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An UWB-MIMO Antenna with Altered Coupling and Enhanced Isolation based on EBG Structures

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ABSTRACT

This work proposes a small planar quad-element ultrawideband (UWB) antenna with a band-notch and low coupling for multiple-input multiple-output (MIMO) systems. The antenna is made up of four circular monopoles with a modified defective ground plane and a regular electromagnetic band gap (EBG). The suggested EBG structures differ from classic mushroom-like structures in that they are made up of grid patterns on the top patch, the metallic ground plane, and many vias that link the top and bottom planes. It is printed in the dielectric substrate's centre to reduce electromagnetic coupling between parallel parts. Moreover, a strong band-notched feature is created by etching four crescent ring-shaped resonant holes on the radiators. From the experimental results, the −10 dB bandwidth of the antenna is extended covers from 3.0 to 16.2 GHz, with a sharp notched band at 4.6 GHz. And the isolation is greater than 17.5 dB between its elements, with a peak gain of 8.4 dB and a peak efficiency of 91.2%. Moreover, it has a compact size at 3 GHz and could be a good candidate for portable devices.

Keywords: MIMO, EBG, ELECTROMAGNETIC COUPLING.

Software Tools: CST

INTRODUCTION

Due to low complexity, low transmit power, large channel capacity, and its ability to work with low SNR, ultra-wide band has captivated vast attention from the time FCC announced a spectrum of 3.1-10.6GHz for market purposes. As an advancement in the sector of communication, MIMO can increase capacity and reliability despite having additional spectrum, good isolation between elements of antenna can lead to good performance and alike advancement in antennas. Here, compact ultra-wide band Multi

Input Multi output antenna with altered mutual coupling and enhanced isolation is presented and designed using CST software. Firstly, single element which includes circular monopole at top surface and defected ground plate which aims to grab ultra-wide band frequencies. A crescent slot is etched on monopole region to achieve reject band for the inhibition of interference. From the properties of rectangular and spatial arrangements, we can use orthogonal arrangement of elements to achieve low coupling between orthogonal elements, a 3×3 electromagnetic band gap structure is clipped on the center of ground plate to provide isolation in a better way. Lastly, experimental results which depicts about antenna's frequency range, optimum isolation value, s-parameters, Efficiency, voltage standing wave ratio (VSWR), impedance. So, we have a scope for designing a four port antenna which can radiate frequencies in the range of UWB region for wireless communication applications.

Antenna Configuration:

This antenna will be designed using FR-4 substrate that has permittivity of 4.0,and thickness 1.4mm, with tangent loss 0.015. CST Studio Suite® is used for attaining s-parameters

A. Mono element Antenna

The outline of designed single pole antenna with overlapped crescent ring shaped is shown in Figure 1 followed by evolution of mono element antenna to grab ultra-wide band range at band notch at 4.8GHz is shown in Figure 2.

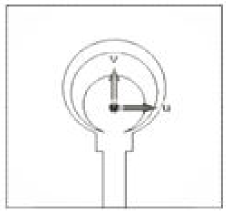

Fig. 1. Outline of mono Element antenna

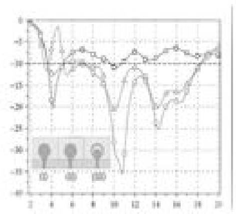

Fig. 2. Freq vs S11 without and with slots

Ground plate is of rectangular shape and the circular monopole has an advantage from modified ground plate which has an impact on impedance matching such that the simulation result provide a radiation from 3.2 to 20GHz below -10dB bandwidth. The resonant slot acts as open circuit transmission line which will reject frequencies from 4.2 to 5.5GHz, the slot length is half the value of wavelength at the mid frequency of reject band and can be obtained by using the formula.

$$\frac{LL_2 + LL_3}{2} = \frac{c}{2 f_{center} \sqrt{\varepsilon_{eff}}},$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2},$$

where,
$LL2$ = etched slot's outer arc length
$LL3$ = etched slot's inner arc length
C = speed of light in air
f_{center} = center frequency at band notch
εr = relative permittivity
εeff = effective dielectric constant

B. Quad element Integration

A simulated model of a quad-element UWB-MIMO antenna is developed utilising the element presented in the preceding section. Individual elements with a surface area of 0.082*(wavelength)^2 is

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position symmetrically in a square substrate with a 90-degree angle between them. Figure 3 displays the integrated four elements of antenna. As shown in Fig 4, the Scattered-parameters between parallel elements (i.e., 1-3 and 2-4) display suppressed isolation, which is significantly less than 16 dB. Nonetheless, the orthogonal arrangement (i.e., 2-1, 4-1) demonstrates strong isolation, which is primarily more than 19.9 dB over the entire band

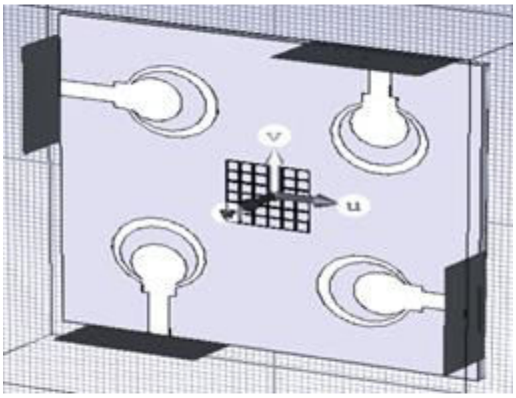
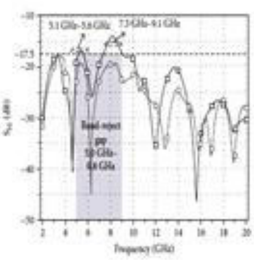


Fig. 3. A compact quad-element antenna Integration

Because of the perpendicular polarization field invented by elements, the orthogonal arrangement of elements in the antenna may assure great isolation for adjacent elements, and mutual coupling is decreased.



.Fig. 4(a). S-parameters of four port antenna with EBG

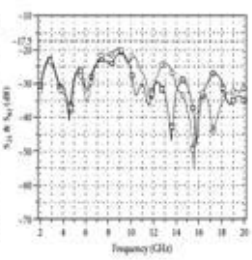
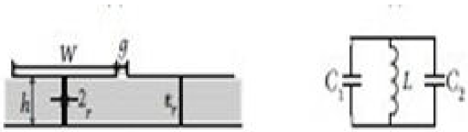


Fig. 4(b). S- Parameters of four port antenna Without EBG

Because parallel components may generate a symmetrical electromagnetic field with comparable polarization, when they are activated, power will flow from antenna 1 to antenna 3 and from antenna 2 to antenna 4 resulting in significant coupling between parallel elements. Following section proposes EBG structures to prevent mutual coupling

C. Exploring Electromagnetic band gap structures

EBG structures, as is popularly publicized, can prevent wave propagation in the area between the elements.so, a 3×3 array cell EBG is added to inhibit coupling among parallel elements. The working mechanism of these potential unit cells can be explained by the usage of LC ciircuit as shown in the following diagram.



The picture on left shows the geometry anf parameters of unit cell and picture on right is the equivalent LC Circuit.The initial parameters of unit cell can be obtained by using following formulae:

$$C_1 = \frac{\varepsilon_0 W}{\pi} \operatorname{arch}\left(\frac{W+g}{g}\right),$$

$$C_2 = \frac{\varepsilon_0 \varepsilon_r W'}{\pi} \operatorname{arch}\left(\frac{\sinh\left(\pi\left(W'+g\right)/4h\right)}{\sinh(\pi g/4h)}\right),$$

$$L = \mu_0 h \left\{\frac{1}{\pi}\left[\ln\left(\frac{a+\sqrt{a^2-(2r)^2}}{2r}\right)+\ln 2^{1/2}\right]\right\}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}},$$

Where, C1 = Air gap capacitance between adjacent cells
C2 =Capacitance between metallic patch and ground plate

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L = Inductance of metal vias
W = Width of the patch
g = gap width

After the calculation of initial parameters by substituting the values of target band in above equations, it is the time to study further about high impedance surface of EBG structures. It is considered that side walls have periodic conditions at their edges. From the simulation results, we have observed reject band 5.1–5.6GHz and 7.3–9.1GHz which can be eliminated if the values of cell are optimized. As a result, the isolation between parallel components increased from 17 dB to 20 dB between the band-reject gap when the 3×3 EBG array structures were positioned in the middle of the dielectric substrate, as shown in Figure 4b

Measurements and Results:

TABLE 1: COMPARISON OF PROPOSED ANTENNA WITH OTHER MIMO ANTENNAS

Ref	No: of elements	-10dB bandwidth	Minimum isolation(dB)	Total area(λ^2)
[1]	4	46.8	15	0.6
[2]	2	131.0	15	0.34
[3]	2	4.3	31	1.03
[4]	4	23.9	14	0.43
This work	4	137.5	17.5	0.36

This section discusses the simulated and measured findings of the quad-element UWB-MIMO antenna system. The proposed antenna's measurements are carried out using the ZVM network analyzer which is invented by Rohde and Schwarz in the year 1996.Firstly, with the help of CST software, s-parameters are simulated which showcased the radiation frequency range is from 3.2 to 20GHz below -10 dB level The variance of the S11 curve at larger frequencies between the calculated and simulated outcomes is mostly due to fabrication, welding, and testing errors.

We can also observe that there is least side isolation of 17.5dB for antenna elements in entire range. The comparison of parameters such as bandwidth, low par isolation, entire area is briefed in the above table. We can observe that designed antenna has achieved good isolation, bandwidth by occupying limited area as compared to previously designed MIMO antennas that are available in market.The following pictures are simulations, obtained from CST software which includes s-parameters of designed four port antenna, voltage standing wave ratio, impedance, efficiency

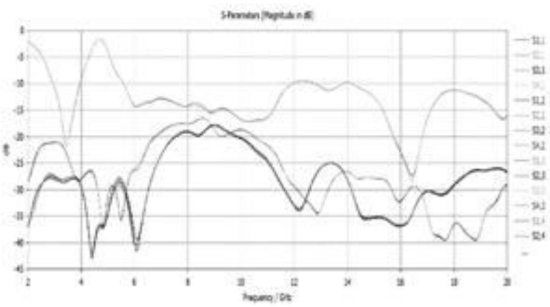

Fig. 6. S-parameters of four port antenna with EBG

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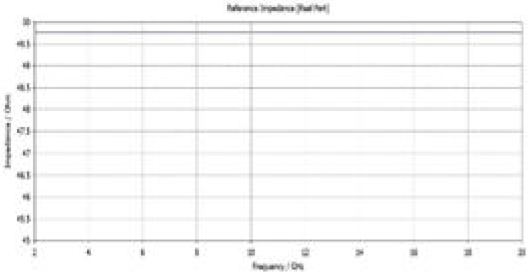

Fig. 7. Impedance corresponding to frequency of four port antenna

From this graph, we can conclude that the designed four port antenna radiates frequencies from 3.8GHz to 20GHz and also scattering parameters S11 is reflection coefficient and explains about how well the power you put into an antenna stays there and doesn't reflect back into radio whereas S21, S12 are the parameters which explains about voltage gain and can be expressed as transmission coefficient. Antenna impedance is the ratio of electric field divided to magnetic field at input. In antennas, 50-ohm impedance is taken as ideal value because it corresponds to minimum loss, maximum power, maximum voltage when the characteristic impedance vs normalised value graph of co-axial cable. From figure 7 we can conclude that 49.75-ohm impedance designed four port antenna by observing the flat line throughout the range of frequencies designed four port antenna by observing the flat line throughout the range of frequencies

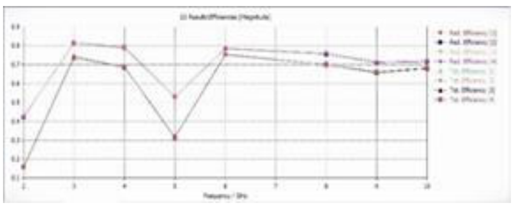

Fig. 8. Efficiency corresponding to frequency of four port antenna

Antenna's total efficiency can be defined as how much RF power delivered to the antenna is actually transmitted to the air and it can be mathematically expressed as

$$\eta_t = \frac{P_t}{P_s}$$

where, P_t = Transmitted power and P_s = Source power

Antenna's radiation efficiency can be defined as how well an antenna converts the frequency power accepted at the edge slots into radiated power and it is mathematically expressed as

$$\eta_e = \frac{P_t}{P_{in}} = \frac{R_r}{R_r + R_L}$$

where, P_t = Transmitted power

P_{in} = Power accepted at input side of antenna

R_L = Load resistance

R_r = Radiation resistance

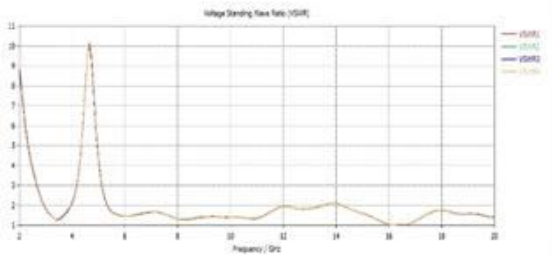

Fig. 9. VSWR of four port antenna

From figure 8, we can observe that the designed four port antenna's total efficiency is around 78% ,as we know any efficiency above

70% can be considered as worthy antenna which validates our case.VSWR can be defined as amount of efficiency radio-frequency power is transmitted by a power source, through a transmission line, into a load.A voltage standing wave ratio value below 2 is considered as preferable for antenna related devices. From the above graph, we can say that designed four port antenna is good, as VSWR value is under 2 for a frequency of interest

Conclusion:

Based on EBG structures, this work presents a fixed planar four element UWB-Multi input multi outcome antenna with enhanced isolation and altered coupling. The antenna is built on a FR4 copper material and has total dimension of 60 × 60 × 1.6mm3. Over the 10 dB operational bandwidth, the antenna system has acceptable impedance matching. At 4.6 GHz, a distinctive band-notched feature is created by etching four ring shaped slots on the radiators. Reduced mutual coupling is accomplished by orthogonal element arrangement and loaded EBG structures. Briefing it, the quad-element UWB-MIMO antenna with band rejection and high isolation has an application value in modern WiFi systems

References:

[1] A. MoradiKordalivand, T. A. Rahman, and M. Khalily, "Common elements wideband MIMO antenna system for WiFi/LTE access-point applications," IEEE Antennas and Wireless Propagation Letters, vol. 13, pp. 1601–1604, 2014.

[2] M. S. Sharawi, M. U. Khan, A. B. Numan, and D. N. Aloi, "A CSRR loaded MIMO antenna system for ISM band operation," IEEE Transactions on Antennas and Propagation, vol. 61, no. 8, pp. 4265–4274, 2013.

[3] Y. Gao, R. Ma, Y. Wang, Q. Zhang, and C. Parini, "Stacked patch antenna with dual-polarization and low mutual coupling for massive MIMO," IEEE Transactions on Antennas and Propagation, vol. 64, no. 10, pp. 4544–4549, 2016.

[4] K. Ding, G. Cheng, Q. Dexin, and Q. Yin, "Compact broadband MIMO antenna with parasitic strip," IEEE Antennas and Wireless Propagation Letter