Predicting the Behavior of Planar Spiral Coils for Superconductive NMR Probes

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Introduction

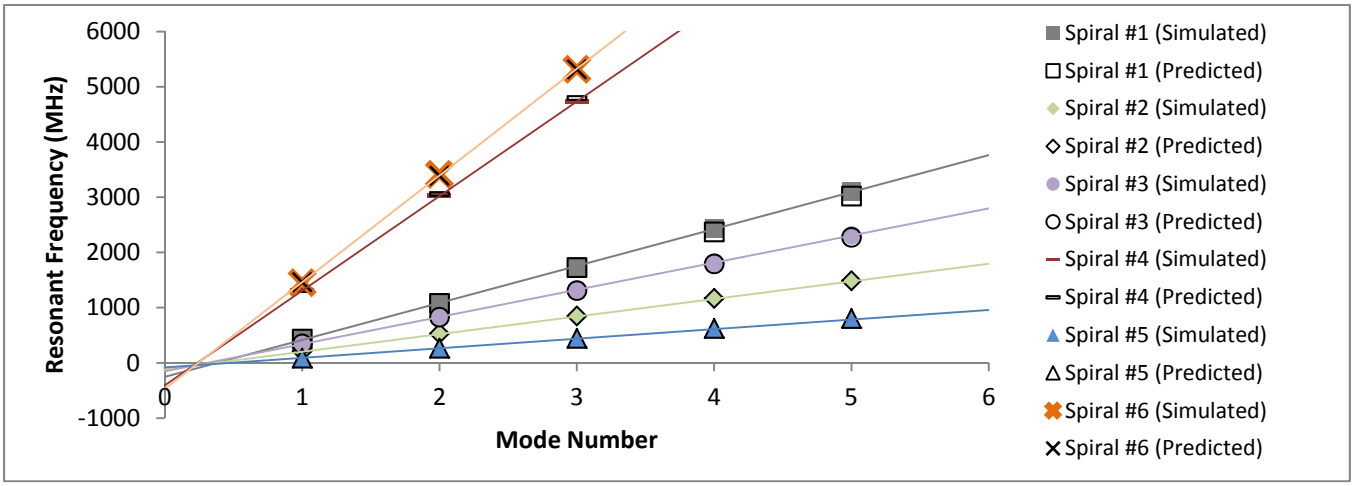
Planar spiral resonators are commonly used for low frequency channels in high sensitivity NMR probes based on high temperature superconductors[1]. The simple spiral structure patterned on sapphire or other ceramic substrates resonates at many frequencies; only the lowest of which is useful for NMR of low gamma nuclei. It is necessary that the higher order resonance modes do not overlap with the NMR frequencies of other channels in the probe. Unlike a simple transmission line resonator, the higher modes of a spiral resonator may not be harmonic. A better understanding of the basic structure can reduce reliance on simulation, and thus significantly reduce the length of time required to generate new coils.

Experimental

Spirals with varying parameters including, inner radius, outer radius, pitch, conductor width, gap width and number of turns, were analyzed to determine their resonant behavior as well as the dependence of that behavior on the various parameters.

Results and Discussion

Using data gathered from simulations, we have developed an empirical formula for predicting the resonant frequencies of planar Archimedean spirals. The deviation from a harmonic spectrum is largely a function of the ratio of the inner and outer radii of the coil. The number of turns and the relative conductor width also generate a small effect. As seen in Fig. 1 below, the predictions match very well, generally within 2% of the simulated values. In Fig. 1, the colored shapes represent the simulated values, and their outlines represent the predictions. This is a vast improvement over the transmission line approximation which has been observed to be off by as much as 50% in some cases and provided far less insight into how the different parameters affected the resonant frequency.



As a result of this formulation, we have developed a better understanding of the effect of the different characteristics of a spiral on the resonant frequencies.

Acknowledgements

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References

[1] W. W. Brey, *et al.,* J. Magn. Reson., **179**, 290–293 (2006).