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Compact UWB-MIMO Antenna for Portable Devices

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ABSTRACT: A compact printed ultra-wideband (UWB) multiple input–multiple-output (MIMO) antenna system with a size of 35×60 mm^2 operating at a frequencyrange of 3.1–10.6 GHz is proposed. The wideband isolation can beachieved through a tree-like structure on the ground plane. Simulated S-parametersshow that the isolation is better than -16 dB (-20 dB inmost of the band) across the UWB of 3.1–10.6 GHz. The radiationpatterns, gain, and envelope correlation coefficient are also simulated.The proposed antenna is suitable for some portable MIMO/diversity applications.

KEYWORDS: Diversity, isolation, multiple-input–multiple-output (MIMO), ultra wideband (UWB) antennas.

I.INTRODUCTION

Multiple-Input Multiple-Output (MIMO) has proved itself as animportant technique for wireless communication systems. Using MIMO, wireless system's capacity or the range canbe increased signicantly [1].On the other hand, Ultra Wideband (UWB) technology is a potential candidate in the race of the wirelessworld since the Federal Communications Commission (FCC) releaseda report for approving the use of UWB devices operating in the 3.1-10.6 GHz frequency range [2].But this technology is limited to short-range communications due to extremely low allowable transmittedpower, i.e.,-41.3 dBm/MHzto overcome this limitation, thecombination of MIMO techniques with UWB technology is found to beone of the solutions.However, another bottleneck while implementingthe MIMO technique for compact or portable devices arises from thepoor isolation and strong mutual coupling between the closely packedantenna elements. Both mutual coupling and isolation can be improvedby increasing the distance between the antenna elements but thecompact size of the wireless devices limits this approach. Therefore,a good challenge appears to enhance the isolation or to reduce themutual coupling by using some other technique.To combat the multipath fading problem in an indoor UWB wireless communication system, an UWB diversity antenna system is a promising candidate. Both MIMO and diversity UWB systems require an increase of the isolation among antennas.At the same time, the MIMO/diversity UWB antennas should be compact enough for portable devices. Therefore, compact MIMO/diversity UWB antenna systems with low mutual coupling among antenna elements are desirable for practical portable MIMO/diversity UWB applications.Many studies have been made to reduce the size of the antennas and increase the isolation and impedance bandwidths for MIMO/diversity UWB antenna systems [3]–[6].In [3], aUWB diversity monopole antenna has been designed, and aT-shaped reflector has been inserted between the two radiatorsto reduce the mutual coupling.Another diversity UWB antenna has been proposedin [4], and the impedance bandwidth is 3.1–5.8 GHz. Theisolation can be enhanced through a slot etched on a T-shapedreflector. In [5], a diversity antenna for PDA application hasbeen proposed, and it covers the band of 2.27–10.2 GHz. Threestubs have been introduced to weaken the mutual coupling.In [6], a coupling element is added between twoclosely packed antennas to improve the isolation. A neutralizationtechnique to enhance port-to-port isolation is presented in [7] for two PIFAstructures.Lowmutual coupling is also difficult to achieve in the whole UWBwith the decoupling structure in [8]. In this letter, we propose a compact UWB MIMO/diversity antenna system. The designed antenna system has a small size of 35×60mm^2 and can cover the whole UWB (3.1–10.6 GHz). Through a tree-like structure, the measured isolation better than -16 dB in the whole UWB (-20 dB in most of the band) can be achieved.

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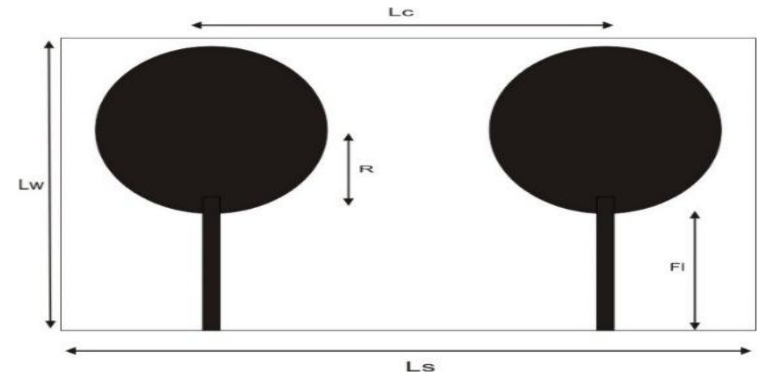
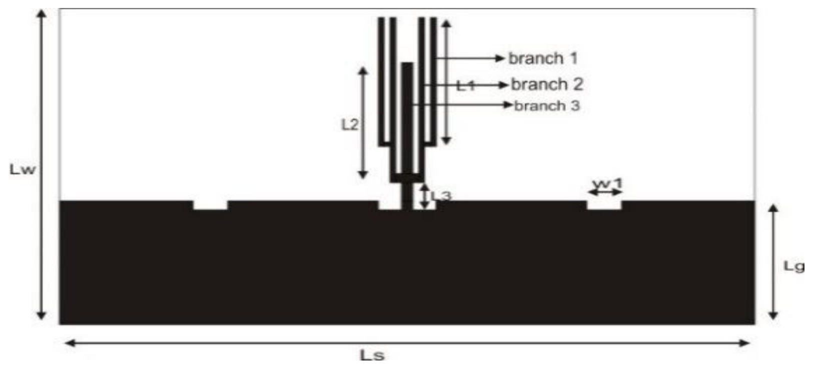
II.ANTENNA GEOMETRY AND DESIGN

The proposed UWB-MIMO antenna consisting of two radiating elements is illustrated in Fig.1a circular disc monopole fed by 50-micro stripline is used to develop the proposed UWB-MIMOantenna. The selection of this antenna can be justified by its goodperformance, size, and ease of integration. Antenna is optimized inthis paper using FR4 substrate having relative permittivity of 4.4,0.8mm thickness and 0.02 dielectric losses. The individually optimizedantenna elements are placed on a single substrate and are studied againparametrically and then optimized.The distance between the tworadiators is only 35 mm. Each radiator is fed with a 50- microstripline. The wideband isolation between the two UWB radiatorscan be efficiently enhanced by a tree-like structure thatextends from the ground plane.



(a)



(b)

Fig.1 Geometry of the proposed UWB MIMO/diversity antenna system: (a) top view, (b) back view.

Dimensions of antenna is given by the table as shown.

R	Lw	Ls	Fl	Lc	L1	L2	L3	W1	Lg
10	35	60	13.7	35	5	5	1.5	1	13.2

Table 1.Detailed dimensions (in mm) of antenna

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III.EFFECTIVENESSOF THE TREE-LIKE STRUCTURE

A wideband isolation can be achieved with the tree-like structure. Branch 1 [see Fig.2] can be viewed as a reflector, which can reduce the wideband mutual coupling through separating the radiation patterns of the two radiators. When the number of branches of tree like structure increases, mutual coupling further can be reduced and more resonance will be introduce. The wide band isolation can be efficiently enhanced as the resonances are in different frequency range.

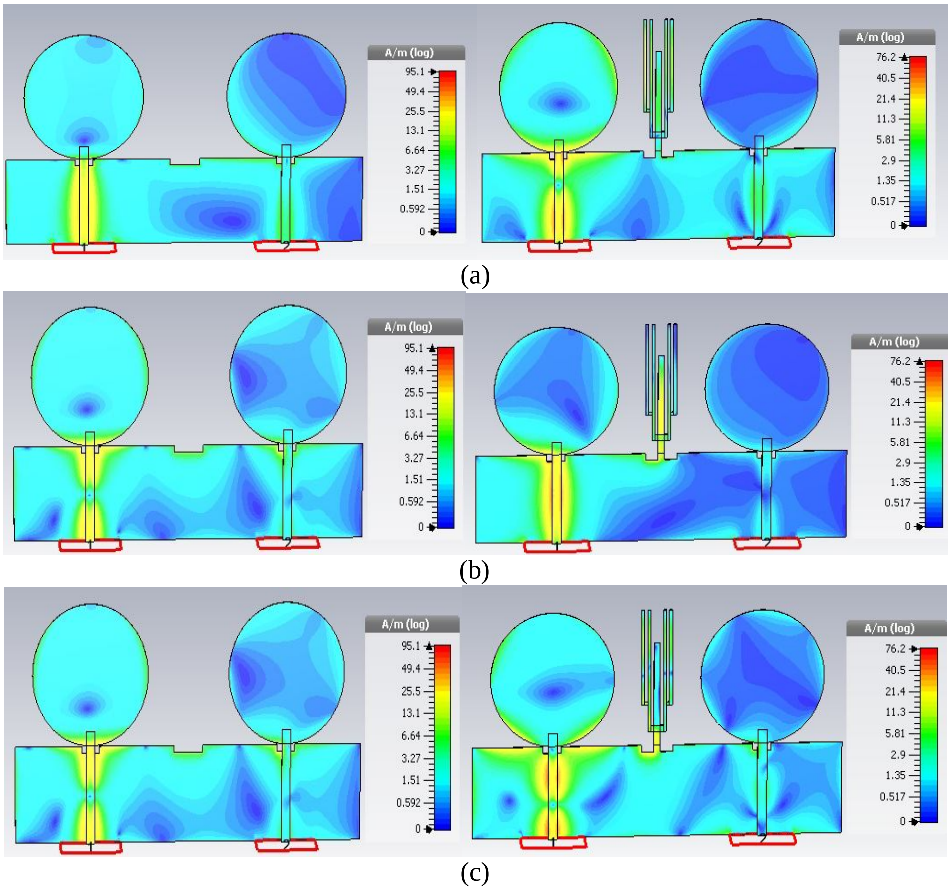

Fig. 2Surface current distributions with Port 1 excitation: (a) 4, (b) 7, and (c) 10 GH**z.**

In Fig.2, We can see that the surface current distribution at 4,7and 10 GHz are in fig.3 with and without the tree like structure. When port 1 is excited, the current from it is blocked by tree like structure and cannot flow to the other radiator through the ground plane. The effect is same when port 2 is excited. From the result we can see that the tree like structure can efficiently enhance the isolation between the radiators across the whole UWB.

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IV.RESULT AND DISCUSSION

A.*Impedence performance*

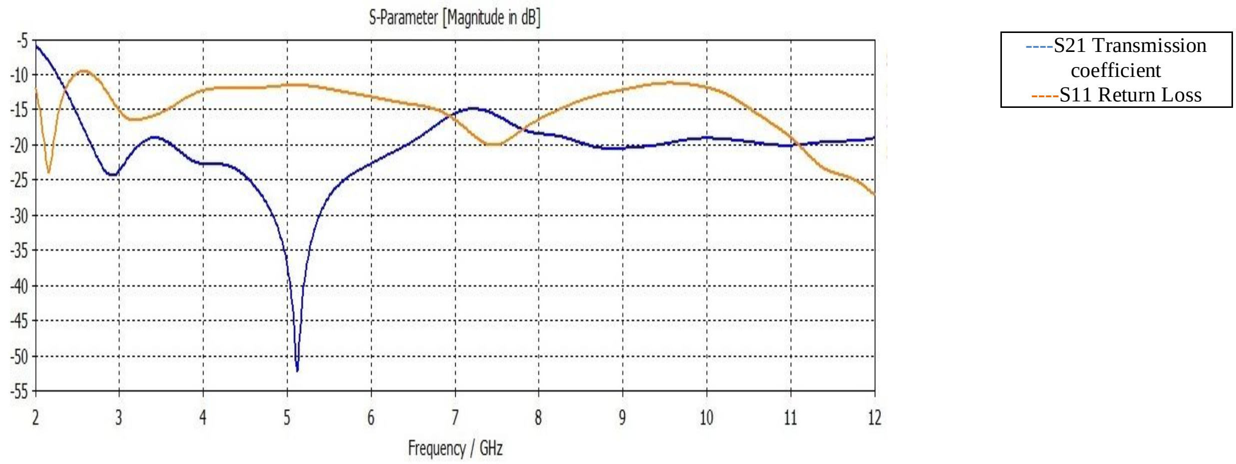
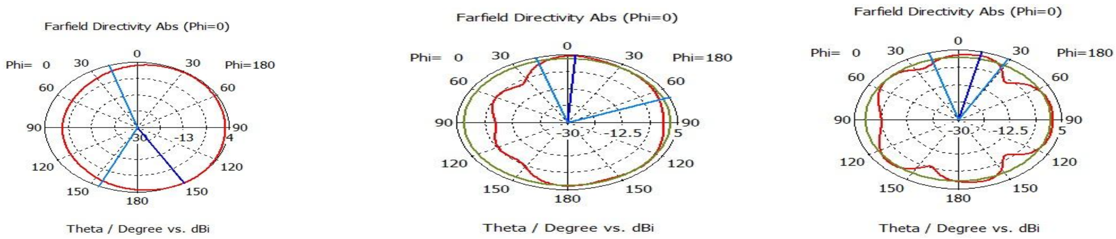


Fig.3simulated S-parameters of the UWB-MIMO antenna system.

Simulated S-parameters for the proposed UWB MIMO/diversity antenna system are shown in Fig.3. Impedance bandwidth (S11<-10dB) can cover the whole UWB of 3.1–10.6 GHz, and an isolation of more than -16 dB (more than -20 dB in most of the band) in the whole UWB is achieved.

B.*Radiation pattern*

The radiation patterns aremeasured at 4, 7, and 10 GHz and shown in Fig. 4.The radiation patterns of the designed antenna are relatively stable across the UWB.The antenna gives almost monopole radiation pattern throughout the bandwidth.



(a) (b) (c)

Fig.4Radiation patterns simulated at frequencies of(a)4 GHz, (b)7.0 GHz and (c)10 GHz.

C.*Diversity performance*

For a two-portsystem in uniform propagation environment, the envelope correlationcoefficient $\rho_v$can be simply calculated by

$$\rho_v = \frac{|S11^*S12+S21^*S22|^2}{(1-(|S11|^2+|S21|^2))(1-(|S22|^2+|S12|^2))} \quad (1)$$

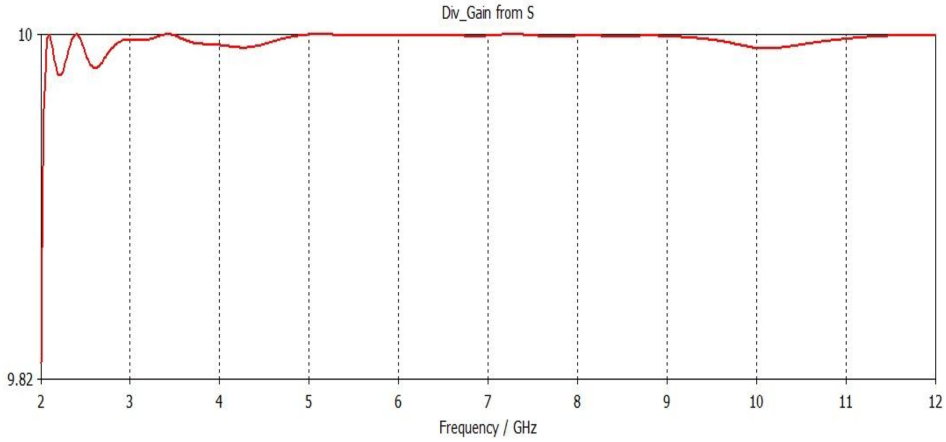


Fig.5 simulated Envelope correlation coefficient (b) Diversity Gain

In fig.5, The Envelope correlation coefficient for UWBMIMO/diversity antenna, obtained from the measured S-parametersand it is below 0.01 across the whole UWB of 3.1–10.6 GHz.

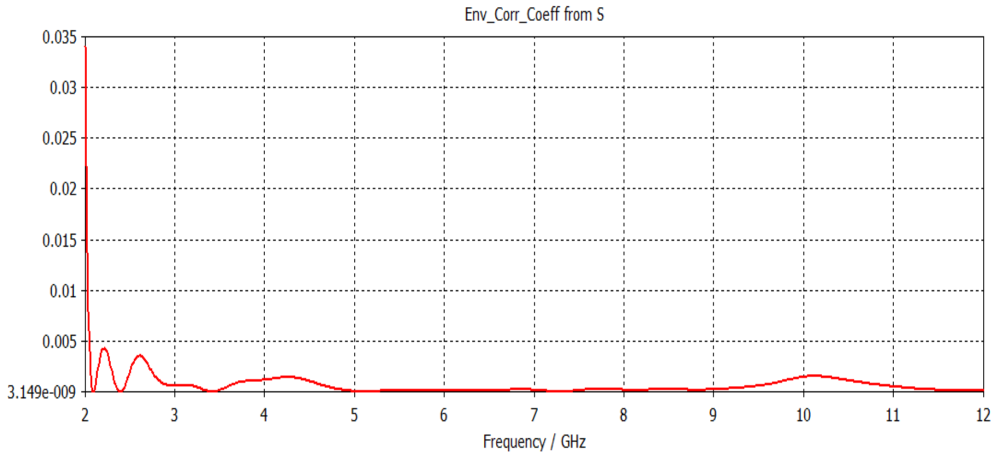


Fig.6 simulated Diversity Gain

The diversity gain (1%) has also been calculated and is larger than 9.95 dB across the whole UWB of 3.1–10.6 GHz as shown in fig.6. These indicate that the designed antenna has a good MIMO/diversity performance.

D.*Time domain performance*

The radiating elements of the designed UWB-MIMO antenna are also characterized for its time domain performance to confirm theircapability for UWB operations. The radiating elements are fed bythe fifth derivative of Gaussian pulse of 0.13 ns wide where the pulsewidth is measured at 50% of the maximum amplitude. The selection of this excitation pulse can be justified by its spectrum that efficientlymeets the requirements of FCC approved UWB spectral mask.

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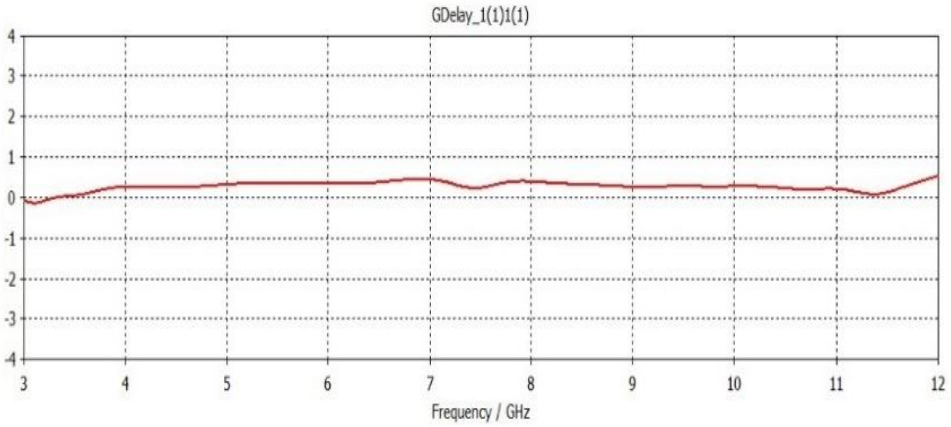

Fig.7simulated group delay

It indicates good time domain response and it can be further justified by group delay shown in Fig.7. The variation ofgroup delay is found to be less than 1 ns showing good phase linearity and thus it fulfils the requirement for UWB operations.

V.CONCLUSION

Compact MIMO antenna for Ultra-Wideband applicationsis designed and simulated. The wideband isolation can be achieved through anappropriately designed tree-like structure. The effectiveness ofthe tree-like structure has been shown. The obtained impedancebandwidth of designed antenna can cover the wholeUWBof3.1–10.6 GHz.Within the UWB, the measured isolation is better than 15 dB in the whole band and 20 dB in most of the band.The radiation patterns, antenna gain, envelope correlationcoefficient, and time domain response have also been simulated. The simulated resultshave shown that the proposed antenna system is very suitablefor portable MIMO/diversity applications.

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