CASE STUDY

MRI Coil Improvement for Cardiac Imaging in Mice

Overview

- Joint effort between University of Cyprus and Duke Center for In Vivo Microscopy
- **Challenge**: Create a better performing MRI coil for cardiac imaging in mice.
- **Solution**: Analyze new coil performance using EM simulation and compare to live trials.
- **Result**: New spiral coil design successfully outperformed traditional flat coil.
- **Product used**: XFdtd® Bio-Pro

Customer

Dr. Christakis Constantinides, Ph.D
Biomedical Engineering
Assistant Professor, Department of Mechanical and Manufacturing Engineering, University of Cyprus

It is common knowledge that mice often serve as models for the study of human health conditions and experiments to improve human medical treatments. But most people probably don't consider the accuracy of the experiments themselves, focusing instead on the results to give us confidence in the progression of our health care. It is vitally important that the experimental conditions are as precise as possible in order to get reliable results.

The Challenge

Mice are commonly used as models for the study of cardiac function. MRI is the favored imaging technology, but there can be accuracy issues with the conventional surface coils; in particular, the size and geometry of the coils can lead to imaging attempts with poor performance when used for something as small as a mouse. More focus is needed on this issue and on designing coils that provide better readings. Dr. Christakis Constantinides, Assistant Professor in the Department of Mechanical and Manufacturing Engineering at the University of Cyprus, led a research team in the design of a new surface coil in a spiral configuration; several variations of the design were tested, including a single-loop flat coil, a flat four-loop spiral coil, and a cylindrical four-loop spiral version. The team used electromagnetic simulation calculations to ascertain whether the cylindrical spiral coil outperformed the flat versions as well as commercially available birdcage coils for mouse imaging.

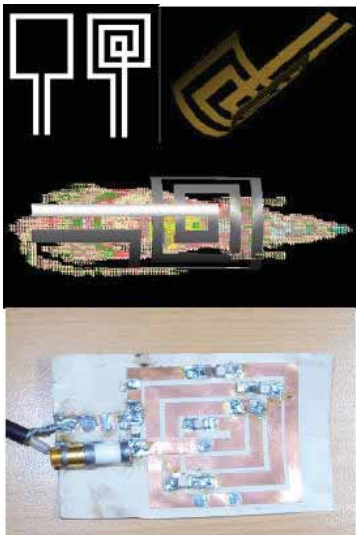
How Remcom Helped

Dr. Constantinides needed an electromagnetic simulation tool to simulate the electrical response of the newly designed spiral coil. The software needed to be versatile enough to also be used in future work for the University of Cyprus and needed to meet technical and IT capability and cost requirements. After evaluating three competing vendors, Dr. Constantinides chose Remcom's XFdtd Release 7 (XF7, Bio-Pro version), which he could also use to teach his undergraduate courses in mechatronics and physiology for engineers.

Dr. Constantinides listed XF7's strong design and CAD import capabilities among his reasons for selecting XF7. "The design features of XF7 are excellent," he said. "You can match real applications and real geometries and material characteristics. Also, XF7 has the unique feature of allowing you to import a geometry or computer generated model from a CAD package. This is important because literally any coil can be designed first then imported into XF7 for analysis."

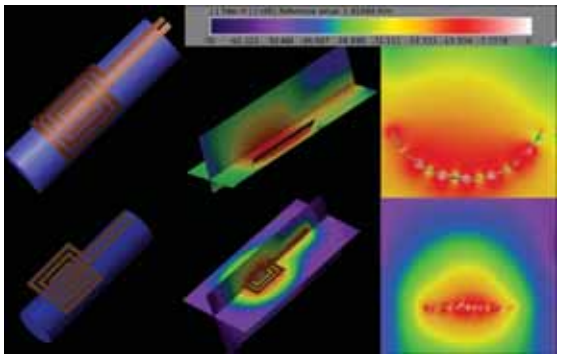
The three variations of the examined coils were designed in a CAD program and the resulting design files were imported into XF7. The simulation results were compared against each other as well as actual live applications of the spiral cylindrical coil via three steps:

1. Validation: The results generated by XF7 first needed to be validated. This was achieved by simulating the coil's magnetic field in free space where the desired outcome was already known. This was necessary to ensure XF7 would provide accurate results in comparison with control tests. The XF7 results matched the predicted results.
2. Phantom Imaging: The coil design was simulated under loaded conditions with phantom models having similar properties to real phantoms and a live mouse and compared to the MRI results of the actual phantoms (a vial or bottle filled with a life-like gel solution).
3. Real Mouse Cardiac Imaging: Here the coil design was simulated using a scaled down version of XF7's rat mesh, and then compared with actual MRI results of real mice (post-mortem and under anesthesia).



Autocad coil designs and imported XF7 cylindrical design; [top] (left to right) single loop, three-leg flat, and three-leg cylindrical spiral coils; [mid] XF7 mouse model superimposed on the cylindrical three-loop spiral surface coil; [bot] constructed prototype four-leg spiral RF coil.

Much communicative work was needed between Dr. Constantinides' team and Remcom engineers. "Remcom was excellent at providing what was needed to make the experiment effective," said Dr. Constantinides. "For example, Remcom engineers used the existing rat mesh that comes with XF7 and scaled it down to be more similar to a mouse. Without that effort, the results would not have been reliable."



Magnetic field simulation setup for a cylindrical (top) and a flat (bottom) four spiral surface coil upon loading with a water phantom. (Middle, right) Magnetic field simulation results in sagittal, coronal, and axial orientations.

Results

It was proven that the team's cylindrical spiral coil not only performed better than the flat versions, with increased field of penetration/visualization, but also compared fairly well with the commercial birdcage coil. Dr. Constantinides concluded that future work is needed to test whether the cylindrical spiral coil performance can be improved so that it at least matches or outperforms the commercially available birdcage.

The detailed technical paper on this work may be downloaded free of charge from Remcom's website. Go to **www.remcom.com/articles-and-papers-index** and search on "cardiac imaging."

Please contact Remcom to learn more about how XFdtd can be used for MRI coil design:
sales@remcom.com | 814.861.1299 | **www.remcom.com**

Acknowledgment: Remcom thanks Dr. Christakis Constantinides for his assistance and support of this case study.

Remcom, Inc.
315 S. Allen St., Suite 416
State College, PA 16801 USA

+1.888.7.REMCOM (US/CAN)
+1.814.861.1299 phone
+1.814.861.1308 fax

sales@remcom.com