Application Note

Using a Digibridge to calibrate transfer standards for LCR meter calibration

Summary

The IET Labs 1689 and 1693 Digibridges can easily be used to calibrate inexpensive capacitors, resistors and inductors which in turn can then be used to calibrate other 0.1% benchtop or handheld LCR meters.

This application note details how to successfully use an inexpensive standard as a transfer standard when used in combination with a Digibridge.

The 1689 and 1693 can both be used for this application. The specifications are similar on both Digibridges with the 1693 covering a wider frequency range and being slightly more accuracy for low impedance devices under test.

More information on the 1689 and 1693 Digibridges can be found at the links below.

https://www.ietlabs.com/1689.html
https://www.ietlabs.com/1693.html

Detail

A variety of inexpensive standards and decade boxes, when calibrated before use with a Digibridge, can easily be used to calibrate a wide variety of LCR meters.

IET Labs manufacturers a variety of RS, CS and LS decade boxes. These decade boxes typically have an accuracy of 0.05% to 1% of the set value. This accuracy maybe insufficient when calibrating a 0.1% LCR Meter especially we want to maintain a total uncertainty ratio TUR of 4 to 1.

Links to IET Labs decade box can be found at the links below.

https://www.ietlabs.com/rsbox.html

https://www.ietlabs.com/capacitance/decade-capacitor/csbox.html

https://www.ietlabs.com/ls-series-inductance-decade-box.html

One option is to use a 1689 or 1693 Digibridge to first calibrate the decade box at the specific value and frequency of calibration. This way we are calibrating the standard before use which minimizes uncertainty contributors such as stability over long periods of time or the initial calibration accuracy of the standard.

For example, if you want to calibrate an LCR meter at 1 kHz and 1 nF, you can set the CS box to 1 nF, perform and open and short, and then measure the capacitance with the Digibridge. We would then measure the CS box without changing any settings on the LCR meter to be calibrated. This way we are performing a short-term transfer from the Digibridge to the LCR meter being calibrated using the CS box as a transfer standard.

We need to make sure the cables are similar between the Digibridge and the LCR meter undertest. The open and short should be performed in the same manner on both the Digibridge and LCR meter.

We also want to make sure we minimize error due to transfer method by keeping frequency, signal level and source impedance the same between the Digibridge and LCR meter undertest.

The accuracy of the Digibridge should also be calculated from the formulas given in the manual or IET also has an accuracy calculator to assist with this.

The accuracy calculator for the 1693 and 1689 can be found at the links below.

https://www.ietlabs.com/notes/1693_digibridge_accuracy_calculator

https://www.ietlabs.com/notes/digibridge_accuracy_calculator

Entering 1 nF, 1 kHz, slow and 1 V into the accuracy calculator gives a measurement accuracy for the Digibridge of 0.022%.

We would still have to account for repeatability, reproducibility, resolution, environmental, stability, transfer method and calibration of the standard. The calibration of the standard would be the measurement accuracy for the Digibridge.

Assuming the timeframe between the measurement of the standard with the Digibridge and the LCR meter is relatively short, say within 30 minutes the uncertainty contributors due to environmental conditions, and stability should be negligible.

Assuming the frequency, ac signal, source impedance and cabling are identical then the error due to the transfer method is minimized as well. All contributors to measurement uncertainty still need to be taken into account and documented but should be small as compared to the accuracy of the Digibridge.

This type of transfer can also be done using the Digibridge for resistance and inductance measurements as well using the RS Decade Box and LS Decade Box.

It is important to make sure that the equivalent circuit chosen is the same for both the Digibridge and LCR Meter. When measuring with the Digibridge you can select either a series or parallel equivalent circuits i.e. Rs, Cs and Ls or Rp, Cp and Lp.

When measuring impedances of < 10 kΩ we typically measure using a series equivalent circuit. Above 10 kΩ we would use a parallel equivalent circuit. The most important thing is that the Digibridge and LCR meter undertest use the same equivalent circuit so both using series or both using parallel.

When performing calibration using the LS Box or similar inductance standards it is extremely important to use the same signal level and source impedance. The signal level and source impedance affect the amount of current flowing through an inductor. Inductors such as the LS Box and 1492 Decade Inductor use ferromagnetic cores, so the inductance will change based upon the amount of current flowing in the inductor. The main concern is to make sure the signal level and source impedance are as similar as possible between the Digibridge and the LCR meter undertest to minimize errors.

Conclusion

The 1689 Digibridge and 1693 Digibridge have a basic accuracy of 0.02% which makes them ideal for calibration of a variety of capacitors, inductors and resistors.

These standards can then be used as transfer standards to calibrate a variety of LCR meters.

The use of the Digibridge with an economical decade box can be significantly less expensive as compared to purchasing several individual capacitance or inductance standards. As well calibration of just the Digibridge versus calibration of several individual capacitance or inductance standards can amount to thousands of dollars in savings on a recurring basis.