

Hole-Slotted Phased Array at 7 Tesla

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Introduction

The development of RF coils is always focused towards increasing SNR and optimizing the RF penetration into the sample. Multi channel receiver arrays have been shown to increase the SNR and/or the speed (if combined with parallel imaging) in clinical and animal MRI studies [1]. Array coils for high fields are usually based on simple loops and are mostly used in rat imaging studies [2]. The hole-slot magnetron is a vacuum tube which is useful as a high frequency oscillator in radar applications. Electrically, each slot and hole are equivalent to a tuned resonant circuit [3]. Recently, a MRI surface coil based on the hole-slot magnetron's geometry was introduced [4, 5]. It was shown that this coil exhibits a deeper RF penetration than a conventional coil at 1.5 and 4 Tesla [6, 7]. In this work, four different conventional coil geometries were compared with a hole-slotted coil in order to investigate its performance at 7 Tesla. Furthermore a hole-slotted phased array was built and evaluated.

Methods

1. In a first step different configurations of slotted loop coils and different conventional loop geometries were simulated and evaluated using CST Microwave Studio at 7Tesla. In a second step these coils were constructed and their performance in MRI experiments was tested. Figure 1 shows the schematics of the conventional loop coils and a hole-slotted loop coil with similar geometry.

All loops are aligned on a cylindrical surface parallel to the magnetic field direction. Each loop is tuned and matched to 50 Ω . The loops are actively decoupled by a 300.3 MHz tuned trap circuit including a PIN diode. As a transmitter a Bruker 1H quadrature birdcage coil with a diameter of 72 mm was used.

2. In addition, three and four element phased arrays based on the hole-slotted loop coil element was built in order to investigate its performance at 7 Tesla. The array is 29 mm in inner diameter. Each neighboring element in the array is decoupled using capacitive decoupling.

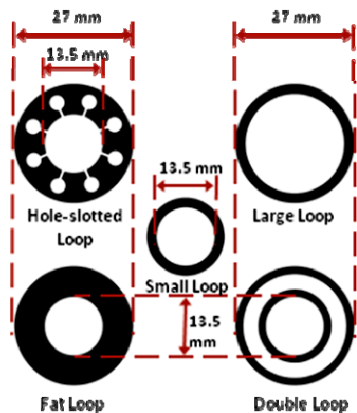


Figure 1. Different loop

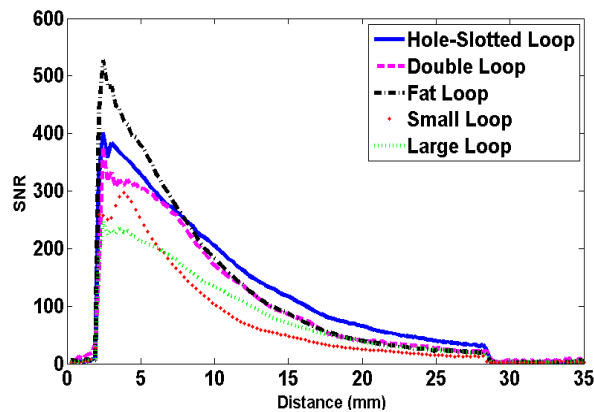


Figure 2. SNR transverse profiles comparison

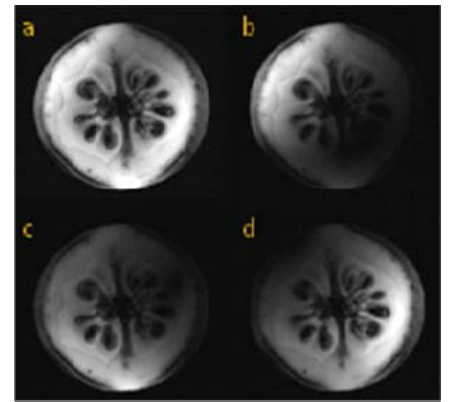


Figure 3. Transverse image of a tomato, a) sum of squares, b, c, d) single coil images

Results

1. The Q-factor drops by approximately a factor of 2 from unloaded to loaded case for all coils. Active decoupling by the traps is -30dB. SNR maps for all loops were calculated from the acquired data and compared. In figure 2, transverse SNR profiles for all loop coils are shown. The hole-slotted loop coil exhibits improved RF penetration compared to conventional loop coils with similar geometry, but shows decreased SNR for small depths.

2. In the array, the isolation between elements is better than -25dB. Figure 3 shows first images of a tomato acquired with a three channel hole-slotted array (sequence parameters: Flash, FOV=32X32 m², TR=400 ms, TE=10 ms, Slice Th. =2 mm, Matrix 256X256). The array shows visually an improved SNR performance in the centre of the object, but a full SNR comparison with conventional arrays is still in progress.

Conclusion/Discussion

1. In the simulation, the hole-slotted loop shows improved RF penetration depth compared to other geometries. The experimental results obtained in phantoms confirmed these findings. The hole-slotted loop shows a significantly improved SNR and RF penetration depth, see figure 2, but exhibits a reduced SNR performance on the surface.

2. The images acquired with the hole-slotted array show high SNR as well as good homogeneity and RF penetration depth. The array also shows good isolation between single elements. In summary, based on the experimental results it can be anticipated, that phased array coils based on hole-slotted coil elements have the potential to improve the performance in the centre of the object at the expense of reduced performance on the surface.

References

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