Dual-Antenna System Composed of Patch Array and Open-Ended Waveguide for Eliminating Blindness of Wireless Communications

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1. **Abstract**: In mobile communications in urban area, it is a significant problem that blind spots of in the narrow street are caused by high buildings. In our previous works, a reflectarray antenna was developed to solve the problem [1]. However, the gain of reflectarray becomes very low when a very broad scattering angle is required. In this research, a new dual-antenna system is proposed, including a receiving and a reradiating antenna to realize a broad-angle beam control. An equivalent bistatic radar cross section (BRCS) is deduced to evaluate the antenna performance.

2 . **Equivalent BRCS and Results**:Figure 1 shows the schematic of propagation channel in an urban area, where Antennas #1, #2, #3, and #4 represent the base station, receiving and transmitting antennas of the dual-antenna system, and the user, respectively. In this design, the electromagnetic (EM) waves for downlink propagate as follows: first, Antenna #2 receives the EM wave from the base station; then, the received wave is guided by a low-loss transmission line and reradiated by Antenna #3, and finally received by Antenna #4. Here the dual-antenna system can be evaluated in terms of an equivalent BRCS, just similar to an ordinary scattering object. The channel gain can be calculated by two methods: Friis transmission equation and radar range equation, as shown in Figure 1, where G_{t1}, G_{r2}, G_{t3}, and G_{r4} are gains of Antennas #1, #2, #3, and #4, respectively, and σ_{eq} is the equivalent BRCS of the proposed dual-antenna system and λ is the free-space wavelength at the operating frequency. Then, σ_{eq} can be calculated by

$$\sigma_{eq} = \frac{\lambda^2}{4\pi} G_{t2} G_{r3} \tag{1}$$

It is clear that σ_{eq} is proportional to the gains of Antennas #2 and #3. In our design, a microstrip patch antenna in [2] is employed to build a 4×1 array as the receiving Antenna #2, and a waveguide antenna with a flare angle of 40° as the transmitting Antenna #3, so one unit of this dual-antenna system operating at 2 GHz is shown in Figure 2 (a). Additionally, a stripline-based power divider and a transition from a stripline to a rectangular waveguide are included in the unit. The radiation patterns of the waveguide antenna is given in Fig. 2 (b), but the maximum of the simulated equivalent BRCS is along 17° direction because of the complicated scattering process when the plane wave is normally incident to the patch array, and the same reason causes the achieved BRCS larger than that by Equation (1). It is obvious that 4-unit dual-antenna system can provide much large equivalent BRCS in $\theta < 30^\circ$ along both $\phi = \pi/2$ and $\phi = 3\pi/2$ directions than a metal plate with a same area placed in the xz plane, proving the effectiveness of this method.

3. Conclusion: A dual-antenna system for large beam angle application to eliminate blindness of wireless communications was developed. This system can reradiate the EM wave to any desired direction which is difficult to be realized by reflectarray antennas.

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[1] L. Li, *et al.*, *IEEE Antennas Wireless Propagat. Lett*, vol. 8, pp. 881-885, 2009.

[2] S.L. Yang, *et al.*, *Microwave Optical Tech. Lett.*, vol. 45, pp. 352 – 355, 2005.

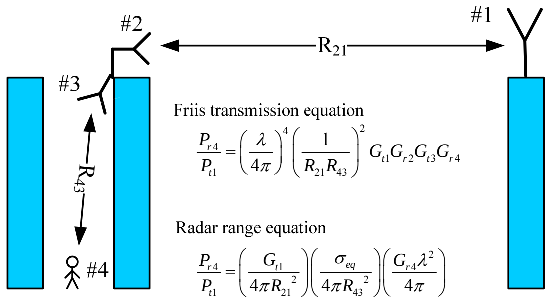
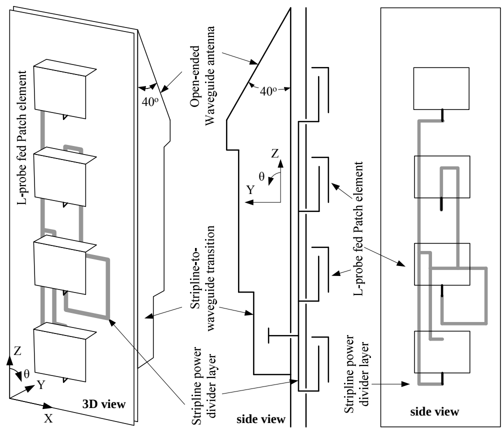
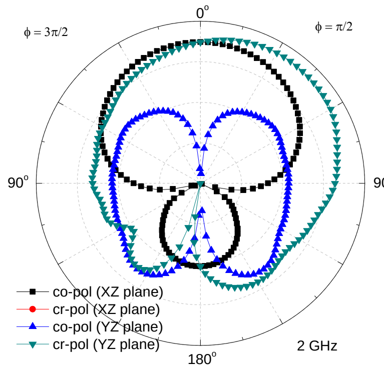


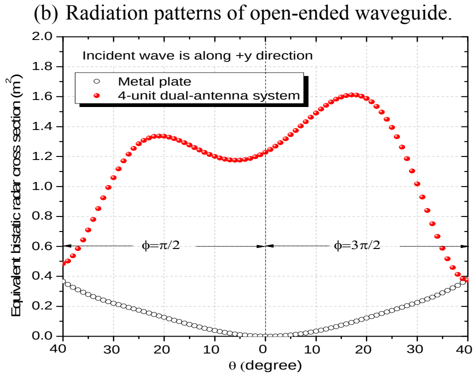
Figure 1 Schematic of propagation channel in urban area.



(a) Geometry of one unit dual-antenna system.



(b) Radiation patterns of open-ended waveguide.



(c) Simulated equivalent BRCS of 4-unit combination along x direction and the metal plate with the same area.

Figure 2 Dual-antenna system and its performances.