Development of Circular Polarization MACKEY

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***Abstract*— In this study, a meta-surface-inspired antenna chip developed by the KIT EOE Laboratory (MACKEY) that is sufficiently robust to a metal object, has been proposed. The MACKEY transmits circularly polarized signals by combining multiple antennas and substrates.**

***Keywords*— MACKEY; WiFi-2GHz; meta-surface inspired antenna; AMC substrate; circularly polarized wave;**

I. Introduction

An electrically small antenna, named MACKEY basic-type, which is sufficiently robust to a metal object, has been proposed [1]. In addition, a reduced-thickness model, MACKEY II has been 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 demonstrate that the MACKEY II operates in both free space and metal.

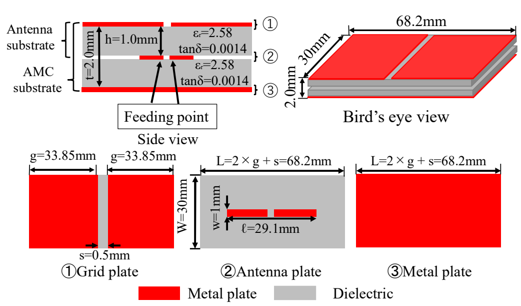


Fig. 1. Model diagram of the MACKEY II back feed type

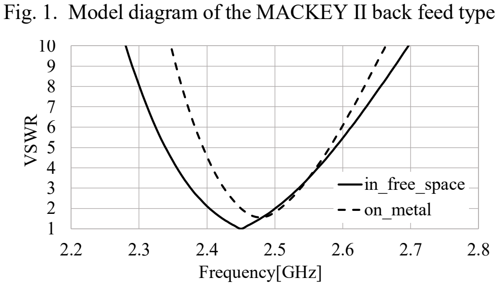


Fig. 2. VSWR characteristics of the MACKEY basic type

In this study, MACKEY that transmits circularly polarized waves by combining multiple antennas and substrates is proposed.

II. PROPOSAL FOR THE CIRCULAR POLARIZATION MACKEY

To radiate a circularly polarized wave, it is necessary to add a 90° phase difference between two orthogonal linearly polarized waves. The normal MACKEY II is an antenna that radiates the linearly polarized waves. Hence, two MACKEY IIs of the same size were combined in an orthogonal arrangement. The two antennas share a part of the grid plate, as shown in Fig. 3. By feeding them with a phase difference, it is believed that circularly polarized waves can oscillate. In this study, an impedance matching model was used with a single-port power supply having aligned grid plate length and width.

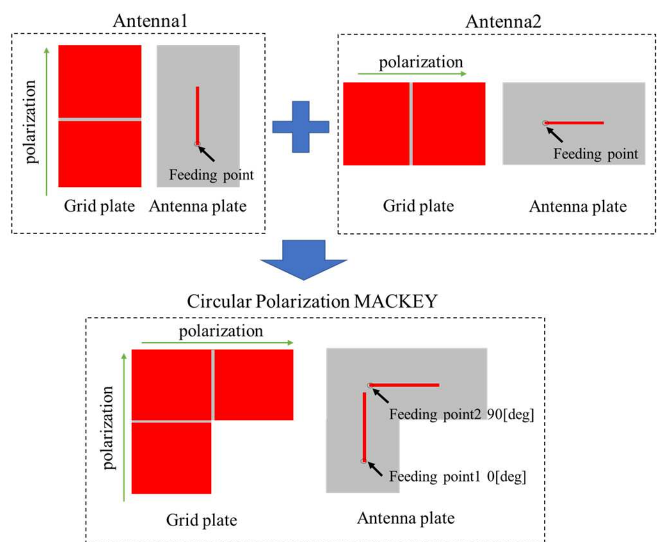


Fig. 3. Simplified diagram of the circularly polarized antenna

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 shown in the lower part of Fig. 3.

III. Designed circularly polarization MACKEY.

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

Impedance matching is 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.

As a result, the top and bottom widths of the antenna substrate denoted by L are 81.2 mm and the antenna length ℓ is 29 mm.

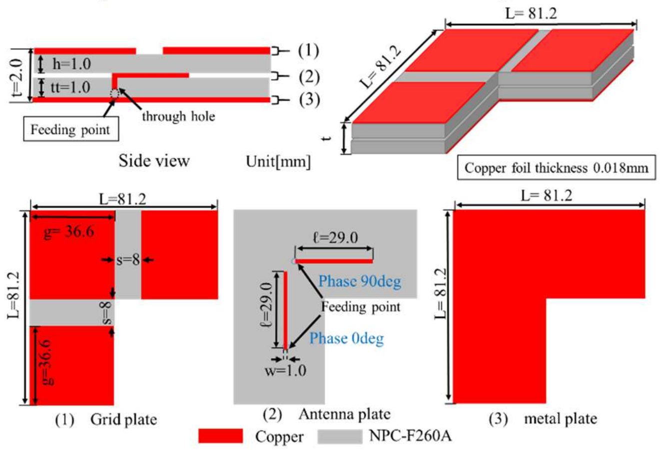
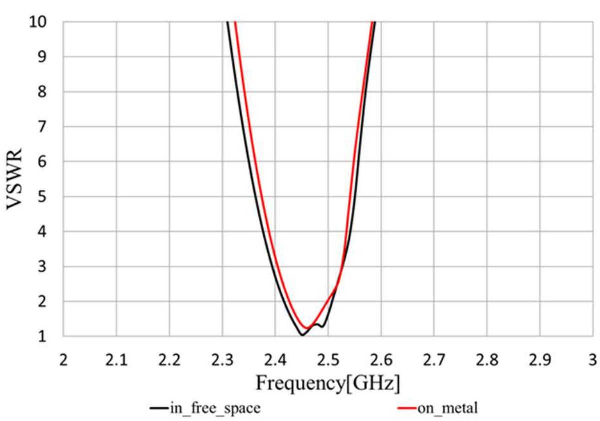


Fig.4 Model diagram of circularly polarization MACKEY

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

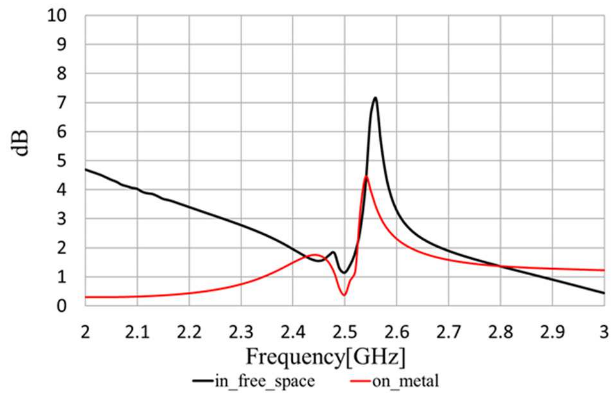
Fig. 6 shows the axial-ratio characteristics. Axial ratio characteristics of less than 3 dB were obtained over a wide range, both in free space and on metal. Therefore, it can be observed that the metal is not affected by the axial ratio characteristics.

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 is 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]	2.40～2.52	2.41～2.52
Specific Bandwidth [%]	4.88	4.46

Fig.5 VSWR characteristic.



	free	on metal
Axial ratio characteristic = 3[dB] or less Bandwidth [GHz].	2.27～2.53	2.0～2.52 2.57～3.0

Fig.6 Axial ratio characteristic.

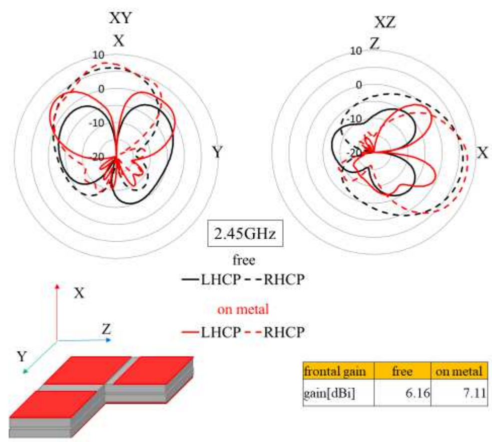


Fig.7 Radiation patterns of circularly polarized waves for two models.

IV. Conclusion

In this paper, a circularly polarized MACKEY is proposed. This model functions 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 metal, which was the original feature of the basic-type MACKEY. Future studies will include the feeding circuit for this antenna.

V. Acknowledgments

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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 model with reduced thickness,” 2021 15th European Conference on Antennas and Propagation (EuCAP), pp1-4, Mar.2021