A NOVEL 4 T DOUBLE TUNED (1H-23Na) SURFACE TEM RESONATOR

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INTRODUCTION

MRI and MRS benefit of the improved SNR obtainable at high field (3-12 T). TEM resonators are especially designed for high-field applications [1]. Single- and double-tuned volume TEM resonators have been described [1-2]. A single-tuned surface TEM resonator [3-4] is generally composed by N identical elements (coaxial or strip lines) each connected to a ground plane by two end capacitors. A single-tuned surface TEM resonator presents a spectrum with N modes of resonance with a constant frequency separation. Unfortunately, this design does not allow one to independently tune the modes for two nuclei such as, for example, 1H and 23Na.

AIMS

In this work, we report the design of a double-tuned surface TEM resonator suitable for sodium and proton imaging. The TEM prototype was tested on the workbench and in a 4 T scanner.

METHODS

The double-tuned TEM prototype [5] (Fig. 1) is made by: 1) a central copper micro-strip (10 mm x190 mm) for the proton channel, connected to the ground plane by two end capacitors (8.2 pF); 2) two lateral strips (5 mm x190 mm) for the sodium channel, each strip connected to the ground plane by two end capacitors (68 pF). The center-to-center separation between the sodium strips is 35 mm. The ground plane made by adhesive copper foil (100 mm x 190 mm) is separated by the strip plane by an 11 mm thick PVC slab, then by an air gap of 29 mm and finally by an 11 mm thick PVC slab. Non-magnetic trimmer capacitors, connected in a balanced fashion, were used for fine-tuning and matching. The TEM resonator was tested on the workbench and in a 4 T scanner. It was loaded with a cylindrical phantom (dia=150 mm; H=78 mm) filled with a solution composed of 1 litre of water with dissolved 1.25 g of $NiSO_4$-$6H_2O$ and 5 g of NaCl. The TEM resonator was tested at the MRI scanner in TX/RX mode using a gradient echo sequence.

RESULTS

Workbench tests yielded a frequency spectrum comprising 3 modes of resonance (Fig. 2); the first mode is tuned to the sodium frequency (44.5 MHz) and the third is tuned to the proton frequency (168.3 MHz). Modes 1 and 2 are arising from the mutual coupling of the two external strips (each tuned at about 52 MHz when isolated). Mode 1 gives a RF field with a pattern enclosing the two external strips and used in this work for sodium detection. Mode 3 is tuned at the proton frequency, and the useful RF field extends around the central strip.

When loaded with the phantom, the measured Q factor of Mode 1 and 3 were about 80 and 50, respectively. The matching was better than -20 dB. The MR images were acquired with a 3D gradient echo sequence with a FOV of 287x287 mm^2 and a resolution of 128x128 pixels in the axial and coronal directions. The MRI testing (Fig. 3) shows that the modes have a common region of homogeneity for the two nuclei in the axial direction. The coronal images show that the coil is quite homogeneous along the micro-strip direction. A minimum of signal is observed in the lower central region of the sample in the sodium image, and this is probably due to the relatively large distance between the two external strips. An optimised selection of the strips width and positioning should reduce or eliminate this effect.

CONCLUSIONS

In this work, we have designed and realised a novel double-tuned surface TEM resonator suitable for sodium and proton MRI at 4 T. MRI testing shows that the TEM resonator is really selective in the axial direction and homogeneous along the micro-strip axis. This design should be very useful for the study of subcutaneous tumours or musculoskeletal disease.

REFERENCES

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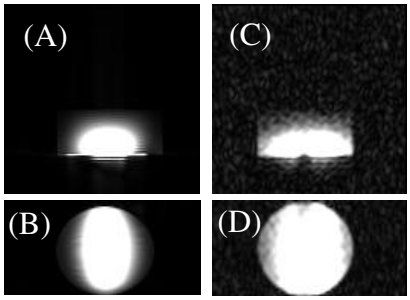

Fig. 3: 1H images (TR=50ms, TE=3.7ms, NEX=1): (A) Axial and (B) coronal. 23Na images (TR=21ms, TE=2.1ms, NEX=24): (C) axial and (D) coronal.

Fig.1: The 4 T double-tuned surface TEM prototype.

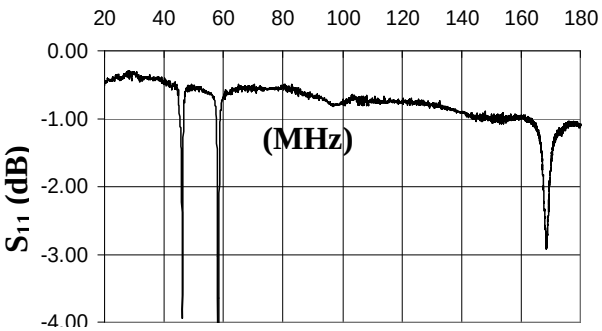

Fig. 2: The measured S11 spectrum of the double-tuned surface TEM resonator.