Bidirectional Dielectric Resonator Antenna Using Slotted Ground Structure

Nan Yang, Kwok Wa Leung, and Wei Wei Li
State Key Laboratory of Millimeter Waves, Department of Electronic Engineering
City University of Hong Kong, Hong Kong SAR, China

Abstract— A bidirectional cylindrical dielectric resonator antenna (DRA) is proposed in this paper. The DRA operating in its fundamental $TM_{01\delta}$ mode is fed by an axial coaxial probe protruded from a circular ground, which has the same radius of the DRA. Two slots are fabricated on the ground to obtain a bidirectional radiation pattern. It was found that the measured gain on the azimuth plane is 3.75 dBi and −10.16 dBi in the mainlobe and sidelobe directions, respectively.

1. INTRODUCTION

Bidirectional antennas can be used in narrow and long spaces, such as railways, tunnels or straight roads [1]. Usually, the bidirectional antenna is long in length or large in size to increase the antenna gain. For example, two sets of stacked-microstrip dipole antenna are placed back to back to achieve bidirectional performance with a length of more than 2λ. In [2], six ring antennas are cascaded, giving a length of 2.4λ. Similar sizes are found in bidirectional leaky wave antennas [3]. Patch arrays are considered in [4] but occupied an area of more than $10\lambda^2$. In [5], a smaller bidirectional antenna is given, with the dimensions of $0.7\lambda * 0.35\lambda * 0.4\lambda$ and directivity of 4.43 dBi.

This paper presents a bidirectional cylindrical dielectric resonator antenna (DRA) with a radius of 0.25λ and height of 0.16λ It is excited in its fundamental $TM_{01\delta}$ mode by a coaxial probe. The DRA and ground plane have the same radius. As the $TM_{01\delta}$-mode DRA has an omnidirectional radiation pattern [6], two arc-shaped slots are introduced in the ground to obtain bidirectional radiation pattern. The two slots are symmetrically located along the x axis, stopping the surface current that flows in the $+/-x$ directions. As a result, the gain in the $+/-x$ directions are suppressed and that in $+/-y$ directions can be enhanced. To demonstrate the idea, a prototype was designed, fabricated and measured The simulated and measured gains are 4.64 dBi and 3.75 dBi in the main-lobe ($+/-y$) direction, respectively, and drop to −12.12 dBi and −10.16 dBi in the sidelobe ($+/-x$) direction, respectively.

2. ANTENNA CONFIGURATION

The configuration of the proposed antenna is shown in Figure 1, where Figure 1(a) displays the side view of the antenna while Figure 1(b) gives the top view of the slotted ground only. With reference to Figure 1(a), a cylindrical dielectric resonator with a radius of R, height of h, and dielectric constant of ε_r is mounted on a circular ground plane having a radius of R_g and thickness of t. To excite the fundamental $TM_{01\delta}$ mode, a probe with a radius of r_p and length of l_p is inserted into the DRA at its center. Two arc slots symmetrical about the center are etched on the ground to

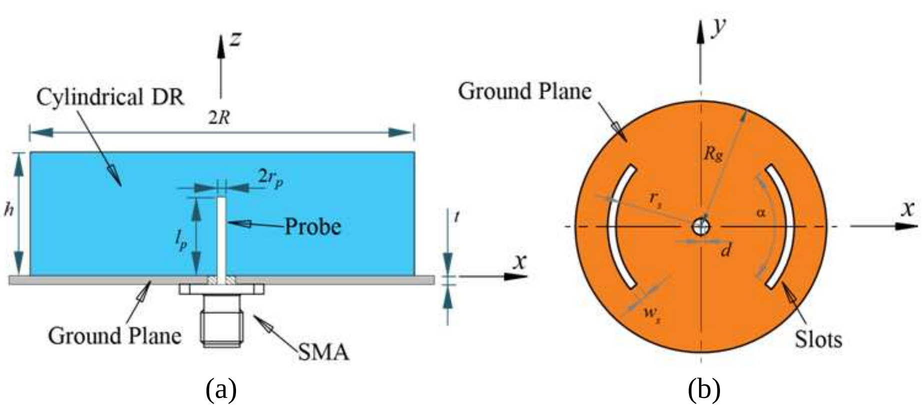


Figure 1: Configuration of proposed antenna. (a) Side view of the antenna. (b) Top view of the slotted ground.

generate bidirectional radiation. Each arc slot has an inner radius of r_s, width of w_s, subtended angle of α, and displacement of d.

3. EXPERIMENTAL RESULTS

To demonstrate the idea, a cylindrical DRA with $\varepsilon_r = 6.85$ operating at 2.4 GHz was designed, fabricated, and measured. Other design parameters are listed in Table 1.

Figure 2 compares the measured and simulated reflection coefficients of the proposed antenna. As can be seen from the figure, the 10-dB impedance bandwidth is 6.9% (2.39–2.56 GHz), entirely covering the 2.4-GHz WLAN band (2.40–2.48 GHz). The frequency shift of the measured result is due to fabrication tolerances. It was found that the effect of adding two slots on the reflection coefficient is not significant, which is desirable for the design.

Figure 3 displays the measured and simulated gains of the proposed antenna along $+y$-axis ($\theta = 90°$, $\phi = 90°$). With reference to the figure, the measured maximum gain is 3.75 dBi at 2.48 GHz, whereas the simulated one is 4.64 dBi at 2.44 GHz. It was found that the measured efficiency is higher than 85% over the entire WLAN band, which is not shown here for brevity.

The measured and simulated radiation patterns of elevation and azimuth planes are shown in Figure 4. As can be observed from Figure 4(a), the radiation pattern of the elevation y-z plane is similar to that of a conventional omnidirectional DRA. The crosspolarized field is at least 20 dB weaker than the copolarized counterpart. Figure 4(b) shows the radiation pattern on the azimuth plane. With reference to the figure, the main- and side-lobe radiations are along $+/-y$ ($\phi = 90°$, 270°) and $+/-x$ (($\phi = 0°$, 180°) directions, respectively. The measured copolarized

Table 1: Design parameters of the proposed antenna (unit: mm).

R	h	R_g	t	r_p	l_p	r_s	w_s	d	α
31	20	31	2	0.635	14	22	2	1	80^o

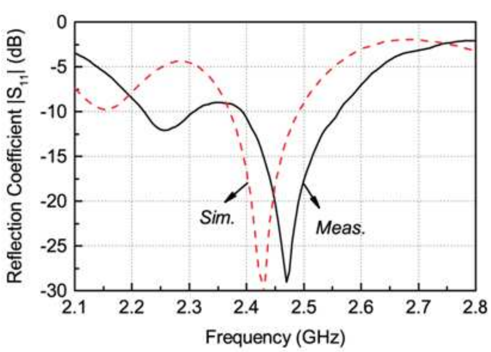


Figure 2: Measured and simulated reflection coefficients of proposed antenna.

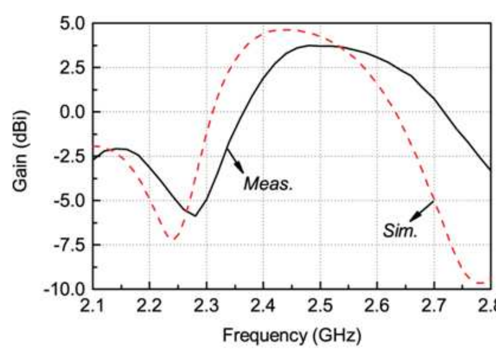
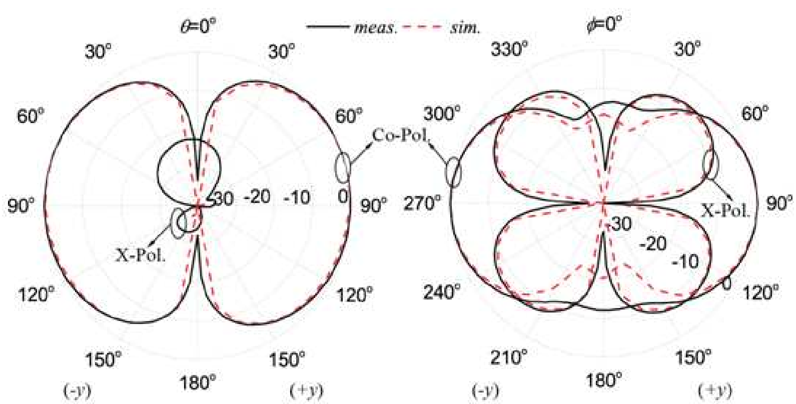


Figure 3: Measured and simulated gains of proposed antenna.



(a) y-z plane (b) x-y plane

Figure 4: Measured (2.48 GHz) and simulated (2.44 GHz) radiation patterns of proposed antenna. (a) Elevation y-z plane. (b) Azimuth x-y plane.

field at $\phi = 90^\circ$ is stronger than that at $\phi = 0^\circ$ by 13.9 dB, showing satisfactory bidirectional performance.

4. CONCLUSION

The bidirectional DRA with slotted ground has been investigated in this paper. By adding two arc slots to the ground, the current distribution is perturbed, converting the conventional omnidirectional radiation pattern into a bidirectional one. The reflection coefficient is not affected by the slots significantly. Since it does not require any special-shape DRA, the design can be realized very easily.

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