Radiation Characteristics of a Microstrip Antenna on a Triangular Ground Plane

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1. Introduction:

Recently, much attention has been paid to ultra high-speed indoor wireless LANs (Local Area Networks) at microwave or millimeter wave band. At Communications Research Laboratory(CRL), three kinds of different antenna configurations are now under consideration[1]. Among them, a swiched multi-sector-beam antenna composed of pyramidal antennas(Fig.1)[2] is one of the candidates for ultra high-speed indoor wireless LAN antennas. Because they have following advantages, such as directivity improvement, suppression of multipath fading and electric beam control capability.

In this antenna, the effects of finite ground plane and the asymmetrical shape of substrate and ground plane in elevation angle seems affect the radiation characteristics. The former investigations[3][4], however, mainly focused on the finite rectangular ground plane and the effects of them have not been clarified yet.

In this paper, we experimentally investigated the radiation characteristics of a microstrip antenna on a triangular ground plane. The experiment was conducted at 5.0GHz band. The beam tilt, depending on the location of an MSA antennas on a triangular ground plane, was observed.

2. Antenna configuration:

Figure 2 shows the schematic view of MSA on a triangular ground plane and the coordinate system. The antenna parameters are listed on Table 1. For convenience, only an equilateral triangular ground plane and circular microstrip antenna was considered. MSA was designed so that it had the resonant frequency of about 5.0GHz. The direct pin-fed method was used to feed MSA.

3. Radiation patterns:

Figure 3a shows the radiation pattern in the XZ-plane(E-plane) at 4.968GHz when the polarization was parallel to the X-axis, while Figure 3b shows the pattern in the XZ-plane(H-plane) when the polarization was parallel to the Y-axis. In both cases, side length of the ground plane was 120mm(2.0λ) and MSA was at the center of gravity of the ground plane. The beam tilt can be seen for both cases. The tilt angle was -7.0 degrees(Fig. 3a) and -9.0 degrees(Fig. 3b) from the zenith direction. This beam tilt may be due to the asymmetry of the ground plane. Because no beam tilt were observed in the YZ-plane for both cases.

Figure 4 shows the XZ-plane(E-plane) patterns as a function of triangular ground plane size, when the polarization is parallel to the X-axis and MSA was located at the center of gravity. The side length of 97mm, 108mm, and 114mm were examined. The patterns on half base line side($\theta \leq 0$) were unchanged, while those on half vertex side($\theta \geq 0$) were changed depending on the ground plane size. This means that the diffraction at the vertex may be the main contributor to the degradation of patterns.

Figure 5 shows the relation between the maximum received power direction angle and MSA offset from the center of gravity at 4.968GHz. Here, MSA was moved along the X-axis, the polarization was parallel to the X-axis and the side length was fixed to 120mm. In Fig. 4, the line shows the least mean square value obtained from the measured data and expressed as;

$$\text{Beam tilt [deg]} = -1.07 * \text{offset[mm]} - 6.24$$

Figure 6 plots the 3dB beam width as a function of the offset from the center of gravity. The other conditions were same as those in Fig. 5. The beam width became wide as the offset increased. From these figures, it can be said that changing the location of MSA changes the diffracted fields and consequently the beam is tilted. Figure 7 plots E-plane pattern at 4.968GHz when MSA was 5.4mm offset from the center of gravity. The beam was tilt by 14.5 degrees from the zenith direction. The level at zenith direction was about 1dB down, compared to the peak. The cross polarization level was less than -20dB within the considered angle range.

4. Conclusion:

In this paper, we presented the radiation characteristics of a microstrip antenna on a triangular ground plane. Effects of finite ground plane size and the location of a microstrip antenna on a triangular ground plane were examined. The beam can be tilt by means of the change in the location of a microstrip antenna on a triangular ground plane.

Obtained results will be helpful to realize pyramidal antennas for indoor wireless LAN at millimeter wave band.

References:

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[3] S. H. Zainud-Deen, et. al., 'Air Dielectric Microstrip antenna on infinite and finite size ground planes,' Proc. of ISAP'89, pp.13-16, 1989.
[4] D. I. Kaklamati and N. K. Uzunoglu, 'Scattering from a finite size grounded dielectric substrate excited by a plane wave or an elementary dipole source,' 1993 IEEE AP-S International Symp., Antennas Propagat. Digest, pp.956-959.

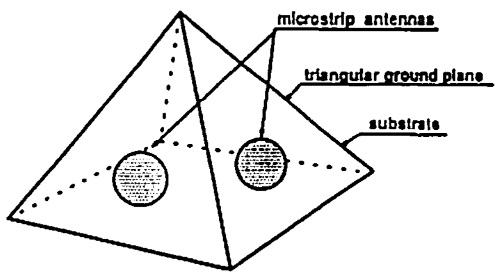

Figure 1: Schematic view of pyramidal antennas.

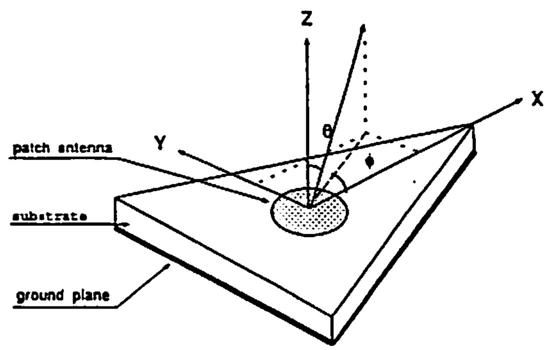

Figure 2: Schematic view of MSA on a triangular ground plane.

Table 1: Antenna parameters

dielectric constant	$\varepsilon_r = 2.6$
substrate thickness	0.8mm
patch shape	circular
patch radius	10.5mm
resonant frequency	4.968GHz(Exp.)

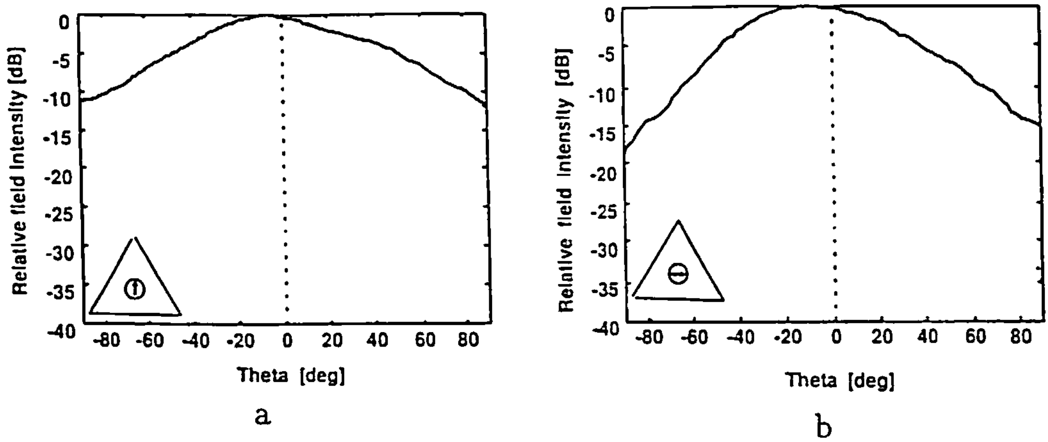

Figure 3: Radiation patterns in the XZ-plane, when the polarization was parallel to X-axis(a) and to Y-axis(b).

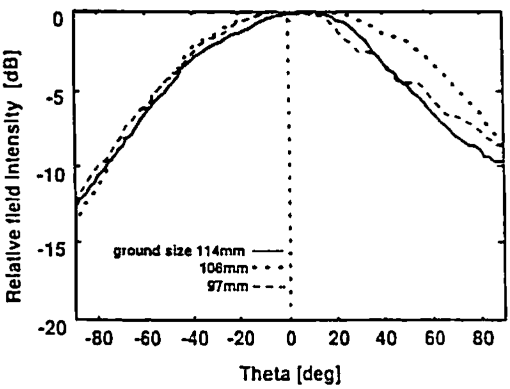

Figure 4: E-plane radiation pattern as a function of triangular ground plane size.

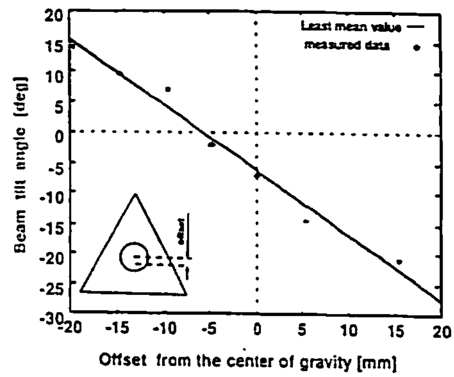

Figure 5: The maximum received power direction as a function of the offset from the center of gravity.

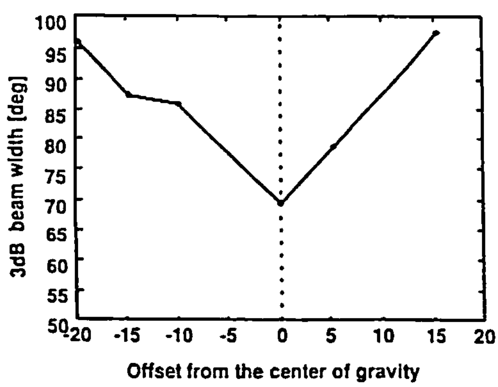

Figure 6: 3dB beam width as a function of the offset from the center of gravity.

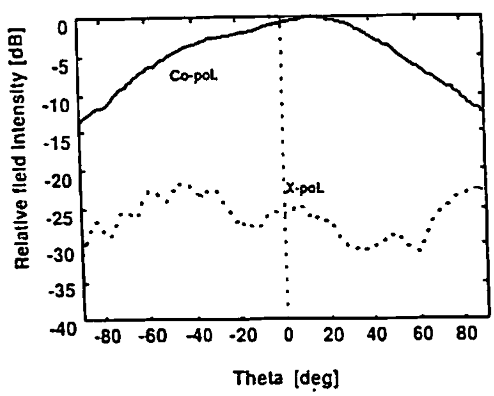

Figure 7: E-plane pattern at 4.986GHz when MSA was 5.4mm offset from the center of gravity.