A Dual-Tuned Two-Element Array for ^{1}H/^{2}H Imaging at 1 Tesla

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TARGET AUDIENCE: Researchers interested in dual-tuned coils, coil arrays, and proton/deuterium imaging in MRI systems.

PURPOSE: Deuterium has shown great utility in magnetic resonance imaging and spectroscopy. A subset of uses includes monitoring of glucose [1], tracking bolus diffusion [2], and providing a signal lock [3]. The eventual goal of our work is to develop a system capable of simultaneous proton and deuterium imaging with a phased array system at 1T, similar to a recent study using ^{1}H and ^{23}Na with two trapped elements in an array was performed at 4T [4]. This work reports a dual-tuned, two element array of loops for ^{1}H and ^{2}H. Preliminary results using a distilled water/deuterium oxide phantom are presented.

METHODS: A 1.0T ONI OrthOne magnet, with an 18 cm horizontal bore and axial field, was used for imaging. All coils were cylindrical and concentric with the magnet bore. The outer transmit coil, comprised of two saddle coils (one for proton and one for deuterium), was constructed on an acrylic former of diameter 5.75 inches. The inner receive coil, comprised of two geometrically decoupled [5] dual-tuned elements, was constructed on a separate acrylic former of diameter 3.75 inches. The signal path on each loop was split; one end was connected to a tank circuit for ^{1}H and the other into a tank circuit for ^{2}H. Each of the four ports was independently matched and tuned. Passive detuning was accomplished with crossed diodes. A cylindrical phantom containing six test tubes of diameter 1 cm with distilled water and deuterium oxide in various ratios surrounding a larger container of diameter 2 inches of equally mixed distilled water and deuterium oxide was constructed and placed in the receive coil. The discrete parts of the phantom and their respective solution concentrations are shown in Figure 1. An in-house developed system was used for signal generation and acquisition. A spin echo sequence for proton was used to obtain an image from each element, followed by a spin echo sequence for deuterium. A prototype console was used to acquire the images. Proton spin echo: TR = 5 s, TE = 30 ms, Slice Thickness = 1 cm, FOV = 120 mm x 120 mm, Matrix = 256 x 128, 50 kHz spectral width, 6 ms sinc pulses. Deuterium spin echo: TR = 5 s, TE = 40 ms, Slice Thickness = 10 cm, FOV = 120 mm x 120 mm, Matrix = 64 x 64, 8 kHz spectral width, 8 ms sinc pulses.

RESULTS: Images were obtained for each element at each frequency, for a total of four images shown in Figure 2-5. Several artifacts are present in the images. Vial 1 does not provide the greatest ^{1}H signal in Figure 2-3 as expected and vial 6 does not provide the greatest ^{2}H signal in Figure 4-5 as expected. The cause is likely array coupling to the volume transmit coil, resulting in local B1 inhomogeneity. The remaining vials display greater signal from greater concentration in the images as expected.

CONCLUSION: Imaging using a dual-tuned surface array has been successfully demonstrated for ^{1}H and ^{2}H at 1 Tesla. Future work will utilize the current hardware to explore the clinical applications of simultaneous imaging of a deuterated compound with a proton reference image and extend this work to other nuclei.

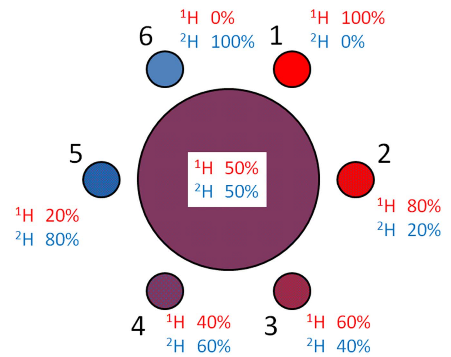

Figure 1: Phantom with Solution Concentrations

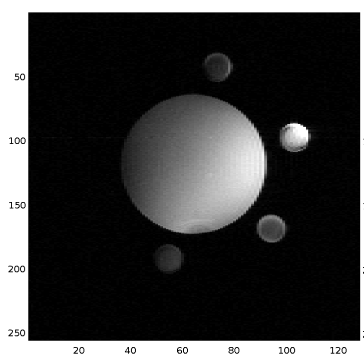

Figure 2: Element 0, ^{1}H

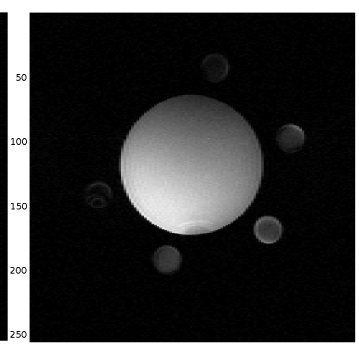

Figure 3: Element 1, ^{1}H

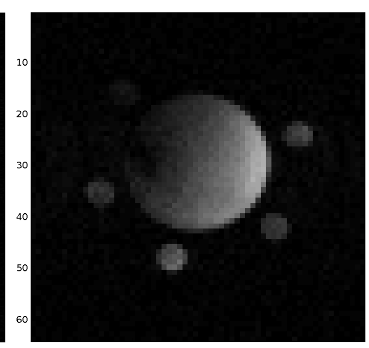

Figure 4: Element 0, ^{2}H

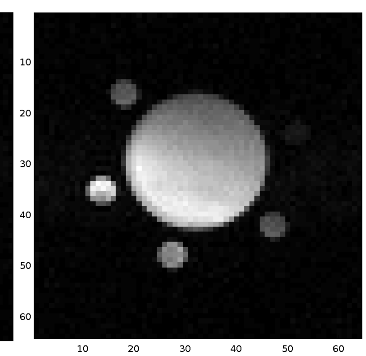

Figure 5: Element 1, ^{2}H

REFERENCES: [1] Mateescu, Gheorghe D., et al. "In vivo assessment of oxygen consumption via Deuterium Magnetic Resonance." *Oxygen Transport to Tissue XXXII*. Springer US, 2011. 193-199. [2] McDouall, Jacqueline B. Larcombe, and Jeffrey L. Evelhoch. "Deuterium nuclear magnetic resonance imaging of tracer distribution in D2O clearance measurements of tumor blood flow in mice." *Cancer Research* 50.2 (1990): 363-369. [3] Derome, Andrew E., and Andrew E. Derome. *Modern NMR techniques for chemistry research*. Vol. 6. Oxford: Pergamon press, 1987. [4] Ha, Seunghoon, et al. "A PIN diode controlled dual-tuned MRI RF coil and phased array for multi nuclear imaging." *Physics in medicine and biology* 55.9 (2010): 2589. [5] Roemer, P. B., et al. "The NMR phased array." *Magnetic resonance in medicine* 16.2 (1990): 192-225.

ACKNOWLEDGEMENTS: Funding provided by Samsung Research America – Dallas.