BEMS Abstract 2013

Title: Apparatus for Human ELF Exposure at 50mT

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Short Abstract (500 characters max): 498 characters (78 words)

OBJECTIVE: Design and production of an up to 50mT ELF MF exposure system inducing detectable effects in humans (e.g., magnetophosphenes).
METHODS: We have developed a custom exposure system including a water-cooled coil utilizing a MRI gradient amplifier.
RESULTS: The system is able to generate a MF flux density over 50 mT from 20 to 100 Hz.
CONCLUSIONS: We have designed an exposure system minimizing heating and vibration, producing ELFMF at levels reported to induce biological effects in humans.

Long Abstract (10,000 characters max): 4898 characters (824 words)

INTRODUCTION
The Human Threshold Testing Group at Lawson required an exposure system inducing systematic biological effects in humans, such as magnetophosphenes (classically reported as flickering lights occurring in the visual field when the retina is exposed to a strong time-varying MF). The perception of magnetophosphenes is used by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) as a basis for its recommendations. In order to enable systematic and detectable effects in humans, such as magnetophosphenes, it is required to design a system able to generate an ELF MF in a wide range of ELF frequencies (20 to 100 Hz), at MF flux densities (up to 50 mT).

MATERIAL AND METHODS
Early in the project concept phase, it became apparent that MRI gradient amplifiers could be an appropriate solution to achieve the power requirements to meet our needs. Techron 8300 gradient amplifiers (Techron 1718 W. Mishawaka Rd. Elkhart, IN) and MTS 0106475 gradient amplifiers (MTS Automation 433 Caredean Dr. Horsham PA) were tested. Both models of amplifiers work in a controlled current mode and are ideal for driving inductive loads by matching the coil current to the input signal voltage. This gives another advantage of generating complex waveforms with high fidelity. Since the MTS amplifiers have more than 4 times the current capacity with an output impedance of 0.15 ohms, we selected these amplifiers to drive

our new exposure system. The MTS amplifiers are rated for 208 Volt 3 phase 80 Amp inputs and output of 345 Volts, 200A Rms for >300 Seconds.

After selecting the appropriate amplifiers, it was required to match a coil design that would function with our existing amplifiers, managing the heat load generated while producing the required field (on the order of 50 mT from 20 to 100 Hz). With the advice from the Physics and Astronomy Department at Western University, we decided to use hollow copper tubing and selected 5 mm square outer diameter (OD) with 3 mm round inner diameter (ID.) Starting with a moderate current of 90 amperes, the Biot and Savart law predicts that a 176 turns coil will yield a MF flux density of 52 mT. The final physical design was decided to be 16 layers of 11 turns each, wound on a bobbin 60 mm diameter by 55 mm wide, producing a 22 cm OD coil.

In order to minimize vibrations of the coil, and also sounds produced during the exposure, a process called 'wet winding' was used to apply thermal epoxy to the copper tubing as it was wound. It is important that the test subject be blinded as to whether the field is on or off. In addition, in order to dissipate the heat generated by the strong current flowing through the coil, brass ports have been designed and manufactured to enable and facilitate plumbing and electrical connections to the coil. Approximately 860 watts of excess heat is removed by circulating cold (on the order of 10 degrees Celsius) tap water through the hollow tubing.

RESULTS

The coil was tested at frequencies between 20 and 100 Hz, to generate MF flux densities measured up to 50 mT. The MF values measures were matching our theoretical calculations (see Figure 1). The coil was able to produce MF flux densities up to 50 mT 3 cm away from the face of the coil, in the desired frequency range (20-100 Hz).

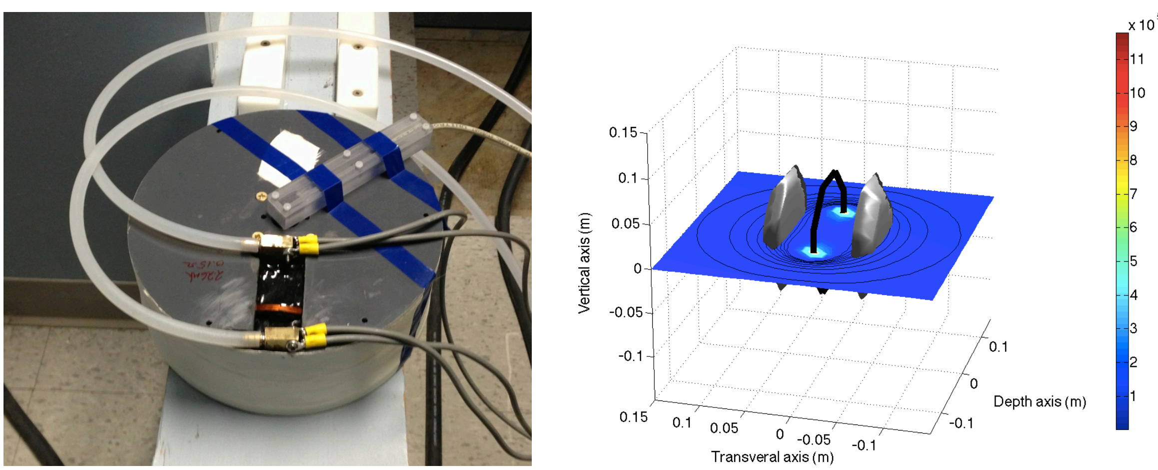

Figure 1. Left: the coil itself, shown here (cover removed), with the input and output of water for cooling (white tubing) and a MF measurement probe to validate theoretical calculations regarding the MF flux density produced. Right: theoretical MF

distribution generated by the coil, with 5 mT contour lines, and with the 45-100 mT volume represented in grey (the color vertical scale on the right is expressed in microtesla).

No significant heating was noticed by touching the coil even after several minutes of exposure at full power. We measured the temperature of the water flowing out of the coil compared to the temperature of the incoming water, and observed an increase of a few degrees (<5°C) after several minutes of use at full power. This showed that our cooling system was sufficient to dissipate excess heat generated by the current flow. There are two thermistors imbedded within the windings of the coil, but are not yet activated.

Accelerometer tests will be conducted to determine actual vibration levels when the coil support structure is complete.

CONCLUSIONS

We have designed an exposure system capable to generate MF at frequencies between 20 and 100 Hz and up to 50 mT of MF flux density 3 cm away from the face of the coil. The system uses an MRI gradient amplifier and a coil based on hollow copper wire through which water circulates for heat dissipation. This solution is effective in terms of cooling and does not generate perceivable vibrations. We anticipate that this technical solution should be applicable for a broad range of applications in bioelectromagnetics research.