A 14.1 Tesla Animal Coil Design for homogenous and focused RF excitation

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INTROCUCTION

In-vivo large animal MRI is now reaching field strengths of 11.1 tesla [1] and 14.1 tesla [2]. At such field strengths even for medium and large animal studies, there are RF inhomogeneities that can be compared to current ultra high field human systems [3-4]. In this work, we present a theoretical design using full wave electromagnetic modeling of a high-Q RF coil for medium/large-sized animal imaging that is capable of producing highly 1) homogenous and 2) focused RF excitation at 14.1 tesla (600 MHz). The design is based on transverse electromagnetic (TEM) distributed circuit concepts [5].

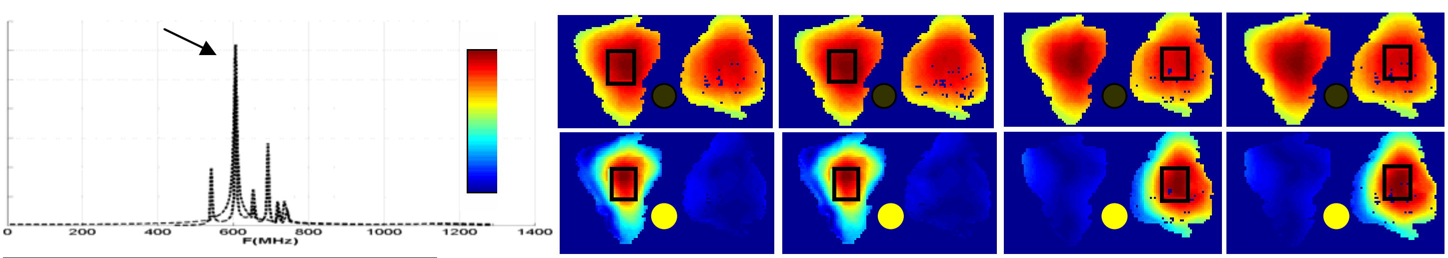
METHODS

The geometry of the RF Coil was custom designed to fit two large rats side by side (in this work, anatomically detailed rate models were obtained from Brooks Air force Base, www.brooks.af.mil/AFRL/HED/hedr and were utilized in the numerical studies.) The coil geometry consists of 12 co-axial elements (struts). The cores of the co-axial elements are the inner struts (rods), and the outer shields of the rods (outer struts) with a Teflon dielectric filling between the inner and outer struts. The gap between the halves of the inner struts is adjusted in order to tune the RF coil to the frequency of interest. The coil was closed from both ends with copper plates. A finite difference time domain (FDTD) model was developed for such coil where the tuning elements were adjusted to tune the coil's linear mode to 600 MHz (as shown in Figure 1: left.) The upper frequency limit for the chosen coil geometry was found to be near 800 MHz for the same mode.

RESULTS AND DISSCUSSION

The Q of the 2-rat phantom loaded coil (simultaneously present as shown in Figure 1) was calculated numerically using the FDTD method and was found to be 190. Figure 1 displays axial, coronal, and sagittal slices of the coil driven in a single port (first and third row) and in 12-ports (second and fourth rows). The single-port study shows good excite field homogeneity (15% as denoted by the standard deviation of the excite fields) over the volume of both rat phantoms. The 12-port drive was targeted for a focused RF field excitation individually on a 3-D volume inclusive of each of the rats' hearts. The ratio of excite field in the region of interest (one of the rats' hearts) over elsewhere in both of rats was maximized by varying the weights (amplitudes and phase shifts) of the drive ports. Figure 1 demonstrates that very good RF field focusing can be selectively chosen in different volumes of both rat phantoms while suppressing the excite fields in the non-chosen regions in both phantoms. This suppression is on the order of 15 times in the non-selected rat phantom (as demonstrated in Figure 1.) The results also show that using 12-port excitation, the ratio of the excite field in the region of interest (one heart in one rate phantom) over elsewhere in both rat phantoms can increase by factors of 3-4 compared to the single-port excitation.

The presented excitation approach combined with RF tailored pulses show excellent promise for dual/selected rat studies at 14.1 tesla.



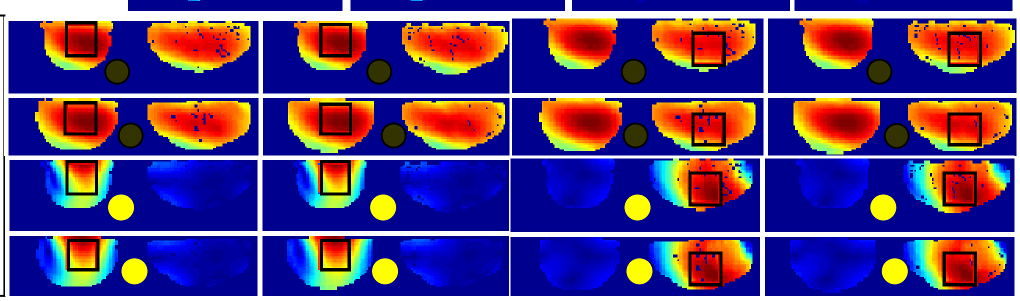


Fig1. ***Top:*** Spectrum of the 12-port animal coil tuned to 600 MHz (14.1 tesla). ***Right:*** MRI excite field distributions though out the two rat models loaded in the coil under both quadrature (•) and RF localized (•) excitations. □ represents the rats' heart regions in which 3-D RF localized excitation were performed to focus the MRI excite field in each heart individually.

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