Microstrip Loop Array (MLA) for Parallel Imaging

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Introduction

It has been recognized that coil array geometry plays a crucial role in performance of parallel imaging. Conventional loop surface coil arrays have well localized and orthogonal sensitivity profiles which are suitable for parallel imaging [1] but their performances suffer from strong mutual coupling among elements. Recently an intrinsically decoupled coil design, planar strip array (PSA) [2, 3] was introduced, but this linear structure can not provide as high sensitivity as loop coil in its local area, and consequently has poorer SNR and RF penetration. In this work an improved version of planar strip array, named microstrip loop array (MLA), is presented. This novel design takes advantage of the microstrip characteristic which can inherently minimize mutual coupling, and a loop geometry which can provide well-localized sensitivity profile. In addition, compared with PSA, MLA allows capacitive fine tuning and matching which makes it much easier to fabricate.

Method

The structure of a two-element MLA is shown in Fig. 1. Basically MLA employs a microstrip structure except that the strip forms a loop. The strip length is less than half wave-length. The small capacitors C_T are used to compensate the strip length for fine tuning, and C_M serve as matching capacitors. It has been well recognized that planar strip coil are intrinsically well decoupled. For microstrip loop coils, the broad-band decoupling characteristic is still effective. Quantitive analysis shows that when $s/h>5$ (s denotes distance between coil elements, h denotes the thickness of substrate), S_{21} is less than –20 dB. To verify this, two microstrip loop coils of the same size (75×80mm) with Teflon ($\varepsilon_r = 2.1$, thickness = 8mm) substrate were built and the decoupling performance was tested in terms of S_{21} measurement.

In order to investigate the performance of MLA, the magnetic field of a microstrip loop coil was simulated using Finite Difference Time Domain (FDTD) method. To demonstrate the benefit of this improved design, a 4-element MLA (shown in Fig. 4) was designed for cardiac application, and cardiac imaging was performed using an ECG triggered, TrueFISP sequence (matrix = 256×135) with breath-holding at 1.5T. SENSE reconstruction was carried out with 2-fold acceleration.

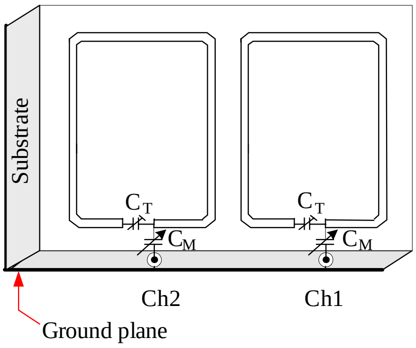

Fig. 1 Structure of a 2-element MLA

Results

The S_{21} measurement results presented in Fig.2 well confirm our decoupling prediction of MLA. The curve shows that S_{21} is 10-20dB less compared with conventional loop coils at the same distance. Note that for the conventional surface coils, when the distance of the pair reduces to 5cm, S_{21} decreases again. This is because a frequency split occurs at that distance, indicating a strong mutual interference. While for the microstrip loop pair, no frequency split is observed at all distance.

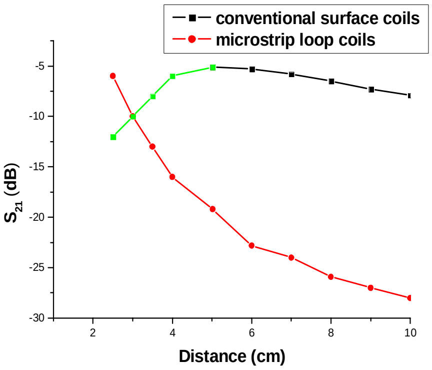

Fig. 2 S_{21} measurement of two coils side by side: (1) conventional surface coils; (2) microstrip loop coils

The simulated B1 field of a microstrip loop coil is shown in Fig. 3. It is obvious that unlike strip line coil, the microstrip loop coil has a well localized sensitivity profile. As such, MLA has more orthogonal sensitivity profiles than PSA and consequently is more suitable for parallel imaging.

Fig. 5 shows a transverse cardiac image acquired by the 4-element MLA sketched in Fig. 4 with 2-fold SENSE.

Conclusion

The microstrip loop array is proposed for parallel imaging. Without much loss of the well-decoupling benefit of a strip line array, the proposed microstrip loop arrays have well-localized sensitivity profiles which are more suitable for parallel imaging and result in high SNR. Furthermore, MLA allows capacitive fine tuning and matching which makes it much easier to fabricate. Simulation and experiment results show that the MLA has well-localized sensitivity profiles due to the loop geometries, while the mutual coupling is 10-20dB less than conventional surface coil arrays. A sensitivity-encoded cardiac imaging was performed to demonstrate the suitability of MLA for parallel imaging.

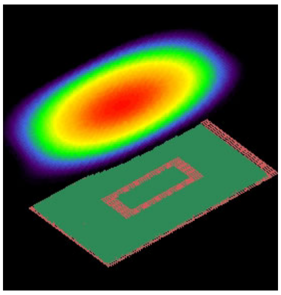

Fig. 3 simulated B1 field of a microstrip loop coil

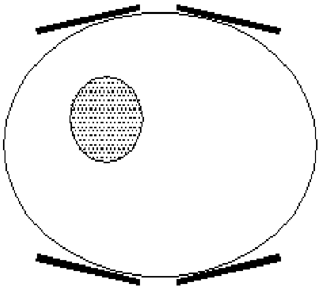

Fig. 4 A 4-element MLA for cardiac application

Fig. 5 A transverse cardiac image acquired with a 4-channel MLA

Acknowledgement

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References

[1]Bankson JA, Wright SM, MRM 47: 777-786 (2002)
[2]Lee RF, et al. MRM 45: 673-683 (2001)
[3]Kumar A, Bottomley PA, Proc. ISMRM 10, p. 57 (2002).