A Novel RF head coil for 7T Homogeneity and Parallel Imaging Applications

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Introduction:

RF field losses and non uniformities due to shortwave attenuation and interference patterns are problems of ultra high field MRI. To ameliorate these problems in order to take advantage of the SNR benefits of 7T head imaging, a new strategy in coil design was investigated. A "two-stage" multi-channel, microstrip TEM coil was built in which alternating elements were designed to couple to the center and periphery of the head respectively. The superposition of the shallow and deep fields of this two-stage coil should produce a more uniform image requiring less power.

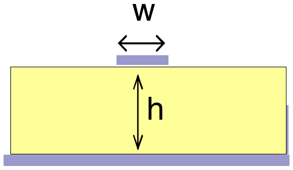

Fig. 1a) Microstrip parameters: h = height, w = conductor width

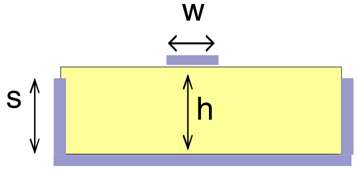

Fig. 1b) Microstrip w/ sidewalls

Methods:

To accomplish this coil, two microstrip TEM[1,2,3] designs, one which improves the SNR in the periphery and the other which improves SNR in the center of the coil were incorporated into one coil design. Conductor widths (w) and dielectric substrate heights (h) were varied[4] and conductive sidewalls were adjusted on alternating TEM elements to achieve desired B_1 field penetration depths at 7T (300MHz) **(Fig.1a, b)**. To optimize and compare theoretical B_1 magnitude field patterns at 300 MHz, numerical Maxwell solutions of microstrip-based volume coils were calculated using XFDTD (Remcom Inc., State College, PA). A sixteen channel volume coil with an inner diameter of 10"and length of 5.5" with Teflon as a substrate ($\varepsilon_r = 2.2$) was used as a standard for the coil with a 7" diameter saline sphere phantom (conductivity = 0.9 and permittivity =78)[5] placed in the center of the coil. Introduction of sidewalls for the ground plane were analyzed for SNR performance for the 0.5" signal line width, 0.5" substrate height and 2.0" ground width. Maintaining the same ratio between the signal line width and substrate height, increasing the height of the substrate to 0.75" was also investigated (the resultant signal line width was 0.75"). All elements were driven independently and tuned to 298 MHz. To compare the performance of the different microstrip element configurations, the SNR maps were normalized to input powers for evaluation of receive profiles as a function of power of the respective coil configurations.

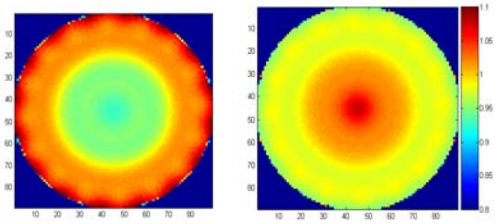

Fig. 2a) **Fig. 2b)**

Fig. 2a) SNR ratio of 16 channel microstrip TEM h=0.5", w=0.5" with sidewalls vs. h=0.5", w=0.5"with no sidewalls **Fig. 2b)** SNR ratio of 16 channel microstrip TEM h=0.75", w=0.75" with sidewalls vs. h=0.5", w=0.5"with sidewalls

Incorporating the two designs into one, a sixteen-channel coil with 8 thin strips (0.5" width, 0.5" height, and sidewalls) and 8 thick strips (0.75" width, 0.75" height, and sidewalls) was built using Teflon substrates and Cu tape **(Fig. 3)**. The coil configuration consisted of alternating thin and thick microstrip elements with decoupling capacitors between elements to achieve nearest neighbor decoupling[6]. The inner diameter of the coil was 10.0"and the length of each resonance element conductor strip was 5.5". All experiments used a 7T magnet with a Siemens console and custom 50 ohm T/R switches. The transmit phase of each element was adjustable.

Results:

Simulations of a sixteen channel coil with element substrate thicknesses of 0.5", conductor widths of 0.5" and sidewalls produced a 10% increase in SNR in the periphery of the load compared to the same design without sidewalls (**Fig. 2a**). However, by increasing element conductor widths to 0.75", substrate thickness to 0.75", the SNR in the center of the load was calculated to be 10% greater than in the periphery **(Fig. 2b)**.

Imaging performance was evaluated using FLASH (TR/TE: 22/5ms), to acquire sagittal, coronal and axial slices. The resulting FLASH images *(TR/TE: 22/5ms)* are shown in **Figures 5a, b, c**. The images demonstrate good penetration and coverage. Some signal intensity variation is present, but much of that is due to sub-optimal coarse adjustment of the transmit phases. The noise correlation matrix (**Fig. 4**) is uniformly low, indicating that the channels are adequately isolated from one another, due in part to the ground sidewalls on each element.

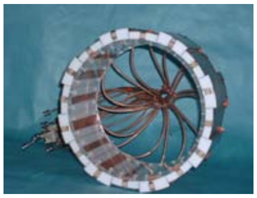

Fig. 3) TEM coil w/alternating elements

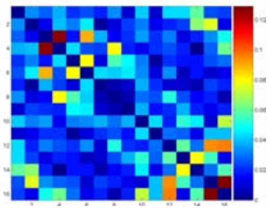

Fig. 4) Noise correlation matrix (experimental)

Conclusions

A novel two-stage, 16 channel microstrip TEM resonator is introduced for high field applications. This coil demonstrated efficient coupling to the central and periphery of the head by the use of alternating TEM elements designed for shallow and deep penetration. These independently driven elements were sufficiently decoupled to facilitate (transmit) parallel imaging as well. Both simulations and images acquired demonstrate good penetration and coverage with a uniformly low noise correlation matrix.

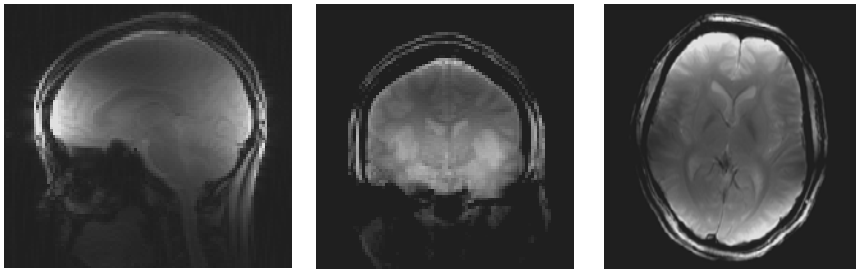

Fig. 5a) **Fig. 5b)** **Fig. 5c)**

Fig. 5a,b,c) FLASH images acquired with TEM coil shown in **Fig 3**.

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