Multi-element wireless stacked phased array coil

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Introduction: Phased array coils have been widely used in MRI since their introduction by Roemer, et al in 1990 [1]. It is well known that for a desired targeted imaging volume, higher number of smaller size elements will provide higher SNR, faster imaging acceleration, and a larger FOV. The desire for a larger FOV in the abdomen, pelvis and lower extremities can significantly increase the number of elements in a phased array design. However, there are obstacles that prevent continuously increasing the number of elements in an array. One of issues is the arrangement of the elements in the array structure. It is custom for the elements of an array to be placed adjacent to each other in a geometrically decoupled fashion. Thus for a given geometry, there is a limitation to the number of elements that can be included. Another obstacle is the large number of RF conductors to accommodate high density array design. For such structures, array design is complicated due to the size and weight of the RF coil and its impact to the operator and patient

In this paper, a novel wireless stacked decoupled phased array design is presented [2] that successfully address both these obstacles without sacrificing the coils performance in terms of SNR and coverage. The stacked coil configuration allows for higher number of channels within a restricted geometrical envelope while the wireless technology eliminated the need for RF cables. Dandan Liang et al [3] described a coupled stacked coil in which two identical elements were stacked vertically and separated by a certain distance. This configuration created strong coupling between the stacked elements which required pre and post signal processing to address this issue. The presented design introduces a novel wireless stacked phased array coil configuration in which shared capacitive decoupling is used to achieve element isolation up to -23 dB. The receive signal of the stacked coils are inductively coupled to the receive signal of the body coil [4] that results in superior image quality and coverage without the use of integrated preamplifiers and cables. Such an array configuration can improve SNR by 35% compared with the same geometrical sized single loop configuration.

Methods: As a proof of concept a representative configuration of the stacked element wireless phased array coil is shown in figure 1. The stacked coil has dimensions of 17 x 17 cm and inner element cross length of 15.5 cm. The coil was constructed using ¼″ copper tape on FR4 laminate. The elements were tuned to 123.2MHz to be used with the Siemens Verio MR system. The two passive decoupling circuits provide protection from the body coil during the transmit phase. Capacitive decoupling between the two elements is achieved using a shared capacitor C0. As a benchmark test, this coil was compared with a single loop coil (figure 2) that occupies the same geometrical space as the stacked coil. Bench tests were conducted using Siemens 1900mL phantom with measured Q factor and isolation provided in Table 2. In the stacked configuration, isolation of -23 dB can be achieved with the loaded phantom. A transmit RF power change test was conducted using the magnet which produced a 0.8% change in power due to the presence of the coils verifying the effectiveness of the passive detune circuit.

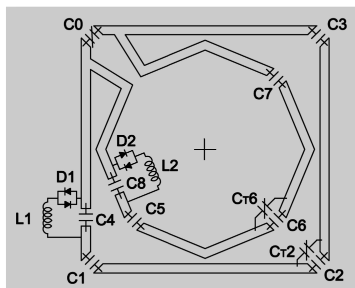

Figure 1 Stacked Coil

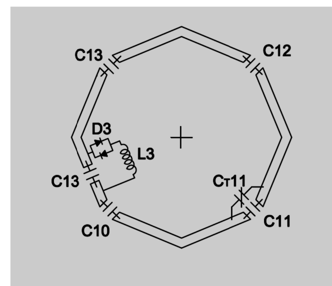

Figure 2 Single Loop Coil

Results: After successfully completing all the MR safety tests, SNR measurements on the Siemens 1900mL phantom and human volunteer imaging was performed for both the stacked coil and single loop configurations. The measured SNR numbers are provided in table 2. It is observed that that the stacked coil improves SNR by 35%. In addition, volunteer imaging was conducted with a T2 weighted sequence (TR/TE = 6000/96, Slice thickness = 4 mm, FOV = 230 mm) with the results depicted in figure 4 and figure 5. Improvement in SNR and image depth of the wireless stacked coil is clearly visible.

Table 2

Coil		Q_{UL}	Q_L	Q_{UL}/Q_L	Isolation (UL)	Isolation (L)	SNR	ratio
Stacked	squared	283	85	3.3	-23dB	-15dB	217	**1.35**
	octagon	310	103	3				
Single loop		365	109	3.3	N/A	N/A	161.3	N/A

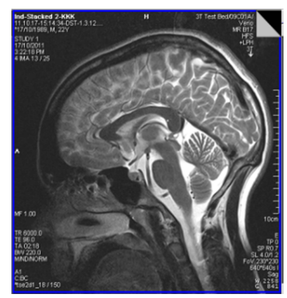

Figure 4 T2 image with stacked coil

Figure 5 T2 image with single loop coil

Conclusions and Discussion: A novel wireless stacked decoupled phased array coil was presented. It was shown that this coil can greatly improve image quality in terms of SNR and penetration. SNR improvements of 35% were measured compared with a single element coil of similar size. Such coil design will allow us to increase the number of elements on the phased array design without increasing the overall coil dimensions. The wireless technology will allow for user friendly lighter coils without sacrificing image quality. This design can be extended for standard phased array coils combined with preamplifier decoupling to further enhance the isolation between the adjacent elements.

References:

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4. Haoqin Zhu et al, US patent application 13/090816, April 20 2011