

A Dual-tuned quadrature microstrip volume coil for $^{13}\text{C}/^1\text{H}$ MRI/S at 7T

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Introduction

Microstrip transmission line (MTL) resonators have demonstrated advantages of high quality factors, high reproducibility, and low radiation losses in designing volume RF coils at high and ultrahigh magnetic fields (1-3). In this work, we present an 8-element by 8-element dual-tuned microstrip volume coil for in vivo $^{13}\text{C}/^1\text{H}$ MRI/S animal studies at 7T. The design strategy of using a mix of $\lambda/2$ resonators and $\lambda/4$ resonators was employed to provide the 300MHz and 75MHz operating frequencies simultaneously. Preliminary results from a corn oil phantom and a mouse were acquired using the proposed coil at 7T.

Methods

A quadrature dual-tuned microstrip volume coil was built on a Teflon cylinder with dimensions of 6.6cm O.D, 5.2cm I.D, 10.2cm in length. The Teflon cylinder serves as both dielectric material and mechanical support. Fig.1 shows a picture of the prototype coil. In the proton channel, each of its 8 resonant elements is a $\lambda/2$ microstrip resonator with capacitive termination on both ends. The carbon channel also comprises of 8 resonant elements. In order to operate at the relatively low frequency of 75 MHz, $\lambda/4$ microstrip resonator was used for each element of the carbon channel. Circuits of both ^1H and ^{13}C elements are shown in Fig 2. 8 proton elements and 8 carbon elements are alternatively positioned around the Teflon cylinder in order to generate homogeneous B_1 fields for both proton channel and carbon channel. Bench tests on coil resonance modes and isolation between two quadrature ports (and between the proton and carbon channels) were implemented on a network analyzer (Agilent E5070B). The termination capacitance measurement was conducted on a RCL meter (Fluke PM6303A). The proton MR imaging and ^{13}C spectroscopic imaging experiments were performed on a GE 7T magnet (GE Healthcare, Waukesha, WI). A cylindrical corn oil phantom and a mouse were used in this preliminary study. A set of fast spin echo images in sagittal orientations and axial gradient echo images were acquired. An 8x8 2D ^{13}C FIDCSI was also performed with TR=2sec, 10mm in plane and 20mm thick, 1 average (i.e. NEX=1).

Results and Conclusions

The proton channel and carbon channel were tuned to 298.14 MHz and 75MHz on the two quadrature ports respectively. Each port was matched to system 50 Ohm by a series capacitor. Well-defined five resonance peaks for ^1H channel and five peaks for ^{13}C channel are clearly identified on the network analyzer. On the bench test, the isolation between driving ports was better than -20dB for both ^1H channel and ^{13}C channel. These results indicate that the two channels ^1H and ^{13}C are decoupled sufficiently. Proton GRE image and ^{13}C spectra are shown in Fig 3. Based on the preliminary results on bench test and MR scans, dual-tuned microstrip volume coil with a mix of $\lambda/2$ and $\lambda/4$ microstrip resonant elements is feasible and efficient, provided that sufficient radial separation is maintained between the strip conductor and the ground to provide sufficient coupling between corresponding elements. The proposed design may provide a simple approach to dual-tuned volume coil design for in vivo multinuclear MR at ultrahigh fields.

Reference (1) Zhang X, et al, MRM 46:443-450 (2001); (2) Zhang X, et al, IEEE Trans BME 52:495-503; (3) Xie Z, et al. ISMRM Workshop on Advances in High Field MR, March, 2007;

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Fig.1 The 7T dual-tuned coil with 8 $\lambda/2$ resonators for ^1H channel and 8 $\lambda/4$ resonators for ^{13}C channel.

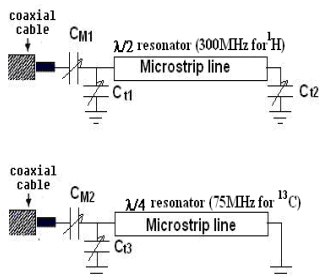


Fig.2 Diagrams of resonant elements which were tuned to 300MHz and 75MHz.

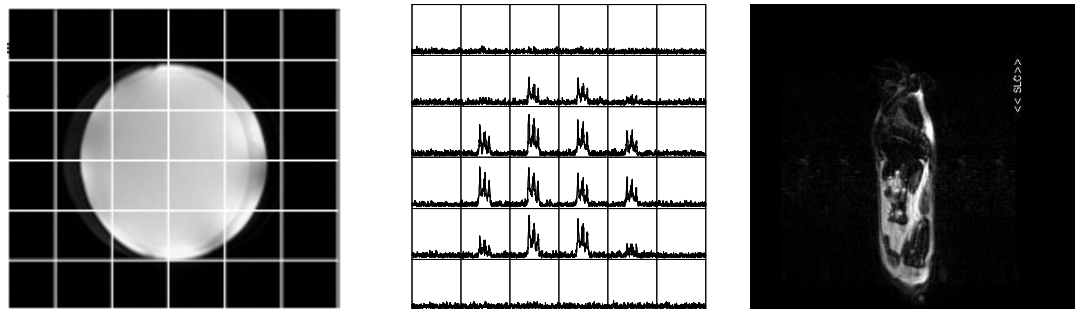


Fig.3 preliminary results from the proposed dual-tuned microstrip volume coil for mouse imaging: 7T proton image (left) and ^{13}C spectroscopic image (center) of a corn oil phantom acquired using the prototype at 7T. The artifacts in the proton image are due to chemical shifts of the oil phantom; The right insert shows 7T proton image of a mouse.