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BANDWIDTH ENHANCEMENT OF MICROSTRIP PATCH ANTENNA

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ABSTRACT

This paper discusses bandwidth enhancement of microstrip patch antenna using metamaterial and defected ground structure. A patch antenna is designed and simulated for 2.45GHz. Substrate is used for this purpose is FR4 glass epoxy with dielectric constant of 4.4 thickness of 1.6mm.The shape used for conventional patch antenna is rectangular with inset feed. For metamaterial antenna circular split ring resonator are used. Metamaterial SRR and Defected Ground Structure is designed and simulated for 2.45GHz. After comparing both antennas bandwidth enhancement antenna is reported. High Frequency Structure Simulator is used for this purpose.

INTRODUCTION

In the age of communication everyone wants to be wireless. Antenna is device which is converts circuit energy into field energy. It makes system wireless. There are various types of antennas such as wired, non wired, wideband, narrowband, frequency independent, low, moderate and high gain antennas. The shape and size of antenna affects system design. From simple dipole antenna varieties of antennas are
available such as helical, dish, log periodic, yagi uda. These antennas have certain advantages. However size and geometric structure of these antennas are major drawbacks. Therefore microstrip patch antennas are becoming more popular over these antennas due to their features such as small size, conformability to the surface and ease of production, but narrow bandwidth is major drawback of microstrip patch antenna
Rapid development of microwave technology, there is a growing demand on the bandwidth keeping this vision in mind bandwidth of microstrip patch antenna is enhance. The various techniques are use for bandwidth enhancement. In recent day metamaterial are gaining important due to their amazing properties. Bandwidth of patch antenna is enhancing using metamaterial and defected ground structure. The conventional and proposed enhance bandwidth antenna are designed at 2.45GHz using high frequency structure simulator (HFSS).

1. Antenna Geometry

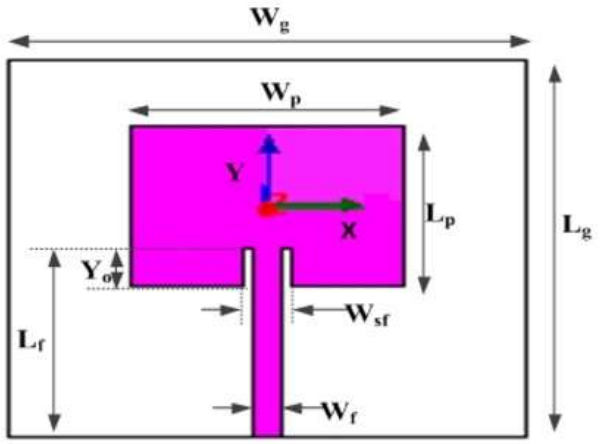

Fig. 1 Conventional Patch Antenna

The parameters are calculated as follows:

- **Step 1: Calculation of the Width (W):**

The width of the Microstrip patch antenna is given as,

$$w = \frac{c}{2fr\sqrt{\frac{\varepsilon r + 1}{2}}}$$

Where, c is velocity of light (3*10^8)
f_r is resonant frequency (2.45GHz)
ε_r is relative dielectric constant. (4.4)
By putting values we get ,

W = 38.05mm

For the calculation of the length of patch which involves several other factors; the first would be the effective dielectric constant (ε_{eff}). The value of the effective dielectric constant of the substrate with substrate height (h) is given by:

- **Step 2: Calculation of Effective dielectric constant(ε_{reff}):**

$$\boldsymbol{\varepsilon reff} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left(1 + 12\frac{h}{w}\right)^{-1/2}$$

By putting values of h , w and εr the value of effective dielectric constant is obtained i.e.

$$\boldsymbol{\varepsilon reff} = \frac{4.4 + 1}{2} + \frac{4.4 - 1}{2}\left(1 + 12\frac{1.6}{38}\right)^{-1/2}$$

$$\boldsymbol{\varepsilon reff = 4.3986}$$

- **Step 3: Calculation of the Effective length (L_{eff}):**

$$\mathrm{Leff} = \frac{c}{2fr\sqrt{\varepsilon\, reff}}$$

By putting values,

$$\mathrm{Leff} = \frac{3 * 10^{\wedge}8}{2 * 2.4 * 10^{\wedge}9\sqrt{4.39}}$$

$$\mathbf{Leff = 29.82mm}$$

- **Step 4: Calculation of the length extension (ΔL):**

$$\Delta L = 0.412h\frac{(\varepsilon\, reff + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon\, reff - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

Hence by putting values from above equation,

$$\mathbf{\Delta L = 0.748mm}$$

- **Step 5: Calculation of actual length of patch (L):**

$$L = \mathrm{Leff} - 2\Delta L$$

By putting values of Leff and ΔL we get

$$\mathbf{L = 28.30mm}$$

- **Step 6: Calculation of the ground plane dimensions (L_g and W_g):**

L_g = 6h + L
Hence,

L_g = 6*1.6 + 28.30

L_g = 37.9mm

Now for ground width,

$W_g = 6h + W$

$W_g = 6*1.6 + 38.03113$

We get,

$\mathbf{W_g = 47.63mm}$

- **Step 7: Calculation of the inset deapth (y0):**
  y0=10^-4{0.001699εr^7 + 0.13761 εr^6 – 6.1783 εr^5 + 93.187 εr^4 -682.69 εr^3 + 2561.9 εr^2 - 4043 εr + 6697}L/2
  y0 =8.1016

- **Step 8: Calculation of the feed location design (Xf) and (Yf):**

$$Xf = \frac{L}{2\sqrt{\varepsilon\ reff}}$$

$$Xf = \mathbf{13.50mm}$$

$$Yf = \frac{w}{2}$$

Yf =19mm

The dimensions of conventional patch antenna obtained using above equation

3.Metamaterial Geometry

After obtaining the results for conventional patch, a metamaterial structure is incorporated. Ground is defected by adding split ring in ground plane .

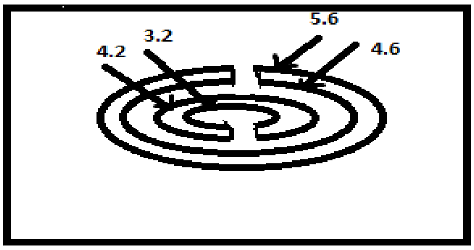

Fig.2 Proposed SRR Structure

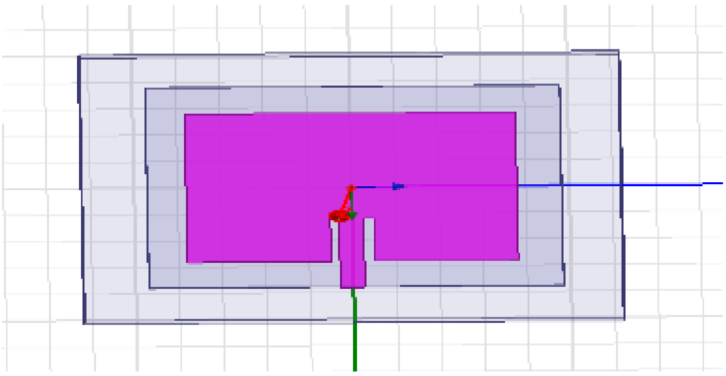

Fig.3 Designing of conventional antenna

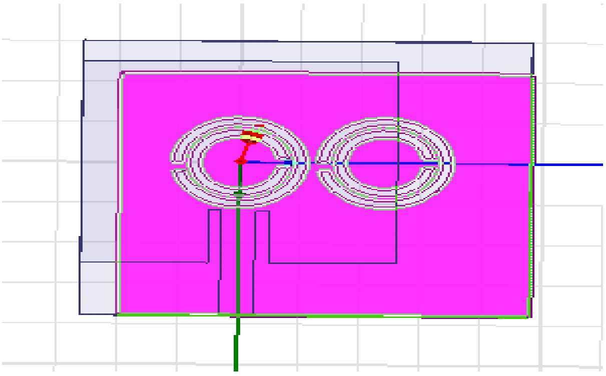

Fig. 4 Designing of proposed antenna

RESULT AND ANALYSIS

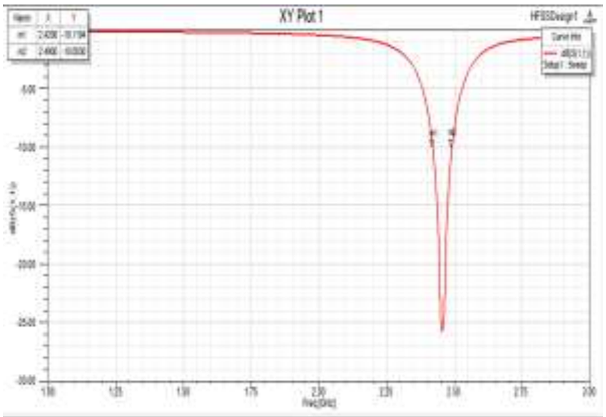

Fig.5 Simulation of Return Loss S11 of conventional patch antenna

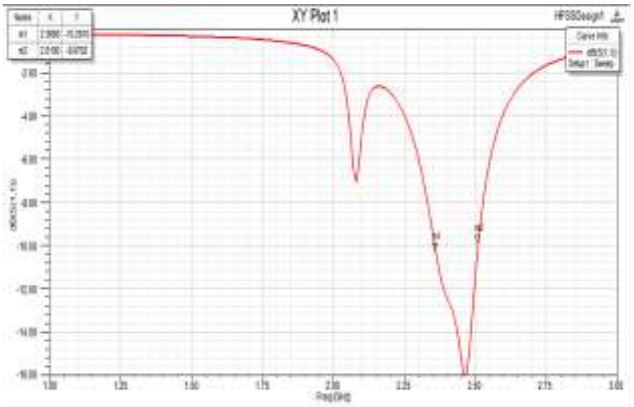

Fig. 6 Simulation of proposed antenna

In conventional patch antenna RL=-25DB at resonating frequency of 2.45 GHz is reported as in figure 5 and the bandwidth achieved is only 70MHz. In proposed patch antenna RL=-15.97DB at resonating frequency of 2.45GHz is reported as in figure 6. The proposed antenna structure achieved bandwidth up to 150MHz.

Table 1: Comparison table between conventional patch antenna and proposed antenna

Parameter	**Simple patch**	**Metamaterial Patch**
Frequency	2.45GHz	2.45GHz
Bandwidth achieved	70MHz	150MHz
Return loss	-25DB	-15.97DB
VSWR	1.10	1.41

CONCLUSION

The effect of periodic structure of SRR and defected ground structure on microstrip patch antenna studied. The bandwidth of antenna showed as increase as compared to normal patch. Bandwidth achievement is 150MHz as compared to the 70MHz for the conventional patch antenna. This is due to the introduction of interdigital capacitance and inductance**.**

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