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A Horizontal Polarized Omnidirectional Pattern Antenna composed of Two Notched-Plate Panel Elements

Nobuhiro Kuga Kazuhiro Kowaita
Faculty of Engineering, Tokyo Polytechnic University
1583 Iiyama, Atsugi-shi, Kanagawa, 243-0297, Japan
TEL: +81-46-242-9557 FAX:+81-46-242-9566
kuga@m.ieice.org

1. Introduction

Horizontal polarized omnidirectional pattern antenna containable in a thin cylindrical radome is attractive for a basestation in mobile microwave-communications. When radome-radius is small, however, there is a difficulty in sharing the inner-space with the supporting device containing array-feeding cables and a lightning rod, etc. In most of the conventional small elements including C-type antenna[1], sharing the inner space with the supporting devices is difficult in the higher band such as S-band, therefore, panel-type antennas are primarily used to control or minimize the reflections from the supporting structure[2]. In many cases the supporting structure is a triangular or square tower, however, which may be too large to be contained in a thin cylindrical radome especially in the S-band.

On the other hand, the notched-plate antenna that is composed of the two feeding notches and the two parasitic notches had been proposed as a horizontal polarized omni-directional pattern antenna[3][4]. It was characterized by the wide-width notch that excites the notched groundplane, and the parasitic notch that excites the circular current producing the omnidirectional radiation pattern. It had an advantage in the structural simplicity of the power divider compared with the conventional turnstile-notch antenna. However, the space for feeding circuits is too small because the parasitic notch has closely placed, and gain enhancement in the horizontal plane by vertical-array of the element is difficult as in the presented structure.

In this paper, a novel antenna configuration applicable to panel-type omnidirectional antenna in a thin radome is proposed. The proposed antenna is based on the notched-plate antenna in the references [3][4], which is applied to a small two-panel structure sharable the inner space with the supporting structures. The basic characteristics of the antenna designed for 2GHz band are examined by using the finite integration theory[5], and the obtained horizontal polarized omnidirectional pattern is presented in this paper.

2. Antenna configuration

Fig.1(a) shows the configuration of an antenna as model-A. It is composed of two panel-elements placed axis-symmetrically for z-axis, and the spacing between them is defined as d_r. They are excited simultaneously in phase and with the same amplitudes. In this configuration, the feeding cables or circuits can be installed behind the reflector that is advantageous to form an array antenna in z-axis and suppress undesired radiation from the array feeding circuit. The front view of the panel-element (model-B) is shown in fig.1(b). It is composed of a notched-plate on a dielectric substrate and the conductive plate with W_r*L_r that is worked as a reflector. The three-notched plate of which corner is chamfered with the length of L_b is mounted perpendicularly and grounded on the conductive plate, in which the wide notch A is excited by a strip line. The model-A shown in the fig.1(a) is a realistic model for prototyping, however, an approximate model as shown in fig.1(c) is also introduced as model-C for simulation. In the model-C, the microstrip line with 50Ω as feeding circuit is neglected.

3. Antenna characteristics

At first, we examine the characteristics of the panel-type component antenna designed at 2GHz. Fig.2 shows the calculated radiation pattern of the model-C when the reflector has the width of

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W_r=100mm and the length L_r=100mm. The measured results for the model-B are also plotted and agreed well with the calculation when the E_ϕ-component is considered as a co-polarized one. Therefore, the validity of the analysis model is successfully confirmed. As shown in the fig.2(a) and (b), the panel antenna has cardioid-pattern in the xy- and the zx-planes with the half power beam width about 115°. In the yz-plane as shown in the fig.2(c), the large radiation in the E_θ-component is observed along the z-direction. It is considered as undesired cross-polarized radiation, however, which would not be serious problem because it can be cancelled when the element is used as like model-A.

Fig.3 shows the input characteristics of the component antenna. The broken line and the dot and dashed line represent the calculated and the measured ones for the model-B, which includes the effect of feeding microstrip line on the substrate in the fig.1(b), respectively. They have resembled tendency in the frequency characteristics although some small discrepancies are observed, which validates the analysis results. On the other hand, the solid line represents the calculated s11 obtained by using the model-C. As shown in the results, the input characteristics are degraded when considering the feeding microstrip line. It indicates that the narrow groundplane at the junction between the groundplane on the substrate and the reflector affects the input characteristics of the antenna, however, which can be neglect in examining radiation characteristics.

Next, the synthesized radiation pattern is evaluated in terms of circularity in the horizontal plane. The circularity here is defined as the ratio of maximum and minimum in radiation pattern. Fig.4 shows the pattern circularity of the model-A as a function of the reflector width W_r. It is shown that the width W_r does not affect the circularity while the reflector spacing d_r degrades the circularity. To obtain the horizontal pattern of which lowest level is greater than -3dB or -4dB, the reflector spacing d_r should be smaller than 10mm or 20mm, respectivly, which may not be enough to contain the feeding circuits.

Fig.5 shows the horizontal radiation patterns for different supporting structure, where the model-A1 is same with the model-A. In the model-A2, two parallel reflectors are connected on both side-edges such as a rectangular-tube. Comparison between their patterns is shown in fig.5(c). Since the radiation pattern does not depend on supporting structure, the model-A2 is used in examination hereafter. Incidentally, the mutual coupling between two panel-elements is less than -40dB which can be omitted in antenna design.

Fig.6 shows the circularity of the chamfered antenna with L_b=25.0 (model-A2) as a function of reflector spacing d_r, where the notched-plate length W_x is chosen as a parameter. Considering the spacing d_r to obtain the horizontal pattern with the minimum value of -3dB, it can be extended up to 35mm when the antenna is chamfered and the length W_x is chosen in short length while it is only 10mm for the no-chamfered antenna as discussed in the fig.4. This characteristics is degraded when the element length W_x=90mm is chosen as shown in the figure.

Fig.7 shows the calculated radiation patterns of the antenna in the form of model-A2, where the the length W_x and L_b are chosen as parameters. The vertical patterns with ϕ=0°,45°,90° are presented here in addition to the xy-plane pattern. It is found that the cross-polarized radiation observed around θ=±45° and 180°±45° can be reduced down to about -15dB when the short plate-element with W_x=75mm is chamfered at the corner such as L_b=25.0mm. Also in the xy-plane, circularity of the horizontal pattern is improved when W_x=75mm and L_b=25.0mm. This antenna can be installed in a thin cylindrical radome with the diameter of around 100mm, which is advantageous compared with conventional antenna.

4. Conclusion

The horizontal-polarized panel-type omnidirectional antenna which was applicable to a thin cylindrical radome was proposed, and its characteristics examined by using the finite integration theory were presented. It was confirmed that the two-panel antenna produced quasi-omnidirectional pattern even when the reflector-spacing is 35mm at 2GHz, which was obtained by using the chamfered and short-length element. Cross polarization was also suppressed by the element chamfering. Radiation characteristics as a function of frequency will be investigated as a future study.

5. Acknowledgment

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6. References

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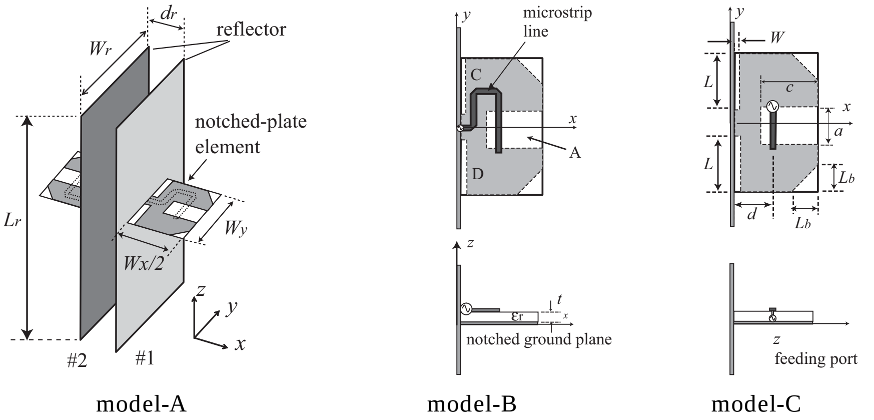
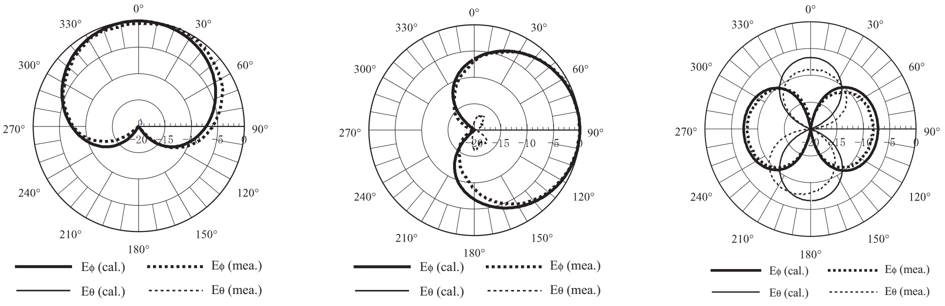


(a) two-panel antenna (b) notched-plate panel element (c) analysis model

a=15.0, c=30.0, W =1.25, L=37.0, d=25.5, L_r=100[mm], ε_r=2.6,

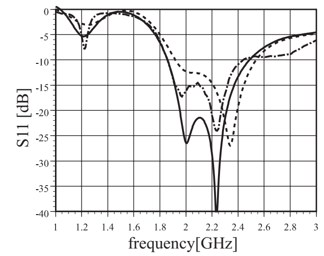
fig.1 Antenna configuration



(a) xy-plane (b) zx-plane (c) yz-plane

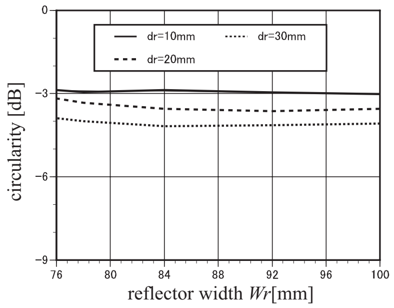
Wx =90 , Wy =78 , Wr=100, L_b=0.0 [mm]

fig.2 Calculated radiation pattern of the element #1 compared with the measurement.



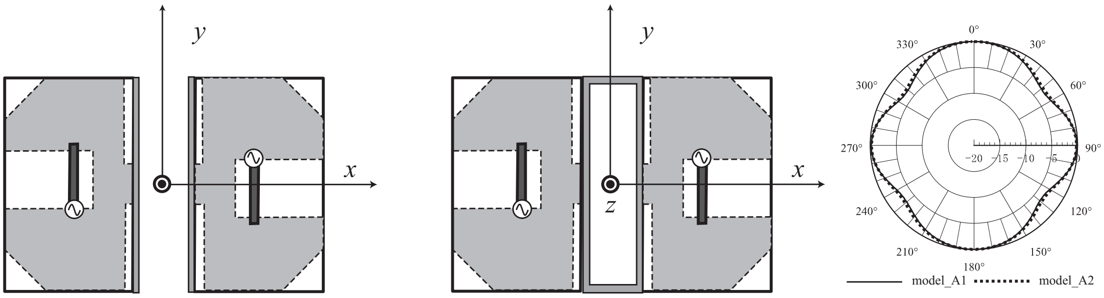
W_x =90 , W_y =78, W_r=100, L_b=0.0 [mm]

fig.3 Comparison of S11 characteristics between calculation and measurement.



Wx =90 , *Wy* =78, L_b=0.0[mm]

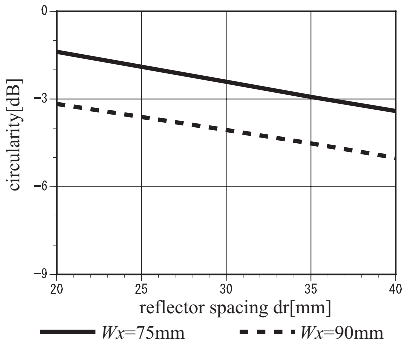
fig.4 Horizontal circularity of the two-panel antenna as the reflector width



(a) model-A1 (b) model-A2 (c) horizontal pattern

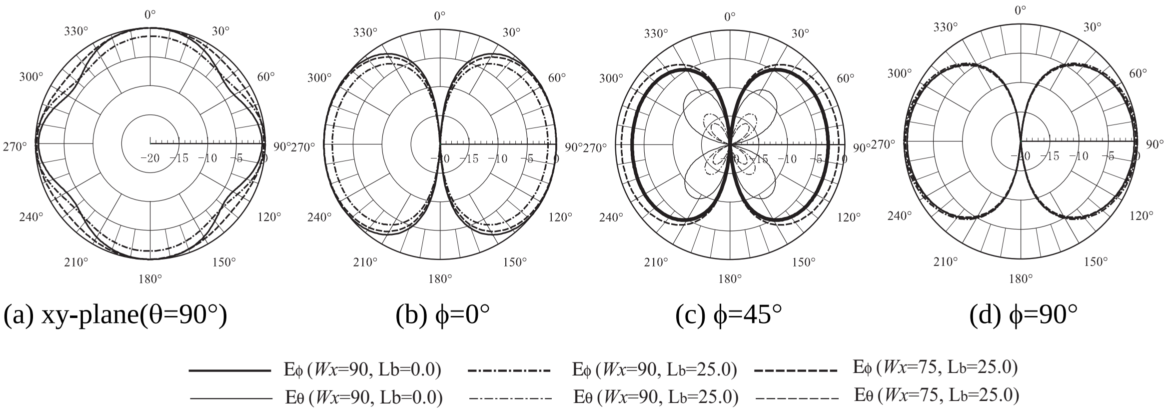
W_x=90, d_r=20, W_r=100, L_b=0.0 [mm]

fig.5 Horizontal radiation pattern for the different shape of supporting structures



W_y=78, W_r=100, L_b=25.0 [mm]

fig.6 Radiation pattern of the chamfered antenna as a function of reflector spacing d_r.



(a) xy-plane(θ=90°) (b) ϕ=0° (c) ϕ=45° (d) ϕ=90°

W_y=78, d_r=35, W_r=100[mm]

fig.7 Radiation pattern of the chamfered antenna