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Miniature IL Chip Ferrite Antenna for T-DMB Applications

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1. Introduction

The frequency of digital mobile TV service such as T-DMB is assigned in the range of 174 to 216 MHz. Since the length of a monopole antenna is proportional to λ/4, the antenna length should be 38 cm long. Accordingly, the antenna size is an issue to address. The antenna size can be reduced by the permeability (μ) and permittivity (ε) of ferrite [1]. Futhermore, the input impedance matching between air and ferrite and magnetic loss tan δ should be taken account for integration of radiator in ferrite substrate. In this paper, we report the effect of ferrite substrate thickness on the impedance matching thickness (IMT) for meander and spiral IL antennae and also gain patterns. As a result, a 0.121 cm^3 volume ferrite antenna with acceptable gain was found to be suitable for T-DMB applications.

2. Design and simulation

The inverted L (IL) type antennae, shown in Fig. 1, were used for this study. The dimension of radiator was 7 turns-0.5 mm wide coil meander with 0.2 mm gap, and 2 turns-0.5 mm wide spiral coil with 3 mm gap. The antenna is embedded in Co_2Z barium ferrite, which is mounted on 40 x 80 x 1 mm Cu/FR4/Cu. The Cu/FR4/Cu is ground. The permeability of Co_2Z barium ferrite is 15 ~ 17, tan δ about 0.02, and ε 12 ~ 20 [2, 3] in the T-DMB frequency range. In this study, both μ and ε of the Co_2Z barium ferrite were fixed to 15. The ferrite thickness were varied from 0 to 10 mm. It was found that the impedance matching occurs at 4 mm ferrite thickness. Therefore, tan δ of the 4 mm thick Co_2Z barium ferrite was varied from 0 to 2 for gain pattern simulation. The Ansoft HFSS V. 10.1 3D-FEM software was used to simulate antenna characteristics.

3. Results and discussion

The input impedance (Z_{in}) of incident electromagnetic wave is dependent on relative μ (μ_r), relative ε (ε_r), and thus the matching thickness (IMT) can be determined by both μ and ε [4]. The IMT of ferrite rapidly decreases as μ_r increases. However, the μ_r is more effective than ε_r in reduction of the IMT. We used effective μ (μ_{eff}) and ε (ε_{eff}) instead of μ_r and ε_r because of dimension and shape dependence of μ and ε. Therefore, both μ_{eff} and ε_{eff} were estimated by electromagnetic computer simulation. We found that the central frequency (f_c) of the ferrite antenna rapidly decreases with the ferrite thickness up to 4 mm, and then the decreasing rate is getting smaller beyond 4 mm. This is attributed to the magnetic flux concentrated adjacent to the surface of radiator. Furthermore, the inductance of radiator is more or less saturated at a certain thickness of ferrite, which results in a limited frequency.

The central frequency was found to be 198 and 196 MHz for the 4 mm thick ferrite meander and 0.5 mm thick ferrite spiral antennae, respectively. These frequencies were determined by VSWR plot in terms of the ferrite thickness. As shown in Fig. 2 (a) and (b), we have successfully achieved omni directional gain patterns in y-z plane for both antennae. The average gain was -12.28 dBi for the 4 mm thick meander antenna, while the 0.5 mm thick

spiral antenna shows the average gain of -13.25 dBi. These performances well meet the requirements for T-DMB internal antenna in the mobile handsets.

4. Conclusion

The IL chip Co_2Z ferrite antennae were proposed and their performances were investigated. The IL antennae include meader and spiral shaped radiators. We have found that the following antenna parameters meet the requirements of T-DMB antenna: 4 mm thick ferrite for meander; 0.5 mm thick ferrite for spiral antenna; μ and ε of 15; 10 mm x 10 mm of radiator area; 7 turns of 0.5 mm wide coil for meander with 0.2 mm gap; 2 turns of 0.5 mm wide coil for spiral with 3 mm gap. The antenna volume are 2.592 and 0.121 cm^3 for the meader and spiral, respectively. Both antennae show omni directional radiation patterns. Furthermore, the average gain for the meader and spiral antennae are -12.28 dBi and -13.25 dBi. Our proposed antenna structures are well suited for T-DMB antenna applications. Fabrication of these antennae are in progress.

5. References

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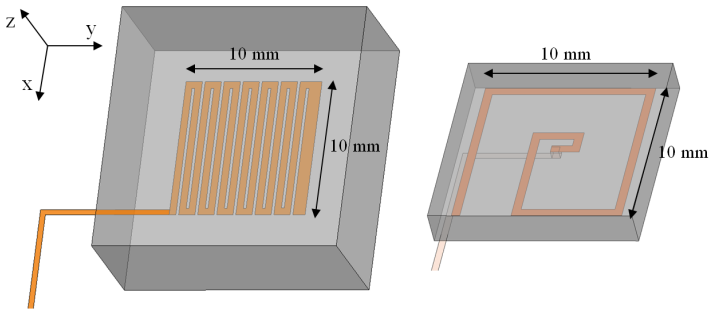
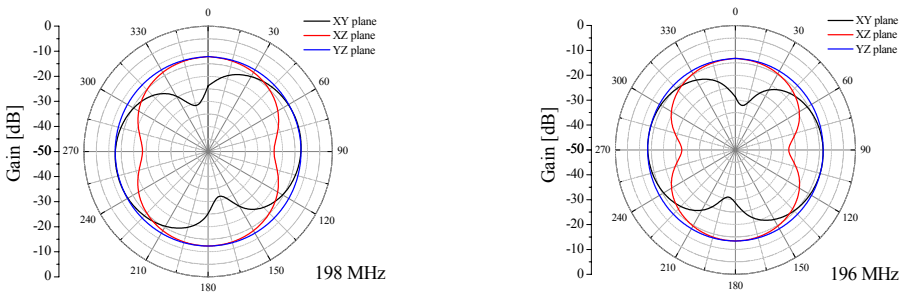


(a) (b)

Fig. 1. Structures of (a) ferrite embedded IL meander antenna, (b) ferrite embedded IL spiral antenna.



(a) (b)

Fig. 2. Gain patterns of (a) meander IL antenna with 4 mm thick ferrite and (b) spiral IL antenna with 0.5 mm thick ferrite.