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Designing of RMPA of Double Band Antenna by Modified "Interconnected SRR" Metamaterial Structure

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Abstract

A dual band structured antenna is designed after implementing "split rectangular" shaped MTM structure on a normal patch. Initially designed antenna was operating on the frequency of 3GHz but for the application requirement metamaterial was implemented. This implemented structure not only diminished the measure of antenna but also converted it into double band antenna. Modified antenna is able to work at 2.72GHz and 2.27GHz.

Keywords: *Metamaterial, Double band, Split rectangular, Microstrip Patch, Wireless communications.*

INTRODUCTION

Nowadays, numerous application requirements are developing an interest to improve antenna parameters. By virtue of that research in this field is growing with the demands of microwave and WCS. MPA is very applicable at numerous fields like medical application, telecommunication system, Satellite and military. And for these motives, the sources for wireless applications must be smaller and lighter. However, besides its significant and numerous advantages MPA has their drawback such as narrowband, typically half space radiation [1]. Many types of size reduction techniques, like using of MTM [3], feed length variation [2], DGS [4] at the ground plane or any combination of them have been proposed and applied to MPA.

MPA converts the electromagnetic waved into the electrical signal at the time of receiving and do vice versa at the time of transmission of the signal. EMT MTM can be defined as artificial effective homogeneous EMT materials with uncommon features that are not willingly found in nature [5-6] Negative Media that display negative ε and μ. This marvel can be depicted by the negative refraction index which is otherwise called in reverse wave.

DESIGNING AND SIMULATION OF PA & IMPLEMENTATION OF METAMATERIAL

A new patch antenna has been proposed for the resonating frequency of 3GHz. Parameters were calculated by formulas listed below,

Desired Parametric Analysis [8]:

Calculation of Width (W):

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{c}{2f_r}\sqrt{\frac{\ }{\varepsilon_r}} \quad (1)$$

Where,

c = velocity of light in free space,

ε_r = Substrate's Dielectric constant

Effective dielectric constant will be calculated by**:**

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\Bigg(\frac{1}{\sqrt{1+\frac{12}{w}}} \quad (2)$$

Actual length of the Patch (L)

$$L = L_{eff} - 2\Delta L \quad (3)$$

Where,

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon}} \quad (4)$$

LengthExtension will be calculated by

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (5)$$

And then antenna was designed in CST simulation software and the simulation results were analyzed. Designed antenna is shown in figure 1 and then in corresponding figure 2 simulation results showing radiation pattern is presented of the antenna designed at 3GHz.

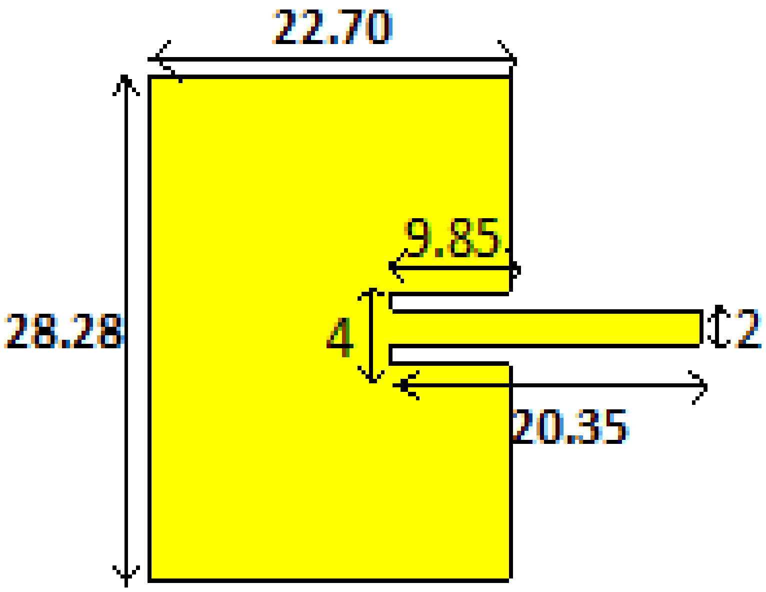

Fig: 1. *Designed antenna at 3GHz frequency (all dimensions are in mm).*

Antenna shown in listed figure 1 is to be designed and simulated in microwave studio tool of CST simulating software. Simulated result of this designed antenna is shown in figure below showing return loss of -34dB.

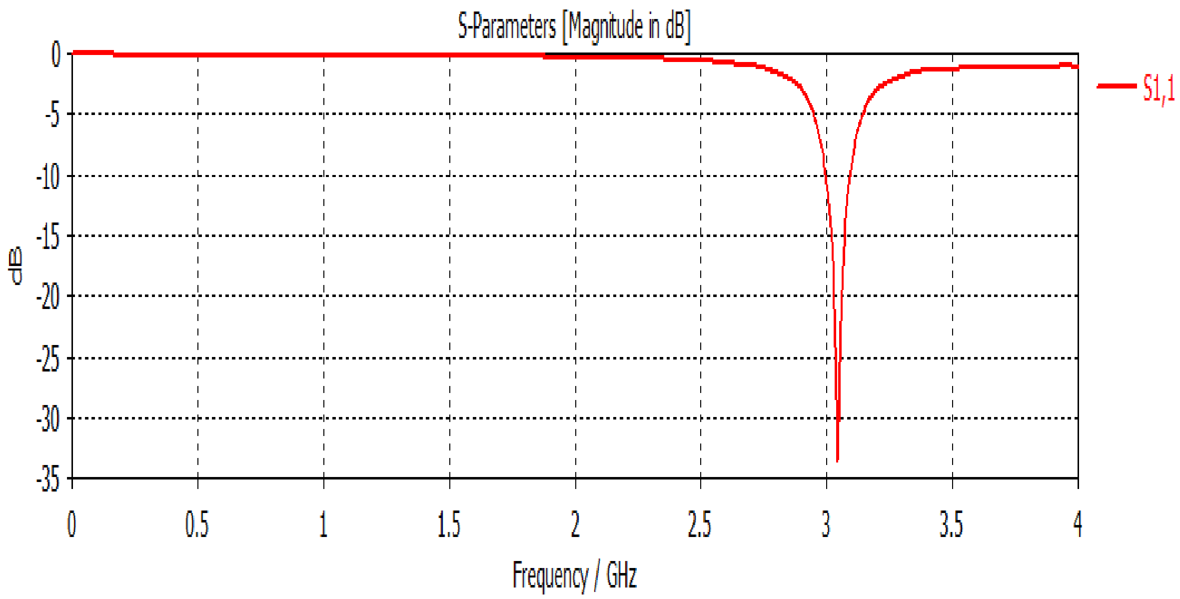

Fig: 2. *Simulated result of PA showing return loss of -34dB at 3GHz.*

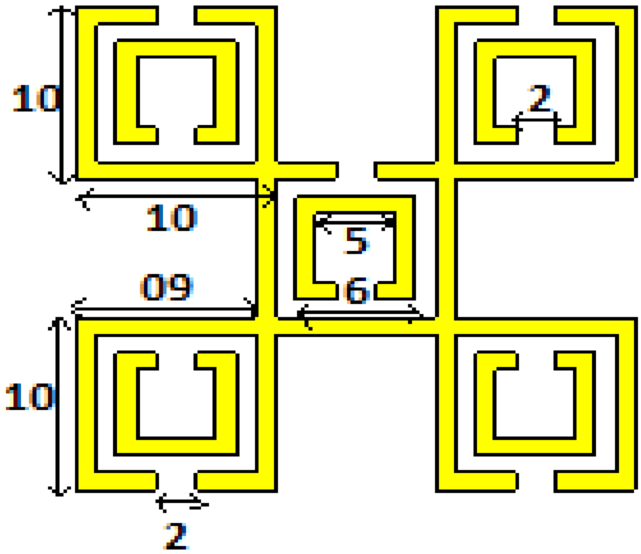

Fig: 3. *Implemented metamaterial structure.*

Designed was reenacted and its outcome was introduced in figure 2. Reproduced result indicates return loss of -34dB. These parameters are not up to the mark, therefore parameter improvement is desirable. To fulfill demand MTM cover was implemented; MTM structure in figure 3 and following figure shows its simulated results. In this proposed design, split rectangular rings are used in the structure and this was used to modify the antenna parameters; this structure improves the antenna performance by increasing the band and improving the BW along with that size of antenna also reduced.

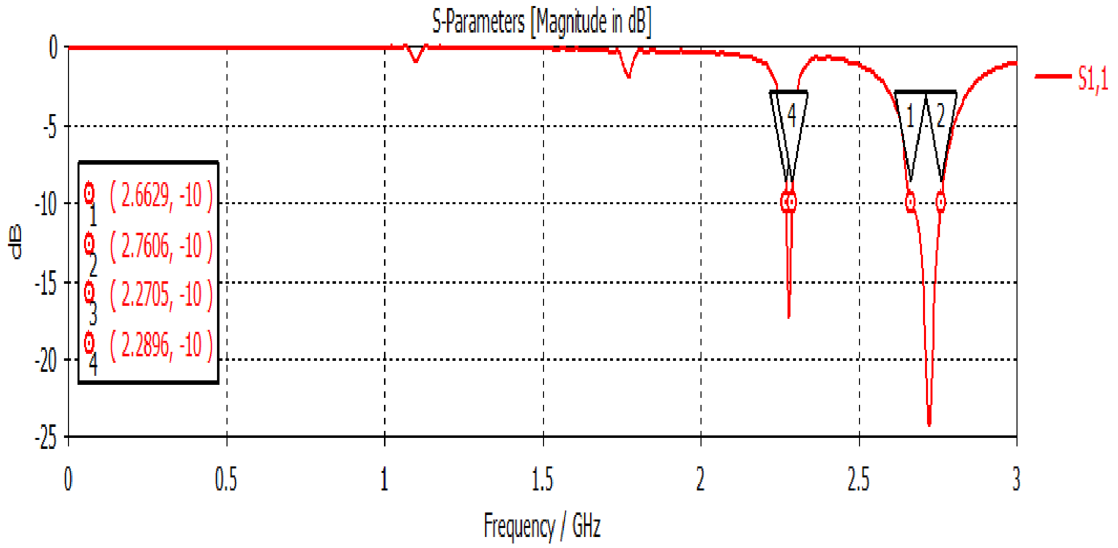

Fig: 4. *This is the simulated result of design proposed above patchin figure 3, dip at 2.72 GHz shows return loss of -24dB and at 2.2GHz its -17dB.*

After the comparison, it has been seen that the offered MTM structure modified the parameters up to a great extent [9], the proposed MTM method improves antenna by converting it into double band and reducing the size of an antenna.

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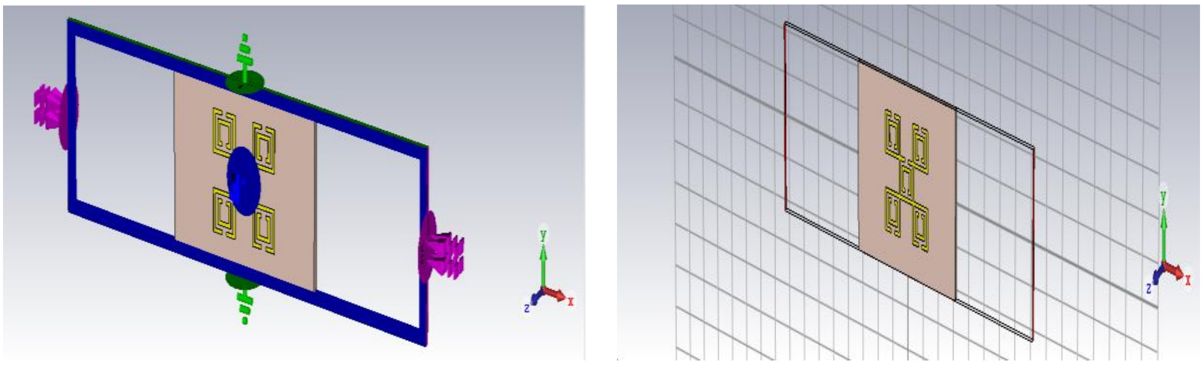

Fig: 5. *Metamaterial Placed under boundary conditions with applied waveguide ports*

Two (WG) waveguide ports and boundaries were plot at the left and right of the X-Axis as shown in above figure 5, in order to calculate the Sll& S21 [7] parameters.The obtained S-parameters are exported to MS Excel Software for finding the value of the μ_r, ε_r of the proposed MTM structure, using the NRW approach and get permittivity vs frequency graph is shown in figure 6 and permeability vs frequency graph as shown in figure 7 and obtained values of permittivity and permeability at the operating frequency as shown in table 1 and table 2 respectively. [9][10].

Following formulas were used in proving NRW approach

$$\mu_r = \frac{2.c(1-v2)}{\omega.d.i(1+v2)} \quad (6)$$

$$\varepsilon_r = \mu_r + \frac{2.S11.c.i}{\omega.d} \quad (7)$$

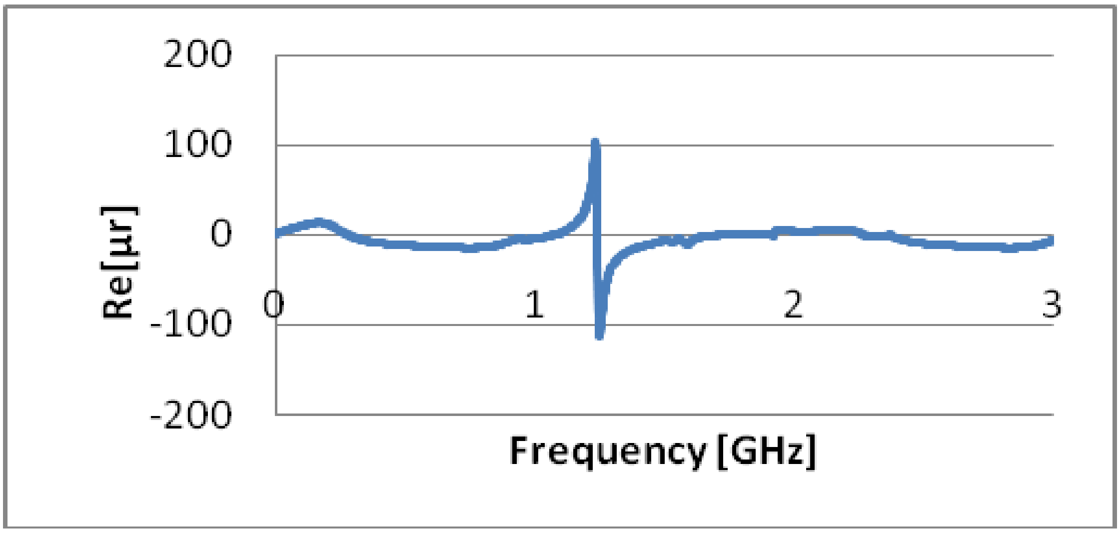

Fig: 6. *Permeability Vs Frequency Graph*

Table: 1. *Value of Permeability at operating frequency*

Frequency [GHz]	Permeability[μr]	Re[μr]
2.7149997	-13.4807588349571-45.6053494800867i	-13.48075883
2.7179997	-13.5210869110121-45.5406888730578i	-13.52108691
2.721	-13.5614553291899-45.476956861581i	-13.56145533
2.724	-13.6018300604846-	-13.60183006

	45.4140273435829i	
2.727	-13.6421808787615-45.3517764117093i	-13.64218088

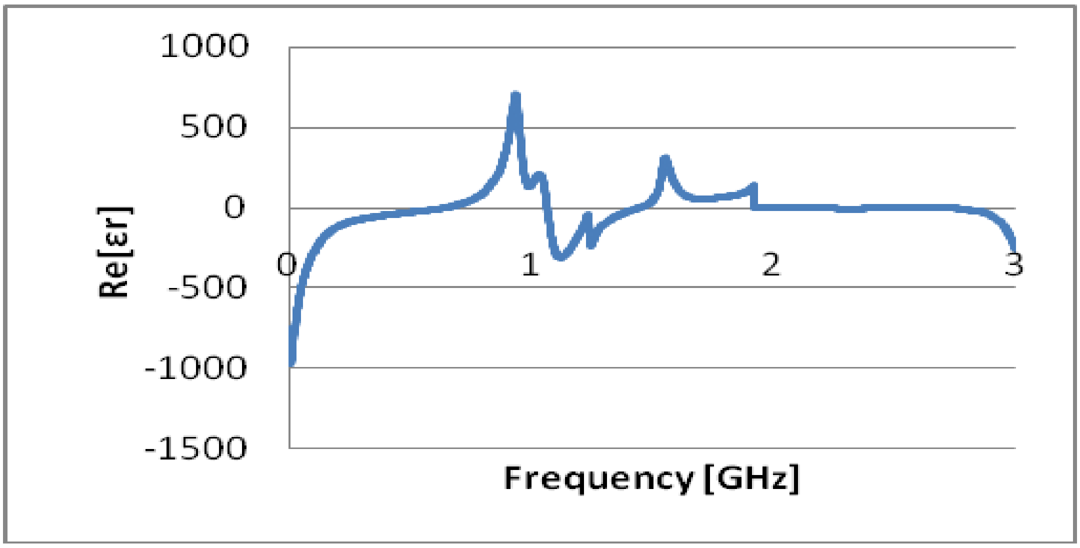

***Fig: 7.** Permittivity Vs Frequency Graph*

***Table: 2.** Value of Permittivity at operating frequency*

Frequency [GHz]	Permittivity[εr]	Re[εr]
2.7149997	-1.57370052988531-17.8321650869078i	-1.57370053
2.7179997	-1.71335017967309-18.8315011899137i	-1.71335018
2.721	-1.86160914852152-19.8782153878762i	-1.861609149
2.724	-2.01911399362449-20.9757744355629i	-2.019113994
2.727	-2.18667211931569-22.1280489872831i	-2.186672119

RESULT

By observing the reproduced results appeared in fig. 2 (simulated result of PA before DGS implementation) & in listed fig. 4 & 5 (recreated result in the wake of consolidating DGS) that there is significant improvement by achieving in size reduction, return loss, gain, Bandwidth as shown in figure 8. Efficiency is merely gets affected. Dimension comparison after and before metamaterial implementation is shown in table.

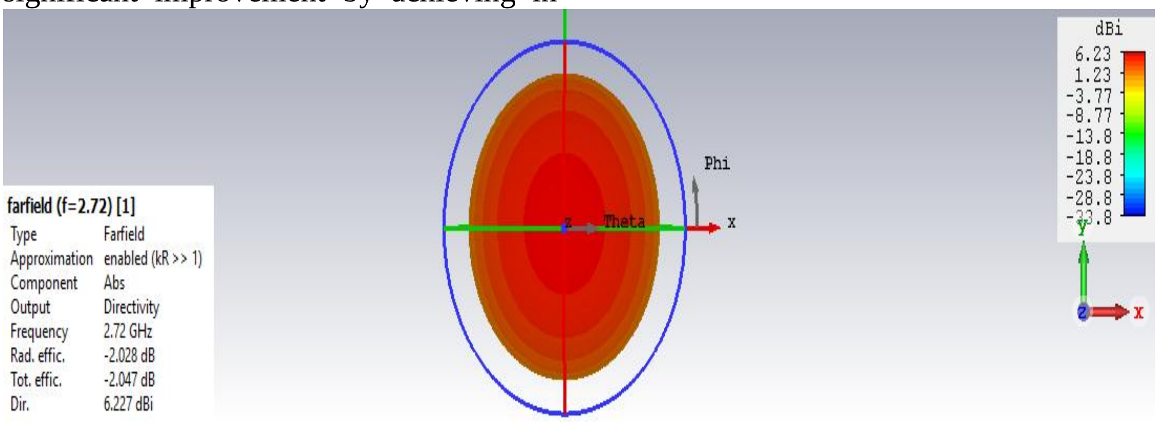

***Fig: 8.** This is the simulated result of design in figure 3, showing radiation pattern with efficiency and gain of 6.227dBi.*

Table: 3. *Comparison Chart (all dimensions are in mm)*

S. no.	**Parameters**	**Dimensions of Patch at operating frequency**	**Reduced dimension of patch**
1	Length of patch	26.20	22.70
2	Width of patch	33.87	28.28
3	Cut length	10	9.85
4	Cut width	6	4
5	Feed length	26.73	20.35

Table: 4. *Comparison chart of parameters is shown below in table.4*

SNO.	PARAMETERS	RMP ANTENNA AT 3	RMPA WITH MTM AT 2.2 and 2.72
1.	Return Loss	-34dB	-17dB, -24dB
2.	Directivity	5.672dBi	5.814dBi, 6.227dBi
3.	Radiation Efficiency	-3.726dB	-3.726dB, -2.028dB
4.	Gain	3.174dB	3.8dB, 4.199dB
5.	Bandwidth	68MHz	88MHz, 95MHz

CONCLUSION

Metamaterial implementation not only reduced the size of the antenna but also converted it into double band. BW of the antenna was also increased. Modified antenna is operating at the two different frequencies by applying single operating frequency. Antenna is radiating at 2.22 and 2.72GHz with the maximum return loss of -24dB and bandwidth of 95MHz. Metamaterial structure was also proved by using NRW approach and satisfied DNG property.

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