

NDnano Undergraduate Research Fellowship (NURF) 2011 Project Summary

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Project title: Design of nanomagnet logic devices

The goal of the project was to design and build a quadrupole magnet that can precisely generate magnetic fields in arbitrary, in-plane directions and can be used to magnetize nanoscale magnetic samples. In developing nanomagnets it is important to have the ability to not only build the magnet but also to test the magnet. Testing the magnet requires the development of a field that can be controlled in both direction and in magnitude. My project was to develop an electromagnet for precisely controlling the strength and direction of a magnetic field.

I proposed the desired field could be created by applying two perpendicular fields to the test area. The direction and magnitude of the resulting field would be determined by the magnitude of the source fields. The original design was a ring with 4 perpendicular poles facing the center. (See Figures 1 & 2) This hypothesis was simulated in a two-dimensional Finite Element Methods Magnetics, FEMM v4.2. The tests proved to be successful.

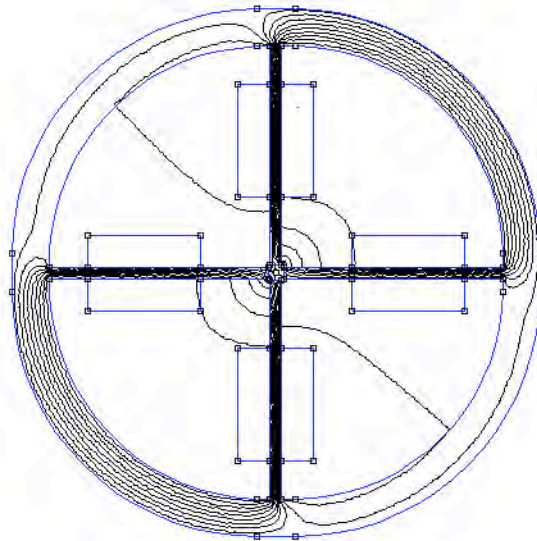


Figure 1: Two dimensional design with equal fields generated at all poles.

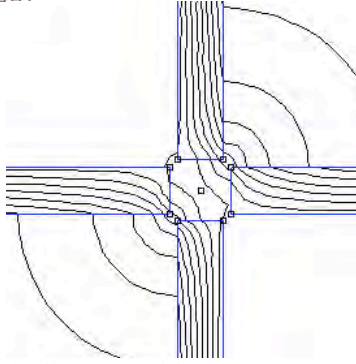


Figure 2: Close up of field created in Figure 1

It was the simplest to design and test but it would not be practical to build. I developed a modular iron core that would allow for interchangeable poles. The new design (See Figure 3) was simulated in Maxwell v12. It also proved to be successful. The iron core assembly was machined by contractors. The magnet has integrated, calibrated Hall Effect sensors to monitor the fields. The sensors are mounted on the poles and their output signal is sent to a microcontroller that calculates the resulting field and displays the results on a computer. The finished project is shown in figure 4.

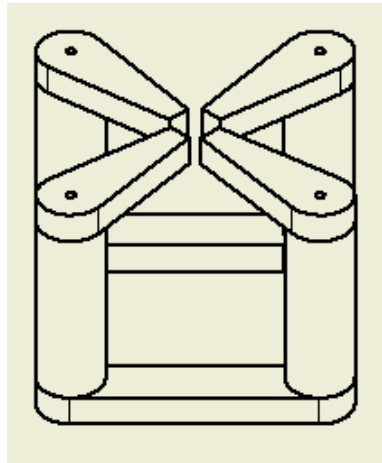


Figure 3: Electromagnet iron core assembly with copper windings removed from vertical columns for easier viewing of assembly



Figure 4: Completed electromagnet and control circuit