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A PERFORMANCE ANALYSIS OF VARIOUS DE-COUPLING METHODS IN MIMO RESONANT ELEMENT FOR NEXT GENERATION 5G COMMUNICATION SYSTEM

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Abstract
In this study, a comparative analysis of several MIMO patch antennas is provided. For the isolation improvement of MIMO antenna in the last decade there are different methods are presented. In this comparative study of the discuss the different method based patch antenna. Mutual coupling evaluation and envelop correlation rectification are just two of the features used to evaluate the performance evolution for MIMO. For better performance with various parasitic components, have been conducted in the last decade on the diverse MIMO antennas that are available. This research work discusses the design of several MIMO antennas for improved performance employing various intrinsic components in the region. The results of this study demonstrate that there are two distinct types of tables that represent various structures. In this research work discuss the different De-Coupling Methods and analysis the performance in different MIMO patches.
Keywords: Decoupling and Matching Network (DMN), Dielectric Block (DB), Wireless Local Area Network (WLAN), Envelope Correlation Coefficient (ECC), Multiple-Input-Multiple-Output (MIMO), Electromagnetic Band Gap (EBG), Perfect Electric Conductor (PEC), among others.

I. INTRODUCTION

Using multiple antennas at both the receiver and the sender in a system of wireless communication is known as MIMO (multiple input, multiple output) (receiver). Antennas at both ends of a communications network work together to improve the range, reliability, and speed of radio transmissions by spreading the signals out over several channels.

The signal-to-noise ratio and error rate can both be enhanced by increasing the number of times the very same signal is sent to the receiving antenna. MIMO has many benefits, including better connectivity and less interference. It does this by increasing the capacity of RF systems.

1.1The importance of MIMO for users

In Release 8 of the Broadband Internet Specification, developed by the 3rd Generation Partnership Project (3GPP), MIMO was included. Wi-Fi networks, cellular fourth-generation

(4G) Long-Term Evolution (LTE), and wireless fifth-generation (5G) technologies all employ Multiple-Input Multiple-Output (MIMO) technology. This technology is used in many different industries, including government, broadcast media, and enforcement agencies. Also, all wireless devices that support 802.11n will be able to use it on wireless local area networks (WLANs).

Wi-Fi 6 (also referred to as 802.11ax) improved wireless networking by introducing various new technologies that made it possible to connect even more Wi-Fi devices to a single network without experiencing any noticeable performance degradation. It is anticipated that Wi-Fi 7 will be released in 2024, and work on it has already begun.

Two of the most frequently used types of advanced antenna technology prior to MIMO (SIMO) were several inputs, single output (MISO) and single inputs, several outputs (SIMO). MIMO builds on these techniques.

1.2 LTE applications of MIMO

The introduction of LTE and the wireless broadband technology standard Worldwide Interoperability for Microwave Access (WiMAX) relied heavily on multi-input, multi-output (MIMO), one of the most prevalent kinds of wireless. In order to achieve rates of 100 mbps and above, LTE employs MIMO and orthogonal frequency-division multiplexing (OFDM). Compared to the older Wi-Fi standard, 802.11a, these speeds are impressive. In order to accomplish its goals of broadcast diversity, spatial multiplexing (to broadcast spatially separated independent channels), and supporting both multi-user and single-user systems, LTE employs MIMO.

High-bandwidth reliability is improved, and information bits are increased using MIMO in LTE. When sent, the material is segmented into several streams. Transmission of data and reference signals through the air assists the receiving end with channel estimation since the receiving end is already familiar with the signals.

1.3 MIMO and 5G massive systems

As the wireless industry expands to accommodate more antennas, networks, and devices, MIMO undergoes constant improvement and expansion as a result of its employment in enormous new applications. The introduction of 5G technology is a prime illustration of this.

Massive 5G MIMO systems use a large number of tiny antennas to provide bandwidth to consumers, rather than just increasing transmission rates like 3G and 4G cellular technologies. The frequency division duplex (FDD) system used by 4G MIMO to accommodate numerous devices is distinct from the time division duplex (TDD) setup in use by 5G massive MIMO (TDD). It has several benefits over FDD (see image below).

1.4 MIMO and beamforming

Beam forming, a kind of radio frequency (RF) administration, improves reception by directing broadcasted data towards individual users rather than the whole coverage area. Fifth-generation (5G) networks use three-dimensional (3D) beam forming to focus on the user from all angles. In fact, they may communicate with equipment located at the very top of a tall building. The beams follow the users wherever they go and shield them from other radio communication.

1.5 MIMO's primary advantages

Different configurations of MIMO's sophisticated antenna systems provide a variety of benefits over MISO and SIMO:

• Through MIMO, signals may be amplified. In this way, a device type does not need to have a direct line of sight to the base station since the signals may be reflected and re-transmitted.

• Massive amounts of data, such as videos and other huge files, may be sent through a network. Since MIMO allows for maximum bandwidth, this information can be sent more rapidly.

• Audiovisual clarity may be enhanced by using several streams of data. Furthermore, they lessen the possibility of data transmission errors.

1.6 Massive MIMO systems are influencing the future

Multi-input, multi-output, or MIMO, is a crucial technology for improving wireless networks and communication. It has a significant impact on 5G technology and is changing consumers' regular interactions with these systems. The following factors contribute to these effects:

• High network abilities. Through the use of 5G New Radio, more people have access to data (5G NR). More people can share the same bandwidth and data speeds thanks to MU-MIMO and 5G NR.

• More coverage. Soon, even those on the outside of coverage regions will have access to lightning-fast Internet. With the use of 3D beamforming, the cover may adjust to the user's position and orientation in the environment.

• Better user experience (UX). Images and videos appear instantly, and adding new material takes less time. UX is evolving due to massive MIMO and 5G technology.

II. PREVIOUS CONTRIBUTION IN THIS RESEARCH WORK

On the basis of the coupling mechanisms targeted for more effective suppression of antenna coupling, past approaches are summarized in this chapter as sub-sections under these major categories. In these subsections, define and describe three key wireless applications essential to this study in these subsections. Broadband, Narrowband, and Multiband.

A. Defected Ground Structure (DGS)

A number of alternative DGS forms have been suggested, such as dumbbell-like [03], rectangular defects, spiral periodic DGS [13], S-shaped periodic DGS [20], and various faulty strips as described in ref [21]. Other fractal flaws exist, and a recent review of these geometries is available [05]. Except for the works presented here, most of the current research has focused on E-plan coupling alone. These works, however, lack impedance matching and other critical information (for example, how much droopiness there is in radiation efficiency).

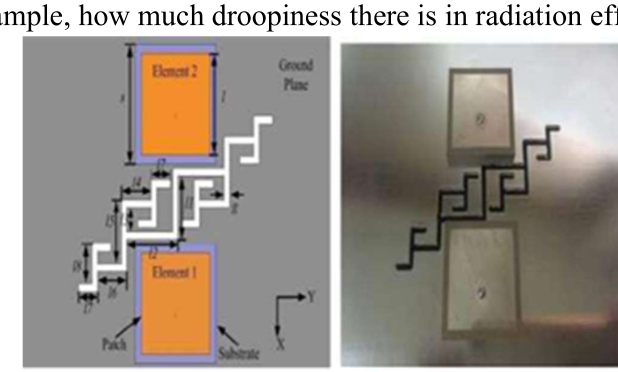

Fig 5. Closely-packed antenna with FDGS construction for narrowband isolation. Extended MIMO (a) Schematic (b) [03]

Multi-Band-MIMO Antennas – Previous studies on dual-band applications, tri-bands [04], and quad-bands were presented. Specifically, one of these designs is characterised as follows: for LTE and WiFi applications in portable devices, suggested a new quad-band antenna with two radiating components. More than that, the writer demonstrated good ECC and relative MEG for all working bands.

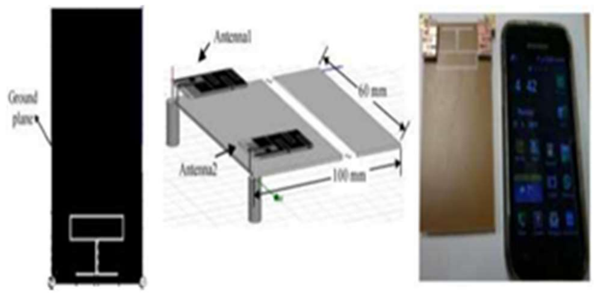

Fig 6. Configuration of MIMO antenna with DGS for multiband applications. (a) DGS top view (b) 3D view and (c) antenna [04].

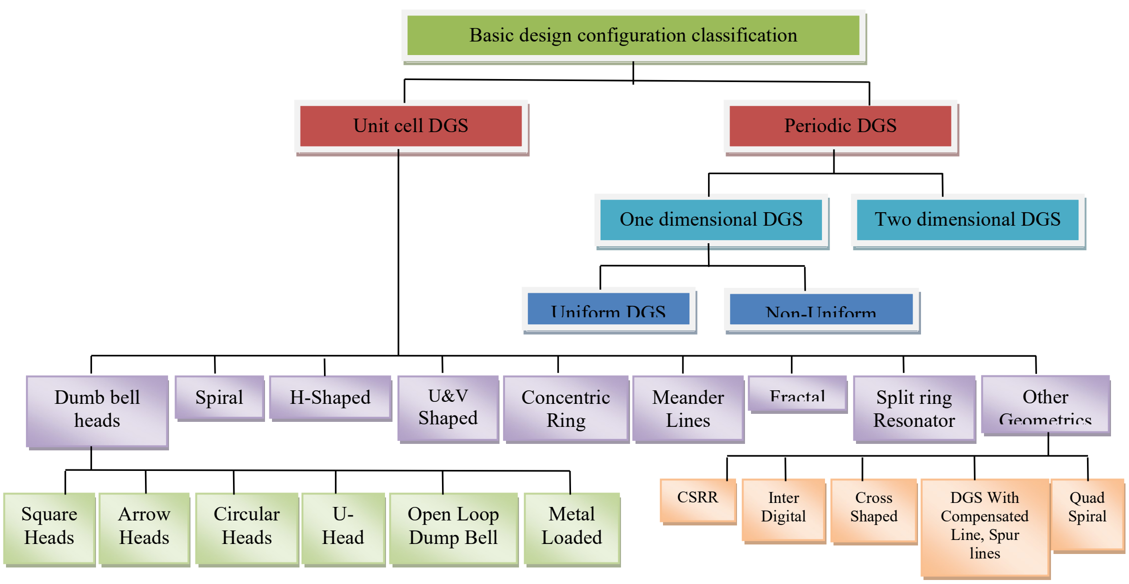

Fig 7. Classification of the DGS

In 5G communications, multiple-input, multiple-output (MIMO) antennas have become standard. However, in fully integrated systems, substantial reciprocal interaction between nearby and nonadjacent parts is inescapable. To prevent surface waves from spreading between antenna parts, this research proposes using an electromagnetic bandgap structure (EBG) with a slit inserted for fungi. Complimentary (CSRRs) are then frequently built on each side of the soil in order to steer towards the ground wave. The admittance between antenna components has been significantly reduced thanks to the successful use of the unique electro-magnetic features of EBG and CSRR to regulate the propagation of surface waves. Last but not least, a partial ground structure (DGS) in the form of a H is incorporated to increase the decoupling effect. This design idea has to be tested for practicability so that a working prototype of the planned antenna can be developed and evaluated. With a reduction in reciprocal coupling of 12 dB, the results support the decoupling concept. [03].

Fig 8. The prototype of proposed antenna: top view (left) and bottom view (right)[06].

Antennas for WiMAX, RADAR altimeters, and X-band applications are suggested. It is recommended to use a tri-band multi-IMO antenna having resonances at 7.7 GHz, 4.3 GHz, or GHz. The major characteristics of the antenna include mutually coupled at 2.9 GHz, 28 GHz, and 7.7 GHz. It is judged in two different ways: DGS (first two) DGS with Vias Vias and DGS mutual coupling is reduced by 12 dB. ECC of the antenna is less than 0.0001. Co-pol, X-pol, and ECC are all calculated and simulate.

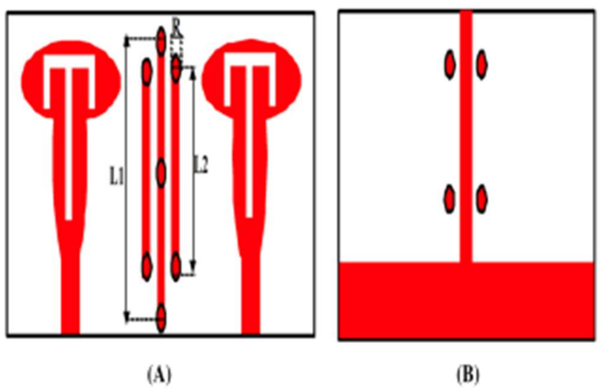

Fig 9. Front view (a) and back view (b) of the proposed design employing DGS and VIAS [20].

An H-shaped deficient grounding is used to decrease the interference between and pass-polarization. structure (DGS) string is used in this article. The development of a 2.4-GHz MIMO antenna with two equal square sections. The suggested DGS lowers mutual coupling and cross-polarization by 46 dB and 11 dB, respectively. The extent of mutual coupling is being analysed using a new term, couplings to decoupled ratio (CDR). The mathematical dependence of CDR on frequency and inter-element spacing is investigated using multiple polynomial regression analysis. Also, a DGS-comparable circuit is built and tested. The ECC and MEG ratios of this MIMO antenna show acceptable values of 0.0002 and 0.03 dB, respectively. Prototypes are built and measured. The experimental findings match the simulated outcomes well.

This design's maximum peak gain of 2dBi and radiation efficiency of 74% further show its utility[20].

Table 1. Comparison Table DGS

S. N	Author by (year)	Title	Shape	Range	Return Loss	Bandwidth Band WB/UWB
1	ZHUO YANG [2020][02]	Enhancing MIMO Antenna Isolation Characteristic by Manipulating the Propagation of Surface Wave	H-shape	3.2-3.35GHz	S11(3.25) = -18DB,	150MHZ
2	Srinivasa Rao Pasumarthi1 [2019][03]	Design of Tri-Band MIMO Antenna with Improved Isolation using DGS and Vias	E-shaped	4.2-4.6GHZ	S11(4.4) = -25DB,	400MHZ, WB
3	Juin Acharjee [2018][13]	Reduction of Mutual Coupling and Cross-Polarization of a MIMO/Diversity Antenna using a String of H-Shaped DGS	H-shaped	2.36-2.44GHZ	S11(2.4) = -38DB	800MGZ, WB
4	Shahanawaz Kamal [2017][20]	Printed Meander Line MIMO Antenna Integrated	T-shaped	0.7-1.1GHZ	S11(0.9) = -20DB	400MHZ, WB

		with Air Gap, DGS and RIS: A Low Mutual Coupling Design for LTE Applications				
5	Guorui Han [2016][21]	A Novel MIMO Antenna with DGS for High Isolation	square shaped	2.44GHZ	S11(2.4) = -45DB	50MHZ, WB
6	Duong Thi Thanh Tu1,2 [2016][22]	Compact MIMO Antenna with Low Mutual Coupling Using Defected Ground Structure	rectangular shape	3.5 GHz	S11(3.55) = -55DB	250MHZ, WB

B. Electric Band Gap (EBG) Approach

It is suggested to connect a multi-input, multi-output (MIMO) antenna with electromagnetic band gap structures (EBGs). The features of EBG buildings' seclusion are examined. The integrated antennas in the antenna structure have been tuned to resonate in the 2.45 GHz band, making them usable for communications in the band, and have resulted in a decrease in transmission coefficient S21 of 16 dB in simulation and 25 dB in measurement.

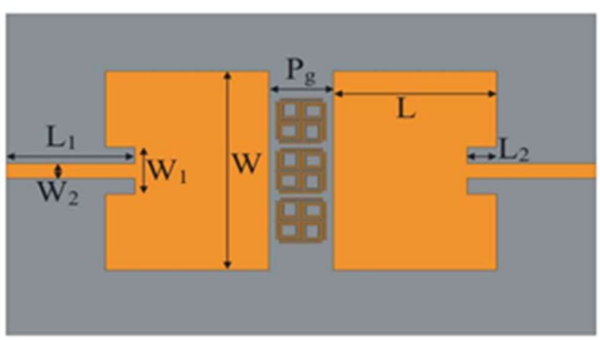

Fig 10. 1 × 2 Proposed Structure with three EBG structures [27].

As a result of its design, the antenna has high impedance and gain characteristics that work well in the ISM band. The antenna has a minimum ECC of 0.09, which is much closer to the ideal value of 0 than earlier designs. This makes it a better choice for MIMO applications [27]. A unique dual-layer double-patch EBG (DLDP-EBG) structure is developed in this study by the author to significantly improve the degree of isolation among wide MIMO antenna array. Over the whole bandwidth of 4.2-6.5 GHz, the DLDP-EBG structure has the ability to increase isolation between closely placed micro strip slot antennas by 10-56 dB.

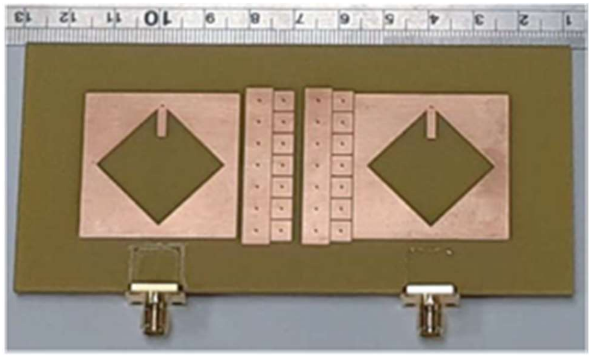

Fig 11. DLDP-EBG MIMO antenna in top view after fabrication [27].

The DLDP structure is also able to decrease the correlation between the two antennas by deflecting the main radiation beams over the operating bandwidth of the antennas. Results from CST simulations and experiments demonstrate close coherence.

The impacts of altering the size and quantity of EBG unit cells are also examined, and the best outcomes are then shown. Due to the enhanced port isolation and deflected beams of the antenna elements, the array gain and radiation efficiency have been improved after employing the DLDP-EBG structure. A detailed comparison with recent published work has been performed to show the uniqueness and usefulness of the proposed antenna. It is worth noting that the proposed MIMO radiating system integrated with an EBG Meta material structure is the first in the literature to exhibit such high isolation over a wide bandwidth while also allowing for beam deflections and gain enhancement [29].

An inductance-boosted, compact electromagnetic band gap (IB-CEBG) MIMO/diversity antenna is described here. The conventional EBG cell is shrunk via spiral defects. Tri-band gaps in 3.3–3.6 GHz, Wi MAX, 5–6 GHz WLAN, and X-band satellite communication (7.2–8.4 GHz).Wi MAX, WLAN, and X-band satellite communication all benefit from IB-CEBG cells being smaller than EBG cells by a factor of 46%, 50%, and 48%, respectively. Isolation between the four tiny UWB magnetic dipoles is enhanced by the use of rectangular gaps in the ground plane and parasitic coupling.

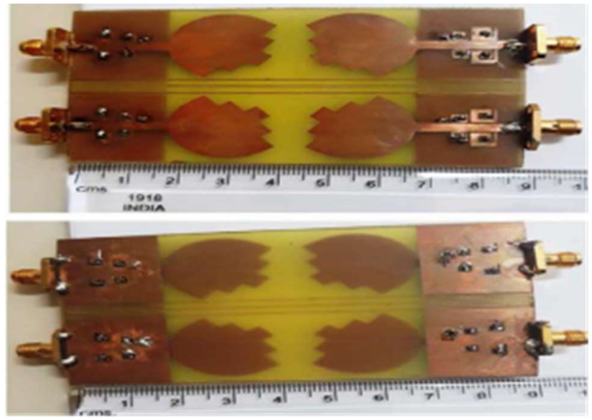

Fig 12. Front and backside view of the fabricated antenna [29].

Individual monopoles also have a 90° stepped construction to minimize influences that are coupled together. Stepped construction improves balancing resistivity by boosting route length. The findings indicate that the transmission coefficient between the proposed antenna components is higher than 15 dB. For the UWB frequencies band, its envelope correlation value (ECC) is under 0.5, which is satisfactory. Punctuated oscillation is dependent on IB-CEBG cell characteristics. The suggested antenna is built on a FR-4 substrate measuring 58 x 90 1.6mm3 [29].

Table 2. Comparison Table for EBG

S.NO	Author by (year)	Title	Shape	Range	Return Loss	Bandwidth Band WB/UWB
1	Ravichandran Sanmugasundaram [2021] [01]	A Compact MIMO Antenna with Electro-magnetic Band gap Structure for Isolation Enhancement	T-shaped	1.5-3.5GHz	S11(2.4) = -80DB	2.0GHz, WB
2	Oludayo Sokunbi [2020][04]	Dual-Layer Dual-Patch EBG Architecture for MIMO Antenna Arrays Isolated Enhancing and Connectivity Reduction	square-shaped	4.6-6.3GHZ	S11(4.7) = -32DB,	1.7GHZ, WB
3	Naveen Jaglan, [2020][05]	Antenna Designs with Band Notches for UWB MIMO and Diversity and The inductance Boosted Compact EBG Architecture	spiral shaped	3.5,4.5,7, 9.8GHZ	S11(3.5) = -16DB, S11(4.5)= -25DB, S11(7)= -12DB, S11(9.8)= -10.7DB,	1.5,1,1.1, 1.7GHZ, NB
4	Kompella S. L. Parvathi1 [2020][06]	A New Compact Electrical Band Gap Structure for Multilayered MIMO Antennas to Reduce Similar Coupling	S-shaped	5.5-6.2GHz	S11(5.9) = -30DB,	700MHZ, WB
5	Palanisamy Prabhu [2019][11]	Novel mutually coupled reductions for a small quad port UWB antenna with MIMO used double-side EBG	four polygon shape	3.8-7.8GHZ	S11(6.5) = -23DB,	4GHZ WB
6	Tanvi Dabas [2018][14]	Using a small-size uniplanar EBG with several stop bands, the UWB MIMO antenna's elements are reduced in mutual connection.	two circulars shaped	3.6-17.6GHZ	S11(15.4) = -53DB,	14GHZ, WB

7	Wenjing W [2018][15]	A Quad-Element UWB-MIMO Antenna Using EBG Structures with Band-Notch and Reduced Similar Couplings	four crescent ring-shaped	6.5-18GHZ	S11(11) = -36DB,	11.5GHZ, UWB
8	Yi Fan [2018][16]	A Miniaturized Four-Element MIMO Antenna with EBG for Implantable Medical Devices	cross-shaped	2.1-2.6GHZ	S11(2.4) = -13DB	300GHZ, WB
9	Niraj Kumar [2018][17]	MIMO Antenna Mutual Coupling Reduction for WLAN Using Spiro Meander Line UC-EBG	T shaped	5.7-6.3GHZ	S11(5.9) = -25DB,	600MGHZ, WB
10	Ahsan Altaf [2017][18]	A New EBG Architecture to Enhance MIMO Antenna Isolated	two H-shapes	22-27 GHz.		290 MHz
11	Hao Qin* [2014][26]	Compact Dual-Band MIMO Antenna with High Port Isolation for WLAN Applications	T-shaped	2.5,5.4GHZ	S11(2.5) = -22DB, S11(5.4) = -24DB	200,250MGHZ
12	Mohammad Naser-Moghadasi1 [2014][27]	Compact EBG Architecture for Patch Antenna MIMO The arrays to Reduce Mutual Coupling	T-shaped	5.3GHZ	S11(5.3) = -72DB	100MHZ
13	Fan Yang, Member [2003][29]	The characteristics of the EBG Ground Plane's Reflections Phase for Low the profile Wire Antenna Systems	squere-shaped	12.3-13.8GHZ	S11(13) = -27DB,	100MHZ

III. SLOTS/SLITS - ETCHING APPROACH

These A dual-band planar slot antenna is proposed for multiple-input, multiple-output (MIMO) array conformation, which achieves the 2.4GHz and 5.8GHz bands for WLAN applications. The isolation between two antenna elements in the operating frequency bands is greater than 20 dB by employing the decoupling slot structure. The envelope correlation coefficient (ECC) in the operation bands is less than 0.01, which shows that it has excellent performance in the MIMO system [ECC].

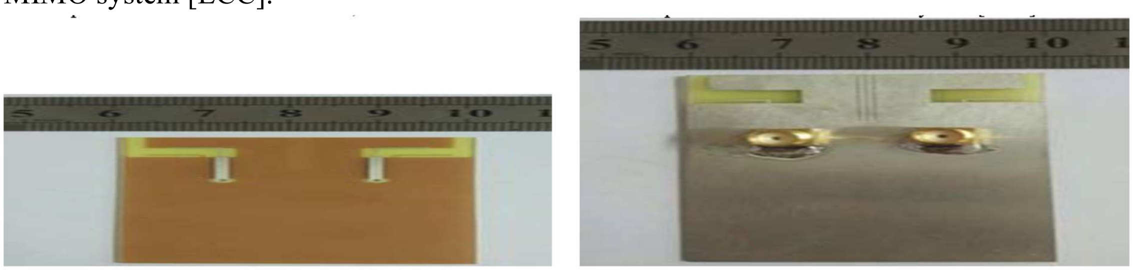

Fig 13. Physical photos of the antenna, (a) front perspective and (b) back perspective [17].

In this paper, the resonance, matching, and isolation properties of the capacitive slot inside shorted microstrip antennas were analyzed. The slot creates an additional resonance within the PIFA and can be easily adjusted to the desired frequency. By placing the feed to the right of the slot and the ground on the opposite side, a bandstop filter is created, reducing the signal inside the stop band by over 20 dB. By optimising the slot parameters (diversity, MIMO, and combined GSM and 3G/4G antennas), they can be constructed with very low coupling, low envelope correlation, wide bandwidth, and high efficiency in the limited space within mobile terminals[19].

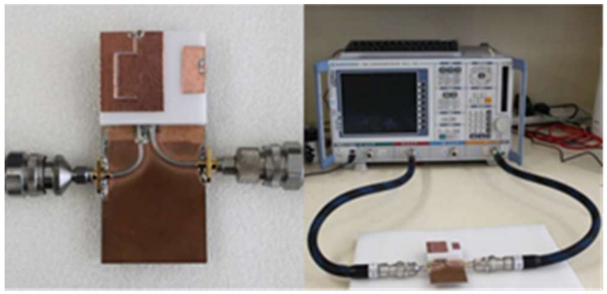

Fig 14. Antenna and PCB prototype

Table 4. Comparison table for Slot/Slit

S.NO	Author by (year)	Title	Shape	Range	Return Loss	Bandwidth WB/UWB
1	Wen Jiang, [2017] [19]	A High Isolation Dual-band MIMO Antenna for WLAN Application	L shape	2.4GHz and 5.8GHz	S11(2.4) = -17DB, S11(5.8) = -23DB	200MHZ,250MHZ, NB
2	Corbett Rowell [2012][28]	Multiple Frequency Band and High Isolation Mobile Device Antennas Using a Capacitive Slot	C-shaped	0.9-1.1GHZ	S11(1.05) = -17DB	200MHZ, NB

IV. Decoupling and Matching Network (DMN) Approach

In this paper presented by the author, a network consisting of parallel coupled lines and micro strip lines is proposed for uniform two-element antenna arrays matching and decoupling. The matching and decoupling conditions of the output ports of the decoupled antenna array are expressed through the scattering parameters that are derived using the analyses in odd- and even-mode. The transmission coefficient between the two array ports and the reflection coefficients at these ports are expressed as functions of five design parameters of the DMN. These include the electrical lengths of the microstrip lines and the electrical lengths and characteristic impedances of the coupled lines. These design parameters can be varied to find a transmission coefficient below a certain threshold (e.g., 40 dB) between the two array ports while simultaneously satisfying an impedance matching condition that the reflection coefficients at the ports are lower than 10 dB. The proposed DMN can be used to decouple two parallel antennas in a number of applications, including single-band, two-element arrays, dual-band ones with varied operating-frequency ratios. This is possible because of the great degree of freedom in the parameters used for design. Three design examples for the DMN have been demonstrated with good agreement between the simulation and experimental results. When comparison to the identical array without the DMN, results for the decoupled, single-band antenna array demonstrate a decrease in separation of the array ports of roughly 30 dB.

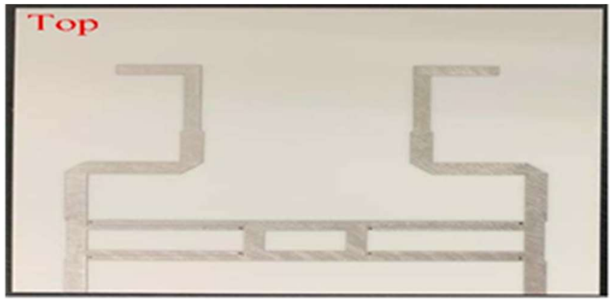

Fig 15. photographs of a fabricated prototype of the single-band, two-element array with the DMN [07].

For the two dual-band arrays, improvements in the inter-element isolation of over 20.8 dB for array A and more than 15.2 dB for array B at both operating frequency bands were realized. Moreover, the DMNs improve the efficiencies of the antenna arrays in the operating frequency bands while having a negligible impact on the shapes of the radiation patterns. The proposed DMN, with its flexibility and simple design procedure, offers a good solution for decoupling and matching two-element antenna arrays in various application scenarios [07].

In this paper presented by the author, a novel two-level DMN design has been developed. In comparison to prior works, the proposed technique can offer wide decoupling bandwidth, compact size, high isolation, improved radiation efficiency, and pattern diversity. For specific applications, a trade-off between decoupling bandwidth and isolation level can easily be attained by the proper selection of transmission zero frequencies. The proposed DMN method is general (with explicit design formulas) and can be applied to various types of antenna elements[12].

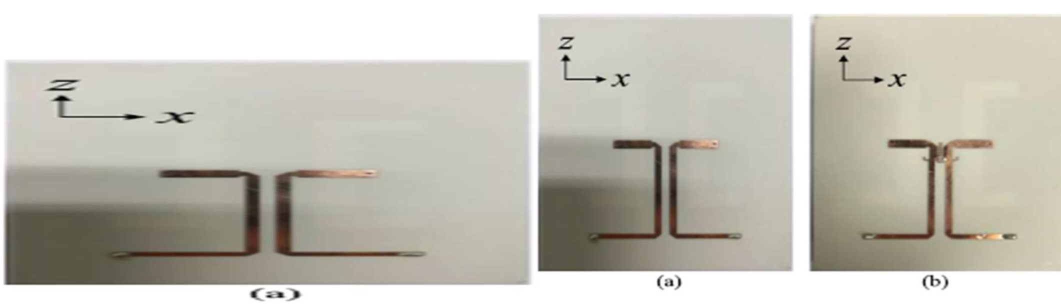

Fig 16. Basic circuit topology of the proposed DMN [15].

This study presents the analysis, design, fabrication, and experimental verification of two novel DMN circuits for three-element UCAs. Equations for designing DMNs with arbitrary antenna impedances have also been presented. In the real world, tiny UCAs have indeed been realised using basic coplanar radiators. Using microstrip technology, the DMNs were constructed. Because none of them need cross-overs, they can all be easily implemented on planar printed circuit boards. Accordingly, it was shown that odd-numbered UCAs may provide an almost constant gain in an azimuthally-cut antenna, but even-numbered UCAs (with one extra component) exhibit gain oscillations, with the lowest having about the same gain as odd-numbered UCAs. Following extensive research into three- and four-element matrices, we have concluded that, in practice, the same array performance is attained with strange UCAs. It was looked at theoretically, simulated, and empirically. Beyond the theoretical understanding, one of the provided DMNs offers high overall efficiency across a wide bandwidth, while the other shows high matching and decoupling bandwidth at the expense of efficiency.

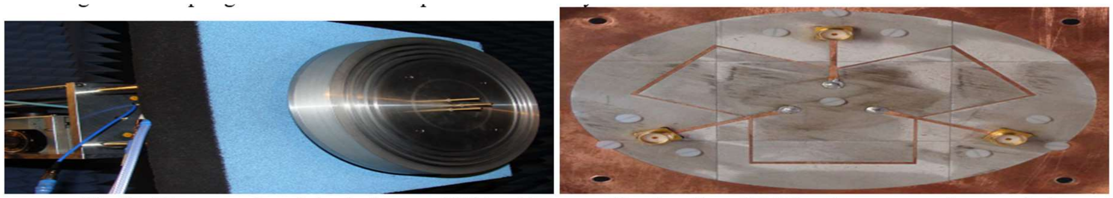

Fig 17. Photographs of the 3-element UCA with neutralization-lines DMN and corrugated ground plane. (a) Mounted in an echoic chamber, front view. (b) PCB of DMN, rear view [17].

The decoupled and authorised licenced use is restricted to: matched UCAs, which enhance gain and efficiency by roughly 1 to 1.5 dB compared to plain UCAs without DMNs. These enhancements have come at the price of more complicated DMNs, which tend to be rather large in our realisations. Nonetheless, compact realisations of the DMNs are achievable using aggregated elements (as explained theoretically inside the study), transmission lines in multilayer PCBs, or even insulated transmission systems [17].

Throughout this research, the author emphasised a straightforward and effective method for dampening the mutual coupling between closely spaced MIMO nodes. To lessen the unwanted related interaction here between MIMO components, we used a modified U-shaped resonator as a decoupling structure. A coupling suppression of 14 dB was accomplished by maintaining an edge-to-edge gap of only 1/10 between the MIMO components. Through the use of associated resonance theories, the MIMO components' interaction performance was analysed. The system's suggested frequency of 5.4 GHz has a significant front-to-back ratio of 22.1 dB with a unidirectional emission pattern [16].

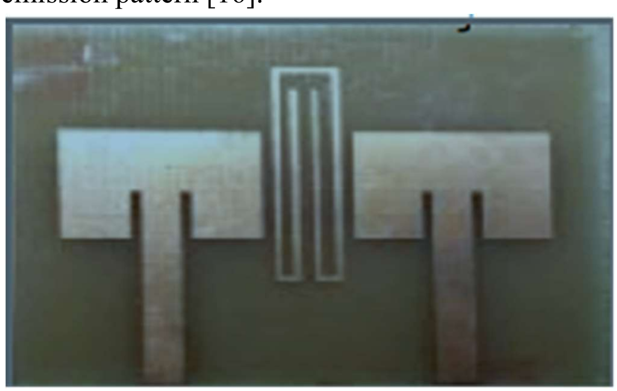

Fig 18. Geometry of the proposed MIMO antenna [6]

This article introduces the first multi-element mobility MIMO array lumped elements decoupling and matched networks (DMN). The DMN is built on an existing approach, but with better BW and more network components. The array operates at 2.6–2.7 GHz LTE. The DMN is used on a four-element MIMO antenna array on the phone's chassis. The array's strong coupling is improved to 7 dB using the DMN. That is a 30% decrease in coupled power. The DMN also increases overall efficiency by up to 21% [23].

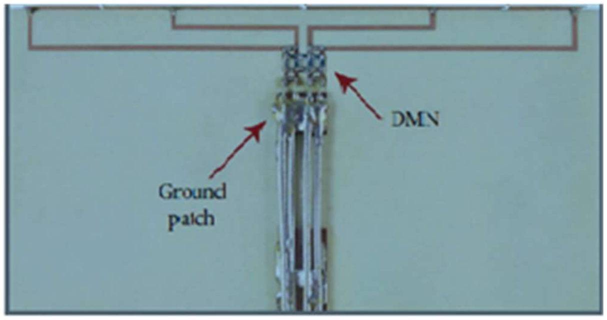

Fig 19. Top view of the manufactured prototype [16].

In this paper, we present a simultaneous decoupling and matching technique for Tx and Rx ports of SR-MIMO systems. The first process establishes parallel SISO links using hybrids, and the second offers simultaneous matching in each SISO link, which maximises channel capacity. In the sense that the proposed technique fulfils both requirements signal and power separation and efficiency enhancement this idea is also applicable to simultaneous wireless power and data transfer. Numerical analyses of 2x2 SR-MIMO were introduced to investigate the proposed and conventional DMN approaches in terms of (i) simultaneous decoupling and matching effects and (ii) channel capacity improvement. The results confirmed the advantage of the proposed technique given the very close arrays that are common in NFC applications.

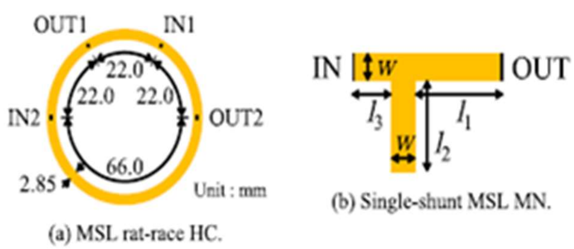

Fig 19 The entire prototype [26].

Table 5. Comparison Table for DMN

S. NO	Author by (year)	Title	Shape	Range	Return Loss	Bandwidth Band WB/UWB
1	Kai-Da Xu [2020][07]	A Decoupling and Matching Network Design for Single- and Dual-Band Two-Element Antenna Arrays	T-shaped	2.1GHZ	S11(2.1) = -15DB,	200-MHZ, NB
2	Yi-Feng Cheng [2020][08]	Dual-Antenna Arrays Compact Wideband Decoupling from one and Matched Network Design	L-shaped	3.45GHZ	S11(3.45) = -22DB,	200MHZ, NB
3	Jonas Kornprobst [2020][09]	Compact Uniform Circular Quarter-Wavelength Monopole Antenna Arrays with Wideband Decoupling and Matching Networks	Star-triangle	3.45-375GHz	S11(3.65) = -35DB	300MHZ, NB

4	Riku Kormilainen [2019][12]	A Four-Element Mobile Handset MIMO Antenna with a Lumped-Element The decoupling and Matched Networks	linear four-element antenna array	2.65GHZ	S11(2.65) = -13DB,	100MHZ, NB
5	Amjad Iqbal [2021] [10]	Modified U-Shaped Resonator as Decoupling Structure in MIMO Antenna	U-shaped	5.4GHZ	S11(5.4)= -36DB,	200MGZ ,NB
6	Kentaro MURATA [2016][23]	Short-Range MIMO Simultaneous Decoupling from one and Matched Techniques	Π-shape	0995-1.005GHZ	S11(1) = -40DB	10MGZ, NB
7	Rui-Peng Li [2015][24]	Compact microstrip decoupling and matching network for two symmetric antennas	S shape	2.50-2.80GHZ	S11(2.50) = -25DB	300MHZ, NB
8	Xinyi Tang [2015][25]	Simplification and Implementation of Decoupling and Matching Network with Port Pattern Shaping Capability for Two Closely Spaced Antennas	U-shape	2.35-2.5GHZ	S11(2.45) = -25DB	150MHZ, NB

V. CONCLUSION AND FUTURE WORK

This study compares and contrasts several MIMO antennas based on their mutual coupling and the range they cover. Mutually coupled evaluation and wrap correlation adjustments are two examples of features that may be used in performance estimates for MIMO antennae. Research shows that there are two tabular representations of different structures, one showing geometry and reactance mutual inductance. In future work will present comparative analysis of based on other EBG, as well as Meta materiel based analysis. Also focus on other such as ECC as well as current flow analysis.

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