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Design And Devlopment Of Circular Inspired Uwb-Mimo Patch Antenna

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ABSTRACT

In The present work a circular inspired dodecagon shaped monopole patch antenna having a compact size of 30x22mm^2 in MIMO configuration has been proposed. The proposed antenna is covering entire UWB band (2.-11 GHz) having a better isolations approx. -25 dB in the entire operating band, also it exhibits a better performance in terms of ECC and Diversity gain. The simulated and measured response are in a very close agreement to each other.

1. INTRODUCTION

As wireless communication is not only required for transmission of signal in a prolong distance application but also it has many significance application in personal area network. In 2002 FCC has assigned a bandwidth of 3.1 to 10.6 GHz for UWB application, basically used in many household controlling/operating applications.

UWB is desirable because of the wide frequency band to transmit signals at the low energy level, low power consumption, immunity from noise and interferences than other traditional wireless technology. Regardless of several advantages, UWB in a multipath environment suffers channel fading and interference from commercially narrowband systems. Further channel capacity and link quality can ameliorate by introducing multiple-input-multiple-output (MIMO) technology in UWB systems to provide diversity gain and multiplexing gain [2], [3]. At the same time for portable UWB application, placing multiple antennas in a close vicinity give rise to large mutual coupling [4]. Isolation can be intensified by placing antenna element half a wavelength apart [5], but size is a constraint for UWB MIMO antenna.

To design UWB MIMO/Diversity antenna, major provocation faced are:- bandwidth of 7.5 GHz for UWB application, to enhanced the isolation among the antenna elements while maintaining the compact size.

In the literature, many techniques have been proposed to conquer the above-mentioned provocation. By using UWB diversity antennas [6- 9], low mutual coupling between the elements can be achieved by placing them orthogonally while maintaining the compact size. By employing decoupling structure [10- 13] between the radiators enhanced much isolation. In [10] parasitic meander lines are located between the elements which reduce mutual coupling. A tree-like structure is presented in [11] to enhance wideband isolation better than -16dB and have a compact size of 35 x 40 mm^2. In [12] a reconfigurable MIMO antenna is presented; a decoupling structure consists of four C-shaped layered between the three vertical stubs.

In this paper, a compact monopole UWB MIMO dodecagon antenna is presented. The antenna has a compact size of 30 x 22 mm^2 and can cover UWB (2.5-11 GHz) isolation better than -25 dB is observed in most of the UWB. Detailed geometry and its design evolution are discussed in section II. Simulated results are discussed in section III, followed by conclusion in section IV.

2. ANTENNA CONFIGURATION

The geometry of the proposed UWB MIMO antenna along with its fabricated prototype is depicted in Fig. 1. It has a compressed size of 30mm x 22mm. For the ease of availability FR4 epoxy substrate of dielectric constant 4.4, thickness of 1.6mm and loss tangent of 0.002 is used for printing purpose. Two symmetrical patch of circular inspired (twelve side regular polygon) separated by a small distance ‘d’ is used as reflector, tapered fed by a quarter wavelength 50 Ω microstrip line to match the high impedance. Monopole structure configuration is chosen to minimize the overall size of the proposed antenna, increased gain and bandwidth of proposed antenna. To enhance bandwidth and improved isolation a small block of W1mm x L1mm is notched on the upper middle of the ground. Parameters of the proposed antenna is outline in table I.

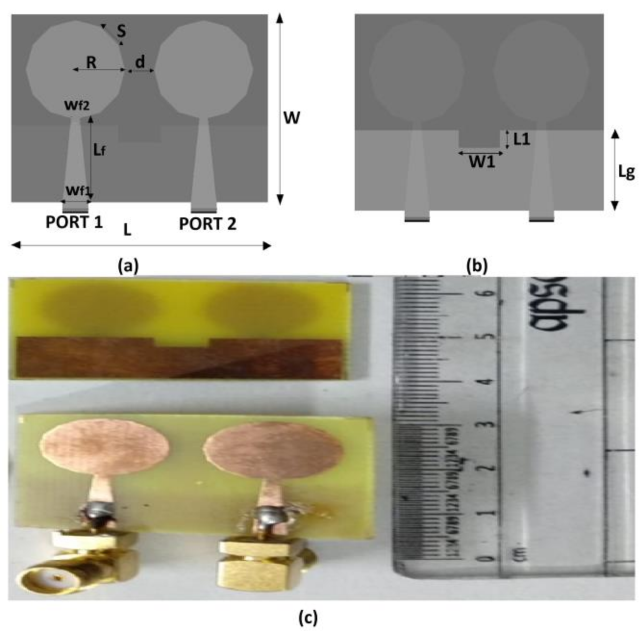


FIG 1 Proposed MIMO Patch Antenna (a) Radiator (b) Ground Plane (c) Fabricated Prototype

TABLE I DIMENSIONS OF PROPOSED ANTENNA

Parameters	L	W	L_f	W_{f1}	W_{f2}	R
Unit (mm)	22	30	10	3	1	5.8
Parameters	S	d	L_g	L_1	W_1	-
Unit (mm)	3	3.4	9	2	5	-

3. RESULT AND DISCUSSIONS

3.1 Reflection Coefficient and Isolation

Fig. 2 shows the simulated s-parameters. Since antenna elements are symmetrical therefore both the port yields same results. For port 1 reflection coefficient (S11< -10dB) is observed from 2.5-11 GHz, which covers more than the entire UWB. Isolation (S21< -15dB and less than -25dB in most of the band) is observed which make antenna a good candidate for UWB application. Also, the measured values of S11 and S21 are in close agreement to simulated one.

Further isolation mechanism can be understood from the surface current distribution depicted in Fig. 3. When port 1 is excited and port 2 is terminated by a 50 Ω load shown in Fig. 3(a), surface current is confined in the first radiator and negligible current is coupled to the second radiator, this is achieved by notching middle rectangular stub at the ground. In the same way when voltage source is given to port 2, insignificant current is coupled to port 1.

The input impedance was well matched, and isolation is also observed to be optimal throughout the UWB range.

3.2 Radiation Patterns

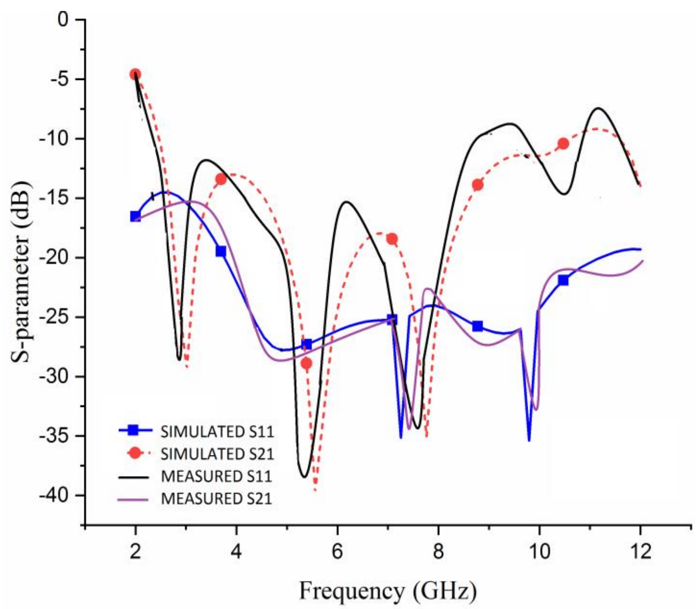
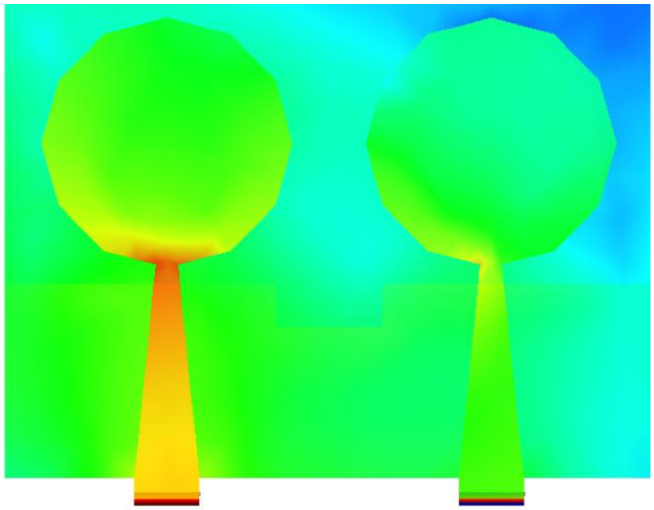
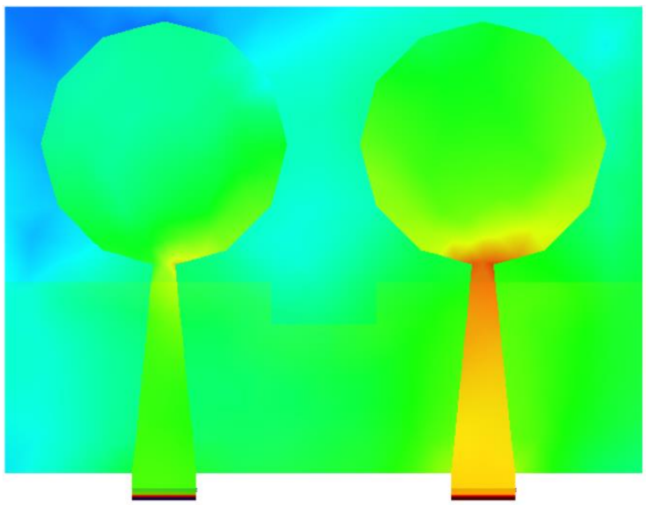


Fig. 2. Simulated S parameter of the proposed UWB MIMO



(a)



(b)

Fig 3 Current Distribution at resonnat frequency 5.5 GHz (a) When port 1 is excited (b) When port 2 is excited.

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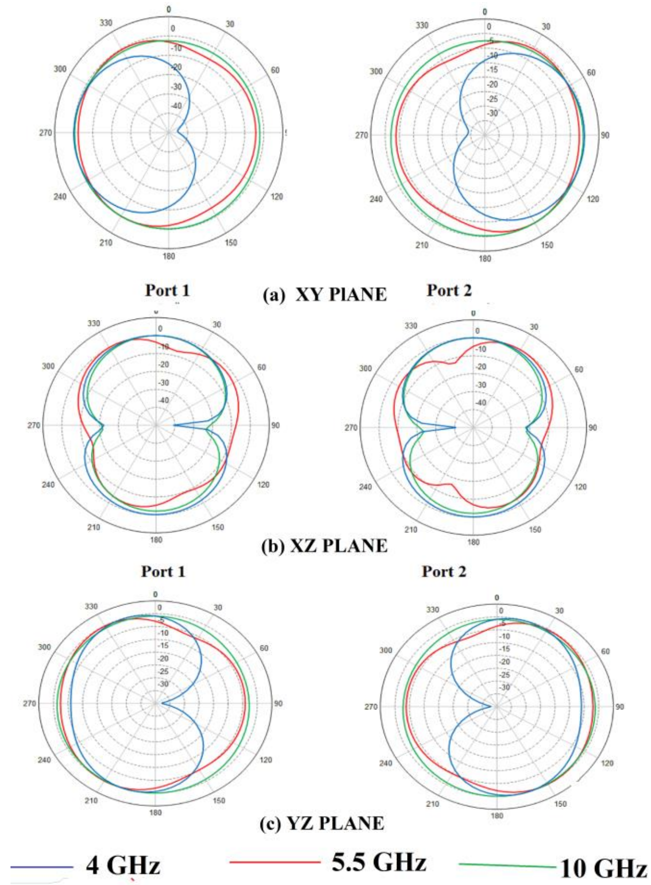

Fig. 4. Simulated radiation pattern of the proposed antenna at 4,5.5 and 10 GHz: (a) x-y plane; (b) x-z plane; (c) y-z plane.

The simulated far-field radiation patterns at 4, 5.5 and 10 GHz for port 1 and port 2 excited separately while another port is terminated with a 50-**Ω** load are shown in Fig. 4. The omnidirectional pattern is observed for xz and yz plane except for 4 GHz, tilted inward at 90^0 for port 1 and at 270^0 for port 2. While for xy plane quasi-omnidirectional pattern is perceived. It can be clearly understand from Fig. 4 that for both the port pattern is symmetrical in anti-direction, such differences shows pattern diversity.

The simulated and measured efficiency and gain pattern of the antenna with port 1 excited are shown in Fig.5. It can be observed that the simulated and measured average efficiency is around 8o and 70% respectively across the operating band with peak simulated and measured efficiency is approx. 90% at 4 and 9GHz respectively. The peak simulated and measured gain over the operating frequencies are observed at 10.6 and 7.9 GHz respectively having 6 and 4.25dBi. The measured gain at the respective resonant frequencies ie 4.5,5.5 and 10.5 GHz are 2.5,3.2,2.45 dBi respectively. The gain is dropping at non-resonant frequencies and also the graph reflects an average gain of 2 dBi in the whole range of operation.

3.3 MIMO/Diversity Performance

In this section MIMO/Diversity performance of antenna is going to be performed. The basic quantity which shows the grade of MIMO/Diversity performance are envelope correlation coefficient (ECC), diversity gain (DG)

ECC is the amount of correlation between each antenna element and mutual coupling among adjacent antenna element. The ECC can be calculated using s-parameters [13].

$$ECC = \frac{[|S_{11}^{*}S_{12} * S_{21}^{*}S_{22}|]^2}{(1-|S_{11}|^2-|S_{21}|^2)(1-|S_{22}|^2-|S_{12}|^2)} \qquad \textbf{\textit{(1)}}$$

For an uncorrelated MIMO antenna, ECC should ideally be zero but its practical limit is < 0.5. It is observed from Fig. 6, that simulated ECC using Eq. (3) is <0.01 in the operating range of frequencies. Whereas the diversity gain (DG) of the proposed UWB MIMO antenna is determined by

$$\mathrm{DG} = 10\sqrt{1-\mathrm{ECC}^2} \qquad (2)$$

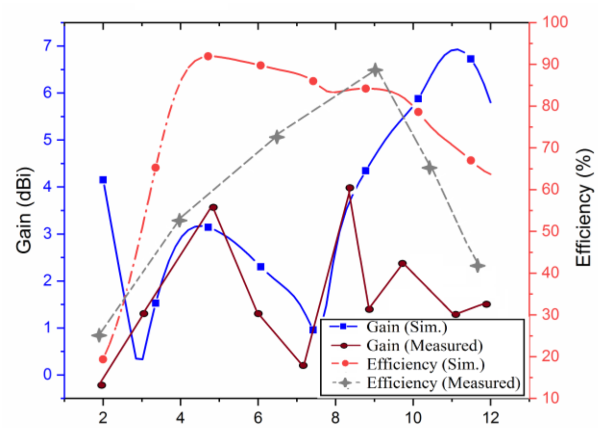

Fig. 5. Simulated and measured efficiency and Peak Gain

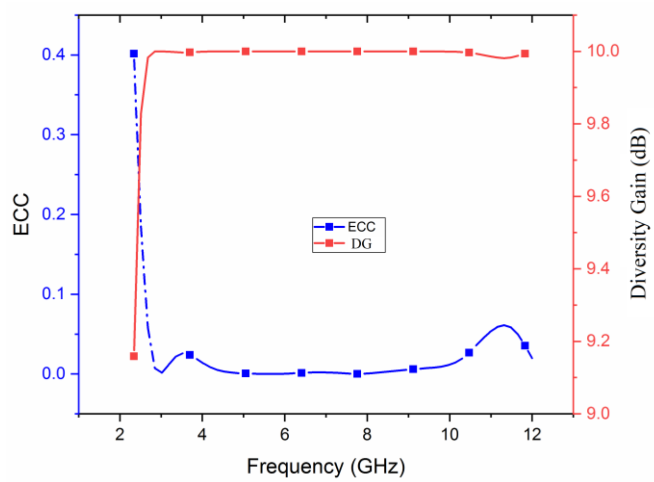

Fig. 6 Simulated ECC and Diversity Gain (dB)

Fig.6 shows that simulated DG >9.95 dB throughout the desired frequencies. This reflect that the antenna is fulfilling all the basic requirements of a MIMO antenna.

4. CONCLUSION

A compact MIMO antenna consisting of two circularly inspired dodecagon shaped radiating elements is presented for UWB application. For the purpose of isolation improvement small rectangular block is notched at the ground plane. The proposed antenna can cover more than the UWB frequency from 2.5-11 GHz, with the isolation better than -25 dB in most of the band. The simulated and measured reflection coefficient, insertion loss, antenna gain, efficiency and simulated radiation pattern shows a better behavior of antenna. The MIMO behavior of the proposed antenna is also entertained, and the whole outcome indicates that the designed antenna is a good candidate for portable UWB MIMO applications.

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