A Wideband Dual-Polarized Stacked Microstrip Patch Antenna with a Dumbbell Shaped Aperture

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***Abstract*—A new design for a wideband dual-polarized aperture-coupled patch antenna with dumbbell shaped coupling slots is presented. The printed antenna consists of two stacked patches and an aperture slotted ground plane which is excited using a microstrip line feed. A two-slot dual polarized antenna with a return loss bandwidth of 505 MHz is introduced using the proposed configuration. The proposed antenna is designed for 2.45 GHz and achieves stable and desirable radiation characteristics across the band.**

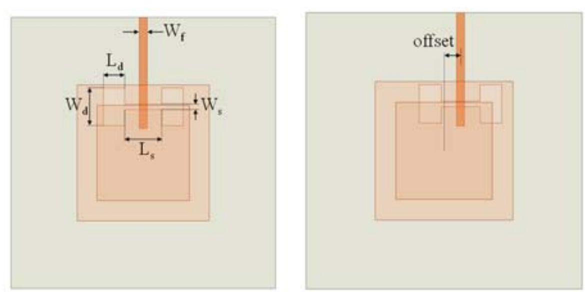
I. INTRODUCTION

With the rapid development of modern communication systems, polarization reconfigurable antennas have attracted a great deal of attention [1-2]. In microwave tagging systems polarization diversity antennas can provide a powerful modulation scheme, typically by switching between two circular polarizations [3, 4]. Multi-linear polarization reconfigurable antennas on the other hand can mitigate the polarization mismatching problems in complex wireless channels such as body-centric systems [5].

In this work, we report on a dual-polarized patch antenna configuration that achieves a bandwidth of more than 20% with good radiation characteristics across the band. The stacked aperture coupled antenna has a dumbbell shaped aperture that increases the coupling between the feed aperture and the patches which enables good impedance matching with relatively small aperture opening, and at the same time allows for dual-polarized operation. Some major design parameters of the antenna are discussed and a dual-polarized antenna with more than 500 MHz bandwidth operating at the Wi-Fi band is presented.

II. A STACKED MICROSTRIP PATCH ANTENNA WITH A DUMBBELL SHAPED APERTURE

Owing to their low-cost, low-mass, low-profile, and conformality, microstrip antenna technology has been the most rapidly developing topic in the antenna field in the last few decades [6]. While the classical microstrip antenna is inherently narrowband, many broadband techniques have been developed over the years to overcome this fundamental limitation. Amongst these techniques, the aperture coupled stacked patch configuration, not only yields a wide bandwidth, but it also provides the advantage of isolating from spurious feed radiation [6-8]. Here we outline the design process for a broadband aperture coupled antenna with a dumbbell shaped aperture which achieves a broad impedance bandwidth. A linearly polarized single dumbbell-shaped slot aperture antenna is shown in Fig. 1. In this design, the field is coupled from the microstrip feed line to two square stacked patches through the dumbbell-shape aperture cut in the ground plane. The substrate parameters of the radiating patch and microstrip feed line have a significant effect on the input impedance of aperture coupled microstrip antenna. One layer of Rogers 6006 laminate with a dielectric constant of 6.15 and height of 1.016 mm is used for feed substrate. The second layer is a Rogers 4003 laminate with a dielectric constant of 3.44 and height of 9.144 mm and is placed above the feed layer where the first square patch is placed. A second patch is placed above this layer on a foam substrate with a thickness of 10 mm. Finally, a second layer of Rogers 4003 laminate with a thickness of 1.524 mm is placed on the top patch which acts as a radom. The microstrip feedline is designed for 50-ohm impedance and the antenna is analyzed using Ansys HFSS [9].



(a) (b)

Fig. 1. (a) Geometrical parameters of the aperture and feed line. (b) The offset configuration of the aperture.

The major design parameters of the aperture are shown in Fig. 1. The coupling level is primarily determined by the length of the slot, as well as back radiation level [6]. In this antenna dumbbell-shape slot is used for better coupling. Based on the parametric analysis for the dumbbell width (W_d), the optimum width was chosen to be 7 mm. The dimensions of square patches were chosen to be 25 mm for bottom patch and 17.5 mm for top patch. To enable dual-polarized operation it is necessary to offset the feed system as shown in Fig. 1 (b). The offset has very little effect on the impedance matching as shown in Fig. 2. However, it results in a slight decrease of antenna gain and an increase in cross-polarization, thus it has to be kept to a minimum. For this design, the maximum offset required was 3 mm. This design achieves a bandwidth of 460 MHz from 2.135 to 2.595 GHz.

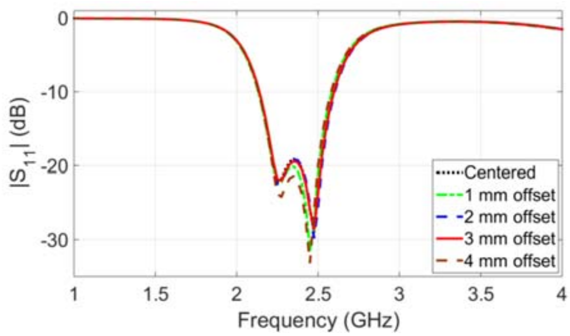


Fig. 2. $|S_{11}|$ versus frequency for different offset distances.

III. The Dual-Polarized Microstrip Patch Antenna with a Dumbbell Shaped Aperture

A dual-polarized microstrip patch antenna with two dumbbell shaped coupling apertures is depicted in Fig. 3. This flexibility about the optimization parameters of the dumbbell-shaped slot makes it possible to position the two coupling slots within the boundaries of the patch antenna. The simulated results for return loss and gain of the dual polarized aperture antenna are presented in Fig. 4. The gain is about 6 dBi across the matching bandwidth. The simulated return loss shows a bandwidth of 505 MHz from 2.085 to 2.590 GHz.

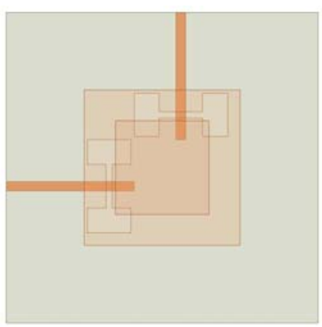


Fig. 3. The dual-polarized aperture coupled patch.

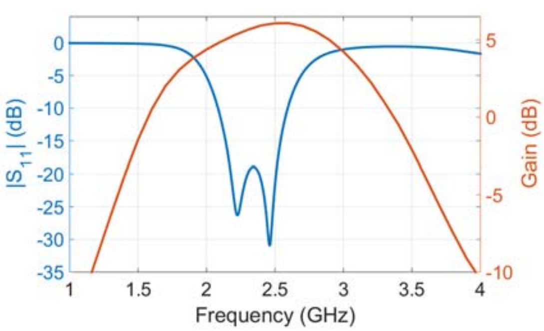
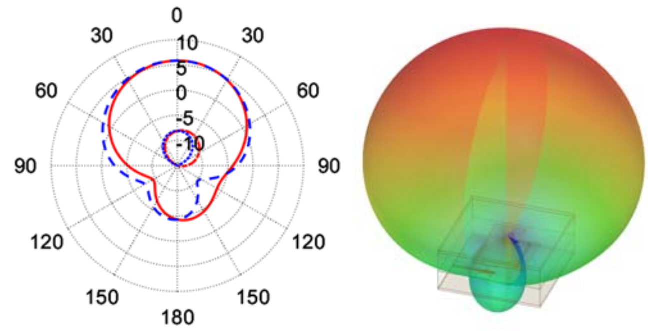


Fig. 4. $|S_{11}|$ and gain versus frequency for the dual-polarized aperture coupled patch antenna.

The simulated E -plane and H-plane radiation patterns of the antenna at 2.45 GHz are presented in Fig. 5 (a), where it can be seen that the antenna achieves a desirable directive radiation pattern. The cross-polarization level is also below 16 dB in the principal planes. We note that as discussed, offsetting the aperture feed has no significant impact on the radiation pattern of the antenna. The 3D radiation pattern of the antenna at 2.45 GHz is also shown below in Fig. 5 (b).



(a) (b)

Fig. 5. (a) 2D gain patterns of the antenna in principal planes [$\phi = 0°$ co-pol (red-solid), $\phi = 0°$ x-pol (red-dotted), $\phi = 90°$ co-pol (blue-dashed), $\phi = 90°$ x-pol (blue-dotted),]. (b) 3D pattern of the antenna.

IV. Conclusions

A new design for a dual polarized aperture coupled patch antenna is presented. The dual polarized antenna yields a bandwidth of 20.6% (from 2.085 GHz and 2.590GHz) and good radiation characteristics across the matching bandwidth. The enhanced bandwidth is achieved by using a stacked patch configuration and dumbbell shaped slots. The proposed antenna is designed for 2.45 GHz operation in the WLAN band.

Acknowledgement

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