KEITHLEY

Application Note Series

Number 2922

Measuring Inductance Using the 4200-CVU Capacitance-Voltage Unit

Introduction

Although the 4200-CVU capacitance option for Keithley's Model 4200 Semiconductor Characterization System does not measure inductance directly, users can easily extract the inductance from the parameters it does measure: impedance (Z), phase angle (theta or θ), and the test frequency (f). This application note describes how users of the Model 4200-SCS can determine inductance using the 4200-CVU option.

Equipment Requirements

This application requires the use of a Model 4200-SCS system with the 4200-CVU option installed. Although the procedure given here does not depend on the use of a specific KTEI version, 4200-CVU is only supported by KTEI version 7.0 and later.

Implementation procedure

The formulas for deriving the inductance are as follows:

$$X = Z \sin\theta$$

where:
X = Reactance
Z = Impedance
θ = Phase angle between capacitance and conductance C,G (rads)

$$L = \frac{X}{2\pi f}$$

where:
L = Inductance
X = Reactance
π = Archimedes' constant (3.141592…)
f = Test frequency

To incorporate these formulas into a KITE project:

1. Create an Interactive Test Module (ITM) and choose the 4200-CVU (CVH1 and CVL1) for the measurements at the device terminals in the ITM.
2. In the Force Function/Measure Options window, set the Measured Options Parameters to "Z,Theta" as shown in ***Figure 1***.
3. Open the Formulator and type in the formula for the reactance using the Data Series parameters Z, Theta, and F. The units for "Theta" are in degrees. To use the trigonomic functions in the Formulator, you must convert the units to rads using the "RAD" function as shown in ***Figure 2*** for a device with terminals A and B:

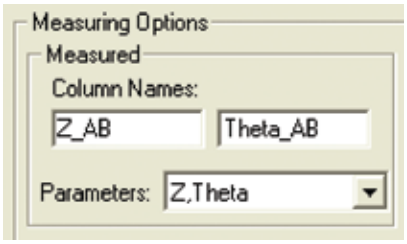


Figure 1

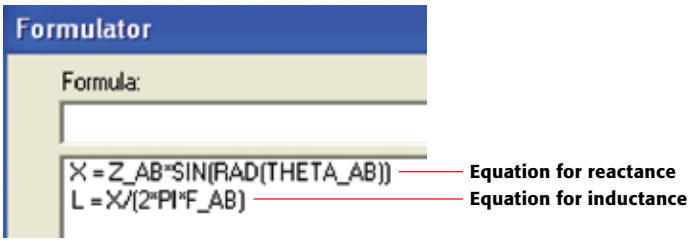
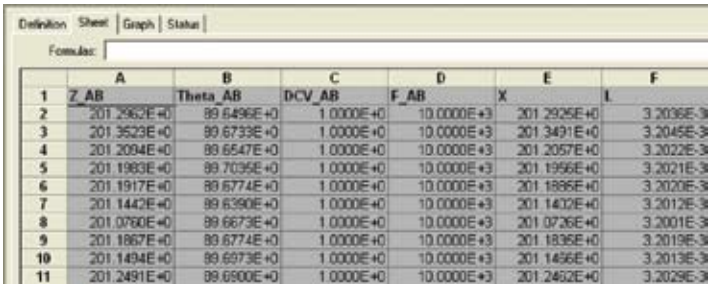


Figure 2

4. Type in the formula for inductance from X and F. "Pi" (π) can be found in the constants area of the Formulator.

Example results

Once the project is saved and executed, the inductance (L) will appear in the Sheet tab as shown in ***Figure 3***. It can also be plotted on a graph.



	A	B	C	D	E	F
1	Z_AB	Theta_AB	DCV_AB	F_AB	X	L
2	201.2962E+0	89.6496E+0	1.0000E+0	10.0000E+3	201.2925E+0	3.2036E-3
3	201.3523E+0	89.6733E+0	1.0000E+0	10.0000E+3	201.3491E+0	3.2045E-3
4	201.2094E+0	89.6547E+0	1.0000E+0	10.0000E+3	201.2057E+0	3.2022E-3
5	201.1983E+0	89.7035E+0	1.0000E+0	10.0000E+3	201.1956E+0	3.2021E-3
6	201.1917E+0	89.6774E+0	1.0000E+0	10.0000E+3	201.1885E+0	3.2020E-3
7	201.1442E+0	89.6390E+0	1.0000E+0	10.0000E+3	201.1402E+0	3.2012E-3
8	201.0760E+0	89.6673E+0	1.0000E+0	10.0000E+3	201.0726E+0	3.2001E-3
9	201.1867E+0	89.6774E+0	1.0000E+0	10.0000E+3	201.1836E+0	3.2019E-3
10	201.1494E+0	89.6973E+0	1.0000E+0	10.0000E+3	201.1456E+0	3.2013E-3
11	201.2491E+0	89.6900E+0	1.0000E+0	10.0000E+3	201.2462E+0	3.2029E-3

Figure 3

Other considerations and possible sources of error

This method is useful for measuring inductances ranging from microhenries to millihenries. The actual range that can be measured and the quality of the results achieved will depend on the characteristics of the specific device under test—its own impedance, etc.—and the instrument settings, such as the test frequency.

According to the inductance equation, use lower frequencies to measure higher inductances and vice versa.

Standard best practices for high quality electrical measurements should be used, including the use of four-wire connections as close to device as possible, etc.

References

1. 4200 system overview: http://www.keithley.com/data?asset=50733
2. 4200 start-up sequence: http://www.keithley.com/data?asset=50696

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