

Orthogonal Polarization Position Based MIMO Antenna For Wireless Applications

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Abstract

In this paper, we design a 4 element MIMO antenna with reduced ground plane structure to reduce the mutual coupling. Here the ground plane is reduced by etching metamaterial based concentric square shaped rings from the ground plane both in XY axis. Here initially the single antenna which is in the resemblance of F shape is considered and it operates at 6.94GHz and 9.46GHz. The 4 element antenna is considered by placing the antenna in a orthogonal polarized positions. The frequency band we considered is in-between 6GHz to 10GHz for the analysis purpose. The dielectric material used is Rogers RT/Duroid 5880™. The comparative analysis is presented with the help of return loss curves according to the port excitation given and the MIMO antenna at each port have dual bands in the considered frequency band 6-10GHz.

Keywords: Metamaterials (MM), F Antenna, Reduced Ground Planes (RGP), MIMO Antenna

Introduction

In recent times MIMO antennas have become very important in now a day's communication systems where multiple channels need to be dealt at the same time and the need for handling larger data and with high data rates for video streaming made it very vital to create new kind of antennas to satisfy. F antenna is one of the key antennas in mobile, vehicle applications [1, 2]. In the recent time the designing of antennas that are suitable of handling large band widths are considered for the 5G systems several countries showing interest in finding the proper frequency bands that can be utilized for 5G applications but the most speculated bands are 6GHz and above. The designing of F antenna above the 6GHz is very easy that is why it is considered most [3]. Placing the radiating elements in a compact way is very daunting task in working with the MIMO antennas. In order to avoid mutual coupling, envelope correlation etc several methods were used like placing minimum distance between the radiating elements, are having a neutral line in between the radiating elements etc, but placing the radiating elements in a orthogonal ways another way to do it.

Reducing the antenna size without affecting its performance is one of the key factors in implementing any new antennas. Etching slots from both radiating elements and the ground planes is considered to reduce the actual size of the antenna[4,5]. Now a days to reduce the overall size of the antenna and also as an alternate to the Metamaterial structures defective ground surfaces are used. Whenever there is a need to alter the feeding given to the radiating element it is usual to

etch some slot on the ground below the feed. Here in the metamaterial based reduced ground planes we etch slots similar to the periodic structures in the particular area or the entire can be proved to be very useful in generating the frequency tuning or the radiation reconfiguration in our case we use it to isolate the each element radiation to reduce the mutual coupling[6-8].

Due to the increase in traffic in communication systems which can process multiple gbps data to vast number of users, the demand for 5G is high there are few frequency bands which are being considered for the 5G applications in different countries. It is very important to have high bands to allow high data rate in Gbps the easy way to have high band width is when working with very high frequency bands like above 6GHz [9]. Though it is expected to deploy 5 generation communication systems early 2020 several researches already started exploring various secure coding methods as well as design problems and the adaptive hardware setups and it is very important to have the proper antennas which can satisfy the needs of 5G both in transmission and reception. So here we proposed to design antenna which can work at frequencies higher than 6GHz.

DESIGNING OF PROPOSED F ANTENNA AND THE MM BASED MIMO ANTENNA WITH RGP METAMATERIAL STRUCTURE

A. Proposed F antenna

As the F antenna is one of the most popular antenna used for mobile communication applications we considered it for the analysis purpose here the ground plane is considered with dimensions 4.5×4.5cm. and the dielectric substrate Rogers RT/Duroid 5880™ with dimensions 4.5cm×4.5cm× 62mil is considered. The F shape is followed with strip line carrying feed from port with width 0.1cm and length 1.5cm short arm of F with dimensions 1×0.5cm, and log arm with 1.5×0.4cm and the connection between them is of 0.3×0.3cm dimensions the entire proposed model of F antenna in top view is shown in the following figure [1].

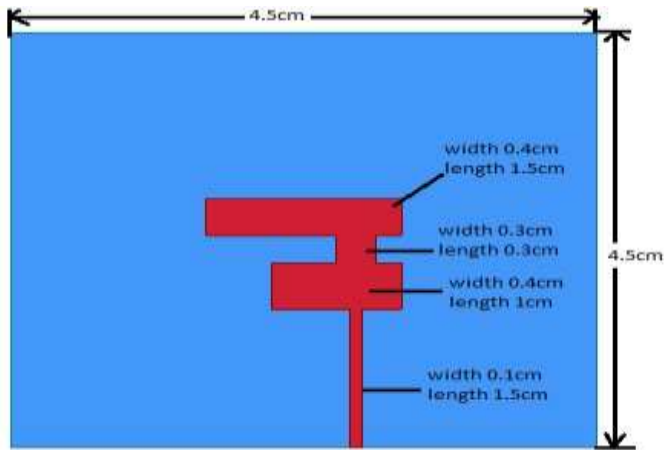


Figure [1] Top view of the proposed F antenna

The proposed F antenna return loss curve is shown in the following figure [2].

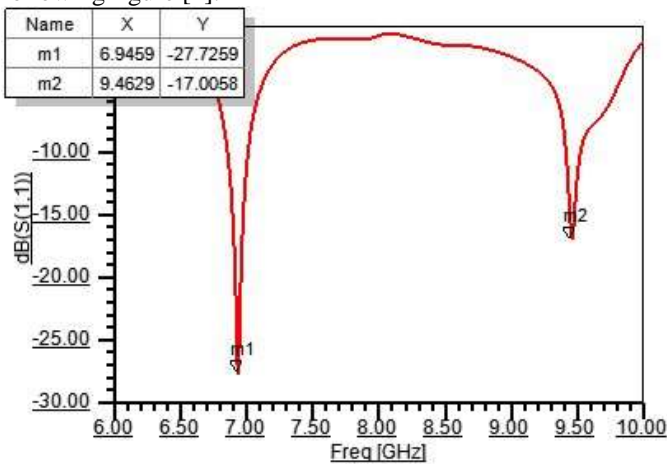


Figure [2] Return loss curve of the proposed F antenna. The antenna works at dual band with operating frequencies at 6.94GHz and 9.46GHz with return loss -27.7259dB and -17.0058dB respectively.

B. Proposed MIMO antenna setup

The F antenna designed above is placed in a orthogonal polarization manner as shown in the following figure [3]. Here the MIMO antenna has 4 elements in the 4 corners.

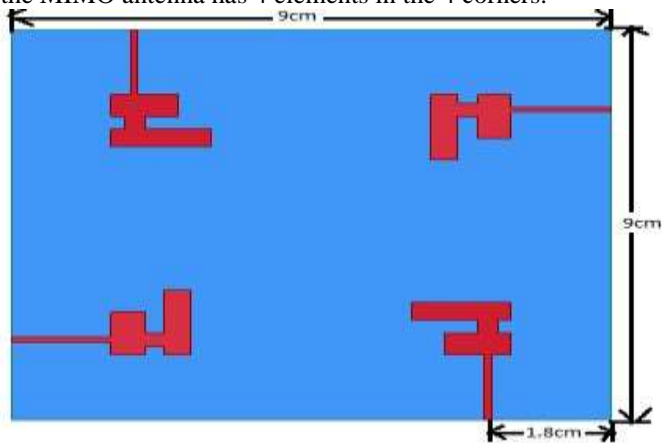


Figure [3] Top view of the proposed MIMO antenna. In the above figure substrate and ground plane have dimensions 9×9cm.

C. Proposed 4 element MIMO antenna with MM based RGP

The above MIMO antenna shown in the figure [3] will be changed by etching the square shaped rings from the ground plane as shown in the following figure [5].

Here the MM based rings are etching like split ring resonator model from ground the square shaped ring etched from ground are 1cm length and ring width of 0.4cm and a square patch inside the ring with 0.4cm×0.4cm dimensions as shown in the figure [4].

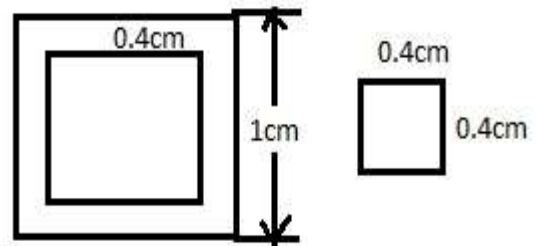


Figure [4] square ring and square patch for etching. The above shown square ring and patch are etched in XY axis based on center of the antenna.

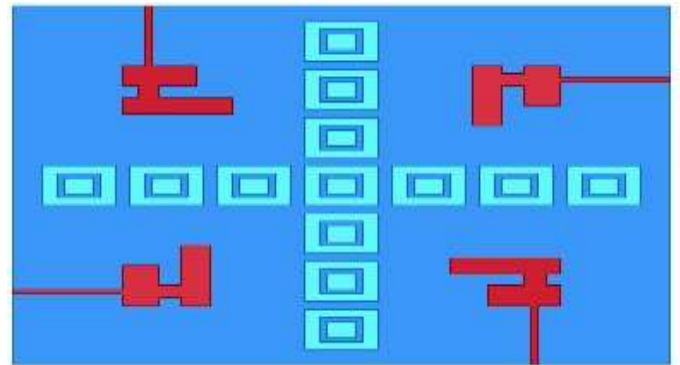


Figure [5] Proposed MIMO antenna with MM based RGP

Simulated Results and Analysis

D. Proposed MIMO antenna

The proposed antennas shown in figure [3] is designed and simulated and the results are presented when only port1 is excited, when port1 and 2 are excited, when port1 and 3 are excited, when port1, 2 & 3 are excited and when all ports are excited.

Return Loss curves

a) When only port 1 is excited

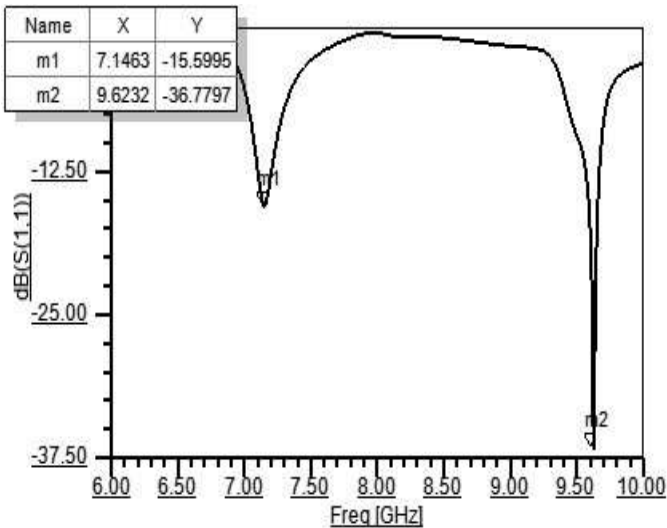


Figure [6] Return loss curve for Proposed MIMO antenna without RGP when only port 1 is excited. Here the S_{11} curve has dual band operating at 7.14 and 9.62GHz with return loss -15.5995 and -36.7797dB respectively.

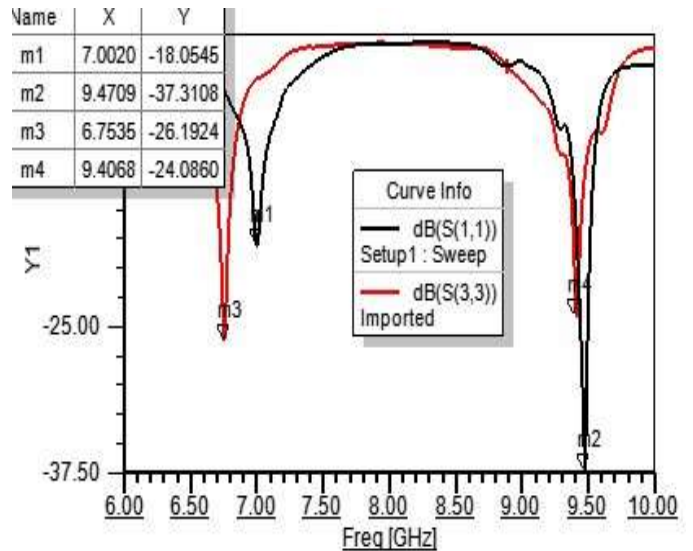


Figure [8] Return loss curve for Proposed MIMO antenna without RGP when only port 1 and 3 are excited. In the above figure we can see that when port 1 and 3 are excited both S_{11} (black line) and S_{33} (red line) curves have dual bands at almost same frequency bands S_{11} at 7.0020GHz, 9.4709GHz with return loss -18.0545, -37.3108dB and S_{33} at 6.7535, 9.4068GHz with -26.1924, -24.0860dB respectively.

b) When port 1 and 2 are excited

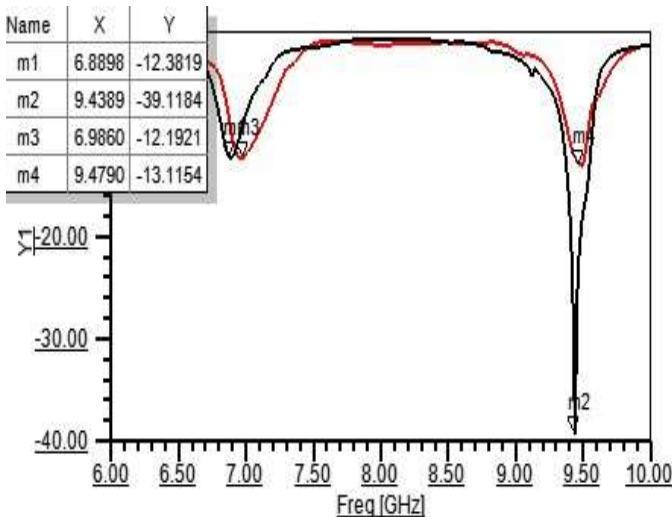


Figure [7] Return loss curve for Proposed MIMO antenna without RGP when only port 1 and 2 are excited. In the above figure we can see that when port 1 and 2 are excited both S_{11} (black line) and S_{22} (red line) curves have dual bands at almost same frequency bands S_{11} at 6.8898GHz, 9.4389GHz with return loss -12.3819, -39.1184dB and S_{22} at 6.986, 9.479GHz with -12.1921, -13.1154dB respectively.

c) When port 1 and 3 are excited

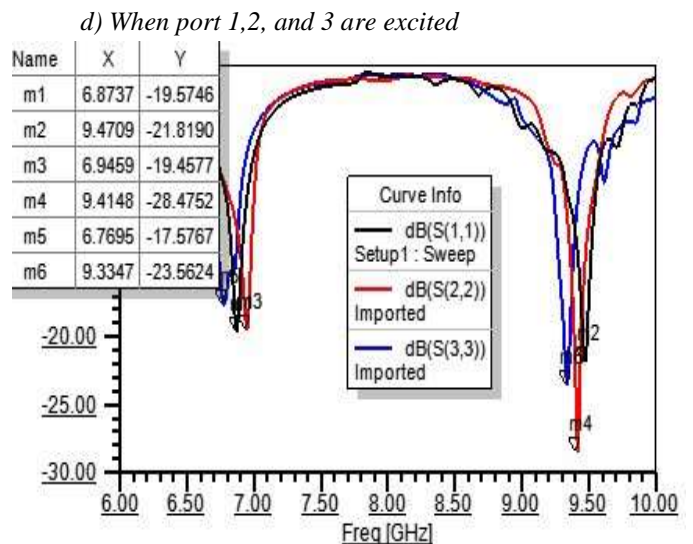


Figure [9] Return loss curve for Proposed MIMO antenna without RGP when only port 1, 2, and 3 are excited. Similarly in the above figure [9] S_{11} , S_{22} and S_{33} all have dual bands. S_{11} at 6.8737, 9.4709GHz with return loss -19.5746dB, -21.8190dB, S_{22} at 6.9459, 9.4148GHz with return loss -19.4577dB, -28.4752dB and S_{33} at 6.7695, 9.3347GHz with return loss -17.5767dB, -23.5624dB respectively.

e) When all ports are excited

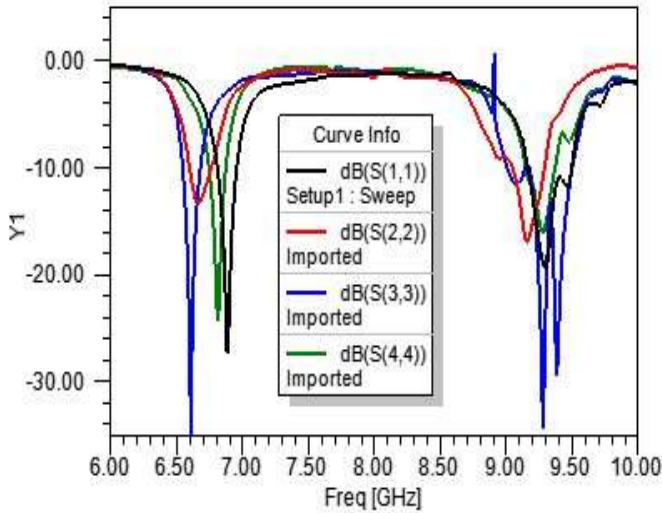


Figure [10] Return loss curve for Proposed MIMO antenna without RGP when all ports are excited.

In the above figure [10] S_{11} curve operates at 6.8898, 9.3029GHz with return loss -27.2344, -19.2945dB, S_{22} curve at 6.6733, 9.1633GHz with return loss -13.3317, -16.8193dB, S_{33} at 6.6172, 9.2786GHz with return loss -34.8551, -34.2440 and S_{44} at 6.8176, 9.2786GHz with return loss -24.3367, -16.0386dB respectively.

E. Analysis for Proposed MIMO antenna with MM based RGP

Similarly here also the results are presented as same manner from figure [6-10]. For the model setup in figure [5].

a) When only port 1 is excited

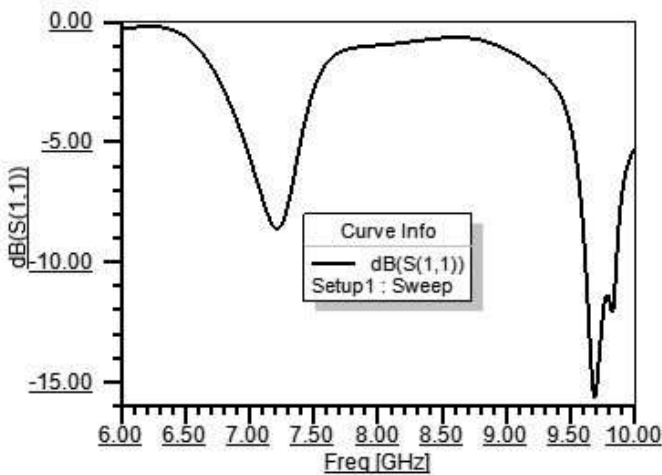


Figure [11] Return loss curve for Proposed MIMO antenna with RGP when only port 1 is excited. Here the S_{11} curve has dual band operating at 7.2024 and 9.6713GHz with return loss -8.5727 and -15.5002dB respectively.

b) When port 1 and 2 are excited

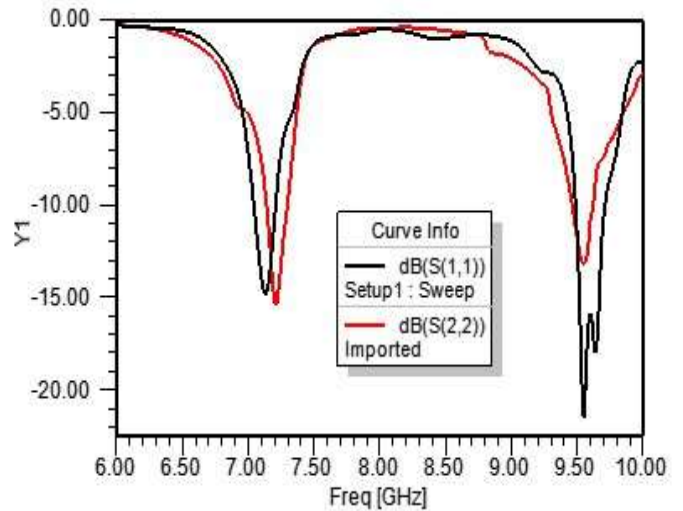


Figure [12] Return loss curve for Proposed MIMO antenna with RGP when only port 1 and 2 are excited. In the above figure we can see that when port 1 and 2 are excited both S_{11} and S_{22} curves have dual bands at almost same frequency bands S_{11} at 7.1383GHz, 9.5511GHz with return loss -14.8190, -21.4717dB and S_{22} at 7.2184, 9.5511GHz with return loss -15.3615, -13.1725dB respectively.

c) When port 1 and 3 are excited

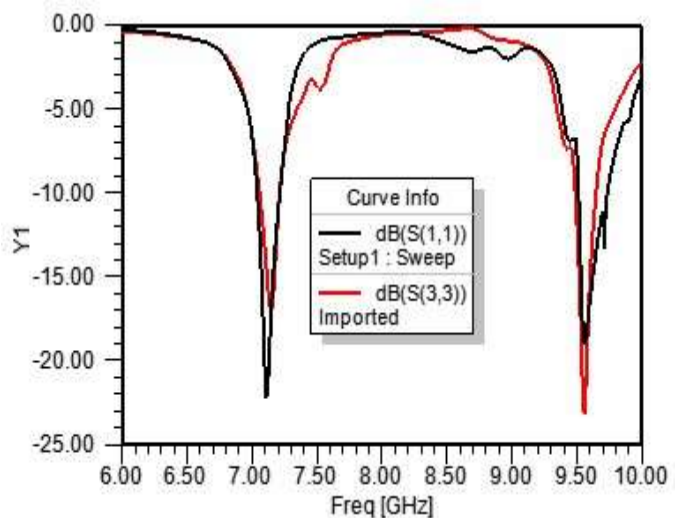


Figure [13] Return loss curve for Proposed MIMO antenna with RGP when only port 1 and 3 are excited.

In the above figure we can see that when port 1 and 3 are excited both S_{11} and S_{33} curves have dual bands at almost same frequency bands S_{11} at 7.1142GHz, 9.5511GHz with return loss -22.1372, -19.0220dB and S_{33} at 7.1543, 9.5511GHz with -16.9669, -23.0920dB respectively.

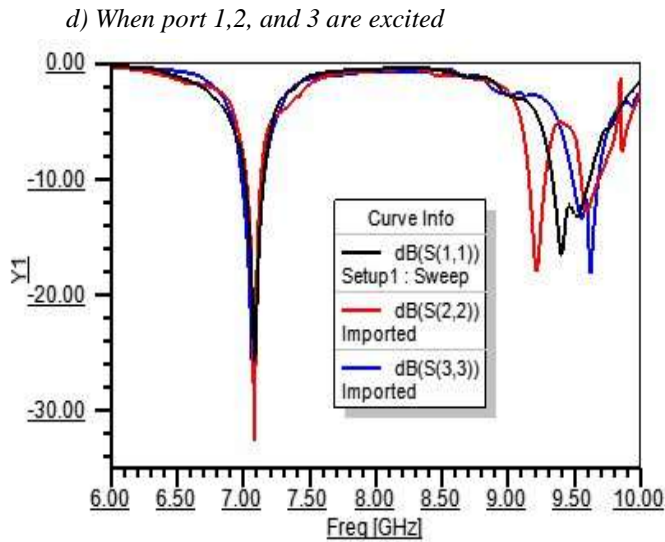


Figure [14] Return loss curve for Proposed MIMO antenna with RGP when only port 1, 2, and 3 are excited.

Similarly in the above figure [9] S_{11} , S_{22} and S_{33} all have dual bands. S_{11} at 7.0902, 9.4068GHz with return loss -24.8144dB, -16.5378dB, S_{22} at 7.0902, 9.2144GHz with return loss -32.5554dB, -17.9957dB and S_{33} at 7.0822, 9.6232GHz with return loss -26.9475dB, -18.1262dB respectively.

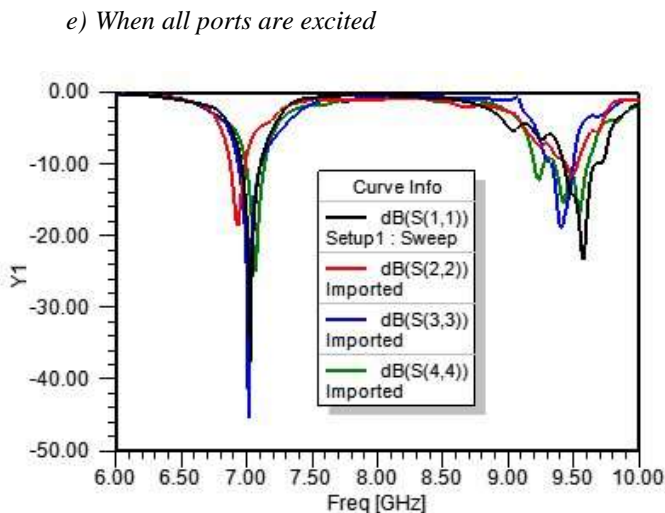


Figure [15] Return loss curve for Proposed MIMO antenna with RGP when all ports are excited.

In the above figure [10] S_{11} curve operates at 7.0341, 9.5671GHz with return loss -37.4557, -23.3979dB, S_{22} curve at 6.9379, 9.479GHz with return loss -18.6278, -11.7131dB, S_{33} at 7.0180, 9.3988GHz with return loss -45.2838, -18.9663

and S_{44} at 7.0661, 9.5351GHz with return loss -24.9745, -17.0642dB respectively.

Comparative analysis

For the comparison purpose we consider when all ports are excited S_{11} curves for proposed MIMO antenna without and with MM based RGP

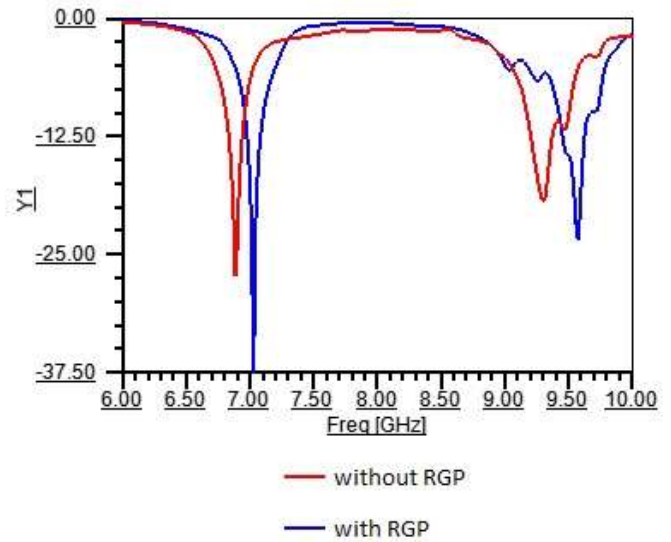


Figure [16] Comparison of S_{11} when all ports are excited without RGP and with RGP.

In the above figure [16] we can clearly see that with RGP the return loss is good which means it gives better performance with RGP.

Similarly comparing S_{43} curves

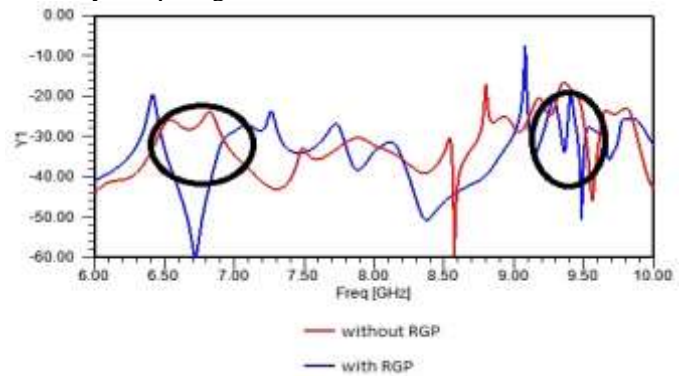


Figure [16] Comparison of S_{43} when all ports are excited without RGP and with RGP.

In the above figure when RGP is present mostly the S_{43} curve with RGP is below the S_{43} curve without RGP except some bands. Especially the in the working frequency bands of the designed antenna S_{43} curve with RGP is below the S_{43} curve of without RGP that means the mutual coupling reduced.

Conclusion

The performance of proposed 4 element MIMO antenna with and without RGP is analyzed and as we can see there is slight improvement in reducing the mutual coupling by etching the ground in MIMO antenna here the proposed model without and with RGP mostly worked in frequency bands approximately around 6.5-7.2GHz and 9.2- 9.7GHz with good return loss. This higher frequency band belongs to c and x bands are also being in consideration for future 5G wireless applications.

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Several members pursuing their Ph.D degree. He has published several papers in National & International Journals & Conferences. He is the life member of FIETE, IE & MISTE.