SENCORE NEWS

New "Z" Meter
LC53 Capacitor-
Inductance Analyzer

3200 SENCORE DRIVE, Sioux Falls, S.D. 57107

Address Correction Requested

Find defective components all other testers miss . . .

with the all new patented Sencore

"Z" Meter

Model LC53 Capacitor-Inductance Analyzer

Dynamically & confidently test capacitors, coils, transformers, flybacks, yokes, SCRs, and other troublesome components that bog you down and cost you time and money.

According to Howard Sams Electronic Servicing Magazine "Symcure" and Electronic Technician Magazine "Service Seminar" articles, these components cause 66% of all common circuit failures in today's electronic circuits.

Only $695

Answers more questions about components than any other tester on the market today.

Here are the components you can check from A to Z with your new "Z" Meter

Conventional capacitors: for values and for leakage with up to 600 Volts applied.

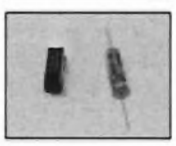
Electrolytic capacitors: for value, leakage with up to 600 Volts applied, and for dielectric absorption. Reforms dried out electrolytics, too.

Transformers: for value and ringing capability as good or bad.

Flyback transformers: for value and ringing capability as good or bad.

Deflection yokes: for value and ringing capability as good or bad.

SCRs and TRIACs: For ability to turn off and turn on with voltage applied

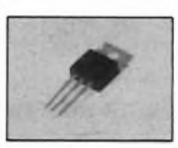


Relays: For inductance value to know your right.

Hi voltage stacked diodes: applied voltage overcomes high diode threshold level to check front to back ratio.

Critical diodes & rectifiers: for front to back ratio and leakage to be sure they balance in bridge rectifiers, etc.

Transmission lines: capacity per foot is used to locate exact break in open line; inductance per foot is used to measure length to a short.



And 1001 other uses such as matching capacity of tone arm cable to cartridge, breaks in motor windings, leakage between electrolytic sections, capacity of transistors and FETs for proper circuit design, etc.

See page 13 for winners of 20 $138 DVM35s.

Your name may be there.

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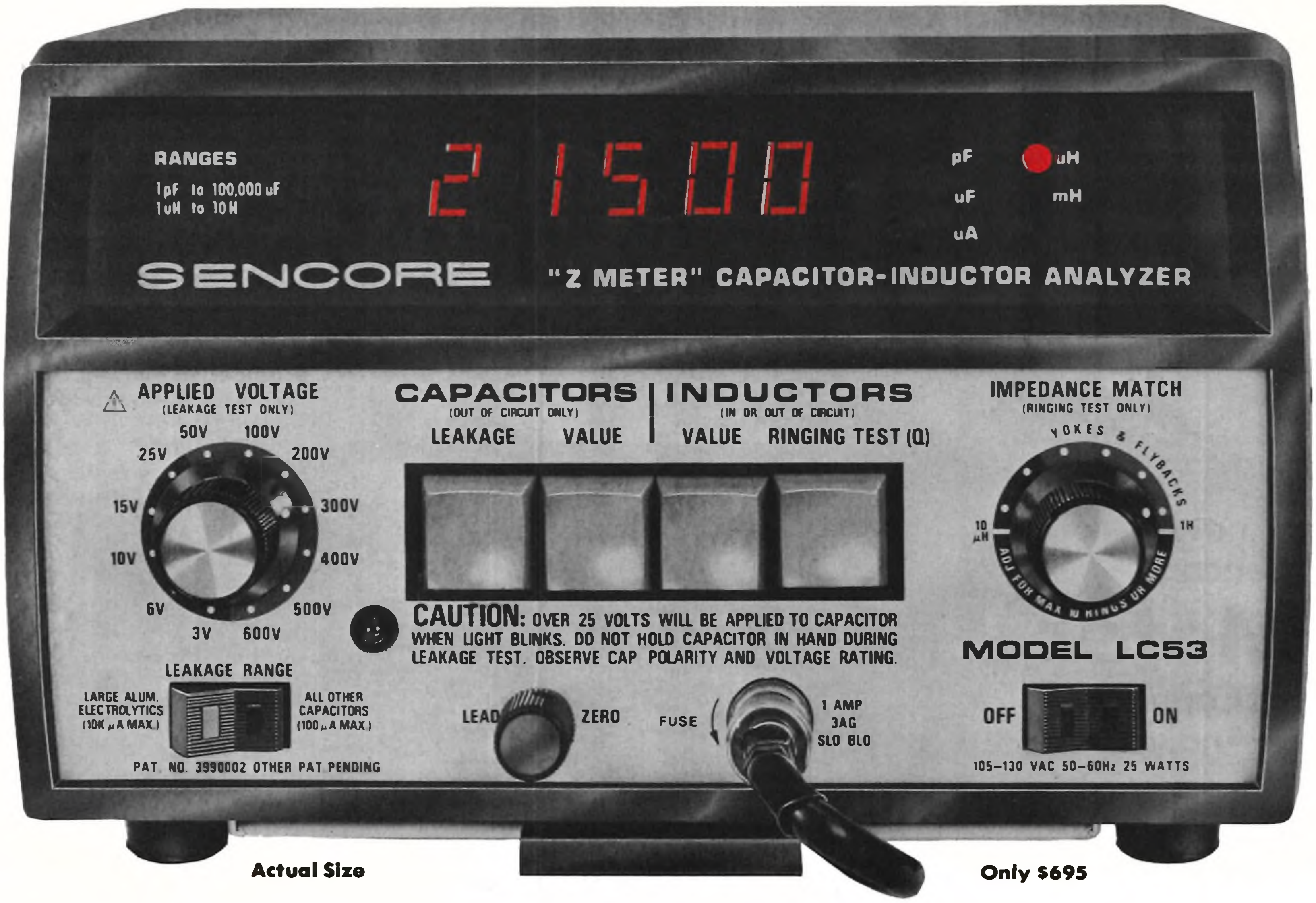
Your Choice of a "Z" Meter or "C" Meter



Actual Size **Only $695**

LC53 "Z METER" Capacitor-Inductor Analyzer

Automatically checks • Conventional Capacitors • Electrolytics • Coils • Transformers • Flybacks • Relays • Deflection Yokes • SCRs • TRIACs • Hi Voltage Diodes • Critical Rectifiers • Transmission Lines • Transistor and FET Capacity • Audio Cartridge Matching Capacity, etc.

Actual Size **Only $495**

CA55 Capacitor Analyzer

Automatically checks • Conventional Capacitors • Electrolytics • SCRs • TRIACS • Hi Voltage Diodes • Critical Rectifiers • Leakage Between Electrolytic Sections • Transistor and FET Capacity • Cartridge Matching Capacity, etc.

21 Questions & answers about the dynamic all new Sencore LC53 "Z METER" . . . and CA55 Capacitor Analyzer

by Jim Smith, Field Engineer

Remove opposite page, with actual size photos, and place in front of you for reference when you read this article.

Answers your component testing questions with dynamic, automatic direct readout

Introduction

This article covers the questions and answers, asked of Sencore Sales Engineers, on the new LC53 "Z METER" Capacitor-Inductor Analyzer and the CA55 Capacitor Analyzer. The "Z METER" is used for reference throughout the questions and answers for simplification purposes. However, it should be kept in mind that the CA55 Capacitor Analyzer operates just like the "Z METER" but does not check coils. The CA55 can be used to make many other checks as well. These different uses are spelled out on the opposite page. It is a good idea to review these applications before beginning this article.

The "Z METER" has been designed to answer more questions about more non-active electronic components than any instrument designed to date. What's more, the "Z METER" makes all tests automatically with full auto-ranging. It was designed with your time in mind, automatically placing at your fingertips a two fold test for all capacitors and inductors. A direct reading value test is backed by a dynamic use test to be sure that the component will work in circuit. The "Z METER" has also been designed to check SCRs, TRIACs, high voltage diodes, transmission lines, transformers, relays, defection yokes, flyback transformers, and nearly every passive component that you encounter, except resistors. The "Z METER" really takes the costly guesswork out of testing up to 75 percent of all components that you will run into in your lab, production line, incoming inspection, quality control, broadcast studio or transmitter, radio-TV shop, communication shop, or whatever your specialty might be. Specifications are tight enough for the finest research lab while the ease of operation insures error free testing for even the one man radio-TV repair shop. Competition? Sencore won't have any as one patent has already been issued and several more are pending on this fabulous time saving, money making instrument. What's it worth to you to know for sure that a suspected faulty component is really good or bad before you make that long trip to the stockroom, or order from the distributor only to find that you purchased an extra component after waiting two weeks, or waiting for special components that no one carries? Look over the answers that we give technicians and engineers at our seminars and see if you aren't already paying for this instrument in lost time every single day. The "Z METER" costs you only 50 cents a day if written off over four years. Can you afford not to have it today? These questions and answers should help you decide.

The Sencore News is written, edited, and published by the Field Engineering Department of Sencore, Inc., 3200 Sencore Drive, Sioux Falls, South Dakota 57107. The Sencore News is distributed without charge to all individuals or companies who have registered the purchase of any Sencore instrument by means of the warranty card packed with that instrument. The information herein has been taken from one or more sources which we consider reliable. Although such information has been carefully prepared, we make no representations as to its accuracy or completeness. Prices and specifications are subject to change without notice.

1. What really goes wrong with capacitors?

A capacitor is nothing more than two metal plates separated by an insulator called the dielectric. There are really five different types of capacitor failures. 1. Excessive dielectric leakage, 2. A change in capacity value, 3. An increase in dielectric absorbtion, 4. Leakage between sections of a multi-section capacitor, and 5. Capacitor deforming from sitting on the shelf. Let's look at each of these types of failures in more detail to understand their cause and the effects on the circuit in which the capacitor is used.

Most defects are caused by excessive leakage

According to Sencore customer feedback, capacitor leakage accounts for up to 90 percent of all types of failures.

Leakage in an aluminum electrolytic capacitor is more common than in other types. The insulating dielectric in an aluminum electrolytic is made up of a very thin layer of aluminum oxide on one of the two pure aluminum plates. This oxide is maintained by a liquid called the "electrolyte". Heat and age can cause some of this electrolyte to dry out which, in turn, allows some of the oxide to dissappear. This causes the amount of leakage to increase, when voltage is applied, often to the point where the circuit's operation is affected.

Leakage can also become excessive in paper, film, and ceramic capacitors if the insulating dielectric absorbs moisture. The capacitors are sealed in a special "encapsulation" material. This material often has small flaws that allow moisture to creep in. If the seal is not perfect or vibration causes small cracks around the leads, moisture can also enter the capacitor around the leads. Any moisture inside the dielectric material will reduce the insulation resistance and result in increased leakage.

Any type of capacitor may develop excessive leakage if the capacitor is subjected to excessive applied voltage or high voltage spikes. These types of overloads may actually puncture the dielectric material and produce a short or high resistance leakage path. Leakage often shows up only when the capacitor is charged to its normal operating voltage and may not show up under a low voltage check such as you might make with an ohmmeter. You need to be able to test a capacitor at, or close to, its rated voltage in order to locate these common leakage troubles. The "Z METER" is the only capacitor tester that provides a sensitive leakage test with applied test voltages from 3 to 600 volts. That's why the "Z METER" finds faulty capacitors that all other testers miss.

Capacitors change in value

Some capacitors change value. The most common capacitor to change value is the ceramic disc capacitor. These capacitors often have small cracks or fissures in the ceramic dielectric material that were created during the manufacturing process. The construction of the ceramic disc involves the plating of a fine layer of silver on each side of the ceramic dielectric. Changes in temperature or excessive vibration may cause these fissures to widen and eventually cause the silver coating to separate. The result is a sudden and severe loss of capacity.

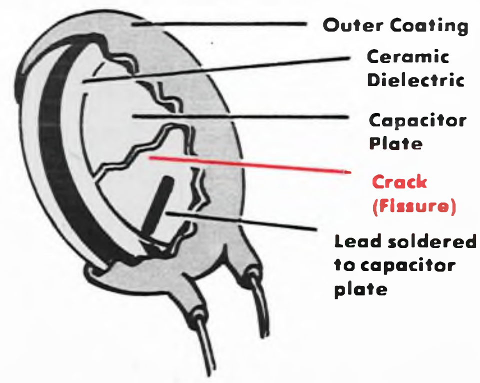


Fig. 1—The small cracks (fissures) in ceramic capacitors can become larger with exposure to heat and cold, splitting the dielectric and plates, making the capacitor a smaller value.

Ceramic disc capacitors also change value as the ceramic dielectric material ages. The capacitors are actually made slightly larger in capacity value by the manufacturer because up to 16% of the value is lost over a year's time. Up to 10% of this value change happens in the first 40 days of operation. This aging usually slows after the first year's life and typically only 20% of the value is lost over a ten year span. This is especially important to remember when the capacitor has been used more than a few years. You may also encounter capacitors that age much more quickly than the expected aging cycle and others may drop more than the predicted amount.

Other types of capacitors may change in value with age, or may never have been marked or color coded correctly in the first place. A reliable value test is very important when you suspect that a capacitor may have changed value or is the wrong value when new. The "Z METER" provides a totally auto-ranged value test to let you test capacitors from 1 pF to 200,000 uF. Many other high priced capacitor testers test only to 2,000 uF, never beginning to reach values used in computer circuits, etc. This is another reason why the "Z METER" finds defective capacitors that other testers miss.

Electrolytics develop dielectric absorption

Modern capacitor theory tells us that the charge of a capacitor is not held in the plates but rather in the dielectric material. We are told that the actual charge consists of small, randomly arranged electric dipoles inside the dielectric. These dipoles are oriented along the lines of force extending between the two plates when a charge is applied to the plates. These dipoles will remain oriented in this direction until the capacitor discharges.

These dipoles in the dielectric material are not totally mobile. Most of the dipoles will quickly turn from the random arrangement to the polarized arrangement and back again as the capacitor is charged and discharged. But, there are a few dipoles that remain oriented in the wrong direction after the capacitor is discharged. If, for example, you had a very sensitive voltmeter, you could measure a small voltage across the capacitor plates, even though the capacitor had been discharged. This effect is called "dielectric absorbtion" and is found, to some extent, in all types of capacitors. The action is sometimes refered to as "battery action" or "capacitor memory".

Circuit operation can be affected if the amount of dielectric absorption becomes too high. Excessive dielectric absorption is most common in aluminum electolytic capacitors that have partially "dried out" or deformed. These capacitors may not show excessive leakage or a loss of capacity value but will not work properly in circuit. If, for example, the capacitor is used as a blocking capacitor, or emitter bias bypass, the voltage generated by the capacitor may change the bias on the stage. This may change the operation from class A amplifier to class B amplifier with resulting distortion or signal clipping. You may suspect a leaky transistor or tube with high grid leakage when the actual culprit is the capacitor.

Dielectric absorption will also reduce the filtering effects of a lytic used in a power supply. This is especially true on equipment that has not been turned on for some time. The fact that the capacitor does not completely discharge means that its *effective* capacity, with a DC voltage applied, may be much lower than when the capacitor is tested without this applied voltage. A reliable capacitor analyzer must be able to identify excessive dielectric absorption as well as leakage and capacity value. The "Z METER" is the only capacitor tester that provides a reliable test for dielectric absorption and is another reason why we say that the "Z METER" will find faulty capacitors that all other testers miss.

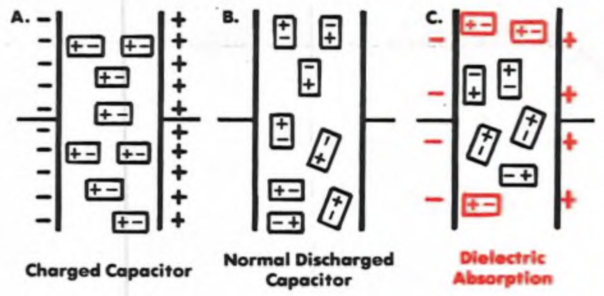


Fig. 2 — Not all dipoles return to a random arrangement in the dielectric of a capacitor with dielectric absorption which causes the capacitor to act like a small battery.

Multi-section electrolytics may have leakage between sections

What a headache this type of capacitor failure can be! Each section of a multi-section electrolytic can be perfectly good as far as leakage, value, and dielectric absorbtion, but the capacitor may still be the cause of your problem. These multi-section capacitors sometimes develop high-impedance leakage paths *between* the individual sections. You won't find this problem by checking capacity because each section has the correct value. You won't even find this problem with a leakage test, because each section has acceptable leakage. The problem is that the signal from one electrolytic section is coupled to the circuit associated with another section. In a TV receiver, for example, the same capacitor may be used for both the power supply and the vertical section. The 60.00 Hz AC line frequency signal is then mixed with the 59.94 Hz vertical sweep frequency through a common resistance path and you can't really tell one problem from the other without a lot of costly guesswork and troubleshooting. A complete capacitor analyzer needs to be able to measure leakage between sections as well as the leakage of each individual section. The "Z METER" is the only capacitor tester that has a leakage check between electrolytic sections and is another reason that we say that you can find faulty capacitors that all other testers miss.

Capacitors go bad sitting on the shelf

It is not bad enough that a capacitor can develop all of these different problems when in the circuit. They go bad sitting on the shelf as well. Electrolytics dry out and get leaky or develop excessive dielectric absorbtion. Ceramics change value because of the change in the dielectric or because one of the fissures opened up due to changes in room temperature over a long period of time. Some capacitors may not even have been good when they left the factory.

The expected shelf life of a general purpose aluminum electrolytic capacitor, for example, is quoted by many manufacturers as only one to two years! It's not bad enough that the cap may have been sitting on your shelf for that long but you have no way of knowing how long it has been sitting in a warehouse waiting to be shipped. We are sure that everyone has experienced the replacement of a faulty capacitor with one that you thought was good only to find that the problem was not cured. Every capacitor should really be checked before you install it into the circuit. This means that the test must be very fast and easy to perform to avoid wasting a lot of time testing good capacitors. A bridge, for example, is just too time consuming for most technicians to use on every capacitor taken from the shelf.

The Sencore LC53 "Z METER" has simplified capacitor analyzing for you with a test that is designed to do one thing; identify *bad* capacitors. It doesn't matter whether the capacitor is already in the circuit or whether you have just taken it off the shelf to put into a circuit. The tests are fast, reliable, and easy to perform.

2. Can we find these common capacitor defects with present test equipment?

Let's talk about capacitor leakage checks first. Most technicians attempt to measure capacitor leakage with an ohmmeter. This method applies only a few volts to a capacitor and, generally speaking, finds only capacitors that are shorted. The full rated operating voltage should be applied to make sure that the capacitor does not break down under load. This requires a power supply that is adjustable from 3 volts to several hundred volts and a sensitive current meter to measure less than one microamp of leakage. The "Z METER" is the only meter on the market that tests capacitor leakage with rated voltage applied.

Let's have a look at capacitor value testing. There are many competitive units that are designed to measure capacity value. These, of course, are already limited because they do not have a leakage test but many have range restrictions as well. Some testers in the same price range of the "Z METER" are limited to value tests of only 200 uF or 2,000 uF as the highest value capacitor that can be read. A comparison chart on page 15 shows how the "Z METER" compares to other capacitors testers.

Modern electronic circuits often use "brute-force" power supplies with capacitors as large as 20,000 to 180,000 uF. These large values are found in audio amplifiers, digital circuits, and many other places. These filtering systems can cause real problems if the filter capacitors have lost some of their rated capacity. You need to be able to measure all the way to 200,000 uF in order to test all the capacitors you will encounter.

Bridges have been used for years to test capacitors. The biggest drawback of a bridge is that it is very time-consuming. Even an experienced technician can spend several minutes nulling out the controls and then interpreting the results. Bridges have another limitation in that they do not actually measure capacity but rather measure capacitive reactance. Capacitive reactance varies with the applied frequency. It is common for a capacitor to read differently on two different bridges because the frequencies of the test signals are different.

Now, let's look at dielectric absorption. To detect troublesome dielectric absorption, one must be able to charge the capacitor to its full rated voltage, then discharge the capacitor, then test the capacity value again after the capacitor is discharged. The capacitor value should not change value between value checks. If it does, it has dielectric absorption. This means that you need a power supply, a discharge circuit, and a test circuit that checks for actual capacity value. Testers without all three tests will leave you guessing again when it comes to the testing of electrolytics. The "Z METER" is the only capacitor tester on the market to test dielectric aborption.

Let's talk about leakage between electrolytic sections. Leakage between electrolytic sections is checked by applying the power supply voltage to one section of a multi-section lytic, making the leakage test and then shorting the *other* sections to ground to be sure there is no change in leakage readings. An ohmmeter may show up problems that involve a direct short between sections but this leakage path often has a high-resistance. This type of leakage will only show up with a full applied voltage test. A low test voltage may leave you guessing. The "Z METER" is the only capacitor checker on the market to test for leakage between electrolytic sections.

3. Show me how the "Z METER" can check capacitors over such a wide range of values and still be so simple and easy to use.

Capacity test

The "Z METER" makes use of the true definition of capacity by measuring the RC charge curve of capacitors under test through precision resistors. This means that the "Z METER" measures the true ability of the capacitor to conduct electrons in a given time, determined by the size of the capacitor and the series resistor. Advanced digital logic automatically selects the proper capacitance range from 10 internal ranges. All you do is connect the capacitor to the test leads, press the capacitor VALUE button, and read the value on the digital display.

The "Z METER" reads out in the two standard values you are used to seeing on schematics, in parts lists, and on the capacitor themselves; microfarads (uF) and picofarads (pF). Some less sophisticated capacitor testers read out in nanofarads and millifarads (both non-standard units) simply because it takes less circuitry than it does to convert to the standard values of pF and uF. This means that you must go through complicated decimal manipulation when you make a capacitor measurement to convert the reading to standard multiplier values.

Fig. 3 —The "Z METER" is so simple to operate, just connect the capacitor and push the button to get the capacity value in pF or uF on the digital readout. Its all automatic, no range switches to select.

Leakage test

Testing a capacitor for leakage on the "Z METER" is simple and fast. Just connect the capacitor, set the APPLIED VOLTAGE switch to the rated voltage or the next lower voltage, depress the capacitor LEAKAGE button, and read the leakage in microamps on the digital display.

The "Z METER" has a special warning LED that flashes any time the APPLIED VOLTAGE switch is set to 50 volts or more to warn that a shock hazard may be present when testing for leakage at high voltage. This voltage is only applied when the LEAKAGE button is pressed. The voltages between 50 and 600 volts are also marked in red as an additional safety reminder in case the LED should ever burn out.

Different types of capacitors have varying amounts of leakage before they begin to affect circuit operation. Large aluminum lytics, for example, have higher allowable leakage than other types. The "Z METER" has two leakage ranges that cover the normal leakage for all types of capacitors. One range is marked "Large Aluminum Electrolytics" because they are the only capacitors that have normal leakage values over 100 uA. This range reads to 10,000 uA to test even the largest computer-type capacitor. The other range is marked "All Other Capacitors" and reads from .1 to 100 uA of leakage for critical capacitors like films, micas, and tantalum lytics. The LEAKAGE RANGE switch is labeled in this way to make it easy for you to remember which range to use for different types of capacitors to save you even more time.

Fig. 4 — The EIA maximum allowable leakage for aluminum and tantalum capacitors are shown on the handy pull-out chart on the bottom of the unit.

The first question that will usually come to mind is how much leakage current is permissible, especially when checking electrolytics. The "Z METER" makes thi easy for you too as a special leakage guide chart is mounted right on the pull out tab on the bottom of the instrument. Just pull the chart out, look up the capacity and rated voltage as it is labeled on the capacitor and find the maximum allowable leakage for that "lytic" right on the chart.

The chart even shows which LEAKAGE RANGE position to use. Allowable leakage current figures are derived from EIA (Electronic Industries Association) standards as determined by the capacitor manufacturers. You don't have to wait for the capacitor to fully charge to see if its good or bad. Simply depress the LEAKAGE button and watch the digital display until the leakage current reading drops below the maximum allowable leakage figure listed in the chart.

Dielectric absorption test

Testing for dielectric absorption with any method other than the "Z METER" is extremely complicated, time consuming and involves expensive test equipment that is not found in most engineering labs. Capacitor manufactures recomend that the capacitor under test be charged to its full rated working voltage until the charging current is below the maximum allowable leakage level. The charged capacitor is then discharged for a predetermined time and allowed to sit for 30 minutes. After the capacitor has sat for 30 minutes, the residual voltage created by the dielectric absorption is measured with a laboratory type electrostatic voltmeter. The measured voltage is compared with the original charging voltage and a percentage is computed from the figures.

Excessive dielectric absorption lowers the effective capacity because the capacitor cannot totally discharge after a DC voltage is applied. The "Z METER" value test will show this loss after the capacitor has been fully charged with the leakage power supply and then discharged when the leakage button is released.

Testing for dielectric absorption is as simple as 1, 2, 3 with the "Z METER". Just push the capacitor VALUE push-button and read the value of the capacitor. Then push the LEAKAGE button to charge the capacitor to its rated working voltage. Release the LEAKAGE button to discharge the capacitor and depress the capacitor VALUE button again. If the value for the capacitor is lower than the original value, and slowly increases toward the original value, the capacitor has dielectric absorption. If there is virtually no difference in the value readings, the capacitor has very little or no dielectric absorption.

If the difference in value is less than 15%, the capacitor is questionable. If the difference is greater than 15%, the capacitor is definitely defective and should be replaced. You may not be familiar with dielectric absorption problems in electrolytics and think that it doesn't happen often. The "Z METER" has proven to us in Field Engineering that it happens more often than any of us suspected. Only recently, Sencore Incoming Inspection rejected 1,000 brand new capacitors for dielectric absorption as they would have caused tough dog analyzer problems on the production line.

4. Please show me a capacitor with each of these defects and how the "Z METER" detects the trouble.

Leakage problem

Leakage is not only the biggest problem with capacitors, it can create a lot of trouble that is hard to find. A good example was with the vertical circuit of a General Electric C-2 chassis. The symptom was poor vertical linearity which showed up as a stretched out picture in the top portion of the screen. The problem could be any one of the wave shaping components between the vertical oscillator output and the control grid of the output stage. DC voltages were all within tolerance so the next step was to check the values of the resistors. All the resistors checked out to be within tolerance also.

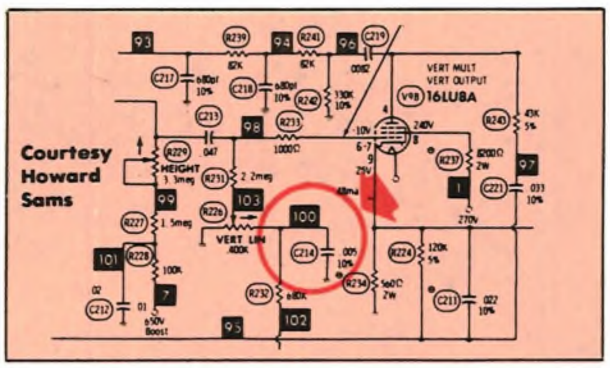


Fig. 5 — A leaky capacitor, C214, caused a stretched out picture at the top of screen, uncorrectable with the linearity control.

The next suspect components were the capacitors. The "Z METER" was put to use here to check the capacitor values and leakage. When we checked out C214, we found that the value was very close to the value shown on the capacitor but the capacitor showed up as leaky on the leakage test at its rated voltage. The leakage of the capacitor would definitely upset the wave shaping, causing the distortion and non-linearity on the screen. A new capacitor cleared up the problem. We checked the new capacitor with the "Z METER" before we installed it as we had gotten hooked on putting in a defective replacement before.

If we had used a "capacity only" tester here, we would not have found the problem. When the capacitor was tested on a capacity only tester, sure enough, it showed the proper value. The capacity value had not changed, but the capacitor was defective because of leakage. An ohmmeter didn't find our trouble either. Only the "Z METER" could find the leaky capacitor and save a lot of costly guesswork.

Value problem

The fact that capacitors change value was recently proven by one of the technicians in our own lab. A circuit was constructed for a project that included an oscillator. The frequency range of the oscillator was checked out on the bench and the data recorded. The circuit was then placed in the environmental chamber to test for frequency drift at different temperatures. The circuit passed this test but failed to operate properly after it was removed from the chamber. The circuit became unstable. It would oscillate strongly at times and then not oscillate at all at other times. This, of course, became quite frustrating to the technician when the circuit worked fine, passed the temperature tests but then began acting up.

The instability could have been caused by a number of things, so first the transistor was checked and found to be good. The "Z METER" was then used to test the capacitors. When the 20 pF feed back capacitor (that goes between the collector and the emitter of the transistor) was checked, it measured only 4 pF. Replacing the capacitor with one that measured 19 pF corrected the instability. In this case, the change in value was probably due to the thermal stress put on the part in the testing which opened a fissure in the dielectric material and reduced the capacity.

Fig. 6 — Ceramic capacitors that change value due to thermal stress can cause real headaches for circuit designers. This one changed from 19 pF to 4 pF during a standard temperature test.

You should be aware that film type capacitors have been found to reduce in capacity as well. Generally, the weld or physical contact between the foil plate and capacitor lead becomes poor and the number of foil plates connected to the lead decreases. This reduces the capacity of the capacitor. It will be as much as 50% lower in value in many cases.

You may find times where the wrong value capacitor has been installed in a circuit. This often happens when a technician is unable to read the code of the replacement capacitor. There are several different types of coding used and this is an easy mistake to make. It is often faster to check the capacitor than to decode the code to tell the capacitor value. The most common capacitor codes are shown in the back of the "Z METER" manual but there may be a few "odd-ball" codes that are not covered. A reliable capacity test makes this type of confusion much easier to deal with.

Dielectric absorption problem

Excessive dielectric absorption in a lytic is not directly related to either the value or the leakage. Some capacitors with excessive dielectric absorption may show higher leakage than the limits shown on the pull-out chart while other capacitors may show a very small leakage current and still be defective. Remember that the main problem caused by dielectric absorption is that the effective capacity is reduced when a DC voltage is applied. A good example of how this affects circuit operation is shown in this Sylvania E11-5 chassis.

The symptom on the TV was distortion and a slight fold-over at the center of the screen. The yoke and output transistor proved to be good, and the voltage at the junction of the two resistors, R360 and R347 were close to normal. One lead of the coupling capacitor, C344, was opened and the capacitor tested with the "Z METER". The value was within tolerance as it read 2620 uF compared to the marked value of 2500 uF. The leakage test showed some excessive leakage as the lowest leakage current was 1600 uA compared to the maximum allowable leakage of 1200 uA. We were not sure whether to reject the capacitors for this slight excess leakage.

The real cause of the problem, however, was dielectric absorption. When the LEAKAGE button on the "Z METER" was released, and the capacitor was re-tested for value, the first reading was only 1800 uF. The value then climbed to the original reading of 2620 uF. The effective value of the capacitor in the circuit was somewhere below the 1800 uF reading which is a sufficiently large change to affect the circuit operation.

Another example of excessive absorption was found in a power supply circuit. This problem really drove one of our Sencore customers crazy. The original symptom was excessive ripple. He suspected that the filter capacitor was bad and replaced it with a new one off the shelf. He tested the capacitor with a "capacity-only" tester and found the value to be well within the specs. But, when the replacement electrolytic was put into the circuit, the ripple became worse instead of better!

He tested the suspected capacitor on the "Z METER" and found that the leakage and value were both well within the tolerance for the capacitor but the dielectric absorption test showed that the capacitor had only one-half of its labeled value when it was fully charged.

The complete tests of the "Z METER" would have saved this technician a lot of headaches. He could have tested the replacement capacitor before it was installed in the circuit to make sure that the capacitor was really good. Have you run into situations like this one where component substitution did not do the job you expected? The "Z METER" can save much frustration and eliminate this costly guesswork when you are about to install a new electrolytic that may have already deformed on the shelf.

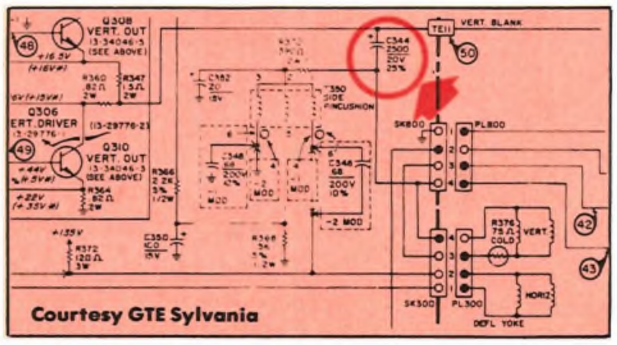


Fig. 7 — On this Sylvania chassis E11-5, a distorted picture near the center of the screen was caused by some leakage and dielectric absorption in C344, the vertical yoke coupling capacitor.

Leakage between sections problem

Leakage between the sections of a multi-section lytic does not happen too often, but when it does you will most likely see odd and multiple symptoms. DC voltages may be out of line or signals may appear at unexpected places. Let's look at a typical power supply circuit to see an example of what we mean.

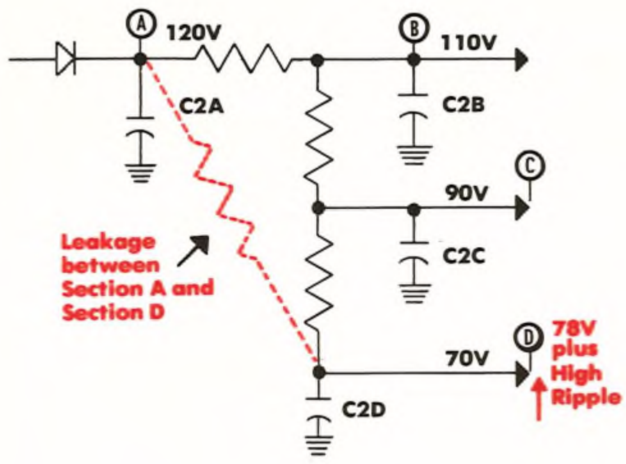


Fig. 8 — Leakage between sections of a multi-section lytic changes voltages, couples signals, and creates odd symptoms in the circuit.

This power supply uses four lytics in the same can with three voltage dropping resistors to produce four output voltages. Internal leakage between section A and D will shunt the voltage dropping resistors. This causes the voltage at point D to be larger than it should because some of the DC voltage from A is feeding through the leakage path. There is also an increase in ripple at point D because some of the ripple from the A section is fed through the leakage path as well.

The problem is reduced, but not corrected, when an external capacitor is paralleled across section D. The added capacity may reduce the ripple but the DC voltage will still be higher than normal.

It is common for a technician to begin troubleshooting the load connected to point D. He reasons that the parallel capacitor reduced the ripple but that the voltage is high at this point because the load is not drawing enough current. This step of the circuit analysis can get quite involved as the faulty capacitor "leads you down the garden path".

You may eventually change the filter capacitor anyway, even though you have no real proof that it is the problem. Once again, this involves costly guesswork. You may even waste more time trying to figure out why changing the capacitor corrected the problem in the first place.

The "Z METER" will let you check for inter-section leakage anytime you suspect that it might be the problem. The test simply involves checking a section for leakage in the usual manner. Just set the APPLIED VOLTAGE switch to the proper voltage, choose the proper LEAKAGE RANGE position and push the LEAKAGE button. Then, simply connect a short circuit (use a screwdriver when you can) across the other sections of the cap. The leakage should not increase with the short present. If it does increase, you know that there is leakage between the sections.

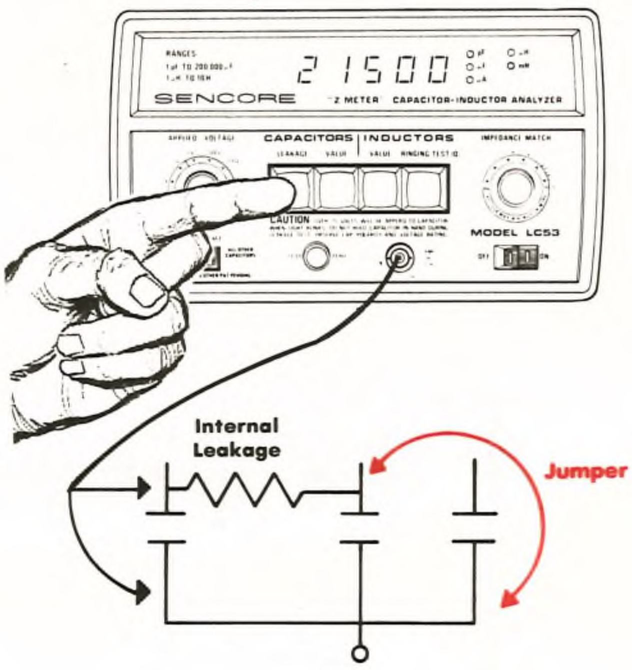


Fig. 9 — Leakage between sections of a multi-section lytic shows as an increase in leakage current when testing one section and a short is connected across another section.

5. How are technicians and engineers finding these faulty capacitors now?

Most technicians and engineers isolate the problem to a functional stage or circuit. After checking enough parameters to suspect a defective capacitor, the time is taken to hunt up a replacement from stock. The suspected capacitor is then unsoldered and the substitute soldered in its place. If the new capacitor doesn't cure the problem, it is unsoldered and the old capacitor soldered back in its original spot in the circuit. Our technician or engineer is still not absolutely sure that the capacitor is not defective because he may have replaced it with a defective capacitor from his stock.

Substitution is no sure fire method of finding defective capacitors. The substitute capacitor often becomes defective sitting on the shelf and misleads a person into believing that they have substituted a known good capacitor. Most engineers and technicians are not the best stock keepers anyway and often work out of their favorite "junk box" for substitutes. Watching a person hunt for a replacement part out of a junk box is pretty much like our mystic on the front cover of this publication. He is really looking for that black magic answer and looks more surprised than confident when the replacement actually works. Some don't know capacitor codes and may wind up installing the wrong value.

Some use substitution boxes, such as the Sencore RC167. This is indeed a great improvement but has shortcomings, too. It is impossible to have exact replacements in a substitution box and the selected substitute may be as much as 50 percent off needed value. Substitute electrolytics should be operated near their specified working voltages to produce the capacity indicated. If they are not, an additional error is generated. Then, too, the substitute may not have an adequate voltage rating to use in the circuit. It is true that many technicians and engineers substitute in these higher voltage circuits for a short period of time. But, if that is done, how are we to know that the substitute capacitor is not made defective with the excess voltage applied to become part of our problem the next time it is substituted. Lead capacitance also becomes a problem on all capacitors below 100 pF and substitution becomes next to impossible.

Some technicians and engineers use an impedance bridge to check capacitors. The bridge is very time-consuming, reads only value, and does not make the all important leakage or dielectric absorption checks thus finding only about 15 percent of the actual circuit problems. Also, the bridge checks capacitive reactance and not true capacity as is done in the "Z METER". Reactance changes with frequency, making it possible to get different readings on different bridges even after going through the time-consuming balancing act that it takes to set up the bridge.

Some are using digital readout capacitor "value only" meters. These meters are much faster and do measure true capacity but leave much to be desired as they, too, only find a fraction of the defective capacitors. They do not make the all important leakage check or the all important dielectric absorption check . It should become more and more obvious that all three of these checks are important if one really wants to find defective capacitors that all other testers miss and cut the costly guesswork.

6. Can you check capacitors in-circuit?

Everyone would like to be able to say yes to this question, but the real answer is no. Further, Sencore engineers believe that there never will be a reliable in-circuit capacitor tester because the shunt impedences around the capacitor in the circuit do not allow a correct or reliable value reading. Even if we could discover a way to measure capacitor values in-circuit with any reliability, it would not help much. As we mentioned earlier, a change in value constitutes only 10% to 15% of all the capacitor problems, the rest are related to leakage and/or dielectric absorption.

We also mentioned that a leakage check must be made with applied voltage if it is to be reliable. It is virtually impossible to apply a voltage to the capacitor while it is in a circuit to test for leakage when you have parallel and shunt paths that also show up as leakage. Applying an external test voltage of up to 600 volts will damage other components in the circuit such as transistors, FETs, and ICs. Sencore engineers have tried for several years to develop a way to check capacitors in-circuit, only to find that you cannot get a safe and reliable check. Inductors are a different story as they can be checked in-circuit with high reliability with the all new Sencore patent pending inductance circuit because a much lower voltage can be used to make the test. This is covered in more detail in the inductance testing section of this article.

7. Can I reform an electrolytic capacitor that has deformed from sitting on the shelf and save from buying a new one?

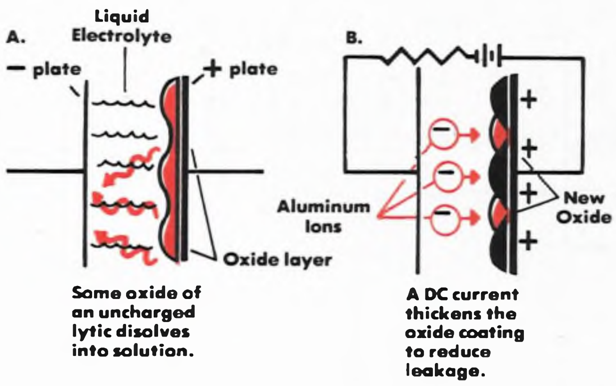


Fig. 10 — The limited current of the LC53 leakage power supply may be used to reform the oxide layer in a leaky lytic by slowly reforming the oxide dielectric.

Yes, the "Z METER" is ideal for reforming electrolytics. Electrolytics sometimes deform because some of the aluminum oxide dielectric material dissolves back into the liquid electrolyte. These capacitors can often be reformed by repeating the forming process that was used at the factory in the first place to build up the oxide layer. This simply involves the application of a DC voltage with limited current over a period of time.

The "Z METER" leakage power supply can be used to reform a capacitor that has lost some of its oxide material. The "Z METER" is supplied with a special pushbutton holder rod that fits between the leakage button and the "Z METER" handle to keep the LEAKAGE pushbutton held down for extended periods of time. This arrangement is used, instead of a locking-type pushbutton, for safety purposes. The LEAKAGE button is spring-returned so that the capacitor under test is always automatically discharged as soon as the leakage test is completed. Lifting the handle to operate the "Z METER" automatically releases the leakage button and discharges the capacitors. This reduces the possibility of an electrical shock from a charged capacitor or from test leads. It also prevents the possibility of applying a charged capacitor to the value checking circuit if it were used next.

The "Z METER" monitors the status of the capacitor during the reforming process as the leakage current is read at all times to determine when the "healing" process is complete. The leakage of a deformed lytic will normally be higher than the value shown on the pull-out leakage chart. This leakage should drop to below the allowable level after the reforming process. This process may take several hours with a capacitor that has been allowed to deform over a long period of time.

Be sure to completely check the capacitor after the leakage drops to an allowable level to make sure that you have actually reformed the capacitor. Be especially sure to test for dielectric absorption. There is usually no cure for dielectric absorption and the capacitor will continue to get worse as it is used.

8. Are capacitors here to stay? Will we be checking more capacitors each year?

Yes, capacitors are here to stay. Capacitor usage is increasing each year. According to recent EIA figures, the dollar amount of capacitors that have been sold over the past four years has increased a staggering $500 million dollars. The EIA sales chart shows a steady upswing and steady increase of capacitor sales. EIA usage projections continue to show this upswing. One might think that the use of integrated circuits would decrease capacitor usage. Actually, the opposite is true as the IC does not have capacitance built-in and capacitor usage increases with the increase in IC usage.

The size and nature of the construction of the capacitor make it impractical to include in the IC like the resistors and transistors. A good example of the increase usage of capacitors is the comparison of the older tube operated color TV receiver versus a modern day receiver using ICs. A typical tube receiver used about 120 capacitors while a typical solid-state receiver uses almost 300 capacitors. Other areas of electronics are showing similar growth curves because of the increased usage of ICs. The capacitor is here to stay and will increase in usage tomorrow. Don't you think it may be time for you to look into a reliable no-nonsense capacitor tester?

9. Can the "Z METER" power supply be used to check SCRs and TRIACs?

Yes, the "Z METER" tests these components, too. Silicon Controlled Rectifiers (SCRs) and TRIACs are used more and more to control a DC or AC voltage. They are used in many applications, such as light dimmers, motor controls, remote control circuits, and sweep circuits in TV sets. They operate much like a solid-state relay. Both the SCR and the TRIAC can be tested by simply testing whether they will turn on and off with the right set of signal conditions.

	Open Cathode or Anode	Anode Shorted to Cathode	Open Gate	Gate Shorted to Anode or MT2	Gate Shorted to Cathode or MT1
SCR	000 on all tests	Flashing 888 on all tests	000 on all tests	Flashing 888 on all tests	Will not latch on DC test
TRIAC	000 on all tests	Flashing 888 on all tests	000 on all tests	Flashing 888 on all tests	Will not latch on DC test

Fig. 12 — Common problems of SCRs and TRIACs and how they appear when testing on the CA55 or LC53.

There are really two tests that need to be made on these devices. The first one is to make sure that they are properly controlled by the gate signal, and the second is to make sure that they do not break down at their rated voltage. The "Z METER" supplies test voltages up to 600 volts for these tests. There are two types of signals supplied by the "Z METER", one which is filtered DC up through 10 volts, and the other is pulsating DC from 15 volts to 600 volts. The two types of signals are used for two different tests when testing the SCR and TRIAC.

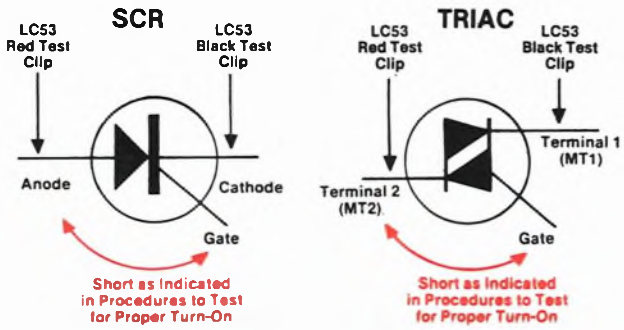


Fig. 13 — CA55 or LC53 lead connections and jumper connections for testing SCRs and TRIACs for turn ON and OFF conditions.

Latching test:

The first test is to make sure that the SCR or TRIAC will properly latch when a DC potential is applied across the device and a trigger voltage of the proper polarity is applied to the gate lead. The "Z METER" leads are simply connected across the input and output terminals as shown in Fig. 13, and the APPLIED VOLTAGE switch set to the 10 volt (filtered) position. Set the LEAKAGE RANGE switch to the 10,000 uA position. When the LEAKAGE button is pressed, there should be a zero reading on the "Z METER" digital display, indicating that the device is turned off. A "jumper lead" is then connected from the anode to the gate lead of the SCR under test. This should cause the SCR to turn on. When this happens, the device becomes an effective short circuit across the "Z METER" test leads and draws a great deal of current. This is indicated on the display as an overrange indication of flashing "888" with a stationary zero to the right which in-

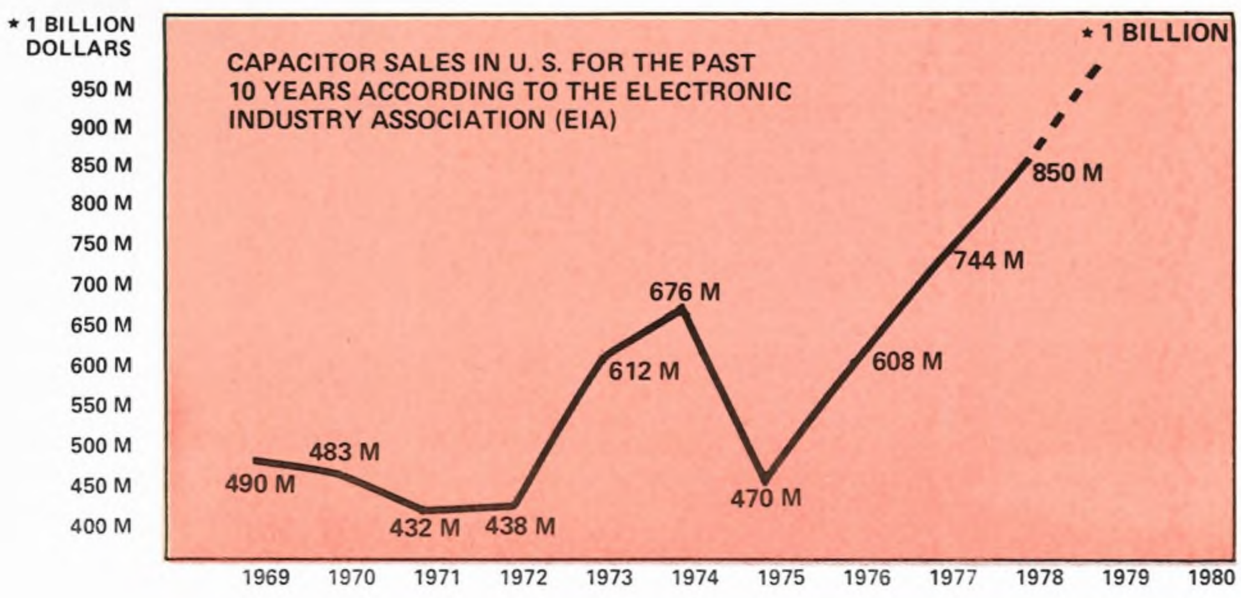


Fig. 11 — Capacitor sales have increased over $500 million in just the past 4 years.

dicates that the "Z METER" is drawing more than 10,000 uA. The display should continue to overrange even when the "jumper wire" is removed as an SCR should stay turned on until the anode voltage is interrupted. This indicates that the device has "latched" into a conducting state.

Removal of the applied voltage by releasing the LEAKAGE button and then pressing it again should result in a zero reading indicating that the device has again turned itself off. We have now checked the turn-off and turn-on capability of an SCR or TRIAC. Catastrophic failures can be found by this simple test method and will catch most defective SCRs and TRIACs.

Leakage test:

If you are in design, or working on a tough dog, you may want to go further. The next step is to make sure that the device does not have leakage when the full rated voltage is applied. To do this, connect the test leads the same as you did for DC latch check and switch the APPLIED VOLTAGE switch to the rated voltage of the device under test. The LEAKAGE button is then pressed. There should be a zero reading again which indicates there is no leakage at the rated voltage.

The final step is to confirm that the device will turn on and off at the rated voltage. This is done by again connecting the "jumper wire" between the anode and the gate lead. Be very careful because you are handling up to 600 volts. The display on the "Z METER" should again overrange to indicate that the device has turned on. This time, however, the signal that is applied is pulsating DC, as all voltages above 10 volts are not filtered. This enables us to check the device for AC switching capability. This means that the device should turn itself off, whether or not the LEAKAGE button is released, when you remove the jumper wire between the anode and the gate lead. If the overranging does not stop in about one to two seconds after the gate lead is removed, the device is defective. It takes a second or two for the overrange to stop because of the automatic circuits in the "Z METER" leakage test.

There are a few special conditions that you may encounter in extremely high sensitivity or high powered devices. Be sure to refer to the "Z METER" instruction manual and the special notes that accompany the manual for complete details.

SCRs and TRIACs are just two more components that required component substitution and guesswork before the introduction of the "Z METER". Substitution of these components is usually difficult because most technicians do not have samples of the hundreds of different types that are in use. A replacement part usually has to be ordered in order to make the substitution which wastes even more time when the SCR or TRIAC is not the cause of the circuit defect.

Most SCR and TRIAC applications are in some way related to the timing of one or more signals. This requires the use of many coils and capacitors in these circuits. The pulse generator circuits in a motor control or light dimmer, for example, must be referenced to the AC line voltage. The trace and retrace circuits of an SCR driven horizontal output must be synchronized to the horizontal sync pulses. This requires many coils and capacitors. The "Z METER" is the only analyzer that lets you check the SCR or TRIAC plus all of the other critical timing components to tie down problems in these circuits with the least amount of costly guesswork.

10. There are many diodes that I can't check with an ohmmeter. Will the "Z METER" help me here?

You bet it can. The variable power supply and microammeter of the "Z METER" makes it an ideal instrument for the testing of diodes. Diodes can be tested for reverse leakage, forward conduction, and the peak inverse voltage up to 600 volts. You can also measure the junction capacity of silicon diodes for that perfect match in those critical high frequency demodulator circuits.

The small signal diodes used in the bridge circuits of modulators and demodulators should be balanced and have the same reverse leakage. This is to insure that the signals are modulated or demodulated equally in both directions. To check reverse leakage, connect the diode to the test leads, red lead to the cathode and black lead to the anode, and set the APPLIED VOLTAGE switch to the rated voltage of the diode. If the rated voltage falls between steps of the switch, use the next lower setting. In the case of a 75 volt diode, for example, use the 50 volt setting. Set the LEAKAGE RANGE switch to the 100 uA ALL OTHER CAPACITORS range, depress the LEAKAGE button and read the reverse leakage in microamps on the digital display. Leave the diode connected as it was for the leakage test to check the junction capacity of silicon diodes and match the diodes for both reverse leakage and capacity for the best balance. Then, simply depress the capacitor VALUE button and read the capacity on the digital display. NOTE: Germanium diodes can be measured for reverse leakage but cannot be measured for capacity due to the high reverse leakage of the device.

Testing high voltage diodes:

High voltage and focus type rectifiers have always been a problem to test. These diodes are really several diodes connected in series. An average of about 200 volts is required before a high voltage rectifier will begin to conduct current and ohmmeters normally supply a test voltage of 2 volts or less. The variable power supply of the "Z METER" supplies a high enough voltage to cause the diode to conduct. The diode is first connected with the red test lead to the anode and the black test lead to the cathode. Set the APPLIED VOLTAGE switch to the 50 volts position, and the LEAKAGE RANGE switch to the ALL OTHERS range. Depress the LEAKAGE button and observe the digital display. If a zero reading is displayed, advance the APPLIED VOLTAGE switch to the next position. Keep increasing the APPLIED VOLTAGE one step at a time until the digital display shows a current reading. Do not advance the switch any further or you may damage the diode. Conduction normally should begin between 100 and 200 volts. If you get all the way to the 600 volts position with no leakage reading, the diode is open.

The same rectifier can be checked for reverse leakage by simply reversing the test leads, setting the APPLIED VOLTAGE switch to the 600 volt position and depressing the LEAKAGE button. A good diode will display 00.0. Any other reading indicates a leaky diode.

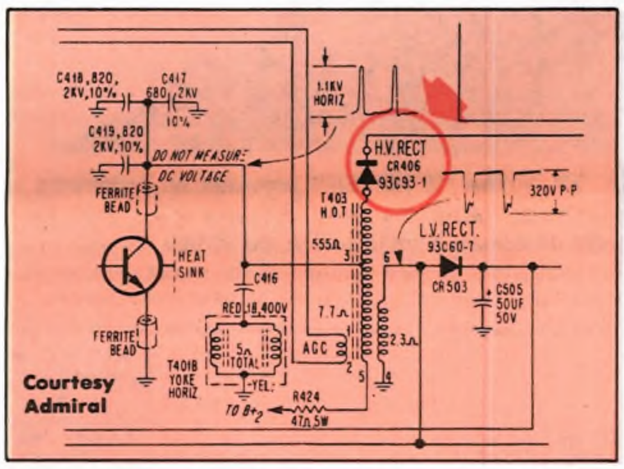


Fig. 14 — With the "Z METER" you can test high voltage rectifiers such as the ones shown here used in a portable TV receiver.

Testing zener diodes:

The "Z METER" can even give you an idea of the zener voltage of a zener diode using the APPLIED VOLTAGE power supply, the microammeter, a series resistor, and a voltmeter across the diode. If the diode voltage is above 10 volts, a 20 uF, 100 volt electrolytic capacitor must be placed across the output of the "Z METER" to filter the voltage to DC. If you don't, the voltage readings will be meaningless because all voltage above 10 volts are pulsating DC. The series resistor is chosen to limit the maximum current read on the digital display to about 5000 microamps. A 1000 Ohm, ½ Watt resistor will work for most zener diodes in the range of 4 to 12 volts.

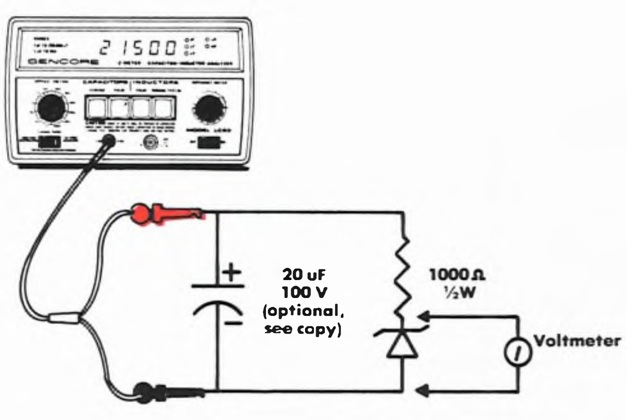


Fig. 15 — The "Z METER" leakage power supply is used to test zener diodes with the use of a limiting resistor and a voltmeter. The filter capacitor is only needed if voltages above 10 volts are used.

To check the zener diode, connect the negative lead of the voltmeter, the black test lead of the "Z METER" and the negative lead of the lytic (if used) to the anode end of the diode. Connect the series current limiting resistor from the red test lead of the "Z METER" to the cathode end of the zener diode. Connect the positive lead of the voltmeter and the lytic to the cathode of the zener diode. Depress the LEAKAGE button and observe the digital display to be sure that the current does not go over 5000 microamps. The voltage read on the voltmeter is then the zener voltage of the diode. If the current is too low, the diode may not go into a zener mode and give an incorrect voltage. In that case simply increase the APPLIED VOLTAGE switch to the next range and check the diode again. Be sure to let the capacitor charge up to the new voltage before determining the current through the diode.

11. I have difficulty matching the cartridge to the pre-amp in high fidelity systems. Will the "Z METER" help me?

Yes, the "Z METER" is ideal for this application. Many manufacturers recommend that the tone arm capacity be matched to the input capacity of the pre-amp for the best frequency response possible. If the load capacity of the cartridge is not the same as the input capacity of the pre-amp and the interconnecting wiring, some of the high frequency information is lost and the overall quality of the system suffers. The value of input capacitor on the input of the pre-amp can be selected to match the cartridge capacitive load.

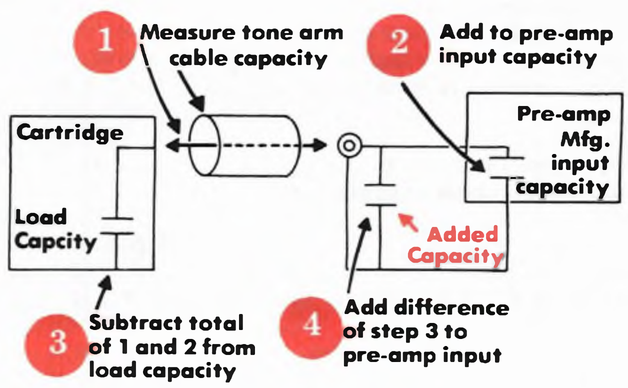


Fig. 16 — Tone arm cartridge can be matched to the pre-amp input with the "Z METER".

The cable capacity is measured just like a normal capacitor with the "Z METER". The tone arm cable must be disconnected at both ends so that it is open and not terminated. The "Z METER" will give no capacity reading if the cable is terminated or shorted. Measure the tone arm capacity, and add this figure to the manufacturer's stated input capacity of the pre-amp and subtract it from the capacitive load specified by the cartridge manufacturer. This figure is the amount of capacity that must be added to the input of the pre-amp to match the cartridge load to the pre-amp input capacity.

An example is a tone arm whose cable measures 122 pF. The listed input capacity of the pre-amp is 125 pF. The total of the two figures (122 pF plus 125 pF) is 247 pF. Subtract this capacity from the cartridge load capacity which, in this case, is 400 pF and get a figure of 153 pF. This is the amount of capacity that should be added to the input of the pre-amp for the best match. Remember to add this capacitor to both channels of a stereo system. You can use the "Z METER" to measure the capacitor that you put in to get one that is as close to the value as possible. The capacitor should be within 10% of the calculated capacity for best results.

All of the applications we have covered up to this point have involved capacitor tests. Every one of these applications is covered with the capacitor testing section of the LC53 "Z METER" or by the CA55 Capacitor Analyzer. Every test on the CA55 is identical to those we described for the "Z METER". The CA55 may suit your needs if you only have need to test capacitors and do very little work with coils. Fill out the Instrument Interest Coupon or call toll-free 800-843-3338 if you are interested in the CA55.

Most technicians also need a way of eliminating the costly guesswork when coils are involved. Coils are one of those components that are difficult to substitute because there are so many special types used but substitution has been the most common method of troubleshooting a coil problem. The following sections cover the applications of the "Z METER" in coil testing.

12. In a nutshell, what goes wrong with coils?

The survey made by the field engineering department indicated that the most common problem with coils, and the most difficult to detect, was shorted turns. Shorted turns are generally caused by weak insulation that breaks down under voltage. The insulation is sometimes "rubbed off" allowing the wires to short. In some cases, a bubble might have formed in the coating process resulting in a much lower voltage breakdown rating at the spot where the bubble is located. A circuit malfunction that causes excessive voltage across the coil can also lead to shorted turns.

The next most common problem is when an entire section of a multi-section transformer or coil shorts to the next section. This is most common in TV flyback transformers but also occurs in other high voltage supplies or anywhere a multi-layer coil or transformer is used. This again is generally due to insulation breakdown at some point where the windings are close to each other. This point is often where voltage difference (voltage gradient) between the two coils is the greatest.

On very rare occasions, the core of a ferrite type transformer can break. This does not actually affect the windings or any of the coils on the transformer but does change the inductance which, in turn, changes operation of the coil or transformer in the circuit. There are some television flybacks that use replacement windings that are mounted on the old core. The small spacers between the two halves of the core may get lost when the assembly is put back together. These spacers are critical. The inductance of the transformer will be altered if they are not replaced or are replaced with spacers of the wrong thickness.

Coils also open up. Occasionally, too much stress is put on the coil when it is wound. This may cause the wire to break. At other times, the coil is stressed when it is placed in the circuit or removed for testing. Coils can also open from a screwdriver, or some such object, accidently falling or making contact with the windings on unprotected coils. Finally, the coil may open if too much current causes a wire to burn open.

Some coils can change inductance. This may be caused by overstressing the wire in the winding process. The wire may then relax after a period of time which changes its position and shape. You may also find coils that have been altered in inductance by a previous technician who spread or compressed the windings to attempt alignment or tuning when some other component was really at fault. You will also find some coils that were never the right value to begin with, were replaced with the wrong value by another technician or engineer, or were mislabeled.

Fig. 17 — The "Z METER" provides an automatic inductance value test and Ringing "Q" test to locate problems in coils and transformers.

13. Can we find these common defects with present test equipment?

This has to be a rather qualified yes as many of the problems can be found but may take a lot more valuable time and may not be as accurate as the "Z METER".

A bridge will locate most of these common defects but many technicians do not have access to a bridge. A bridge, of course, is time consuming and often gives questional results because the inductance reading often changes with the amplitude of the signal selected. There are also some instruments available that test inductance digitally, but these are usually very expensive and not found in most service operations.

As we mentioned earlier, the most common coil defect is a shorted turn or group of shorted turns. Some technicians attempt to test coils with an ohmmeter but a shorted turn will typically only change the coil resistance by as little as .001 Ohms. There are no ohmmeters than can detect this small change even if you knew what to compare it to. The only reliable way to test for a shorted turn is to either test the inductance value or the effective Q of the coil.

The only failures that can be detected with an ohmmeter are coils that are completely shorted or opened. These are less common than the other types of failures, however, which means that you are left guessing on any type of a failure that changes the inductance of the coil but leaves the resistance close to the original value.

Cracked cores can often be spotted with a visual inspection. Some core problems, however, will change the inductance of the coil. Again, the resistance will not be affected when the core is the cause of the problem.

Most technicians simply analyze all other parameters and components in the circuit and then, in desperation, suspect the coil and remove it for replacement. An exact replacement is often difficult to get, especially if the product is an import, and the entire product is tied up waiting for the replacement just to make a test. Most coil values are called out on manufacturers' and Howard Sams schematics and the check could easily have been made with the "Z METER", avoiding costly guesswork.

14. Where can I find coil values and how many technicians are equipped to check coil values? How does the "Z METER" test coils?

Coil values have been shown on schematics or in the parts lists of most electronic equipment for many years. Our surveys shows, however, that 9 out of 10 technicians do not have any way to measure inductance. The exceptions were found in two-way radio shops and engineering labs.

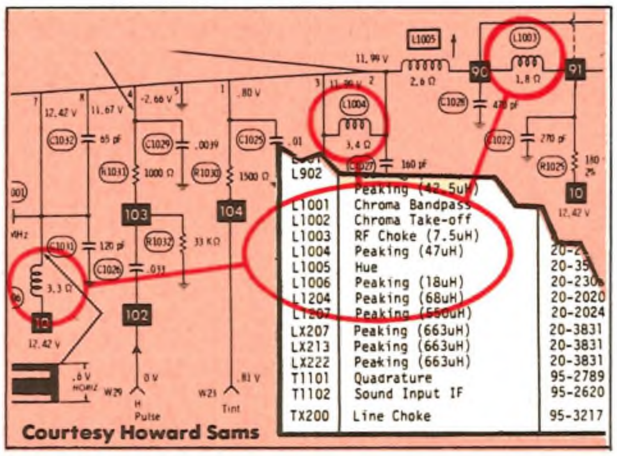


Fig. 18 — Partial schematic of Zenith 19KC48 chassis showing section of chroma and parts list. Note the coil values in parts list.

These two groups often have access to a bridge. Most technicians that have a bridge, however, indicate that they do not use it often because it is too slow and the results are often questionable. The readings on many bridges, for example, will change depending on how much signal is used. Everyone surveyed wanted a faster and more dependable way to test coils.

The "Z METER" provides two reliable tests that are designed to analyze coil defects from small RF coils to large power transformers. The "Z METER" is so easy to use that all you need do is connect the coil and push a button. The inductance value test is fully auto-ranging, just like the capacitor test section. The "Z METER" automatically selects one of the six internal ranges to use and displays the inductance value in either microhenrys or millihenrys from less than 1 uH all the way to 10 H. The "Z METER" Lead Zero is adjusted to null out the effects of the test leads when testing very small value coils.

The heart of the inductance value circuit is a special current ramp generator. A ramp with a known current change per given time is fed through the coil under test. The reverse EMF generated by the coil is detected with a sensitive digital voltmeter circuit. The change in voltage, for a given change in current, indicates the coil value. The inductance value test, just like the capacitor test, checks the inductance of the coil, not the inductive reactance which is dependent on frequency. The test has special circuits that subtracts the effects of the coil resistance for most coils. This eliminates the need of resistance/inductance tables for accurate reading as are needed with some other inductance testing systems.

15. What if I don't know the coil value and just want to know if the coil is good or bad?

There are times that the inductance value of the coil is not on the schematic or listed in the parts list. There are other times that you just want to speed up your testing and not have to take time to trace down the inductance value of the coil. The patented Ringing test checks the coil's ability to work in circuit without knowing the inductance value. Just connect the test leads, depress the RINGING TEST button, and look for a reading of 10 or more on the digital display as you turn the "Impedance Match Switch" for the highest reading.

The "Z METER" uses a tried and proven coil ringing test, just like the system used in the Sencore YF33 Ringer, to check yokes and flybacks but is extended over a wider inductance range. The ringing test gives reliable good/bad readings for the full range of coils from 10 uH to 1 H, except for coils or transformers with iron cores. The value test should be used on these transformers and chokes.

The Ringing test is a dynamic test that applies a sharp pulse to the coil. The coil will ring and continue to ring until it dampens out. A special circuit counts the number of rings to a predetermined damping point. The sensitivity of the test is adjusted to give 10 or more rings for a good coil and less than 10 for a bad one.

The Ringing test results are dependent on the Q of the coil. Higher Q results in more ringing cycles. You don't need to know the Q of the coil, however. Just push the button and look for a reading of 10 or more as an indication of a good coil. The Ringing test makes your coil testing faster and easier than any other test method to take that costly guesswork out of coil testing.

16. Can I check coils in circuit? Some of these coils are easily damaged and difficult to remove for testing

Most coils can be tested in circuit with either the value test or the Ringing test with reliable results. The key point to remember is that the "Z METER" will never lie to you on an in circuit test. If the coil shows good, you know it is good. If it shows bad, the coil is probably bad or is being loaded by a parallel circuit with a very low impedance. In such cases, remove one lead of the coil and check it out-of-circuit as a 100 percent back up check.

You may wish to identify the loading source to eliminate it or for troubleshooting purposes. This can even help you find circuit problems that are not caused by the coil you are testing. Let's look in Fig. 19 at a typical flyback transformer in a TV set. Notice that there are several different coils that feed signals to various circuits. A bad Ringing test indicates either that the flyback itself is bad or that there is a short in one of the other circuits that is connected to the flyback. If your first test shows a bad reading,begin by disconnecting the flyback loads one at a time and repeating the test. The first loads you should remove are the deflection yoke and the damper diode in a solid-state chassis. If you still get a bad test, remove one or more of the other loads. If the test suddenly changes from bad to good after removing one of these loads, you know that there is a loading problem in the circuit that was just disconnected. If, on the other hand, you have all of the loads removed, and still get a bad test, you know for sure that the flyback is the problem. You really haven't wasted any time because you have to remove all the loads to replace the flyback anyway. You have actually saved time because you have confirmed that the flyback is actually the problem before putting a new one on order. This procedure can save you a lot of troubleshooting time and component expense.

The value test also has a high in-circuit accuracy. This enables you to measure the value of a coil before you

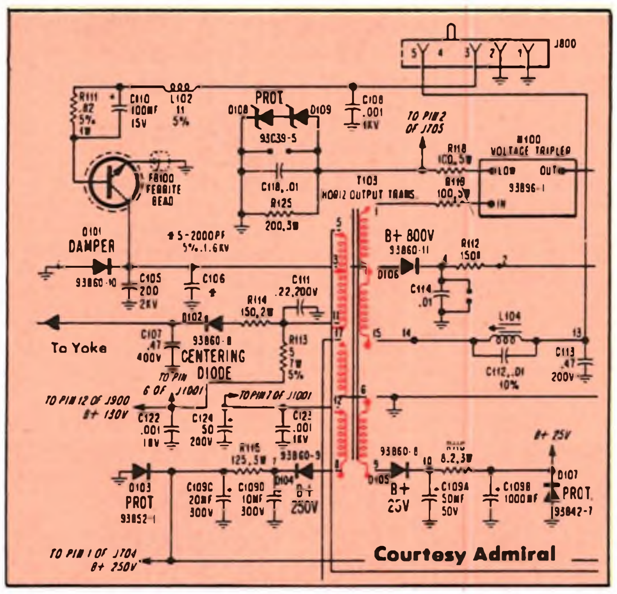


Fig. 19 — A typical TV flyback system showing the many circuits that may load the flyback and give a bad indication on the Ringing test.

unsolder it to prevent more time from being wasted. The value may be slightly off due to parallel circuit loading but is generally within a few percent of the actual coil value. Once again, the "Z METER" will never lie to you as you can always disconnect the coil and measure it out-of-circuit. The "Z METER" instruction manual lists the typical testing accuracy for different loading circuits so that you know what to expect when testing in circuit.

Sometimes a coil or transformer is soldered to the PC board and has no exposed leads to which you can make your connections. The optional 39G85 Touch Test Probe is the answer to this problem. The 39G85 is simply connected to your "Z METER" test leads and used to make contact to the foil side of the P.C. board with needle sharp points. The 39G85 may be used for either value or Ringing tests. The 39G85 test probe is optional at $10.00.

You may find some schematics that do not list coil values. This may cause problems when it comes time to order a replacement coil. The in-circuit test can save you time here, too. The same type of coil, with the same part number, is often used in several different circuits, such as IF amplifiers. Simply measure the inductance of another coil that has the same part number as the one you want to replace to determine its value. You then have the data you need to locate a suitable replacement.

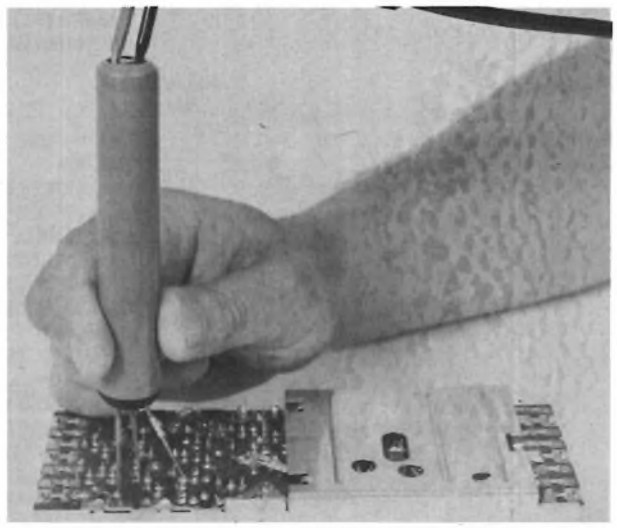


Fig. 20 — Inductors can be checked right in-circuit for value and effective Q with the optional 39G85 Touch-Tone probe.

17. Will you please show me how the "Z METER" detects troubles in coils?

Shorted turn problem:

A typical example of a coil with shorted turns came from a Zenith chassis, 19DC20. The picture was distorted and reduced in height. There was also a curvature from left to right across the picture. A scope was used to check the vertical waveforms but they all looked good right up to the output stage. The next suspect was the yoke. The Ringing test on the "Z METER" showed that the vertical yoke was good. This indicated the problem was in the series path between the vertical output and the yoke.

A check of the schematic showed that the pincushion phase coil and transformer were both in series with the vertical yoke windings. The pincushion phase coil was

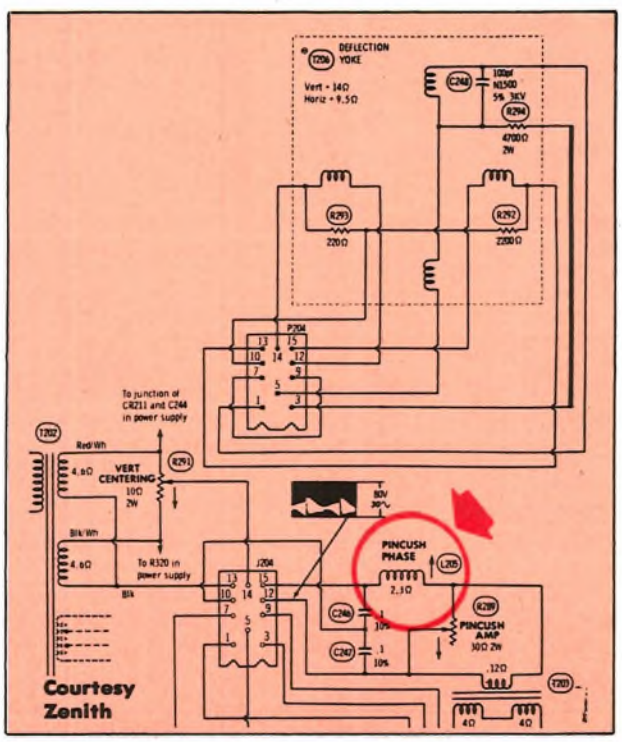


Fig. 21 — Defective components such as the Pincushion phase coil, in series or parallel with the yoke can also cause deflection problems.

tested first and it showed only 2 ringing cycles. One end of the coil was lifted from the circuit to be sure that nothing else was loading the coil but it still read only 2 rings. The coil was replaced and the problem corrected.

(Continued on Page 14)

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★WINNERS	ADDRESS	Instruments Purchasing
John D. Bozard	Orangeburg, SC	CR31A
Harry Raplan	Clarksmas, OR	CR31A,TF46, HP200
Tom Handley	Portland, OR	VA48, FC51
Miles A. Booth	Miami, OK	VA48, LC53
Hi's Electronics	Cedarville, CA	DVM38
Bernard Johnson	Longwood, FL	VA48
Goodwin's Elect.	Albany, GA	LC53, FC51
R. M. Witt	Lynchburg, VA	CG25
S. R. Pierce	Chula Vista, CA	SG165
J & M Electronics	Dearborn Heights,MI	RC167, PR50

★WINNERS	ADDRESS	Instruments Purchasing
Lower's TV & Appl.	Kingman, KS	PS163
Joe Thompson	Crayling, MI	TF46
Earl K. McNabb	Memphis, TN	VA48
Robert Menwood	San Diego, CA	TF54
William Gariepy	Cumberland, RI	RC167
Raymond Lyford	Dover-Foxcroft, ME	CR31A
James D. Amos	Philadelphia, PA	VA48
Smitty's TV	Kennewick, WA	TC28
Spottswood TV	Longview, TX	CR31A
Robert Bader	Williston, ND	SG165

(Continued from Page 11)

The old coil was checked with an ohmmeter to see if the shorted turns that showed up on the Ringing test could be detected. The coil measured 2.28 ohms. The new coil was measured and read 2.27 Ohms. This proved once again that the ohmmeter could not have picked out the problem as this small difference in resistance reading would not cause you to reject the coil. The Ringing test on the "Z METER" helped us confirm that the coil was our problem.

In circuit test:

Open coils can generally be found quite easily with an ohmmeter if the coil is tested out-of-circuit. However, there are often times resistors inside the coil assembly and one doesn't know they are there. This was pointed out by a case where the "Z METER" was taken to a two-way radio shop to demonstrate its versatility.

The technician had been working on a CB and had gone around in circles. He had traced the signal down to the area between the buffer and amplifier stages. This indicated an open transformer but he had checked for continuity with an ohmmeter to be sure and said he had found the coil to be "good". You can see on the schematic in Fig. 22 that a small value resistor was shunting the coil. The value was only 47 Ohms.

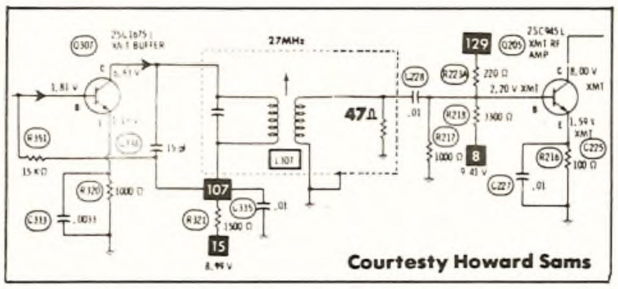


Fig. 22 — Low value resistors across coils can sometimes confuse the unsuspecting technician if the coil is open and checked in-circuit with an ohmmeter.

The "Z METER" was fired up and put to work to see if it could help find the problem. Shorted turns in the transformer were suspected. When the "Z METER" was connected to the secondary of the transformer, however, the coil would not ring indicating that it was indeed defective. The inductance value was read to double check the Ringing test. The "Z METER" showed a reading of 2.8 millihenrys because current was flowing through the resistor. The inductance value should have been 2 microhenrys, however, so something was really wrong. The coil was removed from the circuit and rechecked. It was found to be open.

We asked the technician to show us how he had measured the coil with his ohmmeter. We discovered that he was using too high of a range to detect the 47 Ohms. The 47 Ohm resistor looked like a short which lead him to the conclusion that the coil was good. The "Z METER" does not depend upon range switching and, therefore, showed the coil as being the problem right in the circuit on both the Ringing and value tests. The technician agreed that the in-circuit testing ability of the "Z METER" would save him quite a lot of time and placed his purchase order for his brand new "Z METER".

Industrial applications:

One defective component can put dozens of people out of work in factories, mines, etc. Our own Production Engineering group related an experience they encountered the other day. The computer controlled drill for drilling PC boards for the entire factory stopped working. After a short period of troubleshooting, it was discovered that the minus 14 volts to the logic board of the control system was missing. The problem was tracked down to an open filter choke in the power supply. A call to the parts department

Fig. 23 — The industrial technician must be able to locate problems quickly because many people's jobs depend on the operation of a key production machine.

of the manufacturer found the choke was not in stock and on back order. They thought they would have one in about two weeks. This would mean that a good portion of the factory would have to be shut down and some employees layed off until the problem could be solved.

Rather than wait for the part, the Production Engineer measured the inductance of an identical filter choke in the plus 14 volt supply. It read 30 millihenrys. The current drawn from the supply was calculated to be about 3.5 Amps. Armed with this information, the engineer took a trip to a local distributor. He found a substitute that was close but did not physically fit in the space occupied by the defective choke.

The substitute filter choke was rigged up and the drill was put back into operation. The substitute was not the proper choke but it allowed the drill to be put back into use until the proper choke was received. The production line was able to keep running smoothly during the short time the drill was down.

18. How are technicians and engineers finding these faulty coils now?

Most technicians try everything they can do to prove that the coil is *not* the defect. They will trace signals, do complete DC voltage analysis, test transistors, substitute capacitors, and measure resistors. The coils are usually left as the last resort because most technicians do not have a large assortment of replacement coils. If all else fails, they will order the coil and hope like crazy that the new coil corrects the problem. The replacement coil often has to be back ordered because there are so many special types. Sound familiar?

We had an experience like this a short time ago before we had samples of the "Z METER". We were working in the IF stage of a TV receiver. One stage simply refused to tune up when we were doing an IF alignment. Voltage measurements did not show any problem in the other components. We substituted some of the capacitors but still could not get the stage to tune properly. Finally, we decided to order a replacement transformer, thinking that it was the problem.

The transformer took two weeks to arrive. We installed the new transformer and, much to our disappointment, the problem did not go away. Further testing of the circuit, with a proto-type sample of the "Z METER", found the problem. One of the disc capacitors that we had installed was defective! Its value was about one-third of the marked value. We had not checked it before installing it because we were still under the impression that "new components are always good". We now know that this is not true.

The "Z METER" would have saved us time in two ways. Firstly, it would have let us confirm that the coil was not the problem before we put a new one on order. Secondly, the replacement capacitors could have been checked, in just a few seconds, to make sure that each component we installed was actually good. Needless to say, we now use our "**Z METER**" any time we think a coil or capacitor is the cause of our problem. We are even learning to check coils early in our troubleshooting rather than trying to work around them as in the past. Can you see how the "**Z METER**" can save you time too?

19. Are coils here to stay?

Yes, they are. Coil usage is increasing even faster than capacitor usage. Recent EIA figures show that the annual usage of coils has increased over 54 percent in the last four years to over 500 million dollars per year. The reason that coil usage is increasing so fast is about the same as with capacitors. These are really the only two passive components that will not fit inside an IC.

The usage of ICs is rising at a rapid rate because more and more functions that were controlled with other systems, such as relays, and discrete transistor circuits, are now going inside the IC. As the usage of the IC increases, the proportionate number of resistors and transistors reduce, but coils and capacitors must increase.

Another reason for increased coil usage is the increased number of two-way radios and other RF control systems. The coil and capacitor are tied directly into the use of any type of oscillator or tuned circuit. Together with the IC usage, we can safely predict that you will be seeing more coils and capacitors every year for some time.

20. Since I can measure capacity and inductance, can I use the "Z METER" to check transmission lines?

You will find that the "**Z METER**" is an ideal instrument for checking transmission lines. You can use the "**Z METER**" to determine the length of a coaxial cable or pinpoint an open or a short. Each type of coaxial cable has a published capacity per foot. A chart of the most common cables is included in the "**Z METER**" manual. All you do is measure the capacity of the cable with the "**Z METER**" and divide by the capacity per foot to see how long the cable is or find out where a break point is located. It doesn't matter if the break is in the shield or center conductor. The "**Z METER**" reading will still indicate the distance to the break or open. You can even use this technique with the spool of coaxial cable in your shop or lab to see how much cable is left on the spool or how much cable you really used on that last job.

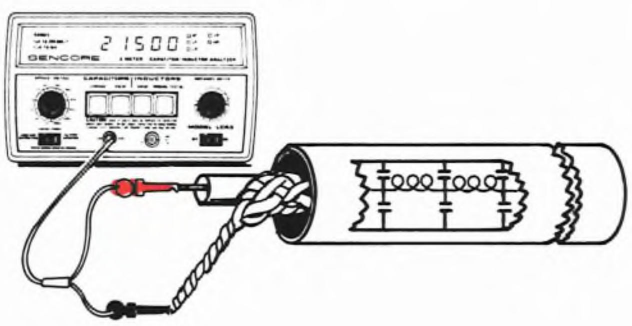


Fig. 24 — Coaxial cable has a fixed capacitance and inductance per foot. Capacitance is measured to find the distance to an open or inductance to find the distance to a short.

A short in a coaxial cable can be easily pinpointed by measuring the inductance of the cable. Inductance per foot is not a published figure. Simply use the "**Z METER**" to measure a known length of the cable to find the inductance per foot. Divide the inductance reading by the length and find your own inductance per foot. This figure can be entered in a special blank column in the "**Z METER**" service manual for that particular cable for future reference. To find a short, simply measure the inductance and divide by the inductance per foot. This figure will tell you the number of feet from the measuring point to the short. A more detailed procedure on testing coaxial cable can be found in the service manual of the "**Z METER**"

21. Who needs the "Z METER"?

The need for the "**Z METER**" is as broad as electronics itself. Sencore has designed the "**Z METER**" with the following industries and people in mind:

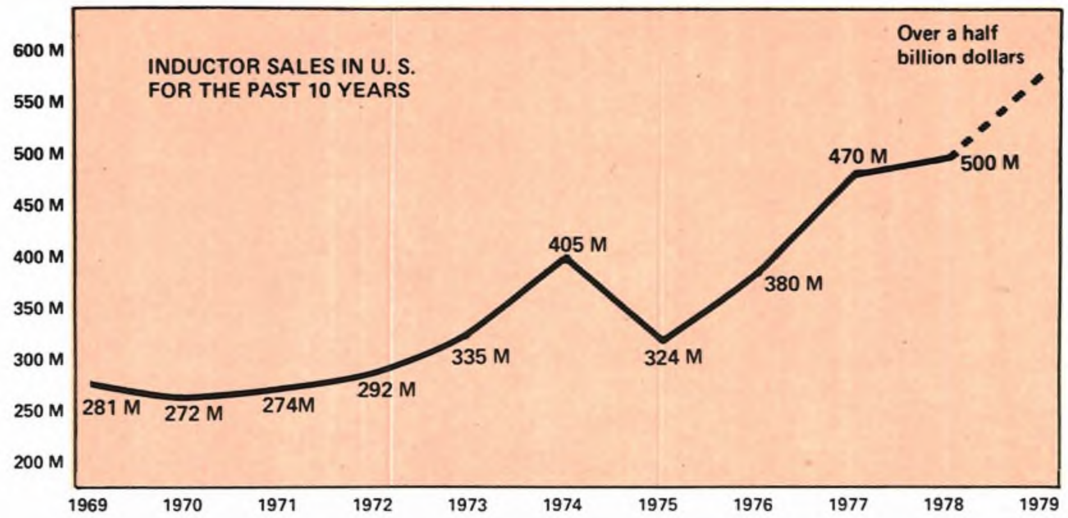


Fig. 25 — The sale of inductors has almost doubled in just the past 4 years. The predicted growth of inductors for the years to come is a steady increase.

The engineer, the technician, two-way radio maintenance, hospital maintenance, industrial control maintenance, incoming inspection, production line analyzers, hams, component manufacturers and, in general, anybody that has to test, use, or measure capacitors and coils. In fact, over half the requests and orders for the "**Z METER**" have come from the engineering and industrial sections of the electronics field. If you have to test capacitors or coils, repair or design electronic circuits that use capacitors and coils, you too should consider the "**Z METER**".

If you only deal with capacitors, then take a look at the CA55 Capacitor Analyzer. It has the same capacitor value and leakage tests found on the "**Z METER**" with the same accuracy, automatic ranging, and reliable test results. If you need more information, would like a free demonstration in your place of business, or just want to find the Sencore distributor nearest you, fill in your Instrument Interest form or call toll-free 800-843-3338 and ask for the Customer Service Department. Do it today because there will be more coils and capacitors in use tomorrow and the day after and you should be ready for them.

SPECIFICATIONS

Digital Readout (LC53 & CA55)

Accuracy: Function accuracy ± resolution error.
Resolution: 3 significant digits ± 2 counts on 3rd digit.
Autoranging: Fully automatic decimal placement. One or two place holding zeros added as needed (does not affect accuracy).
Range Indicators:
Type: LED
Operation: Controlled by the autoranging circuits.

Capacitors (LC53 & CA55)

Dynamic test of capacity value determined by measuring one RC time constant when capacitor is charged to +5V through:
10 Megohms for 0 to 9000 pF
10 Kilohms for 9000 pF to 90 uF
100 Ohms for 90 uF to 199,900 uF
Accuracy: ±1% + resolution error (0 to 1000 uF); ±5% + resolution error (1000 uF and up).
Ranges: 1.0 pF to 199,900 uF in 10 autoranges.

Leakage (LC53 & CA55)

Accuracy: ±5% + resolution error.
Ranges: 0 to 100 uA and 0 to 10,000 uA in two switch selectable ranges.
Voltages: 12 selectable voltage ranges. DC voltages from 3 VDC to 10 VDC filtered. From 15 VDC to 600 VDC, non-filtered. Capacitor under test does the filtering. Available only when LEAKAGE pushbutton is depressed. Capacitor automatically discharged when LEAKAGE pushbutton is released.

Inductance (LC53 "Z METER" only)

Dynamic test of inductance value determined by measuring the emf caused by a constantly varying current through the coil under test. Current rates are:
10 mA/usec — 0 to 90 uH
1 mA/usec — 90 to 900 uH
.1 mA/usec — 900 uH to 9 mH
.01 mA/usec — 9 to 90 mH
1 uA/usec — 90 to 900 mH
.1 uA/usec — 900 to 9,990 mH
Accuracy: ±2% + resolution error (except on high resistance coils).
Ranges: 1.0 uH to 9,990 mH (9.99 H) in 6 autoranges.

Ringing Test (LC53 "Z METER" only)

Dynamic test of inductor quality determined by counting the number of cycles the inductor rings before reaching a preset damping point after a given exciting pulse has been applied. (U.S. Patent 3,879,749).
Exciting pulse amplitude: Approximately 7 volts peak.
Accuracy: Minus one count.

General (LC53 "Z METER")

Power: 105-130 VAC, 60 Hz, 25 Watts.
Fuse: Test lead input with in-line 1 Amp 3 AG slo-blo fuse.
Size: 6" x 9" x 11.5" (15.24 cm. x 22.86 cm. x 29.21 cm.)
Weight: 7¾ lbs. (3.56 Kg.)

General (CA55 Capacitor Analyzer)

Power: 105-130 VAC, 60 Hz, 17 Watts.
Fuse: Test lead input with in-line 1 Amp 3 AG slo-blo fuse.
Size: 4" x 8" x 11.5" (10.16 cm. x 20.32 cm. x 29.21 cm.)
Weight: 6.5 lbs. (2.98 Kg.)

MODEL	Capacity Range	Auto Ranging	Reads in Standard Units of uF & pF	Leakage	Input Protected from Charged Capacitors	Inductance Range	Good-Bad Test on Inductors In- or out-of-circuit	Price
SENCORE LC53 & CA55	0 to 200,000 microfarads 10 Autoranges	Yes 10 Ranges	Yes, Place-holding zeros added as necessary	2 Ranges 0-100 uA 0-10K uA 12 Voltages 3 to 600 VDC	Yes, Fuse & voltage sensing relay	6 Autoranges 0-10 Henrys (LC53 only)	Yes, Patented Sencore Ringing test	**LC53 $695** **CA55 $495**
ESI252 (Electro Scientific, Ind.)	0-200 microfarad 7 Switch Ranges	No	No, has nF*	None	No	0-200 Henrys 7 Switch Ranges	No	$745
ESI253 (Electro Scientific, Ind.)	0-2000 microfarad 7 Autoranges	Yes	No, has nF*	None	No	0-200 Henrys 7 Autoranges	No	$845
B & K 820	0-999,900 microfarad 10 Switch Ranges	No	No, has nF* & mF**	None	Fuse	None	No	$130
ECD (Doric) 130A	0-200,000 microfarad 10 Autoranges	Yes	No, has nF* & mF**	None	Yes, possible damage if large value cap or high voltage	None	No	$325
IET CM-500 (IET Labs, Inc.)	1 pF to 200,000 microfarad 10 Autoranges	Yes	No, has nF*	None	Not specified	None	No	$299
Data Precision 938	0-1999 microfarad 8 Switch Ranges	No	No, has nF*	None	Fused	None	No	$149

* nF = nanofarads, non-standard prefix halfway between uF and pF.
** mF = millifarads, non-standard prefix larger than uF by 3 decimal places

All information taken from manufacturer's published specifications. No claim is made to their accuracy.

NOTE: None of the above competitors check SCRs, TRIACs, stacked diodes, or bridge rectifiers.

Fig. 26 — Comparison of competitive L/C Testers.

INTERFERENCE FREE & FCC ACCURATE

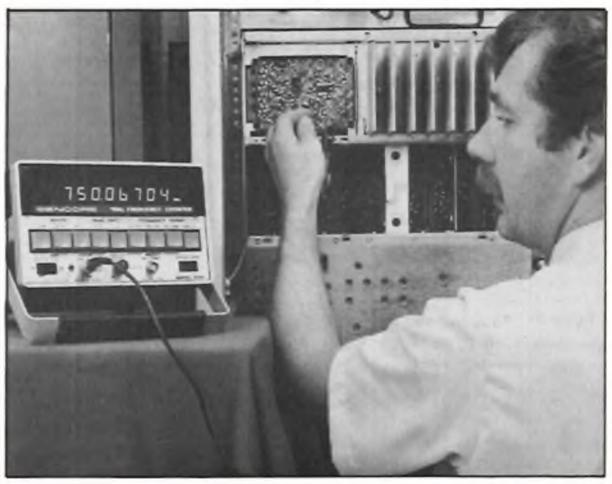
Reach for one universal Frequency Counter for every job from 10 Hz to 1000 MHz

And know that you will always be FCC Accurate and Interference Free

That's the Sencore FC51 1 GHz Frequency Counter Only $975

Lowest priced 1 GHz .5 PPM frequency counter on the market

Your FC51 is FCC accurate with .5 parts per million from 0 to 40 degrees centigrade: Just what you need to service two-way radios all the way through the new 800 MHz band. A must for documenting studio to transmitter link at broadcast stations, documenting radio & TV station frequency accuracy, or when working in the 902 to 928 MHz medical band.

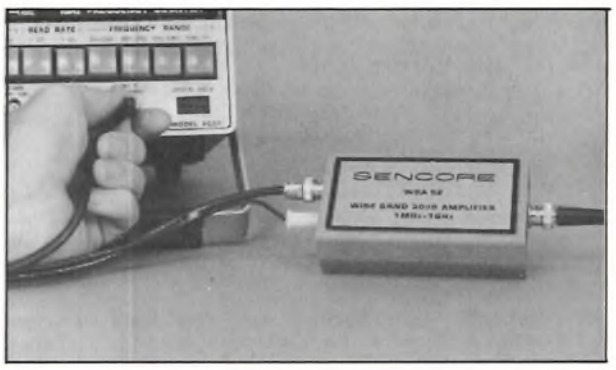


Your FC51 is Interference Free: Park your FC51 right under your high power transmitter or set it right next to a TV high voltage cage and it won't jump a digit. Station operators repeatedly call us and tell us that they can't believe the FC51 is quiet as a cucumber when their high priced frequency counter is doing the disco.

Use your FC51 for direct circuit connection readings: A special 1 megohm input jack with a sensitivity of 25 millivolts provides low loading and high sensitivity for digital count down circuit measurements, PLL circuit testing, etc.

Use your FC51 to measure high power output transmitters: Also tripler or doubler stages or other high signal level stages where excess sensitivity can cause more than one signal to be picked up. A 50 ohm input jack, with an input sensitivity of 100 millivolts, provides just the right sensitivity for maximum stability from 10 MHz to 1 GHz.

Use your FC51 where you need super sensitivity too: There are many times when you'll want to measure in low level circuits, or use the FC51 pick-up loop to "hang back" from the circuit so you don't upset the operating frequency. Then, too, you may want to boost your communication monitor output so it can be read on a frequency counter for accuracy checks. If so, the 30 dB WBA52 Wide Band Amplifier, optional at $295, swings into action to increase the 50 Ohms input sensitivity to the most sensitive frequency counter on the market of 3 millivolts.



Use your FC51 to measure complex signals: Two or more simultaneous signals are difficult to read if you don't have a way to pick out the signal with the greatest amplitude. The built-in sensitivity adjustment on the FC51 reduces the sensitivity until only the signal with the greatest amplitude reads, and thus stabilizes.

Use your FC51 to measure sub-audible tones, too: Push the 10 Hz to 500 Hz frequency range button and a .01 Hz resolution multiplier is switched in to read video tape recorder speeds, two-way guard tones, etc., to a fraction of a Hertz.

Use your FC51 to check crystals: Crystals are used in nearly every communication device today and a frequency counter wouldn't be complete without one. Simply insert the crystal in the crystal holder, push the crystal push button, and read the crystal fundamental frequency.

Shipped with everything you'll need to go right to work: Your FC51 is shipped with all matched leads (others aren't), a special untuned pick-up loop, an adjustable antenna that connects directly to the 50 ohm input jack, and a special 12 volt cigar lighter attachment to operate your FC51 from any vehicle.

No down time for accuracy documentation: A 10 MHz clock is buffered and brought out the rear to use as a calibration standard or to check accuracy against WWV. This time base is removeable and exchangeable with the factory on an exclusive 6 month perpetual calibration exchange system; if you desire the service. The replacement module is sent to you first so there is no down time.

Interested? Fill in your Instrument Interest Card and mail today, or call **800-843-3338** toll-free. Want a special deal? Fill in the coupon below.

Special Offer

Buy the FC51 at $975 — Buy the WBA52 for only $99

If you want to get in on this $196.00 savings, just fill in this coupon and Sencore will authorize your nearest disributor to deliver the FC51 and the WBA52 to you. SPECIAL NOTE: If you own a Sencore FC45 Frequency Counter and wish to trade up to the FC51, we will give your full purchase price of the FC45 for a limited time, but this does not include the $99 WBA52 deal. Just call toll-free 800-843-3338 or fill in this coupon.

Name ______________________ Address ______________________

City ______________________ State ______________ Zip ________

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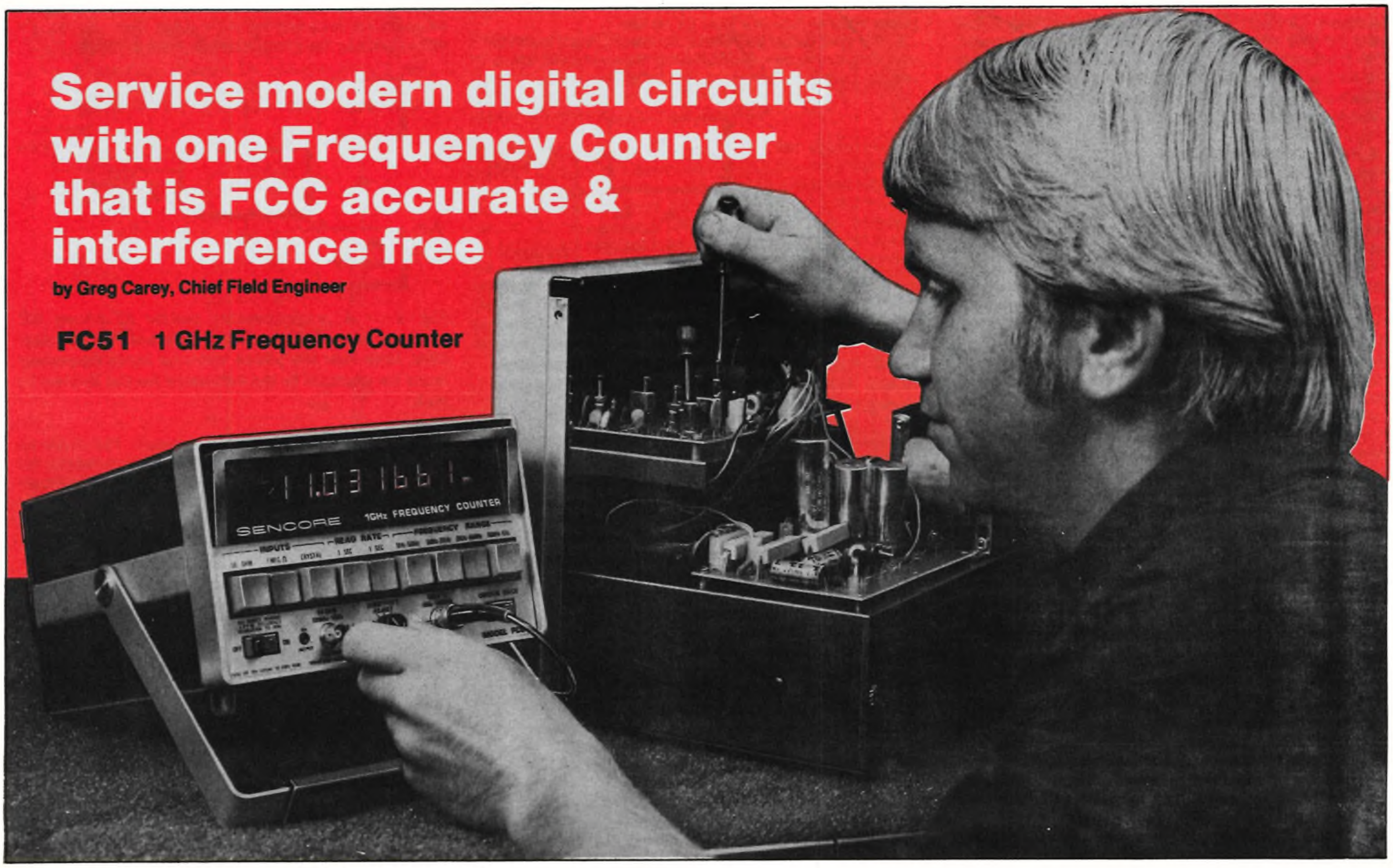
☐ Yes, I am interested in the Sencore FC51 and $99 WBA52. Please see that I get it.
☐ I want to trade in my FC45 frequency counter on the new FC51.

Service modern digital circuits with one Frequency Counter that is FCC accurate & interference free

by Greg Carey, Chief Field Engineer

FC51 1 GHz Frequency Counter



Introduction

This article explains how the Sencore FC45 and FC51 frequency counters are used to troubleshoot digital IC circuits and phase-locked-loops (PLL). Digital circuits and phase-locked-loops are being used in more and more of today's new electronic devices. A design engineer from a large TV manufacturer, for example, recently told us, "You might as well get used to electronic tuners . . . there won't be a single mechanical TV tuner available on a new TV set in a year or so."

It is a good idea to start looking into the instruments required to efficiently service these new digital circuits. The PLL deals primarily in frequency change and frequency stability. Therefore, a high-quality frequency counter is the one instrument that can greatly simplify your troubleshooting. Beware of low cost "bargain" counters, however, because they have only limited usefulness in actual servicing. They are usually limited in upper frequency limits, limited in low frequency resolution, often less accurate than the circuit you are testing, subject to instability on noisy signals, and are subject to interference from signals entering through the unshielded case. Any of these limitations can make the counter useless in these low signal level troubleshooting applications.

Fig. 1 — The FC45 counting system allows you to update your counting capabilities at any time with two optional prescalers and a digital noise filter for use in PLL troubleshooting.

The two Sencore frequency counters offer high performance features at an affordable price. Both the FC45 and the FC51 frequency counters are double-shielded so that you can get dependable readings in strong RF fields. Both offer FCC accuracy because they use oven-controlled reference crystals. You have a choice of the lower cost FC45 counter system or the "accessory free" FC51 counter. The FC45 measures signals from 10 Hz through 230 MHz, with the optional PR47 UHF Prescaler ($125) extending the counting range to 600 MHz. The FC45 measures audio and sub-audible signals to .01 Hz resolution when used with the PR50 Audio Prescaler ($125). Noisy signals, which are common in digital work, are easily measured by adding the NE206 Noise Eliminator ($25), with its three steps of filtering and attenuating action, in series with the input leads.

The FC51, on the other hand, costs more but has all of these options built in and has an upper frequency counting limit of 1 GHz (1000 MHz). The input sensitivity of the FC51 is designed to give the best balance between sensitivity and noise rejection. The optional WBA52 30 dB Wideband Amplifier extends the sensitivity to an unbelievable 3 mV over most of the frequency range for measuring even the lowest level signals. Either one of the Sencore counters is well suited for digital work. The choice is yours.

Doesn't it make sense to buy just one frequency counter to do every frequency counting job; a frequency counter that is especially designed to measure transmitter outputs to FCC standards but sensitive enough for troubleshooting, too? The wide range of applications of both Sencore counters means that they will be usable for more and more applications as the usage of digital circuits continues to increase. The so-called "bargain" counters may not be a bargain at all when they may not be usable in these special applications.

The following article gives you examples of how the FC45 and FC51 are used in troubleshooting digital and PLL circuits. We will cover the different frequency counter requirements you should consider when selecting a frequency counter and then show you how these counter features are actually used in troubleshooting. We look forward to hearing from you after you have finished the article. Fill out your Instrument Interest Coupon or phone our Customer Service Department (toll-free) at 800-843-3338 to find out more details about your Sencore frequency counter.

The digital phase-locked-loop is used in many applications.

The Digitally Controlled Phase-Locked-Loop (PLL) is one of the most common digital circuits that requires a frequency counter for efficient troubleshooting. The PLL is replacing many types of oscillators in a wide variety of applications. The PLL offers high stability because all output frequencies are referenced to a crystal oscillator or some other stable signal source. The PLL is also very versatile because stable, adjustable DC voltages are used to determine the output frequency. This allows low-cost DC switches to be used to select RF frequencies in some applications and complete electronic control of the output frequency in others. Let's review some of the most common uses of the PLL and some of the extra requirements a frequency counter needs for each.

Fig. 2 — Digital phase-locked loops replace standard oscillators in these applications.

TV tuners:
Most TV receivers that use a calculator type keyboard to select channels use a PLL for the tuner local oscillator. Some even use a microprocessor to skip unused channels.

fine tune for cable TV systems, and other programmable functions. TV PLL circuits generate frequencies up to 250 MHz for VHF channels and 850 MHz for UHF channels. The frequency counter should be well-shielded because the strong field put out by the flyback transformer can otherwise cause inaccurate readings when measuring in these low level signal circuits.

Digital vertical oscillators:
Digital circuits are used in the new TV receivers that have no vertical hold control. A PLL is used to reference both the vertical and horizontal signals to the TV station horizontal sync. These digital circuits provide better noise immunity, less jitter on a weak signal, and much better interlace scanning for better vertical detail. The frequency counter used to troubleshoot this system must again be interference-free because of the high voltage section, and also should be able to read frequencies down to 60 Hz to a fraction of a hertz with good resolution. Most direct reading frequency counters do not have this extra resolution, and it is a good thing to check before you make your purchase.

Two-way radio applications:
Most new CB radios, as well as amateur and commercial radios, use PLL circuits to develop the final transmitter frequencies and local oscillator frequencies to receive these signals. The four main factors in selecting a frequency counter for this work are: 1. Full frequency range, 2. FCC accuracy, 3. Full RF shielding because you are often making frequency measurements around operating transmitters, 4. Adjustable sensitivity because you are often trying to measure some frequency other than that put out by the RF output stage. As far as we know, the FC45 and FC51 are the only frequency counters with all these features under $1,000.

Police scanners:
Most new scanner radios use PLL circuitry for the RF local oscillator. These are often controlled by a microprocessor which is programmed for the channel frequencies the customer wants to receive. An accurate frequency counter will assure that the scanner is tuned to the proper frequency in order to produce best sensitivity. Most scanners now operate to 512 MHz which means that your frequency counter must be able to measure to 520 MHz in order to test the local oscillator. Added sensitivity may also be needed for testing in some of the low-level circuits.

AM and FM receivers:
Many Hi-Fi and automotive radios with digital readout channel indicators are PLL operated. An accurate frequency counter is needed to make sure that the digital readout of the receiver is tuned properly so that the receiver has best sensitivity.

RF generators:
Most RF generators use PLL circuitry to allow the use of simple DC switching to select the desired output frequency. The switching may be pre-programmed for specific frequencies, such as the CB band, or programmed with a series of switches into which the desired frequency is dialed. Your frequency counter needs to be able to measure the total range of frequencies put out by the generator being tested and will also need exceptional sensitivity in order to measure the low-level signals put out by most RF generators.

These are just a few of the applications in which the PLL has replaced a conventional RC or LC oscillator. The digital PLL will generally be found any place that you need a stable signal source that can be changed in output frequency. We will need to understand how a PLL operates in order to see how the frequency counter simplifies its troubleshooting. We will start with the most basic type of PLL which only produces a single output frequency referenced to some other signal source. We will then look at the differences between this simple PLL and the digitally programmable type.

How a basic PLL works

The horizontal oscillator of a TV receiver is the most common example of a basic phase-locked-loop. It, like any PLL, must have three main operational sections: 1. A reference signal source, 2. A Voltage Controlled Oscillator (VCO) whose output frequency is controlled by the amount of DC applied to its control input, and 3. A phase detector that produces a DC output voltage proportional to the difference in frequency of the two signals applied to its two inputs. The horizontal sync pulses from the TV station provide our reference signal in this case.

The block diagram in Fig. 2 shows how these three sections are connected together. The VCO will operate at some frequency close to the desired frequency when there are no sync pulses present at the sync input of the phase detector. Let's then see what happens when we apply sync pulses when we tune in a local TV station.

1. The sync pulses and the signal coming from the VCO are compared in the phase detector. There is a DC output voltage produced if they are not the same frequency.

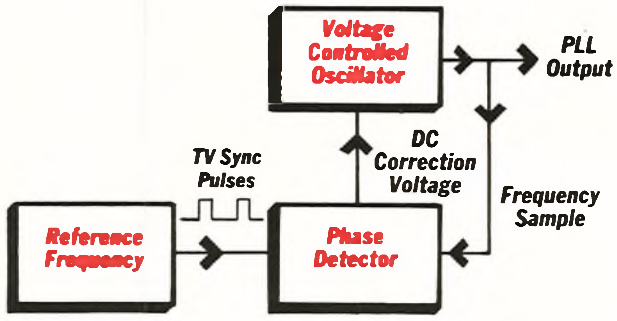


Fig. 3 — All PLL systems must have the three basic blocks. The output is locked to the reference signal through the phase detector.

2. The DC voltage from the phase detector is fed to the VCO input which causes it to change frequencies. The direction the frequency changes depends on the polarity of the correction voltage.

3. When the VCO output is exactly the same frequency as the reference input, the correction voltage is zero. The PLL is now "locked".

4. Any frequency drift in the VCO causes a DC output from the phase detector which will start the entire process over.

All phase-locked-loops operate with this basic feedback action. Additional circuits are required to allow the output frequency of the PLL to deliver any frequency other than the reference frequency. These circuits are covered in the next section.

Why you need a frequency counter for digital PLLs

The two inputs to the phase detector of *any* PLL must be the same frequency for the PLL to lock. Let's see what happens if we insert a flip-flop (or "divide by two") stage between the VCO output and the phase detector input. The frequency at the phase-detector input will be exactly one-half of the VCO frequency. The feedback action of the phase detector will change the VCO frequency until the signal coming from the flip-flop output is exactly the same as the reference signal. This can only happen, of course, if the VCO operates at *twice* the reference oscillator frequency because only half the frequency is making its way to the phase detector. We are actually using a dividing stage to multiply our output frequency. If the divider were a divide-by-four stage, the VCO would have to operate at four times the reference frequency in order for the PLL to lock. Special ICs are available with many flip-flop stages inside a single component for use in PLL design. The PLL that uses only fixed dividers, however, will only put out a single frequency that is a multiple of the reference signal's frequency.

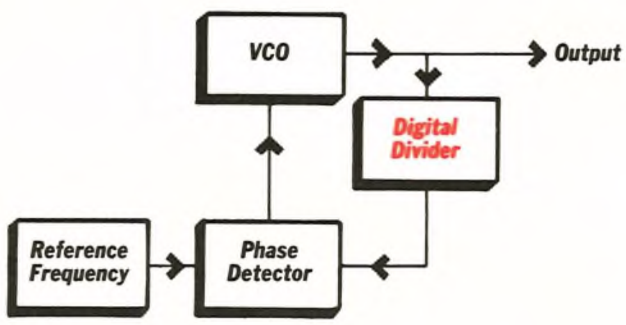


Fig. 4 — The addition of a digital divider produces a PLL output frequency that is an exact multiple of the reference frequency.

The programmable divider:
A special type of IC called a "programmable divider" allows the frequency of the PLL to be changed by use of DC control voltages. A programmable divider is similar to a fixed divider IC except that it has extra "programming" or "JAM" pins. Tieing these pins to B+ in different combinations will cause some of the flip-flop stages to be bypassed which results in a different divide-by number. One such IC, for example, allows any divide-by number from 3 to 15,999 to be selected by applying voltages to the correct combination of 16 programming pins. This IC allows a PLL to be programmed for up to 15,996 (15,999 minus 3) different frequencies, all of which are referenced to the same master oscillator through the phase detector.

Either a programmable or fixed divider IC is easily tested with a frequency counter connected to the input and then the output. The difference in these two frequencies indicates the divide-by number of the stage. These divider ICs often divide by the wrong number, when defective, resulting in the wrong PLL output frequency. The divide-by number of a programmable divider is determined by the combination of programming pins tied to B+. The service literature for the PLL usually shows which pins are tied to B+ for key PLL output frequencies so you can test the IC with a frequency counter.

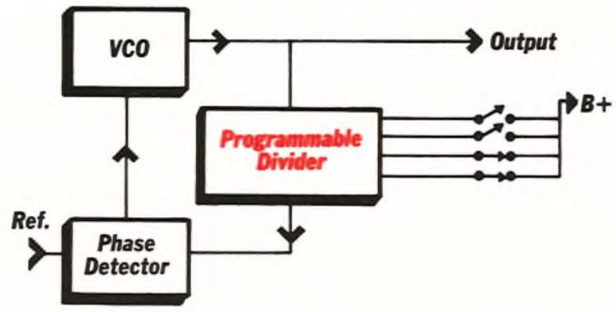


Fig. 5 — A programmable divider IC allows DC voltages to be used to select different PLL frequencies. Note that the phase detector input frequency must be identical to the reference for the system to lock.

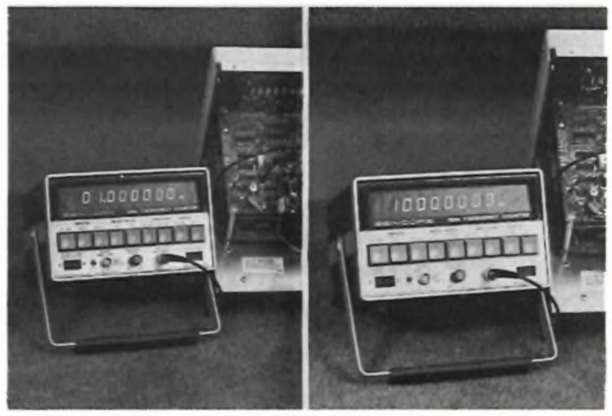


Fig. 6 — The input and output frequencies of a divider are measured to assure it is dividing the signal properly.

Troubleshooting dividers:
Either fixed or programmable divider ICs may divide by the wrong number when defective. A frequency counter with the proper input bandwidth allows you to quickly test the IC. Simply measure the input and then the output frequency to confirm the proper frequency division. You will need to compare the measured division to the programming instructions on a programmable divider. Service literature often provides this information in tables that show which programming pins are to be tied to B+ for certain divide-by numbers.

Stability circuits:
Most PLLs have a few additional stages that are included to provide extra stability in the output frequency. The phase detector operates best with input frequencies in the audio range. One kilohertz is a typical operating frequency. The reference oscillator, however, is usually crystal controlled for extra stability over a long period of time. Crystal oscillators operate best in the frequency range of 1 to 10 MHz. Additional IC dividers are simply added between the crystal oscillator and the phase detect-

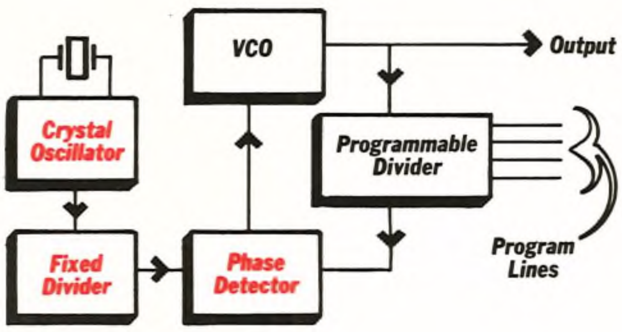


Fig. 7 — Maximum stability requires a crystal oscillator and low frequency phase detector. Fixed dividers are used to match the frequencies.

or so that the best parts of both worlds are built into the PLL. A 1 MHz oscillator, for example, may be divided by 1000 to produce a phase detector frequency of 1 KHz. The programmable divider between the VCO and phase detector must also produce an output frequency of 1 KHz when the VCO is operating at the correct frequency. The frequency counter that you use to troubleshoot this circuit should then provide accurate readings of audio frequencies. The FC51 is ideal for this application because the resolution at 1 KHz is .1 Hz. This allows the phase detector input frequencies to be accurately tested. The same resolution is available with the FC45 when the optional PR50 Audio Prescaler is used.

Master oscillator:
The frequency counter is also used to check the output frequency of the master oscillator. All of the PLL output

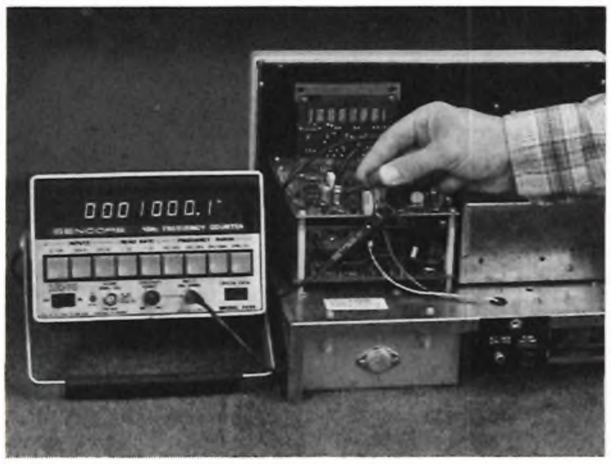


Fig. 8 — The FC51 measures audio frequencies with extra digits of resolution for accurate testing of the phase detector input frequencies.

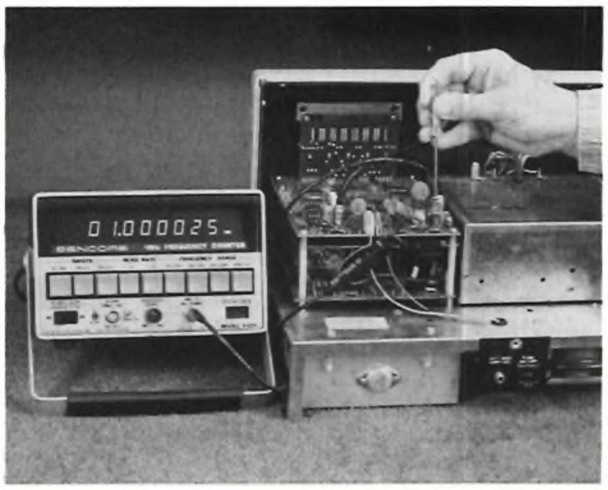


Fig. 9 — The reference oscillator, which is usually crystal-controlled, must operate at the correct frequency or every output frequency will be in error.

frequencies will be incorrect if this oscillator is not operating at the proper frequency. This test requires the highest frequency counter accuracy. Many competitive counters are really no more accurate than the crystal used in many PLL systems. Both the Sencore FC51 and FC45 have ovens to control the accuracy of the frequency counting system to assure high accuracy in every signal that is measured. This assures you that the measurements you make are accurate and that you are not wasting times guessing whether an incorrect frequency is caused by the circuit you are testing or by the frequency counter wandering off calibration.

Voltage Controlled Oscillator (VCO) problems:
Problems in the VCO itself can also result in an improper output frequency. The VCO can only be controlled over a certain range of frequencies known as the "VCO lock-in

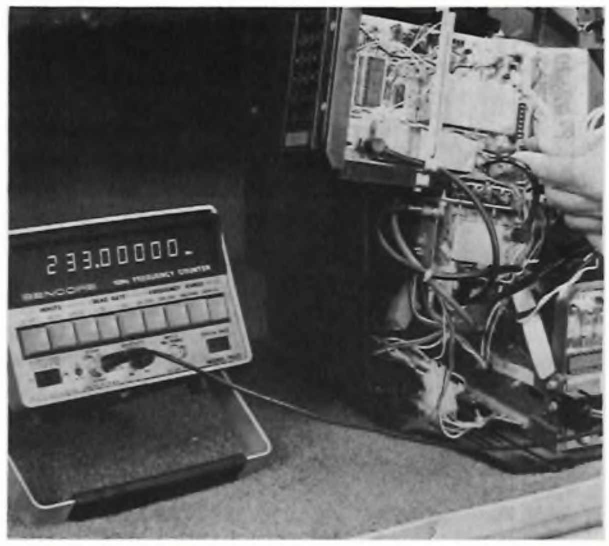


Fig. 10 — The VCO output frequency should be checked to make sure the PLL is operating at the correct frequency. The use of the WBA52 30 dB Wideband Amplifier allows extremely small signals to be measured.

range". The lock-in range is determined by the VCO tuning circuit made up of coils, capacitors and varicap diodes. The varicap diodes receive the DC voltage from the phase detector to change the operating frequency of the PLL.

Most VCOs use at least one adjustment that controls the upper and lower limits of the lock-in range. This adjustment is set to center the lock-in range frequencies over the normal operating frequency range of the PLL. The VCO may lock in a either the highest or lowest frequency but fail to lock at the other extreme. This usually indicates that one of the frequency determining components has changed value. The frequency counter aids in locating this type of problem.

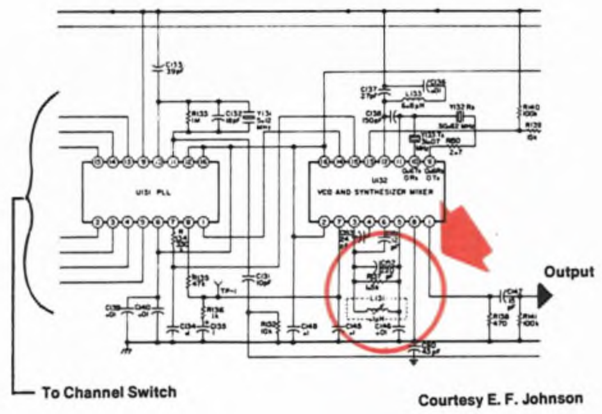


Fig. 11 — The lock-in adjustment should allow you to get stable readings on the highest and lowest frequency.

Simply connect your FC51 or FC45 to the VCO output to check for proper lock-in range. Then select the highest and then the lowest PLL frequncy with the channel selector switch or PLL frequency control. The frequency counter should show a solid reading at both frequency extremes. You should try to adjust the lock-in range adjustment if either of the frequencies are either unstable or off-frequency. There is a problem in the VCO tuning circuits if this adjustment does not allow you to lock both the highest and lowest frequency. The use of a capacitance and inductance analyzer like the Sencore "Z METER" will allow you to isolate problems caused by a defective coil or capacitor.

Why a reliable frequency counter is necessary and why a scope alone will not do the job.

An oscilloscope can be used to trace a few of the signals in a PLL but is limited to only a few sections of the PLL. The main limitations are 1. Limited frequency response, 2. Frequency measurements are very time consuming, and 3. The frequency measurement accuracy is not adequate for proper PLL testing.

You should be able to measure the VCO output frequency to determine if it is correct. This measurement will tell you if the PLL is operating at the correct frequency and is also necessary when testing a divider stage connected directly to the VCO output. Remember that the VCO output is often several hundred megahertz for many PLL applications. This is well beyond the frequency limits of most scopes.

The amount of time required to measure a frequency with a scope is much longer compared to the direct frequency measurement of a frequency counter. First, you must make sure that the horizontal sweep vernier is in the calibrated position. It is a common mistake to forget to check this control with totally meaningless results. You must then determine the amount of time for one cycle of the waveform by counting the number of divisions on the CRT and multiplying by the setting of the timebase switch. Finally, you must convert the time measurement to frequency by dividing it into one. The sad thing is that after you have done all of these things, your measurement is only within about 5-10% of the actual frequency. This accuracy is inadequate for PLL troubleshooting.

Scope measurement errors come from many places. You start with the calibration of the sweep speeds on the scope which is typically only 3-5%. Then you must add interpretation errors such as determining exactly where the waveform starts and stops, estimating the distance between the divisions on the CRT screen and even the width of the trace itself. All of these interpretation errors are eliminated with a frequency counter like the FC51 or FC45 because the counter reads out directly in frequency. The accuracy is determined by the accuracy of the frequency counter crystal which is oven-controlled in both Sencore counters for FCC accuracy on every reading. The FC45 accuracy is 0.0001 percent and the FC51 is 0.00005 percent as a comparison to 5 or 10 percent on the best oscilloscopes.

Frequency counters simplify troubleshooting of digital vertical oscillators in TV receivers.

Digital circuits are now used in many applications that formerly used discrete circuits. A good example is the new digital sweep circuit found in many TV receivers. A single IC replaces both the vertical and the horizontal oscillator. No vertical or horizontal hold controls are needed because of the digital operation.

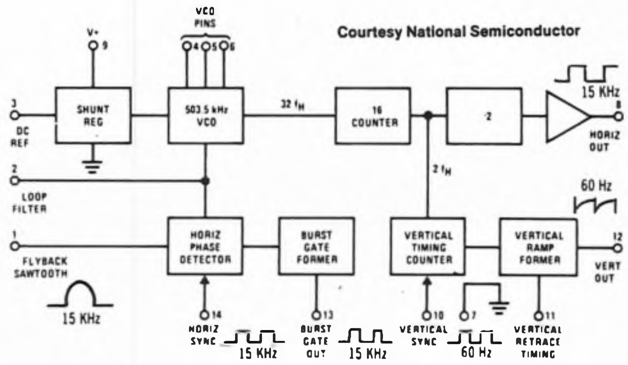


Fig. 12 — This special IC uses a PLL to replace both the vertical and horizontal oscillators in a TV.

The heart of the system is a phase-locked loop that is referenced to the horizontal sync pulses. The PLL runs at 503 KHz which is 32 times the horizontal sync frequency. This frequency is much more stable than the horizontal frequency because a component called a "ceramic resonator" is used to keep the PLL stable between horizontal sync pulses. A ceramic resonator is similar to a crystal but is much lower cost and only slightly less accuracte.

The 503 KHz signal is first divided by 16 with digital dividers. This frequency is needed to provide precise interlace scanning during vertical trace. The resulting 31.468 KHz signal is contained inside the IC and cannot be measured.

The 31 KHz signal is then divided by two to provide the horizontal frequency of 15.734 KHz which is fed to the horizontal output stage. The 31 KHz signal is also divided by 525 in additional digital counter stages to produce the vertical frequency of 59.94 Hz which is fed to the vertical output through special shaping circuits. Additional digital circuits reset the internal counter stages at the proper time to maintain vertical and horizontal sync.

Troubleshooting the vertical oscillator circuit with a frequency counter

The main frequency that we must measure is the 503 KHz PLL output to make sure that the PLL is working properly. Be sure that there are horizontal sync pulses at the IC input, either from a TV station or a signal generator like the Sencore VA48, or the PLL will not be locked to an incoming signal. You will run into problems with many frequency counters at this point because of the strong field put out by the flyback transformer. The fully shielded design of the Sencore FC51 and FC45 will prevent this interference.

The 15.734 KHz horizontal output signal should be measured next. This confirms that the internal digital counting stages are dividing the PLL output by the correct number. You will find that most frequency counters will not measure this signal easily because of interfering signals

Fig. 13 — The FC51 attenuator allows noisy digital signals to be measured which will cause most other frequency counters to give an incorrect reading.

that ride along with the desired signal. The FC51 takes care of this for you with an input attenuator that lets you decrease the counter's sensitivity until the only signal that the counter displays is the desired 15 KHz output. The FC45 has an optional Noise Eliminator (NE206) that provides a similar reduction of noise.

Then measure the vertical output. You will probably again need to reduce the noise pickup because this signal is shaped into a ramp which may cause some counters to give false readings. The frequency should be 59.94 Hz. Most frequency counters do not have sufficient resolution to read out to two places past the decimal. The FC51 has a special circuit that automatically extends the resolution to .01 Hz when the 10 Hz to 500 Hz frequency range button is pushed. The FC45 has an optional PR50 Audio Prescaler that provides this same function.

If either of the output frequencies are incorrect, you know that you have a bad IC. There are no other components in the circuit that could cause the output frequencies to be incorrect.

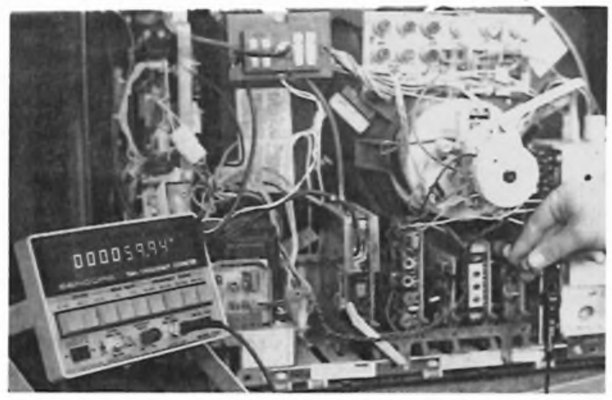


Fig. 14 — The vertical output of a digital TV sweep system should have a frequency of 59.94 Hz when receiving a signal from a TV station. The FC51 provides a direct readout with the necessary resolution to make this test accurately.

Other frequency counter applications

A frequency counter will help you find other types of problems related to oscillator circuits, many of which are not digital. An example we ran across recently in the Field Engineering lab was an old RCA CTC24 chassis that would not give good flesh tones. We used our FC51 to measure the color oscillator frequency when the set was picking a signal off the air and found that the frequency was not 3.579545 MHz as it should be. We then pulled the crystal and tested it on the Crystal Check function of the FC51 and found that it would not oscillate. Replacing the crystal cured the problem.

Video cassette recorders also require the use of an accurate frequency counter for setting color converting oscillators, FM modulation carriers, and servo circuits. You need high accuracy and the ability to measure the 30 Hz control signal to an accuracy of only .01 Hz. Many VCRs also have digital clocks and microprocessors that require precise frequencies.

Some audio turntables require frequency counters for accurate tests of the motor speed. Many motors are now controlled by a crystal oscillator and PLL to maintain constant speed. The high resolution of the FC51 helps troubleshoot these circuits too.

One frequency counter does it all

The usage of PLL and digital circuits is increasing every day. Some technicians have a low-cost frequency counter which helps with some troubleshooting but these counters are usually limited as to the types of circuits they can test. Why buy one counter now and have its usage limited with the next new circuit that comes out? The FC51 lets you measure all signals from 10.01 Hz all the way to 1000 MHz with FCC accuracy all the way. The FC45 takes you from 10 Hz to 230 MHz direct and is easily updated to .01 Hz resolution or 600 MHz upper counting capabilities with two low-cost prescalers. Both Sencore counters are FCC accurate and both are double shielded to prevent erratic counting in RF fields.

There is no doubt that buying one frequency counter that does the whole job actually saves you money in the long run. Why don't you decide which Sencore frequency counter you want right now and fill out your Instrument Interest Coupon? If you would rather, simply call the Customer Service Department toll-free at 800-843-3338. We'll see that your new Sencore frequency counter is on its way to you today.

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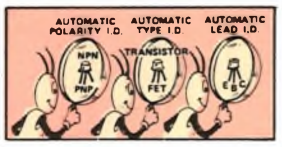

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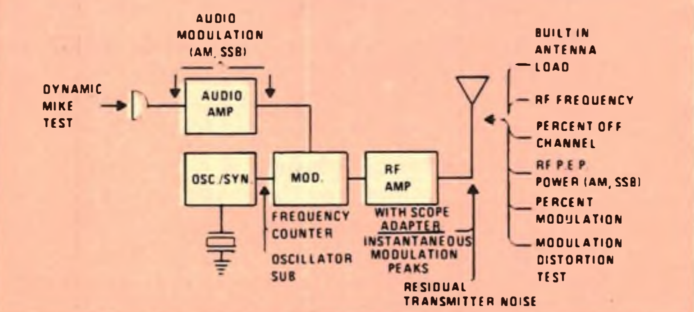

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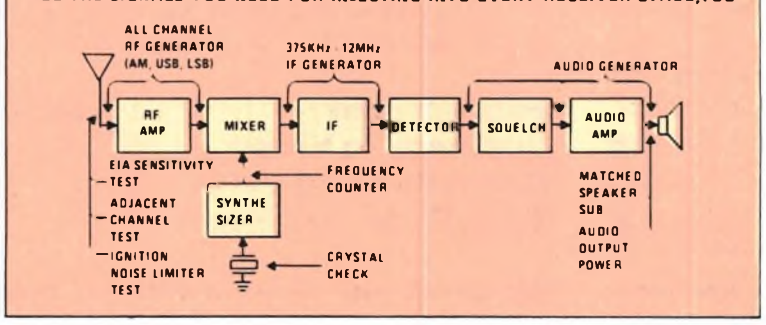

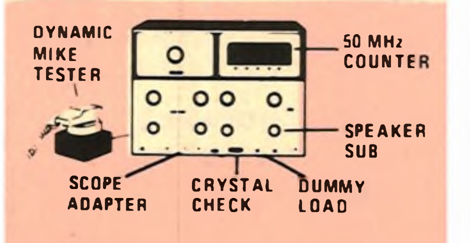

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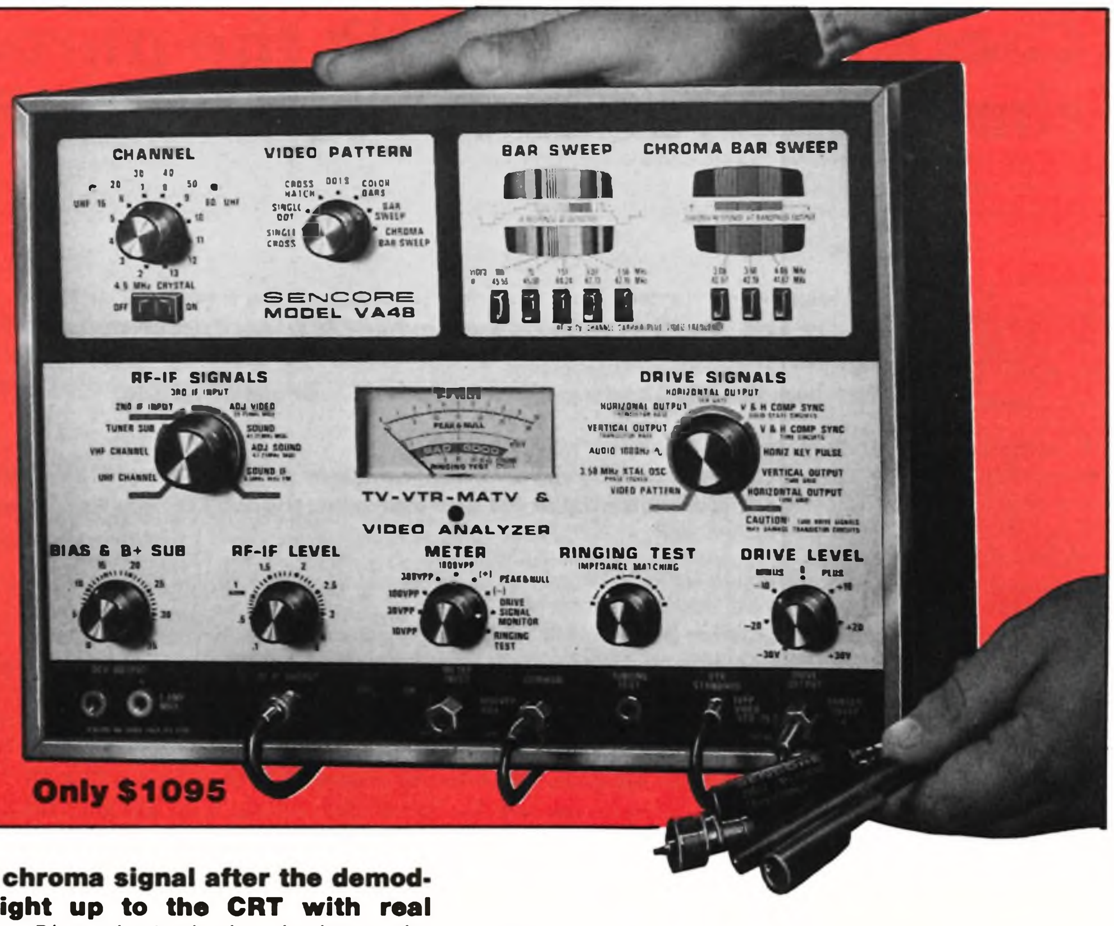

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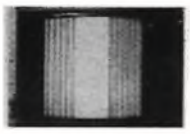
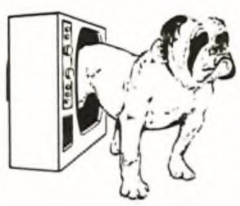


1. **Check all VHF and UHF channels.** *No other analyzer checks them all.*
2. **Substitute for all tuners.** *No need to carry a separate tuner sub.*
3. **Check sensitivity of the receiver or simulate fringe or rabbit ear conditions.** *The only analyzer that has calibrated RF output.*
4. **Pinpoint troubles to each IF.** *Has preset IF outputs for each IF stage.*
5. **Set IF traps with crystal accuracy.** *1000 Hz modulated crystal provided for each trap so you can set them right on the nose on the CRT.*
6. **Check alignment without a scope.** *View pattern right on CRT.*
7. **Set traps and coils with built-in peak and null meter.** *No need to keep a second analog meter for this purpose.*
8. **Align IF amplifiers as you troubleshoot them.** *Bar Sweep pattern makes it easy.*
9. **Check the AGC system dynamically.** *Change signal level and watch affect on AGC as actual sync pulses trigger gated AGC.*
10. **Do away with a bias box to tie down AGC for alignment.** *15,734 Hz sync signal produces "station-like" dynamic "true" AGC bias.*
11. **Align new synchronous detectors.** *Set detector linearity with built-in video step pattern and set frequency response, too, with only sweep system that produces the needed video carrier.*
12. **Check video amplifier frequency response, closed circuit video response, VCR video.** *Simply switch to video pattern with no RF or IF.*
13. **Check out MATV and CATV systems.** *Has both 75 and 300 Ohm matching transformers.*

Color Alignment and Troubleshooting Made Easy

14. **Substitute for the 3.58 MHz color oscillator and keep colors in sync.** *All signals are phase-locked.*
15. **Substitute signals before the color demodulator and keep colors in sync.** *Phase-locked signals makes the job easy.*
16. **Inject a chroma signal after the demodulator right up to the CRT with real meaning.** *Phase-locked signals keep the entire system in sync so you can tell what you are doing.*
17. **Align the chroma bandpass amplifiers right on the CRT.** *3.08 MHz, 3.56 MHz, and 4.08 MHz chroma bars makes the job a snap.*
18. **Set the color oscillator on CRT without grounding test points.** *Easier and more accurate than procedure described in TV manufacturer's service literature.*
19. **Check and adjust color killer dynamically right on CRT.** *Faster, easier, and more accurate than procedure in TV manufacturer's service literature.*
20. **Set CRT and drive signals without using set-up switches.** *Easier and more accurate as circuits are not upset with service switches.*
21. **Check new comb filters in TV and VTR circuits.** *Signals must be phase-locked to make this check.*

Dynamically check sweep circuits and kick those tough dogs off your bench



22. **Check yokes and flybacks in tube or solid-state.** *Used in or out-of-circuit with tried and proven patented ringer test.*
23. **Check SCR horizontal output stages.** *Provides special signal for SCR outputs. Checks SCR, too.*
24. **Check all keyed stages with adjustable keying pulse.** *Pulses are positive or negative to catch every tube or solid-state stage.*
25. **Walk troubles out of vertical stages with adjustable and universal drive signals.** *Shaped for tube and solid-state separately.*

Expand your Business to Video Cassettes and Video Tape Recorder Repair

26. **Check with standard VTR test signal.** *1 Volt peak-to-peak into 75 Ohms as specified by manufacturers.*
27. **Check frequency response on record and playback.** *Use patented bar sweep pattern to set frequency responses on VTRs.*
28. **Service or align VTR tuners and IF stages.** *Works just like it does for color TV.*
29. **Inject signals into defective recording circuits.** *Phase-locked signals makes it easy.*
30. **Check chroma response of VCR.** *Check full 1 MHz chroma response with Chroma Bar pattern.*

Troubleshoot with More Confidence with Everything You'll Need

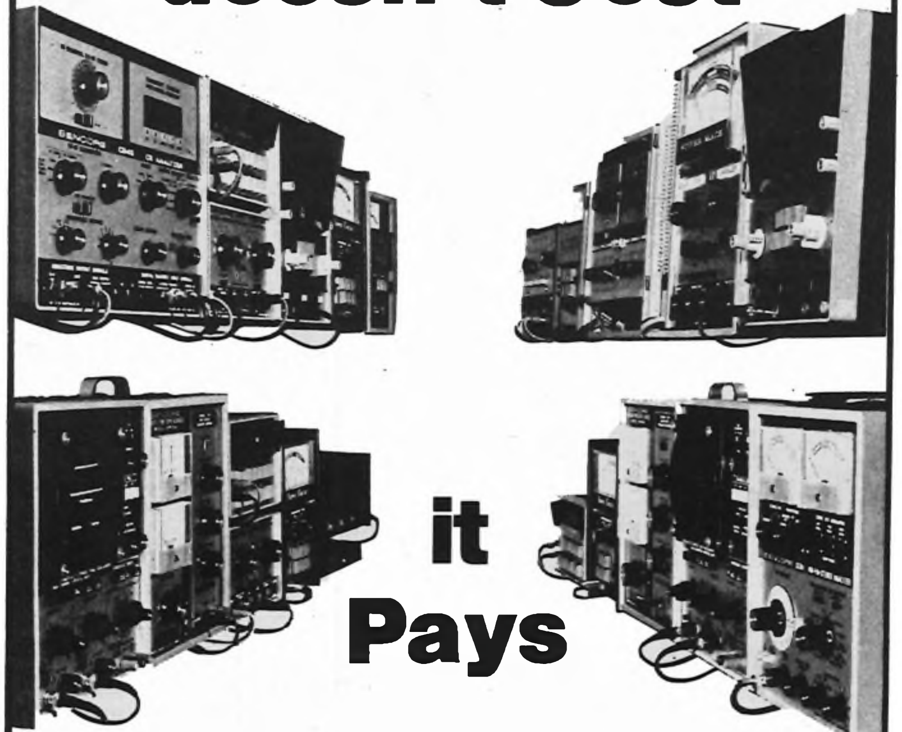
31. **Keep TV in sync at all times.** *Makes no difference where you inject a signal as long as all stages after that point are okay.*
32. **Use electronic patterns all the way.** *No need to fuss with mechanical systems.*
33. **Troubleshoot audio, sound IF, and even drive the speaker.** *Provides signals for every test.*
34. **Substitute signals in every stage from antenna to CRT.** *Only analyzer that has a signal for every stage.*
35. **Check sync stage with true FCC specified sync pulses.** *Patterns look just like those on schematics with no interpretation.*
36. **No need to remove a single component in any stage for test.** *VA48 output swamps out incoming signals so you can inject signals without unsoldering a single component.*
37. **Substitute signals for every input and output.** *All signals are fully adjustable positive and negative.*
38. **Monitor your drive signals so you know what is going on.** *Built-in meter monitors all signal peak-to-peak values at all times.*
39. **Substitute bias in AFC, APC, ACC, and AGC for troubleshooting stage.** *Provides B Plus power for substituting for scan derived voltages, too.*
40. **Signal trace stages if you prefer.** *The built-in meter can be switched to a broad band peak-to-peak signal tracer where signal tracing is faster.*

Be sure to attend a Sencore seminar this Fall where these 40 things are demonstrated.

INTERESTED? *Fill in your Instrument Interest Card and mail it today, or call toll-free* **800-843-3338** *and let's talk about it.*

Rich Brockway
Customer Service

Test Equipment doesn't Cost



it Pays

Important ideas on the "business" of test equipment

One often thinks of test equipment as an outlay of money and an expenditure. One should think of the purchase of test equipment as an investment in greater profits and capability for the future. A man is only as good as his tools and tools only as good as the knowledge and know how of the man. Test equipment is that tool that enables the knowledgeable to do things *that* he couldn't before and thus expand his capability. It is this expanded capability *that* insures a bright future.

Technology is moving at a rapid pace. Periodicals, such as the Sencore News, are being read by more and more people each month to keep up as we move into microprocessor applications. One can learn much more about circuit operation by working in that circuit, viewing waveforms, studying circuit action or learning to analyze faster and more thoroughly with instruments that are designed by "updated" engineers. Sencore engineers are right on top of this new technology and now designing instruments with microprocessors in them.

Why instruments "cost" just pennies

Let us have a realistic look at the cost of instrumentation. Suppose you purchased one of every instrument in each category of the Sencore line so you were totally prepared for the future. Your total investment would be somewhere around the $6,000 mark, or perhaps $8,000 if you chose only the top of the line or selected more than one from some categories. What is an $8,000 investment in the entire Sencore line? First, it is no more than the cost of one popular piece of communication test equipment, the cost of the production line calibration tester that we use to calibrate your DVMs, or a delivery wagon to pick up TV sets.

You don't write off your test equipment in one year. You normally write this kind of an investment off in four years. You don't save up all your pennies to buy a station wagon, do you? Why not finance your test equipment the same way you buy your station wagon? Makes real good sense (and cents), doesn't it? What's more, the interest is tax deductible, lowering your real cost even further.

Okay, so over a four-year period, your entire shop or lab of Sencore equipment, purchased in the middle of the line, costs you approximately $2,000 a year (interest and all). Is that so much for all the tools that you really need to do a job? If you get in 300 working days with your equipment, you are spending only $6.60 a day or 75 cents an hour. Imagine that, the entire line, and the top of the line all the way at that, for only 75 cents an hour, one-fifth the cost of a receptionist.

A well-equipped shop adds profit dollars

Most technicians' labor is billed or calculated out anywhere from $15 to $25 an hour these days, including overhead. Just how much would you guess a full line of up-to-date equipment would save you in efficiency? Would you estimate 50 percent? Would you estimate 25 percent? Well, it is pretty hard to estimate below 10 percent, now isn't it? Taking the very worst case conditions of $15 an hour and only 10 percent increase in efficiency, this comes to a savings of $1.50 per hour and you rack up 75 cents an hour in the profit till after subtracting 75 cents for the cost of equipment. If you normally "knock out" five jobs and a full line of equipment could help you get out six, the savings amounts to a 20 percent increase, or an added $3 per hour in effective labor with $2.25 per hour going into profits. If you happen to be in a position to share this equipment with one other person, you have saved an effective $6 per hour in labor. If you should share with three people, the entire cost runs only a quarter an hour and the effective labor-saving could run $9 an hour and $8.25 per hour profit.

You're paying for it, why not own it?

Isn't it pretty obvious that you are already paying for the equipment that you don't have? If you are paying for it every single day, why don't you own it? Think about it and then think about the Sencore line of time-saving test instruments. Get out a sharp pencil and perhaps you will see why the progressive technician always seems to be up to date on the latest circuit technology and has the latest in test equipment as well. Which do you think came first, the knowledge or the instrument?

Join the growing Sencore sales team

Ever think of selling Sencore Instruments? If you have a good technical background, understand these Sencore Instruments, and realize how they are designed to save time, you may want to join the growing Sencore sales team. Sales experience is important but not essential. If you can influence others, and think you can sell, you probably can.

What does Sencore give you?

- A classy Sencore van with a full set of Sencore equipment.
- A full set of demonstrators, video taped technical programs and video tape player, and all the selling tools you'll need.
- A protected territory so your efforts are proportionate to your talent and energies.
- A complete list of Sencore News readers and tons of sales leads.

How do you get trained?

- You spend two weeks at the factory, two weeks in the territory, two weeks back in the training lab, one week out, and another week back in training. This includes both technical and sales training.
- A sales manager works with you in the field to sharpen your selling technique. Duane Shultz, our technical director, travels with you one additional week for on-the-job training.

What are my basic requirements for the job?

- Good technical background with knowledge of new digital logic circuits.
- Ability to teach at seminars and not put people to sleep.
- Ability to travel on a limited basis depending on geographical size of territory.
- Ability to relocate if opening is not in your area.

How am I compensated?

- A healthy draw that you don't have to repay should you fall short.
- Full company benefits including profit sharing.
- A weekly expense account.
- Straight commission after guaranteed draw is met so you have a real piece of the action.
- Prizes and awards for goal making.

What areas are now open?

Presently most openings are in California, southeastern area from Atlanta to New Orleans, New England, and New York City.

How do I apply?

- Just call me, Al Bowden, toll-free at 800-843-3338 and let's talk about the job openings and how you might fit into them.
- Fill out the short form below and I will get back to you at your convenience.

Sales Engineer Application Form

Name ______________________

Address ______________________

City, State, Zip ______________________

Phone Number that you want to be contacted at: ______________________

Best hours and days to be contacted here: ______________________

I think I would like to go into selling because: ______________________

____

I have the following background that should help me in selling: ______________________

____

I am presently employed as ______________________

Here are some of my previous jobs and dates I held these positions: ______________________

____

Be the AM-FM Stereo Expert in your area

with the SG165 AM-FM Stereo Analyzer

- **You will need the SG165 to check out combination CB-AM-FM radios.**
- **All signals delivered through a single output cable.**

Only $695

- **Pinpoint troubles to any stage from the antenna to the speakers in minutes.** Customer after customer writes us each month and tells us "we don't know what we would do without the SG165, now that we have learned to service the easy way".
- **Simplify AM-FM troubleshooting beyond your fondest dreams:** Cut servicing time in half and put the profits in your pocket.
- **Expand your shop to take advantage of the exploding FM and audio business.** There are now more FM stations on the air than AM and the audio business is just beginning to expand.
- **Protect your ears or avoid getting a screwdriver in the back from your service buddy on the next bench:** Two 100 Watt dummy loads substitute for speakers so you can work in silence, avoiding that annoying 1000 Hz howl.
- **Prove to yourself or your customer that you have really done a job.** Two 10 Watt and 100 Watt meters monitor your work to show you wattage dissipation in both channels and the amount of dB separation between them.
- **Clean up your bench and reduce connecting time:** One cable is all that's needed for every signal substitution in every stage of any AM-FM or stereo system.
- **Align the receiver too, and add it to the service bill:** A built-in sweep and marker enables you to align in a conventional way. A speedy vector alignment method is also explained in the operating manual.

INTERESTED? Fill in your Instrument Interest Card and mail it today, or call toll-free **800-843-3338** and let's talk about it.

Rich Brockway
Customer Service

Renew your Sencore News with this coupon

— or use the Instrument Interest Card if included with this Sencore News.

NOTE: 20 DVM35s are given away each month from drawing of all who tell us what they intend purchasing soon, regardless of what form you put it on.

YOU MUST RENEW YOUR SENCORE NEWS EVERY 24 MONTHS. If you have not sent this coupon in recently, please do so now. If you tell us what you plan on purchasing soon, you will qualify for the monthly DVM drawing.

IMPORTANT

Don't miss a single issue of the Sencore News.

IF IN DOUBT, send your renewal form in again. We will simply update you to the date you send it in. Your name won't be duplicated.

Save $8.00
Save $8.00
Save $8.00
Save $8.00
Save $8.00
Save $8.00

SENCORE NEWS IS SENT FREE OF CHARGE TO OWNERS OF SENCORE INSTRUMENTS OR THOSE WHO INDICATE THEY ARE GOING TO PURCHASE A SENCORE INSTRUMENT(S) IN THE NEAR FUTURE. All others, except field engineers and instructors pay $8.00 to cover the cost of postage and handling. Please fill in the questions below if you wish to continue being on the Sencore News mailing list free of charge for the next 24 months. Also, use this form to request being on the Sencore News mailing list if you have not been receiving the Sencore News.

☐ I am a Sencore customer. I own the following Sencore instruments: ______________________

I plan on purchasing the following Sencore instruments soon. (Qualifies for monthly FREE DVM35 drawing if filled in.): ______________________

☐ I do not now own any Sencore instruments, but am interested in purchasing the following Sencore instruments. (Qualifies for monthly FREE DVM35 drawing if filled in.): ______________________

☐ I am an electronics instructor or field engineer and am qualified to receive the Sencore News free of charge.
☐ I do the following work, which I think qualifies me to receive the Sencore News free of charge: ______________________

☐ None of the above: Enclosed is $8.00 for payment of mailing and handling the Sencore News for the next two years.

Please indicate your major occupation (check only one).
☐ Radio/TV Service ☐ Communications Repair ☐ Broadcast ☐ Audio/Sound Work ☐ Design
☐ School or Teaching (not student) ☐ Industry Maintenance and Repair ☐ Hospital or Medical Equipment Maintenance
☐ Other (specify) ______________________
My company employs ______ (number) people
Please indicate by a check mark (✓) to which address you want the Sencore News sent.

☐ NAME ______________________ ☐ COMPANY NAME ______________________
HOME ADDRESS ______________________
CITY ______________________ ADDRESS (If different from home address) ______________________
STATE ____________ ZIP ________
PHONE ______________________ PHONE ______________________

I wish that Sencore would design and market the following instruments for my use: ______________________

Return to: Sencore, Inc., 3200 Sencore Drive, Sioux Falls, SD 57107

Form 1927SN