Design and numerical evaluation of an 8-element quadrature transceiver array using single-feed CP patch antenna for parallel reception and excitation

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Introduction: It has been demonstrated that a single-feed transceiver patch coil is able to generate a circularly polarized (CP) magnetic field, which can improve the MR sensitivity by 40% and reduce the excitation power by half compared with linear coils [1]. This single-feed quadrature patch coil has a simple structure similar to a conventional linear surface coil, which can be easily used for building quadrature transceiver arrays for both parallel imaging and parallel transmission. In this work, an 8-element quadrature transceiver planar patch array is designed and modeled at 298 MHz. Its feasibility is demonstrated and evaluated using FDTD simulation.

Material and method: The structure of 8-element quadrature patch array is shown in Figure 1. Each element was built as a nearly square ring microstrip patch antenna [2] using copper tape. The outer dimension of the ring was 12.2 cm by 12 cm, while the square slot cut was with side length of 4.4 cm. This square cutting was used to increase the path length of the surface current so as to reduce the resonant frequency to 298 MHz. The coaxial feed port (blue points in Figure 1) was along the diagonal and very close to the square slot. The 8 patch elements were equispaced distributed on the substrate and the distance between the neighboring elements was 4 cm. The ground was built by adhering a single copper sheet to the bottom of the substrate which was a piece of TMM 13I material with permittivity of 13.1. The XFDTD 6.4 (Remcom Inc.) was used to model this 8-element quadrature patch array, calculate the reflection and transmission parameters between port 1 and the other 7 ports; (c) simulated S11 of a single patch coil (non-array).

Results: The simulated S11 and the transmission parameters S21 to S81 are plotted in Figure 2. At 298 MHz the S11 is -8dB and the S21 to S81 are all better than -35dB. Also, the S11 of a single patch coil is -7 T, which is 7% of the field strength at 36cm above array surface. The blue points denote the square slot. The 8 patch elements were equispaced distributed on the substrate and the distance between the neighboring elements was 4 cm. The ground was built by adhering a single copper sheet to the bottom of the substrate which was a piece of TMM 13I material with permittivity of 13.1. The XFDTD 6.4 (Remcom Inc.) was used to model this 8-element quadrature patch array, calculate the reflection and transmission parameters and evaluate the magnetic field distribution.

Conclusion and discussion: In this work, a novel design of quadrature planar array has been proposed using the nearly square ring microstrip patch antenna technique. Compared with the conventional quadrature coil, the structure of patch coil is simple and easy to be built as coil array. From the FDTD simulation results it can be seen that the penetration of patch coil is not worse than traditional loop coil. This quadrature array design is advantageous for parallel imaging because it can not only accelerate the imaging but also improve the SNR by 40% and reduce the RF excitation power during transmission. In practical design, the ring size and the position of the feed point need to be chosen carefully, because the ring size determines the resonant frequency while the feed point is related to the match impedance.


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