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MINIATURIZATION OF MICROSTRIP PATCHANTENNA USING INTERCONNECTED HEXAGONAL RINGS OFDOUBLE NEGATIVE MATERIAL STRUCTURE

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ABSTRACT

In the aeon of nanotechnology, size isconcern. Proposed, the design is focused on miniaturized the size of micropatch patch antenna. In this design, firstly design a microstrip patch antenna at resonating frequency 3.304 GHz. After that, the antenna design with the planned “Interconnected hexagonal rings” of double negative material structure, due to this cover of double negative material structure the antenna is start resonating at frequency 2.088 GHz.. For designing an antenna at resonating frequency 2.088 GHz is required more space than the design . The resonating frequency decreases when the size of antenna is increased. The purpose of this design, the size of antenna is constant and still managed to decrease the resonant frequency. In the design, the micropatch patch antenna (MPA) is incorporated with the double negative material cover which has some special properties so the antenna is miniaturized the size 60%, return loss reduces 247%, VSWR improves 41% and radiation efficiency also improves 36% . The purpose of this work is to design a compact, improve its return loss, radiation efficiency and VSWR all simulated results are analyzed by using computer simulation technology microwave studio software(CST-MWS) 2010

KEYWORDS: *Double negative material (DNG), Nicolson-Ross-Weir(NRW), Microstrip Patch Antenna(MPA), Return loss (RL)*

I. INTRODUCTION

Microstrip Pacth Antenna (MPA) is popular antenna due to its low profile, light weighted and easy to fabricate. MPA consist a very thin metallic strip (patch) placed on a dielectric substrate above a ground plane[1].

Double negative material is an artificial materials (not found in nature) which is firstly theoretically introduced by Victor Georgievich Veselago [2] in 1967. Double negative material has unique properties such as negative values of permeability and permittivity [5][8], negative refractive index, backward wave propagation etc. Due to these properties, the double negative material is used to ameliorate the antenna. Double negative material is also used in various applications other than the improvements of antenna parameters.

CST-MWS 2010 Software has been used for all the simulation and designing. CST Microwave Studio is ultimate software to simulate the design, as this software is desirable for a 3D platform in simulating a full wave simulation. After obtaining the S-parameters from the CST software, they were exported to Microsoft Excel for verifying the values of permeability and permittivity by utilizing the Nicolson-Ross-Weir (NRW) Approach. Hence MS Excel Software has been used for verifying the double negative properties of the planned double negative material cover.

II. FORMULATION AND DESIGNING

The MPA parameters are calculated by using these formulae given below [1]:

Effective dielectric constant of the dielectric material

(1)
$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}[1 + 12\frac{h}{W}]^{-1/2}$$

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Calculation of width:

(2)

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Actual length of patch:

(3)

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta L$$

Calculation of extention of length:

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

calculation of VSWR (S):

$$S = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (5)$$

Where,

|Γ|= Reflection coefficient**,** c = velocity of light,εr=Dielectric constant of substrate, fr= Resonating frequency,εreff= Effective dielectric constant, h = Height of substrate,W = Width of patch, L = Length of patch ,ΔL =

Effective Length

The micropatch patch antenna is fabricated on FR4 (lossy) material dielectric constant εr = 4.3 and thickness h = 1.6 mm at 50Ω matching impedance. In the design, the area of ground and the area FR-4 lossy material is same and it is 80 X 80 mm^2. All parameters of MPA at resonating frequency 3.304GHz are shown in figure 1 and all parameters are shown in millimeter (mm).

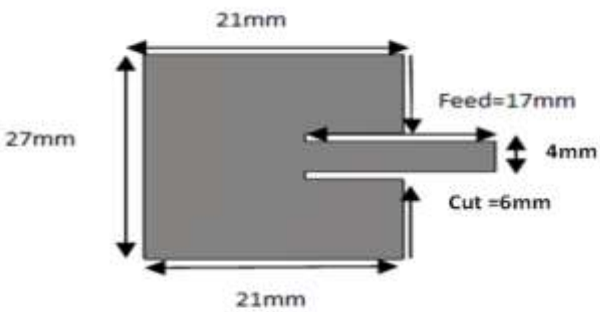

Fig.1 Geometry Microstrip Patch Antenna

The figured MPA is simulated in CST-MWS software at the operating frequency (3.304GHz). The simulation results of return loss and radiation efficiency of antenna is shown in figure 2(a)(b).

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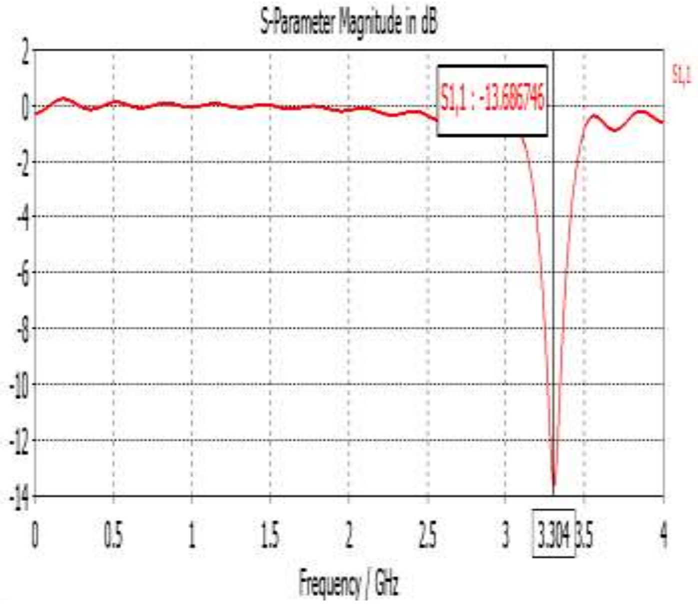

Fig.2(a)

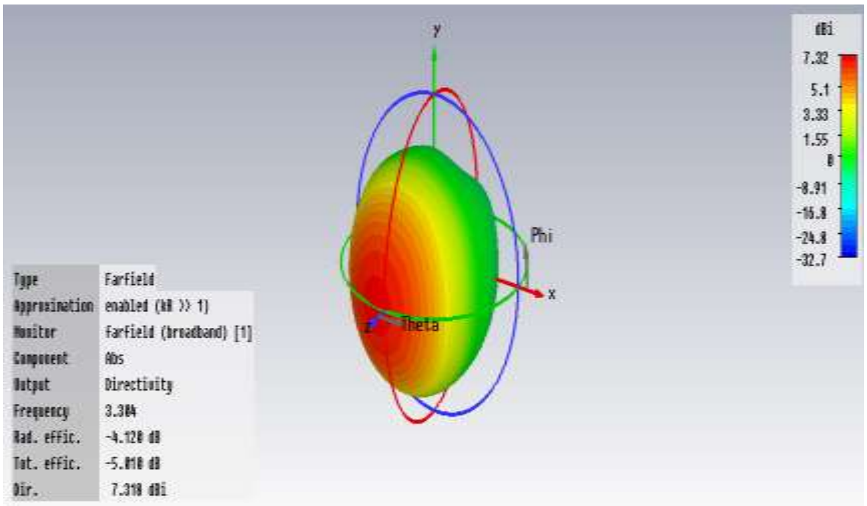

Fig 2(b)

Fig-2 (a)(b) Simulated result of Micropatch patch antenna shows return loss -13.68 dB and radiation efficiency -4.120dB

III. DESIGN AND ANALYSIS OF DOUBLE NEGATIVE MATERIAL STRUCTURE

After designing and analyzing the MPA the proposed "Interconnected hexagonal rings" double negative material structure is designed as shown in below figure 3.

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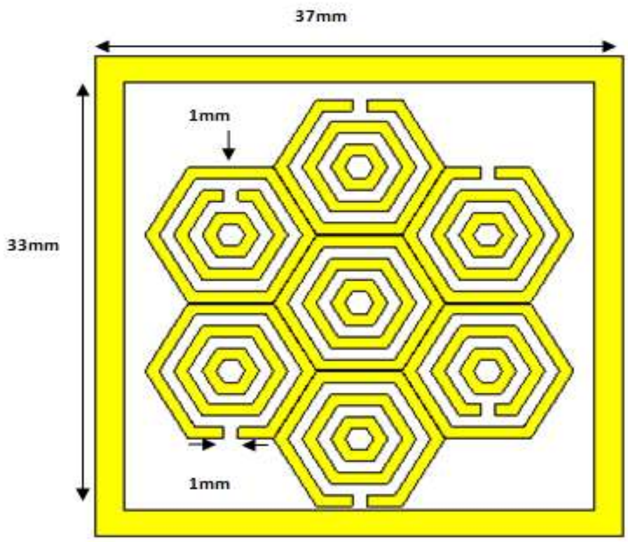

Fig -3: Geometry of simulated Interconnected Hexagonal Rings of double negative material

This structure is then placed between two waveguide ports at left and right side of the X-axis shows in fig.4, for calculating S11 and S21 parameters. The signal is excited such that it travels from left side to right side assuming that structure is surrounded by air. Here Y-plane is defined as PEB (Perfect electric boundary) while z-plane is defined as PMB (Perfect magnetic boundary). Port 1 is defined as negative x-axis while Port 2 is defined as positive x-axis[14].

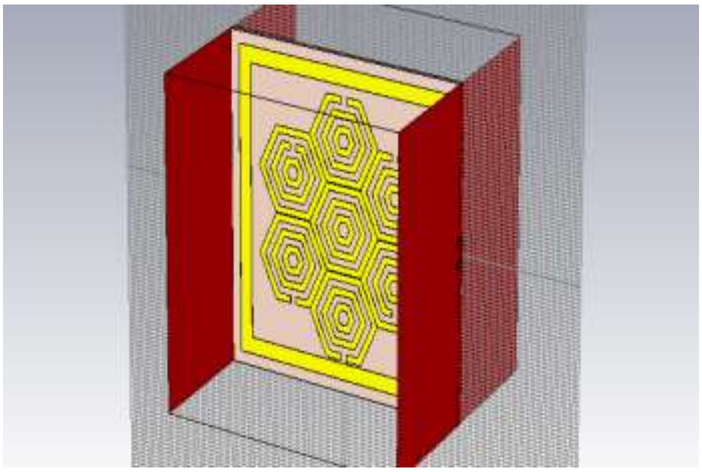

Figure 4:- Double negative material structure placed between the two waveguide ports at the left and right hand side of x axis

The obtained value of S11 and S21 parameters was in complex form, export to MS-Excel program for verifying the double-negative properties of the proposed material cover structure by using NRW approach.
Formulae for determining the value of permittivity & permeability using NRW approach[9][10]

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

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

Where, V2= S21-S11, d = thickness of substrate c = velocity of light, ω = frequency in radian, v2 = voltage minima.

The values of permittivity (ε) and permeability (μ) were calculated by using above equations 5 and 6. Figure 6 and 7 shows that the planned double negative material cover possesses negative values of permittivity & permeability at the same resonating frequency.

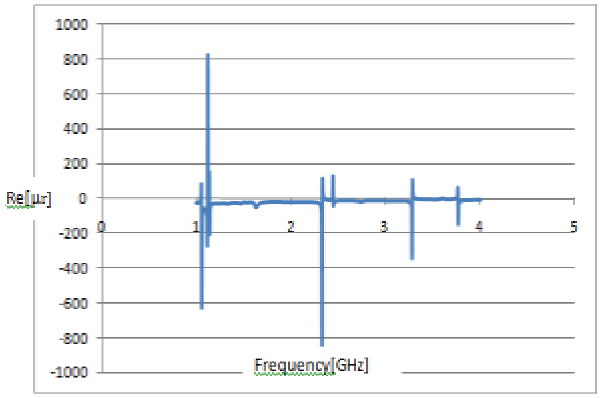

Fig.5 shows permeability versus frequency graph obtained from Microsoft excel software

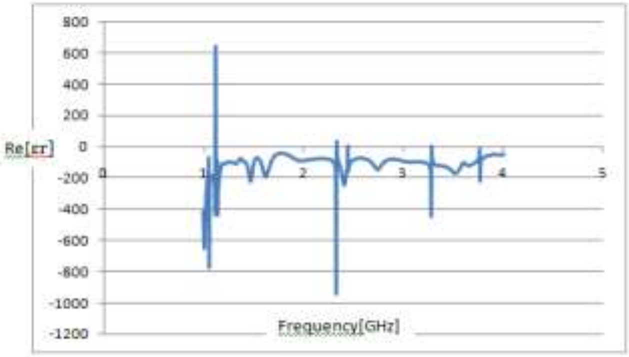

Fig.6 shows permittivity versus frequency graph obtained from Microsoft excel software

NRW (Nicolson Ross Weir) method is used for verifying negative permeability and permittivity by using equation 6 and 7 at the same resonant frequency MPA integrated with "Interconnected hexagonalrings " double negative material structure as shown in fig.7 is simulated using CST software. When the MPA is combined with the "Interconnected Hexagonal Rings" double negative material structure it observed that the resonating frequency is decreased to 2.088 GHz from 3.304 GHz. The resonating frequency decreases when the size of antenna is increased. The purpose of this design, the size of antenna is constant and still managed to decrease the rasonant frequency.

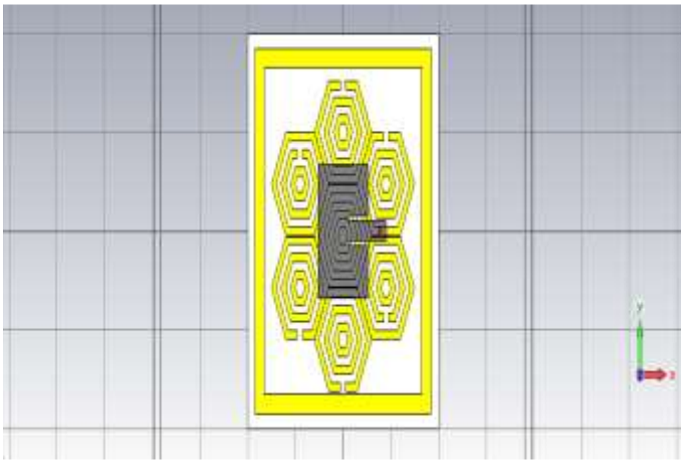

Fig.7Double negative material structure superimposed on micropatch patch antenna

Simulated structure is shown in fig.7. The MPA is combined with the "Interconnected Hexagonal Rings" of double negative material structure it observed that the resonating frequency is decreased to 2.088 GH z from 3.304 GHz.This is because of double negative material structure in other words it can be said that the size of MPA is greatly reduced or that the same antenna can be used at two different frequencies one with double negative material structure one without it. Simulation results of micropatch patch antenna superimposed by double negative material structure. Fig.8 (a)(b) shows return loss of -47.566 dB, radiation efficiency -3.027dB and VSWR 1.008 at frequency of 2.088 GHz.

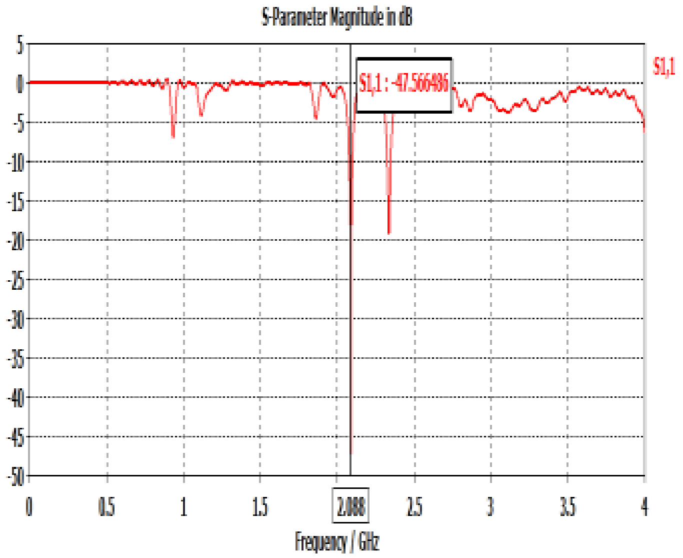

Fig.8(a)

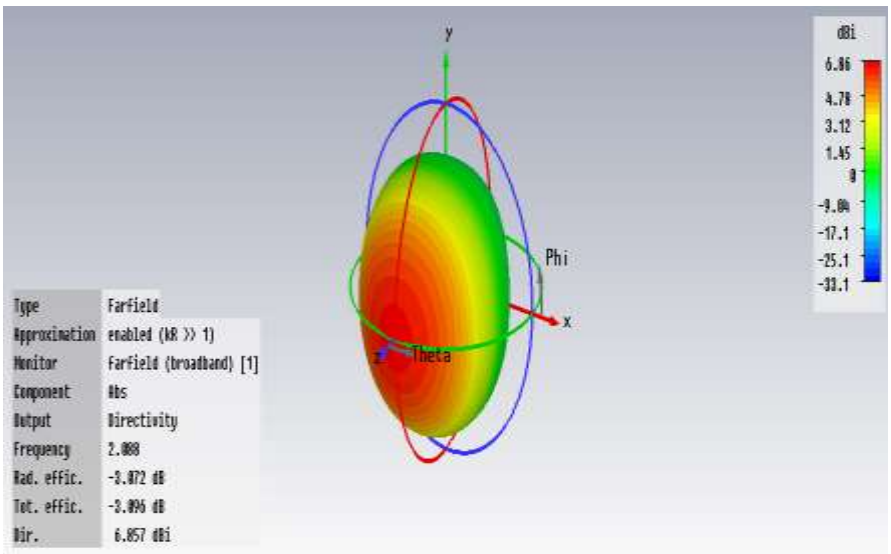

Fig.8(b)

Fig.8 (a) (b) Simulated result of the micropatch patch antenna along withdouble negative material cover

IV. RESULTS

Simulated results of micropatch patch antenna with and without double negative material. Shown in table.1

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Table 1

Parameters	MPA without double negative material	MPA with double negative material	Percentage %
Frequency[GHz] Size reduction	3.304	2.088	60%
Return loss[dB]	-13.686	-47.56	247 %
VSWR	1.521	1.008	41%
Radiation efficiency [dB]	-4.120	-3.072	36%

V. CONCLUSION

The proposed design of double negative material structure superimposed at the height of 3.276 mm from the ground plane of the micropatch patch antenna. Due to its small size , the antenna have many applications in communication system. Along with these improvements this construction is simple, improved antenna can be produced with little effort at low cost. On the basis of the simulation results it is observed that there is reduction in size of the MPA at the frequency of 2.088 GHz, return loss is reduced by 247% , VSWR improved 41% and the size is being reduced to 60% by incorporating the proposed double negative material structure. It is clearly observed that the return loss, size, radiation efficiency and VSWR has improved significantly by incorporating the structure satisfies Double Negative property within the simulated frequency range.

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