Application Note

ACCURACY CALCULATION TOOL FOR R&S®LCX100 AND R&S®LCX200

Products:

- R&S®LCX100
- R&S®LCX200

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http://www.rohde-schwarz.com/appnote/1GP138

Contents

1 Overview

This application note is about measurement accuracy of the LCR-Meters R&S®LCX100 and R&S®LCX200.

On the R&S®LCX100 and R&S®LCX200, the accuracy is calculated in real time and displayed on the lower part of the instrument display. However, if you do not have a test instrument available or do not have a DUT at hand, you can still calculate the accuracies using this Accuracy Calculation Tool.

The following document first presents an example of the accuracy estimation. In the third section the software is introduced and explained.

2 Example

Here is an example on how to calculate the accuracy of a capacitor. The necessary formulas and factors for the calculation of the measurement accuracy of the R&S®LCX100 and R&S®LCX200 are available in the datasheet [1] and are also explained in more detail there.

In this example, the accuracy of a **10 nF** capacitance is calculated. This is done via the impedance and phase accuracy calculation, which can then be converted to a capacitance accuracy. The chosen measurement frequency is **1 MHz**, test signal level shall be **1V**, measurement speed is "**SLOW**" for maximum accuracy, the source impedance is **100**, the cable length is **0m**, bias is **off,** the mode is **AC**, and the temperature is room temperature of **23**°C.

1. If the accuracy is to be calculated without a device or the DUT being available, theoretical values can be used:

$$Z = \frac{1}{2\pi \cdot 1\text{MHz} \cdot 10\text{nF}} = 15.915\ \Omega$$
$$\theta = -90°$$

2. Since the impedance is below 100 Ω, LowZ mode is chosen. From the respective accuracy map, an accuracy value of 0.2% is obtained

3. Adding the influence of the short impedance yields the basic accuracy: 0.2% + 0.009% = **0.209%**

4. Under the specified conditions, all factors except the frequency factor result in the value 1. Kf is calculated as:

$$K_f = \frac{1000[\text{kHz}] + 4550}{4850} = 1.144$$

   The impedance measurement accuracy is then 0.209% * 1.1443 = **0.239%**.

5. Knowing the impedance measurement accuracy, the phase measurement accuracy can be calculated:

$$\left(\frac{180°}{\pi}\right) \cdot \frac{0.239}{100} = 0.137°$$

6. The calibration accuracy for the specified conditions is ±0.03% (for phase ±0.025°). This results in an absolute impedance accuracy of **0.269%** and absolute phase accuracy of **0.162°**.

7. Using these values, minimum and maximum values for Z and θ can be calculated. Using the measured values from above:

$$Z_{min} = 15.9530\ \Omega \quad \theta_{min} = -89.838°$$
$$Z_{max} = 15.8769\ \Omega \quad \theta_{max} = -90.162°$$

Finally, this can be converted to a min / max value (and thereby accuracy) for the parameter C by interpreting the imaginary part as the desired capacitance value:

$$C_{\text{min}} = \frac{1}{2\pi f \cdot Z_{\text{max}} \cdot \sin\theta_{\text{min}}} = 9.973\ \text{nF}$$
$$C_{\text{max}} = \frac{1}{2\pi f \cdot Z_{\text{min}} \cdot \sin\theta_{\text{max}}} = 10.027\ \text{nF}$$

3 Accuracy Calculation Tool

This chapter is about calculating the accuracies of passive elements and how it is simplified with the software provided by Rohde & Schwarz. Thereby it is described step by step how to proceed. Before you get started, you need to download and install the software from the Rohde & Schwarz website.

3.1 Prerequisites

The software runs on Windows 10 and Windows 11. Older operating systems have not been tested and are therefore not supported.

It might be that the Installer of the Accuracy Calculation Tool displays a warning message. This is due to the version of the Microsoft Edge WebView2 control, which is used as the rendering module for this software and displays the web content of the app. If the installer doesn't display the warning message, then WebView2 is already installed and there is no need to go through the following.

The latest version of WebView2 is available at the following location:

https://developer.microsoft.com/en-us/microsoft-edge/webview2/#download-section

► On this page, the version marked in red in the following figure can be downloaded and then installed. Afterwards, the Accuracy Calculation Tool should run without any problems.

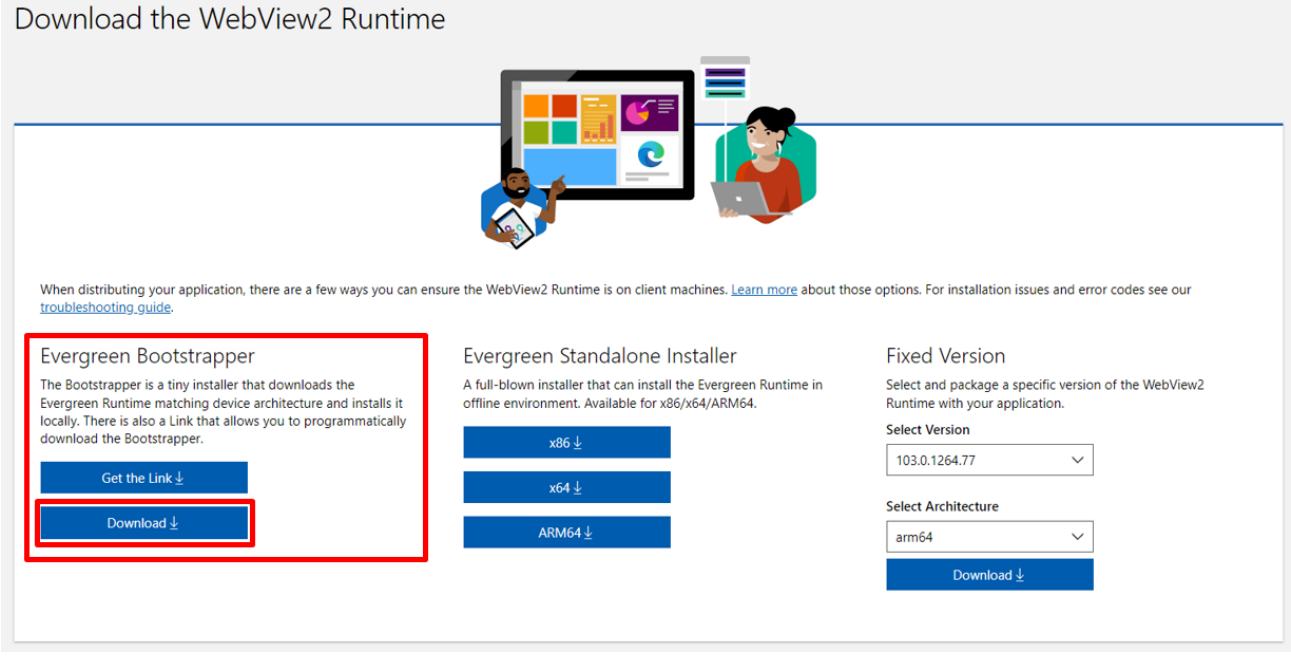

Figure 1: Download information WebView2

3.2 Using the Tool

The Accuracy Calculation Tool comprises three tabs. The "About" tab provides all relevant links to data sheets, product pages and version controls. The "Example" tab shows the same example as in section 2 of this document. The tool is controlled on the "Accuracy calculation" tab, shown in Figure 2. This tab provides all the necessary functions and parameters to calculate the measurement accuracy for a given nominal impedance or component value, depending on the settings of the LCR meter R&S® LCX100 or LCX200.

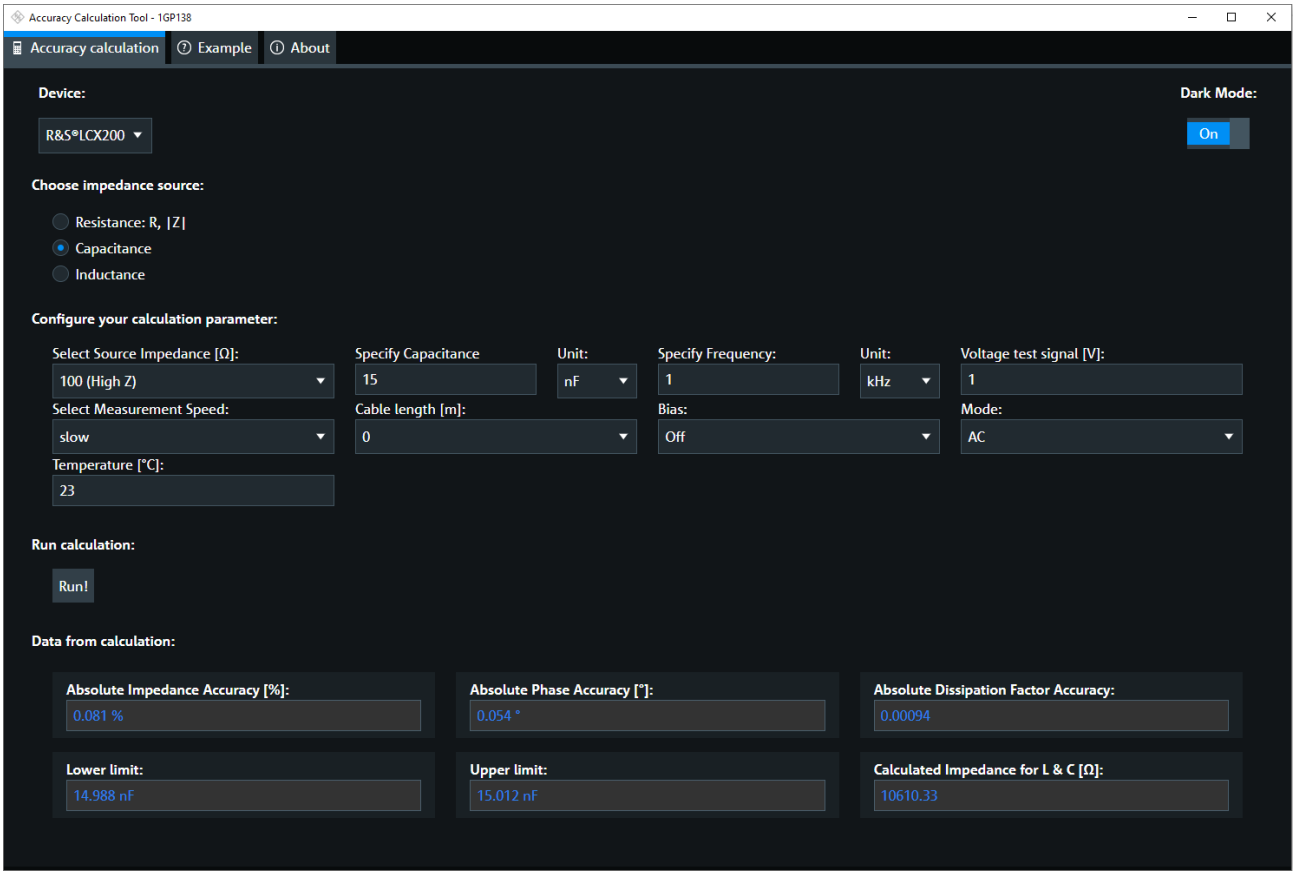

Figure 2: Accuracy Calculation Tool

You have the option to choose either the R&S®LCX100 or R&S®LCX200, along with the type of passive element for which you'd like to determine accuracies. Once you've selected the element type, you can specify its parameters using the input fields and the dropdown menus. The following section outlines the specified parameters, their ranges, and their impact on accuracy calculations:

- Source impedance:
  - 10 Ω (low Z mode): Measured impedance between 10 mΩ and 100 Ω
  - 100 Ω: Measured impedance between 100 mΩ and 100 MΩ
- Frequency:
  - R&S®LCX100: 4 Hz to 300 kHz
  - R&S®LCX200: 4 Hz to 500 kHz
  - R&S®LCX200 with option R&S®LCX-K201: 4 Hz to 1 MHz
  - R&S®LCX200 with option R&S®LCX-K210: 4 Hz to 10 MHz
- Measurement speed, three measuring times are available:
  - Fast: ≤15 ms

- Medium: ≤ 100 ms
- Slow: ≤ 500 ms

► Cable length:

- [0m, 1m]: cable extension k_{cl} factor 1 or 1.5

► Bias:

- Voltage: bias coefficient is 2
- Current: bias coefficient is 5 (Frequency < 1kHz) or 2 (Frequency ≥ 1kHz)
- Off: bias factor is 1

► Temperature:

- 20°C to 30°C: temperature coefficient is 1
- Else, but still in the range of 5°C to 40°C: 1 + 0.1 × |T – 23|

On the basis of the transferred parameters, the calculation is then started via the "Run" button. Afterwards the relative impedance measurement accuracy, the absolute impedance measurement accuracy and the absolute phase accuracy are displayed. The impedance is also calculated and displayed. Based on this and the determined accuracy ranges, the lower and upper limits of the uncertainty of the component value are determined.

The absolute dissipation factor (D) accuracy is calculated as tangens of the absolute phase accuracy. It is valid for low D values / high Q values and designates the measurement limit for determining the quality or dissipation factor of high-quality capacitances and inductances.

4 Conclusion

This application note from Rohde & Schwarz provides valuable information on the measurement accuracies of LCR-meters, specifically the R&S®LCX100 and R&S®LCX200 models. The note introduces the Accuracy Calculation Tool, which is specifically designed for calculating impedance measurement accuracies if no device or DUT is available. Users can obtain information on impedance measurement accuracy, absolute impedance accuracy, absolute phase accuracy, and calculated impedance. Based on these results and determined accuracy ranges, the tool also calculates the uncertainty range of the passive component value.

5 Ordering Information

Designation	Type	Order No.
LCR-Meter, 300kHz	R&S®LCX100	3629.8856.02
LCR-Meter, 500 kHz	R&S®LCX200	3629.8856.03
Frequency upgrade to 1 MHz, for R&S®LCX200	R&S®LCX-K201	3630.1880.03
Frequency upgrade to 10 MHz, for R&S®LCX200	R&S®LCX-K210	3630.1900.03

6 Bibliography

[1] Rohde & Schwarz, "R&S®LCX LCR Meter - Data Sheet," [Online]. Available: https://www.rohde-schwarz.com/search/download-center_63448.html?term=lcx%20data%20sheet. [Accessed 13 03 23].

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