MEMS Reconfigurable Coils

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Target audience: Coil design engineers, multi nuclear spectroscopy researchers

Purpose: MR compatible micro electro-mechanical switches[1] (MEMS) have the potential to reconfigure coils 'on-the-fly' by enabling/disabling conducting paths and/or circuit components. In this work, we consider the feasibility of reconfiguring (1) coil geometry to switch field of view (FOV) and (2) coil frequency to image multiple nuclei.

Methods: A proto-type coil was designed to switch between a larger (15cm x 11cm) and smaller (8cm x 11cm) geometry, switching the FOV larger/smaller, by enabling/disabling conducting paths. MEMS were placed on two conducting paths on the coil to switch the length wise dimension from 15cm to 8cm. Two additional MEMS were placed on the impedance matching circuit to switch in/out a capacitor and an inductor to transform coil impedance to 50 ohms when the geometry was switched. The coil was placed on a phantom, imaged (1.5T, GE Signa* HDx, Waukesha, WI) in larger geometry configuration, then immediately switched to smaller geometry configuration and imaged.

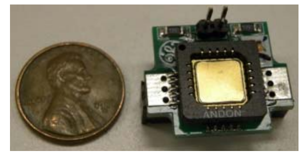

Fig 1 MR compatible MEMS

A 4.5cm coil was modified to switch between 64MHz (1H, 1.5T) and 16MHz (13C, 1.5T). The coil was placed on a phantom, tuned and the loading was estimated at the two frequencies. A circuit model of the coil, including coil inductance, loading resistance, tuning capacitance and impedance matching circuit was generated (ADS, Keysight Technologies). The tuning capacitances and the impedance matching circuits for the two loading resistances at the two frequencies were obtained. Based on the circuit model, a proto-type coil was built with one MEMS to switch the frequency (64MHz/16MHz) and two MEMS to switch the impedance matching circuit.

Results: The geometry reconfigurable coil is shown in Fig. 2 (top). In order to realize smaller/larger geometry configurations, MEMS in inner conductor switched close/open and MEMS in outer conductor switched open/close. The images of the phantom for the two geometries are shown in Fig 2 (center, bottom).

The loading in 4.5cm coil was estimated to be 8 ohms at 64MHz and 1 ohm at 16MHz. The prototype coil is shown in Fig. 3 (left). The coil impedances at each frequency are shown in Fig 3 (center, right).

Discussion: The geometry reconfiguration was realized with two MEMS and frequency reconfiguration was realized with a single MEMS. However, impedance matching circuits required two additional MEMS in each case.

MEMS have been investigated to switch one channel of a tri-channel knee coil[2] in previous work. This work evaluated directly reconfiguring the conductive paths of a coil and switching in/out circuit components to switch resonance frequency. Since the coil geometry determines the field of view as well as SNR at particular distance from the coil, the ability to reconfigure geometry provides greater capability to switch between applications (spine vs abdominal, for example). Reconfiguring the frequency provides capability to switch between anatomical (1H) and metabolic (13C) imaging, for example.

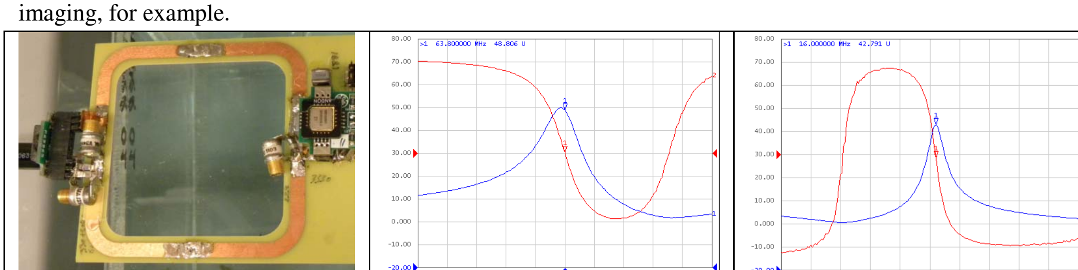

Fig. 3. 1H/13C reconfigurable coil on phantom (left), 64MHz configuration (center), 16MHz configuration (right). The blue line shows magnitude and the red line shows phase of impedance.

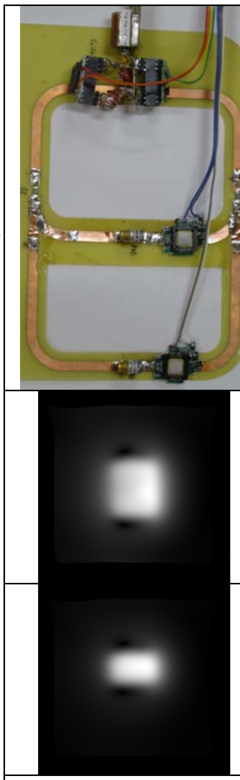

Fig. 2. Geometry reconfigurable coil (top), larger FOV (center), smaller FOV (bottom)

Conclusion: MR compatible MEMS can reconfigure coils 'on-the-fly', enabling/disabling conducting paths and circuit components.

References: 1. Nustad, T., MEMS Executive Congress, Nov 2014 **2.** Fuentes, M., ISMRM, 2010, p422

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