Conductor Losses in Many Channel RF Coil Arrays

R. Duensing[1], J. Akao[1], C. Saylor[1], D. Molyneaux[1]
[1]MRI Devices, Gainesville, FL, United States

Introduction

With the recent growth in the number of receiver channels available on clinical MRI systems (now at up to 32), it is important to consider the losses incurred when many small coils are used to cover a large area. In an array with many elements there would be opportunities for losses from coupling, components, shield currents, etc. In this work one basic mechanism of loss is considered for certain types of arrays. The conductor losses of RF coils are well known, but the behavior of these losses in the context of a large array is only beginning to be considered (1). Any loss which is proportional to conductor length would fit the analysis below.

Methods

In this work, two different approaches to a planar array are investigated. The first is an array of overlapping loops as shown in Figure 1. The second is an array of grid loops (Figure 2), in which adjacent elements share a single conductor, cover the same total area and have the same perimeter. The array of Figure 1 represents typical design strategy for state-of-the-art arrays. To investigate the similarity of these two approaches, the mode which corresponds to this virtual large loop is chosen. This means that each small loop is assumed to be driven with exactly the same current. For the case of the grid coil array, it is clear that this drive will result in exactly the same current pattern as the large loop. However, for the overlapping coils, the case is not so clear. There will be current in areas that do not contribute significantly to the magnetic field at depth that will be associated with conductor losses as well as local sample losses. To compare these structures, a pseudo-static simulation was performed, using Matlab programming, that calculated magnetic and electric fields from the two current patterns shown in Figures 1 and 2.

Figure 1. Array of 9.5 cm loops

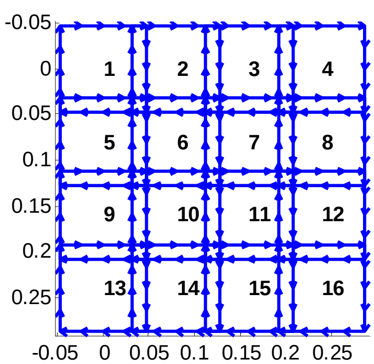
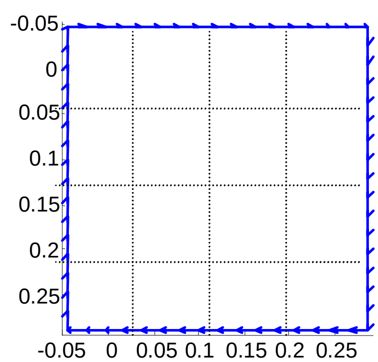


Figure 2. Perimeter loop



Results

One element of the simulated planar array was constructed using ¼ inch copper tape and 24 gauge wire in the corners and ATC capacitors. This loop was 9.5 cm across, and in the simulated array the loops are overlapped in a 4 x 4 grid with 8 cm center to center spacing. These overlaps would approximately make adjacent neighbors inductively isolated. The perimeter of the array is equal to a square 33.5 cm across. The physical test coil was tuned to 64 MHz on a saline spine load 47 cm x 36 cm x 7 cm, spaced 2 cm from the elements. In the table below, the Q's are measured on this sample and in free space. For the comparisons, it is assumed that all non-sample losses are proportional to conductor length. The simulation indicated very similar sample loading for both current patterns. The total resistance of large loop was approximated by assuming the relative shared resistance between adjacent loops was 1/3.

	Small Loop (#6)	**Overlapped loops**	**Large Loop**
Loaded Q, 1.5T	75 (bench)		
Unloaded Q, 1.5T	275 (bench)		
Sample Loading	RLoad_Small	RLoad_Small x 50	RLoad_Small x 50
Conductor Length	38 cm	608 cm	134 cm
Copper Resistance	RCoil_Small	RCoil_Small x 16	RCoil_Small x 3.52
RLoad/RCoil, 1.5T	2.66	2.66 x 50/16 = 8.3	2.66 x 50/3.52 = 38

Discussion

It was found that if only sample resistance is considered, the SNR's of both approaches are identical. However, the results indicate that the SNR for the virtual large loop constructed of overlapping loops suffers an SNR loss of approximately 5% in comparison to a single large loop when loading of the individual loop is 2.66, due solely to copper losses of the base element coil.

References

1. Eigenmode Analysis for Understanding Phased Array Coils and their Limits, King et al, #427. Proceedings of the ISMRM, 2003