CPW-fed Dual-Polarized Wide Slot Radiator for Wireless Applications

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Abstract

CPW-fed strip and slot antennas are known to deliver narrow-band and wide-band characteristics with high polarization purity and the concepts are utilized to design a dual-polarized wide slot radiator for ISM band applications. The proposed structure resonates at 2.45GHz with good isolation (less than 15dB) between the ports concerned. The steps of optimization to propose the final prototype are described. The surface current distributions and the radiation patterns are investigated to validate the claims of dual-polarized radiation. The layout of the geometry encourages easy fabrication and the results are found to be in agreement with the practical standards.

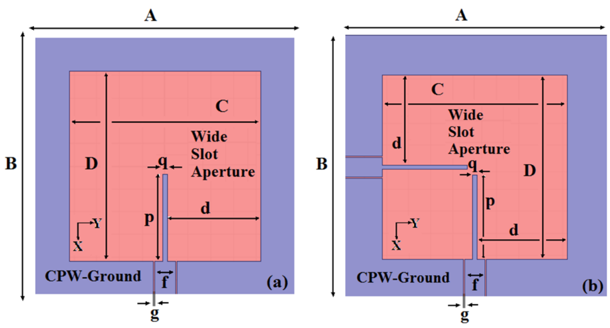
1. Introduction

With the advent of multiuser communication systems enjoying seamless data-transfer capabilities, omnidirectional transmitting and receiving antennas with high isolation between the employed channels have become the key components of interest in microwave researches. Radiators with polarization diversity characteristics are proposed to be the most efficient solutions in this context [1]. Orthogonally placed narrow-slot radiators or feed configurations are used to generate dual-polarized radiation [2-3]. CPW-fed strip or wide slot antennas are well-known in literature [4-6] for wideband and multiband applications. Empirical relations are reported in [7], between the dimensions of the slot and that of the CPW-excitation incorporated for the slot radiator, to facilitate easy design and development of such structures. A dual-polarized CPW-fed patch radiator is also reported [8] for single-frequency operations at 2.45GHz with an orthogonal feed structure for WLAN applications. From all these literature, it may be inferred that, if a wide-slot be used as an aperture to be illuminated by CPW-compatible radiators – it will resonate at proper frequencies, tunable with the dimensions of the incorporated feed structure used for slot-excitation. Extending the concept, an orthogonal feeding is arranged with proper isolation between the ports to conceive a configuration supporting dual-polarized radiation – utilizing the same radiating aperture. This approach further enhanced the space-effectiveness of the component.

In this article, the authors present a CPW-fed dual-polarized wide-slot radiator for ISM band applications – utilizing the same radiating aperture, with an orthogonal feeding configuration. The design started with a single CPW-fed strip monopole structure, which excites a wide slot (as shown in Fig. 1a) and later orthogonal feeds are arranged (as shown in Fig. 1b). The dimensions are then optimized with parametric variations, to propose the final prototype as depicted in Fig. 1c – and the simulated results are presented. Section II describes the structures investigated and the design aspects of such configurations. The simulated results are depicted and discussed in Section III followed by the conclusions. The structure has been designed and optimized to operate at 2.45GHz, which falls under the ISM Band of Operation and is used for various civil and military applications.

2. Problem Formulation

A CPW-fed slot aperture can be used to radiate at resonance, as described in [7-8], when the length of the feed monopole is around $\lambda_g/4$ and the arm dimensions of the square aperture are around $\lambda_g/2$ respectively. Where, λ_g is the guided wavelength at the frequency of resonance. Simulations do validate this proposition as will be discussed in the relevant section. Fig. 1(a) depicts the initial structure where a CPW-fed strip monopole is used to excite a wide-slot, etched out on the CPW-ground with proper dimensions.



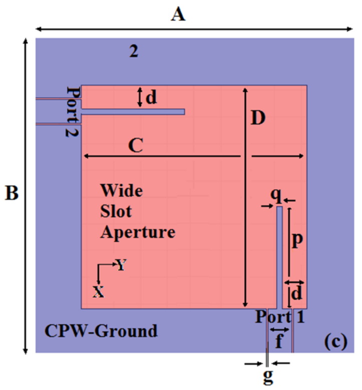


Figure 1: The proposed structures, (a) Structure 1, (b) Structure 2 and (c) Structure 3 respectively

Theoretically, the design dimensions are calculated as,

$$C = D = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} \quad (1)$$

$$p = \frac{c}{4 f_r \sqrt{\varepsilon_{eff}}} \quad (2)$$

where, *c* is the velocity of light, f_r describes the frequency of operation and ε_{eff} signify the effective dielectric constant of the substrate. The design is carried out on an FR-4 glass epoxy substrate material having a relative dielectric constant, ε_r=4.3 and loss tangent, $tan\delta$=0.003 respectively. The substrate thickness was taken as 0.762mm. The dimensions for *f* and *g* in the structures, which characterize the CPW-feed – are calculated using the IE3D line gauge calculator [9] to represent a lossless transmission line with 50Ω characteristic impedance.
Fig. 1(b) describes the first prototype to sustain dual-polarized radiation and its dimensions are further optimized with the help of parametric variations to finalize the structure depicted in Fig. 1(c) which is the proposed radiator of this article. The dimensions for the proposed structure (Structure 3 as in Fig. 1(c)) are described in Table I. The optimization steps with parametric variations are described in the following section. The dimensions of the monopole and the wide-slot was kept fixed for all the designs in Fig. 1 and the focus was to optimize the offset *d* which was essential to achieve a proper isolation between the ports concerned.

TABLE I
DIMENSIONS OF THE PROPOSED RADIATOR, STRUCTURE 3 (AS DEPICTED IN FIG. 1(C))

Parameter Name	Value in mm
A	60
B	60
C	42
D	42
f	4.46
g	0.3
d	4.5
p	19.25
q	1

3. Results and Analyses

The proposed structure was conceived to have orthogonal feed-placements and therefore it was necessary to utilize spatial displacement to obtain isolation between the ports. In this context, for the single-polarized radiator (Structure 1, as in Fig. 1(a)) the strip monopole used for excitation, was to be investigated for the variations in the offset *d*. The curves for S_{11}, for the investigations, are depicted in Fig. 2. From the figure it is observed that with respect to a displacement of the feed from the central position, a right-shift of the frequency of resonance is observed with better matching performances. It is seen that, when the displacement is maximum (in case of the variation), best matching performances are observed and the resonance is achieved near 2.4GHz, which falls under the ISM band of operation.

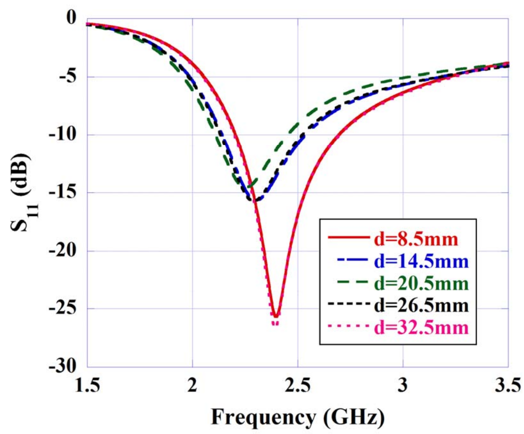
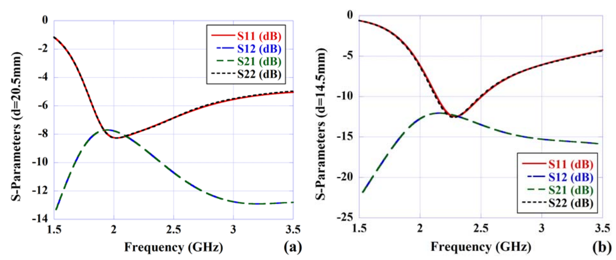


Figure 2: S11 plots for Structure 1 (as in Fig. 1(a)) for different values of the offset *d*

The offset *d* was found to have a dominant effect on isolation when the proposed structure with orthogonal feed configuration was investigated. For Structure 2 (depicted in Fig. 1(b)), Fig. 3(a-d) describes the S-parameters for different values of *d* as shown. It is observed that, as the displacement with respect to the central position, increased – isolation between the ports improved gradually and the value of S_{21} could successfully be brought down below -15dB as per the standards. However, it is also observed that beyond a limit, if the displacement was further increased, with respect to the central position – the matching performances at the ports reduced and the results degraded.



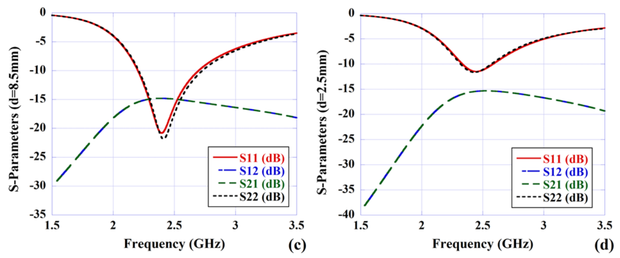


Figure 3: S-parameter variations for Structure 2 (as depicted in Fig. 1(b)) for different values of *d*

Fig. 4 represents the S-parameters of the proposed structure (Structure 3, as in Fig. 1(c)) which shows good matching at both the ports and good isolation between them – thus validating the dual-polarized characteristics. Fig. 5(a-b) represents the surface current distributions at 2.45GHz for the proposed structure, with each port excited individually. In each of the diagrams, the individual monopoles are seen to depict concentrated currents around them, signifying isolated radiation characteristics for each case.

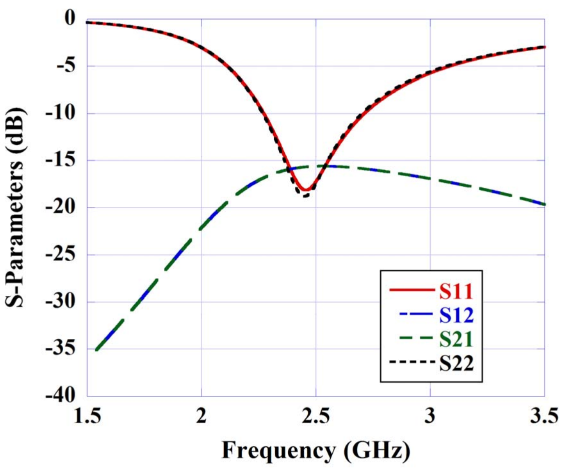


Figure 4: S-Parameters for the proposed Structure (Structure 3, as in Fig. 1(c))

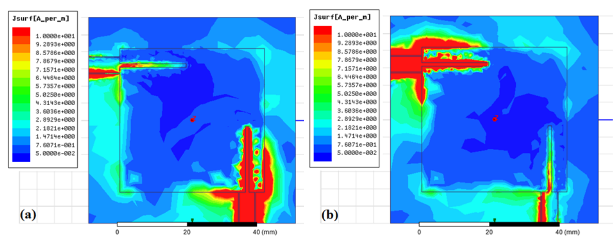


Figure 5: Surface current distribution at 2.45GHz for (a) Port 1 excitation and (b) Port 2 excitation respectively for the proposed structure

Fig. 6(a-d) represents the radiation patterns at individual planes for the proposed structure with co-pol and cross-pol patterns plotted separately for observation. It is noted that, for each monopole structure the corresponding planes (XZ-Plane and YZ-plane for Port 1 excitation; YZ-Plane and XZ-Plane for Port 2 excitation) represent monopole-like radiation patterns, which further justify the claims of dual polarized radiation. The cross-pol radiation is found to be small enough so as to justify practical usage of the proposed structure.

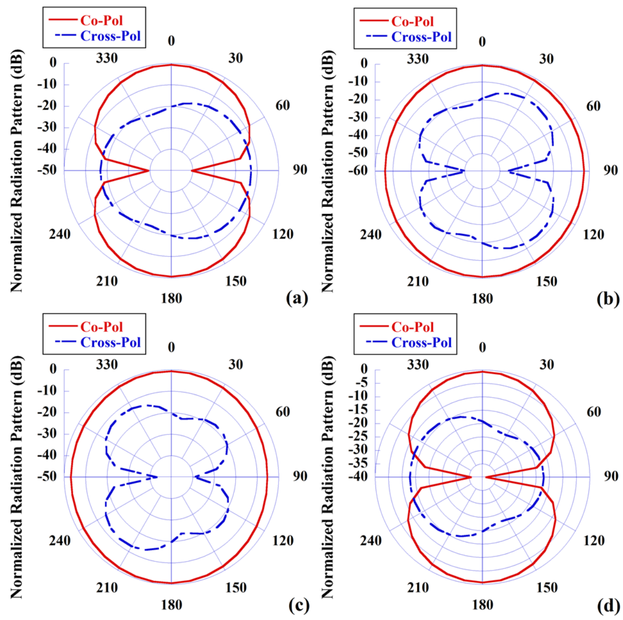


Figure 6: Co-pol and Cross-pol patterns at 2.45GHz for (a) XZ-Plane with Port 1 excitation, (b) XZ-Plane with Port 2 excitation, (c) YZ-Plane with Port 1 excitation and (d) YZ-Plane with Port 2 excitation respectively

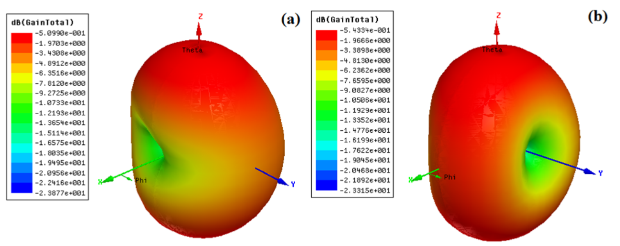


Figure 7: 3D Polar radiation plots at 2.45GHz for the proposed structure when (a) Port 1 is excited and (b) Port 2 is excited respectively

Fig. 7 represents the 3-dimensional polar plots for total radiation obtained from the proposed structure when each port is excited separately and the natures further validate dual-polarized characteristics and justify the claim of the proposed structure.

4. Conclusions

A novel CPW-fed dual-polarized radiator with orthogonal feed configuration is reported for ISM band applications at 2.45GHz. The design is validated with simulations and the dimensions are optimized with the help of parametric variations. Representative results are discussed in detail to justify the claim of the authors and to validate the suitability of the proposed structure for practical applications.

5. Acknowledgements

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6. References

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