MACKEY Q-Type Miniaturized Using Two Shorting Plates

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***Abstract*—The metasurface-inspired antenna chip developed by the KIT EOE laboratory (MACKEY) is a small antenna unaffected by metal. In the paper, we propose a MAKCEY Q-Type miniaturized to approximately λ/4 squared using two shorting plates in the MACKEY.**

I. Introduction

The metasurface-inspired antenna chip developed by the KIT EOE laboratory (MACKEY) is a small antenna unaffected by the surrounding metal [1]. MACKEY II, a thinner version of MACKEY, was developed by inserting an antenna plate in the AMC substrate of MACKEY [2]. In addition, an unbalanced MACKEY II with a single-port feed was developed using an inverted L-shaped antenna as the feed element of MACKEY [3].

Figure 1 shows the model diagram of the unbalanced MACKEY II designed for the Wi-Fi 2 GHz band. The model consists of three layers: a metal plate, an antenna plate, and a grid plate, with dielectric filling the gap between the plates. Grid plate (1) and metal plate (3) act as AMC substrates for working on metal, and grid plate (1) and antenna plate (2) act as antenna substrates for radiation (Figure 1). Figure 2 shows the voltage standing wave ratio (VSWR) characteristics of this model. This model works both in space and on metal (Figure 2).

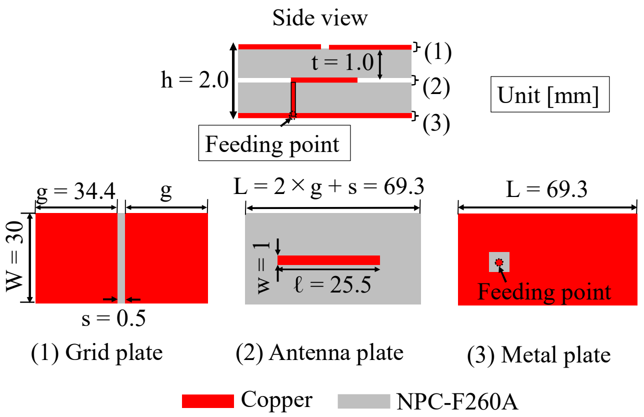


Fig. 1. Model diagram of the unbalanced MACKEY II

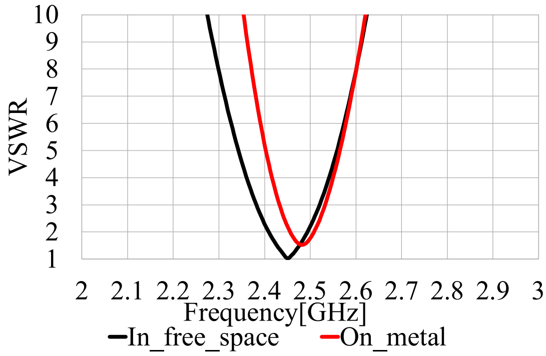


Fig. 2. VSWR characteristics of the unbalanced MACKEY II

II. Development of MACKEY Q-Type

The width, L, is a parameter that depends on the design frequency, which is approximately λ/2. The model shown in Figure 1 has a width, L, of approximately 69.3 mm. In this paper, we propose the MACKEY Q(Quarter wavelength)-type, a miniaturized version of the type shown in Figure 1.

The concept of miniaturization is illustrated in Figure 3. The mirror image principle was used to miniaturize the antenna by installing two shorting plates inside the unbalanced MACKEY II. The antenna structure is a three-layer structure, similar to that of the unbalanced MACKEY II, and it is supplied with power from the antenna plate. The supplied power is transmitted between the shorting plate and grid slits, and radio waves are radiated at the left and bottom edges of the grid plate. Because the radio waves radiated from each side are orthogonal with equal amplitude and phase, the combined wave radiates a linearly polarized wave of φ = 135°, and the gain is 3 dBi greater than φ = 90°.

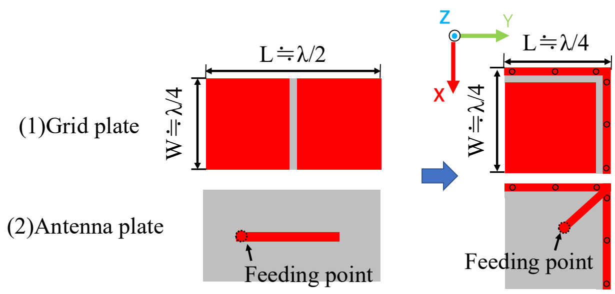


Fig. 3. Concept of miniaturization

III. ANALYSIS RESULTS

The analysis results of the MACKEY Q-type are presented below. The analysis was performed using an electromagnetic field simulator (Ansys HFSS) based on the finite element method. A model diagram of the MACKEY Q-type used for the analysis is shown in Fig. 4. The VSWR characteristics of the MACKEY Q-type and unbalanced MACKEY II in free space and on metal are shown in Fig. 5(a) and 5(b), respectively. The radiation patterns at 2.45 GHz for cut planes φ = 45° and 135° are shown in Fig. 6.

Fig. 5(a) and 5(b) show that the Q-type is narrower than the unbalanced type but works at 2.45 GHz in free space and on metal. Fig. 6(a) shows that the gain is 4.96 dBi in free space and 6.89 dBi on metal, indicating that the radiation is sufficient in free space and on metal. A comparison of the frontal gain (Fig. 6(a) and 6(b)) indicates that the Q-type is 1.5 dBi lower than the unbalanced type in free space and 0.92 dBi lower on the metal. In terms of the antenna area, the MACKEY Q-type is approximately 70% of the unbalanced MACKEY II. Hence, the antenna can be miniaturized without much loss of gain.

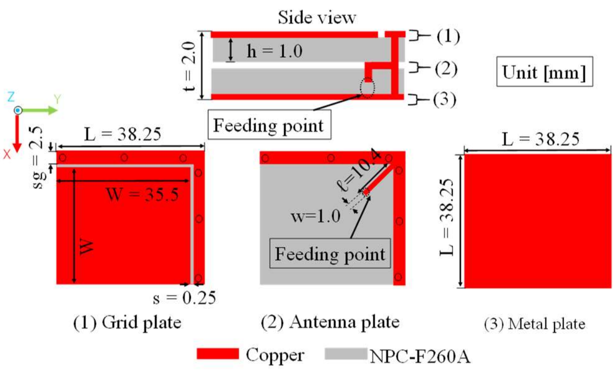
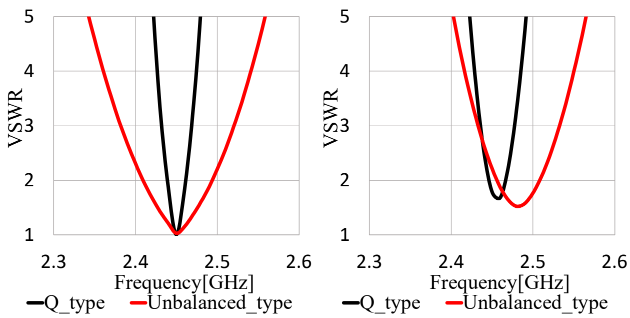
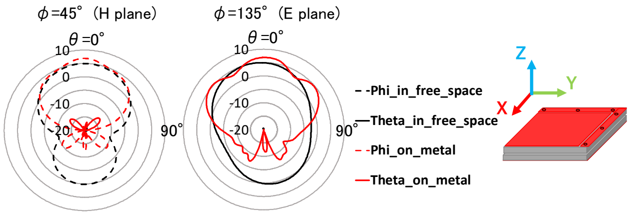


Fig. 4. Model diagram of the MACKEY Q-type

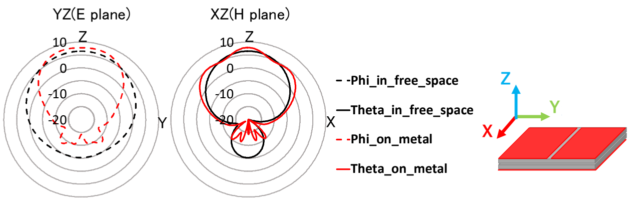


(a)In free space (b)On metal

Fig. 5. VSWR characteristics of the MACKEY Q-type and unbalanced MACKEY II



(a) MACKEY Q-type



(b) Unbalanced MACKEY II

Fig. 6. Radiation pattern

IV. CONCLUSION

In this study, a compact MACKEY Q-type was developed using two shorting plates in an unbalanced MACKEY II. The miniaturization was based on a mirror image principle using a shorting plate. Based on the analysis results, the antenna worked at 2.45 GHz, although the VSWR characteristics were narrower than those of the unbalanced MACKEY II. The gain in the frontal direction was 4.96 dBi in free space and 6.89 dBi on metal, indicating that the antenna radiated well. In addition, the area of the MACKEY Q type could be miniaturized to about 70% of that of the unbalanced MACKEY II.

ACKNOWLEDGMENT

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