EFFECT OF CONDUCTOR GEOMETRY ON SNR OF MICRO-COILS

Y. Li, A.S. Edison (UF); S. Saha, W.W. Brey (NHMFL)

The effects of conductor geometry on the signal to noise (SNR) ratio of solenoid microcoils for NMR spectroscopy at high fields have been investigated. The SNR performance of coils made from round and rectangular wire has been compared using simulation and experimental methods. The simulations were performed in a 3D full wave electromagnetic simulator based on the finite-element technique (Ansoft HFSS) at 750 MHz. NMR experiments were performed in the 750 MHz / 89 mm spectrometer in AMRIS. The results indicate that the choice of round or rectangular wire depends upon the length to diameter ratio of the coil.

Figure 1a and b show the 3D structure of two 8-turn solenoid microcoils of 2.0 mm in length and 1.0 mm in diameter, but made from rectangular and round wire respectively. Simulations of the SNR, which is proportional to the $B_1$ field over the square root of the ohmic loss in the conductor, were carried out for both coils. They predicted that the SNR would approximately 1.48 times better with the rectangular wire. Figures 2a and 2b show the amplitude of magnetic field profiles measured along the coil axis. It is seen that $B_1$ field is more homogeneous for the rectangular wire coil compared to the round wire coil. Experimental results found the SNR with rectangular wire coil to be 1.45 times better than that of the round wire coil, confirming the simulations.

A similar analysis was also performed for round and rectangular wire coils of 1.7 mm in length and 2.5 mm in diameter with 4 turns. This time, the simulation predicted that the SNR of the round wire coil would be 1.11 times better than that of the rectangular wire coil. Experimental results determined that the SNR from round wire coil is 1.16 times that of the rectangular wire coil, again confirming the simulation. Thus, it can be concluded from both simulation and experimental results that as the length to diameter ratio of coils is smaller than a particular number, it is better to use round wire than the rectangular wire. On the other hand, when the length to diameter ratio of coils is larger than this number, rectangular wire is preferred. Some further simulations show that this particular number is between 0.7 and 1.0.

Figure 1. RF coils with dimensions 2 mm in length and 1 mm in diameter wound with (a) rectangular wire of dimensions 0.05 x 0.23 mm$^2$ and (b) round wire of diameter 0.15 mm.

Figure 2. Magnetic field profiles along the coil axis for (a) rectangular wire and (b) round wire coils for the same driving current.

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