Design of a Coil System for Hyperpolarized 3He Human Lung Imaging

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Introduction:

Clinic hyperpolarized ^{3}He gas human lung imaging has been widely conducted in recent years. Multi-channel coil designed for human lung parallel imaging has been reported [1] to accelerate the imaging speed. Large asymmetric birdcage coil were also developed to replace the single loop coil for better B_1 homogeneity [2]. This work presents a design of a coil system for hyperpolarized ^{3}He gas human lung imaging that consists of a large asymmetric quadrature birdcage transmit coil and a receive coil array. The birdcage transmit coil occupies nearly the entire scanner bore for maximum patient comfort.

Methods:

The non-circular asymmetric profile coil was designed using the conformal transformation [3,4]. The circular coordinates z=r*exp(-iϕ) was transformed into a non-circular profile, w=f(z), while still maintaining the homogeneity of the B_1 field inside the coil volume. The overall dimension of the designed coil is W=58cm, H=43cm and L=65cm in order to fill the bore volume and cover the upper airway (the throat) and entire lung. The birdcage coil was designed as a 16-rung high pass coil (figure 1a). The open and unshield transmit coil provides ability of proton anatomy scanning without petiant movement. The end-ring frame structure is designed to split into top and bottom parts for easy patient access.

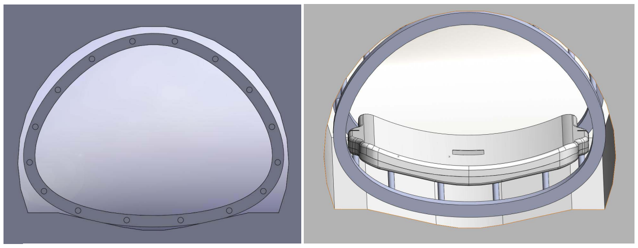

Figure 1, a) Left: transmit coil profile in scanner bore.

To determine the capacitor value on the end-ring, the inductance and mutual inductance of each segment was calculated with empirical formula [5] with the consideration of the MRI scanner body coil RF shield and image current (figure 2a) [6]. The inductance and mutual inductance was also calculated by modeling with HFSS (Ansoft) (figure 2b) as well as to measure on the actual coil frame [7]. Then, the capacitor value on each end-ring was calculated with the formalism in reference [8] at main mode frequency with the circular current vector. A preliminary B_1 field modeling of the transmit coil is shown in figure 2c. The transmit coil was also designed to be operated in transmit/reciev mode to obtain MR images without the receive coil array.

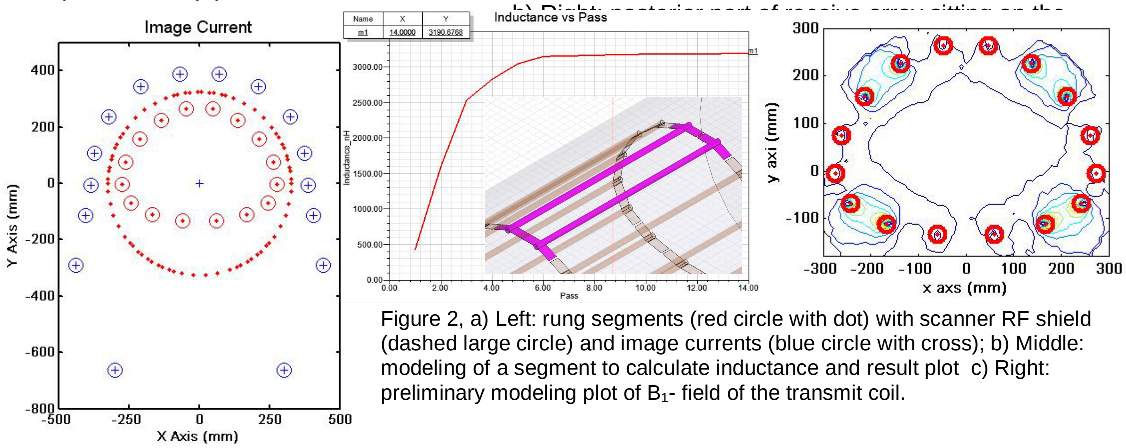

Figure 2, a) Left: rung segments (red circle with dot) with scanner RF shield (dashed large circle) and image currents (blue circle with cross); b) Middle: modeling of a segment to calculate inductance and result plot c) Right: preliminary modeling plot of B_1- field of the transmit coil.

The receiving coil array was designed to build based on an 8-channel proton cardiac coil array (GEHC) in order to avoid mechanic works and to ensure patient safety because this clinic coil array was designed with careful consideration of patient safety. The posterior part of the receive array sits on the birdcage transmit coil (figure 1b) and the flexible anterior part of the receive array will follow the patient's chest with Welco fastener during image scanning. The rebuilding process consists of retuning of each coil loop, on-loop decoupling circuits, on-coil pre-amplifiers, baluns and adding IRF (figure 3). All process follows the coil manufacturing test specifications.

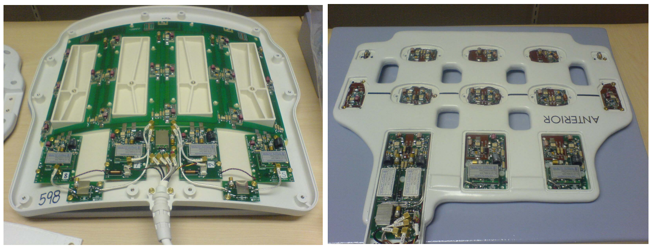

Figure 3. Receive array. Left. posterior part. right: anterior part.

Discussion and Conclusion:

This coil system combines a large transmit coil that can deliever high power and homogenous B_1 field and a receive coil array with parallel imaging possibility for hyperpolarized ^{3}He human lung imaging. The open structure provides proton anatomy reference imaging ability. It demonstrate an approach to the desired non-proton human body MR imaging device.

References:

[1] RF. Lee, ISMRM (2008); [2] N De Zanche et al., ISMRM (2008); [3] MC. Leifer, MRM 38:726-732 (1997); [4] N De Zanche et al., MRM 53:201-211 (2005); [5] F. Grover, "Inductance Calculation", Dover, New York (1962); [6] D. Lu et al., MRM 19:180-185 (1991); [7] J. Tropp, JMR, 126:9-17 (1997); [8] MC. Leifer, JMR 124:51-60 (1997)