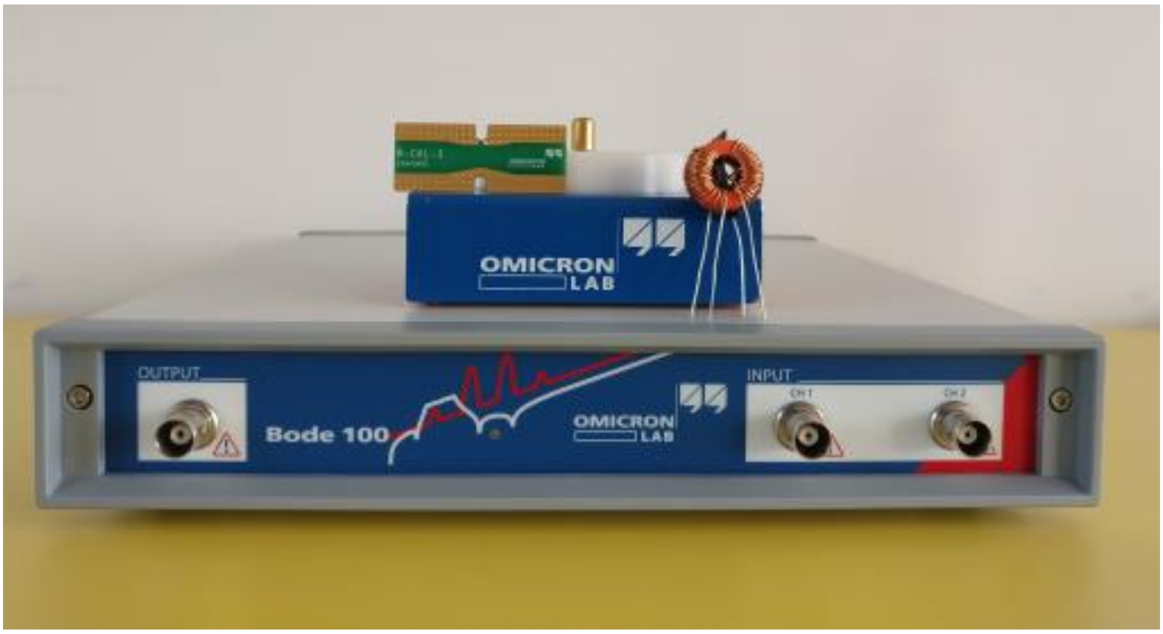
Analyzing a Common Mode Choke

By measuring Common Mode and Differential Mode Inductance



Contact **sales02@telesplicing.com.tw** for technical support.

1 Introduction & Purpose

Common-mode chokes, See Figure 1, are a special type of inductors or transformers which are used for the design of electronic circuits. Common-mode chokes are used to filter common mode disturbances. This can be required at the line-filter or also at dc-lines. In this document, the difference between the differential mode & common mode behavior of the choke is explained. The Bode 100 in conjunction with the B-WIC impedance test fixture is used to measure the frequency response of the choke to derive common mode inductance as well as the differential mode inductance.

A common mode choke is constructed of a core with two windings. The following picture shows a typical common mode choke with winding A and winding B. This choke has a rated common mode inductance of 2.8 mH and a rated current of 4 A as well as a voltage of 250 Vac.

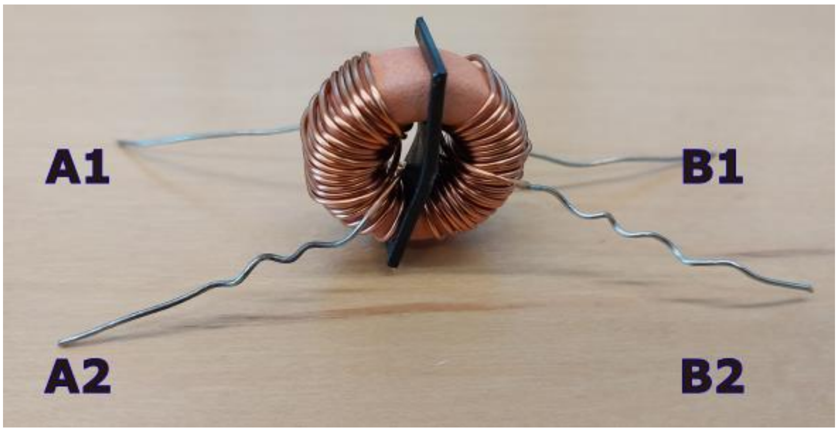


Figure 1: Common mode choke device under test (DUT)

2 Differential Mode & Common Mode

Common mode chokes, as illustrated in Figure 2, are specialized inductors with two or more distinct windings. In this case, the focus is centered on two windings only. When this component is traversed by a common mode signal, as it is indicated in the Figure 2 by the red and blue arrows, the accumulation of magnetic flux within its core is induced, resulting in the manifestation of high impedance at specific frequency ranges. On the other hand, differential signals serve to nullify the magnetic flux within the core. Also, the current travels in opposite directions, as it is illustrated in Figure 3, resulting in a lowered impedance and facilitating the smooth passage of the signal.

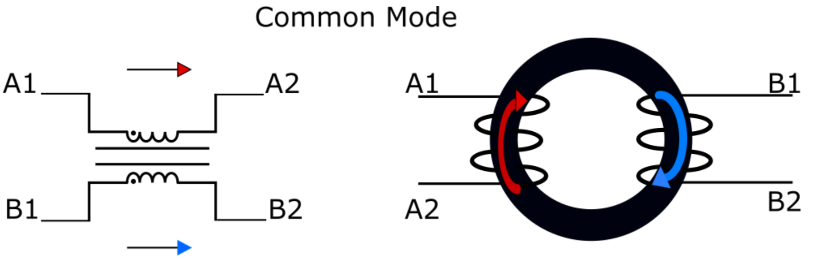


Figure 2: Choke coil - Common mode equivalent circuit

In practical common mode chokes, perfect cancellation is not attainable, giving rise to a non-zero impedance in the differential mode, as depicted in Figure 3. This phenomenon is commonly referred to as "leakage". While it serves a valuable purpose in filtering differential mode signals, it is imperative to assess the potential saturation effects, particularly in applications involving high current.

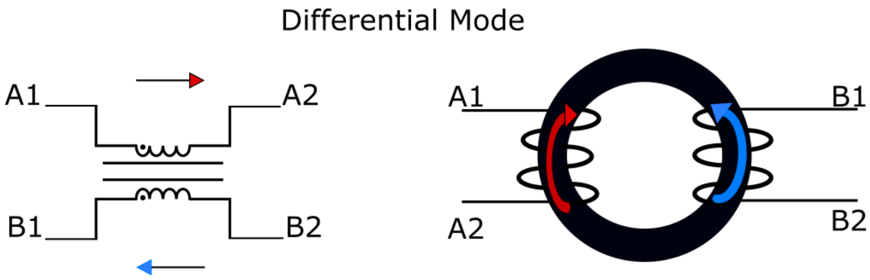
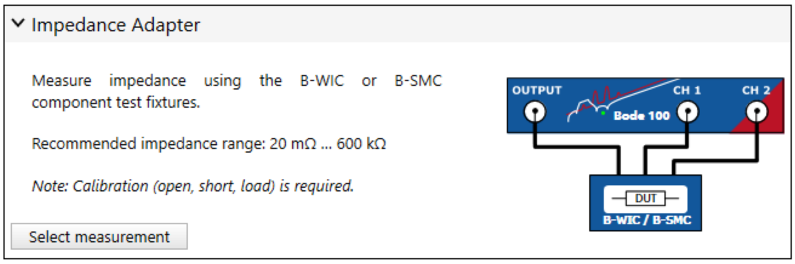


Figure 3: Choke coil - Differential mode equivalent circuit

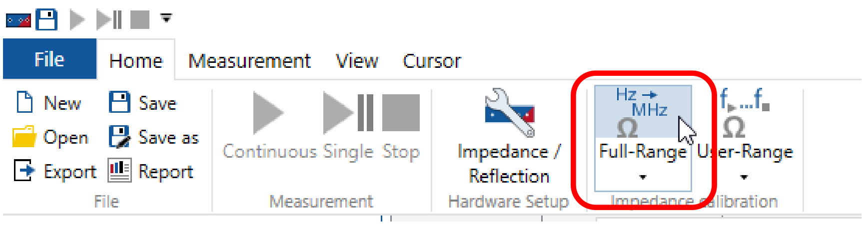
3 Measurement Setup & Calibration

Before starting to work with the Bode 100, the Bode Analyzer Suite needs to be configurated. **Select** the **"Impedance Adapter" measurement** under "Impedance Analysis":



Then, **connect** the **B-WIC** impedance **adapter** to the Bode 100 using the three BNC cables.

As a next step, **calibrate** the **B-WIC** by clicking on the Full-Range calibration button:



Afterwards, **perform open, short** and **load calibration** using the B-CAL calibration board. For more information, please check out the user manual of Bode 100.

4 Measuring the Common Mode Choke

4.1 Common Mode Setup

To measure the choke in common mode, the choke must be connected as shown in Figure 4. Wire A1 and B1 as well as A2 and B2 are short circuited by twisting the wires. The wires A1 and A2 are placed in the B-WIC as shown in the picture below.

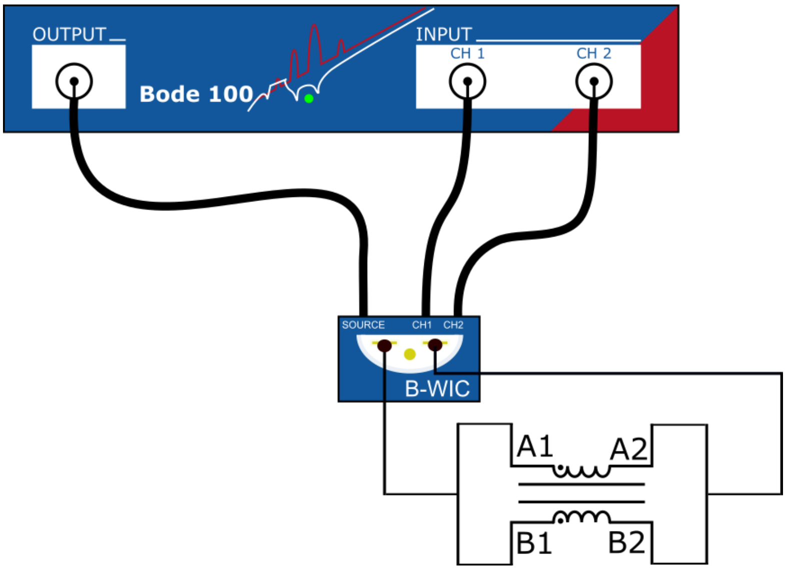


Figure 4: Schematic Setup for Common Mode

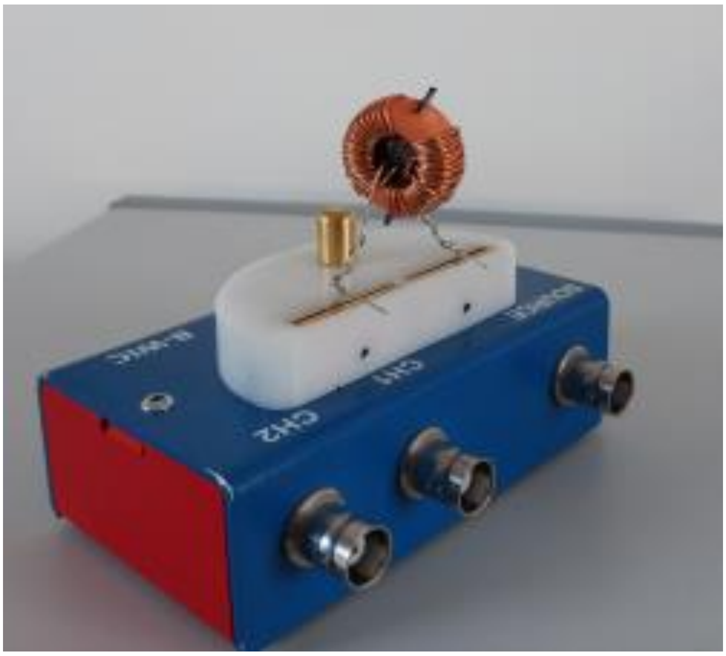


Figure 5: Setup for Common Mode

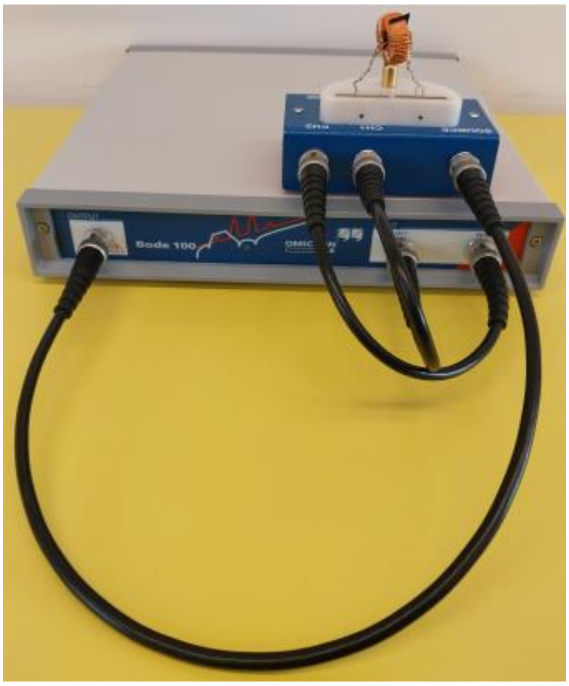


Figure 6: Setup for Common Mode

Figure 7: Setup for Common Mode

4.2 Differential Mode Setup

Figure 8 shows the connection of the DUT to the Bode 100 and B-WIC. Wire A1 and B1 are connected to the B-WIC while the wire A2 and B2 are short circuited.

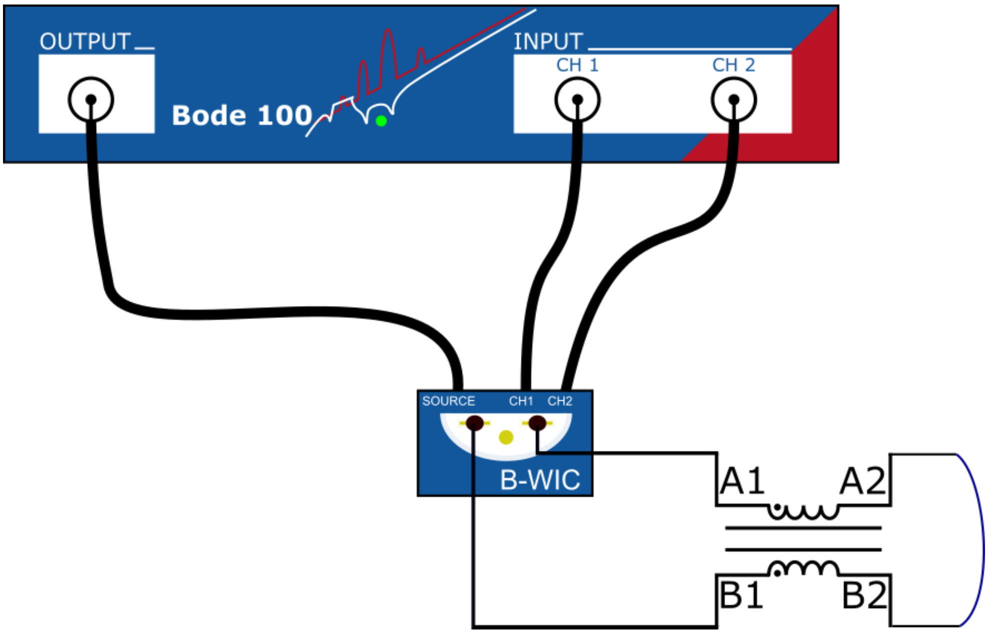


Figure 8: Schematic Setup for Differential Mode

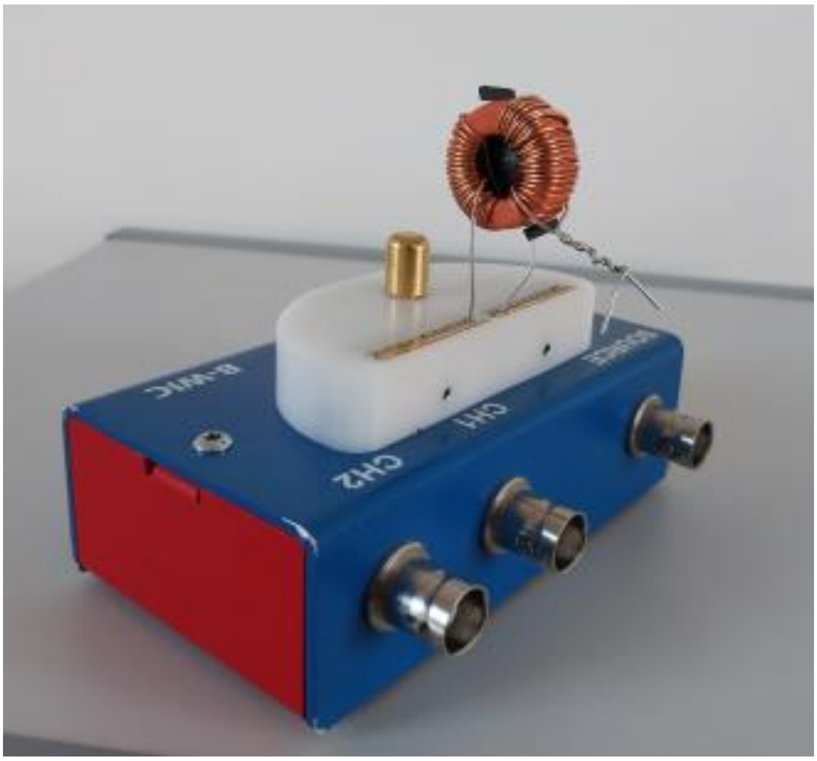


Figure 9: Setup for Differential Mode

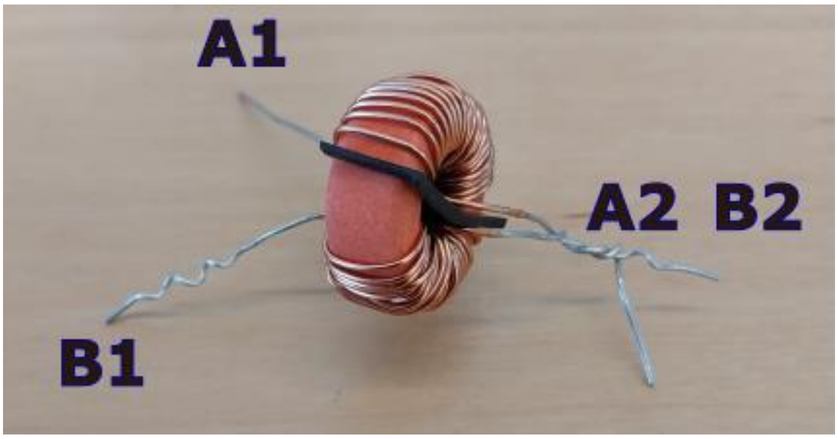


Figure 10: Setup for Differential Mode

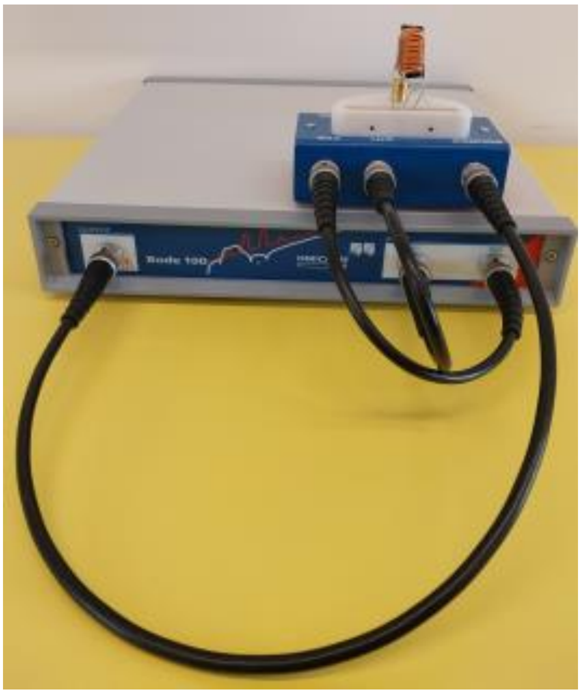


Figure 11: Setup for Differential Mode

5 Results

Figure 12 shows the results obtained with the Bode 100 concerning to common mode and differential mode operation. As it can be observed, the impedance magnitude of the common mode increases when the frequency is going up. It reaches a saturation and it start to decrease. On the other hand, for the differential mode operation, from 10 Hz to 300 Hz indicates a resistive behavior, from 300 Hz to around 20 MHz the behavior is inductive. From a frequency higher than 20 MHz the behavior is capacitive.

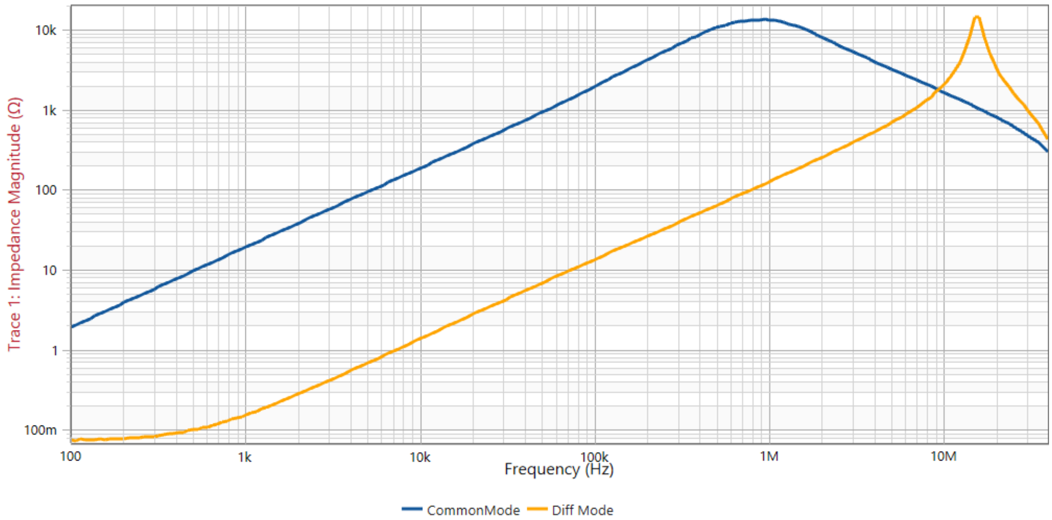


Figure 12: Common and Differential mode operation result

Figure 13 and Figure 14 shows the results of the common and differential mode measurement. The leakage along the frequency from 10 Hz to 10 MHz shows an approx. value of 22 µH while the value of the common mode choke in common mode operation shows approx. 3 mH.

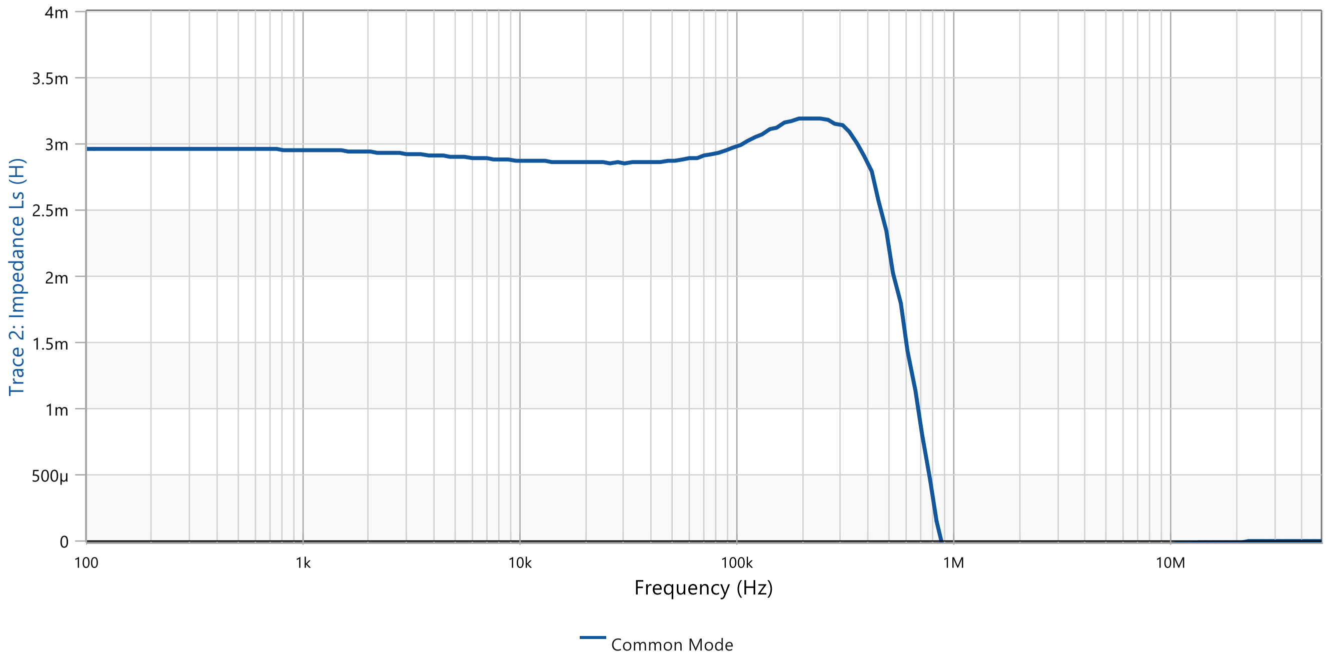


Figure 13: Common mode operation result

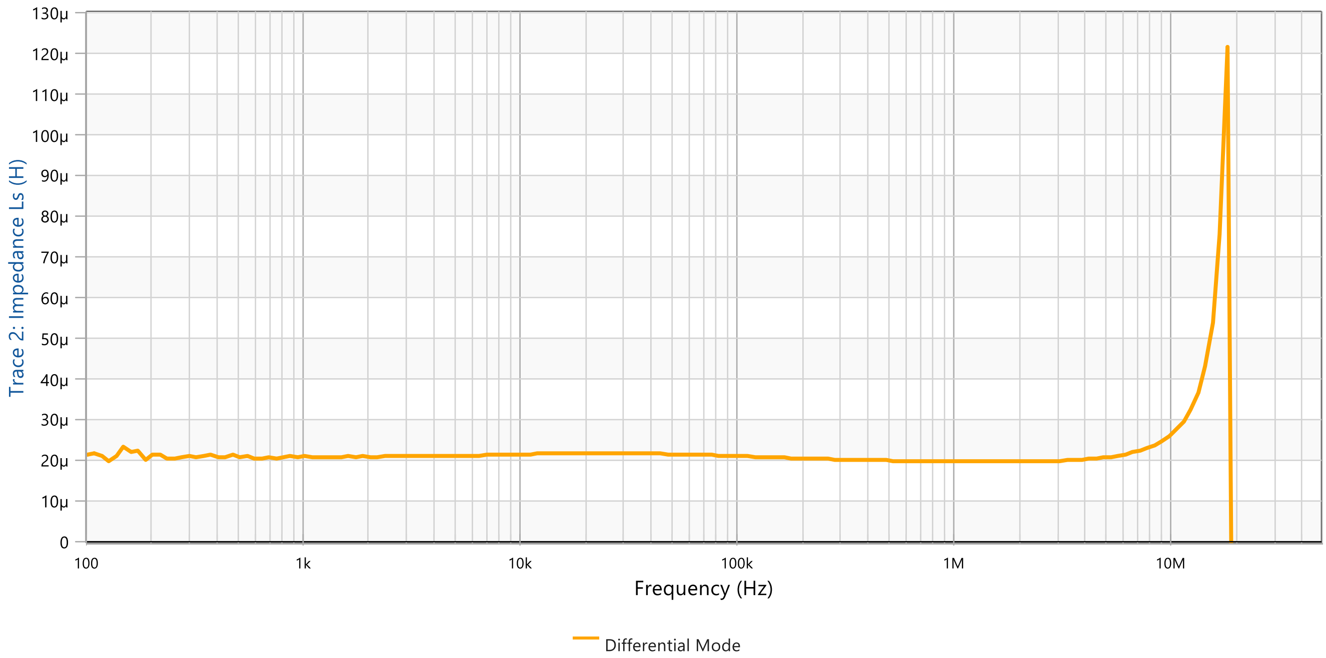


Figure 14: Differential mode operation result