Feasibility of Radiation Pattern Measurement using a Photo Detector for Small Antennas in the 60GHz Band

[#]Kazuki Kinoshita , Kimio Sakurai , Jiro Hirokawa and Makoto Ando
Dept. of Electrical and Electronic Eng., Tokyo Institute of Technology
S3-19, 2-12-1, O-okayama, Meguro-ku, Tokyo, 152-8552, Japan , kinoshita@antenna.ee.titech.ac.jp

Abstract

This paper demonstrates the measurement of radiation patterns with a short propagation distance of about 0.5m for weak signal using a photo detector for a patch antenna in the 60GHz band. The radiation patterns within ±36.5 deg. fairly agree with those measured in an anechoic chamber at a distance of 6m.

Keywords : Optical feeding method Patch antenna Photodetector Millimetre-wave

1. Introduction

Broadband wireless communication systems such as wireless personal area network (WPAN) using unlicensed 60 GHz band are desired for indoor high-speed applications. Integrated antennas on a chip and in a package for the RF modules have been recently investigated. It is important to measure a small antenna integrated in a RF module accurately. Because feed by a RF cable could sometimes affect the radiation pattern by unwanted current on it [1][2], the feed combined with optical fibres and photonic devices has been developed [3]-[6]. We are developing a measurement system using a photo detector (PD) and a modulator for a short distance of about 0.5m between a test and a receiving antenna because the signal level radiating from the test antennas is very weak (about -40dBm). Unfortunately we have not finished yet, so that we show the measured results using a RF cable in this paper.

2. Measurement system using a photo detector in the 60GHz band

Figure 1 shows the measurement system using a PD in the 60GHz band. Because the modulation frequency by RF signal is high such as 60GHz, we cannot use direct modulation in a laser. We have external modulation. A light wave generated by a laser is modulated by a modulator with input of RF signal. The modulated light wave is then transmitted by an optical fibre to a PD and is converted back to the RF signal. The RF signal is fed to a test antenna. Forward bias of 2.9V is applied to the modulator. Reverse bias of 2.0V is applied to the PD. Figure 2 shows the frequency dependence of the transmission by measuring the RF output signal from the PD directly. The transmission is quite small (about -40dB) at 60GHz. This reduction comes from the optical-electrical (O-E) and E-O conversion losses. If the RF input signal is 0dBm, the RF output signal feeding the test antenna is -40dBm. The radiation level from the test antenna is so weak that we construct a radiation pattern measurement with a short propagation distance (or height) of 0.472m to a receiving waveguide probe which is fixed with a linear actuator of 0.7m long as shown in Fig.1. The measuring angle range is ±36.5 deg. We correct the receiving level by including the radiation pattern of the waveguide probe and the distance between the test antenna and the waveguide probe depending to the receiving angle.

3. Design of a patch antenna

We design a patch antenna shown in Fig.3. The patch antenna with a rectangular shape is placed on a dielectric substrate of 45mm square. The dielectric substrate is placed in a metal fixture of 55mm square. The patch antenna is fed through a glass bead. An air gap is placed between the dielectric substrate and the glass bead for matching. We determine the size of the patch antenna, the feeding position and the dimension of the air gap to minimize the reflection at 60GHz.

4. Measurement of the patch antenna

4.1 **Reflection**

At this moment, we have not done the measurements by the PD. We have done by direct connection by a RF cable in the above-mentioned equipment with the short height of 0.472m between the test antenna and the waveguide probe. Figure 4 shows the frequency dependence of the reflection. In the design, the bandwidth is 6.3% for less than -10dB. The operation frequency in the measurement agrees with that in the design. However, the measured reflection is -10.5dB at that frequency.

4.2 **Radiation pattern**

Figure 5 shows the radiation patterns at 60.0GHz. For comparison, we add the radiation patterns measured in an anechoic chamber where the propagation distance is 6m between the test antenna and a receiving horn antenna. The agreements among the three results are fairly good. In the H-plane, the radiation pattern by the short distance has a bit narrower beamwidth. In the E-plane, the short-distance measurement gives ripples by the finite size of the metal fixture.

5. Conclusion

We have shown the radiation patterns with propagation distance of 0.472m with the angle range of ±36.5 deg by using a RF cable, which fairly agree with those measured in an anechoic chamber at a distance of 6m. We are trying to show the results by a PD at the conference.

References

[1] T. Fukasawa, K. Shimomura, M. Ohtsuka, "Accurate Measurement Method for Characteristics of an Antenna on a Portable Telephone," IEICE, vol. J86-B, no. 9, pp.1895-1905, Sep. 2003.
[2] K. Fujimoto, "Measuring Method of Small Antennas," IEICE Technical Report, AP89-S9, 1989.
[3] K. Li, H. Cheng, M. Izutsu, "Research and Development of Photonic Feeding Antennas," Review of the Communications Research Laboratory, vol. 48, no.1, pp. 37-44, Mar. 2002.
[4] S. Nabekura, R. Amemiya, Y. Okano, M. Tokuda, "Radiated Electric Field Characteristics of a Monopole Antenna using the Optical Feeding Method," IEICE, Tech Rept., EMCJ 2003-103, Sep. 2003.
[5] M. L, VanBlaricum, "Photonic Systems for Antenna Applications," IEEE Antennas Propag. Mag., vol. 36, no.5, pp. 30-38, Oct. 1994.
[6] K. Miura, K. Sakurai, J. Hirokawa, M. Ando, "A Study of Radiation Pattern Measurement using Optical Fiber for Small Antennas in High Frequency Band," IEICE General Conf., B-1, 59, Mar. 2008.

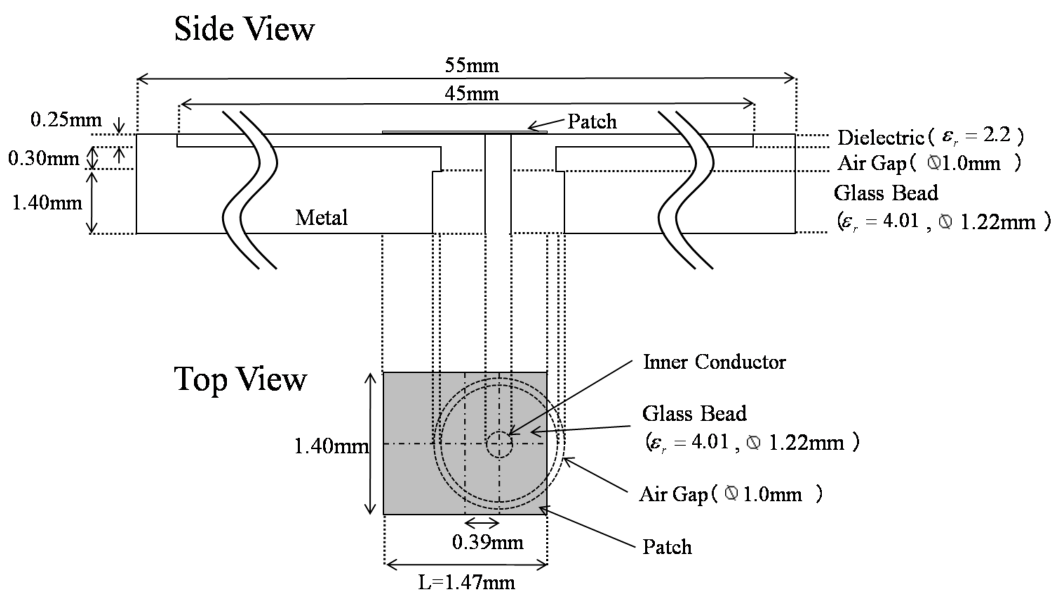

Figure 1: Patch antenna

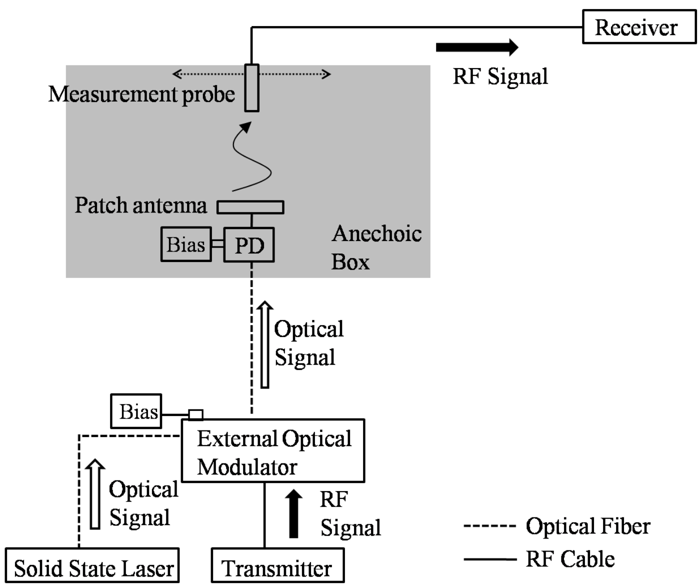

Figure 2: External laser modulation

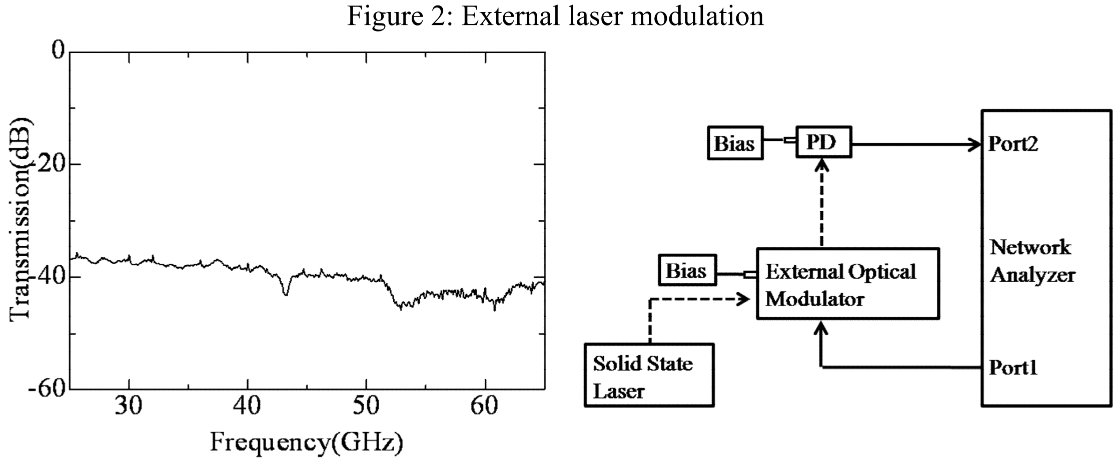

Figure 3: Transmission

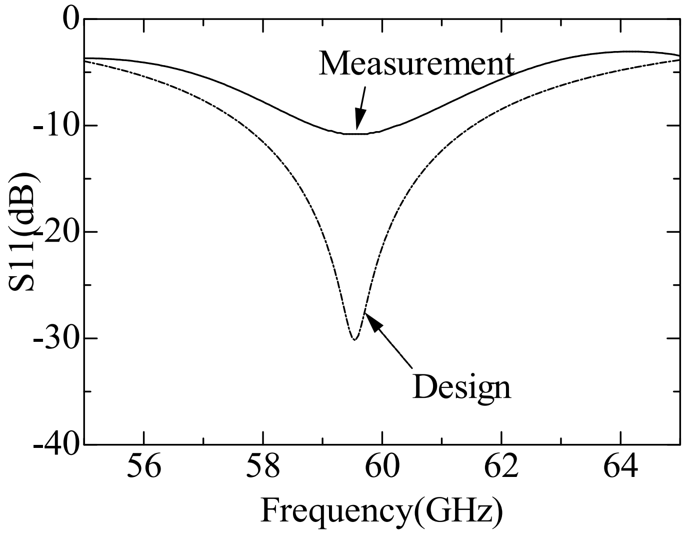

Figure 4: Reflection

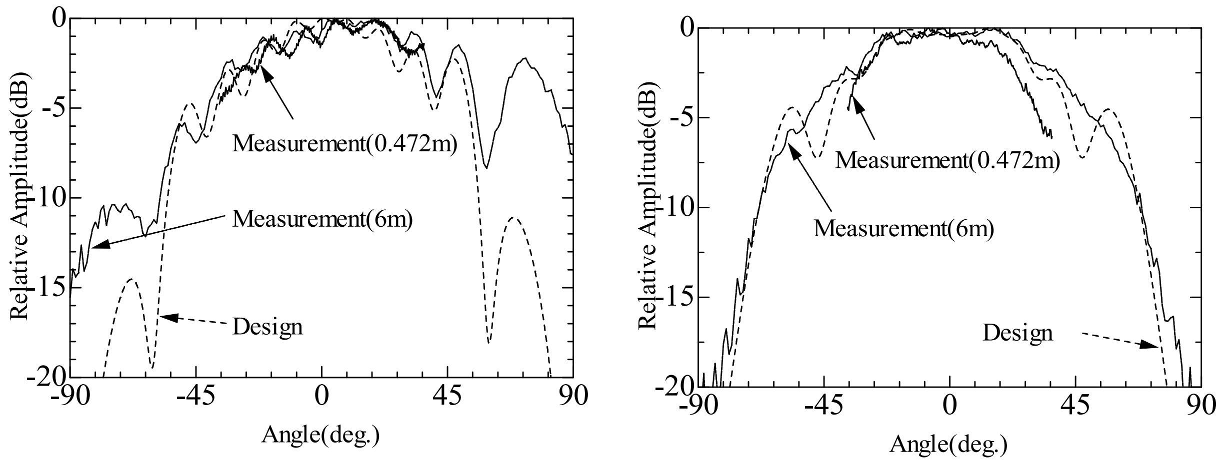

Figure 5(a): E-plane

Figure 5(b): H-plane

Figure 5: Radiation pattern of a patch antenna