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# Development of TEM Head-Size Resonator for 3T MRI Head Coil

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## I. INTRODUCTION

Until now, the conventional birdcage type of head coil has been widely used for the most clinical MRI studies, but it was not proper in high magnetic fields because of losing inherent values of its constituent elements (capacitor and inductor). Moreover, it is limited to SNR (Signal to Noise Ratio) due to low Q factor. Vaughan and coworkers described a theory and description of TEM resonator coil for a 4.1T MRI [1,2]. The development of TEM coil may be a simple task if we have the valid equations that relate the tuning frequency, coil quality factor and dimensions such as the length, inner and outer diameters of each coaxial cavity resonator. In the present study, we applied a distributed circuit theory, developed a head-size TEM resonator coil for a home-built 3T whole-body MRI and reported an efficiency of the coil.

## II. MATERIALS and METHODS

In order to evaluate the performance and discrepancy between the theory and the experiment, we designed a specific TEM resonator coil for a home-built 3T MRI system. The dimension of TEM resonator with 16 cavity elements at 3T MRI (127.7 MHz) are 34cm outer diameter, 29cm inner diameter and 36.9cm length, respectively. For each cavity element, the diameter of copper rod was 0.63cm and its length was 13.75cm. As raw materials, the purity of copper rod was 98% and the dielectric constant of teflon was 2.08.

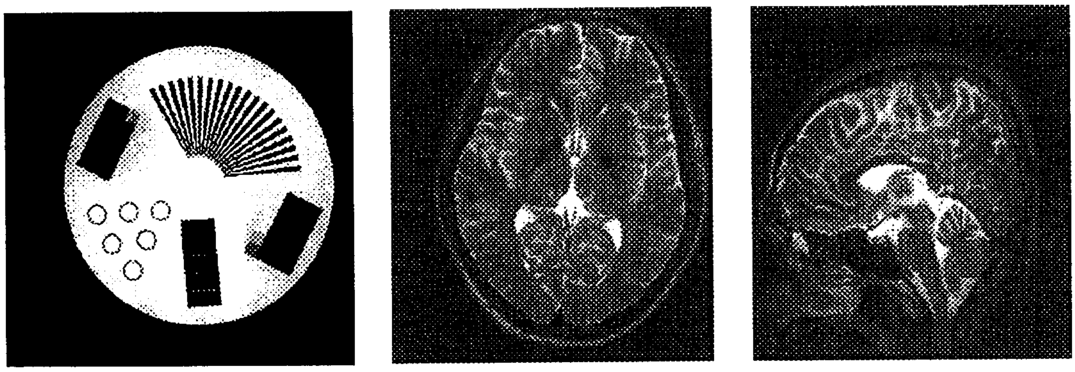
## III. RESULTS and DISCUSSION

In Table 1, distinct discrepancies between the theory and the experiment were shown with the element length, resonance frequency and coil quality factor. These discrepancies could be resulted from the mutual inductance, and stray capacitance. The significant difference of coil quality factor may be attributable to the insufficient craftmanship and the purity of copper rod.

| | Element Length | Resonance Frequency | Q Factor (Unloaded) |
|---|---|---|---|
| Theory | 12.46cm | 136.0 MHz | 1524 |
| Experiment | 13.75cm | 127.7 MHz | 1054 |

**Table 1.** Comparison of length, resonance frequency, and coil quality (Q) factor between the theory and the experiment in cavity element.

The TEM head-size resonator with 16 cavity elements exhibited 9-mode resonances was robust to the surrounding influences due to the self-shielding structure [3]. The isolation of quadrature channel could be easily achieved with the higher value than 25 dB. The loaded coil quality factor with a human brain was 364 and the ratio of Q(unloaded)/Q(loaded) was 2.9. Using the TEM head-size resonator, MRI studies were performed on phantom and healthy human volunteers. Gradient echo pulse sequence was employed with TE = 9ms, TR = 500ms, average = 1, FOV = 25, matrix size = 256x256, flip angle = 30°. For human study, we also employed fast spin echo (FSE) pulse sequence with TE = 108ms, TR = 4000ms, average = 1, FOV = 200 and 220, matrix size = 192x256.



(a) (b) (c)

**Figure 1.** Sample images obtained by tuned TEM resonator coil at 3T (127.7 MHz). (a) Phantom image with gradient echo pulse sequence, (b) and (c) Human brain images with T2-weighted fast spin echo (FSE) pulse sequence. Fine anatomical structures were well demonstrated. In particular, putamen, globus pallidus and nerve tissues around thalamus were clearly identified in the MR images.

## IV. CONCLUSIONS

In the present study, we successfully demonstrated that the TEM head-size resonator with high Q factor can provide high quality MR images at 3T MRI system. In addition, the TEM resonator coil has an advantage for a fine tune with length adjustment of each cavity elements. Thus, it is expected that the TEM resonator at 3T, even higher field could be used in the clinical and research studies in near future.

## REFERENCES

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