

A 32 Channel Lattice Transmission Line Array for Parallel MRI

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Objective: To increase parallel imaging performance at 7 Tesla, through an arrangement of concentric transmission line arrays oriented perpendicular to each other.

Introduction:

Signal to noise ratio (SNR) and parallel imaging performance increase consistently with higher field strength and number of coils [1-3]. For a given target volume, however, there are practical limits to the number and size of coils that still can yield sufficient decoupling among the different elements and result in improvements in SNR and parallel imaging performance. This limit may be relaxed by concentric coil arrangements [4-6]. In this work, we pursued combinations of concentric transmission line elements to demonstrate that the transmission line elements can be used both in parallel and perpendicular orientation to the magnetic field and to investigate whether an array consisting of a combination of both type of elements improves SNR and parallel imaging performance (SENSE [7]) performance. Since at such high fields, transmit arrays with a large number of independent channels are of considerable interest for RF transmission [8] we designed an outer 16 channel transceiver array that allows for independent phase, amplitude and pulse shape control. This 16 element transceiver array was then combined with a second 16 channel array of short transmission lines used for reception only, yielding an array with 16 transmit and 32 receive channels.

Methods:

A sixteen-channel transceive array with an inner diameter of 32cm was built with decoupling capacitors between elements [9] to achieve element decoupling and thus allow for independent element control. The resonance elements were built from Cu-tape and a 12mm thick Teflon substrate was used (Fig. 1A). The ground conductor for each array element was 4cm wide and electrically separated from neighboring elements. The length of each resonance element conductor strip was 16cm. High voltage ceramic chip capacitors (ATC 100E) were used to capacitively shorten the individual resonance elements and to achieve $\lambda/2$ resonance. A second coil array was built using a 1cm thick Teflon cylinder of 24cm inner diameter. Two sets of eight, 6cm long strip line elements were arranged perpendicular to the main field direction, as depicted in Fig. 1B. To decrease the RF shielding effect during transmission, the width of the ground plane for these coils was reduced to 2cm. The distance between the two sets of eight coils was 10cm. The perpendicular arrangement provided excellent decoupling between the elements of the outer and the inner arrays. A PIN diode shortened each 6cm long resonance element of the inner coil towards ground during signal transmission. This increased the decoupling by ~ 20 dB from the outer transmit coil for a total decoupling of ~ 35 dB. For all experiments a 7T Magnet with a Varian Inova console and an in-house built 32 channel digital receiver was used. Parallel imaging performance was evaluated using gradient echo images (TR/TE: 22/5ms), acquired for sagittal, coronal and axial slices. The average and maximal g-factors were then calculated for a tight FOV. For data presented, a 22cm diameter phantom was used with concentric oil and saline compartments (Fig. 1D).

Results and Discussion:

The noise correlation matrix of the combined coil as shown in Fig. 2 indicates excellent isolation and minimal crosstalk between the two arrays. There was no need for decoupling circuitry between the inner and outer arrays, nor was preamplifier decoupling used. Decoupling capacitors (with values ~ 2.5 pF and ~ 1 pF, respectively for the outer and inner coils) were, however, required between neighboring elements in the two concentric arrays. With this, the resonance elements could be tuned and matched independently and no resonance peak split was observed. G-factor data (Tab. 1, Fig. 3) showed that parallel imaging performance improved, particularly in sagittal and coronal slices. Similar improvements can be expected for oblique slices.

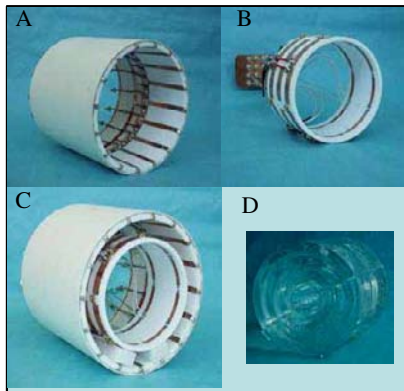


Fig.1 Shows the coils. **A:** 16 channel Transceive Array, 32 cm i.d. **B:** 16 channel concentric receive array, 24 cm i.d. **C:** Combined 32 channel lattice coil. **D:** Phantom that was used for evaluation.

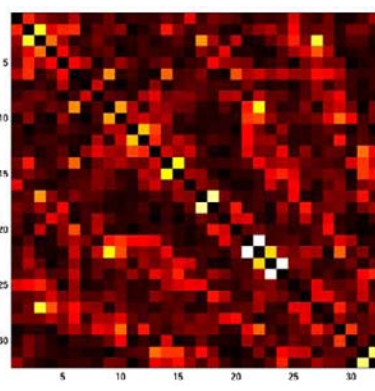


Fig. 2 Noise correlation matrix. Axis depict coil element numbers, 1 to 16 are the outer transceiver array elements oriented parallel to the z-axis. Channels 17 to 32 are the inner radial elements.

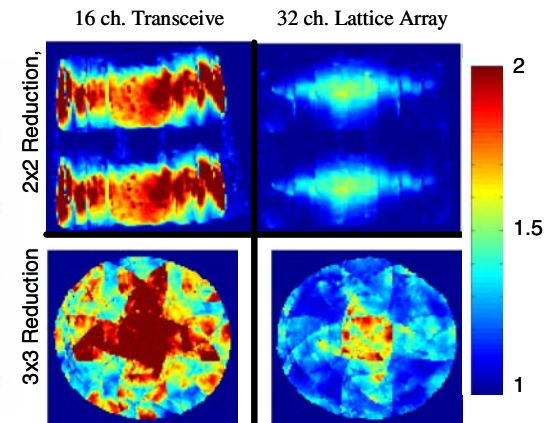


Fig. 3 G-factor maps for the 16 channel transceiver coil alone and the 32 channel lattice coil. A Phantom with concentric oil/water chambers was used. The structure seen (most pronounced in the top row) is due to the presence of multiple chambers.

Conclusions:

These results demonstrate that concentric arrangements of transmission line arrays are feasible at 7 Tesla and improve the achievable reduction factors significantly.

Acknowledgements:

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Mean Max. g- factor	Axial Slice		Sagittal Slice	
	16 channel Transceive Array	32 channel Lattice Array	16 channel Transceive Array	32 channel Lattice Array
R=	1.05	1.02	1.99	1.12
2x2	1.17	1.05	4.35	1.48
R=	1.73	1.26	4.58	1.59
3x3	2.39	1.72	9.74	3.11

Tab. 1. 2-D average and maximal g-factor comparison for indicated reduction factors and axial and sagittal slices. Reduction factors also correspond to maximal aliasing