

How to Use an LCR Meter

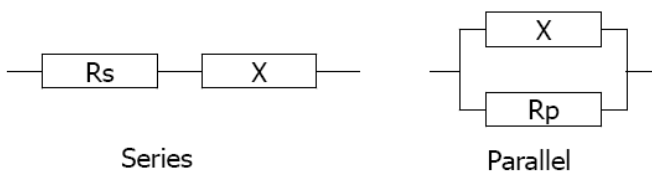
Our thanks to BK Precision for allowing us to reprint the following article.

Most LCR meters use AC signals to measure the impedance of components. Using an LCR meter is usually simple—but there are some setting choices you need to be aware of that will affect your measurements. In some cases, choosing the wrong settings can result in poor measurement accuracy. This article will give guidelines for picking the right settings for measurement frequency, measurement level, and equivalent circuit choice, along with some measurement tips.

Measurement frequency: Since the reactance is a function of frequency, your choice of measurement frequency should reflect the usage of the component. For capacitors, larger values (tens to hundreds of μF or more) are often used in power supply filtering applications, so should be tested at twice the line frequency. Smaller capacitors (fractions of a μF) tend to be used at higher frequencies, so should be tested at 1 kHz or more. A similar consideration applies for inductors. Smaller inductors (below 1 mH or so) should be measured at 1 kHz or higher, as they are often used in audio frequency or RF applications. Larger inductors are typically used as chokes and can be measured near line frequency.

Measurement level: Again, let the application of the component reflect your test conditions -- the measured value may depend on the voltage level across the component.

Equivalent circuit: components are modeled with one of the two following equivalent circuits:



where X is the reactance of the component, R_s is the series resistance, and R_p is the parallel resistance. If the reactance is large, the series resistance may be negligible, so the parallel model might be a better fit. Conversely, if the reactance is small, the parallel resistance may be negligible, so you may want to use

the series model. Thus, the guideline would be to tend to use the parallel circuit model for small capacitors and the series model for large capacitors (see Figure 1).

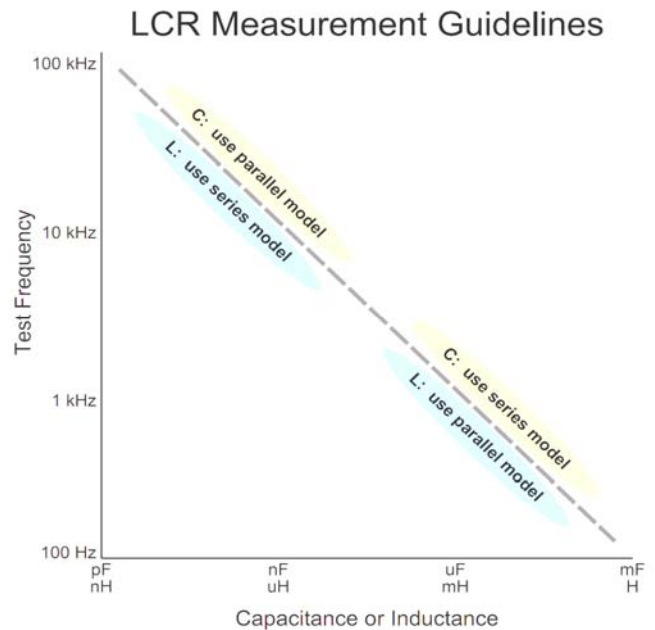


Figure 1.

Conversely, lean towards using the parallel circuit model for large inductors and the series model for small inductors. Remember these circuits are models of a component and they might not model the actual behavior well as the frequency increases because the lumped parameter model may no longer be appropriate. Your incoming inspection procedures or contractual requirements may define which measurement model you should use.

D or Q: D is called the dissipation factor and is the real part of the impedance divided by the reactance (the imaginary part of the impedance). Q is called the quality factor and is the inverse of D. When D is very small (or Q is large), the component is essentially a pure reactance.

Capacitance accuracy discrepancies: Measurement accuracy can be affected by choosing the wrong measurement frequency, measurement model, or trying

to measure a part whose value is out of the meter's range. Small capacitors with low dissipation D values are generally easy to measure with the parallel model. Larger electrolytic capacitors need to be measured at low frequencies and with the series model. The real part of the series model's impedance is usually called ESR for equivalent series resistance. The ESR of electrolytic capacitors tends to increase with time and higher temperature exposures. ESR may increase or decrease with frequency, depending on the capacitor type.

Inductance accuracy discrepancies: Some inductors are intended to be operated with a DC bias. Unless the instrument's manual says that such operation is permitted, you shouldn't test with an added DC bias. Thus, the value you measure may not be what would be encountered in an operating circuit.

Resistance accuracy discrepancies: There are two types of resistance measurements: DC resistance and AC resistance. The LCR meter may be able to make both types of measurements. The AC measurements at higher frequencies may show higher resistance values than a DC resistance because of parasitic effects (e.g., a wirewound resistor's inductance). When comparing resistance values, ensure the same types of measurements are being compared.

Measurement Tips

1. If your LCR meter allows it, measure the impedance at the application frequency if you can. Seeing the impedance magnitude in ohms helps you use your

intuition—and the phase angle tells you quickly if you have a pure reactance or a mixture of resistance and reactance.

2. You can estimate lead inductance using 10 nH per cm of lead length. For typical leads, the lead inductance shouldn't become relevant for frequencies less than about 1 MHz.
3. Review your LCR meter's manual for accuracy specifications. This will also familiarize you with the measurement ranges. Beware of trying to measure capacitors or inductors that are larger than the meter's capabilities. Also realize that temperature changes can affect component values and measurements.
4. Build a stock of components you can use as measurement standards to check that your instrument is reading correctly (these standards can help guide you in choosing test frequency, test amplitude, and circuit model).
5. When using measurement leads, measure them first and subtract out their contributions.
6. Make sure capacitors are discharged before measuring (also be aware that dielectric absorption might affect your measurements).

