Considering of Circularly Polarized Antenna by Combining Two MACKEYs

Keito Yokoe (1), Kota Hakamata (1), Shigeru Makino (1), Kenji Itoh (1)

(1) Kanazawa Institute of Technology 7-1 Ogigaoka, Nonoichishi Ishikawa, Japan
B1995149@planet.kanazawa-it.ac.jp

***Abstract*— Herein, a meta-surface-inspired antenna chip developed by the KIT EOE Laboratory (MACKEY) which is sufficiently robust to a metal object proposed. By combining two MACKEYs, we propose an antenna that radiates circularly polarized waves.**

I. Introduction

An electrically small antenna, named MACKEY basic-type, which is robust to a metal object, has been proposed [1]. In addition, a thinner and improved MACKEY II was proposed [2].

Fig. 1 illustrates the MACKEY II designed for the Wi-Fi 2.4GHz band. The model is a three-layered structure comprising a grid plate, an antenna plate, and a metal plate in descending order, with a dielectric filled between them. Impedance matching is performed based on the grid width g and antenna length ℓ. Fig. 2 depicts the analysis results of the voltage standing wave ratio (VSWR) characteristics in free space and on metal. The analysis results in Fig. 2 show that MACKEY II works well on metal.

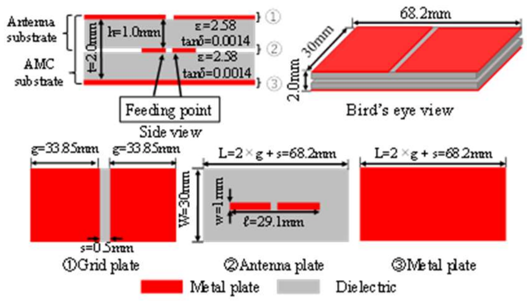


Fig. 1. Model diagram of the MACKEY II

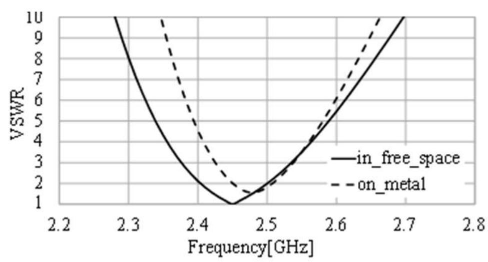


Fig. 2. VSWR of the MACKEY II

II. Proposal for Circular Polarization MACKEY

To radiate a circularly polarized wave, it was necessary to add a 90° phase difference between two orthogonal linearly polarized waves. The common MACKEY II was an antenna that radiated linearly polarized waves. Hence, two MACKEY IIs of the same size were combined in an orthogonal arrangement. As Fig. 3 shows, the two MACKEY IIs shared a part of the model. By feeding them with a phase difference, it was believed that circularly polarized waves could oscillate. In this study, an impedance matching model was used with a single-port power supplied with an aligned grid plate length and width.

To feed the two antennas, a 0° current was applied to feed point 1, and a 90°current was applied to feed point 2, as the lower part of Fig. 3 shows.

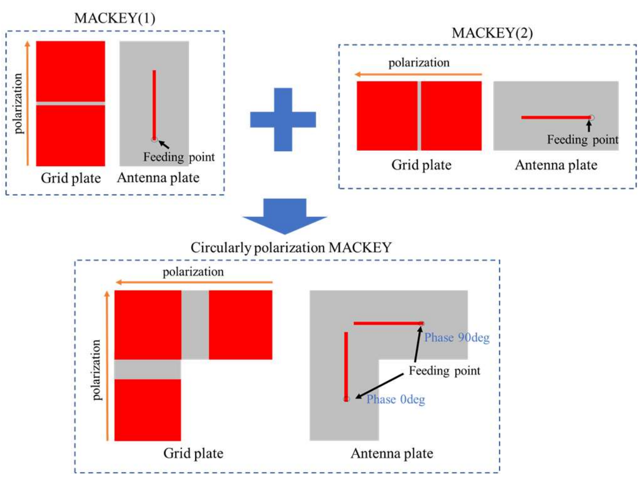


Fig. 3. Simplified diagram of the circularly polarized antenna

III. Structure of MACKEY C3 type

Based on the aforementioned proposal, the name of the model with three grid plates and two antennas was the MACKEY C3 type, and Fig. 4 presents the structural diagram. The stacked structure was the same as in MACKEY II, with an AMC substrate having a thickness of 2 mm and an antenna position of 1 mm. A current with a phase of 0°and 90° was supplied to each of the two feed points shown in the figure.

Impedance matching was performed by varying the length ℓ of the antenna and the height and width g of the grid. In addition, the slit width s was varied to adjust the axis ratio.

The top and bottom widths of the antenna substrate denoted by *L* were 81.8 mm and the antenna length ℓ was 29 mm.

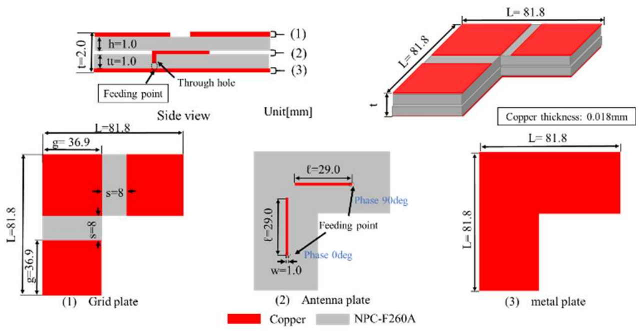


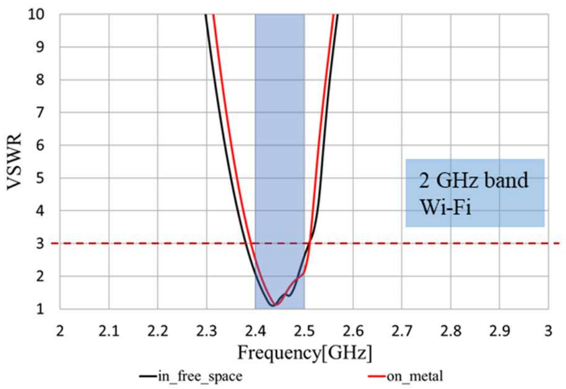
Fig.4 Model diagram of circularly polarization MACKEY C3

IV. Analysis Results

Fig. 5 shows the analysis results of VSWR characteristics. The results in free space are depicted by black lines, and the results for metal are depicted by red lines. The VSWR was less than 3 dB in both free space and on metal, and there was no significant difference in the specific bandwidth. Therefore, the Wi-Fi 2GHz bandwidth was satisfied.

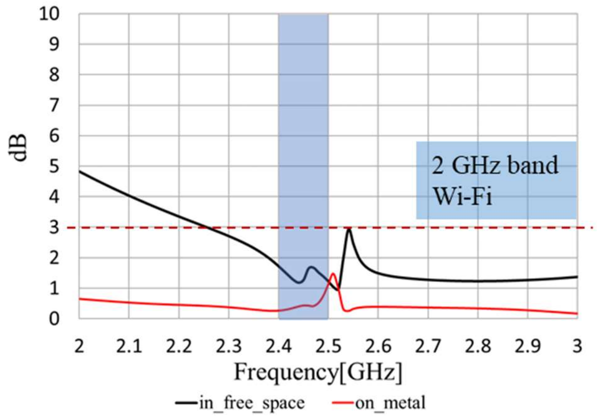
Fig. 6 shows the axial ratio characteristics. Axial ratio characteristics of less than 3 dB were obtained over a wide range, both in free space and on metal. Therefore, it was observed that the axial ratio characteristics did not affect the metal.

Fig. 7 shows the radiation pattern diagram. The solid lines indicate left-handed circular polarization, and the dashed lines indicate right-handed circular polarization. Moreover, the dashed lines in the figure show that this antenna was a right-handed circularly polarized antenna. The radiation on the metal radiates in the *x*-direction, similar to the radiation in free space.



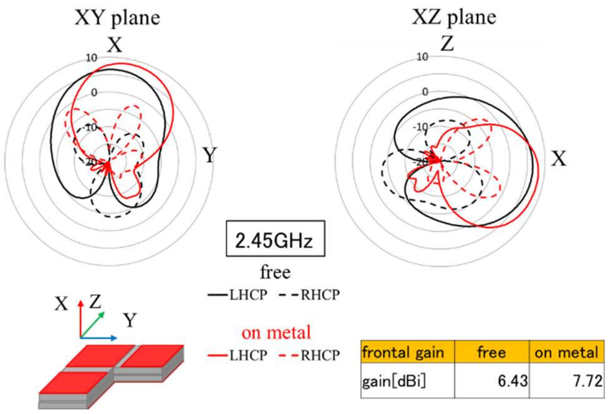
	free	on metal
VSWR=3[dB] or less bandwidth [GHz]	2.39〜2.50	2.40〜2.51

Fig.5 VSWR characteristic.



	free	on metal
Axial ratio of 3[dB] or less Bandwidth [GHz]	2.26〜3.00	2.00〜3.00

Fig.6 Axial ratio characteristic.



frontal gain	free	on metal
gain[dBi]	6.43	7.72

Fig.7 Radiation patterns of circularly polarized waves for two models.

V. Conclusion

Here, a circularly polarized MACKEY was proposed. This model functioned as a circularly polarized antenna by combining two MACKEYIIs rotated by 90° and feeding each antenna with a phase difference of 90°. It was also demonstrated that this antenna could operate on a metal, which was the original feature of the basic-type MACKEY. In the future, the miniaturization of this antenna should be considered.

Acknowledgment

This work was supported by JST CREST Grant Number JPMJCR20Q1, Japan.

REFERENCES

[1] T.MOROYA et al, "AMC Inspired Small Antenna MACKEY," IEICE. Trans. Commun, vol. J99-B, no. 9, pp. 786794, Sep. 2016

[2] K.MIYASHITA et al, "MACKEY II with reduced thickness by using a new structure," IEEE APS-2020, pp599-600, Jul.2020