Design for the feeding structure of a metal cap with two slots attaching at the edge of a mobile module substrate for 60GHz Band

Haruhisa Hirayama, Jiro Hirokawa, and Makoto Ando
Dept. of Electric & Electronic Engineering, Tokyo Institute of Technology,
S3-19, 2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan

***Abstract* - This paper presents a design of a metal cap with two slots attaching at the edge of a mobile module substrate for a 60GHz-band wireless personal area network (WPAN). The metal cap is fed by a post-wall waveguide (PWW) converted from a micro strip line (MSL). The size of the metal cap is 8.01× 2.34× 4.45 mm^3. The reflection is less than -11 dB and the realized gain is larger than 9 dBi over 57-66 GHz.**

***Index Terms* — wireless personal area network, millimeter wave, slot array antenna.**

1. Introduction

60-GHz WPAN is expected as high-speed wireless file transfer systems [1]. We proposed a metal cap with two slots to insert the end of a mobile module substrate for 60GHz band for a WPAN system [2]. The directivity was higher than 10dBi over 57-66GHz. However, there was a fabrication error relating to the small thickness (0.20 mm) of the feeding T-junction for a substrate with the thickness of 0.254mm the relative permittivity of 2.17 [3]. In the structure, the edge of the substrate had to be modified to insert the T-junction. That makes mass production difficult. In order to avoid this difficulty, in this paper we propose a new structure for a straight edge of the substrate without modification as shown in Fig.1.

2. Structure of the Designed Antenna

Fig. 1 and 2 show the structure of the metal cap with two slots. In the previous research, the metal cap was directly fed by a MSL. Note that Fig.1 shows the half section of the cap to understand the internal structure. With that structure, *Lt* needed to be half of the thickness of the substrate to suppress the reflection from the T-junction. It could cause a fabrication error. We propose a feeding structure fed by a PWW. The PWW is converted from the MSL and created near the edge of mobile device substrate. The metal cap is attached on the edge of the substrate. The PWW is converted to a hollow waveguide at the insertion point. The reflections from the T-junction, slots and the PWW-to-WG transformer are cancelled for the matching. The two slots are excited by equal amplitude divided by the T-junction. The design specifications are listed in Table I. The relative permittivity and the thickness of the substrate are 3.9 and 0.21 mm, respectively. The parameters of the metal cap are shown in Table II. *Lt* is 0.46 mm, which is thick enough to avoid the fabrication error. The length of the cap is about twice as long as that of the previous structure. That is because the distance between the PWW-to-WG transformer and the T-junction is set to about λ_g / 4 (λ_g : guide wavelength at 61.5 GHz) so that the reflections from the two components can be canceled out to each other. This makes *Lt* thicker.

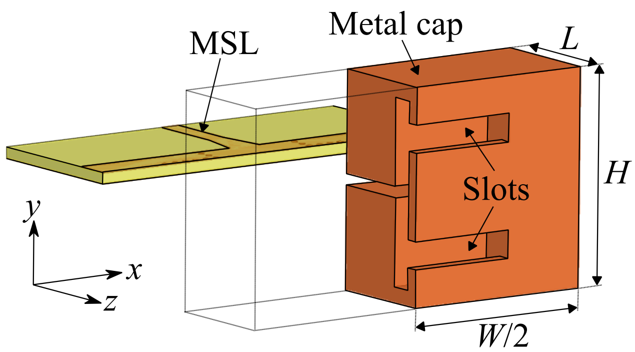

Fig. 1. Structure of the proposed antenna (half section view)

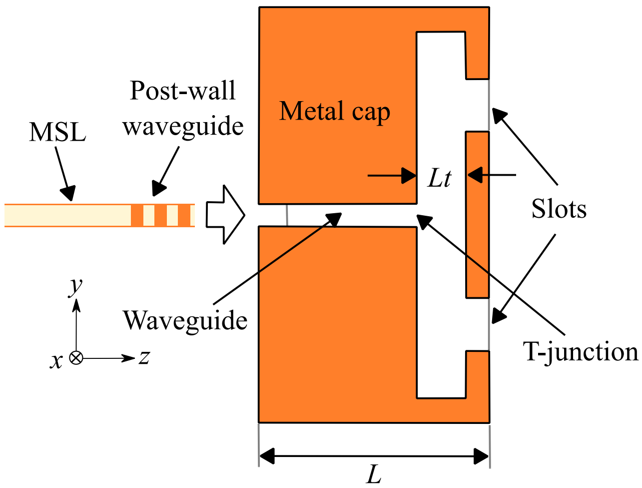

Fig. 2. Structure of the proposed antenna (cross section view in the *y-z* plane)

TABLE I
Design Specifications

Center frequency	61.5 GHz
Reflection band (below -10dB)	15% (57-66 GHz)
Gain	9dBi
Beamwidth	45～60°

TABLE II
Parameters of the Metalcap

Parameters	Size [mm]
W	8.01
L	2.34
H	4.45
Lt	0.46

3. Analysis Results

The metal cap is designed and analyzed by HFSS. In the simulation, the conductivity is assumed to be 5.8×10^7 S/m in the metal cap and the MSL. The complex dielctric constant of the substrate is assumed to be ε_r = 3.9 and $\tan\delta = 8.0 \times 10^{-3}$. Fig. 3 and 4 show the frequency characteristics of the reflection and the gain. The reflection is less than -11dB, and the realized gain exceeds 9dBi over 57-66GHz. The radiation patterns in the E- and H-planes are shown in Fig. 5. The 3 dB-down beamwidths in the E- and H-planes are 55.2° and 55.7° at 61.5GHz, respectively. Equal beamwidth is obtained both in the E- and H-planes. These results fulfill the design specifications.

4. Conclusion

We have presented the design and the simulated results of the metal cap with two radiating slots for a mobile module substrate. The reflection, the realized gain and the beamwidths fullfill the design specifications. From these results, this antenna can be used to realize a WPAN for mobile devices. As future works, we will fabricate the metal cap and measure the characteristics.

References

[1] WPAN Millimeter Wave Alternative PHY Task Group 3c (TG3c), “IEEE 802.15,” Jan. 2015. [Online]. Available: http://www.ieee802.org/15/pub/TG3c.html

[2] K. Ito, J. Hirokawa, K. Sakurai and M. Ando, “Design of a metal cap with two slots covering the tip of a module substrate for 60-GHz,” IEEE iWEM Aug. 2014.

[3] K. Ito, J. Hirokawa, K. Sakurai, M. Ando, "Metal Cap with Two Slots covering an Edge of a Mobile Device Substrate for 60GHz Band," Intl. Synp. Antenna Propagat., TH1D-03, Dec. 2014.

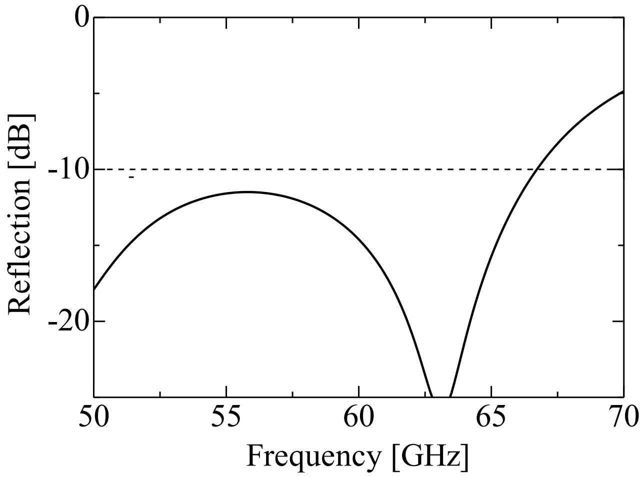

Fig. 3. Frequency characteristic of reflection

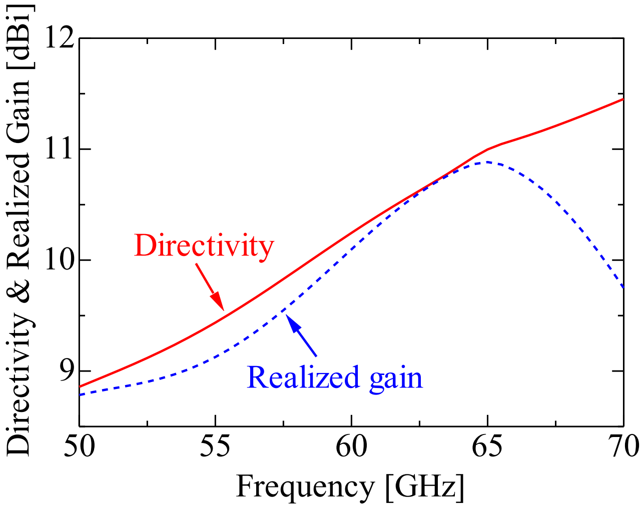

Fig. 4. Frequency characteristic of directivity and realized gain

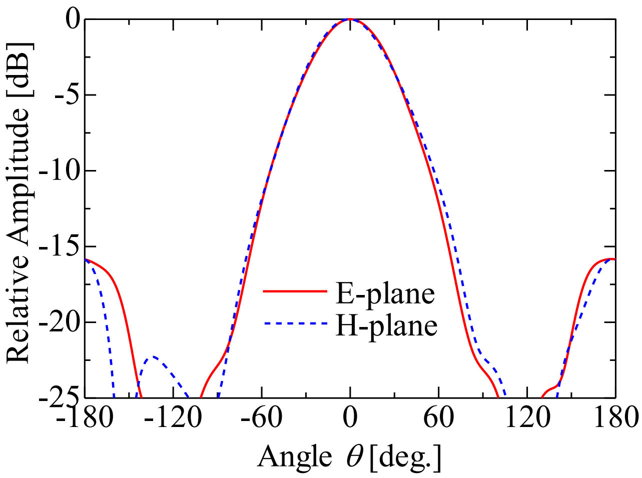

Fig. 5. Radiation patterns of the designed antenna (at 61.5 GHz)