SENCORE NEWS

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Issue #142 November/December 1988

Inside This Issue:

Answers To Often-Asked Questions About Audio – pg. 27
Sneak Preview On New PA81 Stereo Power Amplifier Analyzer – pg. 30
And, 10 Steps To Successful Video Servicing – pg. 3

Plus...

Cut Your Troubleshooting Time – pg. 5
Save Thousands Of Dollars On Your Tax Return – pg. 12
New LC102 AUTO-Z Gives You More Capability And Confidence – pg. 22
Save Time On Tough MATV Service Calls – pg. 24

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Servicing today's video problems would be a simple matter of trial and error if it weren't for feedback loops and adjoining stages. When several stages are thrown off by a problem that's buried deep inside one integrated chip, successful troubleshooting using your voltmeter and transistor checker becomes impossible. That's when basic functional analyzing and signal substitution becomes a necessity.

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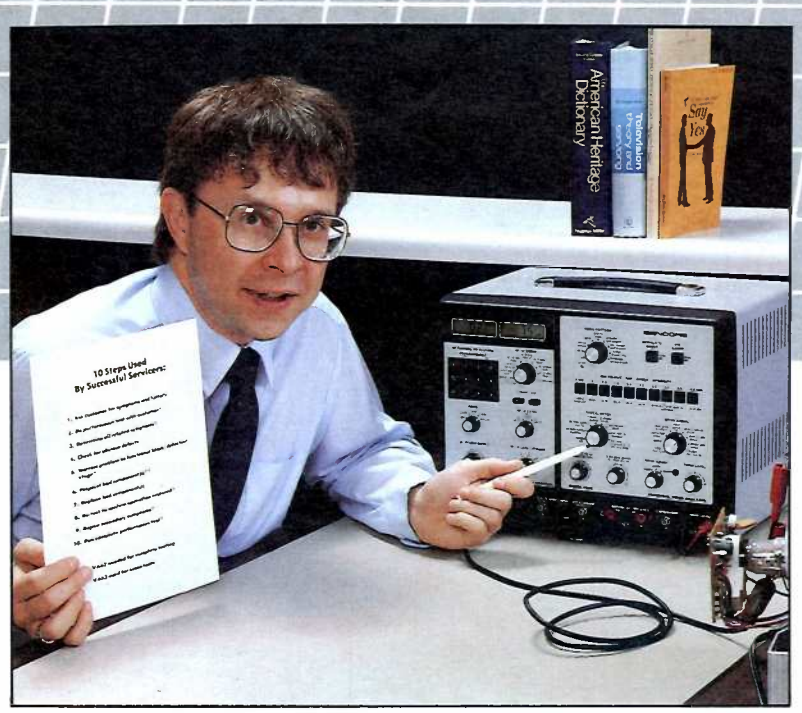
The 10 Steps To Successful Servicing With Your VA62 Universal Video Analyzer™



by Greg Carey, CET, Applications Engineer

> "Use your VA62 on every set you service, so you'll be better at running it when you meet a 'tough dog' . . ."

Many video technicians see the VA62 Universal Video Analyzer as a tool which is only used for "tough dog" problems. While it does a good job of helping you troubleshoot the tough problems, it can serve a more important function on nearly every set you service.

The processes covered in this article are based on reports from many successful video technicians who use Sencore video analyzers. If you adopt these methods, you will find that troubleshooting is easier, your customers respect you more, and you have fewer callbacks for marginal performance in the circuits you've worked on. As a side benefit, you will be using your VA62 more often, so you will be better at running it when you do meet a tough-dog problem.

Learn The Ten Steps That Can Guarantee Your Success

If you break your servicing down into steps, you'll see that most service jobs need the same steps. You might try to skip a step or two, but doing so often leads to more work later, as you have to back up and re-do the skipped steps.

You can follow these steps without the VA62, but they will be more difficult, will call for more component-level testing, and will often cause you to backtrack because you follow the wrong circuit path. The VA62 gives you the tests you need in one, integrated analyzer. It has been designed to give you your best effectiveness in any video troubleshooting. As you see, the VA62 plays a role in all except 3 of the 10 steps.

Here are the 10 steps used by successful servicers:

1. **Ask customer for symptoms and history**
2. **Do performance test with customer***
3. **Determine all related symptoms***
4. **Check for obvious defects**
5. **Narrow problem to functional block/defective stage***
6. **Pinpoint bad component(s)****
7. **Replace bad component(s)**
8. **Re-test to confirm operation restored***
9. **Repair secondary symptoms***
10. **Run complete performance test***

* VA62 needed for complete testing
** VA62 Used for some tests

Let's look at these steps, so that you can understand why each is important.

1. Ask the customer for symptoms and history.

Many servicers get a chuckle about this step. Often times, they explain, the only clue they get from a customer is, "It quit working." While this may be all you can get from some customers, the set's owner can often fill some gaps in the diagnosis process.

Notice that this step asks for two kinds of information, symptoms and history. If the customer can explain the exact symptom, such as, "The picture went first, then the sound," you can get an important clue about the mode of the failure. Modern television receivers often appear to work fine one moment, and then fail to start the next time, so "It doesn't work" might be all the customer knows.

Don't forget to ask about the set's history. Did it do this before? Has it been fixed by another shop? If so when and where? Were there any unusual symptoms in the week or month before the failure, such as popping in the audio or sparkles in the picture? Was there a thunderstorm in the area recently? All these clues can be especially helpful when tracing an intermittent or a failure that's out of the ordinary.

"The picture doesn't hold anymore." Be sure to ask your customer for all the symptoms and service history. (Step 1).

2. Do a performance test with your customer.

Few technicians bother with this step, yet some of Sencore's most successful customers tell us that it's the most important. With the customer watching, plug the set into a live outlet and run through every function to see what works and what does not. Sometimes, you'll find there's really nothing wrong—the problem is a dead AC outlet, a bad antenna, or a disconnected cable-TV tap.

(Continued on page 8)

Contents

How Your SC61 Can Help You Cut Troubleshooting Time—Page 5

New VCR/TV Instrument Demonstration Schedule—Page 11

Save Thousands Of Dollars On Your Tax Return—Page 12

Buyer's Guide—Page 13
Year-end Countdown Specials—Page 16

Performance Test Every Set And Earn Extra Bucks—Page 21

New Improved AUTO-Z Gives You More Capability And Confidence—Page 22

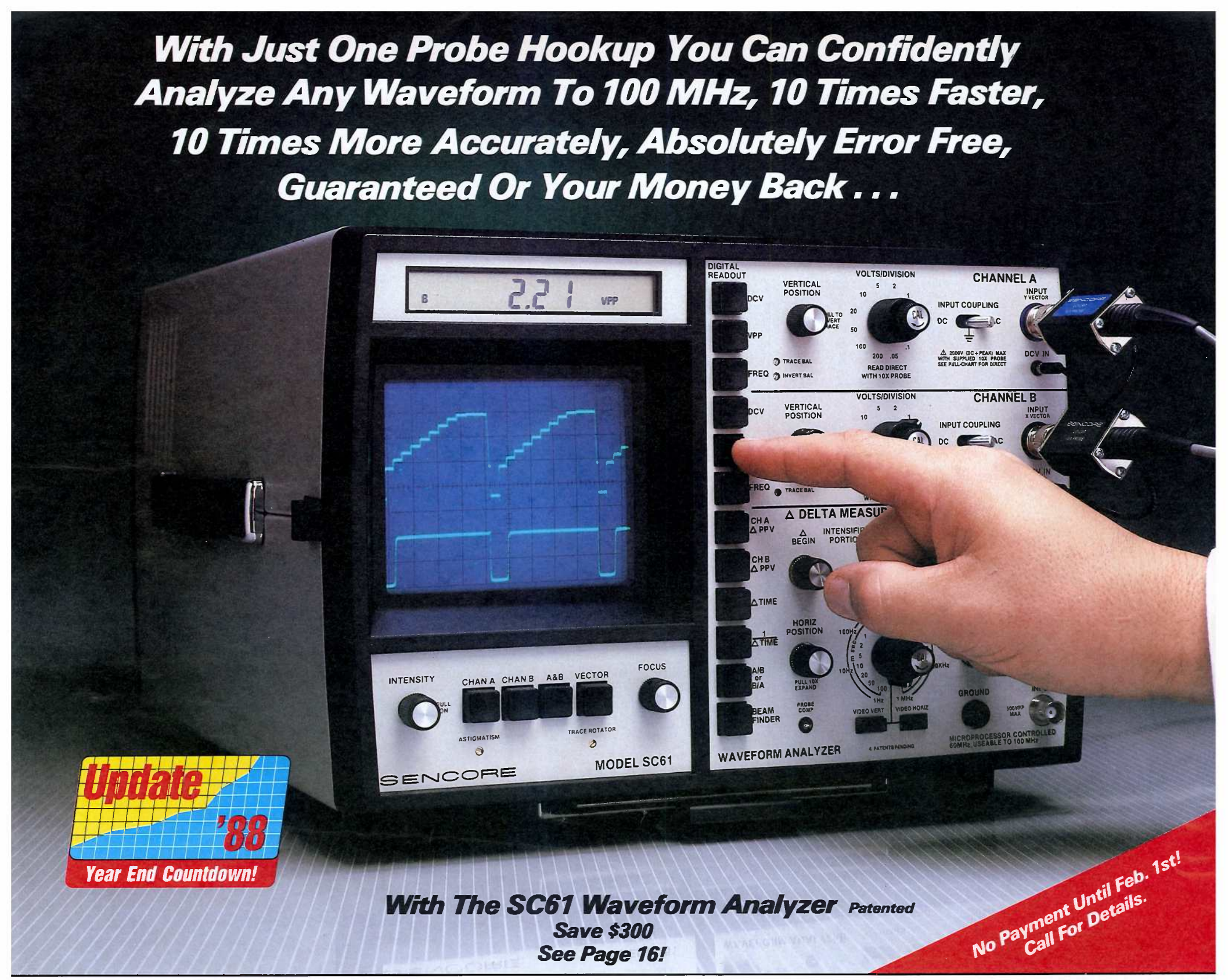
How Your CHANNELIZER Saves Time On Tough MATV Service Calls—Page 24

Answers To Often-Asked Questions About Audio—Page 27

New PA81 Stereo Power Amplifier Analyzer—Page 30

New LC102 AUTO-Z Capacitor-Inductor Analyzer—Page 31

With Just One Probe Hookup You Can Confidently Analyze Any Waveform To 100 MHz, 10 Times Faster, 10 Times More Accurately, Absolutely Error Free, Guaranteed Or Your Money Back . . .



Update '88
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Promises of increased productivity from other oscilloscopes fade fast when compared to the speed and accuracy of the SC61 Waveform Analyzer. Eliminate the confusing menus, cursors and complexity of regular oscilloscopes at the push of a button. Here's what the SC61 Waveform Analyzer does for you:

Analyze Waveforms Easily

- Accurate Waveform Display - 60 MHz Bandwidth (useable To 100 MHz) To Test The Latest Digital Circuits.
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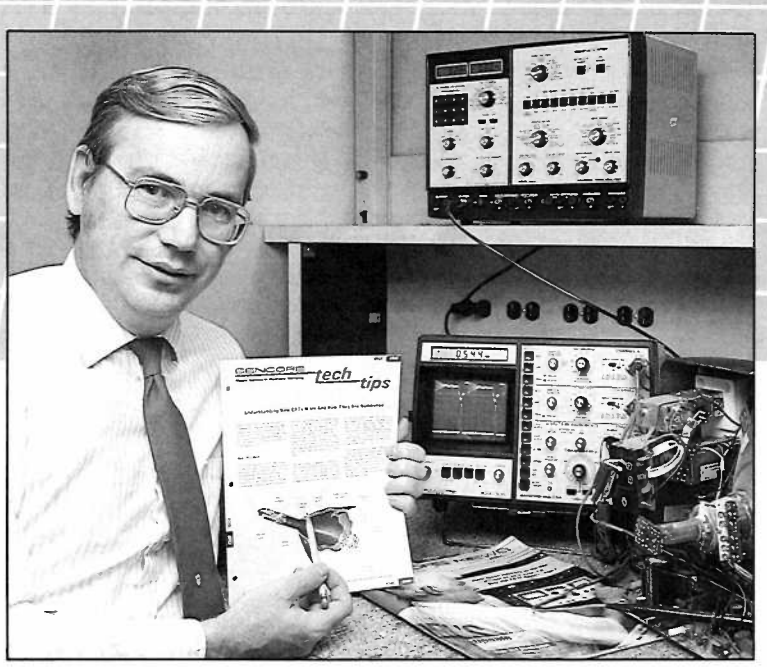
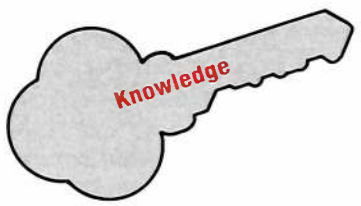


How Your SC61 Waveform Analyzer™ Works With Other Sencore Instruments To Cut Your Troubleshooting Time

by Rick Meyer, Application Engineer



> "Improve these constantly, they are the keys to your success . . ."

What does it take for success in electronics service? Knowledge, modern test equipment, and efficient troubleshooting techniques; improve these constantly, they are your keys to success. We gain *knowledge* through technical schools, colleges, manufacturers training schools, EIA schools, Sencore Seminars, and technical publications like the Sencore News. This knowledge helps us understand how basic circuits work and how to troubleshoot them.

Modern test equipment helps us test and analyze circuits within the TV, VCR, audio amp, or whatever we are servicing. To service today's complex circuits, we need instruments that are accurate, that let us make the tests we want to make, where we want to make them, and with features that save us valuable time. Your SC61 Waveform Analyzer, for example, allows you to completely analyze any waveform at any test point without fear of damage to the circuit or the SC61. Total waveform analysis gives you valuable clues that point to the source of a circuit defect. You can then use your component test instruments to check the suspected components.

Efficient troubleshooting techniques come from applying your knowledge and experience to each troubleshooting challenge . . . your efficiency multiplies when you use "human engineered" test instruments that make the necessary tests, plus help you understand and interpret the results.

Let's look at how one servicer used these three important keys - knowledge, tools, and efficient troubleshooting techniques - to troubleshoot a real life, servicing problem.

How Fred Turned A Potentially Difficult Repair Into A Simple One

Fred is an owner of a two man service shop located in a mini-mall. Fred built his business from scratch after graduating from technical school and working for various shops around town. Fred recently added a new tech who does much of the out-of-shop calls. This allows Fred to be at the shop and deal more directly with the customers when they bring their TVs and VCRs in for service.

One day, an elderly lady brought in a small portable black and white TV. Fred greeted her with an air of apprehension. He had serviced many of these small black and white TVs and knew that there was a fine line in the amount of money a customer was willing to spend on these types of sets. He would need to be selective in deciding whether to accept this job.

The lady sat the TV on the counter and asked Fred if he could fix it for her. "What is the TV doing? " Fred asked. "Well, the picture is dark and I can hardly watch it anymore!" she explained.

Fred paused and studied the situation. The symptom she described, appeared to be caused by a weak CRT. Fred had purchased a CR70 "BEAM BUILDER" a month ago and had tried it on several picture tubes with excellent results. He reasoned that if this TV did have a weak tube, he could restore it in about 5 minutes. The lady's set would be fixed for a reasonable price and Fred would make a nice profit.

Fred agreed to check the TV over and the lady went on her way. Fred had been working on another set but decided to check this set out right now. It would give him a break and he could quickly add another completed set to his shelf of repaired sets.

Fred brought the set over to the workbench and plugged it into the PR57 "POWERITE"™ . He took the RF cable from his VA62 Video Analyzer and hooked it up to the antenna terminals on the set. He turned the TV on and waited for a couple of minutes. There was sound from the speaker, but nothing appeared on the picture tube. But wait! Looking closely at the CRT, Fred could see the faint outline of a multiburst pattern. The customer was right. The picture was indeed dark. Fred smiled. He would be a hero in the eyes of his customer for bringing life back to her favorite black and white TV (Figure 1).

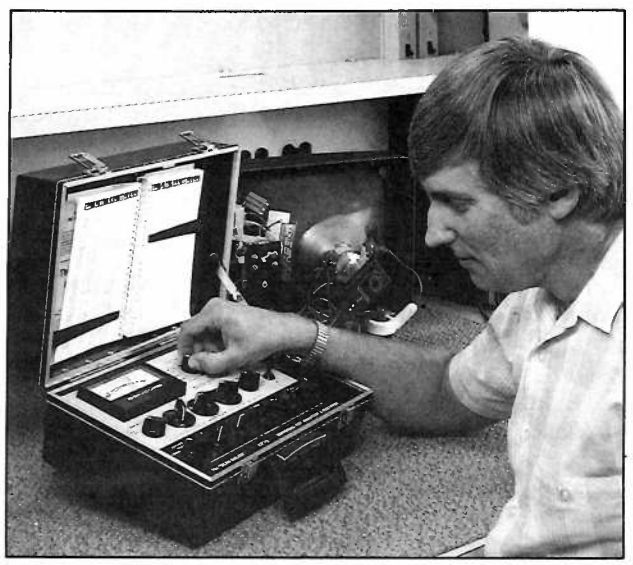


Fig. 1: The CR70 quickly identified and rejuvenated the weak picture tube.

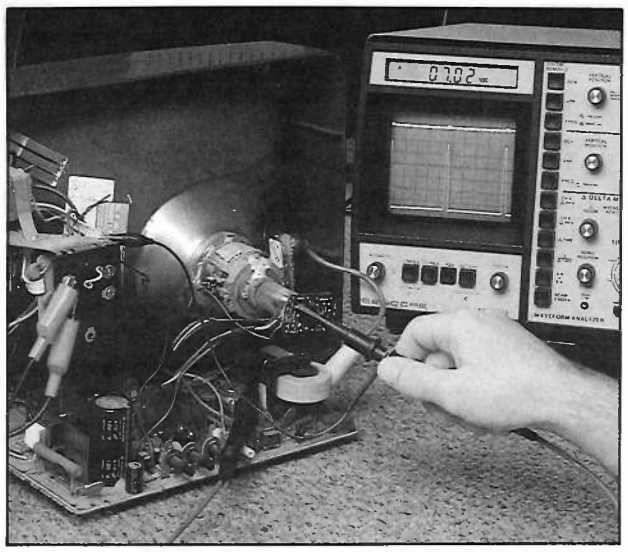


Fig. 2: The SC61 Waveform Analyzer proved that the filament voltage was low. The digital display read 7.02 VDC, a lot lower than it should be.

The CR70 "BEAM BUILDER" Quickly Tested And Rejuvenated The Picture Tube

Fred unplugged the set and removed the back; he carefully removed the CRT socket from the picture tube, hooked the CR70 "BEAM BUILDER" up to the CRT, set the function switches according to the setup book, and turned the CR70 "BEAM BUILDER" on. He tested the CRT and it verified Fred's diagnosis, a weak CRT. "A good test for my new CR70 'BEAM BUILDER'," Fred thought to himself.

Fred confidently restored the CRT and again checked it. It now tested good. Fred beamed with pride. This customer would thank him for a job well done.

Fred removed the CR70 "BEAM BUILDER" socket from the picture tube, replaced the CRT socket, and plugged the set back into his PR57 "POWERITE". He confidently turned the set back on and waited for a picture. Fred stood back smiling. He waited and waited but no picture appeared on the screen. His smile changed to a look of concern as he reached over and checked the brightness control. It was turned all the way up. "What's going on", Fred thought to himself. "The set had a weak CRT and I restored it. The set should be giving a good picture. Maybe this won't be so easy after all."

Careful Observation Often Gives Clues To The Problem

Fred sat back on his stool and thought for a bit. Experience had taught him to look for the obvious and not disregard any clues. He looked into the back of the set for anything obvious. He glanced at the neck of the picture tube to verify that the filament was lit. It was, but wait! The filament looked darker than it did when it was running on the CR70 "BEAM BUILDER". In fact, it was barely glowing at all.

Fred grabbed the probe from his SC61 Waveform Analyzer and hooked up the ground lead. He recalled that the CR70 "BEAM BUILDER" setup book indicated that this tube had a 12 volt filament and the filament pins were 3 and 4. Fred pressed the A channel DCV button on the SC61 Waveform Analyzer and touched the probe to pin 3 on the CRT printed circuit board (Figure 2). The SC61's digital meter read zero volts. "This must be the ground pin", Fred said to himself. He moved the test probe to pin 4 and the digital display read 7.02 volts. "Wow!! That's a lot lower than it should be", Fred exclaimed. He pressed the VPP button on the SC61 Waveform Analyzer to determine if this set used an unfiltered scan derived filament voltage supply. The display read only 0.36 volts. Fred had just confirmed that the filament voltage was low. This could be the cause of the weak picture.

Fred went over to his service literature cabinet and found a schematic for the set. He opened it up and looked for the power supply to the picture tube (Figure 3). The filament voltage came from a scan derived power supply. Several possibilities snapped into Fred's mind. The Zener diode D605 could be bad, the series limiting resistor R617 could have increased in resistance, or there could be a problem in the horizontal circuits or low voltage power supply.

The PR57 "POWERITE" Let Fred Check The Power To The Television

Fred looked back at the power supply portion of the schematic (Figure 3). There were only two other things that could cause low voltage at the input of the regulator: low line voltage or a large voltage drop across resistor R701 due to excessive current drop through the resistor. Fred already had the set running through the PR57 "POWERITE". He pressed the AC VOLTS OUTPUT button and the meter read 118 volts; right on the button. He next pressed the 0-1.5A 470W current button. The meter came to rest at 490mA. The schematic showed current consumption of 365mA. The TV was drawing more current than it should be drawing (Figure 5).

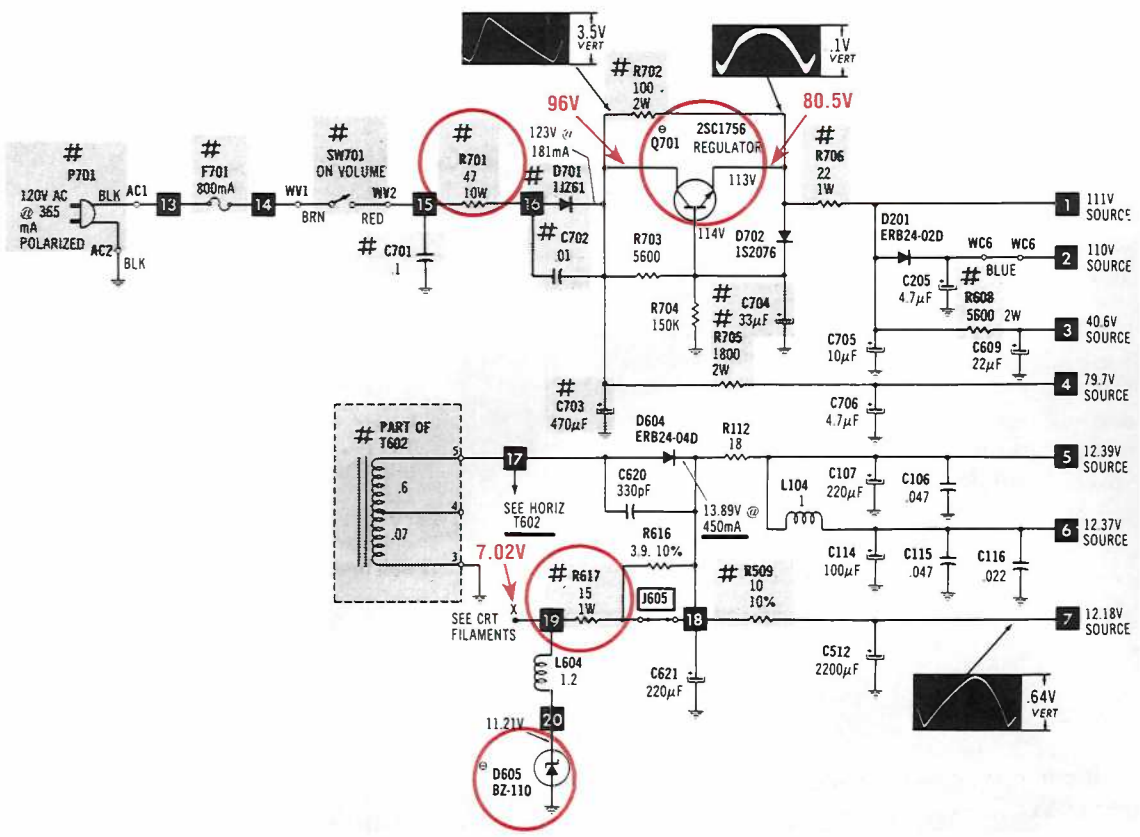


Fig. 3: The Power supply voltages were found to be lower than they should have been. Could R701 be bad?

Fred again picked up the SC61 Waveform Analyzer test probe and located the collector of the horizontal output transistor. The schematic showed that the DC voltage on the collector should be 101 volts (Figure 4). Fred pressed the DCV button on the SC61 Waveform Analyzer and connected the probe to the collector of the horizontal output transistor. The digital display read only 55 volts. "That's certainly low", Fred thought to himself. "There must be a problem in the low voltage power supply. There's a picture on the CRT, it certainly couldn't be a problem in the horizontal section." *(Editor's note: Fred made a costly error here. We'll see why later).*

Fred looked back to the schematic and examined the power supply (Figure 3). The power supply was straight forward: a simple rectifier diode, filter and single transistor regulator. Fred moved the SC61 Waveform Analyzer probe to the emitter of Q701, the regulator transistor. The digital meter on the SC61 Waveform Analyzer displayed 80.5 volts. Definitely not the 113 volts shown on the schematic. He moved the test probe to the collector of Q701 and the SC61 Waveform Analyzer digital display read 96 volts, well below the 123 volts shown on the schematic. There could be only one reason for this, he thought. R701, a 47 ohm 10 watt resistor, must have increased in resistance. Fred turned the set off and reached for his DVM56A "MICRORANGER" test leads. He connected the leads across R701 and looked back at the digital display. It read 46.3 ohms. What!!! "The resistor's good!!", Fred muttered to himself. "What's happening here?"

The SC61 Waveform Analyzer Let Fred Completely Analyze The Horizontal Waveform

Fred thought for a few seconds about what could be consuming this much power. He remembered that the horizontal section was the main power consumer in a television. He suddenly realized that he had made a costly error. He grabbed the SC61 Waveform Analyzer test probe and connected it back up to the collector of the horizontal output transistor. He realized that he had not taken the few seconds needed to completely analyze the horizontal pulse and had wasted valuable time.

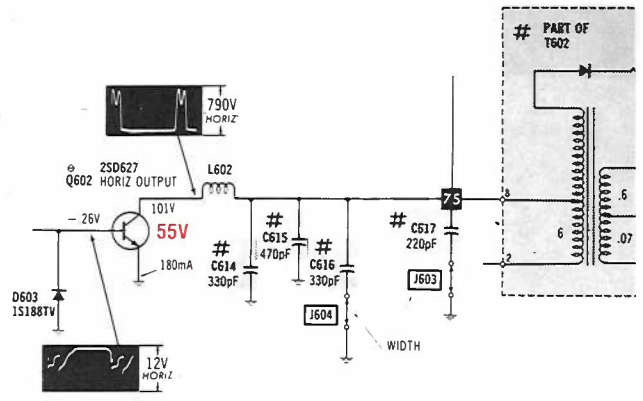


Fig. 4: The DC voltage on the collector of the horizontal output transistor was much lower than it should have been.

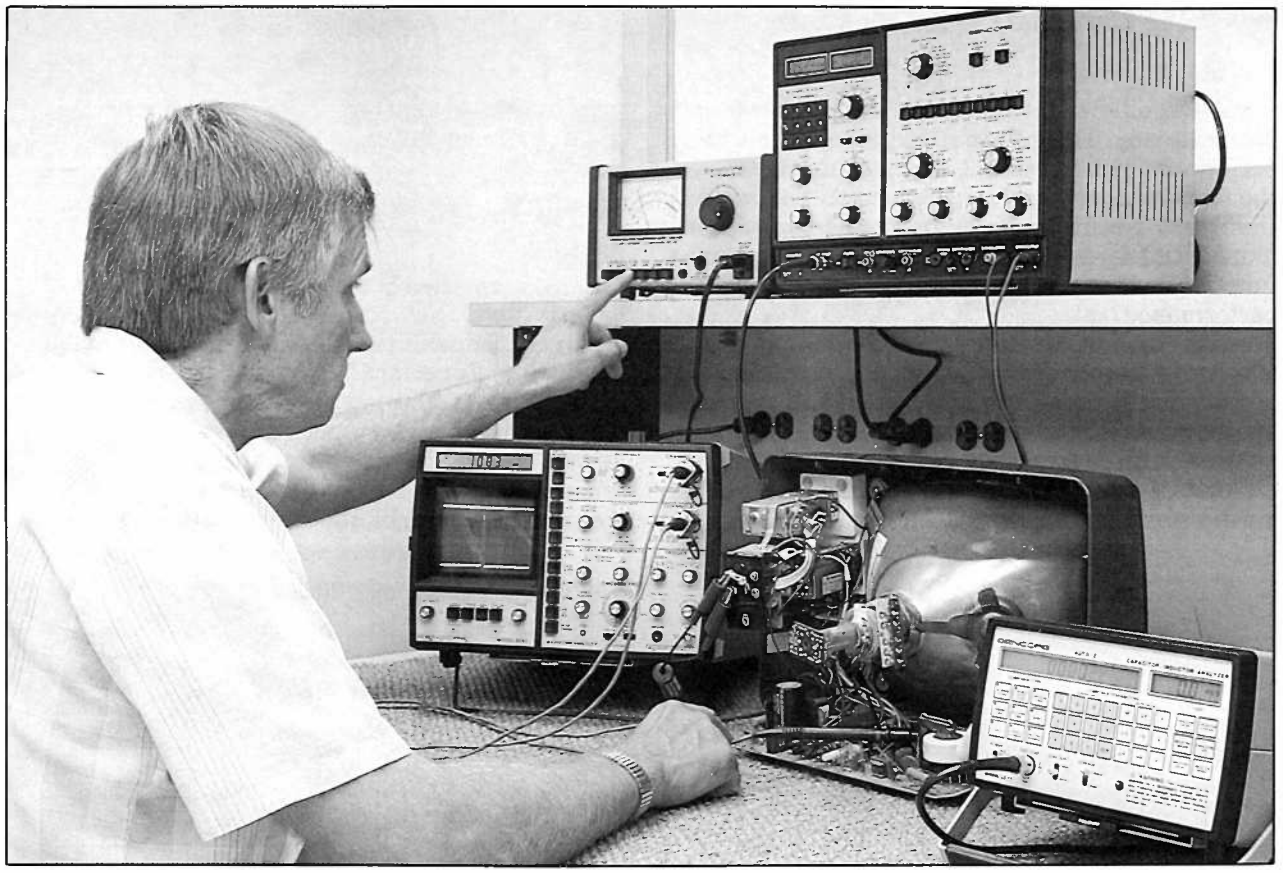


Fig. 5: The PR57 "POWERITE" confirmed that the set was consuming too much power.

Fred pressed the DCV button on the SC61 Waveform Analyzer and read the DC voltage on the collector. It was still 55 volts. He next pressed the PPV button on the SC61 Waveform Analyzer. The display read out 1079 VPP. This was odd, Fred thought. The schematic showed the amplitude of the pulse at 790 VPP. Fred looked at the pulse on the CRT of the SC61 Waveform Analyzer and noticed that it looked narrower than usual. He pressed the DELTA TIME button on the SC61 Waveform Analyzer and used the DELTA BEGIN and DELTA END controls to intensify just the horizontal pulse. The SC61 Waveform Analyzer digital display read less than the 10 to 14 usec width a normal pulse should have (Figure 6). The SC61 Waveform Analyzer had pinpointed the problem, Fred thought, "If only I had remembered to take the few seconds needed to analyze the pulse when I first looked at it, I would have saved a lot of chasing!"

There were only two possibilities that Fred could see for a narrow pulse. Either one of the timing capacitors was bad or the flyback was defective. Fred turned the set off and grabbed his soldering iron. Only two of the four capacitors were in the circuit. J604 and J603 had been clipped out at the factory. Fred unsoldered the remaining two capacitors, C614 and C615, and grabbed his LC77 AUTO-Z Meter. He'd know in a few seconds if these capacitors were good or bad (Figure 7).

Fred turned on the LC77 AUTO-Z Meter and zeroed the leads. He connected up one of the capacitors to the test leads and selected the ceramic caps button on the LC77. The capacitor he was testing was marked 330. He entered 330 330 pF, and standard ceramic capacitor tolerance values using the keypad on the LC77. The capacitors were not marked with voltage but Fred knew that caps in this application were subject to high voltages. He programmed in the maximum voltage of the LC77, 999 volts.

Fred was ready to prove this capacitor good or bad. He pressed the capacitor value button and the display registered 320 pF along with a GOOD indication. He pressed the leakage button and the digital meter displayed 0.00 uA and GOOD. This wasn't the cause of the narrow pulse. Fred knew he didn't need to perform D/A and ESR since they are not used for this size or type of capacitor.

He grabbed the other capacitor, entered the new capacitance value into the LC77 AUTO-Z and performed the two tests again. The second capacitor also read GOOD for both tests. This left one other culprit, the IHVT.

Fred did not suspect a problem in the IHVT since the set was running and he could see a dark picture on the TV screen. Normally, Fred figured, a bad IHVT would destroy the horizontal output transistor and result in a dead set. He decided to test the IHVT anyway (Figure 8).

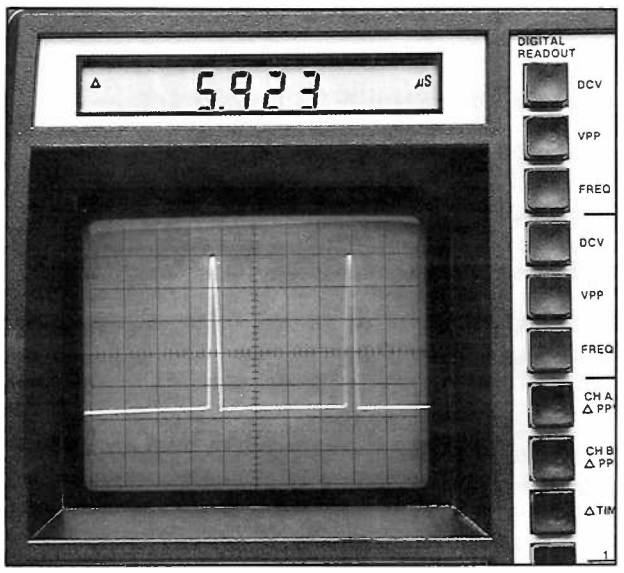


Fig. 6: The SC61 Waveform Analyzer showed that the horizontal pulse was much too narrow causing the horizontal section to consume too much power.

The schematic showed the primary connections to the IHVT to be terminals 2 and 8 (Figure 4). Fred left the IHVT in circuit and connected the LC77 AUTO-Z test leads up to pins 2 and 8. He pressed the YOKES & FLYBACKS button on the LC77 AUTO-Z and then the INDUCTOR RINGER button. The display read 4 RINGS and BAD. Fred was not yet convinced that the IHVT was bad. It was still in circuit and something outside the IHVT could be loading it down. He grabbed one of the ground leads from his SC61 Waveform Analyzer probes and wrapped it around the core of the IHVT. He pressed the LC77 AUTO-Z INDUCTOR RINGER button and read the display. It still read 4 RINGS and BAD. This looked serious.

Fred grabbed his soldering iron and unsoldered the IHVT from the PC board. He removed the ground lead he had previously wrapped around the core and pulled the IHVT off of the PC board. Connecting the LC77 AUTO-Z test leads up to the IHVT and again performing the ringing test confirmed to Fred that the IHVT was bad. It still read only 4 RINGS.

Fortunately for Fred, and his customer, Fred was able to find an inexpensive replacement IHVT for this set. The price of the part and Fred's half hour of troubleshooting was still a fair price and the customer agreed to fix up the set. He replaced the IHVT and a bright, clear picture appeared on the screen.

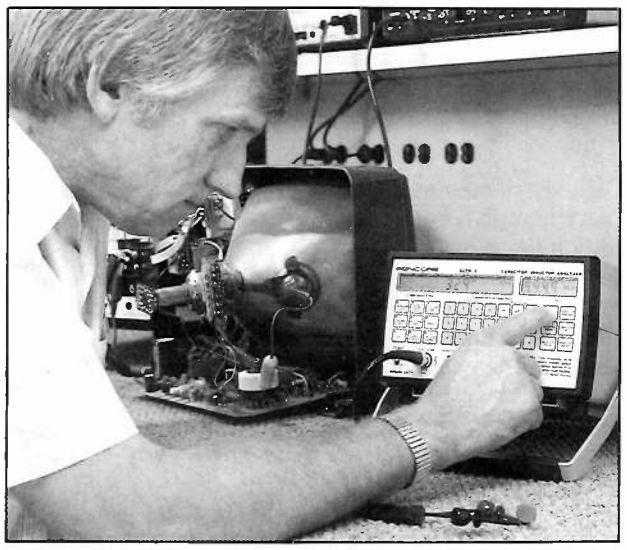


Fig. 7: The LC77 quickly proved that the capacitors were not the reasons for the narrow horizontal pulse.

Always Remember To Analyze The Signal Using The SC61 Waveform Analyzer

Fred learned two valuable lessons while troubleshooting this set:

1. Take the few seconds and completely analyze the waveform at each testpoint using the SC61 Waveform Analyzer. It can save minutes and maybe even hours of troubleshooting in the wrong area.

2. Don't assume anything. The presence of a raster does not rule out the possibility of a bad IHVT, as this problem showed.

Fred's knowledge, modern test equipment, and good troubleshooting techniques helped cut this problem down to size. ■

Fig. 8: Fred checked the IHVT with the LC77 AUTO-Z Meter in-circuit. The INDUCTOR RINGER test verified that the IHVT was bad.

(Continued from page 3)

Servicer: "The horizontal circuits don't hold. Did you also notice that your picture is weak?" Always do a performance test with your customer (Step 2).

But, there's an even more important reason to run through a complete performance test. The set may have more than one problem, and the customer has only mentioned the most recent one. For example, they may be complaining about the loss of horizontal sync, but your test shows that audio is also weak. Or, they may not have noticed the low brightness caused by a weak picture tube, and may be glad to learn that you can restore the picture tube with your Sencore CR70 "BEAM BUILDER"™

Most especially, it shows the customer that you are concerned about doing the job correctly. You've taken the time to show that you want to do a complete job.

The VA62 lets you test the performance of every TV circuit by connecting to the antenna terminals. You don't even need to take the back off the set to do these tests. A special "Performance Test Report Card" is supplied with your VA62 (order a free copy by calling Sencore, 1-800-843-3338). The report card has a space for you to insert your company's name and address before taking it to your printer to have copies made. It lets you mark down the performance of every function, before you begin repairs, so that your customer knows which things need work. There's also a place to write the results of the performance after the repair, so that the customer can see how much you've improved operation.

Before the customer leaves your shop (or before they leave the room if you're doing home service), have them agree with you on what they want fixed. You and your customer come to an agreement on such questions as whether they want the picture tube restored, or whether there are some other, secondary problems they want you to look at. By pointing out that there are several, unrelated problems, it's easier to itemize the bill. Otherwise, they may think that all your work was to find only one problem, and may feel you are over-charging them when the final bill is presented.

3. Determine all related symptoms.

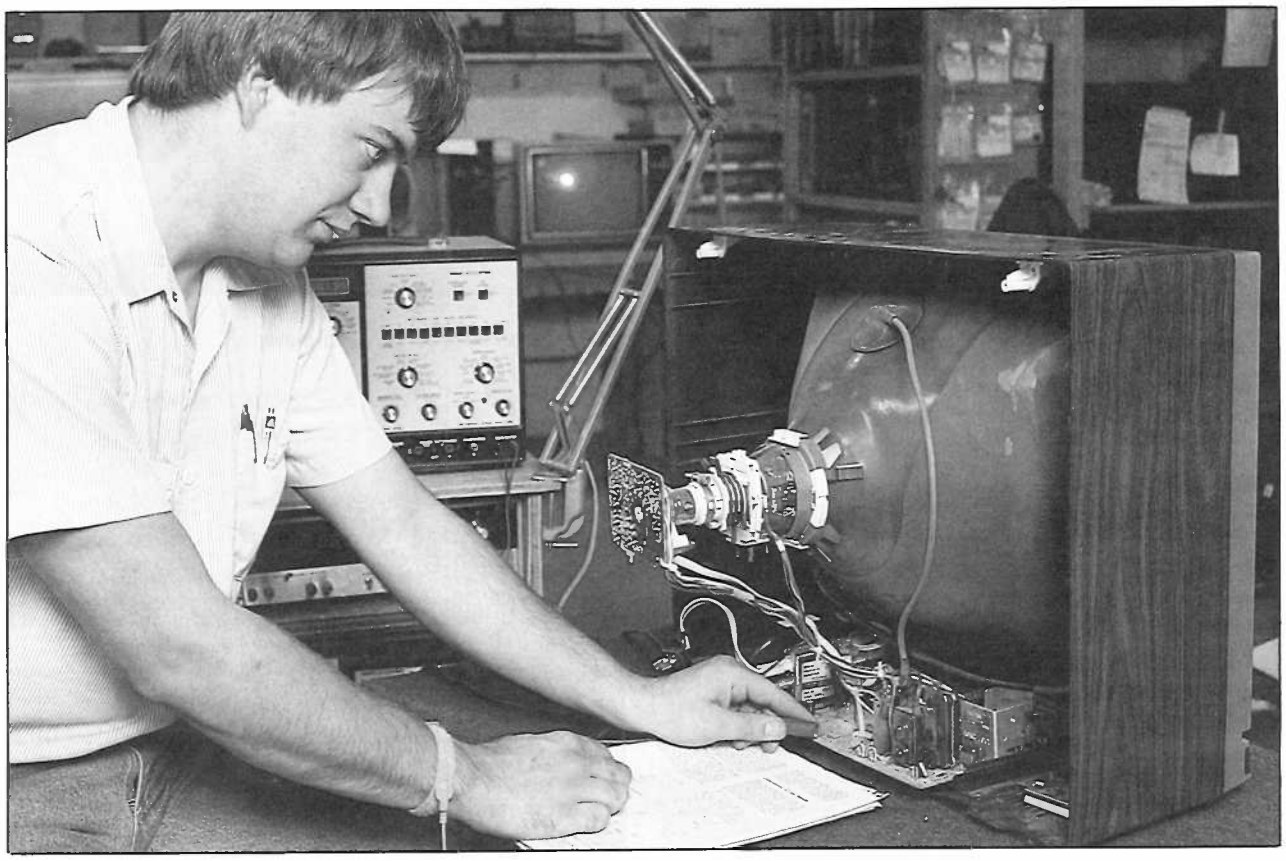
Here's one of the steps where many technicians build in their own inefficiency. Instead of identifying ALL the symptoms, they find one symptom and begin tracing it. But, this symptom may be a secondary symptom of an even larger problem. If they had taken a few more moments, they may have noticed that two or three symptoms all point to the same source, such as a bad tuner, or poorly regulated power supply.

If you use all the features of the VA62, this step becomes easy. The information gained from the performance test in step 2 already has identified the main symptoms. Now, it's a matter of using the VA62 to refine these symptoms, by making a more detailed test, or by using some VA62 functions not used when doing the simple performance test.

If you confirm several symptoms, you need to decide which one to troubleshoot first. You should not try to follow more than one at a time, because it is too easy to get crossed up as one affects the other. Since one problem may cause multiple symptoms, finding one bad component often clears up all the symptoms. Always repair circuit problems in the following order, to find the problems most likely to affect other circuits :

1. High Voltage
2. Sweep
3. Sync
4. Luminance (Video)
5. Color
6. Audio

Each of these general symptoms directs you to one of the areas of the "trouble tree" troubleshooting guide supplied with your VA62. They, in turn, let you isolate the defective stage in four troubleshooting steps or less.



"I'm going to start with the poor horizontal sync. I think it could be the oscillator, sync separator, or compression ahead of the video detector." Determine all related symptoms (Step 3).

4. Check for obvious defects.

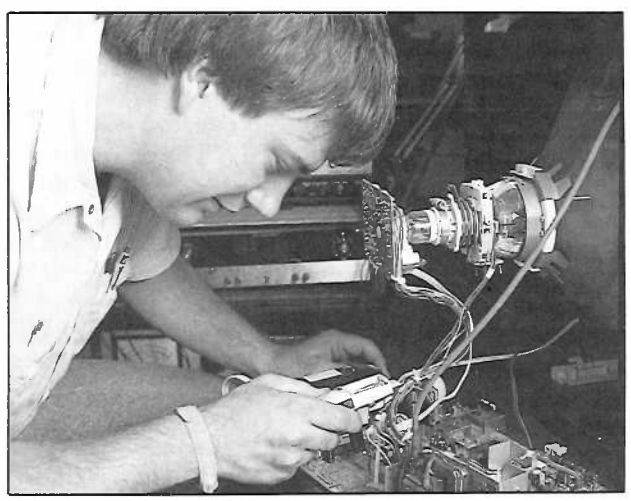
This step relies on your senses of observation and your own practical experience. If, for example, you see a burned resistor, or smell smoke, you should attend to these obvious defects, even before making a measurement. Sometimes repairing the burned part solves the problem. But, even if it doesn't, you have fixed something you know must be corrected before the service job is done.

You may also know that a particular chassis has a manufacturing defect which causes a particular symptom. Service literature, for example, may instruct you to resolder certain connections, or to replace certain components with improved ones. Here again, checking for these obvious defects first, ensures that they won't mislead you in your final troubleshooting.

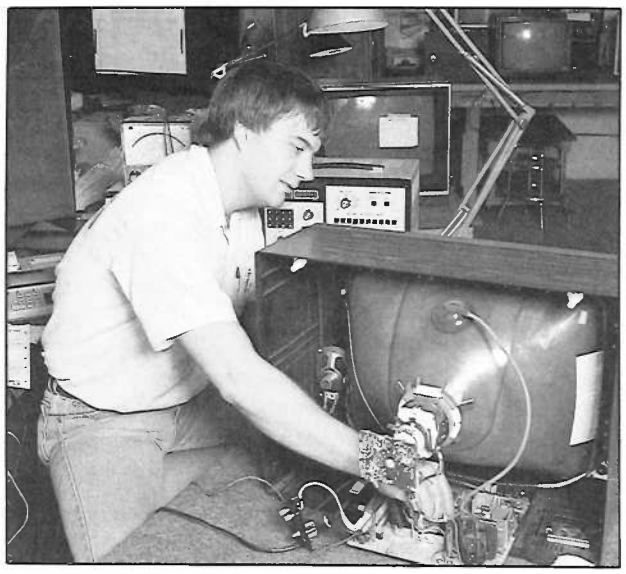
5. Narrow the problem to one functional block.

To this step, the VA62 has been used to make general tests. Now, it's time to put its full analyzing capabilities to work with functional analyzing. Functional analyzing means that you base your troubleshooting on the *function of a circuit,* instead of the specific parameters of each component. This lets you move through the suspect stages much faster than using conventional troubleshooting methods, such as analyzing waveforms with an oscilloscope or measuring DC voltages with a voltmeter.

Functional analyzing calls for a duplicate of the normal signal into each of the stages you think might cause the symptom identified earlier. These substitute signals are good, so injecting them into a good circuit causes it to operate



"I'd better make sure that the factory-specified changes have been made." Check for obvious defects (Step 4).



"I've injected sync at the oscillator input and the sync was solid. The problem must be ahead of that point." Narrow the problem to the functional block-defective stage (Step 5).

normally. If you inject a signal into a test point, and the symptoms improve, you know that all the circuits from there to the output are working correctly. If, by comparison, the symptoms remain, you know that the bad circuit is affecting the substituted signal, and the problem is between the injection point and the output.

You inject the VA62 signal right over the top of whatever signals are at the test point. There's no need to disconnect the components to interrupt the original signal, because the VA62 output circuits "swamp" out the signal already in the circuit. This is done by using output amplifiers with a driving impedance well below the normal circuit impedance (about 9 ohms on the solid-state drives), allowing the VA62 to over-power the circuit signal. The VA62 has DC blocking built in, so you don't need to worry about the VA62's circuit shorting out the bias circuits and damaging the good components in the circuits.

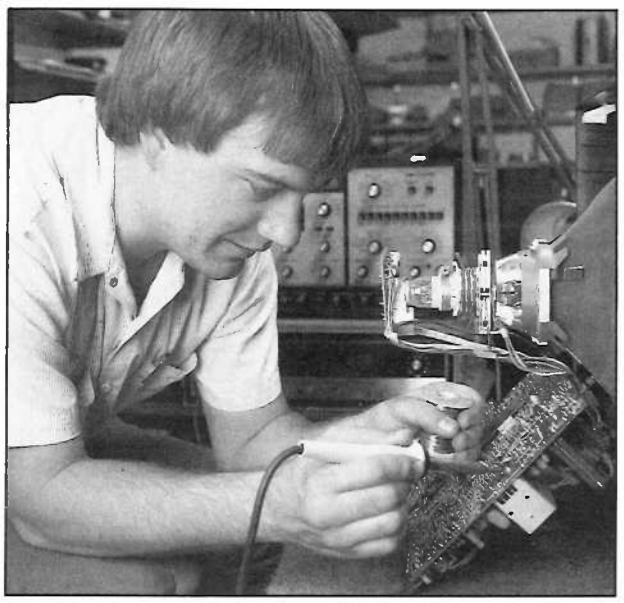
If you use the "divide and conquer" trouble-shooting method, you find the bad stage in four troubleshooting stages or less (Steps 3-6 above). The VA62 is supplied with troubleshooting guides based on this highly effective method.

The charts instruct you to substitute into a test point about half-way through the circuits related to the symptoms. If the symptom improves, you have proven that all the circuits to the output are good, so the chart tells you to move toward the input. If the symptom remains, you are ahead of the bad stage, so you are instructed to move toward the output. In either case, the chart divides the remaining stages in half again. This halving process repeats until you have found the bad stage. You know that you have the bad stage when you get an improvement in the symptom when injecting at its output and the original symptom when injecting at its input. The isolated stage has only a few parts that might be bad. These are tested with conventional testing methods.

6. Pinpoint bad component(s).

It's only after using the VA62 to isolate a single stage that you bring in your conventional testers. You might use a scope or waveform analyzer to look at a signal. You might use your volt-ohmmeter to measure a resistor or to test a power supply. You can use a Z METER™ to test a capacitor or an inductor, or you can use the TF46 Portable SUPER CRICKET™ to test a transistor. The VA62's digital meter lets you test DC and peak-to-peak voltages, plus test flyback transformers, yokes, and high voltage triplers with special tests.

Whichever conventional test method you use will be more effective, since the VA62 has narrowed the suspect parts to a dozen or so. Functional analyzing has isolated the problem stage, so that your conventional tests are more effective than ever before.



"I'll test the sync separator transistor next. Oh, it's bad." Pinpoint the bad components (Step 6).

"This replacement part should do the trick." Replace bad components (Step 7).

7. Replace bad component(s).

This step doesn't directly involve the VA62. It is a good idea, however, to use your component testing methods to check parts associated with the bad part you found. For example, don't forget to check emitter resistors if a transistor was bad. Also, look for shorted P.C. boards, bad solder connections, and other mechanical problems.

8. Re-test to confirm operation restored.

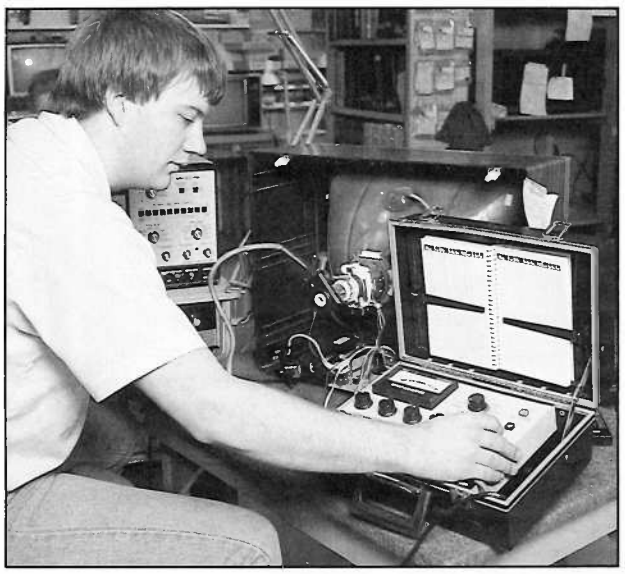
Changing a part may only partly return normal operation. Double check your work by feeding in the VA62 signal which dynamically tests the circuit associated with the original problem. The exclusive video patterns produced by the VA62 provide dynamic tests you can interpret right on the screen of the TV you are testing. For example, the MULTIBURST BAR SWEEP video pattern checks the video bandwidth of the IF stages, video detector, and video amplifiers. The 10-BAR STAIRCASE pattern dynamically tests these same stages for grey-scale tracking and dynamic range. The CHROMA BARSWEEP confirms that a color circuit works correctly.

If your tests show there is still a problem, use the VA62's signal substitution to find its cause. This time, start at the input or the output of the circuit you just repaired, to learn whether another part in the same circuit might be defective.

"There, now the sync is stable." Re-test to confirm that operation is restored (Step 8).

9. Repair secondary symptoms.

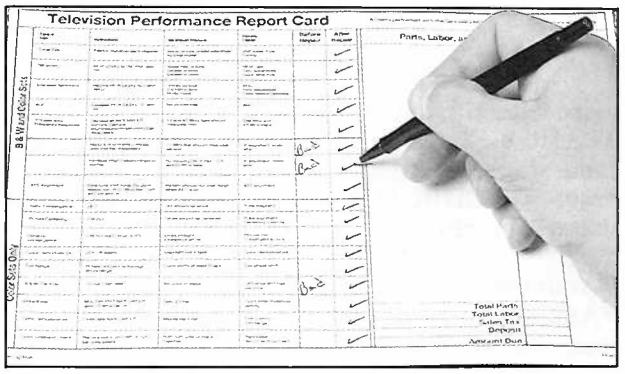
If repairing the first problem did not clear up secondary problems, you now turn your attention to them. Move back to step number 3, and follow the troubleshooting sequence to find each remaining problem, one at a time. Use your VA62 to test, isolate, and then confirm each defect.



"The picture tube is weak. I'll restore it to improve the picture." Repair secondary symptoms (Step 9).

10. Run complete performance test.

When you have found all the problems, repeat all the steps of the performance test used at the beginning of the process. This time, write the test results in the second column of the "report card" to show your customer the improvement in operation compared to before. Then, the customer can see that you took care of each of the troubles that you agreed to when they dropped off their set.



"Okay, all of the tests look good now. I've taken care of all the problems." Run a complete performance test (Step 10).

The VA62 does much more than help you fix "tough dogs". It is a complete video analyzer, which becomes part of a professional approach to video servicing. The ten steps we've covered apply equally well to TV receivers,video monitors, VCRs, and NTSC capable computer monitors. It applies to any video system based on NTSC standards.

If you follow the steps used by successful servicers, your customer will know you are doing a good job. More importantly, each step directs you to the problem, using the most efficient troubleshooting methods ever devised. That translates to less time wasted and higher profits on every service job. ■

20 Tips To Help You Use Your VA62 Better

1. Find tuner and tuner-control problems: A bad tuner-control circuit can be confused with a bad tuner. Use your VA62's all channel VHF and UHF RF generator to test each channel to tell which needs work.

2. Isolate cable tuning problems: Cable tuners normally have 5 tuning bands, compared to 3 for a conventional VHF/UHF system. Plus, cable offsets may be affected by AFT. Use your VA62's cable channels and programmable cable offsets to duplicate conditions that affect cable tuners.

3. Find fringe level or overload problems: You may be tempted to do fringe and overload testing in the customer's living room to duplicate their signals. Instead, use the VA62's microprocessor controlled variable RF output to duplicate signals from "far fringe" to "excessive", right at your bench.

4. Eliminate adjacent channel cable interference: Customers often see more interference when they connect to cable, because cable uses the adjacent sound and adjacent video channels. Use your VA62's patented trap-setting signals to touch up the traps, by simply watching for least interference on the CRT.

5. Correct contrast and brightness problems: Problems affecting the dynamic operating range of the video IF and video amplifiers are tough to find with a meter or scope. Use your VA62's 10-BAR STAIRCASE video pattern to trace these problems. Watch for all 10 brightness levels on the CRT.

6. Isolate causes of "poor video": Smear or lack of fine detail makes the picture nearly unwatchable. Your VA62's MULTIBURST BAR SWEEP video pattern lets you check for correct performance, right on the picture tube.

7. Check for full chroma response, right on the screen: Poor tint range is often hard to find. Use your VA62's CHROMA BAR SWEEP video pattern to confirm full chroma bandwidth, without taking the back off the set.

8. Test "station-controlled color" circuits: Many big-screen sets use VIR signals to automatically correct color. Your VA62's "VIR Adder" lets you dynamically test these circuits, without the hassle of interpreting an off-the-air signal.

9. Confirm proper vertical sync on non-broadcast signals: Some sets use different vertical circuits when locked to computers or games. Use your VA62's "Interlace Adder" to form standard non-interlaced or interlaced signals to find troubles in either sync circuit.

10. Isolate video problems, from the antenna to the CRT: Video problems often affect bandwidth or dynamic range only, scope and voltmeter readings may look good. Use your VA62 to substitute a good signal into a circuit. Watch the CRT to confirm which stages are working.

11. Narrow audio troubles to their source: Audio troubleshooting can be just as complex as video. Use your VA62 to inject audio from the antenna, through the video IF stages, and then to the audio circuit. Just listen for an improvement at the speaker.

12. Troubleshoot vertical circuits faster than ever: Vertical circuits can be some of the toughest to troubleshoot. Use your VA62's regulated power supply to isolate bias (DC) problems, then use the drive signals to isolate the bad stage.

13. Watch for color-lock when tracing color problems: The ICs used in color circuits need phase-locked inputs to work. Use the VA62's phase-locked signals to test these ICs in the circuit. Since the VA62 signals are phase-locked, just watch for a return of color on the CRT.

14. Drive horizontal circuits to see if they're really bad: Horizontal failures don't leave you with many symptoms—other than a dead set. Your VA62 supplies three kinds of horizontal drive signals, to let you feed into any circuit from the oscillator, right up to the output transistor or SCR. If the "lights" come back on, you know you've found the problem.

15. Dynamically test yokes, fly-backs, or triplers: Deflection components are more likely to fail than others because of the high voltages and currents involved. Use your VA62's patented ringer test, along with the innovative tripler and "integrated flyback" tests, to confirm whether they are good or bad.

16. Measure peak-to-peak voltages, as well as DC, with autoranged speed: Many times you want to know how much signal is in a circuit. Remember that your VA62's digital meter is a complete signal tracer, too. Just touch the probe from your VA62's autoranged meter to the test point, and read the digital display directly.

17. Meet manufacturer's requirements for TV and VCR servicing: When combined with its optional accessories, your VA62 meets the warranty requirements of manufacturers for servicing TVs and VCRs.

18. Test VCR heads, rotary transformers, and amplifiers, right in the circuit: There are 12 to 16 different circuits in a VCR which cause symptoms identical to a bad video head. Use your VC63 VCR Test Accessory with your VA62 to quickly identify the correct bad part.

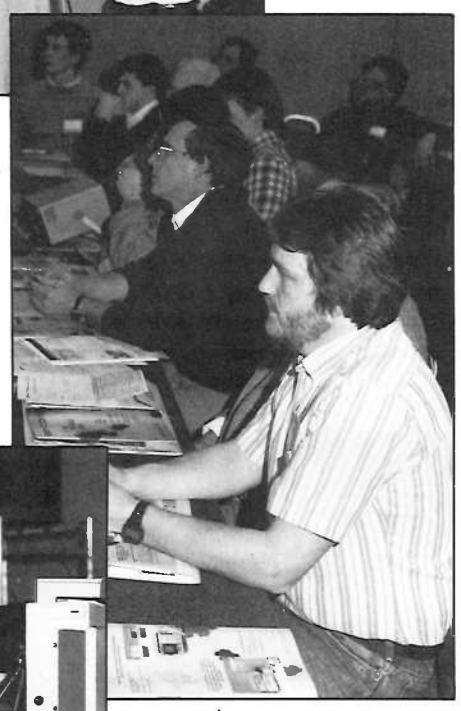
19. Block VCR servo feedback loops to see what still works: VCR servo circuits contain a feedback loop inside a second feedback loop. A problem in either loop causes all the voltages in both loops to be bad. Use your VA62's bias supply and 30 Hz servo drive to block the loops and confirm where you have the trouble.

20. Expand to VCR, MTS stereo, or RGB monitor service: Video includes much more than television. Your VA62 gives you a choice. Add the accessories you want to expand your business into the kinds of video service you like the best.

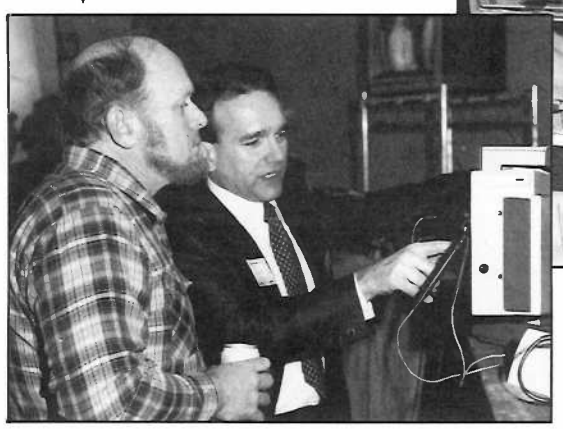
Sencore VCR/TV Instrument Demonstrations

Plan Now To Attend . . .
See How You Can Easily Update Your 1988 VCR/TV Servicing Techniques

• *See and try the Sencore instruments yourself . . .*



• *Get your technical questions answered by a Sencore Factory Applications Engineer . . .*



• *Mix and compare notes with other area top technicians . . .*

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Nov. 28 Savannah
Nov. 29 Augusta

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Dec. 12 Kansas City

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Nov. 15 Pittsburgh
Nov. 16 Washington
Nov. 17 Greensburg
Nov. 28 Altoona

Pennsylvania
Call Trent Litten

Nov. 30 Harrisburg
Dec. 1 Reading
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Dec. 14 Allentown
Dec. 15 Scranton

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Dec. 12 Norfolk
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- ***How to tame any "Tough Dog" VCR/TV problem in half the time:*** See a proven trouble-shooting technique that is guaranteed to cut your VCR/TV "Tough Dog" troubleshooting time in half.
- ***How to isolate frustrating shutdown problems in 5 steps or less:*** See how you can locate tough shutdown problems with pin-point accuracy. Exclusive troubleshooting techniques will bring any chassis out of shutdown and turn those "tough to find" shutdown problems into a quick servicing job.
- ***How to dynamically analyze any VCR head or head circuit problem with 100% reliability:*** See how special substitution signals isolate VHS, BETA, or U-Matic problems with 100% proof positive results.
- ***How to walk through any VCR system control problem with a simple 5 step microprocessor troubleshooting technique.***
- ***How to determine if a cap or coil is simply good or bad, easily and with 100% reliability:*** See how the All New quadruple-patented, microprocessor controlled LC102 AUTO-Z locates bad caps or coils at just the push of a button.

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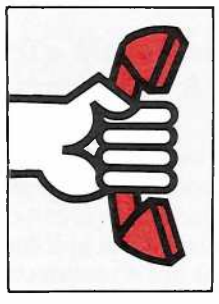
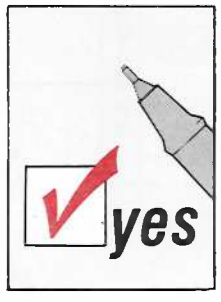
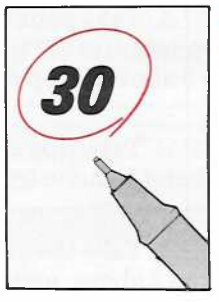


1 Call Your Area Sales Engineer to reserve a seat at your scheduled workshop.



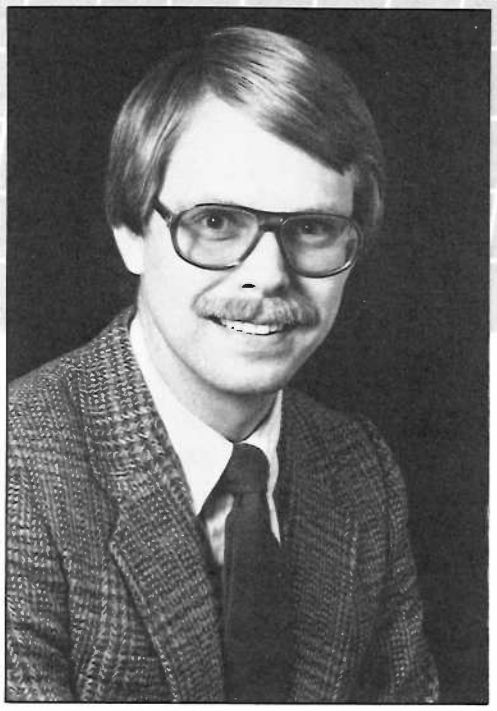
2 Check "yes" I plan on attending the Sencore Workshop on the enclosed seminar return card.



3 Next mark your calendar so you don't forget. Even if you do, we'll remind you a few days before your scheduled workshop. (P.S. Bring a technical friend.)

4 Then be sure to attend to receive your Free Sencore Workshop attendance gift — two specially prepared Video Servicing Workbook Study Guides. A $40.00 value.

Your servicing success is our success. Please join us and your technical friends at Sencore's all new workshops.



This Is Your Final Countdown To Tax Savings In 1988, And Your Last Chance To Save Up To 47% On Your Sencore Investment.

Randy Koepsell, Vice President Of Finance

In the last issue of the Sencore News, I informed you about the great tax savings opportunity available to you in 1988. I'd like to remind you that you only have a few more weeks to make business decisions that can significantly impact your 1988 taxes.

By acting before the end of the year, you can save up to 47% on your 1988 Sencore investment with the help of our "Year-end Countdown Specials" and Uncle Sam. The 1988 tax laws allow you to write off up to $10,000 of business equipment purchases as an expense. In addition to that, you can depreciate your business investments even if you have already used up your equipment write-off. All of this makes it possible for you to save thousands of dollars on your tax return.

If you've ever considered updating your shop with the latest in electronic test equipment from Sencore, now is the time. Use this worksheet to find out how much you can save by acting before the end of 1988. Don't let this opportunity slip through your fingers!

Tax Saver Number 1:

$10,000 WRITE OFF. Uncle Sam allows you to write-off up to $10,000 of business equipment purchases as an expense. That means that your investment in Sencore Test Equipment now, in 1988, can mean saving thousands on your tax bill!

Let's assume that your taxable income falls between $17,850 to $43,150, you are filing a single return, and your business income is at least as much as the net equipment cost.

Here's a few examples showing what you can save:

	Enter Your Figures Here:	Example #1 (Special Package #7)	Example #2 (Special Package #1)
STEP 1: Fill in the catalog price of the equipment you are interested in purchasing:	_____	$2,572.90	$10,813.00
STEP 2: Write in the amount of savings shown in our specials.	_____	$677.90	$1,890.00
STEP 3: Subtract **Step 2** from **Step 1** to find your net cost of the equipment.	_____	$1,895.00	$8,923.00

This is what Sencore saves you by acting now. Let's see what Uncle Sam can save you.

STEP 4: Enter here the savings on your taxes versus what you would have had to pay if you did not invest the amount in **Step 3.** (For example - use 28% if you made from $17,850 to $43,150)	_____	$530.60	$2,498.44
STEP 5: Subtract tax savings in **Step 4** from net cost in **Step 3. This is your final cost!**	_____	$1,364.40	$6,424.56
You Save	_____	$1,208.50 OR 47%!	$4,388.44 OR 41%!

Tax Saver Number 2:

DEPRECIATION: Uncle Sam lets you depreciate your business investments, even if you have used up your $10,000 capital equipment write-off. This allows you to still update your equipment and write-off some of the expense, even though you have already written off your $10,000. Tax Saver Number 2 is as easy as A, B, C.

	Enter Your Figures	Example #1	Example #2
STEP A: Take your first year's depreciation of 20% on the amount in **Step 3** above. (Step 3 x 20%)	_____	$379.00	$1,784.60
STEP B: Take this times your tax bracket. (Assume 28%, as above)	_____	$106.12	$499.69
STEP C: Take the savings you calculated in **Step 2** above, and add **Step B** to it. This is your FIRST YEAR savings! Plus, you still get to depreciate the remainder over the next five years!	_____ Your First Year Savings	$784.02 Your First Year Savings	$2,389.69 Your First Year Savings

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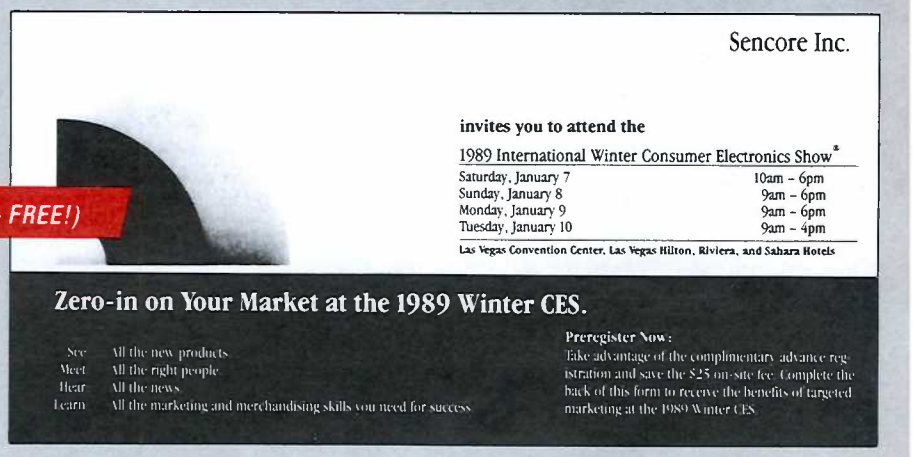

INDEX

Page 14 — Waveform Analyzer

Page 15 — Video Analyzing System
— Video Analyzer
— VCR Test Accessory
— NTSC Pattern Generator Accessory
— RGB Monitor Adaptor

Page 16 — Year End Countdown Specials

Page 17 — Year End Countdown Specials

Page 18 — Capacitance and Inductor Analyzers
— SCR/Triac Test Accessory

Page 19 — TV-RF Signal Analyzer
— TV-RF Performance Tester

Page 20 — CRT Analyzer and Restorer
— Isolation Transformer
— Color Bar Generator
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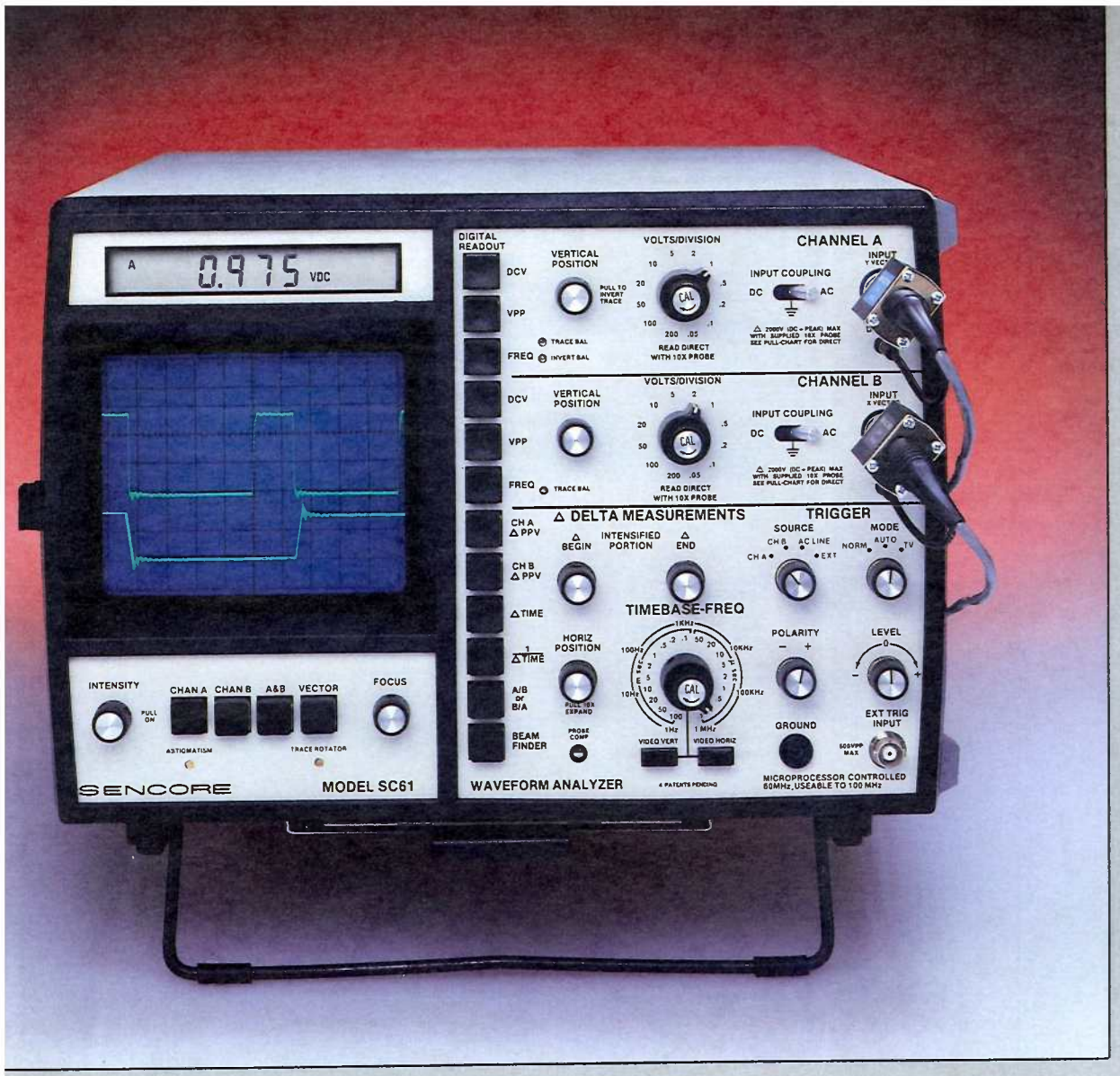

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Dual Trace Waveform Analyzer

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Analyze Any Waveform To 100 MHz, 10 Times Faster, 10 Times More Accurately, Absolutely Error Free . . . Or Your Money Back

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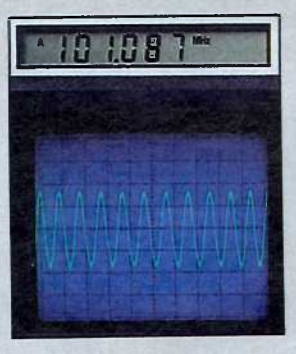
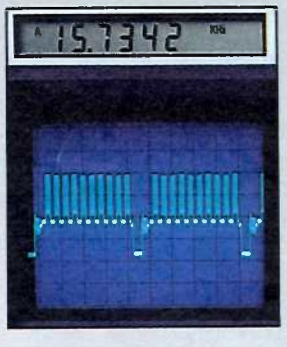
Analyze Waveforms Easily - VPP, DCV, Freq, Through One Probe!

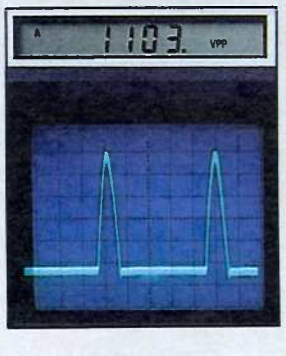
Accurate Waveform Display - 60 MHz Bandwidth (Usable To 100 MHz) To Test The Latest Digital Circuits. Analyze signals up to 100 MHz and update your present troubleshooting needs and future requirements. The SC61 provides high performance features such as: addition, subtraction, 10X expand, and vector capability.



Rock-Solid Sync - ECL Logic Circuits And Differential Amplifiers Give Fiddle-Free Operation. Lock onto tough video waveforms and other evasive signals easily. The SC61 gives you complete control over even the hardest to trigger signals.



Four Times The Measuring Range - Measure from 5 mV To 2000 Volts (3000 Volts Protection) For Expanded Signal Handling. Now you can confidently measure the pulse on the collector of a horizontal output transistor without the fear of damaging your instrument. Only the SC61 gives you this peace of mind.



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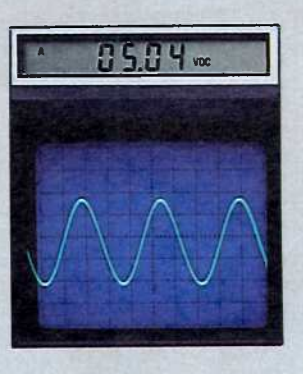
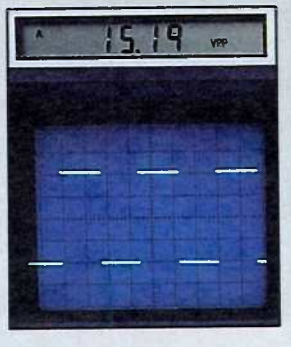
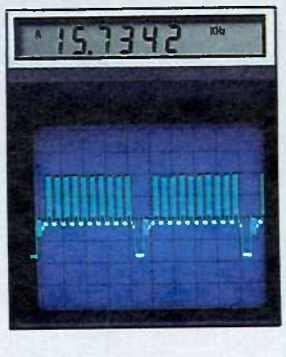
Autoranging DC Volts Through Single Probe. Now you can quickly determine DC Volts, at the push of a button, while still viewing the waveform. The SC61 gives you .001 Volts resolution for superior accuracy.



Automatic Peak-To-Peak Volts - Even If Variable Control Is ''Out Of Cal''. Now, eliminate the errors that are common to conventional scopes. The SC61's Automatic Digital Readout will tell the EXACT level, even if the attenuator is left ''Out Of Cal''.

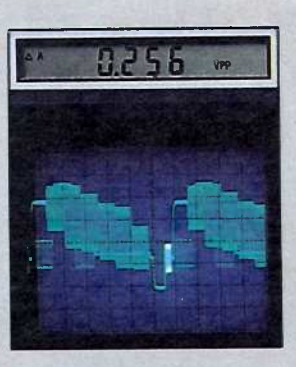


Automatic Frequency Measurements Without Sensitivity Adjustment Or Range Switching. The SC61 will display the frequency of any waveform without the hassles of other ''digital'' scopes. Simply lock in the waveform and push a button. It's that easy.

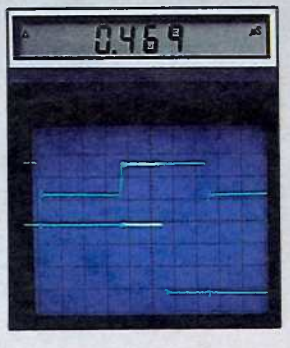


Delta Digital Tests Analyze Any Part Of The Signal.

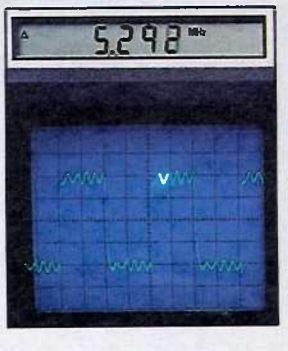
Delta Peak-To-Peak Volts - Peak-To-Peak Volts Of Any Part Of The Signal. Analyze part of a waveform by setting the starting and stopping point with the ''Delta'' controls. The (Delta) PPV function of the SC61 lets you measure any part of the waveform you want, like the color burst on a composite video signal.



Delta Time For Any Time Reading - Including Delay Between Traces. An easy way to determine the time of any waveform segment or between two waveforms.



1/Delta Time - Or Frequency Of Part Of The Signal - Finds Sources Of Interference Or Ringing. Track down the source of interfering ripple on a power supply line, or on top of a digital waveform, with the 1/DELTA TIME function. Simply intensify one cycle of the interfering signal and read the signal's approximate frequency.



VA62
Universal Video Analyzing System

$3,495 Accessories additional Patented

The Only NTSC Video Analyzing System Guaranteed To Cut Your Service Time By 54%* . . . Or Your Money Back!

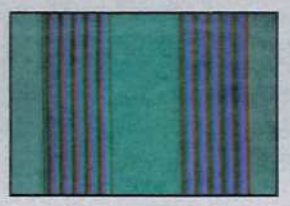
On GSA Contract NSN #6625-01-187-5516

Isolate Video Troubles In Half The Time With The Only Universal Video Analyzer

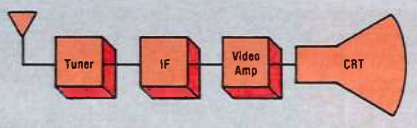
Identify Tuner Problems With All-Channel, VHF, UHF, And Cable RF Generators. The VA62 lets you completely test every TV channel. Simply select ''STD TV'' for VHF and UHF channels, and ''STD CABLE'' for all cable channels. Select ''PROG CABLE'' to duplicate HRC, ICC or any cable carrier shift to test lock-in range.

Pinpoint IF Problems With Modulated Troubleshooting Signal And Exclusive Programmable IF/RF Generators. Isolate any IF trouble by simply injecting a signal and watching the picture tube. The fully modulated, crystal referenced, 45.75 MHz IF signal is preset to match the 1st, 2nd or 3rd IF input.

Cable ready TVs and VCRs require accurate IF trap adjustments — the VA62's patented IF trap setting signals allow you to set any IF trap by simply looking at the CRT.



Isolate Any Video Problem With Patented Video And Standard Color-Bar Patterns. Do a complete system check without even taking the back off the TV or cover off a VCR. Exclusive video signals let you dynamically test for video resolution, color circuit response, synchronous detector linearity, and IF performance, plus standard color generator patterns make it easy to learn.



Find Defective Stages, Without Disconnecting Parts, Using Exclusive Phase-Locked Drive Signals. Special drive signals quickly isolate defective stages by injecting into any circuit, and watching the response. No need to disconnect components. The VA62's output circuits automatically ''swamp out'' the circuit's signal, and replace it with a known good substitute signal.

Test Yokes and Flybacks, Plus Measure Signal Levels With Autoranged Digital Meter. Reliably test expensive yokes and flybacks before replacing them with the patented ringing test. Plus, measure DC volts, Peak-to-Peak Volts, and monitor drive signal levels with the built-in digital meter. Dynamically test IHVTs, too.

*Based on a nationwide survey of users who reported an average time savings of 54% compared to their previous test equipment.

Expandable: Update For New Technology With Exclusive Phase-Locked Accessories.

VC63 VCR Test Accessory $495

The VC63 Solves The VCR Service Challenge With Substitute VCR Signals, Phase-Locked To Your VA62.

- Isolate Problems In VHS, Beta, and U-Matic Formats
- Find Defective Heads Without Expensive Substitution
- Pinpoint Defective Stages With Exclusive Substitution Signals
- Troubleshoot Color Problems With Special Reference Signals

NT64 NTSC Pattern Generator $495

Add The NTSC Full-Field And Split-Field Patterns To Your VA62 Universal Video Analyzer - Meets All Warranty Requirements.

- Produces EIA RS189 Standard Full-Field And Split-Field Color Bar Patterns
- Meets All VCR Manufacturers' Requirements For Color Bar Generator
- Fully Phase-Locked To All Other VA62 Signals

ST65 Video Analyzer Stereo TV Adder $995

Quickly, Easily And Accurately Test, Troubleshoot And Verify Any Mono/Stereo Sound Or SAP Channel Or Your Money Back.

- Updates Your VA48 or VA62 Video Analyzer To An Integrated Multichannel Television Sound (MTS) Stereo TV Analyzing System
- Exclusive Phase-Locked Generator Locks The ST65 To Your VA48 Or VA62 For Rock Solid Analyzing
- Makes Stereo And Second Audio Program (SAP) Performance Tests On Any MTS Stereo TV System
- Exclusive Adjustable RF/IF, COMPOSITE SIGNAL and AUDIO Levels Match And Isolate Troubles In Any Stage — Including The Decoder
- The Only Tester Guaranteed To Tie Troubles Down To Any And All Stages

RG67 NTSC Video Monitor Adapter $890

Updates Your VA48 Or VA62 Video Analyzer To Expand Into Analog Digital Monitor Service

- Phase-Locked R, G, B And I Signals Drive Any NTSC Analog/Digital Monitor
- Selectable Signal And Sync Polarity With Adjustable Amplitude To 5 VPP; Matches Any Input
- E-Z Hook™ Leads For Fast Hookup To Separate R, G, B, & I Inputs

E-Z HOOK is a registered trademark of E-Z HOOK, Division of Tektest, Inc.

Save up to 36%, plus delay your first payment or payment in full until February 1, 1989! (Send for additional information on page 12).

Update '88

Year End Countdown!

SPI

#1 The Complete Video Update Package

Here's our offer:

Buy the Complete Video Update Package that includes:

The SC61 Waveform Analyzer	**$3,295.00**
The VA62 Universal Video Analyzer	**$3,495.00**
The VC63 VCR Test Accessory	**$ 495.00**
The NT64 NTSC Pattern Generator	**$ 495.00**
The ST65 Video Analyzer Stereo TV Adder	**$ 995.00**
The EX231 Expander Jack	**$ 148.00**
Total Investment:	**$8,923.00**

And you receive the following absolutely FREE!:

The LC76 PORTA-Z	**Normally $1,395.00**
The PR57 "POWERITE"	**Normally $ 495.00**

That's a $10,813 package for only $8,923.00!

Save $1,890!

Now, you can put the SC61 Waveform Analyzer, and the VA62 Universal Video Analyzing System on your bench and service today's TVs, VCRs and MTS Stereo Video Systems, as well as future video products.

But this special update package doesn't stop there! Now you can pinpoint defective capacitors, coils and other components that could cause problems in video circuits with the LC76 PORTA-Z. It's yours absolutely FREE with this special package deal!

Plus, the PR57 "POWERITE" Variable Isolation Transformer and Safety Analyzer pays for your investment! And it's yours FREE when you invest in this package! By routinely performing and charging for the safety leakage test on every set you service, you'll be able to pay for this complete package and make a profit in the years to come.

#2 The Video Update Bench

Save $1,485!

This package allows you to update your bench to handle today's TV and VCR servicing requirements. Now you can enjoy big savings on the SC61 Waveform Analyzer and the obsolete-proof VA62 Universal Video Analyzing System.

When you say "Yes" to this package, you'll receive the VC63 VCR Test Accessory, the NT64 NTSC Pattern Generator Accessory, and the PR57 "POWERITE" Variable Isolation Transformer and Safety Tester at no additional charge!

By performing and charging for the important AC Safety Leakage Test on every set you service, you'll generate the extra income you need to pay for your investment and put profits in your pocket!

Here's our offer to you:

Buy the Video Update Bench that includes . . .

The SC61 Waveform Analyzer for	**$3,295.00**
The VA62 Universal Video Analyzer for	**$3,495.00**
Total Investment:	**$6,790.00**

And you receive the following absolutely FREE!

The VC63 VCR Test Accessory	**Normally $495.00**
The NT64 NTSC Pattern Generator	**Normally $495.00**
The PR57 "POWERITE" Variable Isolation Transformer and Safety Analyzer	**Normally $495.00**

A $1,485.00 Value
Normally $8,275.00
Your Total Investment $6,790.00

#3 The VA62 Universal Video Analyzing System™

This Video Analyzing System provides you with everything you need to quickly and accurately analyze TVs, VCRs, and MTS Stereo TVs common in today's hi-tech consumer electronics industry.

Here's our offer:

Buy the VA62 Universal Video Analyzing System that includes . . .

The VA62 Universal Video Analyzer	**$3,495.00**
The VC63 VCR Test Accessory	**495.00**
The NT64 NTSC Pattern Generator	**495.00**
The ST65 Video Analyzer Stereo TV Adder	**995.00**
Total List Price Normally $5,480.00	
Your Investment Total $4,295.00	

Save $1,185!

#4 The SC61 Waveform Analyzer™

Now you can update your bench with the ultimate in waveform analyzing equipment — guaranteed to cut your troubleshooting time in half or your money back! Put the triple patented SC61 to work for you and discover how, with just one probe hook up, you can confidently analyze any waveform to 100 MHz, 10 times faster, 10 times more accurately, and absolutely error-free, guaranteed or your money back!

Here's our special offer to you:

The SC61 Waveform Analyzer normally lists at $3,295.00
But you can own it today for only $2,995.00!

Save $300!

ECIALS

Offers End Dec. 31, 1988!

Call 1-800-843-3338 today!

In Canada Call 1-800-851-8866!

#5 The LC75 Z METER 2 ™

Update your cap/coil troubleshooting ability and solve new high tech cap and coil challenges with the LC75 Z METER 2! Test for four capacitor failures: Value, Leakage, ESR and Dielectric Absorption. Plus, test coils for value change and shorts down to one shorted turn.

And now you can save TWO different ways!

Buy the LC75 "Z METER 2" alone for $895.00 - Save $100!

OR

Buy the LC75 for the normal price of $995.00, and you'll receive the following accessories - FREE!:

SCR250 SCR/Triac Accessory	Normally $168.00
CC254 Custom Built Carrying Case	Normally $ 99.00
CC237 Universal Lead Pouch	Normally $ 24.95
39G85 Touch Test Probe	Normally $ 17.00

Save Up To $308.95!

#6 The LC76 PORTA-Z ™

Put the tried and proven Z Meter test to work for you, anytime, anywhere, with the LC76 PORTA-Z. Plus, extend your capacitor analyzing capabilities with 1000 volts applied potential for locating tough leakage problems in high voltage circuits.

Plus, we offer you TWO big ways to save!:

Buy the LC76 PORTA-Z alone for $1,095.00. Save $300!

OR

Buy the LC76 for the normal price of $1,395.00, you'll receive the following accessories - FREE!:

SCR250 SCR/Triac Accessory	Normally $168.00
CC254 Custom Built Carrying Case	Normally $ 99.00
CC237 Universal Lead Pouch	Normally $ 24.95
39G85 Touch Test Probe	Normally $ 17.00
FC221 Field Calibrator	Normally $ 65.00
BY234 Rechargeable Battery	Normally $ 59.95

Save Up To $433.90!

#7 The LC77 AUTO-Z ™

The LC77 is the only dynamic, portable, automatic capacitor/inductor analyzer guaranteed to help you quickly find the defective caps and coils that the other testers miss. With just the information supplied on the component itself, you can test anytime, anywhere, without calculations, look-up tables or error.

Plus, save TWO different ways!

Buy the LC77 AUTO-Z alone for $1,595.00 Save $300!

OR

Buy the LC77 AUTO-Z for $1,895.00 and receive the following accessories - FREE!

SCR250 SCR/Triac Test Accessory	Normally $168.00
CC254 Custom Built Carrying Case	Normally $ 99.00
CC237 Universal Lead Pouch	Normally $ 24.95
39G85 Touch Test Probe	Normally $ 17.00
FC221 Field Calibrator	Normally $ 65.00
BY234 Rechargeable Battery	Normally $ 59.95
CH255 Component Holder	Normally $195.00
CH256 Chip Component Test Lead	Normally $ 49.00

Save Up To $677.90!

#8 The CR70 "BEAM BUILDER" ™

Buy the CR70 for only $1,195.00— A $100 savings, plus receive a special advertising package absolutely free!

Test every CRT on the market—now and in the future, plus restore 90% of all weak or shorted CRTs—guaranteed, or your money back! Plus, you'll receive our special advertising package absolutely FREE. This special package shows you how the CR70 can generate profits for your business.

Take our CR70 Challenge:

"Try the CR70 for thirty days, if you find it does not at least make your first payment—return it to us for a complete refund!"

Save $100!

#9 The PR57 "POWERITE" ® Variable Isolation Transformer and Safety Analyzer *Save $46!*

Buy the PR57 "POWERITE" for only $449.00—A $46 savings, plus receive a special AC leakage promotional kit absolutely FREE!

The PR57 gives you everything you need to know your AC power is right and safe. Now you can own the PR57 "POWERITE" for only $449.00 and you'll also receive a special AC Leakage Promotional Kit that lets you use the PR57 to pay for itself—and at no extra charge!

#10 The FC71 1 GHz Frequency Counter! *Save $259.85!*

Now you can own the FC71, the only portable counter especially designed with an exclusive microprocessor controlled timebase to measure 10 Hz to 1 GHz to .5 PPM accuracy.

Buy the FC71 for only $1,195.00 - a $100 savings, and receive the following accessories - FREE!:

AN210 Frequency Counter Pick-up Antenna	$25.00
BY234 Rechargeable Battery	$59.95
CC237 Universal Lead Pouch	$24.95
CC238 FC71 Carrying Case	$49.95

That's a $1,455.85 package for $1,195.00! You save $159.85 in FREE accessories, plus $100 of the normal price for a grand total savings of $259.85!

#11 The FS73 CHANNELIZER JR.™ *Save $284.00!*

Now you can performance test any CATV, MATV or RF distribution system in less than half the time you now spend. Fully automatic measurements eliminate interpretation, so you get the right answer every time.

Buy the FS73 CHANNELIZER JR. for $2,395.00, and receive the following accessories - FREE!:

(2) BY242 Rechargeable Batteries	$ 88.00
PA241 Power Adaptor	$ 48.00
CC243 Custom Built Carrying Case	$148.00

That's a $2,679.00 package for only $2,395.00. This means you save $284.00 in FREE accessories!

#12 The FS74 CHANNELIZER SR.™ *Save $352.85!*

Finally, you can thoroughly analyze and pinpoint any RF video trouble in any RF video distribution system—accurately and automatically—in half the time you spend now.

Buy the FS74 CHANNELIZER SR. for $3,495.00, and receive the following accessories — FREE!:

(2) BY242 Rechargeable Batteries	$ 88.00
PA241 Power Adaptor	$ 48.00
CC244 Custom Built Carrying Case	$148.00
HF247 Earphone Accessory	$ 9.95
SH257 Strand Hook	$ 29.00
PF246 External Panel Light	$ 9.95
RE248 Range Extender Probe	$ 19.95

That's a $3,847.85 package for only $3,495.00! That means you save $352.85 in FREE accessories!

LC77 AUTO-Z™

Automatic Dynamic Portable Capacitor And Inductor Analyzer

$1895 Four Patents And One Applied For U.S. Funds

THE Z STANDARD

For The First Time In Electronics Servicing History, You Can Take The Numbers Right Off The Part And Prove, Once And For All, That The Part Is "Good" Or "Bad", To Industry And EIA Standards — Anywhere, Anytime, Without Look Ups, Calculations, Or Error.

IEEE 488 BUS-COMPATIBLE

On GSA Contract NSN #6625-00-557-0399

Automatic Microprocessor Controlled For Accurate Error Free Cap/Coil Analysis

Exclusive Advanced Digital Technology Completely Analyzes Capacitors From 1 pF to 20 Farads And Inductors From 1 uH To 20 Henrys. Test Method (Patented), Dielectric Absorption (Patented)

Automatic Ranging Of Capacitance And Inductance Value, Percentage Calculator, Lead Zero, And Good/Bad Determination

Exclusive Leakage Readings In Current Or Ohms To 1000 Volts And 1000 Megohms

Exclusive Equivalent Series Resistance Test Measures 0.10 Ohms To 2000 Ohms (Patented)

Exclusive Automatic Inductor Ringing Test With Good/Bad Determination (Patented)

100% Battery Operated Portability Lets You Do All These Exclusive Tests Where 115 VAC Is Unavailable Or Hard To Get At

LC76 PORTA-Z™

Portable Dynamic Capacitor And Inductor Analyzer

$1,395 U.S. Funds Four Patents On GSA Contract

Battery Operated, Patented Capacitor/Inductor Analyzer Designed To Locate Defective Caps And Coils Other Testers Miss

Exclusive Capacitor Tests Analyze Value, Leakage At Rated Voltage To 1000 Volts, Dielectric Absorption (Patented), And Equivalent Series Resistance (ESR) (Patented)

Exclusive Inductor Tests Analyze True Inductance Value (Patented) And Ringing (Patented).

100% Battery Operated Portability Lets You Do All These Exclusive Tests Where 115 VAC Is Unavailable Or Hard To Get At

Finds Distance To Within Feet Of Open Or Shorted Transmission Lines

Tests SCRs, Triacs, Hi-Voltage Rectifiers, Diodes, With SCR250 Accessory

Hi-Pot Test Checks Leakage As Low As One Microamp Up To 1000 Volts In Cables, Switches, PC Boards, Connectors, Etc.

LC75 Z METER 2™

Dynamic Capacitor And Inductor Analyzer

$995 U. S. Funds Exclusive Four Patents

Patented Cap/Coil Analyzer Designed To Locate Defective Capacitors And Coils That Other Testers Miss

On GSA Contract NSN 6625-01-250-9554

Exclusive Capacitor Tests Analyze Value, Leakage At Rated Voltage, Dielectric Absorption (Patented), And Equivalent Series Resistance (ESR) (Patented)

Exclusive Inductor Tests Analyze True Inductance Value (Patented) And Ringing (Patented)

Finds Distance To Within Feet Of Open Or Shorted Transmission Lines

Tests SCRs, Triacs, Hi-Voltage Rectifiers, Diodes, With SCR250 Accessory

Checks Leakage As Low As One Microamp Up To 600 Volts In Cables, Switches, PC Boards, And Connectors

SCR250

SCR And Triac Test Accessory

$168 U.S. Funds On GSA Contract

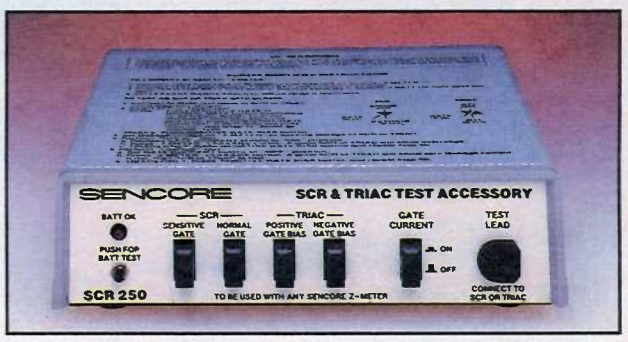
Dynamically Test All SCRs And Triacs For Leakage And Turn-On With 100% Reliability, With Any Sencore Z Meter

Tests All SCRs And Triacs

Exclusive Dynamic Leakage Test At Applied Voltage

Easy To Use, No Set Up Or Specifications Needed

Tests Industrial And Protected Gate SCRs And Triacs, Too



FS74 CHANNELIZER SR.™

TV-RF Signal Analyzer - $3,495 U.S. Funds Patented

Thoroughly Analyze And Pinpoint Any RF Video Trouble In Any RF Video Distribution System, Accurately And Automatically, In 1/2 The Time, Or Your Money Back.

IEEE 488 Bus Compatible
On GSA Contract

IEEE 488 BUS-COMPATIBLE

All Channel Digital Tuner — Tunes In Any Cable, HRC, ICC, VHF, UHF, and FM Channel. The FS74's digital tuner lets you tune in all sub-band, cable, VHF, UHF, and FM frequencies from 5 MHz to 890 MHz. The FS74's unique circuits test the carrier frequency and displays the carrier offset with 1 kHz resolution. HRC and ICC offset lets you confirm correct shifts at the flip of a switch.

Exclusive 5 Microvolt (–46 dBmV) Sensitivity With Automatic Attenuation and Ranging For Fast Hands-Off Operation. Troubleshoot from the head-end or antenna to the subscriber tap with full range from –46 dBmV to 60 dBmV. The FS74 automatically selects the proper attenuator range for instant measurements.

Exclusive Automatic Tests, Even On Fully Modulated Channels. Microprocessor technology now lets you fully test each channel without dropping modulation or carrier. Perform these tests automatically:

- Audio-to-Video Carrier Ratio Test - Direct meter reading confirms the required 15 dB A/V.
- Hum Test On Any In-Use Channel - Measure percentage of hum on any channel, automatically.
- On-Channel Signal-to-Noise Test - Exclusive, patented signal-to-noise tests WITHOUT tuning to an unused channel.
- Digital Readout Of Frequency Offset - Determine the exact location of your carriers.

Exclusive Picture Quality Check With Integrated Wide Band Video Monitor — Isolates Problems Meters Can't Show. No other Field Strength Meter gives you this unique problem locator. The FS74's monitor gives you 4 MHz (320 horizontal lines of resolution) response to track down problems that regular meters and portable TVs miss.

Exclusive ACV/DCV Measurements Through RF Input Or Special DVM Input — No Need To Carry Additional Test Instruments. Leave your volt-ohm-milliamp meter at the shop, because the FS74 gives you complete voltage measurements, even through the RF input! Plus, the FS74 has a special low level ohmmeter to test for contact resistance.

FS73 CHANNELIZER JR.™

TV-RF Performance Tester - $2,395 U.S. Funds Patented

Completely Performance Test Every Single TV Channel, In Any RF Distribution System, To FCC Specifications, 100% Automatically And 100% Faster Than Ever Before

On GSA Contract
IEEE 488 Bus Compatible

IEEE 488 BUS-COMPATIBLE

All Channel Digital Tuner - Tunes In Any Cable, HRC, ICC, VHF, UHF, And FM Channel. The FS73's digital tuner lets you tune in all sub-band, cable, VHF, UHF, and FM frequencies from 5 MHz to 890 MHz.

Exclusive 5 Microvolt (–46 dBmV) Sensitivity With Automatic Attenuation And Ranging For Fast Hands- Off Operation. Troubleshoot from the headend or antenna to the subscriber tap with full range from –46 dBmV to 60 dBmV.

Exclusive Automatic Hum And Signal-To-Noise Tests On Any In-Use Channel. The FS73 lets you perform these dynamic tests on any in-use channel. No more need to tune off of a used carrier.

Microprocessor Controlled Fine Tuning With Readout Of Frequency Offset. Test for HRC, ICC, or any carrier offset with the FS73. The FS73 lets you easily determine where your carriers are - quickly and accurately.

IB72 IEEE 488

Bus Interface Accessory $625 U.S. Funds

Interface Selected Sencore Instruments To Personal Computers And Instrument Controllers For Automatic Testing And Time Savings

IEEE 488 BUS-COMPATIBLE

Interfaces Selected Sencore Instruments To The IEEE 488 Bus For 100% Automatic Testing.

Selectable Address, External Reset, And Data Indicator LED Aid Program Development And Debugging.

Meets IEEE Standards 488-1978 (Electrical) And 728-1982 (Data).

CR70 "BEAM BUILDER" ™

Universal CRT Analyzer and Restorer

$1,295.00 U.S. Funds Patented

For the first time ever, test every CRT on the market—now and in the future—plus restore 90% of all weak or shorted CRTs, guaranteed, or your money back!

On GSA Contract NSN#6625-01-187-4395

Test every CRT (Old or new) on the market—no need to buy additional sockets. Just six adaptors allow you to test:

- All black & white and color video CRTs
- Projection CRTs
- Computer display CRTs
- Closed circuit video CRTs
- Camera pickup tubes—broadcast, industrial & surveillance
- Even scope, radar and other industrial CRTs

Exclusive tests cover CRTs full dynamic range, from cutoff to peak emission—for highest test reliability.

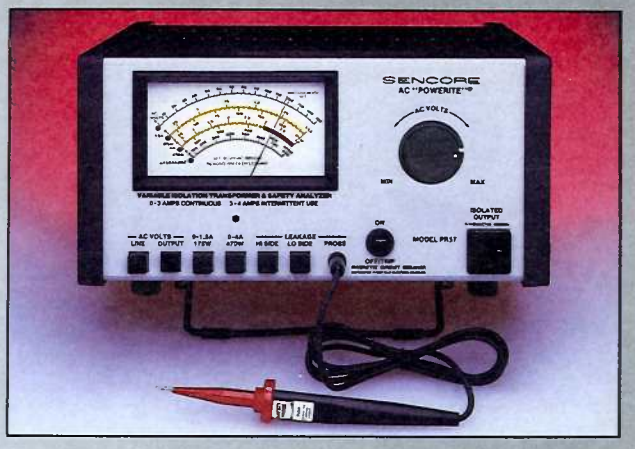
Guaranteed to safely restore 9 out of 10 weak or shorted CRTs—or your money back.

Guaranteed to be totally protected against damage from charged CRTs—keeps your investment working for you.

PR57 AC "POWERITE"®

Variable Isolation Transformer And Safety Analyzer

$495 U.S. Funds Patented



One totally integrated supply that lets you know that your AC power is right and safe.

NSN #6625-01-124-6296

Variable isolated 470 watt power transformer to isolate your AC line and vary your output voltage from 0 to 150 volts.

Voltage, current and wattage power monitor to determine that the equipment under test is not drawing excessive current or power at any voltage setting.

AC line leakage safety test to assure that excessive leakage current is not present on any exposed part of the equipment being tested.

ST66 Stereo TV Analyzer™

$1,395 U.S. Funds Patented On GSA Contract

Quickly, Easily And Accurately Test, Troubleshoot And Verify Any Mono/Stereo TV Sound Or SAP Channel Problem, Or Your Money Back.

It's A Completely Portable, Battery Operated MTS Stereo TV And VCR Analyzer.

All The Special Signals You Need To Performance Test And Service MTS Stereo TV—Stereo Decoder, SAP And Audio.

Quickly Eliminates The RF/IF Section As A Source Of Trouble—Test From The Antenna To The Speakers/CRT With One Simple Connection.

Exclusive Video Patterns To Service The Entire Stereo TV From The Antenna To The CRT.

Surpasses All Others On The Market In Performance, Price, Portability, And Reliability.

FC71 Portable 10 Hz To 1 GHz Frequency Counter

$1,295 U.S. Funds Patented

On GSA Contract NSN #6625-01-076-2595

The Only Portable, Battery Operated Counter Especially Designed With An Exclusive Microprocessor Controlled Timebase To Measure 10 Hz To 1 GHz To 0.5 PPM Accuracy In High RF Environments

Five Times More Accurate Than FCC Requirements, Even On The Toughest Job; 0.5 PPM.

Exclusive Microprocessor Timebase For Super Stability From – 12 F to122 F.

Measures All Signals, Even Complex And Noisy Signals, With Exclusive Sensitivity Control.

Super 5 mV Average Sensitivity over Full Range.

Double Shielded For Interference-Free Frequency Measurements Anywhere.

SR68 Stereo TV Readout

$595 U.S. Funds On GSA Contract

Dual Meters And Loads To 100 Watts Solve Stereo TV Servicing Challenges

Analyze Stereo TV Audio Line Or Speakers In dB Or Watts.

Loads To 100 Watts For Dynamic Tests And Speaker Substitution.

Battery Operated - Use In The Shop Or In The Field.

SG165 AM/FM Stereo Analyzer

$1,495 U.S Funds On GSA Contract

Designed To Boost Your Audio Troubleshooting Efficiency—Everything You Need To Completely Analyze/Service An AM/FM Stereo Receiver

Provides Every AM/FM Stereo Signal Needed For Efficient Analyzing.

It's Five Generators In One—RF/IF, Audio, Stereo MPX, Sweep/Marker, And SCA.

Dual dB, Watt, Stereo Separation Meters With Built-In 100 Watt Speaker Loads For Complete Amplifier Testing.

DVM37

3 1/2 Digit, 0.1% Bench/Portable Digital Multimeter $395 U.S. Funds Patented

Fully Protected, Super Rugged Digital Multimeter You Can Use Anywhere

An Indestructible DVM For Both Bench And Field.

0.1% Lab Accuracy In A Portable Meter For Measurements You Can Count On.

15 Megohm Input Impedance For Least Loading Error Especially In High Impedance Circuits.

Protected Inside, To Better Than Any Other DVM On The Market To 2 kV DC With 8 kV Transient Protection And To 10 kV With TP212 Probe.

DVM56A "MICRORANGER"

Automatic 4 1/2 Digit DVM $995 U.S. Funds Patented

100% Automatic, Microprocessor Controlled, 3, 4, or 4 1/2 Digit DVM, Designed To Save You Time With The Fastest Measurements On The Market Today

100% Error Proof, You Can't Make A Mistake, Even If You Operate Everything Backwards.

The DVM56A Makes Tests For You That No Other Single Meter Can Make.

Tough, Fully Protected To 10 kV; Better Than Any DVM On The Market.

TF46 "Super Cricket"

Portable Transistor/FET Tester $495 U. S. Funds Patented

On GSA Contract NSN #6625-01-058-9564

Automatically Tests Any Transistor Or FET With 99.9% Reliability In Less Than 15 Seconds—In Or Out-Of-Circuit

Portable Battery Operation So You Can Completely Analyze A Transistor Or FET Anywhere.

Needs No Set-Up Book Or Instructions.

Automatic Power Shut Off After 20 Minutes' Use; Saves Your Batteries.

CG25 Little Huey™

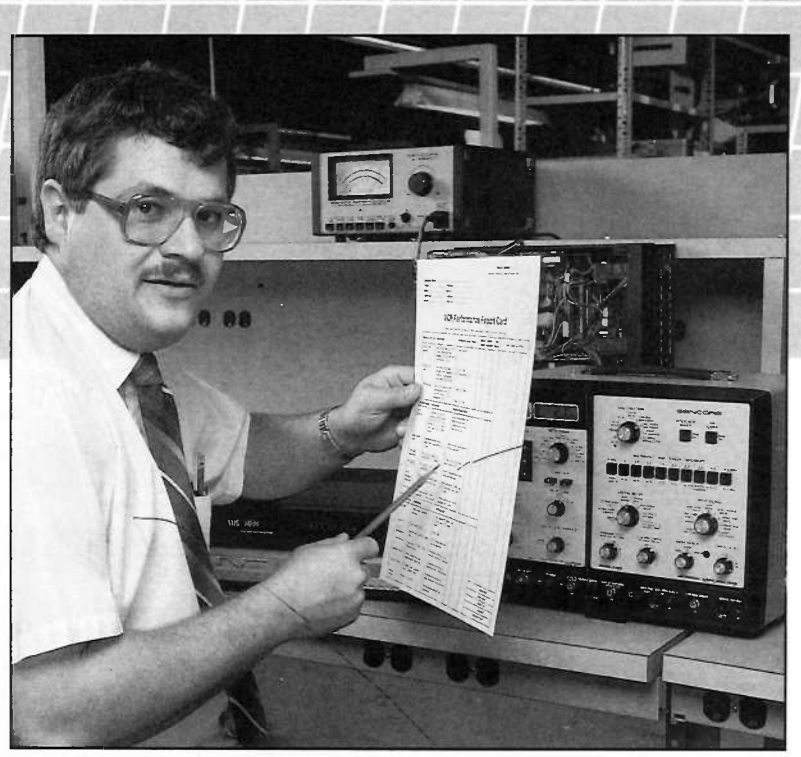
Portable Digital Color Bar Generator - $198.00 U.S. Funds On GSA Contract

Rock Solid Digital Patterns In A Small, Portable, Battery Operated Package

Built Rugged For Field Use—With Built-In Test Leads.

Big Generator Features With Variable Dot And Adjustable Channels.

Automatically Shuts Off After 20 Minutes So Your Batteries Don't Run Down.



Performance Test Every Set And Earn Extra Bucks

by Paul Nies, Application Engineer

If you own a VA62, you have the finest piece of video analyzing and troubleshooting gear available. But do you realize that you also have an extra income generator, and a way to make your customers happier? You see, your VA62 is also the best performance tester on the market. Let's see how you can use this performance tester to generate added income while at the same time make your customers happier.

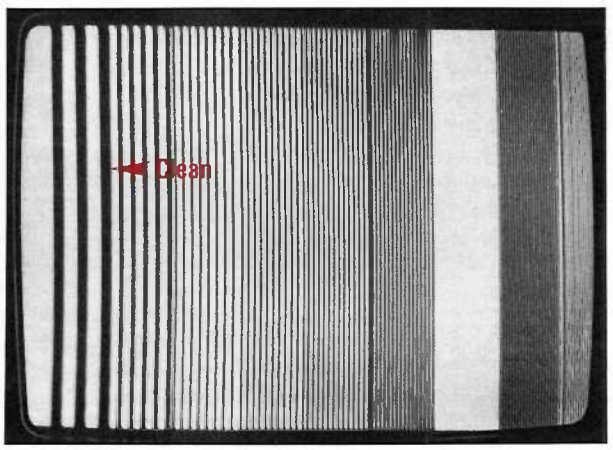
Why Should You Do A Performance Test?

If you have read through your VA62 manual, you've probably seen the "Overall Television Performance Tests" on page 36. These tests check all operating parameters. If you are a thorough technician, you have already made these tests a part of your routine service. Since each test checks the operation of specific circuits inside the television receiver, all the tests together function as a guide to tell you when a set is completely repaired.

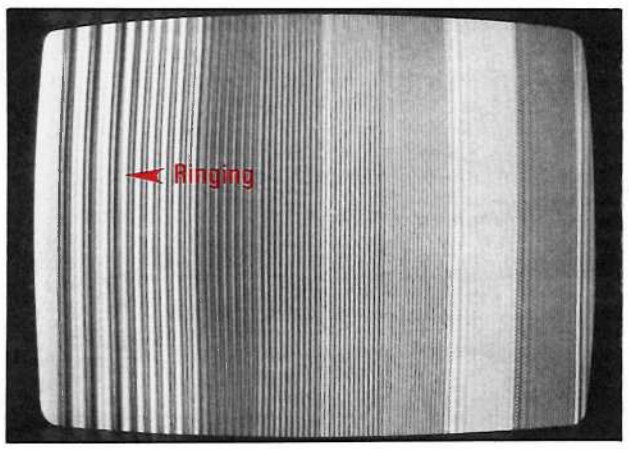
Many of the service shops we've spoken with say that doing a complete performance test on a set before it leaves their shop cuts their number of callbacks in half. Why? Because doing a complete performance test allows you to find marginal conditions that the customer may notice. Isn't it true that most customers will live with problems (like poor convergence or a weak picture) for a long time. But, when they get the set back from the service shop, they notice! Why not send that set back to them with a better looking picture than it had before it went bad? They'll appreciate you for it, and they'll be willing to pay a few dollars extra too.

How To Make The Performance Test Pay For Your VA62

One of our customers recently wrote and told us that he uses his Sencore equipment to thoroughly analyze every set that leaves his shop. He has been adding an additional "equipment charge" to each customer's bill for over a year. To date, only two people have commented about the extra charge. Neither of those were complaints. In fact one asked why he didn't charge even more.



The VA62 Multiburst Bar Sweep Video pattern should produce a clean pattern like the one above.



Bad IF or video amplifier stages often cause ringing. Note the harsh edges in the Multiburst Bar Sweep above.

We have included the performance test from the VA62 manual below. We have added a few lines for you to indicate the before and after condition of the set. When the customer first brings in his set, take a couple of minutes and run through the tests, marking the set's performance on the performance report card. (Of course if the set doesn't work at all, you will have to get it working before you can fill out the "Before" column.)

After you have completed the repair, go through the test again and make any minor adjustments necessary to get the set into top working condition. Of course, you may run across items which require additional service and additional service charges. (Make sure you clear them with the customer first!)

When the set is in the best working condition it can be, fill out the "after" portion of the performance test report card. When the customer comes to pick up the set, make sure you take a minute to explain to him what you have done and show him how much the picture quality has improved.

By charging an additional $3 to $5 per set on just four sets a day, you will earn an extra $60 a week. In just one year you will have paid for your VA62. Just think of the quality image you will instill in the mind of your customer, just because you took the extra couple of minutes to document the performance tests you are already doing. ■

Television Performance Report Card

All tests performed with the Sencore VA62 Video Ana

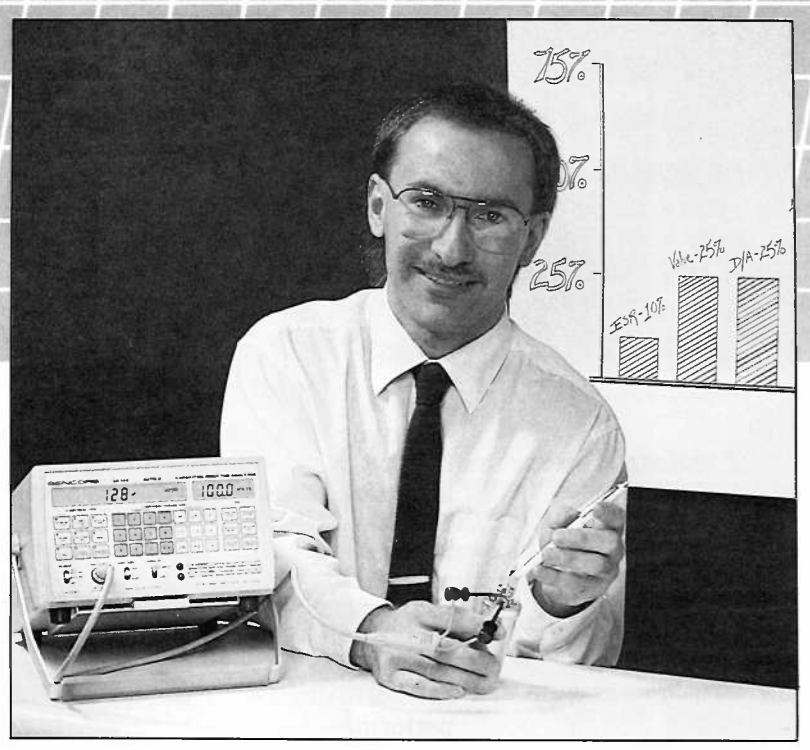
B & W and Color Sets

Type of Test	Instructions	Set Should Produce:	Circuits Tested	Before Repair	After Repair	Parts, Labor, and Price
Tuner Test	Feed in signal on each channel	Good picture unless overdriven by local signal	VHF tuner, Fine Tuning			
Sensitivity	RF-IF LEVEL to "NORM" and "HI"	Snow-free picture Locked in sync Locked in color	RF/IF gain Sync separators Color detectors			
Low-level Sensitivity	Reduce RF-IF LEVEL to .1 and "MED"	Snowy picture Locked in sync Noisy color	AGC Sync separators Color detectors/killers			
AGC	Increase RF-IF LEVEL "5" and "HI"	No picture tear	AGC			
IF/Video Amp Frequency Response	Depress all BAR SWEEP buttons. Reduce brightness/contrast until 1 bar disappears.	3.5 and 4.5 MHz Bars should disappear first	3.58 MHz and 4.5 MHz traps			
	Reduce brightness/contrast until 2nd bar disappears.	3.0 MHz Bar should disappear second	IF alignment, video amp			
	Increase brightness/contrast to normal.	No Ringing On "0 Ref.", 0.5, and 1.0 MHz bars	IF alignment, video amp			

We will provide camera ready artwork if you want to have copies of this performance sheet printed with your own shop's name and address. Call 1-800-851-8866 and ask for the "TV Performance Report Card".

All New And Improved LC102 AUTO-Z Gives You More Capability And Confidence

by Larry Schnabel, Applications Engineer



"Every time I use the Z Meter it makes me doubly proud that we build it. That's why I have to tell you about our newest Z Meter, the all new and improved LC102 AUTO-Z . . . it's the Z Standard!"

Two hum bars drift slowly up the television screen. Is it a power supply problem? One by one, I checked the power supply waveforms with my SC61 Waveform Analyzer™—raw B+ had 45 volts PP ripple; the schematic showed 4 volts PP was normal. Hmmmm. Ripple could cause the hum bars, but what could cause the ripple? Experience told me to suspect C802, the main filter cap.

There was a time, of course, that I would pull the cap and test it with the impedance bridge. . . *that was before the Z Meter.* I had to read the manual before every test; never did understand dissipation factor. You'd think they could have explained it better . . .

Darn! The cap measured 494 uF on the Z Meter, compared to the 470 uF marked value. No problem with value. Could it be equivalent series resistance (ESR)? Nope, the Z called it GOOD too— within EIA and industry standards for this size and type of capacitor. What about leakage? A quick check at the working voltage told the story. Was it BAD? You bet . . . Replacing that cap solved the problem; the picture came in bright and clear. My bridge couldn't have found this problem, it wasn't much better than an ohmmeter on leakage tests. And, it would have had me running in circles troubleshooting the other power supplies. You can trust your Z Meter. After all, it's the only tester on the market that dynamically and automatically tests capacitors and inductors for all the ways they fail.

However, a few of our customers have experienced a special challenge with very large value capacitors with high operating voltage, like you might see in photo flash systems. These large capacitors(or capacitor banks), are beyond the design limits of the Z Meter. They require a large charging current (but, you can charge them with your Z Meter over time). When charged, these capacitors become a safety hazard and can damage your valuable test instruments too, if not discharged properly.

All Z Meters automatically discharge capacitors as soon as you release the leakage test button. Plus, to protect your investment in case you accidentally connect to a live circuit, the Z Meter test lead input is fused. What happens if you try to test a very large bank of high voltage capacitors whose capacitance and voltage product exceed the capabilities of your Z Meter? (Such capacitors are capable of spot welding, as you well know!) What happens? The fuse blows, leaving a charged capacitor for you to deal with—a certain safety hazard if you are unaware.

New Audible And Visual Alert Warns You If Your Z Meter's Internal Discharge Circuit Fails Or The Test Lead Fuse Blows

Although few servicers will ever try to test such large value high voltage capacitors with their Z Meter, we have decided to add an audible and visual alert to warn you if your Z Meter's internal discharge circuit fails or the test lead fuse blows. Plus, we've made engineering changes that improve performance and accuracy. And, we have completely repackaged the AUTO-Z. The result? An all new and improved LC102 AUTO-Z that gives you more capability, confidence, and safety than ever before.

Z Meters Always Measure True Capacitor Value

The LC102 tests capacitor value from 1 pF to 20F, automatically, with no calculations, lookups, or error.

Fig. 1: Paralled banks of high value, high voltage capacitors can exceed the design limits of your Z Meter. Always test these capacitors one at a time.

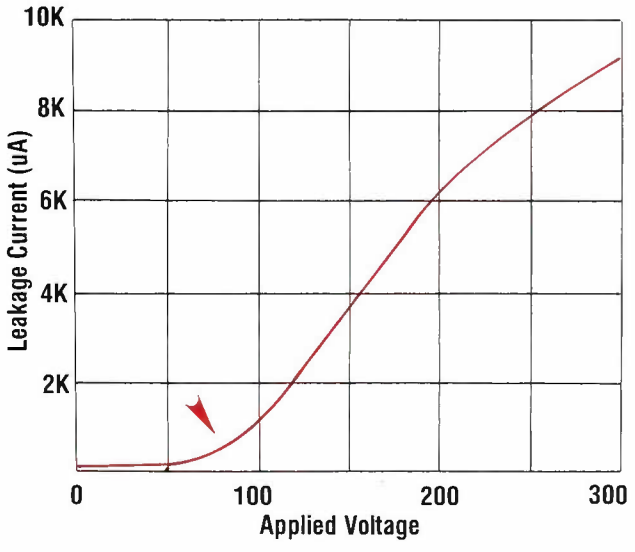


Figure 2a: This 300 volt electrolytic capacitor showed no leakage at all until the test voltage reached 50 volts.

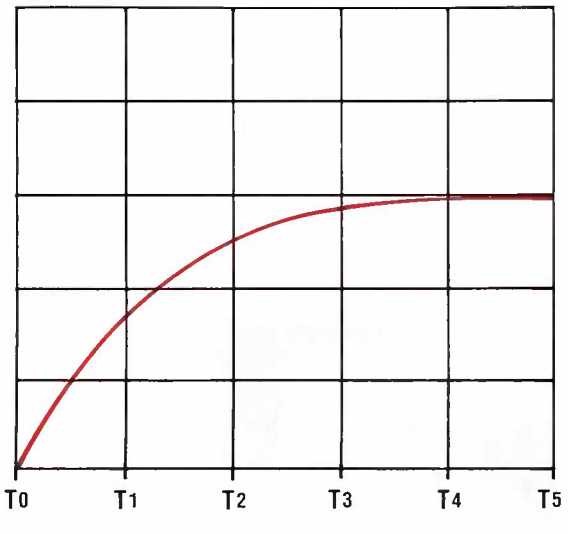


Fig. 2b: The charging curve for a normal capacitor.

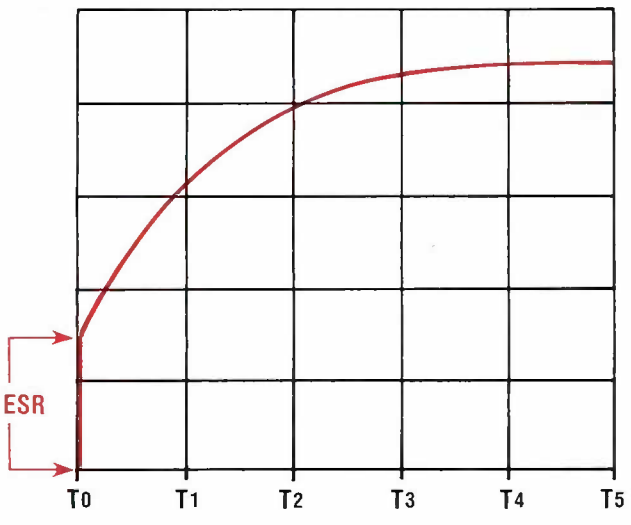


Fig. 2c: The charging curve for a capacitor with ESR.

Of all the defective capacitors, 25% have value change. The LC102 tests capacitor value by charging the capacitor through a precision resistor and measuring its time constant. Bridges test for capacitive reactance, usually at 120 Hz or 1 kHz. Capacitors that are highly frequency selective (aluminum electrolytics, for example) will not show the same value when measured with a bridge and a Z Meter.

The Truth Is Out On Electrolytics

Studies by the Physics Department of South Dakota State University (SDSU) show that the electrical resistance of the water in the electrolytic increases at higher frequencies because of the resonant properties of the water molecules. This increased resistance, in series with the capacitive reactance of the capacitor, causes a bridge to measure capacitor value lower than its true value. Since most capacitor manufacturers test electrolytic capacitors with a bridge, caps are often marked with the lower value. The LC102 Z Meter test gives you the correct, higher value that the capacitor produces in a DC circuit. (The SDSU report is available upon request.)

Find Capacitor Leakage, Dynamically, At The Capacitor's Rated Voltage

The LC102 finds bad capacitors that value-only testers miss; checks capacitors dynamically, at their operating voltage.

Over 40 percent of all capacitor failures are caused by leakage. Leakage acts like an internal parallel resistance that bypasses current through the dielectric. Capacitor leakage is not linear with applied voltage, that's why ohmmeter checks often lead you astray. Leakage must be tested dynamically, at the rated operating voltage (Figure 2a).

The LC102's Dielectric Absorption Test Saves Time On Tough Troubles

The LC102 makes D/A tests automatically; gives you the percentage of D/A, plus tells you if the capacitor is GOOD or BAD, to EIA and industry standards.

Dielectric absorption (D/A) prevents a capacitor from completely discharging. D/A acts like a battery, changing circuit bias and timing. The LC102's patented test finds dielectric absorption, present in 25 percent of all defective capacitors, by automatically measuring the change in capacitor value before and after charging. The results are displayed as a GOOD or BAD percentage on the LC102's LCD display.

You'll Quickly Find The Toughest Troubles ESR Can Cause

The LC102's automatic ESR test finds defective capacitors other testers miss; 10% of all defective capacitors fail because of high ESR.

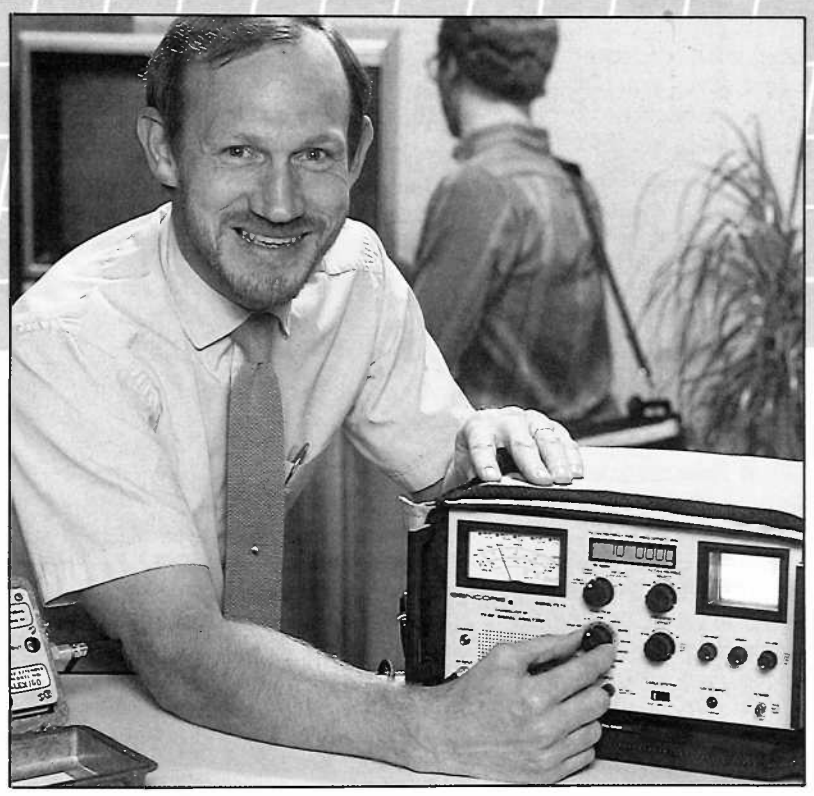
ESR is the electrical resistances in series with the plates of a capacitor (leakage is resistance in parallel). ESR includes the resistance of the metal leads, the plates, and the connections between them.

The charge in a capacitor with ESR (Figure 2c) instantly rises to a DC level based on the ratio of the current applied and the amount of ESR. The larger the ESR, the higher the step before the charging curve.

The LC102's patented ESR test charges the capacitor while measuring the rise in voltage during the first microsecond after applying current. The LC102 converts the instantaneous voltage step directly into a resistance value.

Only the LC102 AUTO-Z gives you *four* patented field proven tests, automatically, at the push of a bottom, plus battery operated portability and guaranteed measurements anywhere, anytime, without lookups, calculations, or error.

Do you have questions about the new LC102? Give your Area Sales Engineer a call: **1-800-843-3338.** ■



Depend On Your CHANNELIZER To Eliminate Wasted Time On Tough MATV And Cable Service Calls

by Tom Schulte, Application Engineer, CET

Servicers who work with master antenna and TV-RF distribution systems deal with customer complaints every day. They learn to listen carefully as the customer explains problems with reception, quality, or interference. "The picture is bad"; "It's too snowy"; "There's funny lines rolling through the picture"; "The sound is bad"; etc.

From their comments, you can't *always* tell if the problem is hum, signal to noise, interference—or whether the problem is in the "system" or the customer's TV. Could it be as simple as a set not working or misadjusted fine tuning?

Sure it could! And you know how irate customers can become when the problem affects their "pay channels", even if it's their problem. All the while the customer is talking, you're probably thinking: "Is the problem in the superband or the midband?" "Is the TV tuner bad or are the channels off frequency?" "How long will it take me to analyze the symptoms, locate the trouble, make a trip to the shop for parts, convince this customer, and get on my way?"

It's the *proof* that counts, both to you and your customer. What you need is a source of confidence that lets you locate the trouble quickly, correct it, check the signal levels, verify the video and audio quality, look at the important channels, convince the customer and move on . . .

> "It's the proof that counts, both to you and your customer . . ."

Successful Servicing Requires System Know-How And A Complete TV-RF Signal Analyzer

Slip into the driver's seat of our service truck as we go on a CATV service call; you'll see what we're talking about.

Your service call? A "poor reception" complaint. The customer greets you at the door with a list of problems. "Reception has been bad for a long time and the sound isn't good either." She says. "Funny lines showed up this morning, and I'm not going to pay! How long will it take, anyway?" Sidestepping her question, you politely ask if you might step inside and look at her TV.

The First Step Is To Analyze The Symptoms

Tuning through the channels, you notice that the sound on channel 12 is scratchy, there are diagonal lines in some midband channels, and the superband channels are snowy. There's also a hum bar rolling through the picture on every channel (Figure 1). Does the TV need repair, or is the problem in the cable?

Fig. 1: Trust your CHANNELIZER to prove whether the cable system is causing a hum problem.

Error-Free Signal Level And A/V Ratio Measurements Cut Time On Any Cable Service Call

You disconnect the cable from the back of the TV and attach it to your FS74 TV-RF Signal Analyzer. Channel 12's signal level is a good +6 dBmV and the digital readout shows a frequency offset of "00", telling you that the channel is right on frequency (Figure 2).

Fig. 2: The analog and digital meters quickly show you that the signal level and frequency are correct.

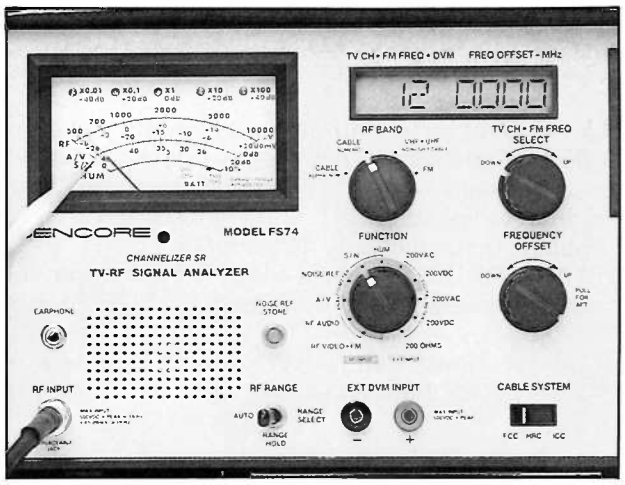


Fig. 3: The automatic A/V ratio test speeds testing and eliminates calculation errors.

The FS74 automatically tunes to the audio carrier and displays the level at −9.5 dB when you turn the function switch to RF AUDIO. Then you switch to A/V. The FS74 calculates the ratio and shows the audio to be 15.5 dB lower than the video; right where it should be (Figure 3).

Channel 12's video and audio signal levels are good. Turning up the FS74's volume control produces clear station audio from the built-in speaker. The audio problem must be in the customer's TV, not the cable system.

Signal Level And Signal Quality Tests Quickly Isolate System Problems

What about the diagonal lines showing up on several midband channels? A check of the signal levels shows all the midband channels are within FCC level specs. The FS74 confirms your fears though; the diagonal lines are very distinct on the wideband video monitor (Figure 4). The cable signal does have an interference problem.

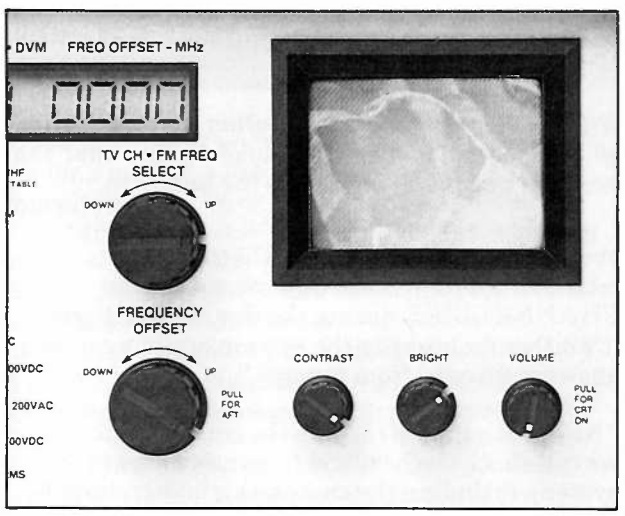


Fig. 4: The FS74's wideband monitor shows you when interference is present in the picture.

Your FS74 Proves Whether The Problem Is In The System Or In The Customer's TV

Is there also a system hum problem to run down, or does the customer's TV have a power supply problem? You turn the FUNCTION control to HUM. The FS74 shows about 3% hum as you tune from channel to channel—the cable system hum is within FCC specs (Figure 5). This problem is also in the customer's TV.

Tuning the FS74 to the superband channels to check the snowy picture symptom, you notice that the superband channels above channel N have fallen below the required minimum level of 0 dBmV. The score now stands at two problems in the TV (audio and hum), and two problems for you to track down in the cable system (interference lines and low signal level). It's time to put your FS74's troubleshooting abilities to work to locate the source of your problems.

Before you leave the customer's home though, you reattach the cable to the TV and check on the audio problem. Sure enough, fine-tuning the set on channel 12 restores clear audio. There's one problem licked already.

Portability Gets You Started Troubleshooting Without Delays

The first step in troubleshooting the cable system is to check the signal at the customer's tap. You take the battery-operated FS74 TV-RF Signal Analyzer back to the pedestal containing the 20 dB tap and again measure signal levels and check picture quality. The monitor still shows lines in the midband channels and the superband channels above N are about +5 dBmV. You know that +5 dBmV at the tap is too low to provide a good signal at the TV set, once the signals are attenuated by the drop cable to the house.

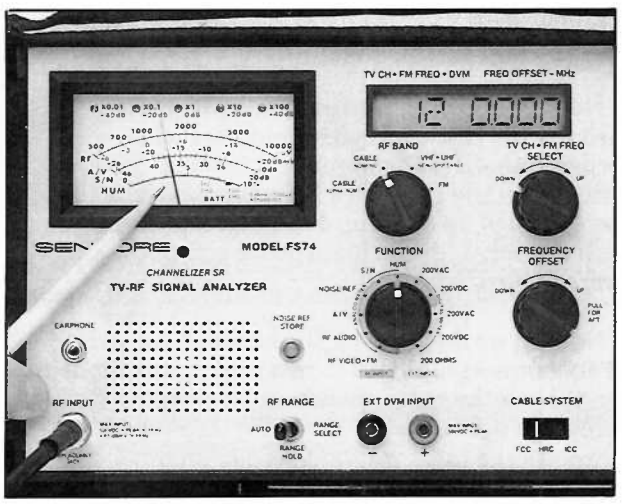


Fig. 5: The automatic on-channel hum test lets you know the cable signal isn't causing hum. The problem is with the customer's TV.

Signal Quality Tests Take You Right To The Source Of The Problem

You then follow the system back to the line extender that feeds the 20 dB tap (Figure 6). Opening the housing of the line extender, a Magnavox 5LE330, you measure the cable input signals. The levels are around +20 dBmV on the superband channels and the lower channels are all higher, indicating the correct cable levels and correct slope at the amplifier input. A glance at the built-in monitor shows nice clear picture quality on all channels. A quick AC power check at the amplifier input with the FS74's built-in DVM shows 54 VAC. Everything is right at the amplifier input. Is the output okay? Could the amplifier be bad?

With the FS74 test cable at the amplifier output, you again measure signal level and check picture quality. The output levels on the superband channels are 5 dB too low and the lines are back on the video monitor. The maximum amplifier gain is 24 dB, although it normally has a maximum gain of about 30 dB. The amplifier isn't working properly—a 5 dB signal loss is enough to cause problems.

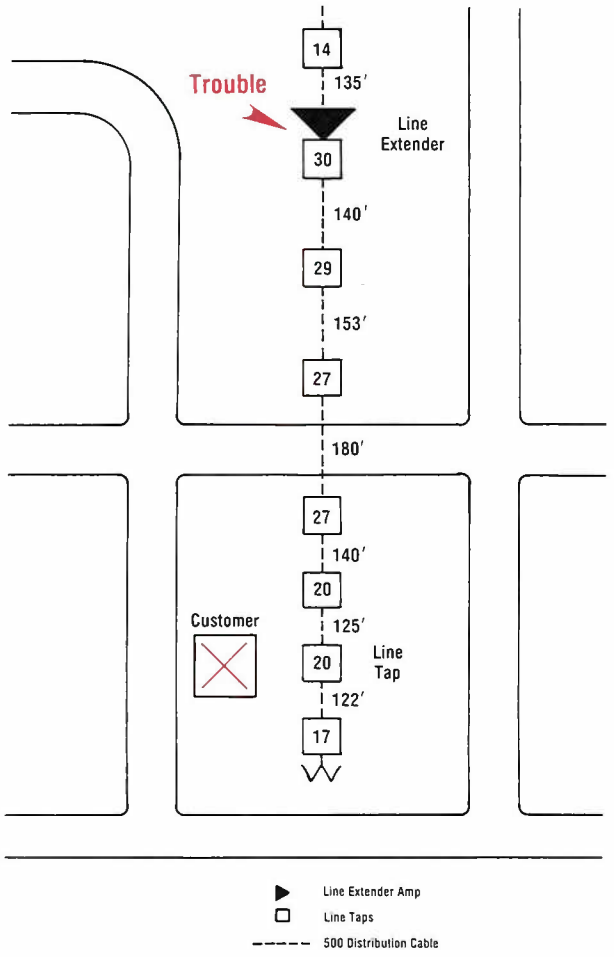


Fig. 6: The FS74's automatic tests and wideband troubleshooting monitor quickly prove where the trouble is.

The FS74's Built-In DVM Keeps You Testing, Not Scrambling For Equipment

After a quick trip back to the shop, you return with a replacement 5LE330 line-extender module and install it. Checking the AC power selections, you test DC power to the amplifier with the FS74's built-in DVM. The FS74 digital meter reads 23.8 V; close enough to the 24 V rated value (Figure 7). Verifying that the correct cable equalizer and pad are installed, you set the gain and slope controls for proper output levels.

Signal/Noise And Hum Are Important Tests Of Signal Quality

After adjusting the amplifier, you tune through the channels and watch the FS74's wideband monitor for signal quality. A signal quality test includes signal/noise and hum modulation, so you store an on-channel noise reference. A quick turn

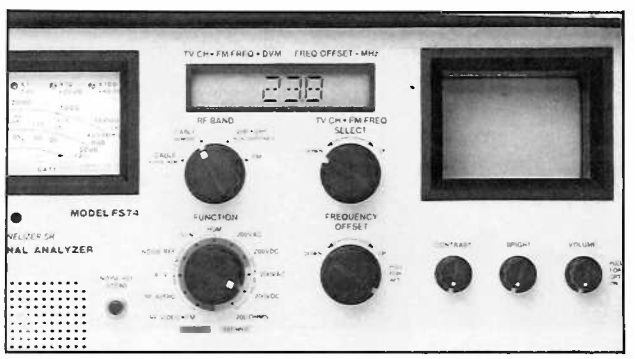


Fig. 7: The FS74 checks AC and DC supply voltages through the RF or EXT inputs.

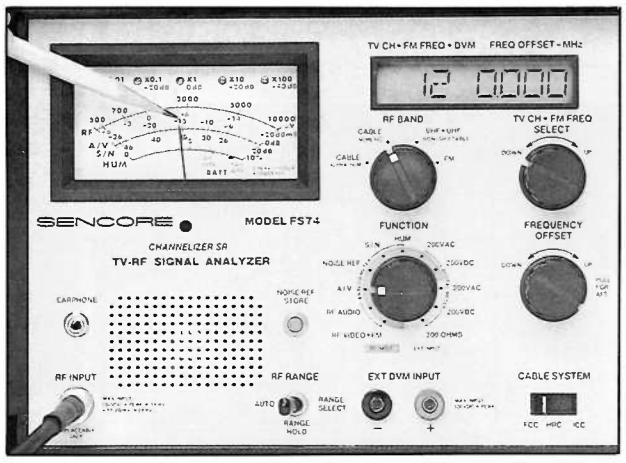


Fig. 8: The automatic on-channel S/N check tells you that the customer's signal quality is good.

of the FUNCTION control to S/N, and the FS74 automatically calculates and displays the signal/noise ratio at 46 dB. The line extender is now working perfectly; time to close up the case.

A Overall Signal Quality Test Is A Must On Every Service Call

Later, at the customer's home, you see the results. Your FS74 shows that all the signal levels have been restored to FCC specifications, 1 millivolt minimum. A signal/noise test shows 45 dB S/N (Figure 8), and the hum test shows less than 3% hum, indicating the hum bars are not a fault of the cable system.

You reattach the cable to the TV, and it now displays sharp, clear cable pictures. Hum bars are still present, but the clear, hum-free picture on the FS74 monitor convinces the customer that the cable signal is good.

As you drive on to your next service call, you reflect on how tough that service call would have been without a total TV-RF Signal Analyzer. You could have spent hours finding and fixing the problem, instead of only 45 minutes. The CHANNELIZER is a real customer convincer, it takes the guess work out of tough cable problems.

Have questions? Call your Area Sales Engineer, **WATS FREE 1-800-843-3338.** ■

Testing With The FS73 TV-RF Performance Tester

"Glad you called, Dave. Say, we've learned a few tricks you guys at Sencore might be interested in. By the way, you were right about the FS73 CHANNELIZER JR., it cuts troubleshooting time and helps us keep downtime to the absolute minimum—fits the bill to a 'T'; in fact, it's saving us quite a bundle. We use it for the regular things, you know, like checking carrier levels, A/V ratios, signal-to-noise, hum, channel checks, and so on, but the really neat thing we did, was to tie the '73 into our computer program."

"We're pretty excited about that; here's why we did it . . . we got together and figured that the savings, just in having recorded performance readings to fall back on when we had a problem, would probably pay for it. There had to be a better way — we even thought about training Sheri (she's the secretary) to run the '73 as a backup, so we could just call in. We're out of the place a lot, with installs and chasing customer complaints, you know. The complaints? That's why we first looked at the '73 . . . you could have customers calling in from all over the system, at random . . . sounded like the Bell System at times. A lot of those calls kept us running—we were out of the office burning up gas and chasing around all day for nothing. The real hurt, though, was after normal hours, when you want to relax; seems that's when things always went haywire. Hard to keep smiling when you've been at it all day . . . the customers notice that, too."

"Now, everything's different . . . we use our FS73 around the clock. Do you remember when we ordered that IB72 computer interface? Well, we tied it and the FS73 to a telephone modem/IEEE box. Picked up a laptop computer for the crew, an extra modem for the main office computer and we were in business!"

"Now all we do to check the headend (especially from home at night) is to just dial up the modem and check the channel we're interested in. The program (we wrote it ourselves) steps the FS73 through the tests we want on any channel, and dumps the results to memory."

"We simply list the results to the screen and decide if there's a problem with the channel or the system. And, if we want it, we can print out a hard copy for the file."

"During the day, of course, we use the FS73 for regular testing and troubleshooting, just like always. This system is really easy to operate; for example, when we're away from the headend

Without remote testing, we often started testing all the customer locations, only to find that the problem was much further up the line.

overnight, we connect the FS73 to the IB72 interface adaptor. That way we can use our CHANNELIZER during the day, and at night it's either monitoring the system or giving us the answers we need from remote."

"Now, with the FS73, plus the computer hookup, we can check the headend from anywhere in the system, including the customer's home—they'll usually let you use the phone."

"Our technicians love it, and who wouldn't? They don't even have to leave their chair! In a matter of minutes they know if the fault is in our system, or the incoming signal."

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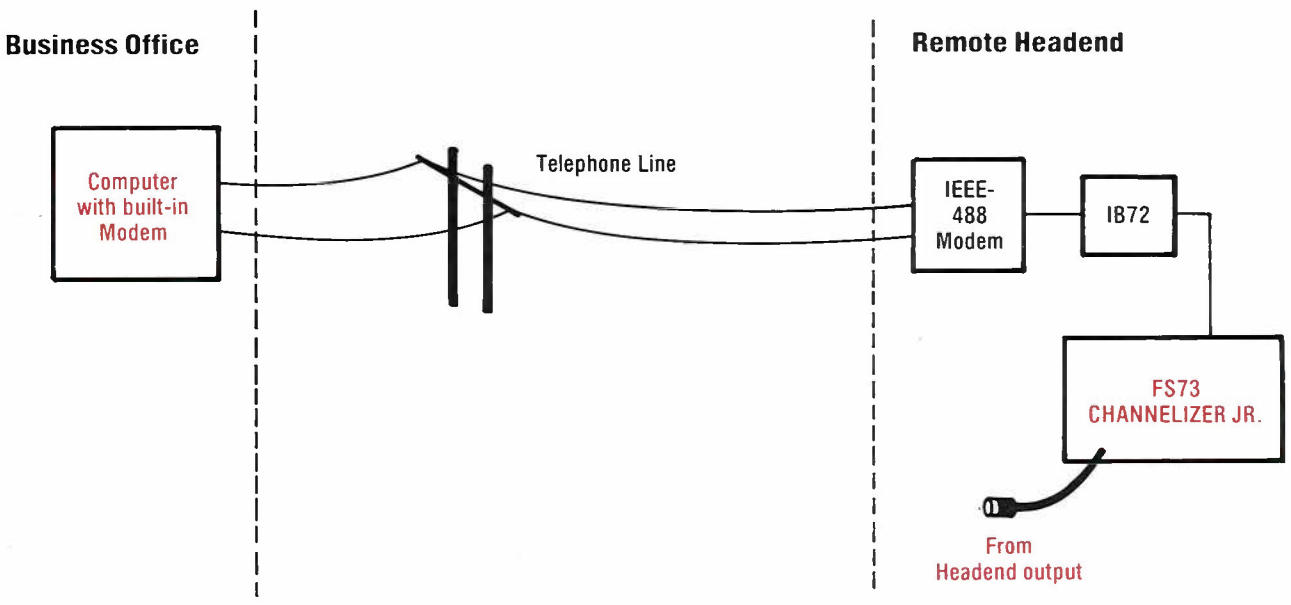

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Answers To Often-Asked Questions About Audio

by Paul Nies, Applications Engineer

"How can you tell if an audio system is reproducing the signal correctly? What do you do if it isn't? We'll cover these questions and more . . ."

The questions and answers in the first article in this series (Sencore News 141) explained why today's audio servicers are seeing stereo systems with better quality and higher power levels, reviewed some audio basics, such as the need for dB, and discussed how audio power is measured.

For some, audio servicing is a nightmare, for others it is a snap. Audio service is becoming an exciting and highly profitable industry, that's why many callers are asking us to write more about audio systems and how to troubleshoot them. Is there anything that can make audio servicing easier? How can you tell if an audio system is reproducing the signal correctly? What do you do if it isn't? We'll cover these questions, and more, in this and future "Answers To Often-Asked Questions About Audio".

How Do I Know If An Audio System Can Reproduce The Signals That Are Applied To It?

The sinewave is often used to check audio system operation. You must keep a couple of things in mind, however, when using a sinewave to check a system. First, audio signals are much more complex than simple sinewaves. Second, an audio system must operate over a vast range of signal amplitudes. New technologies, such as CDs, Hi-Fi VCRs, and Digital Audio Tape place tremendous, demands upon an audio system's dynamic range and frequency response capabilities.

Audio signal waveforms are complex, but they are all combinations of different frequency and amplitude sinewaves. A squarewave, for example, consists of a fundamental sinewave plus all of its odd harmonics. Therefore, a 1 kHz squarewave really consists of a 1 kHz sinewave, plus harmonics at 3 kHz, 5 kHz, 7 kHz, 9 kHz, 11 kHz and so on.

The oscilloscope and spectrum analyzer displays of a 1 kHz squarewave are shown in Figure 1. Note that the number of odd harmonics continues beyond the spectrum analyzer's display limit, and theoretically to infinity. If you were to similarly analyze other audio waveshapes, you would find that all consist of combinations of harmonics of a fundamental sinewave. The harmonics extend well beyond the 50 Hz to 15 kHz audio frequency range.

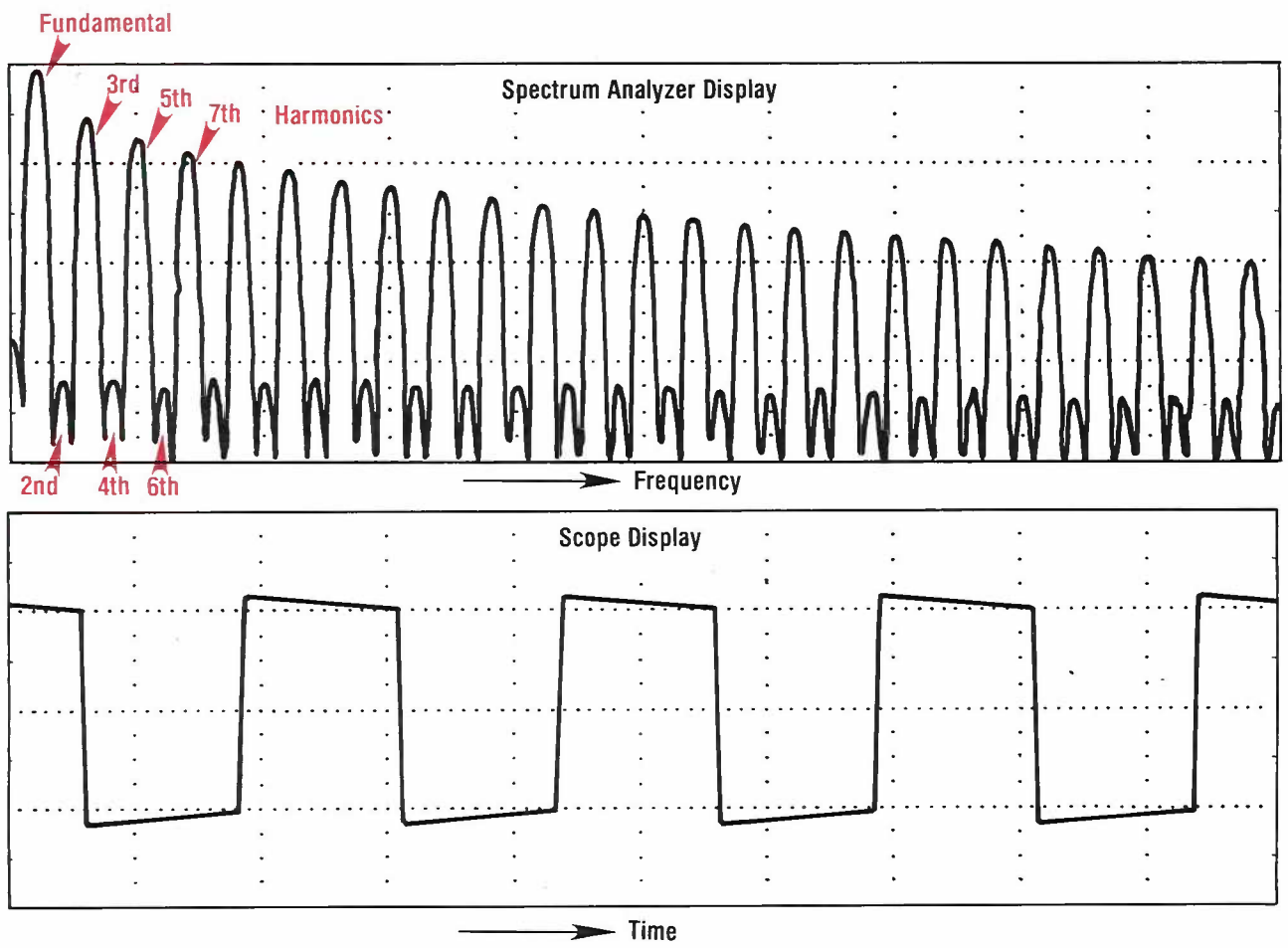


Fig. 1: The square wave includes the fundamental sinewave plus harmonics. The low even order harmonics are caused by non-symmetrical duty cycle.

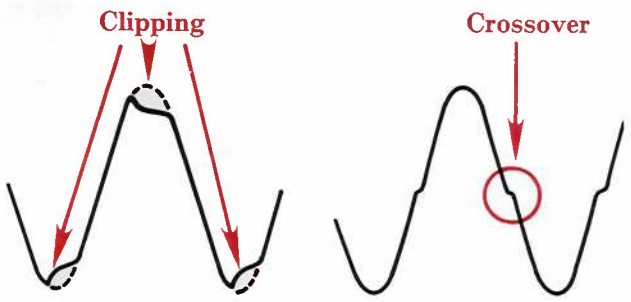


Fig. 2: Harmonic distortion occurs when the top or bottom of a waveform is clipped. Crossover distortion is also a form of harmonic distortion.

No audio system can reproduce all of the applied signal's harmonics; this would require an infinite bandwidth. However, some audio amplifiers have a frequency response that extends to 30 kHz, 100 kHz or even higher to maintain the harmonic content of the waveshape. When checking the operation of an audio amplifier, you should check the response over the total range of the amps specifications, not just to 15 kHz.

When servicing an audio system, in particular the audio amplifier portion, keep in mind that it must reproduce sound levels ranging from soft whispers to loud, ear-shattering shouts. Compact discs, for example, have nearly a 100 dB dynamic signal level range. Will the amplifier properly amplify complex audio waveshapes at all loudness levels? The only way to know is to test over the amplifier's entire range. Apply a complex waveform into the amplifier's input (such as a squarewave or triangle wave), connect an oscilloscope to the output, and view the reproduced waveform at full power output. That's the only way to be sure that the amplifier is faithfully reproducing the signal. The amplifier's true capability (and RMS power rating), is the power level at which the output sinewave signal begins to distort.

What Kinds Of Distortion Are Produced If The Audio Amplifier Does Not Reproduce The Waveforms Correctly?

Basically, three kinds of distortion can result when an audio amplifier alters the applied signal:

1. Harmonic distortion
2. Frequency distortion
3. Intermodulation (IMD) distortion

Harmonic distortion, often called "total harmonic distortion" (THD), occurs when a waveshape is clipped or limited in amplitude, producing extra harmonics (Figure 2). As the top and bottom of a sinewave are clipped off, the sinewave begins to resemble a squarewave, which contains harmonics. Harmonic distortion is often the result of poor dynamic range in an amplifier stage.

Another type of harmonic distortion occurs when the middle portion of the waveform is altered. This is "crossover distortion" and is caused by an unmatched "push-pull" amplifier output stage (Figure 2).

Frequency distortion, also called "phase distortion", results when an amplifier does not properly amplify all the harmonics in a waveform (Figure 3). When the frequency response is not flat or rolls off too quickly, the amp will alter the phase of certain frequencies. In any case, some harmonics are altered and the reproduced waveform is distorted. Although the harmonic content of waveforms other than pure sinewaves is infinite, no significant frequency distortion will occur if the amplifier's response is flat for all frequencies up to about the 10th harmonic.

Intermodulation distortion (IMD) occurs when two or more signals mix together in an amplifier. The mixing is the result of non-linearities (an improperly biased transistor, for example). When this happens, the amplifier's output will contain the original frequencies, plus the sum and difference frequencies and the sums and differences of those frequencies, etc.

Don't confuse mixing with adding. In normal operation, all of the input signals are added together by the amplifier, and the output frequencies are just those present in the input signal. But when an amplifier *mixes* signals, the output consists of the input signal, plus *new* frequencies and waveshapes not present in the input signal. These new frequencies and waveshapes are the IMD distortion.

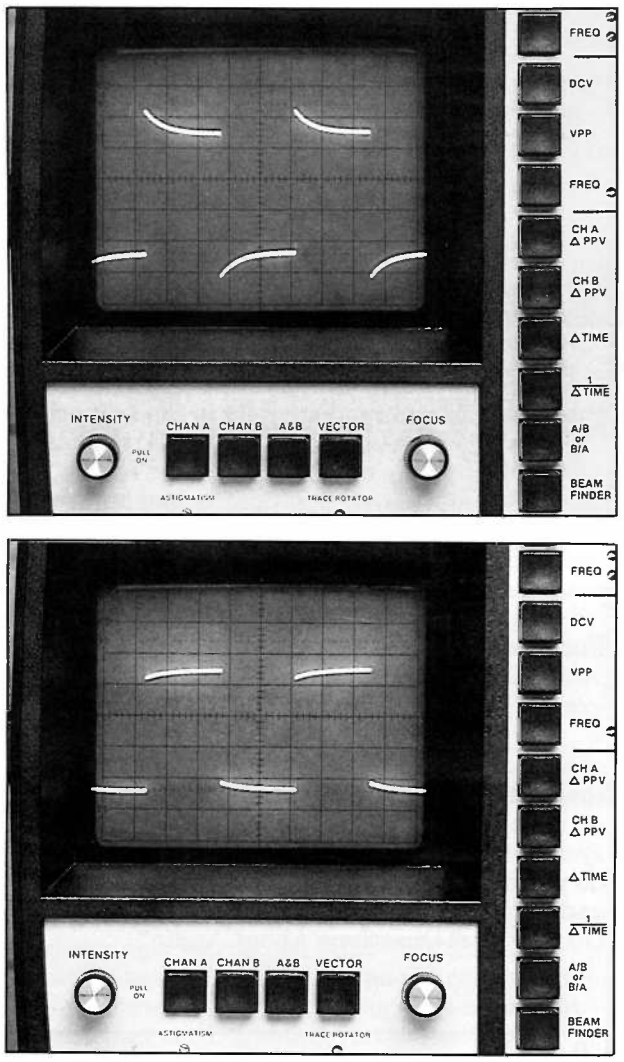


Fig. 3: Phase distortion occurs when an amplifier does not properly amplify the harmonics in a waveform.

Isn't Troubleshooting Audio Correctly Often Tougher Than Troubleshooting Video?

Audio troubleshooting may seem more difficult than video, especially if you're new to audio. You have no visual symptoms and the ear doesn't always respond to changes or differences in audio. Plus, audio circuits are often quite particular and unforgiving. Power amplifier stages, for example, are direct (DC) coupled to minimize distortions and provide a wide frequency response. But, this means that any small DC errors, resulting from bias problems or component leakage, are amplified all the way to the output. Most power amplifiers use push-pull or complementary symmetry output stages; both halves of these amps must be equally DC balanced.

Many audio amplifier stages are current amplifiers rather than the more familiar voltage amplifier circuits. This further complicates troubleshooting, as the circuits may look unfamiliar and take time to figure out. Failures in current amps tend to "eat parts" (including your new replacements) if not quickly found and corrected.

Figure 4 shows a typical amplifier. Except for one capacitor at the input, all the stages are DC coupled. A "DC BIAS" adjust matches one half of the push-pull output to the other. The amps in each channel must be balanced, both AC and DC wise, for equal gain and response.

Can You Reduce An Audio System To A Basic, Simplified Block Diagram To Make Troubleshooting Them Easier?

Playback devices such as CDs, phonos, and tape decks provide a fixed amplitude signal output. This "Line Out" signal connects to the "Audio Line" input on the amplifier.

Volume and tone control is done in the PRE-AMP (Figure 5). The pre-amp and its following blocks are often combined into a single unit in most low power amplifiers, such as the "Receiver" component commonly found in home audio systems. A separate pre-amp is used with audio amplifiers over 100 watts, as these higher powered amps often operate at a constant, fixed gain.

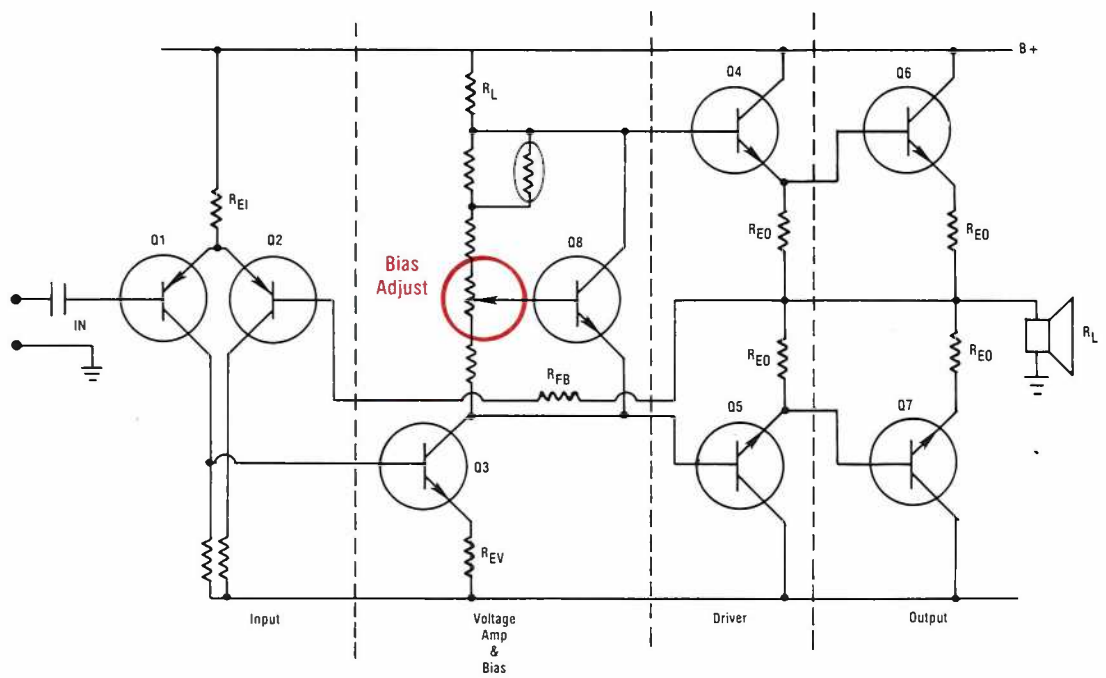


Fig. 4: Failures in direct coupled power amplifiers tend to eat parts (including your replacements) if not quickly found and corrected. These amps must be balanced for proper gain and response.

The Driver block converts the voltage signal from the pre-amp into the current signal needed to operate the Power Amplifier stage. The driver is always a part of the same chassis as the power amplifier.

Can You Simplify Stereo The Same Way?

Troubleshooting high power stereo amplifiers can be a challenge if you don't have the proper troubleshooting tool to help you; many times you'll need to compare one channel to the other.

A stereo amplifier is simply two matched mono amplifiers that work independently of one another (Figure 5). This independence is called "separation". Crosstalk, or poor separation, occurs when the signal from one channel interferes with the other. In addition to good separation, both channels must produce the same level and frequency response when the same signal is applied to both. This is called stereo "tracking".

The key to good stereo separation and tracking is that the total gain of all of the amplifiers from input to output in one channel, must match the other channel. This must be true for all signal levels and frequencies.

While the need for both channels to match might complicate stereo troubleshooting, having two identical channels often makes troubleshooting easier. This is because you'll usually have one good working side to follow. Simply compare as you trace signals through both channels.

Is There A Way To Speed Up Measurements In An Audio Amplifier?

Signal levels in an amplifier can appear to be completely wrong, with none of the levels matching the other channel. This may be the result of unequal input signals, a defective or mis-set balance control, a defective volume control, etc. You can eliminate the doubt and speed up audio amplifier servicing by using dB gain measurements.

Troubleshooting with dB measurements is faster because a dB is the ratio of two numbers, not an absolute level. Therefore, stage gains are relative when expressed in dB. Your measurements do not depend upon the actual signal levels applied. To find the gain of an entire system, or any part of it, you simply add up all of the individual stage gains.

Another advantage of dBs is that you can quickly compare one channel to the other without worrying if the input signals are the same. Simply measure the signal at the input and output of a stage in dB and add or subtract to find the dB gain (or loss). Then, do the same with the other channel.

As long as you are comparing SIMILAR points in both channels, the impedances will be the same and your dB readings will be relative and meaningful.

To see if the amplifier (Figure 5) is performing correctly, measure the dBm signal level at the input. (Remember, we are not concerned what this actual number is, but only that the level at the output is 10 dB greater.) Since the input level is −4 dBm, the output of the first stage should be: +6 dBm, or −4 dBm +10 dB; the second stage +12 dBm; the third stage +13 dBm; the fourth stage +14 dBm, and the output should be +6 dBm.

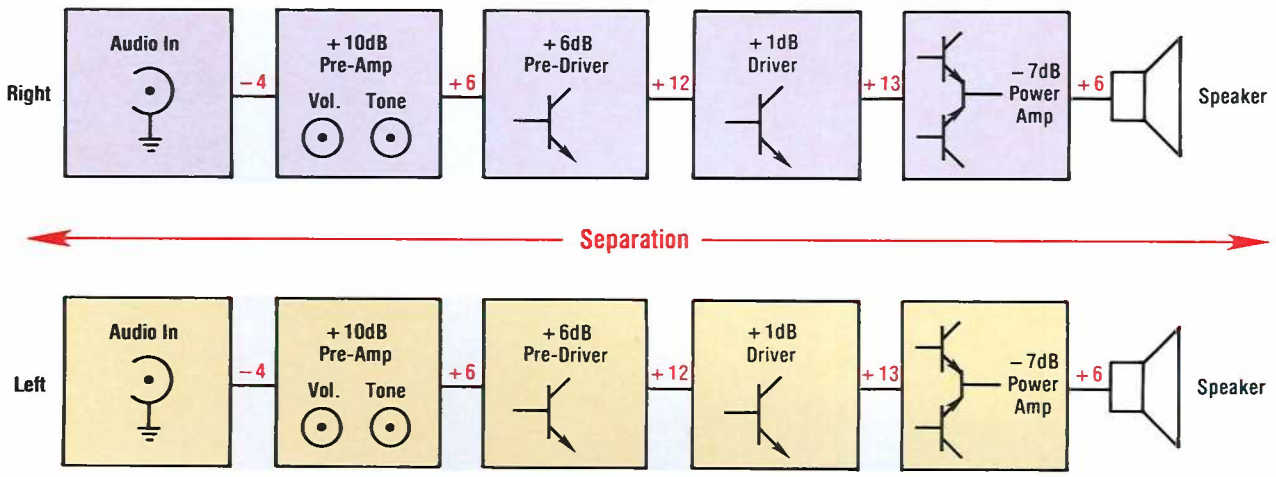


Fig. 5: A stereo amplifier is simply two matched, independent mono amplifiers. This independence is called "separation". Crosstalk occurs when the signal from one channel interferes with the other.

You can further simplify troubleshooting by using a "programmable" dB function (dBp). The dBp function lets you measure the input level to a stage and set that level as your zero dB reference point. Then, when you move to the output, you simply read the dB gain or loss directly.

Can You Make Audio System Tests To Industry Standards?

A set of standards established by the Institute of High Fidelity (IHF), and later adopted by the Electronics Industry Association (EIA), insures that all audio equipment is tested in a similar way. Without these IHF/EIA standards, comparing one audio unit to another would be meaningless. Standards help you confirm the operation of equipment that you repair. To test to IHF/EIA standards, you need special load resistors and audio filters.

"Dummy Load" resistors of the proper value and power rating are needed to test each stereo channel. The resistors must be able to handle the amplifier's full power output without overheating or changing value. And, they must be low reactance resistors to terminate the amplifier in a constant impedance for all frequencies. Standard values of 2, 4, 8, 16, and 32 ohms are needed to service all the amplifiers on the market.

Four special filters are also required to perform the IHF/EIA audio tests. These filters connect in series with your audio voltmeter or wattmeter that you use to measure the output, and remove a certain range of frequencies before the output is measured. Each filter must have a flat response, have less than 3 dB attenuation within the passband, and must rolloff at a rate of 18 dB per octave. Briefly, here are the filters you'll need:

200 Hz to 15 kHz bandpass filter - Specified for audio separation and power measurements. It removes low frequencies such as hum, and high frequencies such as the FM pilot to make standard tests of power and separation.

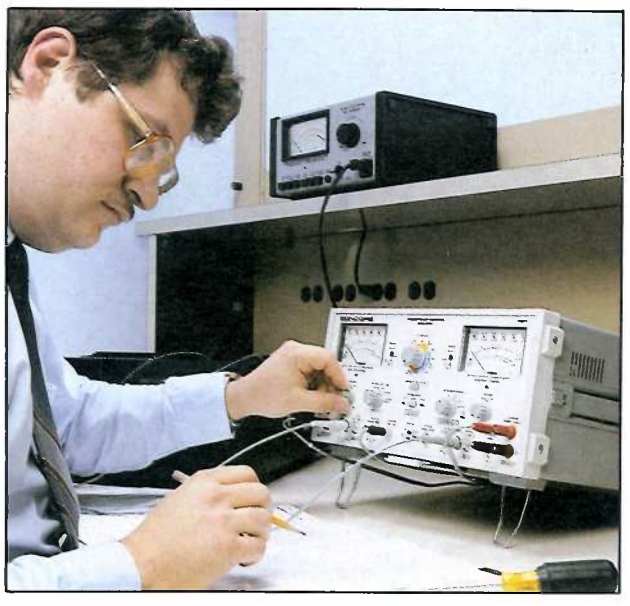
200 Hz high pass filter - Blocks low frequency hum signals. Used in conjunction with a "no filter" reading to check for hum. For example, the "no-filter" measurement should agree with the "200 Hz high pass" filtered measurement when a pure sinewave is applied. If the 200 Hz high pass filtered reading is lower, the amplifier output contains low frequency hum.

15 kHz low pass filter - Blocks all frequencies above 15 kHz, such as the FM pilot. When compared to an unfiltered measurement, the 15 kHz filtered readings check for FM receiver pilot leakage into the audio.

30 kHz low pass filter - Used when CD is the audio source; filters out clock noise generated by some CDs.

How Much Audio Power Should I Be Able To Check?

For many audio systems and tests, the ability to read up to 100 watts continuous will suffice. But, if you do much audio work, you will want to be able to check up to 250 watts for long enough periods of time to make dynamic, full power tests. If you work on high-end, high power audio systems, you should have the capability of measuring 500 watts, when necessary. ■



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* IHF - Institute of High Fidelity
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