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Four-Port Collocated Antenna With Directional Radiations For Base Station Applications

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Abstract

This paper proposes a four-port planar antenna collocated with dual-polarized crossed slot and dual-polarized dipole array, which can realize directional radiations with artificial magnetic conductor (AMC) reflectors. The proposed antenna can cover 1.71-1.78 GHz frequency bands by the dipole array and 2.11-2.18 GHz frequency bands by the crossed slot, which can be applied for base station communications. The couplings are lower than -15 dB, and the gains for all the ports are higher than 8.2 dBi.

1. Introduction

With the development of the wireless communications, antennas have made achievements in different standards in wireless mobile communication systems. In order to optimize the resource utilization efficiency of base station antennas and further improve the aperture utilization, the common aperture antenna and the transceiver coaxial antenna have been researched [1].

When there is a gap between two operating frequency bands, the antenna operating at higher frequency can be located in the lower-frequency antenna aperture[2], causing a low coupling and directional radiations, but this design needs obvious gap between two frequency bands and a high distance between two antenna elements [3]. Stack technology can also realize a common aperture antenna design, which loads the antenna elements into another antenna as a parasitic component, such as split PEC surface[4], frequency selective surface[5], and helical torsion coaxial cable excitation [6]. However, these structures are too complicated.

A new collocated antennas with magnetic and electric dipoles were researched for compact structure and high DoFs at same frequency [7]. It composed of magnetic and electric dipoles collocated at same centers with high isolation, such as tri-polarized printed inverted antennas (PIFAs) collocating with tri-polarized slots antennas [8], tri-polarized dipole antennas collocating with tri-polarized loop antennas [9],[10]. However, the collocated antennas with magnetic and electric dipoles cannot realized directional radiations in literatures. Therefore, a design combining the collocated antenna and common aperture antenna with directional radiations is considered.

This paper proposes a four-port antenna composed of crossed slot and ±45deg-polarized dipole array. The crossed slot can operating in 1.71-1.78 GHz band, and the ±45deg-polarized dipole array can operating in 2.11-2.18 GHz band, which means that the proposed four-port antenna can be applied for base station communications. In order to reduce the profile and realize directional radiations, the AMC reflectors are designed for the dipole array and the crossed slot, respectively. The gain results are higher than 8.2 dBi for all ports. The coupling between the four ports are lower than -15 dB, and the crossed polarization results are lower than -17 dB.

2. Antenna Topology

The proposed four-port antenna topology is shown in Figure 1(a). It is composed of six parts: DP, AMC1, SLOT, EBG, AMC2, and FEED. The overall structure is based on planar design and the centers of the six parts are located in +Z axis line.

The topology of DP is shown in Figure 1(b), and the substrate is FR-4 (ε_r=4.4, tanδ=0.02, thickness=1.0 mm). DP has two polarization radiators DP1 and DP2. DP1 is a 1×2 dipole array, and it points in φ=+45deg. The element is a circular-ended structure for wideband operation [11], which can cover 2.11-2.18 GHz. DP2 is same as DP1 in topology, but it points in φ=-45deg. The topology of SLOT is shown in Figure 1(c), and the substrate is F4BM350 (ε_r=3.5, tan δ=0.005, thickness=0.8 mm). SLOT is a crossed slots antenna operating in 1.71-1.78 GHz band. SLOT1 radiates y-polarized waves, and SLOT2 radiates x-polarized waves. SLOT1 and SLOT2 are fed by a crossed T-shaped power divider printed in the bottom side of SLOT. AMC1 is the reflector designed for DP [12], which can reduce the distance between DP and SLOT. AMC2 is the reflector designed for SLOT, which can enhance the broadside gain and reduce the profile compared with the PEC reflector. AMC1 and AMC2 are FR-4 substrate. EBG is the electromagnetic band gap structure designed for surface wave generated by SLOT, and further reduce the coupling between DP and SLOT. FEED is the feeding network designed for DP, which is located in the back of AMC2. FEED is composed of T-shaped dividers in order to excited the each two elements of DP1 and DP2.

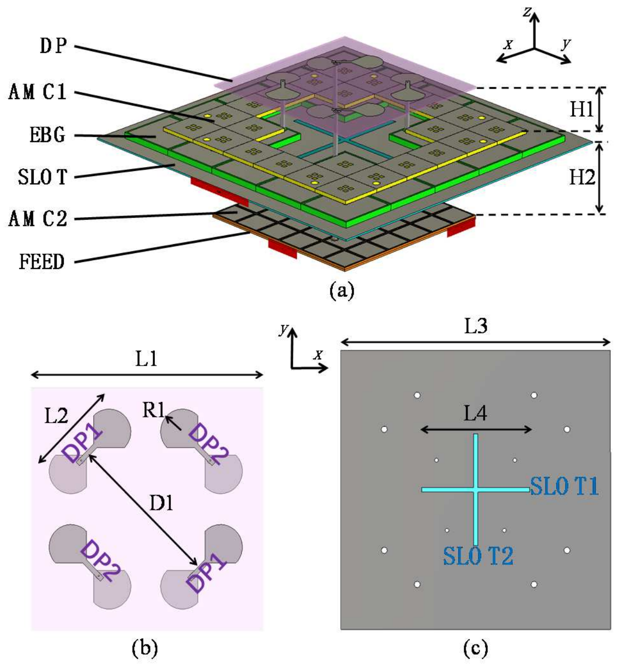

Figure 1. Antenna topology (a) in 3D view; (b) DP; (c) SLOT. *(L1 = 95.0 mm, L2 = 40.0 mm, D1 = 70.0 mm, R1 = 7.9 mm, L3 = 180.0 mm, L4 = 72.0 mm, H1= 20.0 mm , H2 = 28.0mm)*

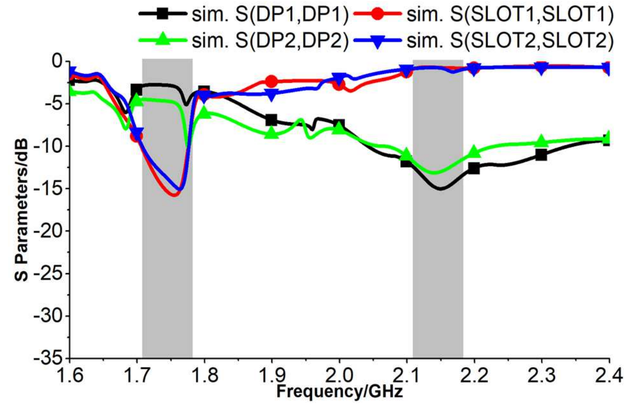

Figure 2 Reflection coefficients S_{ii}

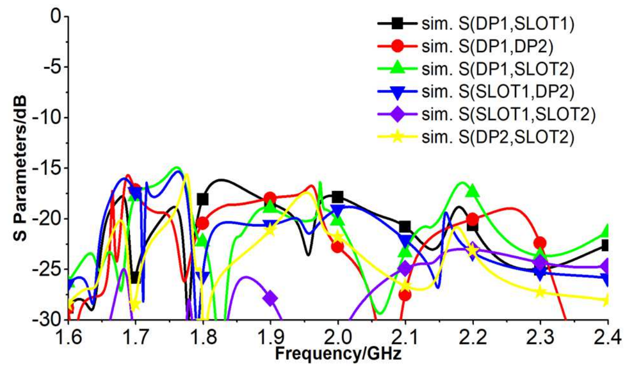

Figure 3 Coupling coefficients S_{ij}

3. Results

The proposed antenna is simulated by ANSYS HFSS Solver. The reflection coefficients S_{ii} are shown in Figure 2, and the coupling coefficients S_{ij} are shown in Figure 3. When the four ports realize impedance matching (Sii < -10 dB), the results show that DP1 and DP2 can both cover 2.11-2.18 GHz, respectively, and SLOT1 and SLOT2 can both cover 1.71-1.78 GHz, which realizes the design expectation. Figure 3 shows that all the coupling coefficients are lower than -15 dB, which are acceptable for base station communications.

The radiation patterns and the gain results are shown in Figure 4 and Figure 5, and when one port is excited, other ports are loaded with 50 Ω load. Figure 4 shows the results of DP1 and DP2, and it shows DP1 and DP2 can realize directional radiations in upper half space. The simulated gain is 8.7 dBi for DP1 and is 8.4 dBi for DP2. The crossed polarization are lower than -17 dB in the broadside direction. The simulated results of radiation efficiency are that 80.5% for DP1 and 78.1% for DP2.

Figure 5 shows the results of SLOT1 and SLOT2, and it shows they can also realize directional radiations in upper half space. The simulated gain is 8.8 dBi for SLOT1 and is 8.2 dBi for SLOT2. The crossed polarization are lower than -17 dB in the broadside direction. The simulated results of radiation efficiency are that 95.6% for SLOT1 and 94.7% for SLOT2.

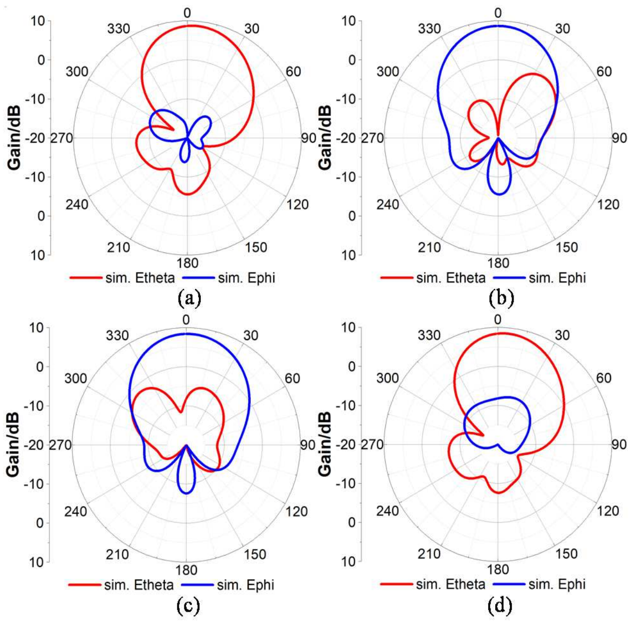

Figure 4 Radiation patterns and gain results for DP1 and DP2 at 2.15 GHz. (a) on phi=+45deg when DP1 is excited; (b) on phi=-45deg when DP1 is excited; (c) on phi=+45deg when DP2 is excited; (d) on phi=-45deg when DP2 is excited.

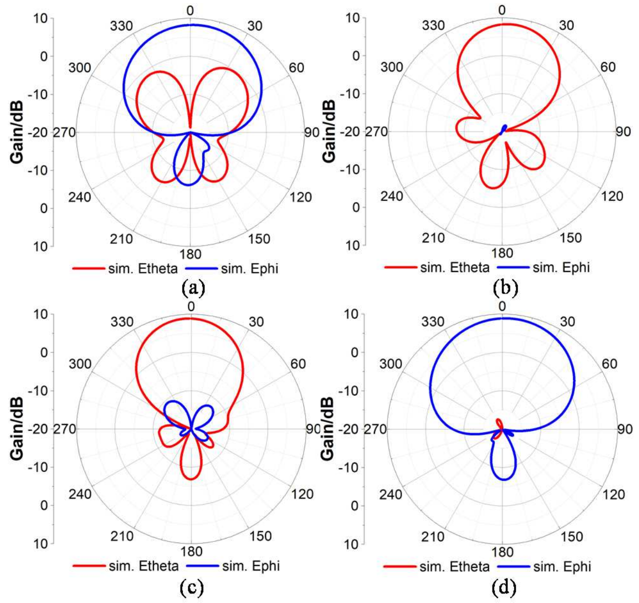

Figure 5 Radiation patterns and gain results for SLOT1 and SLOT2 at 1.75 GHz. (a) on XZ plane when SLOT1 is excited; (b) on YZ plane when SLOT1 is excited; (c) on XZ plane when SLOT2 is excited; (d) on YZ plane when SLOT2 is excited.

4. Conclusion

This paper proposes a four-port antenna composed of crossed slot and ±45deg-polarized dipole array with directional radiations, and the proposed four-port antenna can be applied for base station communications. In order to reduce the profile and realize directional radiations, the AMC reflectors are designed for the dipole array and the crossed slot, respectively. The gain results are higher than 8.2 dBi for all ports. The coupling between the four ports are lower than -15 dB, and the crossed polarization results are lower than -17 dB.

6. Acknowledgements

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