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A PRINTED MIMO/DIVERSITY MONOPOLE ANTENNA FOR UWB APPLICATIONS

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Abstract: This paper introduces printed diversity monopole antenna for the UWB applications. The diversity antenna comprises of two CPW feed symmetric semicircular discs placed orthogonally to each other and sharing a common ground plane. The return loss of both the ports exhibit the bandwidth 7.4 GHz (from 2.4-9.8 GHz). The isolation between both the ports is controlled by the cross stub in the ground plane and is around 15 dB at lower frequencies and better than 20 dB above 5 GHz. The proposed antenna measured results are in close agreement with the simulated results. The radiation pattern of the antenna is omnidirectional in H-plane and bidirectional in E-plane. The diversity parameters like envelope correlation coefficient and diversity gain are calculated and found in acceptable range.

Keywords: UWB antenna, Microstrip feed, Horizontal Polarized antenna, MIMO and Diversity

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INTRODUCTION

Ultra wide band technology is attracting a number of researchers when FCC released the unlicensed band from 3.1-10.6 GHz. Ultra wide band has many advantages such as huge band-width, low power contents, high speed bit rate, carrier-less transmission. Recently, wireless communication systems demand for reliable transmission and reception of signals along with increased capacity of the channel and robustness. But when the signals propagate through highly dense or multi path environment they undergo various signal distortion phenomenon, such as fading and co-channel interference. Hence to overcome the problem of fading and co channel interference, the diversity or MIMO techniques are used. This technique helps in improving the wireless transmission of the signal without increasing the original bandwidth and power of the signal.

In diversity technique, two or more antennas are placed at transmission and reception wireless devices like wireless microphones, WLAN, Wi-Fi, Bluetooth, Wi-Max and mobile handsets [1-3]. In order to implement antenna diversity at mobile terminals, the size of the antenna should be as small as possible with minimum mutual coupling between the antennas. Hence, it is challenging to design the compact size antenna with less mutual coupling.

Some of the reported diversity antennas along with their isolation are discussed here. In [4], an ultra-wide band diversity antenna consists of two square monopoles which are truncated at one end and placed orthogonal to each other. It has a return loss of S_{11}<-10 dB from 2.3-7.7 GHz with overall size of 48 x 115 mm^2. The isolation is found to be less than 15 dB. In [5], a diversity antenna which has bandwidth from 1.85-2.31 GHz consists of two slot monopole hybrid elements placed symmetrically to each other. The isolation is found to be less than 14.8 dB and overall size of the antenna is 95 x 60 mm^2. An UWB antenna is proposed in [6] for multiple input multiple output applications, consists of two circular discs placed side by side with return loss of -10 dB from 3.2-10.6 GHz. The isolation between both the radiators is less than 15 dB. The overall size of the antenna is 40 x 68 mm^2. A multiple input multiple output antenna is proposed in [7] having E-shaped monopole. The antenna has its centered frequencies at 2.4 GHz, 5.4GHz and 5.8 GHz with return loss -10 dB with single antenna having size of 35 x 38 mm^2 for diversity size will be at least 70 x 72 mm^2. The isolation is below 14 dB. In [8], an antenna is proposed for LTE (2.5-2.7 GHz) and WLAN (2.4-2.5 GHz) bands. The overall size of the antenna is 95 x 55 mm^2 and isolation below 15 dB. In [9], an antenna operating over 2.4-4.2 GHz is proposed for Diversity/MIMO applications. The antenna has overall size of 90 x 40 mm^2 with crescent shaped monopoles. The isolation achieved less than 17 dB between both the monopoles.

In this paper, the semi-circular disc shaped monopole antenna is proposed. The diversity antenna has bandwidth ranging from 2.4-9.5 GHz with isolation around 15 dB over lower frequencies from 2.4-5 GHz and better than 20 dB above 5 GHz. The antenna is fabricated and the measured results are compared with the simulated which shows good agreement with each other.

2. ANTENNA GEOMETRY

The proposed antenna is printed on 40 x 40 mm^2 FR-4 substrate. The FR-4 substrate has thickness of 1.6 mm with relative permittivity of 4.4 and loss tangent of 0.025. The geometry of the antenna is shown in Figure 1.

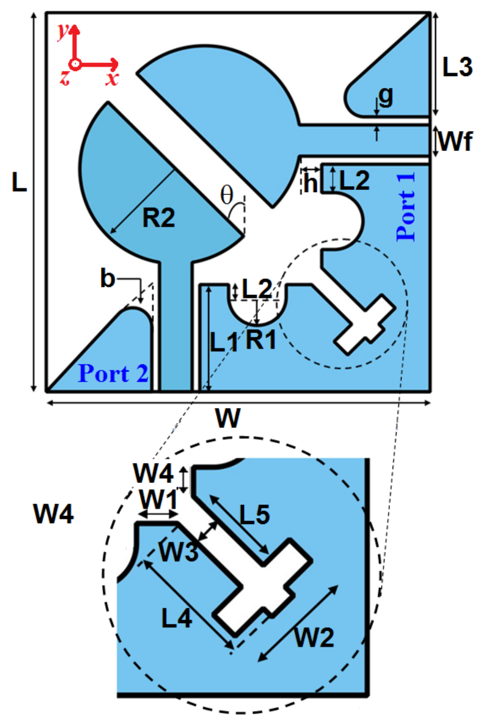


Figure 1: Proposed Antenna Geometry

The CPW –fed antenna comprises of the symmetric semi-circular discs which are placed orthogonal to each other. The semi-circular discs are rotated by an angle of 45^0 from its diameter as indicated by θ as shown in Figure 1. The ground plane is blended from its corners, this is done to improve the impedance bandwidth of the antenna. While the semi-circular slots in ground plane serves the same purpose of impedance matching. The isolation is improved by the cross shaped stub placed in the ground plane. The geometry is designed and simulated using CST Microwave studio software.

3. RESULTS AND DISCUSSIONS

The diversity antenna is designed and fabricated with optimized dimensions. The S-parameters of antenna are measured using Vector Network Analyzer R&S ZVA40. The Figure 2 shows the comparison of the simulated and measured S_{11}, S_{22} and S_{21} of the proposed antenna which shows good agreement with each other. The return loss S_{11} of port1 and S_{22} of port 2 are nearly same due to symmetric geometry. The impedance bandwidth achieved for both the ports is 7.5 GHz from 2.4-9.5 GHz as shown in Figure 2(a) and 2(b). The cross slot made in the ground plane improved the isolation around 15 dB for 2.4-5 GHz and 20 dB above 5 GHz shown in Figure 3(c).

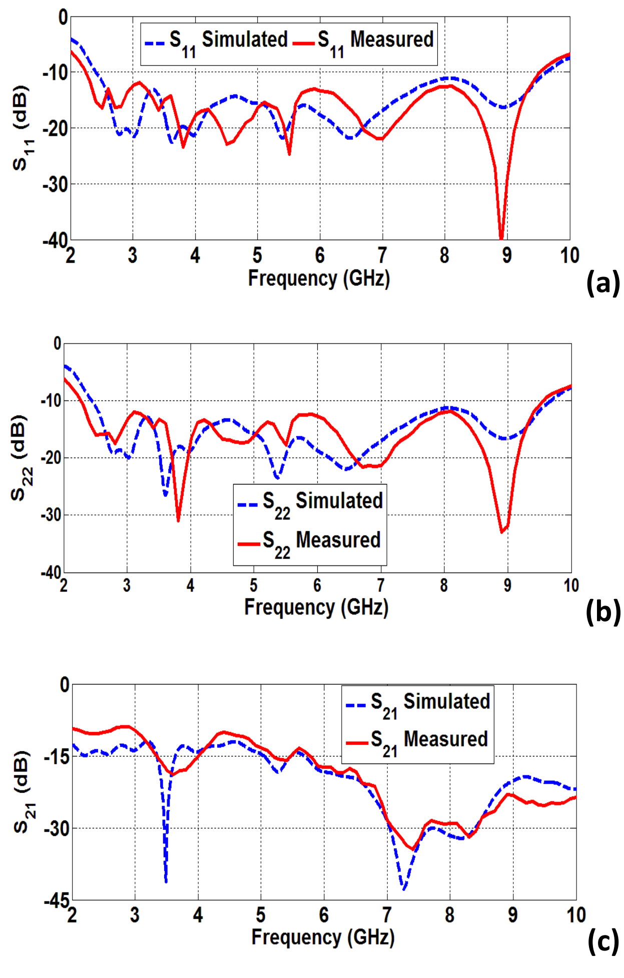
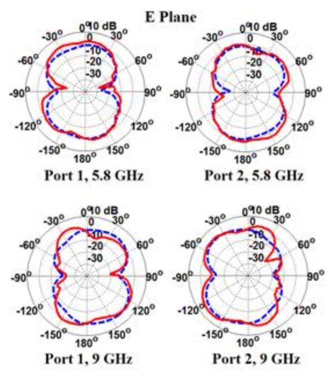


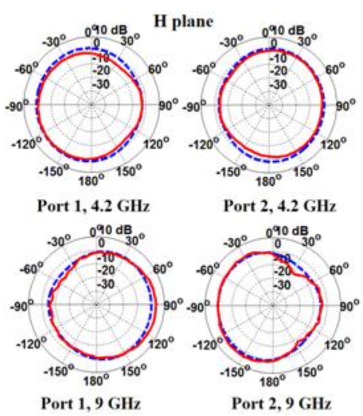
Figure 2. The simulated and measured S-parameters (a) S_{11} (b) S_{22} and (c) S_{21}

4. RADIATION PATTERNS

The simulated and measured far-field radiation patterns are as shown in Figure 3. The comparison between simulated and measured radiation patterns is shown at 2 different frequencies falling in the bandwidth of the antenna. As can be seen from Figure the E-plane radiation patterns show dumbbell shaped behavior while the H-plane radiation patterns show omni-directional behavior.



(a)



(b)

Figure 3. Measured and Simulated Radiation Patterns

5. Envelope Correlation Coefficient

The Envelope correlation coefficient describes the diversity performance of the antenna for multiple antenna arrangement systems. The signals in the case of multiple antenna systems get correlated with each other to some extent and this correlation is given by Envelope correlation coefficient (ECC). The simulated and measured ECC of the proposed antenna is shown in Figure

4, which is below 0.008 and shows good agreement with each other. The reference value of ECC is 0.5 [7] and the ECC for proposed antenna is much below it. The measured ECC can be calculated with the help of equation (1).

$$\rho = \frac{|S_{11}^* S_{21} + S_{12}^* S_{22}|^2}{|(1-|S_{11}|^2-|S_{21}|^2)(1-|S_{22}|^2-|S_{12}|^2)|} \quad (1)$$

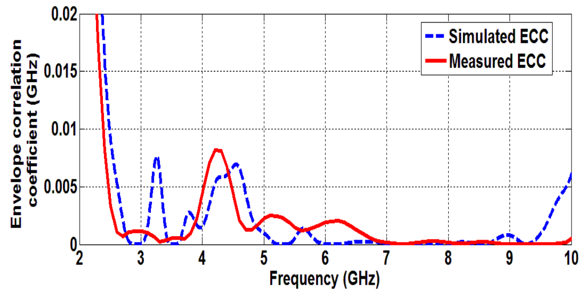


Figure 4. Measured and simulated Envelope correlation coefficient

6. DIVERSITY GAIN

Diversity gain is another parameter which gives the performance of the diversity antenna. The diversity gain is related to the envelope correlation coefficient as shown in equation (2) and is calculated when ECC is below 0.5[10]. High isolation between the radiators provide low envelope correlation coefficient and high diversity gain. The diversity gain is shown in Figure 5 and calculated using equation(2);

$$G = 10\sqrt{(1 - |\rho_e|^2)} \quad 2$$

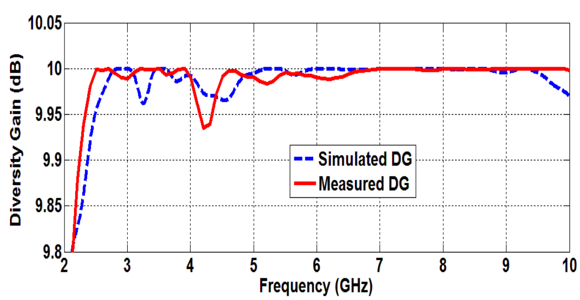


Figure 5. Measured and Simulated diversity gain of proposed antenna

7. CONCLUSIONS

This paper provides the compact diversity antenna design and its validation. The impedance bandwidth of proposed diversity antenna at both the ports is from 2.4 – 9.8 GHz. The isolation between both the radiators is improved by using the cross stub placed in the ground plane. It is 15 dB below 5 GHz and better than 20 dB above 5 GHz. The measured and simulated results of the antenna are in good agreement. The diversity parameters such as envelope correlation coefficient is found to be less than 0.008 while diversity gain is closer 10. Such compact diversity antenna is useful for reliable transmission and reception in multiple scattering environment.

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