Technology Offer

Advanced Multichannel Coil for Ultra-High Field MRI

Ref.-No.: 0107-4677-BC-JK

Abstract

This technology introduces a multichannel radiofrequency (RF) coil setup for ultra-high field (UHF) magnetic resonance imaging (MRI) at ≥7 Tesla. Designed for optimal imaging of the human brain, the system combines a 16-channel dual-row transmit array with a 31-channel receive array. It addresses the challenges of uneven signal distribution (B_1^+ field inhomogeneities) and enhances signal-to-noise ratio (SNR) through innovative RF shimming and tightly coupled coil configurations. This solution is ideal for high-resolution imaging, offering exceptional whole-brain coverage and groundbreaking performance in brain imaging applications.

Background

UHF MRI systems offer superior resolution but are hindered by RF field inhomogeneities due to the shorter wavelength of electromagnetic fields at higher frequencies. This leads to artifacts and signal voids, especially in the brain's deeper regions. Current coil technologies often require compromises in either transmit efficiency or receive sensitivity. To overcome these challenges, separate transmit and receive arrays with advanced configurations have emerged as the most promising solution for high-quality UHF MRI imaging.

Technology

An advanced multichannel RF coil system tailored for ultra-high field (UHF) MRI, specifically optimized for human brain imaging at 9.4 Tesla was developed. The system consists of a 16-channel dual-row transmit array and a 31-channel receive array, which together enhance both the homogeneity of the RF transmit field (B_1^+) and the signal-to-noise ratio (SNR).
The transmit array is designed with two rows of eight coil elements each, providing additional degrees of freedom for RF shimming. Static and dynamic RF shimming techniques allow precise control of the B_1^+ field, ensuring uniform excitation across the brain and eliminating signal voids (Fig. 1c), particularly in lower brain regions such as the cerebellum and temporal lobes. Additionally, integrated transmit/receive (TR) switches enable both transmit-only and transceive operation, increasing flexibility for different imaging protocols.

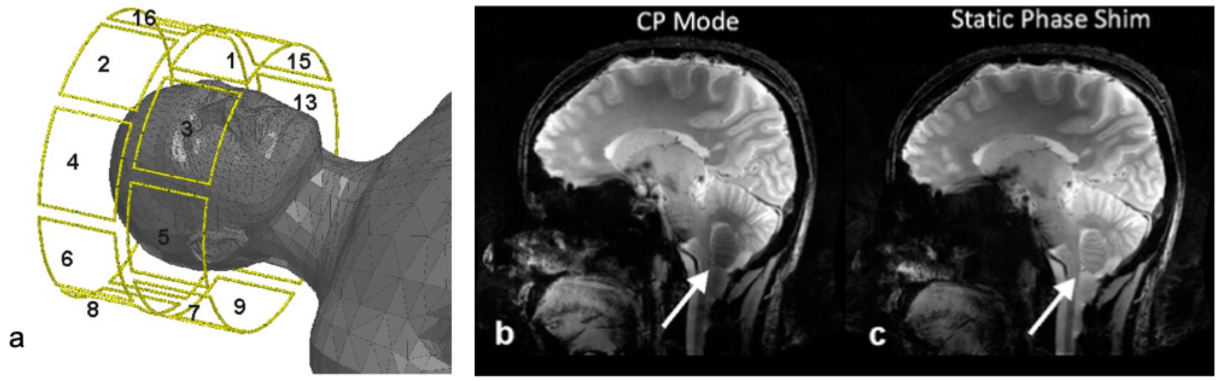

Figure 1: (a) Simulation model of the 16-channel dual-row transmit array for ultra-high field (UHF) MRI. The numbered yellow coil elements illustrate the spatial arrangement around the human head, enabling RF shimming and optimized B_1^+ field distribution for enhanced brain imaging at 9.4 Tesla. **(b)** Images taken in conventional CP mode feature darks areas indicative for inhomogeneous excitation **(c)** in comparison to the use of phase shimming featuring homogenous excitation of the entire volume (Shajan, et al., 2014).

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The 31-channel receive array is shaped to the contours of the anatomy, significantly improving parallel imaging performance and maximizing SNR (Fig. 1a). The coil elements are strategically arranged to ensure optimal decoupling between adjacent elements, reducing interference and enabling high-resolution imaging. Together, these features provide unprecedented whole-brain coverage, allowing for superior image quality in UHF MRI applications (Fig. 2).

Advantages

- **Enhanced Signal Quality:** Increased SNR through a 31-channel close-fitting receive array.
- **RF Shimming:** Static and dynamic methods improve B_1^+ field homogeneity.
- **Dual-Mode Flexibility:** TR switches enable transmit-only and transceiver modes.
- **Efficient Decoupling:** Minimizes interference between coil elements for high-performance imaging.
- **Complete Brain Coverage:** Superior imaging even in challenging regions like the lower brain and cerebellum.

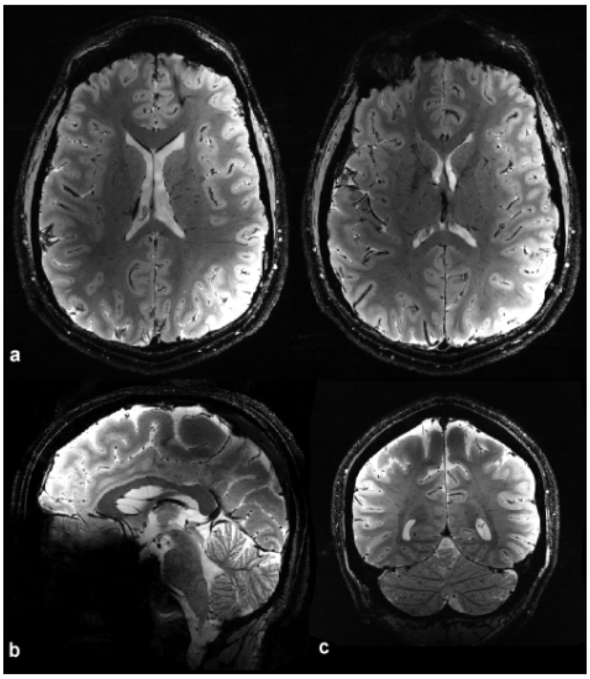

Figure 2: Performance record: In-vivo images with high SNR and whole brain coverage (Shajan, et al., 2014).

Potential applications

- High-resolution brain imaging in neuroscience research.
- Clinical diagnostics for neurological disorders.
- Functional MRI (fMRI) studies at ultra-high fields.
- Preclinical trials involving detailed brain imaging.
- Advanced imaging protocols in neuroimaging facilities.

Patent Information

PCT (*WO2015043612A1*; 25.09.2013), active in US

Publications

Shajan, G., Kozlov, M., Hoffmann, J., Turner, R., Scheffler, K., & Pohmann, R. (2014). A 16-channel dual-row transmit array in combination with a 31-element receive array for human brain imaging at 9.4 T. *Magnetic resonance in medicine*, *71*(2), 870-879.

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