Keysight Technologies
Characterizing Coils in Wireless Charging Systems Using the Keysight E4980A/AL Precision LCR Meters

Application Note

- Wide impedance range to characterize inductance and quality factor
- High accuracy DCR measurements
- Fast measurement speed for manufacturing
- A wide variety of test fixtures to choose from
Overview

Continually new functionalities are being added to smart terminals and battery life is becoming one of the biggest headaches for users. The wireless charging technique gained a lot of attention due to its convenience and versatility compared to the portable power supply and cable power supply, and thus has become one of the best solutions in the market. Mobile devices, as one of the most popular application of wireless charging technology, requires even higher charging performance due to the long operation time.

This note describes how Keysight’s E4980A/AL precision LCR meters are suitable for characterizing the coils that are the most commonly used component in the wireless charging system.

Coils in wireless charging systems

Several wireless charging standards are in use today, but generally all of them are using coils to create electromagnetic fields and transfer energy. Typically a wireless charging system consists of two sections: transmitter and receiver, between which the power and energy transfer can be achieved through the inductive coupling (Figure 2). Normally the transmission coil and the driver circuit are installed in a charging block, and the receiving coil and the related circuit is embedded in the devices that need to be charged, such as a smart phone etc. The power transfer efficiency is a key specification of a wireless charging system. It is affected by many factors, including the distance between the coils, parasitic of the inductors, how the coils are aligned and so on. For a single coil, minimal loss (low DCR) and parasitic (high Q) are desired during the design phase in most cases. The typical test parameters for the transmitter and receiver coils are Ls (series inductance), Rs (series resistance) and DCR (DC resistance). The test frequency is typically up to 1 MHz or higher.

The E4980A/AL precision LCR meter is the industry standard solution for LCR component measurements up to 2 MHz. It is well known and accepted by the component manufacturing market because of its most accurate and repeatable measurements, wide impedance range and fast measurement speed.
Standard DCR measurements with high accuracy

The DC resistance of the transmitter coil and receive coil will directly affect the resistive loss of the energy transfer, therefore low DCR (normally down to mΩ) is desired to ensure high power transfer efficiency.

DCR measurements is a standard function in the E4980A/AL precision LCR meters. DCR values down to mΩ can be measured very accurately. Meanwhile, the E4980A/AL supports low contact resistance fixtures such as 16047E and the fixture compensation function. If the DCR of the coil is 100 mΩ, the DCR accuracy of the E4980A/AL can be as good as 5%, which means the true value is approximately between 95 mΩ to 105 mΩ. This is considered very high accuracy due to the difficulty in low DCR measurements using LCR meters based on the auto balancing bridge method.

Wide impedance range for inductance and stable small ESR measurements

The inductance of transmitter and receiver coils is typically in μH range and tested above several tens of kHz frequency range. Therefore the impedance range is about mΩ to several Ωs. The E4980A/AL LCR meter offers excellent performance for wide impedance range, from 4 mΩ to 100 mΩ within 10% accuracy (Figure 2), which is perfectly suitable for coil measurements in wireless charging systems.

The equivalent series resistance (ESR) of the inductors is also desired to be small and stable to meet the low power consumption needs. The E4980A/AL provides exceptional measurement stability for ESR measurements (Figure 3).
Fast measurement speed increases production yields

A major concern for manufacturing is to improve throughput and reduce cost of test. The E4980A/AL features fast measurement speed that improves test productivity in both design and manufacturing. For E4980A, the measurement speed is as follows:

- 5.6 ms per point at 1 MHz with SHORT mode
- 88 ms per point at 1 MHz with MED mode
- 220 ms per point at 1 MHz with LONG mode

A wide variety of test fixtures to meet your needs

The E4980A/AL can be used with over twenty fixtures to meet a variety of evaluation needs; from materials to SMD components. The 16047 series lead type fixtures are the best fixtures to measure lead-type coils of low DCR and ESR. Also, built-in compensation functions in the E4980A/AL minimize the influence of test fixtures.

E4980A and E4980AL product comparison

Keysight offers multiple frequency options based on the E4980 platform to fit your application needs and budget. The key product specifications for the E4980A and E4980AL are listed in the table below.

<table>
<thead>
<tr>
<th></th>
<th>E4980AL</th>
<th>E4980A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>20 Hz to 300 kHz /500 kHz / 1 MHz</td>
<td>20 Hz to 2 MHz</td>
</tr>
<tr>
<td>Test signal level</td>
<td>0 to 2 Vrms /0 to 20 mArms</td>
<td>0 to 2 Vrms or 20 Vrms (Option 001) / 0 to 20 mArms or 100 mArms (Option 001)</td>
</tr>
<tr>
<td>Auto level control (ALC)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DC bias capability</td>
<td>Built-in 1.5 V, 2 V</td>
<td>1.5 V, 2 V or ± 40 V (Option 001)</td>
</tr>
<tr>
<td>Programmable list sweep</td>
<td>201 points</td>
<td>201 points</td>
</tr>
<tr>
<td>Remote control</td>
<td>GPIB, LAN, USB</td>
<td>GPIB, LAN, USB</td>
</tr>
<tr>
<td>Interface option</td>
<td>None</td>
<td>Handler (Option 201)/ Scanner (Option 301)</td>
</tr>
<tr>
<td>Parameters</td>
<td>Impedance, DCR</td>
<td>Impedance, DCR</td>
</tr>
<tr>
<td>Control commands</td>
<td>E4980A/4284A compatible</td>
<td>E4980A/4284A compatible</td>
</tr>
<tr>
<td>Basic accuracy</td>
<td>0.1% at Short 0.05% at MED/LONG</td>
<td>0.1% at Short 0.05% at MED/LONG</td>
</tr>
<tr>
<td>Measurement time mode</td>
<td>149 ms at 100 Hz 26 ms at 1 kHz 12 ms at 1 MHz Short mode</td>
<td>100 ms at 100 Hz 20 ms at 1 kHz 5.6 ms at 1 MHz Short mode</td>
</tr>
<tr>
<td>Storage devices</td>
<td>Internal/USB memory</td>
<td>Internal/USB memory</td>
</tr>
<tr>
<td>Cable length</td>
<td>0, 1, 2, 4 m</td>
<td>0, 1, 2, 4 m</td>
</tr>
<tr>
<td>Cabinet dimensions (mm)</td>
<td>370 (W) x 105 (H) x 390 (D)</td>
<td>370 (W) x 105 (H) x 390 (D)</td>
</tr>
<tr>
<td>Weight</td>
<td>5.3 kg</td>
<td>5.3 kg</td>
</tr>
</tbody>
</table>
Summary

The Keysight E4980A/AL precision LCR Meter is the industry standard LCR meter that provides highly accurate, repeatable high-speed measurements. It is the ideal measurement platform to test coils in wireless charging systems. The DC resistance measurement function with high DCR accuracy and low ESR measurement capabilities can improve test quality and productivity in both design and manufacturing.

Related literature

Keysight E4980A Brochure, 5989-4235EN
Keysight E4980AL Brochure, 5991-2305EN
Keysight E4980A/AL Data Sheet, 5989-4435EN
Keysight LCR Meters, Impedance Analyzers and Test Fixtures Selection Guide, 5952-1430
Keysight Technologies Impedance Measurement Handbook, 5950-3000

Web resources

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www.keysight.com/find/e4980al
www.keysight.com/find/impedance
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