

R_1 is the beginning temperature

a is the temperature coefficient

Dt is the temperature rise in °C

For our problem

DR is the change in resistance

R_1 is the initial resistance 0°C (28.8Ω)

a is -0.00025

Dt is 25°

So,

$$DR = 28.8\Omega\ C \times (-0.00025)/^{\circ}C \times 25^{\circ}$$
$$= 0.18\ \Omega$$

The calculation shows that the resistance of the carbon filament bank drops by 0.15625Ω, so the resistance at 50° is

$$28.8\Omega - 0.18\Omega$$
$$= 28.62\Omega$$

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

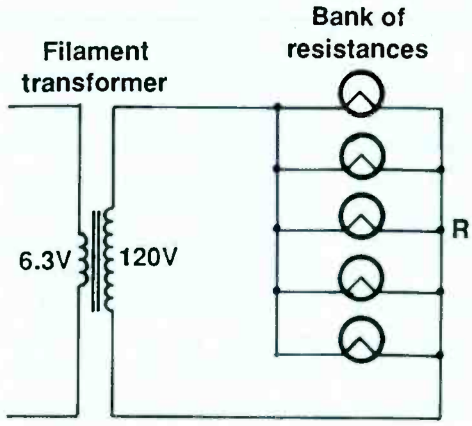


Figure 1

So, to summarize, the resistance of the bank drops from 28.8 Ω to 28.62 Ω. You can see why I disregarded the resistance change in the Phrone story!

How did statistics get into electronics?

When I was very young (about 8 years old), I made a mistake. I made a pencil mark in my (assigned) book. I wanted to remember where I had left off reading in a story. The teacher fetched me such a clout along the side of my head that it erased everything I had read and I had to start reading the story over. (In those days corporal punishment was the order of the day.) Up to this moment, I absolutely refuse to make a mark in any book — including the books I own.

I tell you this true story to explain why I can't find the references to some of the things I put in WDYKAE? However, I know they are true! An example is the story that follows.

You will remember that Einstein was not a great mathematician, and he never claimed to be one. One time, he derived an equation for a universal constant. Scientists all over the world set about to use that equation. Then, a student in Russia showed the error in Einstein's derivation. Einstein claimed it was the worst mistake he ever made.

Another time, he was working on a problem that, as the story goes, he could not solve. Finally, he developed a statistical method to solve the problem. This time his solution was correct. Scientists all over the world jumped on that statistical method and the rest is history.

Einstein hated that. He did not intend for it to be a method of developing theory. One day, he was arguing against it with Niels Bohr - the man who developed the idea of the Bohr atom. "God does not play dice," Einstein argued. "Stop telling God what He can do," Bohr replied.

Bohr and Einstein were great friends. They walked the sidewalks of Princeton talking about . . . who knows what?

The example of how statistics got into the story of the electron follows. You know that the story (you may have been told) about an electron being a little red particle is totally false. The truth is that an electron may, at any time, be a particle or a small bundle of energy. But, how can you tell which it is?

Now comes the Law of Probability, the Uncertainty Principle, Statistics and the next issue where this is all put together. You're involved in the field of electronics , so, you should understand something about the electron.

"Wait a minute!" says Phrone, "am I going to make more money if I know this?"

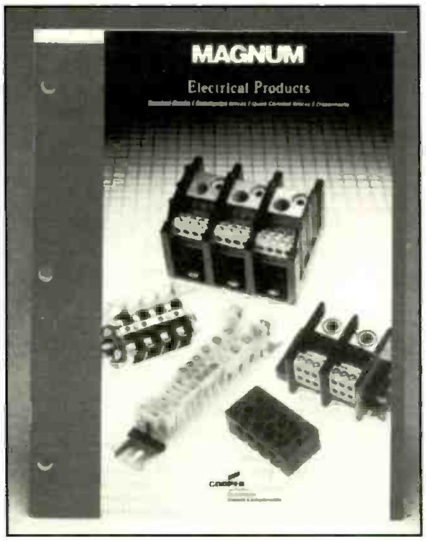
Answer: Phrone hasn't grasped the concept of Ohm's law and yet he is making money (for the time being).

Table I

Temperature Coefficients Of Resistance

Material	Per Celsius Degrees
Aluminum	0.0038
Carbon (0 to 1850° C)	0.00025
Constantan (0 to 100° C)	negligible
Copper (at 20° C)	0.00393
Iron	0.0050
Lead	0.0043
Manganin (0 to 100° C)	negligible
Mercury	0.00090
Nichrome	0.00018
Platinum	0.0038
Silver	0.0040
Tungsten	0.0045
Zinc	0.0037

Observe the negative temperature coefficient for carbon which means the resistance decreases with an increase in temperature.



Electrical products catalog

A new 31-page catalog featuring MAGNUM double row terminal blocks, power distribution blocks, quick connect blocks, disconnects, and various other products from Bussmann has been recently released.

Featured in this new catalog is MAGNUM's complete line of DIN Rail Mounted products, which includes terminal blocks, circuit breakers, and fuse holders, along with a full array of options and accessories.

The catalog includes complete specifications, illustrations, and easy ordering information for all products.

Circle (90) on Reply Card

Free online IC information

Hearst Business Communications, Inc./UTP Division announces that access to IC MASTER Online, at <http://icmaster.com> is now free.

When originally launched, access to the online product was limited to catalog and CD-ROM paid subscribers only. In less than two years, with manufacturer and subscriber support, the online access by paid subscription requirement has been eliminated. The site is now free.

The online database offers full part number and specification search capability. Updated frequently, it covers current and discontinued ICs from over 345 manufacturers with device specifications for more than 135,000 base part numbers, including, pinout diagrams, and package styles for over 90,000 of these devices.

Using this powerful online search tool, engineers and technicians can immediately narrow their search for an IC to a few possible devices. They can then make their final device selection by using "deeplinks" to go to the most current and reliable information available: the manufacturer's own data!

From this site, users can link directly to the manufacturer's own Website. And, for devices selected by the manufacturer, link directly to the actual datasheets for the device on the manufacturer's own Website. These "deeplinks" save valuable online hours searching through hundreds of pages on manufacturer's Websites looking for data on specific ICs.

The annual IC MASTER three-volume printed catalog and CD-ROM for Windows will continue to be published and is available by paid subscription.

Circle (91) on Reply Card

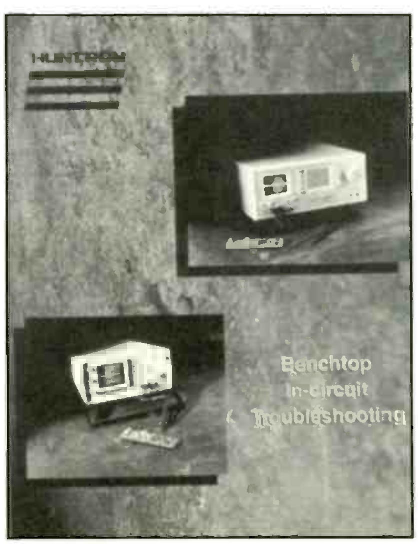
Test equipment catalog

Huntron Instruments announces the new Tracker benchtop in-circuit troubleshooting test equipment catalog. This 12-page full-color catalog describes the full range of the company's low-cost test equipment, available from their network of industrial distributors.

Special emphasis is given to two new products: the Huntron Tracker 4000 and Huntron Tracker 2500. Both instruments include new ranges to troubleshoot laptop PCs, PDAs, cell phones, and other new products built with 3V, or lower, logic.

Both the portable/bench Tracker 2500 and the slightly larger dual-trace CRT Tracker 4000 use power-off analog signature analysis (ASA) troubleshooting technology. This technique involves applying a current limited ac signal across two points of a component or circuit. The current flow causes a vertical deflection of a CRT trace, while the applied voltage causes a horizontal deflection. The resulting display is a unique V/I signature representing the overall "health" of the device under test. An engineer or test technician can then analyze the signature to determine whether the component is good, bad, or marginal. The dual trace capability of the Tracker 4000 enables technicians to quickly compare the signature of a device under test with signatures of known good devices.

Circle (92) on Reply Card



Data acquisition supplement

More than 50 new products are featured in the new 1998 *Data Acquisition Boards* supplement catalog from Datel Systems. This 48-page catalog offers a wide range of high-speed, high-performance, and multi-function Data Acquisition boards.

Features include on-board DSP coprocessor and FIFO memory, simultaneous sampling, non-stop data streaming to disk, and much more. New products include advanced performance boards for PCI, ISA, and VME bus. The four-color catalog contains complete specifications, selection charts, block diagrams, and configuration information.

The company provides free technical assistance and detailed information via their Website at www.datel.com.

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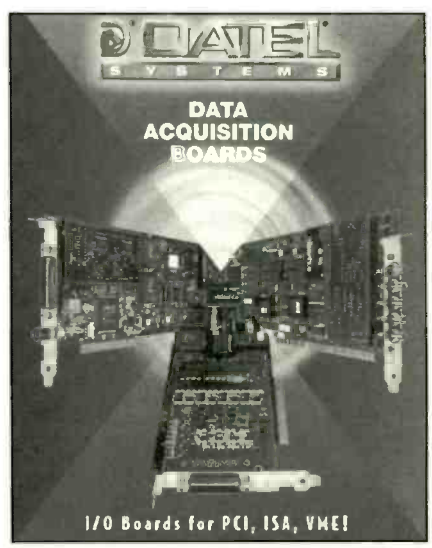

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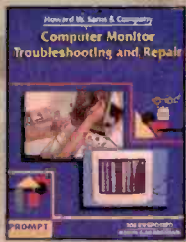

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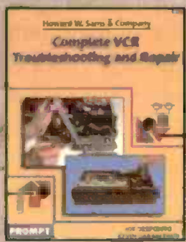

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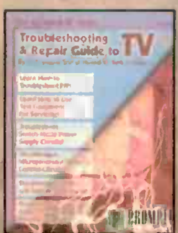

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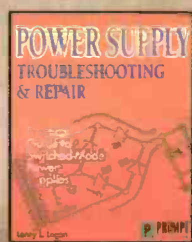

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Servicing Computer Monitors

(from page 13)

new video cards. Moreover, crossover applications, such as digital video disks and image viewers, will integrate nicely with the more powerful video adapters.

TTL and RGB video signals

Digital video displays accept *transistor-transistor logic* (TTL) video signals as an input. Two bipolar transistors work together in a single package and control the logic level of a signal. Four TTL signals — video input, highlight input, vertical sync, and horizontal sync, flow into the monitor through a nine-pin D connector. Unlike the composite video signals that separate at different stages within the monitor, the TTL signals connect directly to their respective stages. While older graphics standards relied on TTL video signals, newer standards ranging from CGA to SVGA require the RGB signals. Some monitors accept both digital and analog signals.

RGB video

Rather than rely on the same composite video signal used in television signal circuits to carry information, analog computers use *red, green, blue* (RGB) video. The RGB video signal produces sharper images than the composite video signal. During operation, RGB video consists of three separate signals for red, blue, and green. In contrast, composite video mixes the three signals together.

Computer monitor operation

While the smaller flat-screen monitors support VGA graphics adapters, the larger 17-inch offers multi-syncing capabilities and automatically adjusts to the frequency of the video adapter. Thus, it will interface with video technologies ranging through VGA, Super VGA, and TIGA. Despite featuring 100 percent compatibility with existing VGA video sources, Zenith's flat screen technology monitors differ from other VGA monitor technologies in several ways. Obviously, some of the differences begin with the CRT.

Most monitor CRT's utilize a high bi-potential focus, high resolution electron gun. The phosphor screen for the monitor is a fine pitch, black matrix, dot trio system with an anti-reflective coating. Given the same levels of resolution and contrast, the display is 80 percent brighter than conventional high-resolution CRT's. The CRT also has a 70 percent increase in the contrast ratio that provides more definite blacks. Along with enhanced brightness and blackness, the design offers a lower trade-off between contrast, brightness, and resolution.

A monitor CRT relies on precision printing of the red, green, and blue phosphor elements and black matrix to its flat faceplate. This replaces the traditional method of using a photolithographic process to apply the phosphors. The traditional process paints the phosphors onto the screen during a multi-stage process, while the precision printing process prints the phosphor elements into the respective red, blue, and green apertures within a precise set of parameters. Machining techniques produce the precision glass panels necessary for the screen printing process.

Computer monitor circuits

Figure 2 shows a block diagram of a sample monitor. As the diagram shows, the monitor consists of four circuit sections and the CRT. The four sections include the video modules, deflection module, and the dynamic focus and pincushion module. The video board contains a video amplifier for the analog color signals, video drivers, dc restoration circuits, a beam current limiter, and video output amplifiers. In the exploded view of the monitor, the deflection module incorporates the sync processing, horizontal deflection, vertical deflection, and high voltage circuitry.

Video circuitry

Figure 3 shows the schematic diagram for the video signal board. Video input signals enter the board through connector 5R9, while capacitors C5101, C5102, and C5103 couple the red, blue, and green analog color signals to the video inputs of IC5101. The signal inputs connections at IC5101 are pin 12 for red, pin 15 for green, and pin 18 for blue.

IC5101 operates as a three-channel variable gain video amplifier and controls most of the video signal processes for the monitor. A variable dc voltage at pin 2 of the integrated circuit and supplied through the contrast control controls the gain of the three video signals. The voltage varies from +8Vdc at maximum contrast to 0V at minimum contrast.

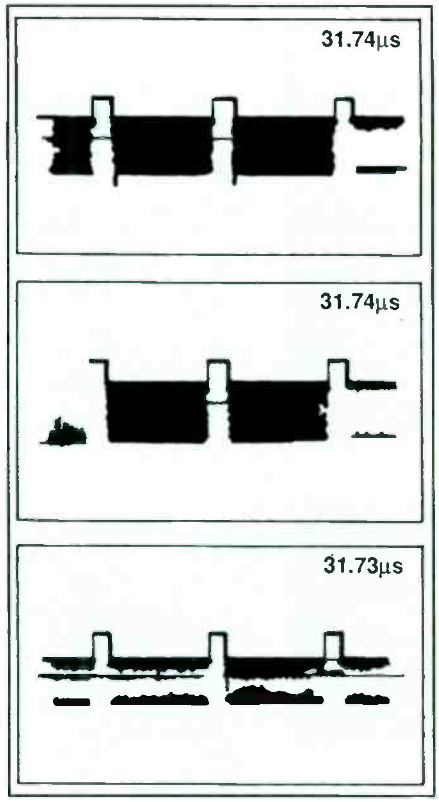

Figure 7. These are the waveforms that you should see at the CRT in the monitor whose vertical deflection circuit schematic diagram is shown in Figure 5.

Looking at the diagram, the contrast control operates as a voltage divider and supplies a variable voltage to pin four of connector 5A1. R5112 and C5111 make up an integrator that smooths the action of the control, so that the variable voltage stays within three percent of its designed range. The gains of the three channels should track to within about 3% over the range of the contrast control. Again looking at the schematic diagram, each of the output transistors is configured as an emitter follower.

An automatic brightness limiter (ABL) circuit within IC5101 also controls the gain of the video signals. In this case, the circuit causes the video signal to decrease if the average anode current goes past 750uA. The anode current is sampled at the secondary of the flyback transformer, averaged by R5111 and C5119, and then applied to pin one of IC5101. Negative feedback produced by the ABL circuit forces the average anode current back to the 750uA level.

After the video amplifier IC processes the input signals, three different stages

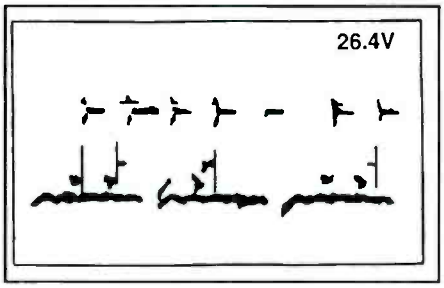

Figure 8. The waveforms at the emitters of Q103, Q104, Q203, and Q204 should look like this. The lack of a good waveform at any of those points allows us to focus our attention on IC401, the video processor.

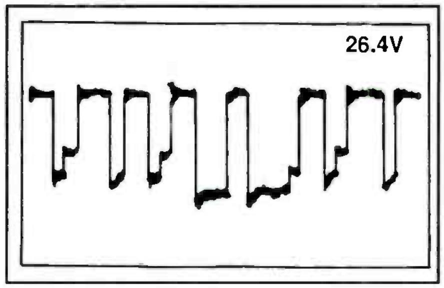

Figure 9. If the waveforms at the emitters of Q103, Q104, Q203, and Q204 are correct, you can move to the collectors of Q102, Q202, Q302 and expect to find a waveform similar to this.

further amplify and add to the signals. First, three resistors form a resistor attenuator, which attenuates each color signal before it couples to its respective video driver. Using the green video amplifier section as an example, each signal becomes applied to the cascode output amplifier consisting of Q5205 and Q5206. The red and blue video amplifier circuits have identical conditions.

DC restoration

Because of the original ac-coupling of the video input signals to the video amplifier circuit, the dc portion of the signal is restored by a combination of transistors, integrated circuits, and passive components. The amplified video signal appears at the Q5206 collector and across load resistors R5212 and R5213.

An RC network formed by R5209 and C5214 samples the voltage at the emitter of Q5205 during the retrace interval. Sampling occurs during the period that the video signal is at the black level and feeds a sample voltage to pin 14 of IC5101. During this time interval, the clamp pulse at pin one of connector 5R6 is at a logic high. The RC network also combines with C5205 and R5211 to provide frequency compensation for the cascode amplifier.

From there, a comparator compares the sample voltage with a reference voltage found at pin 13 of the IC. Depending on the size and polarity of the difference voltage, the comparator uses a push-pull current source at its output to either charge, or, discharge hold capacitor C5105. The voltage developed across C5105 controls the dc bias of the signal at pin 15 of IC5101. All three video channels rely on the comparison between the sample and reference voltages.

When an active clamp pulse appears, the condition of the dc restoration loop allows the black level emitter voltage at Q5205 to equal the reference voltage at pin 13 of the IC. When clamping stops and video begins, the dc restoration loop turns off and the hold capacitor supplies the dc bias. The action of the dc restoration loop and hold capacitor provides a stable dc bias for the cascode output amplifier. As a result, the ac-coupled video signal applied to the input of the video amplifier IC is dc-restored.

The video output stage

Again using the green video amplifier section as an example, we can trace the amplified video signals from the collector of Q5206 to a pair of transistors, Q5207 and Q5208, connected as emitter followers and as a complementary pair. Diodes CR5205 and CR5206 force the complementary pair to operate in the class AB mode and reduce any crossover distortion. Along with ac-coupling the video output signal to the CRT, the stage also provides isolation and low-impedance drive.

The isolation of the cathode capacitance from the collector of the output transistor protects the output circuit from the possibility of excess capacitive reactance. Because capacitive reactance has an inverse relationship with frequency, a large capacitive reactance would reduce the load impedance of the output stage, thus, reducing the gain of the amplifier.

Horizontal and vertical sync signals

The horizontal and vertical sync circuitry includes the sync input buffering, mode selection, sync waveform adjusting circuits, horizontal and vertical size control, phase control, and the hold controls. Of particular interest, our example monitor can operate in one of three video modes. With mode 1, the monitor uses the EGA mode, while mode 2 produces a CGA display. Mode 3 establishes the VGA display. Each of the modes depends on the 31.49kHz scan frequency and is determined by the polarity of the horizontal and vertical sync signals.

Horizontal deflection circuitry

Referring to the schematic of the horizontal deflection circuit shown in Figure 4, the horizontal oscillator output voltage is applied to the base of Q3403, the horizontal driver. From the collector of Q3403, the output signal from the driver goes to the interstage, an impedance matching transformer. TX3401 steps down the B+ voltage, while a waveshaping circuit consisting of C3009, R3007 and R3009, shapes the rectangular drive waveform for the horizontal output transistor. The drive waveform is applied to the base of Q3003, the horizontal output transistor. Q3003 becomes cut-off during retrace and a portion of the trace. When Q3003 cuts off after flyback, the damper diode or CR3003 conducts and produces a portion of the trace at the left side of the raster. In addition, the damping diode suppresses oscillations that could produce white vertical bars on the left side of the raster. Retrace capacitor C3008 forward biases the diode.

The action of the transistor and the diode reduces the average amplifier current and increases the efficiency of the amplifier circuit. Looking at other components in the horizontal deflection area, the circuit uses the impedance of coil LX3002 to change the yoke current and improve linearity. Also, the combination of the horizontal centering control or R3001 and a voltage divider consisting of Q3001 and Q3002 provides electrical horizontal centering of the display.

Vertical deflection circuitry

Figure 5 shows the schematic diagram of the vertical deflection module. The module contains circuitry for vertical signal processing and vertical deflection. A differentiator consisting of CR2122, R2101, and C2103 couples the vertical sync signal at the collector of Q2116 to pin three of IC2101. Together, IC2101 and Q2101 form the oscillator stage, while C2101 and R2102 determine the

Table 3 — Connector Pin-out for SVGA Signals	
Pin#	**Signal**
1	Red Video
2	Green Video
3	Blue Video
4	NC
5	Self test
6	Ground for Red
7	Ground for Green
8	Ground for Blue
9	NC
10	Digital Sync Ground
11	Digital Ground (mode)
12	NC
13	Horizontal Sync
14	Vertical Sync
15	NC

time constant for the oscillator.

In the oscillator stage, IC2101 functions as a comparator using positive feedback. The voltage of Q2101, an emitter follower, follows the output of the comparator. When the IC2101 output moves from low to high, Q2101 turns on and charges C2115 through CR2102 and R2102. In addition, the threshold voltage at pin three of the comparator rises. C2101 charges until its voltage goes beyond the voltage at pin three. Then, the output of IC2101 goes low and C2101 discharges. With that action, the oscillator stage develops a free-running frequency.

The output from the driver transistor, Q2106, is applied to the input of a complementary-symmetry amplifier consisting of Q2107 and Q2108. When a positive-going sawtooth appears at the base of Q2106, a negative-going drive is applied to the base of Q2107 and increases the collector current of that transistor. With the same negative drive applied to the base of Q2108, the forward voltage at the Q2108 base and the collector current decrease. If a negative-going sawtooth appears at the base of Q2106, the driver applies a positive-going drive to the base of Q2108. With that, the collector current of Q2108 increases while the Q2107 collector current decreases.

Capacitor C2112 increases the load impedance in the collector circuit of Q2106 and keeps Q2108 in a conducting state at all times. With C2112 supplying positive feedback, the Q2106 circuit gain increases. By keeping Q2108 conducting, the capacitor prevents large positive peaks in the signal from placing the base and emitter at the power supply potential and cutting off the transistor. This occurs because of the voltage due to the charge stored on the capacitor.

Blanking

Still looking at the vertical deflection schematic, capacitor C2118 ac-couples vertical pulses from the flyback to two transistors. In the circuit of Figure 6, transistors Q2117 and Q3401 use those 5.6V p-p pulses to generate part of the blanking signal. After the pulse is applied to the base of Q2117, its conduction brings the base of Q3401 to ground. Since this action turns Q3401 off, +5V appears at the Q3401 base during vertical blanking.

The remainder of the blanking signal results from a similar operation. C3413 ac-couples the -70Vdc horizontal flyback pulse to the base of Q3401. With the high-amplitude, negative pulse at its base, Q3401 again shuts off. Consequently, a +5Vdc blanking pulse appears at the Q3401 collector during the horizontal blanking interval. Conduction of diode CR3404 during the retrace portion of the horizontal flyback pulse protects Q2117 and Q3401 from any reverse-bias damage. During the trace portion of the horizontal flyback pulse, the conduction of the diode holds the collector of Q3401 to a lower value. Given that condition, a composite blanking pulse appears at the collector of Q3401.

High voltage circuitry

Output from the horizontal oscillator begins to develop the high voltage. From the base of Q3201 and transformer TX3201, the horizontal oscillator output goes to the anode voltage driver transistor or Q3202. The combination of the transistor and the flyback transformer or TX3202 produces high voltage. While the focus control determines the amount of voltage applied to the last grid of the CRT, the high-voltage resistor block is the source for the focus and G2 voltages.

IC3201, Q3205, Q3206, Q3203, Q3202, and various passive components make up the anode voltage regulator. An amplifier, labeled as IC3201, takes a reference voltage and feedback voltages and uses the difference between the two voltages to drive Q3205. Subsequently, Q3205 drives two regulating transistors — Q3204 and Q3206. To insure a stable regulated output voltage from this stage, Q3206 provides additional feedback. Diodes CR3205, CR3206, CR3216, and CR3217 protect IC3201 from transients.

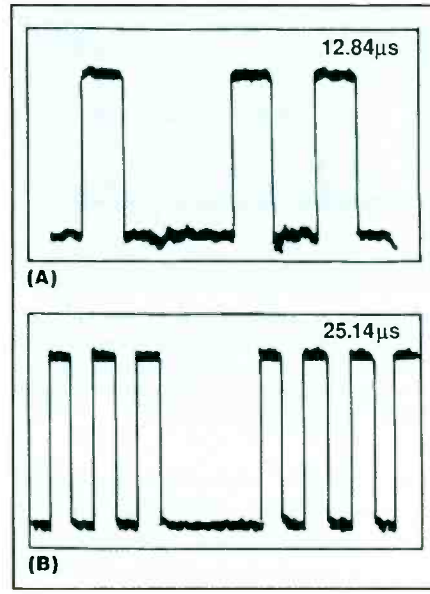

Figure 10. When checking IC401, check waveforms at pins 12, 15, 18, 5, 8, and 3. The waveform at pins 12, 15, and 18 indicates that a problem exists within Q101, Q201, and Q301. Figure 10A shows the correct waveform for pins 12, 15, and 18 while Figure 10B shows the waveform that should appear at pins 5, 8, and 3.

High voltage shutdown

If the high voltage exceeds specified limits, shutdown circuitry consisting of Q3207, R3228, R3232, 3228, Q3208, Q3209, CR3207, and IC5203 shuts the high voltage down. Q3209 senses the anode current at the secondary of the flyback. When excessive beam current occurs, diode CR3207 goes negative and biases Q3207 on.

R3228 holds the collector of Q3207 to a dc voltage, while R3253 and R3256 adjust the shutdown threshold voltage IC5203. After R3232 and R3233 divide the voltage at the Q3207 collector, the voltage divider output turns on Q3208. Therefore, horizontal sync pulses at the collector of Q3208 become shunted to ground. This cuts the base drive of Q3201 and shuts down the high voltage circuitry.

Troubleshooting computer monitors

Many service organizations shy away from troubleshooting computer monitors because of the lack of schematics and ser-

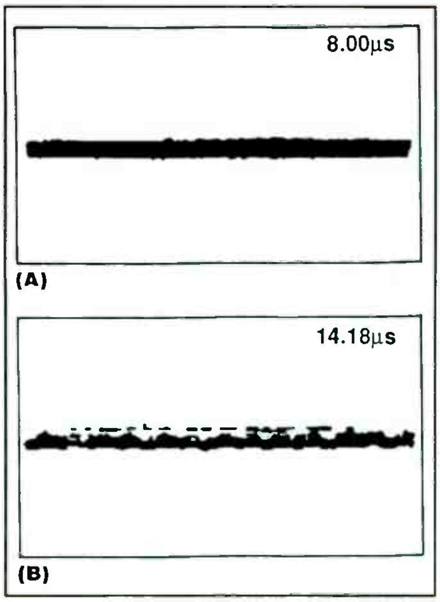

Figure 11. If the monitor lacks vertical deflection, check for the vertical waveform shown in Figure 11A at pin 6 of the vertical processor IC, U303.

vice documentation. When troubleshooting a computer monitor problem, remember that monitors rely on the same type of circuits that you'll find in a television system. Monitors rely on:

- Switched-mode power supplies;
- Sync signal processing circuits;
- Video signal processing and output circuits;
- Chroma signal processing and output circuits;
- Vertical deflection circuits;
- Horizontal deflection circuits;
- High voltage circuits and a CRT.

Given the knowledge that you have gained through your studies of this text, you should have the background necessary to successfully repair a monitor.

By combining that knowledge with experience, we can often find problem sources and solutions without the aid of a schematic. For example, a problem with an RGB drive board becomes easier to define because that type of board relies on three separate drive circuits. Therefore, the measurement of voltages, currents, and resistances in the problem circuit, and the comparison of those measurements with known good values from the other drive circuits, can narrow the search.

We also know that computer monitors rely on standard electronic parts and circuit designs. If the components have distinct labels, we can use master semiconductor replacement guides to find transistor and IC pin layouts along with voltage and current ratings. From there, we can begin to look for unexpected voltage readings throughout the circuit under test. Because monitors rely on standard designs, it also becomes easier to pinpoint different sections within the entire chassis. For example, the vertical output transistors and deflection IC's are generally located close together on the main board.

When troubleshooting power supply problems in a monitor, use the same techniques that you would when troubleshooting television power supply problems. That is, use an isolation transformer and a variable transformer (variac) to power the set slowly while monitoring the voltages around the switch-mode regulator. In addition, perform out-of-circuit checks of the regulator transistor or MOSFET and the passive components found in the supply. Always check the filter capacitors and always observe safety procedures.

While this procedure should allow you to repair most monitor power supplies, always remember that variants of the switch-mode power supply design exist. For example, Sony monitors take advantage of a separated power supply that provides voltage for (1) the flyback transformer and (2) the deflection yoke circuitry. In comparison to the single power supply that provides voltages to both the flyback and the deflection circuit across a single circuit, the Sony power supply system establishes a more stable power source for both devices and a more stable video image.

The implementation of the Sony system also allows users to adjust the pincushion balance, keystone, balance, and moiré cancel controls. Given these additional adjustments, consumers can adjust the stability of the picture. As an example, the Sony system will display a spreadsheet application with numerous cells without the pincushioning effect seen with other designs. With separate voltage supplies, the power consumption difference between white and black areas of the spreadsheet highlights balances.

Troubleshooting the video circuitry

Problems that occur with the video board involve the loss or distortion of the color signals. When checking the video circuits, always ensure that video input connector and cable are fastened securely and that no breaks exist in the cable. Then, use an oscilloscope to verify the presence, amplitude, and shape of the waveforms located at the CRT. Figure 7 shows the correct waveforms. If the waveforms are correct, then suspect a problem with the CRT.

Incorrect waveforms lead us back to the first set of video amplifiers and a check of the waveforms at the emitters of Q103, Q104, Q203, and Q204. Figure 8 illustrates the correct appearance of the waveforms. The lack of a good waveform at any of those points allows us to focus our attention on IC401, the video processor. With good waveforms at those points, we can move to the collectors of Q102, Q202, Q302, and expect to find a waveform similar to that shown in Figure 9. A distorted or zero amplitude waveform at those locations points towards defects in the processor IC, while good waveforms at those points, suggest that defects exist in Q102, Q202, and Q302.

When checking IC401, check the waveforms at pins 12, 15, 18, 5, 8, and 3. The presence of a good waveform at pins 12, 15, and 18 indicates that a problem exists within Q101, Q201, and Q301, while the lack of a waveform or a distorted waveform at those pins indicates that the IC is defective. Figure 10A shows the correct waveform for pins 12, 15, and 18, while Figure 10B shows the waveform that should appear at pins 5, 8, and 3. With a waveform similar to the figure, suspect the IC. A distorted or low amplitude waveform at pins 5,8, and 3 takes us back to the video cable and connection.

Troubleshooting the deflection circuitry

When attempting to troubleshoot problems with the deflection and pincushion circuitry, always ask these preliminary questions: Is vertical deflection present? Is horizontal deflection present? Does the display have the property symmetry? Answering these three basic questions allows you to refine your troubleshooting procedure and narrow the scope of your work. If the monitor lacks vertical deflection, check for the vertical waveform shown in Figure 11A at pin 6 of the vertical processor IC, U303. The presence of a good waveform tells us to direct our attention toward the vertical deflection amplifier, U302, and transistors Q307, Q308, and Q314.

If no waveform or a distorted waveform exists at pin 6, then check for the waveform shown in Figure 11B at pin 11. A good waveform at pin 6, combined with the absence of vertical deflection, points towards a defective U302. A missing or distorted waveform at pin 11 tells us to check for the proper vertical sync signal at connector 5A9. As always, we should verify the quality of the video connectors and cables when performing checks of the vertical and horizontal deflection circuits.

A symptom of no horizontal deflection almost automatically takes us to an out-of-circuit check of the horizontal output transistor, Q404. If the transistor tests good and the symptom persists, check pins 1 and 3 of the horizontal processor IC, U400, for the waveforms shown in Figures 12A and 12B. If neither of those waveforms are present or correct, check for the proper horizontal sync signal at connector 5A9. If the symptom remains and the waveforms are good, suspect that the horizontal processor has a defect.

Service Call: Apple monitor with bright red raster

When the school district technology director brought the Apple monitor in for repair, it displayed a bright red raster. The technician removed the cover from the monitor and began looking for the three main video output transistors on the RGB board. The transistors were labeled as Q6b2, Q6g2, and Q6r2. A quick check of the collector voltages of each transistor showed that the voltage at transistor Q6r2 was zero volts. However, the transistor checked as good out-of-circuit.

After resoldering the transistor, the technician began checking back through the red video output circuit for the proper supply voltage. With this, he found that the correct supply voltage existed on one side of inductor L6r2, while zero volts existed on the output side. A further check with a multimeter showed that the coil had opened. After the replacement of the coil, the monitor was restored to its normal operating condition.

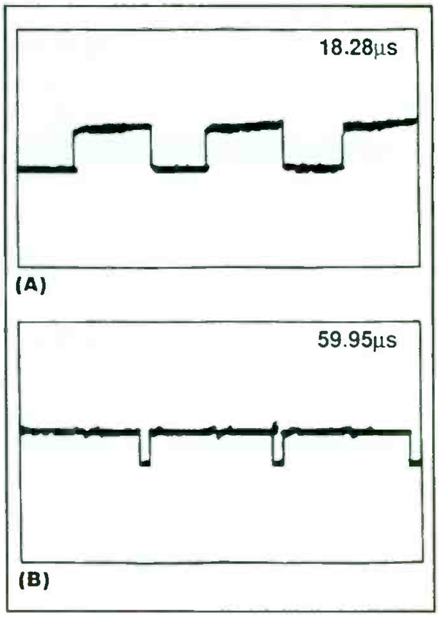

Figure 12. A symptom of no horizontal deflection almost automatically takes us to an out-of-circuit check of the horizontal output transistor, Q404. If the transistor tests good and the symptom persists, check pins 1 and 3 of the horizontal processor IC, U400, for the waveforms shown in Figures 12A and 12B.

Service Call: TOC monitor does not have vertical deflection

The technician found that the monitor returned to his shop had no vertical deflection and displayed only a bright white line across the screen. After locating the vertical output transistor and the vertical deflection IC, the technician performed voltage and resistance checks on the transistor. Everything was correct. After seeing those results, the technician began to concentrate on the integrated circuit.

Since he could not obtain a full schematic for the monitor, the technician used the label on the IC and a semiconductor reference book to find the pin layout for the device. Then, he checked for the proper supply voltages at the IC and found zero volts, instead of the required 24 volts. Tracing along the printed circuit board, the technician found that a burned fusible resistor was preventing the application of the supply voltage.

Given that the resistor was fusible and installed as a protective device, the technician used the ohmmeter function of his multimeter to check the IC for any possible short-to-ground conditions with the monitor powered off. No shorts surfaced. With that, the technician concluded that the IC had an internal short and replaced both the IC and the fusible resistor. The replacement of those parts restored the vertical deflection of the monitor. ■

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3. 5000
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7. $\frac{\sqrt{35}}{\sqrt{7}} = \sqrt{5}$
8. 0.000000333
9. A (See Table in WDYKAE?)
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FOR SALE

Hewlett Packard 331A audio distortion analyzer, $175.00. Wavetek 130 audio-function generator, $75.00, Hewlett Packard 1222A dual channels oscilloscope, $150.00. Shipping not included. *Contact: J. Kowalcyzk, 1036 Woodhaven Dr., Lynchburg, VA 24502, 804-610-5473.*

Phillips PM3350 analog/digital storage 50mhz 2 channel oscilloscope with GPIB port & manual, $900.00. Phillips PM3365 analog/digital storage 100Mhz 2 channel oscilloscope, $1100.00 (both for $1850.00) Sams Photofacts Vol. 1 to 1387 complete $1500.00 and various others after that $350.00. RCA oscilloscope model WO535A, $45.00. Conar oscilloscope model 250, $35.00. Hundreds of new/old stock and used tubes from the 1950s on, all for $250.00. Shipping not included. *Contact: Tim Gallagher, 860-658-1945, e-mail: t.gallagher@juno.com.*

Sams Photofacts ranging from 3 to 1872, $85.00 per cabinet full(about 70 PF) or $1.00 each. *Contact: Sigmund Salmento, 717-264-3846, e-mail: salmento@epix.net.*

Sencore Model SC61 waveform analyzer with all accessories and manual, $750.00. Sencore AC "Powerite" Model PR57 with manual, $200.00. Both in excellent condition. *Contact: Ron, 309-452-3073 or 309-454-2428(fax).*

Sencore SG165, $250.00, SC61, $600.00, VG 91, $900.00, LC76, $600.00, Leader LCG396, $500.000, LBO510 100 meg scope, $300.00. *Contact: Joseph Fritzinger, 732-968-1145.*

Assorted complete camcorder service manuals. All makes and models up to 1997, $7.50 each or $1000.00 for all 200. *Contact: Frank G., 413-533-4180 or e-mail: frankg57@aol.com*

WANTED

Sony TA 1150 stereo amplifier, Sony TA-F70 stereo amplifier, Project One/DC Series tuner amplifier, Mark 460 (distributed by Playback Inc.- Sin 806832B) Schematics needed for all of above. *Contact: Stacey Chambers, 31 Salem Street, Newark, NJ 07106.*

Philco-switch mode transistor for Model 5865TAK02. Transistor Mfg. 3619700001. *Contact: Mike, 802-464-0694.*

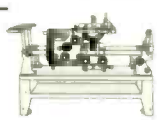
Heathkit ET-3400 or ET-3400A manual. Will buy trainer and manual. *Contact: Sidney, 2147 Trombas, CA 94577, 510-357-3788.*

JVC Stereo Amplifier Model AX-S95BK schematic. Will pay postage plus cost. *Contact: Leslie Jones, Jr., Electrofax Company, 82 Manly St., Portsmouth, VA 23702, 757-399-2528.*

Emerson horizontal output transformer part 4221051014 (HFT 683) for model EC12PA TV. *Contact: Dudley Overton, 843-406-9942.*

TEAC reel to reel tape deck dual VU meter, Model A-1500-W, part 58116. Also need good schematic, parts list or service manual. *Contact: John Koneski, 919-362-3076 (day), 919-776-2411 (eve).*

Zenith module 953508 or 953512R SYSIII, working with IC's included. *Contact: George Schierer, 2125 NE 63 Court, Ft. Lauderdale, FL 33308, 954-771-0406.*

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