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tech tips

How To Find Defective Coils With The LC102 AUTO-Z™

The increasing use of integrated circuits is making coil applications more frequent.As the circuits inside the IC become more complex, they need more inductors to make the circuits function correctly. Most inductor values do not fit inside the IC. Consequently, as ICs become more common, the number of inductors used will also increase.

At the same time, more circuits are using high frequency switched-mode power supplies, sometimes called ''switcher'' or ''chopper'' supplies. Inductors combined with capacitors do a better job of filtering high frequency ripple than capacitors alone. This Tech Tip explains how the LC102 can be used for testing these and other coils. It will give you an understanding of how and why both the ringing test and the inductor value test should be done.

What Goes Wrong With Coils

Inductors can develop three kinds of failures: opens, shorts, and shorted turns. An open, of course, breaks the circuit path and stops the current. A dead short replaces the inductance with a piece of wire. A shorted turn reduces the quality (Q) of the coil at high frequencies.

A shorted or open coil will cause some fairly obvious changes in circuit operation, but let's see how a shorted turn affects circuit operation.

How Shorted Turns Affect The Circuit

To see why a shorted turn affects the circuit, we need to look at what the coil did when it was good. During times of increasing current, the coil stores energy in the form of an increasing magnetic field. Then, during times of falling current, the coil converts the collapsing magnetic field back into current. This smooths AC ripple, since the coil's charge/discharge action bridges the power supply ripple.

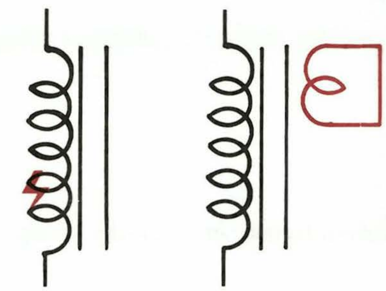

Fig. 1: A shorted turn absorbs power in the coil, and acts like a secondary winding of a transformer.

When the coil develops a shorted turn, it no longer acts like a pure inductance. The shorted winding acts like a small secondary winding on a transformer. The short absorbs part of the stored energy and converts it to heat within the coil. This reduces the amount of current available for the load, which reduces its filtering capabilities.

The shorted turn has more effect with high frequency signals than with low frequency signals. The net result is loss of high frequency Q. Figure 2 shows how the effectiveness of an RLC filter is affected by Q. When the coil is good, it is a high impedance to the ripple frequency. At lowered Q, it has less effect on the high frequencies.

In a bandpass filter, such as in a receiver's front end, the depth of the filter is reduced by a coil with a shorted turn. In a waveshaper, a shorted turn has a major effect on the signal shape. In an oscillator, the shorted turn prevents the circuit from reaching oscillation.

Shorted Turns Are Tough To Find Without A Z Meter

Before the Z Meter, technicians had only two ways to find bad coils. They could measure the inductance or the resistance and compare either reading to normal values. These methods often found shorted or open coils. Shorted turns, however, often went undetected, so substitution was still common.

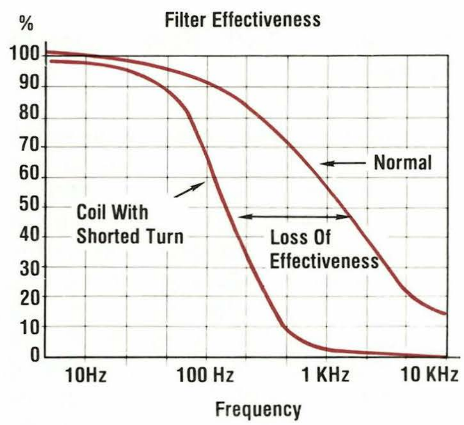

Fig. 2: A shorted turn in a power coil causes a much lower effect on the ripple signal.

Consider a coil with 500 turns of wire. If the insulation on the tiny wire lets one turn short to its neighbor, the coil's inductance and resistance both drop by 1/500th of the original values. If the coil had a 10 ohm resistance, for example, the shorted turn would only drop the resistance by 0.02 ohms. An ohmmeter does little to help find this small change in value. A value tester is also of little help, since the inductance value has not dropped by a noticeable amount either. But, this shorted turn has a major effect on the circuit. As we will see next, the LC102's Ringer test easily finds this trouble.

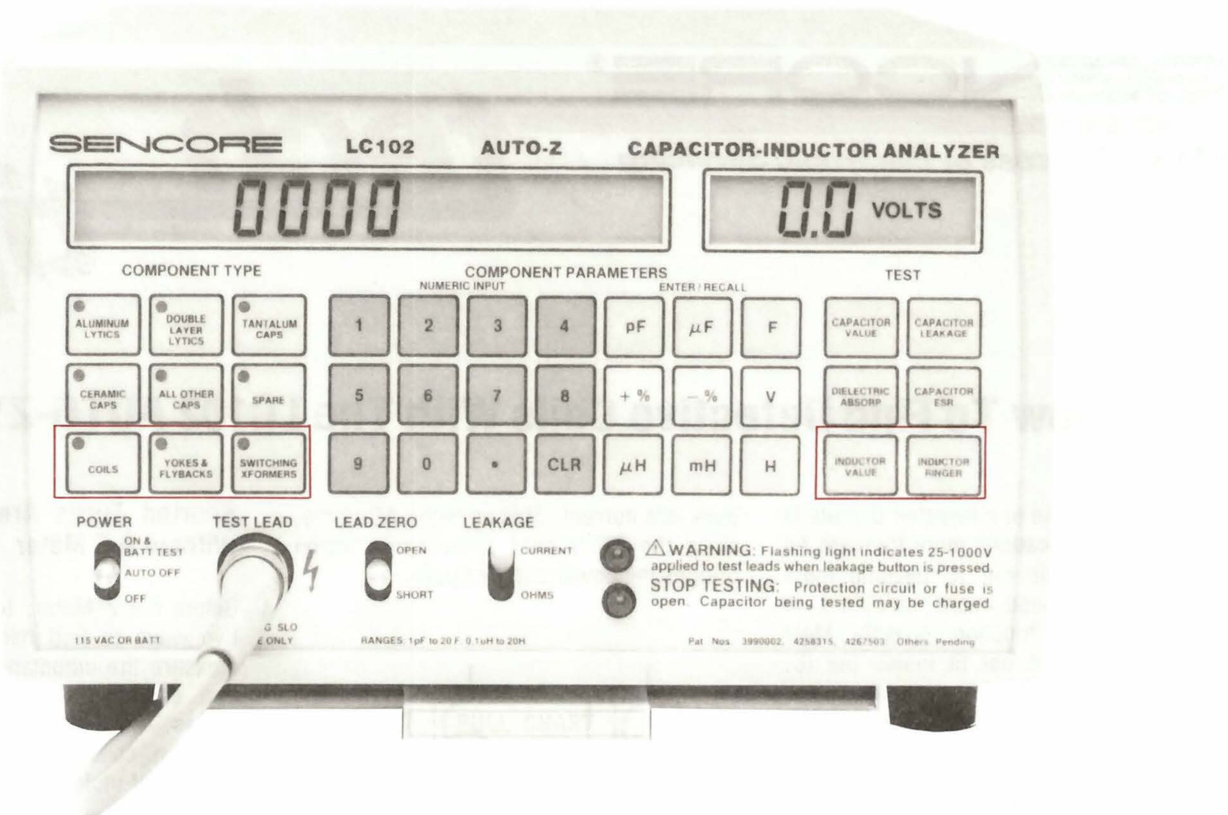

Fig. 3: The LC102 gives you two tests with GOOD/BAD readout for error free testing. The coil test sections of your LC102 are color coded blue.

The Ringer Test Finds Shorted Turns

The Ringer has been proven reliable by the tens of thousands of units in use since it was introduced in the Sencore YF33 Yoke and Flyback tester back in 1975. The test was expanded to test other coils on the LC53 Z Meter in 1979. Today, the LC102 has automated the test, so the microprocessor sets the test levels and automatically finds the correct resonating capacitor. All you need to do is press the test button and view the digital display for good/bad results.

The LC102's Ringer tests the effective Q of the coil, but you don't need to know the original Q value. (The Q of a coil is normally not published, and is frequency dependent.) Instead, all you need to remember is the number ''10''. Good coils show a Ringer number higher than 10 and bad ones a number below 10.

The Ringer places a fixed capacitor in parallel with the coil, and then hits the tank with a single exciting pulse. The coil and the capacitor ring at their resonant frequency. Digital circuits count how many ringing cycles occur before the signal drops (damps) below a preset level.

A coil with a high Q produces more ringing cycles than one with the same inductance value and a lower Q. A shorted turn causes the ringing to dampen very quickly.

The LC102 circuits automatically scale their sensitivity, depending on which of the ''Component Type'' buttons you've picked. If, for example, you are testing a deflection yoke or a flyback transformer, the digital circuits stop counting the ringing pulses after their amplitude has dropped to the 25% level. If you are testing some other inductor, the circuits continue to count to the 5% level. This automatic scaling lets you use the same number ''10'' for different kinds of coils.

There are two limits you need to know. First, the Ringer does not test inductors with laminated iron cores, such as power chokes and power transformers. The

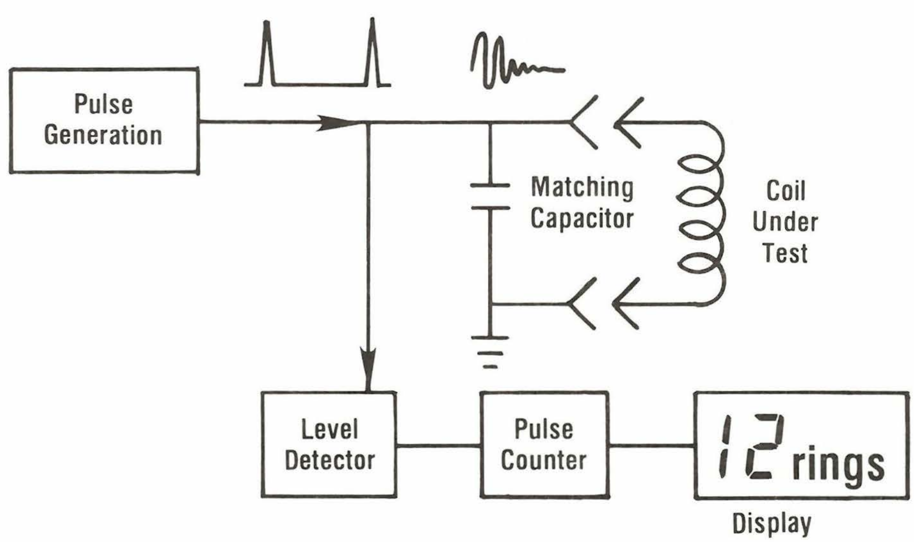

Fig. 4: The Ringer test places the coil in parallel with the capacitor. Then pulses the tank circuit, and digitally counts the resulting oscillations.

laminations act like shorted turns, causing the coil to ring less than 10 times. Second, the number 10 is only valid for inductors larger than 10 microhenries. Smaller coils can be tested if you have a known-good coil for a comparison. The good coil may, however, ring less than 10 times.

To ring a coil:

1. Connect the LC102 test leads directly across the coil.

2. Select the correct COMPONENT TYPE: COILS, YOKES & FLYBACKS, or SWITCHING XFORMERS.

3. Press the INDUCTOR RINGER TEST button.

4. Check the LCD display for the number of rings and a GOOD/BAD reading.

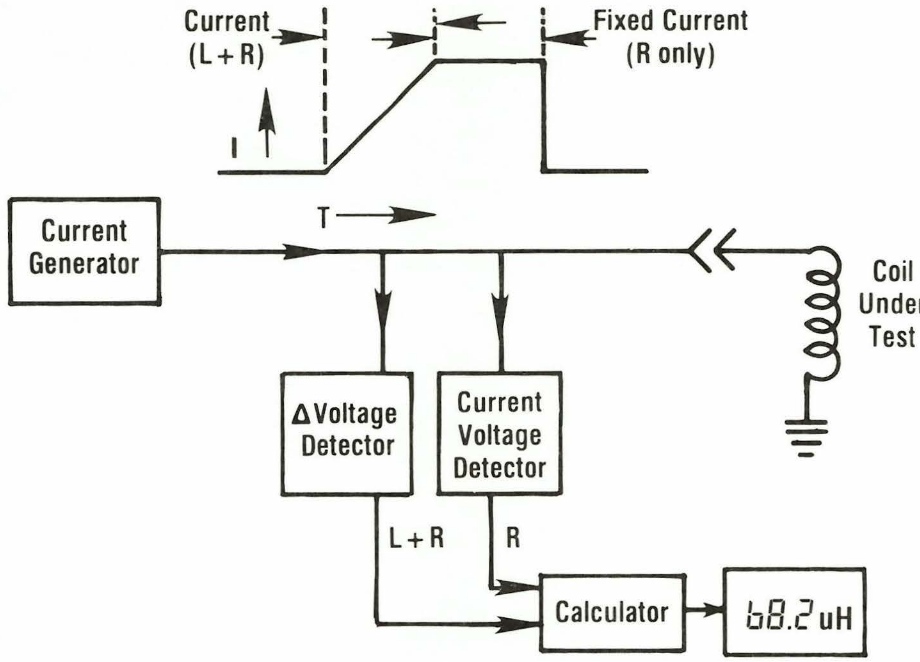

Fig. 6: The LC102 tests true inductance by applying a currect ramp to the coil, and then measuring the induced voltage.

How the Z Meter Tests True Inductance

The LC102 tests true inductance, not inductive reactance as is done with impedance bridges. Figure 5 shows the engineering definition of inductance. Notice that the definition does not include a term representing frequency. So, inductance (L) should not vary with applied frequency. Before the Z Meter, attempts to measure inductance relied on applying a frequency and then measuring how the coil changed some part of the signal. The two most common test instruments were the AC impedance bridge and the Q-meter. Both methods gave errors with certain coils.

$$V(t)=L\frac{di(t)}{dt}$$

Fig. 5: The engineering definition of inductance does not include frequency or inductive reactance.

The patented Z Meter test uses the basic definition of inductance to determine value. The circuits feed a fixed current ramp through the coil, while measuring the induced voltage. Additional circuits correct for voltage drop caused by the coil's DC resistance.

The autoranging circuits test the true inductance of the coil, without the problems associated with test frequencies. The test works in most circuits, so it's not necessary to remove the coil from the circuit in order to test it.

To test a coil's value:

1. Zero the test leads, and connect the LC102's test leads directly across the coil to be tested.

2. If you know the value and tolerance enter them into the COMPONENT PARAMETERS sections of the LC102.

3. Press the INDUCTOR VALUE TEST button.

4. Watch the LCD display for the value of the coil. *NOTE: You will only see a GOOD/BAD reading if you have entered the value and tolerance of the coil under test.*

When you do both the Ringer and value tests in circuit and you get "good" results, the coil is good, but if you get "bad" results you should then remove the coil from circuit and retest it. If the coil still tests "bad" it *is* bad, but if it tests "good" it is good. This lets you confirm whether the inductor is the cause of a problem or not, and lets you get right to troubleshooting the actual defect.

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