



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 3, March 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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# Interference Cancellation in MIMO System Using MAAD (Meta Surface Antenna Array Decoupling)

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**ABSTRACT:-** The electromagnetic wave propagation will be blocked from first antenna to second antenna due the loading of metasurface (artificial sheet material with sub-wavelength thickness).i.e., single negative metasurface of effective permeability and permittivity .In contrast with coupled array the efficiency and the gain of the systems are improved in decoupling array. Meanwhile ,the envelop correlation for decoupled array is reduced. The proposed MADD technique has great potential to be used in improving the performance of MIMO antenna.

**KEYWORDS** - MIMO, Metasurface antenna array decoupling (MAAD), Split ring resonators(SRRs)

## I. INTRODUCTION

Side-lobes might occur and it will affect the beam-scanning capability of the array. The SNR of the array will be deteriorated as unwanted coupling between elements will cause data streams received by other antenna elements rather than radiating into free space. The envelop correlations between elements become high thus data throughput is significantly reduced. Gain and total efficiency of the array will drop since effective radiated power are coupled elsewhere and dissipated on the loads of the antenna elements. Consequently, the mutual coupling reduction technique, or termed as the antenna decoupling technique has drawn great attention from both the academia as well as the industry.

The existing and developing decoupling solutions include: neutralization lines decoupling with parasitic scatters eigenmode decomposition techniques and passive decoupling. networks. However, only a few of them can be readily extended to Massive MIMO antenna arrays with dozens of elements. Metamaterial based or inspired solutions are also becoming popular, but most of them are very effective for arrays with limited number of antennas where inter-element spacing is moderate (no less than  $0.1 \lambda_0$ ). In the paper, a metasurface suspended over an antenna array is proposed for antenna decoupling purpose. The idea of covering a metasurface over an antenna for performance enhancement is not new, but most of them are not used for array antenna decoupling, they are used

- To form a Fabry-Perot resonator type antenna for gain enhancement.
- For low-profile antenna (array) design.
- To reduce the Radar Cross Section (RCS) of the antenna.

For beamforming or beam scanning applications. To the best of the authors' knowledge, it is for the first time that a metasurface covering with negative permeability characteristic is used for antenna decoupling. The proposed MAAD method for compact antenna arrays utilizing meta-surface cover possess the following remarkable features: Both the decoupling and matching bandwidths of the array with the metasurface are very broad without any extra matching measures. It can be applied to compact antenna arrays where inter-element spacing is extremely small (smaller than  $0.02 \lambda_0$ ); Because of the periodic nature of metasurfaces, it has great potential to be applied to Massive MIMO antenna arrays where a few hundreds of antennas are excited simultaneously; It is also able to enhance gain and efficiency of the antenna array thanks to the focusing capability of the metasurface.

In this project, a metasurface-based MIMO microstrip patch antenna system will be designed. Antenna parameters will be improved by utilizing metasurface technology. A metasurface is two-dimensional structure with properties equivalent to meta materials. Metasurface structures are planar, thin and practical for implementation. Hence, they have been getting antenna researchers attention in recent years. The word metamaterial is deduced from Greek it combines

two words, meta and material. Where meta can be described as something unnatural, modified and advanced. It is synthetic material, engineered to have physical properties that are not naturally occurring. The metamaterial term, was first used in 1999 by Rodger M. Walsler in University of Texas. He described metamaterials as –“Macroscopic composites having a synthetic, three dimensional, periodic cellular architecture designed to produce an optimized combination not available in nature, of two or more responses”. There is a wide range of materials that fit the definition of being meta materials. Hence, any engineered material with sub-wavelength dimensions that exhibit unnatural properties can be classified as a metamaterial.

## II. ANTENNA DESIGN

When designing a MIMO antenna system, one has to consider parameters that are utilised to measure the performance of a MIMO system. These parameters include but are not limited to coupling, envelope correlation coefficient, diversity gain and channel capacity which is the maximum transmission rate of which communication can be achieved and it can be calculated. Mutual coupling can be described as electromagnetic interaction between antenna elements in a MIMO system.

It is usually a result of two phenomena, the first being radio leakage received through space between antenna elements. The second being signal leakage from currents on the ground surface or surface waves from the substrate. The envelope correlation coefficient is a mutual coupling measuring parameter; it measures the radiation pattern correlation and isolation of MIMO antenna pairs.

## III. METASURFACES CLASSIFICATION AND APPLICATIONS

There are different types of metasurfaces available in the market; these different types are used for different applications ranging from antenna enhancement application to cloaking applications. In this section, we will look at the classifications and applications of impedance metasurfaces, Huygens metasurfaces and dielectric metasurface.

### IMPEDANCE METASURFACES

When a propagating wave in space hits a surface. The resulting transmission and reflection outcomes are determined by the properties or characteristics of the surface, which can be defined in terms of impedance. Impedance metasurfaces provide ways in which the impedance of the surface can be, manipulated and designed for different applications. These applications include but are not limited to polarisation control, absorption, leaky wave radiation and cloaking.

### HIGH IMPEDANCE METASURFACE

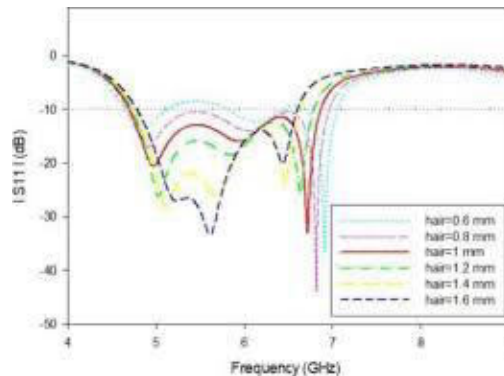
In many antenna systems, close proximity of metal planes to the radiating antenna is highly unwanted due to the out of phase reflection from the metal plane that causes destructive interference. Destructive interference results in power inefficiency, reduced gain and a degraded radiation pattern in an antenna. In addition to that, if the distance between conducting ground plane and the radiating patch or element is less than a quarter wavelength. Then the image currents radiation will interfere destructively with the radiating antenna, resulting in an impedance mismatch. The above mentioned issues can be resolved by using a high impedance metasurface. That can reflect all the incident plane waves in phase, resulting in constructive interference in the normal direction.

### METASURFACE DESIGN

This section outlines the design of the metasurface unit cell. Where an MNG high impedance metasurface is designed for mutual coupling reduction purposes. An MNG metasurface is a metasurface that is equivalent to negative permeability and positive permittivity medium. This metasurface was selected due to its ability to reject wave propagation in the designed frequency band.

The metasurface is formed by a pair of subwavelength split ring resonators (SRR) printed on a dielectric substrate, with split gaps located 180 degrees from each other. The metal loops of the SRR results in an inductance while the split gaps between the rings results in a capacitance, hence forming an LC circuit.

The formed LC circuit is responsible for producing the resonant frequency of the metasurface. This is the frequency where wave propagation will be rejected. The induced magnetic field in the SRR is responsible for creating negative permeability.



Field Distribution. To further reveal the underlying working mechanisms of the array with the metasurface, the vector magnetic field distributions on a cutting surface within XOZ-plane are investigated using ANSYS HFSS. Without the metasurface, the vector H-field is rotating in Region A with the metasurface, the H-field in Region B is almost along the X-axis. On the same cutting plane, the Poynting vector distributions are also plotted and shown in Fig. 3(c) and (d) for the arrays without and with metasurface, respectively.

The Poynting vectors for the array with metasurface are almost in parallel to the Z-axis without any lateral radiation. The contours of the electric field for the arrays without and with metasurface are also shown in Fig. 3(e) and (f). In the simulation, Ant 1 is excited while Ant 2 is terminated with matched load. It can be concluded from Fig. 3(e) and (f) that, in the array without metasurface, stray coupling from antenna 1 will be coupled to antenna.

**PARAMETRIC STUDIES:**

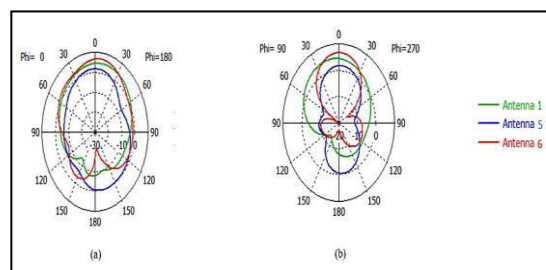
Parametric studies are conducted to analyze the sensitivity of different design parameters. Two clusters S-parameter curves are obtained with respect to different lengths of the SRR, and different heights of the metasurface covering,  $h_2$ . They are superposed. It can be seen that parameter  $a$ , the length of the SRR is more sensitive in the design, since the length of the SRR will directly affect the negative permeability frequency band of the SRR, as shown in Fig. 1(d). Therefore, the band-rejection frequency of the metasurface will shift to lower frequencies if parameter  $a$  increases, and it will shift to higher frequencies if parameter  $a$  decreases, which is consistent with the observation.

The isolation performance of the antenna array with the metasurface is not very height-sensitive. This is reasonable since the rejected propagation band of the metasurface remains unchanged, yet the return losses of the array vary significantly because of different parasitic effects of the metasurface with respect to different meta-surface height.

In order to explore the optimum configuration of the SRR units on the metasurface, the matching and isolation performances for the array with metasurface of  $6 \times 4$ ,  $8 \times 6$  and  $7 \times 5$  periodic SRR units are also compared.

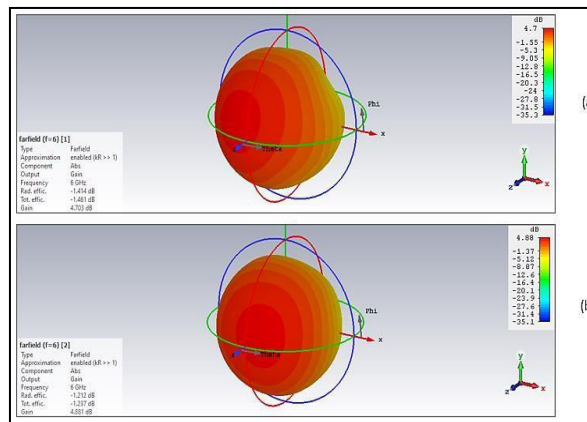
We can conclude that the both the matching and isolation performance of the array with only  $6 \times 4$  SRR units are not ideal. The isolation performance for the array with  $8 \times 6$  SRR units is better than the array with  $7 \times 5$  SRR units only within the bandwidth from about 5.65GHz to no more than 5.8GHz

**IV. RESULT AND DISCUSSION**



The Figure shows the Normalized radiation patterns of reference antenna and the proposed antennas (a) in the H-plane (b) In the E-plane.

The figure shows the gain of the antenna 1 and the gain of the antenna 2



## V. CONCLUSION

In this project, metasurface-based antenna designs were conducted for the purpose of reducing mutual coupling between a 2-port MIMO microstrip antenna. These designs were compared for the best performing antenna. Three single element microstrip antennas with different geometries and feeding methods were first designed. This was done to get the best performing single element antenna to use in the 2-port MIMO microstrip antenna design. The first single element antenna design conducted was the rectangular inset fed microstrip antenna (RIA). The second design was the rectangular probe fed microstrip antenna (RPA). Finally, the last design was the triangular inset fed microstrip antenna (TIA). The first design (RIA) was found to be the best performing antenna with the smallest return loss of -21.82 dB. Followed by the third design (TIA) with the return loss of -17.30 dB. The second design (RPA) came in last with an unacceptable return loss of -7.72 dB. The first design, which is the rectangular inset fed microstrip antenna, was then used for the 2-port MIMO microstrip antenna design. The 2-port rectangular microstrip antenna obtained mutual coupling parameters of -23.06 dB. The metasurface-based antenna designs were then employed to reduce the mutual coupling of the 2-port antenna.

## VI. FUTURE WORKS

For future research one can look at, the limit of metasurface walls and metasurface substrate one can fit before they stop reducing mutual coupling. This will obviously depend on the available surface area between the radiating antenna elements and the available height above the antenna. These designs utilized an SRR metasurface for mutual coupling reduction because it is a 2D structure, hence it is less complicated to fabricate and it costs less. If costs and fabrication complexities are not a limiting factor, one can look at combining other mutual coupling reduction methods with this type of design. Mutual coupling methods that do not change the original structure of the antenna would be recommended. This is because the radiation pattern of the antenna is not affected, and the design can be implemented on already existing antennas without changing the whole antenna design i.e. 1D EBG structure, MTM-EBG decoupling slabs.

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