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tech tips

Testing Cables With The LC102 AUTO-Z ™

We all use coaxial cables every day in one way or another. There are underground cables, overhead cables, cables inside of transportation vehicles, and interconnecting cables to name a few. These coaxial cables are vital for the correct operation of computers, antennas, transmitters, televisions, instant cash machines, and the list goes on and on.

Coaxial cables don't last forever. They can tear, decay, break, short, open, erode, become victim to accident, or just plain wear out with age.

If you plan on replacing the entire cable or cable system, that poses no special problem. But, what if only one length of cable is causing the problem? And what if that length is buried 10 feet underground or somewhere behind a plasterboard wall? Your goal is to find and replace the defective break quickly - without digging up or tearing out the whole cable.

This tech tip explains why cable problems are so hard to find and how your LC102 Auto Z will help you find these nagging cable problems.

Why Are Cable Problems So Hard To Find?

Cable breaks that are buried underground or inside walls are tough to find. Very seldom do you have the luxury of being able to physically look for the break. You need a method of electrically finding the problem.

There are several pieces of equipment that can be used to find problems in cables. Among them are the ohmmeter, the cable fault meter, a TDR (time domain reflectometer), and the LC102 AutoZ.

An ohmmeter will tell you if the cable has an open or a short, but it won't tell you exactly where the fault is. Since most cables have a low resistance, a shorted cable will yield a very small resistance reading with an ohmmeter. This makes finding the exact location of the cable defect extremely difficult. Similarly, an open cable will show just that on an ohmmeter, an infinite resistance reading. An infinite resistance reading hardly points to any point in the cable that has a defect.

Cable fault meters are sometimes used to find problems in cable systems. They can locate breaks or shorts within 10 feet. Cable fault meters have two big problems. First, a typical fault meter costs $1,000. That's a lot of money to tie up into one piece of equipment that can only be used to locate cable problems and identify wires. The second problem is that they only work with a few types of cable. If you run across a new, or different type of cable, you won't be able to use the fault meter.

The third piece of equipment that could be used to find a cable problem is a time domain reflectometer (TDR). TDRs are primarily an engineering tool used to analyze a cable. Consequently, there are problems associated with using them for troubleshooting work. First, TDRs are quite expensive. A typical TDR costs $5,600. In addition to the initial expense, keep in mind that TDRs can only be used to analyze cables - they have no other use. TDRs are complicated to use. A TDR sends a pulse down the cable and then displays the reflected signal on a CRT. This means that you must interpret the different re-

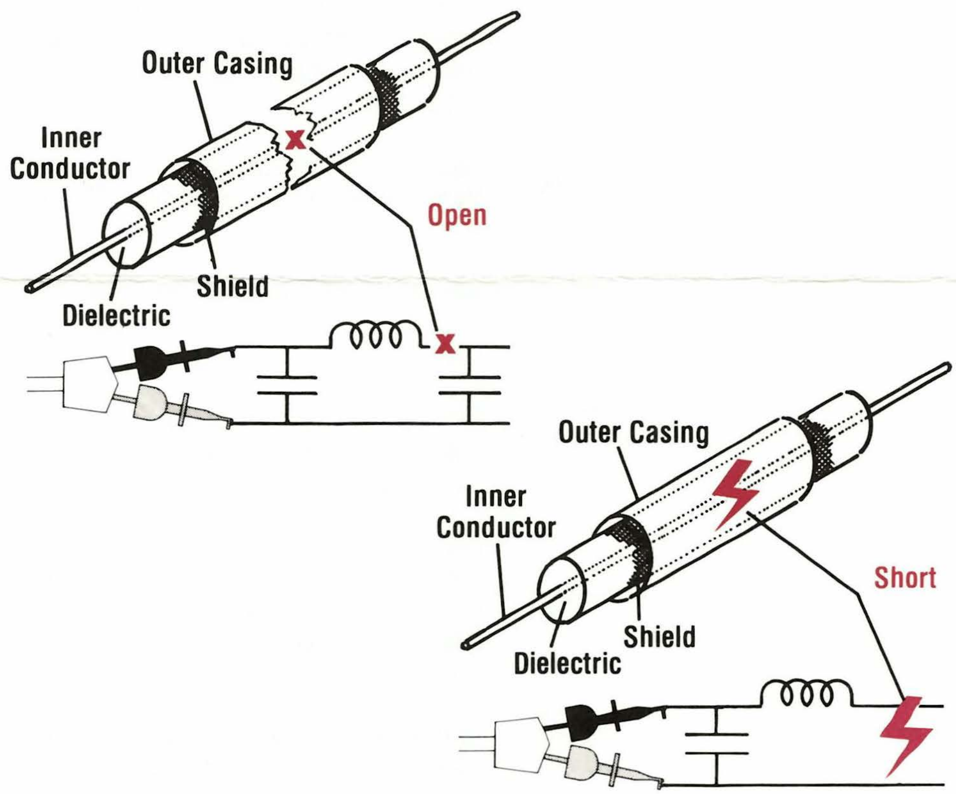

Fig. 1: A length of coaxial cable consists of capacitance and inductance distributed throughout the cable's length.

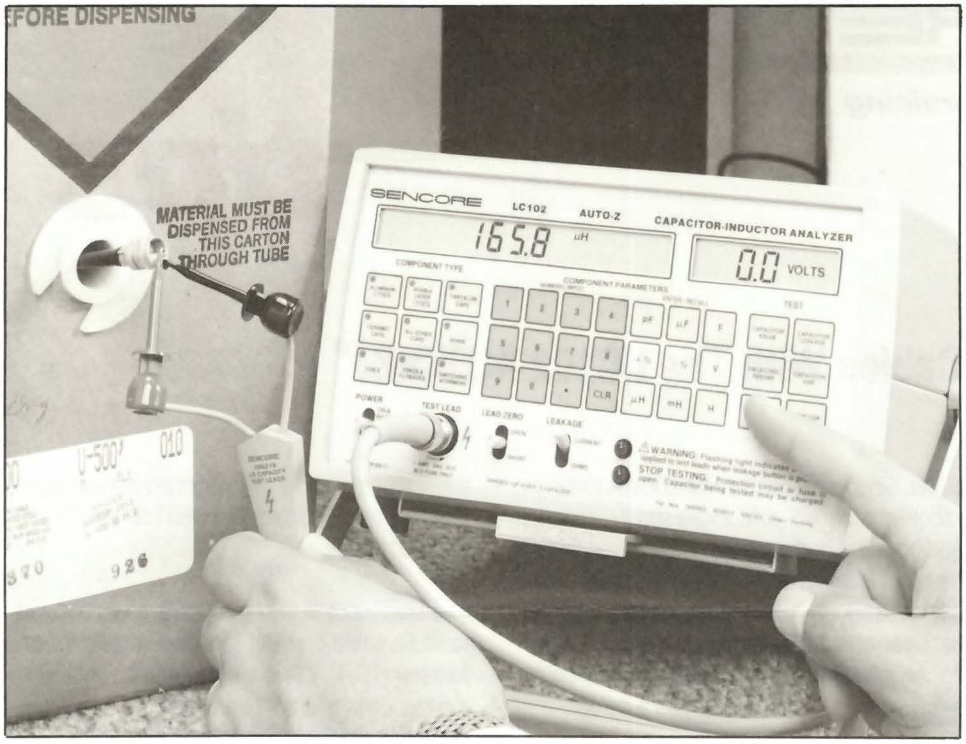

Fig. 2: Use the LC102 to measure the distance to breaks or shorts in buried cable.

flected signals produced by each different cable type.

How Does The LC102 Find Defects In Cables?

Any length of coaxial cable consists of capacitance and inductance distributed throughout the cable's length as shown in figure 1. Every type of coaxial cable has a normal amount of capacitance per foot of open cable and a normal amount of inductance per foot of shorted cable. The length of a cable or the distance to an open or a short is found by simply measuring the capacitance or inductance between the center and outer conductors and dividing this total by the cable's normal per foot value. In most cases, the calculation will be within 1 - 2 %.

Finding The Capacitance Per Foot Of An Unknown Cable

When a cable has a break, it acts like a long capacitor. The amount of capacity varies very closely with the length of the cable. If you know how much capacity the cable has per foot, you can use the total capacity of the cable to calculate the distance to the break.

Several characteristics of the cable, such as the spacing between the center conductor and the outer shield and the type of insulation, contribute to the capacitance of the cable. Each type of coaxial cable has a standard amount of capacitance per foot, which is specified by the cable manufacturer.

Figure 3 lists the capacitance per foot values for the most common coaxial cable types. The values listed may vary slightly with cable manufacturer and excessive crimping or clamping of the cable will change the total capacitance reading. The capacitance per foot values are also in the LC102 manual.

The capacitance per foot of any cable is very easy to determine if you cannot find it in either the LC102 manual or in manufacturers' data sheets.

First, find a sample piece of cable that is the same type as the cable you are testing. The sample should be at least 10 feet long so that any irregularities and measuring errors are averaged out.

To measure the capacitance, connect the red LC102 test lead to the center conductor and the black LC102 lead to the shield of the cable. Now push the CAPACITOR VALUE button on the LC102. This will give you the capacitance of the whole length of cable.

To find the capacitance per foot, divide the total capacitance by the length of the sample. For example, if a 10 foot sample of cable measured 270 pf with the LC102, dividing 270 pf by 10 feet results in 27 pf per foot.

Finding The Length Of A Cable

Now that you know the capacitance per foot of the cable, you can find the length of a long piece of cable. To calculate the length of a cable:

1. Zero the LC102 test leads.

2. Connect the red LC102 test lead to the center conductor and the black LC102 test lead to the braided shield outer conductor of an open (unterminated) cable.

3. Press the CAPACITOR VALUE button and read the total capacitance of the cable.

4. Divide the LC102 capacitance reading by the cable's capacitance per foot value. This gives the length of the cable, or the distance to the break in feet.

For the sample cable given earlier, if the capacitance of the cable were 2295 pf, dividing 2295 by 27 pf per foot would give us 85 feet of cable.

Locating A Break In An Open Cable

Using the LC102 to find the distance to a cable break is similar to the method used to find the length of piece of cable. After all, a cable with a break is just a long piece of cable that is shorter than it should be. To determine the distance to a break in the cable:

1. Zero the LC102 test leads.

2. Connect the red test lead to the center conductor and the black test lead to the braided shield outer conductor of an open (unterminated) cable.

3. Press the CAPACITOR VALUE button and read the total capacitance of the cable up to the break.

4. Divide the LC102 capacitance reading by the cable's capacitance per foot value. This gives the distance to the break in feet.

For the sample cable we're using, let's say the LC102 showed a capacitance reading of 1647 pf. If you divide 1647 by 27 (pf per foot), you

50-55 Ohm

	Nominal	Nominal	Nominal
RG/U Cable Type	Impedance	Cap in pF/FT	Inductance
5B/U	50	29.5	
8U	52	29.5	
8U Foam	50	26	
8A/U	52	29.5	
10A/U	52	29.5	
18A/U	52	29.5	
58/U	53.5	28.5	
58/U Foam	50	26	
58A/U	50	30.8	
58C/U	50	29.5	
58C/U Foam	50	26	
74A/U	52	29.5	
174/U	50	30-30.8	
177/U	50	30	
212/U	50	29.5	
213/U	50	30.5	
214/U	50	30.5	
215/U	50	30.5	
219/U	50	30	
225/U	50	30	
224/U	50	30	

70-75 Ohm

	Nominal	Nominal	Nominal
RG/U Cable Type	Impedance	Cap in pF	Inductance uH/FT
6A/U	75	20	
6A/U Foam	75	20	
11U	75	20.5	
11U Foam	75	17.3	
11A/U	75	20.5	
12A/U	75	20.5	
13A/U	74	20.5	
34B/U	75	20	
35B/U	75	20.5	
59/U	73	21	
59/U Foam	75	17.3	
59/BU	75	20.5	
164/U	75	20.5	
216/U	75	20.5	

90-125 Ohm

	Nominal	Nominal	Nominal
RG/U Cable Type	Impedance	Cap in pF	Inductance uH/FT
62/U	93	13.5	
62A/U	93	13.5	
63B/U	125	10	
71B/U	93	13.5	
79B/U	125	10	

Fig. 3: Capacitance per foot values for common coaxial cable types with column for you to fill in the inductance per foot.

come up with 61. This means the break in the cable is 61 feet from the end of the cable you are measuring.

If you want to be even more accurate, you can perform the same procedure from the other side of the cable and average the two suspected break points if they aren't exactly the same.

Determing The Inductance Per Foot Of A Cable

A coaxial cable which has a short between its center conductor and outer conductor is similar to a very long inductor. Each type of coaxial cable has a typical amount of inductance per foot. The amount of inductance per foot of a coaxial cable is usually not published by the cable manufacturer, and the amount for the same type of cable may vary significantly from one manufacturer to another. So in order to determine the inductance per foot of the cable you are working on, you will need a sample length of cable.

For the best accuracy, you should use a sample length of cable that is at least 20 feet long. Since the inductance of some cables may be quite low, make sure that you zero the LC102 first. Next, short the center conductor to the shield at the opposite end of the cable. If you use a jumper wire to make this connection, make sure that the jumper wire is as short as possible to avoid adding noise to the reading.

To read the total inductance of the cable, hook the LC102's test leads up to the cable and push the INDUCTOR VALUE button on the LC102. This gives you the inductance of the entire length of cable.

To find the inductance per foot, divide the total inductance by length of sample cable in feet. For example, if a 20 foot sample measured 36 uH with the LC102, 36 uH divided by 20 feet results in 1.8 uH per foot.

Locating A Short In Coaxial Cable

After you have determined the inductance per foot of the cable, you can use the information to determine the distance to the cable short. The procedure is very much like the one used to locate an open in the cable. To determine the distance to a short:

1. Zero the LC102 test leads.

2. Connect the red test lead to the center conductor and the black test lead to the braided shield outer conductor of the shorted cable.

3. Press the INDUCTOR VALUE button on the LC102 and read the total inductance of the cable.

4. Divide the LC102 inductance reading by the cable's inductance per foot value. This gives the distance to the short in feet.

Use The LC102 On Multi-Conductor Cables, Too

One of the problems with other equipment that is made to find cable problems is that they only work with certain kinds of coaxial cable. Much of the cable that is used today is multi-conductor cable, with or without a shield. The LC102 locates opens and shorts in these cables too. However, there are a few differences.

First, there are no standard inductance per foot or capacitance per foot values for non-coaxial cables. This means that you will need to determine the values by using a sample length of cable. Secondly, the LC102 is not quite as accurate on multi-conductor cables. Measurements on cables with less than four conductors are easily affected by noise and stray pick-up. Using the LC102 to find cable opens or shorts in these types of cables may not be as reliable as coaxial cable. On cables with four or more conductors, the LC102 will locate the distance to the problem with an accuracy of between five and 10%. This is still within 10 feet out of 100 feet however, which is as good as the best resolution offered by many of the other types of cable testers

Finally, when testing multi-conductor cables without a shield, you must wrap all of the wires, except one, together to form a "shield". Once you have wrapped the wires together to form a shield, you test the cable using the same procedures used to test coaxial cable.

Using The LC102 To Find Aging Cable

All coaxial cables exposed to the elements eventually degrade to the point where they need to be replaced. The LC102 can be used for preventative maintenance checks of coaxial cable to determine if deterioration is beginning to occur. As a cable begins to fail, the dielectric separating the conductors becomes contaminated causing a change in the cable's capacitance and the DC leakage through the dielectric.

All coaxial cable has a normal amount of capacitance per foot and any significant change that occurs over a period of time indicates a developing problem. The best check for aging cable is to measure and record the total capacitance of the cable when it is first installed. If the initial value is not known, you can multiply the length of the cable by its nominal capacitance per foot. Then compare periodic capacitance measurements back to the initial amount and look for any changes. As the dielectric becomes contaminated, the LC102 capacitance reading will increase.

Using The LC102 To Find Leakage In Cables

The LC102 leakage power supply also provides a good test of a cable's condition. Simply measure the amount of leakage through the dielectric between the conductors. Most cables have a maximum operating voltage of 1000 volts or more and should be tested with the LC102 leakage supply set to 999.9 volts. A few "air space" dielectric types of coaxial cable, such as RG37, RG62, RG71, and RG72 have a maximum operating voltage of 750 volts and should be tested at this lower voltage.

A good piece of cable should have no leakage when the voltage from the LC102 is applied between the center conductor and outside shield. The length of the cable being tested will make no difference on the leakage reading. Any leakage reading indicates the dielectric is breaking down.

For More Information
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