A 32 channel Transmit/Receive Transmission Line Head Array for 3D RF Shimming

G. Adriany[1], A. Gozubuyuk[1], E. Auerbach[1], P-F. van de Moortele[1], P. Andersen[1], T. Vaughan[1], and K. Ugurbil[1]
[1]Center for Magnetic Resonance Research, University of Minnesota Medical School, Minneapolis, MN, United States

Introduction:
At very high frequencies and field strength the ability to influence the B_1 fields by means of unique coil layout [1-4] or a high number of independent RF transmit coils is crucial to improve image homogeneity and parallel imaging performance [5-8]. Recent numerical calculations of designs based on short transmission line coils with up to 80 individual elements seem to indicate great potential of such coils for RF shimming [9]. Here we describe a head coil design with 32 short transmission line elements, discuss practical considerations and present initial data acquired with a 32 channel transmit system when using equal RF amplitude per channel.

Methods:
The transmit/receive array consisted of two segments with sixteen concentrically arranged 8cm short resonance elements each (Fig.1A). The coil dimension was 21cm x25cm and a 12mm thick Teflon substrate between the conductors and shield was used. Decoupling capacitor networks [10, 11] between immediate neighboring elements were utilized to isolate the individual coils from each other (Fig. 1B). To avoid the potential for a signal loss at the seam between the two 16 element segments, the distance between the segments was minimized to 5mm. The ground of each array element was 5 cm wide and physically separated from neighboring elements. The length of each resonance element conductor strip was 8 cm. Gradient induced eddy currents in the ground plane were reduced by using a circuit board material with 5 µm thin copper substrate. High voltage ceramic chip capacitors (ATC 100E and C series) were used to capacitively shorten the individual resonance elements towards ground and to achieve $\lambda/2$ resonance. A 7T Siemens whole body system based on TIM technology with 32 receive channels was used in conjunction with a 8 kW CPC RF amplifier (NY,USA), a 32 times equal amplitude RF splitter (Werlatone, NY, USA) and 32 T/R switches (16 Stark Contrast, Erlangen, Germany and 16 Varian Inc, CA). The transmit phase could be controlled by phase shifters.

Results and Discussion:
By building the transmission line coil with extensive decoupling capacitor networks (Fig.1B), we were able to reduce the average crosstalk between the 32 coil elements for the human head below -20dB (Fig.2). Initial experiments indicate that we can allow for fixed adjusted decoupling capacitors and even prefixed tune/match capacitors for similar head shapes. This reduces the setup time for such an array significantly. At 7 Tesla we were able to cover the whole brain with two segments of transmission line elements (Fig. 3). We attribute being able to avoid signal voids between the segments (Fig. 4) to the narrow gap of only 5mm.

Conclusions:
Our preliminary results indicate that coils based on short transmission lines can be built and decoupled at 7T. Such coils improve RF shimming ability and are expected to aid 3D parallel imaging performance. The presented coil for example allowed for two independent B_1 shim sets to be applied along the z direction. While certainly more careful studies will be needed to evaluate the true potential and the limitations of such coils the initial results are very encouraging.

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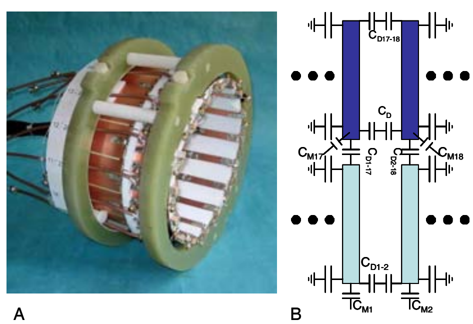

Fig.1 The coil and a schematic of the circuitry.

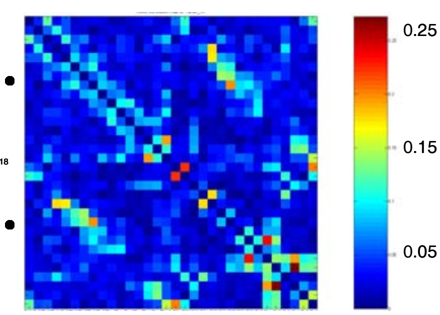

Fig.2 Noise Correlation Matrix

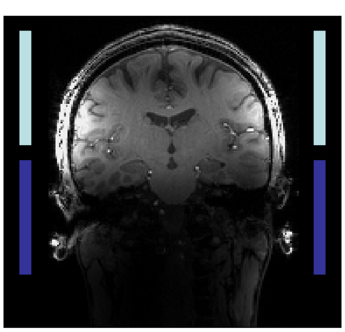

Fig. 3 Indicates the typical position of the 2x16 element sections relative to the subjects head.

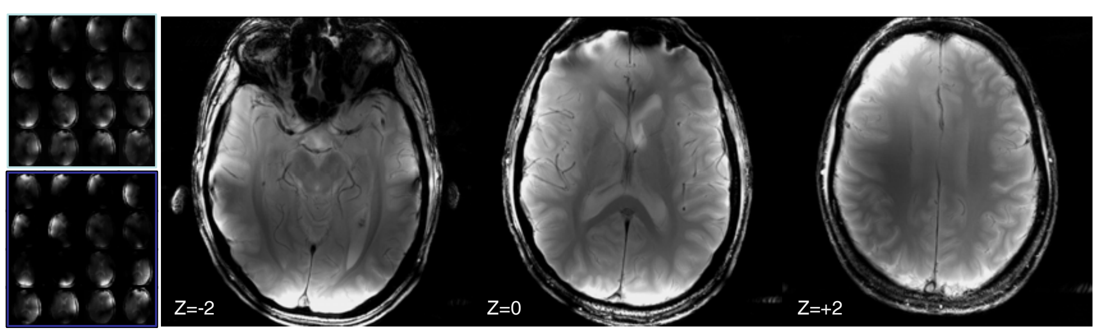

Fig. 4 Individual and combined T_2* weighted images. Shown are three axial slices demonstrating field continuity between the non overlapped coil sections. TR/TE: 100ms/8ms, 0.375x 0.375x 5mm^3 resolution.