A User-Configurable 96 Channel Head Array for Use in a 32 Channel 3T System

T. Grotz[1], B. Keil[2], A. Mareyam[2], S. Sigalovsky[2], B. Zahneisen[1], M. Zaitsev[1], J. Hennig[1], and L. L. Wald[2]
[1]Dept. of Diagnostic Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany, [2]Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, United States

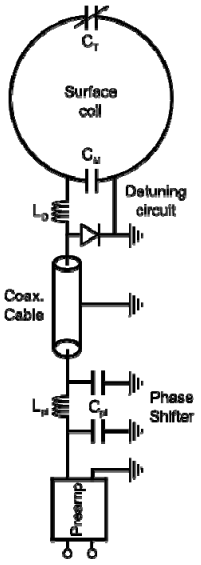

Fig. 1. Schematic of the circuit of a single coil element.

Introduction: While the increasing the number of elements of surface coil arrays can provide improved sensitivity near the detectors and increased parallel imaging performance [1], applications such as One Voxel One Coil (OVOC) imaging [2], Inverse Imaging (InI) [3] or Single Echo Acquisition (SEA) [4] implemented on systems with a limited number of channels (e.g. standard 32 channel scanners) can potentially benefit from focusing the channels on a limited spatial region. In order to avoid the need to construct different arrays for different brain regions, we developed a 96 channel head array coil which allows the selection of an arbitrary subset of 32 receiver channels from the 96 channels available.

Methods: The 96 coil elements were arranged in a soccer-ball geometry on a fiber-glass helmet shaped to closely fit most human heads [1]. Each of the 96 loop coil elements (~5cm diameter) was formed from 18AWG copper wire, using the tuning/matching, active detuning circuitry and preamplifier as shown in Fig. 1. The overlap of each element with its next neighbors was modified such that the S12 coupling was at least -15db. The preamplifiers (Siemens, Erlangen Germany) are mounted on a rack surrounding the helmet in close proximity to the elements and attached to the coils by relatively short (7cm or 14cm) length semi-rigid coaxial cable. Preamplifier decoupling was achieved by transforming the impedance of the preamplifier to a low impedance across the trap circuit of the coil using a π-circuit. Cable traps at the output of each preamplifier reduced excitation of common mode currents on the output cables during transmit. To allow the selection of an arbitrary subset of 32 channels a „patch panel" was implemented on a circuit board after the preamplifiers using 96 MMCX connectors. 32 are connected to a standard 32 channel coil-plug set, while the rest are terminated with 50 Ohm. To ensure active detuning for all channels during the transmit phase, the 32 bias lines of the scanner were split 3 ways to detune all 96 channels during transmit. The user selects the element subset using the MMCX patch-panel. The coil array was tested on a standard 3T Tim Trio System (Siemens). SNR comparisons with the commercial 32 channel Trio head array were made with 2 different coil configurations.

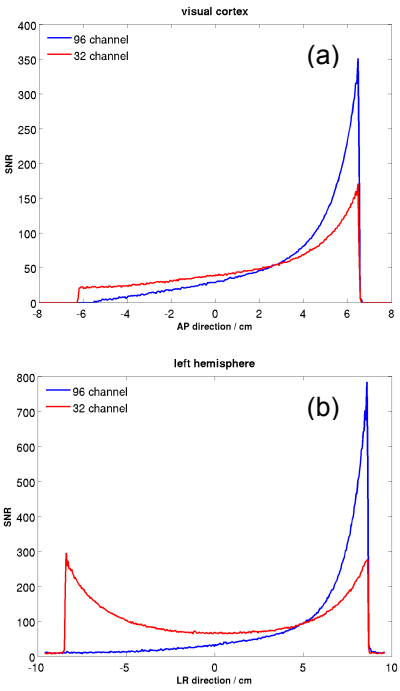

Fig. 3. SNR comparisons along a line through the center of a measured phantom.

Results: The unloaded to loaded Q-ratio for a coil surrounded by other elements was measured to be on average Q_{UL}/Q_L=220/100=2.2. Fig.2 shows views of the coil displaying the „patch panel". Fig.3 shows the SNR for both coils in a phantom measurement along a cut through the center of spherical phantom for 2 coil configurations. For configuration (a) only coil elements at the back of the head were selected and for (b) only elements above the left brain hemisphere were selected. The plot direction for (a) is anterior/posterior while it is left/right for configuration (b). For configuration (a) the SNR is twice the SNR of the 32-channel coil at the edge of the phantom. In case (b) the SNR of 32 channels from the left side of the 96 channel array is ~3x higher than the 32ch array directly above the selected coil elements and becomes equal in sensitivity about 40% of the distance to the center. It drops below the 32ch whole-head array SNR and finally reaches 50% of the 32 channel coil SNR at the center.

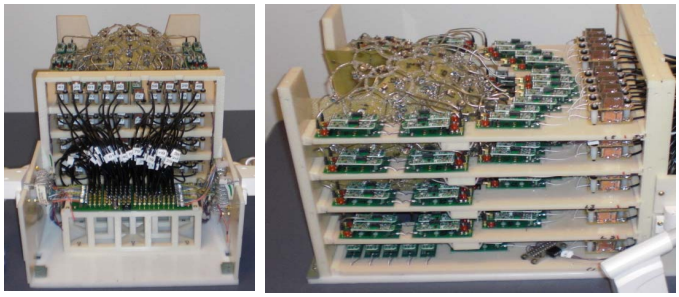

Fig. 2. The coil without cover viewed from the back and from the side.

Discussion: The SNR gain over the 32 channel coil in the periphery translates into a better performance for fMRI experiments focused on activation studies in the cortex. The limitation is, of course, the restriction to only parts of the brain. The present design of the coil using a patch panel to select an arbitrary subset of coils is simple and does require only minimal additional space and no external power sources. The disadvantage certainly is the time it takes to change to another set of coils. In principle a more sophisticated solution would be to use an electronic switch matrix that can be controlled by a PC interface, but the costs, the required space and implementation time, render this option rather difficult. It can be expected that future commercial scanner generations will eventually be shipped with support for more receive channels. In such a case the current design of the coil will allow for a quick modification to use all available channels.

References:

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