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DUAL-POLARIZED CPW-FED CONFORMAL ANTENNA FOR ULTRA-WIDEBAND APPLICATIONS

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ABSTRACT

In this paper, we introduce a new compact dual-polarized conformal slot antenna fed by two orthogonal Coplanar Waveguide (CPW) semi-discs. To achieve a high isolation between the two ports, a strip is inserted diagonally in the ground plane. The simulations are done using the Computer Simulation Technology (CST) Microwave Studio software. The simulated results show that the proposed antenna provides an impedance bandwidth enough to cover the Ultra wideband spectrum, and exhibits a good isolation across the operating band. These features make the proposed concept very attractive for conformal ultra-wideband (UWB) antenna applications which used polarization- diversity technique.

Keywords: ultra-wideband antennas, polarization-diversity applications, conformal antennas, cylindrical antennas.

INTRODUCTION

Ultra Wideband (UWB) applications are one of the most used technologies in the modern wireless communication systems, which has been received a lot of interestafter the FCC (Federal Communications Commission) released the UWB license in 2002(FCC 2002). This interest is mainly related to their attractive merits, such as small size, low profile and easy fabrication. The slot antenna is an interesting candidate for wireless applications. However, this type of antennas suffers from a limited narrow band, which is not enough for UWB applications. Recently, a variety of techniques have been proposed in order to improve the slot antenna bandwidth. These techniques suggest various geometrical configurations of planar ultra wideband slot antenna with different feeding technology, such as circular slot antenna (Dendini and Habib 2006), (Angelopoulos, Anastopoulos, Kaklamani, Alexandridis, Lazarakis and Dangakis, 2006) rectangular slot antenna (Shagar and Wahidabanu, 2010) and other forms (Leib, Freiand Menzel, 2009), (Hocine Djamel and Brahim, 2010).

On the other hand, dual- polarized operation is a suitable feature for reducing multipath phenomenon in hostile environments. With this approach, the multipath effects can be reduced, which improves the transmission quality and increase the capability of the communication systems (Yahya and Denidni, 2011), (Chacko, Augustin and Denidni, 2013). The combination between the UWB wireless communication systems demands and the polarization diversity techniques have been received much attention, and many investigations have been pursued and published in literature (Lu and Lin, 2014), (Padhi, Karmakar, Law and Aditya, 2003), (Adamiuk, Zwick and Wiesbeck, 2010), (Yoon, Yoon, Kim, and Lee, 2011), (Yue, Zhijun, Wenhua, Zhengheand Iskander2010), (Yahya and Dendini2011). Unfortunately, some of them have bulky forms, mounted on planar substrates, which mainly reported for radar, medical microwave imaging systems, cognitive radio applications and weapon detection systems (Ahmed, Sebak and Dendini 2010)(Augustin, v and Dendini2014), but they are not large enough to cover the full requests of UWB applications. The antennas used for these applications need to have some additional characteristics such as low weight, thin substrate thickness, and flexibility to conform to non-planar surfaces (Nikolaou, Tentzeris, and Papapolymerou 2007). Actually, some research groups have been focused their work in the study of cylindrical antennas for UWB applications and extended this concept for other study like asdual-polarized conformal antennas, which can offer certain desirable characteristics that are not provided by planar structure, which are needed for many electronic applications. However, the effect of the conformal dual-polarized shape has not thoroughly been investigated.

In this paper, we propose a new dual-polarized UWB slot antenna with circular shape that is conformed on a cylindrical substrate using CPW technology. To achieve a high isolation between the two ports, a strip is inserted diagonally in the ground plane. The electromagnetic characteristics such as S parameters and radiation patterns are presented and discussed. The obtained results show that the proposed antenna can achieve a good matching and isolation over an ultra large frequency band from 3.1GHz to 12GHz.

ANTENNA DESIGN

Figure-1 shows the proposed concept geometry. This structure composed of a circular slot fed by two identical orthogonal CPW lines with 50 Ω impedance and ending by semi-circle patches that have the same distance from the slot centre. The circle is then modified and closed on both sides until getting a heart shape, as illustrated in Figure-1a. Moreover, it is important to note that the isolation performance between the antenna ports plays a crucial role. For this issue, a strip is inserted between the two ports to achieve low mutual coupling between the two antenna ports. The proposed antenna is printed on Rogers RO3003 substrate with a relative permittivity $\varepsilon_r=3$, thickness h=0.254 mm and loss tangent of 0.0013, and

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conformed on a cylindrical Styrofoam (ε_r =1.03) with radius R=40 mm, as shown in Figure-1c. The effects of different antenna parameters on the antenna performances have been studied and optimized using the CST Microwave Studio. The optimal values of the antenna parameters are summarized in the following table.

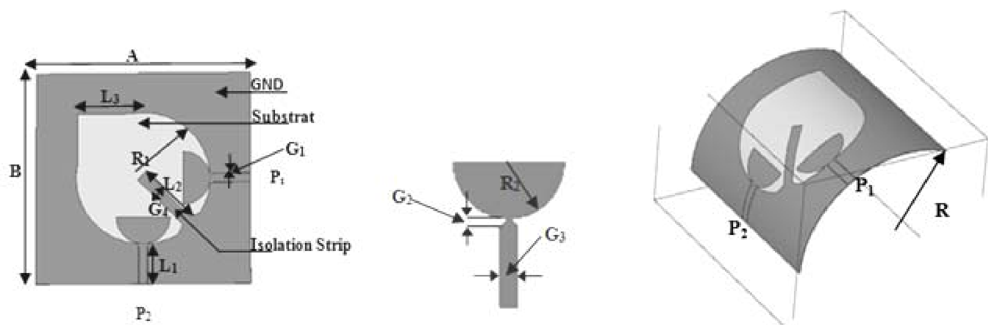
Table-1. Final optimised dimensions of the proposed structure (in mm).

A	B	L_1	L_2	L_3	G_1	G_2	G_3	G_4	R_1	R_2
80	80	15.1	16	35	0.2	0.05	3.2	4	25	10

NUMERICAL RESULTS AND DISCUSSIONS

The simulations were carried out using the commercial electromagnetic simulator CST Microwave Studio, which is based on Finite Integration Technique (FIT) in time domain. The simulated S parameters of the proposed structure are plotted versus the frequency in Figure-2.

From Figure-2a, it can be seen that the impedance bandwidth of this design is from 3.1 GHz to 12 GHz for return loss below -10 dB, which is enough to cover the UWB applications operating in the band: 3.1-10.6 GHz. The observed divergence between the parameters S_{11} and S_{22} is mainly caused by the effect of radius when the slot antenna is curved on a cylindrical substrate, this indicate that there Ł#˚#¹æ ˚ºº#˚¹Êæ æ ˇ-ßÊ# ¸ˇ-Ö ˇˇı#the most sensitive geometrical parameters corresponding to port1 and port2 as illustrated in Figure-3, we note that the only case which gave better isolation is for R = 40mm as shown in Figure-4. Furthermore, the transmission coefficients (S_{12}/S_{21}) between the two ports are similar, less than -15dB between 3.1GHz - 5.7GHz and less than -20dB in the rest of the full operating band, which ensures a good isolation between the two antenna ports, as illustrated in Figure-2b.



(a) (b) (c)

Figure- 1. Geometry structure of the proposed antennas. (a) Planar forme, (b) Conical CPW line. (c) The proposed antenna conformed on a cylindrical substrate.

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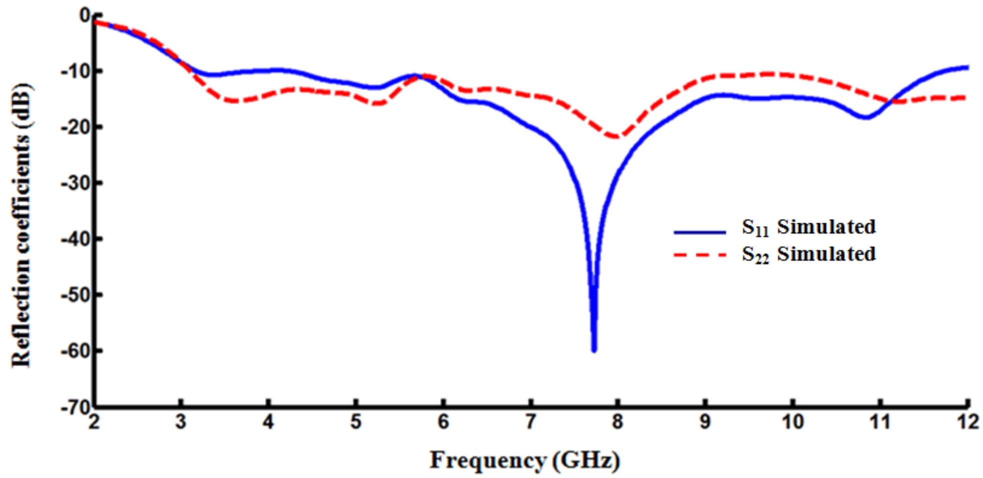
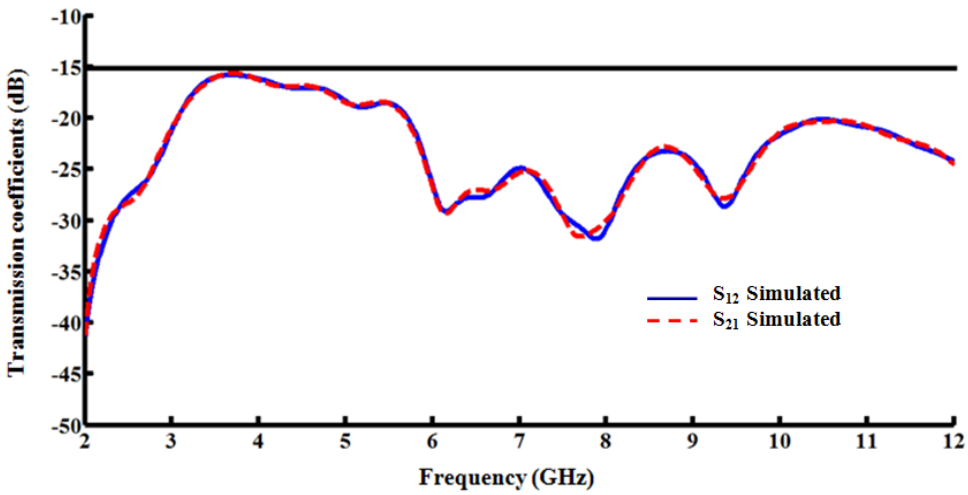


(a)



(b)

Figure-2. S parameters of the conformal antenna. (a) Reflection coefficients, (b) Transmission coefficients.

The radiation pattern simulations were performed in the two principal planes with the directivity direction being the intersection of the two planes. The antenna was studied in a far-field range from 3.1GHz to 12GHz, but only patterns at 3.5 GHz, 6.5 GHz, and 10.6 GHz are presented. The simulated radiation patterns at these frequencies are shown in Figure-5. Nearly omni-directional patterns are observed in the lower frequency region whereas at higher frequencies the patterns are slightly distorted because of the effect of the high order modes.

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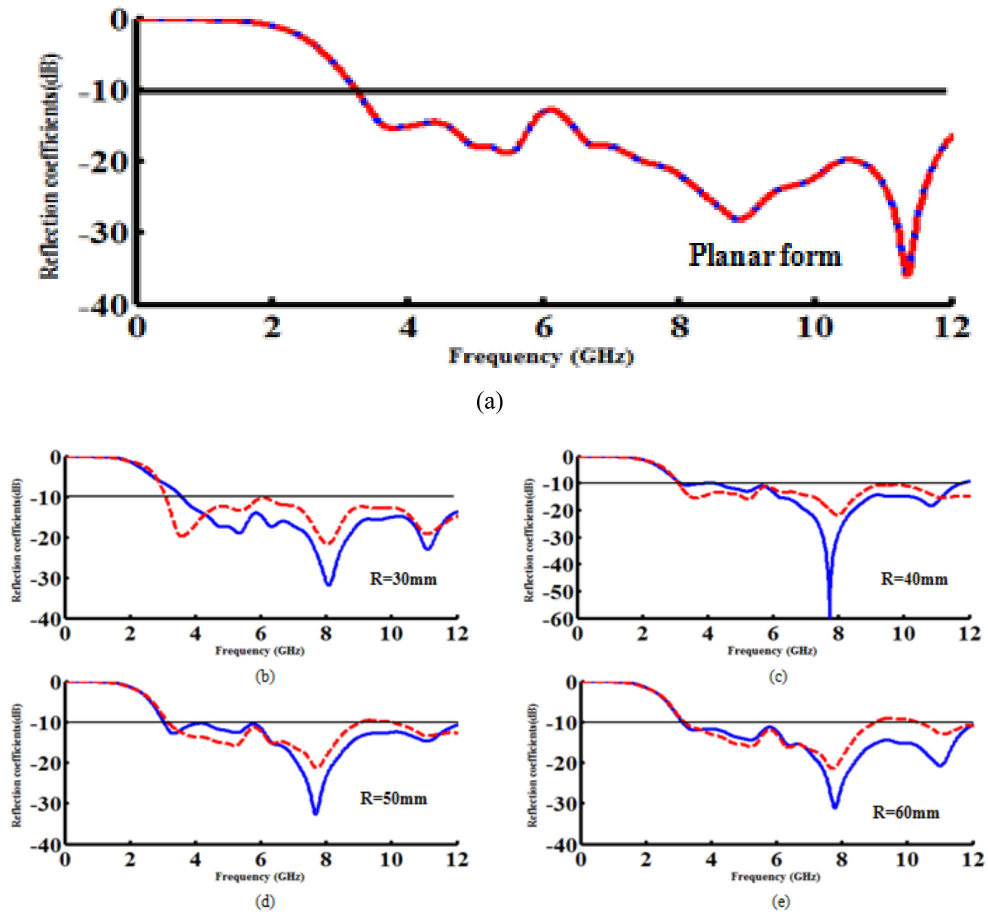
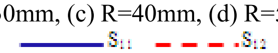


Figure-3. S_{11}/S_{22} parameters of the conformal antenna for planar form and different radius: (a) planar form, (b) R=30mm, (c) R=40mm, (d) R=50mm and (e) R=60mm.



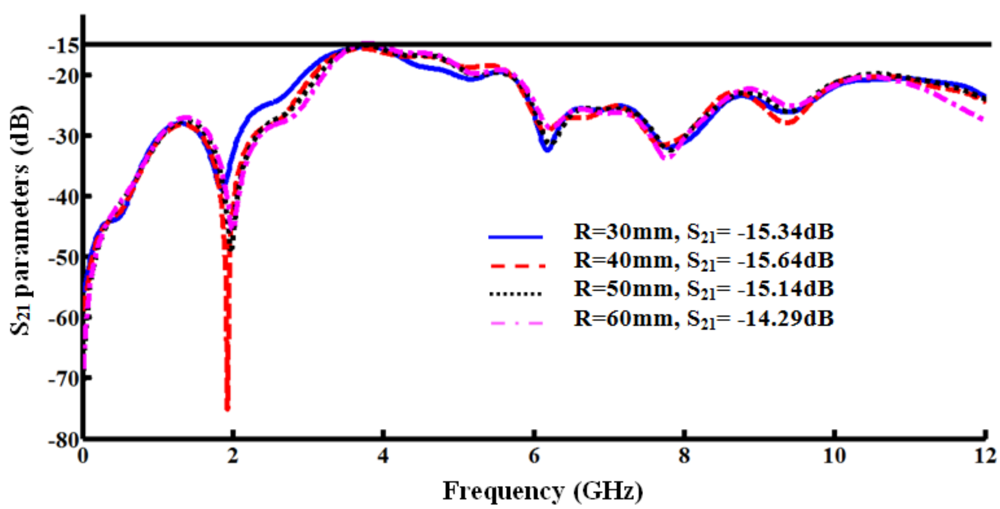


Figure-4. S_{21} parameters of the conformal antenna for different radius R= 30, 40, 50, 60 (mm).

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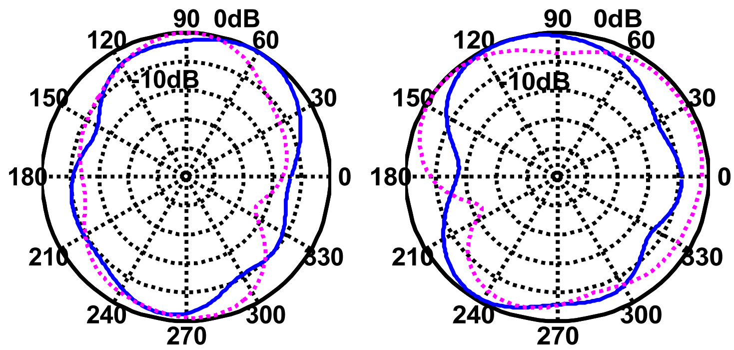
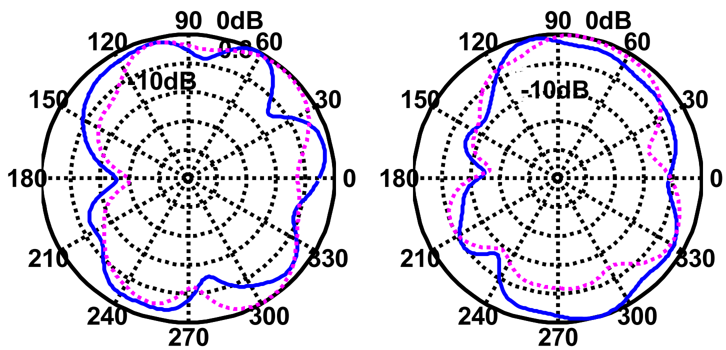


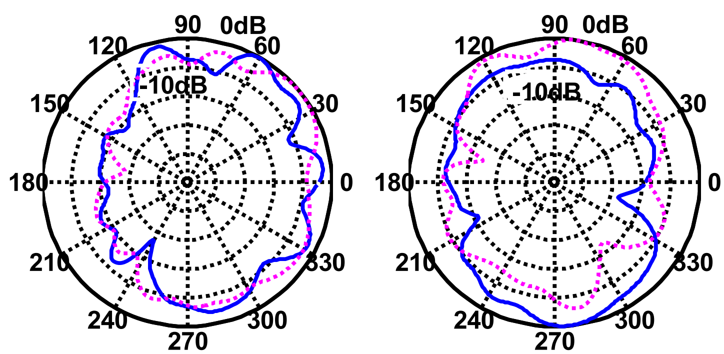
P1 P2

(a)



P1 P2

(b)



P1 P2

(c)

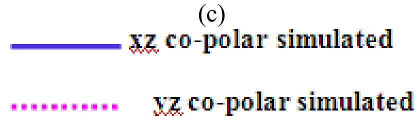


Figure-5. Simulated radiation patterns of the proposed structure antenna at (a) 3.5GHz. (b) 6.5GHz and (c) 10.6GHz.

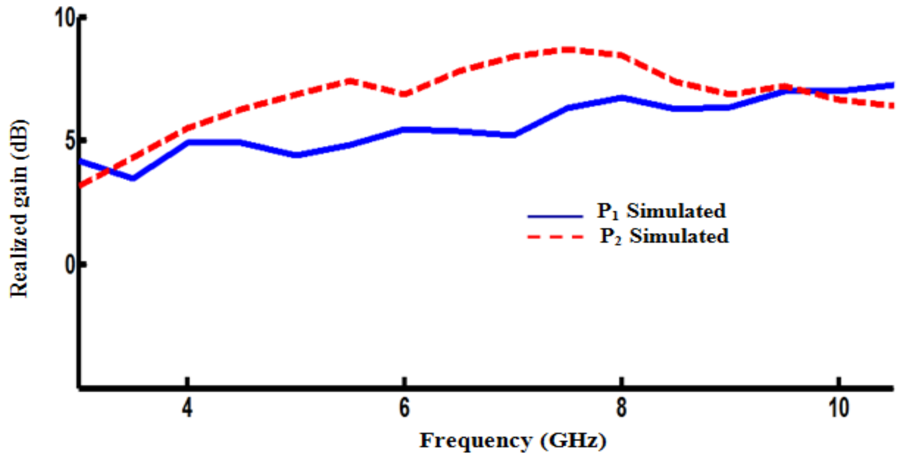


Figure-6. Simulated gain of the proposed antenna.

The simulated gain of the wideband antenna for P_1 and P_2 (when P_1 is excited, P_2 is terminated with 50 Ω load and vice versa) is presented in Figure-6. It is found that the UWB antenna gain for P_1 ranges from 3.472 dB to 7.249 dB and from 3.161 dB to 8.703 dB for P_2.

CONCLUSIONS

A new dual-polarized ultra-wideband antenna conformed on a cylindrical substrate using CPW technology has been simulated. The obtained results have been shown that the proposed structure antenna can provide an ultra-wideband characteristic with low transmission coefficient below -15dB over the all operating UWB spectrum, which ensures a good isolation between the two orthogonal ports. Additionally, this antenna has an omni-directional far-field radiation pattern. The proposed concept is a promising candidate for the UWB wireless communication systems with polarization-diversity operation.

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