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Compensation for too wide Antenna when using Helmholtz coils

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Summary

Helmholtz coils can provide a uniform magnetic field. If the loop antenna to be measured is too large, the field will not be uniform. This paper explains how to compensate for that effect.

1 Introduction

Our research project consists in finding a new method to evaluate the magnetic field from trains between 9 and 150 kHz. The standard EN 50121-2 states that a loop antenna at 10 meters from the centre of the track should be used from 150 kHz to 30 MHz. [**?**]

2 Principle behind the Helmholtz coils

They generate a uniform magnetic field if placed at a distance equal to their radius.

3 Measurement setup

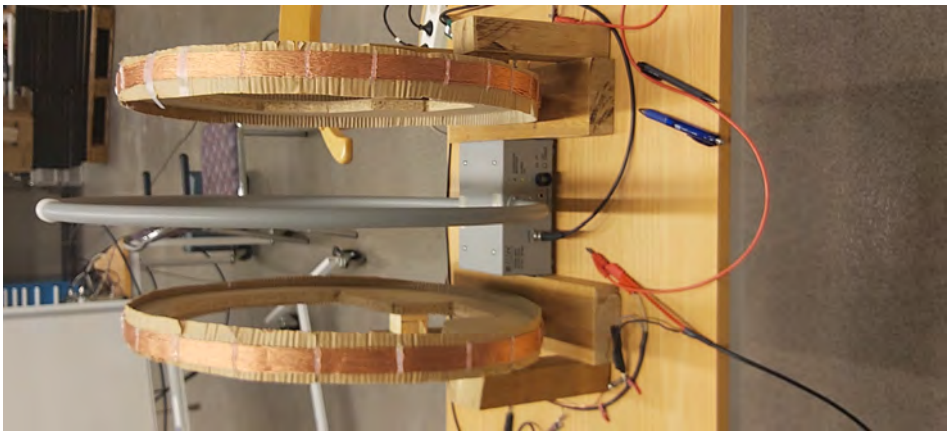

Figure 1. Measurement setup.

The receiving antenna is an EMCO model 6502, denominated as an active loop 10 kHz–30 MHz. It has a radius of 28.5 cm. The transmitting antennae are two home-made Helmholtz coils with 14 windings and radius 25 cm. The setup is shown in Fig. 1.

4 Measurements

The values from the producer together with the measured values are presented in Table 1 and in Fig. 2 for different frequencies.

Table 1. Measurement data for different frequencies in kHz

Fq	9	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Prod	-35.0	-36.0	-39.0	-39.5	-39.9	-40.2	-40.4	-40.6	-40.8	-40.9	-41.0	-41.0	-41.1	-41.2	-41.2	-41.3
Meas	-38.8	-39.1	-40.9	-41.4	-41.5	-41.8	-41.8	-42.1	-42.3	-42.7	-42.9	-43.1	-43.4	-43.6	-44.0	-44.5

5 Analysis

The interesting factor is how fast the magnetic field diminishes when leaving the axis through the Helmholtz coils. The formula for the density of the magnetic field is:

$$B = \oint \frac{(r - r\prime) \times dl}{|r - r\prime)|^3} \tag{1}$$

A numerical integration gives the curve in Fig. 3. The flux through the receiving antenna must take into account the increasing area when the radius increases. That gives a quotient of 1.51 between a uniform field passing through the antenna and the actual field. The quotient is the same as a difference of 3.56 decibels.

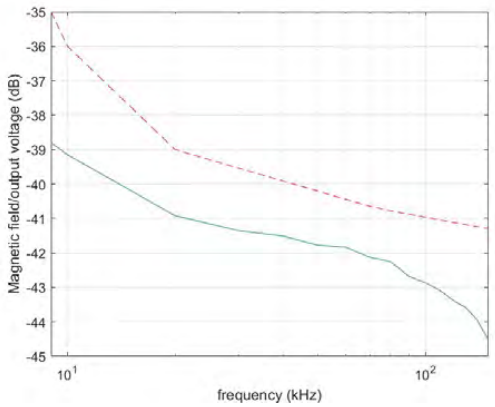

Figure 2. Difference between the datasheet (straight blue line) and the measurement data (red dashed line).

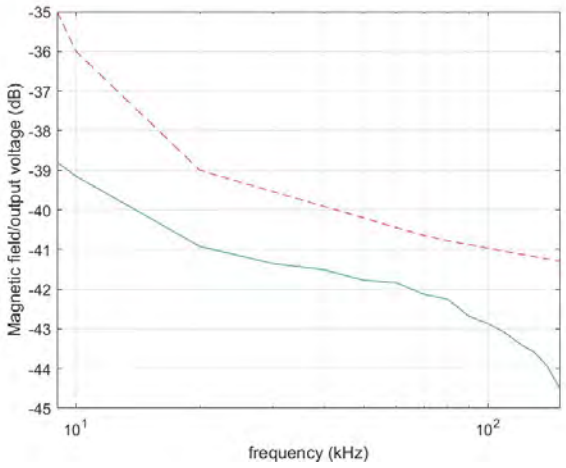

Figure 3. Dependence of the magnetic field on the radius from the axis through the Helmholtz coils.

6 Conclusion

The calculation predicts well around 10 kHz and about the double in decibels up to nearly 100 kHz.

Acknowledgements

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