Development of Cross-pole RF Tx array for Breast imaging at 7T

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Introduction: Despite the advantage of high SNR, developing the RF arrays for high field MRI, presents significant technical and physical difficulties due to B1 field inhomogeneity and high SAR. Such issues arise due to shorter in-tissue wavelength and destructive/constructive electromagnetic field interference. B1 shimming has observed as a technique that can alleviate many of these problems by adjusting the phases and the amplitudes of the RF array excitation ports [1, 2]. In this study, we have developed a two-sided RF resonator based on 8-channel Tx Tic-Tack-Toe (TTT) design [3] for breast MR imaging at 7T. To evaluate the performance of the RF array, full wave simulation using FDTD (finite difference time domain) method was performed with a breast model [4] and compared with experimental outcomes. The array was constructed and tested with breast phantom (Supertech, IN) and in-vivo volunteers.

Materials and Methods: For the simulation, coil geometry was created, and customized FDTD code was applied on 3D breast model (iso-2.5mm^3) to calculate the B1 field distribution (**Fig. 1a**). A 3D grid with spatial resolution of 1/16(inch) and temporal resolution of $3*10^{-12}$(sec.) was used to meet the stability condition (Total iterations = 200000). **Fig. 2a-b** displays the FDTD calculated tuning and coupling of 1 side of the array. A TTT RF array consisting of two-sided 2 x 2 cross-pole antennas (6.75 in^2) aligned in the x-y was constructed based on the simulation. Fine-tuning was numerically evaluated and manually adjusted at the 7T resonant frequency (**Fig. 2**). Breast phantom consists of 50% glandular and 50% adipose tissue was used (**Fig. 1b**) to measure the B1 map. All scans were performed on a 7T scanner (Siemens Medical Solutions, Erlangen, Germany) and two healthy subjects were enrolled in this IRB approved study. GRE-sequence with variable flip angle (12 steps) was used to measure the B1 map in breast phantom and compared with the simulation (**Fig. 3a-b**). Fine morphologic details of the breast tissue were depicted on MR images acquired using 3D-DESS (dual-echo steady state) sequence (**Fig. 3c**).

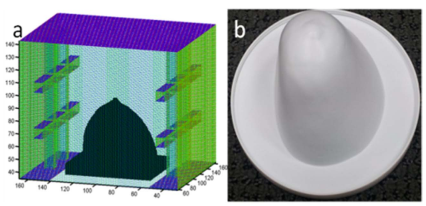

Figure 1. a) Geometry of TTT coil with the breast model which were used to evaluate the B1 field distribution. b) Breast phantom composed of 50% glandular and adipose property (height x width x length = 9 x 10 x 12 cm.).

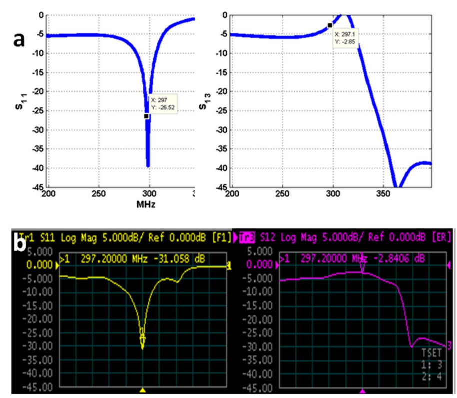

Figure 2. Reflection (S11) and transmission (S12) coefficient of the excitation calculated in a) simulation and measured in b) experiment.

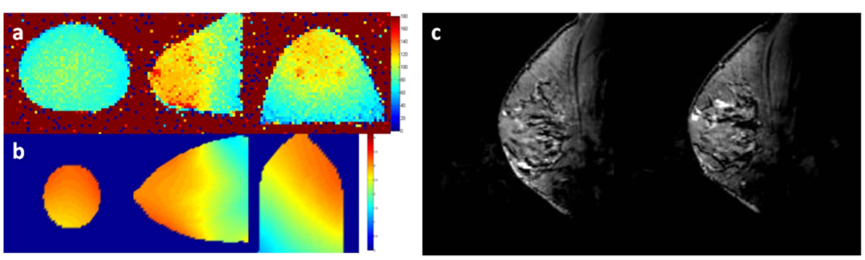

Figure 3. B1 map of a) breast phantom (degree/100V), b) simulation (unit is arbitrary) and c) 3D–DESS breast MR images of two normal volunteers in the sagittal plane.

Results and discussions: B1 maps acquired from the breast phantom were comparable to that obtained with simulations. The results show homogenous (>78%) and efficient B1 field can be achieved in this 8 channel configuration utilizing 4-port quadrature (one side) and anti-quadrature (opposite side) excitations.

References: [1] Ibrahim TS et al, Magnetic Resonance Imaging, Vol. 19, 1339-1347, 2001. [2] Hoult DI et al, J Magn Reson Imaging 12:46-67, 2000. [3] Ibrahim TS et al. Proc. Intl. Soc. Mag. Reson. Med. 16, 2008. [4] Mashal A et al, Microwave and Optical Technology Letters, Vol. 53, 1896-1902, 2011.

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