Using Piezoelectric Actuators For Remote Tuning Of Transmit Coils

C. J. Snyder[1], L. DelaBarre[1], J. Tian[1], C. Akgun[1], and J. T. Vaughan[1]
[1]University of Minnesota, Minneapolis, MN, United States

Introduction: The ability to tune and match multi-channel transmit or transceive arrays is necessary for increased transmit efficiency, reduced coil coupling and optimal receive sensitivity. However, tuning and matching each element in a high numbered array can be time consuming and significantly increase scan times. Varactors have been used to automate tune and match of receiver arrays remotely, however, there are currently no known components on the market that can the transmit powers required in MR imaging or spectroscopy. Piezoelectric motors and actuators have been shown useful in MR compatible infusion systems (1) and are known be able to remotely adjust resistive and reactive components(2). A piezoelectric actuator was used to remotely tune a single element transceive coil, which is the building block of any multi-channel array.

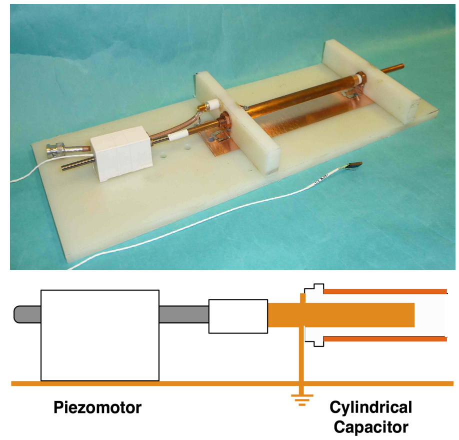

Figure 1(a) Single element TEM coil with piezoelectric actuator (b) cross-sectional diagram of the actuator and coil

Methods: A single TEM coil was constructed (fig 1a). The TEM element was 150mm in length with a 12.8mm wide copper tube conductor and a 50mm copper foil ground plate. A 12.7mm air dielectric separated the conductor from the ground plate. Cylindrical capacitors at both end of the element allowed for coil tuning. The element was tuned, on the bench to a 3.78L, 100mM saline phantom doped with 4mM $CuSO_4$, to proton's Larmor frequency at 7T (296.8 MHz) using a calibrated E8362B PNA series network analyzer (Agilent Tech, Santa Clara, CA).

A piezoelectric actuator (New Scale Technologies, Victor, NY) was physically attached to a cylindrical capacitor via a nylon standoff (fig. 1b). The actuator was controlled from a PC via a PCB drive board.

Once positioned in the magnet isocenter, the piezoelectric actuator was used to retune the TEM element from the console.

Imaging experiments were performed on a 7T (ω_o=297.14MHz), 90cm bore magnet (Mangex Scientific, UK) equipped with Siemens console and head gradients. A single 8kW RF amplifier (CPC, Hauppauge,NY) was used. Sagittal and axial FLASH images (TR/TE: 100/4.1ms, 1.37 x 1.37 x 5 mm sagittal res; 1.0 x 1.0 x 5.0mm axial res) were acquired. The piezoelectric actuator was then physically removed and the images were reacquired to determine if the motor has any affect.

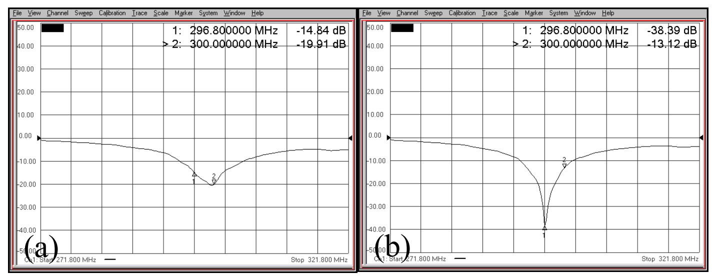

Figure 2 The frequency response magnitude of the coil in the magnet isocenter (a) before retuning and (b) after retuning.

Results: Once positioned in the magnet isocenter, the resonant frequency of the coil shifted approximately 3MHz high to about 300MHz (fig 2a). The piezoelectric actuator was used to retune the coil and shift the frequency back to proton's Larmor at 7T (fig 2b).

Figures 3a,c show the sagittal and axial FLASH images, respectively, with the piezoelectric actuator in position, while figures 3b,d show the same images with the actuator removed. It clear from the images the actuator does not induce gross B_0 inhomogeneities, eddie currents or gradient spikes; nor does increase either structured or non-structured noise.

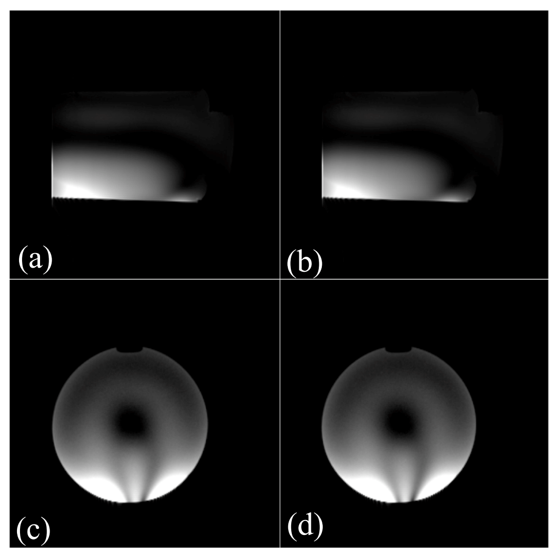

Figure 3 (a,c) sagittal and axial FLASH images with the actuator attached to the coil, (b,d) the same images the actuator removed.

Conclusions: Piezoelectric motors can be used to tune/retune coils elements in magnet isocenters. Furthermore it has been shown that the introduction piezoelectric actuator does not alter the image quality. While we have shown this remote tuning system for a single element and are currently designing multi-channel array which use this technology. It is believed that this remote tuning system will reduce time spent on tuning/matching of large number or arrays. Furthermore, this system allows tune and match of each coil element to periodically monitored throughout a scan and adjusted as needed.

References: (1)Turowski SG, et al. MRI 2008, 426-432 (2)Provisional Patent 61158345

Acknowledgments: NIH-NIBIB-EB000895, NIH-NIBIB-EB006835, NIH-NIBIB-EB007327, NIH-NCRR-P41-RR08079, Keck Foundation.