DEVELOPMENT OF MULTIBAND ANTENNA USING METAMATERIAL

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Abstract
In this paper the design of a multiband antenna by using a metamaterial structure is presented. Proposed antenna could operate in three different frequencies that are (1.941, 2.586 & 2.784) GHz. simulated results present here shows that the minimum return loss achieved is -22.4dB and maximum is -29.1dB on 2.786 and 1.941GHz respectively. The proposed antenna implemented on substrate called FR4 lossy with dielectric constant 4.3 and height 1.6mm. The designing and simulation work has been done on the CST-MWS software. To operate three different frequencies three antennas required, but by using a single cover of metamaterial the number of antennas reduced to one. i. e. instead of three a single antenna with incorporated metamaterial will be sufficient to operate on all three different frequencies.

Keyword: Negative Media (Metamaterial), Rectangular microstrip patch antenna (RMPA), return loss, multiband, directivity.

I. INTRODUCTION

Microstrip patch antenna design has become one of the greatest extent fields in the communication studies. In previous years when radio frequency was invented, not very high technique or compound design was used as atransducer to convert electrical energy intoelectromagnetic wave through the air in all direction. Feeler is significant elements in the RF system to receive or transmit the radio waves from and to the air. Rectangular microstrip patch antenna is one of the significant types of wireless antenna. The microstrip antenna has been the most innovative area in the antenna engineering, which is because of its low material cost (PCB) and its easiness of fabrication which the process can be made inside institutes. Wireless communications has been exponentially increasing in the cellular telephony, wireless Internet, and wireless home network. The wireless networks also include wireless local area networks (WLAN). The standard group for wireless LAN in IEEE is IEEE 802.11.In this letter, design and simulation of RMPA alone at 2GHZ has been elaborated, thereafter modification of that RMPA into a distinguishedtriple band microstrip antenna for wireless communication applications, which will able to deliver power in 1.941, 2.586 & 2.784GHz. This significant transition shows that a single patch antenna with an implementation of negative media at the height of 3.276mm will be able to generate power in 3 different frequencies while driving by a single supply of operating frequency 2 GHz.

Initially V. G. Veselago presented theory about the negative media or metamaterial in late 60's. veselago defined metamaterial as a material which physically not existed in social media but this artificial material produces a negative index of refraction. The theory presented by veselago later used in many studies, one of them is microstrip patch antenna. In 21st century J. B. Pendry proposed split ring resonator concept, which was a typical design of metamaterial in antenna designing. This split ring concept enhanced the antenna parameter such as bandwidth, return loss, directivity etc. Metamaterial also exhibit negative permittivity (ε) and permeability (μ) which gives it another name of negative media. In this letter its negative media property is used to prove the material used here to improve the parameters of RMPA is metamaterial.

I. DESIGN SECTION

All the designing and simulation technique is used to prepare this letter has been done on the computer simulation technology microwave studio (CST-MWS). The proving of material which modifies the single band antenna into triple band antenna has been processed in MS Excel software. Microsoft paint software was used to show the dimension in patch and metamaterial design.First of all dimension of patch antenna was calculated from formulas given below for the operating frequency of 2 GHz. Substrate used was FR4 lossy which has dielectric constant of 4.3 and height 1.6mm.

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

$$L = Leff - 2\Delta L \quad .... (2)$$

Where,

$$Leff = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}} \quad .... (3)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \quad .... (4)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right) \quad .... (5)$$

In above used formulas the symbols have their usual meanings.
e.g.
c = Velocity of light in free space,
ε_r = Substrate's Dielectric constant,
ε_{eff} = Effective dielectric constant,
L= Actual length of the patch,
W= Width of the patch.

After calculation of dimensions, rectangular microstrip patch antenna was designed on previously indicated software. Length and width of the proposed RMPA were calculated by using above listed formulas, and the designed RMPA is shown in figure 1. The simulated result of the patch in figure 1 is shown I n figure 2 which show the comparative graph of return loss in dB and frequency in GHz. Simulated result of patch at 2 GHz shows return loss of -10.11dB and bandwidth of 9.4MHz.

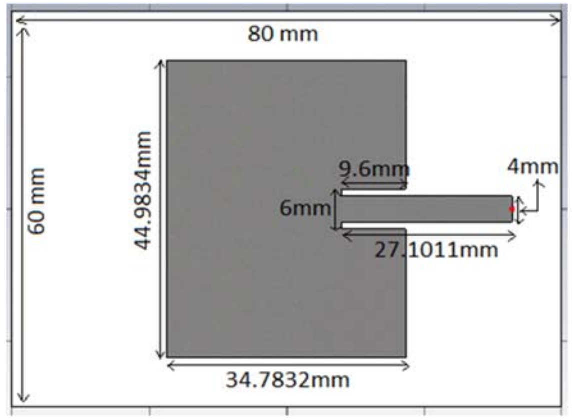


Figure 1: *RMPA at 2 GHz.*

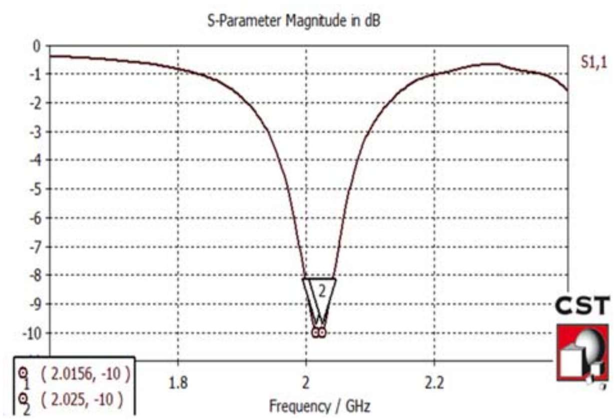


Figure 2: *Simulated result of RMPA shown in figure 1*

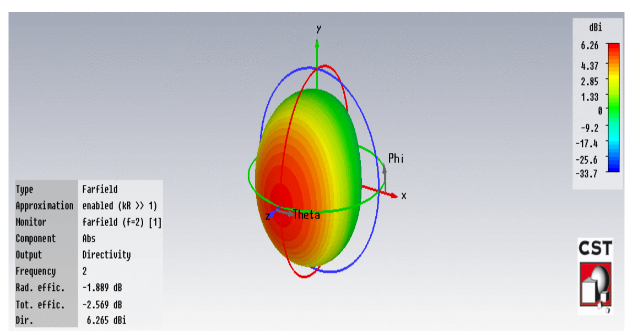


Figure 3:*Simulated result of RMPA showing directivity of 6.265dBi and efficiency of 55.3% with radiation pattern of respected patch.*

After patch analysis it comes out that the RMPA is not showing good enough result to use at a standard level, therefore metamaterial cover was implemented over patch shown in figure 1. This metamaterial implementation modifies the antenna parameters to a great extent. e.g. single band antenna converted into triple band antenna, bandwidth of all three dips also increased than the bandwidth of RMPA alone, efficiency also increased than later. The negative media design which modifies the patch parameter is shown in figure 4 and simulated results of the respected design for all three operating frequency are shown sequentially in figure 4, 5, 6, 7 and 8.

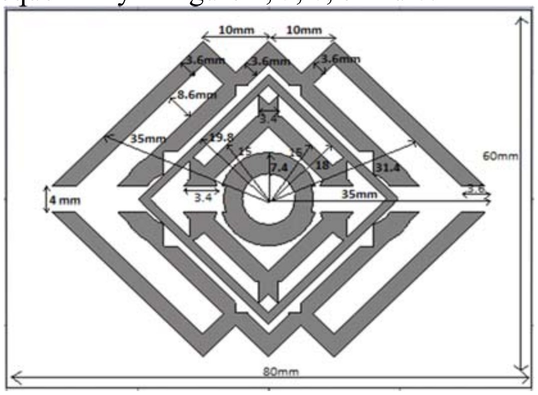


Figure 4: *Proposed metamaterial design at the height of 3.2mm from ground.*

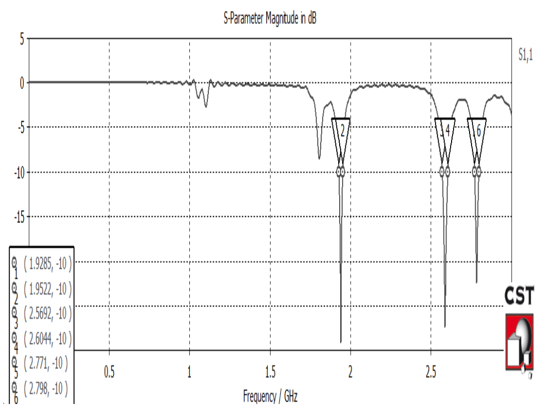


Figure 5: *This is the simulated result of design in figure 4, showing 3 dips at 1.941, 2.586 & 2.784. The value of return loss and bandwidth was introduced before.*

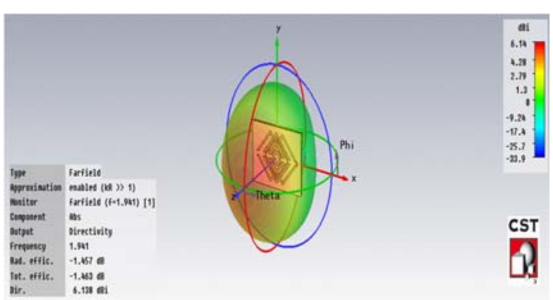


Figure 6: *Radiation pattern at frequency 1.941 GHz having directivity 6.138dbi and efficiency 71.4%.*

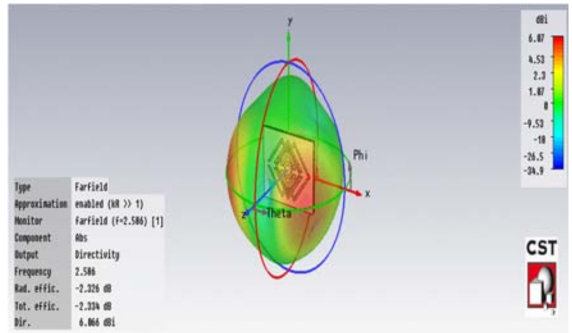


Figure 7: *Radiation pattern at frequency 2.586 GHz having directivity 6.066dbi and efficiency 58.4%.*

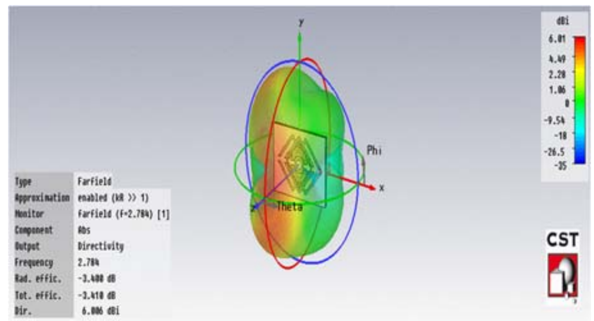


Figure 8: *Radiation pattern at frequency 2.784 GHz having directivity 6.006dbi and efficiency 45.6%.*

It has been observed by comparing these results with simulated result of RMPA alone that there is dramatic increment in return loss, bandwidth, andefficiency. Directivity remains unaffected with slight variation, which is bearable. Comparative chart is shown below in table 1.

Table 1: *Comparison chart.*

s. no.	Parameters	RMPA alone at 2 GHz	After metamaterial introduction at 1.941GHz	at 2.586 GHz	at 2.784 GHz
1	Return loss	-10.11dB	-29.1dB	-27.3dB	-22.4dB
2	Band width	9.4MHz	23.7MHz	35.2 MHz	27MHz
3	Directivity	6.265dBi	6.138dBi	6.066 dBi	6.006 dBi
4	Efficiency	55.3 %	71.4%	58.4 %	45.6 %

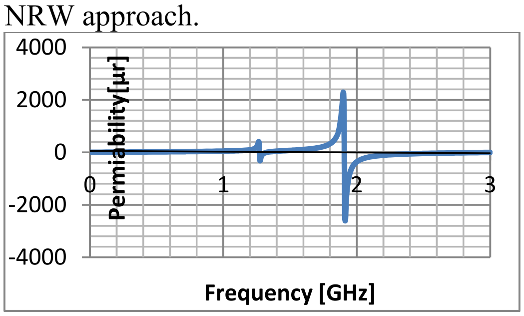
After the comparison it has been observed that there were many modifications occur by implementing a metallic design cover over the patch antenna. Now it had to be prove that weather it was metamaterial or not. For that purpose Nicolson ross weir (NRW) approach was used. In that approach structured design placed between two waveguide ports on X-axis in respect to calculate S11 and S21. Y and Z plane were defined as perfect electric and magnetic boundary respectively. After arrangement, wave excited from left to right to get S parameters. Later these S parameters were imported into the Microsoft excel software for further calculation. In Microsoft excel below formulas were used to get negative permittivity and permeability. These below formulas belong to NRW approach.

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

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

Where,
V_2 = S21 - S11
ω = Frequency in Radian,
d = Thickness of the Substrate,
c = Speed of Light,
V_2 = Voltage Minima.
μ_r = Relative permeability
$\mathcal{E}_r$ = Relative permittivity

In below figures graph of negative permittivity and permeability are shown, which are result of NRW approach.



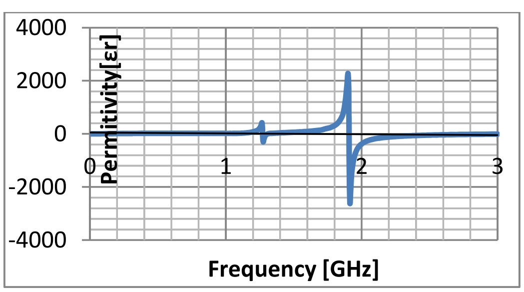


Figure 9: (a) Negative value of permeability at operating frequencies. (b) Negative value of permittivity at operating frequencies.

II. CONCLUSION

The designed antenna could be used in wireless communication for L band and even for S band.By applying frequency of 2 GHz it will be able to operate power in three different frequencies with low return loss, large bandwidth and more efficiently. This proposed design by authors can reduced the number of antennas required, because a single antenna can work in place of three distinguished antennas. It also been proved that the cover used to enhance the antenna parameter is metamaterial by using NRW approach.

III. REFERENCES

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