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論題	20GHz／30GHz帯開口共用フェーズドアレー向け円偏波リングスロット・カールアンテナ素子の基礎検討
Title	Fundamental Study on Circularly Polarized Ring Slot and Curl Antenna Elements for 20-GHz / 30-GHz Band Shared-Aperture Phased Arrays
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Fundamental Study on Circularly Polarized Ring Slot and Curl Antenna Elements for 20-GHz / 30-GHz Band Shared-Aperture Phased Arrays

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Abstract - This paper presents a fundamental study on circularly polarized ring-slot and curl antenna elements for a shared-aperture phased array operating at 20 GHz and 30 GHz. Left-handed circular polarization is generated at 20 GHz by applying a phase difference to the ring-slot antenna, while right-handed polarization is achieved at 30 GHz by changing the curling direction of the curl antenna. Simulation results confirmed low reflection and low axial ratio in both bands.

Keywords — Dual-band operation, Circular polarization, Ring slot antenna, Curl antenna

I. INTRODUCTION

Recently, low earth orbit satellite communication has attracted attention, requiring antennas with wide-angle beam scanning and the ability to handle polarization changes due to the satellite's movement. Ground stations also need to be compact and cost-effective, integrating both transmission and reception. While previous studies have achieved circular polarization and wide-angle scanning, most are limited to a single band or use linear polarization for dual bands [1][2]. To address this, we conducted a fundamental study on dual-band circularly polarized antenna elements capable of wide-angle beam scanning. This paper reports the results.

II. ANTENNA STRUCTURE

The structure of the proposed 20-GHz / 30-GHz shared-aperture ring-slot and curl antenna element is shown in Fig. 1. The antenna comprises a stripline-fed ring-slot element for the 20 GHz band [1] and a microstrip-fed curl element for the 30 GHz band [3]. Two identical curl antennas are placed at the center and edge of the analysis model; when viewed from the radiation direction, their right-handed curling produces right-handed circular polarization. The ring-slot antenna employs two coupling slots, with one slot rotated by 90° relative to the other, and left-handed circular polarization is obtained by introducing a 90° excitation phase difference in the stripline at Port 1 and 2. Power is supplied directly to the curl antenna, whereas the ring-slot antenna is excited through stripline electromagnetic coupling.

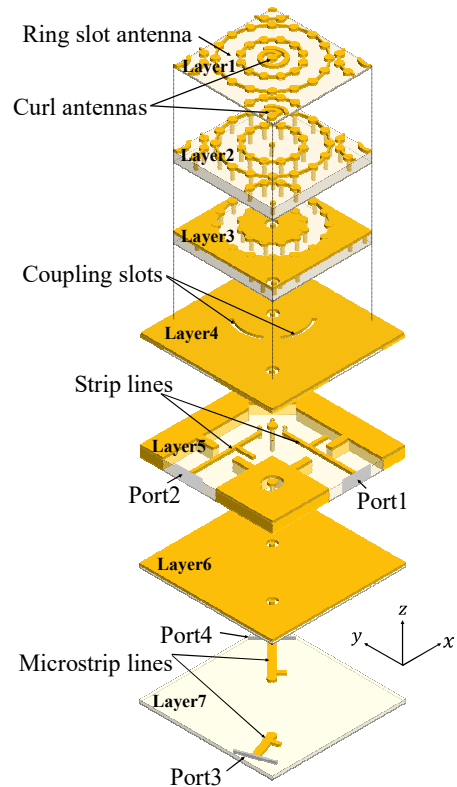


Fig. 1. Antenna structure

III. ANTENNA ANALYSIS AND DESIGN RESULTS

The antenna structure was analyzed using a finite-element electromagnetic simulator. The target frequency ranges are 17.7–20.2 GHz for the 20 GHz band and 27.5–30 GHz for the 30-GHz band. For the 20-GHz ring-slot antenna, performance was tuned by changing its subtended angle, while for the 30-GHz curl antenna, both the perimeter length from the feed point to the tip and the metal reflector, the ground, were adjusted to optimize the axial-ratio characteristics. Fig. 2 presents the frequency responses of the S-parameters for each port. S11 remains below –10 dB across 16.7–18.8 GHz, resulting in a bandwidth of 2.1 GHz. The isolation in Fig. 2(a) remains better than –17.5 dB within the desired portions of both the 20-GHz and 30-GHz bands. S33 stays at –7.2 dB at the

design frequency. The poorer S33 is attributed to an impedance mismatch: the center element has a double-ring structure, while the edge element has only a single ring. Because the present design uses identical antenna structures, improving S33 remains a topic for future work.

The isolation in Fig. 2(b) is also below -11.5 dB across the target ranges of both the 20-GHz and 30-GHz bands; however, the isolation between Port 3 and Port 4 is degraded. A likely cause is leakage from the curl antenna into the dielectric substrate rather than radiation into free space.

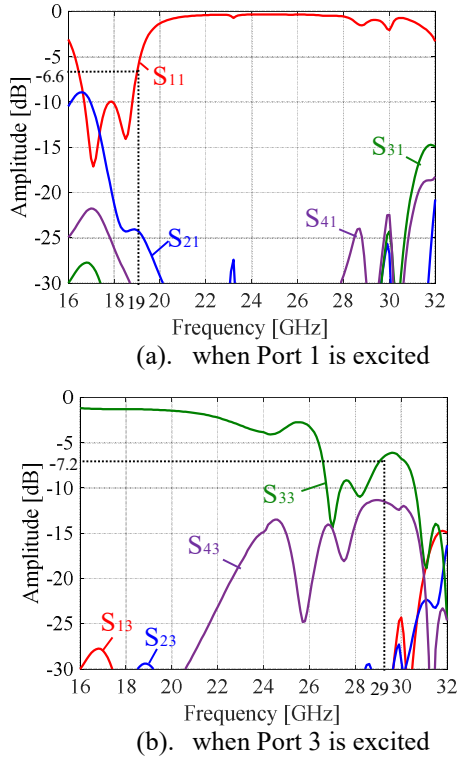


Fig. 2. Frequency characteristics of S parameters.

The frequency characteristics of the axial ratio are shown in Fig. 2. At the design frequency of 19 GHz, the axial ratio for Port 1 and Port 2 excitation was 0.81 dB, while at 29 GHz, the axial ratio for Port 3 and Port 4 excitation was 1.8 dB. The frequency characteristics of the boresight gain in the 20 GHz and 30 GHz bands are shown in Fig. 3. At 19 GHz, the realized gain of left-handed circular polarization with Port 1 and Port 2 excitation was 2.3 dBi, and at 29 GHz, the realized gain of right-handed circular polarization with Port 3 and Port 4 excitation was 8.1 dBi.

The radiation patterns at 19 GHz and 29 GHz are shown in Fig. 4.(a) At 19 GHz, there is no significant difference between $\varphi = 0^\circ$ and 90° , and the cross-polarization level remains below -20 dBi over the range of $\theta = -90^\circ$ to 90° . Similarly, in Fig. 4(b), at 29 GHz, no notable difference is observed between the $\varphi = 0^\circ$ and 90° planes, and the cross-polarization level is also suppressed below -20 dBi. These results confirm that cross-polarization is sufficiently suppressed in both frequency bands.

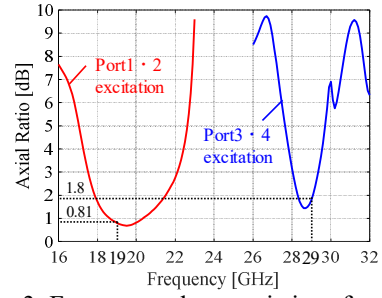
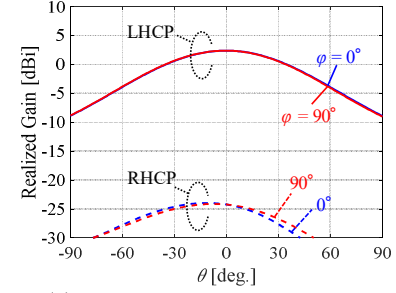
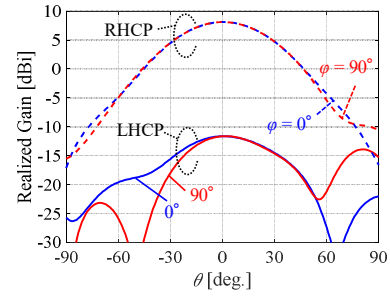


Fig. 3. Frequency characteristics of axial ratio



(a). 19 GHz Port 1 and Port 2 Excitation



(b). 29 GHz Port 3 and Port 4 Excitation
Fig. 4. Radiation Pattern

IV. CONCLUSION

This paper presents a fundamental study on circularly polarized ring-slot and curl antenna elements for a shared-aperture phased array operating at 20 GHz and 30 GHz. Left-handed circular polarization is generated at 20 GHz by applying a phase difference to the ring-slot antenna, while right-handed polarization is achieved at 30 GHz by changing the curling direction of the curl antenna. Simulation results confirmed low reflection and low axial ratio in both bands. This research was supported by a grant (JPJ012368G50501) from the National Institute of Information and Communications Technology (NICT).

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