UHF-Band Meander Line Antenna and 60-GHz-Band Patch Antenna with Single Feed Structure for 5G Terminal Application

S. Yoshida[1], K. Maruyama[2], D. Matsushita[2], and K. Nishikawa[1]

1 Research Field in Engineering, Research and Education Assembly, Kagoshima University
1-21-40 Korimoto Kagoshima, 890–0065 Japan
Email: yoshida@eee.kagoshima-u.ac.jp
2 Dept. of Electrical and Electronics Engineering, Graduate school of Science and Engineering, Kagoshima University
1-21-40 Korimoto Kagoshima, 890–0065 Japan

***Abstract* — This paper demonstrates a UHF- and 60-GHz bands antenna with single feed structure for 5G terminal application. The single feed structure by a coaxial connector is used in the proposed antenna to be integrated with the dual-band frontend. A meander-line-antenna and a circular patch antenna is adopted for UHF- and 60-GHz-bands operation. Gains of 1.8 dBi at 795 MHz and 7.8 dBi at 62 GHz is achieved by the simulation.**

***Index Terms* — patch antenna, balanced antenna, UHF antenna, millimeter-wave antenna.**

1. Introduction

Wireless communication system for cellular networks is widely developed and successfully realized the 4G system. The next generation cellular system, called 5G is a new target of the development in recent years. Sub-mm- or mm-wave-band is considered to be used in the 5G system. An antenna for the new band is required to be integrated in the terminal. Conventional UHF- and microwave-bands antenna is packaged into the 4G terminal. The mm-wave-band antenna will be additionally packaged into the 5G terminal. Toward realization of the 5G terminal, a 60 GHz CMOS chipset is proposed [1].

As for the mm-wave-band antenna, single frequency band 60 GHz antenna has been developed [2]–[4]. On the other hand, a single frequency UHF-band antenna was proposed [5]. For the 5G terminal, mm-wave-band antenna is strongly demanded to be integrated with the conventional 4G terminal antenna (UHF band and 2.4/5 GHz band). A tri-band (2.4, 5.2 and 60 GHz) antenna is proposed [6]. The integration of the dual-band monopole antenna and the microstrip grid array antenna are described. However, a UHF-band antenna was not integrated with 60-GHz-band antenna.

This paper proposes a UHF- and 60-GHz bands antenna with single feed structure for 5G terminal application. As a first step evaluation, the proposed antenna is designed by 3-D electromagnetic field simulation. S-parameter, gain, and radiation pattern are evaluated in this simulation.

2. Antenna Design

In this section, the proposed antenna is designed using a 3-D electromagnetic field simulation. CST STUDIO SUITE is used in the simulation. Figs. 1 and 2 show a whole structure of the proposed antenna and enlargement of the feed structure, respectively. Total size of the proposed antenna is 21 mm (a) x 84 mm (b) x 5 mm (e). Other relevant parameters are c = 9 mm, d = 1 mm, f = 10 mm, g = 2 mm, and h = 1.2 mm. A UHF-band meander line antenna (MLA) is placed using folded-structure. The folded-structure is utilized in the proposed antenna to increase input resistance at the feeding point. Total turn number is eight. Distance between an upper and a lower element is 0.8 mm. A 60-GHz-band single element circular patch antenna is located at the center of the MLA. Substrate material of Rogers RT5880 with thickness of 2.5mm is used. Relative dielectric constant and loss tangent of 2.2 and 0.0009 is used in the simulation. A diameter of the patch element is 1.6 mm. The feed point locates at a point of 0.45mm away from the edge of the patch element. The MLA operates as a balanced antenna while the patch antenna operates as an unbalanced antenna.

A feed point is set at the back side of the patch antenna as a coaxial port. The MLA is directly connected to the patch element as well as ground plane without a balun.

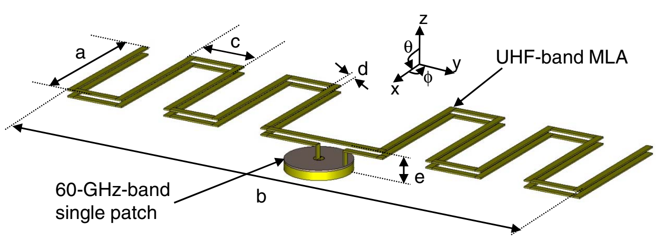

Fig. 1. Proposed antenna for UHF- and 60-GHz bands with single feed structure.

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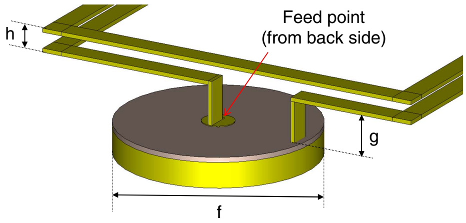
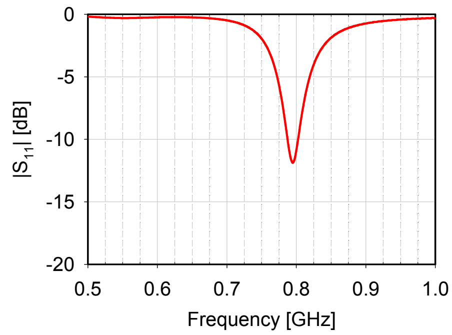
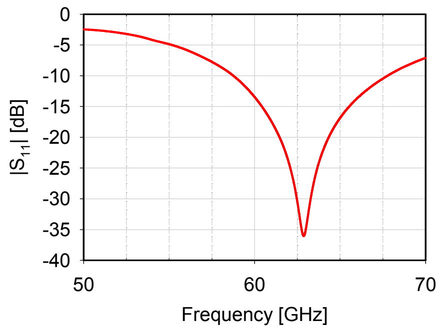


Fig. 2. An enlargement of the feed structure.



(a)



(b)

Fig. 3. Simulation results of S-parameters: (a) UHF-band and (b) 60-GHz-band.

3. Simulation Results

Fig. 3 shows a simulated result of a S-parameter. Acceptable reflection characteristics of below -10 dB was obtained for both frequency band. More improvement may be required for UHF-band operation in the next step. Figs. 4 and 5 show simulated results of radiation patterns. The radiation pattern is plotted in gain. The gains of 1.8 dBi and 7.8 dBi were obtained at 795 MHz and 62 GHz, respectively. The radiation patterns at 795 MHz is derived from the MLA. The radiation patterns at 62 GHz is derived from the single patch. The radiation patterns are slightly distorted by the UHF-band MLA. However, the radiation patterns still keep the original patterns of a single patch antenna. From these simulation results, the proposed antenna proved to operate in both UHF- and 60-GHz-bands.

4. Conclusion

UHF- and 60-GHz bands antenna with single feed structure for 5G terminal application is developed as a first step evaluation. The single feed structure by a coaxial connector is used in the proposed antenna to be integrated with the dual-band front-end. A MLA and a circular patch antenna is adopted for UHF- and 60-GHz-bands operation. Gains of 1.8 dBi at 795 MHz and 7.8 dBi at 62 GHz is achieved by the simulation. The development of the proposed antenna is continued to be feasible being used in a future 5G terminal.

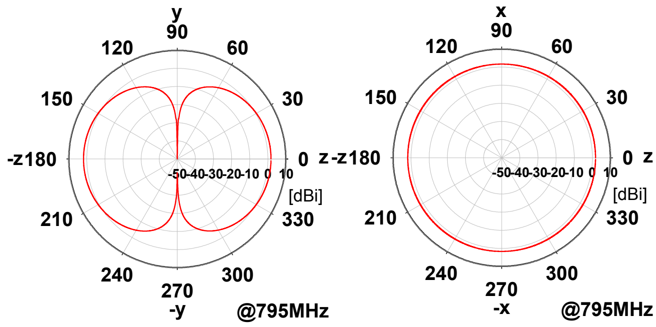


Fig. 4. Simulation results of radiation patterns at 795 MHz.

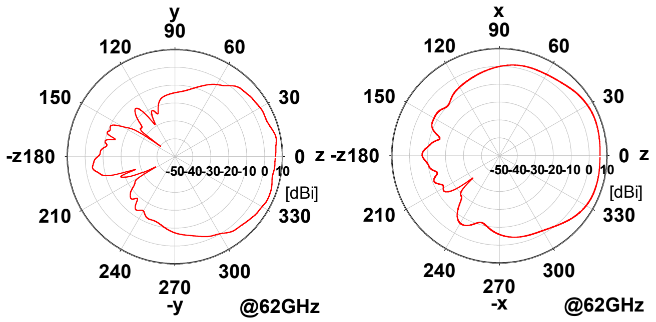


Fig. 5. Simulation results of radiation patterns at 62 GHz.

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References

[1] G. Mangraviti, K. Khalaf, Q. Shi, K. Vaesen, D. Guermandi, V. Giannini, S. Brebels, F. Frazzica, A. Bourdoux, C. Soens, W. Van Thillo, and P. Wambacq, "A 4-antenna-path beamforming transceiver for 60 GHz multi-Gb/s communication in 28nm CMOS," in *IEEE Int. Solid-State Circuits Conf. Dig. Tech. Papers*, pp. 246–247, Jan. 2016.

[2] A. E. Mansour, H. H. Abdullah, S. E. Kishk, M. E. A. Abo-Elsoud, and G. Boeck, "60 GHz compact omnidirectional printed antenna," in Proc. *IEEE AP-S Int. Symp.*, pp. 1865–1866, July 2014.

[3] Y. P. Zhang, M. Sun, K. M. Chua, L. L. Wai, and D. Liu, "Antenna-in-package design for wirebond interconnection to highly integrated 60-GHz radios," *IEEE Trans. Antennas Propag.*, vol. 57, no. 10, pp. 2842–2852, Oct. 2009.

[4] R. Suga, H. Nakano, Y. Hirachi, J. Hirokawa, and M. Ando, "Cost effective 60-GHz antenna-package with end-fire radiation from open-ended post-wall waveguide for wireless file-transfer system," in *IEEE MTT-S Int. Microw. Symp. Dig.*, pp. 449–452, May 2010.

[5] F. Paredes, G. Zamora, F. J. Herraiz-Martinez, F. Martin, and J. Bonache, "Dual-band UHF-RFID tags based on meander-line antennas loaded with spiral resonators," *IEEE Antennas Wireless Propag. Lett.*, vol. 10, pp. 768–771, Aug. 2011.

[6] L. Zhang, K. Y. See, B. Zhang, and Y. P. Zhang, "Integration of dual-band monopole and microstrip grid array for single-chip tri-band application," *IEEE Trans. Antennas Propag.*, vol. 61, no. 1, pp. 439–443, Jan. 2013.