A Flexible 4 ch. Transmit / 16ch. receive Auditory Cortex Array for HiRes fMRI at 7 Tesla

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Target Audience: RF Engineers, Neuroscientists, UHF Labs

Objective

The aim of this work was to develop a dedicated 7 Tesla coil array for bilateral high-resolution fMRI of the temporal lobe [1] for auditory neuroscience studies. Ideally, the coil housing has to permit secure patient positioning and flexibility regarding head sizes and relative coil position without compromising its robustness. Furthermore, the housing should allow for bite bar mounting and back projection of images in case audio-visual presentation is required. For this, it is desirable to elegantly combine the required transmit coils with the receive arrays within the same slim holder design. Preamplifier protection and coil decoupling, particular of a bilateral array, represent significant additional challenges in this design.

Methods

A dedicated coil housing that allowed for flexibility regarding head sizes and coil placement was built utilizing Fused Deposition Modeling (FDM) (Fig. 1). The base holder was designed to support precise coil positioning relative to any given head size, as well as secure attachment of a bite bar and task presentation hardware. Both the transmit and receive coil arrays were built into two separate bilaterally-positioned housings (Fig. 1,2), while the base holder contained the required RF components for the transmitter interface, such as power splitters, phase shifters, and T/R switches. The slim coil housings had provisions for receive interface hardware, including secure locations for preamplifier mounting and cable routing. The 4 channel transmit array consisted of two ~ 9 cm diameter loop coils for each side. Each of the unshielded loops was connected to one of four dedicated T/R switches located in the base. This setup supported local multi-channel transmission as well as signal reception with high SNR. For significantly improved SNR and parallel imaging performance, six overlapping ~6 cm receive loops where integrated into each of the two independent coil housings as indicated in Fig. 3. Geometric coil decoupling of ~10 to 15dB was achievable through optimized overlap between the transmit and neighboring receive loops; coil isolation was further optimized with preamplifier decoupling techniques. Additionally, two PIN diodes (M/A-com, Lowell, MA) for each receive loop provided resonant detuning and achieved the required preamplifier protection of ~-45dB. For the initial prototype, 4 transceiver and 12 receiver-only coils were realized from 12-AWG enamel-coating wire with two capacitive breaks per coil loop. Receive coils were matched with a lattice balun network [2,3]. Preamplifier decoupling was achieved with lumped element phase shift networks connecting each coil element to an on coil low-noise preamplifier (WanTcom, Minneapolis, MN) [4,5].

Results and Discussion

The design of the coil housing provided both task presentation capabilities and patient comfort. All receive loops had excellent Q_u/Q_l ratios of 10 to 16 and achieved high SNR and low noise correlation <0.2. Due to the lower Q of loop coils (compared to striplines), all experiments could be performed without subject specific tune and match re-adjustments, which significantly reduces setup time. To achieve optimal transmit efficiency and RF homogeneity, the Tx array allows for full flexibility in terms of B_1^+ shimming, however, we observed that an experimentally determined average phase distribution and equal RF amplitude can be used for most studies. The B_1^+shimmed transmit array resulted in sufficiently uniform spin inversion and refocusing in the FOV seen by the receive array coils.

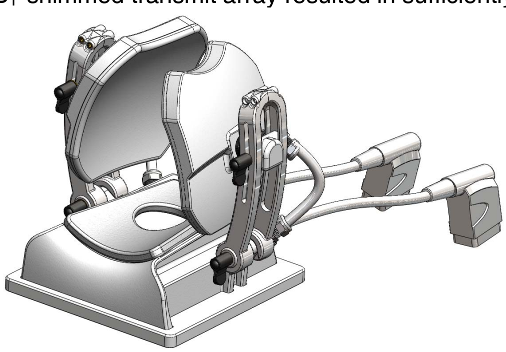

Fig. 1 Drawing of the Housing Design

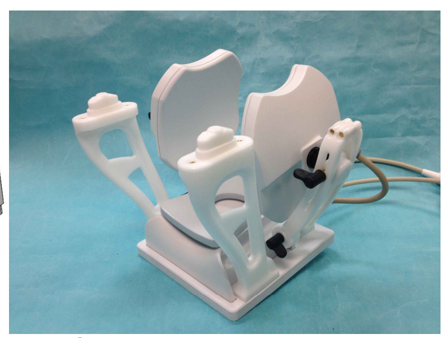

Fig. 2 Shows the realized coil, including provision for bite bar and mirror.

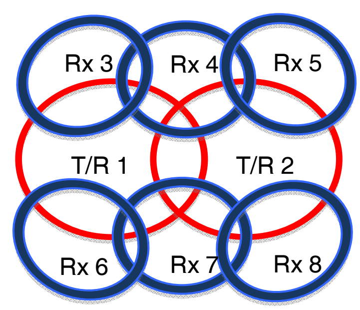

Fig. 3 Indicates the layout of the loops for each side. per side 2 T/R loops(Red) +6 Rx only loops (Blue)

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Acknowledgement: NIH-NIBIB-P41-EB015894 R01-EB006835, P30 NS057091 R01-EB007327, S10 RR26783 and W.M. KECK Foundation