A 4-element array of volume coils for accelerated dynammic contrast-enhanced tissue modeling

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Introduction

Small animal models of human disease play an increasingly important role in the basic sciences and in the preclinical evaluation of experimental therapies. Non-invasive, imaging-based characterization of these models simultaneously increases the breadth of knowledge gained and reduces the number of animals required to achieve statistically significant results. Unfortunately, there is a high cost associated with the use of such imaging instrumentation, and methods that improve throughput without sacrificing image quality or resolution are highly desirable.

Recently, investigators have demonstrated the simultaneous imaging of multiple animals using an array of independent birdcage coils [1-3], typically used for phenotyping genetically modified mice. Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) experiments are a crucial tool for the characterization of tumor response to experimental cancer therapies. We wish to use an array of volume coils to improve throughput and reduce the price barrier for investigations requiring DCE-MRI and pharmacokinetic modeling of tumor tissue.

Methods

We have implemented a four-element array of independent, linear, birdcage-style resonators for use on a four-channel 4.7T Biospec MRI scanner (Bruker Biospin, Billerica, MA). Coil conductor paths were etched on flexible circuit substrate and wrapped around a quartz bore with 27.5 mm I.D., which is just sizeable enough to accommodate large mice and the various tubing and devices required for anesthesia, injections, and physiological maintenance. Because DCE-MRI requires rapid image acquisition rates, this array was designed for use with B-GA12 actively shielded gradients, which provide a free bore with 120mm diameter, a maximum gradient strength of 400 mT/m, and a rise time of 150μs. Each element of this array is seated and centered within one shielded quadrant of the housing cylinder.

This system is equipped with a single transmit chain. Transmit power is split among the four elements, and manual attenuators can be used to further optimize excitation power if coils are not equally loaded. Four actively controlled T/R switches are used to isolate receiver circuitry during transmit. Commercial low-noise preamplifiers (Advanced Receiver Research, Burlington, CT) that can be located in close proximity to T/R switches and coils provide a noise figure of 0.5dB with an overall gain of approximately 21dB.

Results & Discussion

Several shielding configurations were evaluated with an initial goal of 25dB isolation between adjacent elements due to their close proximity. Coupling along coaxial cables was severe but easily attenuated with baluns. Bench measurements on the final design indicate better than 50dB of isolation between elements.

Preliminary imaging results support bench measurements and indicate that ghosting due to coupling between elements will not likely be a problem. In phantoms, slight RF inhomogeneities across the regions of interest are obvious, as shown in Figure 1, but not surprising due to the asymmetric shielding configuration. We do not expect for this to complicate DCE-MRI experiments. We are currently evaluating and revising our protocols and animal handling devices and procedures in order to conduct DCE-MRI experiments as efficiently as possible.

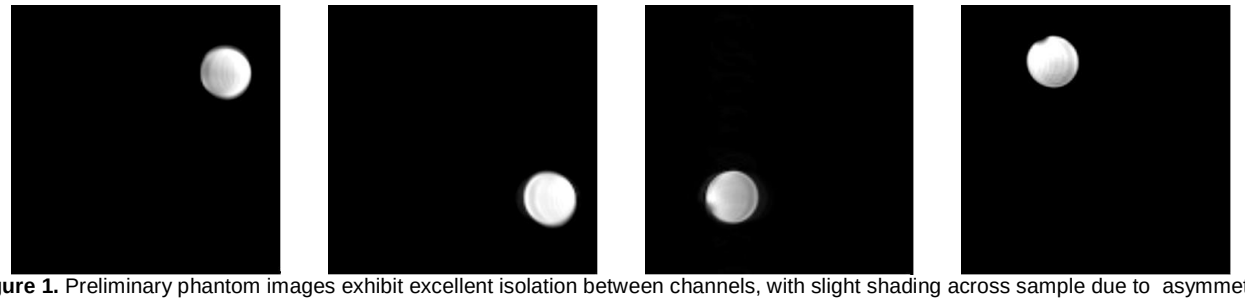

Figure 1. Preliminary phantom images exhibit excellent isolation between channels, with slight shading across sample due to asymmetric shielding.

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References

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