A 16-channel micro strip Tx/Rx array for bilateral breast imaging at 7 Tesla

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Introduction

Breast imaging at 7 T is promising due to the higher SNR in comparison to 1.5 and 3 T, but at the same time it is challenging due to the short wavelength and the lack of a body coil for transmission. First studies [1,2,3] have demonstrated the feasibility of 7 T breast MRI, though often providing only unilateral coverage [1,2]. In this work we present a 16-channel transmit/receive micro strip line array for bilateral breast MRI at 7 Tesla.

Material and Methods

The array consists of two U-shaped 8-channel arrays similar to the 8-channel ankle array presented in [4]. Each U (Fig. 1a) consists of 6 inverted micro stripline modules with a width of 5 cm and 2 modules with 3 cm width at the ends. The strip length is 15 cm and its width is 7.5 mm. The distance from strip to ground plane is 9 mm. The opening of the U has a width of 15 cm.

Figure 1b shows an electrical schematic of the array. Each strip element has an end-capacitor C_e = 6.8 pF. The matching network consists of a parallel capacitor C_p = 2.5-12 pF and a series capacitor C_s = 0.7-2 pF. To optimize decoupling, the end of each strip is connected to the nearest and next nearest neighbors within the same U. The connection to the nearest neighboring elements is realized with a coupling capacitor C_{c1} = 0.7 pF. The connection to the next nearest neighbors is accomplished with a second coupling capacitor C_{c2} = 1.0 pF interconnected with 100 mm of semi rigid coaxial cable necessary to bridge the distance. The two elements where the open ends of the two U arrays are adjacent below the sternum are directly interconnected with a capacitor C_{c1}. The ground planes of all elements are interconnected with capacitors C_g = 1000 pF.

The two U-shaped parts are fitted into a PMMA (Plexiglas) housing as seen in Figure 1c. The width at the sternum is 4 cm, and the opening for each breast has a width of 13.5 cm, a length of 18 cm and a depth of 13.5 cm to allow accommodation of large breasts. For patient comfort a foam cushion of 3 cm thickness with two D-shaped holes was placed on top of the array.

The pre-amplifiers and TR switches are located in a separate multi-purpose box about 40 cm away at the head of the patient table.

Imaging experiments were performed on a Magnetom 7T MRI system (Siemens Healthcare Sector, Erlangen, Germany) equipped with a custom 8-channel shimming system. To drive the 16-channel array with the 8-channel system, 8 Wilkinson power splitters were used to drive both halves of the array simultaneously. For the initial experiments, phase increments between neighboring channels of both 22.5° and 45° were used.

The first imaging experiment was conducted on a female volunteer in accordance with the rules of the local ethics committee. Amongst other sequences, 2D FLASH sequences with fat saturation were used with TR = 36/18 ms, TE = 3.19/2.14 ms and an isotropic in-plane resolution of 0.44/1 mm and a slice thickness of 3 mm. The TIAMO imaging method [5] was applied with the two sets of phase increments for increased homogeneity. The acquisition was accelerated by a factor of 2/8 in the A-P direction.

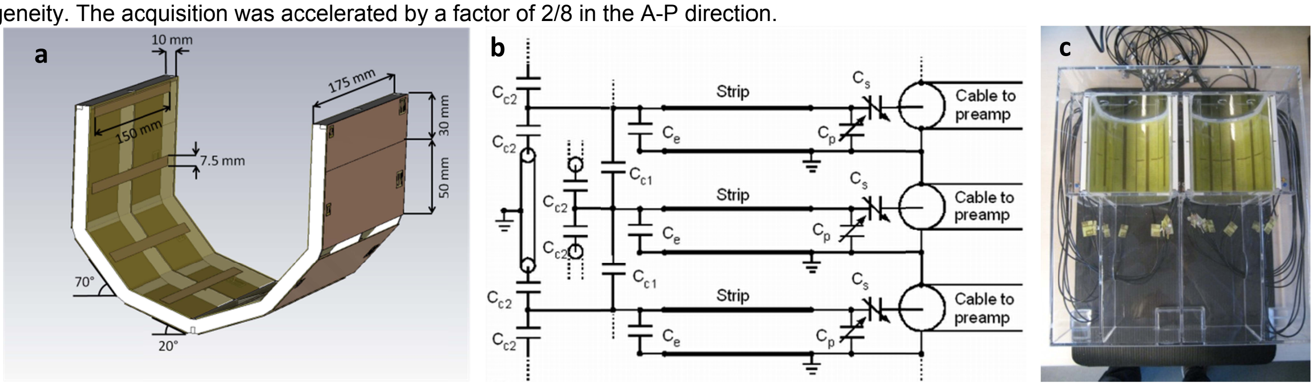

Figure 1: a) Mechanical layout of one half of the array. b) Electrical schematic of 3 out of 16 elements. c) Assembled array with housing.

Results and Discussion

The reflection factor at the inputs of all elements loaded with a volunteer was well below S_{ii} < -15 dB, while the coupling between all elements was below Sij < -15 dB.

After a 40 minute test run with a human volunteer, the array was reported to be fairly comfortable.

Figure 2a and b show slices from the 2D FLASH sequence acquired with an acceleration factor of 2 and 8, respectively. As expected from earlier results with a similar layout [4], high resolution/high acceleration factors are feasible. The fat saturation worked well within the field of view.

Figure 2c shows the noise correlation matrix with a maximum value of 0.25 and a mean value for neighboring elements of 0.1.

In a next step, a segmented body model is to be assembled from acquired 3D data for more precise SAR simulations.

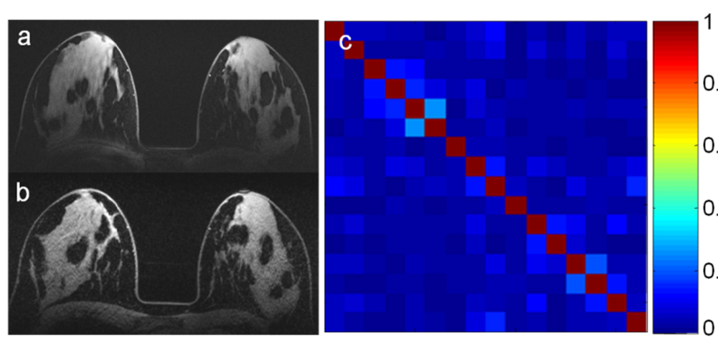

Figure 2: a+b) 2D FLASH images with fat sat. The image b) was acquired with 8-fold GRAPPA acceleration in A-P direction. c) shows the noise correlation matrix of the array with a maximum value of 0.25.

References

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