Novel 24 Element Multi-Transmit Volume Coil for High Field MRI

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Background:

At very high frequencies and field strengths, high number of independent RF transmit coils have been shown to benefit applications such as RF shimming[1-3] and parallel transmission and reception[4-6]. With the increase in the number of coils in these applications, the RF coil design becomes limited as the coils become electrically short and, hence, RF inefficient compared to a traditional multi-element volume coil[7]. In this study, we introduce a 24 element TEM volume coil strategy with a combination short microstrips and loops which has RF efficiency that compares well to an 8 element volume coil consisting of long microstrip elements. Simulations for an anatomically correct head are performed at 7 Tesla for 8 and 24 element volume coils.

Methods:

Three transceiver arrays were simulated; two consisted of microstrip elements and the other a combination of microstrips and loops. The microstrip based arrays consisted of one 24 element coil with 3 segments (Fig. 1a) containing eight concentrically arranged 3.5 cm short resonance elements and the other coil, and the second 8 element transceiver consisted of eight 15 cm long resonance elements (Fig. 1b). The coil dimension was 25 cm in diameter and a 12 mm thick Teflon substrate between conductors and shield was used for the arrays. The ground of each array element was 5 cm wide and physically separated from neighboring elements. Gaps in the longitudinal direction of 1.7 cm existed between the ends of the 24-element microstrip.

The 24 element microstrip-loop-microstrip array consisted of two concentrically arranged rings of 8 short microstrip elements (3.5 cm in length) separated by an 8 element array consisting of 8 rectangular loop elements (5.0 cm in length and 6.5 cm wide (o.d.)) (Fig.1c). The loop consisted of 0.5 cm copper foil also had a ground plane 6.5 cm wide and 5.0 cm long. The loop contained 4 capacitors located in the middle of the longitudinal and transaxial sections. Gaps of 0.75 cm existed between the ends of the strip signal lines and the loop and the coil dimension and substrate used were identical to the previously mentioned microstrip based designs (Fig 1c).

Numerical Maxwell solutions of the 8-channel transceiver arrays were calculated with an anatomically correct human head using xFDTD version 6.5 (Remcom Inc., State College, PA). Each channel was simulated individually and combined in post-processing with B1+ geometric phases at the center of the brain to produce a circularly polarized B1+ field by Matlab (version 7.5). All the coils were normalized to 1W input power and normalized to provide the same power per channel for comparison purposes.

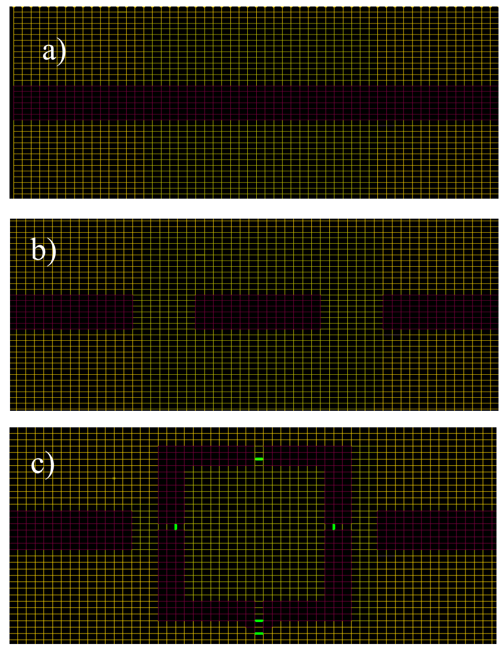

Figure 1 a) microstrip element b) 3 microstrip element c) microstrip-loop-microstrip element

Results:

The 8-element microstrip array and 24-element microstrip-loop-microstrip array compared well for B1+ profiles. The 8-element had a peak B1+ value of 0.432 (μT/V) while the 24-element microstrip-loop-microstrip array had a value of 0.427(μT/V). The 24-element microstrip only array had peak B1+ 1.48 (μT/V) indicating that the microstrip dimensions were too short for efficient B1+ penetration.

Conclusions:

A novel strategy in designing coils is introduced. A 24-element volume coil consisting of strips and loops is shown to perform as well as an 8-element traditional microstrip based volume coil. The 3 fold increase in coil number has great implications for applications such as B1+ shimming and parallel imaging.

References:

[1] Mao, MRM 2006 [2] Van de Moortele, High Field Symposium 2007 [3] Adriany, ISMRM 2007 [4] Wiesinger MRM, 2004 [5] Wiggins, ISMRM 2010 [6] Avdievich, ISMRM 2006 [7] Vaughan, MRM 1994

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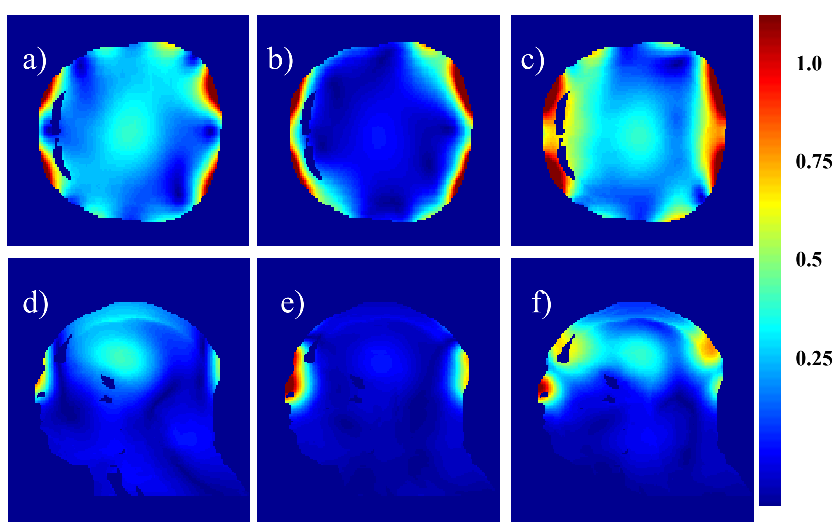

Figure 2) Axial and sagittal B1+ plots of a-d) microstrip element b-e) 3 microstrip element c-f) microstrip-loop-microstrip element