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Diverse Isolation Techniques for Electromagnetic Coupling Reduction between UWB Planar Monopoles

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ABSTRACT: Novel miniaturized two-layer electromagnetic band gap (EBG) structures are presented for reducing the electromagnetic coupling between closely spaced ultra wideband (UWB) planar monopoles on a common ground. The EBG structures employ two closely coupled arrays, one comprising linear conducting patches and the other comprising apertures (slits) in the ground plane. A microstrip line excitation is initially used for the efficient analysis and design of the slit–patch EBG structures, which are subsequently employed between two UWB printed monopoles. Different isolation techniques can be used to further reduce the electromagnetic coupling. Along with S parameter plots different antenna parameter plots can be taken.

KEYWORDS: Electromagnetic band gap; miniaturization; multiple input multiple output antennas; mutual coupling

I. Introduction

Wireless communication systems with multiple transmitting and receiving antennas are well known for achieving a greater system capacity than the conventional ones employing only single antenna at two sides of a communication link. Multiple-input-multiple-output (MIMO) technology has been widely used in modern wireless and mobile communications systems. However, when multiple antennas are employed for compact portable devices, the high electromagnetic coupling between antenna elements is a critical factor which affects the performance of the system. Mutual coupling describes the electromagnetic interactions that exist between antenna elements of an MIMO.

A novel miniaturized double-layer slit–patch EBG structures are used for significantly reducing the mutual coupling between two closely spaced ultra wideband (UWB) planar monopoles in a compact wireless device. The slit– patch EBG structures are shown to improve the isolation between the two UWB planar monopoles placed at two different distances, which shows the flexibility in their applicability. Moreover, the slit-patch structures occupy very little space on the common ground between the antenna elements, allowing for small antenna separation values and increased flexibility in their use with compact ground planes and wireless devices. It is proposed to use defected ground structures for improving the isolation.

II. Related work

In [1], [2] authors have described about MIMO antenna system. When multiple antennas are employed for compact portable devices, the high electromagnetic coupling between antenna elements is a critical factor which affects the performance of the system. In [3], [4] several methods have been presented to reduce high mutual coupling between antenna array elements, such as novel antenna designs and the application of electromagnetic bandgap (EBG) structures. In [5]–[7] authors have mentioned about electromagnetic bandgap (EBG) structures. The use of single [8], [9] and multiple [10] defects (slots or slits) on a ground plane has also attracted significant interest due to the ease of fabrication and applicability with different antenna types. In [11] authors have defined about a new convoluted slit configuration was proposed offering small structural footprint and improved isolation between narrowband printed monopoles. The key design feature of the double-layer structure is the coupling of the evanescent fields within the dielectric region separating the two arrays of slits and patches, respectively, [12], [13].

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III. EXISTING SYSTEM

A. *Double layer slit-patch design:*

The geometry of double-layer slit- patch EBG structure excited by microstrip is shown in fig.1. The conducting patches and aperture slits are placed on either side of a very thin (55 μm) dielectric layer. Strong electric fields appear between the two conducting layers which are equivalent to a high capacitance. The slit apertures are rotated with respect to the conducting patches in order to maximize the coupling and hence the equivalent capacitance.

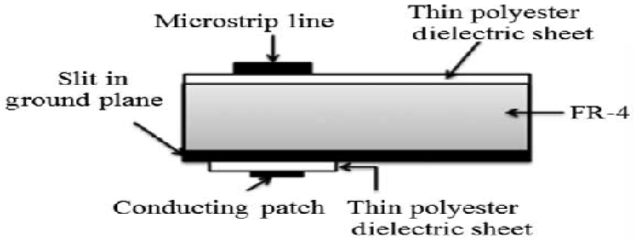

Fig.1 cross-section of the two-layer slit–patch structure

In order to obtain more bandwidth, multiple slit–patch EBG structures are implemented on the ground plane, as shown in fig.2.

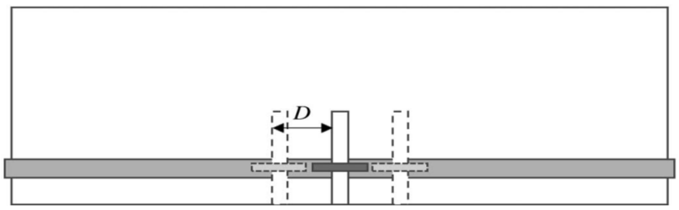

Fig.2. Geometry of double-layer slit- patch EBG structure.

B. *UWB planar monopole with the slit-patch:*

A dual-element UWB planar monopole array is printed on a 60 × 50, 1.5 mm thick, fr-4 substrate (εr = 4.5). The geometry of the two-element UWB planar monopole array with a conventional ground plane designed to operate from 3 to 6 GHz, is depicted in fig.3. The separation between the two radiating elements is only 15mm.

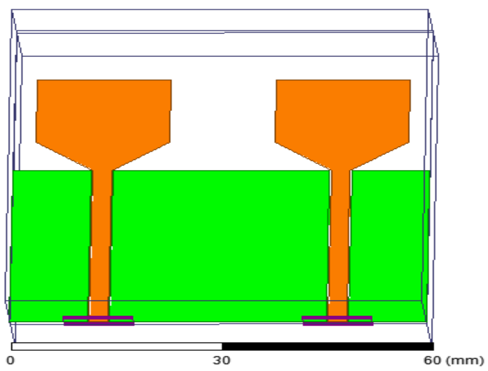

Fig.3. Two-element UWB planar monopole array with a conventional ground plane

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Three slit–patch structures are inserted in the ground plane between two UWB monopoles, as shown in Fig.4.The separation between each slit is 2.1 mm. The distance between two conducting patch edges is 0.1 mm.

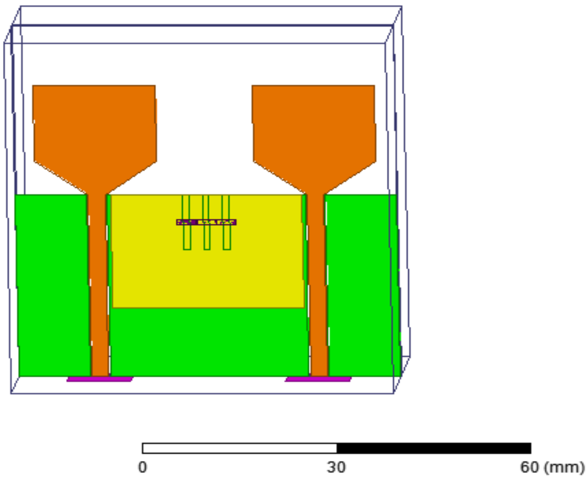

Fig.4. Two-element UWB planar monopole array with three slit patch structure.

In order to further investigate the use of the slit–patch EBG structures and to produce the maximum reduction of the area of antenna array, the separation between the two antenna elements is reduced to 1 mm resulting in the configuration of Fig.5. By employing the slit–patch EBG structures, the area of antenna array has been reduced significantly while maintaining the performance of the antenna.

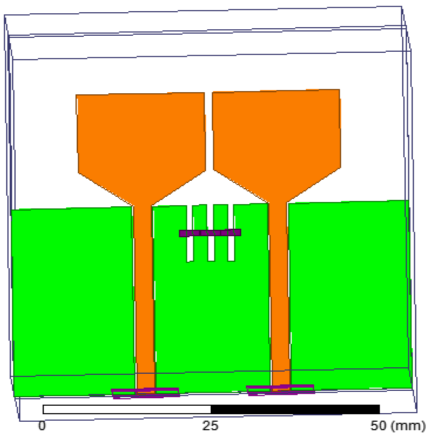

Fig.5. Two-element UWB planar monopole array when interelement distance is 1mm.

III. **PROPOSED SYSTEM**

It is proposed to use defected ground structures for improving the isolation as compared to electromagnetic band gap structure. Monopole antenna structure is varied to reduce the self-interference and to analyse the effect in radiation pattern. In order to increase the bandwidth feed to feed transition technique is used. A microstrip-slot transition is a structure that uses a microstrip line on one side of a planar dielectric substrate and a slot line in the ground so that a

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signal is passed between the two sides. In order to perform this function with minimal power losses, the microstrip line and the slot line have to be orthogonal to each other and use suitable reactive terminations at their ends.

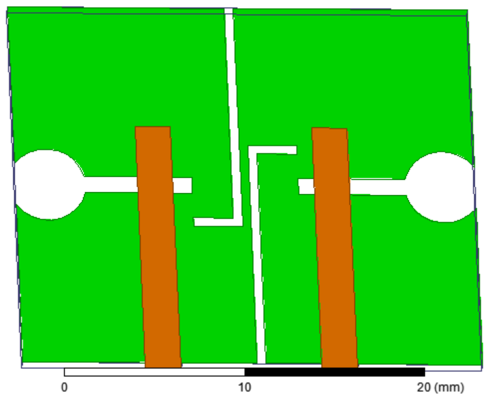

Fig.6. Proposed UWB planar monopole array

IV. Simulation Results

The simulated *S*-parameters of the dual-element antenna array are shown in Fig. 7. Due to the two antennas being completely symmetrical on the substrate the simulated *S*11 and *S*22 are identical within the operating frequency band of UWB monopoles. Nevertheless, the simulated *S*11 is less than −10 dB across the operating frequency band (3–6 GHz).

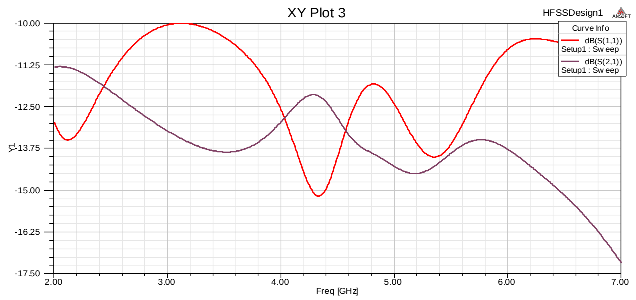

Fig.7. Simulated S-parameters of UWB antenna array with conventional ground plane

Fig.8. shows the simulated *S*-parameters of the UWB planar monopole array with the three slit–patch structures. The *S*21 in simulation is less than−15 dB across the whole operation frequency band.

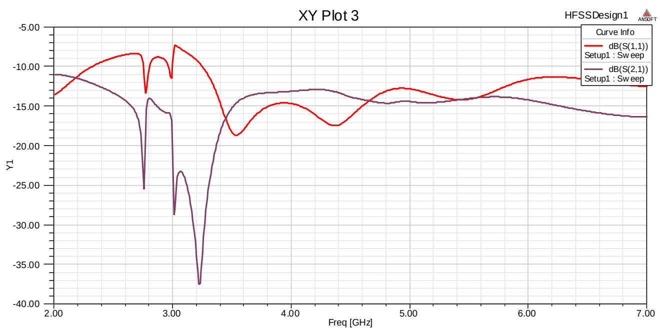

Fig.8. Simulated S-parameters of UWB antenna array with three slit patch structure

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The current distribution on the UWB monopoles as well as on the ground plane is shown in Fig.9. When the UWB array is built on a compact conventional ground plane, a large current is induced on the monopole on the left when the monopole on the right is excited, thus producing a high mutual coupling between the antenna elements.

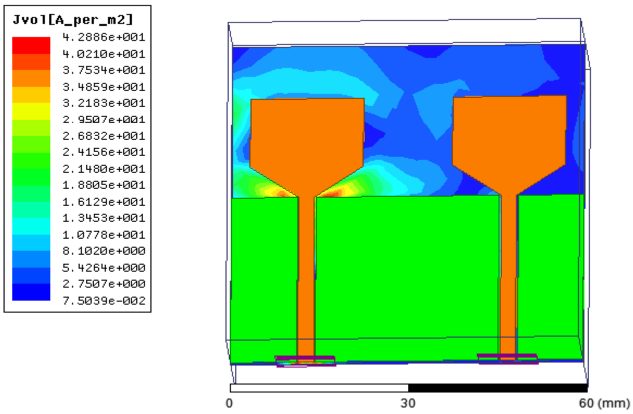

Fig.9. Simulated current flow of UWB antenna array with conventional ground plane

After the slit–patch unit cells are inserted on the ground plane between the two antennas, the current induced on the passive monopole (left) is significantly reduced as shown in Fig.10. This is attributed to the proposed slit–patch EBG structure which, due to its stop band characteristics, significantly disturbs the fields and induced currents between the two monopoles and reduces their mutual coupling.

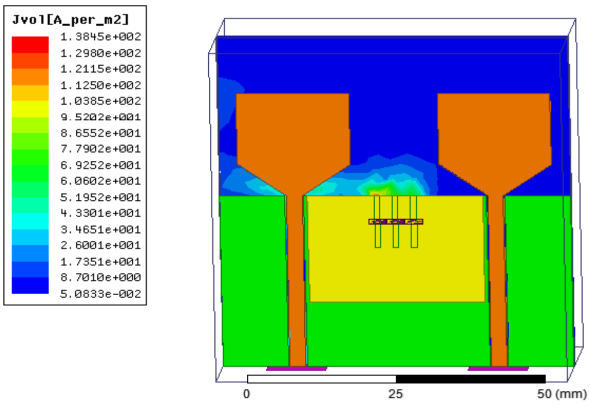

Fig.10. Simulated current flow of UWB antenna array with three slit patch structure

The radiation patterns of the UWB antenna array for the two cases are presented in Fig.11. and Fig.12.

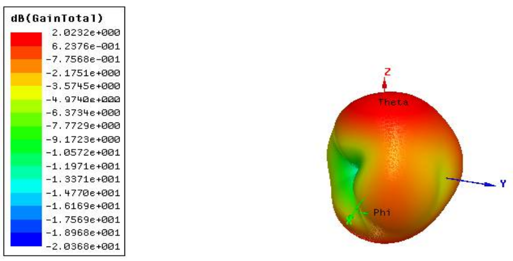

Fig.11. Simulated radiation pattern of original UWB antenna array configuration

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(An ISO 3297: 2007 Certified Organization)

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The radiation patterns in the presence of the proposed slit–patch structures are only slightly different from the antenna system without the structure.

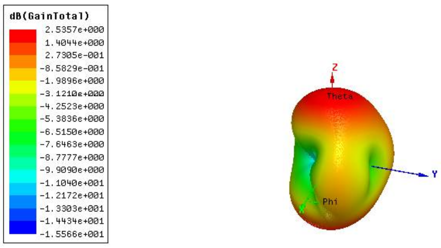

Fig.12. Simulated radiation pattern of array with three slit patch structure

Fig.13. shows the simulated *S*-parameters of the UWB planar monopole array with the three slit–patch structures when interelement distance is 1mm. The *S*21 in simulation is less than−25 dB across the whole operation frequency band.

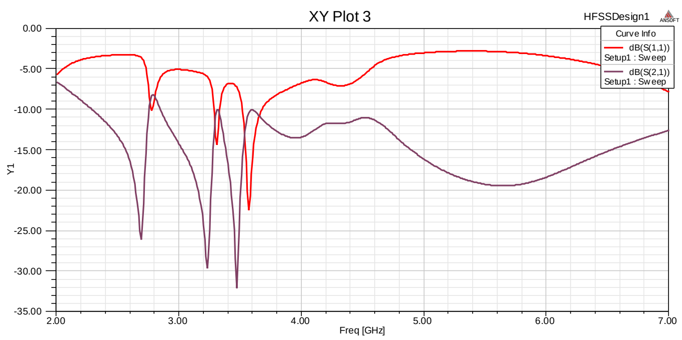

Fig.13. Simulated S parameter of array with three slit patch structure when interelement distance is 1mm

The surface current on the ground plane of the proposed slit is shown in Fig.14. By employing the three slit–patch structures, most of the current on the ground plane has been trapped around the slit–patch structure even when the separation between the two antenna elements is 1 mm.

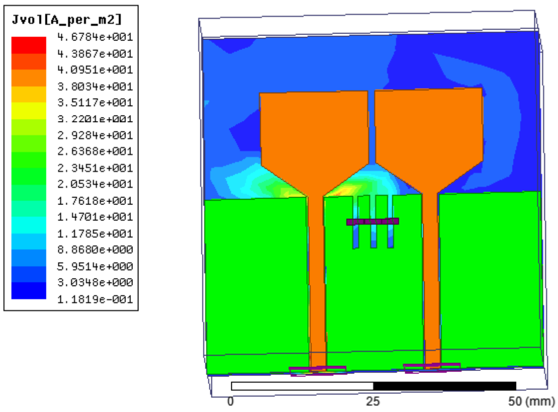

Fig.14. Simulated current flow of array with three slit patch structure when interelement distance is 1mm

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The simulated *S*-parameters of the proposed structure are shown in Fig. 15. The simulated *S*11 and S21 is less than −10 dB across the operating frequency band. The bandwidth is increased as compared to the existing system.

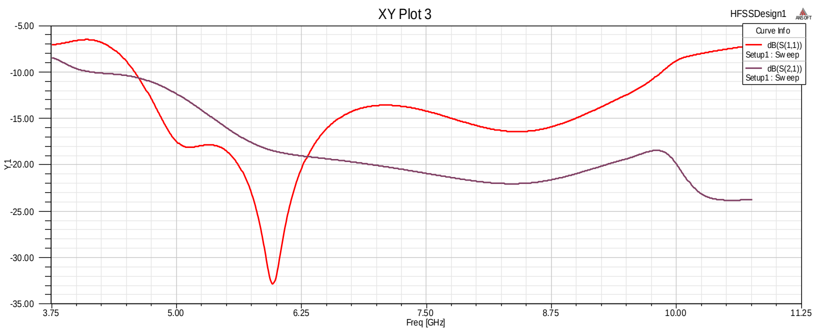

Fig.15.Simulated S parameter of array with defected ground structure

The current distribution of the proposed structure when defected ground structure is used is shown in Fig.16. The current induced is significantly reduced as compared to the existing system when electromagnetic band gap structure was used.

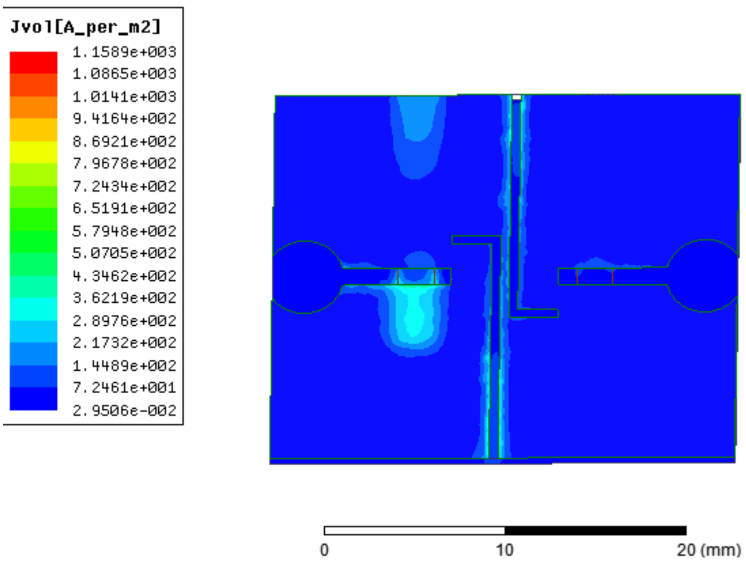

Fig.16. Simulated current flow of array with defected ground structure

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Vol. 4, Issue 6, June 2016

V. CONCLUSION

A novel approach for reducing the electromagnetic coupling between closely spaced UWB monopole antennas has been evaluated. The existing technique is based on the insertion of miniaturized slit– patch EBG structures on the common ground plane. It is proposed to use defected ground structure for improving the isolation. Feed to feed transition can be provided to increase the bandwidth. Monopole antenna structure is varied to analyse the effect in radiation patterns.

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BIOGRAPHY

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