A Practical multi-tuned Birdcage Resonator for MRI/MRS at 7T

C. Wang[1], B. Wu[1], D. Vigneron[1], and X. Zhang[1,2]

[1]Dept. of Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, California, United States, [2]2UCSF/UC Berkeley Joint Graduate Group in Bioengineering, San Francisco & Berkeley, California, United States

Introduction:

MRI/MRS at ultra high static magnetic field (>4T) is proved to be very successful since it yield increased SNR, allowing improved spatial resolution, and also provides better spectral resolution. Multiple-tune radiofrequency (RF) coils [1-4] are very useful for multinuclear magnetic resonance applications, because they ensure spatial co-registration of signal from different nuclei without exchanging coils for imaging and spectroscopy examinations. In this work, a multiple-tuned birdcage coil was built and tested at 7T.

Methods:

A multiple-tuned Birdcage coil (Diameter: 4", Length: 5") showed in Fig. 1 was built with 16 copper tubes (OD: 0.25", Length: 5"). Compared with copper tape, copper tube has enlarged surface and hence has lower resistance because of skin-depth effect, which will reduce coil loss and increase coil Q factor. Trimmer capacitors (Voltronics, Denville, NJ) were placed between copper tubes and end-rings. Fix capacitors (ATC, NY) were placed on the other end of each element. The elements were tuned to high frequency and low frequency alternately. The coil was driven in quadrature at all frequencies. Each port was matched to 50Ω while loaded with a cylindrical corn oil phantom (Diameter:2.5" , Length:6") by matching capacitor. Baluns were used to reduce RF current leakage on the coax cable shield. Resonant modes were measured with a network analyzer (Agilent E5070B). The measured frequency responses of the multi-tuned Birdcage resonator were illustrated in Fig. 2. The imaging mode (mode 1) for ^{13}C MRS and ^{1}H MRI were tuned to 75MHz and 298MHz respectively. The proton MR imaging and ^{13}C spectroscopy experiments were performed on a GE 7T/90cm MRI system (GE Healthcare, Waukesha, WI). Proton image was acquired using a gradient echo sequence with TE = 7.3ms, TR = 500ms, Flip angle = 30°, FOV = 10cmx10cm, slice thickness=3mm, matrix size = 256x256, NEX=1, and bandwidth=15.63 kHz. ^{13}C spectrum of corn oil was acquired with single shot and TR = 2 sec.

Fig.1 16-element double-tuned birdcage with Diameter=4" and Length=5"

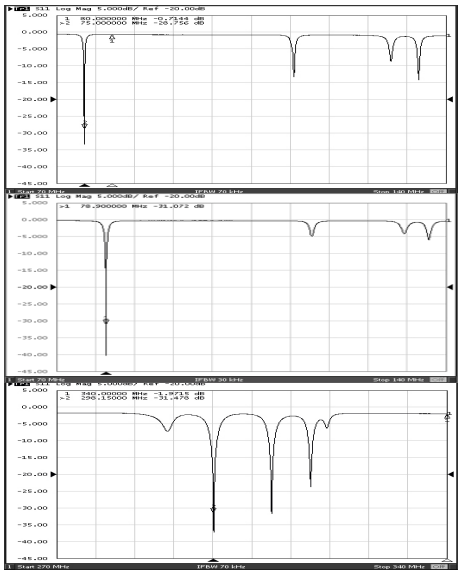

Fig.2 Measured frequency response of the multi-tuned birdcage coil for ^{13}C (top) , ^{23}Na(middle) and ^{1}H (bottom) with the frequency span of 70MHz

Results and Discussion:

The unloaded Q is ~273 for ^{13}C and ~198 for ^{1}H by S11 measurement. Because the loading is corn oil, the loaded Q almost the same as the unloaded Q. Well-defined resonant mode peaks for ^{13}C MRS and ^{1}H MRI were easily identified. Axial proton image of the cylindrical corn oil phantom acquired using the prototype birdcage coil was shown in Fig.4 (left). It demonstrated the relatively homogeneous intrinsic B1 field pattern generated by the prototype coil. Fig.4 (right) illustrated high SNR for ^{13}C spectroscopy with single shot acquisition. Moreover, this coil can be easily tuned to sodium resonant frequency (78.9MHz). Fig.3 (middle) illustrated the measured frequency response of the multi-tuned coil for sodium. Based on the bench test and MRI/S experiment, the multi-tuned birdcage coil was used successfully at 7T.

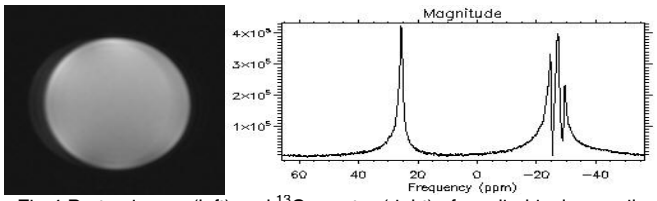

Fig.4 Proton image (left) and ^{13}C spectra (right) of a cylindrical corn oil phantom acquired using the multiple-tuned birdcage. Artifacts in (left) were caused by chemical shift.

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References:

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[3] Gerald BM, etc. MRM 42:173-182 (1999) [4] Gary Shen, et al, MRM 38:217-725 (1997)