CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
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Project Number
S1006

Project Title
Optimizing Microwave Field Profile for a Quantum Sensor

Abstract

Objectives/Goals
Magnetic field sensing is a powerful technique that allows for non-invasive measurements of magnetic structure. For example, magnetic resonance imaging (MRI) allows for non-invasive imaging of internal organs. An outstanding challenge is creating sufficiently strong and homogenous radio frequency (RF) magnetic fields to control the magnetic sensor. The objective is to improve a wide field magnet sensor by designing an RF waveguide that can produce stronger and more homogeneous magnetic fields than the current omega-shaped waveguide model.

Methods/Materials
The study tested two designs of RF waveguide: an omega-shaped waveguide (existing model) and a spiral waveguide (experimental model). Within the spiral condition, spirals with 3, 5, 7, and 12 loops were simulated. The homogeneity of the magnetic field was tested using the Comsol Multiphysics software. The strength of the magnetic field of each design was tested using the Sonnet software.

Results
Comsol simulations show that square-shaped spiral inductors produced more homogeneous magnetic field than the omega-shaped waveguides; Q-factors output by the Sonnet simulations show that spiral inductors produce stronger magnetic fields than omega-shaped waveguides. Increasing the number of loops of a spiral inductor led to a stronger magnetic field.

Conclusions/Discussion
These results support the theory that an inductor with a spiral design composed of many concentric loops of wire produces a stronger and more homogeneous magnetic field than a single loop of wire. Based on the simulations, a digital mask was created, and prototypes have been fabricated using contact lithography. The performance of the different designs will be tested on the Nitrogen-Vacancy center in diamond, the magnetic field sensor.

Summary Statement
I designed an inductor for use in magnetic field sensing that improved control relative to previous models.

Help Received
I set up and ran simulations using software provided by the lab of Professor Ania Jayich in the UCSB Department of Physics. PhD student mentor Claire McLellan fabricated the prototypes in a cleanroom based on my design, and explained basic principles of magnetic field sensing.