Modified Microstrip Volume Coil for Ultrahigh Field

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Introduction

It is a challenge to design a lumped-element micrstrip volume resonator [1-3] for ultrahigh field (>7T) with large size. Usually, the spacing *h* between strip line and outer ground plane (thickness of the coil) should be selected as large as possible to optimize the SNR [2]. However, excess *h* may greatly decrease the resonant frequency f_0. In practice, thickness of about 2cm is suitable for most of the designs. At ultrahigh field, if thickness of the lumped-element microstrip volume coil is around 2cm, the strip length has to be shortened to raise f_0. As a consequence, the size of this coil cannot be large enough to meet the requirement of most applications.
To solve this problem, a modified microstrip volume coil design is proposed. Through deploying ground line at the back of each strip line, the resonator can be easily tuned to 300MHz without undesired restriction to coil size.

Material and method

The schematic structure of the modified microstrip volume coil is shown in Fig.1 (a) and (b). Ground lines, which are built with narrow copper tapes between strips and ground, are mounted to each copper strip and connected to outer ground plane through conductive wires. Besides adjusting the terminative capacitors, several other means are provided by this modification to tune the resonance frequency, for instance, varying the width of the ground line, or varying the spacing *h* between the ground line and copper strip.

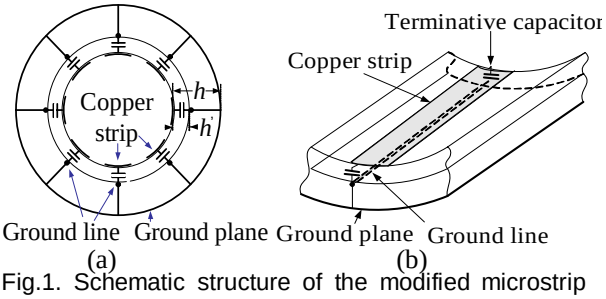

Fig.1. Schematic structure of the modified microstrip volume coil: (a) viewed from the top. (b) view of a section plane.

Using this novel structure, a 16-element microstrip resonator, as shown in Fig.2, was constructed by using two concentric acrylic cylinders with dimensions of 18.0cm o.d./17.7cm i.d. and 11.6cm o.d./11.3cm i.d. respectively. Both acrylic cylinders are 18cm long. Copper strips and ground lines are placed on the inner and the outer sides of the smaller cylinder respectively while the larger cylinder is a supporter of the ground plane of the coil. In our design, the coil thickness is 3.2cm. Each copper strip has an identical dimension of 18cm length and 2cm width. 16 ground lines were built using 3mm wide, 18cm long copper tapes. All terminative capacitors are 6.2pF, except one is a 1~15pF trimmer used for frequency tuning.

Results

A traditional lumped-element microstrip resonator, which was easily obtained by detaching the ground lines from our modified microstrip coil, was used for comparison. S11 shows that all modes of this traditional microstrip coil were resonated at 168-301MHz with the first mode at 183MHz. While frequencies of all modes of the modified microstrip resonator are much higher, ranged from 294MHz to 346MHz with the first mode at 300MHz, The S11 plot of the this coil is shown in Fig 3. The comparison results show that, due to the ground lines, frequencies of lower modes were significantly increased, and the mutual coupling between elements was decreased. While the frequency span of 8 modes is narrowed from 133MHz to 58MHz. XFDTD method was used to simulate the B1 profile of this coil at 300MHz, which is shown in Fig.4. The result demonstrates that the field is homogeneous when the coil was quadrature drived. With smaller terminative capacitances, this modified microstrip resonator can be easily tuned to higher resonant frequencies.

Conclusion and discussion

A modified microstrip volume coil design has been introduced for ultra-high field MRI. Using this novel structure, a 16-element volume coil prototype at 300MHz has been fabricated, tested and simulated. The results show that adding the ground lines is effective to increase the resonant frequency of the lumped-element microstrip resonator for ultra high field usage.

Acknowledgements

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Reference

[1] Bogdanov G et al, MRM2002; 47;p579-593. [2] Bogdanov G et al. ISMRM2004;p1562. [3]Zhang X et al.MRM2004;p1547.

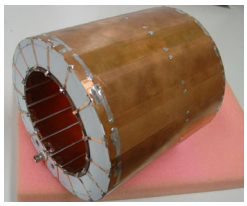

Fig.2. Photo of the 16-element microstrip volume coil using the modified structure.

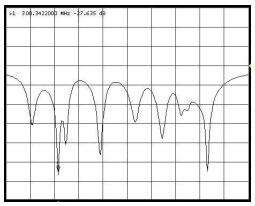

Fig.3. S11 plot of the 16-element microstrip volume coil using modified structure. First mode frequency is 300M. Frequency span of 8 modes is 58MHz.

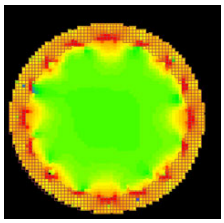

Fig.4. B1 profile of the modified microstrip coil with quarter drive at 300MHz.