A 60GHz Self-Shielded Yagi Antenna with Pyramidal Horn

Tae Hwan Jang, Hong Yi Kim and Chul Soon Park
School of Electrical Engineering, KAIST, 291 Daehak-ro, Yuesong-gu, Daejun 34141, Korea

***Abstract* – The paper presents a 60GHz self-shielded Yagi antenna with pyramidal horn for compact integration to mobile device. The proposed antenna can provide a peak gain of 13.37dBi with 19GHz 3-dB bandwidth and 16GHz of impedance bandwidth. A 5.8dB of antenna gain is increased by adding pyramidal horn. The HPBW is 22deg for the both E- and H-plane.**

***Index Terms* — Pyramidal horn, Self-shielded, Yagi antenna, 60GHz**

1. Introduction

Based on 57-66GHz, 60-GHz unlicensed frequency based communication can be realized up to several-Gbps data-rate unlike other communication method using 2-5GHz frequency band. Frequency reuse can be possible due to severe path loss and the obstacle which makes it ideal for Gbps short distance communication. As a result, numerous practical applications such as mobile distributed computing, wireless gaming, fast bulky file transfer etc. will be feasible with this unlicensed band. In the past 2–3 years, many 60 GHz CMOS transceiver chips and antennas was reported [1]–[3].

Many small mobile gadgets need components of which operating frequency is 60GHz, and this component should be isolated from other component. Self-shielded Yagi-Uda antenna is presented with two metal shields[4]. But that design suffers from large volume and poor aperture efficiency.

In this paper, we present a self-shielded Yagi-Uda antenna with pyramidal horn. The design is based on 60GHz. It occupies small volume and present high aperture efficiency.

2. A 60GHz Self-Shielded Yagi Antenna with Pyramidal Horn

Fig. 1 presents the structure of the 3-element self-shielded Yagi antenna array with pyramidal horn. The Yagi antenna is built on Teflon substrate with a thickness of 250um which is corresponding to 0.05λ_0, a dielectric permittivity (εr) of 2.2, metal thickness (t) of 18um, and loss tangent ($\tan\delta$) of 0.002. For practical use, the Yagi antenna is on the planar circuit board. The Yagi antenna is excited by Coplanar-waveguide with a ground(GCPW) line. The pyramidal horn is used for high aperture efficiency and self-shielded characteristics. The length, width and height of the pyramidal horn is 9mm, 6mm and 8mm. The antenna is optimized using HFSS.

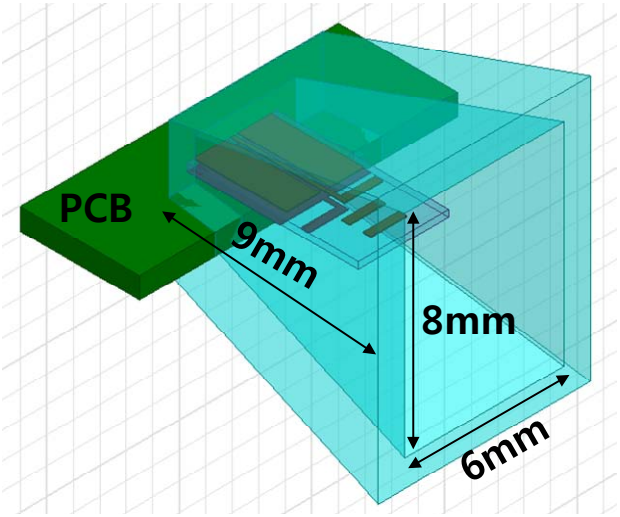

Fig. 1. Structure of the 60GHz Self-shielded Yagi antenna with pyramidal horn

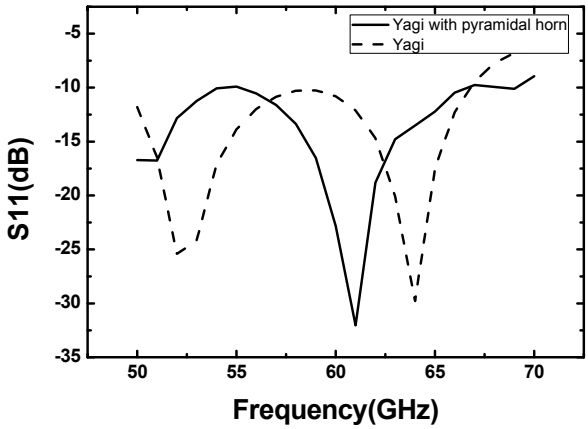

Fig. 2. Simulated S11 characteristic of the 60GHz Yagi antenna and Self-shielded Yagi antenna with pyramidal horn

Fig. 2 and Fig. 3 shows simulated S11 and realized gain characteristics of the 60GHz Yagi antenna with and without pyramidal horn. The simulated impedance bandwidth of the Yagi antenna is 16GHz(50-66GHz). The peak realized gain and 3-dB gain bandwidth of the Yagi antenna is 7.6dBi(at 57GHz) and 20GHz(50-70GHz). The simulated impedance bandwidth for the proposed antenna is 16GHz(50GHz to 66GHz). The peak realized gain is 13.37dBi(at 67GHz) and 3-dB gain bandwidth is 19GHz(51-70GHz). From this data, 5.8dB of gain is increased by adding pyramidal horn. Fig. 4 shows calculated aperture efficiency from simulated gain.

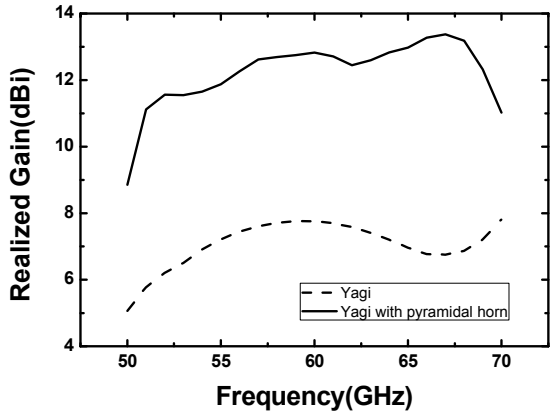

Fig. 3. Simulated gain characteristic of the 60GHz Yagi antenna with and without pyramidal horn

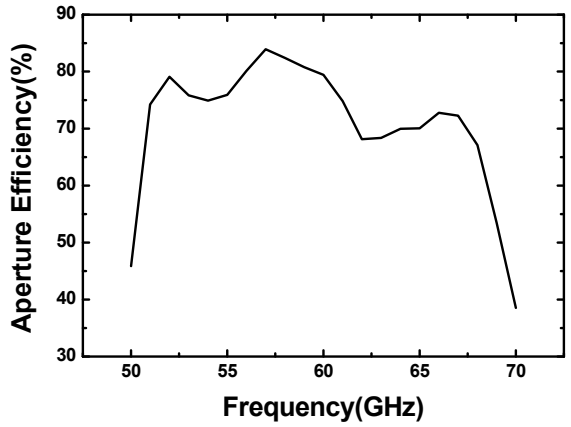

Fig. 4. Simulated aperture efficiency characteristic of the 60GHz Yagi antenna with and without pyramidal horn

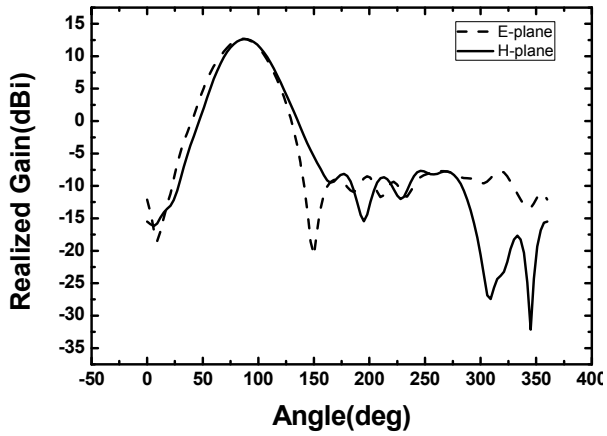

Fig. 5. Simulated radiation pattern of the 60GHz self-shielded Yagi antenna with pyramidal horn

The simulated peak aperture efficiency is 84% at 57GHz, and average aperture efficiency is 75%. Fig. 5 describes radiation pattern of the proposed antenna. HPBW for the E- and H- plane shows 22deg. The radiation pattern of the E- and H-plane is symmetric. Table I shows previously published self-shielded antenna and our proposed antenna for 60GHz communication. The antenna area, gain, bandwidth and aperture efficiency characteristic of the proposed antenna shows better than the Ref.[4]. That's because, overall characteristics of the pyramidal horn antenna is better than rectangular horn antenna.

TABLE I
Previously Published 60GHz Self-Shielded Antenna

Ref.	Peak Gain	Aperture Area	Impedance BW	3-dB Gain BW	Aperture Efficiency
[4]	12dBi	80mm²	10.4GHz	5GHz	39.4%
This work	13.4dBi	48mm²	16GHz	19GHz	84%

3. Conclusion

A 60-GHz self-shielded Yagi antenna with pyramidal horn is presented. The proposed antenna provides a peak gain of 13.37dBi with 19GHz 3-dB bandwidth and 16GHz of impedance bandwidth. The HPBW is 22deg for the both E- and H-plane. Compared to the other types of antenna, the presented antenna shows highest aperture efficiency performance. It implies the presented antenna obtain desirable gain with smallest volume. Therefore, we concluded that the proposed antenna is suitable for use in 60-GHz communication system.

Acknowledgment

This research was funded by the Ministry of Science, ICT & Future Planning (MSIP), Korea in the ICT R&D program of 2016.

References

[1] C. W. Byeon, C. H. Yoon, and C.S. Park, "A 67-mW 10.7-Gb/s 60-GHz OOK CMOS transceiver for short range wireless communications", *IEEE Trans. Microwave Theory and Techniques*., vol. 61, no.9, pp. 3391-3401, Aug. 2012

[2] J. J. Lee, and C. S. Park, "60-GHz gigabits-per-second OOK modulator with high output power in 90-nm CMOS", *IEEE Trans. Circuits and Systems-II : Experss Briefs*., vol. 58, no.5, pp. 249-253, May. 2011

[3] T. Jang, H. Kim, I. Song, C. Lee and C. Park, "Low-profile Wideband E-shaped Patch Antenna for 60GHz Communication", *in Proc. Asia Pacific Microwave Conference(APMC),* Nanjing, China, pp. 1440-1442, Dec. 2015.

[4] R. A. Alhalabi, Y. C. Chiou, and G. M. Rebeiz, "Self-shielded high-efficiency yagi-uda antennas for 60 GHz communications", *IEEE Trans. Antennas and Propagations,* vol. 59, no. 3. pp, 742-750, Mar. 2011.

[5] C.A. Balanis, *Antenna Theory: Analysis and Design*, 3rd ed. New work: Wiley, 2005.