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STUDY OF TEST WIRE LOCATION AND COMPENSATION FOR IMPEDANCE MEASUREMENTS

INTRODUCTION

It is well known that the test wire used for measuring the impedance of ferrite suppression cores can have significant impact on measurements. This is especially true for overly long test wire lengths, at frequencies over 100 MHz, and has been considered in a separate paper by Fair-Rite®, which can be found HERE. The test wire location within the ferrite core aperture will also affect results, and the different results are shown with and without vector subtraction of the complex impedance of the test wire.

Fair-Rite® made use of the Keysight E4991A Impedance Analyzer with the spring clip test fixture model 16092A. Standard calibration and fixture compensations were performed prior to all measurements. Tests were performed at Fair-Rite®'s Wallkill, NY facility in the Measurements Lab at room temperature (23ºC). Three different standard ferrite suppression cores were used and the test wire was AWG# 22 uninsulated buss wire.

TEST WIRE LOCATION

The first evaluation was performed using Fair-Rite® PN 2643169351 (single piece flat cable suppression core). This part has a rectangular outer envelope 33.7 x 6.7 x 13.2mm length and the slot is 27.5 x 1.35 mm. The diameter of the test wire is 0.65 mm. Tests were performed at three locations within the aperture/slot using test wire length of 38 mm (1.5") as shown in figure 1.

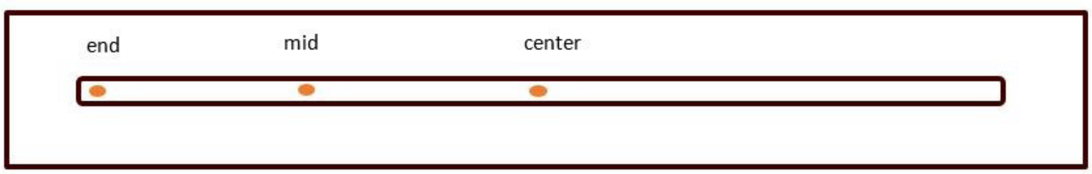

Figure 1

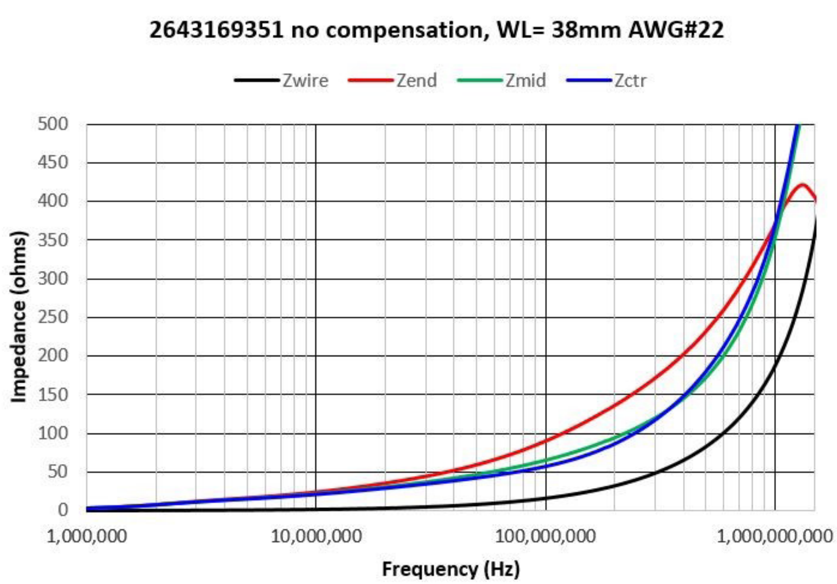

Figure 2

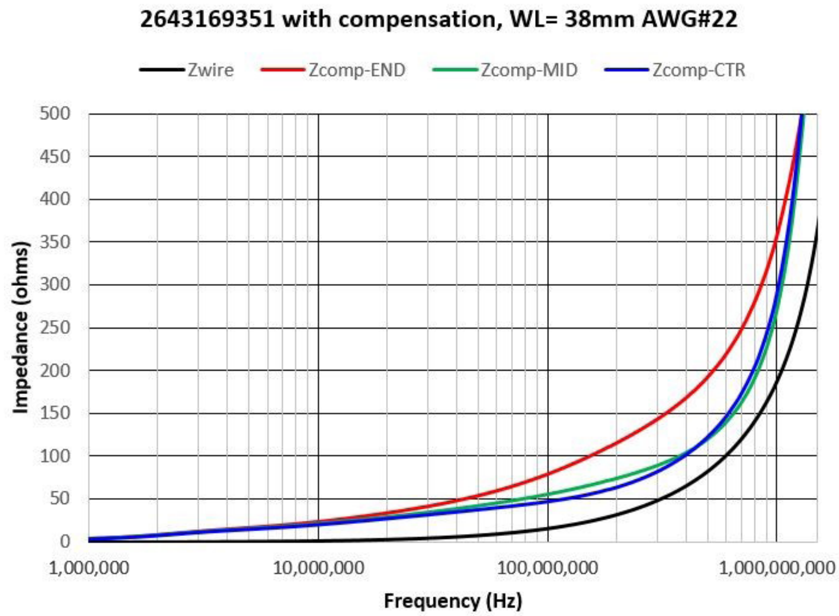

Figure 3

Figure 2 shows the Impedance (Z) as measured by the test wire by itself and with the 2643169351 ferrite core in the three locations shown in Figure 1. Figure 3 shows the same data from Figure 2 with the complex impedance of the wire by itself subtracted from the wire with core measurements.

The math for calculating the compensated values is: $Z = \sqrt{(X^2+R^2)}$,
$Z_{comp} = \sqrt{(X_{comp}{}^2+R_{comp}{}^2)}$, $X_{comp} = X_{meas}\text{-}R_{wire}$, $R_{comp} = R_{meas}\text{-}R_{wire}$
The impedance of the wire is dominantly inductive reactance well into the GHz and therefore it is the inductive reactance (X) that creates the significant difference between uncompensated and compensated data. Figure 4, 5 and 6 give insight into this.

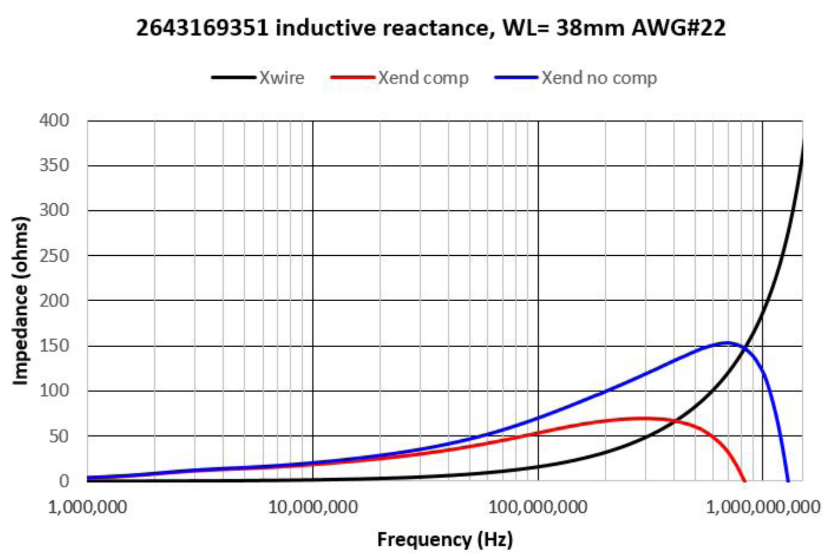

Figure 4

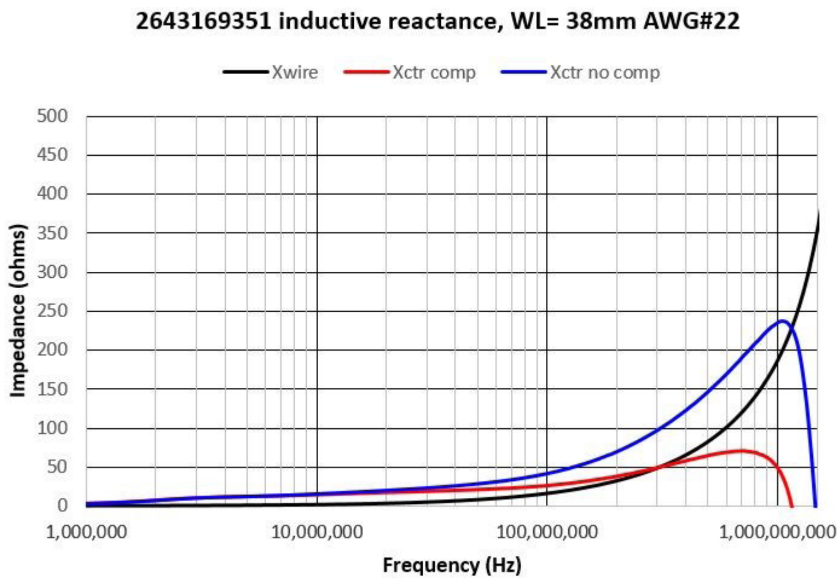

Figure 5

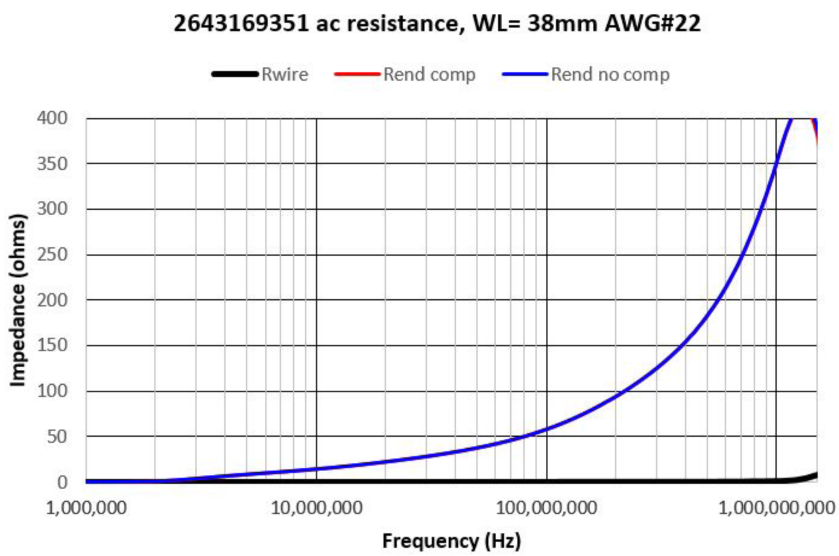

Figure 6

Figure 7 shows the percent difference over frequency with compensation between the mid location and the end location and between the center location and the end location.

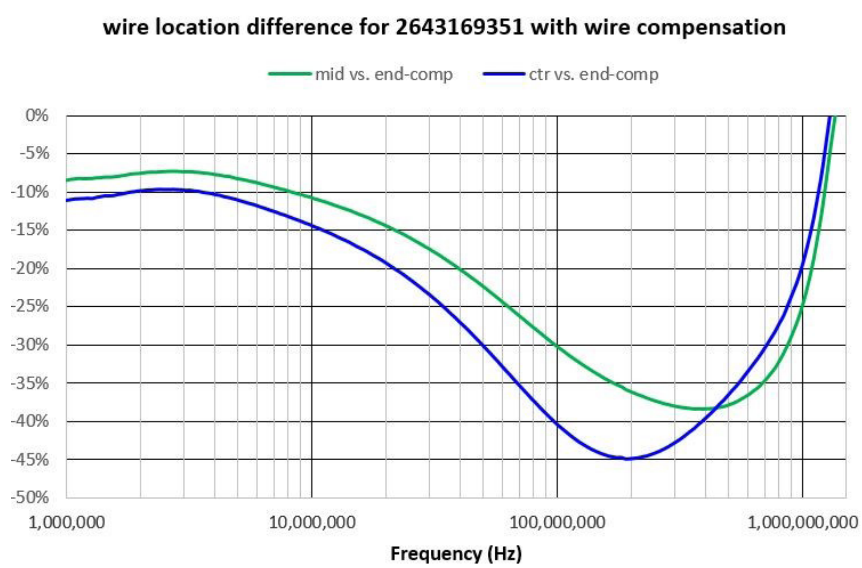

Figure 7

The next example demonstrates the impact of wire location on round suppression cores. Fair-Rite® used two round cores: PN 2643665902 (17.5/9.5/6.35 mm) and PN 2643665702 (17.5/9.5/28.6 mm). The test wire used was also AWG# 22, with wire length of 31.7 mm (1-1/2") for the shorter part and 51 mm (2") for the longer part. A plastic form was fabricated in order to perform the location measurements as seen in figure 8 with the shorter part in the test fixture. The same concept of end, mid and center was used for relative conductor locations.

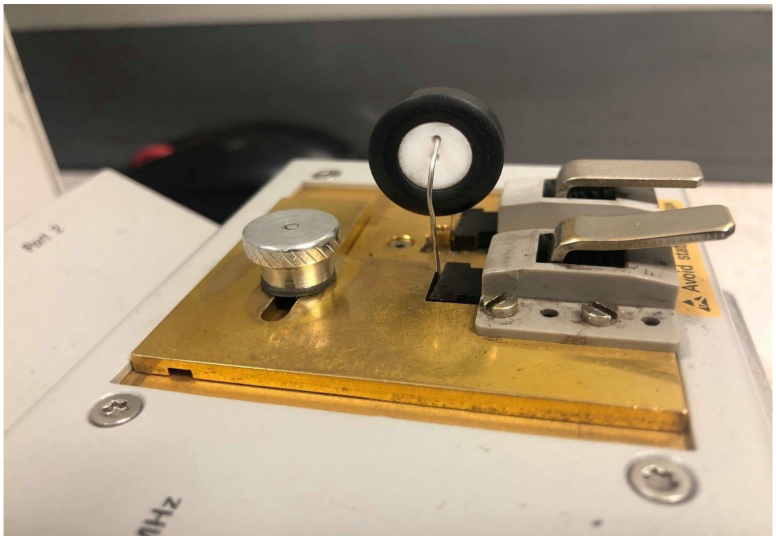

Figure 8

Rather than show all the same curves as was done in the first example, we only show the percent difference over frequency with compensation between the mid location and the end location and between the center location and the end location. Figure 9 is for the shorter part (PN 2643665902 – 6.35 mm length) and figure 10 shows the longer part (PN 2643665702 – 28.6 mm length).

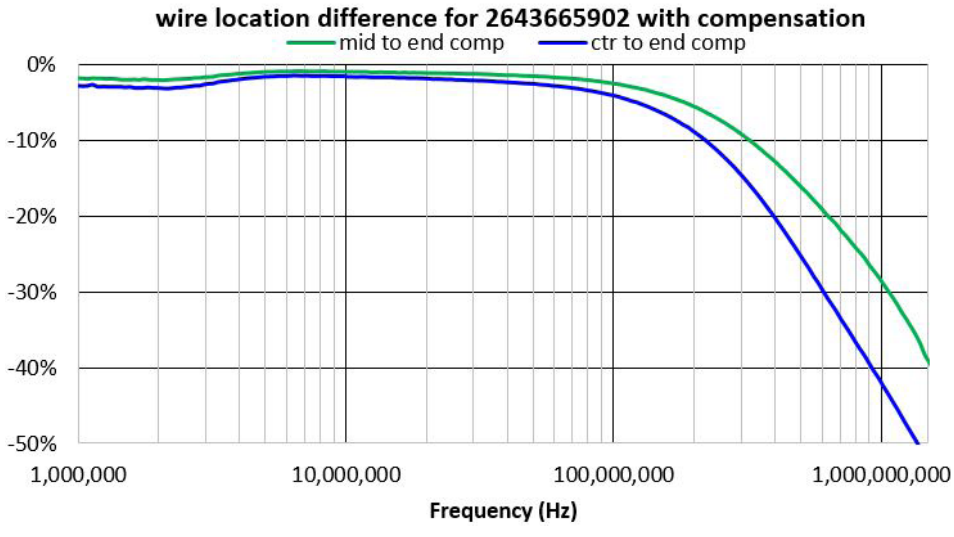

Figure 9

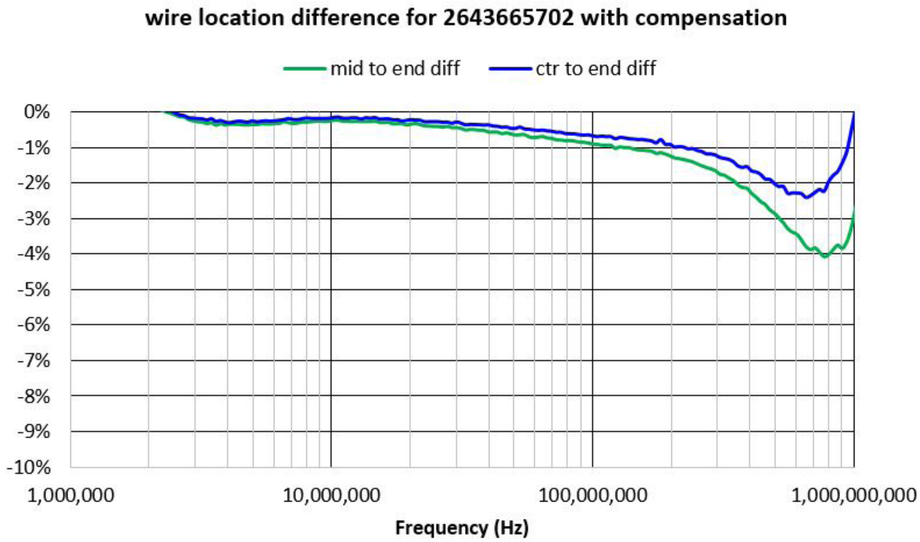

Figure 10

DISCUSSION

In order to have consistency with these tests, the same wire lengths needed to be used for each specific ferrite core size. The Keysight test fixture model # 16092A is only rated up to 500 MHz, while the E4991A impedance analyzer is rated to 3GHz. At this time, there is no good alternate test fixture with this impedance analyzer for larger parts that require a discrete conductor for measurements. Fair-Rite® has and continues to use the 16092A fixture since we consider it the best available for measurements for parts of this type. When test lead compensation is used, the results are satisfactory. It is obvious that the test wire has a significant impact on measurements, especially at frequencies over 100MHz. In daily production and for component impedance curve characterization, Fair-Rite® does not use test wire compensation. For flat cable suppression cores, Fair-Rite® does measure impedance at the end of the slot.

In conclusion:

- Measured impedance variation is dependent on the ratio of conductor diameter to the largest dimension of the aperture that it is placed within. The envelope of the core aperture is proportional to effective magnetic path length (le) of the component.
- As the ratio of length to largest aperture dimension decreases, the degree of variation with conductor location increases.
- The closer the ferrite surrounds the conductor, the better the coupling and therefore the amount of impedance realized.
- Best results are realized by minimizing the difference between conductor and aperture sizes and maximizing the length to aperture size ratio.