Broadband Proximity-Coupled Microstrip Patch Antennas with Dual Polarizations

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1. Introduction

Dual-polarization operation has been an important subject in microstrip antenna designs, as it can find applications in many wireless communication systems that require the frequency reuse for increasing the communication capacity, or the polarization diversity for maximizing the received signals. Till now, many designs of dual-polarized microstrip antennas have been reported, and a variety of techniques for improving the isolation and cross-polarization radiation characteristics between two polarizations have been demonstrated [1-4]. A dual-polarized microstrip antenna can be realized by feeding the patch at two orthogonal edges, through edge feed or probe feed. Dual-polarized slot-coupled antennas have been reported which use dual offset slots and achieve isolation of 18 dB [1], or dual slots arranged in "T" configuration [2], or multiple slots [3]. To further improve the isolation characteristics, hybrid-feeding techniques are used in [4], where the slot coupling and the capacitively-coupled feed are used for each polarization, respectively. A bandwidth of about 13% and isolation of about 30 dB are reported in [4]. Recently, a broadband proximity-coupled microstrip antenna using an H-slot in the ground is proposed in [5]. It has been experimentally demonstrated in [5] that the antenna has important advantages of simple structure, easy fabrication, low cost, broad bandwidth, low cross-polarization levels, etc.

In this paper, we will extend the work in [5] into the case of two-port antennas for achieving both the broad bandwidth and the dual-polarization operation. A novel design of the broadband dual-polarized microstrip antennas is proposed by using the proximity coupling. A prototype antenna is then designed, and experimental results are presented.

2. Antenna design

The configuration of the broadband dual-polarized antenna is given in Figure 1. The rectangular patch is mounted on a two-layer substrate. The substrate consists of an air layer having a thickness of h_0, and a dielectric substrate layer having a permittivity of ε_r and a thickness of h. For producing two orthogonal polarizations, two microstrip feed lines are placed on the dielectric layer. An H-shaped slot is cut in the ground plane below each feed line. The slot is important here, as it could enhance the coupling between the microstrip feed line and the patch [5]. The two H-slots are arranged in a "T" configuration for enhancing the isolation between two input ports [2]. The air gap layer is formed by using plastic supporters having a height of h_0. The patch is fabricated by using the Duroid substrate 5870 ($\varepsilon_r = 2.33, h = 1.575$ mm). The back side of the Duroid substrate carries the patch, while the top side of substrate is etched completely. This is a kind of inverted structure, where the top substrate serves

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as a radome for protection. The Duroid substrate ($\varepsilon_r = 2.33, h = 1.575$ mm) is also used for carrying the microstrip feed lines below the patch. The H slot is defined by the parameters *la1*, *la2*, *wa1* and *wa*2.

The antenna design is achieved by tuning the length and width of the patch, the slot dimensions, the air gap thickness, and open-stub lengths. The simulation results are obtained by using "*Ensemble*" from Ansoft Corporation. The prototype antenna designed has the following parameters: *L*= 30 mm, *W*=30 mm, h_0=6.4 mm. Port 1: *la1*=16 mm, *la2*=2 mm, *wa1*=1 mm, *wa*2=4 mm, *ds*1=6 mm; Port 2: *la*1=14 mm, *la*2=2 mm, *wa1*=1 mm, *wa*2=4 mm.

3. Results and discussions

In Figure 2, the results of measured return loss at two ports are given. As we can see, the return loss is below –10 dB at port 1 within the frequency range between 3.045 GHz and 3.8 GHz, corresponding to a bandwidth of 22 %. At port 2, the return loss is below –10 dB within the frequency range between 3.025 GHz and 3.745 GHz, which corresponds to a bandwidth of 21.3 %.

The results of measured isolation between two ports are given in Figure 3. It is seen the isolation is at least below –34 dB within the frequency bandwidth between 2.5 GHz and 3.8 GHz, which means the coupling between two input ports is very low.

Figure 4 shows the measured radiation patterns of the antenna excited at port 1 at 3.4 GHz. Broadside radiation patterns are observed at both *E*- and *H*-planes, and the cross-polar levels are below –21 dB within the half space above the ground plane. The backward radiation is below –15 dB. We also measure the antenna at several other frequencies, and it is observed that the radiation patterns are stable across the bandwidth.

4. Conclusion

By using the proximity-coupled feeds, a novel design of the broadband dual-polarized microstrip antennas is proposed. H-shaped slots are cut in the ground plane under microstrip feed lines. The prototype antenna yields a bandwidth of 22 % and 21.3 % at the input port 1 and 2, respectively. The isolation between two input ports is below –34 dB across the bandwidth. Good broadside radiation patterns are observed, and the cross-polar levels are below –21 dB at both *E*- and *H*-panes. The antenna has advantages including simplified structure, broad bandwidth, high isolation between two input ports, and low cross-polarization levels. Thus, it is promising for practical applications in various wireless systems.

Acknowledgement

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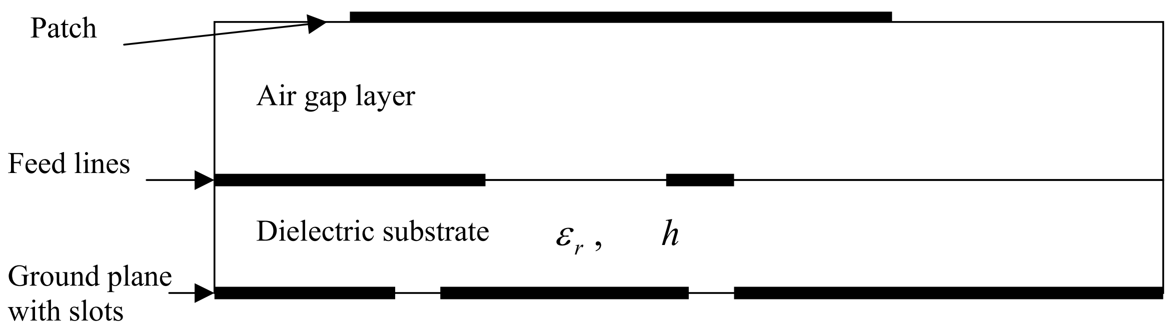
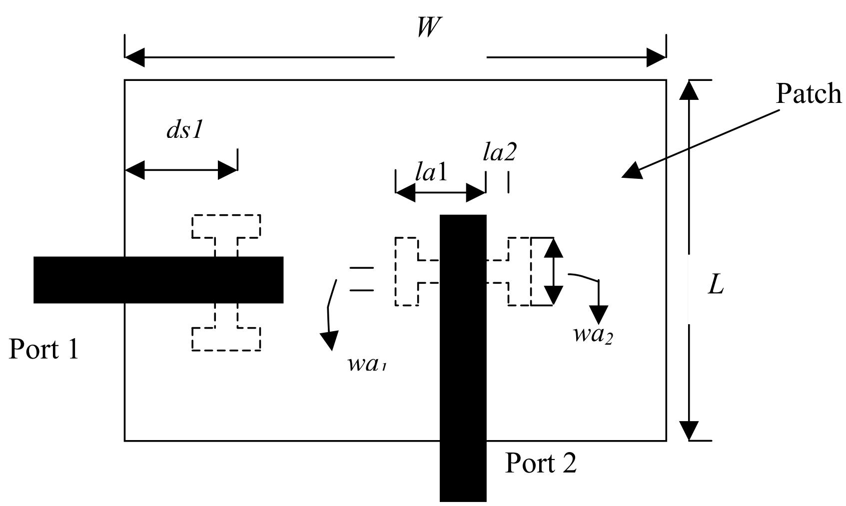


(a) Side view



(b) Top view

Fig. 1 Antenna configuration

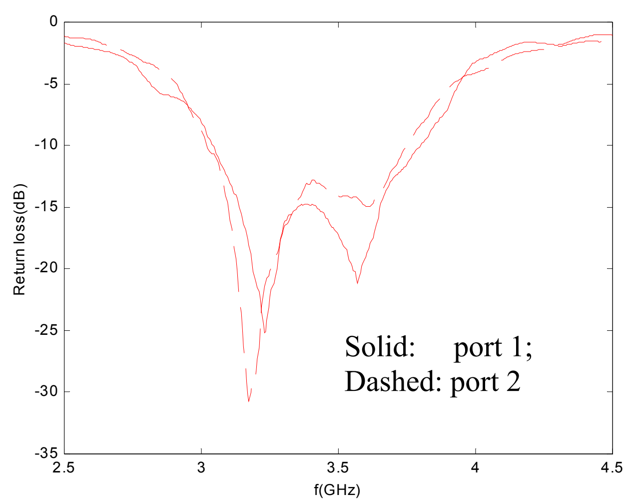


Figure 2. Measured return loss results at two ports

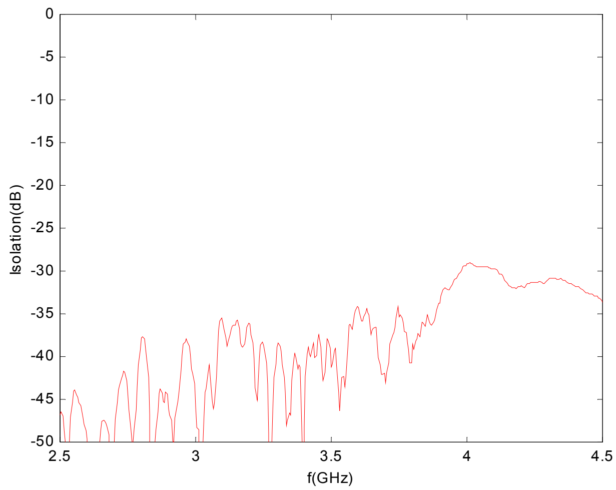
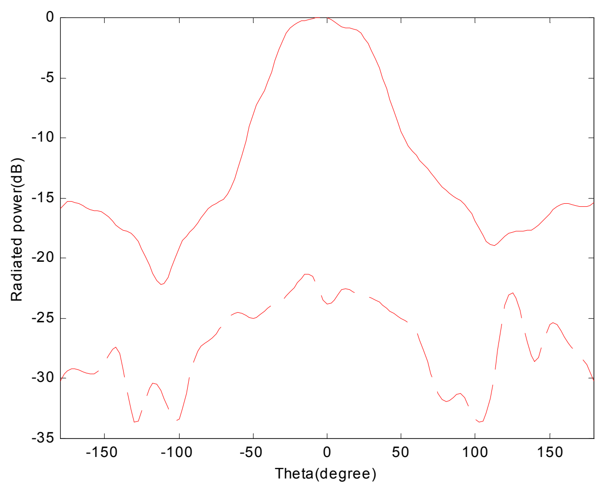
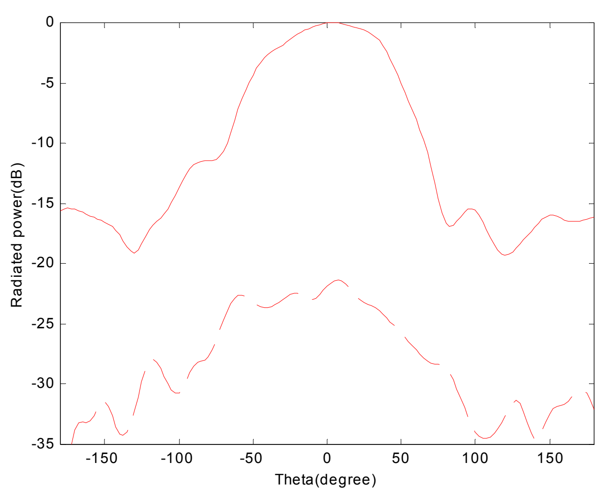


Figure 3. Measured isolation between two ports



(a) *E* plane



(b) *H* plane

Figure 4 Measured radiation patterns at 3.4 GHz for port 1
(Solid line: co-polar; dashed line: cross-polar)