

An Open 16-Channel Transmission Line Array for 7T

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Introduction

The effects of high SNR, parallel imaging and Transmit SENSE capabilities are strongly enhanced with the increase of field strength. Specifically, at field strengths of 4.0 T and above, finite wavelength effects and radiation effects necessitate the use of transmission line technology for construction of multi-element transmit and receive arrays [1]. Traditionally, the construction for such coils utilizes a solid screen that minimizes the radiation effects of the coil as well as a solid non-integrated dielectric in order to enhance the isolation between elements for Transmit SENSE applications. Also, since the advantage of pre-amp decoupling can not be utilized during transmit, added capacitive/inductive decoupling must be used, resulting in more inhomogeneous transmit B_1 fields [2]. In addition, continuous shields often present the problem of spurious Eddy Current effects, and completely encompass coil impeding patient comfort. In the present paper, we propose using an open 16-channel transmit/receive coil design for 7.0T imaging. With this design, using individual, decoupled, transmission lines that were optimized for homogeneity, we have built 16 channels with no continuous shield to obstruct a patient's view. The coil is open and comfortable, reduces concern of claustrophobia, minimizes Eddy Current problems, has high SNR and high reduction factor for parallel imaging, good homogeneity, and can accommodate various visual devices for use in fMRI.

Methods:

The design of this coil uses 16 individual elements for transmission and reception. This T/R coil has transmission line elements that use a Cu-tape return path (shield) over a 1.9cm thick PTFE dielectric and are connected to 1.27cm wide Cu-tape (center) conductors through tuning capacitors [3,4]. The ground shield continues down around the PTFE dielectric to provide added decoupling, and maintain transmit efficiency, as well as to act as a shield to external influences. The size of the elements was arrived at beginning with the work of Bogdanov et al. and constructing a very strongly coupled resonator for homogeneity advantages, and then reducing conductor widths until desired capacitive decoupling could be achieved between elements [5,6]. Element isolation was $<-13\text{dB}$ and $<-23\text{dB}$ between neighbor elements, and next nearest neighbor elements respectively. To minimize sheath currents, the coax feed cables were arranged in a half-wavelength long bundle working as an end-cap to focus the RF field with all grounds tied together to minimize sheath currents. Typically, strong coupling between the patient and the coil at high RF frequencies complicates equalizing of individual resonant elements' performance for different subjects or head positions in an RF coil array; however, it was found at the bench that many differing human loads were matched with good array isolation without retuning either the decoupling or the match capacitors. As shown in Fig. 1, the coil is 15.25cm long and has a diameter of 26cm. This open design reduces claustrophobic effects of the coil and provides access for viewing or manipulating objects located in the interior of the coil. Testing was done on a 7T Magnex magnet, using a Siemens Console and Avanto gradients, with receive system and T/R switching provided by Siemens and Stark Contrast, respectively. The system is located at the CMRR, University of Minnesota, Minneapolis, MN. SNR and isolation imaging/measurements used a 200mm oil sphere head phantom.

Results and Discussion

Images of the spherical phantom for all 16 channels demonstrate very good isolation between adjacent elements, resulting in a low noise correlation as evident in Fig 2. As can be seen in Fig 3, the B_1 field is quite homogeneous throughout the brain with very little spotting about the periphery of the coil and good SNR at the center of the brain. It should be noted that the required transmit adjust voltage was approximately $\sim 30\%$ less than typical for coils of this size and setup. To check the g-factor of the coil acceleration factors of 2 and 4 were applied using an axial fast spin echo T2-weighted protocol. In Figs 4,5 we see that these acceleration factors yield diagnostic quality images. Although some darker spots were evident in some of the images, these may be explained by dielectric susceptibility and is normal at 7.0T field strength. Finally, a sagittal image revealed an FOV which is approximately 160mm long in the S/I direction. Slightly longer than the coil structure itself.

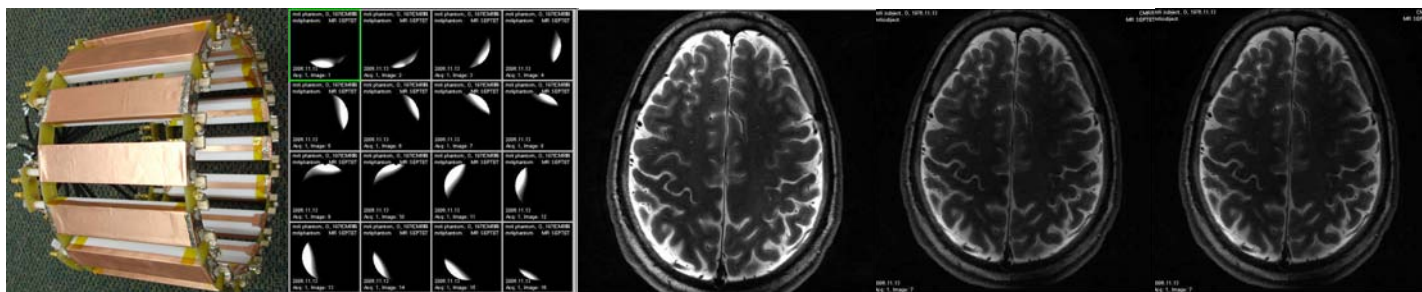


Fig 1: Open T/R Coil

Fig 2: Isolation Images
(2D FLASH)

Fig 3: AX TSE T2 Weight

Fig 4: AX TSE T2 Weight
(Speed Up Factor = 2)

Fig 5: AX TSE T2 Weight
(Speed Up Factor = 4)

Conclusion

These results demonstrate that a transceiver 16-channel array of transmission lines is feasible at 7.0T when constructed with an open (unshielded) elements which allow for much added patient comfort and visual access. It was also shown that the open element structure can be optimized to produce homogeneous B_1 fields and to perform well at high reduction factors, with no significant Eddy Current effects.

References:

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