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tech tips

Understanding The LC103's In-Circuit Capacitor Test

Capacitors continue to be found in electronic circuits in record breaking numbers. In fact, the number of capacitors used in the manufacturing of electronic circuits continues to rise each year. In 1997, U.S. factories sold over 50 billion capacitors. As these capacitors age or are stressed by circuit voltages and heat many will fail causing improper circuit operation.

Finding a bad capacitor and replacing it to restore normal circuit operation is challenging. First, you must identify which capacitor is suspect. Second, the capacitor must be unsoldered, removed, tested and reinstalled if good or replaced. These steps can be time consuming and you also risk damage to the circuit board traces or the capacitor. In fact, many manufacturers suggest replacement of surface mount capacitors when unsoldered and removed. Time and money is wasted if the removed capacitor is good or a replacement doesn't fix the problem.

The Sencore LC103 "ReZolver" provides a patent pending test of capacitors while still soldered in-circuit. The in-circuit capacitor analyzing test determines if the capacitor is good, bad, or if it should be removed for further tests. This Tech Tip covers how to test capacitors in-circuit with the LC103's In-Circuit Capacitor Good/Bad test and explains how to interpret the test results.

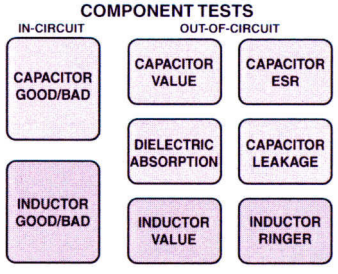

Fig. 1: The Sencore LC103 "ReZolver" provides a patent pending in-circuit capacitor test to reduce servicing time and expense.

In-Circuit Capacitor Testing Challenges

Obtaining meaningful and reliable test results when analyzing a capacitor in-circuit has many complications. First you must make an electrical connection to each of the capacitor's test leads and maintain a stable connection while performing the tests. Second, you must perform analyzing tests that determine with a high reliability if the capacitor is good or if it may have a defect and should be removed for further testing. You also need the flexibility to test a wide range of capacitors found in today's circuits to be comprehensive. Finally, you need a simplified solution to interpreting the in-circuit capacitor test readouts to avoid confusion.

The first challenge is simply making connection to an in-circuit capacitor. Electrical connections to each of the capacitors leads while soldered in-circuit is complicated by a wide range of capacitor types, values, sizes and mechanical lead basings. Since most capacitors do not expose enough lead length for clip lead connections when soldered in-circuit, connections must be made on the solder side of the circuit board. Surface mount capacitors are already mounted directly to the solder side. Connection to the soldered side of the circuit board requires 2 sharp probe tips. Connecting to each of the capacitor legs requires a hand for each probe, leaving no hands to operate a test instrument. Even if you were able to hold each probe with one hand, reaching or looking at the test instrument could easily cause you to slip off the capacitor resulting in improper measurements, frustration and potential circuit damage.

Sencore has overcome these mechanical difficulties with the innovative Adjustable In-Circuit Test Probe. The Adjustable In-Circuit Test Probe (AP291) joins two probe tips and provides an adjustable spacing wheel. The probe mechanically adjusts providing the versatility to fit the lead spacing of capacitors ranging from surface mount to large electrolytics.

The angled tips provide ease in probing surface mount electrolytic capacitors. A push button switch conveniently located on the test probe enables the LC103's in-circuit capacitor test to avoid probe slippage. For most applications, the probe can be adjusted and connected to the in-circuit capacitor with one hand. In addition, the LC103 beeps when the first complete measurement is complete and the readings are momentarily frozen on the LC103 display after the test button is released to be sure you have sufficient time to view the in-circuit test result.

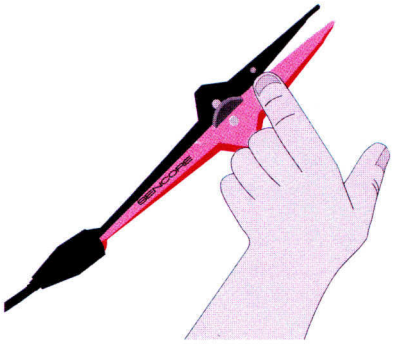

Fig. 2: A push button switch conveniently located on the test probe enables the LC103's in-circuit capacitor test.

While capacitors fail in several ways a combination of two common measurements, capacitor value and equivalent series resistance (ESR), can determine if a capacitor is likely good or suspect in-circuit with a high level of reliability. Aluminum Electrolytic capacitors and tantalum capacitors commonly fail from increased ESR prior to changing value and increasing in leakage. Other capacitor types commonly change value. Testing both value and ESR provides the most comprehensive and accurate in-circuit test results. An ESR tester alone would mistakenly report a shorted capacitor or circuit short as good. Likewise, a capacitor value test alone would miss capacitors with excessive ESR.

Accurate in-circuit capacitor testing can be hindered by the presence of components in parallel with the capacitor. Capacitance, resistance, inductance and semiconductor junctions in parallel with the capacitor may influence the accuracy and reliability of in-circuit capacitor tests. At times the parallel components may have little effect on the accuracy of the tests but at other times the parallel components cause significant changes to the test results. It is important to know when the parallel components are effecting the in-circuit capacitor measurements.

The LC103's In-Circuit Capacitor test function measures the capacitance value and ESR of an in-circuit capacitor. These measurements are simultaneously displayed in the COMPONENT TEST RESULTS display. Capacitance value measurements range from 0.002 µF to 20,000 µF. Capacitor ESR measurements are displayed for capacitors ranging in value from 0.02 µF to 20,000 µF. Measurement voltages are below PN forward bias voltages so the tests are unaffected by semi-conductor junctions.

The LC103's In-Circuit Capacitor test performs several sophisticated tests to determine if parallel components are present which may be effecting the accuracy of the in-circuit capacitance value and ESR measurements. The tests include a test to determine how much current is needed to hold a capacitor charge. Current exceeding the original charging current by 20% indicates parallel resistance that can impact the capacitor value test. A second test uses a selection of test frequencies and analyzes the Xc of the circuit. A capacitance value is determined and compared to a capacitance value determined with an RC time constant value measurement. Large differences in the capacitance values indicate parallel components which would impact the in-circuit measurement accuracy.

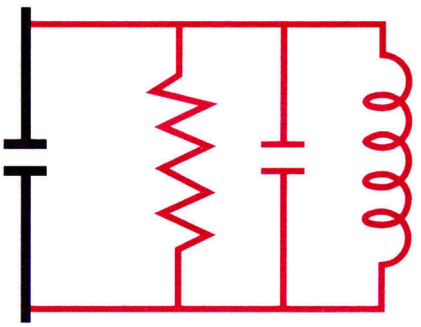

Fig. 3: The LC103 analyzes the capacitor for parallel components that would alter the accuracy of the in-circuit test results.

It can be difficult to determine if a capacitor ESR readout is normal or not as capacitor ESR values vary among different capacitor types and also vary with the capacitor's value and voltage rating. A calculator would be needed to determine if the measured capacitance value is within a normal tolerance.

The LC103 provides Good/Bad test analysis with every in-circuit capacitor test to help determine if the capacitor value and ESR is within a normal range. ESR evaluations are based upon maximum allowable limits established by component manufacturers and the Electronic Industries Association (EIA). Capacitor measured values are automatically compared to maximum and minimum values calculated from the entered value and tolerance of the capacitor being tested.

LC103 In-Circuit Capacitor Testing

The LC103 offers two alternatives for Good/Bad testing a capacitor with the In-Circuit Capacitor Good/Bad Test function, You may perform a basic Good/Bad test of the capacitor or a complete EIA Good/Bad test. Both testing alternatives perform the same analyzing tests but use different references for Good/Bad interpretation. The display readouts vary slightly depending upon the test alternative.

To perform a basic Good/Bad check apply power to the LC103 and attach and zero the test probe. Connect the Adjustable In-Circuit test probe to the capacitor legs and push & hold the front panel CAPACITOR GOOD/BAD push-button switch or the small push-button switch on the In-Circuit Test Probe. The test results are shown in the COMPONENT TEST RESULTS display.

In-Circuit Capacitor Test	Component Parameters	Good/Bad Judgement Factors
Basic Good/Bad Check	None	Measured capacity and 50V Tantalum ESR Chart if >1 µF Ceramic (10Ω) if <1uF
EIA Good/Bad Test	Capacitor type, value, tolerance, rated voltage	Based on the EIA chart for entered capacitor type Measured capacity versus entered value/tolerance

Chart 1: The LC103 performs a basic Good/Bad test of the capacitor or a complete EIA Good/Bad test. Both testing alternatives perform the same in-circuit analyzing tests but use different references for Good/Bad interpretation.

The display readouts shown during the basic Good/Bad check include the capacitance value, capacitor ESR and a "GOOD??" or "BAD??" or "SUGGEST REMOVAL" display readout. ESR is not displayed for capacitor values below 0.02 µF. The good or bad evaluation is based upon the ESR measurement and the measured capacitance value. For measured capacitance values over 1 µF, the measured ESR is compared to the maximum ESR values for a similar value tantalum capacitor as determined by the EIA. For measured capacitor values less than 1 µF, a 10 ohm good/bad reference is used. ESR values of 10 ohms or more are considered "BAD??" while less than 10 ohm are considered "GOOD??."

Question marks accompany both the good or bad readouts during a basic Good/Bad check because the LC103 can not compare the measured capacitance value to the rated value of the capacitor being tested. When you see the question marks, remember to check the LC103's capacitance measurement to the capacitor's rated capacitance value to determine if it is within a normal tolerance.

Note: Double Layer Lytics and High R Double Layer capacitor values are beyond the range and testing capability of the In-Circuit Capacitor Good/Bad test. The In-Circuit Capacitor Good/Bad test should not be used on these capacitor types.

To Perform an In-Circuit Capacitor - Basic Good/Bad Check:

1. Apply Power to the LC103.
2. Connect the In-Circuit Adjustable Test Probe to the LC103's TEST LEAD jack.
3. Perform the Lead Zero Adjustment.
4. Connect the probe tips to the capacitor leads.
5. Push & hold the In-Circuit CAPACITOR GOOD/BAD push-button or test probe push-button.
6. Read the COMPONENT TEST RESULTS display.

IMPORTANT

Do not hold-in the CAPACITOR GOOD/BAD switch or Adjustable Test Probe push-button switch while connecting the Test Probe to an in-circuit capacitor. The LC103 circuitry may be damaged because capacitor discharge protection is lost.

A complete EIA Good/Bad test evaluates both the measured in-circuit capacitance value and ESR.

The display readouts shown during the EIA Good/Bad test includes the capacitance value, capacitor ESR and a "GOOD" or "BAD" or "SUGGEST REMOVAL" indicator. An ESR measurement readout is not displayed for capacitor values below 0.02 µF. The good or bad evaluation is based upon both the measured capacitance value and measured ESR. The measured capacitance value is compared to the entered value and tolerance. The measured ESR is compared to the maximum ESR determined by the EIA for the entered capacitor type. If the measured capacitance value is out-of-tolerance and/or the ESR exceeds the maximum determined by the EIA, a "BAD" readout is indicated. If the capacitance value is within the rated tolerance and the ESR is below a maximum EIA level, a "GOOD" readout is indicated.

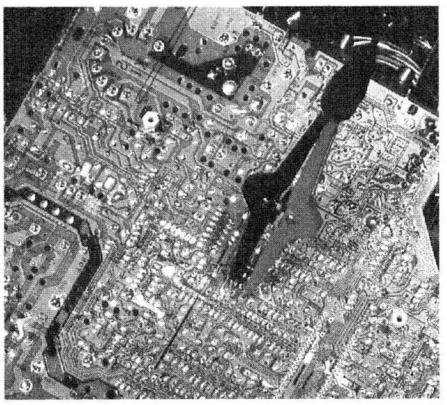

Fig. 4: The Adjustable In-Circuit Test Probe provides reliable in-circuit connections and push-button test ease.

To Perform an In-Circuit Capacitor - EIA Good/Bad Test:

1. Apply Power to the LC103.
2. Connect the In-Circuit Adjustable Test Probe to the LC103's TEST LEAD jack.
3. Perform the Lead Zero Adjustment.
4. a. Enter the capacitor - Component Type Example: Push the "ALUMINUM LYTIC" push-button.
   b. Enter the capacitor value. Example: Push the 2, 2, 0, µF, push-buttons.
   c. Enter the capacitor value tolerance. Example: Push the 2, 0, +%, -%, push-buttons.
   d. Enter the capacitor's rated voltage. Example: Push the 5, 0, V, push-buttons.
5. Connect the probe tips to the capacitor leads.
6. Push & hold the In-Circuit CAPACITOR GOOD/BAD push-button or the test probe's push-button.
7. Read the COMPONENT TEST RESULTS display.

Understanding the "SUGGEST REMOVAL" In-Circuit Capacitor Good/Bad Test Readout

A "SUGGEST REMOVAL" message is sometimes displayed during either the in-circuit capacitor basic Good/Bad test or EIA Good/Bad test. This message indicates that the LC103's tests have identified components in parallel with the capacitor being measured and that the parallel components are influencing the accuracy of the capacitor value and/or ESR measurements. For an accurate evaluation of the capacitor's value and/or ESR the capacitor must be unsoldered from the circuit and tested with the LC103's out-of-circuit capacitor tests.

Most "SUGGEST REMOVAL" messages are accompanied by capacitor value and ESR test readouts. These readouts may not be accurate because of parallel components but are often helpful in

determining if the capacitor likely has a problem. Occasionally, the readings may help you avoid removal and testing time. For example, a capacitor value readout that is much higher than the rated value of the capacitor is likey caused by a capacitor in parallel with the one being tested. If the schematic shows a capacitor in parallel with the one being tested that results in a total capacitance near the displayed value, the value of the capacitor being tested is likely fine. At other times, you may know from previous experience what to expect for capacitance and ESR readouts with the in-circuit capacitor tests across a particular capacitor.

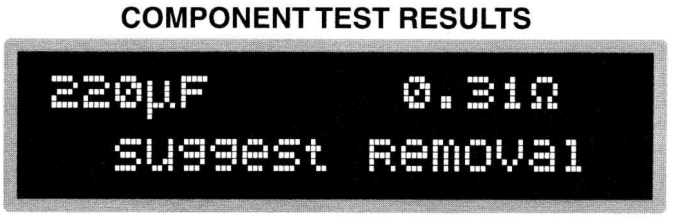

Fig. 5: The "SUGGEST REMOVAL" readout indicates there are components in parallel with the capacitor being measured that ***will*** *influence the test results.*

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