Dual band MACEY type T composed of three radiating grids for WiFi 2/5 GHz application

Shigeru MAKINO[1] Ken HIRANO[2] Kenji ITOH[2] Keisuke NOGUCHI[2] Tetsuo HIROTA[2]

***Abstract* – A meta-surface inspired antenna (MACKEY) has been proposed, which works not only in free space but also on a metal plate. A MACKEY parallel arrangement model will be proposed in which an original MACKEY (WiFi 2 GHz band) and a MACKEY wide-band type (WiFi 5 GHz band) are arranged in parallel. Then, a MACKEY type T will be proposed, where one of the two grids of an original Mackey and that of a wide-band type are shared.**

1. Introduction

An antenna model MACKEY integrating a dipole antenna and an artificial magnetic conductor (AMC) has been developed [1]. It was shown that the MACKEY can match the impedance even when installed in free space or on a metal plate.

The proposed MACKEY satisfies each of WiFi 2 GHz and WiFi 5 GHz bands. However, one antenna cannot cover these bands as the bandwidth of WiFi 5 GHz is too wide. In order to obtain dual-band characteristics, a MACKEY parallel arrangement model will be proposed in which an original MACKEY (WiFi 2 GHz band) and a MACKEY wide-band type (WiFi 5 GHz band) are arranged in parallel [2]. Then, a MACKEY type T model will be proposed to reduce the size, where one of the two grids of an original Mackey and that of a wide-band type are shared.

2. Parallel Arrangement Model

2.1 Structure of Parallel Arrangement Model

Fig. 1 shows the structure of the parallel arrangement model. It is composed of two dipole antenna, four grids and two metal plates in order from the top, and dielectric substrate among them. In WiFi 2 GHz band, impedance matching is possible by determining the optimum combination of ℓ and g. In WiFi 5 GHz band, impedance matching is possible by determining the optimum combination of ℓℓ and gg. The slit width (sp) is a distinctive parameter for the parallel arrangement model, and is provided to reduce the influence of mutual coupling.

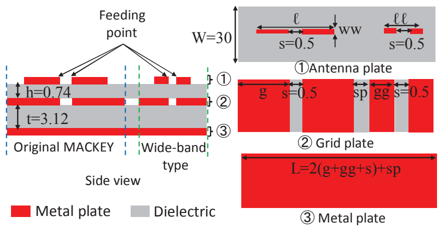

Fig. 1. Structure of a parallel arrangement model.

2.2 Analyzed Result

The design parameters of the parallel arrangement model are g = 26.8 mm, gg = 10 mm, ℓ = 27.9 mm, ℓℓ = 14.3 mm, sp = 4 mm, and ww = 1.0 mm. Therefore, the size is 30 mm × 79.5 mm × 4.0 mm. Fig. 2 shows the VSWR characteristic of the parallel arrangement model in free space and illustrates that the parallel arrangement model covers the WiFi 2 GHz / 5 GHz bands. Fig. 3 shows the radiation patterns of the parallel arrangement model in free space at 2.45 GHz, 5.25 GHz and 5.60 GHz, respectively. From Fig. 3, the analyzed gains are 6.1 dBi, 5.8 dBi, and 7.6 dBi, respectively. Therefore, the parallel arrangement model works for WiFi 2 GHz / 5 GHz bands and the minimum sp is 4 mm to reduce the influence of mutual coupling.

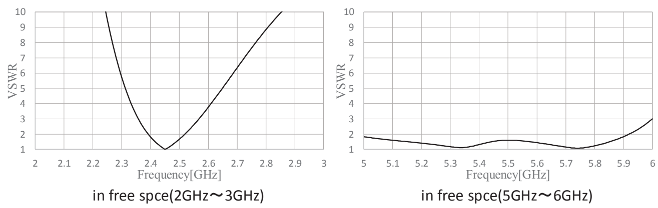

Fig. 2. VSWR characteristicsl.

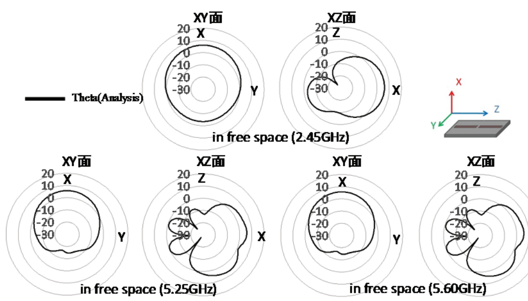

Fig. 3. Radiation patterns.

978-1-5386-6765-1/18/$31.00 ©2018 IEEE

[1] Kanazawa Institute of Technology, 7-1 Ohgigaoka, Nonoichi, Ishikawa, 921-8501, Japan, Email: makino@neptune.kanazawa-it.ac.jp.
[2] Kanazawa Institute of Technology, 7-1 Ohgigaoka, Nonoichi, Ishikawa, 921-8501, Japan.

3. MACKEY type T

3.1 Idea of MACKEY type T

A method for sharing the grids of the original MACKEY and the wide-band type is proposed to reduce L of the parallel arrangement model [2]. Fig. 4 shows the sharing model of the grids. The green dotted line works in the WiFi 2 GHz band, and the blue dotted line works in the WiFi 5 GHz band. Compared with the parallel arrangement model, the overlapping part of the green and blue dotted lines works as a grid of different frequency bands. Therefore, the number of grids becomes triple, and L is small. A MACKEY type T is proposed, where the number of grids is triple. The grid widths corresponding to one frequency are asymmetric on the left and right. In the figure, the slit of WiFi 2 GHz band acts as sp to reduce the influence of mutual coupling. Therefore, the sp of the grid in WiFi 2 GHz band is set to 4 mm where the influence of mutual coupling is small. Also, the slit of WiFi 5 GHz band is set to 0.5 mm.

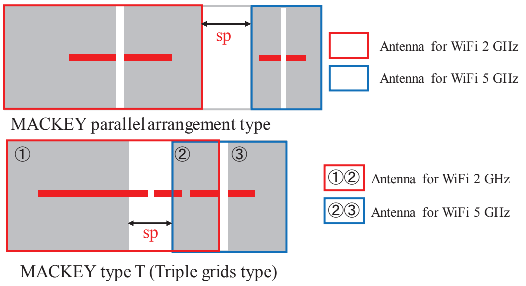

Fig. 4. Idea to reduce length of a parallel arrangement model.

3.2 Structure of a MACKEY type T

Fig. 5 shows the design parameters of type T. As a result of designing type A that covers the WiFi 2 GHz / 5 GHz bands, the shared grid width (gg) is set to 8 mm. For type T in the WiFi 2 GHz band, impedance matching is possible by determining the optimum combination of $\ell\ell_1$ and g_1. For type T in the WiFi 5 GHz band, impedance matching is possible by determining the optimum combination of $\ell\ell_2$ and g_2. The size of the designed type T is 30 mm × 56.8 mm × 4.0 mm, which is downsized by about 30% compared with the parallel arrangement model.

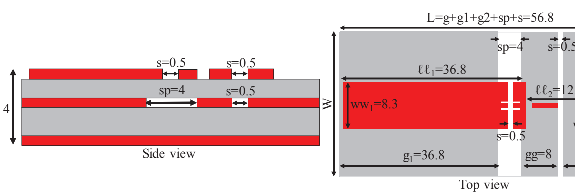

Fig. 5. Structure of a MACKEY type T.

3.2 Measured Result

Fig. 6 shows the VSWR characteristics of type T in free space and on a metal plate. The solid black and red lines indicate the VSWR characteristics obtained from the analyzed results and the measured results, respectively. From Fig. 6, the analyzed results and the measured results coincide very well. The measured bandwidth in free space is more than 6.5 % (2 - 3 GHz) and 13.6 % (5 - 6 GHz) and covers the WiFi 2 GHz / 5 GHz bands. The measured bandwidth on a metal plate is more than 4.2 % (2 - 3 GHz) and 16.0 % (5 - 6 GHz) and covers the WiFi 2 GHz / 5 GHz bands.

Fig. 7 shows the radiation patterns of type T model in free space at 2.45 GHz, 5.25 GHz and 5.60 GHz, respectively. The black and red lines indicate the radiation patterns obtained from the analyzed results and measured results, respectively. In the figure, the solid lines indicate the Eθ component. From Fig. 6, the measured gains are 5.5 dBi, 4.5 dBi, and 3.6 dBi, respectively. Fig. 8 shows the radiation patterns of type T model on a metal plate at 2.45 GHz, 5.25 GHz, and 5.6 GHz, respectively. From Fig. 8, the measured gains are 8.5 dBi, 6.0 dBi, and 6.3 dBi, respectively.

Therefore, type T model is shown to not only work in free space but also on a metal plate over the WiFi 2 GHz / 5 GHz bands.

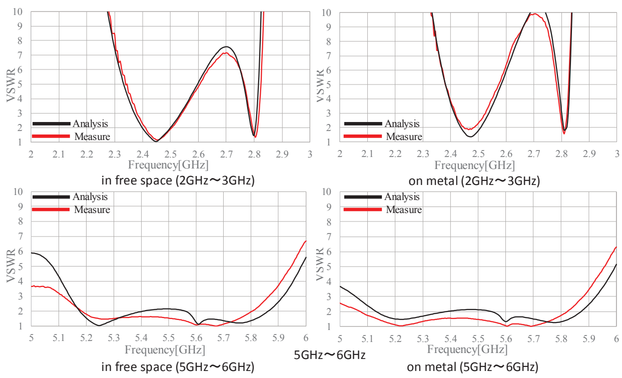

Fig. 6. Comparison of VSWR characteristics.

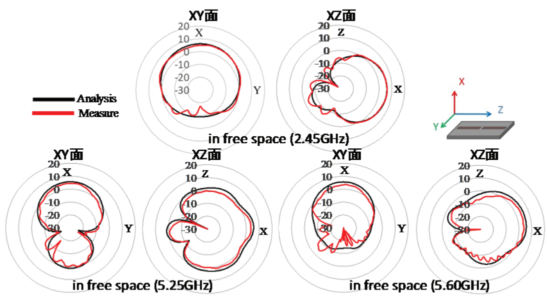

Fig. 7. Radiation patterns in free space.

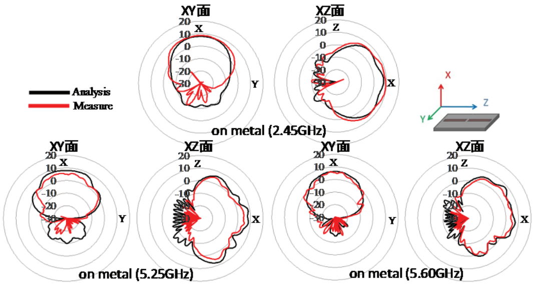

Fig. 8. Radiation patterns on a metal plate.

4. Conclusion

The MACKEY type T has been proposed, which works in the WiFi 2 GHz / 5 GHz bands; it works in free space as well as on a metal plate. Also, type T was downsized by about 30% compared with the parallel arrangement model.

References

[1] T. MOROYA et al, "AMC Inspired Small Antenna MACKEY," IEICE. Trans. Commun, vol. J99-B, no. 9, pp. 786–794, Sep. 2016.

[2] K. HIRANO et al, "Feasibility Study of MACKEY type A," IEICE. Tech. Rep, AP2017-110, pp. 15-20, 2017.