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RECENT TRENDS OF MICROSRIP ANTENNA BASED METAMATERIAL ABSORBER

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ABSTRACT

we have given details on the Microstrip antenna with metamaterial absorber structures. How the metamaterial structures are works and their absorbance capability of different structures with their different characteristics on single band, multiband structures, and unit cells are consist of dielectric of FR-4 and how they are affecting the microstrip antenna's results for overall improvements like keeping radiation pattern preserved and help to increase gain, directivity and also, the reduction in the Radar Cross Section by using this metamaterial structures. And also given the comparative analyses of all three-metamaterial structure combined with simple rectangular microstrip antennas.

Keywords: *Microstrip Antenna (MSA), Metamaterial Absorber (MMA), Ring Resonator, RCS, X-Band.*

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Introduction

In recent time, the metamaterial absorber (MMA) has become a new research focus towards designing a perfect MMA resonant unit. Metamaterials has the various properties which shows different characteristics than the conventional material found in the nature. And these new characteristics provides us totally new area for research and for the understanding of materials. They are showing electromagnetic properties which can be useful for the creating such types of material which are used in various fields for advancements. By using these types of material, we can improve the results of an antennas and can be able to reduce the RCS of an antenna.

MMA's properties offer excellent features includes near-unity absorbance, ultra-thin thickness wide angles of incidence and polarization insensitivity, makes it suitable for antennas designs, for the reduction of radar cross section (RCS) in stealth technology, photodetectors by enhancing absorption in both solar photovoltaic and thermo-photovoltaic cells to improve the performance and also in wireless communication.

Basically, Metamaterials which are widely use with the antenna designs are having the negative refractive index. Which is the most important thing for the characterization of metamaterial. also, the phase of a signal advances as it moves away from the source. The evanescent waves increase as they get farther away from the source. Whereas the E- and H-fields in an ordinary material form a righthanded triplet with the direction of phase propagation, in a material with negative μ and ε, they form a left-handed triplet. Such materials have never been found in nature. However, numerous researchers have suggested ways to produce them artificially. Periodic structures of elements varying from simple straight wires to very elaborate concoctions have been claimed to produce a negative index of refraction. And nowadays wide research is going on in this field, researchers and engineers are getting more capable to design or create these types of material as never before.

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Recent Trends

There are certain numbers of the papers are available on the shorted stub ring resonator metamaterial design, which are basically cover the x- band frequencies. By using These ring resonator metamaterial structures, we can get the effective results for the practical applications.

Here is the general structure which defines the dimensions of the ring resonators.

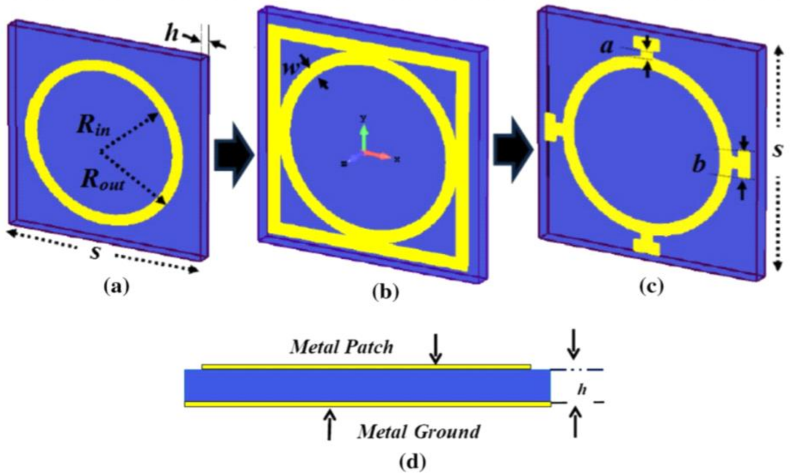
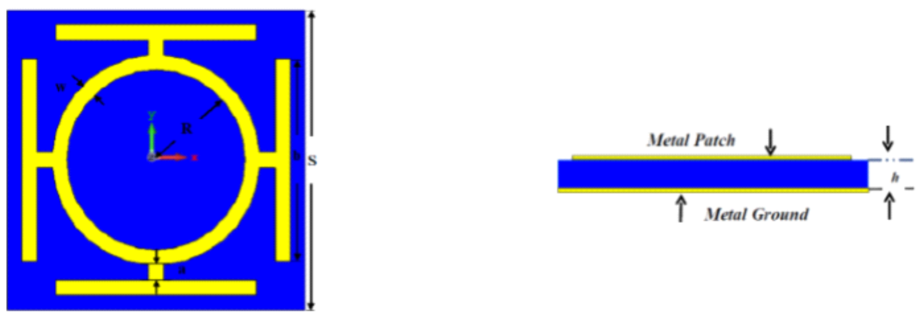


Fig. 1: A Metamaterial Absorber with shorted stubs and split rectangular bars

Fig.1 gives a glimpse of designing process and shows how transformation is made from the simple circular ring to shorted stubs and split rectangular bars to get a passive tuned MMA absorber that operates at X-band. It has been shown that by varying the dimensions of shorted stubs (a) and rectangular bar length (b), we can adjust the resonant frequency to entire X-band and also Ku-band.

The given shorted stub ring resonator structure can be realised for the single and dual band resonant frequencies. Firstly,[3][4] MMA structure for single frequency resonance are given with dimensions, Unit cell dimensions: S = 5 mm, Rin = 1.5 mm, Rout = 1.75 mm, a = w = 0.25 mm, h = 0.40 mm and t = 0.035 mm. Here MMA is tuned to the central resonant frequency of 10 GHz of X-band by mean of varying length of shorted stubs and split square rectangular bars. [3] The periodicity (S) and the thicknesses (h) for the shorted stubs MMA is designed to 5 mm and 0.4 mm respectively.



(a) Front view. **(b) Side view.**

Fig. 2: (a)front view of a unit cell and (b)side view.

We can vary the length of the rectangular bar and the thickness of the substrate material and able to get the various resonance frequencies. by Simultaneously varying the values of parameter “a” and “b”, and also can vary the thickness in order to get the good reflectance at particular frequency. As we can see [4] at the value of 0.30 mm it gives effective reflectance and that will also provide good absorbance rate as per the absorbance equation, A(w) = 1 – T(w) – R(w)

Where, A(w) = Absorbance of structure

T(w) = Transmission coefficient

R(w) = Reflectance coefficient.

For multiple single frequencies the plot of absorbance as given below by varying the values of “a” and “b”.[4]

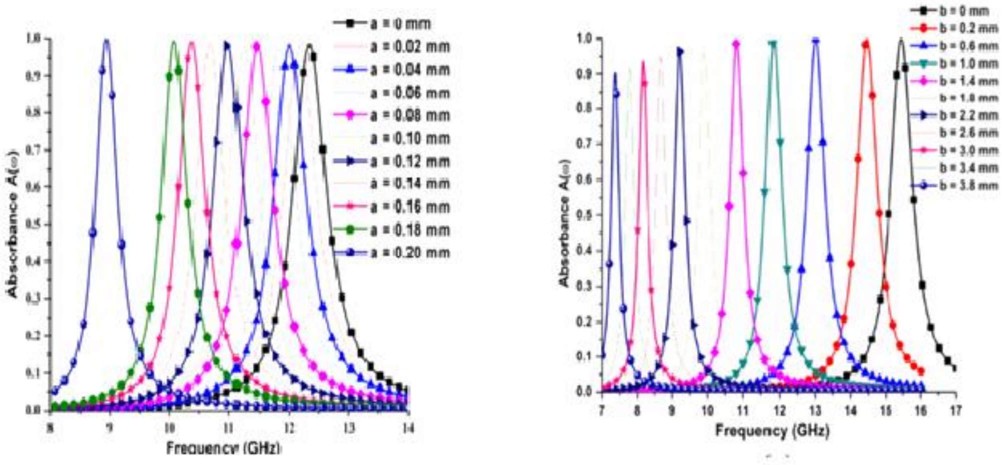


Fig. 3: plot of absorbance by varying values of “a” and “b” simultaneously

And also can get the dual band by rotating the ring structure at angle of 45 degree.

Secondly,[2] we can create the arrays of these structure and will be able to get more improved results in terms of overall antenna results as well as the reduction of the RCS is possible.

We can create array structures of 7 by 7 ,11 by 11 and 15 by 15 and so on as per our requirements. As creating larger array we are able to get the more improved gain and directivity of an antenna and will also reduce the radar cross section values.

Here is the array structure with combined an antenna,

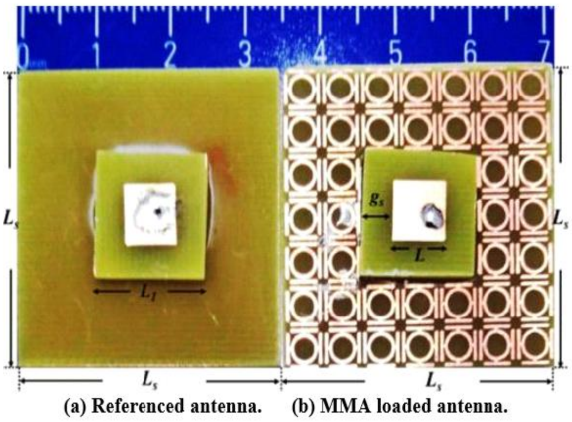


Fig. 3: Referenced and Metamaterial loaded antenna

Where the height of a rectangular MSA is slightly more than the substrate height of MMA, but one can put RMSA at the same height as well and also get good reliable results.

The RCS for the 7 by 7, 11 by 11 and 15 by 15 array structure significantly reduces from 7 by 7 to 15 by 15 array structures.

[1][2] we can also create the array antennas as given in the diagram. it has been given that when the Patch antenna surrounded by MMA structure, it immensely reduces the RCS effect on the system

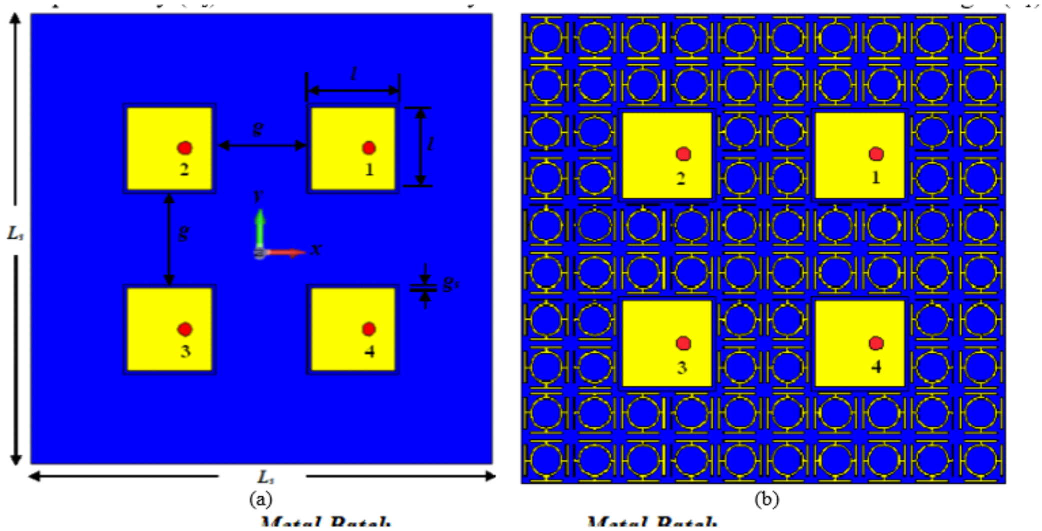


Fig. 4: 2 by 2 array implementation for antenna

without compromising with the performance of the antenna.[5] Thus, one can minimize the structural mode RCS as low as possible and hence emerged as a new design technique.

In this given article[6],they have taken simple slotted hexagonal and square patch on the dielectric of FR-4 of 5.5 mm for single frequency. And the structure as given in the figure.

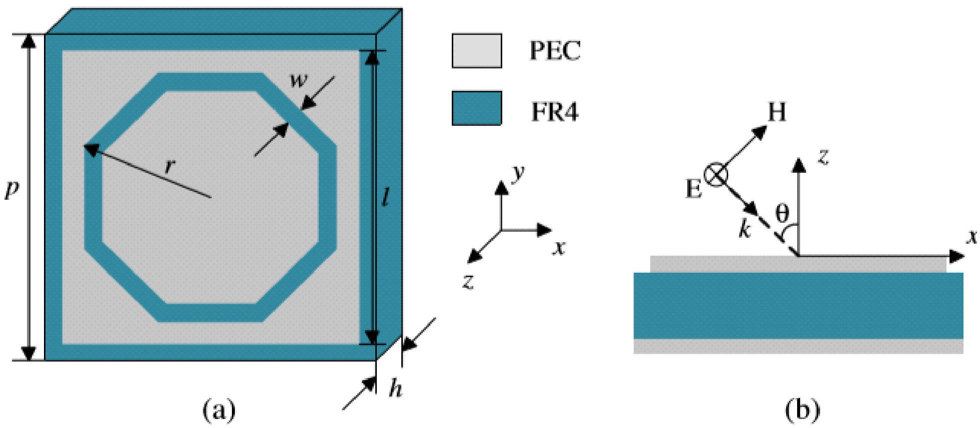


Fig. 5: unit cell of MMA structure

We can combine MMA array with simple rectangular microstrip antenna, and one can get the better reflectance as well as increase the performance of antenna. The antenna is designed at the frequency of the 9.15 GHz,also Metamaterial unit cell is at the same frequency. by using the metamaterial antenna’s radar cross section is reduced efficiently with good amount of absorbate. its radiation pattern get unaffected.

Rectangular resonator ring is also very popular for designing MMA structures. In this given design they have proposed the rectangular resonator, which is consist of one rectangular ring and one square box inside it with dielectric unit cell of 6 mm by 6 mm and connected both the boxes with very thin strip line structure and that generates the broadband for x- band frequencies.

Absorber	Parameters (in mm)						
	L_s	W_s	t	G_1	G_2	L_a	W_c
Dual band	6	6	0.8	0.5	0.6	0.3	0.3
Broadband	6	6	1.6	0.65	0.6	0.3	0.8

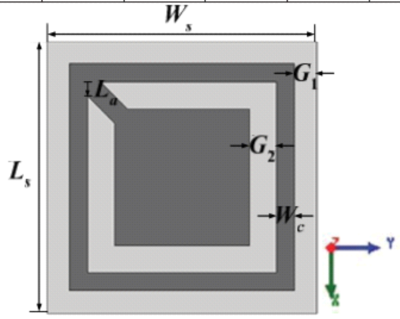


Fig. 1. Top view of the proposed absorber unit cell.

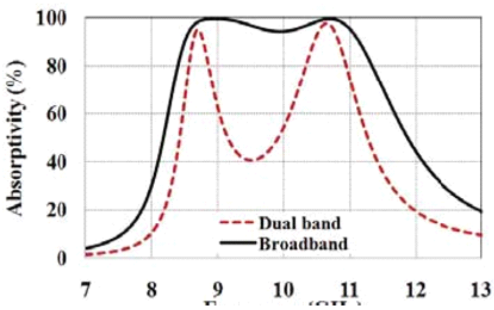


Fig. 6: rectangular ring resonator

By varying the values of gaps between two box structure and dielectric, thickness also possible to generate the dual band MMA with good percentage of absorbance. This structure isn't given with the antenna but will help to understand the broadband using different types of resonating structure, so took it for the idea of broadband structure. In this article[8], they have considered same concept of combination of MMA array structure with conventional microstripantenna, which is given for multiband here. Considered unit cell of 5.7 mm by 5.7 mm and created spiral structure on it.

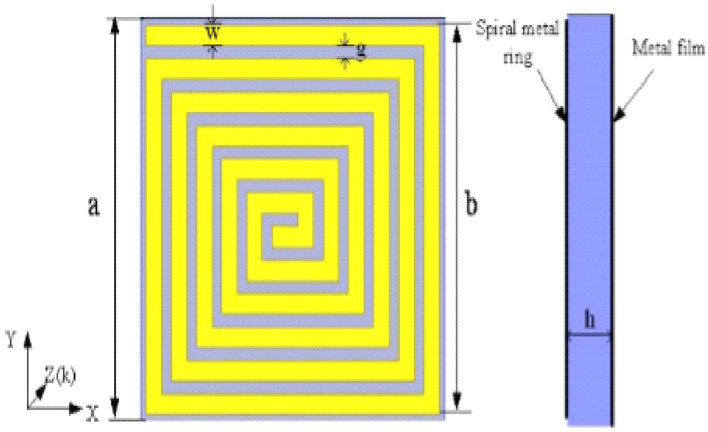


Fig. 7: unit cell structure of MMA

by varying the width and gap of the formed copper as spiral and getting the different frequencies like 5GHz, 6.1GHz, 7.5GHz, 9.1GHz and 10.9GHz by the normal plane wave incidence with the rates of absorption respectively reach 99.2%, 95.3%, 97.8%, 98.6%, 96.3%.

After that they have combined these MMA array structure with normal Rectangular MSA will not affecting the radiation pattern of antenna and the radar cross section is significantly reduces.

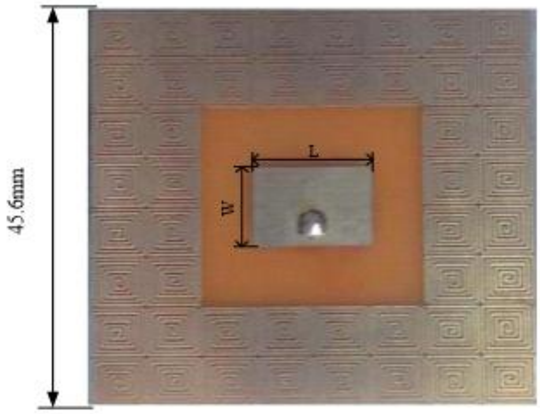


Fig.8: RSMA with MMA structure

So, we can compare all these three rectangular microstrip antenna using metamaterial absorber;

Comparative Analyses

Structure	Resonance Frequencies	Possible Frequency Band	Advantages
Shorted stub ring resonator	Multiple frequencies as per requirement,	Single band and dual band	By varying length of shorted stub one can easily get multiple resonance frequencies as per application. Also help to increase the gain by using a greater number of arrays. Not affecting radiation pattern and increase directivity. Reduces RCS efficiently.
Rectangular ring resonator	Multiple frequencies as from 8 to 12 GHz	Dual band, broad band	Covering Broad band, useful as absorber material. Reduces RCS up to 80 to 98-99% for broad band frequency.
Hexagonal slotted type structure	9.15GHz	Single band	Increases gain of antenna by using as absorber. Not affecting radiation patterns. Reduces RCS significantly.
Spiral resonator	5GHz, 6.1GHz, 7.5GHz, 9.1GHz and 10.9GHz	Single band	5GHz, 6.1GHz, 7.5GHz, 9.1GHz and 10.9GHz by the normal plane wave incidence with the rates of absorption respectively reach 99.2%, 95.3%, 97.8%, 98.6%, 96.3%. Provides Efficient gain and not affecting radiation pattern of an antenna. Reduces RCS effectively.

Conclusion

A single patch antenna design has some limitations and suffers from fringing effects that result in low radiation performance such as narrow bandwidth, lower directivity, gain, radiation efficiency and less power handling capability. Therefore, it cannot be suitable for long-distance communication, especially for military applications. One of the vital solutions is to combine a few antennas to form a patch array. It has been observed that its overall radiation performance enhances and thus, it could compensate for radiation losses after loading it with MMA structure and this is left for future research work. This structure finds its applications in stealth technology for military planes, space aircraft, missiles, ships, and other sensitive vehicles for long distance wireless communication.

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References

1. RCS Reduction of Patch Array Using Shorted Stubs Metamaterial Absorber by Dhawan Singh and Viranjay M. Srivastava Department of Electronic Engineering, Howard College, University of KwaZulu-Natal, Durban - 4041, South Africa.
2. Comparative Analyses For Rcs Of 10 Ghz Patch Antenna Using Shorted Stubs Metamaterial Absorber By Dhawan Singh*, Viranjay M. Srivastava .Department Of Electronic Engineering, Howard College, University Of Kwazulu-Natal, Durban - 4041, South Africa.
3. Singh, D., & Srivastava, V. M. (2018). Dual resonances shorted stub circular rings metamaterial absorber. AUE-International Journal of Electronics and Communication, 83, 58–66.
4. Design Implementation of Concentric Loops with Stubs Metamaterial Absorber by Dhawan Singh1 · Viranjay M. Srivastava1.s
5. Singh, D., & Srivastava, V. M. (2018). Low radar cross section of patch antenna using shorted stubs metamaterial absorber. International Journal of Microwave and Optical Technology (IJMOT), 13(3), 194–202.
6. RCS Reduction for Patch Antenna Based on Metamaterial Absorber by Zi-Xiao Zhang and Jun-Chao Zhang AVIC The First Aircraft Institute, Xi'an 710089, China. Progress In Electromagnetic Research Symposium (PIERS), Shanghai.
7. X-band Metamaterial Absorber with Dual band/Broadband Absorption Characteristics by Mayank Agarwal and Manoj Kumar Meshram Department of Electronics Engineering Indian Institute of Technology (BHU), Varanasi Varanasi, INDIA. 2015 IEEE International Microwave and RF Conference (IMaRC).
8. The RCS reduction of microstrip antenna design based on multi-band metamaterial absorber Wenhui Li, Shen Yang, Jieqiu Zhang, Sui sai, Hangying Yuan and Shaobo Qu College of Science, Air Force Engineering University Xi'an Shannxi Province 710051, China.

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