Receiver-Only Array Geometry and Design influence on B1+ Field and Specific Absorption Rate (SAR)

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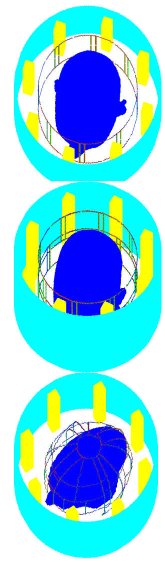

Introduction: Uniformity of spin excitation and patient safety are key in design and development of multi-channel transmit/receive (tx/rx) systems for high (3-4T) and ultra-high (>7T) field magnetic resonance imaging (MRI). Currents induced in receive-only inserts can distort the transmit field and cause changes in electric and magnetic fields [1, 2]. In this work we evaluate the effect of a wide variety of receive-only insert geometry including cylinders and helmets with different trace widths on spin excitation field and SAR of a 7T TEM transmit coil.

Methods: Using full wave numerical simulations, four ports of the TEM coil were connected in quadrature excitation. Overlapped loop array conformed a cylindrical surface of diameter 9.25" and height 5.75". An overlapped 8-loop, a staggered 16-loop and a close fitting 32-loop array were modeled with 2 anatomically detailed head models. Loop copper widths were varied for the 8 and 16-loop arrays from 0.125" to 0.25" to determine if it affected the transmit fields. See Fig. 1 for different array geometry. Experimentally obtained TEM coil coupling matched the full wave electromagnetic simulation shown in Fig.1.

Results and Discussion: The reflection and coupling at 299MHz are summarized in Table1. The differences in reflection across ports were equalized for constant transmitted power by normalizing E&H fields by $\sqrt{\mathbf{1-Sxx}^{2}}$. SAR and B_1^+ changes for the different cases are summarized in Table2. Local SAR peak increased by 15% for the close fitting array and 6-8% for the 8-loop array and 0-2% for the 16-loop array. The global SAR increased 0-2% for the 8-loop array and decreased by 4-6% for 16-loop and close fitting arrays. While the absorbed power and mean B_1^+ in brain increased in the presence of receive inserts, the mean B_1^+ in brain per Watt of absorbed power increased marginally by 3% for the 16-loop array for head2 but decreased by 20-25% for head3. The close fitting array did not degrade the mean B_1^+ field. Changes in copper width for the 8 and 16-loop arrays from 0.125" to 0.25" did not alter SAR and B_1^+ appreciably. Thus, while the peak local SAR increased with increasing number of parallel receive channels, the global mean SAR decreased for the 16-loop and close fitting arrays. The mean B_1^+ in the brain per Watt of absorbed power was both geometry and subject dependent, all these changes to magnetic and electric fields were found even when the transmit coil tuning did not shift appreciably.

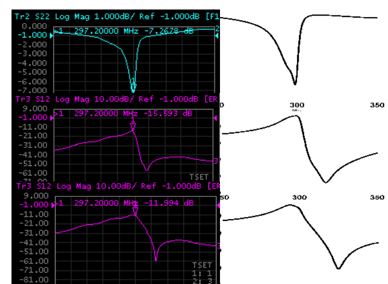

Table1	Scatter Parameters Head2 dB						Scatter Parameters Head3 dB				
		8Loop		16Loop		32Loop		8Loop		16Loop	
	Honly	H+.125"	H+ .25"	H+.125"	H+ .25"	H+.063"	Honly	H+.125"	H+ .25"	H+.125"	H+ .25"
S11	-6.08	-5.38	-5.51	-6.2	-6.21	-6.44	-5.68	-5.29	-5.41	-5.99	-5.98
S22	-5.57	-4.99	-5.11	-5.59	-5.58	-5.79	-4.97	-4.81	-4.91	-5.21	-5.21
S33	-6.71	-5.75	-5.91	-6.58	-6.56	-6.37	-4.96	-5.09	-5.21	-5.72	-5.72
S44	-5.65	-5.09	-5.21	-5.55	-5.53	-5.28	-4.35	-4.74	-4.84	-5.18	-5.18
S12	-15.88	-16.36	-16.22	-15.71	-15.66	-15.72	-16.74	-17.24	-17.09	-16.57	-16.57
S13	-11.36	-11.89	-11.77	-11.37	-11.4	-11.70	-12.65	-12.63	-12.51	-12.18	-12.18

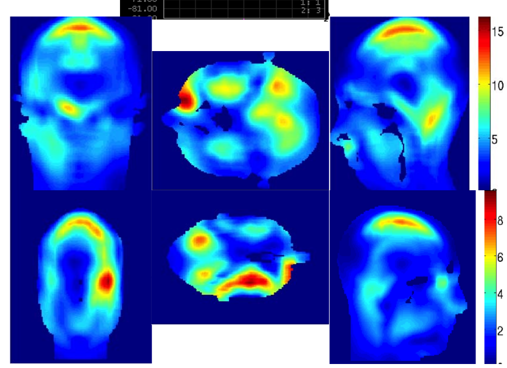

Table 2	**SAR /(mean B_1^+ Brain)^2** W/Kg Per 10gm Max, Mean, Absorbed Power (W)		**B_1^+/sqrt (Absorbed Power)**(Micro Tesla) Max, Mean,	
	Head2	Head3	Head2	Head3
Head only	9.54, 2.79, 7.72	16.18, 4.66, 10.13	2.05, 1.10	1.97, 1.07
H+8 loop array 0.125" copper	10.22, 2.83, 9.09	17.43, 4.69, 11.82	2.04, 1.09	1.55, 0.80
H+8 loop array 0.25" copper	10.17, 2.84, 8.95	17.37, 4.70, 11.63	2.04, 1.09	1.55, 0.80
H+16 loop array 0.125" copper	9.69, 2.63, 8.87	16.11, 4.45, 11.38	2.07, 1.13	1.59, 0.83
H+16 loop array 0.25" copper	9.72, 2.62, 9.09	16.11, 4.45, 11.38	2.07, 1.14	1.59, 0.83
H+32 array .063" copper	10.94, 2.74, 8.41		2.04, 1.11	

Figure 1 Top Right: Geometry of overlapped 8loop, staggered 16loop and close-fitting 32loop array shown inside an 8 element TEM transmit coil. Center Right: Scatter parameters obtained for a subject using a network analyzer is verified with FDTD simulation results of a head model loaded in the TEM coil. Bottom Right: (top/bottom- Head3/ Head2 models): Coronal/axial/sagittal slices of SAR in W/Kg per 10gm. **Table 1:** Reflection and Transmission at 299MHz of different arrays and heads. Transmitted power across cases were matched by scaling $E\&H = H/\sqrt{1-Sxx^{2}}$. **Table2:** Changes of local & global SAR for same mean $\mathbf{B_1^+}$ in the brain, and $\mathbf{B_1^+}$ field per Watt of absorbed power for different cases summarized.

References:[1] N. D. Zanche "MRI Technology: Circuits and Challenges for Receiver Coil Hardware" John Wiley&Son. [2] Y. K. Hue, et al. "A Complete Modeling System for Calculating the Transmit and Receive Fields, Total Power Deposition, Input Impedance, and Coupling Between Coil Elements", ISMRM 2008.
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