A 7T "Capless" Transceive Breast Coil

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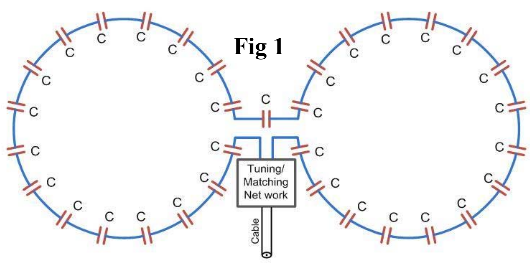
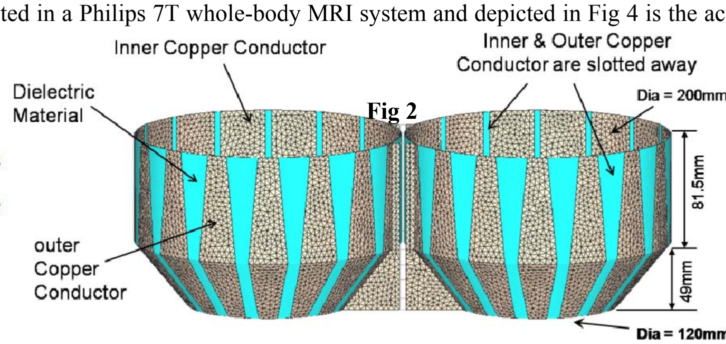
Introduction

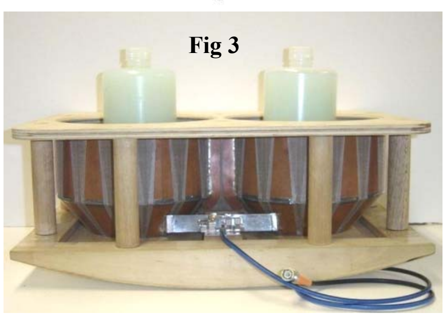
Apart from being a non-invasive imaging modality, MR breast imaging can also provide high spatial and temporal resolution images of the breast, which is advantageous for fast and accurate diagnosis of disease. Studies have shown that it is possible to acquire high resolution breast images at ultra high fields with dedicated transceive RF breast coils that can transmit homogenous local B_1 field and receive high *SNR* MR signals [1-3]. However, some of these breast coils have limitations in their functionalities in that they are either unilateral, have limited RF penetration into the chest wall or require addition splitter/hybrid combiner units to drive a bilateral breast coil. This work presents a new method for designing a ultra high field bilateral transceive breast coil. The design method does not require any discrete capacitors (hence the name "Capless Transceive Breast Coil") and can be driven by a single RF port for simultaneous bilateral breast imaging. A prototype breast coil using this design method was constructed and tested in a 7T Philips whole-body MRI system. Phantom images acquired using the prototype show high homogeneity and excellent RF penetration.

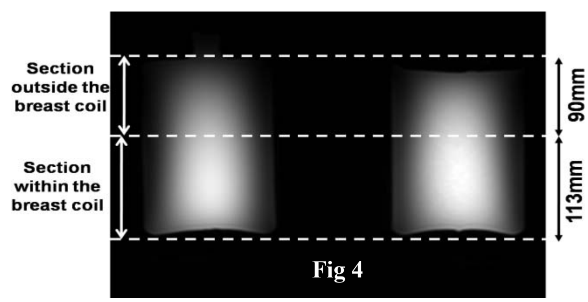
Methods and Results

Depicted in Fig.1 is the schematic diagram of the single-port bilateral transceive breast coil, which has a figure of eight like shape. As the breast coil is electrically large, a conventional design approach would require a large amount of high-power small-valued fixed capacitors to resonate it at 298MHz (7T). Unfortunately, using small-valued capacitors introduces high local field distortions that are undesirable. In addition, the design becomes cost inefficient when large amount of high power capacitors is employed. The best solution to overcome these shortcomings is not to use any discrete capacitors. The question is then how can we resonate the coil at 298MHz. To solve this problem, we have taken advantage of the self-capacitance of a double-sided printed circuit board (PCB). By knowing the thickness and permittivity of the dielectric material, it is possible to machine pre-defined slots on both sides of the conducting copper sheets to create the required capacitance value that will substitute the actual physical distributed capacitors. In addition, by using such a design method, the capacitance and inductance of the coil are homogenously distributed and high local field regions due to the lumped elements are avoided. A MoM/FEM based EM software package (FEKO) is used to confirm the feasibility of the design method and to determine the size and shape of the conducting coppers on the double sided PCB, which will form the coil. Shown in the Fig 2 is the designed breast coil. The upper section of the breast coil consists of a regular cylindrical structure, while the lower section has a cone shaped structure. The rational in using this combined structure is to increase *SNR* by matching the coil's imaging volume to the shape of a human breast, while at the same time increasing the RF penetration depth towards the chest wall and auxiliary regions. Shown in Fig.3 is the constructed prototype bilateral capless transceive breast coil loaded with two homogenous cylindrical phantoms. Under loaded condition, the breast coil is tuned to 298MHz and matched to 50Ω. The breast coil is tested in a Philips 7T whole-body MRI system and depicted in Fig 4 is the acquired MR image of the two cylindrical phantoms.









Discussions and Conclusion

In the MR image of Fig 4, it can be observed that portion of the phantoms situated within the imaging volume of the breast coil, display high homogeneity. In addition, since the breast coil is designed to have its capacitance and inductance homogenously distributed, no local high field spots were generated. Furthermore, the dielectric resonance effect that is usually visible at high field is not that apparent. We also note that portion of the phantoms that is situated outside the breast coil can still be imaged. This is an indication that the prototype breast coil has a high RF penetration depth and therefore will be able to image regions beyond the chest wall. In conclusion, the proposed method for designing the ultra high field transceive breast coil is shown to be feasible. It can offer several advantages and is cost effective. The proposed method is not restricted to breast coils but can also be used or incorporated into the designing of other RF coil types.

References [1] Hornak J.P. *et al Mag. Reson. Imag.,* pp.233, 1987. [2] Lee R.F. *et al. ISMRM* pp 2900, 2006. [3] Warmington.L.L.*et al*. *ISMRM* pp 3006, 2009.