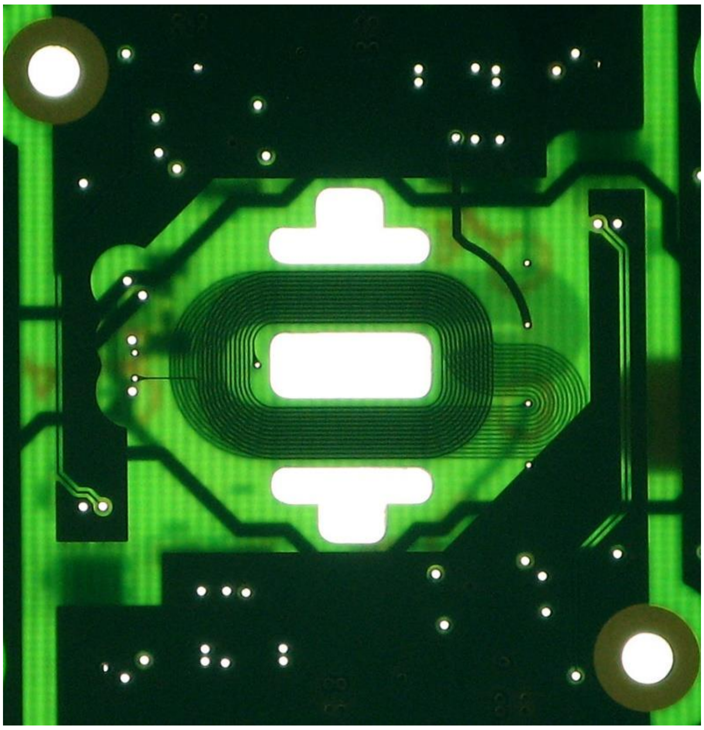
Bode 100 - Application Note

Planar Transformer Measurement Using the Bode100



by Lukas Heinzle

Visit www.omicron-lab.com for more information.
Contact support@omicron-lab.com for technical support.

Table of Contents

Note: Basic procedures such as setting-up, adjusting and calibrating the Bode 100 are described in the Bode 100 user manual. You can download the Bode 100 user manual at www.omicron-lab.com/bode-100/downloads#3

Note: All measurements in this application note have been performed with the Bode Analyzer Suite V3.21. Use this version or a higher version to perform the measurements shown in this document. You can download the latest version at www.omicron-lab.com/bode-100/downloads

1 Executive Summary

This application note explains how to verify the function of planar transformer coils on a printed circuit board (PCB). These coils are usually tested via a flying probe test. A flying probe test only measures the DC-resistance and so it is difficult to determine if the planar transformer will work or not. In our application note we use an AC-impedance measurement to compare defect and non-defect planar coils by looking at their resonance shift and impedance deviation.

2 Measurement Tasks

Using the Bode100 it is possible to measure the impedance characteristics of planar coils over a wide frequency range from 1Hz to 50 MHz. By comparing the measurement results of the windings, a winding-defect can be detected.

3 Measurement Setup & Results-

3.1 Used Equipment

The following equipment was used to perform the measurements described in this application note:

- One Vector Network Analyzer Bode 100 (with its measurement accessories)
- One defective and two fully functional planar transformers
- One measurement probe with tips (Picotest PDN Probe)

3.1.1 Planar Coils / Transformers on PCB

In our application note we use two PCBs containing one defective transformer each. In total there are 6 transformers including two defective ones. The following figure shows the PCB and the defective transformer framed in red.

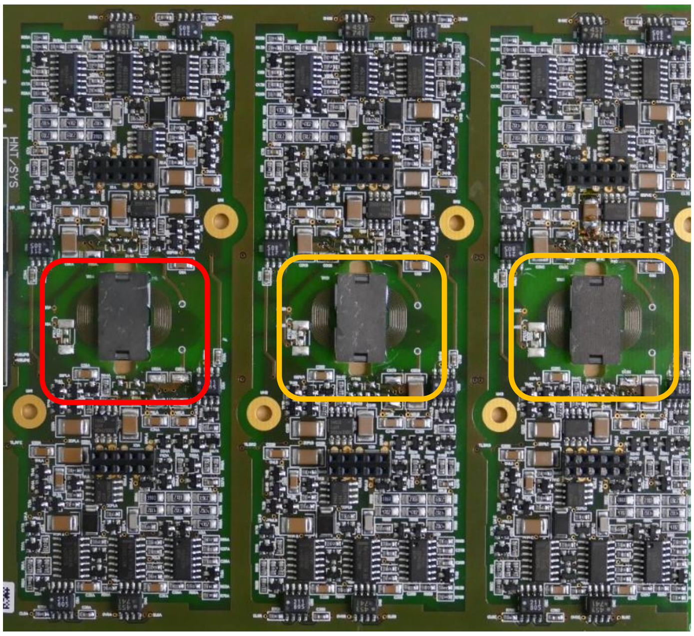


Figure 1: Device Under Test

Each planar transformer has one primary and two secondary coils. The primary coil is called the "outer coil" (visible) and the secondary coils are called "inner coils". The following picture shows the equivalent circuit model of the planar transformer.

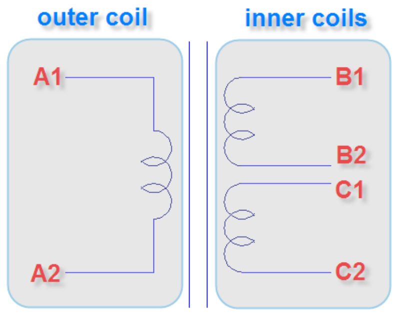


Figure 2:Circuit Model Planar Coils

Before performing the measurement, the ferrite cores and some components are removed to get similar test conditions to the flying probe test which is performed before the PCB assembly.

The following picture shows the connection points used for the measurements. The numbering of the points equals the numbering in the equivalent circuit model (see picture on the previous page).

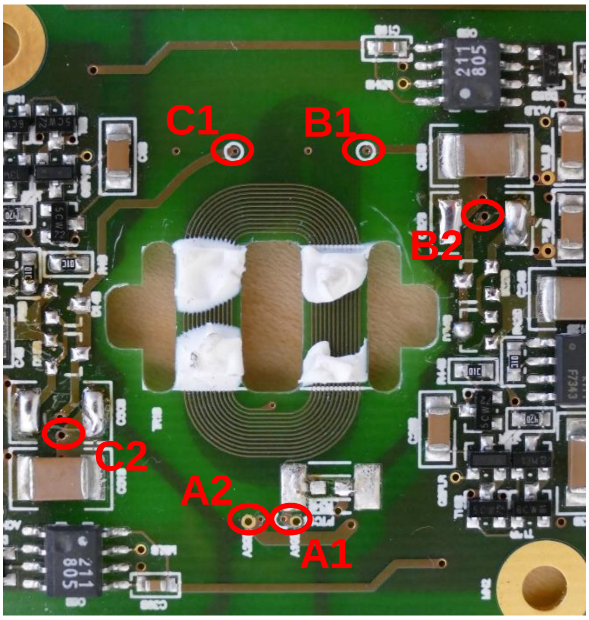


Figure 3: Measurement points on the DUT

3.1.2 Probe

To measure the impedance of the coils, a Z0 probe respectively the Picotest PDN probe shown in the figure below was used.

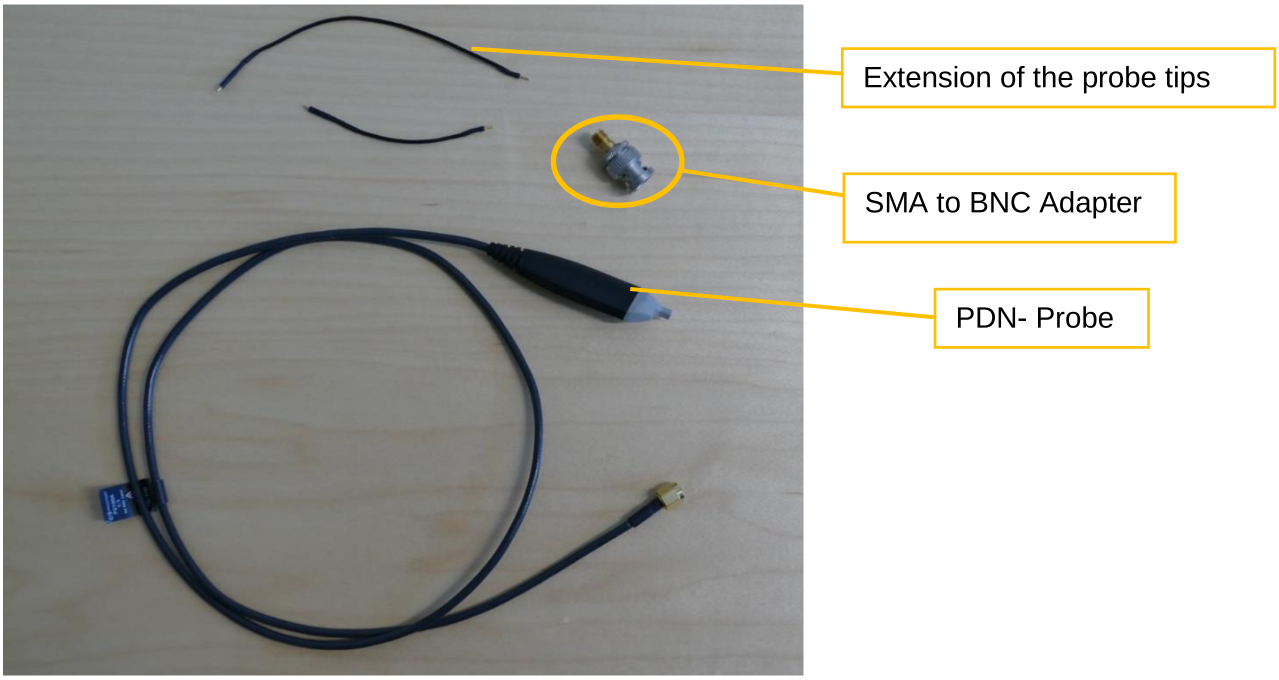


Figure 4:One-Port PDN Probe from Picotest

3.2 DC-Resistance Measurement

PCBs are usually verified using a flying probe test measuring with DC. The results of the following measurements show that the DC test cannot identify the defective planar transformer.

3.2.1 Measurement Setup

The measurement is performed using a digital multimeter as shown below.

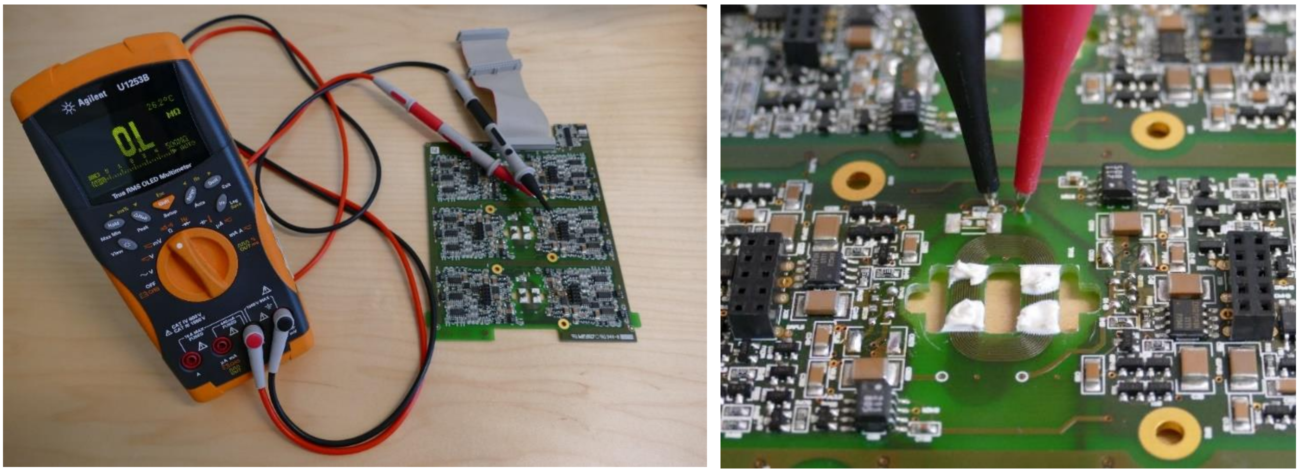


Figure 5:Measurement setup with digital multimeter

3.2.2 Measurement Results

The following table shows the measurement results of the planar transformers. Each transformer consists of 3 coils (A, B and C).

Transformer Number	Outer Coil A Resistance	Inner Coil B Resistance	Inner Coil C Resistance
☺ 1	4.3 Ω	3.1 Ω	3.0 Ω
☹ 2	4.4 Ω	2.9 Ω	3.2 Ω
☺ 3	4.3 Ω	3.2 Ω	3.2 Ω
☹ 4	4.8 Ω	3.1 Ω	2.8 Ω
☺ 5	4.7 Ω	3.1 Ω	3.1 Ω
☺ 6	4.6 Ω	3.1 Ω	3.2 Ω

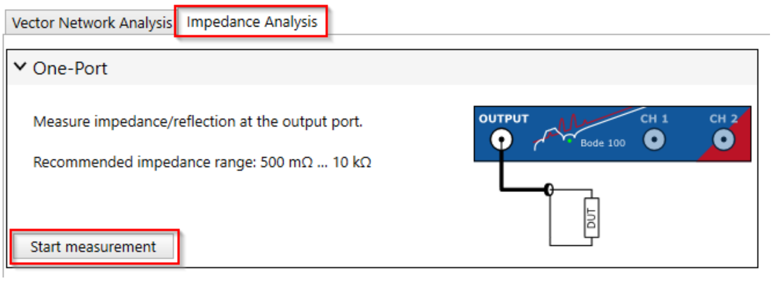
Transformers 1 and 4 were defective non-functional transformers. From the DC resistance measurements, it does not seem obvious to detect non-functional devices.

3.3 AC-Impedance of Planar Coils

When measuring the impedance of the planar coils in a high frequency range up to several MHz, the planar coils show resonance behavior. By measuring deviations of the coil resonance frequency, respectively the coil Q-factor it is clearly possible to distinguish between defective and non-defective transformers.

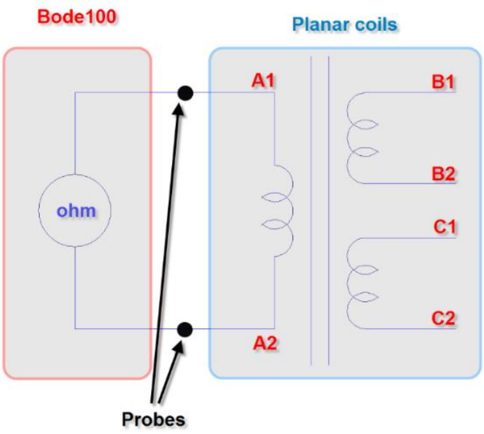
3.3.1 Bode100 Setup

- Open a One-Port Impedance Measurement:



- To ensure exact measurement results, calibrate the Bode 100 using the Probe-Calibration/Impedance. Details can be found in the Bode 100 User Manual.

3.3.2 Outer Coil Measurement



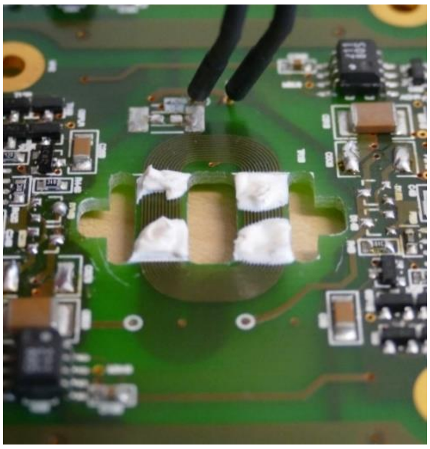


Figure 6:Outer Coil measurement setup

The following graph shows the results for the frequency sweep measurement of the outer coil A.

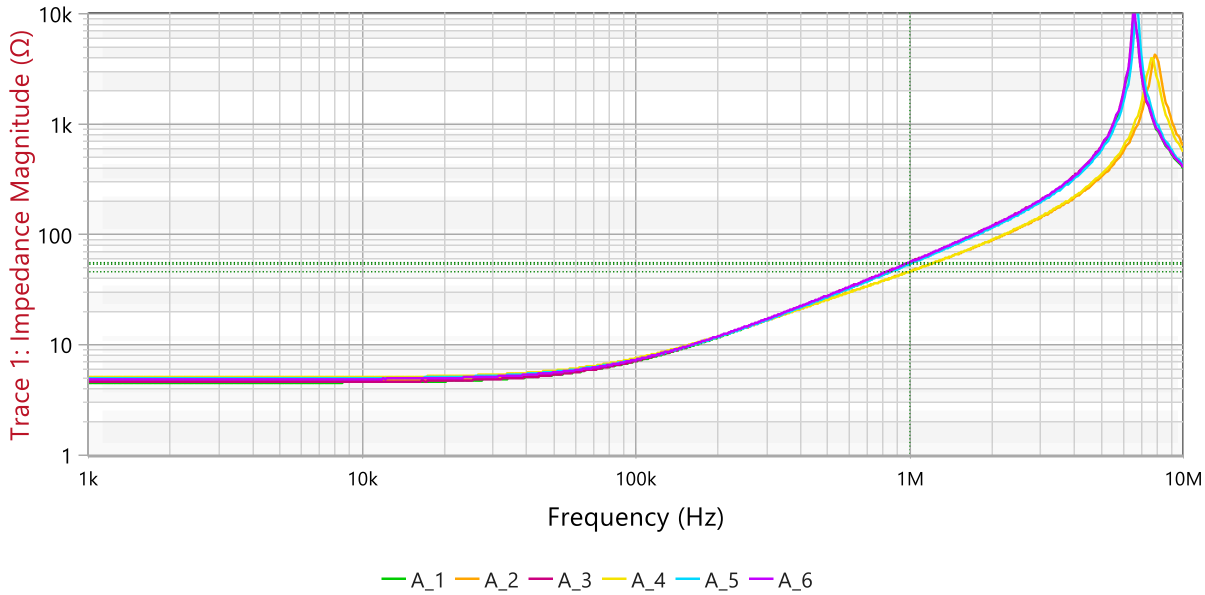


Figure 7:Outer Coil Impedance Sweep

The measurement results show that the primary-inductance self-resonance frequency of the two defective transformers is significantly higher than the resonance frequency of the working devices.

The problem can be easily detected by e.g. measuring the Q-factor at 1 MHz respectively the phase of the impedance between 1 MHz and 5 MHz.

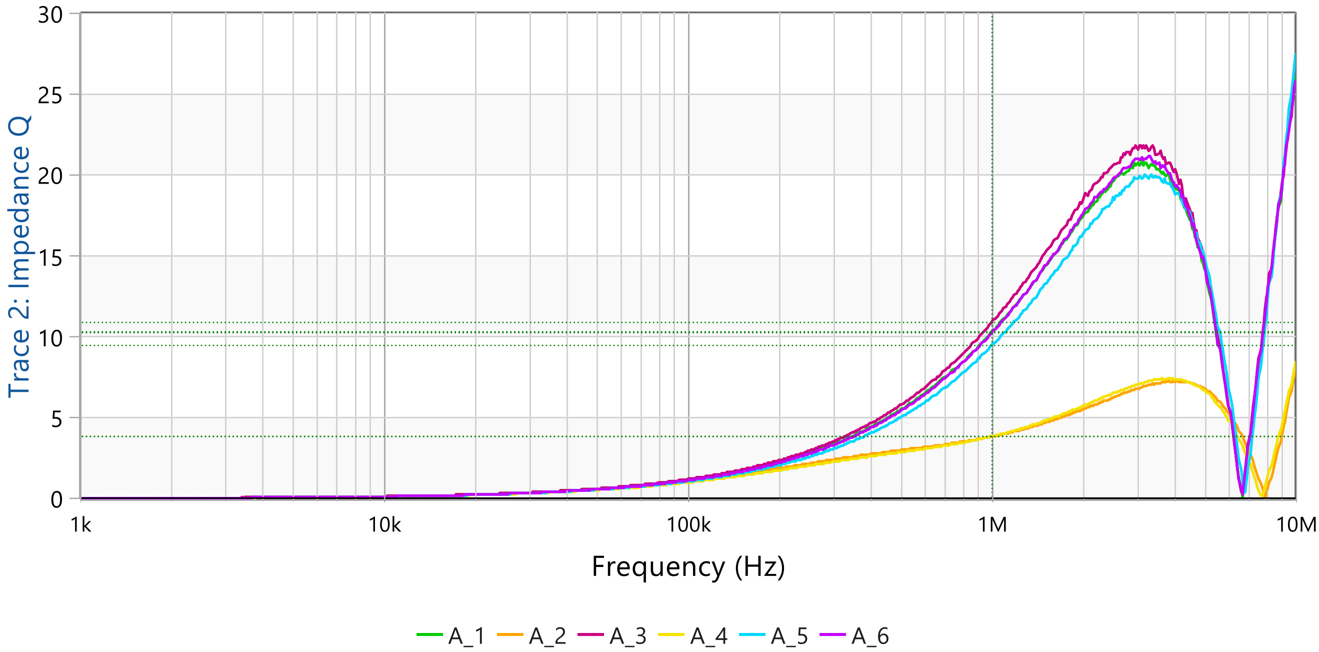


Figure 8:Outer Coil Q-Sweep

The measurement curve above shows that the Q-factor of the primary inductance of the defective transformers is significantly less at frequencies of 500 kHz and above. The following table lists the Q-factors of the outer coil for the six transformers:

Transformer Number	Outer Coil A Q at 1 MHz	Outer Coil A Self-Resonance Frequency
☺ 1	10.3	6.67 MHz
☹ 2	3.8	7.94 MHz
☺ 3	10.9	6.65 MHz
☹ 4	3.8	7.72 MHz
☺ 5	9.5	6.79 MHz
☺ 6	10.2	6.66 MHz

The working transformers have a primary winding Q of around 10 whereas the broken ones have a Q of less than 4 at a frequency of 1 MHz. This means that the Q-factor of the primary inductance with open secondary windings is a very sensitive measure for the working or non-functional transformers.

In the following, the impedance of the secondary windings will be analyzed in addition.

3.3.3 Measurement of Inner Coils B and C

To demonstrate that the inner coils can be used as well, the B-coil and C-coil are measured as well.

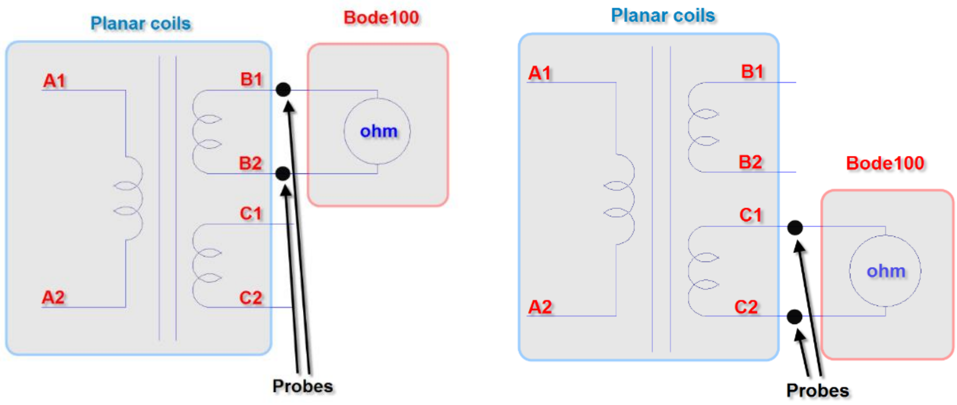


Figure 9Inner Coil Measurement B and C

The following diagram shows the Q-factor of the inner coils B and C over frequency:

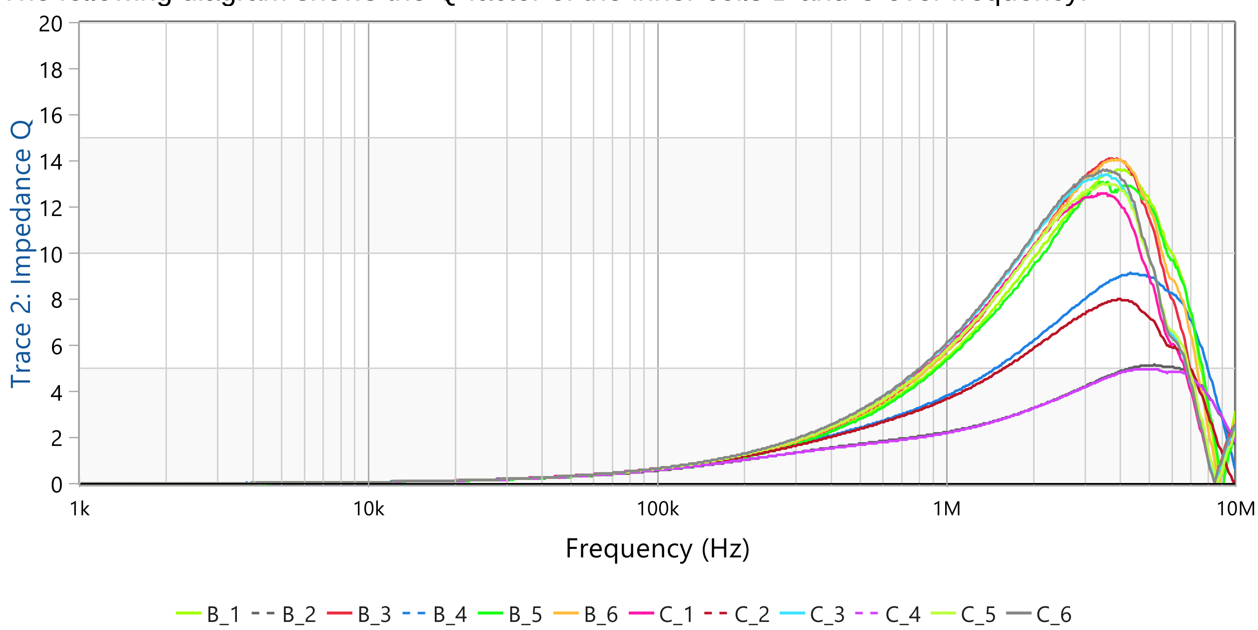


Figure 10:Inner Coil B and C, Q-Sweep

Like the outer coil, the defective coils have a significantly lower Q-factor at frequencies around 1 MHz and above.

4 Conclusion

In this application note it has been shown how the Bode 100 can be used to measure the impedance of planar transformer coils. A simple DC measurement of winding resistance might not be enough to detect defects in PCB-windings but with the Bode100 the defective transformers can be clearly identified. The AC-Impedance measurement of the Bode 100 offers a fast and reliable possibility to detect failures in planar transformer coils. These measurements can easily be automated using the Bode Automation Interface.
For more details, check out: www.omicron-lab.com/BodeAutomationInterfaceHelp

OMICRON Lab is a division of OMICRON electronics GmbH, specialized in providing Smart Measurement Solutions to professionals such as scientists, engineers and teachers engaged in the field of electronics. It simplifies measurement tasks and provides its customers with more time to focus on their real business.

OMICRON Lab was established in 2006 and is meanwhile serving customers in more than 60 countries. Offices in America, Europe, East Asia and an international network of distributors enable a fast and extraordinary customer support.

OMICRON Lab products stand for high quality offered at the best price/value ratio on the market. The products' reliability and ease of use guarantee trouble-free operation. Close customer relationship and more than 30 years in-house experience enable the development of innovative products close to the field.

Europe, Middle East, Africa
OMICRON electronics GmbH
Phone: +43 59495
Fax: +43 59495 9999

Asia Pacific
OMICRON electronics Asia Limited
Phone: +852 3767 5500
Fax: +852 3767 5400

Americas
OMICRON electronics Corp. USA
Phone: +1 713 830-4660
Fax: +1 713 830-4661

info@omicron-lab.com • www.omicron-lab.com