High-Field Transmission Line Arrays for Transmit and Receive

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Introduction

The use of phased array receiver coils [1] at high field has been shown to increase spatial sensitivity and SNR when compared to either local tranceivers or large volume coils [2,3]. Increasing the number of coil elements in phased arrays is also beneficial to parallel imaging techniques [4,5]. At high-field, transmission line arrays and multi-channel TEM coils[6] have shown to be useful transceivers,[7] but the extension to using transmission line resonators in a receive-only array has not been strongly pursued [8]. Here we have developed a 16-element, receive-only, transmission line resonator array to be used in conjunction with a 16-element transmission line volume array for high-field imaging.

Methods

All experiments were performed on a 7T magnet (Magnex Scientific, Oxfordshire, UK) equipped with a Sonata gradient system (Siemens, Erlangen, Germany) and interfaced with a Unity Inova spectrometer (Varian, Palo Alto, USA).

The volume array is a 16-channel transmission line/TEM coil (fig. 1a) tuned to proton's resonant frequency at 7T (ω_0=294.7MHz). The physical dimensions of this coil are 15.25 cm in length and an inner diameter of 32.0 cm. The center conductor is a 1.25 cm wide copper foil strip while the ground plate is a 5.0 cm copper foil sheet. The center conductor is separated from the ground plate by a 1.25 cm thick PTFE (ε_r=2.08) dielectric. Adjacent coil elements were capacitively decoupled. Active PIN diode detuning [2] is used to detune the volume array during reception.

The receiver coil is a 16-element array of capacitively shortened, halfwave, transmission line units. Each element consists of two parallel copper foil conductors separated by a dielectric layer (fig. 1b). Each conductor is 1.25 cm wide and 10.15 cm long on a 1.25 cm thick PTFE dielectric substrate. Each element was tuned to the Larmor frequency for ^{1}H during reception and actively detuned during transmit via a PIN diode in series with the ground conductor. The elements were placed approximately 3.5 cm apart on a flexible Teflon former that was wrapped around a human head. Interconnecting capacitors were used to decouple adjacent coils.

Sagittal and axial FLASH images (T_E/T_R=125/7ms; FA=~10°; NEX=2; Matrix=256 x 336) were obtained with both the receiver and volume coil. The FOV for the axial plane was 25 x 16 cm while the sagittal FOV was 25 x 25 cm.

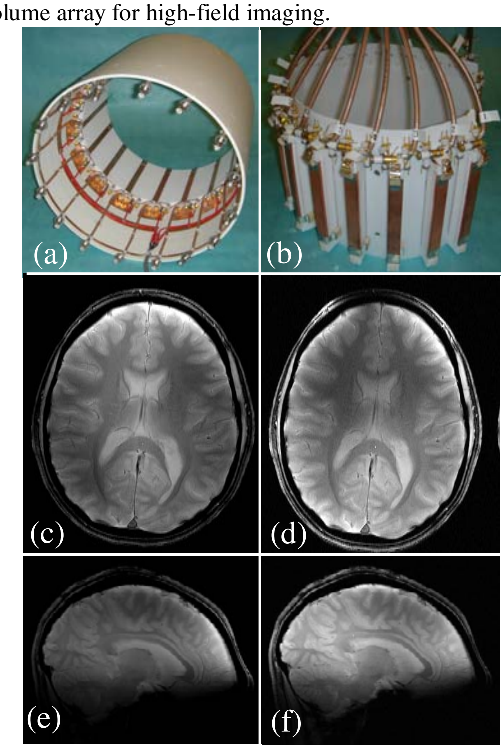

Figure 1: (a) the 16-element volume array; (b) the 16 element receiver array; (c,d) axial slices of from the transmitter (c) and receiver (d); (e,f) sagittal slices from the transmitter (e) and receiver (f)

	R_x=1	R_x=2	R_x=3	R_x=4
R_y=1	1.0 1.0	1.02 1.06	1.17 1.36	1.68 2.20
R_y=2	1.03 1.03	1.07 1.14	1.27 1.61	1.88 2.59
R_y=3	1.11 1.19	1.20 1.46	1.72 2.59	2.86 4.65
R_y=4	1.29 1.58	1.46 1.93	2.49 4.32	5.51 10.61

Table 1: Average g-factors of the receiver array (top value) and the transmitter array (bottom value) for a tight field of view.

Results

Figures 1(c) and 1(e) show the axial and sagittal images, without intensity correction, from the volume array only; figures 1(d) and 1(f) show the axial and sagittal images, without intensity correction, obtained from the receiver array. The receiver array shows greater spatial coverage and the SNR, especially in the periphery over the volume array.

Table 1 shows the average g-factors for both the receiver array (top value) and the volume array (bottom value) for a tight field of view. The local receiver shows significantly lower g-factors especially as the reduction factors increase.

If the volume array is used, in addition to the receiver array, during reception, the SNR at the center of the head is 28% greater then just with the receiver alone. This increase in SNR comes at the cost of increased coupling between volume and receiver arrays, as well as, an increase in the mean g-factors.

Discussion and Conclusions

The receiver array is similar to the transmission line resonators that have been used as transceivers, except for the narrow "shield" conductor. One benefit that this new array design has over loop arrays is the increased cortical homogeneity, making it suitable for fMRI studies. Additionally since loop resonators are geometrically limited by their diameter, the slim profile of these receiver arrays might provide greater benefits in parallel imaging techniques.

Also since both arrays can be used during reception, this coil design provides more flexibility than previous phased array designs.

Acknowledgments

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