DC magnetic field immunity testing

In order to perform magnetic field immunity testing with levels up to 4000 A/m in direct current (as required by the latest standards) it is necessary to select the proper Helmholtz coil. In particular, it is important to choose a device with a good coil factor[1]. This is possible by using an Helmholtz coil with the highest number of turns possible. In this way, high field strengths can be achieved and the current circulating in the coil can be significantly reduced. Possible candidates for DC testing are the Schwarzbeck´s Helmholtz coils HHS 5210-100, HHS 5206-132, HHS 5202- 81, HHS 5201-98, FESP 5133-1330 etc[2].

Example

The user must perform a test, exposing the device under test to a magnetic field of 4000 A/m in DC, using an Helmholtz coil of 60 cm diameter. Which coils should be used and what are the values of the current and voltage which must be applied to the coil?

Solution

Two Helmholtz coils with 60 cm diameter are available: the HHS 5206-16 and the HHS 5206-132. As explained before, it is necessary to select the Helmholtz coil with the highest number of turns. Therefore we choose the HHS 5206-132, which is described here: http://www.schwarzbeck.de/Datenblatt/k5206-132.pdf. The coil factor of this coil is 314.2 A/m/A (to produce 1 A/m a current of $3.183x10^{-3}$A must be applied). Therefore, to produce the required field of 4000 A/m we need to apply a current of: $4000 \cdot 3.183x10^{-3} = 12.7$ Ampere. The resistance of the pair of the Helmholtz coil is 2.84 Ω and therefore, using the Ohm´s law:

$$V=R \cdot I = 2.84 \cdot 12.7 = 36 \text{ Volts}$$

In conclusion, to reach 4000 A/m in DC, we need to apply a current of 12.7 Ampere and a voltage of 36 Volts. It is suggested to add some reserve in order to compensate for losses that can be caused due to the heating of the coil during the operations. Since the resistance rises by 38% from 20°C to 120°C, we suggest to use a 60V 15A power supply. We can offer the DCPS 60V15A which is current regulated.

As shown in the previous example, in DC testing it is sufficient to apply a defined current and voltage. For this purpose, we suggest to use a minimal setup composed by a DC power supply. This solution is much more convenient than to use the power amplifier which is used with the Schwarzbeck MagTest system (NFPA 9730/ LFPA 9733). The reasons for that are:

- The NFPA/LFPA amplifiers require an input signal: it is not convenient and not straightforward to program a function generator in order to provide a DC signal;
- the NFPA/LFPA amplifiers could not be suitable to reach currents higher than 20 A;
- in general, a DC power supply is cheaper.

Another effect which must be taken into account is directly related to the Lenz´s law, which is the negative sign in the Faraday´s equation:

$$\mathcal{E} = -\frac{\partial \Phi}{\partial t}$$

Where $(\mathcal{E})$ is the induced voltage and $(\partial \Phi)$ the change of the magnetic flux. The Lenz´s law states that the magnetic field which is produced by a current i_1 circulating in a closed circuit induces a current i_2, with opposite sign, which opposes to i_1. A consequence of this phenomenon is that the maximum current (and there-

[1] The **coil factor** is the magnetic field which is obtained when a current of 1A is applied to the Helmholtz coil.
[2] The two digits before the symbol "**-**" indicate the coil´s diameter in meters, the two/three digits after the "**-**" indicate the number of turns per coil. Example: HHS 52**06**-**132**: diameter = 0.6 meters, number of turns =132.

fore the maximum field strength) is not reached instantaneously, but after 5τ,where $\tau = L/R$ is the time constant of the RL circuit. This is also shown in the plot of Figure 1. In order to compensate for this effect and to reduce the oscillations caused by the high inductive load, it is suggested to add a capacitor in parallel to the Helmholtz coil and the power supply, as shown in Figure 2.

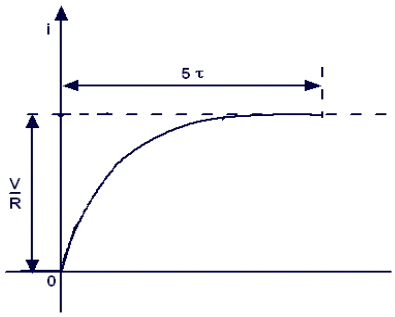

Figure 1: maximum current (and therefore the maximum field strength) is not reached instantaneously, but after five times the time constant.

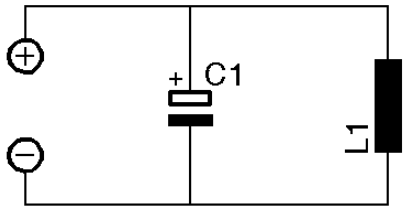

Figure 2: wiring diagram. L1 is the Helmholtz coil, C1 the capacitor, which are connected to the power supply.

It is possible to purchase all the components from Schwarzbeck Mess-Elektronik. In particular, a system for DC testing is composed by:

1. an Helmholtz coil with defined diameter and the maximum number of turns;
2. a suitable power supply with current regulation: DCPS12V10A, DCPS 60V15A, DCPS 160V14A;
3. ELKO 9735 capacitor and the cables which are required to connect all the components;
4. Hall Probe HS 5136 to measure the DC magnetic field: http://schwarzbeck.de/Datenblatt/k5136.pdf

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