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Design and Analysis Double H Shaped Metamaterial Embedded RMPA

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Abstract**—***This paper presents a compact double H shaped antenna using META material with via hole technique. The slots are cut in rectangular microstrip patch antenna (RMPA) to decrease the resonant frequency, but this leads to impedance mismatch. To overcome this effect a double h shaped Meta material is embedded inside the slot. This technique not only provides a good impedance matching and bandwidth, but in addition, also provides the 40% compactness in size. The proposed antenna is simulated and optimized using Zealand 9.0 version IE3D software.*

Keywords*:— Metamaterial Rectangular Microstrip Patch Antenna (RMPA) , return loss.*

1. INTRODUCTION

The demand of antenna is rapidly increasing recently due to varieties of wireless communication systems launched into the market; for instances, 2G/3G mobile services, marine or land vehicle navigations (GPS), wireless LANs access, remote sensors for monitoring systems, and many small devices embedded with Bluetooth, UWB, Zigbee, DVB etc[1]. Among many types of antennas, they can be classified into two categories which are linearly-polarized and circularly-polarized antenna[2]. For majorities of wireless applications, linearly polarized antenna is good enough for transmitting as well as for receiving RF signals. However, for satellite communication and high sensitivity systems like as GPS, satellite phone and the space-to-earth communication, then the circularly-polarized antenna must be used in order to maintain good capability of signal strength[3-4].

Broad band Microstrip patch antenna is widely used in microwave range for transmitting and receiving signals due to their small and conformal size ease of fabrication and planar geometry. There have been different dielectric substrates used for the fabrication of microstrip patch antenna [1].

The aim of the thesis is to design and broadband microstrip patch antenna using META material and via hole technique, which targets to use in C-Band communications and study the effect of via hole technique analyzed different parameters Return loss, VSWR, Gain, Directivity, Efficiency and Bandwidth. The height of the dielectric constant is kept constant (which is 1.5mm) and antenna is designed for S-C band applications, so the resonant frequency chosen is 5.2 GHz. All antenna designs are studied by IE3D Simulator [3].

2. DESIGN ANALYSIS

A. Design Specification

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are[1-4]:

• *Frequency of Operation:*

The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for my design is 5.2 GHz.

• *Dielectric constant of the substrate (εr):*

The dielectric material selected for my design is Fr 4

epoxy substrate having dielectric constant of 4.3 and loss

tangent =0.0025.which has a dielectric constant of 4.3.

• *Height of dielectric substrate (h):*

Height of dielectric substrate is 1.5 mm. So, the essential parameters for the design are :

- f_0 : 5.2 GHz
- ε_r: 4.3
- *h s:* 1.5 mm

B. Design Procedure

Step 1: Calculation of the Width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Substituting c = 3.00e+008 m/s, ε_r= 4.3 and fo = 5.2 GHz, we get:

W = 22mm

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

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{W}]^{\frac{1}{2}}$$

Substituting εr= 4.3, h = 1.5mm and W = 22mm, we get:

ε_{reff} = 1.2.

Step 3: Calculation of the length extension (ΔL):

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

Substituting ε_{reff} = 1.2, h = 3mm and W = 800mil, we get:

ΔL = 0.00130 mm.

Step 4: Calculation of the Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Substituting ε_{reff} = 5.046, c = 3.00e+008 m/s and f = 5.2GHz, we get:

Step 6: Calculation of actual length of patch (L):

$$L = L_{eff} - 2\Delta L$$

Substituting L_{eff} and ΔL, we get: L = 17 mm.

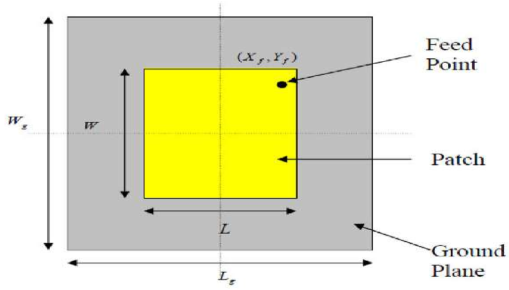

Figure 1: Top View of Design Procedure

C. Design Configurations

Compact broad band antenna design in three configuration in first design theoretical antenna an in second design antenna 1 using Round H-Shape META material and in third design antenna using META material with via hole technique, analyzed and validated all three geometry in IE3D Simulator, the geometry of all three configure is shown.

THEORETICAL ANTENNA Micro strip feeding

Lg= 26mm

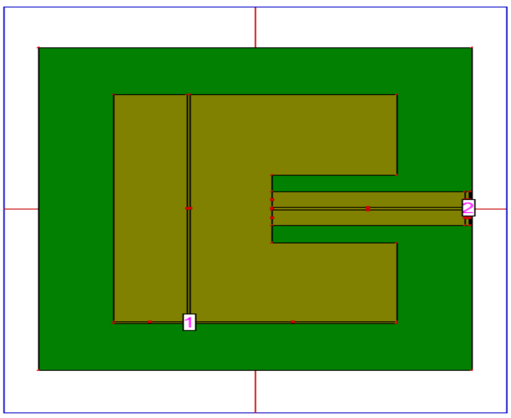

Figure 2 : Theoretical Antenna

PROPOSE ANTENNA 1

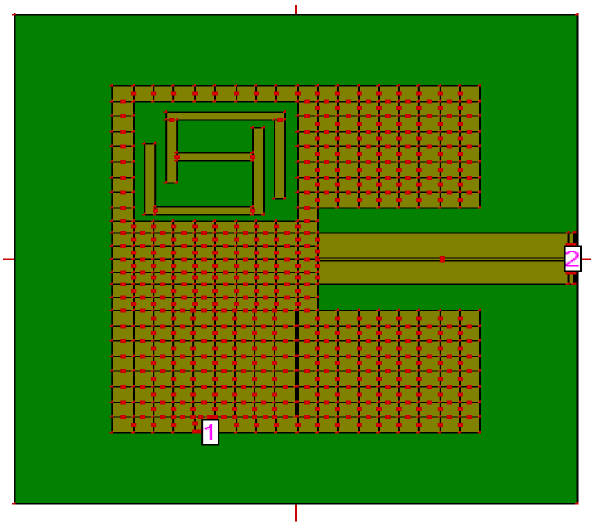

Figure 3: Proposed Antenna 1

Design METAmaterial in round H-Shape is used in left top corner of patch to reconfigure properties of antenna, due to using META material reconfigure permeability and permittivity of design antenna, single H-Shape META material proposed antenna shown in figure 3.

Proposed antenna 2 using meta material and via hole technique

Design METAmaterial in round H-Shape is used in left top and bottom corner of patch with via hole technique and using four rectangular shape META material in ground plane, is used to reconfigure properties of antenna, due to using META material and via hole technique reconfigure permeability and permittivity of design antenna, single H-Shape META material proposed antenna shown in figure 4.

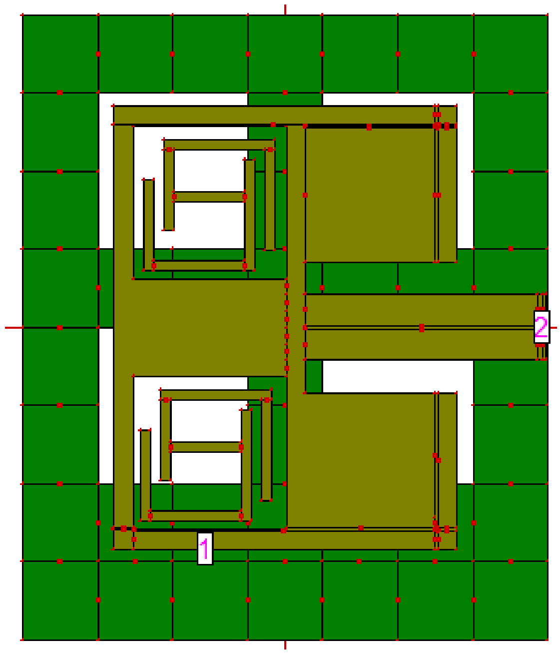

Figure 4: Proposed Antenna 2

3. TESTING AND RESULTS

S11 (return loss) Vs Frequency

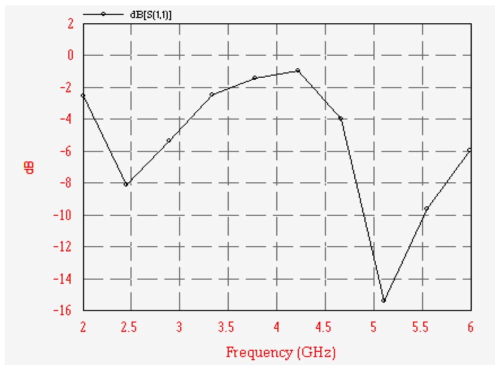

Figure 5: S11 Vs Frequency

Figure 5 shows a S11(return loss) Vs Frequency in which frequency increases return loss have firstly decreases than increases after that fall down to frequency 5.2GHz and again increases, by all these surface current increases due to fringing field**.** This designing gives 13.5% of C-Band from 4.8 to 5.5GHz, return losses at 5.2 GHz is -15.7Db.

Proposed Antenna 1

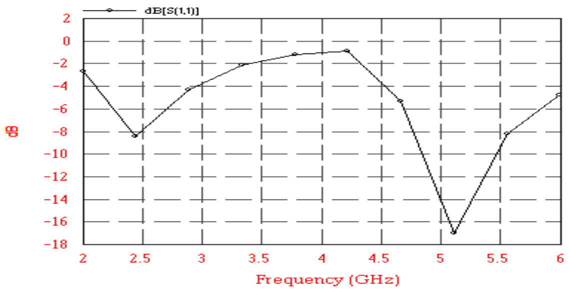

Figure 6: S11 Vs Frequency

S11 Vs Frequency

Figure 6 shows a S11(return loss) Vs Frequency in which frequency increases return loss have firstly decreases than increases after that fall down to frequency 5.2GHz and again increases ,by all these surface current increases due to fringing field. But leads the impedance mismatching. Reflection of port itself S11 Shown in fig 6, this designing gives 13.8% of C-Band from 4.7 to 5.5GHz, return losses at 5.2 GHz is -17db**.**

Proposed antenna 2 using META material and via hole technique S11 Vs Frequency

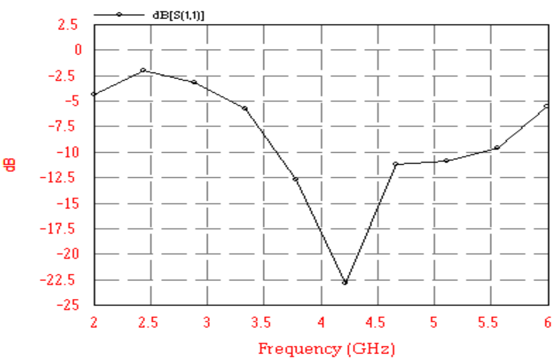

Figure 7: S11 Vs Frequency

figure 7 shows a S11(return loss) Vs Frequency in which frequency increases return loss have firstly increases than decreases and fall down to frequency 4.2GHz and again increases, by all these due to fringing field changes by impedance matching and surface current increases. resonant frequency is shifted to lower side from 5.2GHz to 4.2GHz. Reflection of port itself S11 Shown in figure 7, this designing increases 25% bandwidth from 3.6 to 5.5GHz, return losses at 4.2 GHz is -22.8db.

S21 Vs Frequency

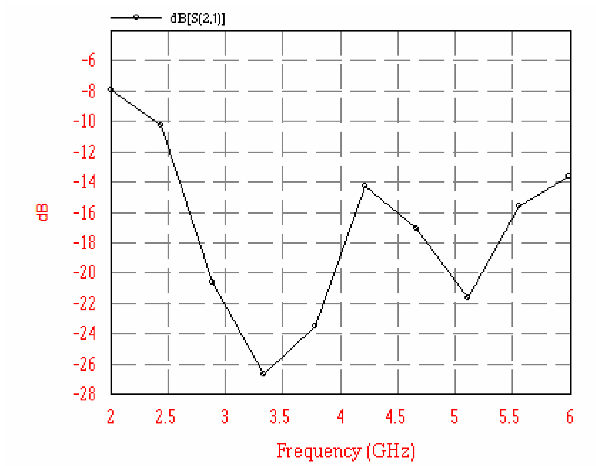

Figure 8: S21 Vs Frequency

Figure 8 shows a S21(reflection loss) Vs Frequency in which frequency increases reflection loss have firstly decreases to frequency 3.4 . All these due to fringing field changes by good impedance matching and surface current increases. in the graph resonant frequency is shifted to lower side from 5.2GHz to 3.4GHz. Reflection between port 2 and 1 S21 Shown in figure 8, obtained maximum value of s21 is -26.8Db.

S12 Vs Frequency

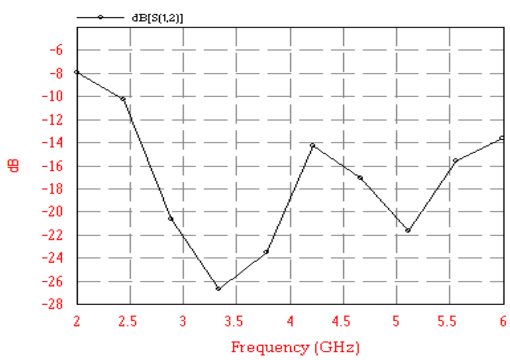

Figure 9: S12 Vs Frequency

Figure 9 shows a S12 (reflection loss) Vs Frequency in which frequency increases reflection loss have firstly decreases to frequency 3.4 than increases. All these due to fringing field changes by good impedance matching and surface current increases. In the graph resonant frequency is shifted to lower side from 5.2GHz to 3.4GHz. Reflection between port 1 and 2 S12 Shown in fig 9, obtained maximum value of s12 is -27.2dB.

S22 Vs Frequency

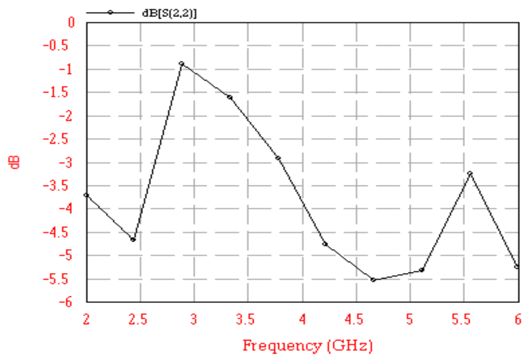

Figure 10: S22 Vs Frequency

Figure 10 shows a S22(reflection loss) Vs Frequency in which frequency increases reflection loss have firstly decreases than increases but maximum decreases at frequency 4.8GHz is -5.5dB . all these due to fringing field changes and Antenna and Radiating Efficiency vs. Frequency of Antenna 2

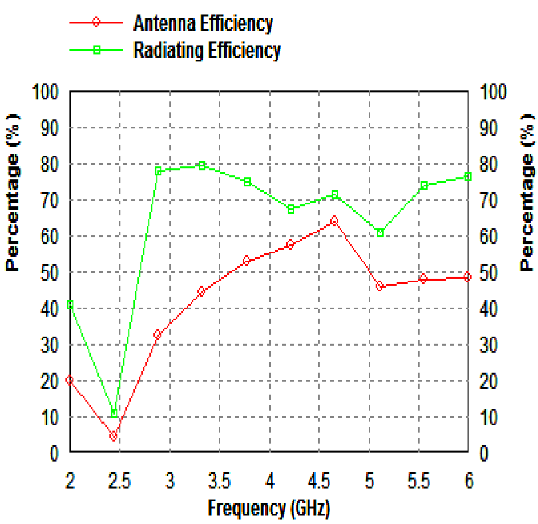

Figure 11: Antenna and Radiating Efficiency vs. Frequency

In figure 11 antenna and radiating efficiency graph shown that the radiating efficiency up to 60% and radiating efficiency up to 80%. For S-Band and C-Band.

Radiation Pattern of Antenna 2 at 4.2 GHz Elevation Pattern at 4.2 GHz

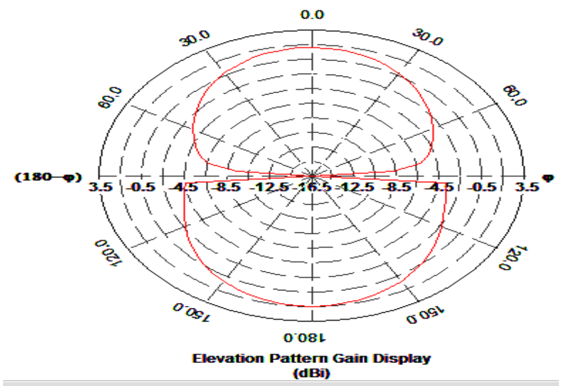

Figure 12: S22 Vs Frequency

Figure 12 shows radiation pattern of proposed antenna 2 at 4.2GHz and obtain minimum reflection at 4.2 GHz, so that analyzed radiation pattern at 4.2 GHz, analyzed elevation and azimuth pattern at 4.2 GHz frequency for different values of θ and φ. The radiation pattern is at 4.2 GHz in Maximum gain obtained at 0 and 180 degrees.

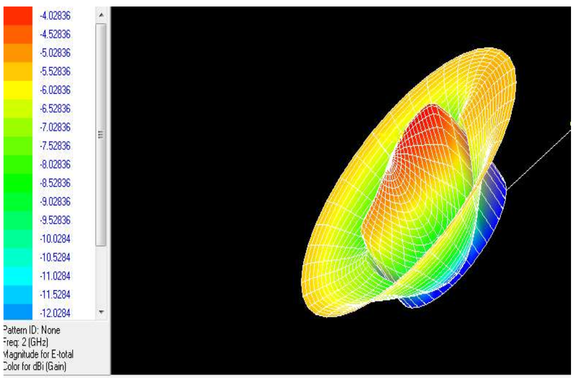

Figure 12 S12 Vs Frequency

4. CONCLUSIONS

Rectangular Microstrip Patch Antenna can provide printed radiating structure, which are electrically thin, lightweight and low cost, is a relatively not too old. The development of system such as Satellite communication, highly sensitive radar, radio altimeters and Missiles systems needs very light weight antenna which can be easily attached with the systems and not make the system bulky. These requirements are main factors to the development of the Rectangular Microstrip Patch Antenna. By doing this we can get required Results. Rectangular Microstrip Patch Antenna are most common and very easy to analysis but to reduce their return loss, enhance bandwidth and to achieve compact in size we need to make some slots on the patch and to work on defected ground structure, defected Microstrip Structure and Meta-material.

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