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tech tips

Testing Ceramic Capacitors With A Z-METER.

Ceramic capacitors are far from ideal — many change value with temperature, applied voltage, and frequency of the applied signal. The circuit designers often take advantage of these factors to compensate for other circuit variables. The Z-METER instruction manual contains information about ceramic capacitors, such as temperature coefficients, how to read tolerance, temperature, and color codes.

Ceramic capacitors come in many sizes and shapes, with values typically ranging from 10 picofarad to 0.1 microfarad and voltages from 10 to 1000 VDC. Ceramic capacitors are used in all stages of electronics from portable AM radios to space satellites. Ceramic capacitors are used to compensate for changes in temperature. They are compact, and very dependable.

Unfortunately, ceramic capacitors do fail. Testing these caps requires a good understanding of their operating characteristics. This Tech Tip explains two ceramic capacitor topics - dielectric stress and monolithic ceramic capacitors - in more detail to help you be more effective in testing ceramic capacitors with your Z-METER.

Dielectric Stress Looks Like Dielectric Absorption, But It Isn't.

The value of most ceramic capacitors normally changes when they are DC biased. This value change is caused by "dielectric stress." The applied DC potential causes physical stress within the ceramic dielectric material, causing a decrease in value. It takes several seconds for the capacitor to return to its non-stressed mode after removing the bias.

Dielectric stress causes the capacitor to read a lower value on the Z-METERs immediately after performing a leakage test compared to the value read before the leakage test. After the leakage test, the value reads low and slowly builds back up to the first value reading as the dielectric stress dissipates. This effect looks like dielectric absorption in other types of capacitors.

Small value ceramic capacitors show a larger percentage value change than larger ones due to the high sensitivity of the Z-METERs value test circuits. The circuits are so sensitive that they detect even small amounts of dielectric stress and absorption in the Z METER's own internal switches, printed circuit boards, and test leads. These changes amount to about 2 pF when the Z METER's front-end circuits have been charged to the typical 500 volt rating of most ceramic capacitors. Thus, a 2 pF capacitor may show more than a fifty percent change in value after testing leakage as the dielectric stress factors of the front-end and the capacitor combine.

The following table shows typical value changes for 500 volt ceramic disc capacitors, as seen on a Z-METER after performing the leakage test.

Value	Percentage Change
Under 10 pF	50%
10-15 pF	35%
15-40 pF	20%
40 pF & up	15%

NOTE: Dielectric stress is only common in ceramic capacitors. The patented dielectric absorption test should be used as explained in the Z-METER manuals for all other types of capacitors.

Some Monolithic Capacitors Read A Normally High Value When Tested With A Z-METER

A newer type of ceramic capacitor, called the "monolithic chip," is now in use. These capacitors combine relatively large values with a small size. Figure 1 shows two .47 microfarad capacitors, a conventional disc on the left and a monolithic chip on the right. Notice how much smaller the 50 volt monolithic type is compared to the 12 volt conventional disc.

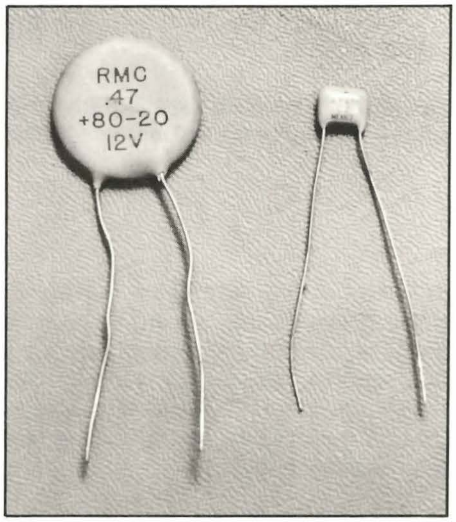

Fig. 1: Both capacitors have the same .47 uF value. The disc on the left is only rated at 12 volts, while the monolithic on the right is rated at 50 volts.

Some monolithic capacitors change value drastically with changes in applied DC voltage. The graph in Figure 2 shows the results obtained with one sample group of .47 microfarad, 50 volt monolithic

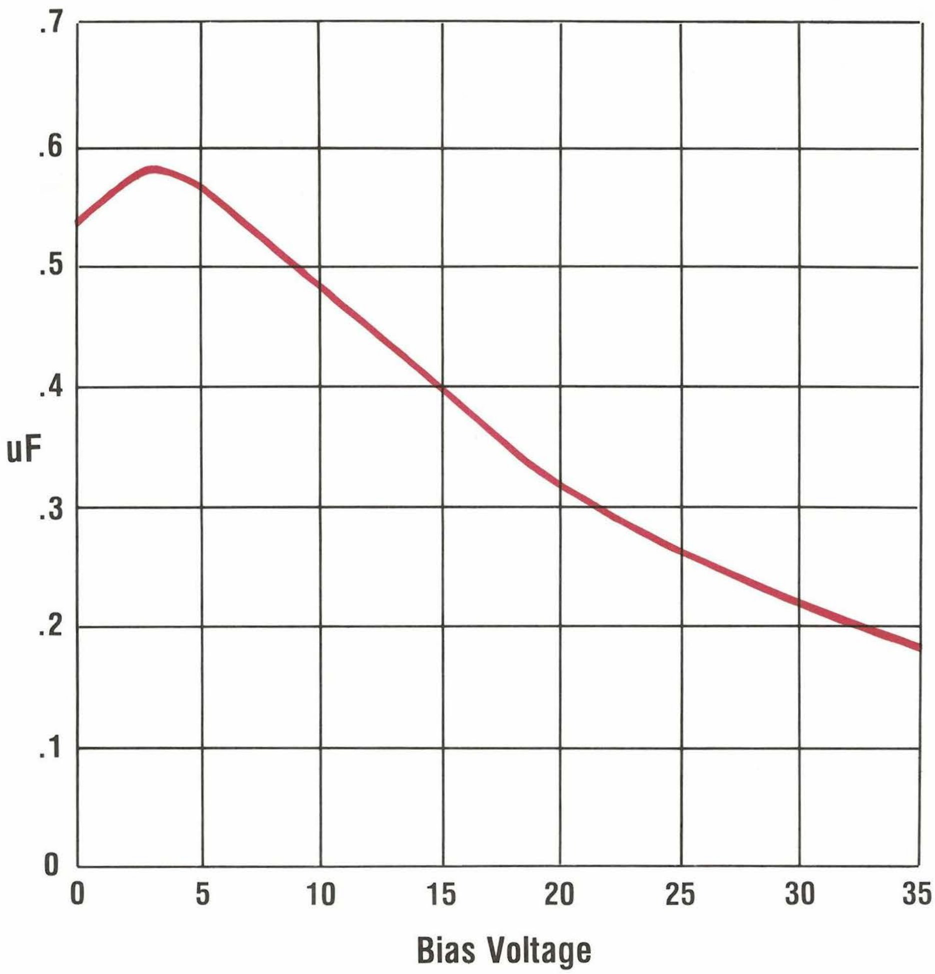

Fig. 2: The monolithic capacitor from Fig. 1 measured about 125% of its rated voltage when biased to 3 volts and measured about 30% of its rated value when biased to 35 volts.

capacitors. The capacitors measured within tolerance on an AC impedance bridge with no DC bias applied. Adding a DC bias caused an increase in the capacitance value. The value increased as the bias increased until the applied voltage reached about 5 volts.

At bias voltages higher than the normal Z-METER test voltage the value plunged rapidly. This sample group of new capacitors showed a value loss of over 70% with 35 volts applied. This is a typical response curve for monolithic capacitors.

These monolithic capacitors read a much higher value on a Z-METER than on an AC impedance bridge with no DC bias. (NOTE: Some bridges have external DC bias terminals, but this requires an external power supply and the extra time needed to connect the supply.) The Z-METER value test uses the DC charging curve of the capacitor under test to determine its value. The test voltage applied by the Z-METER causes the monolithic capacitor to increase to its highest value. This normal action may cause the capacitor to read up to 50% higher on the Z-METER than on a bridge.

The Z-METER value readings are much more indicative of the way the capacitor acts in the circuit; almost all capacitors operate with some DC bias. The only time the bridge value test agrees with the value the capacitor exhibits in the circuit is when the capacitor is used in a strictly AC application.

The monolithic capacitors from this sample group also showed high levels of dielectric stress. This caused even larger variations from the rated value if the test was made after a leakage test.

These capacitors can be used in only a few circuits, where a change in value with applied voltage is not critical. **Do not use this type of capacitor to replace another type unless the circuit is carefully tested to make sure the voltage sensitivity will not cause poor circuit operation.**

Testing Ceramics With The Z-METER

To test a ceramic (or monolithic) capacitor for dielectric stress, you need to know the exact response curve for that particular cap. However, determining the capacitor's condition with a specific voltage applied is a design engineers job. As a servicer testing ceramic caps, we are more concerned with the value and the leakage (with rated voltage applied) of the cap.

Only test ceramic capacitors for value and leakage. Always replace a ceramic capacitor with one that has characteristics identical to the one removed from the circuit. Using a different type may cause improper circuit operation.

For more information
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