THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

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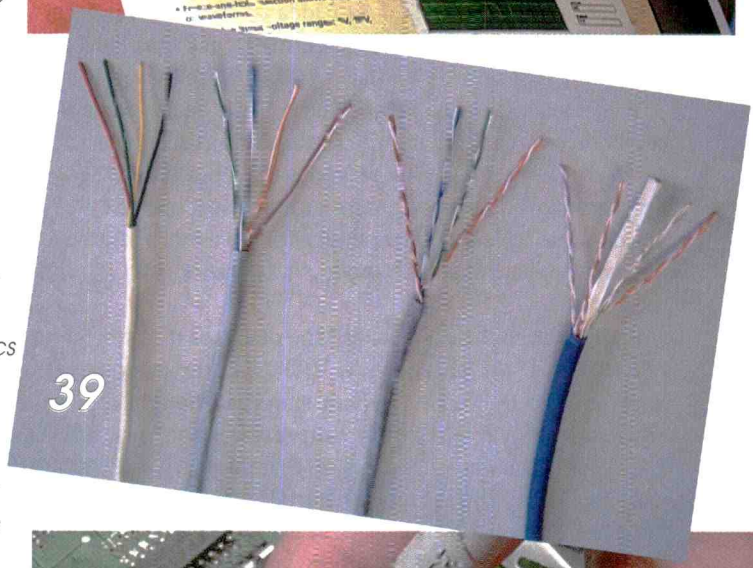
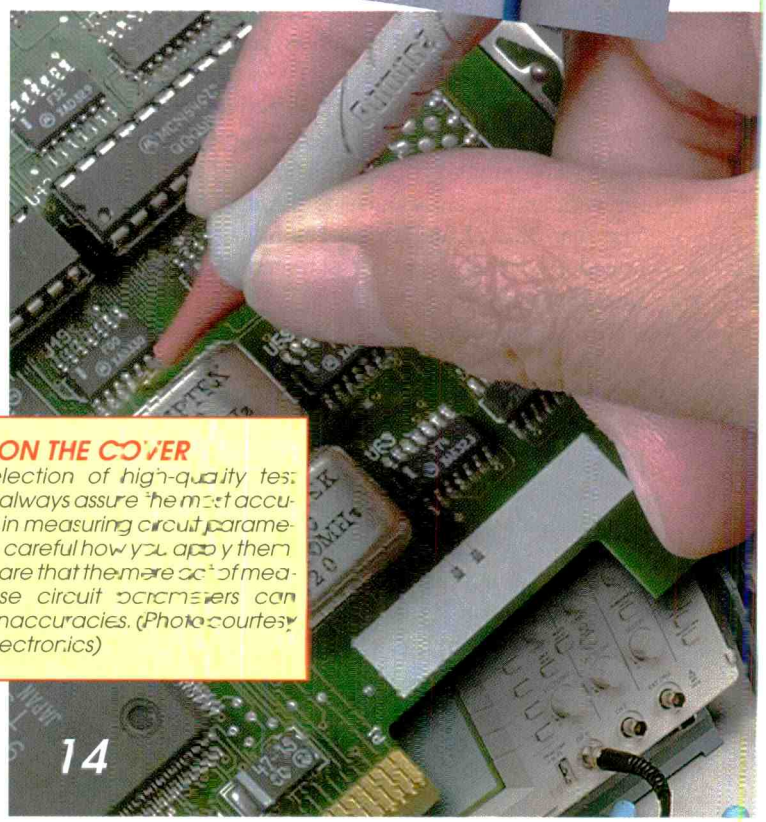
## DEPARTMENTS




**ON THE COVER**
*Careful selection of high-quality test probes will always assure the most accurate results in measuring circuit parameters. But be careful how you apply them and be aware that the mere act of measuring those circuit parameters can introduce inaccuracies. (Photo courtesy Pomona Electronics)*

# Editorial

*by Nils Conrad Persson*

# What's it worth?

How do you determine what something is worth? Interesting question. But meaningless. Something is worth exactly what someone is willing to pay for it at the moment. Well, that's probably not entirely true. Take for example, the commodity that is so prevalent in the developed world: the automobile. You can total up all the costs of all the raw materials and components, add labor costs, tack on shipping costs, and you have a fair idea of the total value in that machine. But still, if no one is willing to pay that, plus a little something extra for the dealer, what's it actually worth?

That's a question that is very dear to the hearts of most consumer electronics centers. If someone brings in a product to be serviced, the cost to repair becomes the labor cost to deal with the customer, observe the product's operation, open up the product, do some testing, remove faulty components, install replacement components, test the product's operation, and return it to the customer.

Well, back to the idea behind the discussion of the automobile earlier. If the product is a VCR, and the customer could have gone to the local discount store and bought a no-name replacement for $59.95, what is the repair worth? Is it worth the $80.00 or so (just to pick a figure) that the service center needs to charge to get its labor and materials and a little profit out of the repair? When that replacement is so cheap? Hmmmmmmm. Perhaps it depends a little on how you look at it. And there is more than one way to look at it.

These things are amazingly subjective, and the idea of value or worth is so nebulous. Different people for whatever reason, value some things differently. Here's an example: the other day my wife and I were wandering through a gourmet food store. The food was of unquestionably high quality, and in general priced accordingly, but not outrageously out of line with the food at the grocery store.

Then we found the caviar. There were different kinds of caviar at different prices, some of it affordable to someone of modest means and with refined taste who didn't mind paying a little more to satisfy their craving for fish eggs. Then there was the Beluga caviar. Now that's expensive.

The beluga caviar at this store was priced at $70 for 30 grams. Do the math with me. There are 454, call it 450, grams in a pound. So I would have had to buy 450/30, or 15 30-gram portions in order to bring home a pound of that fine caviar. At $70 per 30-gram package, the cost of one pound of caviar would be $70 x 15, or $1050. Obviously, someone believes that certain kinds of fish eggs are worth $1050 per pound. They must be really good fish eggs.

There are abundant other examples of people being willing to pay a great deal of money for a product or service. Have you been to a professional sporting event, like football or basketball lately? Between the cost of a ticket, parking, and maybe a hot dog or bag of popcorn and a beverage or two, the total can easily approach or exceed $100 per person. Is that experience worth that much money? Obviously, a lot of people think so.

I recently read a report released by the Electric Power Research Institute (EPRI) regarding the recent deregulation of electrical power. At least half of American electricity consumers are willing to buy electricity even at prices 30-40% higher than they presently pay. A new study offers insights that could make a difference to energy providers who are having difficulty attracting customers (and by extension, anyone who offers a service).

"The results of this research paint a fundamentally different picture of the marketplace than most industry commentators have described," says Patricia Garber, lead researcher for the EPRI project. "Customers will pay more-and substantially more-for energy products which provide them with the value they seek."

Mass-market customers have not been flocking to new energy providers, and many have already pulled out of the market. The EPRI study suggests, however, that retailers who are willing to break out of the box will succeed by meeting the wants and needs of their customers. Offers of energy service characterized by high-quality personal contact, involvement in the local community, customized billing, and other "high touch" services appear to be very attractive to customers, even at prices 30% to 40% higher than competing products.

Some business customers (20% to 30%) indicated a willingness to pay as much as 30% more for a Premium Power Package, which guarantees minimum outages and minimum voltage fluctuations.

All of this leads to the conclusion that people are willing to pay for perceived value. On this basis, if a service center can demonstrate that the value of parts and labor to repair a faulty but otherwise high-quality product, say a VCR, is greater than the value of purchasing a new, lower-quality, product, they might just receive approval to proceed.

There are a number of reasons that a customer might opt for a repair in such a situation. 1. They're familiar with the operation of this unit and don't want to learn a new one. 2. The service center has shown them that their old unit is built better than a new super cheapie. 3. They don't like the idea of sending products to the landfill unnecessarily.

This is not to trivialize the problem of selling service in the face of low-cost, feature-rich, products. It isn't easy. And some people will, of course, always opt for the new product. But a service center should always keep in mind that value is extremely subjective, and the right approach to the customer will sometimes result in a service job rather than a replacement.

Oh, and by the way, even though I'm sure that that beluga caviar was worth every penny of $1050 per pound, we didn't buy any.

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# News

### CEA to help promote benefits of teleworking

The Consumer Electronics Association (CEA) reinforced its support for the country's growing telework trend by announcing a new partnership with the International Telework Association & Council (ITAC). Through the partnership, the two groups will promote the benefits of teleworking (or telecommuting) to consumers and businesses by cooperating on selected promotion, research, and public policy issues related to the rapidly growing segment of America's population that works outside of a traditional office environment.

The teleworking trend has seen a sharp increase in recent years, due in large part to digital technology. According to ITAC, 19.6 million U.S. workers — 10 percent of the adult workforce — teleworked in the third quarter of 1999, up from 4 million in 1990. However, more than 50 percent of the information-related jobs in the U.S. are compatible with working away from a traditional office setting.

Teleworking benefits are significant and include flexibility for workers and cost savings for employers. According to ITAC's 1999 Telework America Research Report, $10,000 can be saved in reduced absenteeism, increased productivity, and the costs of recruiting and retaining employees for a teleworker who works at home one day per week. PC World has found that $8,000 per employee can be saved in office space expenses each year through teleworking.

"The shortage of skilled labor in the workforce is compelling employers to rethink traditional management styles," said John Edwards, president of ITAC. "Add to that the fact that teleworking can drive down costs, and it becomes clear that teleworking is undeniably the business model of the future. The support of the consumer electronics industry can only expedite this trend."

Recent research conducted by eBrain Market Research (a service of CEA), showed that large numbers of consumers expect to buy electronics products and services which improve the efficiency of their home offices in the near future. Specifically, higher speeds and greater access to the Internet were cited as common features that will help them accomplish their teleworking tasks.

"The vast growth in sales of home office equipment, networked devices, and universal access to information are facilitating our ability to telework," said Gary Shapiro, president and CEO of CEA. "As the leading source of information on workstyle technologies, CEA is eager to work with ITAC to encourage the acceptance and growth of telework arrangements."

ITAC is a non-profit organization dedicated to promoting the economic, social, and environmental benefits of teleworking. ITAC members share information about the design and implementation of teleworking programs, the development of the U.S. telework sector, and research.

CEA is a sector of the Electronic Industries Alliance (EIA). CEA represents more than 600 U.S. companies involved in the development, manufacturing and distribution of audio, video, mobile electronics, communications, information technology, multimedia and accessory products, as well as related services, that are sold through consumer channels. Combined, these companies account for more than $60 billion in annual sales.

### DTV sales remain strong

Factory-to-dealer sales of digital television (DTV) displays and sets reached their highest monthly total in March, making the first quarter of 2000 the best quarter yet for DTV sales, according to figures released by the Consumer Electronics Association (CEA).

Monthly DTV display and unit sales in March were 24,332, up seven percent over February sales and 343 percent over March 1999 sales. This brings total sales since the introduction of DTV (in August of 1998) to 202,586 units.

CEA also released first quarter sales figures for stand-alone digital set-top receivers. Since January 11,796 set-top receivers have been sold to dealers. These products can be connected to DTV monitors to receive DTV programming. In 1999, unit sales of set-top decoders reached 21,992.

"DTV sales are still strong and we've had our best month —and best quarter — yet. Consumer interest in this technology is strong and introductory sales have demonstrated that they want the best picture and sound technology has to offer," said Gary Shapiro, president and CEO of CEA. "Moving forward, sales of integrated sets and set-top receivers will continue to reflect the amount of available programming. Broadcasters and other content providers play a critical role in the rate of DTV adoption."

CEA recently released revised DTV sales projections, emphasizing the link between available broadcast programming and sales of DTV receivers. The long-range projections are based on three programming rollout scenarios. According to CEA, if broadcasters choose the "fast lane" to DTV and demonstrate 100 percent compliance with the Federal Communications Commission's (FCC) rollout schedule while providing a high percentage of digitally-originated content to consumers, DTV product penetration could reach 50 percent by 2006. If broadcasters take a "middle of the road" approach and experience continued station conversion delays while providing consumers with a high-percentage of up-converted analog content, DTV product penetration will be no more than 30 percent by 2006. Finally, if broadcasters choose the "off ramp" on the road to DTV — characterized by non-HDTV business models and delays related to reopening the DTV standard, DTV product penetration will only be 15 percent by 2006.

For more information on the consumer DTV transition, contact CEA or go to www.DTVweb.org.

### Listening habits, devices changing with new generation

Since the introduction of the first 45rpm and LP records, most generations during the past fifty years have faced a transition period in which one music format has replaced another. The results of a new study by eBrain Market Research confirm that Generation Y, the children of the Baby Boomers, is currently undergoing just such a transition. This evolution involves digital audio content, particularly the emergence of solid state devices and digital streamed content.

The most talked about form of this transition has been the MP3 music format, and according to the study, with good reason. Among the online segment of Generation Y (approximately 60 percent of the Generation Y population), 57 percent claimed to have played an MP3 music file. Although sound quality expectations vary from consumer to consumer, the data suggests that the majority of Generation Y listening to the MP3 format rate its sound quality as comparable to a typical stereo.

The study also shows that Generation Y is moving away from the traditional stereo system for listening to music. Approximately 14 percent of respondents claimed to use their PC more than a traditional stereo for listening to music. Another one in four claimed to use both

with approximately the same frequency; meaning that nearly 40 percent of Generation Y is using the PC as much as or more than a stereo for listening to music.

As the role of the PC in the audio entertainment of Generation Y grows, the group's product needs will also evolve. When asked about enhancing the PC music experience, respondents were receptive to the possibility of connecting stereo speakers to their PC. Thirty percent stated that they would be very or somewhat interested; with males showing the most interest (38 percent). Also, 55 percent of respondents stated that they were very or somewhat interested in a home stereo with Internet music capabilities. Among the segment of respondents that had already used the MP3 format, the rate jumped to 64 percent.

The "Generation Y: Home Entertainment Market Overview" study was designed and formulated by eBrain Market Research, a service of the Consumer Electronics Association (CEA). eBrain is smarter research and the most comprehensive source of sales data, forecasts, consumer research, international research, and historical trends for the consumer electronics industry.

The study was conducted online via a Web survey with a sample of 1551 young adults aged 15 to 21 (a subset of Generation Y) during March 2000.

### Audio sales surpass $1 billion in only two months

Revenues from factory shipments of audio products to dealers this February increased by eight percent over last February to a total of $542 million, according to figures released by the Consumer Electronics Association (CEA). The fantastic sales in February spurred the year-to-date total for audio sales to more than $1 billion; a six percent increase over the level of sales during the first two months of 1999.

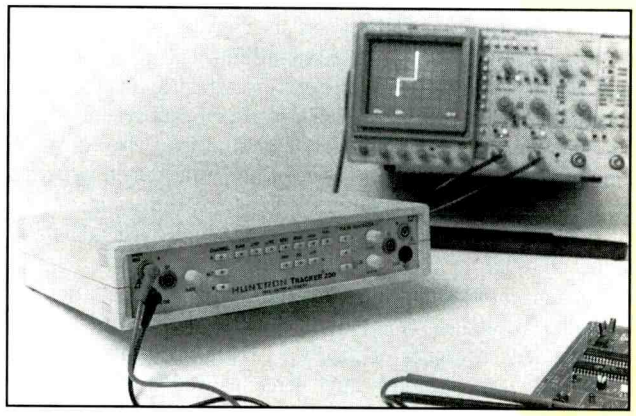
The portable audio sector posted the largest increase in the month, climbing 16 percent to revenues of $135 million. Contributing to the success in the sector were sales of digital portable audio products, such as headset CD players and CD boomboxes, which grew by 39 percent and 15 percent, respectively. Together, these two products comprised more than $80 million of the $135 million total portable audio earnings in the month. In the year-to-date figures, portable audio sales are up by six percent over 1999.

Sales of audio systems this February grew by 11 percent over the first two months of last year, to $118 million. The growth in systems was fueled by sales of compact systems, which typically comprise close to 80 percent of the sector. Sales of compact systems grew by 15 percent in the month, to a total of $94 million. Also contributing to the growth in systems were sales of home-theater-in-a-box products, which have thrived so far this year. Home-theater-in-a-box revenues are currently 40 percent ahead of their total during the first two months of 1999.

The current leading sector of the audio market, aftermarket autosound, posted its twentieth consecutive month of growth in February, with revenues of nearly $177 million. The aftermarket autosound sector is currently three percent ahead of 1999 in the year-to-date total, with revenues of close to $315 million.

Rounding out the stellar sales in February are home audio separates. The separates sector grew by seven percent over last February, to revenues of $118 million. Spurring the growth in the sector were sales of emerging CD-R products, whose strong introductory sales have helped to grow the total home CD equipment subcategory by 30 percent over last February. In the year-to-date figures, home CD equipment revenues have reached nearly $49 million, an increase of 17 percent over the first two months of 1999; sales of CD-R products comprised nearly 20 percent of this figure. ■

# Products



### Analog signature analyzer

Huntron, Inc. announced the Huntron Tracker 200, a troubleshooting tool for power-off, component-level troubleshooting of printed circuit boards. The unit is designed to work with oscilloscopes that can be operated in an X/Y mode.

Oscilloscopes, arguably the most versatile "power-on" troubleshooting tools can now be used for non-destructive "power-off" troubleshooting when paired with the device.

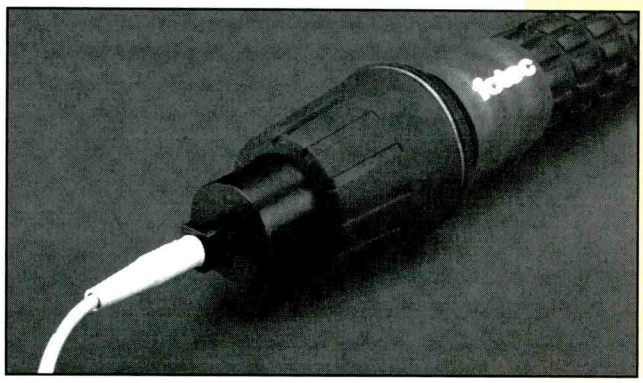
The analyzer uses technology presently available in the company's standard unit except that this product uses an oscilloscope as a monitor while the standard unit has an integrated display. The oscilloscope is used to display that current-voltage "analog signature" generated by the product of a device under test. The resulting display can be used to judge the overall health of a device or circuit being tested. Analog signature analysis technology works equally well for diagnosing digital, analog, or hybrid boards and components.

Huntron, 800-426-9265, Website: www.huntron.com
**Circle (100) on Reply Card**

### Fiber tracer

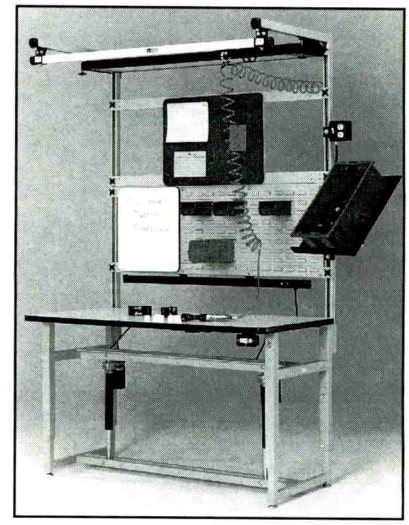
The Fotec S660 fiber tracer and continuity is now adaptable to all the small form factor fiber optic connectors, including the MT-RJ, LC, MU, Fiber-Jack and Volition. The S660 uses the same modular connector as the company's power meters.

The small form factor connectors are becoming very popular because of their small size and low cost. Most are duplex connectors, making it necessary to carefully distinguish between the two fibers. The product allows one to visually identify and trace fibers to simplify installation and troubleshooting.



Fotec, 151 Mystic Avenue, Medford, MA 02155-4615, Phone: 781-396-6395, E-mail: info@fotec.com, Website: http://www.fotec.com
**Circle (101) on Reply Card**

### Electric drive powered workstations



A new electric drive option is available from All Metal Designs to power its rugged, four-legged workstations.

The new option provides a full 12" of worksurface height adjustment, and has a lift capacity of 600 lbs. It utilizes two linear actuators that deliver responsive, high-speed movement, while maintaining the structural reliability of the fully welded, four-legged design.

All Metal Designs, Inc., 700 Windcrest Drive, Holland, MI 49423, Phone: 616-392-3696, Fax: 616-392-2922, E-mail: info@allmetal.com
**Circle (102) on Reply Card**

### Electronics trainer

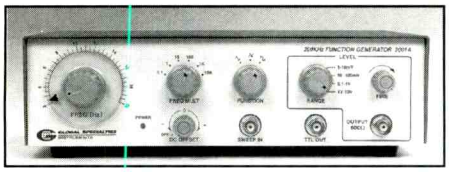
Elenco Electronics announces the XK-150 Digital/Analog Trainer. The product is a complete mini-lab for building, testing, and prototyping analog and digital circuits. It contains a breadboard, a function generator, a range of digital and clock functions and 4 power supplies.

This Digital/Analog Trainer is especially designed for prototyping and school projects. It has a breadboard with 830 tie points including 2 bus strips. The built-in analog function generator can generate sine and square waves, up to 4Vpp in amplitude for sine waves and up to 12Vpp for square waves. The frequency is adjustable in two ranges for 200KHz to 20KHz. There are also two undedicated potentiometers, 1KW and 100KW.

The Digital Section contains eight data switches, two no-bounce logic switches, eight buffered LED readouts and a 5Vpp square wave clock with frequency switchable between 1Hz, 1KHz, 100KHz, and 60 Hz.

There are four built-in power supplies: a variable +1.25V dc to +15V @0.25A, variable -1.25Vdc to 15V @ 0.25A, fixed +5V @ 0.25A, fixed 30V center tapped at 15V @ 0.25A. All of these supplies are regulated and protected against shorts.

Elenco Electronics, 150 W. Carpenter Avenue, Wheeling, IL 60090, Phone: 847-541-3800, Fax: 847-520-0085, Website: www.elenco.com
**Circle (103) on Reply Card**



### Function generator

Global Specialties introduces a new function generator, Model 2001A (part number 105-2008). The generator offers superior accuracy, exceptionally low sine wave distortion and flexibility in design.

The unit also features continuously variable frequency range from 2Hz to 200KHz in 6 decade ranges, variable dc offset, sine square, triangle, and TTL outputs, variable duty cycle, dc offset controls and a total harmonic distortion of less than 1%.

The product also features sweepable 100:1 with +/-10 volt input, high and low level variable 50 and 600Ω output, 1Mv to 10V p-p output, and easy to use front panel layout and is housed in a rugged metal case.

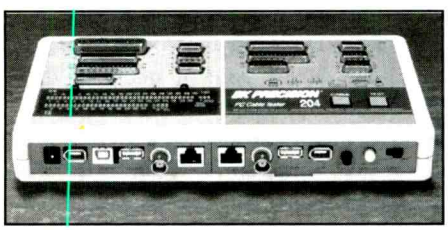
Global Specialties, 1486 Highland Avenue, Unit 2, Cheshire, CT 06410. Phone: 800-572-1028, Fax: 203-272-4330. Website: www.globalspecialties.com

**Circle (104) on Reply Card**

### Cable testers

BK Precision Corporation announces two new stand-alone cable testers, the Model 204 PC cable tester and the Model 205 Universal cable tester. These lightweight, portable, battery powered cable testers can be used for testing just about any cable or harness in fractions of a second.

The Model 204 is a portable, stand-alone PC cable tester that can be used for testing most popular PC data and network cables such as printer, monitor, modem, mouse extension, game BNC coax, RJ45, and USB cables. It is fast and displays opens, shorts, crosswires, miswire, and continuity of wires and pin configuration. In a matter of seconds, the unit will display with bright red LEDs a complete pin out of any cable attached to one of the many cable hubs on the unit.



The Model 205 is a portable, stand-alone cable/harness tester that can be used for testing any type of wired assembly with up to 128 points. A universal connector card is designed to accept up to 28 of the most commonly used cable connectors. It is fast and detects opens, shorts, and miswires in less than 50 ns.

The user-configurable connector card allows the user to mix/match connector types and plugs into the tester with two 96-pin DIN connectors. The connector on the left side of the card, Side B, accommodates 64 receiver inputs and the connector on the right side, Side A, accepts 64 driver outputs.

B&K Precision Corporation, 1031 Segovia Circle, Placentia, CA 92870-7137. Phone: 714-237-9220, Fax: 714-237-9214, Website: www.bkprecision.com

**Circle (105) on Reply Card**

# Test equipment update

**by the ES&T Staff**

A look around any household, or an electronics store today reveals the degree to which people have embraced electronics for entertainment, security, productivity, communications, imaging, calculating/computing. Here's a partial inventory. We'll be as comprehensive as possible, but can't promise we won't miss a few things:

- Television,
- Satellite TV receivers,
- VCRs,
- Camcorders,
- DVD players,
- Digital television recording (TiVo),
- Electronic still cameras,
- Fax machines,
- Answering machines,
- Personal computers,
- Home networking products,
- Home automation products,
- Cellular telephones,
- Cordless telephones,
- Audio systems,
- Personal digital assistants.

Of course many of these products are very inexpensive, and intended to be discarded when they fail, but many of them will be serviced. For the ones that require service, the sheer variety of these products, and the advanced technology of their circuitry requires that the service center have an ever-broadening array of test equipment available to diagnose those products.


This oscilloscope is small enough to fit in a technician's pocket, and provides a 5Mhz bandwidth.

### Factors driving test equipment requirements

There are a number of factors that drive test equipment requirements for a service center. One factor is the product technology. For years a service center could get by with little more than a multimeter and a medium bandwidth oscilloscope. That was in the days when "consumer electronics" consisted of radio and TV.

Over the years, consumer electronics began to change and grow. And the test equipment requirement began to change and grow to keep pace. For example, when they hit the market, VCRs required that service centers add a number of tools and jigs for the mechanical portions of the units. In order to test the function of remote control transmitters, service centers had to have either an IR sensitive card, or some other test device. If a service center is going to service camcorders, their test equipment inventory will have to include a light box and related meters.

When CD players came along, they came with their own set of test equipment requirements, including the laser power meter.

Today, thanks to the "convergence" factor, which is making consumer electronics products more and more computer based, and endowing computers with more and more of the characteristics of consumer electronics, we have added the requirement that the service center have a personal computer on hand as a piece of test equipment.

Another factor driving test equipment requirements is the growing quality of the output of the products, and the growing size of the displays. When TV sets were 19 inches or less, and the broadcast video signal wasn't that great anyway, and the sound almost didn't even count, consumers were very forgiving of a little distortion in the picture or the sound. Nowadays, having been exposed to the marvelous picture and sound in movie theaters, and wanting to recreate the experience in their own homes, consumers are demanding dazzling distortion-free audio and video from their home systems. Service centers can't adjust such systems properly without some sophisticated test equipment.

One such test device is the color analyzer. This product measures the x and y chromaticity and Y luminance or brightness parameters required for making the important color and brightness adjustments on a TV or monitor.

### The computer as test equipment

Take a look at the schematic diagram of a modern TV, VCR, camcorder, CD player, DVD player, and you'll see digital circuitry. At the core of many of these products is a microprocessor and an EEPROM. Notably absent, to a great extent, are adjustment controls. Instead of being made by means of changing the resis-

tance of a pot, adjustments are made by changing bits in a memory location.

A personal computer is one of the pieces of test equipment that at least one major manufacturer requires for any service center that wants to be one of their authorized servicers.

### Always safety first

Today, because consumer electronics products are being manufactured with efficiency in mind, TV sets and other products have power supplies that have full-wave bridge rectifiers. The output of a full-wave bridge rectifier is not at ground potential. Therefore, a portion of the circuitry in the set must operate at voltages that are referenced to what is called a "hot ground." Because of this hot ground, the product must be connected to the power line via an isolation transformer during testing. We published an article on this subject several years ago, but a number of readers have written in lately to ask about this subject. Apparently, it's time for a review.

Take a look at Figure 1. It is a fact that the neutral conductor of the power line is at ground potential. This is for electrical safety reasons, and is required by the National Electrical Code (NEC). The operation of the bridge rectifier is as follows. During the positive-going portion of the 60Hz power sine wave, D1 is reverse biased and D2 is forward biased, thus point a is positive with respect to point b and the output of the rectifier is exactly the same as that of the input. During the negative-going portion of the power-line voltage, D4 is forward biased and D2 is reverse biased. The output is the inverse of the input.

In effect, the negative-going portion of the line voltage has been inverted and the output of the rectifier is a pulsating dc.

Notice what would happen if we grounded point b (Figure 2). In effect diode D3 would have a short circuit placed across it, as both ends are at ground potential. Now when the line voltage goes negative, the voltage forward biases D1, effectively placing the entire Vmax across that diode. The effect will be instant incineration of the diode.

When you use an oscilloscope to check what's going on in the hot part of the chassis, you connect the grounded negative probe to the chassis hot ground

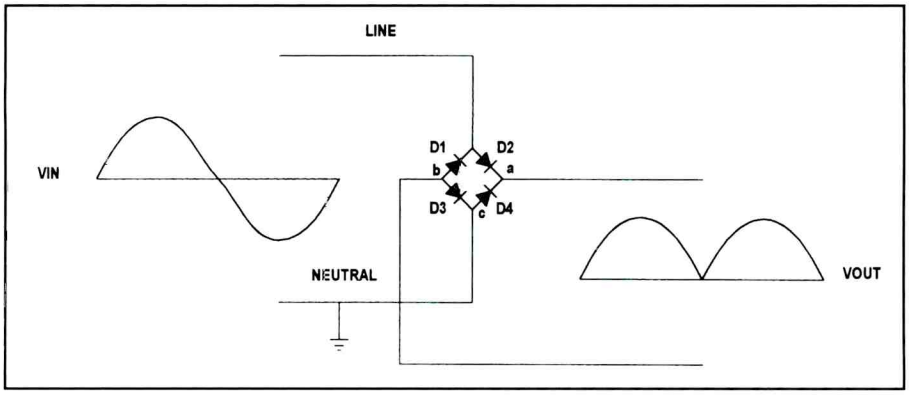



**Figure 1.** A full-wave bridge rectifier effectively inverts the negative-going segment of the power line ac. Note that the common side of the rectifier's output is not grounded.

(Figure 3). Now when you turn the unit on, as before, D1 is forward biased with the entire Vmax across it and it is destroyed. If you're lucky, that's all that will be damaged. If you're not lucky, other circuitry in the set, and possibly in the oscilloscope, could be damaged.

Now let's see what happens when you connect the set to the power line via an isolation transformer (Figure 4). An isolation transformer is simply a transformer with a 1:1 turns ratio and with no electrical connection between its primary and secondary windings. The output of the transformer is the 120V line voltage, but neither output line is grounded. This is because the only connection between primary and secondary is caused by magnetic inductance between the windings. That means that point c is no longer at ground potential, and now the technician can safely connect the grounded oscilloscope probe to point b.

Always use an isolation transformer when you're testing a product with a bridge rectifier in the power supply. Even better, always use an isolation transformer, unless it's otherwise indicated, so you don't forget to use one when you need to.

### A really tiny oscilloscope

A test equipment update wouldn't be complete without an item or two about some interesting new product or products. The following description comes from a press release that arrived at the **ES&T** offices within the past few weeks. The oscilloscope described isn't terribly useful for TV work. It only has a 5 MHz bandwidth. And we can't vouch for its quality. But for control, or even audio work, it might be adequate. And hey, sitting there in your shirt pocket, it's always handy.

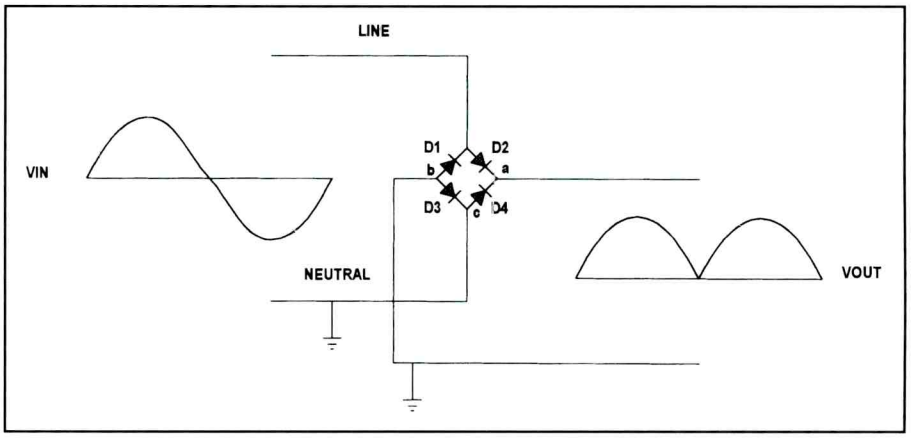



**Figure 2.** If point b were grounded, in effect diode D3 would have a short circuit placed across it, as both ends are at ground potential. Now when the line voltage goes negative the voltage forward biases D1, effectively placing the entire Vmax across that diode.

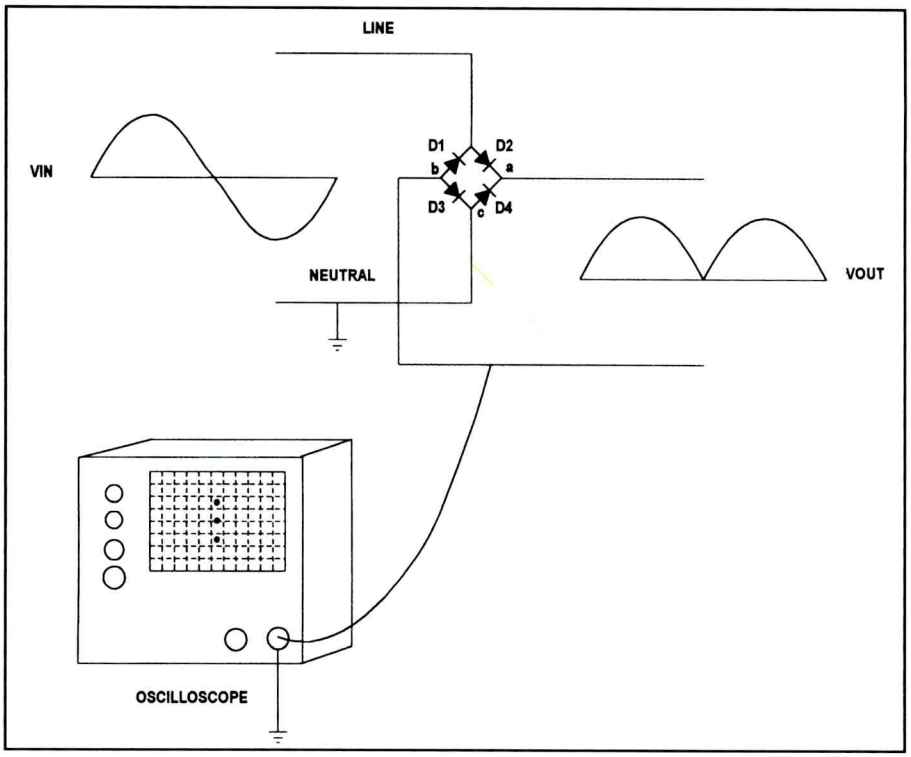



**Figure 3.** When you use an oscilloscope to check what's going on in the hot part of a chassis that features a full-wave bridge rectifier, you connect the grounded negative probe to the chassis hot ground. Now when you turn the unit on, as before, D1 is forward biased with the entire Vmax across it and it is destroyed.

Here's what the manufacturer has to say about it.

The osziFOX is a new 20MS/s handheld oscilloscope that can display waveforms on a built-in LCD or send the signals for logging or display on any PC. Oscilloscopes used to be heavy and clumsy to handle, but over the years they have become smaller and smaller. The latest development in this field is a digital scope in a handy, slim housing, scarcely longer than a pencil and about as thick as your thumb. Despite its small size, the performance of this scope can meet that of a service oscilloscope. With a sampling rate of up to 20MS/s even signals in microprocessor circuits can be measured.

The unit gives you an effective bandwidth of 5 MHz with selectable sampling rates from 50nS to 1mS.

Use this oscilloscope for taking measurements in amplifiers, digital circuits, telephone installations, on-the-spot servicing applications, and for teaching establishments, where the ability to display the signal on a large PC screen is useful. With the DOS, Win3.x, and Win5/98 software and serial cable provided, recorded signals can simply be saved to disk or printed. A Freeze-and-hold function allows comparison of waveforms. The product comes complete with manual and PicoLog software.

You can find more information about this product on the Web at www.saelig.com or 716-425-3753.

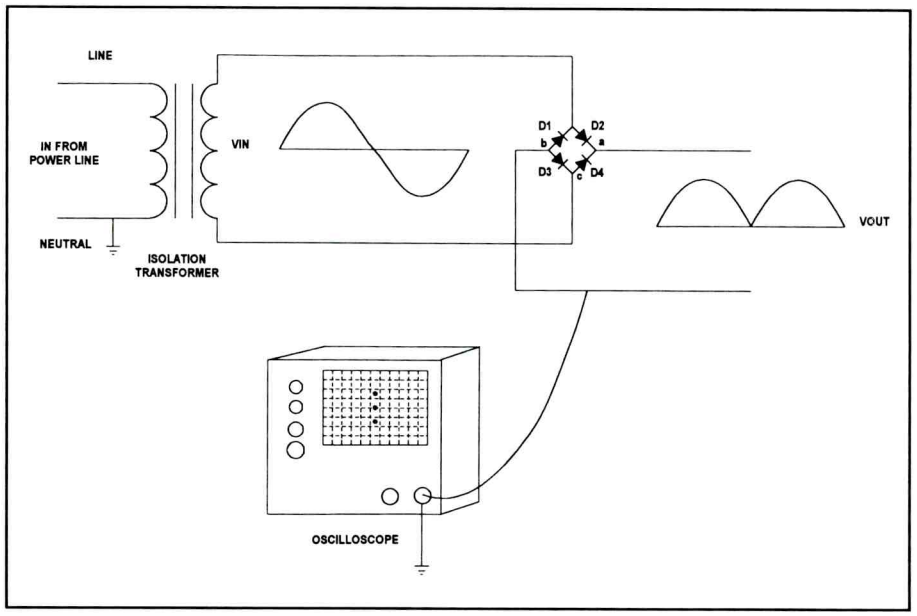



**Figure 4.** When you connect the set to the power line via an isolation transformer the output of the transformer is the 120V line voltage, but neither output line is grounded. Point c is no longer at ground potential, and now the technician can safely connect the grounded oscilloscope probe to point b.

### An oscilloscope simulator

While I was surfing the internet to find information on oscilloscopes for this and other related articles, I ran across a lot of interesting sites. You'd be amazed at all the good information you can find just by going to a search engine such as Yahoo, and searching on the word "oscilloscope." There are articles on how oscilloscopes work, schematic diagrams of an oscilloscope's innards, and a lot more.

One of the sites I visited was www.ozemail.com.au/~acbarren/cro3.htm. This site offered a download of a demo version of an oscilloscope training software program. I downloaded it, then went back to Mr. Barrenger, the "proprietor" of the site (do we have a word for that yet?), and obtained the fully operational version. It's called CRO Tutor v3.01. This program only takes up about 52kbytes of disk space.

It was pretty interesting. You run the program, and all of a sudden your computer screen looks like the front of an oscilloscope. There are several buttons at the top of the screen. Click the cursor on "Instructor," then from the drop-down menu "Introduction," and you get a description of how the program works.

By pressing the "CRO Features," and "Show Me," submenus under "Instructor," you can get a feel for how an oscilloscope works, and how this particular program works.

When you press the "On" button, a waveform appears on the screen. The user can select any vertical or horizontal setting to display the waveform to best advantage and calculate the amplitude, frequency, and period of the waveform.

The software offers three levels of accomplishment: basic, intermediate, and advanced. It's a good way to teach a student or technician how to use an oscilloscope, and to help him develop skills in calculating waveform values from their appearance on the scopeface.

You can find more information about this software either from the website mentioned above, or from Barrenger Software, 7 King St., Sandy Bay, Tasmania, 7005, Australia, (+61) 03 6223 2707, acbarren@ozemail.com.au. If you're in the market for a sailboard, he sells them too.

### The more things change, the more they stay the same

I don't know what the French actually meant by that expression, but there is some truth to it in the case of consumer electronics service. While consumer electronics products continue to evolve, become more sophisticated, become more numerous, the principles on which they're based remain the same. Ohm's law has not been repealed. Kirchhoff's law has not been amended. And an electron is still an electron.

And while the old standard test equipment has been changed, and new test equipment has been introduced, a technician still must apply the test equipment to the circuit of interest, make the measurements, and interpret the results.

Moreover, any time a technician is going to make tests on energized circuits, he must keep personal safety uppermost in his mind.

We hope this article has been of use to the readers of this magazine. If there are any specific subject areas any readers would like to see us address in the next test equipment update, please let us know about them. We'll do our best to present the information requested. ■

## Photofacts

**GE**

TX825QB....4307
VG2040....VCR-322
VG4040....VCR-322
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# Setting up a service center

**by the ES&T Staff**

Finding the optimum setup for a consumer-electronics service center has never been an easy task. With every passing year, however, the task becomes more difficult, and involves more types of products to be serviced, more test equipment, more emphasis on safeguarding delicate components and traces from electrostatic and other types of damage, better lighting, more sophisticated soldering/desoldering equipment, a broader array of supplies, more (and more involved) service literature, care in disposing of hazardous wastes.

Moreover, consumers are more demanding and discerning than they ever have been before.

### Separate reception area

Most people are put off by the inherent messiness of repair work. Have you ever noticed on the TV show ER, they don't allow relatives into the room when they're working on someone. It's an unpleasant process.

And have you ever had someone into your house to do some remodeling? You hear banging, you see messes, and you wonder if things will ever be the same. Most automotive service centers don't allow the customers into the work area. It's dangerous, and it's disturbing for a car owner to see cars with their wheels off, engines out, automotive entrails dangling everywhere.

It's pretty much the same for consumer electronics service. The customer generally sees the neat case surrounding the workings of his TV or VCR. When they walk into a service area and see the circuit boards and other components strewn willy nilly all over the place, or

| Type of equipment serviced * | TV | VCR | LD | AUD | CC | Minimum Specifications |
|---|---|---|---|---|---|---|
| Personal Computer | X | X | X | X | X | IBM or Compatible 486DX 66 meg PC (or LAPTOP) 16 MEG Memory, VGA Monitor, one 3 1/2" floppy drive, 540 Meg or larger hard drive, compatible mouse, one Serial port dedicated for service interface box and one port for mouse, Windows 95, 4X CD ROM, Printer and Sound Card. |
| Isolation Transformer | X | X | X | X | X | |
| Digital Voltmeter | | | | | X | Range .1V DC to 1000V DC, 4 1/2 digit Resolution, .5%/Accuracy |
| Digital Voltmeter | X | X | X | X | | Range .1V DC to 1000V DC, Accuracy: .5%/ |
| True RMS Voltmeter | X | | | X | X | True "RMS" Voltmeter Range: 01 to 1000 Volts .5% Accuracy |
| Laser Power Meter | | | | X | X | Wavelength Range 632 .8nm to 820nm 0.3mw to 3mw, 5% Accuracy |
| Microfiche Reader | X | X | X | X | X | |
| DC Voltage Supply | X | X | X | X | X | Range: 0 to 50V, 2A—-Well Filtered Temperature Controlled |
| Soldering Station | X | X | X | X | X | Grounded Tip Type—Tip Temperature 500F to 800F Adjustable |
| Frequency Counter | X | X | X | X | X | 50Hz to 100 MHz Sensitivity: 25mV to 5V. Equipped with Lo-Cap Probe (10:1 Attenuation) |
| Audio Signal Generator | | X | X | X | X | 10Hz to 1MHz 3%. 3V RMS into 600 OHMS *For LD: Output 10V P-P continuously variable |
| Variable transformer | X | X | X | X | X | Continuously Variable. Isolation Type Preferred |
| NTSC Video Signal Generator | X | X | | | X | Must provide 1V-P-P Negative Sync Video into 75-OHM input. Produce standard NTSC 75% Saturated Color Bars with 100% White Window. |
| RF Signal Generator | X | | | X | | 100 KHz to 150 MHz .1V RMS, Int.Mod. 1KHz 30% TAG001 Tuner Alignment Generator or Equivalent X Equivalent Generator must have RF output capabilities for cable channels 1-125. |
| Cross Hatch Generator | X | | | | | X Must have RF output.S-Video Source X Must Provide standard Y-C separated signal output SVHS VCR, DSS, or DVD will suffice |
| S-Video Source | X | | | | | Must provide standard Y-C separated signal. output SVHS VCR, DSS or DVD will suffice |
| NTSC Vectorscope | | | | | X | Dual Trace, Delayed |
| Sweep Oscilloscope | X | X | X | X | X | 25 MHz with Channel invert capability Sensitivity 5m/V/cm Maximum Sweep Rate:.1us/cm |
| Hot-Air Desoldering Station | X | X | X | X | X | MTS TV |
| Stereo Generator | X | | | | | Must produce L-R, L+R, SAP at 300 Hz, 1KHz, 8KHz |

* TV = Television, CC = Camera or camcorder, VCR = Video cassette recorder, AUD = Home theater audio system, LD = Video laser disk player.

**Figure 1.** One major manufacturer has deemed it a requirement that every one of their authorized service centers have this equipment on hand.

so it seems, they wonder if you can get all those products back together again.

You can avoid any of those negative thoughts in your customer by presenting them with a pleasant reception area. It doesn't have to be fancy, but it should be free from gutted products, and it should present the appearance of competence and friendliness. Then when the customer leaves her baby with you she has a warm and fuzzy feeling about it, and needs never know the horrors that go on in the back room.

### The checkout area

Ideally, the service center should also have a checkout area where the receptionist can go over the details of the problem with the customer. If the problem is thought not to have caused damage to the product, it can be helpful for the receptionist to plug in the product and go through the problem mode with the customer. Now the receptionist can ask questions, like "That reddish tint throughout the picture, is that the problem you're talking about." That can help the receptionist to write up the service order more correctly and thoroughly.

Once the product has been serviced, and the customer comes back in to pick it up, then the receptionist can plug the product in, observe its operation with the customer, and make sure that the problem perceived by the customer has been successfully corrected. Better to make sure before the product ever leaves the service center. Customers become irate quickly, understandably, when they bring a just-repaired product home, that they feel will now reward them with sparkling entertainment, and it fails to perform as they expected.

Of course it costs a little to offer such an area: you have to have an antenna or cable, perhaps a TV set or monitor if you want to demonstrate a successful repair on a VCR or DVD player, or an audio system to demonstrate successful fixes on a tape deck or CD player, but the rewards could be increased business because of the professionalism that it reveals to the customers.

### The work area

Of course, this is the place where the work gets done and the profits are made. It's important to make sure that it's designed, constructed, and laid out to insure the maximum efficiency. Every bench should have certain amenities available, such as:

- good general lighting,
- additional task lighting,
- a good selection of hand tools,
- an up-to-date soldering/desoldering station,
- lots of electrical outlets,
- an isolation transformer,
- a variable transformer,
- oscilloscope,
- cleaning/lubricating chemicals,
- various types of wipes.

In addition to the items that need to be at every bench, there are certain items that the service center should have at least one of to properly service consumer electronics equipment. Figure 1 is a list of the equipment that one major consumer electronics manufacturer requires by any service center that wishes to be an authorized service center.

### The uses of the computer in servicing

It seems like only yesterday that the personal computer was a relatively useless toy used mostly by "geeks" who found them fascinating. Today they're a fixture in most homes that can afford them, and they're a requirement in the service center — that is if you want to be an authorized service center for some manufacturers.

Thomson Consumer Electronics, for example, no longer offers paper manuals. Period. If you want to look at a schematic diagram, read a description of how a circuit operates, follow a suggested service procedure, or consult any of the many service bulletins the company publishes, you'll have to have a personal computer in the service center to do so. Other manufacturers are following suit, or already have.

One manufacturer has plans, at least tentative, to deliver all service information via the internet, so a service center that wants to service that company's products will need not only a personal computer but a reasonably high speed connection to the internet. The alternative, if you have a connection at, say 14.4K, is to tie up the computer and a phone line for the better part of two hours to download a service manual.

But the personal computer is not only useful to access service literature. Large numbers of consumer electronics products these days have microcomputers at their hearts. The personal computer, loaded with the right software, makes a good piece of test equipment that can read the data stored in PROMs, and can be used to alter that data, thus, effectively, acting as an adjustment tool for the digital adjustment "pots."

### Staying on top of everything

For consumer electronics service centers, staying in business means constant effort to keep pace with the rapid and incessant changes and innovations in the products they service. As someone said in "Alice in Wonderland" (or was it "Through the Looking Glass?"), "It takes all the running you can do just to stay in one place. To get anywhere, you have to run even faster than that." Part of the running service centers have to do to get anywhere, is to remain aware of changing requirements in test equipment, and make sure they have, and know how to use, that equipment. ■

# Test probes update

**by the ES&T Staff**

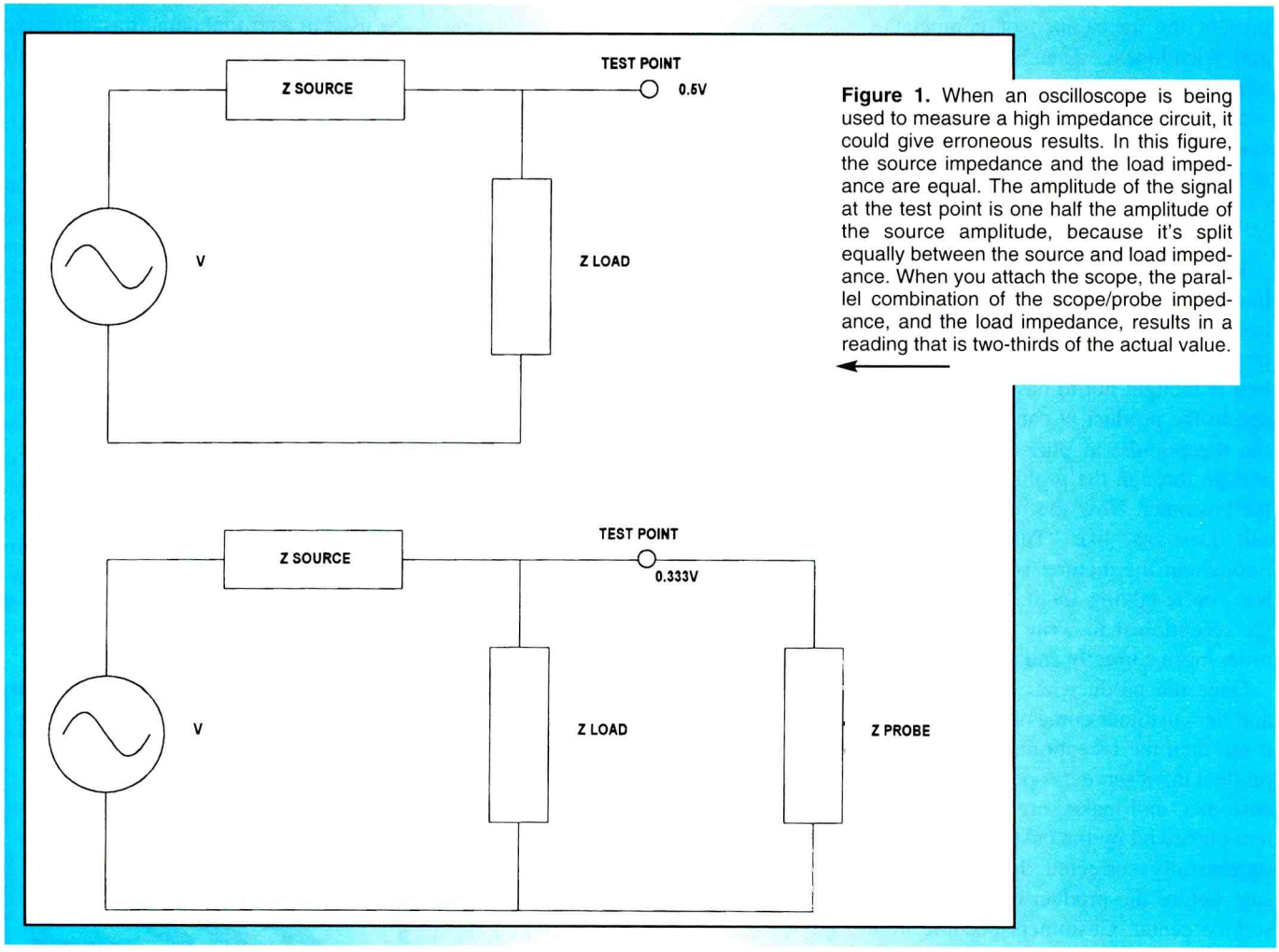


**Figure 1.** When an oscilloscope is being used to measure a high impedance circuit, it could give erroneous results. In this figure, the source impedance and the load impedance are equal. The amplitude of the signal at the test point is one half the amplitude of the source amplitude, because it's split equally between the source and load impedance. When you attach the scope, the parallel combination of the scope/probe impedance, and the load impedance, results in a reading that is two-thirds of the actual value.

Forming a diagnosis of a fault in a consumer electronics product is a many-faceted process. The technician evaluates the complaint of the product's owner, then observes the operation of the set to develop a general idea of the nature of the problem. Only then, generally, does the technician take the back off the unit and begin to check inside.

Even now, the technician rarely begins taking measurements. This is the point at which he observes the circuitry. Are there any burned components? Are any circuit traces shorted, cracked, or burned? Are there any traces of overheating? Did the high voltage come up? Are there any strange odors?

Once the preliminary observations are complete, and the technician has formulated a theory as to which circuits are causing the problem, the technician brings out the two pieces of test equipment that he uses to make voltage and waveform measurements: the DMM and the oscilloscope. With the DMM, the technician makes power-off resistance and continuity measurements, and then power-on voltage measurements.

Frequently, of course, resistance and voltage measurements with the DMM allow the technician to narrow the problem down to the point at which he can pinpoint the component or components that are causing the problem, and he can replace them. In those instances, where the problem won't yield to DMM readings, the technician brings the heavy artillery to bear: the oscilloscope.

The oscilloscope, of course, allows the technician to observe the actual operation of the circuits. The oscilloscope allows the user to observe charging and discharging of capacitor circuits, oscillation in an oscillator, even video signals and sync. Few faults in a consumer electronics product won't yield to an experienced technician with good oscilloscope skills.

### Connecting the test equipment

The test equipment is not very useful until it is actually connected to the points of interest in the circuit. That's where the probes come in. They are the conduit that conducts the circuit information to the meter or oscilloscope where it can be processed and displayed. Generally, the probes for a DMM are not critical, but even in this case, careful selection will be rewarded.

The characteristics of a probe include the following:

- integrity,
- flexibility,
- quality of insulator.

Perhaps none of you have ever had this problem, but the integrity of the probes on the first meter I owned left a lot to be desired. I didn't use it often, but it seemed that every time I began to use it, the connection of the probe to the probe tip was broken. I don't know if this was because of brittle wiring strands, the wrong kind of solder, or some other problem, but it was a time waster and I never quite trusted the readings I got with that meter.

The probe wiring of a high-quality meter, or high-quality replacement probes will be very flexible. The key to this quality is the nature of the wiring strands and the number of strands. Generally, the more strands in a given diameter of wire, the more flexible the wire. It's an annoyance if the probe wires are not sufficiently flexible and their stiffness keep you from placing them exactly where you want them.

Something we seldom think about is the insulation on probe wires. The DMM and the probe are both used on a bench where there is also a soldering iron. Most high-quality probes have insulation that is relatively impervious to burning from the head of a soldering iron.

### Oscilloscope probes

An oscilloscope is used to observe waveforms. Unfortunately, any imperfection in the probe used to conduct the waveform from the circuit under test to the oscilloscope will have some effect on that waveform. In a lot of cases, that isn't too big a deal. But in some cases a little aberration introduced by the probes might be enough to seriously distort the measurement.

### Probes, probes, probes

Modern electronics circuits present measurement problems that electronics products of several years ago did not. Integrated circuits can make it almost impossible for the technician to get the tip of the probe onto the point of the circuit that is of interest. Many of these devices have extremely fine leads that are spaced tiny fractions of an inch away from each other. Even if you can get a probe tip onto one of these leads, your chances of slipping just the smallest bit and shorting two leads together, thus causing disaster, are fairly great.

One trick that has been mentioned in articles in this magazine is to solder fine wires to each of the leads of interest, thus bringing the points of interest a little ways from the body of the IC. This works, but has two drawbacks. For one thing, soldering wires to IC leads can cause thermal damage to the IC if the technician is not careful. Moreover, it takes time.

Fortunately, the manufacturers of test equipment accessories have recognized this problem, and have addressed it in at least two ways. One of the steps manufacturers have taken to make it easier to probe ICs is to offer IC clips: spring loaded devices that clip over the IC, connecting to each individual lead, and leading a conductor to a point some distance from the IC. The upper ends of each of these clip leads are spread farther apart then the ICs leads, giving the technician room to get a probe onto it.

The other approach to solving the problem of crowded IC leads is to manufacture tiny probes with spring clips that attach to the individual IC leads. The other end of the probe is accessible to the oscilloscope probe.

These solutions represent an additional cost to the service center, but when you need them, you need them.

### A little bit about probes

It might be helpful to ask the question "what is a probe?" It is a conductor of some sort that is designed to conduct the signal at some point to the input of a test instrument. To limit the discussion a little, let's talk about oscilloscope probes.

The probe has to make a physical connection to the point of interest in order to establish an electrical connection. As we have seen, even just making that physical connection can be a challenge.

Another consideration of the oscilloscope probe is that it not affect the operation of the circuit it is being used to observe. We seldom think about it in these terms, but the probe is actually conducting a little bit of the signal of interest away from the circuit connection to which it is connected so that the technician can observe it.

It's safe to say that even with the extremely small signals that are sometimes encountered in today's consumer electronics products, that an oscilloscope probe will rarely load the circuit appreciably enough to distort readings. It's still always a good idea to keep in mind that any time you take a measurement, the instrument, and the probe, are having an effect on the signal you're measuring, however slight.

Then there's bandwidth. An oscilloscope probe has to be capable of conducting signals of frequencies from dc up to and greater than the highest frequency used in that device. In the case of television service work, that nominal upper frequency is around 100MHz. From dc to that upper frequency is called the "bandwidth." Actually, the upper frequency of 100 MHz is considerably greater than any frequency used by the television set, but to see complex waveforms with any kind of fidelity it's necessary to be able to handle several higher order harmonics of the fundamental frequency.

That becomes clear if you think about it this way: have you ever observed a square wave using a cheap oscilloscope? Did you ever think that square wave, with its rounded corners isn't really a "square" wave? It could very well be that the square wave you were looking at was a really good square wave, but that the instrument/probe combination you were using didn't accurately display that.

### The effect of probes on measurements

As mentioned earlier, the probe actually conducts a small portion of the signal of interest to the input of your oscilloscope. Depending on the relative impedances of the portion of the circuit being observed and the scope/probe combination, the effect will be greater or less. If you're using an oscilloscope/probe combination with high impedance input, and measuring a low impedance circuit, the effect will be negligible. If you're measuring an extremely high impedance circuit, say with impedance of the same order as that of the oscilloscope, you could be loading the circuit enough to cause a change in signal amplitude. Depending on how critical that signal amplitude is to operation of the product, you could be finding a "problem" where none actually exists.

Take a look at Figure 1, for example. The source impedance and the load impedance are equal. The amplitude of the signal at the test point is one half the amplitude of the source amplitude, because it's split equally between the source and load impedance. Now look what happens when you attach the scope. The parallel combination of the scope/probe impedance, and the load impedance, results in an impedance that's one half the impedance of the load alone. Now the voltage is divided so that two-thirds of the voltage is dropped across the load impedance and one-third at the test point. This results in a reading that is two-thirds of the actual value. Thus, if the amplitude of the signal were supposed to be, say 100V, you'd be reading about 67V. Would you think something was wrong?

If you're looking at a high-impedance circuit point, and you suspect that unexpected readings are being caused by circuit loading, you could do one of two things:

- use a probe that offers higher impedance, or
- try to find a point in the circuit where you can observe that signal that offers a lower impedance.

But this is only one of many possible measurement inaccuracies that you may introduce when you're using an oscilloscope. If your probe doesn't have adequate bandwidth, you may be distorting the signal for the purposes of the display.

### Selecting a probe to minimize probing effects

Most of us use an oscilloscope and never think about possible measurement inaccuracies caused by the scope and probe. But considering the low signals encountered in some consumer electronics products, and the high impedances of some of the circuit points, it's a good idea to always keep in mind that strange waveform appearance may be caused between the probe tip and the oscilloscope, and not actually be happening in the circuit. Some of these problems may be avoided by careful choice of probes, as follows:

- Make sure that the oscilloscope and probe are matched according to the specifications of the scope manufacturer.
- Select a probe that has bandwidth or rise-time capabilities that are adequate for the signal being measured.
- Keep ground leads short.

### Awareness is the key

For most of us, when we're elbow-deep in a problem in a TV or VCR, and trying to determine what the problem might be, we tend to concentrate on the failed unit and its circuitry. We seldom think that circumstances might combine to cause us to observe voltages, waveforms, resistances that are incorrect, not because the value is actually incorrect, but our measurement techniques are wrong for the circumstance.

Every technician should keep in mind when he sets out to diagnose a problem, if he observes an unexpected value, and it just doesn't make any sense, he ought to think about what effects he might be causing with the test equipment and its probes to introduce inaccuracies. ■

# Servicing a Philips DVD player: Servo and system control

**by Bob Rose**

In a previous article, I discussed the power supply for the Philips's DVD 400/420 DVD player, going into detail with respect to how it works and how to service it when it fails. In this article, I propose to deal with the servo and system control circuits. As a technician, you simply must have a good grasp of how a circuit works if you are going to attempt a repair when the circuit fails.

Rose is an independent consumer electronics business owner and technician.

Therefore, I will spend a fair amount of time dealing with how these circuits work and conclude the discussion with a few service related notes.

### The servo system

If you have spent any time at all repairing VCRs, you certainly are familiar with the terms "servo" and "servo circuits." From a technical point of view, a servo system is a closed-loop control system for the control of the speed and position of other electromechanical systems, driven in the instance of the DVD player by electric motors (Check the recent edition of McGraw-Hill Electronics Dictionary, page 415, for an expanded definition.).

The servo system in the DVD 400/420 has the job of driving and controlling three crucial components: (1) the disk motor that causes the disk to spin, (2) the feed motor that moves the disk from its center to its outer edge (the "sled motor"), and (3) the focus and tracking coils that keep the laser focused in the proper track.

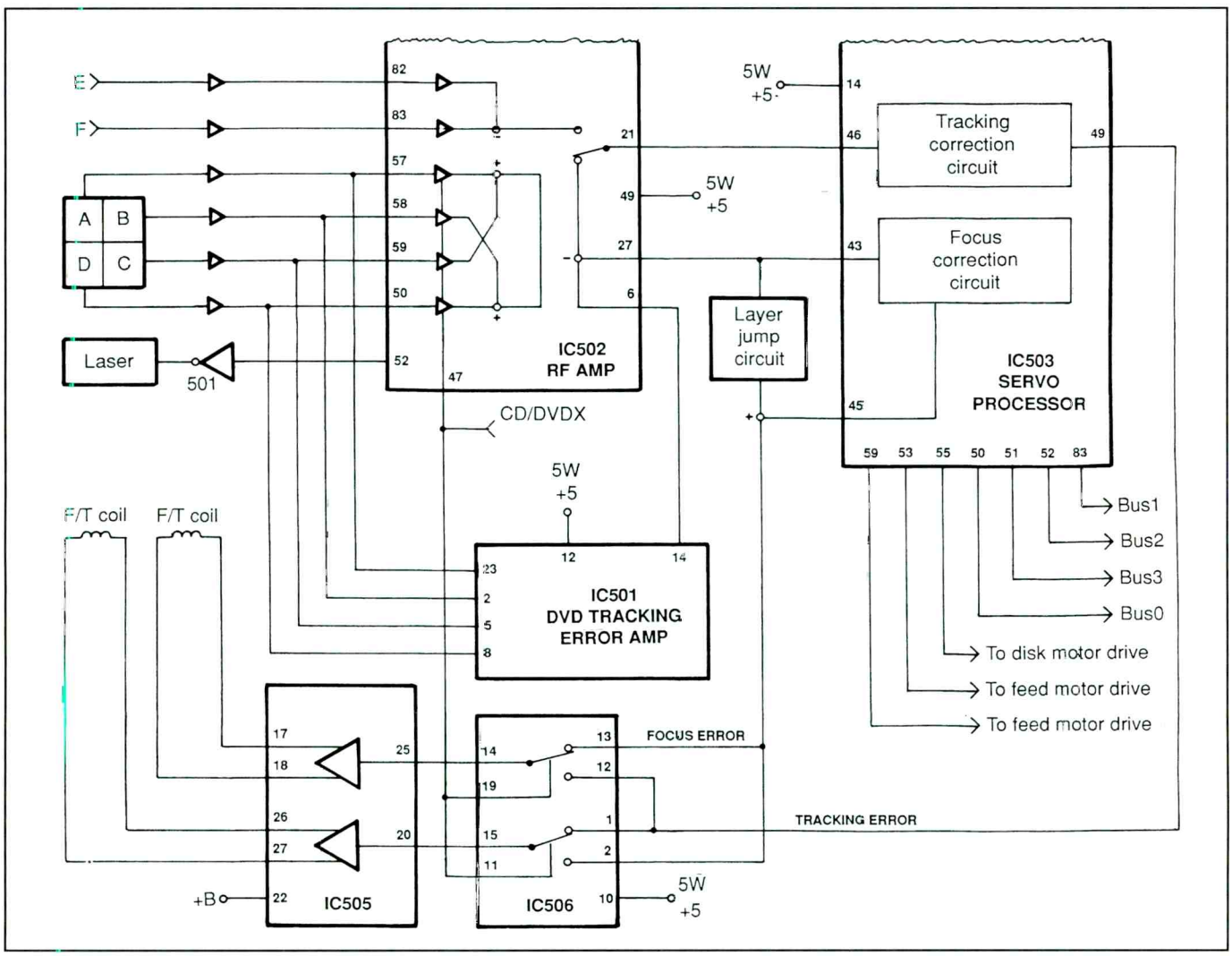


**Figure 1.** The laser, which functions as a single beam system for the DVD disk and as a three-beam system for the audio disk, and the laser pickup, develops the signal that the servo system uses to control focus and tracking.

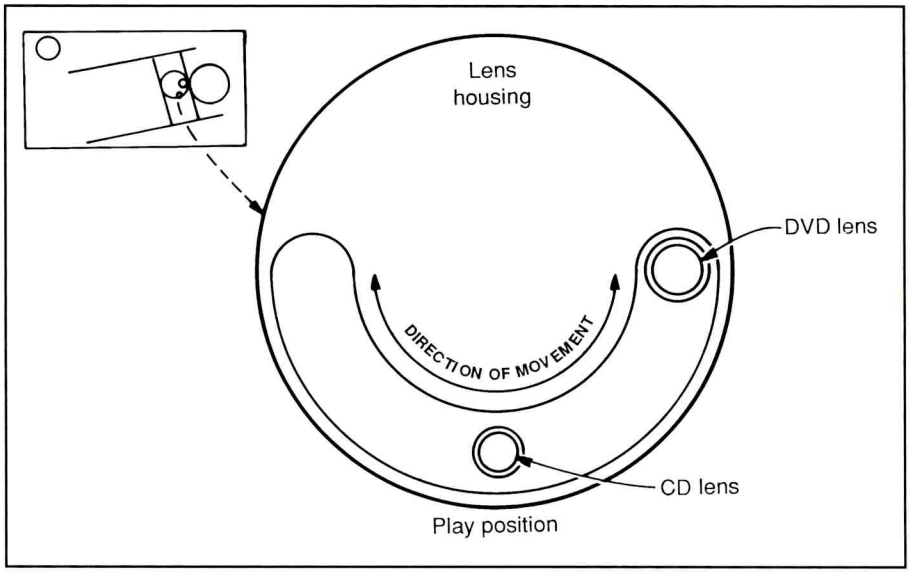


**Figure 2.** Some DVD players utilize two optical pickups, one to play audio CDs and another to play DVDs. The Magnavox player uses one optical block equipped with two lenses to achieve the same purpose.

When I insert a disk into my DVD player, I cause the unit to initiate several events that must take place before the RF and tracking signals develop. First, the feed motor pulls the laser slide assembly toward the disk and stops when the slide cannot move any farther. Then the focus coil pushes the objective lens up and down in an attempt to achieve focus. When the laser achieves focus, the disk begins to spin, and the player goes into the "play mode."

The laser, which functions as a single beam system for the DVD disk and as a three-beam system for the audio disk, and the laser pickup, develop the signal that the servo system uses to control focus and tracking (Figure 1). Three ICs comprise the servo system: (1) IC501, the DVD tracking error amp, (2) IC502, the RF amplifier, and (3) IC503, the servo processor. IC501 receives data from the pickup assembly that it uses to develop information for the tracking circuit. It sends the information to IC503 by way of IC502 where the information is assimilated and used to develop drive for the circuit that helps to focus the laser (IC505).

### Let's get a bit more specific

IC502 (Figure 1) develops the laser drive signal and sends it out of pin 52 to the laser pickup assembly. After the DVD disk begins to spin, laser pickups A, B, C, and D develop the tracking error signals and send them to pins 2, 5, 8, and 23 of IC501. If I had inserted an audio CD, the laser pickup would have

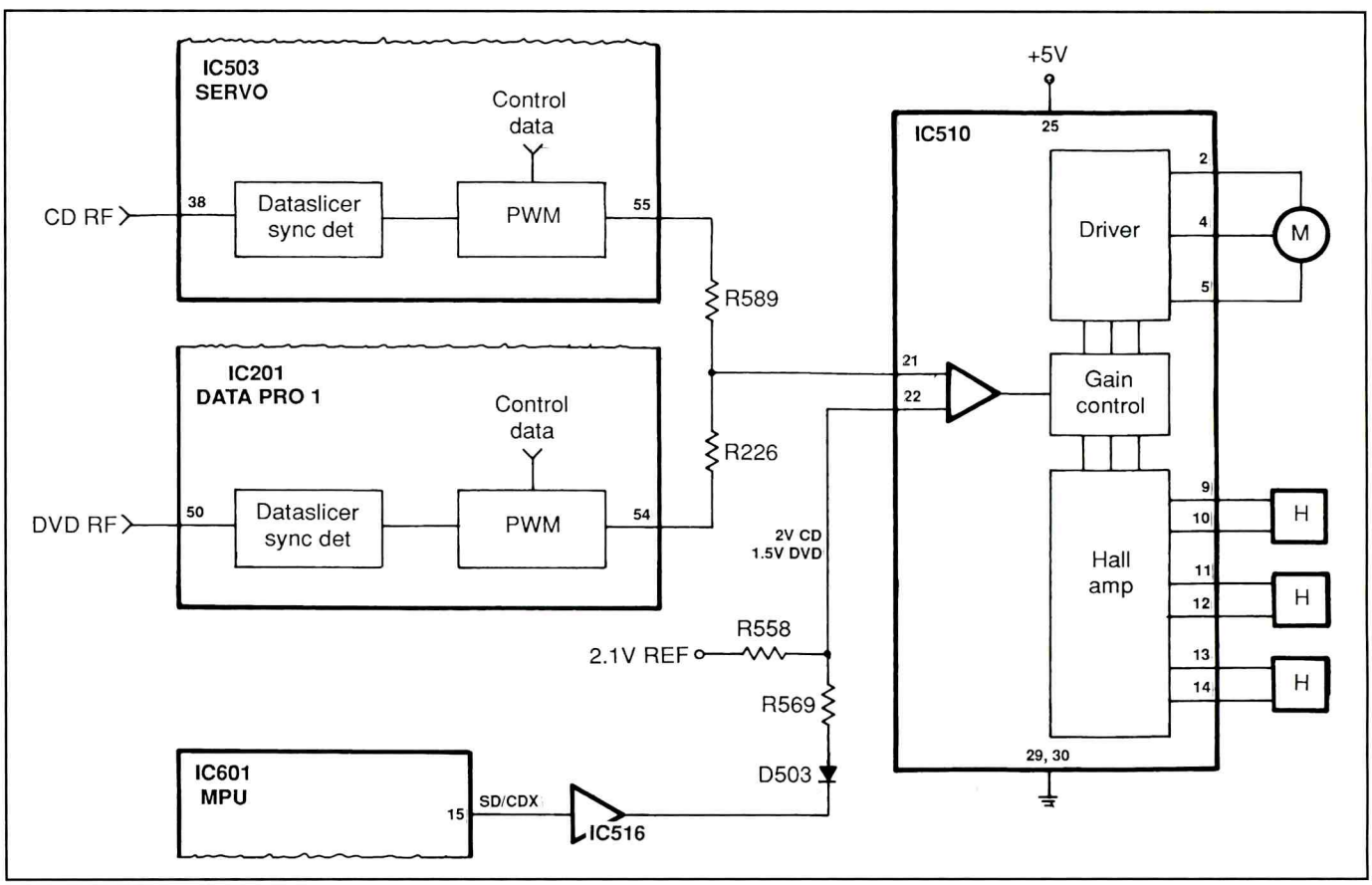


**Figure 3.** When a DVD disk is inserted into the player, after focus has been achieved, the pickup begins to generate an RF signal which is applied to pin 50 of IC201, the so-called "data processor one."

sent the tracking error signals from E and F (Figure 1, top left) to pins 62 and 63 of IC502.

IC501 develops the tracking error signal for the DVD and outputs it at pin 14. The error signal is input to pin 8 of IC502. If the unit is playing a DVD, the error signal exits pin 21 of IC502 (did you see the internal switch at pin 21?) on its way to IC503. The selected tracking error signal leaves pin 21 of IC502 and enters IC503 at pin 46 where it is applied to the "tracking correction circuit." The corrected signal exits at pin 49 and is applied to pin 1 of IC506 if I am playing a DVD or to pin 12 if I am playing an audio CD.

The output of IC506 at pin 15 becomes the tracking drive for a DVD or the focus drive for an audio CD while the output at 14 becomes the focus drive for a DVD or the tracking drive for an audio CD. As you have guessed, IC506 merely serves as an electronic switch to route the drive for the focus and tracking coils between DVD and audio CD.

### The optical system

Some DVD players utilize two optical pickups, one to play audio CDs and another to play DVDs. The Magnavox player uses one optical block equipped with two lenses to achieve the same purpose (Figure 2). If you need to know why the player has to have two, separate lenses, I suggest you read (or reread) John Ross's recent article, "Digital Versatile Disk Technologies: Versatility, Capacity, and Growing Popularity," in the February 2000 issue.

The switching action of IC506 causes the lens in the pickup assembly to rotate to the DVD lens for a video disk or the CD lens for an audio disk so that the unit selects the proper lens. The software ensures that if the pickup cannot achieve focus using the DVD lens, it will switch to the CD lens.

If you are beginning to follow DVD technology, you know that DVD disks are made by bonding two disks together to create a multilayer disk capable of storing an astronomical amount of information (See John Ross's article for details). A multi-layer disk means that the laser must focus first at one depth and then at another. To accommodate the multi-layered disk, a "layer jump circuit" monitors the focus error signal and pulses the signal either up or down to facilitate the focus as the beam switches from one layer to a deeper one or vice versa.

### Focus drive

I have mentioned the feed motor and disk motor but haven't commented on how they are driven. Look back at Figure 1 and locate IC503 on the right side of the diagram. Drive for both motors is developed inside the IC and output at pins 53 and 59 for the feed motor and at pin 55 for the disk motor. As you looked at IC503, I am sure you noticed bus connections at pins 90 through 93. The microprocessor uses these pins to maintain control over the servo processor.

I haven't yet commented on IC505 in Figure 1. It receives information from IC506 on pins 15 and 20 and uses it to develop drive for the two focus/tracking coils. The IC is powered by that all-important +8V supply that the power supply develops. The CD/DVD signal switches IC506 to select a CD or a DVD. The switching signal also goes to pin 47 of IC502 to control the gain of the focus amplifiers. The line goes high to select the CD function and low to select the DVD function.

That takes care of how focus drive is developed. It's time to pay some attention to the motor drive circuits.

### Feed motor and disk motor drive

Assume I have inserted a DVD disk into my player. After focus has been achieved, the pickup begins to generate an RF signal which is applied to pin 50 of IC201, the so-called "data processor one" (Figure 3). Pin 50 is connected to a "data slicer sync detector," a circuit that develops a signal which is applied to a pulse width modulator (PWM) along with a control signal from the microcomputer. The PWM uses both inputs to develop a control signal that it puts out on pin 54. The control signal goes to pin

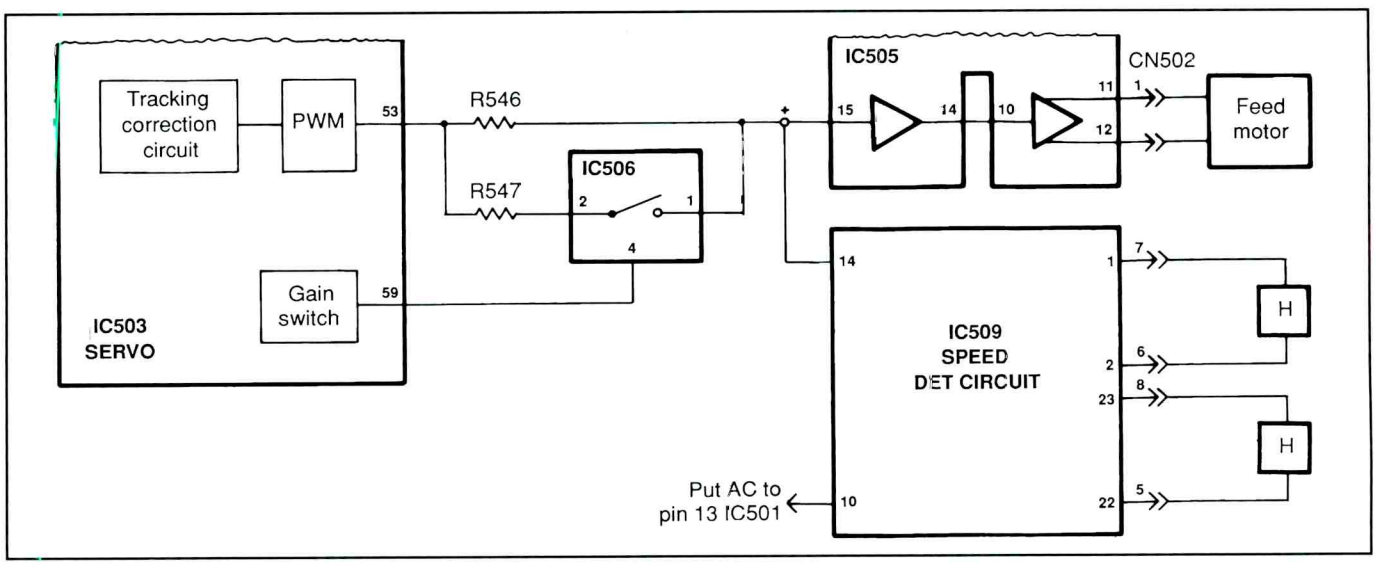


**Figure 4.** Feed motor drive from the tracking correction circuit inside IC503 is routed to a PWM (pulse width modulator) and sent out of pin 53 on its way to pin 15 of IC505, the feed motor drive IC. If you are watching a DVD, the drive goes through R546 before it reaches IC505. If the disk needs to be speeded up, the gain switch inside IC503 turns on IC508 switching R547 in parallel with R546 to increase the gain of the signal.

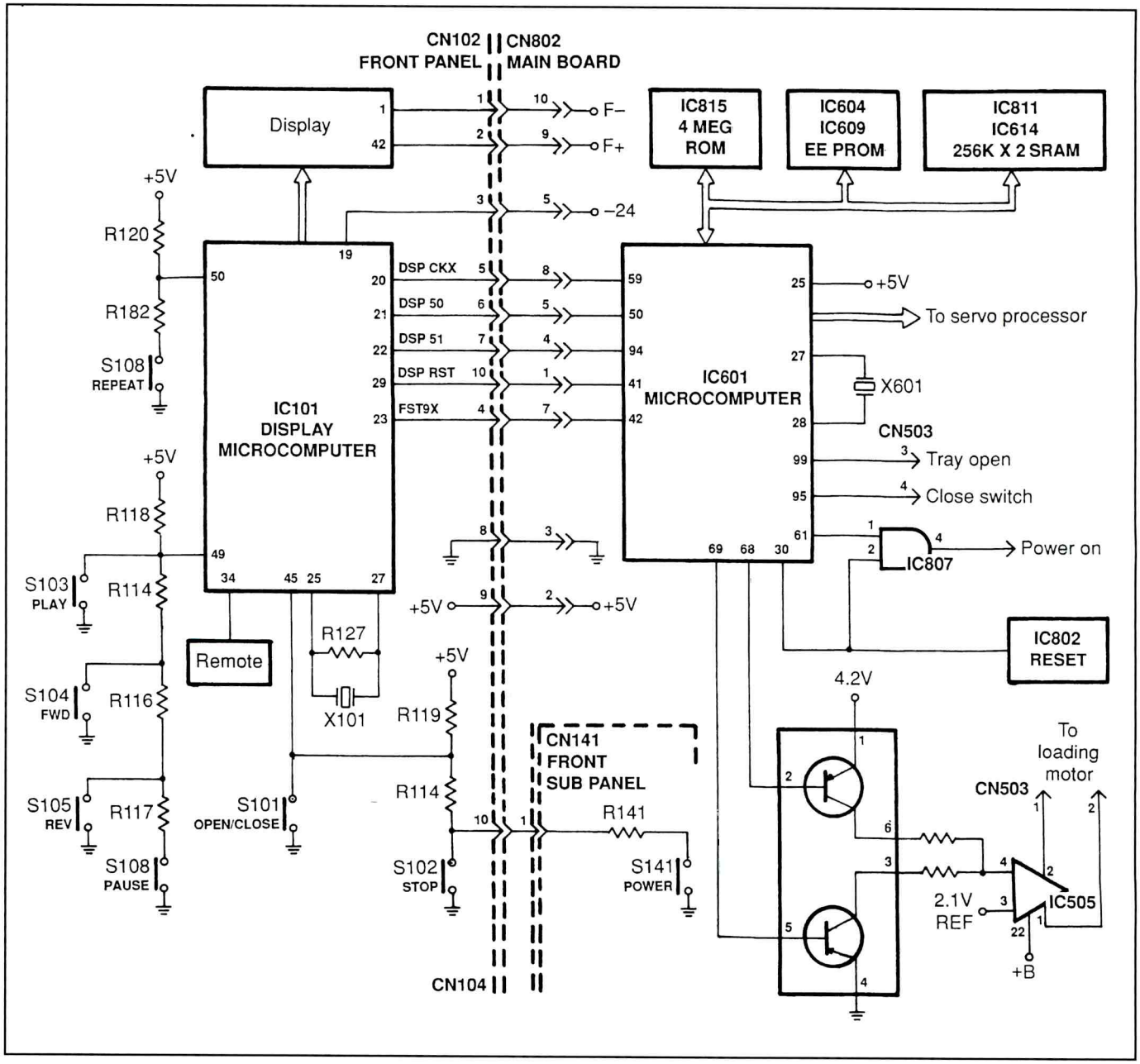


**Figure 5.** System control monitors and directs all functions of the DVD 400/420. The circuit includes the main microcomputer (IC601), the SRAM (IC611 and IC614), the EEPROM (IC604 and IC609), and the four meg ROM (IC615).

21 of IC510, the disk motor drive IC. IC510 responds by developing drive for the motor in question.

This is as good a place as any to point out that the disk motor changes speed as it moves from the center of the disk to its periphery in order to maintain sufficient flow of data to the processing circuits. If the processing circuits don't receive enough data, IC510 receives instructions to speed up the motor. If the circuits receive more data than they can handle, system control instructs IC510 to slow down the motor. The control circuits, you see, ensure that the motor moves the pickup assembly just fast enough to keep data flowing at the right speed.

### Feedback

A servo system must have feedback to operate correctly. This servo system uses information from three sources to control the speed of the disk motor. First, Hall effect sensors report the actual speed of the motor to IC510 by way of pins 9 through 14. Second, IC503 receives data from the pickup assembly that it uses to develop a PWM signal that it sends along to IC510 via pin 55. Third, IC510 receives a reference signal developed by IC601 and input into pin 22 of IC510. By the way, this voltage should read about 2.0V for an audio CD and 1.6V for a DVD.

The servo system is more complicated than I have implied. As I reviewed the information, I kept asking myself, "How much of this do I need in order to service the product?" Using the question as a guideline, I edited the information that I presented. I believe I have included enough to give you both an understand-

ing of and a feel for the circuits, which will, I hope, make service easier.

### Servicing notes

Let's take a few moments to look at some of the possible problems the servo system might cause.

When the player receives a disk, the laser should turn on and attempt to focus, and the disk motor should begin to spin the disk. If the disk motor doesn't turn on, begin by checking for startup voltage at pin 21 of IC510 (Figure 3). The voltage should be higher than the reference voltage on pin 22. If startup voltage is present, check the B+ supply on pin 25. If you have these two voltages, check for the presence of drive voltage out on pins 2, 4, and 6.

If the motor acts erratically, think in terms of a problem with the Hall effect sensors inside the motor. You can check these signals at pins 9, 11, and 13 of IC510. However, keep in mind that you are working with a closed-loop system, meaning the Hall effect sensors might be acting erratically because of an unstable drive voltage to the motor itself. I don't know of a hard and fast rule of thumb that definitively points you to a specific component as a cure to erratic motor operation. I do know these ICs are remarkably reliable and would suspect and probably replace the motor before I even began to think about replacing integrated circuits.

Now shift your attention from the disk motor to the feed motor, the motor that moves the laser assembly from the center to the outer edge of the disk. Feed motor drive from the tracking correction circuit inside IC503 (Figures 1 and 4) is routed to a PWM (pulse width modulator) and sent out of pin 53 on its way to pin 15 of IC505, the feed motor drive IC (Figure 4). If you are watching a DVD, the drive goes through R546 before it reaches IC505. If the disk needs to be speeded up, the gain switch inside IC503 turns on IC508 switching R547 in parallel with R546 to increase the gain of the signal and speed up the motor.

Like any servo circuit, this one requires feedback from the motor to operate correctly. Hall effect sensors under the feed motor gear provides feedback information with respect to the motor's speed. IC509 receives the feedback at pins 1, 2, 23, and 22. This IC uses the feedback information to develop a speed control signal which it sends out at pin 14. The correction signal is mixed with the drive signal from IC503 and used to control the speed of the feed, or "sled," motor.

If you studied Figure 4 carefully, you noticed a "PUTAC" signal developed by IC509 and sent out of pin 10 to the microprocessor. The microcomputer uses this signal to provide system control with information about the feed motor's speed and position and the speed and position of the pickup.

If you encounter a problem with the feed motor drive, begin by checking the voltage on pins 1 and 2 of connector CN502. When the player is operating correctly, voltage should be present on both pins after the disk loads to move the pickup assembly toward the disk motor. If the voltage on pins 1 and 2 of CN502 isn't present, check for a drive signal on pin 53 of IC503. If the voltages are present but the motor doesn't operate, check for B+ of 8V. If you have drive voltage for the feed motor and the requisite B+ of 8V but the motor still doesn't seem to work, check for mechanical problems with the pickup assembly and make sure the ribbon cable is properly seated before you even begin to think about changing the motor.

The literature suggests that the technician should check pin 14 of IC509 when the feed motor acts erratically. I believe, though I haven't tried it, that you can open the trace between pin 14 of IC509 and pin 15 of IC505 and use an external dc voltage to control the speed of the feed motor. If the erratic operation clears up, suspect a problem with IC509 or the hall effect sensors. If such is the case, you might be able to narrow the problem to one or the other by monitoring the output of the hall effect sensors. Does the output smooth out when you apply a constant dc voltage? If it does, suspect IC509. Let me say again, I am theorizing because I haven't had the opportunity to test my theory.

Well, that about takes care of the servo system, meaning it's time to take a brief look at system control.

### System control

System control (Figure 5) monitors and directs all functions of the DVD 400/420. The circuit includes the main

microcomputer (IC601), the SRAM (IC611 and IC614), the EEPROM (IC604 and IC609), and the four meg ROM (IC615). As you gather from the number of components in the circuit, system control is an involved and complicated piece of engineering. System control uses two microprocessors to perform its work.

The brains of the outfit is IC601, a monster of a multi-pin surface mount component. Like any microprocessor, it has its "must haves" which you must check when you suspect a system control problem. It receives +5V from the power supply on pin 25; it is reset by IC602 at pin 30; and it is timed by a 16 MHz crystal (X601) at pins 27 and 28.

Philips calls the second microprocessor (IC101) "the display microcomputer" which is physically located on the front panel. When it becomes operational, IC602 outputs a low on pin 41 to reset IC101, bringing it on line. It has a separate 8 MHz clock operating at pins 27 and 28 and is powered by the -24V supply developed by the power supply. It comes into IC101 at pin 3 of CN102.

This second microprocessor is responsible for driving the fluorescent display. The fluorescent display is powered by the F- and F+ voltage developed by the power supply and fed to it at pins 1 and 2 of connector CN102 respectively.

IC602 and IC101 are connected together by means of a ribbon cable labeled CN102/CN802. The connector provides a good place to check the communications between the two chips. I will reference my remarks to the IC101 end of the cable, which is CN101. For example, reset activity can be checked at pin 4. Communication from IC101 to IC602 takes place on the DSPSI line (pin 7). IC601 uses the DSPSO line to feed data to IC101. Check it at pin 6. The remaining lines, FSTBX and DSPCKX, are data lines and may be checked at pins 4 and 5 respectively.

As you have seen by studying Figure 5, all user commands go first to IC101 where they are interpreted and sent on to IC602 via a data train. IC101 receives information from the outside world in two ways. Commands issued by the remote control are input at pin 34 while commands from the front panel are input into pins 50, 49, and 48. I am sure you have noticed the resistor divider tied to each of these pins. The tact switches are so configured between the resistors and ground that each one generates a specific voltage level at the pin to which it is attached when a tact switch wired into the resistor network has been depressed. IC101 senses the voltage, interprets the request, and sends the information to integrated circuit IC602.

Let's use a power-on request to illustrate how the front panel tact switches operate and what happens when IC 601 receives the information. When I depress the power-on button, the voltage at pin 48 of IC101 drops from 5V to 2.5V. IC101 senses the voltage drop and informs the microcomputer that I have requested that the player be turned on. IC601 responds by pulling pin 61 high, an action that causes pin 4 of IC607 to go high and turn the power supply on via pin 3 of connector CN801 (See the first installment of this series of articles.).

IC601 initiates the disk loading sequence when the "open/close" com-

mand has been executed by providing drive for the loading motor at pins 68 and 69. The drive signal goes directly to pins 2 and 5 of Q506, a solid-state device that drives IC505, that in turn drives the loading motor.

IC601 maintains communication with the servo processor and other circuits in the DVD player over the data bus lines.

### Focus and tracking checks

I gave you a general overview of the focus and tracking circuits in the body of this article. However, the time will come when you need more information than I gave you then. Therefore, let's take a closer look at servicing these circuits.

(1) Begin by checking the focus error signal at TP504. You might want to cycle the power off-on, off-on while you monitor TP504. Tap the side of the player gently to see if the signal changes. If the signal is missing or not up to par, you most likely have a problem on the main printed circuit board.

(2) Check the tracking error signal at TP507 when you suspect a tracking problem. Cycle the power off and on to see the operation of the tracking error voltage. Tap the side of the player to check its operation. If the signal is missing or improper, the main board is most likely at fault.

(3) Check pins 1, 2, 3, and 4 of CN501 for focus or tracking problems. You should see an ac signal riding on about 4Vdc. Incidentally, you are checking the focus and drive signals. If you suspect the drive signals are being loaded down, disconnect the unit from the ac line and unplug CN501. Restore ac power and turn the DVD player on while you monitor pin 1 of CN501. If it is good, the signal will rise to about 4Vdc. The same obtains for the voltage at pins 2, 3, and 4.

Check the tracking error signals going to the main board at pins 12, 13, 14, and 15 of CN501 when you are working with a DVD and pins 10 and 11 when you are working with an audio CD.

(4) If the focus coil doesn't move up and down or if the laser doesn't fire up, check for +5V on pin 19 of CN501 and +2V on pin 20. If the voltages aren't present, wiggle the flex cable to check for intermittent connections. If the voltages still aren't present, unplug the flex cable and check again.

### The feed motor circuit

There are several places to check the feed motor drive signals, but the most accessible point is at pins 1 and 2 of CN502. The signals are the easiest to monitor when the power cycles on and the player is put into the "times eight" scan speed. You might want to keep in mind that the drive signal goes to +4Vdc when the power is turned on. If the dc signal is present, the drive signal from the main board almost has to be good.

The feed motor is an integral part of a closed-loop system, meaning it has to provide feedback to the loop. Monitor pins 5, 6, 7, and 8 of connector CN502 while you cycle the power and play a disk in "times eight" scan speed. You may be thinking, "If the disk won't play, how can I check for feedback?" Try this: (1) turn the power off and push the slide away from the spindle; (2) turn the power on and monitor the signals as the slide moves back into its default position.

By the way, dc voltage for the feed motor hall switches appears at pin 3 of connector CN502. Don't forget to check it if you can't detect activity from the hall switches.

### The spindle motor

The spindle motor rotates the disk itself. Check its drive signals at pins 17, 18, and 19 of CN502. Like the feed motor signals, these are easiest to detect when the power cycles on and the player has been set for "times eight" scan speed.

You may monitor feedback from its hall switches at pins 9 through 13 and 15 while cycling the power and playing a disk in "times eight" speed. Check the hall switches themselves by manually rotating the motor with your finger as you monitor the above-mentioned pins. DC drive voltages for the spindle motor hall switches are available at pins 14 and 16 of CN502.

### The loading motor

Check the loading motor operation at CN503. The signal at pin 1 drives the tray out (i.e. opens the tray) while the signal at pin 2 pulls the tray into the player. The tray position switch signal at pin 3 goes high when the tray is in the out position and low when the tray is in. The tray position switch signal at pin 4 is low when the tray is out and high when the tray is in.

### Video and audio next time

The first part of this series of articles on DVD dealt with the power supply. In this article, we delved into the mechanical portions of this technology. The next, and final, installment, will cover the video and audio paths in a DVD. DVD players are marvels of technology, but they can be serviced by a technician with good skills and the right knowledge. ■

# Literature

### Consumer electronics vision goes online

The Consumer Electronics Association (CEA) has launched the online version of Consumer Electronics Vision, a bi-monthly, four-color magazine for CEA members and the consumer electronics industry at large. With its online version at www.CE.org, Consumer Electronics Vision tackles the business challenges facing both retailers and manufacturers.

Both the print and online versions of the magazine report on activities that impact the industry — consumer electronics legislation, engineering developments, marketing trends and statistics, training and education, and trade shows. The online version also adds an interactive feature with an industry bulletin board that encourages an open dialogue between retailers, manufacturers, and analysts.

The debuting online issue features stories on digital connectivity standards, personalized TV and MIT's Media Lab as well as other business topics. Next month's issue will focus on mobile electronics, Bluetooth technology and encryption.

The readership of the print magazine comprises more than 17,000 retailers, manufacturers, financial and marketing analysts, and CEA members. Individuals who wish to be put on the magazine's circulation list for print editions can download the subscription form from www.CE.org.

Consumer Electronics Association, 2500 Wilson Blvd., Arlington, VA 22201, Phone: 703-907-7600

**Circle (90) on Reply Card**

### Technical book catalog

A just released catalog from PROMPT contains over 200 titles on a variety of electronics related topics. PROMPT Publications, an imprint of Howard W. Sams & Company, provides technical books for the electronics hobbyist, novice and technicians.

This year's catalog has been redesigned to feature best-selling titles, as well as divides titles into categories, regardless of the publisher. It also features a new section on Automotive, Business and Technology, and Electrical Technology, not found in previous catalogs.

The catalog includes select titles from Butterworth-Heinemann, Macmillan Computer Publishing, IDG Publishing, and UCANDO Educational Videos.

PROMPT Publications, 5436 West 78th Street, Indianapolis, IN 46218

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### On-line document center

Andrew Corporation has launched a new document delivery service that conveys information about Andrew products and services 24 hours a day, 365 days a year. The new on-line document center can be accessed directly from the Andrews homepage at http:www.andrew.com. Over 2000 documents can be viewed on-line, sent via e-mail as a .PDF files, or sent to a fax machine. The system may also be used to order printed copies of available literature.

The on-line document center holds a wide variety of the company's information, including product bulletins, technical documents, installation instruction, special publications, antenna patterns, article reprints, reference information and new publications. New information is included and content is updated frequently so that the latest information is always available.

Searching for information is easy. Users can enter product names, part numbers, common phrases, natural language queries, or bulletin numbers.

Many of the bulletins are available in a number of languages including Chinese, English, French, Indonesian, German, Italian, Japanese, Portuguese, Russian, and Spanish.

Andrew Corporation, 10500 West 153rd Street, Orland Park, IL 60462, Phone: 708-349-3300, Fax: 708-349-5222, Website: http:www.andrew.com

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### Theater-to-Go brochure

MARGI Systems offers a specification sheet for its Theater-to-Go for users of DVD equipped notebook computers. Theater-to-Go provides mobile computer users with the total personal movie experience.

Theater-to-Go includes the i-glasses display headset, as well as the MARGI DVD-to-Go hardware decoder card. Padded earphones, battery, and all cables are included. Users will enjoy movies in Dolby Digital stereo sound on their own personal headset. DVD-to-Go is the industry leading DVD decoder card and insures full speed, full resolution video without jerks and audio without skips.

The MARGI high-performance decoder card turns any DVD notebook computer into a full-featured player for full-motion MPEG-2, DVD, MPEG-1, and VCD digital video. I-glasses from i-O Display Systems is an ergonomically designed personal display headset with two full-color liquid crystal display panels and includes a 2.4 amp-hour battery, 6 foot cable and an AC power adapter.

Operating with any Windows 95/98 notebook with DVD, Theater-to-Go comes with onscreen navigations for all DVD controls, giving the user quick and easy adjustments. Hot Plug and Play insures ease of set-up and installation. The headset can also be used alone with any Laser Disc Player, VCR, or home DCD player. The DVD-to-Go card can be connected directly to a TV for larger audiences.

MARGI Systems, 3155 Kearney Street, Fremont, CA 94538, Phone: 510-657-4435, Fax: 510-657-4430, E-mail: info@margi.com, Website: www.margi.com

**Circle (93) on Reply Card**

### PACE Announces 2000 Training Schedule

PACE announces their year 2000 schedule and introduces three new classes for the training facility. This training teaches the skills, techniques, and process control development necessary to perform high quality, non-destructive assembly and repair on all types of electronics modules and assemblies. Open enrollment for the 2000 classes at the facility have been scheduled.

PACE, 9893 Brewers Court, Laurel, MD 20723-1990, Phone: 888-535-PACE, Fax: 301-604-8782, E-mail: www.pace.usa.com

# Understanding communications wiring

**by the ES&T Staff**

*Adapted from the booklet "Uncle Ted's Guide to Communications Wiring," published by Fotec*

Convergence. It's a word you've heard before, and you'll be hearing more and more of, until it's an established fact, then you probably won't hear it any more. Convergence refers to the phenomenon that all of the electronics products in the home are becoming less separate entities and to a greater extent all parts of a single entity. For example, today we still have televisions, VCRs, personal computers, and all of the other electronics products that contribute to the quality of life that we enjoy in the 1990s. But all of these products are becoming more like each other.

Take television. Many modern TV sets no longer have physical adjustments, like potentiometers, for a service technician to use to tweak a set's operation. On some of the more advanced sets, everything is controlled by a microprocessor, a computer really, and the tweaks are set by changing the digits in an EEPROM.

And take computers: all you have to do is buy a television circuit board and install it in the computer and it will act like a television, with the added advantage that you can save some of the information that appears on the screen, if you choose. And you can now buy a DVD-ROM for your computer, or buy a computer with a DVD-ROM already installed, and not only load programs and data into your computer, but listen to compact discs, or watch the latest movie offering on DVD.

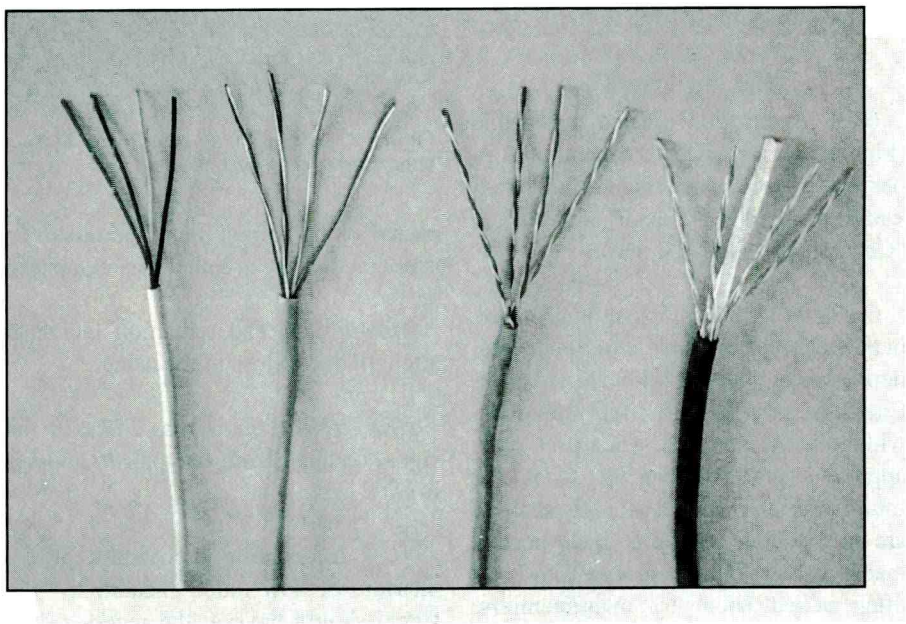


**Figure 1.** These are examples of unshielded twisted pair cable, comprised of 4 pairs of copper conductors.

### Changes in the wires too

But that's only part of the scenario. Today you can send and receive not only voice, but data as well over your phone line. And if you have, say, satellite TV, and wish to have access to pay per view events, you have to have a telephone connection as well, so that you can order them. Soon, once HDTV has begun to thoroughly explore its options, it may well be possible for viewers to receive not only television programs via terrestrial broadcast, but other types of data as well. Data that might be accessed by the home's personal computer.

As the number of computers and other related types of products in the home multiply, more homes will have networks. That means that a technician coming into the home to service a TV or a personal computer might find himself in the middle of a maze of wires. If he has no idea about what those wires are, or how they are connected, he might lose a service job.

Moreover, because the local telephone companies no longer take responsibility for the wiring in homes unless the customer pays a maintenance fee, telephone wiring installation, changes, and maintenance present an area that can be addressed by consumer electronics service technicians. Because the scope of the competence of a technician seems to be constantly broadening as in this area, this magazine deems it important to keep up with those needs. To that end, we present this article on communications wiring, so that our technician readers will have at least a passing acquaintance with them, and possibly be able to identify any further education on the subject that they might need.

### Cabling jargon

You really need a dictionary to understand all these cabling terms. Here's an overview of the basic terms, and we'll explain more as we go along.

To begin with, what do we call this whole area of cabling?

Some people call it "data/voice," some call it "low voltage," but most call it "structured cabling." It's the infrastructure for telephone and LAN connections in most commercial installations and even in some modern homes.

### Cabling Standards Terms

*Structured Cabling*: An architecture for communications cabling specified by the EIA/TIA TR41.8 committee and

used as a voluntary standard by manufacturers to insure interoperability.

*EIA/TIA*: An industry trade association that creates interoperability standards for the products made by member companies.

*EIA/TIA 568*: The main standard document for structured cabling, usually referred to as simply "568."

### Cabling Terms

*UTP*: Unshielded twisted pair cable (Figure 1), comprised of 4 pairs of copper conductors and graded for bandwidth as "Levels" (from Anixter) or "Categories" (EIA/TIA 568)

*Category 3, 4, or 5*: Ratings on the bandwidth performance of UTP cable, derived from Anixter's Levels program. Cat 5 is rated to 100 MHz and most widely used. Cat 5E (enhanced) was approved in November 99. Look for future enhancements. At this time, there are no standards covering higher performance cables, but Cat 6 and Cat 7 are often talked about by manufacturers. (Hint: wait and see for the standard!)

*Other cables*: 568 includes STP, shielded twisted pair, specified by IBM for Token Ring networks. They are considering ScTP, a version of UTP with a foil shield over all four pairs (not individually like STP) for higher frequency performance and less EMI (electromagnetic interference.) Both multimode and singlemode fiber are included as well.

### Connector Terms

*RJ-45*: The popular name of the modular 8 pin connector (Figure 2) used with UTP cable in structured cabling systems.

*Jack*: The receptacle for a RJ-45 Plug.

*Plug*: The connector put on the end of UTP cable.

*Punchdown*: A connecting block that terminates two cables directly. 110 blocks (Figure 3) are most popular for LANs, 66 blocks (Figure 4) for telco, but some installers use BIX or Krone.

### Cable Testing Terms

*Wiremap*: All eight wires must be connected to the correct pins. The test to be sure that they are is called a wiremap test.

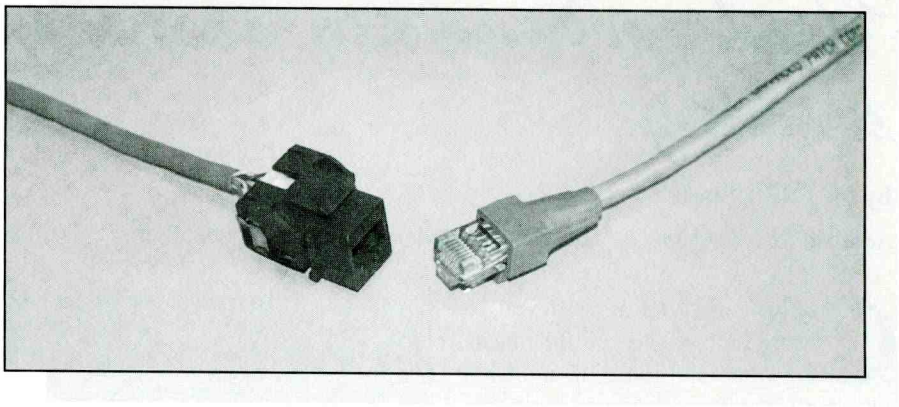


**Figure 2.** RJ45 is the popular name of the modular 8 pin connector used with UTP cable in structured cabling systems.

*Attenuation*: The reduction in signal strength due to loss in the cable.

*NEXT (Near End Cross Talk)*: or the signal coupled from one pair to another in UTP cable.

*ACR*: Attenuation to crosstalk ratio, a measure of how much "headroom" the signal should have at the receiver. Not specified in 568, but most testers calculate it.

### Cable Location Terms

The telecom cable industry has their own terminology for the areas where cable connections are made and the runs between those locations (Figure 5).

*Telecom Closet (TC)*: The location of the connection between horizontal cabling to the backbone.

*Main Cross-Connect (MXC)*: The old telco term for the location of the main electronics in a building. LAN people may call it the equipment room.

*Intermediate Cross-Connect (IXC)*: A room in between the TC and MXC where cables are terminated

### Cable Plant Terms

*Horizontal Cabling*: The connection from the telecom closet to the work area outlet (desktop).

*Backbone Cabling*: The cabling that connects all the hubs in telecom closets or MXCs together.

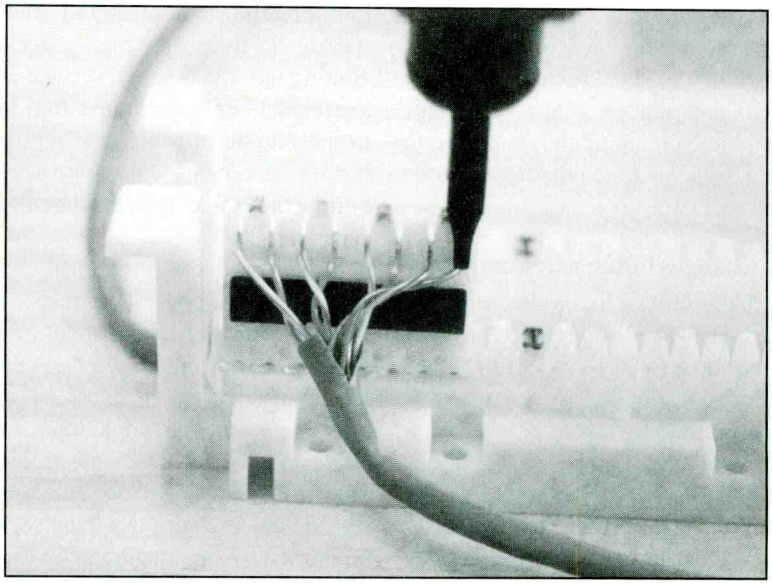


**Figure 3.** A 110 punchdown block. This type of connecting block is most popular for LANs.

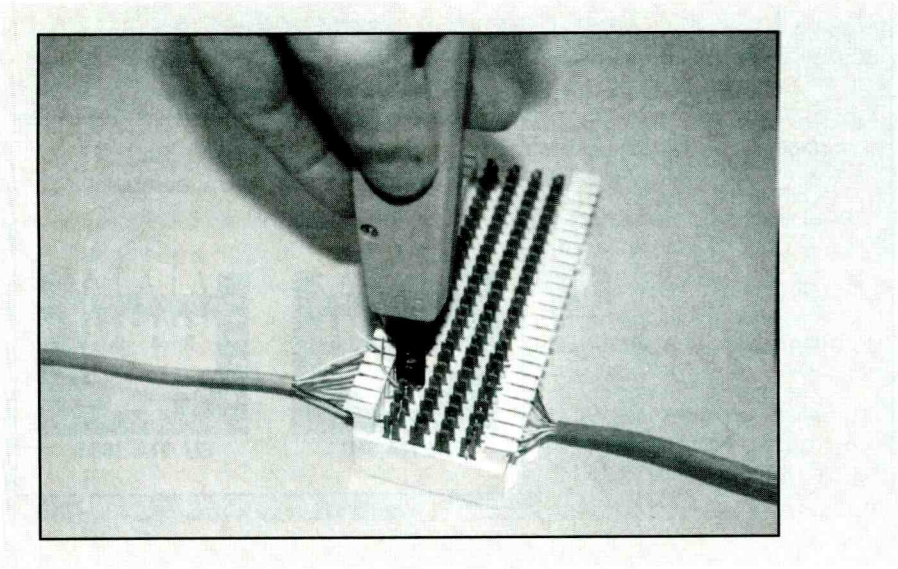


**Figure 4.** A 66 block. This type of connecting block is most often used for telco.

*Work Area Outlet*: The jack on the wall which is connected to the desktop computer by a patchcord.

*Link*: The installed cable plant from work area outlet jack to the patch panel in the telecom closet.

*Channel*: The cable plant including the link plus patchcords on either end to connect the communications hardware.

*Patchcord*: A short length of stranded cable with a RJ-45 plug on either end, used to connect hardware to the link or to connect cables in a Patch Panel.

*Patch Panel*: A rack or box where cables are terminated usually in 110 punchdowns and interconnected with patchcords.

### Network cabling

If you start installing communications cabling, you will have to deal with end users who talk networks (Figure 6). Here are a few network terms to help you translate.

*Hub*: The connecting electronic box that all the horizontal cables connect to which are then connected by backbone cabling.

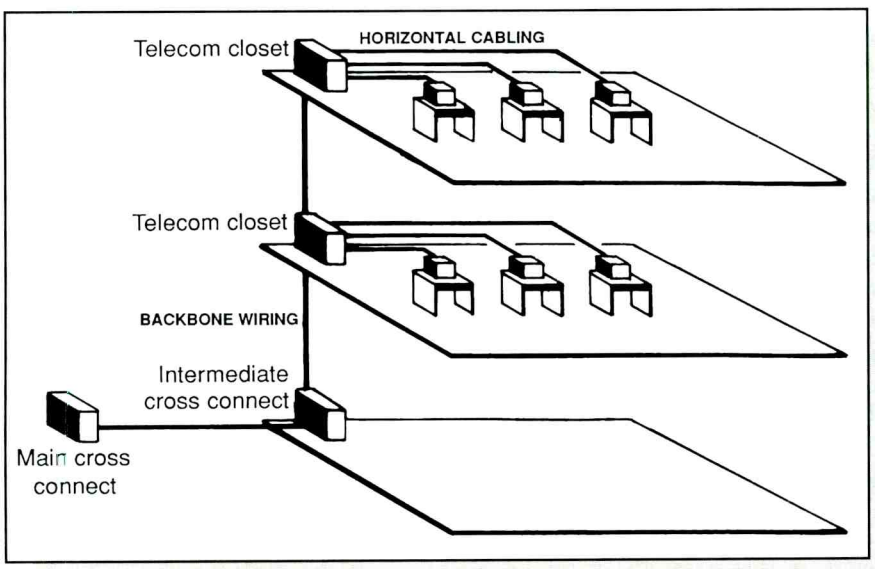



**Figure 5.** The telecom cable industry has developed terminology for the areas where cable connections are made and the runs between those locations.

*10Base-T*: The most popular version of Ethernet operating at 10 megabits per second, connected on UTP.

*Ethernet*: A 10, 100, or 1000 Megabit per second local area network (LAN) that is by far the most popular LAN.

### Wiring for communications — An overview

Communications wiring dates back over a century; over 150 years for the telegraph and 125 years to the beginning of the use of the telephone. From the beginning, phones used a current loop for both voice transmission and signaling (dialing and ringing.) The two wire current loop offered some advantages: it was possible to add phones in series, and an "on-hook" phone did not interfere with the phone in use. The current loop offered adequate bandwidth for voice (only 3,000Hz) and the ability to work over relatively long distances.

During the 1980s, phone signals became digital, LANs proliferated, and new cables and cabling architecture were needed. The goal was to make buildings "smart," able to allow computer and phone conversations over a standardized wiring system. By the early 90s, a scheme of "structured cabling" was standardized by a technical committee of a trade association, the merged Electronic Industries Association and Telecommunications Industry Association (hereafter referred to as EIA/TIA).

Just to confuse everybody, this cabling standard, developed by the EIA/TIA TR 41.8 committee, is referred to by the number of the primary standard, EIA/TIA 568, although there are actually a number of standards, technical advisories, etc. that cover all aspects of structured cabling. We'll go along with the crowd and simply say "568" when we generally mean the entire output of the TR 41.8 committee!

And to further confuse everybody, many people think this standard is a mandatory, even legal, document like the NEC (National Electrical Code.) That is not the case; "568" is a voluntary interoperability standard for communications cabling, developed by a number of manufacturers of cabling components and networking equipment, so that they might make equipment that could use

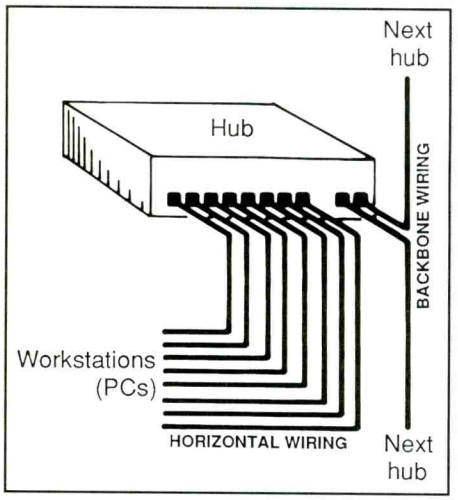
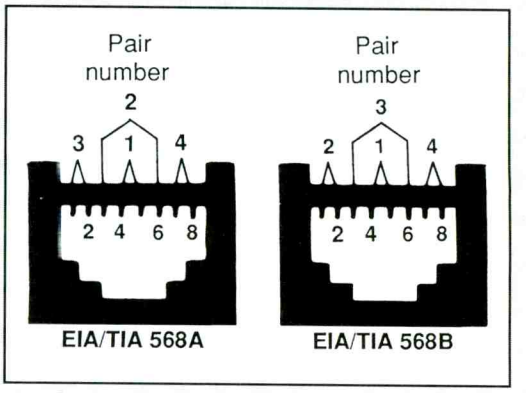



**Figure 6.** If you start installing communications cabling, you will have to deal with end users who talk networks.

**Figure 7.** UTP cables are terminated with standard connectors, jacks, and punchdowns. The jack/plug is often referred to as an "RJ-45," but that is really a telco designation for the "modular 8 pin connector" terminated with an USOC pinout used for telephones. The male connector on the end of a patchcord is called a "plug" and the receptacle on the wall outlet is a "jack."




any 568-compliant cabling system and be upgraded in the future as long as it was designed for the same cable plant.

What 568 is, in fact, is a common sense approach to cabling that offers interoperability, upgradability, and low cost due to the numerous manufacturers offering compatible products. But it does not have the force of any kind of code.

### The basics of "568"

EIA/TIA "568" calls for connecting the desktop (work area) to a telecom closet (the "horizontal" run) with up to 100 meters of cable (including no more than 10m total of patchcords), which is usually Cat 3 or Cat 5 UTP. Most installations today use Cat 5 exclusively, as it isn't that much more expensive than Cat 3 and can support phones or LANs on any outlet. Fiber optics is also a horizontal option in 568, but not often used because of the higher cost except where high bit-rate networks or future upgrades are expected.

The telecom closet houses the hubs for the computers in the work areas. These hubs are interconnected on "backbone" wiring which is mostly fiber optics, as it usually carries higher speed signals over longer distances and provides isolation from ground loops, another bugaboo of LANs. The main cross-connect (MXC) or equipment room contains the network and telco hardware. For the telephones, their lower bandwidth requirements allow longer runs, so they are usually simply connected to backbone cables in the telecom closet with a punchdown and run straight to the MXC.

The 568 standard also includes IBM Type 1 cable, a shielded two pair cable, since it is still used in some networks. However, it ignores coax cable, like RG-58 used in some Ethernet LANs and RG-6 used in CATV and CCTV.

### The cabling

The heart of 568 is UTP cable comprised of four pairs of carefully twisted pairs of copper wire, insulated with carefully chosen material to provide high bandwidth, and low attenuation and crosstalk. We'll say it here and many times more before we're through — the secret ingredient of Cat 5 is the twists. In order to maintain Cat 5 performance, especially as regards crosstalk, the cabling must remain twisted to as near as it is possible to the terminations. If a cable is untwisted for a considerable length before it is terminated, it's performance will be compromised.

The cable is terminated mostly in jacks; connector receptacles that have punchdown terminations on the backside and tricks inside to prevent crosstalk. Some snap into work area outlets, others are incorporated in rack mount patch panels. Standard 568 allows many possible cable configurations, including intermediate punchdowns, but a direct run from a work area outlet to a patch panel will provide the highest performance. If an organization is contemplating upgrades to fast networks like Gigabit Ethernet, then it would be best if only direct runs are used.

Patchcords for connecting network equipment to the outlet or patch panel are usually purchased factory-assembled. The connector (plug) is properly called a "modular 8 pin" but usually is referred to as a RJ-45, which is actually a specific telephone company use of the same plug. Patchcords use stranded cable for flexibility and require special connectors. Patchcords should be ordered to proper length to prevent the mess that patch panels often become after a few moves and changes.

Currently, hardware and cable is available that is rated for Cat 3 or Cat 5. With cable, it's easy to see the difference; it's in the twists. In the case of jacks, however, it is harder to tell the differences. Trust us — they are different. If you terminate Cat 5 cable with Cat 3 jacks, you will get Cat 3 performance — no better!

And today, vendors are hyping Cat 6, Cat 7, and a ton of higher performance cable options. *None* of these are standards, and investing in them today could be a total waste of money, depending on how the standards committees go. You are probably better off saving your money and investing time in installing Cat 5 properly or considering optical fiber if higher performance is your goal.

### Termination

UTP cables are terminated with standard connectors, jacks, and punchdowns. The jack/plug is often referred to as a "RJ-45," but that is really a telco designation for the "modular 8 pin connector" terminated with a USOC pinout used for telephones. The male connector on the end of a patchcord is called a "plug" and the receptacle on the wall outlet is a "jack" (Figure 7).

In LANs, as specified by 568, there

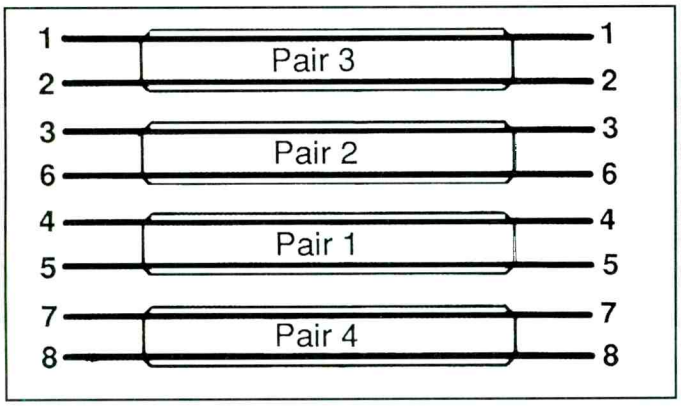



**Figure 8.** Wiremapping simply means that each wire is hooked up correctly, with no open wires or shorts. Most wiremapping failures are simple enough to understand, like reversed wires in a pair, crossed pairs or opens and shorts. The most difficult wiremap problem is a split pair, when one wire on each pair is reversed on both ends.

are two possible pinouts, called T568A and T568B that differ only in which color-coded pairs are connected — pair 2 and 3 are reversed. Either work equally well, as long as you don't mix them! If you always use only one version, you're OK, but if you mix A and B in a cable run, you will get crossed pairs.

The cable pairs are color coded as

- Pair 1 is white-blue/blue,
- Pair 2 white-orange/orange,
- Pair 3 is white-green/green
- Pair 4 is white-brown/brown.

The jacks are then terminated with these layouts, looking into the jack:

Note that Cat 3 jacks and all plugs are going to use these color codes. However, Cat 5 jacks have internal connections that continue the twists as close to the pins in the jacks as possible. Thus the pinout on the back of the jacks will not usually follow these layouts. Always follow the color codes on the back of the jacks to insure proper connections.

The plugs are terminated by straightening our the wires in proper order and crimping on a connector. To repeat an important consideration; you *must* keep the twists as close to the plug as possible to minimize crosstalk.

Jacks usually have punchdowns (see below) on the back or can be terminated without punchdowns using special manufacturer's tools or even a cover for the connector. Again, the twists must be maintained to as close to the receptacle as possible to minimize crosstalk.

Sometimes there are cross connects using punchdowns in the telecom closet. These are called punchdowns because the cable is punched down into the IDC contacts with a special tool, called (surprise) a punchdown tool. Of course, you *must* keep the twists as close to the punchdown as possible to minimize the possibility of crosstalk.

Punchdowns come in 4 varieties: 110, 66, Bix and Krone. Most popular for LANs is the 110, for telcos it's the 66, and the Bix, and Krone are rare (price, proprietary designs, etc.)

There are lots of variations in wiring a horizontal Cat 5 link. For the highest performance, as is needed in high speed networks, cables are run directly from the wall outlet to the patch panel without interconnects. Saves costs too.

### Installing wiring

Everybody knows how to pull wire, right? Wrong! Just as it is important to keep the twists right down to the terminations, there are things you must realize to maintain the performance of Cat 5 wire you paid for.

First of all, pulling tension must be less than 25 pounds. That's not very much. Pulling at higher tension can stretch the cable and affect the twists in the pairs, and it's those twists that make the cable perform well at high frequencies. Likewise, kinking the cable by letting it get twisted or pulled around sharp corners can cause permanent damage. Damaged cable will probably not pass crosstalk tests.

Most cable boxes are designed to allow easy pulling directly from the box. Gather up several boxes and pull a bunch of cables at once. Tape them together and attach a pullstring or just feed them along by hand.

You can pull from the telecom closet or to the closet, whichever is more convenient in the install you are doing. You can also pull to consolidation points then out to individual outlets or vice versa, instead of pulling the bundle of cables all the way.

One item to remember is there is usually 1,000 feet (about 300 meters) of cable in each box. Each cable is also marked with a distance every few feet so you can keep track of length by reading the distance off the cable. Before you pull any cable from the box, find the distance marked on the cable and write it down on top of the box. That way, you can calculate the length of each cable you pull and more importantly, the amount remaining in the box. It's not too cool to start pulling a cable and find out it's not long enough.

Likewise, mark every cable with the location it's going to. Mark it on both ends. You will save lots of time when it comes time to make the correct connections, recording test data, and keeping records for moves and changes.

Cat 5 should be installed on special hooks, bridle rings, or cable trays that limit its bend radius to preserve the Cat 5 performance. You cannot lay the cable on top of ceilings or hang from the drop ceiling hangers: in most places it's against code. Penetrations of firewalls require firestopping to restore fire retardancy. You also have to keep the wire away from sources of interference, such as fluorescent lights and power cables.

Power cables are also a safety hazard. Although this cable is called "low voltage," it runs in areas full of power cables that are a shock hazard. If you are not familiar with electrical safety, fire safety and inspections, I strongly suggest taking a course on the NEC (National Electric Code) to learn about these important topics. It could save your life.

### Testing

Since the Cat 5 cable is used to the fullest extent of its performance envelope, testing is very important. There are four basic tests that are called for as part of the EIA/TIA specs for all UTP cables: wiremap, length, attenuation, and crosstalk. Let's take a look at each of them.

*Wiremapping* simply means that each wire is hooked up correctly, with no

open wires or shorts. That's mostly very straightforward. Each pair must be connected to the correct pins at the plugs and jacks, with good contacts in the terminations (called "IDC" or insulation-displacement connections, by the way, since the wires are held in knife-edge terminations that slice through the insulation and dig into the copper wire, forming a tight seal.)

Most of the failures are simple enough to understand, like reversed wires in a pair, crossed pairs or opens and shorts. One possible failure is crossed pairs, caused when both wires of a pair are crossed at one termination. The usual cause of a crossed pair is a 568A termination on one end and a 568B on the other.

The most difficult wiremap problem is a split pair, when one wire on each pair is reversed on both ends (Figure 8). The usual wiremap will pass but crosstalk will fail. It takes a Cat 5 tester or a more sophisticated wiremapper to find a split pair, as most wiremappers do not check for the presence of crosstalk.

### Length

Since 568 cables must be less than 90 meters (296 feet) in the link and 100 meters in the channel (328 feet), length must be tested. This is done with a *time domain reflectometer* (TDR) which is a fancy term for cable "radar." The tester sends out a pulse, waits for an "echo" from the far end and measures the time it took for the trip. Knowing the speed of the electrical signal in the cable, it calculates the length.

If you have a short or open, the TDR will tell you where the problem is as well, making it a great tool for finding this type of problem.

### Attenuation

The proper operation of a LAN on the cable plant requires the signal strength be high enough at the receiver end. Thus the attenuation of the cable is very important. Since LANs send high speed signals through the cable and the attenuation is variable with the frequency of the signal, the fancy automated testers test attenuation at several wavelengths specified in the 568 specs (TSB-67 to be exact. See figure 9).

This test requires a tester at each end of the cable, one to send and one to receive, then one of them will calculate the loss and record it. There are pass fail criteria for the cable at Cat 3, 4, and 5 max frequencies.

### Crosstalk (NEXT)

NEXT stands for "near end cross talk" since it measures the crosstalk (signal coupled from one pair to another) at the end where one pair is transmitting (and the transmitted signal is largest causing the most crosstalk.) Crosstalk is minimized by the twists in the cable, with different twist rates causing each pair to be antenna sensitive to different frequencies and hopefully not picking up the signals from its neighboring pairs. Remember what we said: you *must* keep the twists as close to the terminations as possible to minimize crosstalk.

Cat 5 testers measure crosstalk from one pair to all three other pairs for each pair and compare it to the 568 specs, giving a pass/fail result. Some also calculate *attenuation/crosstalk ratio* (ACR), as it is a measure of how big the crosstalk signal is to the attenuated signal at the receiver. You want this number as big as possible, as it is an indication of the signal to noise ratio.

### Coming soon

The next generation of test specs will include a number of new tests to insure higher performance from the cable. These tests relate to higher bandwidth usage of the cable and simultaneous use of all four pairs, perhaps even in both directions at once.

Powersum NEXT is the NEXT on one pair when all three others are carrying signals. This is realistic with Fast Ethernet and Gigabit Ethernet where all pairs carry signals, often simultaneously. Manufacturers routinely test cables for this characteristic now, but there is no standard yet for the performance of the cable or terminations.

FEXT is far end crosstalk, looking at the effect of the coupling from one pair to another over the entire length, measured at the far end. ELFEXT is equal level FEXT, or the ratio of FEXT to attenuation, sort of like ACR.

Delay Skew measures how much simultaneous pulses spread out at the far end. This measures the speed on each pair, which may be different due to the variations in number of twists (more twists means longer wires) or insulation.

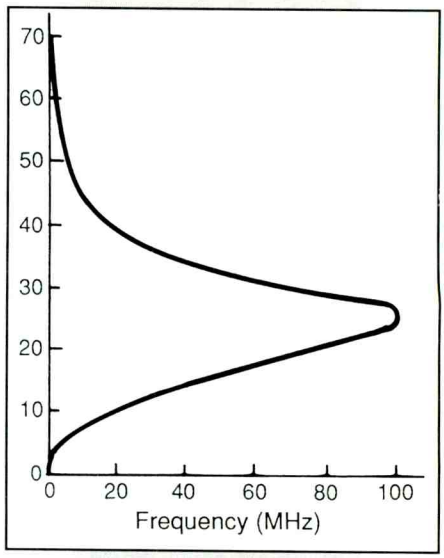



**Figure 9.** The proper operation of a LAN on the cable plant requires the signal strength be high enough at the receiver end. Thus the attenuation of the cable is very important. Automated testers test attenuation at several wavelengths specified in the 568 specs.

Return loss is a measure of the reflections from the cable due to variations in the impedance. These reflections can cause signal degradation, especially if the pairs are used in a full-duplex (bidirectional) mode.

### Testers

UTP testers are mostly automated: push a button get a pass/fail. Simple. Wiremappers test the connections and Cat 5 testers test the performance at high frequencies. In fact, Cat 5 testers test everything: wiremap, length, attenuation, and crosstalk in one connection, give you a pass/fail result, some help on troubleshooting, store the result and practically everything else but make coffee.

Some installers use the Cat 5 tester for all testing, after the cable is installed. Others have each crew use an inexpensive wiremapper to make sure connections are correct before the Cat 5 tester is brought in, since it's a very expensive unit that needs a trained operator and many failures are simply wire map problems. By having each crew find and fix their own wiremap problems, testing and corrections are done as the cable is installed and the cost of the Cat 5 tester is not wasted on simple problems. It's just provides the high frequency tests and documentation required by most users.

Buying a Cat 5 tester today is a bit of a

crap-shoot, since everybody knows the 568 spec will be updated to include more tests at higher frequencies soon, but nobody knows exactly how far. 155 MHz, 200 MHz, 250 MHz, higher? The best bet is to not buy a unit that is not already rated to higher frequencies or is not upgradable easily.

### What the heck is a certified cable?

Did the cable pass an exam and get a certificate? Well, sort of. This term has been used by vendors of testers to mean that the cable was tested and passed by one of the Cat 5 testers. It means that it meets the minimum specifications of TSB-67 and TSB-95, and should work with any network designed to operate on a Cat 5 link.

### How long is a "lifetime warranty" good for?

A Cable U conference included a session on manufacturers certification and warranties. When you get into these subjects, grab your wallet. Manufacturers of cabling products offer warranties of 15 to 25 years or even lifetime warranties if the cabling uses their components and is installed by one of their certified installers. What does this mean?

Many users think it means the manufacturer and installer guarantee the cable plant they install will support their network needs for that length of time. No way. It means the cable plant will still meet Cat 5 performance limits over that period of time. Assuming you could find a working Cat 5 tester in 2013 (anybody starting a Structured Cabling Museum?), the cable would still pass Cat 5 requirements.

The only cable plant warranty that makes sense is the "Lifetime Warranty." since the lifetime of any cable you install today is unlikely to last longer than 5 years. Bottom line: read the fine print.

### Get trained properly before you start

The most important part of getting started in data/voice/video cabling installations is getting trained. The oft-quoted statistic that 80% of all Cat 5 installations will not pass Cat 5 specs is a result of too many installers working without proper training. Maybe they have installed telephone wiring successfully for years, but unless they follow the Cat 5 installation and termination procedures, they will ruin the performance of the cabling they install.

If you have an interest in cabling, it might be a good idea to read everything you can about cabling and even take a online or self-study course to get started. Delmar Publishing is publishing a new book "Data, Voice and Video Cable Installation" soon. There are resources online, such as "Wire U Online" on www.cableu.net

### Change, change, change

The changes keep coming in consumer electronics service. One opportunity begins to close, but another opportunity, such as residential cable/wiring, opens up. It's a constant struggle just to keep abreast of the possibilities. ■

*For more information, you can contact Fotec at 151 Mystic Avenue, Medford, MA 02155-4615, 781-396-6155.*

# Technology update

**by the ES&T Staff**

*Adapted from materials available at the CEA website at www.ce.org*

The consumer electronics scene is shifting so quickly that it's hard to keep up with it. And for companies that are involved in servicing consumer electronics products, it's important to remain abreast of what's going on. Some of the home systems that have recently been introduced, or are currently being introduced include home theater, home control, and home office equipment. The following represents the current situation as regards some of those systems.

### Home theater

Home theater represents an opportunity for consumer electronics service centers to expand their current business by offering to design and install home theater systems. To many, home theater means those sophisticated systems installed in homes whose prices start at several hundred thousand dollars.

For electronics installers who can handle that type of installation, that's great work if you can get it. But there are more modest examples of home theater. Any home that has a large-screen TV and a stereo system is a candidate for a home theater installation/conversion. For service centers that might be thinking of offering this type of service, here's the current state of home theater.

The term home theater describes an experience as much as it does a product or combination of products. Home theater combines a number of audio and video products into one comprehensive system that places the viewer in the middle of the aural and visual action of a film, TV show, sporting event, or concert.

In a chase sequence, for instance, a car can start out behind the hero and be heard behind the viewer as he or she turns around to look at it. As the car passes the hero the sound moves past the viewer too, from rear to front, coordinated with the on-screen action. Planes sound like they're flying overhead. The viewer is in an audience at a concert with people in front of you and behind him. Trains move past on the screen and the sound moves along with it. Surround sound provides a truly three-dimensional experience.

A client who would like to own a home theater system may already have some of the components needed for home theater: a large-screen TV (27 inches or larger), hi-fi VCR, laserdisc player, CD player, A/V receiver or integrated amplifier, and four or five speakers. If you add a few other components and correct them correctly, you will have provided your client with the complete home theater experience.

### Features

An important part of the home theater experience is surround sound. This is the aspect of the system that makes the viewer feel as though he's right in the middle of the action. A surround sound system called "Dolby Pro Logic" surround sound is a home audio technology that divides the stereo soundtrack of a prerecorded film or TV program into four discrete channels, stereo left and right front speakers, a center-channel speaker, and one channel for two surround speakers placed on either side or behind you.

The circuitry in a Pro Logic decoder steers the sound in a Dolby-encoded movie soundtrack to selected speakers. This steering enables a director to design the sound of a film as carefully as he or she designs the pictures.

The center-channel speaker, placed immediately above or below the TV screen, delivers most of the dialog. Left and right front stereo speakers deliver the primary action and special-effects sound. The surround speakers deliver echo and ambient special-effect sounds.

To provide a client with surround sound you need to supply a Pro Logic decoder, which can be bought separately or built into a high-end TV or audio/video receiver. Following are the features that should be available in a home theater receiver.

### Amplification

An A/V Pro Logic receiver provides amplification for all four Pro Logic channels — one channel each for the standard left and right front stereo speakers, one for a center channel speaker, and one for a pair of surround speakers. If you buy a separate Pro Logic decoder to match an existing audio receiver, the system has to include a separate two-channel amplifier to power the center and surround speakers.

In Pro Logic the center channel should be supplied with the same power level as the front left and right stereo speakers. In other words, if the front speakers receive 50W per channel, the center channel must be provided with 50W. This keeps the dialog at the same relative volume as the music soundtrack or special effects. Surround speakers need have only a fraction of this power, usually only one-quarter of the power supplied to the front speakers.

### Modes

Pro Logic is the primary listening mode for films, but many decoders offer other modes, such as regular surround sound, which is three channels, subtracting the center channel. This mode is known as phantom center because if the system doesn't have a center channel speaker, the two front speakers create the aural image of one. A decoder often offers DSP (digital signal processing) settings (church, hall, arena, stadium, etc.) as well as a mono setting and a stereo bypass, which is regular stereo for the two front speakers.

### Source select

A decoder can serve as a preamp and source switcher. All of the source components can be plugged into this decoder instead

of into the receiver. Some decoders have inputs for video equipment only, others for both video and audio components.

### Channel enhancers

Some decoders include a center-channel boost in case the center channel is underpowered and a digital bass enhancer that boosts the bass, simulating a subwoofer.

### Delay

The illusion of being in a theater or other acoustic environment is created by the surround speakers, which deliver their sound a few milliseconds later than the front speakers. This time lag is known as delay, and a decoder will allow the listener to shift the delay to match the size of the room and his distance from the speakers. The longer the delay, the greater the echo, and the larger the room will seem. The delay is usually adjustable between 20 and 50 milliseconds in increments of half milliseconds.

### Variations

There are all-in-one home theaters and complete component systems. The right choice for your client depends largely on what equipment is already installed. If the client has no large-screen TV or stereo at all, you might suggest a package that's available from many TV makers that includes a large-screen TV, a Pro Logic decoder/amplifier, and the five speakers. The front speakers in these systems may be wing speakers mounted on the TV with a small center channel speaker built into the front panel, or they may be separate, depending on the room and the budget. If your client already has a large-screen TV and wishes to add a new audio system, you might want to suggest that he start with an A/V receiver with a Pro Logic decoder built-in. An A/V receiver will provide the decoding, the four-channel amplification, five sets of speaker terminals, source switching for all the audio and video sources, mode selection, and digital signal processing settings.

All you have to do is connect all the A/V source components and five speakers, and you're in business. If the system already has a standard stereo receiver and a pair of front speakers, then you might suggest Pro Logic in a box. These entry-level systems consist of three satellite speakers, center and two surrounds, and a low-power amplifier/ switcher for the two additional channels.

Another option is separate components. Many high-end audio companies make high-quality component Pro Logic decoders/switchers with a variety of high-end sound adjustment features. Add a two-channel amplifier by connecting it to your existing amplifier/preamp setup.

### Loudspeakers

Surround-sound speakers are often designed to reproduce specific sounds. For instance, the center-channel speaker is primarily responsible for dialog and is optimized for these frequencies and reproduction.

It is still a matter of debate whether front speakers must be specialized for video sound rather than music stereo reproduction and whether a good speaker can be used for either. There are good arguments on both sides. Unless your client is an audiophile, rely on what your ears tell you.

Manufacturers offer a complete set of five speakers designed for home theater from a variety of suppliers. Some are satellite/subwoofer systems, others feature full-size front speakers, an oblong center channel, and small satellite-surround speakers.

If the system already has a pair of good front speakers, you can add a pair of inexpensive satellite speakers for the surrounds, or "rear" speakers. Take care in choosing a center channel. A Pro Logic system sounds far better with a specially designed center-channel speaker, particularly if it is one from the same manufacturer as the existing front speakers.

### THX

The sound system you'll see referred to as THX (Tomlinson Holman experiment) was originally developed by LucasFilm, the company operated by George Lucas, creator of "Star Wars" and "Indiana Jones," to supply high-quality sound in theaters. It was then adapted as an advancement on Pro-Logic for home use.

THX is a certification and licensing program that assures that amplifiers, decoders, and speakers for home theater sound as close as possible to a movie theater and conform to a strict LucasFilm THX standard. Any home-theater system meeting home THX requirements has a Pro Logic decoder along with other special electronic circuitry. THX technology is designed, licensed, and enforced by LucasFilm, with more than two dozen speaker and hardware manufacturing licensees of the technology.

### Home control

While home theater is revolutionizing the way movie and music buffs enjoy films and music in their homes, home control is beginning to revolutionize the way people control their homes. Digital technology, including the home computer and peripherals especially designed for controlling products in the home, are allowing even owners of modest homes to control such things as lighting, curtains, audio and video equipment, either automatically, or remotely.

Home control represents another opportunity for consumer electronics service centers, who already deal with homeowners regarding their TVs, VCRS, etc., to offer installation and servicing for home automation.

Home control, or home automation, includes a variety of products that allow for centralized and remote control of groups of related home electronics.

For instance, an automated home audio system provides complete control over all home audio equipment from anywhere in the house. The occupants can control the volume of the speakers in your bedroom while lying in bed, even though the stereo is downstairs in the living room. They can change the air conditioning temperature in your house from a remote location using a TouchTone phone. They can turn the lights on and off at predetermined times. Security systems can be set up so that if motion is detected when the owners are not home the police are called automatically.

### Drawbacks

Unfortunately the control system that controls the stereo system doesn't talk to the system that controls the appliances, and that system doesn't talk to the security system.

Also, communication is one-way, from the occupant to the device he wants to control. There is no intelligence or communication in the system to allow products to talk back, to report status, for instance, or talk to each other. It would simplify things if, when someone presses "play" on the VCR, the TV and audio/visual receiver also came on and the lights dimmed, simultaneously.

Another drawback to the control system is that systems from one manufacturer are often not compatible with those from another. Consumers who buy them must make compromises, or have several control systems to worry about. In the early 1980s, the lack of compatibility and communication between devices and systems was addressed by an Electronic Industries Association committee charged with coming up with multi-industry standards that would allow any product powered by electricity to talk to any other piece of electronics. Included in the project were all home-related electronics: consumer electronics, lighting, power, and security.

### CEBus

The standard that resulted from that committee is the Consumer Electronics Bus, or simply CEBus (pronounced SEE-bus). As most readers know, a bus is the major path for data transfer in a microprocessor. The developers of the CEBus communications protocol made all consumer electronics products equipped with that circuitry able to operate together as if they're part of a single system. Instead of one-way, CEBus is a two-way system, with individual pieces of equipment communicating with each other. An example of the result of this technology is that when the homeowner wishes to play a CD, he doesn't have to send instructions to the CD player, amplifier, and then the preamp. The CEBus goal is for all electronics products, consumer electronics products as well as kitchen appliances, lighting fixtures, heating and cooling equipment, security devices, and power utility products such as thermostats, to contain the CEBus technology, which allows each product to talk to the others. Each electronics products in the home will work fine individually, but will also operate in concert with others when that becomes necessary. Because of advances in technology in other areas, CEBus doesn't require any wiring. The commands can be conveyed along standard power or phone lines, or via radio frequency or infrared wireless controllers. Homes already have much of the necessary wiring. The adoption of the CEBus standard does not limit choices. Consumers can still buy control systems from a variety of companies. CEBus-compatible products may or may not work with the security, entertainment, or automation system already in place. Keep in mind that CEBus is a technical standard, not a product, that is built into home electronics products. When buying electronic products, check to see if the product is CEBus-compatible. CEBus standards are overseen by the non-profit CEBus Industry Council, 4405 Massachusetts Ave., Indianapolis, IN, 46218, (317) 545-6243.

### Features

Home automation offers limitless benefits. Following are some of the features.

With home automation, a homeowner can phone home to activate appliances, change the thermostat setting, or activate or deactivate a security system. Home automation systems can be set up to set off chains of events. For example, the system can be set so that if the smoke alarm goes off, it turns on clock radios, alarms, and lights, and calls the police and fire departments.

Here's another possibility: when a person leaves, he pushes a single button and the house locks itself, turns the lights out, and arms the security system.

The system also allows for timed control of appliances. For example, the heating and cooling systems can be set to raise or lower the temperature at specific times, the lawn sprinkler can go on at predetermined times, certain lights can go on or off at certain times, drapes can be motorized and can open and close depending on the position of the sun, the clothes washer and the dishwasher can be set to go on in the middle of the night when water and electric rates are lower.

Home automation can be set up to control specific rooms. For example, a centralized audio/video center with stereo speakers and/or a TV in each room connected to it can control the volume or the source (CD, radio, TV, VCR) from each room. A number of home control products are available on the market in three levels of complexity: plug and play, multi-room, and computer-controlled.

### Plug and play

With a "plug-and-play" system, you plug a product into a module and send commands to the controller. In most cases the controller is no more complex than on and off, depending on the device. Here's how it works: you plug a lamp into a module, then you plug the module into the wall. You turn the lamp on and off with the control device from a remote location or it can be set to turn on and off at predetermined times. The predominantly used plug-and-play protocol is called X-10, a proprietary standard licensed to several brand-name suppliers.

Plug-and-play systems are simple: no installation is needed. But they allow only limited control.

### Multiroom

Multiroom systems include plug-and-play products, but add more control. Products can be wired together directly using a variety of cables including fiberoptic, coaxial cable, and phone wiring, rather than ac wiring. Panels built into the walls of several rooms contain wiring connected to the products, or a remote controller sends infrared command signals. Multiroom systems usually use a proprietary standard and control audio-visual equipment.

### Computer-based systems

A computer with the appropriate home-control software allows you to program complex functions for current and future use. This eliminates controlling individual or groups of functions one at a time.

Here's an example of what a computer-based system can do. A CD jukebox connected to the audiovisual system can be programmed to play discs in random sequence, for instance. Or it can receive on-line weather reports and set the house climate controls accordingly, whether anyone is home or not. Controllers for computer-controlled systems include not only the personal computer, but in-wall control panels for individ-

ual rooms. Some systems offer rudimentary voice control. You walk into a room and ask the controller to play a CD; it replies in a synthesized voice and executes the command.

### Variations

Home automation is divided into three groups of products: security, entertainment, and general automation.

### Security

Do-it-yourself module security systems are hooked into a home's lighting system. When the alarm is tripped, the lights flash on and off.

To make this work, a security system can include such devices as:

- *Sensors*: The primary components, they are small, twin magnetic pieces that attach to windows and doors. If a door or window is opened, the magnetic contact between the pieces is broken and the alarm system is tripped.
- *Motion detectors*: These flood a room with low-level radio or microwave signals. When the field is disturbed an alarm goes off.
- *Sirens*: Loud noise makers, usually connected to go off in concert with the lights when the alarm is tripped.
- *Automatic dialer*: Connected to a phone, dials emergency numbers automatically when an alarm is tripped or a controller activated. Some units play back a short message you've recorded. Many can dial multiple phone numbers.
- *Wall controller*: A control panel that attaches to a wall controls all aspects of a system, including arming and disarming.
- *Remote control:* A radio-frequency control that arms, disarms, and controls all aspects of a system. Keychain remotes are widely available.

Many suppliers offer packages of products. Most packages include a few window and door sensors and controllers, as well as siren- and lighting-control modules.

### Entertainment

There are two ways to exercise multiple-room home entertainment control: (1) with audio visual equipment designed for multiroom/multisource circuitry (capable of playing a CD in one room, the radio in another, for example); and (2) with special external switching and multiroom control equipment.

A number of suppliers specialize in multiroom, multisource equipment. Other companies specialize in external control and distribution boxes, amplifiers, and speaker and coaxial cable runs. For instance, you'll need a speaker junction or splitter box that allows you to connect multiple sets of speakers to the system. Coaxial cable distribution and amplification boxes connect the video equipment to remote TVs.

The homeowner controls these systems via wall-mounted panels wired to the audio visual equipment or connected to it by radio-frequency or infrared remote control. Wireless remote control usually requires the placement of repeaters throughout the home. These small wall-mounted devices amplify an infrared or radio-frequency wireless command signal to enable it to reach the equipment.

### Home automation

The term "home automation" describes control systems that aren't specific to security or entertainment. It includes modules for lighting, appliances, heating and cooling, and other devices that work on electricity and need to be controlled. Home automation products include control devices such as:

- *Telephone responder*: Allows you to control a number of different devices connected to it from any TouchTone phone.
- *Programmable timer*: Allows you to control a number of devices that are turned on and off at regular times.
- *Switch controllers*: Control on/off functions of varying control modules. Some are RF remote controls that mount on a wall or are tabletop controllers. Each controls a certain number of modules. Many wall-mounted controllers are wireless and have Velcro backing, which allows for flexibility in placement.

### Connections

Control systems need a way to send their messages, through direct wiring or a wireless system, sometimes with a combination of the two. A home control system can use existing wiring in a house, such as phone lines (twisted pair), coaxial cable, and home power lines. Radio-frequency control and infrared technology are used in wireless systems. Both wired and wireless systems require controllers, special remote control devices that allow you to tell the system what to do. The controller can be as simple as a one or two buttons, or it can be a personal computer for complex tasks. Most systems also require modules, small boxes connected to the device to be controlled. The module transmits the command from the controller to the device.

For instance, a home entertainment system may be connected using a combination of hard wiring and wireless modules. The system interconnects in the usual way, and speaker wire and coaxial cable are wired through the walls into individual rooms for TV and speaker hookup. Wired into the wall panels of the primary room are infrared emitters. Similar wall panels with controls and radio frequency transmitters, which send the infrared signal through the airwaves, are built into the other rooms. Because the range of infrared transmission is limited, infrared repeaters are located throughout the house.

Say someone is in a remote room and wants to watch TV. He points a remote control at the wall panel or pushes the appropriate button on the control panel. The infrared signal is then transmitted until it reaches the main equipment room. There the infrared signal is sent to the audiovisual equipment, which then translates the command into action and turns on the TV.

This is only one example of a hookup for entertainment equipment. The actual hookup of a given system would be determined by the user's needs and the type of equipment to be controlled. A system designed for lighting might use just RF transmission of commands, which are translated for each individual lighting fixture by a module the lighting fixture is plugged into. Or, instead of infrared transmitters and emitters, the commands could be transmitted over the home's existing wiring directly to each device module.

One determining factor for the type of system you design is how you would wire your home. In-wall wiring is most often used in new home construction or when homes undergo renovation. Installing in-wall wiring in an existing home (retrofitting) is not always feasible. Infrared transmitters and emitters are often used when retrofitting is not an option. ■

# TV servicing today: Shutdown circuits in the Philips' D7 chassis

by Bob Rose

The D7 chassis is Philips Consumer Electronics new high-end television. It has been reserved for inclusion in 27-inch through 36-inch sets and offers a variety of features designed to please even the "average" TV viewer. From a servicing point of view, it is remarkably sophisticated, requiring the servicer to become acquainted with its unique circuitry and to adopt a new way of service-related thinking.

### New terminology

The D7 is called "a global chassis." Just working with a D7 necessitates becoming familiar with new terms and new ways of referring to old concepts. For example, the IFT is called a "LOT," a "line operated transformer," which is the European designation for flyback. Moreover, when you read the literature, you run across abbreviations like "YUV," a new term for an old concept where "Y" stands for "luminance," "U" for "R-Y," and "V" for "B-Y." These are just a few of the new terms and concepts you come across as you read through the service manual and related service literature.

Rose is an independent consumer electronics business owner and technician.

Even the component designation system has changed, to wit:

| | |
|---|---|
| 0001–0999 | mechanical heatsinks, brackets, etc. |
| 1000–1999 | electro-mechanical assemblies, fuses, relays, switches, connectors, filters, batteries, modules, and "anything not designated below" |
| 2000–2999 | capacitors |
| 3000–3999 | resistors |
| 4000–4999 | surface mount jumpers and insulated wire jumpers |
| 5000–5999 | coils and transformers |
| 6000–6999 | diodes and LED's |
| 7000–7999 | transistors and integrated circuits |
| 8000–8999 | cables |
| 9000–9999 | axial jumpers |

### Service literature

Fortunately, Philips offers us plenty of resources. The service manual is number 7550 and might come with microfiche 98-7550. However, the manual is quite sufficient containing block diagrams, circuit descriptions, schematics, and parts lists. I think it is one of the better manuals Philips has produced

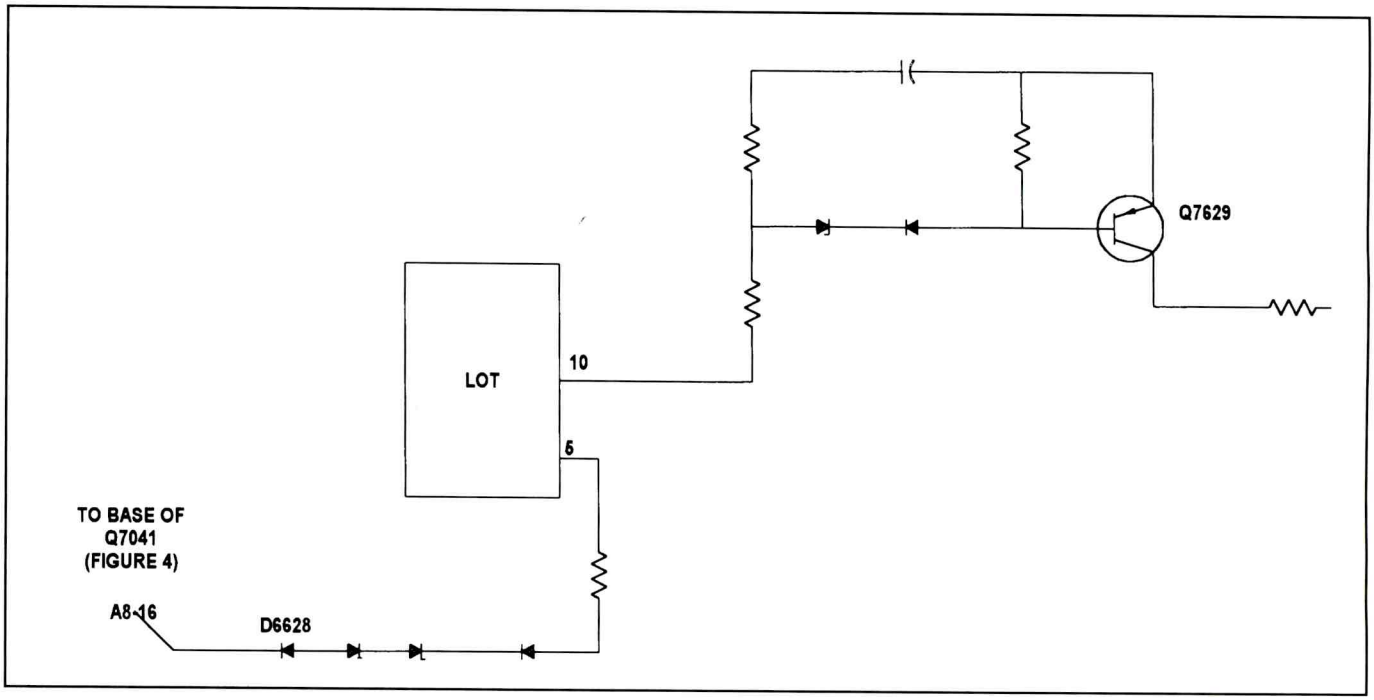



**Figure 1.** Under normal operating conditions, the voltage on the base of 7629 is just slightly negative. But it swings increasingly negative as the CRT draws more current. If the voltage swings sufficiently negative, transistor 7629 turns on, activating the circuit, and the TV shuts down.

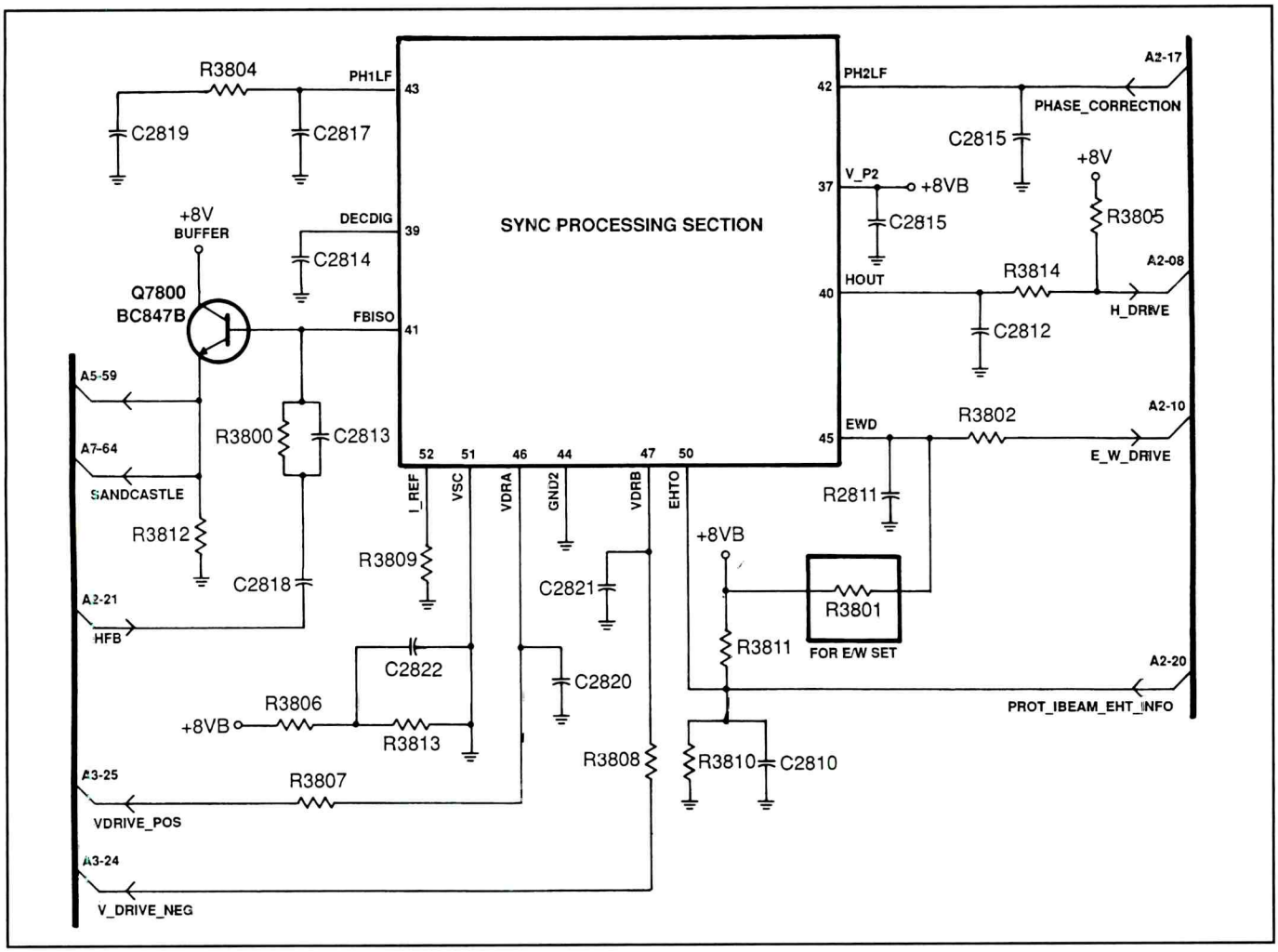



**Figure 2.** The voltage at pin 50 of IC 7150 should be about 0.8V when the TV is in standby, about 2.2V when the TV is on and not receiving a signal, and about 2.5V when it is on and receiving a signal.

in a while even though I find it a bit bulky and somewhat cumbersome. If you service many D7's, you might also consider buying the video, *What's New For Winter 1998*. It comes as a part of the literature authorized service centers receive, but I think it is available to non-authorized servicers for a small fee. Finally, I received the booklet *99RTM Technical Training* at a service meeting in Memphis. It is relatively brief and covers more than the D7 chassis but does a good job dealing with the circuits in the D7. I recommend it if you can get it.

By the way, Manual 7550 is the source for the schematics I use in this article.

### Shutdown mode

The circuits in this set I want to deal with are the shutdown circuits. I suggest you become very familiar with them because my intuition leads me to believe they will present us with more than a modest challenge. The technical engineers at Philips suggest a procedure for dealing with them that I am about to pass along. Those engineers tell us that if we proceed in a logical, methodical manner we shall be able to troubleshoot them with a minimum of difficulty, and they underscore the statement that the circuits should to be checked in the order in which they are presented. I believe they have a point. However, a little experience ought to tell you in which order you should proceed. Here, as always, experience will be your best teacher.

Before getting to the shutdown circuits, perhaps I ought to pose a question, "How do you know when a D7 has experienced a shutdown as opposed to just being a dead set?" First, confirm that the power supply is up and running. Second, take a look at the power LED on the front of the set. If it goes off after about five seconds and blinks at a 1Hz rate (once a second), the set has more than likely experienced shutdown.

Did you pay attention to the phrase "more than likely experienced shutdown?" I have come to the conclusion that few things are certain in the world of electronics. If a TV can "get you," it will. Thankfully, there is a reliable check that confirms the chassis has shutdown. After you have confirmed the operation of the power supply and noted the blinking LED, measure the voltage at pin 11 of the microprocessor. This voltage should *always* be 5.1V, or very close to that value. Oh, it momentarily drops when the TV receives an on command but almost immediately rises again to 5.1V. If you find a reading that is considerably lower than 5.1V, you can be sure the set has shut down. Get ready, then, to investigate the shutdown circuits.

Before I leave this section, let me underline the point that you really should confirm the operation of the power supply before you begin to think about shutdown. I suggested in a previous

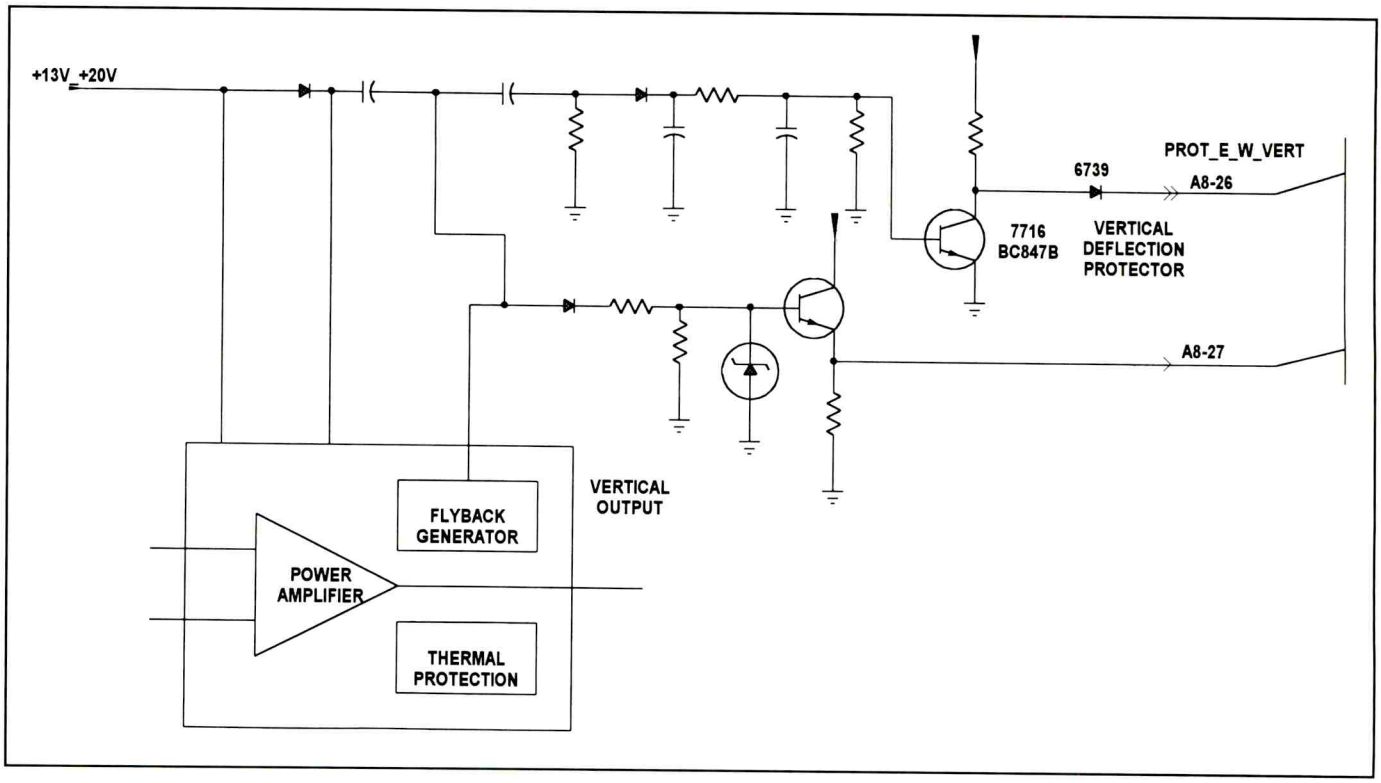



**Figure 3.** Transistor Q7716 provides vertical deflection protection in this set.

article that the best way to do that is confirm the presence of at least two secondary voltages. However, you need just a minute or so to check all of them, and the minute spent confirming them just might save you literally hours of trouble later on.

### The shutdown circuits

I hope you don't get excited when I inform you that the chassis has four shutdown circuits. They are:

1. the circuit that monitors beam current,
2. vertical deflection,
3. horizontal deflection, and
4. the x-ray protection or HEW circuit (the circuit that monitors the high voltage).

The engineers at Philips suggest that you deal with them in the order in which I am about to list them.

### Excessive beam current

The first circuit that can shut the TV down is the one that monitors beam current. You need to look at the horizontal deflection circuit (Figure 1) and what Philips calls the "sync" circuit (Figure 2) to get a feel for the complete beam limiter circuit. The service manual labels the pages that you need to consult "A2" and "A6" respectively.

The circuit under scrutiny is labeled "prot_ibeam_eht." Locate transistor 7629 and the components associated with it. The circuit in which it is located monitors the voltage at the low side of the flyback (LOT) winding that produces the EHT (extra high tension or high voltage) for the picture tube. Under normal operating conditions, the voltage on the base of 7629 is just slightly negative. But it swings increasingly negative as the CRT draws more current. If the voltage swings sufficiently negative, transistor 7629 turns on, activating the circuit, and the TV shuts down. There is nothing new here because almost all modern televisions receivers use a similar circuit.

Now shift your attention to Figure 2 and locate pin 50 of IC 7150. Do you see that resistor 3616 ties the collector of 7629 to it? When you check the voltage, you should find about 0.8V when the TV is in standby, about 2.2V when the TV is on and not receiving a signal, and about 2.5V when it is on and receiving a signal.

Under normal operating conditions, as I pointed out, transistor 7629 is biased off. When excessive beam current causes it to conduct, 7629 puts a voltage considerably higher than 2.5V on pin 50. The IC senses the voltage and interrupts horizontal drive which shuts the TV down.

Let's assume that you have a shutdown problem and want to find out if excessive beam current has caused it. The first question to ask is, "Did the screen become overly bright before shutdown occurred?" If it did, remove the CRT socket and try another on command. If the set stays on, excessive beam current is more than likely the gremlin for which you are looking.

The next question is, "Why is the tube drawing too much current?" Several possibilities pop into mind, don't they? It might be caused by the picture tube itself, loss of the +200V to IC 7830 (the IC that contains the video output transistors), or loss of video because of a component failure on the main chassis. You may proceed to check each possibility with the CRT socket removed from the CRT. I suggest that you begin by checking for the presence of the +200V because it is the most common fault.

Sometimes the circuit activates before the CRT comes on, leaving you to wonder what kind of information really is on the face of the tube. In such an instance, disconnect the CRT to see if the set stays on. If it doesn't, remove the socket and lift

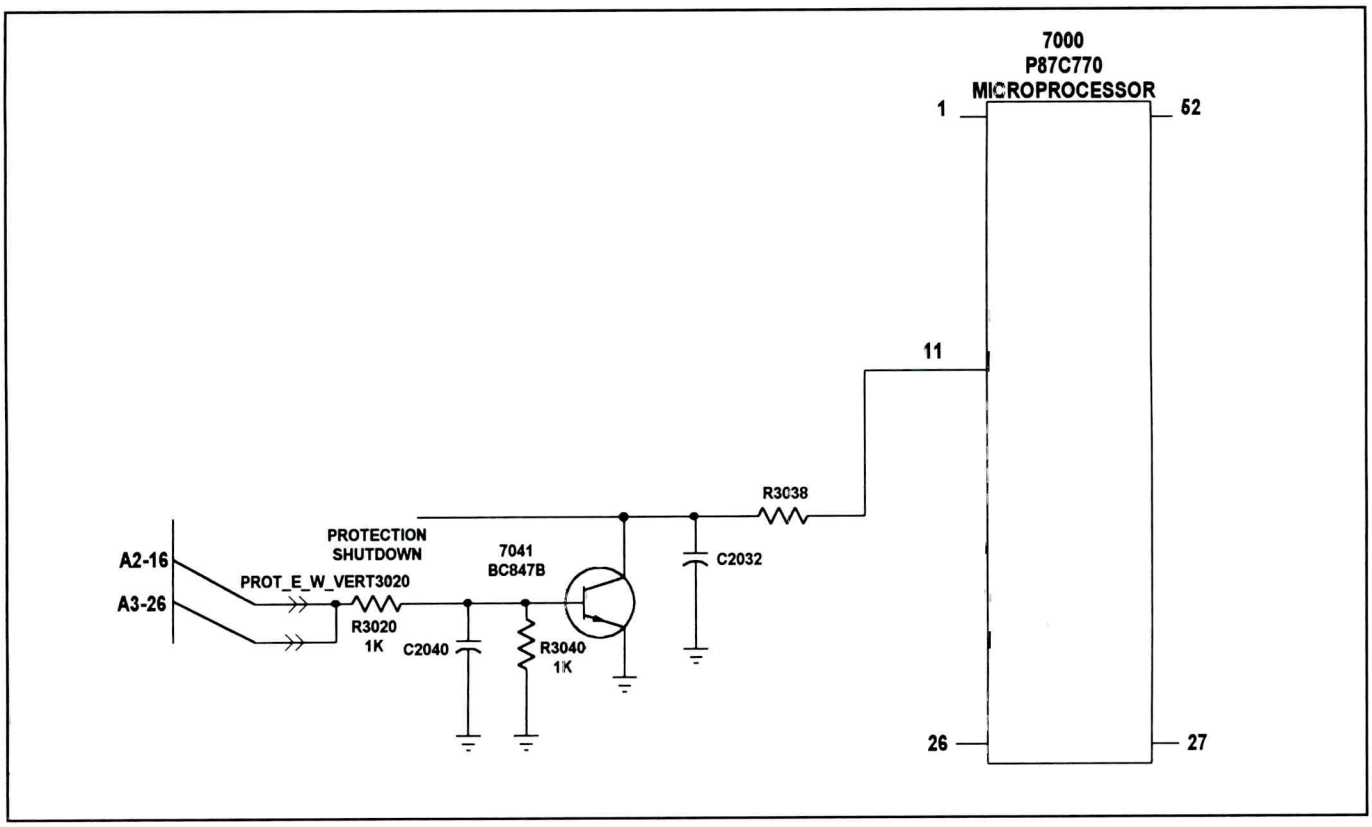



**Figure 4.** If vertical deflection in this set is lost, transistor 7716 turns off, permitting transistor 7041 to turn on and pull pin 11 of IC 7000 low. When pin 11 goes low, the microprocessor "assumes" that vertical deflection has failed and responds by turning the TV off.

the collector of transistor 7629. If the set stays on, the problem is more than likely in the beam limiter circuit itself. The literature suggests that in this event you pay attention to transistor 7629 because it may have become leaky. However, don't forget to check for leaky diodes and open resistors or resistors that have significantly changed value.

### Vertical deflection

Consult Figure 3 and locate transistor 7716 in the vertical deflection circuit. Notice that diode 6739 connects the voltage at its collector to the base of transistor 7041; the collector of which is tied via a resistor to pin 11 of the system microprocessor (Figure 4). If you are following the flow of information given in the service manual, you see the notation "A8-26" at the cathode of 6738. The "A8" refers to page A8 in the service menu, and "26" tells you which breakout on page A8 to consult. Not a bad system once you get used to it.

The voltage on pin 11 of the microprocessor ought to be 5.1V in the no-signal and signal-present condition, indicating that vertical deflection is active. When it turns off, transistor 7716 permits transistor 7041 to turn on and pull pin 11 of IC 7000 low. When pin 11 goes low, the microprocessor "assumes" that vertical deflection has failed and responds by turning the TV off. As we shall see, three shutdown circuits tie into transistor 7041. For the moment, let's assume the problem lies in the vertical deflection circuit.

How can you effectively troubleshoot the circuit when TV won't stay on? Begin by removing the CRT socket to keep the picture tube from being damaged in the event that vertical deflection has failed. I don't suggest that you turn the G2 voltage down because setting it is not as simple as it used to be. Then ground the collector of 7716. If the set stays on, troubleshoot the vertical deflection circuit. However, don't overlook the possibility that the vertical deflection protection circuit itself is causing the problem. I admit that it's not likely, but, hey, we're dealing with televisions, aren't we? Use conventional troubleshooting procedures to repair the vertical deflection circuit if it actually is at fault.

### Excessive high voltage

Let's go back to Figure 1 and locate diode 6628 at coordinate E7. Do you see that it is connected to the base of transistor 7041 the collector of which is tied to pin 11 of IC 7000? If the voltage at the anode of diode 6628 exceeds 1.2V, transistor 7041 turns on and pulls pin 11 of the microprocessor low, and the set shuts down.

You can make a quick check to determine if the HEW circuit has caused the TV to shut down by measuring the dc level at the anode of diode 6628. If it exceeds the trip voltage of 1.2V, the circuit is active. Once you have determined the HEW circuit has become active, you must then decide if the EHT really is high or if the HEW circuit has failed. If the high voltage is excessive and B+ to the horizontal output transistor is normal, think in terms of a defective timing capacitor (2633 and/or 2634) in the collector circuit of the output transistor. These capacitors might have decreased in value or opened, permitting the retrace pulse to become narrow which raises the high voltage the LOT produces.

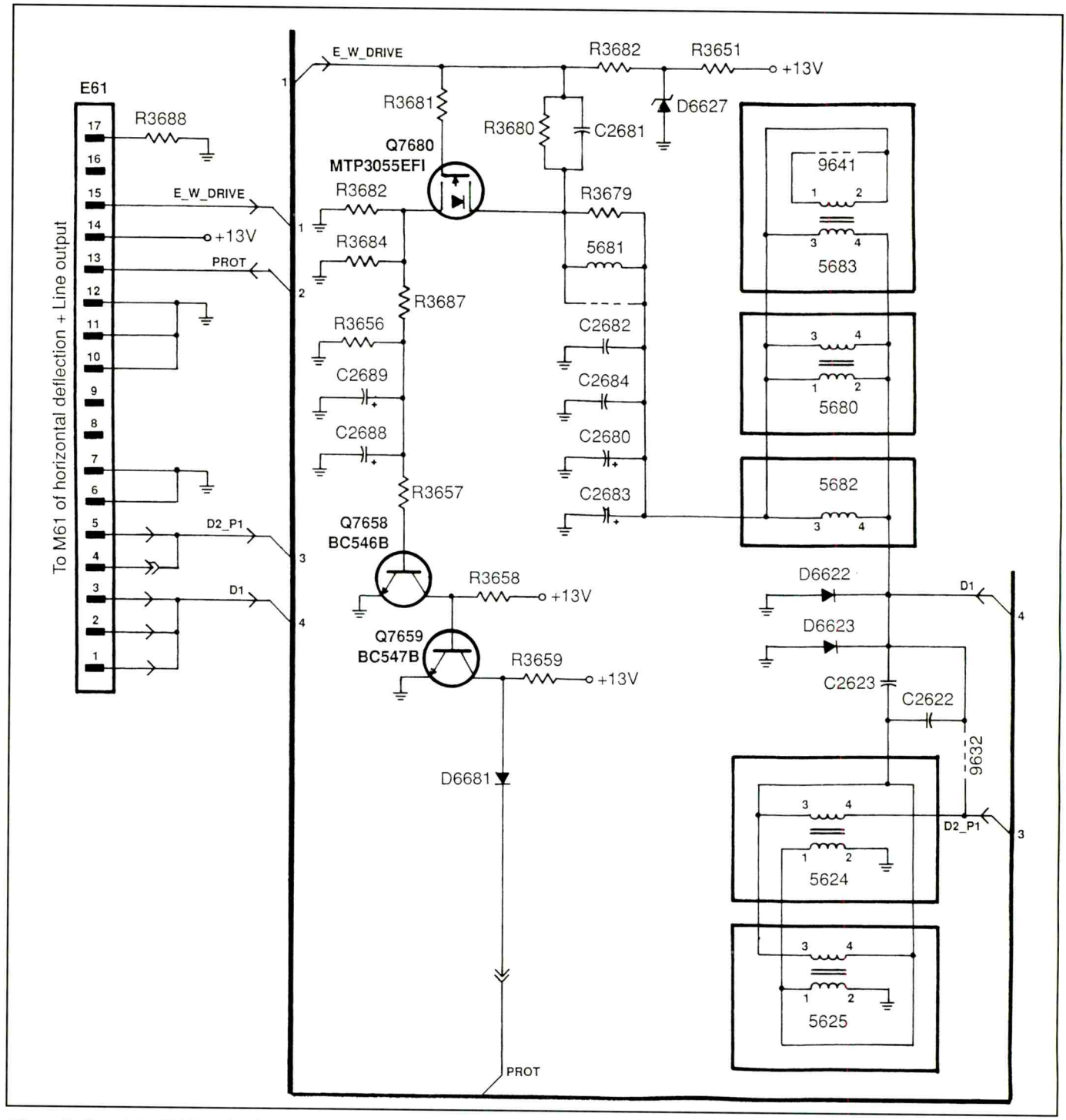



**Figure 5.** Transistor 7680 on the E-W panel monitors horizontal drive. If horizontal drive fails, 7680 turns on permitting transistor 7658 to turn on, which causes transistor 7659 to turn off. Resistor 3959 then applies a dc voltage to the protection line that turns on transistor 7041(Figure 4) which pulls pin 11 of the microprocessor low, and shuts down the set.

If the high voltage appears to be normal, check the diodes in the HEW circuit for possible leakage and the resistors for a change in value.

Whatever you do, think at least twice before you defeat the circuit. If the high voltage really is high, you run the risk of injuring yourself, damaging your test equipment, and/or doing major damage to a television you don't own and for which you are responsible. I remember servicing a Panasonic TV that someone had "tinkered" with. When I turned it on, I thought a lightning bolt had struck near my bench because of the high voltage arc. As a matter of fact, the flash of light temporarily blinded me. I estimate that the EHT the set produced was in excess of 50,000V. The moral of the story is, "Don't defeat the HEW circuit unless you know what you are doing."

### Horizontal deflection

The last circuit that has the ability to cause a system control shutdown is a failure of horizontal deflection which may involve either the horizontal deflection circuit itself (Figure 1) or the East-West correction circuit (Figure 5). Transistor 7680

on the E-W panel (Figure 5) monitors horizontal drive. If horizontal drive fails, 7680 turns on permitting transistor 7658 to turn on, which causes transistor 7659 to turn off. Resistor 3959 then applies a dc voltage to the protection line that turns on our old friend transistor 7041(Figure 4) which pulls pin 11 of the microprocessor low, and the rest of the story you know.

How do you know when horizontal drive has failed, given the fact that these circuits tie to a common point (transistor 7041)? After you have ruled out excessive beam current, loss of vertical deflection, and the HEW circuit as the cause of the shutdown, follow these steps:

1. Remove the CRT socket if you haven't already done so to protect the picture tube and its circuitry from possible damage.

2. Ground the base of transistor 7041 to defeat the shutdown circuits altogether.

3. You may now check to see if horizontal deflection is working.

Monitor the collector of the horizontal output transistor if your scope can handle the voltage. If it can't, find a circuit that you can monitor, like the one that produces the +200V for the video output transistors. If the retrace pulse is present, horizontal deflection is working. If the pulse isn't present, trace horizontal drive backward to the source of the difficulty and use conventional troubleshooting and repair techniques to fix it.

If you ground the base of transistor 7041 and discover that horizontal drive is present, you may logically assume that the problem lies in the E-W panel. With 7041 defeated and the set up and running, you should be able to find the problem in a relatively short period of time. If worse comes to worse, simply order a replacement panel E-W panel and wire it into the set. However, given the fact that there aren't many components on it, you should be able to fix the panel in relatively short order.

Now let me say a few words about the LOT, or flyback. I haven't seen a lot of D7 chassis in the last few months, but every one that I have serviced for horizontal deflection problems had a bad flyback. I called Philips and asked if they were having problems with the flyback and was told that it was a high failure item. However, be of good cheer because it is an inexpensive item, costing just a few pennies less that $15.00. At least the last one I bought did. I am told that Philips is about to increase the price they charge for parts if they haven't already done so.

### Summary

Let me try to summarize what I have been saying like this. The "prot_e_w_vert" line monitors three circuits via transistor 7041, vertical deflection, HEW, and horizontal deflection. A failure in any of these circuits results in 7041 turning on and pulling pin 11 of the microprocessor low, leading the microprocessor to shut the television down. The beam limiter circuit is tied to pin 50 of integrated circuit 7150 and performs its function by shutting off horizontal drive.

I really believe these shutdown circuits aren't as daunting as they appear to be. Given a little experience on these products, I think you will be able to work through a shutdown problem in a D7 chassis in short order. ■

# What Do You Know About Electronics?

by J.A. "Sam" Wilson

## Network Theorems And Laws

In the "What Do You Know About Electronics" in the March 2000 issue, I used an abbreviation, AQL, that may not be familiar to all readers, and didn't include an explanation of the meaning of the abbreviation. Let me correct that omission here. AQL stands for "acceptable quality level." This term describes the number of components (e.g., resistors) that must test o.k. in a shipment (or family) in order for the entire shipment (say, 5,000 resistors) to be accepted. You will find AQL used in incoming inspection departments.

As you may know, if a company orders 5000 10kΩ resistors, it is not a good practice to take the time to test all of those resistors. Instead, they use the AQL rating that tells how many resistors, randomly selected, should test o.k. in order for the shipment to be accepted. It is an economy thing.

The AQL rating is calculated by using statistics. It is usually the company that ships the product that provides the AQL.

### More on network theorems and laws

The method used for solving for a current in a network, using Maxwell's loop equations, is a generalization of Kirchhoff's method. Traditionally, Kirchhoff's method is taught first. However, I have given Maxwell's method first because the math is somewhat easier. Before we have finished this series, you will have reviewed twelve network theorems and laws.

Study the illustration in Figure 1. If you are going to use Maxwell's loop equations in Figure 1(a) to solve for the current through $R_C$, you must first solve for $I_1$ and $I_2$. Then you must subtract those currents to get the value of $I_C$ (this statement assumes that you are using the convention of clockwise currents as suggested by the author).

However, if you move branch b to the outside, as shown in Figure 1(b), you only need to solve for one current ($I_C$) to get the current ($I_C$) through RC.

Satisfy yourself that the circuit in Figure 1(b) is electrically identical to the one in Figure 1(a).

The circuits in Figures 1(a) and 1(b) can be used for charging the battery $V_1$ using generator $V_1$. The point in this discussion is that sometimes you can simplify a circuit before you start your calculations.

### Solution by using Kirchhoff's laws

As a general rule, the Kirchhoff's method will require more equations than the Maxwell method. However, I think both methods are very easy if you are careful in applying the rules.

• *Maxwell's Rule*: Write a voltage loop equation for each closed loop and solve the equations for the desired current.

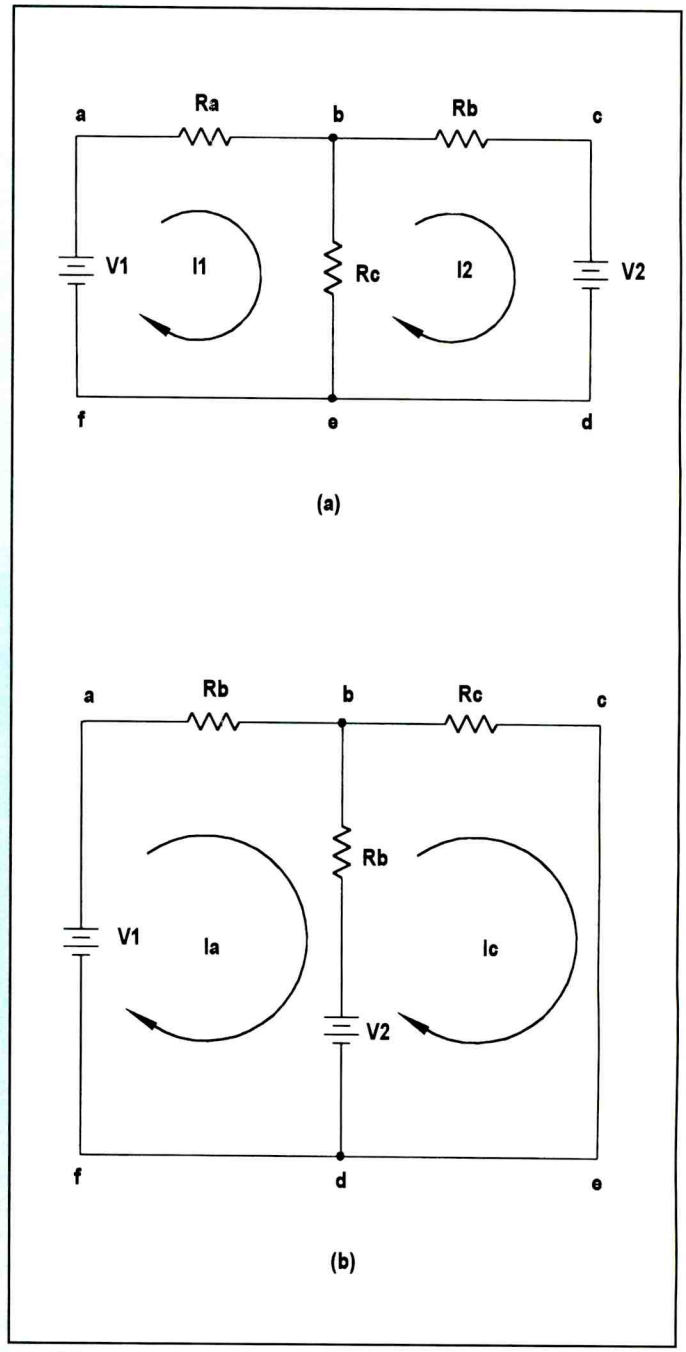



**Figure 1.** If you are going to use Maxwell's loop equations in Figure 1(a) to solve for the current through $R_C$, you must first solve for $I_1$ and $I_2$. Then you must subtract those currents to get the value of $I_C$. However, if you move branch b to the outside, as shown in Figure 1(b), you only need to solve for one current ($I_C$) to get the current ($I_C$)through $R_C$.

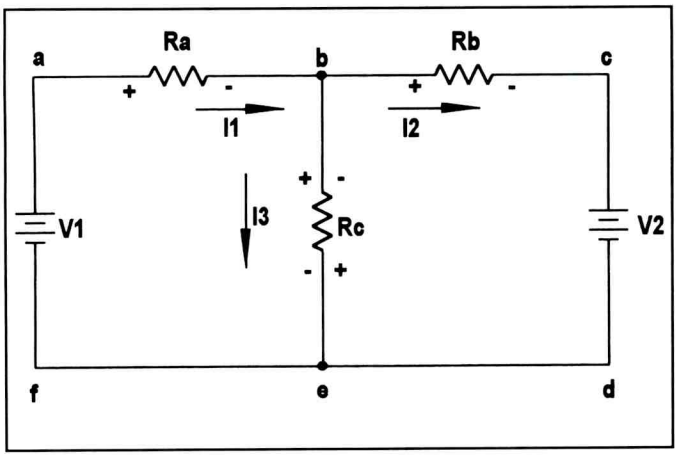



**Figure 2.** The values in this circuit can be determined by using one current node equation and two voltage loop equations.

• *Kirchhoff's Rule*: Write a sufficient number of junction current equations to include all currents in the circuit. Also, write enough voltage loop equations to include all circuit voltages.

Refer to Figure 2. Note how currents $I_1$, $I_2$, and $I_3$ are marked on the drawing. Using junction b, here is the required current equation:

at junction b: $I_1 = I_2 + I_3$
or, $I_1 - I_2 - I_3 = 0$

Note that currents entering the junction are positive, and currents leaving the junction are negative.

The polarities of the voltages across the resistors are marked and are established by the assumed junction currents. Conventional current is used, so, if you enter a positive voltage drop, it is a negative voltage.

Here are the equations for the circuit in Figure 2:

1. current equation: $I_3 = I_1 + I_2$
2. loop abefa: $-I_1R_a - I_3R_c + V_1 = 0$
3. loop bcdeb: $-I2R_b - V_2 - I3R_c = 0$

You can set up a matrix for those three equations. However, I'm going to use an old algebra trick. Note that $I_3 = I_1 + I_2$ in equation 1. So I'm going to substitute $I_1 + I_2$ for $I_3$ in equations 2 and 3. Here is the result of that substitution:

$-I_1R_a - (I_1 - I_2)R_c + V_1 = 0$ (from eq 1 above)
or $-I_1R_a - I_1R_c + I_2R_c + V_1 = 0$
and $-I_1(R_a + R_c) + I_2R_c = -V_1$

If you go back and write the Maxwell loop equation for loop abefa, you will get the exact same equation. Following the same procedure for the loop that consists of bcdeb, you will get the second Maxwell equation.

Conclusion: Maxwell's loop equations can be the equations of Kirchhoff's laws. If you are reading a technical article, you should be able to understand both Maxwell's and Kirchhoff's methods, depending on which the author uses.

### About that Buyers Guide

So you got your March issue of **ES&T** containing the Buyers' Guide, and you tossed it aside without considering important articles that also came with it. You told yourself that you would get back to it later, but probably never will.

One of the important things that you would have learned if you read the issue thoroughly is that there will be *one billion* wireless users by the year 2003, and as many as 400 million using wireless devices to access the internet by the 2004 period. Another article provides suggestions for selling consumer electronics service via the internet.

So the Buyers' Guide is more than just a Buyers' Guide. It contains information that supertechs like you need for keeping up with technology.

### Some abbreviations

Can you identify these abbreviations?

1. Saw filter. _____ filter
2. TDM
3. EIRP

Here are the answers:

1. Surface acoustic wave filter
2. Time division multiplex
3. Effective isotropic radiated power

You correctly identified those abbreviations, right? If not, you should reread the Buyers' Guide. ■

# Books

***DTV: The Revolution in Electronic Imaging*, by Jerry Whitaker, 528 pages, hardcover, $55.00**

The electronics industry is on the verge of the most dramatic advance in imaging technology since the color television. Under the banner of High Definition Television, telecommunications, broadcasting, and computer are being merged into a single digital imaging system with a wide range of exciting new applications. This timely book brings the digital "Grand Alliance," and its role as the HDTV standard, into sharp focus. One of the most respected names in the field provides an engrossing account of the technology, including key aspects of video compression, and details late breaking developments in the effort to bring this emerging technology to the market.

McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020, Phone: 800-352-3566

***Simplifying Power Supply Technology*, by Rajesh J. Shah, PROMPT Publications, 138 pages, $19.95**

*Simplifying Power Supply Technology* offers an entry point for people interested in the field of power supplies. Power supply technology has come a long way in recent years. Many researchers have dedicated their careers to advancing the field of power electronics and a good amount of effort is put into making contributions to the field. One can easily appreciate this field by understanding the basic concepts involved.

*Simplifying Power Supply Technology* simplifies the concepts of power supply technology and gives the reader the background and knowledge to confidently enter the power supply field. It is also useful to experienced technicians as a reference guide to the basic concepts of various topologies.

*Simplifying Power Supply Technology* was written for readers from various backgrounds. Students, hobbyists, professional technicians, engineering assistants, and marketing and sales people will find this a useful and informative companion volume in the power supply industry.

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Chapter 4: Converters — information includes an introduction, switch-mode converters, forward converters, flyback converters, push-pull converters, half-bridge converters, full-bridge converters, and limitations of PWM technique.

Chapter 5: The Control Section — information includes an introduction, transfer functions, closed-loop control system, feedback circuit, pulse-width modulation, linear control, direct duty cycle control, voltage feed forward PWM control, current mode control, and isolation and protection circuits.

Chapter 6: Power Supply System Specifications and Applications — information includes an introduction, specifications, applications, and regulatory agencies.

Rajesh J. Shah is currently working for Delphi Energy and Engine Management Systems on the Electric and Hybrid vehicle programs. He has 15 years experience in the field of electronics, having worked for Lambda Electronics, Branson Ultrasonics, Magnetek, and Valmont Electric. He holds a Master's degree in Electrical Engineering (MSEE) from Polytechnic University, Brooklyn, New York, as well as a Master's Degree in Business Administration (MBA) from Indiana Wesleyan University, Marion, Indiana.

Sams Technical Publishing, 5436 W. 78th Street, P.O. Box 681008, Indianapolis, IN 46268, Website: www.sams.website.com

***Surface-Mount Technology for PC Boards*, by James K. Hollomon, Jr., PROMPT Publications, 512 pages, $34.95**

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***Novell's Dictionary of Networking*, by Kevin Shafer, Novell Press, 640 pages, $24.99,**

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Novell Press, 1-800-762-2974, 317-596-5530

***McGraw-Hill Electronics Dictionary*, by Neil Sclater and John Markus, 544 pages, hardcover, $55.00**

On the market for the past 20 years, this dictionary is now updated for the age of digital communications. The Sixth Edition features more than 14,000 entries including 800 new terms and definitions, covering such fast-growing subject areas as personal computers, digital telecommunications, cellular telephony, and consumer electronics. It also features 220 new illustrations. Outdated entries have been deleted, ensuring the book's usefulness for engineers, technicians, managers, marketers, students, and anyone working in or around the field of electronics.

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

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***Semiconductor Essentials for Hobbyists, Technicians & Engineers,* by Stephen Kamichik, PROMPT Publications, 128 pages, $19.95**

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Chapter 7: Transistor Chemistry

Chapter 8: Transistor DC Analysis — information includes transistor models, amplifier configurations of a bipolar transistor, common-base configuration, common-emitter configuration, common-collector configuration, features of transistors, and problems.

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# Test Your Electronics Knowledge

by J.A. Sam Wilson

The questions and answers in this issue were taken from "TYEKs" in previous issues dated as shown in parentheses. Review is a very important method of locking information into your store of knowledge.

1. Regarding a computer, the interval of time between calling for information in memory and receiving that information is called _____ _____. (October 1994)

2. What is the Boolean output for A x A? (December 1992)

3. Which type of diode is best for sensing the presence of infrared light? _____. (November 1992)

4. Which of the following transistor types has no partition noise? (December 1985)
   A. A bipolar transistor.
   B. A MOSFET

5. Is the following statement correct? Pink noise has more low-frequency energy than high-frequency energy. (December 1985)
   A. Correct
   B. Not correct

6. The advantage of testing an amplifier with a sawtooth waveform over testing it with a square waveform is that the sawtooth wave can show _____. (June 1997)

7. To three decimal places, what is the length of the side of a square that has the same area as a circle with a 3-inch diameter? _____ (September 1993)

8. The primary resistance of a certain power transformer is accurately measured to be 3.8Ω. It's secondary resistance is accurately measured to be 1.4Ω. Can you accurately determine its turns ratio? (July 1991)

9. What is a stroboscope used for? (July 1994)_____

10. Is the following Boolean equation correct?
ABC = A + B + C. (July 1987)
   A. No
   B. Yes

**Answers to TYEK**

1. Cycle time (by definition)
2. A x A = A
3. PIN Diode (The letters stand for Positive Intrinsic Negative)
4. MOSFETs have no partition noise
5. Correct
6. Clipping
7. 2.658 (See the calculation)
   The area of the circle is $\pi r^2 = 3.24 \times 1.5^2$
   $= 3.14 \times 2.25$
   $= 7.065 in^2$
   The area of the square we're seeking then, is 7.065 $in^2$. The side of a square that has area is sqr(7.065), or a little over 2.658 inches.
8. No. The wire sizes are very likely to be different.
9. Measuring rpm.
10. B (yes).

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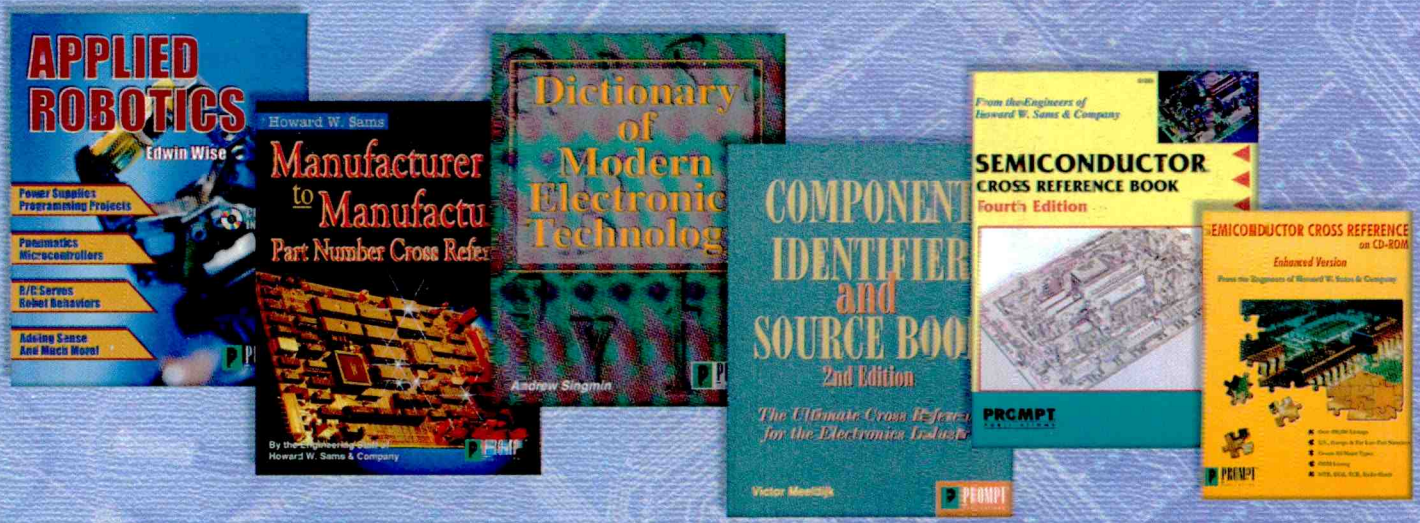


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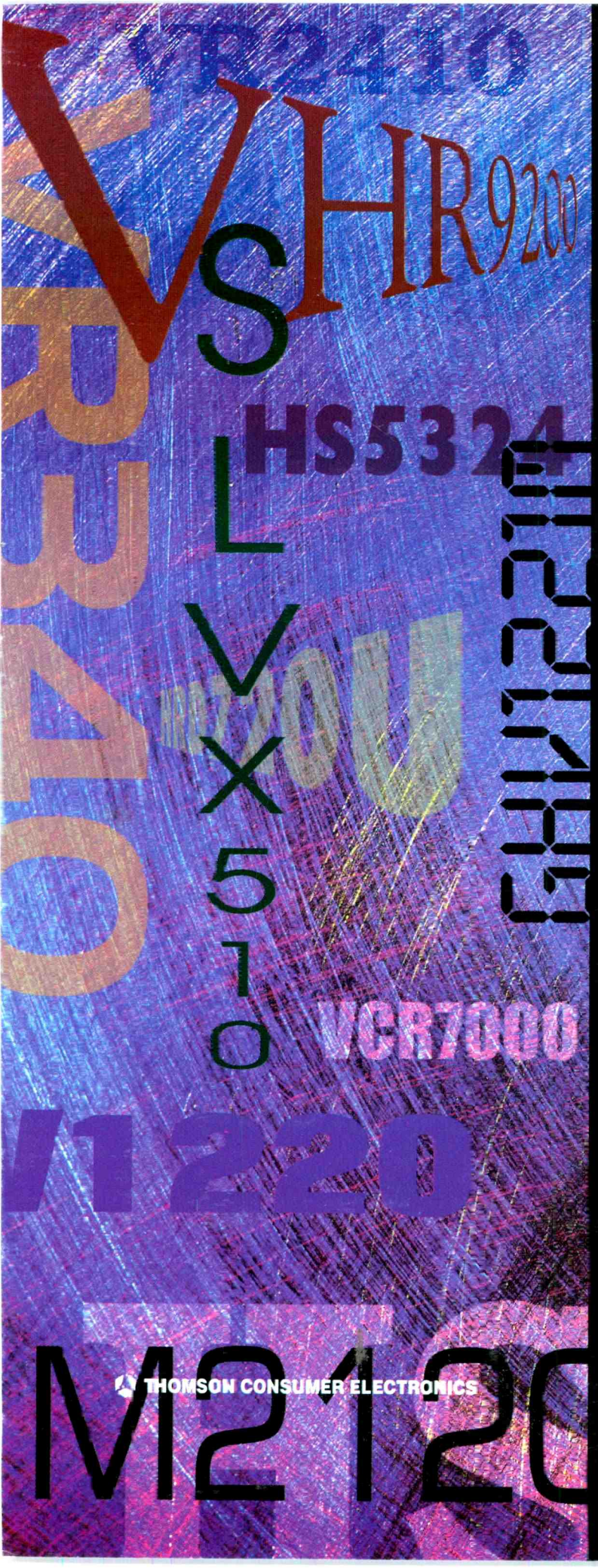


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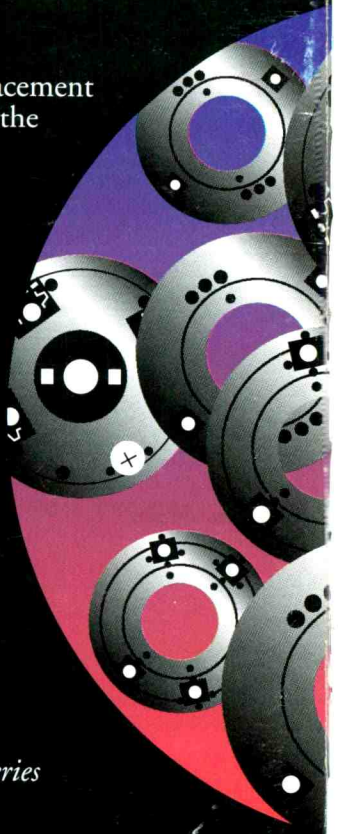

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