THE MAGAZINE FOR CONSUMER ELECTRONICS SERVICING PROFESSIONALS

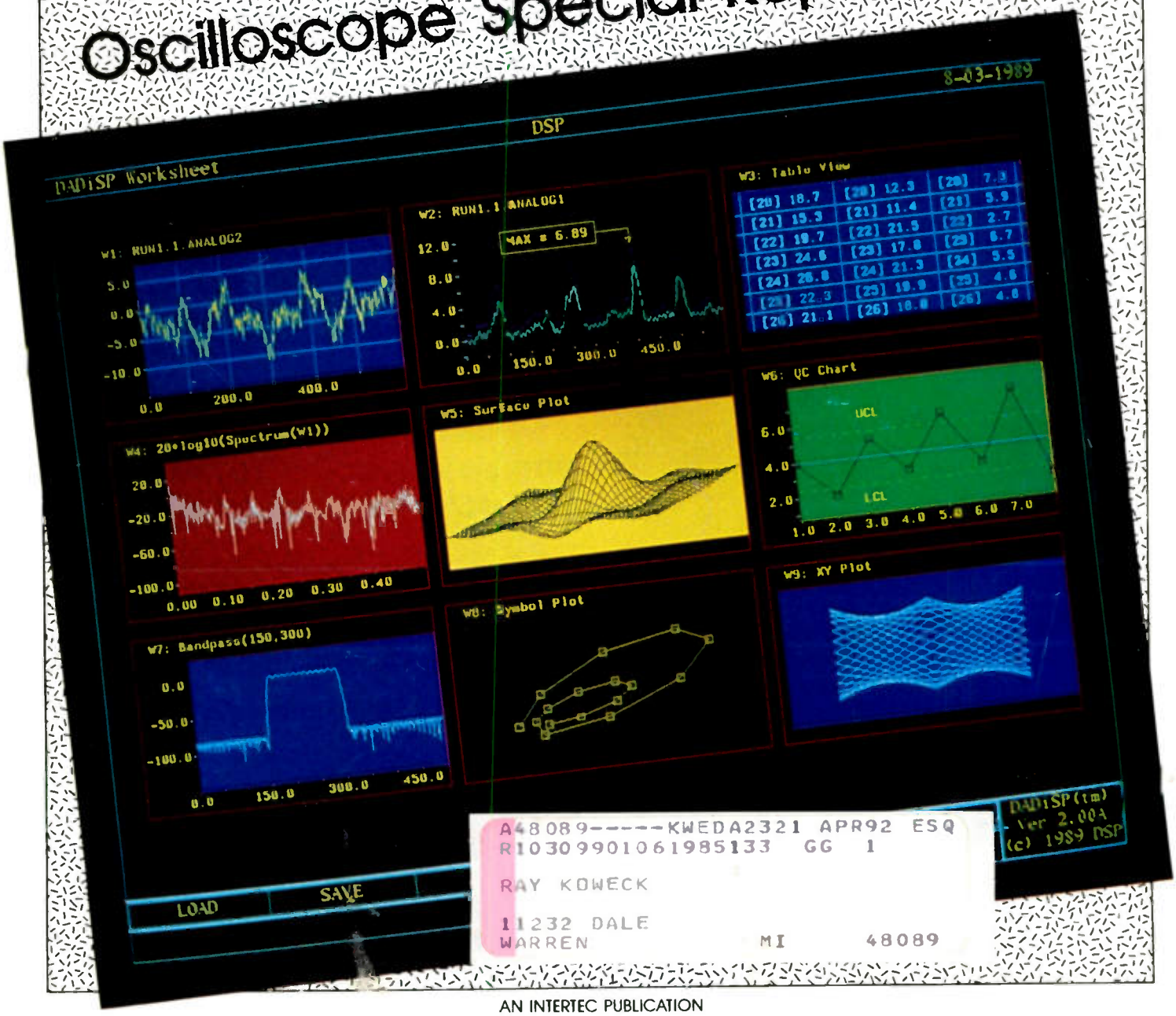
ELECTRONIC Servicing & Technology

APRIL 1990/$3

Oscilloscopes: From "Looking Glass" to High-Tech

Bandwidth and Rise Time — Two Keys to Selecting the Right Oscilloscope

Oscilloscope Special Report



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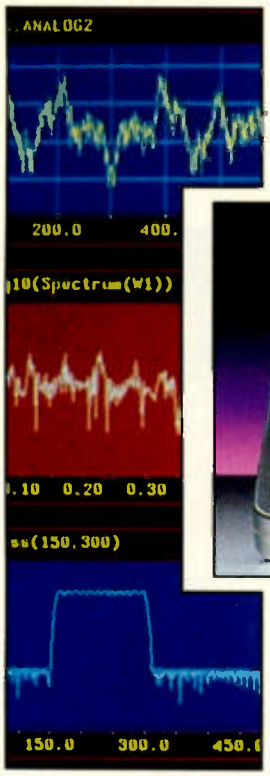

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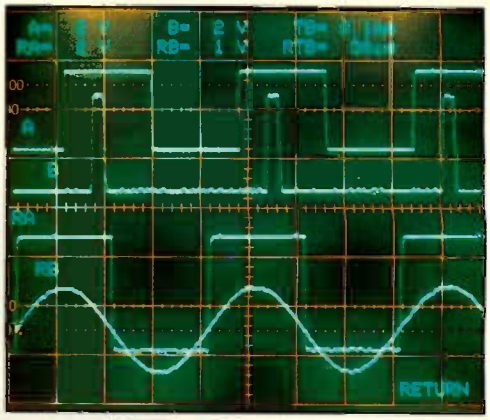

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ON THE COVER

The computer continues to make today's electronic equipment easier to use. This software package analyzes data and displays the results on-screen in graphics windows. (Photo courtesy of DSP Development Corporation, Cambridge, MA.)

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FROM THE WORLD LEADER IN DIGITAL MULTIMETERS

FLUKE

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The hazards of the job

There was a time when we were blissfully unaware of the hazards to our health presented by substances we encounter in everyday life. Then biological researchers began finding that certain substances, some forms of radiation, and even such conditions as overcrowding could be detrimental to our mental and physical well being.

Findings such as these can cause concern and may lead to hasty action. For example, when researchers performed studies involving the feeding of massive amounts of the artificial sweetener cyclamate, an alternative to saccharin, to laboratory rats, the studies suggested that cyclamate was a cancer-causing agent, so it was taken off the market. Further testing failed to corroborate the results of the initial testing of cyclamate, and it now appears that that testing was flawed.

On the other hand, it can often be hard to prove definitely that some hazards are real. For example, there has never been any clear-cut "proof" that cigarette smoking causes lung cancer and many of the other ills linked to it, yet the weight of evidence is overwhelming that cigarette smoking is extremely hazardous to the health of the smoker, and not all that good for others who share that smoke.

Some hazards are job-related. One such possible hazard to the electronics servicer involves consumer electronics products.

It has been known for many years that *ionizing* radiation, such as X-rays and radiation caused by decay of radioactive materials, can cause adverse health effects in humans. However, several recent studies have produced evidence that even non-ionizing radiation — electromagnetic fields from electric wires, transformers or any product that carries an electric current — may be hazardous to the health of humans who are exposed to such radiation.

For example, according to an article by Paul Brodeur in the Nov. 7, 1989, issue of *Family Circle* magazine, a study performed in Boulder, CO, has turned up evidence that children who live in homes that are located close to power-line transformers have a higher incidence of leukemia than children whose homes are located farther from the transformers.

According to the same article, there appears to be other evidence that corroborates this finding. In 1986, the association between high-current wires and childhood cancer was confirmed by a major study conducted under the auspices of the New York State Department of Health. The report stated, "Prolonged exposure to low-level magnetic fields may increase the risk of developing cancer in children." A similar finding was announced by scientists studying childhood cancer in Sweden.

The article lists other preliminary evidence: In 1985, a jury in Houston found "clear and convincing evidence" of potential health hazards from power lines near schools and awarded damages against Houston Lighting & Power; in 1989, a Florida judge ordered children not to play in a Boca Raton schoolyard near overhead power lines. The article even suggested staying three feet back from your TV or CRT, keeping your electric alarm clock some distance from your bedside, and forgoing your electric blanket.

Our purpose here isn't to raise an alarm. Not enough testing has been done to determine the validity of studies that suggest there are adverse health effects caused by non-ionizing electromagnetic radiation. The jury will be out for a long time on this subject. Until all the evidence is in, however, prudence suggests that anyone whose work involves long hours in close proximity to energized electrical/electronic equipment (for example, consumer electronics servicers) take whatever measures he can to minimize exposure to this form of radiation. For example, putting the burn-in bench some distance from where technicians are working can reduce the hazard considerably.

We are currently working on a special issue that will be published in the fall, detailing as much information on this subject as we can. If you have experienced health effects that you suspect may be caused by exposure to electric and magnetic fields related to your work, please write or call. We'd like to talk to you.

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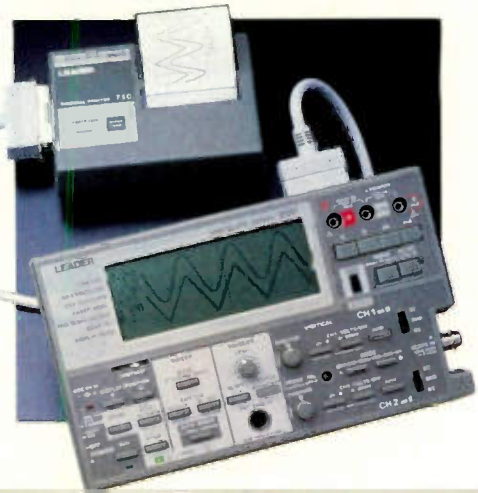

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Oscilloscope special report

By Conrad Persson

The oscilloscope has undergone significant changes since it was introduced as a tool for observing electrical waveforms. From an uncalibrated device useful for little more than getting a rough idea of the shape of a waveform, the analog scope gradually evolved into a tool for studying waveforms with a great degree of mathematical accuracy.

Today's digital storage oscilloscopes (DSOs) not only provide the user with a graphic representation of the waveform on the screen, they also make it possible to store a waveform, compare it with other waveforms, analyze it mathematically. And these oscilloscopes increase in capability and decrease in price every year.

As oscilloscopes have evolved, the consumer electronics equipment that technicians will be servicing has also changed. In addition to all of the sophisticated analog circuitry to be found in today's TVs, VCRs and other consumer products, there's a great deal of sophisticated digital circuitry.

This special report takes a look at today's oscilloscopes. First, what are the criteria for choosing an oscilloscope? The article "Bandwidth and Rise Time — Two Keys to Selecting the Right Oscilloscope" examines the nature of the signals that a servicer will encounter, and analyzes from this information what capabilities the technician will require in an oscilloscope. The article also discusses the required sampling rate of a DSO as determined by the frequencies of the signals to be observed.

The second article in the report, "Oscilloscopes: From 'Looking Glass' to High-Tech," describes the evolution of the oscilloscope from its humble beginnings to the power of today's DSOs. This article discusses how today's sophisticated oscilloscopes do much of

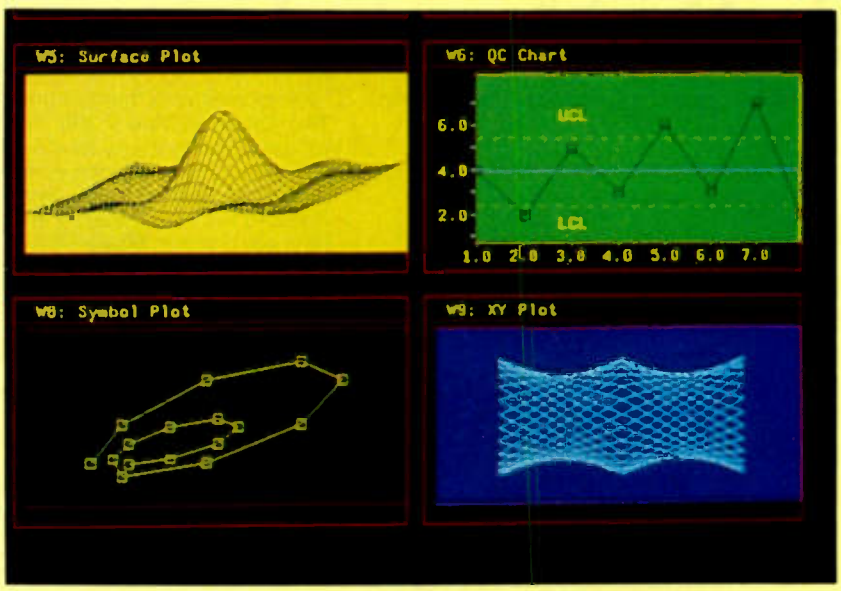
Persson is editor of **ES&T**.

The computer as a waveform analyzer

Computers are finding more and more applications in consumer electronics products as well as in the test equipment that is used in the servicing of those products. Not only that, but recently we have seen more and more software designed to turn a personal computer into a piece of test equipment.

For example, there are software packages that will turn a computer into an oscilloscope. The computer also can be made to emulate the spectrum analyzer.

Here's a software product that will turn a PC into a "spreadsheet" for waveforms, signals or graphs. This program, called DADiSP (pronounced day-disp) allows the user to call waveforms into his computer, analyze them, manipulate them, compare one waveform to another, and possibly diagnose problems in the equipment that produced the waveform. The waveforms to be analyzed might be captured, for example, by a data acquisition system or by a modern instrument that can capture a waveform and transfer it to the computer via an IEEE-488 interface. The program can also accept and display tabular data and text.



The software is an interactive graphics worksheet — a visually oriented software tool for the display, analysis and management of scientific and technical data, requiring no programming. It takes any type of data as described above and plots it in color on-screen. The menu-driven software allows you to run hundreds of analysis routines, displaying the results next to the original data in a variety of dynamic graphic views.

This program can simultaneously display up to 64 separate on-screen windows for viewing all types of data, analysis and graphs. These windows can be individually manipulated and linked to one another, similar to how a spreadsheet allows you to manipulate and link cells of numerical data. If the data in one window is changed, the software automatically recalculates and updates all windows that are dependent on that data. Also, any window can be zoomed in on for detailed examination and modification, allowing scrolling, panning and cursoring through data point-by-point and window-by-window. A number of graph types can be used, simplifying and speed-

the work of calculating waveform parameters, such as frequency and peak-to-peak, average and rms voltage, allowing the technician to concentrate on the business of deciding what points to measure and how to interpret the data observed.

Today's complex consumer electronics products require sophisticated technicians and advanced test equipment to service them. We hope this article helps readers become more aware of the capabilities they will find in the current crop of scopes. ■

ing data interpretation.

Here's a concrete example of what a technician could do with the software. Let's say that you suspect an integrating circuit of not working properly. You could capture both the input waveform to the integrator and the output waveform from the integrator and place them in windows. Then you could use the manipulating abilities of the program to produce the integral of the input waveform on screen. Finally, you could compare the actual output from the integrator with the integrated input waveform produced by the software. If they resemble one another within reason, the integrator is probably good. If they're significantly different, you've probably located a problem source.

There are currently two versions of this program. The original, version 1.05, is priced at $895 and will run on any IBM or compatible from the 8086 on up. It requires 640K of memory and will operate on a monochrome or color monitor. The upgraded version, 2.0, is priced at $1,695 and requires a 286 or 386 and 2MB of RAM. This version is usually run with an EGA or VGA monitor.

For more information on the program, contact DSP Development Corporation at 1 Kendall Square, Cambridge, MA 02139; 617-577-1133.

Special Report

Bandwidth and rise time – two keys to selecting the right oscilloscope

By Mike Hoyer

Bandwidth? Rise time? What are they? What factors of each do I need? Are analog and digital storage bandwidths the same?

These two areas attract the most questions by oscilloscope buyers, and with good reason. Bandwidth and rise time are the main keys to selecting the right oscilloscope for your application. Our goal is to clarify the confusion surrounding these two essential elements.

What is oscilloscope bandwidth?

The bandwidth of any oscilloscope, real-time or storage, is defined as the frequency at which a sinusoidal signal will be attenuated by a factor of 0.707, or reduced to 70.7% of its maximum value. This is called the −3dB point. For example, a 1V, 20MHz sine wave on a 20MHz oscilloscope would appear to be about 0.707V. This seems rather simple, and it is, but things become complex where square waves are concerned.

Square waves and video signals are some of the most complex signals. They need to be considered when choosing an oscilloscope because they are found in more and more electronic products every day. Square waves consist of an infinite number of sine waves: the fundamental frequency (the sine wave that is of the same frequency as the square wave) plus mostly odd harmonics (multiples of the fundamental frequency). Fourier analysis shows that a square wave consists of the fundamental sine wave plus sine waves that are odd multiples of the fundamental frequency: three times, five times, seven times and so on (third harmonic, fifth harmonic, seventh harmonic, etc.).

This phenomenon is expressed in this equation:

$$F(t)=A\ \sin(\omega t)-A\ \sin(\omega t)/3$$

where A is the fundamental amplitude and ωt is the fundamental frequency.

What bandwidth do you need?

The Fourier analysis calculation shows that the fundamental frequency contributes about 81.7% of the square wave. The third harmonic contributes about 9.02% and the fifth harmonic about 3.24%. Harmonics contribute to the shape of the square wave; therefore, if you remove the harmonics, it would be a sine wave. Higher harmonics contribute less and less, and are not as significant in the creation of the square wave. This tells us that about 94% of the square wave is derived from the fun-

Hoyer is product marketing manager for Leader Instruments.

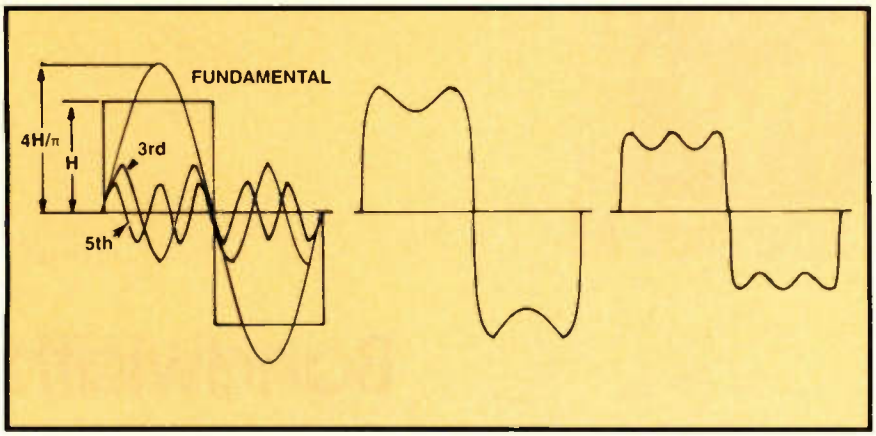


Figure 1. A square wave can be considered to be composed of a sine wave at the square-wave frequency added to an infinite number of sine waves that are odd multiples of the fundamental sine wave frequency (odd harmonics). As this classic illustration shows, the fundamental and the first two odd harmonics (third and fifth) give a pretty good approximation of a square wave. For most servicing purposes, an oscilloscope that has sufficient bandwidth to handle frequencies as high as the third harmonic of any square wave encountered is adequate. The composite at the left shows the individual waveforms for the fundamental and the first two harmonics. The waveform in the center illustrates the resultant when the fundamental and first harmonic are combined. The waveform at the right illustrates the waveform that results when the fundamental and the first two harmonics are combined.

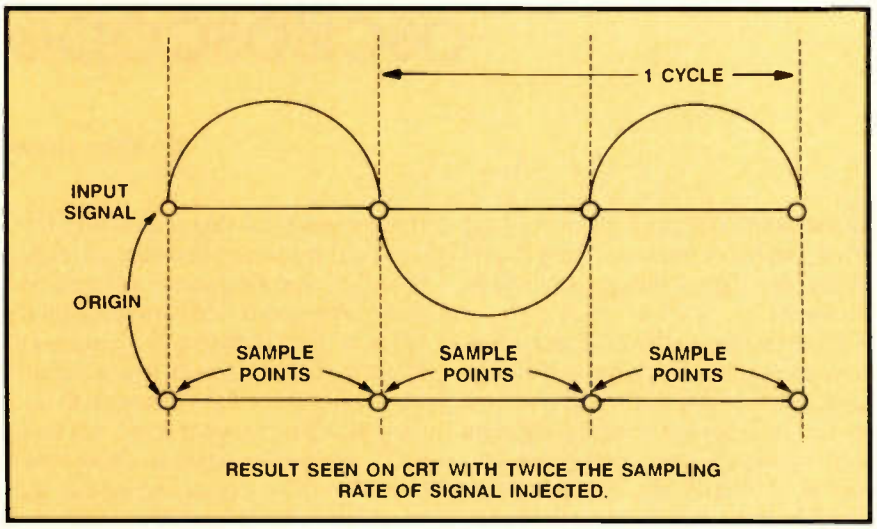


Figure 2. To assure that the waveform representation is correct, a digital storage oscilloscope must be capable of sampling at rates greater than twice the highest frequency that you will encounter. Sampling at less than twice the frequency of the signal can result in a waveform that does not accurately represent the waveform. In this worse case, a sine wave can look like a straight line. This problem is known as *aliasing*.

damental and the third and fifth harmonics. Inaccuracies introduced by the oscilloscope's amplifiers are about 2% to 3%, and the user's ability to accurately read the display may create about 4% error. Thus, a total minimum of 6% error is introduced by interpretation of the waveform. Therefore, 94% of the waveform's characteristic components should be sufficient.

Because a square wave is the most complex of waveforms, and because you don't really need any frequencies above the fifth harmonic of the waveform being studied, the bandwidth you will require in an oscilloscope is about five times the highest fundamental you expect to encounter. In other words, five times the highest fundamental frequency to be measured will give you the bandwidth of the oscilloscope required. Servicing consumer products, such as TVs, VCRs, camcorders, CD players, stereo equipment and computers, requires a 100MHz oscilloscope. The Electronic Industries Association (EIA) recommends using a 100MHz oscilloscope for these applications.

Defining analog rise time

High-speed digital circuits contain quick rise times. The rise time needed within an oscilloscope depends upon the rise time being measured and what degree of accuracy is needed in measuring them. A 2% to 3% rise time accuracy can be obtained with an oscilloscope that has about five times the rise time of the signal being measured. Rise time can be determined from the bandwidth of the oscilloscope:

$$T_r=(0.35)/(\text{bandwidth})$$

A digital bandwidth pitfall

Sad but true, determining digital bandwidth has become confusing. The sample rate of a digital storage oscilloscope must be greater than two times the highest frequency to be measured. Think about it. A sine or square wave starts at the origin and then crosses and recrosses the origin. In this case, if you were to sample two times faster than this signal, you would obtain two points during each cycle, and each could be at the origin. By connecting these two sample points, you would obtain a straight line. This would lead you to believe that there was no signal at all. (See Figure 1.)

How can you determine the sampling rate needed for a digital oscilloscope? Many manufacturers have developed their own rules in deciding the number of samples required per cycle of a waveform. We are not presently aware of any official agency or trade group that has actually set standards for the industry. At Leader, we agree with the view held by the majority of engineers that 10 samples per cycle provides a sufficient representation of a waveform.

This sample rate is necessary for single shot signals or for constantly changing signals; hence the term *single-shot bandwidth*. There is also repetitive bandwidth, which is not related to the sample rate but refers instead to the bandwidth of the analog amplifiers. Here, the digital storage oscilloscope obtains points over a period of several passes of the signal before displaying it on the CRT. Naturally, the signal must remain the same, or a distorted representation of the signal will result. This essentially creates a higher digital storage bandwidth, but beware — it's only for repetitive signals. How many signals actually remain constant?

Beware of varying digital bandwidth

Take note if the oscilloscope has one or two analog-to-digital (A/D) converters. If the oscilloscope has one A/D converter and is in 2-channel mode, the A/D processing is shared among two channels. The sampling rate is cut in half and so is the single-shot bandwidth. Unfortunately, many users have no idea that this is taking place. ■

LIVE ACTION

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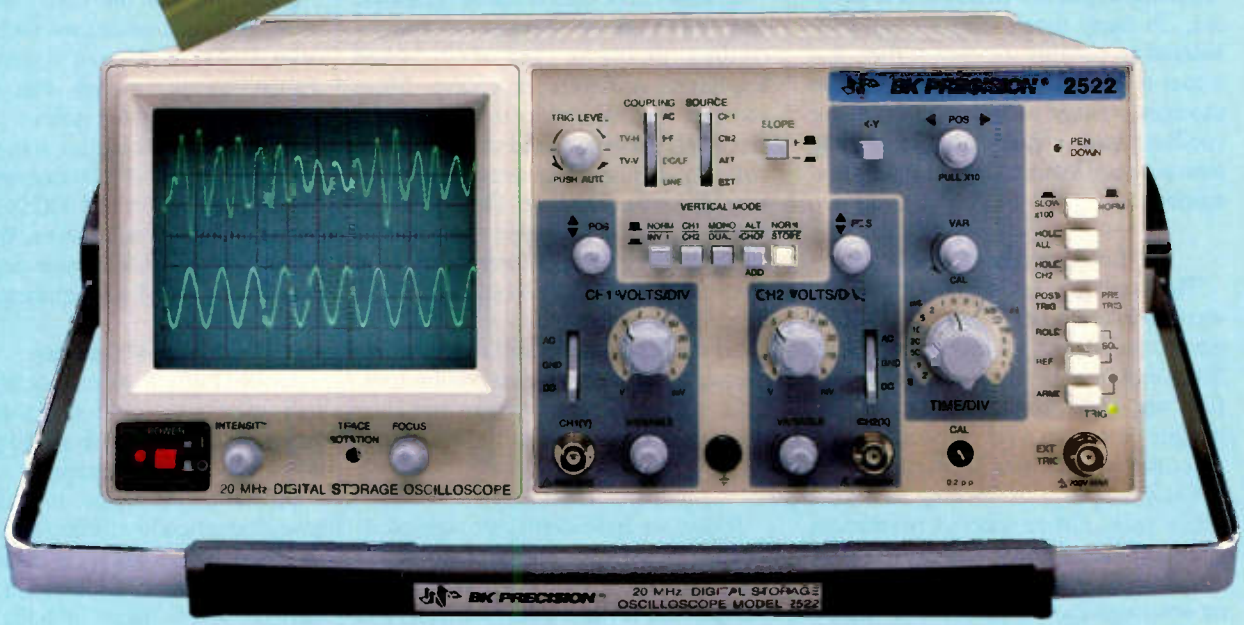

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Special Report

Oscilloscopes: From "looking glass" to high-tech

By Hans Toorens

Oscilloscopes are hardly a new product. To many users, they are not considered an exciting product, either, just a tool to be taken for granted. Recent changes presage an exciting future for oscilloscopes, a future that reaches to new product features and to many new markets.

"Looking glass" tools

The earliest analog oscilloscopes were primarily observation, "looking glass" tools, not measurement tools. They lacked calibrated vertical amplifiers and time bases, and they lacked trigger circuits, so viewing non-repetitive events was impossible.

Early scopes were lacking as observation tools. There wasn't a permanent record of their display. Repetitive events could be shown, but single occurrence or low-repetition events could not be captured, except with a camera, making the operation complex and clumsy.

Special CRTs, called storage displays, later solved these observation and recording problems, but they lacked brightness and were expensive. More accurate vertical and horizontal systems eventually arrived, as did trigger-control circuitry, making calibrated time bases feasible for the first time. Further refinements included expanded vertical and horizontal displays, differential vertical amplifiers, dual time bases, and more trigger refinements.

Yet the oscilloscope still seemed to be primarily used as an observation tool. Even with calibrated voltage and time systems, errors crept in.

DSOs

Today, we have digital storage oscilloscopes (DSOs) — the first to replace analog storage scopes. Early DSOs were too slow for serious electronic tests and were used for mechanical, medical and other "slow" applications. Unlike non-storage or CRT storage scopes, DSOs do not depend on the CRT as part of the measurement system.

It's a fact that the DSO has been a boon to measurement technology. But using DSOs in place of non-storage or display-storage scopes has required some adjustment for users.

DSOs are speeding up, too, with fast analog-to-digital (A/D) converters and charge-coupled devices (CCDs) for economical high-speed capture. With these refinements, DSOs became part of real electronics speed and applications.

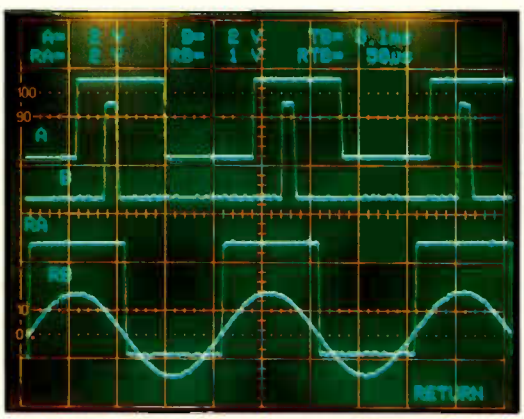
Today's scopes

As DSO development continues, design experience and technology improvements continue to make products faster and more affordable.

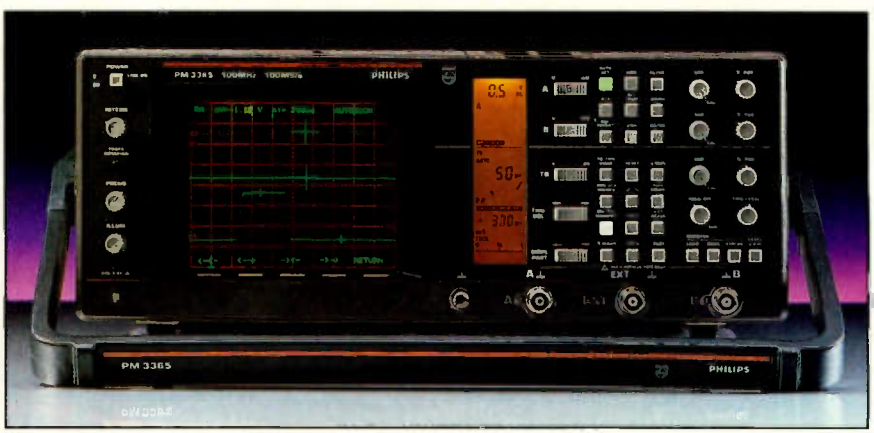
Several technological breakthroughs have dramatically affected the value of oscilloscopes. One such development has been the use of CCDs in the digital-storage acquisition system. Before CCDs, digital storage relied on high-speed A/D converters and memory.

A/D converters were typically one of two types: flash converters, which could digitize high-speed, single-shot events

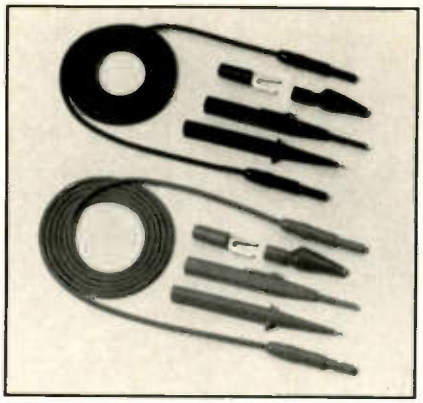
Toorens is product marketing manager at Philips T&M Group, John Fluke Mfg. Co.



Modern DSOs not only display the waveform of a signal, but the microcomputer circuitry also calculates and displays such parameters as frequency, period, amplitude and more.



DSOs and analog oscilloscopes both display electronic signals, but the DSO also stores signals, performs calculations to determine and display waveform parameters, and transmits data to a computer to be saved on disk.



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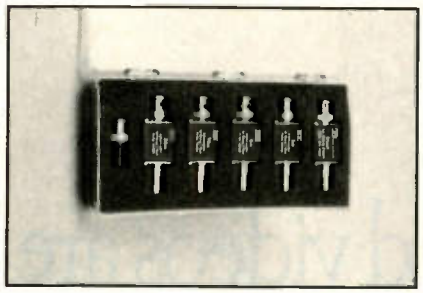

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Contains 4 attenuators — 3dB, 6dB, 10dB, 20dB; 1 feedthrough and 1 termination. Thick-film circuitry for low reactances. Rugged design resists shock and lasts longer. Rectangular shape stays put on the bench. **Impedance:** 50Ω **Frequency:** 1GHz. **Maximum Power:** 1kW peak, 1W avg. **VSWR** 1.2:1. Attenuator Accuracy:±0.2dB. Terminations Resistance Tolerance: ±1%. $150.
TEST PROBES INC. Call toll-free for catalog: 1-800-368-5719.

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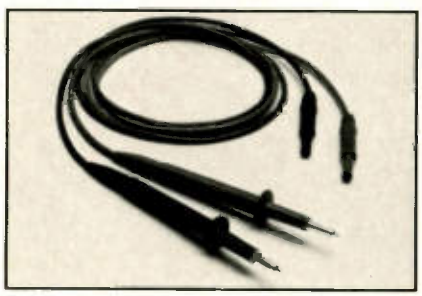

ECONOMICAL SILICON RUBBER TEST LEADS

Best value in moderately priced leads. High quality, soft, silicon rubber cable. Banana plug on measuring tip accepts push-on accessories. Plugs have spring-loaded safety sleeves. Model TL1000 $14. Satisfaction guaranteed.
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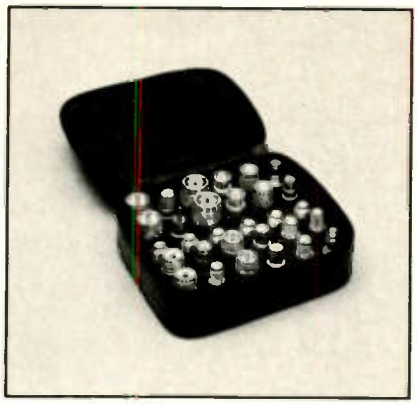

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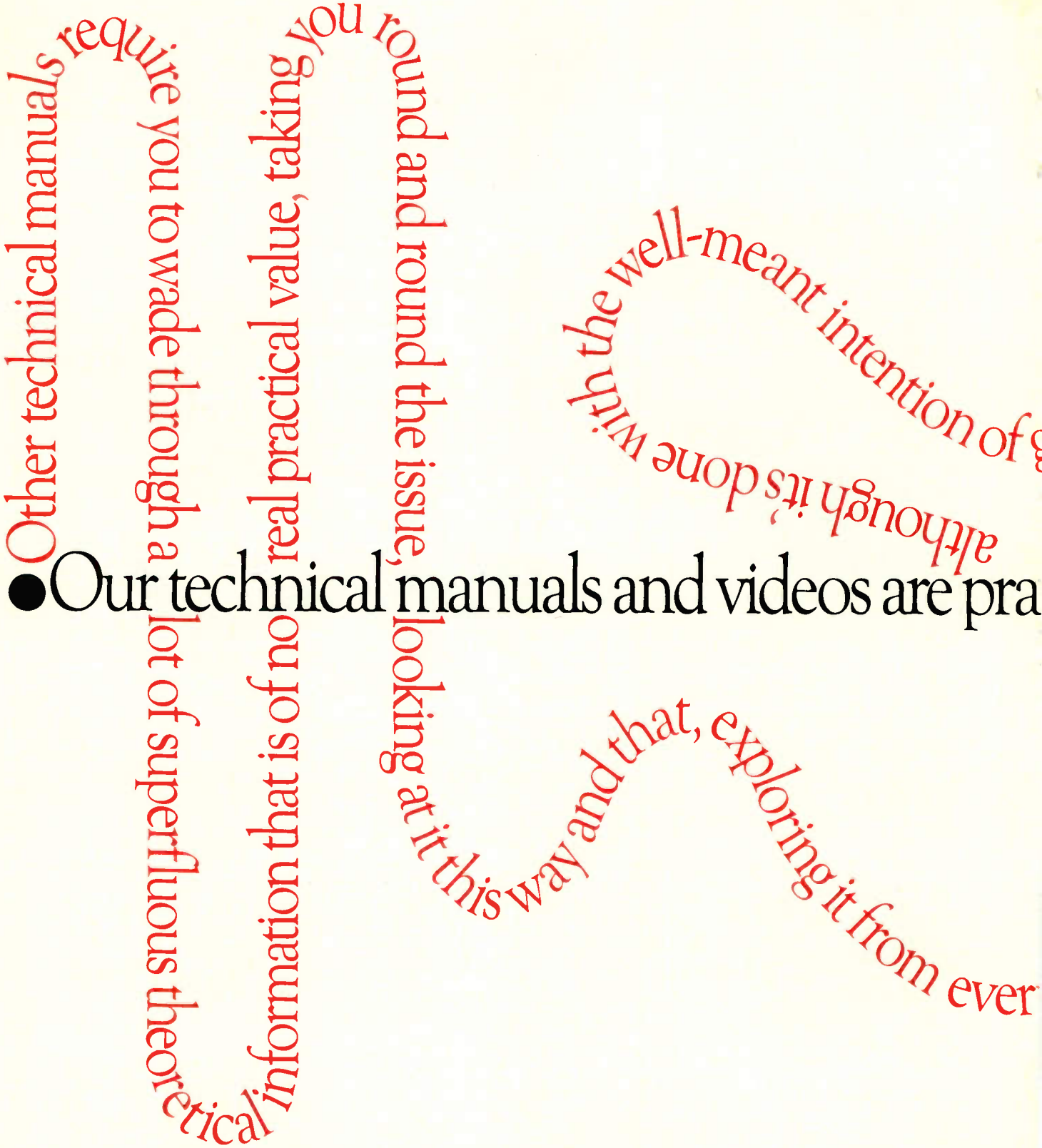

If you want the shortest distance between a problem and a solution, look no further than our troubleshooting guides.

Whether they're for VCRs, CD players, fax machines, projection or direct view TVs, each one gives you the answers you need both quickly and simply. And thanks to our on-screen video indexing, those answers are easy to locate.

But for all the invaluable help our manuals and videos can offer, they are surprisingly inexpensive, ranging from

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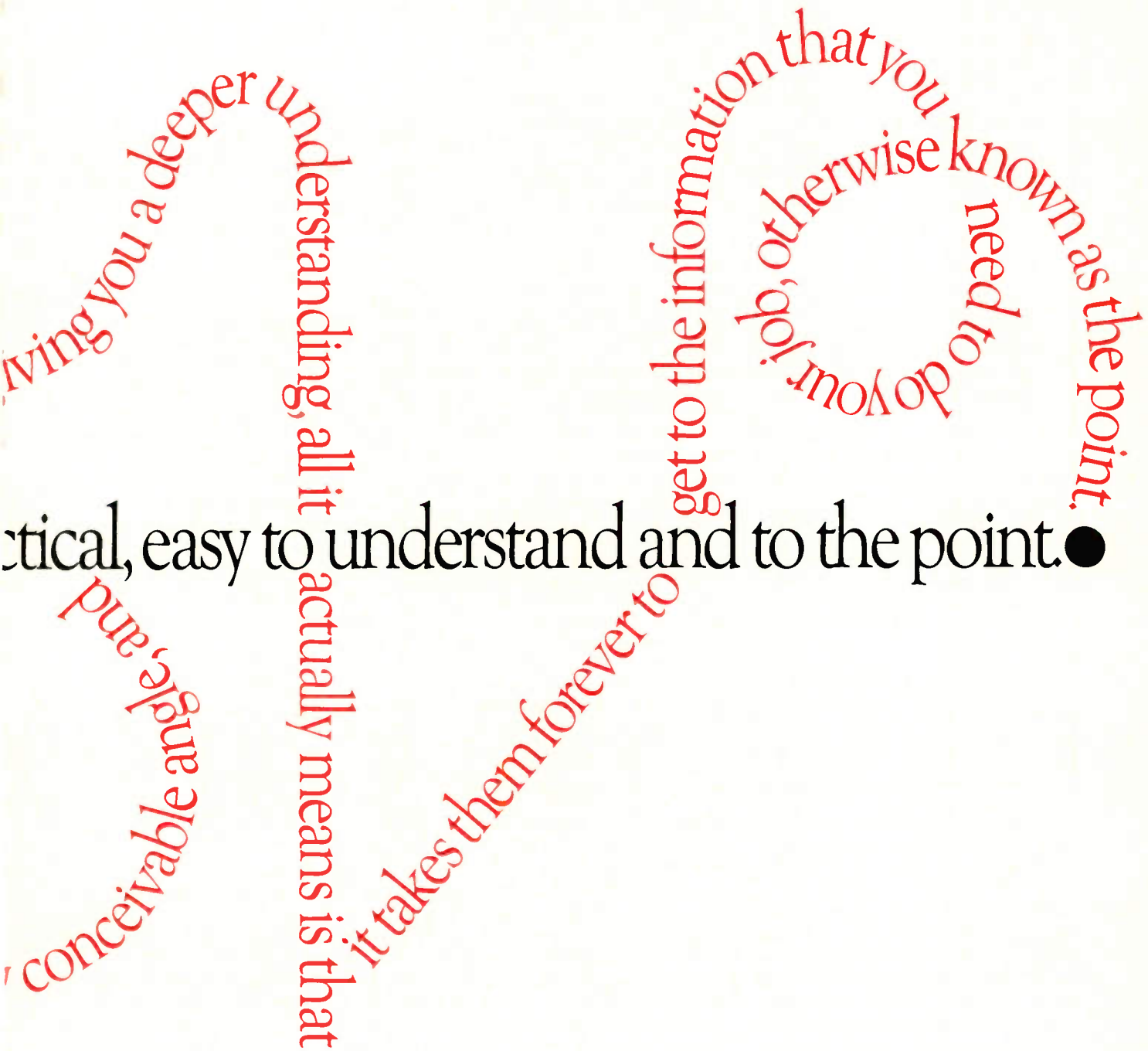

just $40 to $100. For example, there is our step-by-step fax training video (part #TT-107) at $89.95.

If you would like to place an order, call 1-800-553-7278. Or for a free copy of our brochure (simply-worded and to-the-point, of course), write to Mitsubishi Technical Services Division, 5757 Plaza Drive, Cypress, California 90630.

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Circle (13) on Reply Card

Before you buy a scope . . .

Perhaps this article has renewed your interest in purchasing a new oscilloscope. The right scope, like any tool, will make your job easier. Many scopes offer powerful features, and their advertisements make them seem indispensable for any use. So how do you make the right choice? Here are some suggestions:

• *Buy only what you need.* We've spent a lot of time talking about DSOs, and we do believe they will become the predominant measurement tool of the '90s. However, many of you may not need the power of a DSO. Their cost is usually more than that of a non-storage scope. You know best what you need for your job. Don't be caught in the "I need the best scope possible" trap. If your job is well-defined with boundaries, buy specifically what you need. If your job is full of "what if's," such as in engineering, take advantage of more power in modern DSOs.

• *Make sure you're getting current technology.* Even with DSOs, there are products on the market that rely on outdated circuitry. State-of-the-art DSOs have CCD acquisition systems, microprocessor control, and automatic setting capability. Does the one you're considering? If you are uncertain, buy a combi-scope, combining the convenience of the trusted analog scope with the power of a new DSO.

• *Buy from someone you trust.* What is the reputation of the manufacturer, distributor or dealer? What have been your experiences with other products with that nameplate? Does the product have a good warranty? Most high-quality products today offer 3-year warranties. You shouldn't have to pay extra for this coverage.

• *Attend seminars and demonstrations.* Many manufacturers offer free seminars to acquaint potential customers with their products. Ask your salesperson when the next seminar will be presented in your area. Ask for one-on-one demos also, especially if the manufacturer doesn't offer a seminar.

• *Request videotapes, a loaner scope and lots of literature.* Most brand-name manufacturers have introductory videos, a pool of demo instruments for short-term loan, and application guides. All of these can show you what the product can (and can't) do.

• *Find out how the product will be supported after you buy it.* Is there local applications support or a toll-free number to call when you have a question? The best product in the world won't do you much good if you can't get your problems solved and your questions answered.

• *Find out about in-warranty and out-of-warranty repair policies.* We mentioned earlier that a 3-year warranty is typical for today's oscilloscopes, but you need to know exactly how the manufacturer supports that warranty. Do you get an immediate loaner scope if yours breaks? Or a replacement? Where will your product be repaired? How long does it take? Who pays shipping? Get it in writing.

but were expensive; and successive-approximation converters, which were less expensive but couldn't capture high-speed events.

The CCD is an analog storage array. Modern DSOs can capture high-speed events in real time using CCDs, then route the captured information to be digitized with low-cost A/D converters.

Another important innovation has been the widespread use of microprocessors in oscilloscopes. One advantage of a modern microprocessor-driven scope is its *cold-switched* front-panel controls. Cold switching means that complex, failure-prone electromechanical devices, such as attenuator and time base switches, have been replaced by microprocessor-controlled, sealed switching arrangements (reed relays and solid-state switches), so switch failures and worn or dirty contacts are a thing of the past. The introduction of microprocessor power takes full advantage of cold switching. More microprocessor power allows DSOs to calculate results never before possible with any scope: rms, risetime, etc.

The front-panel switches are low-current, long-life units, suitable for use in harsh environments, making the DSO ideal for field service, where it is constantly transported and exposed to weather and dust. The modern scope can also be controlled electronically over an IEEE or RS-232 interface bus, making remote servicing more practical.

Another new product — the combi-scope — combines both analog and digital storage oscilloscope technology in a single package. Combi-scopes are more affordable; they handle both modes; and they're comfortable to use.

Analog oscilloscopes are considered a mature product, but DSOs are only beginning to mature. Users no longer need to treat DSOs as an oddity or a luxury. More important, users are becoming comfortable with DSOs. In the process, they are finding many new uses for them.

Today, two trends exist: The overall scope market is expanding and DSO sales are increasing at 20% a year; and the non-storage scope market is shrinking.

DSOs have replaced display (CRT) storage products almost completely, and they are taking over traditional non-storage markets. In particular, portable scopes aimed at service markets are dominated by DSOs.

One likely reason is that the DSO is regarded as a diagnostic test and measurement tool. Modern DSOs contain internal storage for multiple waveforms, thanks to low-cost memory. Many DSOs contain multiple memories, internal measurements, and stored front-panel settings. These features aid troubleshooting. Readouts provide measurement results and front-panel settings.

Many modern DSOs have a feature that allows the scope to automatically find optimum settings, depending on signal conditions. This time-saving tool eliminates the distraction of changing settings when you are moving between test points. This allows the user to concentrate on the test-point signal, its appraisal and solution of the problem.

Intelligent scopes can now make key measurements and comparisons. Voltage peaks, means and rms values are calculated and displayed. Also, pulse parameters, such as rise- and fall-times, can be calculated. Signal frequency or period are evaluated as well, even for single events.

With oscilloscopes getting smarter and smarter, users can concentrate on test results, not scope settings and calculations to get those results. One danger of the smarter scope, unfortunately, is that as users gain more "what" information, they may lose sight of the "how" of test and measurement. A scope that thinks can lead to a user who doesn't.

The oscilloscope of the future

Now, let's look into the future, based on experience, current trends, "hot" technologies, and a lot of comments from oscilloscope users.

Fiber optics have begun to replace electrical cable as a signal medium, not

Continued on page 38.

Digital Multimeters Have Heavyweight Features, Lightweight Prices.

ECG® DM-26 and DM-27 Pocket DMMs offer the best value available. Rotary Switch with usual ranges and "OFF". 20 Megohm Full Scale and 10 Amps DC. Tilt stand. DM-26 $34.95 Sug. Ret., DM-27 (w/beeper) $39.95 Sug. Ret. At 900 Philips ECG distributor locations or call 1-800-526-9354.

The Smart Choice

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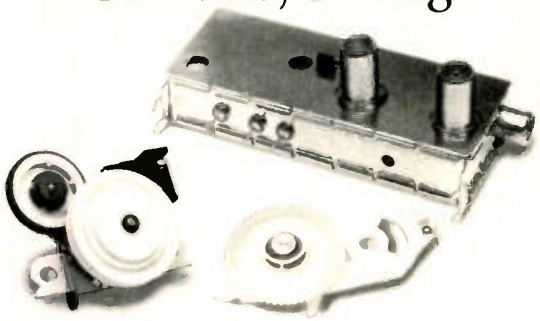
Replacement Work On VCRs Is Easy With ECG® Parts, Catalog.



New from Philips ECG: VCR modulators for many popular brands, more opto sensing devices, additional idler wheels/assemblies and belt kits. Pinch rollers, idler components, and scores of belts complete the selection. At 900 Philips ECG distributor locations or call 1-800-526-9354.

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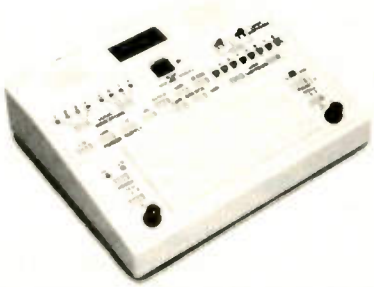

Analog model: 2 DC/2 AC power supplies, 200 Hz to 200 kHz function generator. **Digital** model: 3 DC power supplies, 8 LED logic indicators, built-in logic probe and pulser. Both have 1380 solderless tie points. No support circuits required. At 900 Philips ECG distributor locations or call 1-800-526-9354.

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DISTRIBUTORS SHOWCASE

Choosing your equipment or parts distributor shouldn't be left to chance. When you have someone's malfunctioning TV on your bench and you can't fix it because a part is on back-order, you're treading on thin ice with your customer's satisfaction. That should worry you, and your distributor should feel the same worry over *your* satisfaction. When you place an order for several items, you shouldn't have to check which have arrived, then try to track different promise dates for the ones on back-order.

Whether you choose to do business with only one distributor or several, local or mail-order, there are some important questions you should ask before you place your order. After all, a bargain isn't a bargain if it doesn't work as suggested and you have to send it back. Especially if shipping is extra and there is a restocking fee.

Ask questions

One of the reasons we started this distributors showcase is to help our readers gain some detailed information on some of the companies with whom they might do business. Over the years, we've heard distributor horror stories from several of our readers. One reader found that a certain company held his order until after his check cleared — and then some. In effect, the distributor was getting a quick loan between the time the check cleared and the time the company shipped the merchandise. Our readers object to providing short-term, interest-free loans to their distributors, and they certainly object to unnecessary delays in getting equipment and parts.

Another reader found he was being charged excessive shipping and handling charges. Unfortunately, in this case the distributor had him over the barrel: The company was the only one to provide unauthorized servicers with servicing information on this brand of TV.

Another reader complained about a company that listened to his explanation of the application for which he wanted to use a piece of test equipment, then assured him that the company's product was made for that application. It didn't work, and when he returned it, he was charged a hefty fee by the company just to put the equipment back on the shelf. Restocking fees may be necessary when a customer orders a part and just decides he doesn't really need it. However, when it doesn't work as promised, should the customer really have to pay to rectify the company's mistake?

So ask questions before you order. Once the check is out of your hands, you've lost your leverage. Here are some of the areas in which you might want to do some comparison shopping among distributors:

- Does the company offer a range of products, or does it specialize in a particular area? Determine whether you need a single, generalized distributor or several companies to fill special needs.

- Are prices a lot higher or lower than the competition? Don't assume higher prices automatically mean better quality. If prices are lower, it might be a genuine bargain, but it also could be the only way the company can unload below-par equipment.

- What percentage of orders can the company fill from stock? What percentage of items go on back-order? How long is the average item on back-order?

- How soon after receipt of an order does the distributor ship?

- Does the distributor add a shipping surcharge or a handling charge?

- Does the company make ordering easy? Look into toll-free telephone numbers; ordering options, such as fax, telex and computer ordering options (MCI Mail, Compuserve, EasyLink); payment options (open order account, credit card, C.O.D., check); and shipping (mail, UPS, Federal Express).

- Is there a minimum order amount?

- What kind of special services, such as assembling cables, does the company offer?

- What research services does the distributor offer to help you to find the part you need?

- What is the distributor's return policy? Do you pay shipping, and is there a restocking fee?

- Are all of the distributor's policies well-documented, or do you have to guess at them? Do they differ depending on the company's whim?

- What kind of warranty, if any, does the distributor offer?

This year's showcase

We put these questions to several distributors, and the distributors we've included in this showcase took the time to answer some of those questions for our readers. We're pleased to include profiles of several companies not profiled last year. As you read through this section, it might be a good idea to jot down pros and cons as they apply to your special circumstances. Next time you have to decide to whom you will give your hard-won dollars, a quick glance might tell you who has earned them.

SPECIAL ADVERTISING SECTION

Omega Engineering

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For nearly three decades, Omega Engineering has established itself as the recognized leader in the growing field of process measurement and control. This leadership is rooted in the company's unyielding commitment to quality, innovation and customer satisfaction. Customers at Omega have come to rely on the company's engineering expertise and custom-design capabilities to fulfill their application requirements. The broad range of instruments and sensors are sold via the company's expansive handbook and encyclopedia series. These handbooks (six currently are available) feature detailed product descriptions, prices and ordering information. Each handbook also contains complete technical data and application guidelines, all in an easy-to-read format.

Omega has always sold direct to its customers, eliminating the middleman, thus assuring the level of service that is paramount in the industry. The company's sales and engineering staff can assist customers with technical questions, check inventory status, and place orders, all with a simple toll-free call. Another advantage to selling direct is the precept of selling complete *systems*, rather than individual products, for process measurement and control. Omega's diverse product offerings can be interrelated, allowing convenient monitoring of various process variables. The current Omega handbooks and encyclopedias include the following categories.

• **Heater products** — Strip, immersion, cartridge, band, nozzle and radiant heaters, plus portable space heaters, are available in the "Electric Heaters Handbook." This handbook, designed to meet a broad range of heating requirements, also covers self-regulating and constant-wattage heating cables, connectors and accessories. For customers who need help in specifying heating products, this handbook contains a comprehensive technical reference guide.

• **Data acquisition products** — The Omega "Data Acquisition & Computer Interface Handbook" offers hundreds of products, from software to complete data acquisition systems. This invaluable reference includes an introductory demonstration diskette that introduces Omega's capabilities in data acquisition systems. Major sections include data acquisition and engineering software, communications-based acquisition systems, plug-in cards, data logging systems, and industrial process controls. All pricing, technical data and ordering information have been included for easy product selection.

• **Temperature products** — The Omega "Temperature Measurement Handbook" is the leading source for temperature measurement and control products. Covering all aspects of temperature measurement and control, every product is shown with complete specifications and pricing. In addition to advances in infrared and cryogenics, many new products have been added, including economical hand-held indicators, intelligent panel meters, controllers, recorders and data acquisition devices. An expanded index and more complete product information makes locating products faster and easier.

• **Pressure, strain and force products** — The Omega "Pressure, Strain and Force Handbook" has the latest products and solutions for process industry and laboratory measurement and control needs. New this year are sections on state-of-the-art transducers using sputtered semiconductor technology to produce superior accuracy and stability at bonded strain gauge costs; new miniature load cells, smaller than a dime, that will measure up to 1,000 pounds; and helpful technical articles covering the new commercial scale codes and basic strain gauge applications. Expanded selection guides help speed product selection and make the handbook easier to use.

• **Flow and level products** — The Omega "Flow and Level Handbook" offers hundreds of products from purge rotameters to magnetic flowmeters on up to sophisticated computer data acquisition systems. Some of the new expanded product offerings include all plastic rotameters and paddlewheel flow sensors for corrosive and ultrapure liquids; low-cost, wafer-style magmeter; new air-velocity, hand-held and industrial flow switches; portable, clamp-on, ultrasonic meters for clean liquids; positive displacement meters for viscous liquids; and RF/capacitive level switches for liquids and solids. A comprehensive

reference guide and expanded technical articles help make this an invaluable reference.

• **pH and conductivity products** — The Omega "pH and Conductivity Handbook" offers hundreds of products from pH electrodes to sophisticated data acquisition systems. Major product sections include field service products, laboratory instrumentation, electrodes and accessories, industrial control systems and auxiliary equipment. Some of the new expanded product offerings include pH/ORP controllers, microprocessor-based proportional pH controllers, chemical metering systems, pH/conductivity meters, dissolved oxygen meters, conductivity and pH transmitters, metering pumps, industrial pH and loop calibrators.

See our ad on page 1.

Thomson Consumer Electronics Distributor and Special Products

2000 Clements Bridge Road
Deptford, NJ 08096-2000
800-257-7946
Fax: 609-853-2231

Two of the most recognizable trademarks in the consumer electronics business are RCA and GE. Both represent a long and proud tradition of customer satisfaction and leading edge technology. That tradition is carried on today at Thomson Consumer Electronics' Distributor and Special Products operation in Deptford, NJ. Offering exact replacement parts for RCA and GE consumer electronics products is a major part of the business. Distributor and Special Products provides parts support to more than 7,000 authorized RCA and GE ServiceCenters plus thousands of after-warranty servicers located throughout the United States through its extensive distributor network.

These authorized distributors stock and maintain inventory levels based on Thomson's IMP parts stocking program. The IMP program identifies the most commonly used parts and recommends an adequate stocking level to meet demand. Orders for all items can be placed via toll-free telephone, fax or by using the "Instant Access" system. Distributors with "Instant Access" computer software provided by Thomson can place orders directly into the system and check stock, pricing and delivery status. Distributors can request a Blue Ribbon or Emergency order and have their orders shipped overnight.

Also, Distributor and Special Products offers a line of replacement semiconductors. SK semiconductors replace more than 217,000 original devices, and the recently published SK Cross Reference Guide contains a 329-page cross-reference section to make finding the replacement device easy. SK devices cover a variety of discrete devices and integrated circuits for consumer and industrial applications. Included in the SK line are thyristors, transistors, rectifiers and optoelectronics microprocessors. The new guide also contains expanded specifications in the discrete devices charts.

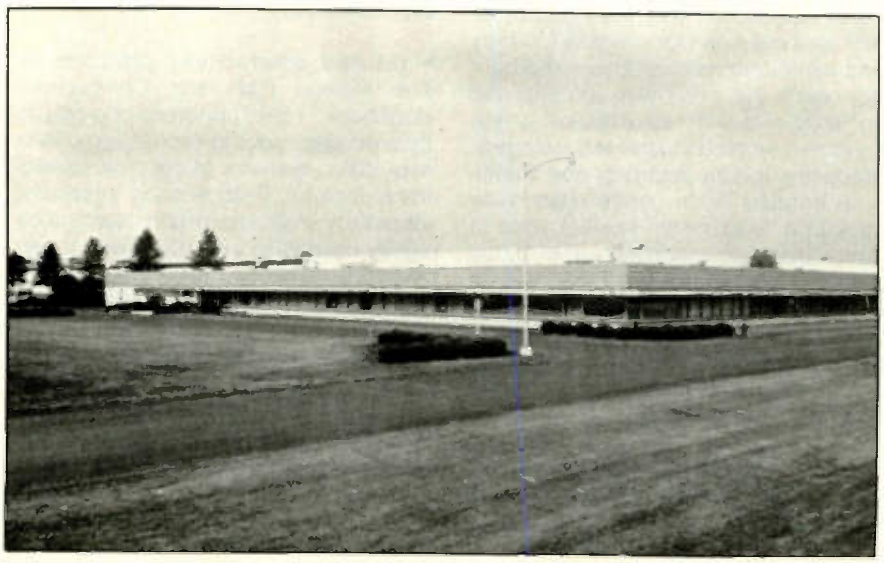
In addition to replacement semiconductors, Distributor and Special Products offers rapid delivery of small quantities of semiconductors and discrete devices produced by major manufacturers. This JEDEC/Generic line includes products from Harris, Fagor, International Rectifier and Powerex.

Another important reference book produced by Distributor and Special Products is the new VCR Key Items Cross-Reference. This comprehensive, 120-page guide provides the servicer with a quick reference source of key wear items, such as belts, motors, pressure rollers and headwheels for nine different VCR brands: GE, RCA, Hitachi, Magnavox, Panasonic, Philco, Philips, Quasar and Sylvania. Listing more than 900 models, the guide contains references to 90% of a servicer's parts needs for these brands. The VCR Key Items Cross-Reference provides the servicer with the Thomson stock number, as well as a reference number corresponding to the number shown on the service data parts list and on the exploded view diagram of the VCR model listed.

Another publication that Distributor and Special Products offers servicers is the 1990 edition of the RCA and GE Remote Controls Catalog. This catalog contains all available direct replacement remote control hand units for RCA and GE televisions, video recorders, videodisc players, camcorders and audio components. The catalog is divided into three sections: One section contains more than 220 photos to aid in identifying the correct remote. The two other sections contain cross-reference material in model number sequence and in remote type number sequence.

Thomson Consumer Electronics' Distributor and Special Products operation provides service from a 358,000-square-foot facility with all aspects of the business located there — customer service, sales and marketing, quality assurance, product analysis, administrative departments, and warehousing. Some parts are also stocked in a satellite warehouse in El Paso, TX. Technical support is available, as is identification for distributors who cannot locate this information in the company's technical literature.

Other product lines at Distributor and Special Products include RCA and GE video accessories, GE audio accessories, RCA and GE videotape and GE audiotape. Picture tubes, surge suppressors, anti-static kits and service aids are also marketed from this operation. The business is managed by Dennis D. Edson, general manager. Thomson Consumer Electronics corporate headquarters is in Indianapolis, where several TV manufacturing facilities are located.



At Thomson Consumer Electronics, we've written four best sellers covering replacement semiconductors and parts.

VCR Key Items Cross-Reference.
READ this to locate the RCA & GE replacement part numbers for over 90% of the parts most frequently used in over 900 VCR models. Ideal for one-stop shopping. Less hassle, too, since the reference is set up by the manufacturer and the model number.

SK Series Solid State Replacement Guide.
READ this to find data on over 3,000 items which replace over 217,000 solid state devices through cross-reference; also included, many replacements for discontinued items and those devices not readily available.

Remote Control Catalog.
READ this for all RCA & GE TV, VCR and audio models using remote controls; catalog includes photo reference and multiple cross-reference.

Manufacturer's Identification Microfiche.
READ this to locate the RCA & GE stock number when your only source is the original manufacturer's number; eliminates the need to refer to service data for stock numbers.

Spending hours locating replacement semiconductors and parts?

READ

Here's $5 to cover postage and handling for all four books.

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Title _____

Firm _____

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Distributor and Special Products

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1K9116

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MAT Electronics

975 Jaymore Road
Southampton, PA 18966
800-628-1118
Fax: 215-364-8554

MAT Electronics is a full-line parts distributor that gears its inventory to the TV, VCR and stereo repair industry. The company's parts are used by technicians, engineers, trade schools, hobbyists and manufacturers.

MAT Electronics stocks an extensive line of replacement accessories as well as one of the largest selections of semiconductors in the nation.

The company publishes an easy-to-read, 32-page catalog with thousands of items, all of which are inventoried in the company's computer, enabling customers to check availability within seconds.

With its huge overseas imports, as well as domestic sources for components, the company is always current with the industry — always emphasizing what is new in electronics components — for VCRs, TVs and stereos.

MAT Electronics takes great pride in its ability to accommodate the varied needs of all of its customers. The company normally ships within 24 hours of your order; however, it offers UPS red and blue labels to ensure even faster delivery service if it is needed.

The company has friendly and knowledgeable telephone operators waiting to take your phone call and courteously deal with any questions you may have about any electronic part — even if you don't see it in the catalog, ask for it!

MAT Electronics knows that there are certain risks involved in mail-ordering certain components, and that is why the company guarantees 100% of all products for 90 days from purchase date. Volume discounts are always available. The company's toll-free lines are open now and waiting for your phone call. Just call 800-628-1118.

VCR PARTS

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TOSHIBA RF Modulator MSU-911/MSU-951	17.95 Ea.
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RCA Idler Original 164113	3.25 Ea.
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RCA End Sensor 161757	10/For 8.50
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Chamois Cleaning Swabs (10 per pack) 144589	2.50 Ea.
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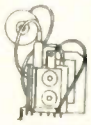

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100MFD/63 Volts	Radial	20 For 10.00
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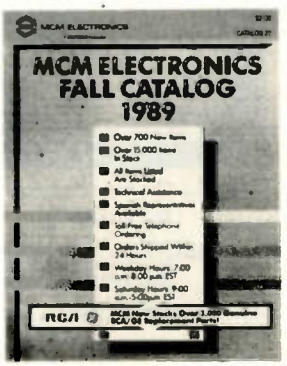

SOURCE NO. ES-51

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800-338-0531
Fax: 513-222-4644

Parts Express, a full-line distributor of electronics parts and accessories, is geared toward the consumer electronics repair industry, manufacturing design and engineering, and the technical hobbyist. The company stocks an extensive line of speaker drivers and accessories for replacement, plus one of the largest selections of semiconductors in the country. The company offers a free 100-page catalog, listing more than 5,000 popular items, and its extensive computer inventory-control system allows it to monitor each item and ensure that it is in stock when you need it.

With overseas and domestic sources for parts and an aggressive new-product research team, Parts Express keeps in touch with the needs of the industry. The company can supply replacement parts for the newest TVs, VCRs and stereos as those products are introduced to the market, and it can special-order nonstocked items for volume users.

The company prides itself on being flexible, and it makes every effort to accommodate special requests. The company normally ships within 24 hours, and most orders received before 1 p.m. EST are shipped the same day. Unlike some companies, Parts Express' service doesn't stop there. The company understands that you aren't always sure what you're getting when you order from a catalog, so it has taken the risk factor out of mail-order. If you are not satisfied with any item you've purchased, you can return it within 15 days for a refund. No questions asked, no restocking fee.

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Herman Electronics

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Miami, FL 33142
800-327-8378
Fax: 305-634-6247

Herman Electronics is a diverse, full-line distributor of everything in electronics. Over the past 40 years, the company has acquired many major lines in order to provide better service to all phases of the electronics industry.

Herman Electronics' product base varies from transistors to satellite antenna systems, including all types of batteries; audio, video and telephone accessories; cable; connectors; capacitors; semiconductors; test equipment; speakers; tools; transformers; line conditioners; relays; antennas; chemicals; audiotape and videotape.

The parts department, at the heart of the business, has several sales representatives to serve your needs from 6:30 a.m. to 5:30 p.m. (EST) Monday through Friday and from 6:30 a.m. to 12:30 p.m. (EST) Saturday. Whether your request is for pricing, stock availability or research, the company's toll-free lines and 24-hour fax lines are readily available to fulfill all of your requests. Herman Electronics uses a state-of-the-art parts distribution computer system, enabling the sales representatives to provide efficient, effective and professional service and to assure that the part is in stock when you need it.

Herman Electronics is a factory-authorized, original replacement parts distributor for Sony, General Electric, Quasar, Samsung, Panasonic, Technics and RCA, catering to the consumer and industrial parts clientele. Stocking one of the largest and most comprehensive inventories, the company fills approximately 80% of its orders out of its 12,000 stocking items. All in-stock orders placed before 1 p.m. (EST) are shipped the same day — guaranteed.

The company has always prided itself on being flexible and accommodating to its customers' requests. "We realize that there are many good distributors throughout the country," says Jeffrey A. Wolf, national sales manager and son of one of the company founders. "It is our job to be better by taking that extra step in giving our customers professional, personalized service. Our industry has clearly become predominantly service-oriented; therefore, we are committed and dedicated to maintaining a standard of excellence in servicing our clientele."

The company provides several key fringe benefits that makes its service and customer satisfaction one of the best in the business. Herman ships all out-of-state orders UPS second-day at no extra charge to the customer. Individual computerized monthly back-order reports are provided upon request, and the company makes its toll-free lines available for research requests. Herman basically does whatever it takes to achieve ultimate customer satisfaction.

Herman Electronics also offers several shipping alternatives, including overnight service and drop shipments. The company offers customers many payment options, including a Net 30 open account (based on credit approval), MasterCard, Visa, American Express or C.O.D. The company has a $15 minimum order.

Call Herman Electronics toll-free at 800-327-8378 (in Florida, 800-432-4357) and see how the company is constantly working harder to serve you better.

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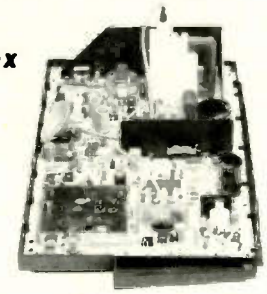

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PTS 5233 S. Hwy. 37 Bloomington, IN 47401 800-333-PTS-1 Fax: 812-824-2848

PTS is the world's largest independent supplier of exact replacement parts for all makes and models of TVs and VCRs.

Exact is the key word. The company takes pride in its expansive inventory: literally thousands of TV modules and tuners, as well as VCR heads, idler assemblies and belt kits. Standards are precise and exacting. All parts meet or exceed manufacturers' specifications.

Ordering from PTS is easy and quick. There's a toll-free number (800-333-PTS-1) for placing orders, and turnaround time is swift. Orders received before 2 p.m. are shipped the same day. Customers who request shipment via Federal Express pay as little as $2 more than UPS surface rates. That ensures next-day delivery to your place of business. PTS also accepts Visa and MasterCard.

There's another cost advantage. "Our prices represent savings of up to 40% from manufacturers' list prices," says Jeff Hamilton, executive vice president. "We believe that our easy ordering and quick delivery system, the precision quality of our parts and modules and our pricing structure make PTS really the only choice when it comes to repair parts and modules for consumer electronics."

PTS stands behind what it sells. Phil Collier, Bloomington plant manager, says, "Every item in our inventory is guaranteed to be an exact replacement and is covered by the best warranty in the business."

The PTS inventory is so vast that back orders for most parts are virtually unheard of. "We know you need parts in a hurry, and we are committed to filling your order immediately," says Collier. Helping to meet that commitment are the professionally trained PTS customer service representatives and a nationwide network of stocking distributors. When you request a part, they know what you're talking about.

But PTS is not just a company of order-takers. Engineers and factory-trained technicians make up a great portion of the staff. It is they who monitor the quality-control standards demanded by thousands of professionals nationwide who order from PTS.

PTS also offers remanufacturing and repair services. Television tuners and modules are restored to original condition quickly and efficiently. On those rare occasions when a module is out of stock, the PTS technical staff will rebuild the defective part.

A new component of the PTS business is a complete remanufacturing service for computer disk drives and computer monitors. This work is guaranteed to meet or exceed manufacturers' specifications. Precision quality is demanded in all of PTS' varied operations. Other rebuilding services include TVRO equipment, VCRs, camcorders and appliance touch-control panels.

This repair/remanufacturing aspect of PTS is a rapidly growing part of the company's business. But the company has built its reputation on providing service technicians with all makes and models of quality, exact replacement parts for TV repair with overnight service.

Nancy Stewart, customer service representative, says, "We have worked extremely hard to establish the kind of a replacement-parts service that the industry can rely on and believe in. That's why we have been so intent on developing this company into what we call the 'world's largest independent supplier of exact replacement parts.'"

The response to the toll-free number has exceeded the company's expectations. "It's been fantastic," Stewart says, adding, "We're pleased to know that PTS products are in such great demand and that our parts are held in such high esteem by the nation's consumer electronics service stations."

PTS has had a phenomenal growth in the 20 years since its founding in a converted garage in Bloomington, IN. From that humble beginning, it has expanded to a network of computerized warehouses, state-of-the-art manufacturing facilities for the repair and remanufacturing processes, and a modern, well-equipped office where orders are taken and processed. The company now employs 550 people.

PTS operates product and service outlets at other strategically located sites in Tampa and Sarasota, FL; Arvada, CO; Longview, TX; Cherokee, NC; Fenton, MI; Fife, WA; Schenectady, NY; Ventura, CA; and West Columbia, SC.

Thus, the PTS system of exact replacement parts is readily accessible to electronics service professionals from coast to coast. Call between 8 a.m. and 5 p.m. (EST) Monday through Friday and from 8 a.m. to noon Saturday.

3063

PROFAX Manufacturers schematics

APRIL 1990

HITACHI
G7XU2/3
CHASSIS
COLOR TV

BASIC CIRCUIT DIAGRAM
CT2087B/W

Product safety should be considered when component replacement is made in any area of a receiver. Components marked with a ! and shaded areas of the schematic diagram designate sites where safety is of special significance. It is recommended that only exact cataloged parts be used for replacement of these components.

Use of substitute replacement parts that do not have the same safety characteristics as recommended in factory service information may create shock, fire, excessive x-radiation or other hazards.

This schematic is for the use of qualified technicians only. This instrument contains no user-serviceable parts.

The other portions of this schematic may be found on other Profax pages.

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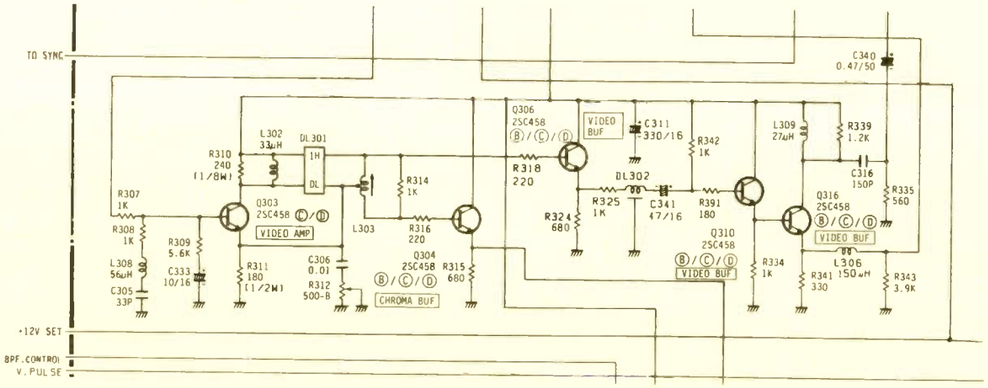
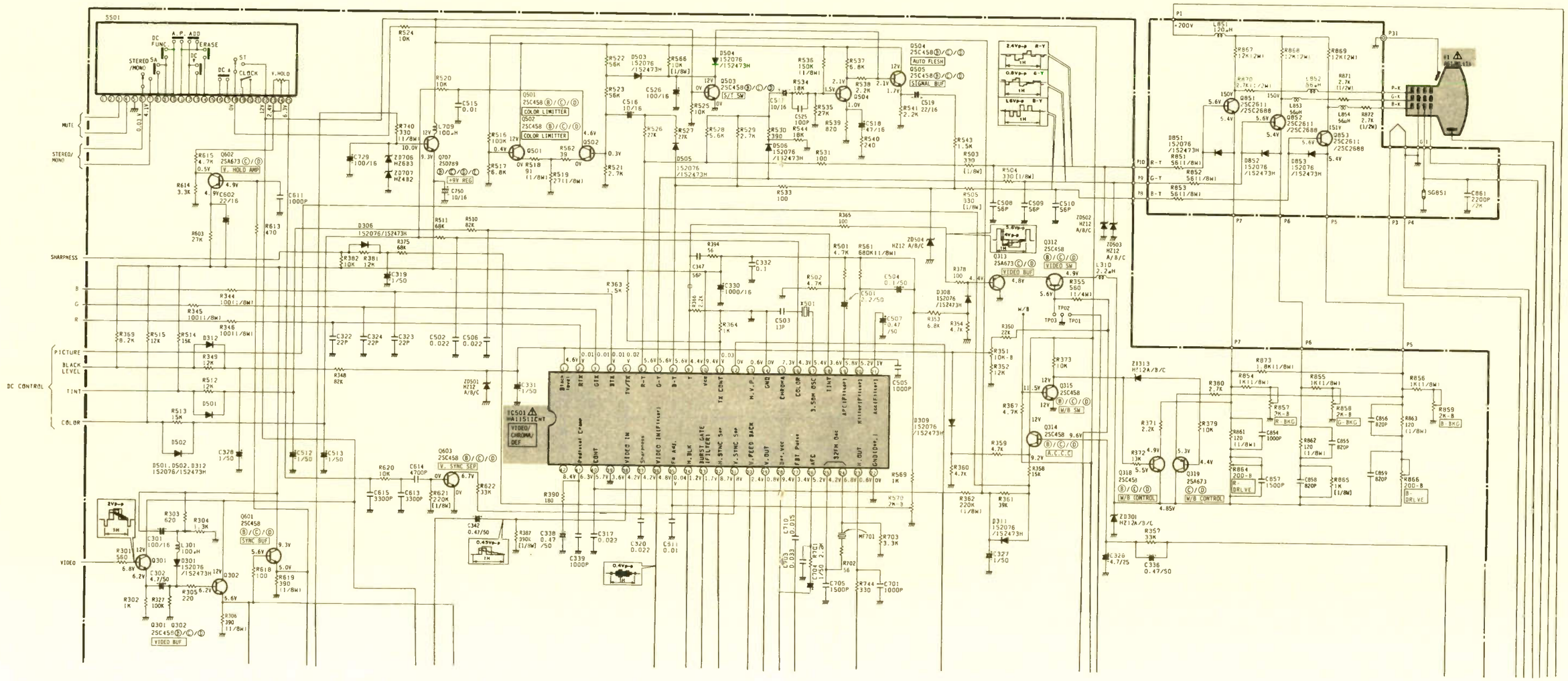
MODEL A087 VARIATION
C7XU2 CHASSIS



NOTE: The model A087 is similar to the CT2087B/W, with some variations. The G7XU3 chassis is similar to the G7XU2 chassis shown here.



BASIC CIRCUIT DIAGRAM
CT2087B/W

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Manufacturers schematics PROFAX 3063

BASIC CIRCUIT DIAGRAM
CT2087B/W

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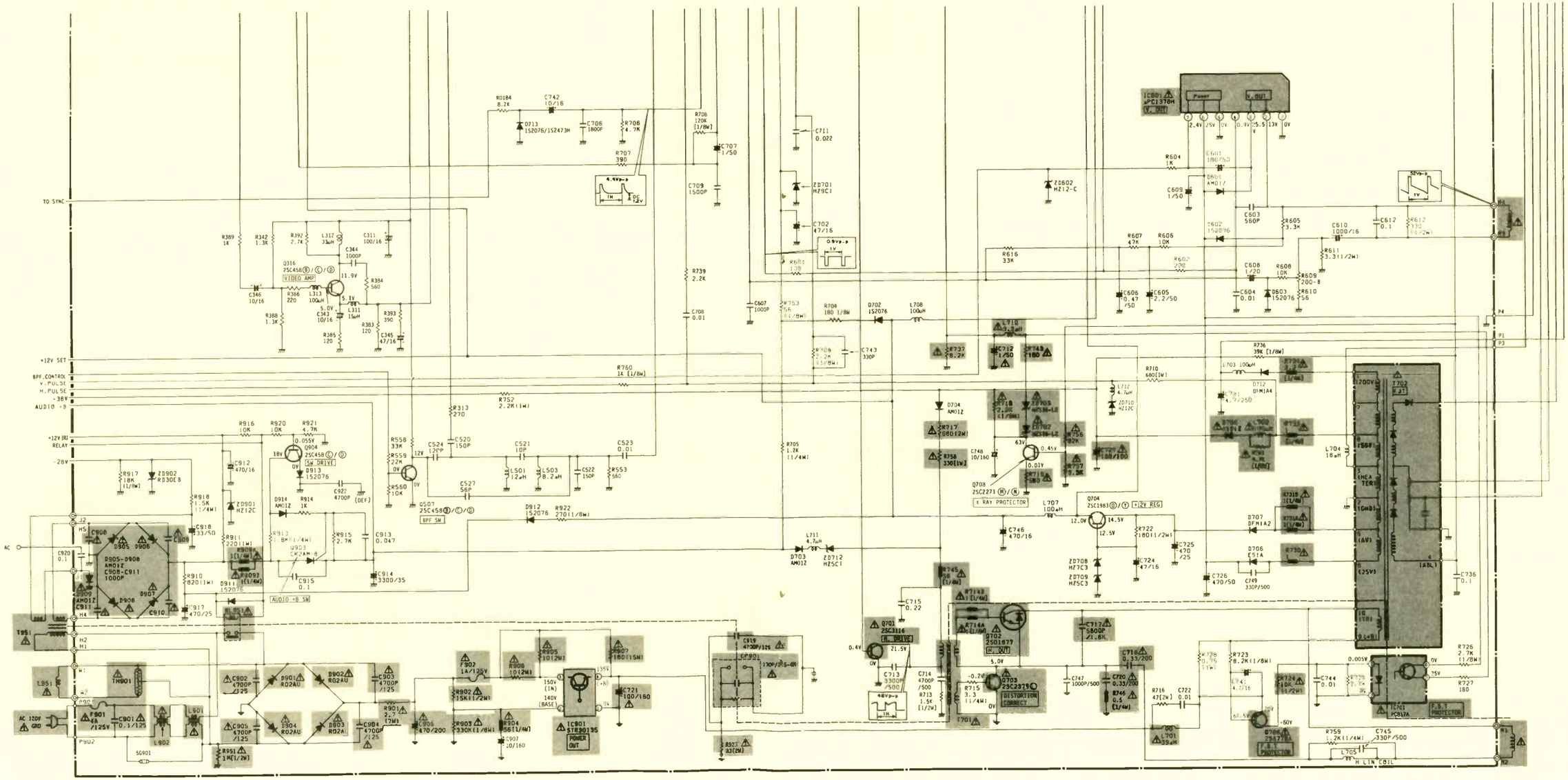
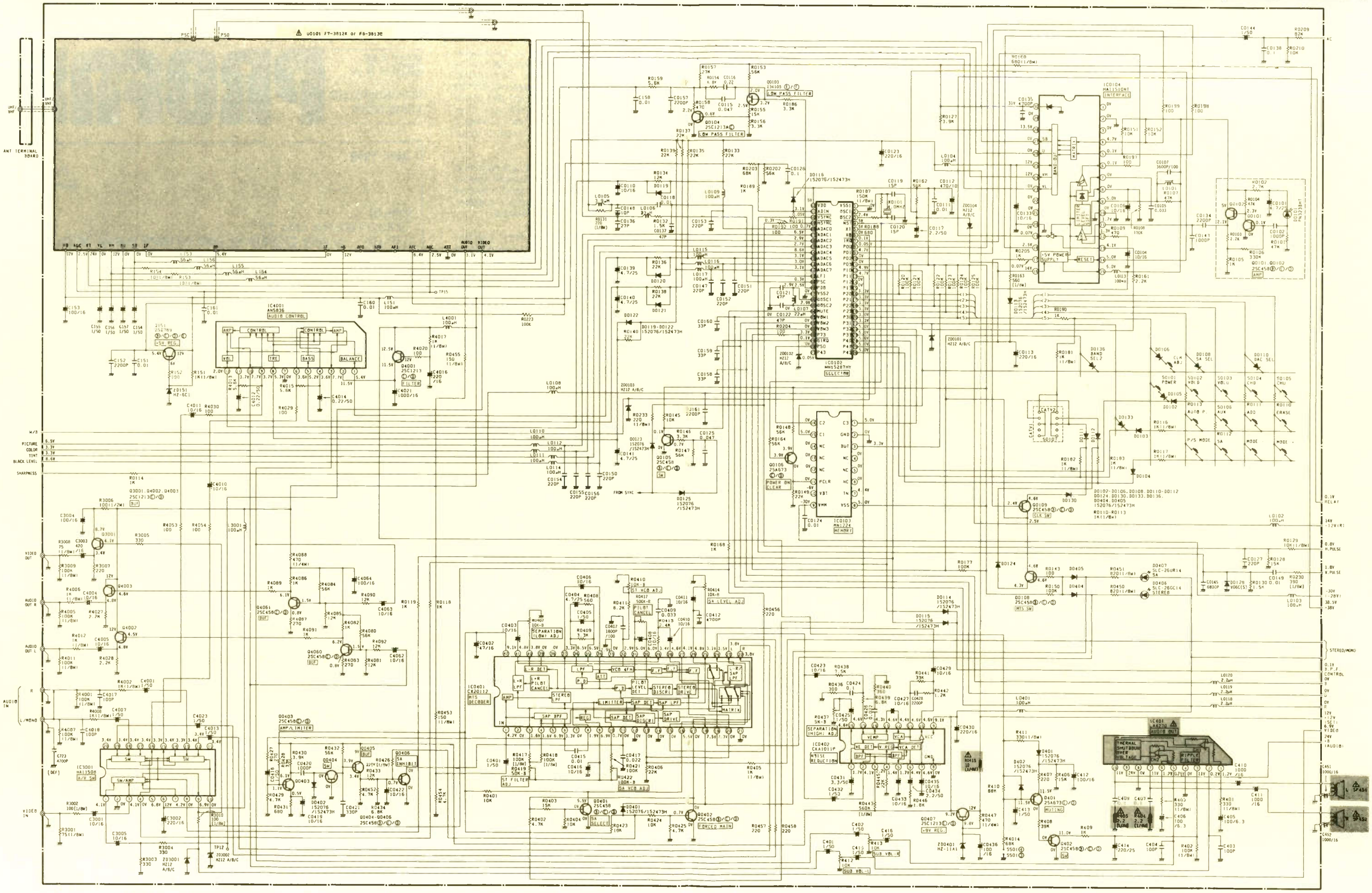


BASIC CIRCUIT DIAGRAM
CT2087B/W

es&t Manufacturers' schematics PROFAX 3063



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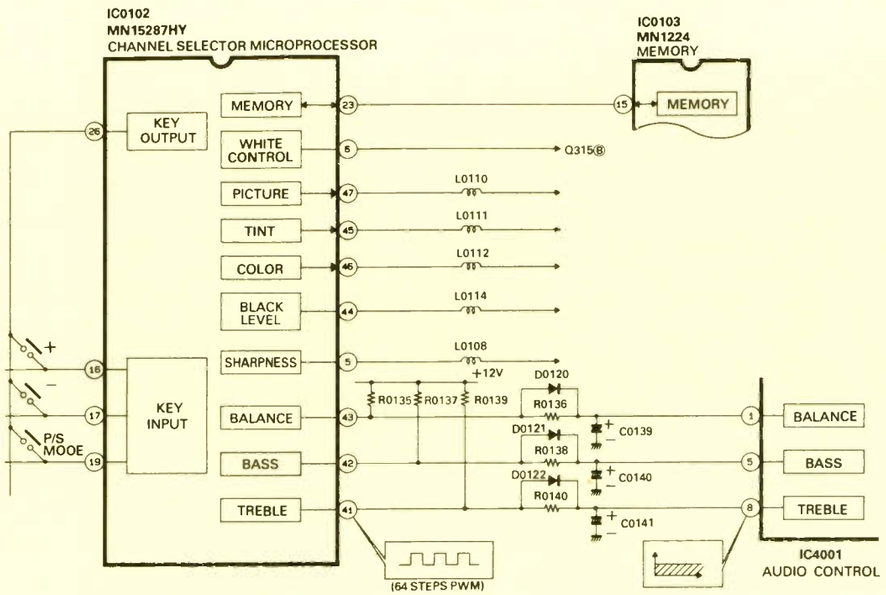
COLOR COORDINATE CONTROL CIRCUIT
CT2087B/W



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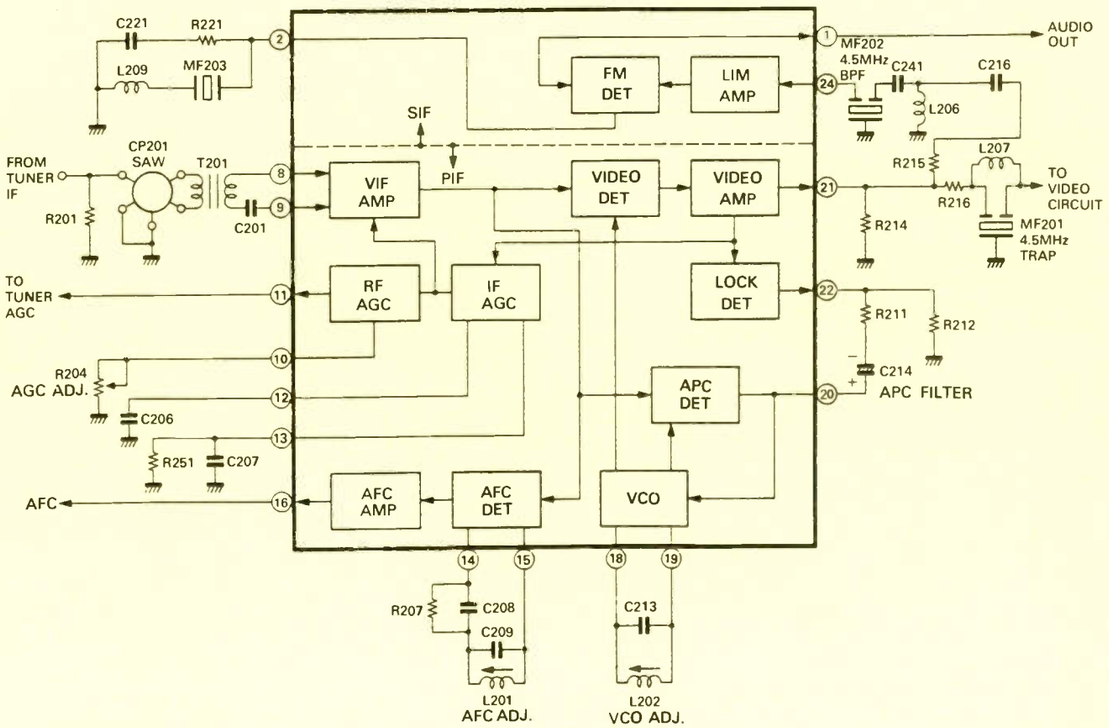
PIF, SIF AND PERIPHERAL CIRCUIT
CT2087B/W



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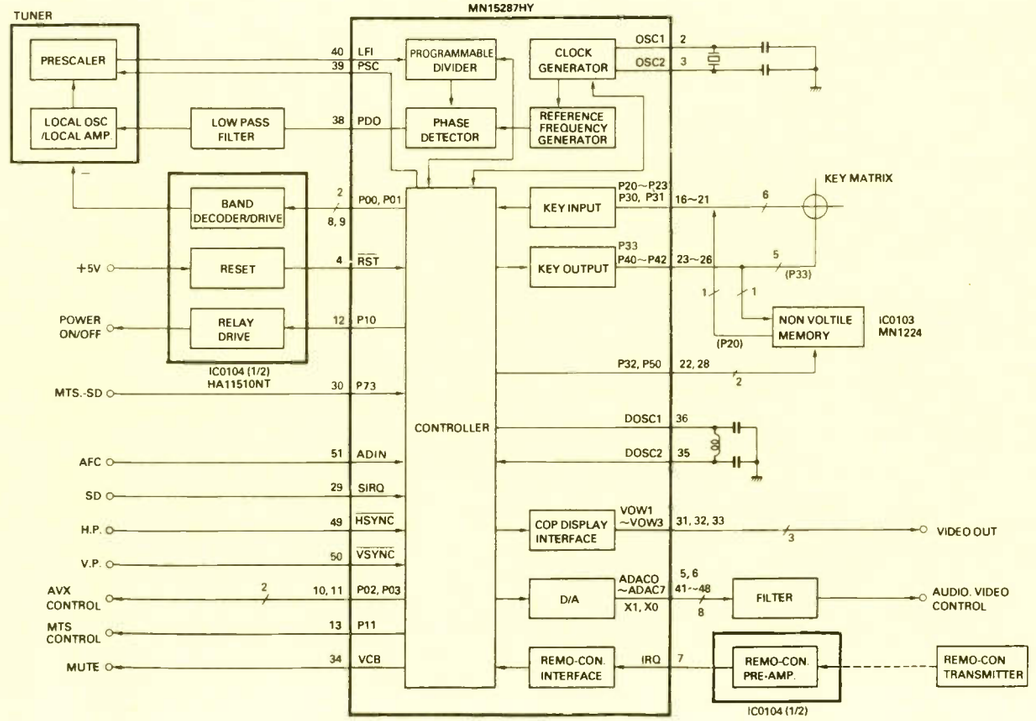
ES&T Manufacturers' schematics PROFAX

April 1990

Profax Number

Hitachi
G7XU2/3 chassis color TV 3063
(G7XU2 — models CT2087B/W, A087 (MT2870 through MT2878)
(G7XU3 — models CT2088B/W, A088 (MT2880, MT2886, MT2887)

CHANNEL SELECTION CIRCUIT
CT2087B/W



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THE MAGAZINE FOR CONSUMER ELECTRONICS SERVICING PROFESSIONALS

ELECTRONIC
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EIA offers VCR workshops

The Electronics Industries Association (EIA) is offering free hands-on workshops for basic VCR servicing. These week-long workshops are conducted by EIA-trained instructors. Technicians must be employed in private industry by consumer electronics sales and/or service organizations. Requests must be on company letterhead and mailed to Product Services, EIA/CEG, 2001 Eye St. N.W., Washington, DC 20006.

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Chicago
April 30-May 4
Aug. 27-31
Video Technical Institute
Los Angeles
April 30-May 4
July 30-Aug. 3
Oct. 1-5

EIA hosts standards meeting

The standardization of home automation and other information technology interfaces will be the focus of an international standards meeting held in Las Vegas following the January 1991 International Winter Consumer Electronics Show. Approximately 100 delegates from across the United States, Europe and Japan are expected to attend the meeting, hosted by the Electronics Industries Association (EIA).

For more information, contact the EIA at 2001 Eye St. N.W., Washington, DC 20006; 202-457-4919. ■

Continued from page 14.

only in long-distance telecommunications, but within local area networks (LANs). In some cases, high-frequency signals are routed within instruments via fiber-optic cables because optical cables don't generate electrical or magnetic radiation and are not susceptible to this radiation.

Fiber optics also are generally physically smaller than their electrical counterparts. As frequency response of optical components continue to improve, so will the popularity of fiber optics.

Observing and measuring signals in fiber-optic cables requires a special interface or an optical, rather than electrical, input connector. Future scopes may have optical input connectors built in.

Another feature of future scopes will be the capability to share information over long distances. Troubleshooting in the field will get easier because the service technician will be able to send and receive waveforms over long-distance phone lines.

In many cases, a waveform is a "signature" of a specific failure mode, and a large database of these failure-mode signatures can be stored on a central computer system for all service technicians to use for comparison.

It used to be that new technology was concentrated in product design areas. Today, and into tomorrow, the focus is high-technology manufacturing. For example, more production lines will be controlled by computers linked to sophisticated sensors.

Already, the automotive industry makes extensive use of robotics. Automobile manufacturing also takes advantage of sophisticated laser optics for quality-control measurements.

Mass transportation technologies, such as linear-motor trains, continue to emerge. Control of these systems is extremely complex.

Many of today's commonplace hospital diagnostic equipment didn't even exist 10 years ago. This trend is sure to continue, with state-of-the-art electronics in hospitals and doctors' offices.

Home entertainment electronics now comes in sophisticated systems, rather than discrete, non-related components. The trend continues at an increasing rate, especially with the advent of CDs, VCRs and HDTV.

These are just a few examples of high-technology electronics in what used to be either non-electronic or low-technology areas. Today's home can have a dozen or more microprocessors in it, plus three or four more in the family automobile. Anyone who services anything will probably need some sort of diagnostic tool for microprocessor-controlled electronics in the future. Many of these tools will be DSOs.

With all of this new technology coming, better trained engineers and technicians are needed. Unfortunately, state-of-the-art test equipment is expensive, and schools always operate on shoestring budgets. To help close the training gap, many companies are getting more involved with engineering and technical schools by donating test equipment.

Once real-world, up-to-date test equipment, such as DSOs, are more readily available, new engineers and technicians will spend less time learning how to use their tools and more time improving their skills.

On-the-job training time also will continue to increase. Already, there is a trend toward much longer on-the-job training cycles for service technicians. This is most evident with high-tech products.

Becoming properly trained for the job will mean learning the products to be serviced, the tools to service them, and the methods for using the tools. Service technicians must not refuse to update their servicing methods.

The scope of tomorrow

As you've probably guessed by now, the oscilloscope of tomorrow will be a digital scope. In some ways, it will be an extension of today's digital scope: more intelligence, more memory, more capability, more ms/$, more powerful and more portable.

We've seen a tremendous increase in microprocessor computing power just in the past few years. That computing ability will increase in ability and speed, become cheaper, and consume less power in the future. Digital scopes will benefit greatly. Complex measurement and analysis of stored waveforms will be possible with even low-cost DSOs.

There will be more measurements and there will be more waveforms to measure. Memory cost-per-bit will continue to fall dramatically. Low-power, non-volatile memories will be commonplace in all portable digital oscilloscopes.

Test electronics will be much different than those in use today. Many of today's troubleshooting tools will be replaced by a single, intelligent DSO used by a highly trained professional to help properly diagnose the high-tech world of tomorrow. ■

Books

Troubleshooting and Repairing Solid-State TVs, by Homer L. Davidson; TAB Books; 453 pages; $17.95, paperback.

This book includes case studies, troubleshooting photos and circuit diagrams to teach methods of repairing solid-state TV circuitry from the major manufacturers. It describes warning symptoms of various problems and indicates the circuits and components to check out. Problems covered include faulty remote controls; defective high- or low-voltage power supplies; defective horizontal sweep circuits, turners, transistors and color processors; and brightness and picture-tube problems.

TAB Books, Blue Ridge Summit, PA 17294-0850; 800-822-8138.

Operational Amplifiers: Applications, Troubleshooting and Design; Prentice Hall; 345+ pages.

This book helps you understand the use of op-amps, how to select them for particular applications, and how to calculate the values of components that must be connected externally. The book describes the basic op-amp amplifier circuit and the 741 op-amp.

Prentice Hall, Englewood Cliffs, NJ 07632.

Electricity and Electronics, A Survey, 2nd edition; by Dale R. Patrick and Stephen W. Fardo; Prentice Hall; 560 pages.

A systems approach with very little math is used to discuss the basics of electronics, applications, testing procedures and operational aspects of equipment and devices. Definitions of terms and a review section with questions and answers are included with each chapter.

Prentice Hall, Englewood Cliffs, NJ 07632.

Electronic Devices: Discrete and Integrated; by Stephen R. Fleeman; Prentice Hall; 939 pages.

This book is targeted to give an understanding of analog, digital, microprocessor and control system fundamentals. Material is detailed enough for analysis and design of practical circuits, and background information to understand how, why and when techniques should be used are stressed. Other topics covered include solid-state physics, the p-n junction and diodes, BJTs, FETs, amplifier models and power amps, negative feedback, dc power supplies, and discrete and integrated oscillator circuits.

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Test your electronics knowledge

By Sam Wilson, CET

In this issue, a combination of word finding and vocabulary is used to test your electronics knowledge. If you don't want to take the time to hunt answers to the clue words out of the letter matrix, jot them down and check your answers against the answers on page 47.

The subject in this issue is *thyristors* and *power amplifiers*. Give the word that is defined in the clues. Find those words in the letter matrix, or go directly to the answers. Words in the letter matrix can be up and down, backward and forward or diagonal.

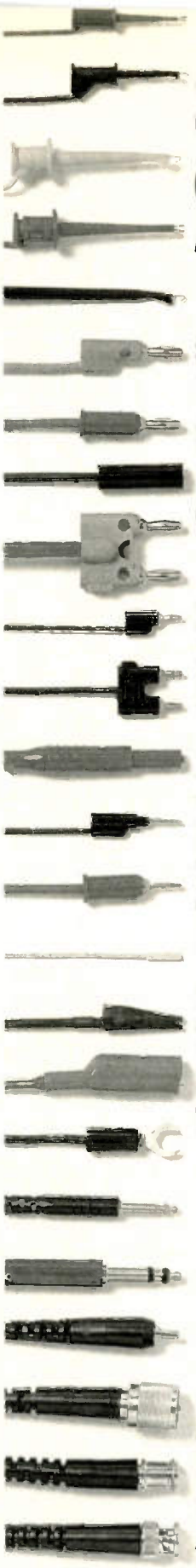
C	O	M	M	U	T	A	T	I	N	G	J
L	R	K	S	D	E	F	S	H	C	D	R
T	F	A	F	C	A	N	C	I	A	S	E
D	H	V	B	Y	H	Z	S	R	I	I	B
M	I	Y	F	W	C	O	L	V	R	D	B
J	J	A	R	F	O	I	T	A	T	E	U
M	L	W	C	A	N	R	J	T	M	C	N
S	K	B	F	G	T	L	C	E	K	N	S
U	A	P	T	O	W	R	L	D	O	Y	U
J	V	O	M	I	R	K	O	E	A	G	T
T	N	F	H	K	R	A	N	N	O	E	N
M	Y	E	L	K	C	O	H	S	I	H	P

Clues

1. Has high current gain and relatively high voltage gain.
2. Method of turning off one SCR with another SCR.
3. Gas tube equivalent of an SCR.
4. Gas tube equivalent of a 3-layer diode.
5. The intrinsic standoff ratio is set by the manufacturer.
6. Another name for a 4-layer diode.
7. Another name for a 3-layer diode.
8. An SCR that is triggered by a gate voltage rather than a gate current.
9. Has the same characteristic as a back-to-back SCR.
10. Power supply protective circuit, usually made with an SCR.
11. Prevents triggering of an SCR by transient input voltages.
12. Has two gates and can be turned on or off by gate signals.

Wilson is the electronics theory consultant for ES&T.

Answers are on page 47.



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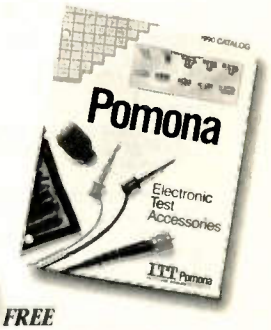

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Thyristors from A to Z

Part II: SCRs, diacs and Shockley diodes

By Bert Huneault, CET

This article is part two in a series of articles on thyristors. In this part, we will focus on diacs and Shockley diodes. In Part III, we'll look at unijunction transistors.

In Part I, we became acquainted with the properties of SCRs in dc circuits. Let's now focus our attention on SCRs in ac circuitry, where the thyristor's ability to rectify is put to good use. After all, it's called a silicon controlled *rectifier*, isn't it?

Rectifier action

We'll start with a simple circuit, that of a static-switch (line-gated), half-wave rectifier. (See Figure 1.)

With S1 open, as in Figure 1a, no gate current can flow; therefore, the SCR remains in the off state and no current flows through the load.

Next, let's close S1 and assume that line A is positive at this time. (See Figure 1b.) Gate current now flows from line B into the cathode, out of the gate, through D1, R_g, S1 and the load to positive line A. Although limited by R_g, this gate current is sufficient to fire the SCR just after the beginning of the ac cycle, effectively closing the cathode-to-anode circuit of the thyristor for virtually the full 180° of the input voltage's positive alternation. This accomplishes two things: First, the load becomes energized because heavy current now flows from line B, through the SCR and the load to positive line A; second, because the conducting SCR's anode voltage drops down to 1V or so (in relation to common line B), gate current is automatically reduced to a negligible amount during the remaining portion of the positive alternation of line voltage. Recall that gate current is no longer needed once the SCR latches on.

When the line voltage reverses in polarity, the SCR reverts back to its nonconducting state. Half a cycle later, with line A positive again, the SCR triggers back on (as long as S1 is still closed). Thus we get half-wave current through the load. The latter could be a dc motor or a heating element, for example.

Now let's open S1. If the SCR is already conducting at that instant, it continues to conduct (remains latched on until the end of the positive alternation in progress at the time). It then shuts down and the load is de-energized. Subsequent positive alternations of line voltage do not re-energize the load because gate current — necessary to trigger the SCR back on each time — cannot flow with S1 open.

Incidentally, diode D1 is simply there to protect the SCR during negative excursions of line voltage. SCRs typically have a peak reverse gate voltage rating of only a few volts (e.g., 5V). The gate-to-cathode junction would therefore break down if it weren't protected by the

Huneault is an electronics instructor and head of the REE department at St. Clair College of Applied Arts & Technology in Ontario, Canada.

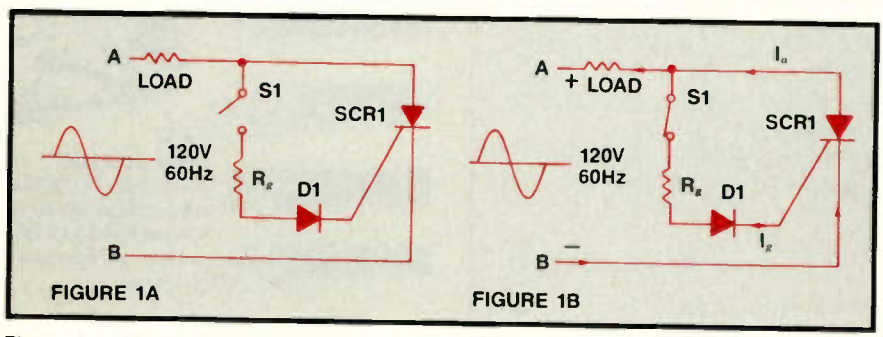


Figure 1. In this static-switch (line-gated), half-wave rectifier, when S1 is open, as in Figure 1a, no gate current can flow. The SCR remains in the off state and no current flows through the load. When S1 is closed and line A is positive (Figure 1b), gate current flows, firing the SCR and effectively closing the cathode-to-anode circuit of the thyristor for virtually the full 180° of the input voltage's positive alternation.

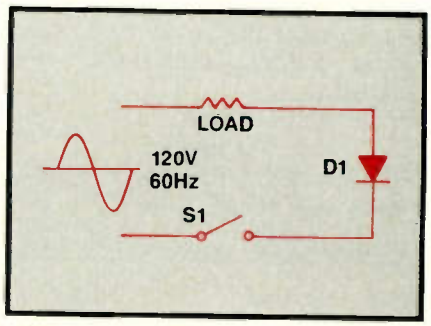


Figure 2. In high-power circuits, switch S1 would be a troublemaker because of intense arcing each time its contacts open and close. In a static-switch, half-wave rectifier, S1 does not interrupt the main load current.

series diode. A small silicon diode with a PRV rating of 200V or 400V is all that's necessary to prevent reverse gate current even during the peak of negative line voltage.

What's the point?

OK, so we've seen how this static-switch, half-wave rectifier works. But isn't that circuit some kind of overkill? Couldn't we achieve the same results with just a simple half-wave rectifier diode, as in Figure 2? After all, the SCR doesn't have the ability to *control* the amount of current flowing through the load in Figure 1. S1 can only switch the SCR on or off. As long as S1 is closed, the full amount of half-wave current (determined by Ohm's law) flows during each cycle. S1 can do the same in Figure 2, so why bother with Figure 1?

The answer lies in the switch itself (S1). In low-power circuits it really wouldn't matter; therefore, the lower-cost circuit in Figure 2 would be in order. But in high-power circuits (with loads of hundreds of amps), switch S1 would be a troublemaker in Figure 2 because of intense arcing each time its contacts open and close. The large, costly switch would require frequent maintenance and/or replacement. In Figure 1, on the other hand, S1 does not interrupt the main load current; it only switches milliamps of gate current and should, therefore, enjoy long, trouble-free service.

So you can see that the SCR, in effect, is a fast, solid-state relay featuring

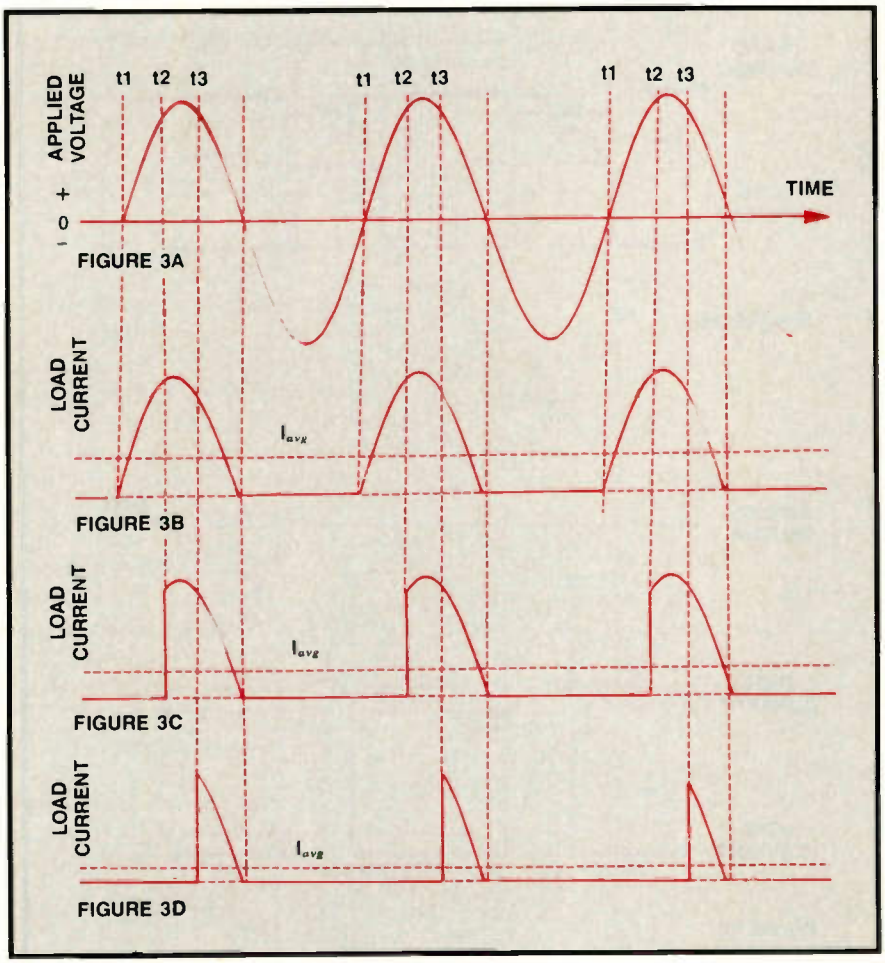


Figure 3. Varying the duty cycle of the SCR controls the average value of anode current. If a trigger pulse of ac voltage is applied so that the SCR is allowed to fire at time t1, the thyristor conducts for the entire duration of the positive alternations, resulting in a maximum value of average load current (Figure 3b). If the trigger pulse is delayed until time t2, there will be a shorter conduction period, reducing the average value of load current (Figure 3c). Delaying the trigger voltage until time t3 causes a further reduction in duty cycle and a corresponding reduction in average load current (Figure 3d).

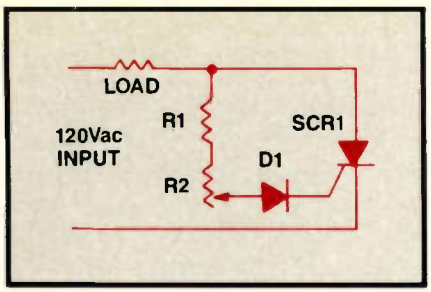


Figure 4. A variable-resistance circuit controls the firing angle from approximately 0° to 90°. If R2 is adjusted for maximum resistance, gate current may never be sufficient to turn on the SCR; thus the load is turned off. As R2's resistance is decreased, gate current eventually reaches sufficient amplitude to trigger the SCR.

no moving parts and suffering from no contact bounce, no arcing, no pitted contacts. And it needs only a small amount of control power (gate current) to switch loads of hundreds or thousands of watts. Not a bad widget, huh?

Controlling average load current

In this section, we'll investigate an important advantage of the SCR: It is a *controlled* rectifier. The gate provides the means of adjusting the current smoothly over the full range from zero to the highest amount that can flow through the load.

Recall that once the SCR has fired, its gate has no control over the anode current. It's obvious that the thyristor cannot *vary* the amount of current flowing through the load during the rest of the ac cycle. However, the gate voltage can determine whether anode current flows at any particular moment.

For example, if a trigger pulse of ac voltage is applied to the gate in such a way that the SCR is allowed to fire at the beginning of each positive half-cycle of input voltage (at time t1 in Figure 3), the thyristor conducts for the entire duration of the positive alternations, resulting in a maximum value of average load current. (See Figure 3b.)

On the other hand, if we delay the application of ac gate firing voltage or trigger pulse — by means of a suitable phase shift or timing current — until time t2, there will be a shorter conduction period, reducing the average value of load current (lower duty cycle), as shown in Figure 3c.

Delaying the trigger voltage even further, until time t3, causes a further reduction in duty cycle and a corresponding reduction in average load current. (See Figure 3d.)

So, by varying the duty cycle of the SCR, we can smoothly control the average value of anode current. This capability has practical applications in lamp-dimmer and heat-control circuits and motor-speed control, to name a few. For example, if the load is the armature of a dc motor, controlling the average current through it varies the speed of the motor. The lower the current, the slower the speed.

There are many types of firing circuits. Some use variable resistance or R-C phase shifting networks to delay the signal applied to the gate; others use magnetic amplifiers (saturable reactors), diacs, unijunction transistors (UJTs) or

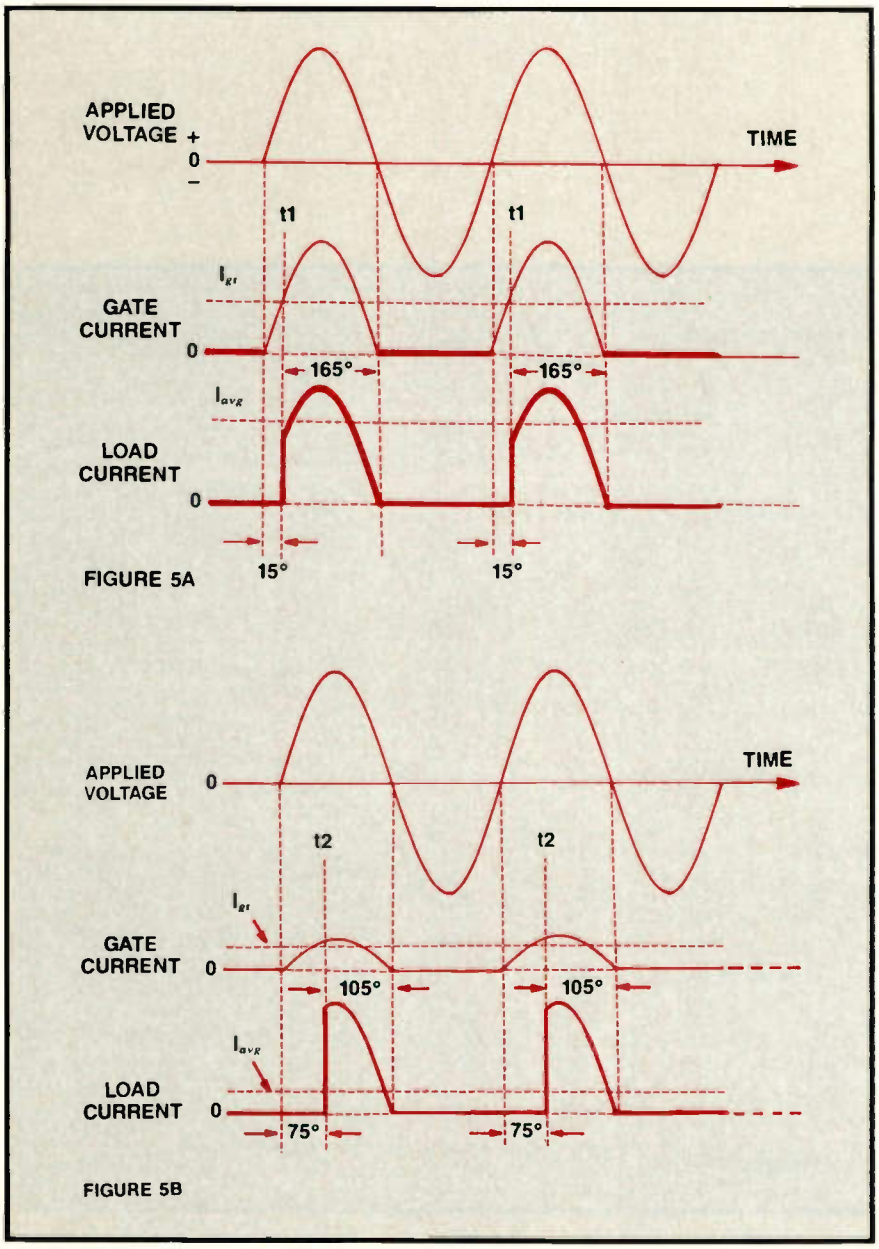


Figure 5. In Figure 5a, a relatively high amplitude of gate current causes the triggering level (I_{gt}) to be reached at time t1, at a phase angle of about 15°, resulting in about 165° degrees of conduction in each cycle and a fairly high value of average load current. In Figure 5b, the amplitude of gate current has been reduced by increasing the resistance of R2. The gate current doesn't reach the triggering level until time t2, which results in a firing angle of about 75° degrees (conduction angle of 105°) and a lower value of average load current.

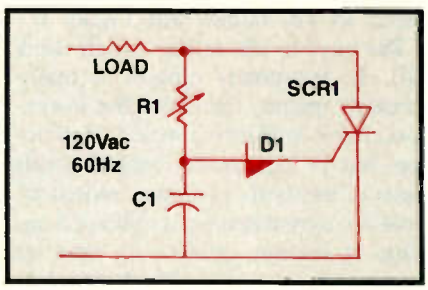


Figure 6. With the addition of an R-C phase shift circuit, up to 90° of phase delay is gained. C1 charges through R1, delaying the triggering of the SCR. An increase in the resistance of R1 increases the firing angle up to 180°, at which point the thyristor remains off and no current flows through the load. Reducing the resistance of R1 allows C1 to charge more rapidly, triggering the SCR earlier and increasing the SCR's conduction angle and power in the load.

other devices to provide the necessary triggering pulses of gate current. But regardless of the type of control circuit used, the principle remains the same: The average value of load current is controlled by the *firing angle* of the SCR — the phase angle of applied ac voltage at the instant firing takes place.

Half-wave variable resistance phase control

Figure 4 illustrates a variable-resistance circuit capable of controlling the firing angle from approximately 0° to 90°. The gate circuit resistance (R1 and rheostat R2 in series) determines the magnitude of gate current during the positive portion of the input voltage. If R2 is adjusted for maximum resistance, gate current may never be sufficient to turn on the SCR; thus the load is turned off. But as R2's resistance is decreased, gate current eventually reaches sufficient amplitude to trigger the SCR, at some point between 0° and 90° of phase.

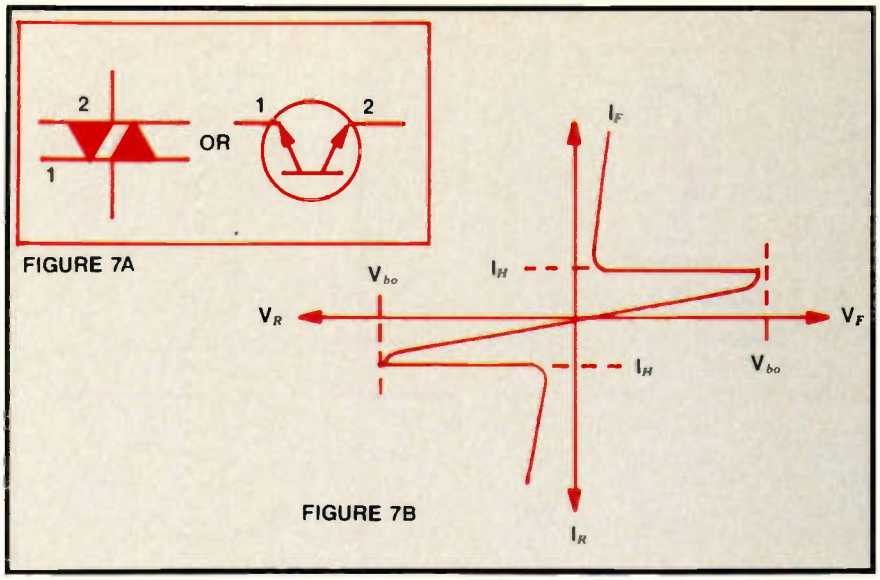
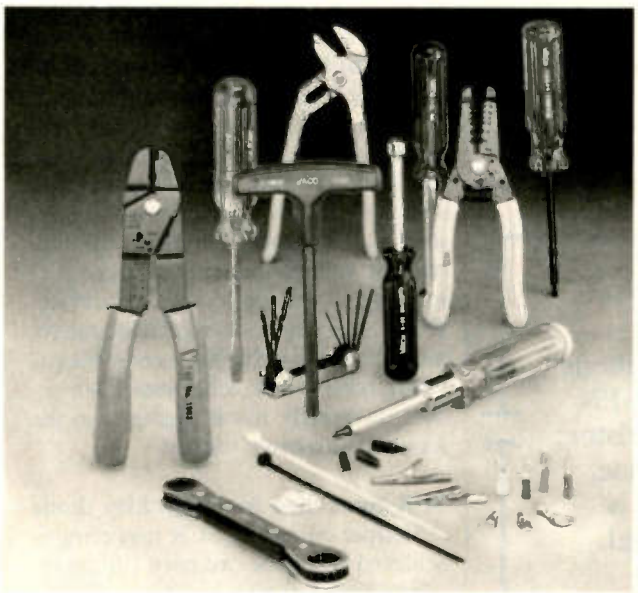


Figure 7. Some SCR gate triggering circuits feature diacs (Figure 7a) for more positive, accurate control of the thyristor's firing point. When a voltage of either polarity is applied across the multilayered semiconductor device, only a negligible amount of leakage current flows, as long as the potential difference doesn't reach the breakover voltage (V_{bo}). When voltage reaches V_{bo}, avalanche occurs. Current then flows easily through the device. To turn off the diac, the current must be reduced below the minimum holding value (I_H), shown in Figure 7b.

For example, in Figure 5a, a relatively high amplitude of gate current causes the triggering level (I_{gt}) to be reached early in the positive alternation (at time t1): i.e., at a phase angle of about 15°. This results in about 165° of conduction in each cycle and a fairly high value of average load current.

In Figure 5b, the amplitude of gate current has been substantially reduced by increasing the resistance of R2. Consequently, the gate current doesn't reach the triggering level until time t2. This results in a firing angle of about 75° (conduction angle of 105°) and a lower value of average load current.

To sum up the operation of the circuit in Figure 4, the power in the load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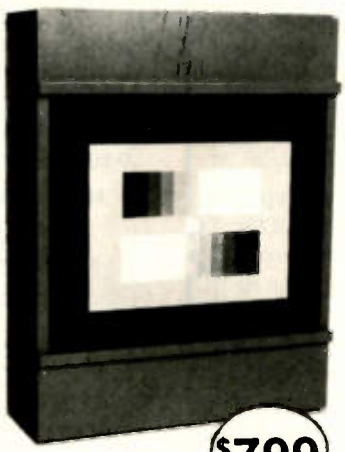

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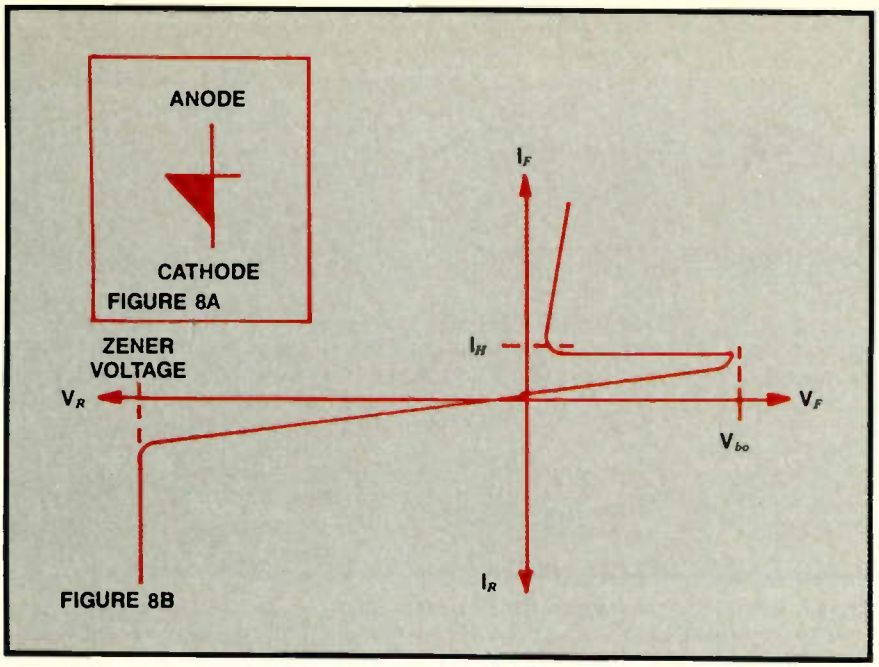

Figure 8. The Shockley diode is a unidirectional PNPN 2-terminal thyristor. When the applied voltage makes the anode positive in relation to the cathode, the diode remains essentially an open switch — even though forward-biased — until V_{bo} is reached. Then the anode-to-cathode voltage suddenly drops as current begins flowing through the device; it thus enters the forward conduction region.

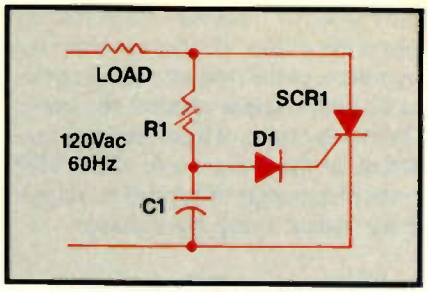

Figure 9. Sharper control of SCR triggering is achieved with a Shockley diode. D1 remains in the blocking state until the C1 voltage is high enough to reach V_{bo}. The capacitor's charging rate is determined by the R1-C1 time constant. When V_{bo} is reached, the diode switches on, allowing a rush of current that fires the SCR, energizing the load.

is controlled by varying the resistance of R2. Diode D1 serves the same purpose as in Figure 1: It prevents the negative alternation of input voltage from reaching the gate of the SCR. That is why no negative alternations of gate current are shown in Figure 5.

Adding an R-C phase-shift network

The circuit in Figure 4 has a drawback: The SCR's firing angle cannot be increased beyond 90°. As a result, the conduction angle cannot be reduced below 90°. That problem can be solved by the addition of an R-C phase shift circuit, which can provide up to 90° of additional phase delay. The circuit is shown in Figure 6. Here C1 charges through R1; this takes a certain amount of time, delaying the triggering of the SCR. By increasing the resistance of R1, we can increase the firing angle up to a maximum of 180°, at which point the thyristor remains off and no current flows through the load. Reducing the resistance of R1 shortens the time constant of the R-C network, allowing C1 to charge more rapidly, thus triggering the SCR earlier in the positive alternation of input voltage. This increases the SCR's conduction angle and power in the load.

Diacs and Shockley diodes

Instead of the circuitry shown in Figures 1, 4 and 6, some SCR gate triggering circuits feature diacs, Shockley diodes or UJTs for more positive, accurate control of the thyristor's firing point.

The diac is a bidirectional thyristor that exhibits negative resistance switching characteristics. It's capable of supplying sufficient gate current for fast turn-on of SCRs and triacs. A 2-terminal avalanche device, the diac conducts equally well in either direction when the potential difference across it reaches its forward-breakover or reverse-breakover voltage rating, typically somewhere between 20V and 35V in different diacs. When breakover occurs, the voltage across the device drops sharply as the current through it increases; hence its negative resistance.

The Shockley diode is another PNPN 2-terminal thyristor; unlike the diac, however, it is unidirectional.

Figure 7 illustrates the diac's symbols and V-I characteristics. When a voltage of either polarity is applied across the multilayered semiconductor device, only a negligible amount (microamps) of leakage current flows as long as the potential difference doesn't reach the breakover voltage (V_{bo}). When voltage reaches V_{bo}, avalanche occurs. Avalanche is non-destructive as long as the diac's power dissipation rating is not exceeded. Current then flows easily through the device. To turn off the diac, the current must be reduced below the minimum holding value (I_H), shown in Figure 7b.

The Shockley diode is another PNPN 2-terminal thyristor; unlike the diac, however, it is unidirectional. As shown in Figure 8, its characteristic curve in the useful forward-bias region is similar to the right-hand half of Figure 7.

When the applied voltage makes the anode positive in relation to the cathode, the diode remains essentially an open switch — even though forward-biased — until V_{bo} is reached. Then the anode-to-cathode voltage suddenly drops as current begins flowing through the device; it thus enters the forward conduction region (closed switch). The zener voltage, where reverse avalanche breakdown occurs, is usually much higher than the forward breakover voltage.

SCR controlled by a Shockley diode

Sharper control of SCR triggering is achieved when the ordinary silicon diode in Figure 6 is replaced by a Shockley diode, as in Figure 9, where D1 remains in the blocking state until the C1 voltage is high enough to reach V_{bo}. The capacitor's charging rate, of course, is determined by the R1-C1 time constant. When V_{bo} is reached, the diode switches on, allowing a rush of current through the gate of the SCR; this current causes the SCR to fire, energizing the load.

Next month we'll take a look at UJT-controlled SCR circuitry. ■

Surge protection applications guide

MCG has released a 40-page catalog, "Surge Protection Applications and Product Guide." The catalog has a selection guide, applications ideas and technical specifications for MCG's line of both ac and data-line lightning-protection devices. Installation instructions and an explanation of IEEE 587 are also available.

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VCR replacement parts cross-reference

The "RCA VCR Key Items Cross Reference" lists the *Thomson Consumer Electronics* (TCE) replacement parts for more than 900 VCR models produced by RCA, GE, Magnavox, Panasonic, Hitachi, Philco, Philips, Quasar and Sylvania. The guide provides a TCE stock number and a reference number, which corresponds to the number shown on the manufacturer's service data parts list.

Circle (126) on Reply Card

Compressed-air tool catalog

Vortec is offering a 94-page catalog that describes the company's line of compressed-air-powered tools. Reference sections describe applications, including electrical control cooling, mancooling, fume exhaust, process cooling, electronics testing, air conveying, liquid spraying, humidification and static neutralization.

Circle (127) on Reply Card

Tape care pamphlet

The Consumer Affairs Department of the Electronic Industries Association's Consumer Electronics Group (EIA/CEG) has produced a consumer education pamphlet titled "Consumers Should Know: How to Choose, Use and Care for Audio and Video Tape." The pamphlet addresses typical questions about purchasing, playing and storing audio and video magnetic tape, and taking care of VCRs. It also features two "Quick Troubleshooting Guide" sections and a glossary. For a single copy, send a self-addressed No. 10 envelope with 25-cent postage to The EIA, Audio & Video Tape, P.O. Box 19100, Washington, DC 20036.

Television catalog

Tektronix' "Television Products 1989/90" catalog caters to component, D-1, D-2 and HDTV formats. Products are available in NTSC, PAL and SECAM standards. The 165-page catalog features waveform monitors, vectorscopes, generators, automatic measurement sets, audio monitors, VITS inserters, spectrum analyzers, portable oscilloscopes, GPIB programmable products, accessories and synchronizers are included. There is also instrumentation for master control, transmitter, van, telecine and maintenance environments.

Circle (128) on Reply Card

Signal conditioning glossary

MetraByte is offering a 22-page "Glossary of Signal Conditioning Terms." Definitions encompass signal processing, data conversion and test instrumentation. Definitions for more than 300 terms are included.

Circle (129) on Reply Card ■

OSCILLOSCOPE

•OS-7020A
20MHz, DUAL TRACE

•OS-8020R
20MHz, DUAL TRACE
CRT READOUT DISPLAY

FREQUENCY COUNTER & POWER SUPPLY

•FC-7011: 100MHz
•FC-7052: 550MHz
•FC-7102: 1GHz

•GP-103: 18V/1.0A
•GP-105: 30V/0.5A
•GP-233: 18V/1.0A, 18V/1.0A
•GP-235: 18V/1.0A, 30V/0.5A

DIGITAL MULTIMETER BENCH & HAND-HELD

•DM-7241: 4½ DIGITS MANUAL RANGING, LED MEMBRANE FUNCTION INDICATION

•DM-6335 3½ DIGITS, AUTO RANGING, MEMORY, HOLD FUNCTION

•DM-8135 3½ DIGITS, AUTO RANGING, MEMORY, HOLD, TR, hFE CHECK FUNCTION, BAR GRAPHIC DISPLAY

•DM-7333 3½ DIGITS, MANUAL RANGING, TR, hFE CHECK CAPACITANCE, FREQUENCY FUNCTION

•DM-8433 3½ DIGITS, MANUAL RANGING, TR, hFE CHECK CAPACITANCE, TEMPERATURE FUNCTION

•DM-8243 4½ DIGITS MANUAL RANGING, TR, hFE CHECK CAPACITANCE, FREQUENCY FUNCTION

GoldStar Precision
13013 East 166th Street, Cerritos, Ca. 90701, U.S.A
Tel.: (213) 404-0101 Tlx.: (910) 583-5719 LGILA
Fax.: (213) 926-0849

Circle (32) on Reply Card

Symptom: High, uncontrollable volume; channel functions lock up.
Set ID: MGA model CD1945R
Photofact: 2435-1

This set would work properly when first turned on, but after a while (usually several minutes, but sometimes just a few seconds) the volume would rise to a very high level and the volume could not be turned down from either the remote control or the TV itself. In addition, the channel up and down functions would usually lock up.

Initially we thought it was a thermal problem, but liberal use of cooling spray and a heat gun brought no changes. A scope check of the microprocessor, IC701, revealed some noise on at least one of the lines feeding the volume-control circuit. We replaced the new microprocessor with one we had in stock, but the symptoms remained.

As a shot in the dark, we wondered if the volume-up control was somehow intermittently on, so we exchanged it with the volume-down switch. Again no change. We also tried replacing diodes D725, D774 and D785; if one of those was leaky it might have been the source of the noise we saw on the scope. Again, there was no change in the symptoms.

As you can see in the accompanying portion of Photofact 2435-1 (see Figure 1), the four resistors feeding the two volume functions and the two channel-changing functions are either 47kΩ or 4.7kΩ. Because resistors R815, R816, R817 and R818 in this set were 47kΩ, we decided to parallel them with other resistors to get the value down to near 4.7kΩ. When we did this, the set appeared to function normally. Apparently this change in resistance was enough to somehow reject the noise signals. Knowing that this wasn't an entirely valid fix, we pursued the matter with MGA.

After we described the symptoms and the troubleshooting steps we took to the MGA representative, he suggested that the spurious noise might be coming from the channel LED display. That circuit unplugs easily from the main board, so it was easy to check. With the LED display out of the circuit, the volume remained where it was set. When we installed a new LED display we obtained from MGA, everything operated normally with none of the original problems. After bench testing for several days with no recurrence of the symptoms, we returned the set to service.

Michael B. Danish
Steven D. Ashcraft
Aberdeen Proving Ground, MD ■

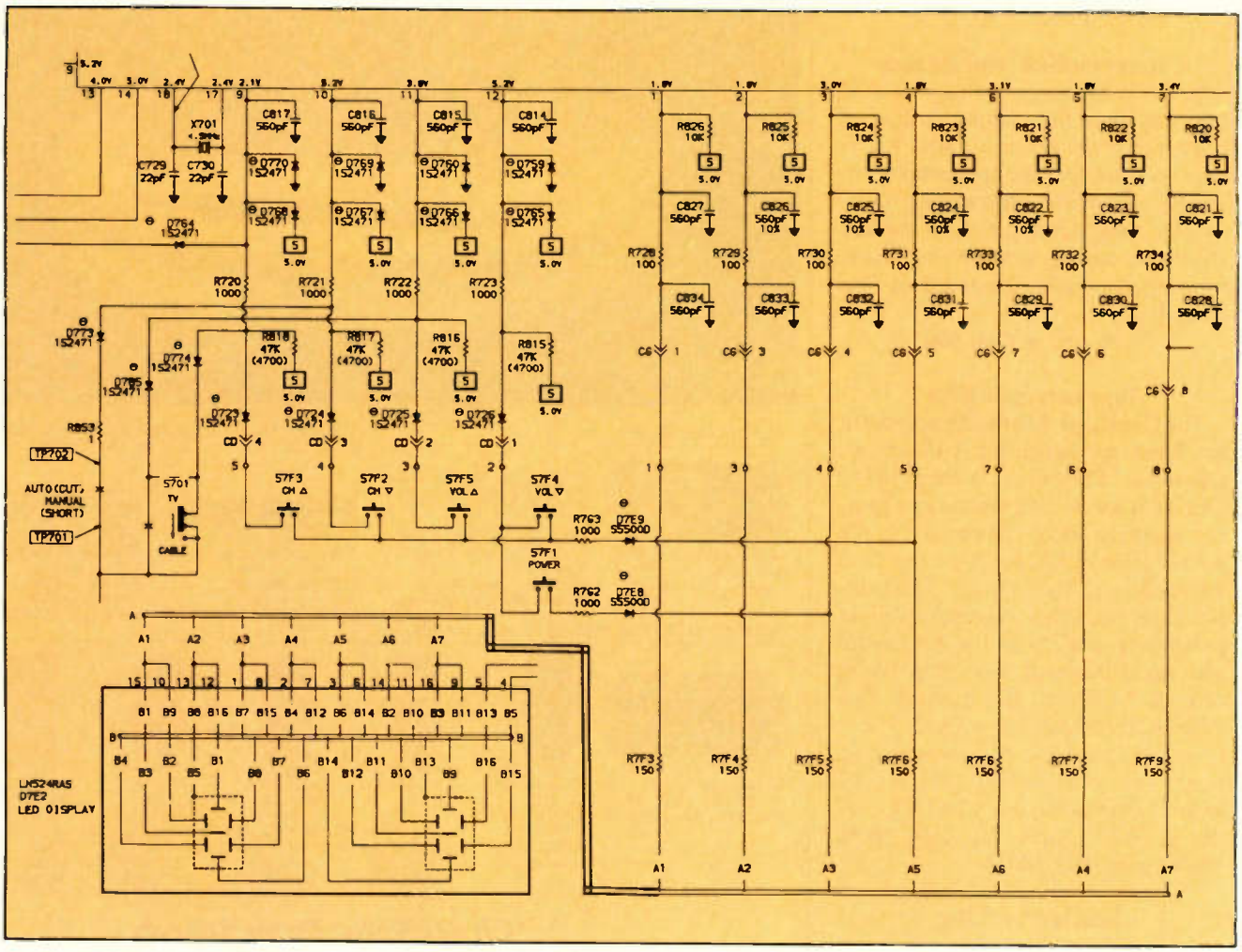

Figure 1. Although paralleling resistors R815, R816, R817 and R818 with other resistors to reduce the resistance treated the uncontrollable volume symptoms in this TV, a new channel LED display treated the underlying problem.

Answers to the quiz

Questions are on page 39.

C	O	M	M	U	T	A	T	I	N	G		
	R		S				S		C	D	R	
T		A		C			C		A	S	E	
D	H		B		H		S	R	I	I	B	
	I	Y		W		O	L		R	D	B	
		A	R		O	I	T		T	E	U	
			C	A	N	R		T		C	N	
				G	T		C		K	N	S	
U			T			R			O	Y		
J		O					O	E				
T	N						N	N	O	E	N	
	Y	E	L	K	C	O	H	S				

1. Darlington
2. commutating
3. thyratron
4. neon
5. UJT
6. Shockley
7. diac
8. sidec
9. triac
10. crowbar
11. snubber
12. SCS

Note: You may find words in the letter matrix that are used in electronics but are not related to the subject of this issue.

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Ask For Fastrap Bulletin #8

Microwave Filter Company, Inc.
6743 Kinne Street • East Syracuse, NY 13057
Toll Free(US/Canada): 1-800-448-1666 • Collect(NY/AK/HI): 315-437-3953
FAX: 315-463-1467 • Telex: 249-613

Circle (23) on Reply Card

Microwave leakage detector

The Microcheck model SMW-1 noncontact microwave leakage detector from *A.W. Sperry Instruments* reads microwave radiation leakage as low as 0.1mW/cm² and the midscale of the meter is calibrated at 1.0mW/cm². The detector uses no leads, switches, control settings or batteries.

Circle (81) on Reply Card

Electromagnetic radiation monitor

Walker Scientific is offering a monitor for measuring low-level electromagnetic field radiation. The ELF-50 field monitor is a hand-held instrument that measures the extra-low-frequency (ELF) electromagnetic field radiation

generated from any ac 60Hz device. A 10-segment LED display illuminates to indicate the level of radiation present. The monitor features two measurement ranges: low range, from 1 to 512 milligauss; and high range, up to 51.2 gauss.

Circle (82) on Reply Card

Semiconductor tester

The Semianalyzer 59C from *Electronic Design Specialists* helps servicers troubleshoot to a defective component. The 59C version 002 will check semiconductor junctions in-circuit; read out the type, polarity and condition of the component under test; check components, such as capacitors, semiconductors, neons and LEDs, for leakage, voltage breakdown and noise level; and trace active audio, video or digital circuits with a signal-tracer function, which also displays dc voltage riding on the signal with $3\frac{1}{2}$-digit accuracy.

Circle (83) on Reply Card

Tool kit

Jensen Tools has introduced a tool kit with a vulcanized fiber case; double-stitched, heavy-duty canvas pallets; and more than 60 tools. The JTK-14 kit includes screwdrivers, nutdrivers, ignition wrenches, hex keys, six pairs of pliers, a penlight, an electrician's knife, scissors, a ball peen hammer, a mini-hacksaw and a soldering iron.

Circle (84) on Reply Card

dc circuits video program

Bergwall Productions has released the "E16 Basic Electricity: DC Circuits" video. The video describes series loads, polarity, open circuits and fuses. Simple mathematical circuit analysis and Kirchhoff's voltage and current laws are introduced. Resistors and their color coding are described, and a demonstration of ohmmeter use is performed. The video teaches how to calculate tolerance, current and voltage levels in combination parallel and series circuits, and how to measure resistance.

Circle (85) on Reply Card

Benchtop ionizer

Chapman has announced another version of the VSE 3000 benchtop ionizer. The updated version that requires no disassembly allows easier access to the emitter points. A specially designed cleaning brush is inserted through the front screen to clean the emitter points. The self-balancing unit has a removable tilt stand and a larger fan for greater air volume at lower speeds.

Circle (86) on Reply Card

VCR maintenance and belt kits

Thomson Consumer Electronics has announced the addition of four VCR maintenance kits and two VCR belt kits. The maintenance kits replace wear-related items in more than 125 RCA and GE VCRs. The kits include tension bands, idlers, pressure rollers and clutch/plates. The packages contain replacement information by RCA and GE instrument model numbers and include cross-references to model numbers for Hitachi, Magnavox, Panasonic, Philco, Quasar and Sylvania VCRs.

Circle (87) on Reply Card

Oscilloscope probe

The PR200A oscilloscope probe from *Philips ECG* has a 200MHz bandwidth and is switchable in X1, X10 and REF. Also featured is a thumb-switch with positive detents, a 57-inch flexible cable and a 360 degree rotatable ground clip. Also included is a ground lead and

clip, BNC adapter, IC tip, insulating tip, retractable hook and trimmer tool.

Circle (88) on Reply Card

Digital multimeters

The SOAR models 3255 and 3250 hand-held digital multimeters from *Carlo Gavazzi Instruments* offer industrial-rated cases; LSI design technology; and 3,200-count, full-scale analog bar graph displays. The DMMs have auto and manual range selection, data hold, high-speed sampling and autoranging of six per second, up or down. Accuracy for the DMMs is 0.3%. Current measurements range from 300μA to 10A, ac/dc. Voltage measurements range from 3mV to 1,000V for dc, 3V to 750V for ac.

Circle (89) on Reply Card

Audio generator

B&K Precision has introduced a pocket-size audio generator with a frequency range of 20Hz to 150kHz. The

model 3001 is a RC-type oscillator that features selectable sine- or square-wave outputs with a 23-position rotary switch and a xl/x100 slide switch to select from 46 frequencies. A separate sync output provides a fixed-level signal at the same frequency and phase as the main output.

Circle (90) on Reply Card

Autoranging DMM

The DM5 DMM from *Universal Enterprises* is a pocket-size, autoranging DMM that features an audible continuity buzzer, a diode-test function, a 3½-digit LCD display, and low-battery and

overrange indicators. The meter autoranges over five dc voltage ranges from 200mV to 500V, four ac voltage ranges from 2V to 500V, or six resistance ranges from 200Ω to 20MΩ.

Circle (91) on Reply Card

Scope probe

The 150MHz scope probe from *Test Probes* has a risetime faster than 1.5ns. The probe eliminates cable microphonics, external interference and is sealed against moisture. The probe has self-cleaning switch contacts, a replaceable ground lead, strain relief and connector crimp.

Circle (92) on Reply Card

Oscilloscope probe kit

The 4900K and 5100K series Gold Probes from *Probe Master* have 18 accessories. A variety of models offer bandwidths of 35MHz to 350MHz, a readout actuator option and various cable lengths. The Convert-A-Tip feature provides a heavy-duty threaded tip (0.055-inch diameter) that can be replaced with a micro-tip (0.030-inch diameter).

Circle (93) on Reply Card

Surge protectors

Three surge protectors have been introduced by *Data Spec*. The DSTM2 modem/fax/telephone lightning surge protector features maximum energy dissipation and plugs directly into ac outlet sockets. The D6OUTSP ac surge protector is a six-outlet strip that offers continuous spike protection, a built-in circuit breaker and a master switch with pilot light. The SP011 offers the same features as the D6OUTSP, but is wall mounted. The SPO11 automatically resets after brownouts or surges.

Circle (94) on Reply Card

Analog/digital multimeters

Soar's 3200 series, 3½-digit multimeters, available from *HMC*, feature a 32-segment, analog bar-graph LCD display and audible continuity. The meter selects the range with the greatest accuracy and resolution and shows function and measurement range. The Range button prevents the instrument from changing ranges. Model 3230 has a DATA-H button that captures the measurement, beeps and locks it on the display.

Circle (95) on Reply Card

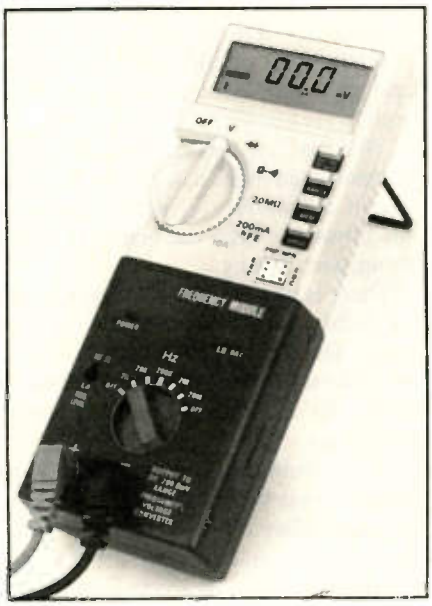
Wire stripper

Rush Wire Strippers has introduced model MH-1, a hand-held, thermal wire stripper. The stripper is designed for stripping thermoplastic insulation, including Teflon and PTFE, from solid or stranded wires from 12 to 43 AWG. A self-contained, continuously rated power unit is connected to the handpiece to provide variable temperature up to 1,400°F. The stripper has a strip-length stop and positive tweezer action.

Circle (96) on Reply Card

Frequency adapter

Extech has introduced a frequency-to-voltage converter that attaches to any multimeter and can measure from 2kHz to 2MHz with an accuracy of 1% of



reading. Minimum sensitivity is 100mV rms (2kHz to 10MHz range) and 200mV rms (2MHz to 200MHz range). Overload protection is 400Vac/dc. To operate, attach the adapter to a multimeter via banana plugs, switch to the multimeter's 200mV range and select the frequency range.

Circle (97) on Reply Card

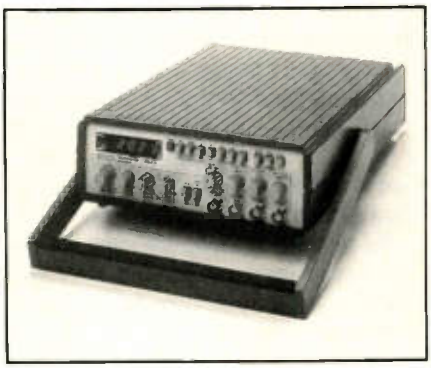
Oscilloscope

Brunelle Instruments has introduced a line of 20MHz oscilloscopes built into a metal case. The scopes feature wide bandwidth, a bright screen and TV and video sync. Model 2987 has a component tester; model 2989 has a cursor for measuring voltage, frequency and period.

Circle (98) on Reply Card

Sweep function generator

Model FG3A sweep function generator from *Beckman Industrial* features seven frequency ranges covering 0.2Hz to 2MHz, and an array of signal outputs,



including sine wave, triangle wave, square wave and TTL and CMOS pulse outputs. The FG3A can add logarithmic or linear sweep to the selected signal outputs, or perform AM or FM modulation with internal or external signals. The generator has a built-in, 5-digit frequency counter and a voltage-controlled frequency jack.

Circle (99) on Reply Card

Hand-held multimeters

The 80 series hand-held multimeters from *John Fluke Mfg.* offer capacitance measurement, frequency, duty cycle, simultaneous minimum-maximum-average recording, relative (zero) model and Touch Hold, which beeps when it senses a stable reading and locks it on the display. The true-rms 87 offers backlighting and a user-selectable, 4½-digit (20,000 count) mode in addition to the 3¾-digit (4,000 count) digital display of the other models. It also features a Peak Min Max recording mode for capturing transient events to 1ms or sine wave plus or minus peaks to 400Hz.

Circle (100) on Reply Card ■

What do you know about electronics?

Copper wires vs. fiber-optic cables

By Sam Wilson, CET

You hear a lot about fiber-optic telephone lines these days. They are rapidly replacing copper wires for communications applications. It is interesting to compare some of the features of the two types of communications lines to see whether there is really any advantage of fiber optics over copper.

In this discussion, the term *copper conductor* means a conductor of electricity; *fiber-optic conductor* means conductor of light.

Assuming equal weights of fiber-optic and copper materials, the fiber-optic material will produce three times the length of the copper material. Putting it another way, if the two materials cost the same per pound, the cost per 100-foot length of the fiber-optic conductor would be one-third of the cost of the copper conductor.

The fiber-optic conductor will permit three times the data-handling capability. The bit-error rate is a comparison of the number of error bits per total number of transmission bits. For copper conductors, an excellent bit-error rate would be one bit per million. However, the number is usually closer to one error bit in 10,000.

For fiber-optic materials, a bit-error rate of one bit per 10 trillion is common.

Whenever there is a bit error in a transmission, it is necessary to take the time to retransmit the signal. That results in lost time and added expense for the company using the system.

Two other important features make fiber-optic cables more attractive than copper cables:

- Fiber-optic material has a long lifetime because of its natural resistance to corrosion.
- Installation and section-replacement costs are less.

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

The committee syndrome

Lately I have encountered an unusually high number of companies with a frightening method of operation. When I try to get something done in those companies, I am told (very politely): "Everything here is done by committee. Your suggestion will be taken under advisement by the _____ committee."

If you aren't careful, you will miss the real message. Let me rephrase it for you:

"We have no leader. No one in this company can make a decision. With the use of committees, it is not necessary for anyone to take the blame if something goes wrong.

"There is no one here who has the guts to stand up and say what should be done. There is no one here who has the nerve to say (when necessary), 'I made a mistake and here is what I am doing to correct it.'

"Our committee structure protects us from anyone who may want to make a dynamic move. We are protected by the fact that if anyone is hired, the committee must first give its approval of the applicant. Thinkers need not apply.

"There is no incentive here for being the best at what you do. Our committees are effective in defusing leader-type personalities. We believe in the great mediocre society."

It makes me wish we could go back to companies and organizations run by a good old Bull Moose.

Being calculator smart

You know from kindergarten that the rms value of voltage (V) can be determined from the peak voltage (V_M) by the following equation:

$$V=(0.707)V_M$$

A more accurate value can be obtained using this equation:

$$V=(1\sqrt{2})V_M$$

For average values (V_{AVE}) when the peak value is known, use this equation:

$$V_{AVE}=(0.636)V_M$$

To get a more accurate value:

$$V_{AVE}=(2/\pi)V_M$$

If your calculator is getting old, it may not be able to do the following calculations. Try this simple arithmetic problem:

$$10-3\times3-1=0$$

My calculator can't handle that one. Instead of zero I get this answer:

$$-1\times10^{10}$$

Try your calculator on this simple trig problem:

$$\text{TAN } 20^\circ=0.3639702$$

$$\text{TAN } (2\times10^7)^\circ=\text{(should be the same answer)}$$

My calculator drops the last two digits. Errors in these calculations are more likely to occur in older calculators.

Letters

I wish I could include all of the letters that we get, but that is impossible. However, I do try to answer every let-

Have a question, a comment, a gripe, a suggestion? Found a better way of servicing an electronics product discussed in an article? Or maybe you would like to see an article about a subject you haven't seen covered yet. We want to hear your ideas. Address your comments to

Feedback
Electronic Servicing & Technology
P.O. Box 12901
Overland Park, KS 66212

ter. Sometimes it takes a long time. If you don't hear from me in six to eight weeks, you know that your letter has dropped to level two.

In this issue, I had room for a couple of interesting letters. This one is from From Pat Cerone, WEZG/WXRA Radio, Clay, NY:

> After all of the trouble I went through to build a remote infrared tester, I found that I already had one.
>
> Not only that, but it will check all types of remotes: infrared, sonic, garage door openers, etc. All you need is a small AM radio; aim the remote to the antenna loop and you will hear it loud and clear.

The Editor (Conrad Persson) and I have both tried this and it works! It may be because the remote control is pulsed and that produces a wide range of harmonic frequencies. In any event, it works very well.

We appreciate your sending this good tip and I'm sure the readers will appreciate it too.

Here's a letter from CAMCO Avionics, Long Island, NY:

> We at CAMCO Avionics find your quizzes very entertaining, but the answer to question three in the December 1989 issue confuses us. Your voltage is going through an inverting amplifier, so it must be true that the positive input voltage should be negative on the output. Right?

The reason the inverting amp is used is that the non-inverting input does not produce a gain proportional to the simple ratio of resistors. Instead, the gain is $1+R_f/R_i$. However, you would not want to be put into a position of saying that $2+4=-6$ or any other negative number. Actually, the absolute value is taken to be the answer for summing amplifiers even though the output is, as you indicated, 180° out of phase with the input.

Thanks for taking the time to write.

Unusual diode applications

You have, no doubt, used LEDs as light indicators, but they have some interesting properties not related to giving off light. As far as I know, these properties have never been put to use.

An LED also works, with some limitation, as a light-activated diode (LAD). Its conduction changes when a bright light is directed to it. The LEDs with clear plastic lenses seem to work best as LADs. If you have any practical use for this LED characteristic, don't tell anyone. Send me a letter explaining your idea.

Another unusual feature of the LED is that it behaves like a zener diode. If you have a curve tracer on your scope, connect an LED into it for an interesting test. You have to supply enough voltage to get it to zener on the reverse half-cycle.

I have played around with this concept and I was able to make a shunt-regulated supply. However, the zener diode that would do the same job costs less than the LED. Still, it is an interesting idea. ■

Replacing the idler pulley

With respect to Victor Meeldijk's article "A VCR Repair Case History — Update to the Sequel" (see the November 1989 issue) concerning replacement of the idler pulley on Fisher VCRs, here is a much easier way of removing the idler assembly on units that do not have a notch for removal of the gear assembly.

Proceed as in the first five steps of the article. Remove the stopper washer from the idler gear and the idler pulley. The large pulley that sits on top of the idler gear is press-fit onto the shaft of the assembly and can be gently pried off.

After you remove the pulley, the plastic, horse-shoe-shaped plate that the black idler gear is attached to can be bent gently downward while the entire assembly is raised off the shaft. Bending this plate downward will allow the black idler gear to clear the metal plate on the chassis. The assembly can then be removed, allowing the idler pulley to be removed.

After replacing the idler pulley, you can replace the gear using the reverse procedure: gently bend the plastic idler gear plate until the gear clears the chassis plate. Replace the large white pulley on the shaft. The stopper washers are then replaced as indicated in the article.

I have used this technique without incident on many Fisher VCRs and have found it to be efficient and time-saving. The entire procedure can be completed in 15 minutes.

Steven Luzik
Coraopolis, PA ■

Reducing lack-parts calls

By William J. Lynott

If your service business were one of the really big ones, chances are you would be paying close attention to the management of your repair parts inventories. An inventory valued at several hundred thousand dollars — or several million dollars — is much less likely to be neglected than is the parts inventory of a small service dealer.

But no matter what size the business is, the ratio of parts inventory to total assets for service companies runs in a fairly narrow range. Parts inventories that account for more than 50% of the total assets of an electronics business are not unusual.

On a relative basis, your parts inventory is just as important to the financial performance of your business as it is in a huge corporate chain. The obvious importance of the direct investment you have in your inventory is only the beginning.

Repair parts management has an immediate and significant effect on the overall profitability of your business in ways that may not be obvious at a casual glance. Here are a few of the most important.

• *Technician productivity.* These days, even the smallest service dealers are tuned in to the importance of technician productivity on bottom-line performance. Because of that, most servicers keep some sort of record of technician productivity. The trouble is, too many of those systems fail to recognize the role that inadequate parts management can play in cases of unsatisfactory performance.

When a technician (in the shop or on the road) needs a part that isn't in inventory, valuable time is lost. Productivity suffers. If that happens often enough (and it doesn't take much to be "enough"), the consequences will be lost profits. The reasons may well be hidden from an uninformed management.

Sound parts management provides levels of inventory that balance cost of investment against cost of lost productivity. The key to successful application of that philosophy rests in records that show exactly how often each part is needed. Only when you have that information can you decide which parts belong in your inventory.

• *Overall efficiency.* Technicians are not the only ones affected by inadequate parts management. Every time a job must be rescheduled for parts, additional paperwork is generated. Workloads are increased for parts-room personnel, dispatchers, office clerks and, yes, even the owner if the company is small. I have seen many cases of chronic frenzy on the part of support personnel that could be cooled down to a reasonable level if only parts management were more effective.

• *Customer satisfaction.* Each time a service call remains incomplete because of a lack-parts situation, one of your customers will remain unsatisfied. Lack-parts calls can never be avoided entirely, of course, but a higher-than-optimum ratio of lack-parts calls has a cumulative effect on overall customer satisfaction with your company. And customer satisfaction is your end product — the product that enables you to remain in business and to meet your profit objectives. When the general level of customer satisfaction begins to decline in a service company, serious problems are inevitable.

• *Employee morale.* I don't know anyone who regards dealing with irate customers as a desirable way to pass the time of day. When overall customer satisfaction is negatively affected by poor parts management, everyone in the organization, from the service manager to the person who answers the phone, will ultimately feel the effects. It doesn't take much imagination to figure out how this situation will affect overall employee morale.

Of all the conditions that can cause employee morale to deteriorate in a service business, none is more damaging than a general atmosphere of customer dissatisfaction. Good employees want to be identified with a company that has high regard for its customers. I have seen the pressures of dealing with avoidable customer problems drive away many valuable employees from service companies whose management couldn't understand their high employee turnover. In this day of tight labor markets, no service dealer can afford to risk losing his best people for the same reasons that he is losing his best customers.

• *Secondary effect.* Poor parts management is, in some ways, like a viral infection in the body. Some of the symptoms are major and obvious. Others are secondary and often hidden even to the trained eye.

A consistent lack of parts that should be in your inventory causes a general increase in the overall workload of your business. This, in turn, can create the impression that everyone is busy with productive work. The overall effect is to lower the efficiency of your organization, which generates unnecessary payroll costs.

Having the right parts on hand when you need them is an absolute requisite to optimum success in the service business. But there's another side to this coin: making sure your inventory isn't burdened with obsolete and unnecessary parts. We'll discuss that problem next month. ■

Lynott is president of W.J. Lynott, Associates, a management consulting firm specializing in profitable service management and customer satisfaction research.

Solving RFI complaints – Part III

By John Shepler

An audio component that glitches and distorts at home but works just fine in your shop should clue you in to one probable cause: radio frequency interference (RFI). The last two Audio Corner columns described external and internal methods of eliminating RFI. In this final part of the series, we'll discuss desensitizing the amp and bypassing the power line.

Transistor and op-amp circuits

When input filtering doesn't do the job, you need to desensitize the amplifiers with more filter capacitors. This will not affect the audio response but will reduce the amplitude of the RF interference so that the amplifiers will not overload.

Figure 1 shows sample circuits for transistors and op-amps. A 5pF to 100pF capacitor from the inverting to non-inverting inputs of the IC will short out the amplifier as far as RF is concerned. As before, the capacitor value is dictated by the impedance seen at the amplifier inputs.

For transistors, the capacitor should be connected between the base and emitter as close to the transistor as possible. For both ICs and transistors, start bypassing at the first amplifier stage and continue until the problem goes away. Often, only one or two capacitors are needed.

On rare occasions, diodes are used in audio circuits for gain control or voice compression. It may be necessary to add small bypass capacitors across each diode to eliminate the RFI.

Shepler is an electronics engineering manager and broadcast consultant. He has more than 20 years of experience in all phases of electronics.

Power-line bypassing

Even if you have excellent shielding and your input and output cables are well-grounded, RF can sneak into the equipment through the power cord. Sometimes a 0.01μF capacitor from each side of the line to the chassis is all that is needed. For stubborn cases, you can buy power-line filters in small metal cans for $8 or so.

Some outlet strips with built-in surge protection also have RFI filtering. You can install one of these close to the equipment and tightly coil up the amplifier's power cord to prevent it from acting as an antenna.

Opportunities

Many service shops have no experience with solving RFI complaints and shy away from this business. This creates opportunities for those who can exorcise the RF demons out of audio and other equipment. As you become comfortable solving these problems, you will want to advertise your services to radio and TV stations, ham and CB equipment dealers, and others who sell electronic equipment. These people are always getting RFI complaints and will be overjoyed to refer the business to you. A simple plug-in filter or a couple of capacitors are worth quite a bit to people plagued by strong RF fields. ■

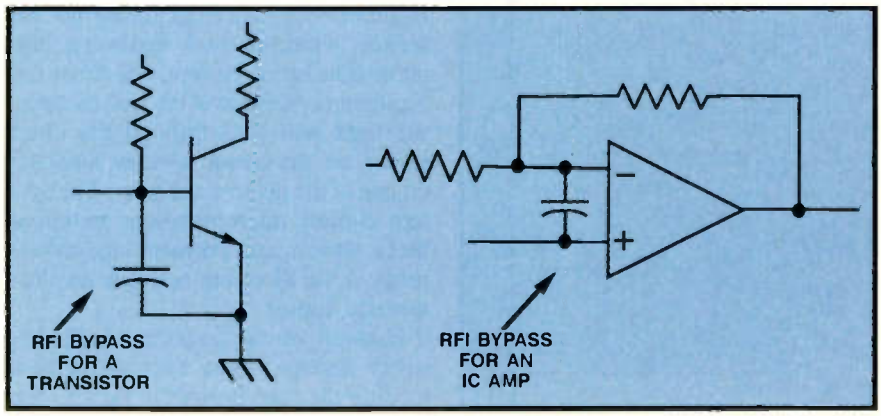


Figure 1. Filter capacitors can be used as an RFI bypass for transistors and IC amps. A 5pF to 100pF capacitor from the inverting to non-inverting inputs can be used with ICs. For transistors, the capacitor should be connected between the base and emitter as close to the transistor as possible.

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Circle (24) on Reply Card

The amplifier as a troubleshooting aid – Part III

By Stephen J. Miller

The first two parts in this series introduced the Radio Shack mini-amp (catalog number 277-1008C), which can be used to amplify waveforms within the range of 30Hz to 30kHz. The electronics servicer can use the amp as a frequency-selective pre-amp, as a tester for PG and FG pick-up sensors in VCR motor circuits, and for testing audio circuits.

What else can be tested with the mini-amp? How about remote control transmitters! You just have to construct a simple pickup probe and add one additional internal resistor to the modified mini-amp described in the February Video Corner. Figure 1 gives the particulars.

The additional 75kΩ internal resistor is connected between the +9V rail and the center pin of the input jack. This resistor provides a small current through the input cable to power the active pickup probe. This resistor does not affect the other functions of the mini-amp because the external input capacitors block this small current when you use the other probes.

Some users of the probe have complained of motorboating when the volume is turned up. Motorboating can be minimized by keeping the volume control turned down. If you wish to eliminate motorboating, modify the circuit as shown by the colored lines in Figure 1.

The active IR probe consists of only four components, all of which are available from either Radio Shack or your local parts distributor. The only critical component is Q1, which cannot be substituted. Also note that the collector of Q1 (indicated by a flat spot) goes to ground. Be sure to use several feet of shielded microphone cable to connect the IR probe to the mini-amp.

To provide proper shielding, choose a suitable metal housing to enclose the probe. I construct my probes inside discarded 300Ω to 75Ω antenna matching transformers. Figure 2 shows the enclosure. The transformer's circuit board can be stripped of its components, shortened and used as a construction base for the IR probe. With an adapter, the microphone cable can be easily connected to the transformer's F connector.

After assembling and testing the probe, I fill the pickup end with translucent blue RTV silicon adhesive. This RTV protects the pickup and filters out some of the visible light while allowing the infrared to pass through. A layer of shrink tubing completes the device.

When using the IR probe, allow 15 to 30 seconds of warm-up for the internal capacitors to charge. Then, with the volume set to maximum, place the pickup near a transmitting remote. If the remote is transmitting data, a tone should be heard from the speaker. The volume can then be adjusted for a comfortable level. Intense visible light will also affect the IR pickup, causing it to either saturate or go into oscillation. Therefore, keep the IR probe away from bright lights while it is in use.

Testing VCR IR LEDs

This IR probe can also be used to test the IR LEDs in VHS VCRs. Other types of IR remote testers cannot provide this feature because they are too bulky to be inserted into the tape department. However, my IR probe's pickup is small and attached to a flexible cable, allowing this probe to be inserted right into the VCR.

To prevent tape breakage or damage, VHS VCRs detect the ends of the tape spools by using a system consisting of clear tape leaders, a lamp or IR LED, and photo pickup transistors. When a cassette is loaded into the VCR, the IR LED or lamp projects light into the cassette through a hole in the center of the cassette. The opaque videotape normally prevents the light from passing out the sensor windows and activating the photo-transistors. However, at either the beginning or the end of the tape cassette, the light will pass through the clear leader, out the sensor window, and turn on one of the photo-transistors. The system control microprocessor monitors these sensors and prevents tape movement in the direction opposite an illuminated sensor.

Because of the importance of this safety feature, most microprocessors monitor the condition of the light source and are programmed to inhibit all tape functions if the lamp or LED becomes defective. A typical failure is sensor lamp or LED burn-out. An open sen-

Miller is a senior bench technician for a Lancaster, PA, repair company.

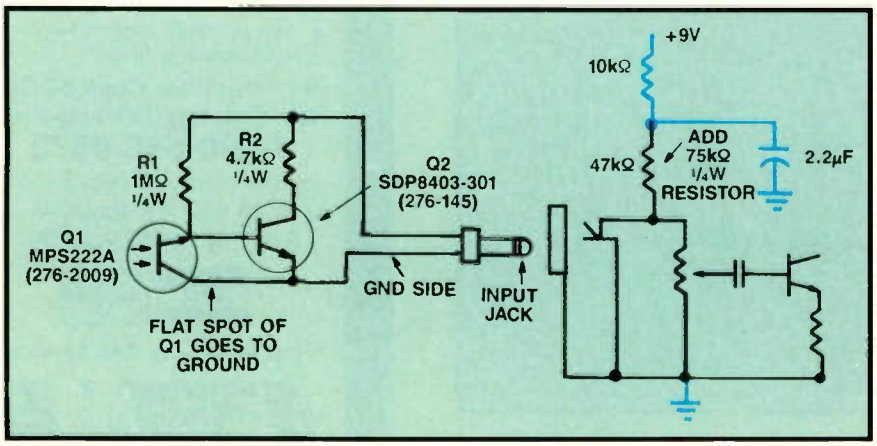

Figure 1. To build a remote control transmitter, construct a simple pickup probe and add one additional internal resistor to the modified mini-amp. To eliminate motorboating, modify the circuit as shown by the colored lines.

sor LED in a late-model Panasonic machine will stop all tape functions. The VCR will load and eject the cassette, but will not allow any tape functions, such as play, fast forward or record. Most other VCRs will also refuse to operate when the lamp or IR LED is defective. In older machines, the lamp was an incandescent bulb, which could be easily checked by visual inspection. Today, all manufacturers are using IR LEDs, which have an invisible light that makes checking the IR LED more difficult. However, by using the IR probe, you can quickly check these LEDs.

The testing method for IR LEDs varies among manufacturers. Some VCRs are designed to power these IR LEDs with ac pulses; other designs use a constant dc voltage. To check the IR LED, turn the VCR on and place the IR probe close to the IR LED. If a constant tone is heard from the amp's speaker, the LED is functioning and is being driven by an ac waveform. If no tone is heard, wave the IR probe back and forth in front of the LED. If you hear a scratching or popping noise, the LED is functioning and is being driven by a dc supply.

A few manufacturers turn on the IR LED only when a cassette is loaded into the machine. To test these machines, load the empty shell cassette into the VCR. (See the April 1989 Video Corner for details on how to construct this device.) Then insert the IR probe through one of the holes in the shell to test the LED. To become acquainted with using the IR probe, test several different models of working VCRs. This

Continued on page 57.

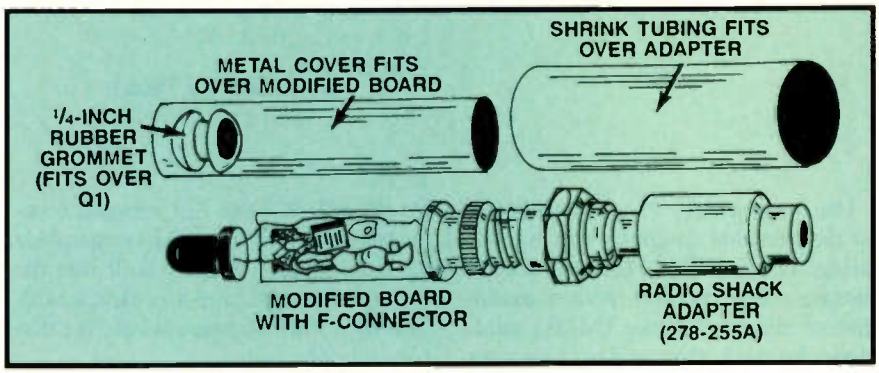

Figure 2. To provide proper shielding, enclose the probe in a suitable metal housing, such as a discarded 300Ω to 75Ω antenna matching transformer. The transformer's circuit board can be stripped of its components, shortened and used as a construction base for the IR probe. With an adapter, the microphone cable can be easily connected to the transformer's F connector.

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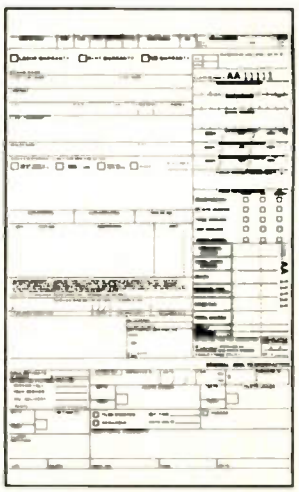

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Video monitors for the IBM PC

By Glenn R. Patsch

The wide variety of video monitors for the personal computer can be confusing. The first IBM PC used a monochrome video monitor with a monochrome display adapter (MDA) card. Monochrome is the standard computer term for a B&W monitor. Monochrome monitors most often use green characters on a black screen. The IBM monochrome monitor 5151 uses a high-persistence green (P39) phosphor.

Amber on black monochrome monitors are a popular alternative to green on black. Some monitors use black characters on a white screen so they look like paper. These are used for word processing and desktop publishing (DTP) where the output is a printed page.

Adapter cards

Displaying information on a computer monitor requires a display adapter card, which is plugged into the PC; a cable to connect the card to the monitor; and a video monitor. The IBM MDA can display text but not graphics on a monochrome monitor. The Hercules graphics adapter (HGA) can display text and graphics on the monochrome monitor.

The HGA quickly replaced the IBM MDA when it was released. The HGA with a monochrome monitor is the most common display adapter and monitor for the PC, XT and AT personal computers. Some of the IBM compatibles have the display adapter built into the PC and do not require an adapter card. The IBM PS/2 computers have the display adapter built in.

The IBM color graphics adapter (CGA) displays color text and graphics on the IBM color display 5153. IBM then introduced the enhanced graphics adapter (EGA) and the enhanced color display 5154. These color adapter cards use a 9-pin RGB digital output to drive the video monitor. The MDA and HGA also use a 9-pin digital output to drive the monitor.

The IBM PS/2 computers have the video graphics array (VGA) built in. These use the IBM 8512 or 8513 color monitors or the 8503 monochrome monitor. The VGA output is a 15-pin analog signal. The PS/2 model 30 and 25 use a multicolor graphics array (MCGA) with the same monitors. The MCGA is a subset of VGA.

Video monitors and display adapters together are often referred to as monochrome, CGA, EGA and VGA. For example, the term EGA is often used to mean an enhanced graphics adapter with an enhanced graphics display.

Monitors

NEC introduced the MultiSync monitor, which can work with a variety of video adapter cards. The MultiSync monitor can work with analog or digital input, 15.5kHz to 35kHz horizontal scan, 56kHz to 62kHz vertical scan and 800×560 (H×V) picture elements. It has a bandwidth of 30MHz. NEC and others have introduced several newer models with the multiple sync capability. Some of these models accept only analog input for use with the analog VGA output.

Several high-resolution monitors are used for desktop publishing. These monitors have a large screen area and use black characters on a white screen. Typical specifications are 100MHz bandwidth, resolution of 1,280×1,024 or more, and 19- to 20-inch screen size. These monitors are sold with a custom display adapter that can only be used with this monitor. Wyse, Cornerstone, Micro Display, Panasonic and others make these paper-white monitors.

IBM also offers an 8514 monitor with a matching 8514/A adapter card for the PS/2. The 8514 provides a 1,024×768 resolution on a 16-inch screen with 16 to 256 colors. The IBM 7554 color monitor is similar to the 8514, except that it has a 19-inch screen. The IBM 8507 is a 19-inch, monochrome, paper-white monitor. These large, color screens are often used for computer-aided design (CAD).

Using video monitors with a personal computer is straightforward once you understand the different adapter cards and displays. Knowing the basic terminology and what the different video monitors are can help you set up the best system for your client's needs. ■

Patsch is a consultant specializing in the selection, evaluation and installation of IBM personal computer and compatible hardware and software.

Comparison Table

Monitor	Type	Video bandwidth (MHz)	Horizontal scan rate (kHz)	Vertical scan rate (Hz)	Resolution Horizontal lines	Resolution Vertical lines	Colors
MDA	monochrome	16.270	18.432	50	720	350	2
HGA	Hercules	16.270	18.432	50	720	350	2
CGA	color	14.000	15.750	60	640	200	4
EGA	enhanced color	16.257	21.850	50-60	640	350	16
VGA	video graphics	28.000	31.500	50-70	640	480	16
MCGA	multicolor	25.000	31.500	60-70	640	480	2

Figure 1. Specifications for the various monitors/adapters. Several adapters and monitors can use different modes. These are typical values for comparison. Two colors is monochrome: green and black.

Continued from page 55.

experience will be helpful when you are using the device to troubleshoot defective machines.

If all of these IR LED tests have failed, trace the IR LED's wires back to the main board. Next, with the power off, disconnect the IR LED's wires and connect a visible-light LED in its place. If this substitute LED lights and the VCR operates, you have confirmation that the VCR's only problem is a defective IR LED. If the substitute LED fails to light, try reversing it. If it still fails to light, troubleshoot the power supply or LED drive circuit.

Some technicians whose hearing is slightly impaired have complained that when they use the mini-amp to test LEDs, they can't hear the sound made by a dc-driven LED as the probe is moved past the LED. The modification shown in Figure 3 replaces the speaker with LEDs to give a visual, not an audible, indication. With this modification, when the probe is moved past the LED being tested in one direction, one of the output LEDs will light. When the probe is moved in the opposite direction, the other output LED will light.

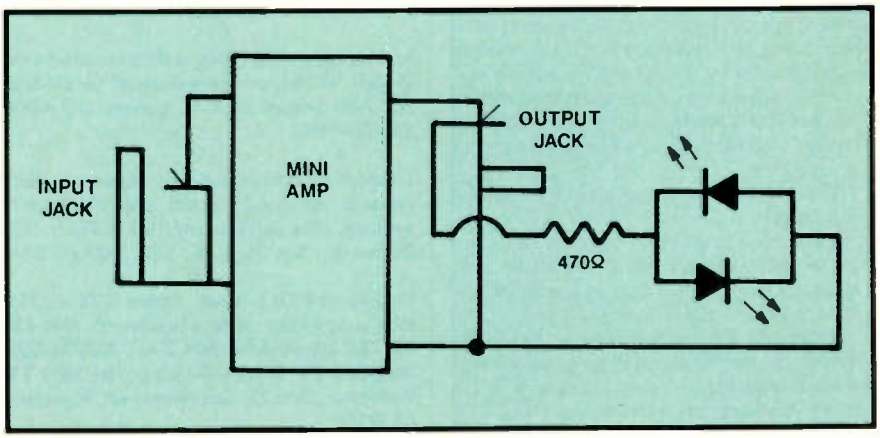

Figure 3. When using the mini-amp to test LEDs, you might find it hard to hear the sound made by a dc-driven LED as the probe is moved past the LED. This modification replaces the speaker with LEDs to give a visual, not an audible, indication.

As we have seen, this mini-amp can be a useful troubleshooting device. Although I have not tried it, I think the IR probe also can be used to check for IR light output from the IR lasers in CD players. Give it a try. It has helped me with countless troubleshooting jobs. ■

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Procedure and information on how to work out tube test setup data for a Jackson 648S. Jackson is out of business, and Coletronics has discontinued updating tube setup data. *Edward Bello, 4803 Wynwood Court, Columbus, OH 43220; 614-451-9248.*

Screen for 6-foot Sony 2-piece TV. *Jim, 895 25th St., Marion, IA 52302.*

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Service literature for Kenwood KR-4600 stereo receiver (copy OK); Sony RM-80 remote control set for TCK444ES cassette deck; service manual for Sony TT-300 tuner/timer. *MSGT R.L. Bray, 6715 Eberlein Ave., Klamath Falls, OR 97603; 503-884-1406 (leave message).*

ES&T issues before January 1986. *George Fogelman, 1201 Idlewilde, El Paso, TX 79925; 915-778-0997 AT&T collect.*

1983-84 issues of ES&T; also need April and June 1986. *Pete Noggle, 106 E. Market, Dodge City, KS 67801; 316-225-4011.*

Schematic and service manual for 1969-1971(?) Fisher 395 AM/FM stereo receiver with Autoscan electronic tuning. Will pay for copies or any info available. *Gene, 12709 Feldon St., Silver Spring, MD 20906; 301-946-5767.*

Schematic or service manual for Hallicrafters SX-122 shortwave receiver and for Technics model SH-3433 4-channel audio scope. Will purchase or copy and return. *Bob Lynn, P.O. Box 1071, Somerville, NJ 08876; 201-722-6664.*

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Heath model 10-101 vectorscope with manual, $65; Sencore model 141 DeLux color bar generator, $55; Heath model 10-4105 solid-state scope, needs minor work, with manuals, $65. *Mr. Lurry, 6738 Amherst St., San Diego, CA 92115; 619-462-7445.*

Harrison 880A regulated lamp 0-100V power supply, $125; Sencore FP201 and 39G89 probes, $25; 538 Sams below #1522, $269. *Long's TV, 801-595-8442.*

TV analyst model 1076, $150; Simpson model 415A AM/FM signal generator, $75; Simpson model 221 RotoRanger, $50. All in excellent condition, with leads and manuals. *L.H. Brinkley, 328 W. Dinehart Ave., Elkhart, IN 46517.*

Large collection of factory service data, schematics, books, Sams, etc., more than 1,500 schematics from 1930-1989. Best offer. *Alvin Sydnor, 806 Meetinghouse Road, Boothwyn, PA 19061; 215-497-2838.*

Sencore VA62, VC63, $2,000, mint condition, in original box, with manuals; most equipment needed for TV/VCR work. *919-752-7245 after 5 p.m. EST.*

Sencore VA62 with VC63, never out of box. *Mike Pristas, 1420 Third St., Howell, MI 48843; 517-546-1367.*

Sencore SC61, VA62, VC63, NT64, EX231, ST66, BY234, LC75, PR57, plus direct and demod. probe; other electronics parts and accessories. *Denny Russman, Box 332 Dow City, IA 51528; 712-674-3631 evenings or 712-643-5922 days.*

B&K, Sencore test equipment; tubes; factory service manuals for Japanese, Korean, etc. TVs; RCA factory service manuals; back issues of ET/D and ES&T. Please send large SASE. *Allan Eisenhaur, 9 Rachel Carson Lane, Centerville, MA 02632.*

Heathkit dual-trace trigger sweep scope, $150, with probes. *Vincent Manning, 1929 W. 26th St., Jacksonville, FL 32209.*

2,000 Sams Photofacts and manuals; B&K 1077 and 415, etc. Send SASE for prices. *Sunset Electronics, 3205 148 Southeast, Bellevue, WA 98007.*

Simpson model 311-2 VTVM with probe and manual, good working condition, $50; EICO model 145 multi-signal tracer with manual, needs probe, good condition, $35. Add shipping. *John Brouzakis, 247 Valley Circle, Charleroi, PA 15022; 412-483-3072.*

Duplicate Sams, #1000-#1918, $1.50 each. Send SASE for list. *Siever's TV, 2715 Rogge Lane, Austin, TX 78723.*

B&K 415 sweep/marker generator, $275; B&K 1076 TV analyst, $125; new Variac Staco 2PF1010, $84. Add postage and handling. *201-694-6374 evenings.*

B&K 520B transistor tester, $180; RCA 98C Senior Voltohmyst, $80; B&K model 177/V-95 V.T.O. meter, $90. *Alex Minelli, 718 Michigan St., Hibbing, MN 55746.* ■

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Effective with March, 1990 Issue

Classified advertising is available by-the-word or per column inch. **By-the-word:** $1.65 per word, per insertion. Initials and abbreviations count as full words. Blind ads (replies sent to ES&T for forwarding) are $40 additional. Minimum charge: $35 per insertion.

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TV TOUGH DOGS: 300 symptoms and cures. Send $9.95 to DAVIS TV, 11772 Old Fashion Way, Garden Grove, CA 92640. 10-87-tfn

REDUCED 75%, Diehl Mark V scanner $219, Diehl Mark III scanner $89. New. 2805 University Ave., Madison, Wis. 53705, 608-238-4629, 608-233-9741. 3-89-tfn

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PHOTOFACTS: Folders under #1400, $4.00. Above #1400, $6.00 Sent same day first-class postpaid. Loeb, 414 Chestnut Lane, East Meadow, NY 11554. 4-90-3t

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Renée Hambleton, Classifieds
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29th Floor
New York, N.Y. 10022
Telephone: (212) 702-3402
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WESTERN U.S.
Len Keeler
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Telephone: (714) 694-0774
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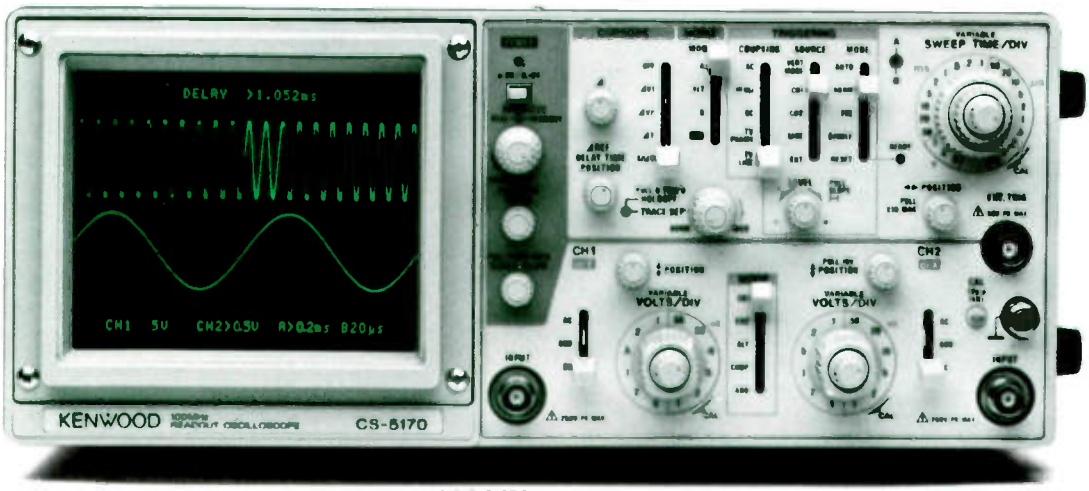
If you want better measurements, check these figures out.



100 MHz CS-5170 **$1595**

The Kenwood CS-5170. No other dual-channel 100MHz oscilloscope more economically combines performance and simplicity. And through February 28, 1990, its reasonable price has been reduced almost beyond reason.

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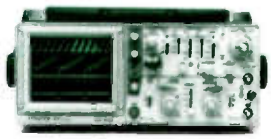
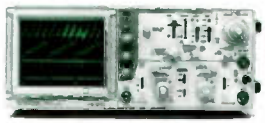
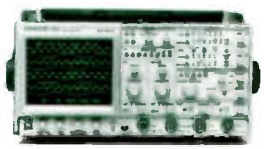


50 MHz CS-5155 **$995**



40 MHz CS-5135 **$895**

100 MHZ CS-6010 **$1995**



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