Reduction of Mutual Coupling for MIMO Antennas

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***Abstract*— Wireless communication is the transfer of information between two or more points that do not use an electrical conductor as a medium for the transfer. Antenna array are inevitable component in any microwave communication system that demands large coverage. With the advancements in communication technology, modern transceivers are required to operate in multiple bands. MIMO (multiple input, multiple output) is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver). The antennas at each end of the communications circuit are combined to minimize errors, optimize data speed and improve the capacity of radio transmissions by enabling data to travel over many signal paths at the same time. Multiple-input multiple-output MIMO technology has been attracting extensive attention in wireless communications, owing to its advanced characteristics of high channel capacity and spectrum efficiency. The replication of identical antenna elements improves the overall radiation performance for long distance communication However, for a size-constraint MIMO device with physical limitation for antennas installation, the service performance is always degraded by the interferences through mutual couplings among antenna elements. This mutual coupling performance degradation can be overcome by isolation enhancement. To achieve isolation enhancement, the use of electromagnetic bandgap (EBG) structures, defected grounded structures (DGS), meta-materials, split ring and complementary split ring resonators (SRR & CSRR) can be used. In this project, the design of noveldual-layer mushroom (NDLM) and back-to-back E-shaped stubs for mutual coupling reduction between microstrip patch antennas. The antenna is studied from the aspects of isolation, return loss, current and electric field distribution, radiation pattern, and diversity performance in a frequency range of 2.45 GHz of -53 dB, gain of 7dBi.**

***Keywords:* MIMO, Antenna, Stub, mutual coupling, Co-axial feed.**

I.INTRODUCTION

An antenna is defined as “a usually metallic device for radiating or receiving radio waves”. Antennas play a major role in the wireless communication systems. The performance of antenna systems can significantly enhance the performance of wireless communication systems. There are different types of antennas depending on their electrical characteristics, shape and size. They are such as Wire Antennas, Microstrip Antennas, Array antennas etc. In this we are primarily discussing microstrip array antennas. Microstrip patch antenna is mostly used in modern communication devices over conventional antennas mainly because of their size. Microstrip antennas are best choice for wireless devices because of characteristics like low profile, low weight, ease of fabrication and low cost. With increasing technological thrust in multiple bands. MIMO comes into role to increase performance of antennas. IMO plays a phenomenal role in the field of wireless communications by employing antennas with multiple elements at both sides of the communication link.MIMO has tremendous edge but comparatively antenna coupling is major problem we come across MIMO. Antenna to antenna mutual coupling describes energy absorbed by one antenna's receiver when another nearby antenna is operating. That is, mutual coupling is typicallyundesirable because energy that should be radiated away is absorbed by a nearby antenna. Mutual coupling in an array causes a)Changes in the radiation pattern of the array b)Changes in the input impedance of the individual antenna elements in an array.Mutual coupling (MC) can be quantified by measuring the antenna isolation. Techniques to reduce mutual coupling are machining the dielectric below the patch, optimizing the antenna dimension so that the surface wave is notexcited, covering the patch by additional dielectric layers, printing various patterns on dielectric. Figure 1 shows the pictorial representation of mutual coupling reduction methods. Therefore there are many literature survey papers on reduction of mutual coupling.

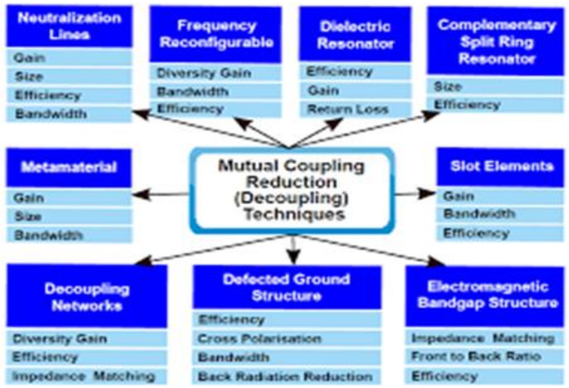

Fig 1.Decoupling Techniques

II. RELATED WORK

In previous papers, several methods were used to reduce the decoupling between antenna elements. Commonly, Defected ground plane structure, Complementary split ring resonator, Dielectric resonator, Electromagnetic bandgap structure are used for reduction of coupling. The use of metamaterial absorber (MA)[1] to achieve high isolation between two patch antennas in a 2-element MIMO system operating at 5.5 GHz resonant frequency useful for WiMAX application is proposed. In [2],a novel analytical design technique is presented to implement a coupled line wideband Wilkinson power divider (WPD).The measured result of the fabricated prototype exhibits an excellent input return loss > 16.4 dB, output return loss > 15 dB, insertion loss < 3.30 dB and a remarkable isolation > 22 dB within the band and with a 15 dB and 10 dB references provide a fractional bandwidth of 110% and 141%, respectively. In paper [3],it provides a new perspective and approach to design decoupling networks based on the parasitic decoupling concept.The measurement results show that good impedance matching for each antenna port, isolations of more than 25dB. In paper [4],the proposed decoupling unit cell consists of an asymmetric loop resonator with a coupled microstrip line for wide stop-band characteristics from 2 – 5 GHz. In [5],A parasitic isolator, which is printed between the two patches, controls the polarization of the coupling field to reduce the antenna coupling. Furthermore, a defected ground structure (DGS) is employed to suppress the cross-polarization (XP) level.In 6,Without the need of any transmission line, a very compact decoupling network based on reactive lumped elements is presented for a two-element closely spaced array.The proposed decoupling network can deal with the matching conditions of the even and odd modes independently to simultaneously achieve good impedance matching and port isolation of the whole antenna array.In 7,an efficient decoupling feeding network is proposed. It is composed of two directional couplers and two sections of sections of transmission line connectionThe measured mutual coupling can be reduced to below -58 dB at center frequency. In 8,The MA is constructed with split-ring resonators to suppress the surface current propagation between two microstrip antenna elements at the resonant frequency.In 9,A dual-layer electromagnetic bandgap (EBG) mushroom structure is proposed ,While the mushroom inner layer aids in the antenna miniaturization, the more compact upper layer acts as a band stop filter further reducing the mutual coupling between the miniaturized patch antenna elements. In 10,High isolation can be achieved through a simple slot structure on the ground between the microstrip antennas. The position, length, and width of the slot have been optimized for maximizing the isolation. It is found that more than 40 dB isolation can be achieved between two parallel microstrip antennas sharing a common ground plane. In 11,A novel structure based on complementary split-ring resonators (SRRs) is introduced to reduce the mutual coupling between two coplanar microstrip antennas that radiate in the same frequency bandHowever, the structures involved plated through-holes (vias), which are not attractive from the electric loss and manufacturing perspective.In this paper mutual coupling reduction for MIMO antennas are achieved with isolation of -54dB by using the design of noveldual-layer mushroom (NDLM) like split ring resonator structure and back-to-back E-shaped stubs in ground plane and antenna array in top layer by aperture feed method.The NDLM comprises of one upper layer of

Complementary split ring resonator and four mini inner layer lattices and it is connected by pin.

III. ANTENNA DESIGN AND ANALYSIS

A.Structure ofAntenna.

The structure and geometry of the designed antenna are provided in Fig.2. The substrate of the antenna is FR4 with loss tangent (δ) of 0.02, It is lossy at high frequencies, absorbs less moisture, has greater strength and stiffness and is highly flame resistant compared to its less costly counterpart.FR-4 is widely used to build high-end consumer, industrial and military electronic equipmentand the total size of the antenna is 90×45×2.4mm^3. It consists of four NDLM elements and two back-to-back E-shaped stubs, which are located between the two antenna elements. The resonant frequency of the designed antenna is about 2.45GHz.

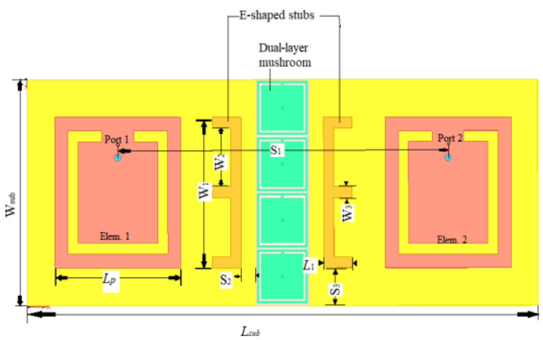

Fig 2. Geometry of the proposed antenna

To obtain this resonance frequency, the patch antenna dimensions are as follows: L_p =24.4mm and W_p =27.4 mm. The two antenna elements are fed by a coaxial probe is shown in Fig. 3a, respectively. The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.The center-to-center spacing (S_1) of the element is 64.1mm, which is equivalent to half of the wavelength corresponding to 2.45GHz.To reduce the surface current flow and the MC between the array radiating elements, back-to-back E-shaped stubs and an array of NDLM have been implemented between the radiating elements. The NDLM units consist of a double-layer split-ring resonator with a similar structure shown in Fig 3(b). The lower layer consists of four mini elements of the same size, and the upper layer is an element of another size. The resistance band of the NDLM is used to prevent the electromagnetic wave transmitting to the non-excitation element. The specific parameters of the work are shown in Table 1.Comparing withthree structure offig 3.Fig 3a has poor isolation because of decoupling and then in fig 3b novel dual layer mushroom like structure is implemented, then mutual coupling is slightly lower than AT1.AT3 has E shaped stub can resonate at 2.45GHz which is the center frequency of the antenna, so it can effectively prevent the electromagnetic wave from coupling to the adjacent antenna element in the ground plane with ports excited of 50Ω transmission line.

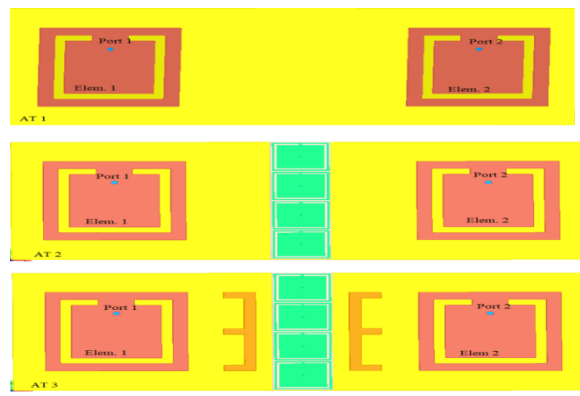

Fig 3(a,b,c). Ant 1,Ant 2,Ant 3 Configuration

Parameters	Dimension (mm)
W_1	27.4
W_2	10.7
W_3	2
L_1	5.5
W	4.8
G	0.3
h_1	*1.2*
h_2	1.2
W_4	0.6
W_5	0.5
W_6	0.6
W_7	0.5

Table 1.Specifications

IV. RESULTS AND DISCUSSION

The proposed design was simulated using commercially available ADS simulator. Advanced Design System (ADS) is an electronic design automation software system produced by a division of Key sight Technologies. It provides complete schematic capture and layout environment, Innovative and industry leading circuit and system simulators and works in Windows platform.Fig 4 gives layout of proposed model.

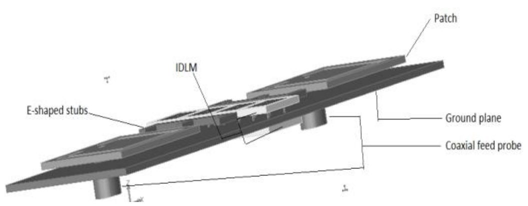

Fig 4. Model of patch with feed

To validate the MC performance of the designed structure,isolation, field excitation,radiation pattern,S-parameters are simulated and measured.Fig 5 shows isolation measurement as measure of the amount of power that leaks from one port of the mixer to another.

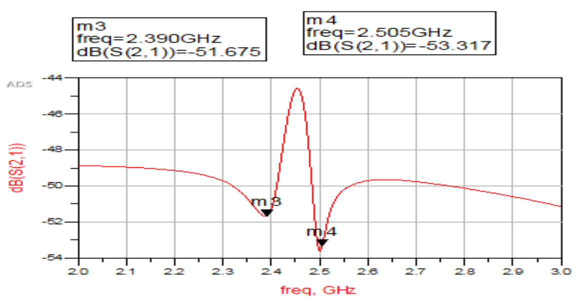

Fig5.Isolation measurement

Gain of an antenna in a given direction is defined as the ratio of the intensity in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.Fig 6 shows gain as -7.18dB.

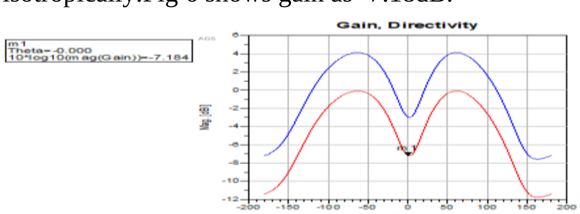

Fig6.Gain measurement

The axial ratio is the ratio of orthogonal components of an E-field. Axial ratios are often quoted for antennas in which the desired polarization is circular. The ideal value of the axial ratio for circularly polarized fields is 0 dB. In addition, the axial ratio tends to degrade away from the main beam of an antenna, so it indicates that the deviation from circular polarization is less than 3 dB over the specified angular range.Fig 7 shows axial ratio as -8.333.

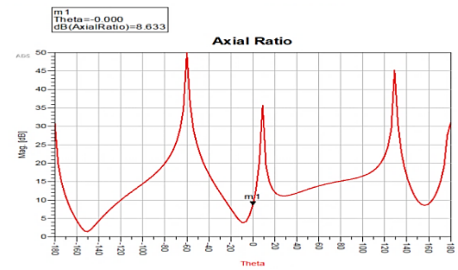

Fig 7.Axial Ratio

Radiation pattern is a graphical depiction of the relative field strength transmitted from or received by the antenna. It defines the variation of the power radiated by an antenna as a function of the direction away from theantenna. The patterns are usually presented in polar or rectilinear form with dB strength. Fig 8 shows radiation pattern at 2.45GHz.

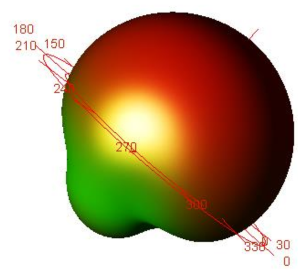

Fig 8.Radiation Pattern

V.CONCLUSION

Thus, reduction of mutual coupling of MIMO antennas using four inner mini layers was designed and simulated.An efficient technique for adding NDLM and back-to-back E-shaped stubs is proposed for MC suppression in micro-strip patch arrays with center-to-center spacing between antenna elements of $0.5\lambda_0$.The proposed antenna is easier to analyse in the ISM band and Structure resembles a good antenna performance of small size, used for radar system ,wireless communication, mobile communication application.

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