Novel RF Resonator Using Microstrip at 3T

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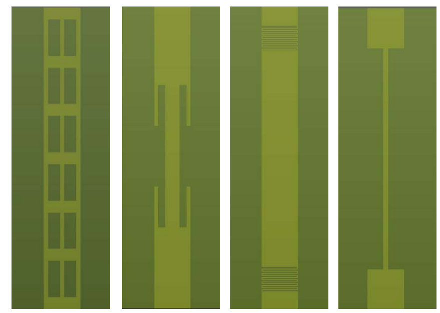
Introduction

Magnetic Resonance Imaging (MRI) systems have good intrinsic SNR (signal-to-noise ratio) and are used an important instrument for diagnosis. Recently, transceive phased array coils using transmission lines in MRI systems have been studied for parallel imaging[1-3], RF shimming[4] and RF homogenization[5]. These coils are composed of several RF resonators that are independently controlled by adjusting the amplitude and phase of the excitation. Microstrip, one of most widely used transmission lines, is used to design a transceive array coil element. The RF resonators using microstrip operate at a Larmor frequency of 128 MHz (3T). In this paper, we introduce four different RF resonators and a slot loaded RF resonator shows better RF efficiencies than other three RF resonators.

Methods

The finite difference time domain method using SEMCAD X[6] was used to calculate B_1^+ field distribution of RF resonators with spherical phantom (ε_r=58.1, σ=0.539 Siemens/m). The diameter of spherical phantom is 20 cm and the distance between spherical phantom and RF resonator is 1.0 cm. Low loss dielectric material Teflon (ε_r=58.1, loss tan.=0.004) was used as a substrate of microstrip with height and length of 2.0 cm and 15 cm, respectively, and microstrip line width is 18 mm. The microstrip line is used as $\lambda/2$ resonator with its ends terminated capacitors. The capacitors are used to reduce the electrical length of $\lambda/2$ and also control the desired Larmor frequency. Four different designs are focused on the variation of the inductive and capacitive components in transmission line. The purpose of the design is to increase B_1^+ value in the center of the phantom by optimizing inductive or capacitive components. The slot loaded RF resonator (Fig. 1a) provides good performance when the each square slot of the width and length is 6 mm and 18 mm, respectively. The Stepped Impedance Resonator (SIR) with four arms (Fig. 1b) alternates the impedance along the line. The width and length of thick alternating line is 18 mm and 40 mm, respectively, and the width and length of thin alternating line is 7 mm and 70 mm. The width and length of each arm is 2 mm and 20 mm, respectively. The meander line loaded RF resonator (Fig. 1c) has two meander lines increasing capacitive components. The SIR (Fig. 1d) widths along the transmission line are 18 mm and 2.6 mm for the alternating impedance. The lengths of thick and thin lines are 20 mm and 110 mm, respectively. To validate the effect of the multichannel RF resonators, the B_1^+ map generated by an eight channel RF resonator. Each RF resonator is placed at any angular position because the phantom is symmetrically spherical. By rotating 45° phase to each RF resonator and using the superposition principle, the B_1^+ map of an eight channel phased RF resonator except for coupling problems between phased RF resonators was calculated in the center of the phantom.



(a) (b) (c) (d)

Fig. 1. the RF resonator geometries. (a) slot loaded (b) SIR with four arm (c) meander line loaded (d) SIR

Results

Fig. 2 shows the B_1^+ value of four different RF resonators in the central transaxial slice of the phantom. When the B_1^+ value was calculated, the input power of four different RF resonators is normalized to the same input power (1 Watt). The slot loaded RF resonator had a peak B_1^+ value of 0.224 µT whereas the SIR with four arms had a peak B_1^+ value of 0.216 µT. The meander line loaded RF resonator had a peak B_1^+ value of 0.218 µT, and the Stepped Impedance Resonator had a peak B_1^+ of 0.204 µT. Fig. 3 illustrates the central transaxial B_1^+ map of the slot loaded RF resonator with different phases and 8-ch combined, and Fig. 3 (i) can be optimized after varying the input power parameters.

Conclusion

Four different RF resonators for transceive array coils were proposed and compared at 3 T MRI systems. The slot loaded RF resonator with inductive components provides the highest B_1^+ peak value in the center of the phantom compared with other three RF resonators. RF shimming and homogenization can be effectively controlled after obtaining higher B_1^+ peak value near the center of the phantom. The slot loaded RF resonator having the highest B_1^+ peak value can be a good candidate for 3 T multichannel MRI systems.

References

[1] Gregor Adriany et al., MRM, 53:434-445, 2005 [2] Can Eyup Akgun et al., IMS, 1425-1428, 2009 [3] P-F Van de Moortele et al., MRM, 54:1503-1518, 2005

[4] G. J. Metzger et al., MRM 59:396-409, 2008 [5] Hyoungsuk Yoo et al., ISMRM 2011 [6] SEMCAD X by SPEAG, www.speag.com

Acknowledgements

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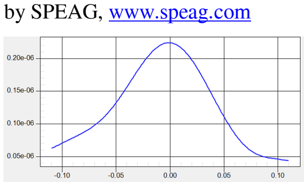
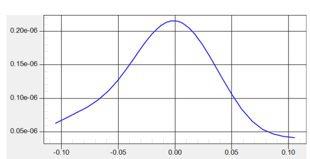
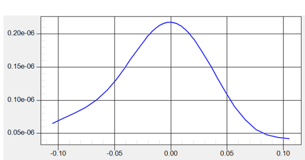


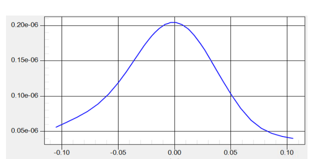
(a)



(b)

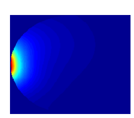


(c)

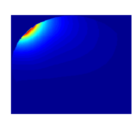


(d)

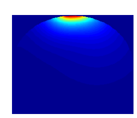
Fig. 2. B_1^+ value in the central transaxial slice of the phantom (a) slot loaded (b) SIR with four arms (c) meander line loaded (d) SIR



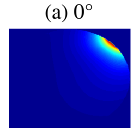
(a) 0°



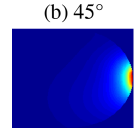
(b) 45°



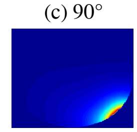
(c) 90°



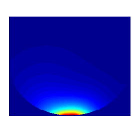
(d) 135°



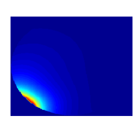
(e) 180°



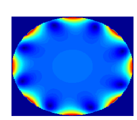
(f) 225°



(g) 270°



(h) 315°



(i) 8-ch

Fig. 3. phantom transaxial B_1^+ map of slot loaded RF resonator with different phase (a)~(h) and (i) 8-ch RF resonator