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ENHANCED THE PARAMETERS OF COMPACT MICROSTRIP ANTENNA BY USING LEFT HANDED METAMATERIAL (LHM)

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ABSTRACT
This paper is presented as a design of Left-Handed metamaterial which upgrades the performance of a compact microstrip patch antenna (MPA). First of all design the compact microstrip patch antenna, then simulate it with and without metemeterial. The result indicates that the metamatarial based microstrip antenna has enhanced the parameter of compact microstrip antenna. The directivity of antenna is increased from 3.30dBi to 5.52 dBi. The Gain of antenna increased from 2.59dB to 3.71dB. The return Loss improved from -12db to -35.63db. The bandwidth of antenna increased from 82 MHz to 109 MHz.

KEYWORDS: MPA, NRW method, Impedance bandwidth, Gain, Return Loss , Nicoloson -Ross-Wier (NRW)

INTRODUCTION
The Microstrip antenna is a printed type of antenna consisting of a dielectric substrate with relative permittivity ε_r and permeability μ_r (usually $\mu_r = 1$) when sandwiched in between a ground plane and a metallic patch. Microstrip antenna has several advantages as compared to other conventional antenna like a Low fabrication cost, its light weight,low volume and low profile configuration that's why microstrip antenna can be easily mounted on the rockets, missiles and satellite without major modification[2]. Inspite of advantage there are some drawbacks, like narrow bandwidth and low gain. A common technique to overcome these drawback is using array of patch antenna however, this technique has drawbacks which are high feed network losses and produce mutual coupling another method to overcome this disadvantage is by using left handed metamaterial. In this paper, metamaterial is used for enhance the parameters of microstrip patch antenna.

Metamaterials are artificially structured to have properties which are not found in nature. They are built by periodically arranging unit cells and these unit cells are not made of physical atom and molecules but instead, contain small metallic resonator which interact with external electromagnetic wave. Metamaterial is also known as double negative metamaterial because it show negative permittivity ε_r<<<<0, and negative permeability [6]μ_r<<<<0. Metamaterial was first introduced by Victor Vesalago in 1967[1][8] , but as only a theoretical concept. Later in the year of 2001 Dr Smith[2], fabricated a structure with spilt ring resonator and thin wire and its named as LHM[15]. These paper show the improvement of gain and bandwidth by placing metamaterial on the top of patch antenna with air gap

DESIGN SPECIFICATION
Microstrip patch antenna (MPA) are calculated from formulas given below [2][7]

Calculation of width (W):-

$$W=\frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r+1}}=\frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Where
C=free space velocity of light
ε_r=Dielectric constant of substrate

The effective dielectric constant of the microstrip patch antenna

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

2.3 The actual length of the patch(L)

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

Where

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

2.4 calculation of length extension

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

2.5 calculation of VSWR (S)

$$S=\frac{1+|\Gamma|}{1-|\Gamma|} \quad (6)$$

Where

$|\Gamma|$= Reflection coefficient

2.6 Calculation Bandwidth

$$BW=\frac{VSWR-1}{Q\sqrt{VSWR}} \quad (7)$$

The Microstrip patch antenna is designed on FR-4 (lossy) Material of Dielectric constant ε_r=4.4 and height is 1.6mm from ground plane. Design of compact microstrip antenna which is resonate at 2.065 GHz is shown in fig 1 and its parameter specification of microstrip patch antenna are mention in Table 1.

Table 1: Microstrip Patch Antenna Specifications

s.no		Dimensions	Unit
1	Dielectric constant (ε_r)	4.4	
2	Loss Tangent	0.2	
3	Thickness (h)	1.6	Mm
4	Operating frequency	2.065	GHz
5	Length (L)	30.72	Mm
6	Width (W)	22.85	Mm
7	Cut length	3.2	Mm
8	Cut width	8.262	Mm
9	Feed length	2	Mm
10	Feed width	18.412	Mm

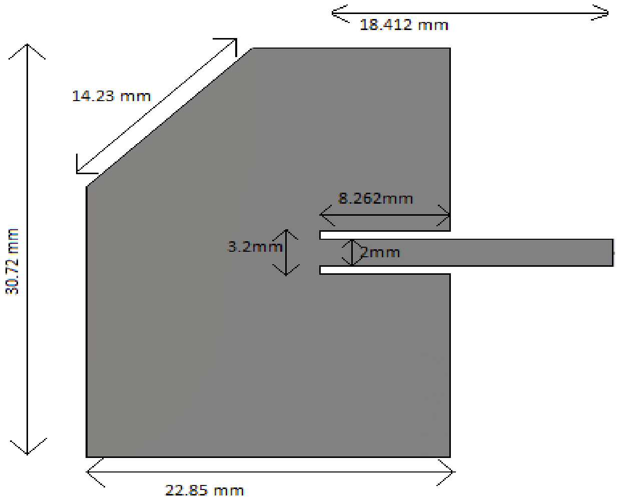

Fig 1. Compact microstrip patch antenna at 2.065GHz

compact microstrip patch antenna shown in fig 1 is simulated in CST-MWS software at resonating frequency of 2.065 GHz and its return loss is shown in fig 2.

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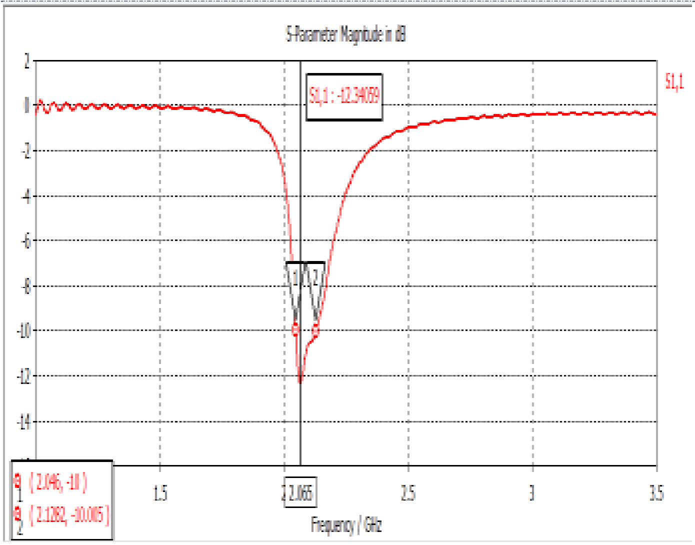

Fig 2. Return Loss (S_{11})

After designing and simulation of compact microstrip antenna next step is to design the metamaterial which improves the performance of the antenna. Design of metamaterial is shown in fig 3. And its specification are shown in table 2.

Table 2: Metamaterial Specifications

s.no		Dimensions	Unit
1	Loss Tangent	0.2	
2	Thickness (h)	1.6	Mm
3	Operating frequency	2.01-2.091	GHz
4	Length (L)	48	Mm
5	Width (W1)	1	Mm
6	Gap	1	Mm
7	Width (W2)	34	Mm

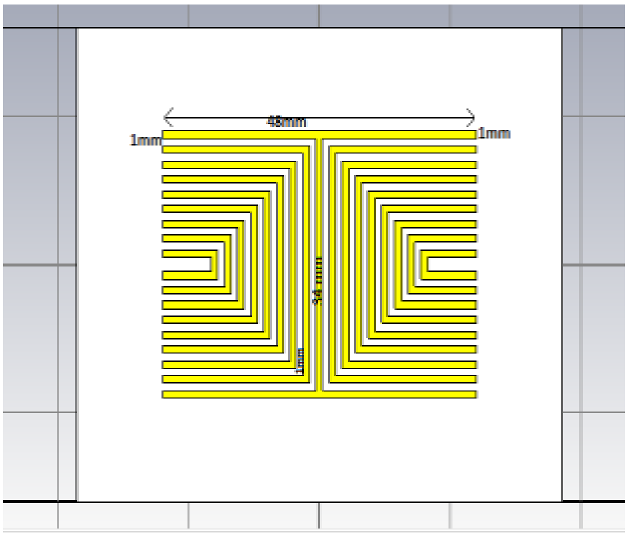

Fig 3. Design of Metamaterial

The proposed structure is placed between the two waveguide ports [9][14] at the left & right of the X-Axis (shown in figure 4) in order to calculate the S_{11} and S_{21} parameters so as to prove that the proposed structure possesses Double Negative metamaterial properties. In figure 4, Y-Plane was defined as Perfect Electric Boundary (PEB) and Z-Plane was defined as the Perfect Magnetic Boundary (PMB). Subsequently, the wave was excited from the negative X-axis (Port 1) towards the positive X-axis (Port 2).

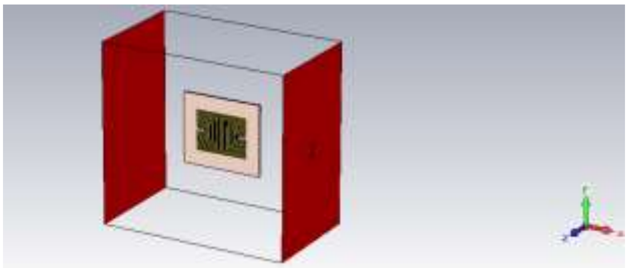

Fig 4. Metamaterial Placed between waveguide port

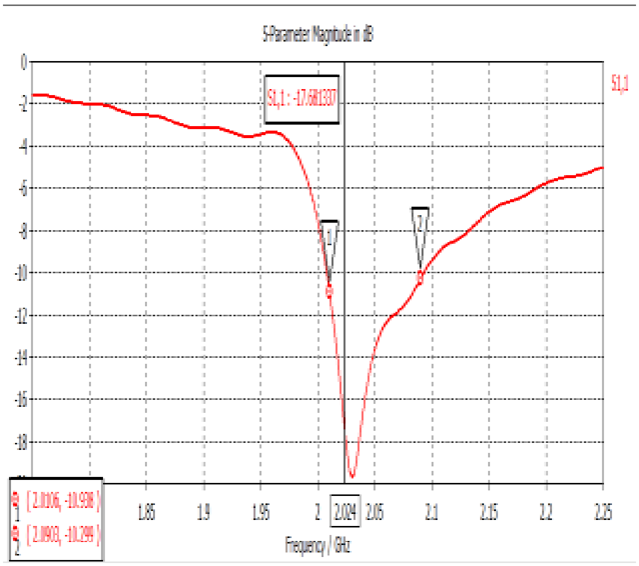

Fig 5. Return Loss (S_{11})

NRW METHOD

Nicolson-Ross-wier(NRW) has given the method to calculate complex permittivity and permeability of the material. Initially, we export S_{11} and S_{21} from CST to Microsoft Excel than with the help of NRW method we find its permittivity and permeability [9][10]

$$\mu_r = \frac{2.C(1-v2)}{w.d.i.(1+v2)} \qquad (8)$$

$$\varepsilon_r = \mu_r + \frac{2.S_{11}.C.i}{w.d} \qquad (9)$$

$$v2 = s_{21} - s_{11} \qquad (10)$$

Where
w= frequency in radian
d=thickness of the substrate
c=speed of light
v2=voltage minima

The value of permittivity and permeability were calculated by using formulae which are given in equation 8,9,10 and graph between permittivity and frequency is shown in fig. 6 and graph between permeability and frequency is shown in fig. 7..

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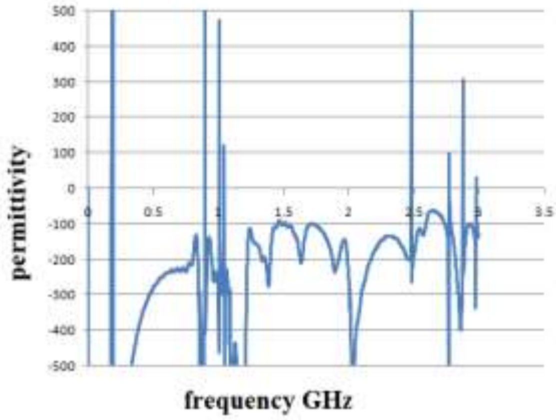

Fig 6. Graph between permittivity and Frequency

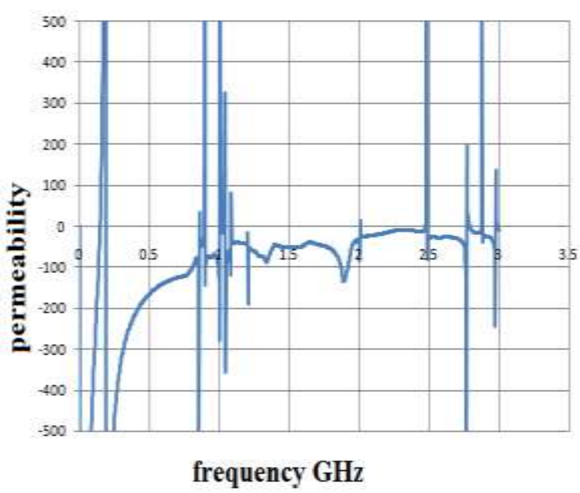

Fig 7. Graph between permeability and Frequency

The structure of metamaterial with microstrip patch antenna is shown in fig 8. In which metamaterial is placing of metamaterial on the top of patch antenna with air gap and its return loss show in fig 9

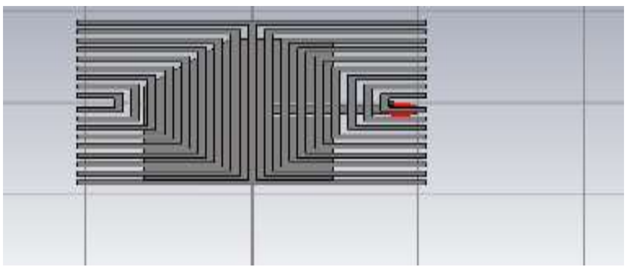

Fig 8. Compact microstrip patch antenna with metamaterial

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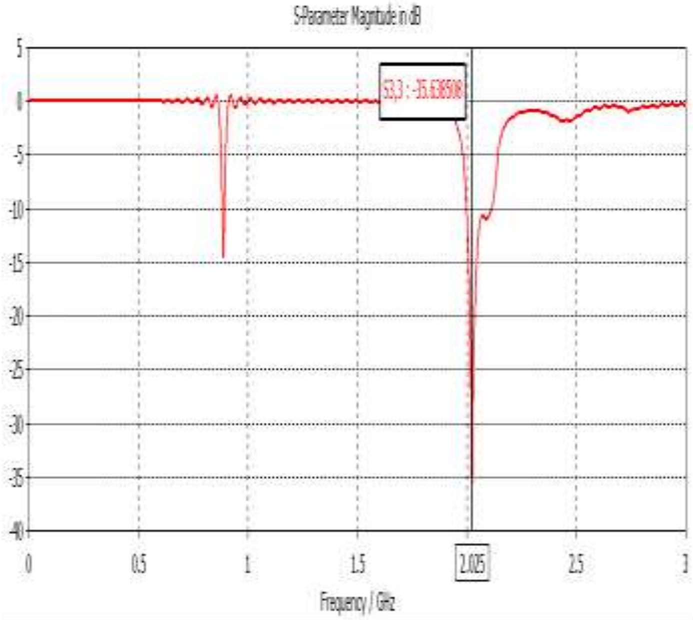

Fig 9 Return Loss (S_{11})

RESULTS
Simulation results of compact Microstrip patch antenna with and without metamaterial

Parameters	Without Metamaterial at 2.065 GHz	With Metamaterial at 2.025 GHz
Return Loss	-12.34	-35.63
Directivity	3.309	5.52
Gain	2.59	3.715
VSWR	1.63	1.03
Bandwidth	87MHz	109MHz

CONCLUSION
On the basis of results, it is observed that the parameter of compact microstrip patch antenna is improved by placing metamaterial in front of an antenna with air gap.Improved parameter- Return Loss reduced by 278% ,directivity increased by 67%,Gain increased by 43% and Bandwidth increased by 27%.Along with these improvements, it has also been verified that this structure satisfies Double Negative property within the operating frequency ranges.

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