# A Broadband Dual-polarized Microstrip Antenna with Cavity-Backed Proximity-Coupling Feeding

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## Abstract

A broadband cavity-backed proximity-coupled dual-polarized microstrip antenna is presented. The cavity backed ground plane is used with optimized parameters to enhance the feeding coupling and thus to broaden the bandwidth of this antenna. A prototype antenna is designed and fabricated. Simulation and measurement results show that the proposed design achieves S11 $\leq -10$ dB bandwidth of more than 30% (8.2$-$11.4 GHz) and the port isolation is larger than 20 dB over that band. This antenna is easy to fabricate, and can be directly mounted on the metal body surface in application.

## 1. Introduction

Dual-polarized microstrip antennas have received increasing attention since they can provide more information for many applications, such as mobile communications and radar systems. Various kinds of dual-polarized antennas have been developed [1]$-$[3]. In [1], the slot-coupled stacked patch antenna structure is presented to provide broadband or multiband operability for commercial communications. In [2], the feeding structure and the slot shape loaded on the patch are elaborately designed to control the surface current distribution for obtaining low cross-polarization and high isolation over a certain frequency band. Despite their success, these techniques are proposed mainly for conventional communication applications with the working frequency lower than 3 GHz, and their structures are relatively difficult to manufacture if we apply them to a much higher frequency band. In this Letter, we focus on the design of a X-band dual-polarized antenna which will be mounted on the surface of a metal body in application. The proximity-coupled microstrip antenna with slotted ground plane presented in [3] may be more appropriate for this frequency band due to its advantages of simple structure and easy fabrication. However, the slotted ground plane of this antenna has the installation issue in our situation that it cannot touch on or close to the metal surface. In addition, the slotted ground structure may also produce some backward directed radiation.

In [4] and [5], modification of the proximity-coupled microstrip antennas has been proposed by replacing the slotted ground with a narrow backed cavity which can overcome the problems mentioned above while maintaining a pretty good broadband performance. However, the antennas presented in [4] and [5] are proposed only for single port and single polarization. Here, we extend such structure to the two-port dual polarization case. The cavity shape is elaborately designed and optimized to achieve broadband dual polarization radiation performance. The antenna prototype is designed and fabricated, and the measured results show good agreement with the simulated ones.

## 2. Antenna design

The configuration of the proposed cavity-backed proximity-coupled dual-polarized antenna is shown in Fig.1. It consists of a square patch, two feed-lines, three dielectric substrate layers and an optimized cavity backed ground plane. The three substrates all have the relative permittivity of 2.2, with the heights of $h_1 = 1.575$ mm, $h_2 = 3.175$ mm and $h_3 = 0.508$ mm, respectively. The radiating patch with size of lp$\times$lp is placed between substrate 1 and 2. The substrate 1 is served as a dielectric matching layer for this patch, which can broaden the bandwidth of this antenna. The two feed lines are orthogonally placed between substrate 2 and 3, and they are connected to the inner conductors of coaxial lines at port 1 and 2, respectively. It was shown in [4] that a narrow cavity backed ground plane can increase the coupling between the feed line and the radiating patch, and thus improve the impedance bandwidth. This idea can be extended here to the dual proximity-coupling case with carefully designing the cavity shape and its parameters. The proposed cavity is like modified L-shape, as shown in Fig. 1. Since the whole structure of the proposed design is exactly symmetrical about the diagonal, this antenna would have the same impedance bandwidth for the two ports and symmetric radiation performance for the dual polarizations. In the prototype of this antenna, the optimized parameters are lg= 28 mm, hg= 4.1 mm, ls= 18 mm, lp= 6 mm, lc= 12.5 mm, wc= 4.3 mm, hc= 3 mm, ld= 2.75 mm, wd= 3.85 mm, and lf= 8 mm. It is worth noting that the height (hc) of the proposed cavity is much smaller than that of a conventional quarter-wavelength cavity designed in X-band.

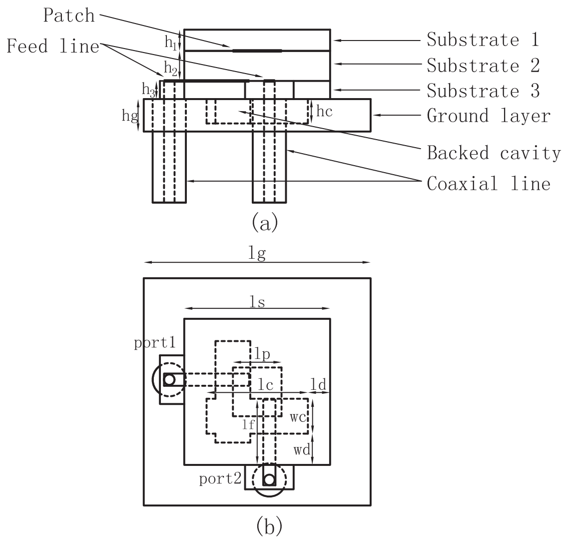


Figure 1: Configuration of the antenna. (a) Side view and (b) top view

## 3. Simulated/measured results and discussion

The prototype of this antenna has been fabricated and experimentally studied (we will show the results only for port 1 due to the symmetric configuration of this antenna). Fig.2 shows results of the simulated and measured S-parameters. As can been seen, the antenna achieves the S11 $\leq -10$ dB bandwidth of more than 30% ($8.2 - 11.4$ GHz for the measurement results), and the S21 keeps a low level of below $-20$ dB over that bandwidth (i.e., the port isolation is larger than 20 dB). This shows that the broad bandwidth for the dual-polarized radiation can be achieved by the simple proximity-coupling structure with a shape-optimized narrow cavity. The radiation patterns of this antenna are measured by the far-field antenna measurement system in an anechoic chamber. Fig. 3 and 4 show the measurement and simulation results of the co-polarization as well as cross-pol. patterns at 9.8 GHz in the E plane and H plane, respectively. It can be seen that the half-power beam width (HPBW) of the co-pol. pattern is about $86°$ in the E plane and $75°$ in the H plane, respectively, and the cross-pol. level is about -18 dB in the E plane and -15 dB in the H plane. Such radiation performance keeps stable over the whole frequency range of $8.2 - 11.4$ GHz, from the measurement results not shown here.

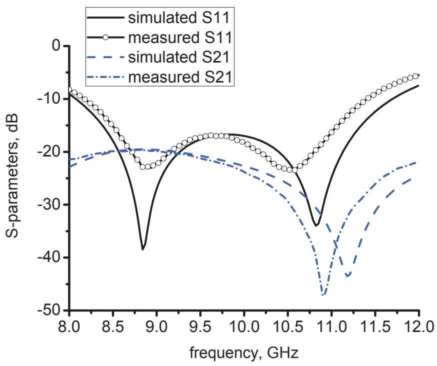


Figure 2: Simulated and measured S-parameters

## 4. Conclusion

A proximity-coupled dual-polarized microstrip antenna with an optimized cavity backed ground plane is proposed. Simulation and measurement results shows that the proposed design achieves more than 30% bandwidth (S11 $\leq -10$ dB over $8.2 - 11.4$ GHz) and the port isolation is larger than 20 dB in that band. The radiation patterns in both the E plane and H plane keep stable and acceptable over the whole bandwidth. The proposed antenna is easy to fabricate, and can be directly mounted on the metal body surface. Therefore, this antenna would be a good candidate for many applications.

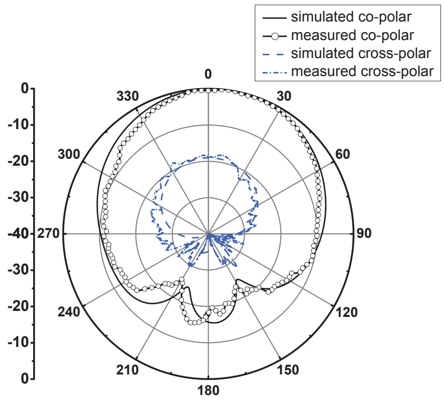


Figure 3: Simulated and measured E-plane radiation patterns at 9.8 GHz

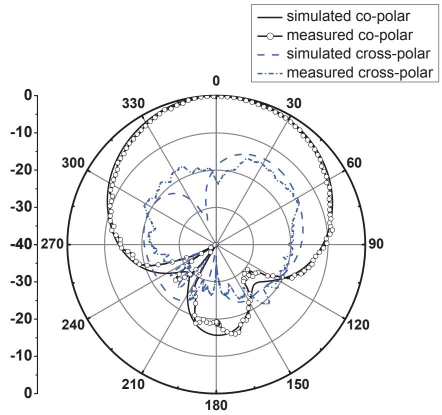


Figure 4: Simulated and measured H-plane radiation patterns at 9.8 GHz

## 5. Acknowledgments

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## 6. References

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