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# DUAL-POLARIZED DIELECTRIC RESONATOR ANTENNA WITH HIGH ISOLATION USING HYBRID FEEDING MECHANISM FOR WLAN APPLICATIONS

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**Abstract**—A dual-feed dual-polarized dielectric resonator antenna (DRA) with high isolation is proposed in this paper. The high isolation is achieved by using two hybrid feeding mechanism: one port having an H-shaped aperture coupled feed and the other with two out-of-phase probe feeds. The antenna is designed to operate at around 5.2 GHz for WLAN (Wireless Local Area Network) applications and experimental results show that it has more than 35 dB isolation over the entire impedance bandwidth. Good symmetric broadside radiation patterns with low cross polarizations are observed in the two principal planes, and in addition, the front-to-back (F/B) ratios for Port 1 and Port 2 are 10 and 18 dB, respectively.

## 1. INTRODUCTION

Dielectric resonator antennas (DRAs) have been widely discussed since it was introduced in 1983 [1]. DRAs offer many advantages, such as low-profile, low-cost, ease of excitation and high radiation efficiency. Extensive studies focused on linear polarization applications [2–8]. Recently, dual polarization operations have been in demand for many applications, particularly for wireless communication. Besides the ability to improve the overall system performance by means of polarization diversity, they are also able to provide double transmission channels in a frequency-reuse communication system. In dual-polarized operation, the isolation between two orthogonal polarization ports is very important in reducing crosstalk in the circuits. It is desirable to have an isolation of 30 dB or more.

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For dielectric resonator antennas, dual linearly-polarized operation can be easily realized by using a pair of probe feeds to respectively excite two orthogonal fundamental modes from a single dielectric resonator (DR); however, it is not easy to achieve high isolation in a probe-fed dual-polarized DRA and asymmetric radiation pattern would also occur at the same time [9]. It is found that symmetric radiation pattern is achieved when the dielectric resonator is symmetrically excited by a dual-feed system with a phase difference of 180°. In [10], using a pair of balanced probes, 40 dB isolation is reported. Furthermore, the high isolation can also be by employing a two hybrid input ports structure. For example, if high isolation is required, a dual-hybrid-feed structure (a combination of probe and aperture design) is recommended [11], however, excess back radiation would be produced by the aperture feed.

In this paper, we propose a new design of a dual-polarized DRA fed by two hybrid input ports: one port having an H-shaped aperture coupled feed and the other with two out-of-phase probe feeds. The proposed antenna is designed to operate at around 5.2 GHz for WLAN (Wireless Local Area Network) applications. Both the feeding mechanisms can symmetrically excite their respective linearly-polarized modes with more than 35 dB isolation over the entire impedance bandwidth. Good symmetric broadside radiation patterns with low cross polarizations are observed in the two principal planes, and in addition, the front-to-back (F/B) ratios for Port 1 and Port 2 are 10 and 18 dB, respectively.

## 2. ANTENNA DESIGN

The configuration of the proposed dual-port dual-polarized dielectric resonator antenna is shown in Fig. 1. The feeding networks of the two input ports are printed on one side of a thin Teflon substrate (thickness 1 mm and relative permittivity 2.65), and on the other side is a ground plane embedded with an H-shaped coupling aperture and two insulation holes for probes. The dielectric resonator is located at the middle of the ground plane with areas of $60 \times 60\,\mathrm{mm}^2$.

The feeding network of Port 1 is comprised of a straight $50\,\Omega$ coupling strip and an H-shaped coupling aperture etched at the center of the ground plane to excite a $y$-directed polarization $TE^{x}_{111}$ mode. Due to fact that the excess back radiation would be produced by the classic T-shaped coupling mechanism, the H-shaped coupling aperture is used here, which also reduce the required size of the resonant coupling aperture for a fixed substrate thickness. As for Port 2, its feeding network consists of a Wilkinson power divider and a half-

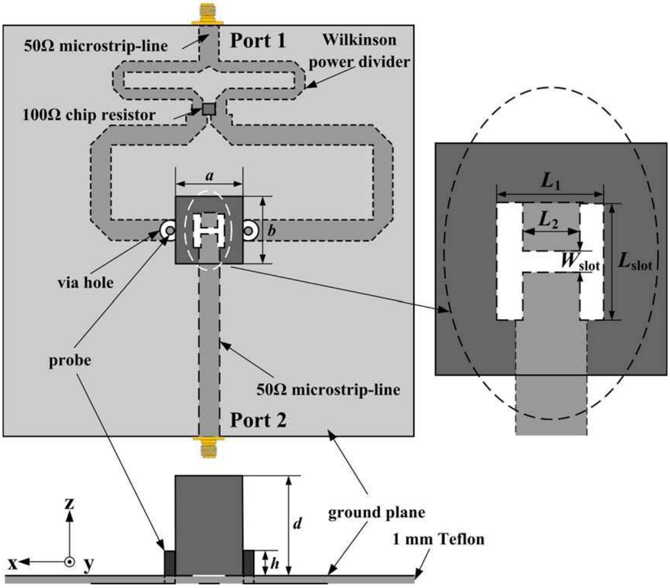


**Figure 1.** Configuration of the proposed antenna.

wavelength delay line, so that the signals in the two probes will have equal amplitudes and 180° phase differences. Consequently, an $x$-directed polarization $TE^{y}_{111}$ mode can be symmetrically excited through Port 2, which ensures symmetric radiation patterns.

In reference to Fig. 1, there are a number of parameters that influence the antenna characteristics. To achieve optimum antenna performance, a parametric study is carried out to investigate the characteristics of the DR antenna. For the design in this study, the initial parameters are chosen as: $a = b = 10\,\text{mm}$, $d = 15\,\text{mm}$, relative permittivity $\varepsilon_r = 10.2$, $W_{slot} = 1\,\text{mm}$ and $L_2 = 2.5\,\text{mm}$. The width and length of the $50\,\Omega$ microstrip feedline for Port 1 are chosen to be 3 mm and 32.5 mm, respectively.

Figure 2 shows the simulated return loss for Port 1 with different values of $L_{slot}$. The H-shaped aperture geometry has a very important effect on the input impedance of the proposed DRA [12]. As the value of $L_{slot}$ decreases, the coupling frequency of DRA to aperture increases. The value of $L_{slot}$ is chosen to be 5 mm here for good aperture coupling at 5.2 GHz. Fig. 3 shows the simulated return loss for Port 2 with different values of probe height $h$. As for probe feeding mechanism, the height of the probe controls the coupling between the feed and DR. The resonant frequency of the DRA varies as the value of $h$ changes, as

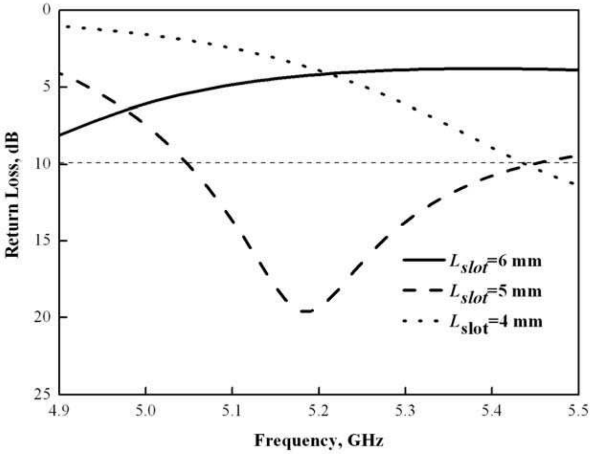


**Figure 2.** Return loss for Port 1 with different values of $L_{slot}$; $a = b = 10\,\text{mm}$, $d = 15\,\text{mm}$, $L_1 = 4.5\,\text{mm}$, $L_2 = 2.5\,\text{mm}$, $h = 5\,\text{mm}$, $W_{slot} = 1\,\text{mm}$ and $\varepsilon_r = 10.2$.

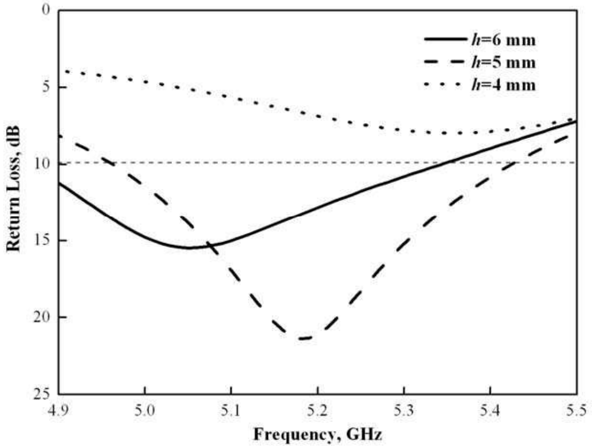


**Figure 3.** Return loss for Port 2 with different values of $h$; $a = b = 10\,\text{mm}$, $d = 15\,\text{mm}$, $L_1 = 4.5\,\text{mm}$, $L_2 = 2.5\,\text{mm}$, $L_{slot} = 5\,\text{mm}$, $W_{slot} = 1\,\text{mm}$ and $\varepsilon_r = 10.2$.

shown in Fig. 3. For better impedance matching of Port 2, the value of $h$ is chosen to be 5 mm here. The high isolation of two ports is achieved by using the hybrid feeding mechanism: one port having an H-shaped aperture coupled feed and the other with two out-of-phase

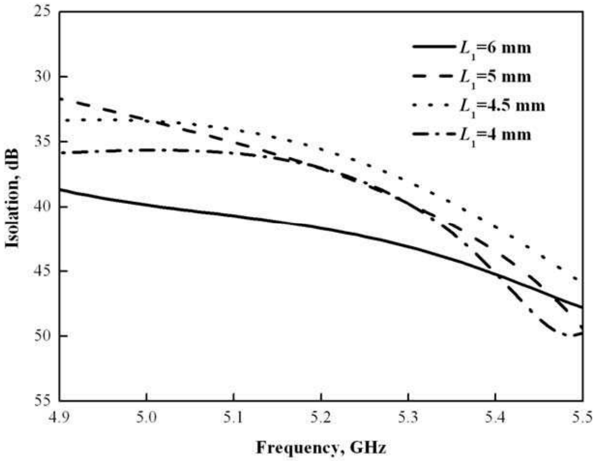


**Figure 4.** Isolation between two ports with different values of $L_1$; $a = b = 10\,\text{mm}$, $d = 15\,\text{mm}$, $h = 5\,\text{mm}$, $L_2 = 2.5\,\text{mm}$, $L_{slot} = 5\,\text{mm}$, $W_{slot} = 1\,\text{mm}$ and $\varepsilon_r = 10.2$.

probe feeds. By using this mechanism, the isolation of two ports stays high as the two ports become close to each other, as shown in Fig. 4. The isolation is higher than 35 dB as the values of $L_1$ varies from 4 mm to 6 mm, which means the isolation is high enough even when the two ports get closer.

## 3. EXPERIMENTAL RESULTS

The optimum performance of the proposed antenna is achieved by the parametric studies carried out by HFSS, and the optimized antenna parameters are chosen as follows: $a = b = 10\,\text{mm}$, $d = 15\,\text{mm}$, $h = 5\,\text{mm}$, $L_1 = 4.5\,\text{mm}$, $L_2 = 2.5\,\text{mm}$, $L_{slot} = 5\,\text{mm}$ and $W_{slot} = 1\,\text{mm}$. The return loss measured at the two feeding ports of the prototype is presented in Fig. 5, along with the simulated results. Due to the fabrication tolerance of the DR, the effective relative permittivity of the DR is lower than 10.2, which results in higher resonate frequency and wider impedance bandwidth compared with simulated results. From the obtained results in Fig. 5, good excitation at around 5.2 GHz are exhibited by both the feeding ports, and the impedance bandwidth (also referred to as 10 dB return loss) measured at Port 1 and Port 2 meets the demand for WLAN applications from 5.15 GHz to 5.35 GHz. The isolation level between the two feeding ports of the prototype is shown in Fig. 6, and an isolation of more than 35 dB over the

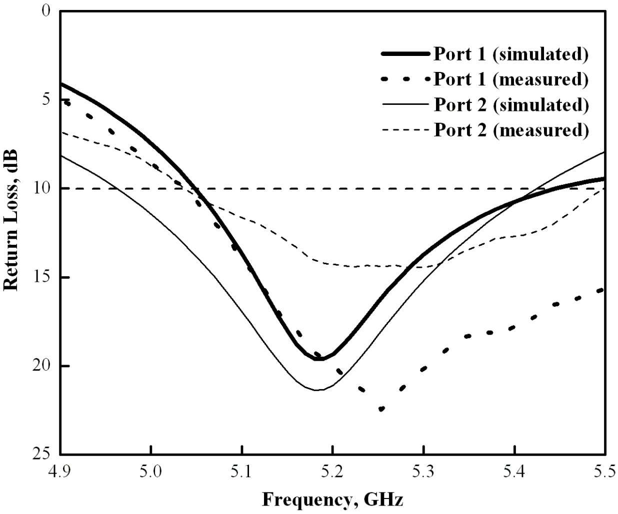


**Figure 5.** Return loss against frequency for Port 1 and Port 2 of the constructed prototype.

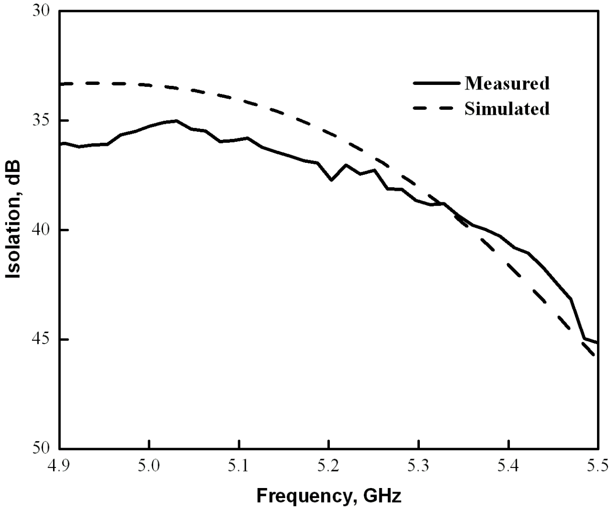
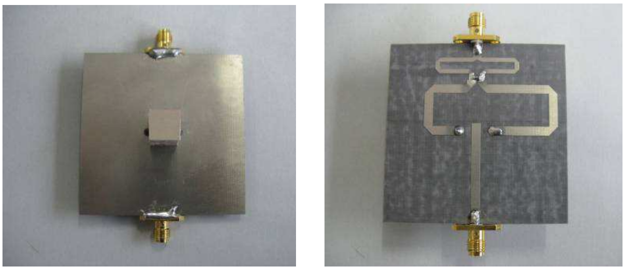


**Figure 6.** Measured and simulated isolation level of the constructed prototype.

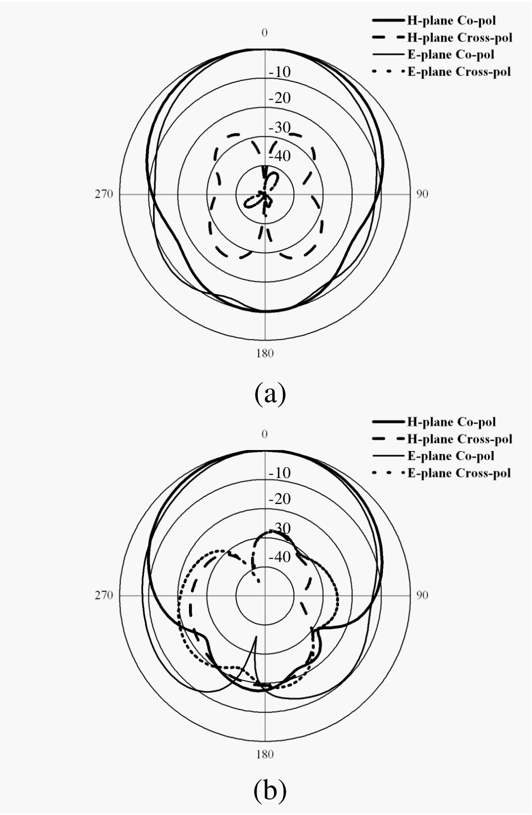
entire impedance bandwidths is demonstrated. The prototype of the proposed DRA is shown in Fig. 7.

The radiation patterns measured at 5.2 GHz for Port 1 and Port 2 are plotted in Fig. 8. Good symmetric broadside radiation patterns



(a) (b)

**Figure 7.** Prototype of the proposed DRA. (a) Front view. (b) Rear view.



(a)

(b)

**Figure 8.** Measured radiation patterns at 5.2 GHz for Port 1 and Port 2 of the constructed prototype. (a) *E*-plane and *H*-plane for Port 1, (b) *E*-plane and *H*-plane for Port 2.

with low cross polarizations are observed in the two principal planes. Since the two feeding ports are well decoupled, low cross-polarization radiation can be expected at each feeding port. For Port 1, the broadside cross polarization level is 46 dB in the $E$-plane and $H$-plane. As for Port 2, the broadside cross polarization level is 29 dB in the $E$-plane and $H$-plane. From these results, it is interesting to learn that the peak gains measured at both ports are almost the same at around 7.2 dBi, and in addition, the front-to-back (F/B) ratios for Port 1 and Port 2 are 10 and 18 dB, respectively.

## 4. CONCLUSION

A dual-feed dual-polarized dielectric resonator antenna operating at around 5.2 GHz for WLAN applications has been presented in this paper. Two linearly-polarized modes of the antenna are excited by a dual-hybrid-feed structure with a combination of probe and aperture design. To avoid the asymmetric radiation pattern caused by single probe feed, $x$-directed polarization mode can be symmetrically excited by the technology of a dual-feed system with 180° phase differences. Another linearly-polarized mode is excited by H-shaped aperture to reduce excess back radiation. From the experimental results, it is found that the isolation level between the two feeding ports is more than 35 dB within the entire impedance bandwidth. The measured far-field pattern results also demonstrated that the two linear polarization radiations have a symmetrical main beam, and their broadside cross polarization levels in both $E$- and $H$-planes are more than 29 dB. Good front-to-back (F/B) ratios at two ports are obtained.

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