

*It's Like Having Your Own "Engineering Team" To Help You Analyze Capacitors And Inductors In-Circuit! See Page 4.*

## Introducing The NEW LC103 "ReZolver" In-Circuit Analyzer!

*NEW Sencore "Lite"  
Instrument Line ...page 6*

*Solutions To Horizontal  
Circuit Challenges ...page 14 & 19*

*See Sencore's Complete Line  
Of Monitor Analyzers ...page 32*

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*In-Circuit Component Testing*

*Complete Out-Of-Circuit*

*Dynamic Capacitor Analyzing*

*Exclusive Inductor Analyzing*

**ReZolver**

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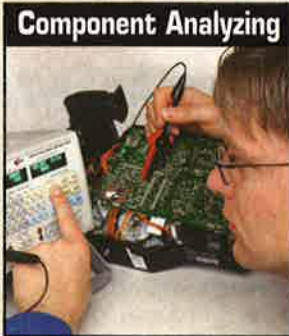


How often have you found yourself removing capacitors or inductors because you thought they might be bad – only to find they test good? Now, with the new LC103 “ReZolver” you will dramatically reduce the use of your soldering iron by removing only the bad components.

The “ReZolver” is guaranteed to save time when testing components – especially, surface mount components. Now, you can test these components in-circuit with confidence. In addition, the LC103 allows you to test flybacks and other transformers with the patented “Ringer” Test – catching even single shorted turns.

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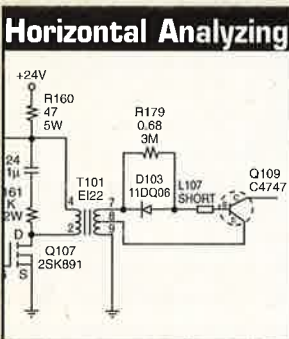
Give us a call at **1-800-SENCORE** for a **FREE** Tech Tip showing how the LC103's exclusive in-circuit tests will catch more defects than any other tester on the market.



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## SENCORE NEWS

The Sencore News is a quarterly publication mailed to Sencore equipment owners and a select list of electronic technical personnel. If you wish to be added or deleted from the mailing list, contact us at 1-800-736-2673.

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*about the cover...*

Sencore has incorporated over 20 years of capacitor and inductor analyzer experience in developing the New LC103 "ReZolver." Every time you check a component, in-circuit, you benefit from the expertise of Sencore's "Product Development Team."

## Sencore News # 183

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**By Jeff Wehmeyer**  
Application Engineer  
Sencore Electronics

## Introducing The LC103 "ReZolver"<sup>TM</sup> In-Circuit Inductor & Capacitor Analyzer

Have you ever heard the expression "Time is Money"? In any service business, this is literally true - the primary commodity being sold is time. As a result, survival and prosperity in any service business today requires the use of tools and technologies that improve efficiency and minimize wasted time.

Have you ever calculated the amount of time you spend troubleshooting, testing and replacing capacitors and inductors? How many times have you wished you could test a capacitor or inductor in-circuit with full confidence in the test results? How much time and money could you save?

Until now, technology has dictated that components be tested out of circuit to achieve accurate and reliable results. This is no longer true; the patented technology designed into the new LC103 "ReZolver" gives you the timesaving ability to test more capacitors and inductors in-circuit more accurately than any other tester, while still providing for complete out-of-circuit analyzing. For the first time you can completely analyze capacitors and inductors for all their failure modes and have the convenience of checking these components in-circuit before spending the time to remove them. The "ReZolver's" patented tests are the quickest and most accurate way to reliably test capacitors and inductors.

### In-Circuit Testing Made Easy With An Innovative Adjustable Probe

(patent pending)

The all-new Adjustable In-Circuit Test Probe makes in-circuit component testing a breeze. Simply adjust the thumb wheel to the component width and press the points to the leads. Next, press the Test Activation button mounted on the probe to activate one of the in-circuit tests. The LC103 even lets you know when the test is complete with a series of three short beeps. Once the

button on the probe has been released, the last readings are held for three seconds. The Test Activation button allows you to make measurements without lifting your head or moving your arm, preventing the leads from slipping off the component and giving a false reading. The adjustable width allows you to test nearly any component, from the smallest surface mount to large leaded components.



*Fig. 1: The in-circuit test probe allows convenient and quick connection to both component terminals.*

Today, many capacitors and inductors are smaller in value and have tighter tolerances than ever seen before. Aluminum electrolytic capacitors, once having a lower value limit of 1 $\mu$ F are now seen with values down to 0.1 $\mu$ F. Plus, large value double layer electrolytic capacitors with values around 5F are common. Finding defects in these components can be tough. Because of these changes in capacitor technology, the new LC103 has extended ranges capable of dealing with the new technology. The "ReZolver" can measure capacitor values from 1pF to 20F, ESR, DA in capacitors with a value as low as 0.02 $\mu$ F, and leakage with an applied voltage of 1V to 1kV.

The "ReZolver" gives you the ability to accurately pinpoint defective capacitors without removing them from the circuit. Using exclusive tests, the LC103 measures the capacitor's value and ESR, checks for parallel components that may otherwise affect the measurements, and gives a GOOD/BAD/SUGGEST REMOVAL message.

Save time and reduce wasted parts by testing capacitors in-circuit for ESR and value; even compare the results to EIA standards automatically for GOOD/BAD results.



Fig. 2: The "ReZolver" clearly displays all test results and even tells you if the component is "Good" or "Bad."

Eliminate the time de-soldering capacitors you suspect are causing a problem, finding replacements, and installing the new ones only to find out you haven't solved the problem. Did you replace the right capacitor? Did you replace a bad one with another bad one? The LC103 lets you check the suspect capacitors first, before spending the time de-soldering. This means you only spend time removing the ones that are bad or unable to be tested in-circuit. Plus, you will know for sure that the replacement is good.

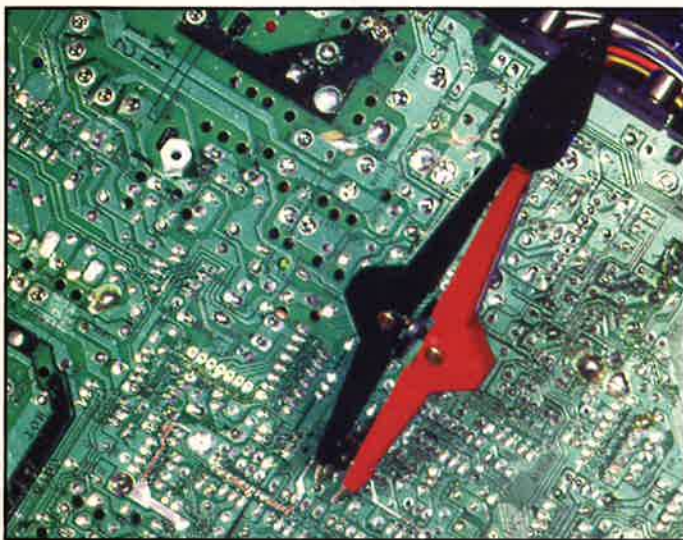


Fig. 3: Testing components in-circuit eliminates wasted time.

Other in-circuit ESR testers can give erroneous readings if a low impedance is in parallel with the capacitor or the capacitor under test is shorted. These ESR meters measure only the ESR at a specific frequency. If the capacitor is shorted, an ESR meter will show a good reading of near zero ohms, missing the fact that the capacitor is shorted. If the capacitor is in parallel with a low impedance, other ESR meters will show a good low measurement. The LC103 will identify both of these circuit conditions and suggest that the capacitor be removed in order to test it properly.

Owners of Sencore's other "Z-Meters" know how good it feels to be confident that when they test a capacitor they will know without a doubt that the capacitor is good or bad. Now, you can have that same confidence with the additional time-saving benefit of in-circuit testing.

## The Advantage of In-Circuit Inductor Testing (patent #4258315 and 5717338)

With all of this capacitor talk let's not forget about inductors. And that means all types of inductors like coils, yokes, flybacks, and switching transformers.

As with the in-circuit capacitor test, the LC103 performs a parallel component check to make sure that the measurements are accurate. The patented Inductor Value test measures true inductance, not inductive reactance. This means no errors due to frequency, interpretation, or calculation.

Don't forget the patented Ringer test. This test has been included on every "Z-Meter" ever made because there is no faster or easier way to identify the most common inductor failure; a single shorted turn. Detecting a shorted turn with an ohmmeter is virtually impossible since the resistance change is very small. An inductance check will also show only a very slight change. A "Q" test will likely do better but interpreting the results and deciding if the inductor is good or bad can be challenging.

Only the LC103 gives you everything you need to test capacitors and inductors in-circuit and completely analyze them out-of-circuit.

To learn more about the new LC103 "ReZolver", give your Product Sales Engineer a call at **1-800-SENCORE**. You can try the LC103 on your bench absolutely FREE for 10 days and see for yourself exactly how you will benefit from quickly and accurately testing components in-circuit. **SN**

### Special Z-Meter Trade-In Program

Product	Trade Value
LC102 "AUTO-Z" .....	\$400-\$800
LC101 "Z-METER" .....	\$400
LC77 "AUTO-Z" .....	\$400
LC76 "Porta-Z" .....	\$300
LC75 "Z-Meter 2" .....	\$300
LC53 "Z-Meter" .....	\$200

Trade In Any Other Capacitor Tester For \$150



**By Doug Bowden**  
Executive Vice President/Owner  
Sencore Electronics

## Sencore, Your Total Service Solution Company... Introduces New Service Solutions For 1999 And Beyond.

My belief that our customers look to Sencore for more than innovative test equipment solutions was confirmed upon carefully analyzing the results of a recent Sencore customer survey. Our customers look for solutions to all their servicing problems. With this in mind, Sencore has changed to meet those needs.

I am pleased to announce that in October, 1998, Sencore will introduce Sencore "Lite," a new line of test instruments that complements our current line of innovative analyzers, comprehensive training programs, and windows based business management software. These affordable, general line products are designed to round out your Sencore service bench. The initial product line will be available for preview at NESDA '98 in Orlando and includes:

- **150 MHz CRT Readout Oscilloscope With Component Analyzer**
- **0-15VDC Power Supply**
- **0-30VDC Power Supply**
- **0-30VDC Triple Output Power Supply**
- **Digital Multimeters**

For 50 years, Sencore customers have invested in highly innovative, time saving analyzers with the end goal of increasing their productivity and profits. Daily, business owners, Service Managers and technicians tell us that they need products such as these, that allow Service Centers and technicians to meet ALL their test instrument needs with Sencore products.

With the introduction of this line, Sencore is positioned to meet all your servicing needs with one phone call, from general test instruments to business management software, and everything in-between.

It is our goal to be your "Total Service Solution" company, with one-stop shopping and flexible investment options that help you pay as you grow.

We are honored that you prefer to do all of your test equipment business with Sencore. Our customers tell us that this is due to our industry-leading customer support. We will continue to provide 1-800 number access, knowledgeable sales engineers, high quality reliable products, 72-hour turn around service, and technical support second to none.

To find out more about our exciting new line, or any of Sencore's innovative service solutions, please call your Phone Sales Engineer at **1-800-SENCORE (736-2673)** and we will answer all of your test equipment questions.

We have changed to meet your needs. As we transition together into the year 2000, all of us here at Sencore look forward to being your partner in productivity and profitability through our commitment to be your "Total Service Solution" company.

*Sencore means success - here is to a successful servicing future for all of us!* **SN**

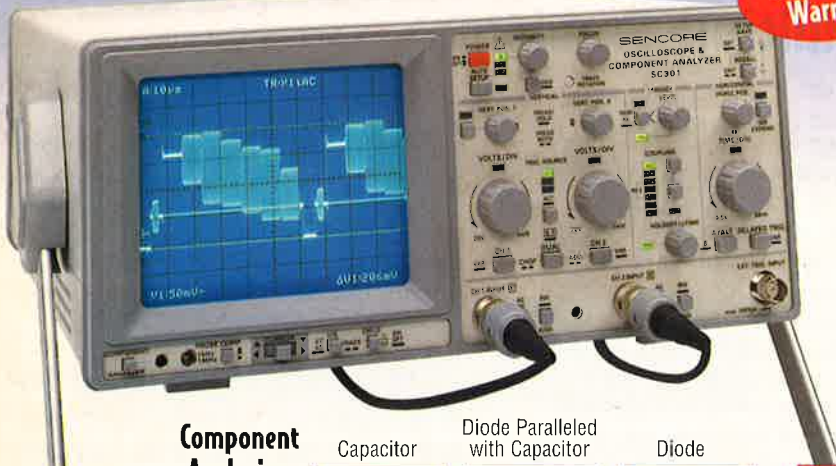
New

# Sencore "LITE"

(High Quality General Instruments)

## SC301 150 MHz Oscilloscope and Component Analyzer

3 Yr. Limited Warranty



Component Analyzing Displays

Capacitor

Diode Paralleled with Capacitor

Diode



- Auto-setup for quick waveform measurement at the push of a button
- On-screen digital cursor measurements of DC voltage, Peak-to-Peak, and frequency
- Component analyzing identifies suspect components using curve-tracer technology
- Video triggering
- 10 on-screen memory recall

1 Yr. Limited Warranty

## PS402 Triple Output DC Power Supply



- 0-30V x 2, 5V fixed 2 Amp
- Master/slave operation
- Constant current or voltage operation

## PS401 DC Power Supply 18V 5A



- 0-18VDC, 0-5 A
- Low ripple
- Series/parallel operation

## PS400 DC Power Supply 30V 3A



- 0-30VDC, 0-3 A
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- Fine/coarse voltage or current adjustment

1 Yr. Limited Warranty

## DM501 Multimeter



- True rms, 3200 count
- Beep Guard™
- .3% DCV accuracy
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- Data hold, freq., cap. tests

## DM500 Multimeter



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Call 1-800-SENCORE



**By Tom Schulte**  
CET  
Sencore Electronics

## Use The CM2125 And HA2500 To Efficiently Service Computer Monitors With Multiple Problems

Do you often service computer monitors with multiple problems, and do you always catch the second or third problem as quickly or easily as you would like for an efficient repair? How about when the first problem is a major power supply or horizontal output problem which prevents you from viewing the display and the second problem is a marginal picture problem? Let's take a look at some troubleshooting procedures that will help you quickly catch and pinpoint all the problems in the monitors you service.

The general procedure we'll use for efficient service of any computer monitor is to test the monitor's performance with the CM2125 Computer Monitor Analyzer as completely as its defect(s) allows, then troubleshoot and repair the most serious problem. We'll repeat this process until our performance test shows no more defects. This allows us to quickly identify and troubleshoot all the problems a monitor might have without wasted effort or missed defects.

To see how easy it is to service multiple computer monitor problems, let's look at a typical monitor repair job that came from a local accounting firm, a 17" Gateway model DX17. As usual, there was no indication of what problems the customer had with the

monitor, so we were on our own in determining what problem(s) the monitor had. This meant that our first step should be to power up the monitor and feed it a normal signal so we could see what problems the monitor had. We call this first step performance testing.

### CM2125 Initial Performance Test

To thoroughly test the performance of the monitor, we want to feed it the same type signal it should receive in normal operation. The monitor had a 15 pin D high density video input connector. This usually indicates that the monitor operates at standard VGA as well as higher resolution modes. While we checked with the manufacturer for what higher resolution modes the monitor operated at, we set the CM2125 for standard VGA output (Recall 7) and selected the Multiburst video pattern. We then connected the monitor to the CM2125 Sync and Video Output jack with the BNC adapter cable.

When we applied power to the monitor we observed no light on the CRT, indicating a probable power supply or horizontal output problem, or both. This turned out to be a rather brief initial performance test. Our next step would be to troubleshoot the horizontal output and power supply circuits.

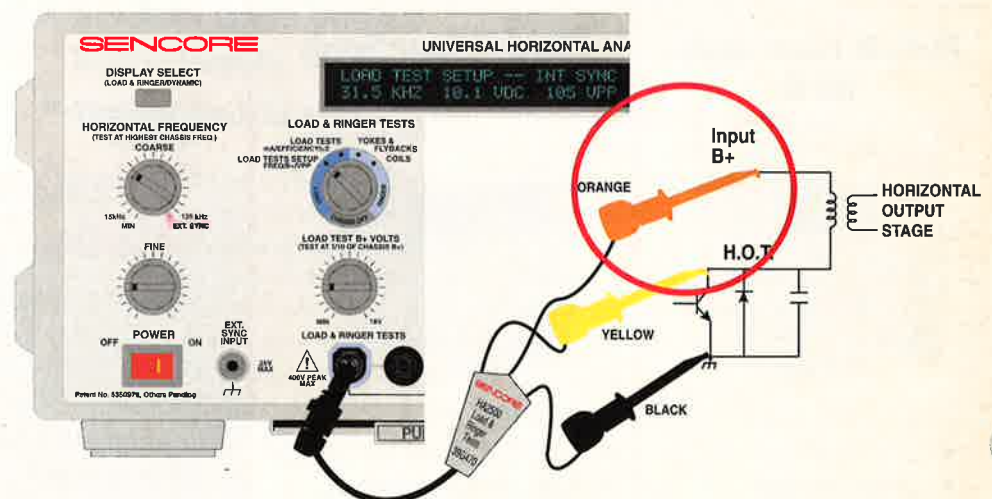


Fig. 1: The HA2500 supplies 1/10th the normal circuit B+ voltage to the horizontal output stage.



## HA2500 Horizontal Load and Dynamic Tests

We next turned to the HA2500 horizontal load test to quickly test whether the horizontal output circuit was capable of operating properly, or whether it was placing an excessive load on the monitor's B+ supply. This load test operates without any AC power applied to the monitor, so it doesn't depend on the monitor's power supply operating properly. During this test the HA2500 supplies its own B+ test voltage to the horizontal output at 1/10 the normal circuit B+ voltage and we expect the circuit to produce approximately 1/10 its normal output voltages



Fig. 2: For the Load Test, the HA2500 horizontal frequency control is adjusted to the monitor's top horizontal frequency.

Our check with the manufacturer's sales information showed that the monitor's top horizontal frequency was 68 kHz, so we adjusted the HA2500 Horizontal Frequency control to match that. We connected the load test leads to the HOT emitter and collector leads and to the flyback B+ input (we checked for flyback continuity from the HOT collector lead). In the Load Test Setup position, we adjusted the HA2500 Load Test B+ Volts control to produce 100 VPP collector pulse (about 1/10 of normal pulse amplitude). We switched to the Load Tests position and found 26 mA B+ current draw, 70 % efficiency, and 3.2  $\mu$ s collector pulse width - all normal for a monitor operating at this frequency, according to the HA2500 pull chart.



Fig. 3: The load tests showed normal readings for a monitor operating at 68 kHz.

This told us that the horizontal output circuit operated properly at 1/10 its normal voltage and current. We then wanted to know whether the monitor B+ power supply was operating properly, whether there was a drive signal to the HOT, and whether the horizontal output circuit was breaking down at full voltage and current.

To determine this, we disconnected the HA2500 load test leads and connected the dynamic test leads to the HOT emitter, base, and collector leads. With the dynamic test leads connected, we chose the HA2500 Collector or Drain Dynamic Test position and applied power to the monitor. The VDC readout indicated 111 VDC, while the VPP and  $\mu$ S readouts both indicated near 0, showing that the HOT was receiving supply voltage, but wasn't switching on and off to produce output signal.



Fig. 4: The HA2500 Dynamic Test showed that the HOT was receiving B+ but wasn't switching.

To check for drive signal to the HOT, we switched to the Base or Gate test position. The VPP test indicated near 0, indicating that there was no horizontal drive at the HOT base. Checking at the collector of the driver transistor, we found no DC voltage, but we found the DC supply was normal, at 24 volts. This led us to check the driver transformer, which we found to have a bad solder joint. Repairing the transformer solder connections restored HOT drive and the CRT display.

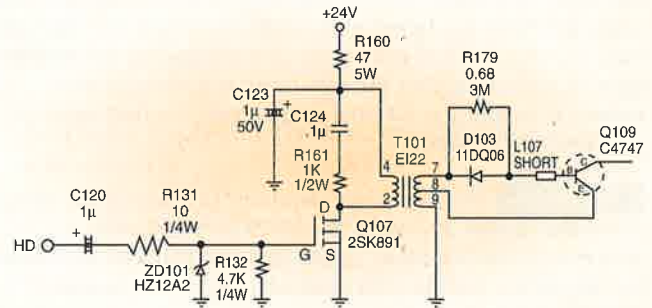


Fig. 5: There was no DC voltage at the collector of the driver transistor, Q107, but the +24V supply was normal.

## CM2125 Complete Performance Test

Now that the monitor again produced a display, we wanted to perform a complete performance test. This would fully exercise all the monitor circuits and find any problems that might not be apparent from a cursory viewing of the display. The eight specially-developed CM2125 troubleshooting video patterns would help us test the monitor's video circuits, power supply, and sweep performance. We will then also test the multiscan switching circuits and the Energy Star power management switching circuits.

We selected Recall 21 on the CM2125 to match the monitor's highest rated resolution mode of 1152 x 870 at 68 kHz. We then selected each of the eight video test patterns in turn:

**Raster** We noted that the white, as well as the red, green, and blue rasters were all free from color impurities. We also noted that when we switched video polarity from "+" to "-" and back again, producing first a white then a black raster with border, the white border did not move by more than twice the width of the border line. This indicated good high voltage regulation at the extremes of high voltage current demand. *No performance problems noted here.*

**Dots** The white dots showed no color fringing in the center of the display and only the very slightest fringing in one corner, not bad enough to be worth readjusting the corner convergence. *No performance problems noted here.*

**Circle** We examined the circle pattern for signs of sweep non-linearity. The circles had a slight oval appearance, but a readjustment of the horizontal width corrected that. The circles were then round and the lines had equal spacing in both the vertical and horizontal directions. *No performance problems noted here.*

**Color Bars** The Color Bars pattern showed all colors present, with uniform colors and the bottom row of bars brighter than the top row. This indicated that the video amplifiers, CRT, and CRT bias were all proper for low frequency color amplification. *No performance problems noted here.*

**Staircase** By adjusting the brightness control, we noted that all 16 staircase bars were visible, each with a distinct brightness change from its adjacent bars. This indicated that the video amplifiers weren't clipping either the white or black peaks of the video signal. Also, neither the dark nor the bright bars showed signs of coloration as we adjusted the brightness control, indicating that the gray scale adjustments were balanced properly at all brightness levels. *No performance problems noted here.*

**Windows** The five white windows in this pattern showed sharp transitions at each of the black-to-white and white-to-black transitions, indicating good dynamic regulation in the B+ power supply with changing current demands. *No performance problems noted here.*

**Multiburst** The Multiburst pattern showed sharply discernable horizontal lines, even down to the 1 pixel-wide grouping, indicating good vertical resolution. The vertical lines, however, were blurred together in the 1 and 2 pixel-wide groupings, with only the 3, 4, and 5 pixel-wide lines individually discernable.



Fig. 6: The blurred 1-pixel vertical lines indicate poor horizontal resolution.

We checked the resolution with only red, only green, and only blue enabled and found all three colors exhibited the same poor resolution. This indicated a loss of horizontal resolution affecting all three video channels, usually caused by decreased high frequency response in the video amplifiers. This was a problem we needed to repair before the monitor could be returned to the customer.

**Text** With the horizontal resolution problem, the Text pattern was blurred, but as we adjusted the monitor focus control, the display did go through a best focus point. This

indicated that the focus circuits were operating properly. *No performance problems noted here.*

Next, we checked the multiscan switching circuits for proper operation. We switched the CM2125 from 1152 x 870 (Recall 21), to 1024 x 768 (Recall 32), to 800 x 600 (Recall 30), and then to 640 x 480 (Recall 7), watching for a properly sized and centered display in each display mode across the monitor's range (or able to be adjusted for such). *No performance problems noted here.*

To complete the performance test, we tested the Energy Star power management switching circuits by disabling first the horizontal sync (Recall 95), then the vertical sync (Recall 94), then both horizontal and vertical sync. At each stage, we watched for a lower power draw by the monitor, with the lowest power draw being under 5 watts. *No performance problems noted here.*

We had completed a performance test of the entire monitor in under 5 minutes and had found that the monitor had poor horizontal resolution, but all other circuits were performing normally. This indicated that we should troubleshoot the video amplifier circuits to find the reason for the decreased high frequency amplification.

### CM2125 Video Signal Substitution

To find the cause of decreased high frequency amplification, we switched back to the Multiburst video pattern. We then used the "divide and conquer" method of signal substitution to localize the circuit causing the problem. We substituted the known-good Multiburst signal at inputs of stages along the video signal path to determine which stages were operating properly, and which weren't. Since the problem affected all three colors, we simply chose one color signal to lead us to the common problem.

Following the divide and conquer approach, we first substituted the CM2125 Multiburst signal Drive Output at the green video amplifier circuit approximate midpoint, the input of Q418 (Fig. 7). Switching the CM2125 video output to green only, we noted a significant improvement in the horizontal resolution. This meant that the last half of the video circuit was working properly, and the problem was in the first half of the video amplifier circuit, between the signal substitution point and the video input. The suspect part of the circuit included the video input buffer IC and the video preamp transistors, Q405, Q411, and Q417.

We chose our second substitution to be the input of Q417, the green video preamp. This time we noted no significant improvement in the green horizontal resolution. This meant the problem was the preamp stage. We repeated our test with Q406 and Q405 in the red circuit to confirm similar operation there.

Since it wasn't likely that there were three defects affecting the three preamp stages, we looked for a part common to all stages which would be likely to cause poor frequency response. We noticed that C431 (22µF/16 V) was a supply voltage filter for the collector of all three preamp transistors,

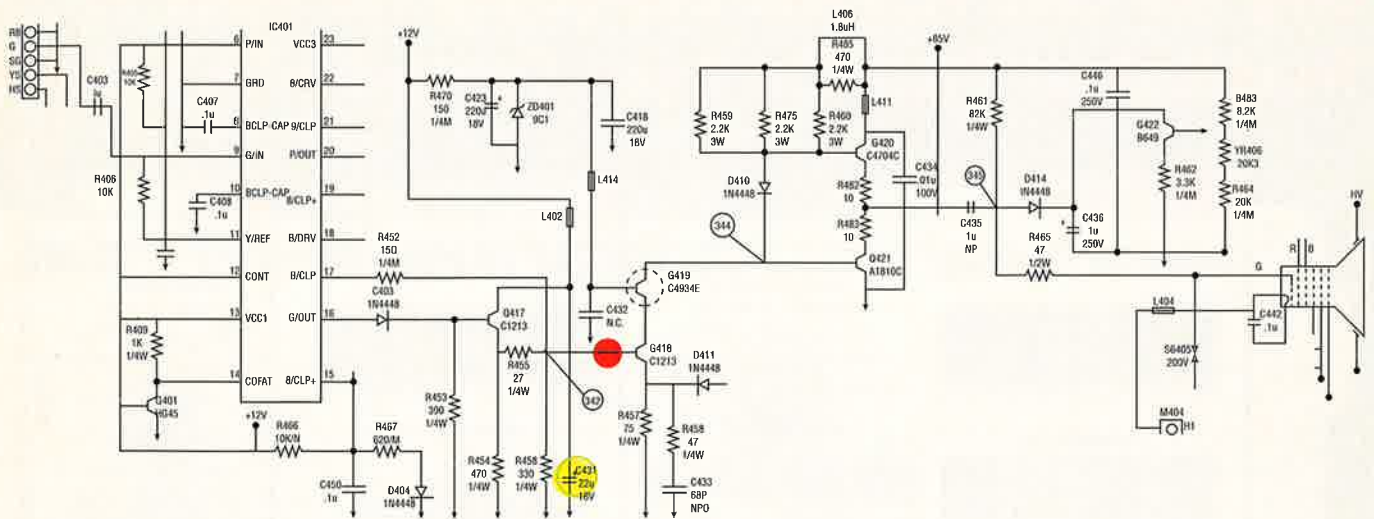


Fig. 7: Gateway video circuits with first substitution point highlighted in red.

and knew from experience that this could very easily cause poor response if it wasn't holding the supply voltage constant at high frequencies. When we tested C431, we found excessive ESR and only 2µF capacitance. We replaced the capacitor, confident we had found the problem.

### CM2125 Horizontal Resolution Performance Test

With the defective capacitor replaced, we reapplied power to the monitor and repeated our original horizontal resolution performance test, with the Multiburst pattern supplied to the monitor video input cable. The monochrome display now showed sharply discernable vertical lines, even down to the 1 pixel-wide grouping, indicating good horizontal resolution. We switched the CM2125 video output to display only red, only green, and only blue Multiburst patterns, and each of the color displays exhibited the same good

horizontal resolution. This confirmed that the repair was complete.

If we had simply repaired the most serious problem and hadn't completely tested the monitor for other problems, we would have sent a poorly performing monitor back to the customer. The customer may or may not have returned the monitor for its continued poor video performance, but they certainly wouldn't have been as pleased with the repair as I'm sure they were in this case. Complete performance testing and efficient troubleshooting methods had made this monitor repair a pleasant experience for both the customer and the servicer.

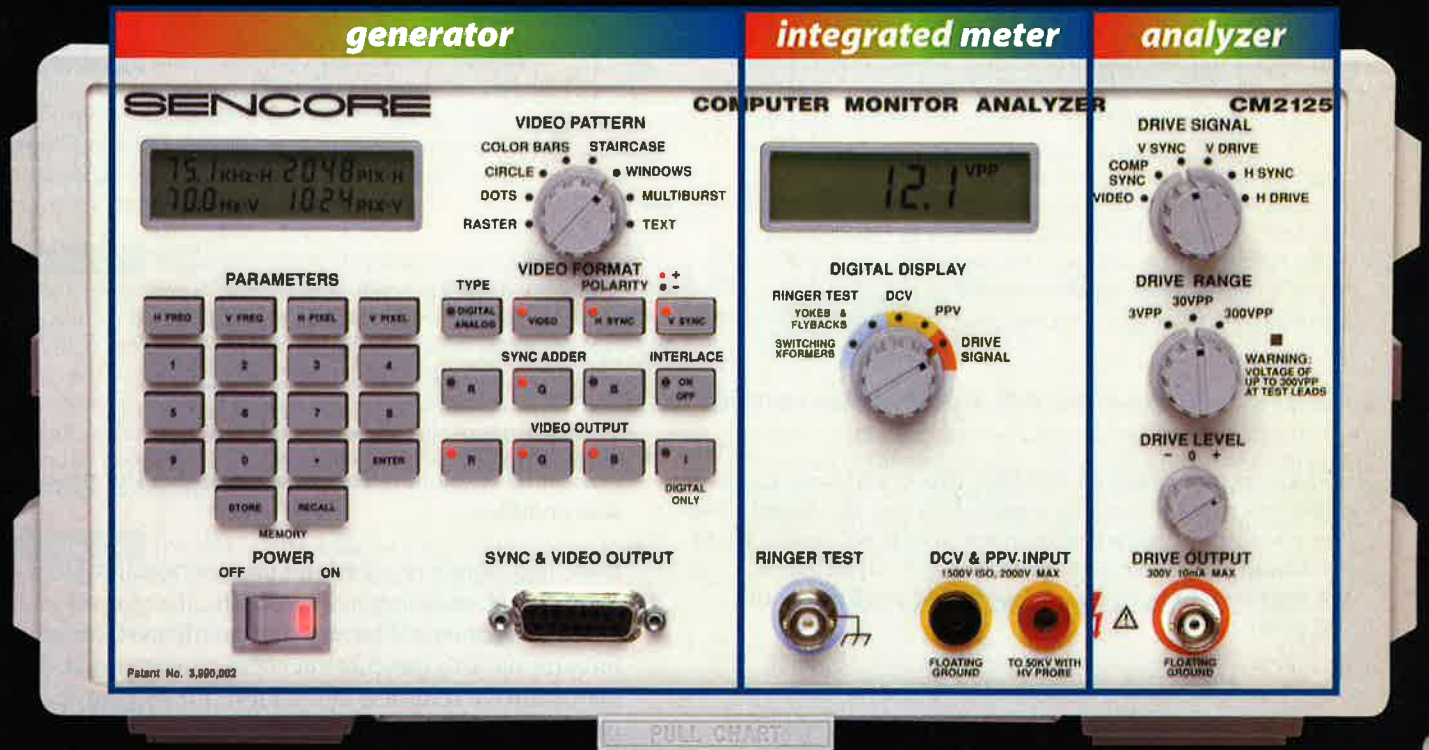
The HA2500 Horizontal Analyzer and CM2125 Computer Monitor Analyzer make a great team. **Call 1-800-SENCORE** today for a non-obligation trial and find out for yourself just how effective this team is in solving those tough, multiple problem repairs. **SN**

One of the biggest challenges for computer monitor servicers is the many display formats. Sencore provides solutions that allow servicers to connect to the many input connector formats. If you are having difficulty getting connected, **CALL 1-800-SENCORE** and ask how we can help.

Connectors Available For Sencore's Computer Monitor Analyzer/Generators					
Connector #	Where Used	CM125	CM2125	CM2250	CM2250-PC/ CM2250-PC-Pro
#1 (39B275)	15 pin to CGA	✓	✓	✓	✓
#2 (39B280)	15 pin to EGA	✓	✓	✓	✓
#3 (39B281)	15 pin to PGC	✓	✓	✓	✓
#4A (39B274)	15 pin to VGA, PS/2, SVGA, and XGA	✓	✓	✓	✓
#6 (39B300)	15 pin to male BNC	✓	✓	✓	✓
#7 (39B416)	15 pin to 13W3 Extension Cable	✓	✓	✓	✓
#8 (39B492)	15 pin to BNC (male) Apple-Mac	✓	✓	✓	✓
#8F (39B493)	15 pin to BNC (female) Apple-Mac	✓	✓	✓	✓
39B377	DB15 to DB15 Extension Cable	✓	✓	✓	✓
39B273 Universal Connector	15 pin to bare wire	✓	✓	✓	✓
39G346 ECL Adaptor	Converts digital (TTL) to ECL		✓	✓	✓

Above connectors require use of 39B440 or 39B560 when used with either the CM2250 or CM2250-PC

# Only The CM2125 Has Everything You Need To Troubleshoot From The Input Connector To The CRT!

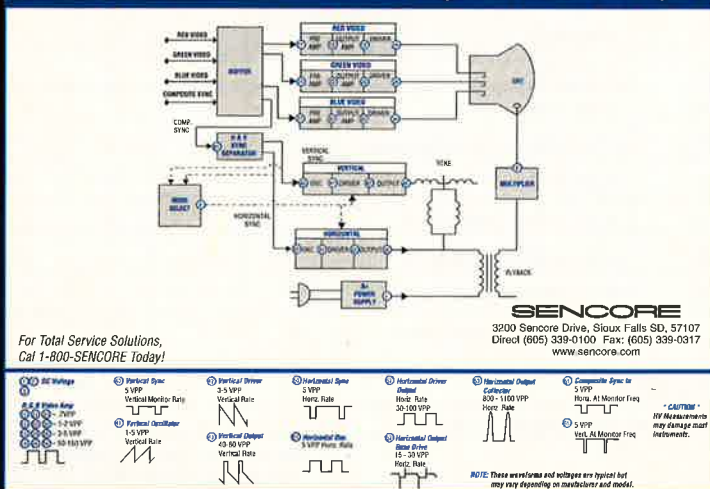


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- A fully programmable sync and pixel generator
- A patented "Ringer" test to dynamically analyze:
  - Yokes
  - Integrated High Voltage Transformers (IHVTs)
  - Switching Transformers
- A special sync-locked signal substituter
- An integrated 2000 VDC and P-P meter
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**I** seem to hear this sentiment being expressed more and more frequently. This greatly concerns me as our success is directly linked to your success. With this in mind, let's look at several critical elements, each of which plays an important role in determining your profitability.

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By Glen Kropuenske

Application Engineer  
Sencore Electronics

## Understanding Horizontal Driver Stages In Multi-Frequency CRT Video Displays

### Sixth In A Series Of Articles Covering Multi-Frequency Horizontal Stage Analyzing

Horizontal output stage component and problem symptoms are often related to defects in the horizontal driver stage. Yet the driver stage is seldom suspected, and often shows a "near-normal" output waveform on a scope when it has a defect.

This article examines the typical circuit configurations and operation of horizontal driver stages found in today's multi-frequency computer monitors. It further examines how multi-frequency monitors alter the output of the horizontal driver stage to optimize the operation of the horizontal output transistor at different frequency modes.

Earlier articles in this series examined how the horizontal output stage in computer monitors and other multi-frequency video displays change operating conditions to properly produce high voltage and deflection as picture resolution or modes change.

### Horizontal Output Transistor Types & Drive Requirements

To understand the horizontal driver stage requires a good understanding of what its output must do. The horizontal driver stage must develop a drive signal that alternately forward biases the horizontal output transistor, and then reverse biases the horizontal output transistor 30,000 to 75,000 times each second, depending on the monitor's resolution capabilities.

There are commonly two types of horizontal output transistors used in today's multi-frequency video display monitors: the conventional bipolar power transistor, and the newer enhancement MOSFET (metal oxide semiconductor field effect transistor) type (see Fig. 1). These transistors have different input drive base or gate requirements, therefore they have different horizontal driver stage requirements.

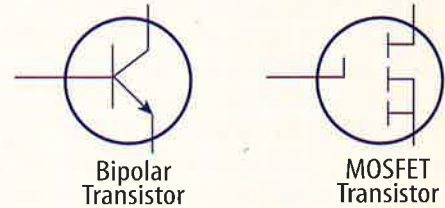


Fig. 1: Common horizontal output transistor types in today's multi-frequency video displays.

The MOSFET power transistor is a voltage-controlled device. A voltage greater than (about) four volts applied to the gate of the transistor forward biases the transistor on. When biased on, the resistance of the channel between the drain and source lead is one ohm or less, permitting current flow from the drain to the source. In a horizontal output stage, the current path from the drain leads through the flyback or coil winding to the B+ voltage source (see Fig. 2). Since the gate is electrically isolated from the transistor's conduction channel, no gate current is required to switch the transistor on or off. Therefore, the MOSFET transistor is said to be a high input impedance device.

Switching the MOSFET power transistor off is as simple as applying a voltage near zero volts to the gate lead with respect to the source. With little voltage on the gate, the channel resistance between the source and drain is high and the transistor acts as an open switch.

The use of MOSFET power transistors for horizontal output transistors is still limited. They are used most often among high-voltage-only horizontal output stages where conduction or drain current is much less than combination or deflection horizontal output stages. MOSFET drain-to-source breakdown voltage is limited to 800 or 1,000 volts, compared to 1,500 for bipolar transistors, requiring unique circuit, flyback or coil design.

The MOSFET has high input or gate capacitance which slows the transistor's ability to switch between on and off states at higher frequencies, especially with high drain currents. For these reasons, it is not uncommon to see MOSFET transistors in parallel to divide the drain current.

A typical horizontal driver stage using a MOSFET horizontal output transistor is shown in Fig. 2. The horizontal driver stage is much simpler than those required by bipolar horizontal output transistors. The driver stage generates a voltage that alternates between zero volts and a voltage above five volts, typically 12 volts, as shown. The amplifier configuration consists of two transistors in a complementary configuration. A horizontal square wave signal, typically from a horizontal signal processor IC, is input to the driver stage. The positive voltage of the input biases on the top transistor, pulling its emitter to near 12 volts. The 12 volts is applied to the gate of the MOSFET horizontal output transistor, turning the transistor on. The low or near-zero voltage transition of the input square wave turns on the bottom transistor, pulling the gate of the MOSFET horizontal output transistor to ground.

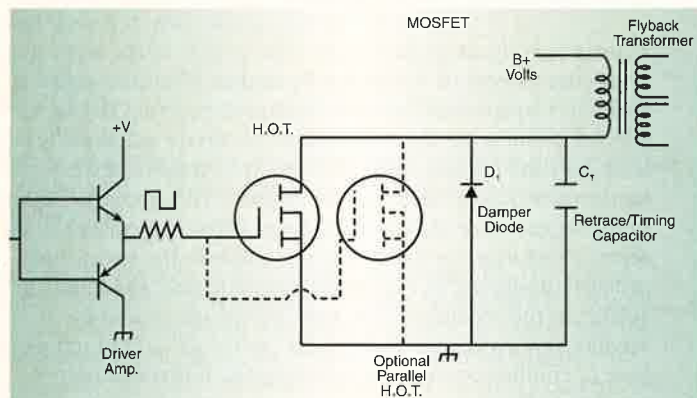


Fig. 2: A MOSFET horizontal output transistor(s) and typical horizontal driver stage.

You can usually troubleshoot this horizontal driver stage by using an oscilloscope such as the Sencore SC3100 "AUTO TRACKER". To analyze the driver stage output, connect and view the waveform at the gate of the MOSFET horizontal output transistor. The horizontal driver stage output voltage waveform should be alternating between approximately zero and the driver stage's power supply voltage, typically 12 volts. The input horizontal waveform to the driver stage typically alternates near ground to approximately five volts. Peak-to-peak measurements should reflect these voltage changes. Low or missing voltage transitions indicate a horizontal driver stage defect.

### Understanding Base Current Requirements For Bipolar Horizontal Output Transistors

A bipolar horizontal output transistor is a current-controlled device. When base current is produced by a forward bias voltage greater than 0.6 volts to the base/emitter junction, the bipolar transistor is turned on. When biased fully on, the

collector-to-emitter resistance path through the transistor is only a few ohms. In a horizontal output stage, the current path from the transistor's collector goes through the flyback or coil winding to the B+ voltage source. The base/emitter junction represents a very low impedance or load on the horizontal driver stage output.

A bipolar transistor is reversed biased or turned off when base current is stopped. Base current is stopped by applying insufficient forward bias voltage or reverse bias voltage to the base/emitter junction. The collector-to-emitter resistance path through the transistor increases to a high resistance, effectively opening the transistor, preventing emitter-to-collector current.

As with any bipolar transistor, it is the base current that is critical for normal operation. It is the horizontal driver stage that outputs drive to produce that base current for a bipolar horizontal output transistor. Base drive current must be sufficient to produce the needed collector current and switch the transistor between "on" and "off" conditions properly.

You may recall from previous articles in this series that the collector current in a horizontal output transistor starts at a low level and increases to a peak level because of the inductance of the flyback or coil primary winding. It can be reasoned that the base current must be at a level that, when multiplied by the transistor beta, allows the collector to reach current peak conduction see fig. 3. An insufficient base current or transistor beta may limit the transistor's conduction and collector current buildup or peak.

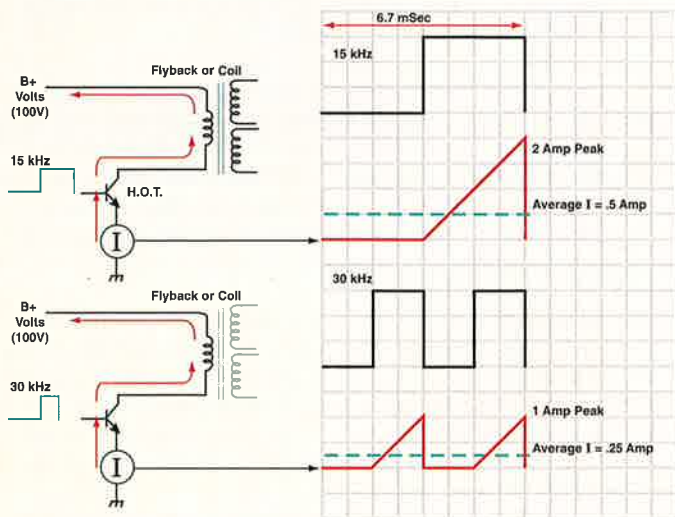
Just as important is reducing or stopping base current quickly. This is necessary to switch the horizontal output transistor quickly off from its full conduction or peak current point. The brief time it takes to switch the transistor off results in transistor power dissipation and heat. The heat results from a diminishing current flow in the quickly increasing emitter to collector resistance. Remember the transistor must be switched off from full peak conduction 30,000 to 75,000 times each second.

To satisfy the collector current peak but maintain best horizontal output transistor switching efficiency, the base drive current is optimized by the design and components of the horizontal driver stage. When designed and working properly, the driver stage produces a rising base drive current that mirrors the rise of the collector current in the horizontal output stage. The base drive current peak when multiplied by the transistor beta produces the collector current peak needed by the horizontal output stage. The base drive current level is further optimized to permit the horizontal output transistor to switch off quickly and operate within its power dissipation rating.

### Horizontal Driver Stage For A Bipolar Horizontal Output Transistor

The horizontal driver stage used to drive a bipolar horizontal output transistor, is commonly a discrete transistor amplifier

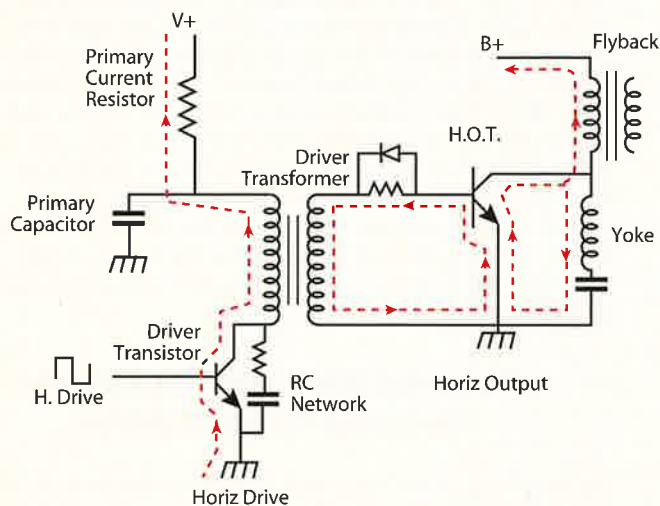
stage. The amplifier stage consists of five main elements as shown in Fig. 4. The basic driver stage includes: 1) transistor, 2) transformer, 3) primary resistor, 4) RC network, and 5) primary filter capacitor.



**Fig. 3: Sufficient base drive current allows the needed collector current peak with good transistor switching efficiency for minimal heat.**

The driver transistor is a medium-power transistor that operates with voltages from 10 to 100 volts. The transistor may be a conventional bipolar or newer MOSFET type and operates as an "on" or "off" switch. When driven "on" by the base or gate drive signal, the transistor permits current flow in the driver transformer primary. When driven "off" by the base or gate drive signal, the current path is opened.

The driver transformer couples the output of the driver stage to the horizontal output transistor and provides impedance matching and current step-up to the H.O.T. A typical driver transformer turns ratio is 30:1 from the primary to secondary. This ratio matches the high impedance of the driver amplifier to the low base/emitter junction impedance of the horizontal output transistor. It further steps up the driver transformer primary current to produce a much higher secondary H.O.T. base current. The nature of the driver transformer output is ideal



**Fig. 4: Basic components of a horizontal driver stage and resulting base currents in a bipolar horizontal output stage.**

for producing a rising base current and quickly changing to a reverse voltage that switches the H.O.T. off.

A primary resistor is part of the current path with the driver transistor and transformer primary. The resistor establishes the level of driver transformer primary current along with the power supply voltage to the driver stage. An increase or decrease in the resistor value directly affects the primary current and the driver stage's output. Two resistors in parallel are used in many chassis'.

A bypass filter capacitor connects from the voltage input side of the driver transformer primary to ground. The filter capacitor effectively increases the transformer primary current by charging and discharging current through the transformer primary.

An RC snubber network parallels the driver transistor from the collector or drain to ground. The snubber network protects the transistor from induced voltages. The snubber network has little impact on the horizontal driver stage's output current. In some driver stages the RC snubber network is placed across the driver transformer primary winding.

A horizontal signal applied to the base or gate of the horizontal drive stage is needed for normal operation. The drive signal is typically a square wave at the horizontal frequency. During a portion of the input drive waveform, the driver transistor is biased on and current flows through the transistor, driver transformer primary, and primary resistor. The discharge action of the bypass filter capacitor produces additional current in the driver transformer primary. Current builds in the transformer primary, producing an expanding magnetic field and induced voltage in the secondary. The induced voltage produces secondary current that depletes the horizontal output transistor base of conduction carriers, switching the horizontal output transistor off.

When the driver transistor is biased off by the remaining portion of the horizontal drive input, current ceases in the driver transistor. The magnetic field in the primary of the driver transformer collapses, inducing voltage into the driver transformer secondary to forward bias the base/emitter junction of the horizontal output transistor. The driver stage and transformer action produce an increasing secondary base current in the horizontal output transistor. The base current increases to a level that biases on the horizontal output transistor and continues to increase to permit the buildup of collector current for the horizontal output stage.

### Changing Driver Stage Output Current In A Multi-Frequency Monitor

Multi-frequency CRT displays operate through a range of many different horizontal frequencies. The horizontal driver stage must produce the proper H.O.T. base current through the entire horizontal frequency range. Monitors with a wide horizontal operating range may change the horizontal driver stage to increase or decrease the base drive current for the H.O.T. At lower operating resolutions or frequencies, the base current may be increased compared to higher operating frequencies.



This is done because the H.O.T. has slightly different collector current requirements, depending on the horizontal frequency. At lower operating frequencies, the horizontal output transistor conducts longer, reaching higher collector current peaks to produce the required high voltage and/or deflection. Therefore, a higher level of base drive current is required to reach the needed collector current. A driver stage designed to supply sufficient base drive current for the highest operating frequency overdrives the H.O.T., producing more than the required base current at much lower operating frequencies. This results in a longer turn-off time of the H.O.T., causing added power dissipation and heating of the H.O.T. To optimize operation of the H.O.T. and reduce transistor heating, the driver stage may be switched between two or more output drive current levels.

Two methods of switching the driver stage output current level to the base of the H.O.T. are shown in Fig. 5. The first method involves changing the level of primary current in the driver transformer. This can be done by changing the power supply voltage applied to the horizontal driver stage or varying the value of the primary resistor. Increasing the power supply voltage increases the driver transformer's primary current and the output base drive current. Decreasing the power supply voltage to the driver stage decreases the output base drive current.

The voltage to the horizontal driver stage can be selected or varied using power supply regulating methods. A pass transistor as shown in Fig. 5 outputs voltage at its emitter according to the voltage established at its base. Switching converters similar to those used by high voltage/deflection regulators may also be used.

Varying the primary resistor value also changes the transformer primary current. The resistance value can be changed by placing a transistor in parallel with the primary resistor. By controlling the transistor's conductance, the resistor value can be changed to increase or decrease the driver transformer's primary current and output current.

A second method of changing the driver stage's output drive current is shown in Fig. 5B. Placing a resistor in series with the base current path of the horizontal output transistor reduces the base current to the required level. By switching in a lower value resistor for lower horizontal frequencies, the base drive current is boosted. The resistor can be switched in or out of the base current path with a MOSFET switching transistor. The transistor is switched by a mode control output which senses the horizontal operating frequency.

## Understanding Horizontal Driver Stage Symptoms

Defects in the horizontal driver stage used to drive bipolar horizontal outputs result in many of the same symptoms caused by defects in the horizontal output stage. Common symptoms include a dead horizontal output stage, horizontal output transistor overheating, abrupt horizontal output transistor failures, and reduced high voltage and/or deflection.

The output of the horizontal driver stage is essential for normal operation of the horizontal output transistor and output stage. If the base drive current is missing, the horizontal output transistor remains off and the horizontal output stage is inactive. No high voltage and/or deflection is produced by the horizontal output stage.

If the horizontal driver stage output or base drive current is reduced from normal, the horizontal output transistor cannot produce the required collector current. The symptom depends on the severity of the current decrease. If the base current is reduced only slightly, little if any change in high voltage and/or deflection may be seen. At some level of base current reduction, the collector current peak is limited causing the high voltage and/or deflection to decrease. The flyback pulses at the collector or drain decrease from normal, indicating a decrease in the flyback and/or yoke currents. Small reductions in base drive current do not

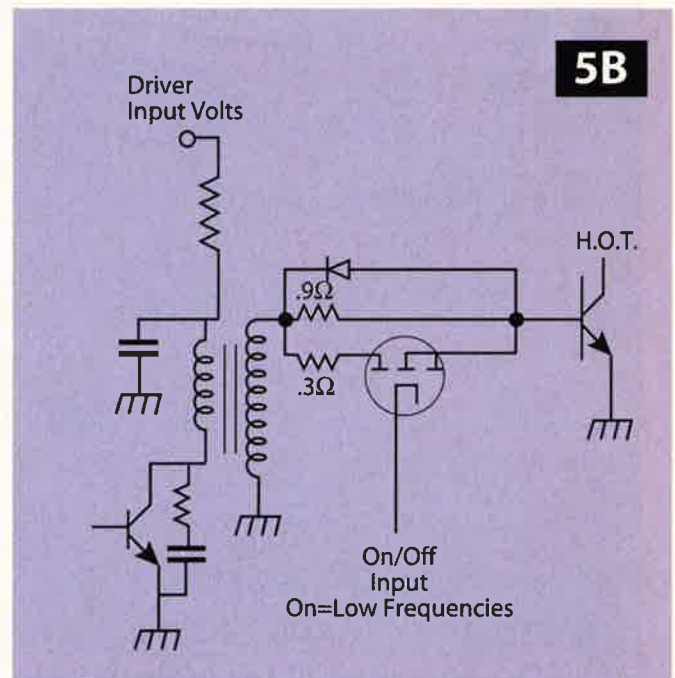
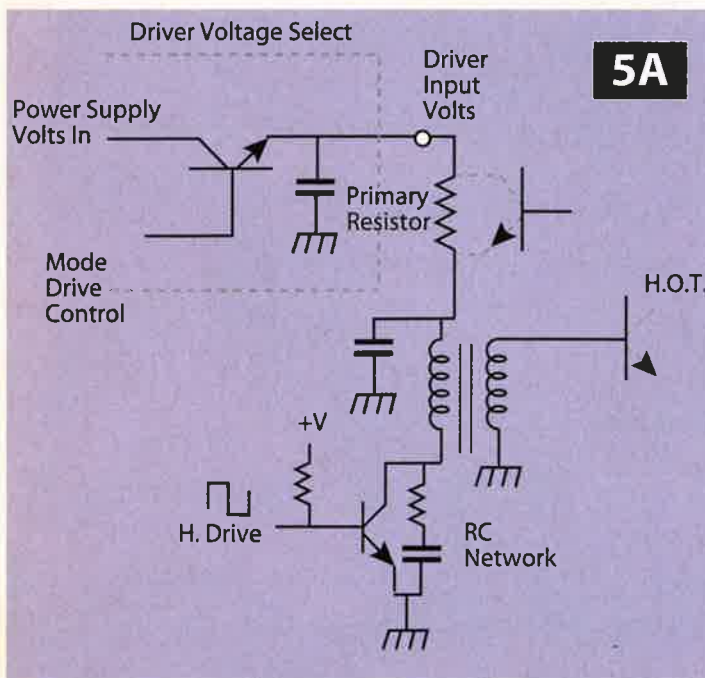


Fig. 5: Two methods in multi-frequency monitors used to control the horizontal driver stage's output drive current.

significantly change the familiar voltage waveform seen on an oscilloscope at the base of the horizontal output transistor. A severe reduction in base drive current results in quick over heating and failure of the horizontal output transistor.

The reverse bias drive voltage applied to the base of the H.O.T. switches the H.O.T. off to stop collector current. Switching off the H.O.T. as it reaches a current peak of several amps and base current of several hundred milliamps is not simple. The base region of the transistor must be evacuated of charged carriers before collector current ceases. Reduced base drive current slows the transistor turn-off, leading to increased H.O.T. power dissipation, heating, and premature failure. This failure commonly occurs with reductions in the driver stage's base current long before decreases in the high voltage or deflection occurs.

Intermittents in the horizontal driver stage can be another cause of horizontal output transistor failure. Intermittents cause a fluctuation in the driver stage's output base drive current. These current changes cause abrupt current variations as the horizontal output transistor is driven on and off. Combined with the high currents and voltages produced by the horizontal output stage, the horizontal output transistor is often damaged.

To learn how you can analyze the horizontal drive stage, read the article "Use The HA2500 To Troubleshoot And Identify Horizontal Driver Problems" starting on page 19 in this Sencore News issue. **EN**

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**By Glen Kropuenske**  
Application Engineer  
Sencore Electronics

## Use the HA2500 To Troubleshoot And Identify Horizontal Driver Problems

### Exclusive HA2500 Horizontal Driver Test Detects Weak or Intermittent H.O.T. Base Drive

The horizontal driver stage often causes symptoms identical to horizontal output stage symptoms. Yet the horizontal driver stage is seldom suspected, and often when it does have a defect, scope waveforms and peak-to-peak measurements at the base of the horizontal output transistor appear normal.

Horizontal driver stage defects and symptoms can be difficult to diagnose for several reasons including:

1. Horizontal driver stage problems are less suspected compared to horizontal output stage defects.
2. Problem symptoms are the same as horizontal output stage defects.
3. Horizontal output transistors may burn-out quickly, leaving no time for measurements.
4. Horizontal output transistors may run hotter than normal and burn-out after several minutes, hours, or days while waveforms and horizontal output stage functions appear normal.

The HA2500 Universal Horizontal Analyzer's Horiz. Driver Test is an exclusive analyzing test designed to identify horizontal driver stage defects. The Horiz. Driver Test analyzes the output of a horizontal driver stage designed to produce base drive to a bipolar horizontal output transistor. The test identifies driver stages which are not producing an adequate current drive for proper operation of a bipolar type horizontal output transistor. This article shows you the exclusive nature of the HA2500's Horiz. Driver Tests and how to identify and analyze horizontal driver stage problems.

For a better understanding of horizontal drive stages and symptoms, read the article "Understanding Horizontal Driver Stages In Multi-Frequency CRT Video Displays" starting on page 14 in this Sencore News issue.

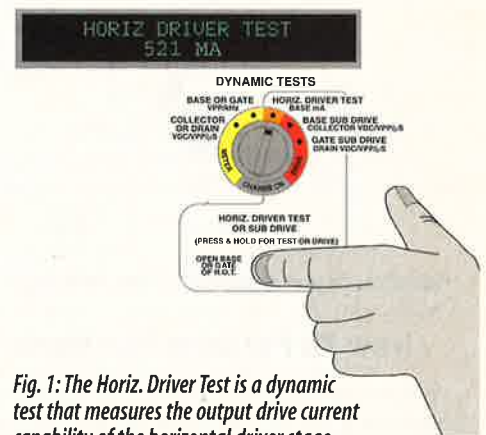


Fig. 1: The Horiz. Driver Test is a dynamic test that measures the output drive current capability of the horizontal driver stage.

### How The HA2500's Horiz. Driver Test Works

The Horiz. Driver Test works by simulating a low impedance base/emitter horizontal output transistor junction and measuring the drive current produced in this low impedance by the horizontal driver stage. In this manner, the Horiz. Driver Test's mA readout quantifies how much base current the horizontal drive stage is capable of producing. This is the current drive to the base of a bipolar horizontal output transistor.

To accurately measure the driver stage's output current capability, the Horiz. Driver Test simulates the base/emitter junction of a bipolar horizontal output transistor. The test uses a low barrier schottky diode and small value resistor (see Fig. 2). The polarity of the schottky diode permits drive current output produced by the driver stage to flow through the resistor during the positive cycle. This closely simulates how the positive drive output cycle of the driver stage produces base current in the horizontal output transistor. The low forward bias voltage of the schottky diode permits a more sensitive current measurement to better test the driver stage's output current drive capability.

Current through the small value resistor produces a voltage that is relative to the amount of potential output drive current during the positive cycle. A metering circuit measures the voltage and calculates the average positive conduction current. This current is the base drive current that is available from the driver stage to the horizontal output transistor.

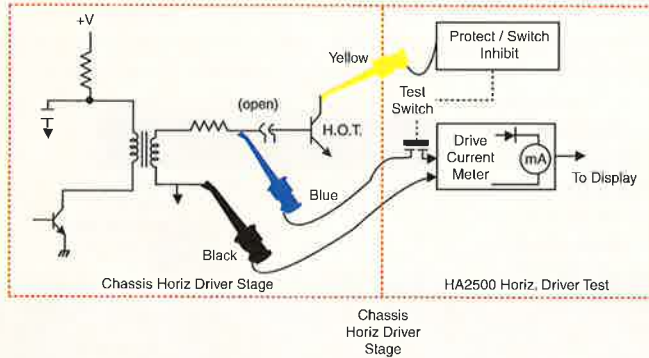


Fig. 2: Block diagram of the HA2500 Horiz. Driver Test.

### How To Perform The Horiz. Driver Test

Performing the Horiz. Driver Test requires that the horizontal output transistor be removed or that the base lead of the horizontal output transistor be opened. This permits all the drive current from the driver stage to be routed to the HA2500's measurement circuit for accurate drive current measurements. It further prevents any chance of damaging the chassis horizontal output transistor.

Before performing the Horiz. Driver Test, remove AC voltage to the chassis and unsolder the H.O.T. or open the circuit path leading from the driver transformer to the base of the horizontal output transistor. There is commonly a jumper, small resistor, inductor and/or diode between the transformer and H.O.T. base. Unsolder one lead of the component(s) and lift from the circuit board to open the circuit path to the base.

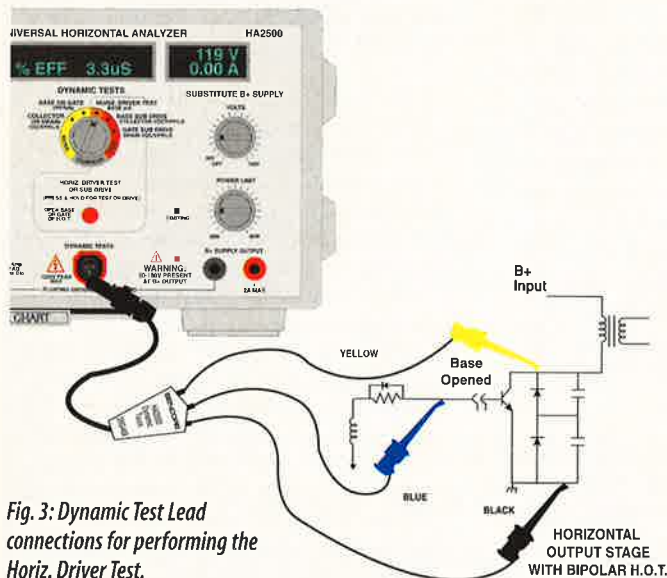


Fig. 3: Dynamic Test Lead connections for performing the Horiz. Driver Test.

The Horiz. Driver Test is performed using the Dynamic Test Leads. Connect the blue test lead clip to the output of the driver stage at the secondary side of the horizontal driver transformer. This corresponds to the transformer side of the opened path between the transformer and base of the horizontal output transistor (see Fig. 3). Connect the black test lead clip to the horizontal output stage ground typically at the H.O.T.'s emitter. Connect the yellow test lead clip to the collector of the horizontal output transistor.

When performing the Horiz. Driver Test, it is important to connect to the circuit point equivalent to the base of the horizontal output transistor. Resistors located between the driver transformer and the base of the H.O.T. impact the level of base drive current. Always connect the blue clip of the Dynamic Tests Lead to the base side of the resistor if it is unsoldered and lifted from the circuit board.

The Horiz. Driver Test is an active test relying on the chassis horizontal driver stage to produce an output.

With no drive output from the driver stage, the test reads little or no mA drive current. To produce an output, the horizontal driver stage must have a horizontal drive input signal from the horizontal oscillator, a power supply voltage, and be operational. To confirm the horizontal driver stage is producing an output, apply AC voltage to the chassis and perform the Base or Gate Dynamic Tests. No horizontal drive is indicated by low PPV readings and no frequency readout. Isolate the cause of no drive output before performing the Horiz. Driver Test.

#### TO PERFORM THE HORIZ. DRIVER TEST:

1. Remove AC voltage to the chassis
2. Unsolder the H.O.T. and remove or open the base circuit path
3. Connect the DYNAMIC TEST leads:
  - Blue clip to driver transformer secondary
  - Black clip to horizontal stage ground
  - Yellow clip to collector
4. Set DYNAMIC TESTS switch to "Horiz. Driver Test"
5. Apply AC voltage to the chassis
6. Push & hold the Horiz. Driver Test Or Sub Drive test button
7. Read the mA current drive
8. Compare reading to Typical mA Range chart (see the HA2500 Pull Chart or Chart 1 in this article)

### When To Use The HA2500's Horiz. Driver Test

Use the HA2500 Horiz. Driver Test when the computer monitor exhibits horizontal related symptoms. Remember many horizontal driver stage problem symptoms are the same as horizontal output stage symptoms. If there is normal high voltage and/or deflection, normal Collector DCV/ $\mu$ S/PPV Dynamic Tests, and the bipolar horizontal output transistor is not overheating, there is little reason to suspect the horizontal driver stage or use the Horiz. Driver Test.

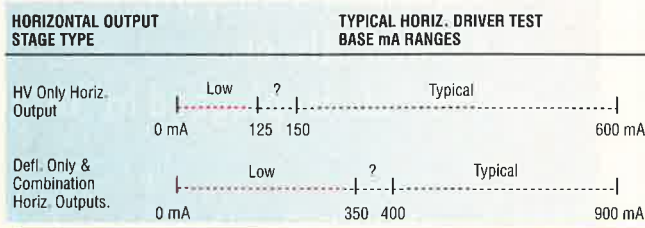
**You should suspect the horizontal driver stage and perform the Horiz. Driver Tests when:**

1. The original problem was a defective bipolar horizontal output transistor and the HA2500's Load Tests indicate normal.
2. The horizontal output transistor was found defective or repeatedly fails, but a replacement seems to restore normal operation.
3. The horizontal output stage produces insufficient high voltage and/or deflection (reduced collector PPV), but the DCV seems normal.
4. The chassis seems to operate normally (Collector Or Drain DCV/uS/PPV meter tests indicate normal) but the horizontal output transistor gets too hot, often failing within hours, days, or weeks of replacement.
5. The horizontal output transistor burns out or gets hot when the chassis horizontal driver stage is used, but is fine when using the HA2500's Base Sub Drive.
6. The horizontal output stage produces insufficient high voltage and/or deflection but the DCV to the horizontal output stage is normal.

### Interpreting The Horiz. Driver Test mA Readout

The mA readout of the Horiz. Driver Test indicates the level of output base drive current the chassis horizontal driver stage can produce. The amount of output drive current varies between chassis' depending on the amount of collector current which must be produced by the horizontal output transistor. The base current peak multiplied by the beta of the horizontal output transistor must satisfy the peak buildup in the H.O.T.'s collector current. The buildup in collector current is determined by the horizontal output stage.

The amount of driver stage output current is determined by the driver stage's power supply voltage, power supply current limiting resistor, driver transformer characteristics, and resistor between the driver transformer and base of the H.O.T. It is also (in part) affected by the gain of the driver transistor and its base current. The driver stage components are determined by designers to satisfy the current requirements of the H.O.T. and the horizontal output stage.



**Chart 1: Typical ranges of current expected during the Horiz. Driver Test.**

Driver stages for bipolar HV-only horizontal output stages typically produce base drive currents ranging from 150 to 600 mA. Driver stages of combination HV/deflection output stages and deflection-only output stages typically produce higher drive currents ranging from 350 to 900 mA.

Horiz. Driver Test mA readouts less than the typical mA range shown in Chart 1 indicate a likely weak or insufficient current drive for the horizontal output transistor. Horiz. Driver Test mA readouts greater than the typical range usually do not indicate a problem unless driver stage components have been improperly substituted. Improper substitution can result in higher-than-normal driver output current and contribute to horizontal output transistor failures.

### Note Specific Chassis Horiz. Driver Test Readings

Added benefits of the Horiz. Driver Test can be realized by recording the normal mA level of a working chassis. On chassis' that switch output drive current levels, be sure to select the monitor's highest and lowest operating frequencies or resolutions and record the drive current readings. Then in the future, you can reference the normal mA drive current for that chassis when confronted with horizontal problems. You can also more accurately identify horizontal driver stage problems that are beginning to weaken the drive before they cause major problems.

### Isolating Intermittent Horizontal Drive Problems

Intermittent horizontal drive problems can be frustrating as they often cause repeat H.O.T. failures while you are attempting to troubleshoot the symptoms. Also, the waveform observed on an oscilloscope at the base of the H.O.T. may or may not change much, and you cannot be sure if a change was caused by the horizontal driver or horizontal output stage.

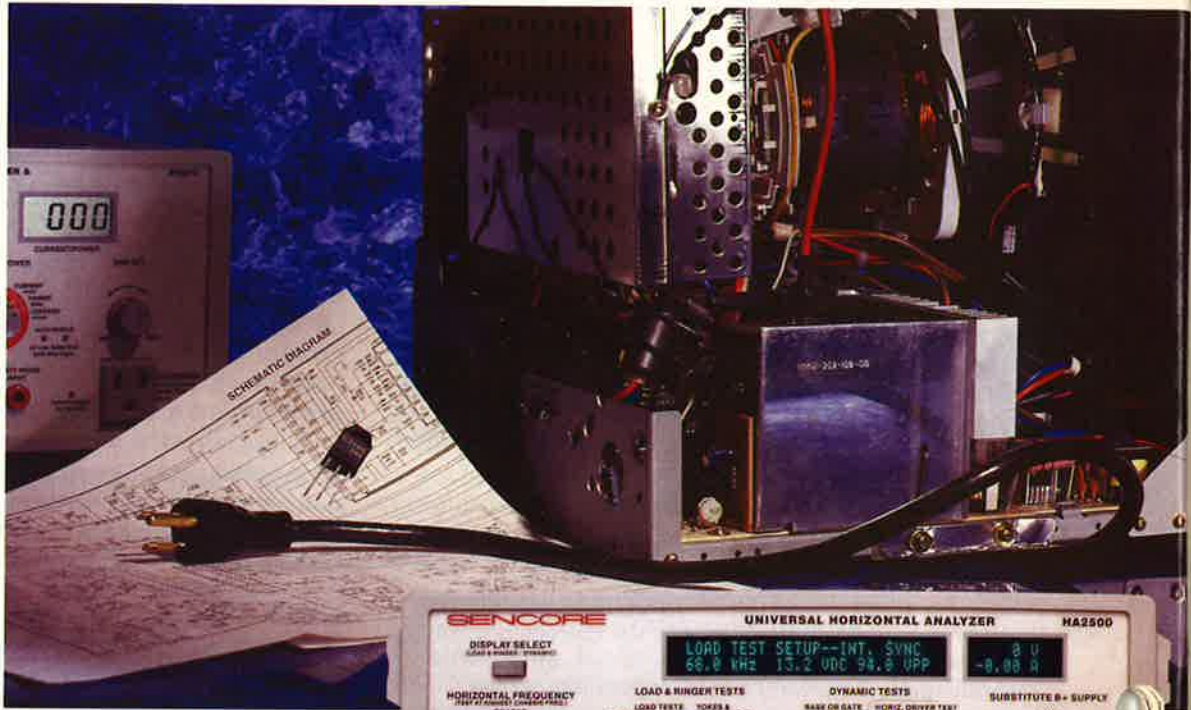
The HA2500's Horiz. Driver Test readout helps you quickly determine if the current output of the driver stage is intermittent. Simply perform the Horiz. Driver Test and monitor the current readout for a short period of time. Watch the mA readout for any big fluctuations or abrupt changes. A normal current drive output changes the readout by only a few microamps. An intermittent output drive current causes substantial changes in the mA output.

To isolate intermittent drive problems, introduce vibration, heating, or cooling stimuli to the horizontal driver stage and components while watching the mA readout. After isolating and correcting intermittents, use the Horiz. Driver Test to confirm a constant mA readout. You'll soon discover that the Horiz. Driver Test prevents damage of replacement horizontal output transistors.

To order or simply learn more about the HA2500's exclusive Horizontal Driver Test or other horizontal analyzing features, call 1-800-SENCORE today. **SN**

# HA2500

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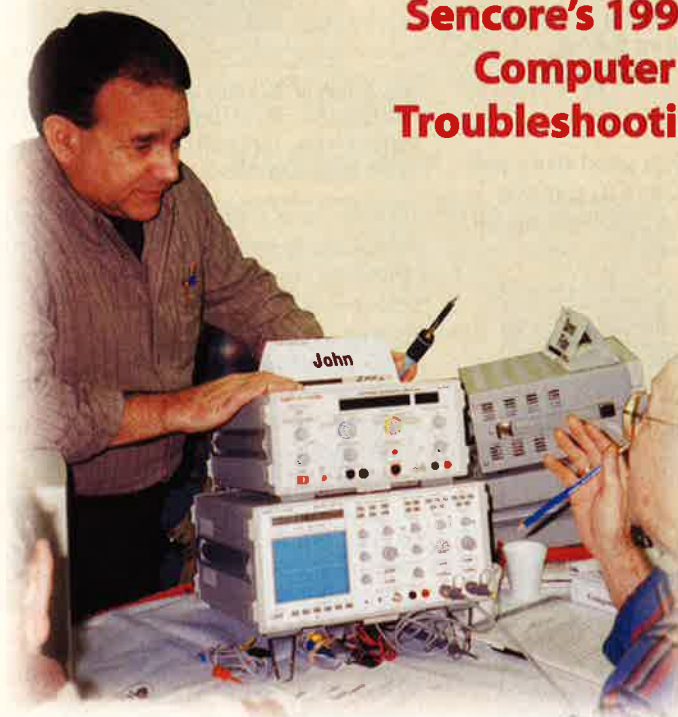
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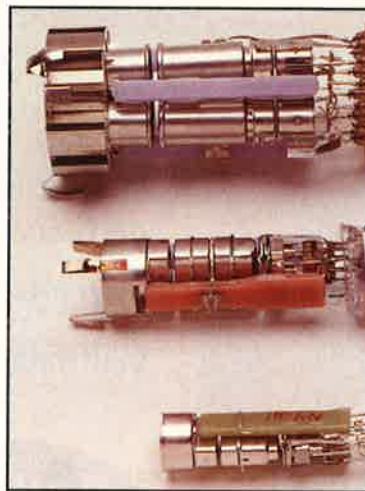


**By Paul Nies**  
CET  
Sencore Electronics

## Accurately Analyze And Safely Restore Modern CRTs With The CR7000

Do you remember when the neck of a CRT was as big around as your 2 year old son's arm and "instant on" meant that voltage was applied to the CRT filaments even when the television was turned off? Those were the good old days of CRT restorers and rejuvenators. The old delta gun designs allowed plenty of room for big cathodes with thick coatings of barium or thorium.

Many servicers made a good day's pay popping television CRTs to remove the layer of oxidation that built up on the ever-warm cathode.



*Fig. 1: Today's electronic guns have gotten smaller and are capable of producing better quality pictures.*

CRT testers and rejuvenators back then didn't need to be elaborate. A simple bias voltage and current meter confirmed if the CRT produced nominal emission. The shorts test often consisted of a light bulb, and since the picture wasn't all that great in the first place (by today's standards), a tracking test was seldom necessary or provided.

Restoration was pretty basic too. Since the large cathode surfaces held plenty of extra emitting material, restoration current could be heavy and applied for long periods of time. Often the restore current came



*Fig. 2: Sizes of CRT's have changed dramatically over the years from the old Delta gun style to today's newest in-line. The smaller in-line gun produces much better convergence.*

simply from a filament transformer low voltage winding. Current limiting provided by a light bulb in series with the winding and the cathode. To restore a CRT, you'd simply select which cathode to restore, push the restore button and watch while the restore current turn the selected cathode cherry red. If one gun needed restoration, most service technicians would restore the other two guns just to be safe. In fact, many Service Centers would routinely clean the CRT guns whenever a television chassis came in for repair.

CRTs have changed a lot over the years in both design and application. Refinements include higher bias voltages, improved focus methods, in-line gun structure and smaller neck diameters, giving today's CRTs exceptional picture quality and resolution. Nearly 1/2 of today's new CRTs are used in computer monitors, where they commonly offer resolutions of over 1.3 million picture elements.

All these changes in CRT design, however, have not altered the basic operation of a CRT - a hot cathode still emits electrons which are focused into a thin beam that strikes a phosphor screen. Today's CRT cathodes still become contaminated and suffer emission loss like their ancestors did. But the emission level and current ratios between guns has never been more critical to picture quality than in today's CRTs. A dozen years ago a 20% decrease in a CRT



electron gun's performance had little or no perceivable affect on the displayed picture. Perhaps the picture was a bit darker, and the viewer needed to turn up the brightness a bit, but the colors still looked the same and the picture detail or resolution wasn't affected. However, a similar change in an electron gun's output in a modern high performance CRT will result in an unacceptable change in the picture's brightness, contrast, or focus.

While they may not become contaminated as often or as badly as the cathodes in yesterday's "instant on" chassis, the cathodes in today's CRTs still become oxidized. But, today's CRT cathodes cannot tolerate anywhere close to the same amount of restore currents that older CRTs could.

What do these changes mean to you? It means that if you are using a CRT tester/restorer other than the CR7000 you are probably inaccurately testing today's CRTs and risk damaging every one you restore.

## Accurate Tests

In order to properly test a CRT, a CRT tester must:

- Check for leakage between elements within the same electron gun, and for leakage between different electron guns
- Closely duplicate the circuit's bias voltages for accurate test results
- Dynamically test the full range of conduction from black (cutoff) to white to detect contrast problems
- Compare the full emission range of each gun relative to the other two guns to detect color tracking problems
- Accurately measure current levels and compare them to the CRT manufacturer's specifications to correctly identify emission-related focus, contrast, brightness and smearing problems.

Let's take a closer look at each of these to see why the CR7000 is the only CRT tester that accurately tests modern high performance CRTs.

**G1 & H-K Shorts Tests** During the H-K and G1 shorts tests the CR7000 functions as a sensitive ohmmeter. It measures inter-element and inter-gun leakage current paths that can cause bias problems and displays the results in a bar graph display. The bar graph for each gun indicates the severity of the short or leakage path. All three bar graphs are displayed simultaneously so you know immediately if a gun has inter-element leakage.

**CRT Bias Range and Cutoff Test** The point at which an electron gun just begins to conduct is called cutoff. This small amount of current corresponds to black video. At the opposite end of a gun's conduction is full emission, or white video level. The only way to determine the condition of a CRT is to test its cutoff and full emission currents under manufacturer's specified operating conditions. The CR7000 provides bias voltages in 16 volt steps from -20 to -180 volts and variable G2 voltage up to 600 volts. These voltages properly test all CRTs at manufacturer's specifications.

Fig. 3 shows a typical manufacturer's cutoff design chart that specifies the combination of bias (G1) and G2 voltages that should produce cutoff current (black video

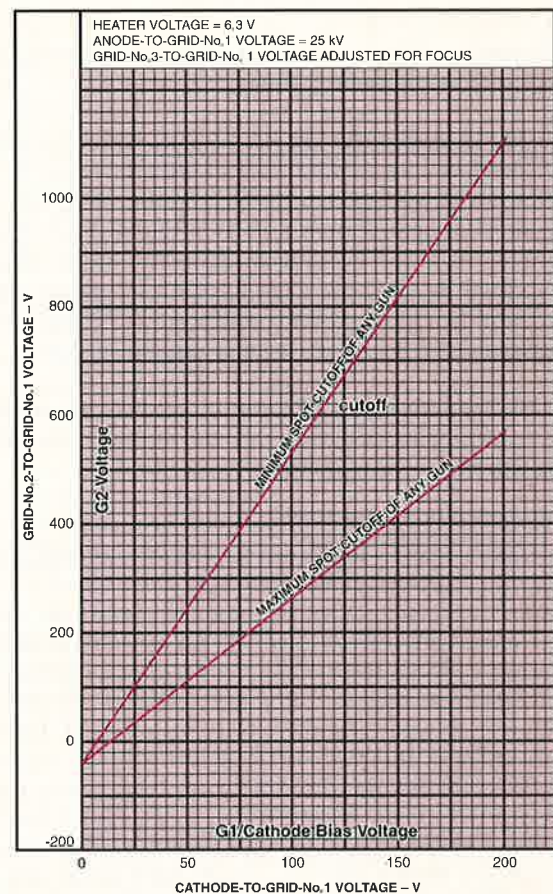


Fig. 3 - The conduction of a CRT changes with applied bias.

level) in a good CRT. Any combination of bias and G2 voltage that produces current within the shaded area is good. If more G2 voltage than specified is needed to produce cutoff current, the electron gun is bad and will have a contrast problem, as indicated by a bad CR7000 cutoff test.

Most of today's high-performance CRT's operate at a high negative bias (typically -100 volts to -132 volts) and corresponding high G2 voltage (400-600 volts). This produces a very fine, tightly focused electron beam, resulting in a very high resolution picture.

Most CRT testers provide a maximum negative bias of just -68 volts. As you can see on the cutoff chart, this bias voltage tests a CRT at the low end of its operating range, well below the normal chassis operating bias. These testers incorrectly identify cutoff related contrast problems, and cannot pinpoint emission-related focus problems. **The CR7000 is the only CRT tester that accurately simulates manufacturers bias conditions to pinpoint these CRT failures.**

**Color Tracking Tests** In order to produce proper colors and a proper gray scale, all three electron guns must produce similar amounts of beam current with the same applied bias and G2 voltages. All CRT manufacturers specify the maximum difference in G2 voltage that is needed to produce cutoff (black video) between the weakest and strongest guns. The CR7000 tests for this ratio of 1.25:1. A "bad" Lo Tracking indication indicates that one of the guns requires over 25% more G2 voltage to reach cutoff current than the other two guns. A CRT

that has this condition can not be set for color balance correctly at low luminance levels.

CRT manufacturers also specify how the three guns of a color CRT track each other at full emission. Here manufacturers specify that the maximum difference in currents must be less than 1.55:1. If one gun produces less than 55% of the current produced by the strongest gun, you will not be able to adjust the CRT setup controls properly and the picture will have poor gray scale tracking and color balance at high luminance levels.

The CR7000 is the only CRT tester that provides both a Lo and Hi Tracking test to thoroughly test gun tracking across the entire video range.

**Sliding Good/Bad Scale** For many years CRT testers simply fixed a point on a current meter scale and marked the current greater than this point "good emission" and currents lower than this point "bad emission". Some CRT testers used 300 uA as this dividing line, while others used 500 uA. This fixed Good/Bad point worked as long as CRTs used a -52 volt or -68 volt bias. However most CRTs today use a much higher negative bias. A CRT tester that uses a fixed Good/Bad emission scale will not find CRT guns that have marginal emission. In fact, these testers may call a CRT "Good" even if the emission has dropped to 10% or less of normal current! Here's why you need a CRT tester that uses a sliding Good/Bad emission scale.

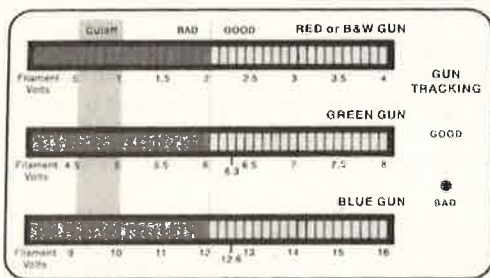


Fig. 4: The CR7000 provides an exclusive sliding Good/Bad scale

The maximum emission current ( $I_{k_{max}}$ ) produced by a CRT varies directly with the amount of negative bias ( $V_{cutoff}$ ) applied to the CRT, according to the formula  $I_{k_{max}} = V_{cutoff}1.5$ . This relationship is summarized in Fig. 5 for various CRT bias voltages. As you can see, the higher the operating bias, the more current a gun produces. All CRT manufacturers use a table very similar to this to determine if a new CRT is good or bad.

To understand why a sliding Good/Bad emission scale is necessary, consider a CRT that operates at -84 volts bias. At this bias, each gun will produce at least 2,310  $\mu A$  of beam current at full emission as fig. 5 indicates. As the tube ages or the cathode becomes contaminated, the CRT's emission drops and the picture it produces becomes noticeably poorer. When the emission has dropped to about 50-60% of normal the picture is no longer useable. (How far the emission can drop before the picture is adversely affected varies somewhat with

Bias Voltage	$I_{k_{max}}$ ("new" emission)	CR7000 "Good/Bad"
20	268 $\mu A$	134 $\mu A$
36	648 $\mu A$	324 $\mu A$
52	1125 $\mu A$	563 $\mu A$
68	1682 $\mu A$	841 $\mu A$
84	2310 $\mu A$	1155 $\mu A$
100	3000 $\mu A$	1500 $\mu A$
116	3748 $\mu A$	1874 $\mu A$
132	4550 $\mu A$	2275 $\mu A$
148	5401 $\mu A$	2700 $\mu A$
164	6301 $\mu A$	3150 $\mu A$
180	7245 $\mu A$	3622 $\mu A$

Fig. 5: The emission current produced by a CRT gun corresponds to its cut-off voltage. The CR7000's Good/Bad dividing line represents 50% of "new" emission current.

with CRT type and application. Some high resolution displays develop poor focus when the emission drops to 75%, while some television CRTs produce a weak, but acceptable picture with as little as 40% of normal emission). At 50% of normal output, this CRT still produces 1155  $\mu A$  of current - well beyond the 300 or 500  $\mu A$  Good/Bad point on most CRT testers. The emission in this CRT has to drop off over 85% before most CRT testers call the CRT bad. To make matters still worse, consider what happens with a CRT that operates at -100, -116 or -132 volt bias!

The CR7000's Good/Bad scale changes with the CRT bias voltage to accurately test electron gun emission. As figure 5 shows, the CR7000's emission test good/bad dividing line is always 50% of the normal "new" emission. In addition, the CR7000's emission scale is linear so that you can accurately determine how much current each gun is producing. This allows you to determine if a focus problem could be the result of decreased emission and accurately determine if a weak or poor contrast picture is caused by low emission.

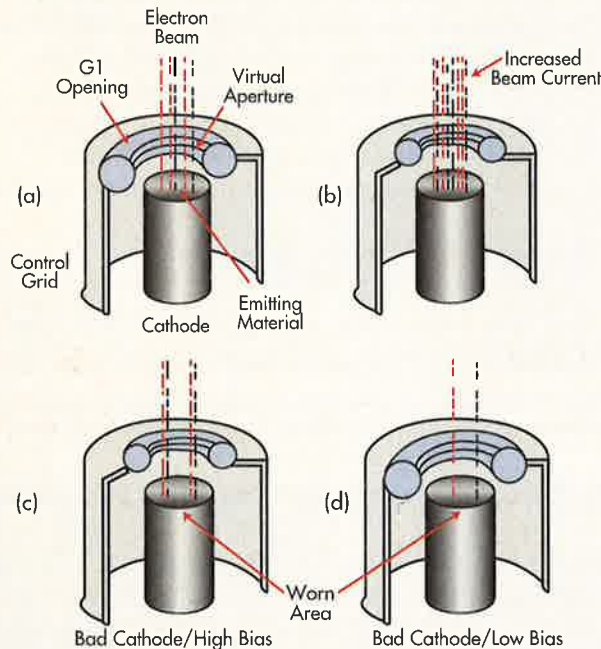
### Safe, Effective Restoration

Chances are very good that if you restore one of today's CRTs with an old CRT restorer you will destroy the CRT. There several reasons why older restorers won't do the job today.

The electron gun structures in today's CRTs are much smaller and the elements much closer together than old-style delta and early in-line types. Heavy restore currents quickly warp these elements, causing them to short or misalign when they cool. Because the cathodes are smaller, they contain less surface area and less reserve emitting material. Even moderate restore currents can quickly strip these delicate cathodes of their emitting material.

Many of the CRTs you test and restore today are used in computer monitors. Computer monitor CRTs have somewhat different failure conditions than television CRTs. Television CRTs more often develop poor color tracking and contrast problems, while computer monitor CRTs fail due to low brightness or poor focus.

The biggest reason for this is that a computer monitor CRT is almost always fully conducting, whereas a television CRT continually changes from minimal to full conduction. Take a look at the closest operating computer. Chances are that the monitor is producing a nearly all white raster, except for some gray borders and black text. To produce this image, the entire cathode's surface is producing electrons almost all the time, as illustrated in figure 6a.



**Fig. 6:** (a) Only a small portion of the cathode emits electrons when high G1 Bias closes the virtual aperture; (b) Reducing the Bias results in more beam current because more of the cathode's surface emits electrodes; (c) A CRT with worn cathode center area (c) still produces good light output at low bias; (d) but cuts off far too soon at higher biases.

Now, take a look at a television picture. The scene is continually varying in color and luminance levels. Seldom is the picture all white or is one color fully saturated. To produce this image, only a small portion of the cathodes continually conduct as the bias opens and closes the virtual aperture to match the picture scene, as illustrated in figure 6. This operation allows part of the cathode's surface to become oxidized over a period of time, lowering emission and causing a dark picture. Because the center of the cathode is always conducting, it wears more quickly than the outer edges. This leads to poor contrast and low level luminance tracking.

A computer monitor CRT fails differently. Because the entire cathode surface is continually emitting electrons, there is little chance for oxidation to build up anywhere on the cathode's surface. This also means that the cathode surface wears more evenly, making contrast and low luminance tracking less of a problem. Additionally, since computer monitors usually display a mostly white image, all three cathodes tend to wear equally.

To effectively restore today's CRTs, the CR7000 was designed with six levels of progressive restoration. These levels are based on extensive field use and feedback from our customers. The best way to use these restoration levels is to start low and step up as needed. Of course you should never restore a CRT unless the CR7000's tests indicate that the CRT has a problem, and you should always re-test the CRT after every restoration attempt.


**Re-activate** This restore function closely duplicates the process that manufacturers use to initially activate a new cathode. This is the lowest restore level provided by any CRT restorer. It produces restore current of 1 mA, which is very near the normal "white" emission level of the CRT gun, and poses little threat to the gun. Many CRTs are successfully restored with one application of Re-activate.

**Restore** The CR7000 provides four levels of restore current: Lo, Normal, High and Extended. These levels differ in the amount and duration of restore current applied to the CRT. Use Lo Restoration if the Re-Activate function fails to return the CRT to acceptable operation. The Restore functions are effective for bringing fresh emitting material to the cathode's surface by effectively removing old emitting material and contamination from the cathode's surface. The amount of restore current and duration needed to restore a cathode varies. The CR7000's four progressive Restore functions provide the necessary current, while minimizing unnecessary strain on the CRT. The lowest level of restoration provided by other CRT restorers is about equal to the CR7000's High restoration level. These restorers will destroy today's CRTs before you have a chance to stop.

**Remove G1 Short** CRTs sometimes develop a short between either the cathode and G1, or between G1 and G2. Most shorts are small pieces of material that wedge between the elements. This material may be fragments from one of the elements, but are usually flakes of oxidation from the cathode's surface. Occasionally, a short is the result of the elements physically touching.

The CR7000's Remove G1 short function provides a safe and effective way of removing most of these shorts. In the Remove G1 Shorts function, the filament voltage is removed to protect the delicate cathode. (The CR7000 waits 20 seconds to insure that the filaments are cooled). Then, a capacitor is discharged through the short and a current limiting resistor. This capacitor discharge safely removes most shorts.

**Rejuvenation** Rejuvenation is by far the most aggressive form of restoration provided by the CR7000. When used on a cathode that is capable of producing emission or Restore current, it can almost instantly stripe the emitting material from the cathode's surface. Yet, surprisingly Rejuv is the main restoration method offered by some CRT restorers. Rejuv should only be used on CRTs that have extremely contaminated cathodes where the oxidation layer prevents restore current in any of the other Restore functions.

Call 1-800-SENCORE for more information today! 



CR7000 "BEAM-RITE"  
CRT Analyzer & Restorer

## Accurately Test All CRTs!

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*The new CR7000 is the latest in state-of-the-art CRT analyzers. It incorporates a new sliding Good/Bad scale, simultaneous 3 gun display, enhanced bias ranges, exclusive "High" and "Low Level" tracking, and new socket design for easier use. All combined to make the new CR7000 the most accurate, safest, and easiest to use CRT tester available.*

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**By Rich Sproessig**  
Field Support Engineer  
Sencore Electronics

## Improve Your Productivity By Using The SC3100 "Auto Tracker"<sup>TM</sup>

Oscilloscopes have been improved and enhanced in many ways over the years. Through advances in technology, modern oscilloscopes offer improved triggering, wider bandwidths and convenient automated features. The days of counting every graticule and doing manual math calculations on a calculator are, for the most part, gone. Many oscilloscopes now have an autoseup feature and cursors that allow you to find the frequency or peak to peak voltage of a waveform. Most of these oscilloscopes also have a digital readout on the CRT that displays measurement results. While these features are nice they all have problems and limitations.

### What problems come with digital readings derived from the CRT circuits?

- Attenuators must be in "CAL" position
- Input coupling must be in the "DC" position to measure DCV, resulting in added steps
- Measurement accuracy is limited
- Waveform must be visible and locked before a reading can be obtained
- User must manually select the measurement channel after selecting a measurement function.
- Measurement functions usually apply to only the selected channel
- Measurements made with cursors increase interpretation and parallax errors
- Measurement cursors may not follow trace position or size changes

### Other problems reported by Sencore customers who use cursor scopes

- Menus may cause the CRT to appear very busy (2 traces, 2 VOLTS/DIV settings, timebase setting, input coupling setting, measurement reading)
- Menus may produce holes in the trace due to on-screen display information
- Confusion due to menus and sub-menus (each button controls numerous functions)
- Sync circuits cause measuring errors on video waveforms (color burst)
- Input voltage range is insufficient to analyze the TV horizontal output transistor collector pulse
- Trace goes out of sync easily

All these problems can cost a technician valuable time and ultimately money. The SC3100 was designed to overcome these problems and save those lost dollars.



Fig 1: A typical Auto Setup display

### Why The SC3100 Is More Efficient Than Conventional Cursor Oscilloscopes

The SC3100 has an exclusive feature called autotracking. Autotracking enables a technician to simply touch a test point with the probe and get a locked waveform without having to reach up and turn any controls. How is that possible? The SC3100 will actually track the signal, digitally adjust the timebase and vertical attenuator, and lock in the waveform on the display. Sounds easy doesn't it? Imagine being able to concentrate only on the IC you're trying to get a reading from and never have to reach over and move your controls around. Not only does this save a lot of time but it also prevents any accidental probe slippage from occurring that could short out expensive components. The second major difference between the SC3100 and its competitors are the separate digital meters and display.

Conventional oscilloscopes derive their readings from the CRT and display them on the CRT. This greatly limits the accuracy of the measurement. The SC3100 processes its DCV, PPV, FREQ, ACV, and DBM readings through separate digital circuits then displays the results on a separate LCD readout. This gives the SC3100 the accuracy of a DVM or frequency counter and still permits the

display of a bright, clean waveform on the CRT. It's like having several pieces of equipment in one box! Best of all, these readings are all taken with only one probe connection. This allows the technician to connect to a test point and see the DC voltage and the waveform at the same time, saving valuable time and eliminating the frustration of having to always reach for another test lead. **SN**

***Simplify your  
troubleshooting today!***

**If you could use a faster and  
more accurate way to analyze waveforms.**

**Give Sencore a call today and  
ask about the SC3100.**



*Fig. 2: Separate digital circuitry allows the SC3100 to be the most accurate waveform analyzer on the market today.*



**You'll  
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Waveforms  
The Same  
Again!**

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- Integrated 2,000 volt DCV and PPV meter eliminates the need for a DVM
- Hook-up adapters available

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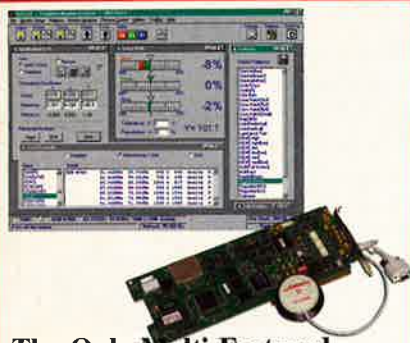
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# Service Solution For Your Service Center

## CM2250-PC "Pro"

### Computer Monitor Analyzer

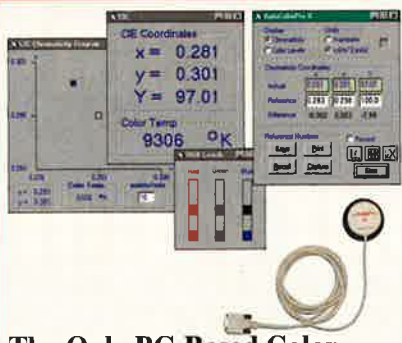


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## CP288

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**The Only PC-Based Color Analyzer To Give You Fast, Accurate Chromaticity & Luminance Measurements On All CRTs, For A Lot Less Green Than You Would Expect!**

- Easy-to-use Windows™ GUI, giving you four options for displaying your measured data, a CIE Chromaticity Diagram, large CIE coordinates, RGB Levels, and the Auto "ColorPro II" control window
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# Sencore News 183 — Fall Specials

These specials are valid through October 1, 1998!

**NEW!** Sencore **"LITTE"** Instruments: **NEW!**

Introducing The NEW  
LC103 "Reoliver"  
In-Circuit Analyzer!

## SC301 150 MHz Scope & Component Analyzer

- Auto-setup for quick and easy waveform measurements
- On-screen cursors for critical waveform parameters
- Ten memory recall locations for quick setup
- Combined Component Analyzer for "power-off" component testing



SAVE!  
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## PS400 DC Power Supply 30V, 3A

## PS401 DC Power Supply 18V, 5A

## PS402 Triple Output DC Power Supply

- Constant voltage or current supplies
- Low ripple
- Digital readout adjustment of voltage or current output



## DM500 Multimeter

## DM501 True RMS Multimeter

- Measures ohms, current and voltage including true RMS
- Beep Guard™ for meter input protection
- Water resistant
- Audible continuity and diode test
- Rugged heavy-duty construction



SAVE!  
**\$CALL**

## Computer Monitor Servicing Packages:

### Basic Troubleshooting Package

**Fall Special \$7,055**

- CM2125 Computer Monitor Analyzer
- Programmable 125 MHz RGB generator
- PR570 Variable AC Supply
- Variable AC Supply and Isolation Transformer
- CP290 "Auto ColorPro" Color Analyzer
- Color Analyzer for White Balance Adjustments



SAVE!  
**\$630**

### High-Resolution Monitor Troubleshooting Package

**Fall Special \$8,995**

- CM2250 Computer Monitor Analyzer
- Programmable 250 MHz RGB generator
- PR570 Variable AC Supply
- Variable Isolated AC Power Supply
- TC100CD Computer Monitor Training CD-ROM
- Interactive computer monitor service course on CD-ROM

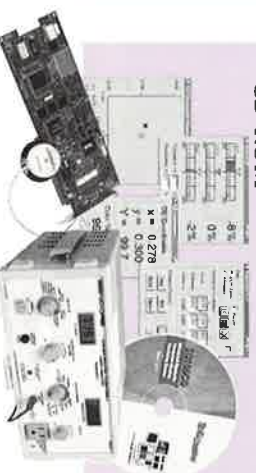


SAVE!  
**\$890**

### PC-Based High Resolution Monitor Troubleshooting Package

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- CM2250-PC Monitor Analyzer
- PC based programmable RGB generator
- PR570 Variable AC Supply
- Variable Isolated AC Power Supply
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SAVE!  
**\$590**

## Television Servicing Instrument Package:

**SAVE!**  
**\$615**

- VG91 Universal Video Generator
- All channel TV-RF generator
- All channel MTS Stereo/SAP
- Y/C, composite video and line outputs



- TVA92 TV Video Analyzer
- Exclusive "TV OFF" testing
- Dynamic horiz. circuit tests
- Exclusive vertical yoke test
- Universal signal substitutor



- SC3100 "AUTO TRACKER" Waveform/Circuit Analyzer
- Auto-Tracking digital display
- Integrated circuit measurements
- Autoranged timebase & attenuators



- PR570 "POWERITE II" Variable AC Supply
- Digitally accurate 0-140 VAC
- Adjustable current trip
- Monitor voltage and current
- Patented safety leakage test



## Switch Mode Power Supply Service Package:

- LC103 "ReZolver" In-Circuit Capacitor/Inductor Analyzer
- Pinpoint bad components in-circuit
- Complete out-of-circuit analyzing
- Automatic "GOOD/BAD"
- Test SCRs/Thacs with accessory

- PSL60 Universal Power Supply Load
- Isolate defect to supply or load
- Simulate different loads
- Analyze any supply from 4-200 volts

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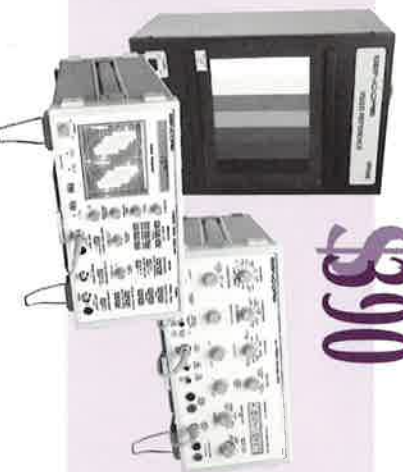
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- Digital waveform measurements
- Digital vectorscope measurements
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- VR940 Video Reference (light box)
- Industry standard light source
- Self-contained 2,000 lux output
- Complete set of charts
- Compact and portable

**SAVE!**  
**\$90**



## Technical Training Specials:

Unit	SAVE
TC100CD Computer Monitor Training CD-ROM	\$35
TC100 Computer Monitor Troubleshooting Self-Study Guide	\$35
TT400 "Hands-On" Switch Mode Power Supply Course	\$200
TC100T 4 1/2 Day "Hands-On" Computer Monitor Course	\$105
TC110T Advanced 4 1/2 Day "Hands-On" Computer Monitor Course	\$105



## Individual Product Fall Specials:

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CP290 "ColorPro" Hand-Held Color Analyzer	\$200
HA2500 Universal Horizontal Analyzer	\$200
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SC3100 "AUTO TRACKER"™ Automatic 100MHz Waveform & Circuit Analyzer	\$100
CR7000 "BEAM-RITE"™ CRT Analyzer And Restorer	\$100
LC103 "ReZolver"™ In-Circuit Capacitor/Inductor Analyzer	\$200
PSL60 Universal Power Supply Load	\$45

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Specials valid through October 1, 1998!

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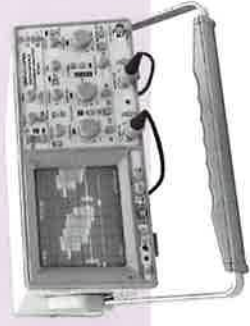
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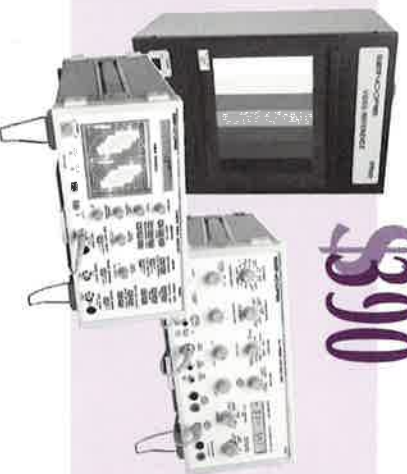
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