PLANAR COIL DESIGN FOR HIGH-TEMPERATURE-SUPERCONDUCTING NMR PROBE

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We are developing a $^{1}H\{^{13}C, ^{15}N\}$ NMR probe for 1 mm solution samples based on oxide superconductor technology. The probe will be used for the study of mass-limited protein samples in the 600 MHz NMR spectrometer at AMRIS. Developing coils for the ^{15}N irradiation channel is a key part of this project.

Rectangular spiral resonators have been designed for the 60.8 MHz ^{15}N irradiation channel. In addition to their fundamental, the spiral resonators exhibit a series of higher order modes. If these higher modes lie too close to the ^{1}H or ^{13}C resonances they can greatly reduce the efficiency of those channels. Therefore, the ^{15}N coils must be designed so that the higher order modes of the resonator fall as far away as possible from the resonances of the other nuclei. We have shown that a method-of-moments based simulator (IE3D [1]) can be used to predict both the fundamental and the higher order modes with sufficient accuracy. The simulator has been used successfully both in the design of new coils and in the tuning process to help plan where conductor must be removed to increase the resonance frequency the desired amount. A transmission mode simulation of a new design for a single ^{15}N resonator is shown in Figure 1. Vertical bands indicate the design requirements: the fundamental resonance must lie within the ^{15}N band, and no modes must lie within the other bands. Small changes in the design that do not significantly affect its performance at ^{15}N have been made to adjust the higher modes away from the ^{13}C and ^{1}H resonances. Fabrication and testing of this design showed remarkably good agreement with the simulation. The inset in Figure 2 also shows the ^{15}N coil structure with the current density at the fundamental indicated by the color. The red region represents high current density while the blue represents low. Note that the current is minimum at the two ends of the coil while maximum near the center, as expected for the fundamental mode. Current also tends to be higher toward the outside of the resonator, indicating that it will couple well to the sample. NMR tests of these coils can now be carried out.

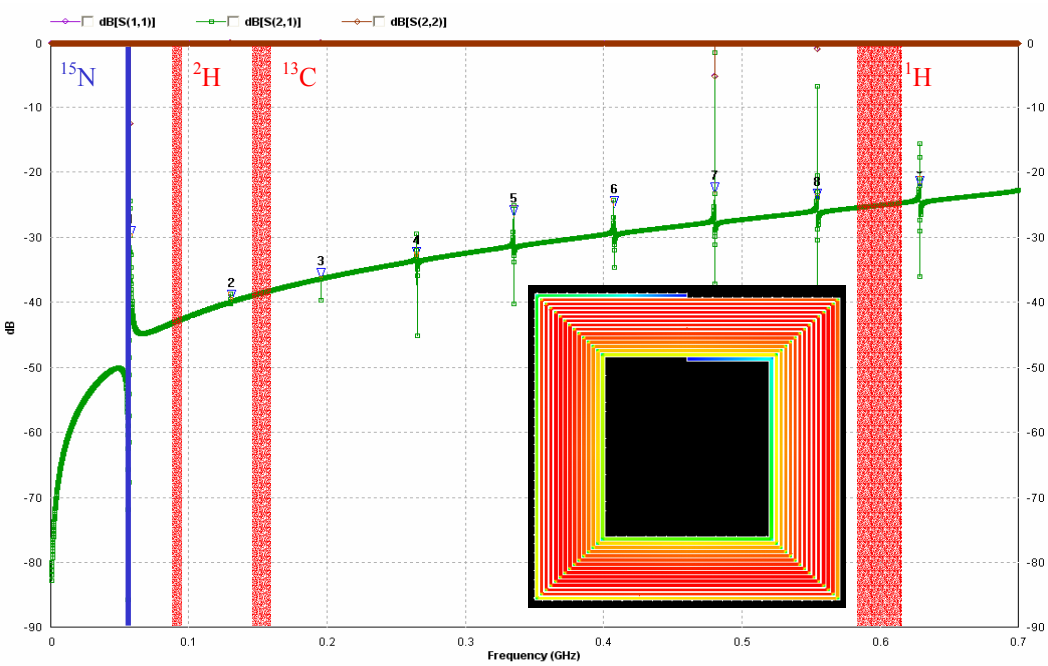

Figure 1. S-parameter plot of the Nitrogen coil showing different resonant modes. It also shows the current density plot in the coil at 60 MHz.

Acknowledgements

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References

1. Zeland Software, Inc., Fremont, CA