Metamaterial Incorporated Planar Antenna for Improving Parameters

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Abstract- *Planar antenna has been widely used having an advantage of low weight, ease of fabrication & small size but it also has a disadvantage of having low gain, efficiency & narrow range of bandwidth. To overcome this limitation of narrow bandwidth, a review on microstrip planar antenna using metamaterials has been elaborated in this paper. Further paper describes introduction, basics of metamaterial structures, design of various antenna using metamaterial structures.*

Keywords- *C-Band, Microstrip planar antenna, Metasurface, SRR.*

I. INTRODUCTION

In present day scenario, the significance in the design and developing the compact, inexpensive antennas are fuelled by rapid developments of various communication services and other wireless services. Hence, compact microstrip slot antennas have found increased usage in wireless applications specifically in C band wireless frequency range. Broadband devices are mainly operated in our daily lives such like mobile phone, radio, laptop with wireless connection and MSP antennas play a important role of these devices. The major drawbacks of MSP antennas in basic form are narrow bandwidth and low gain. Then many techniques are used to enhance bandwidth and gain of MSP antennas. By using thick Substrate with low dialectic constant and compact slotted patch can enhance the bandwidth and gain of antennas. The MSP antenna have some good features such as low cost, low profile, light weight, high efficiency, simply manufacture and easy to implement with circuits. The design structure components of antenna become small in size and have low processing cost.

A direct technique to widen the bandwidth can be done by achieving a good impedance matching between the feeding line and the radiating element [4]. Another technique is adding parasitic elements and cutting slots on the patch. However, the aforementioned techniques could not provide better performance. Hence, a new attempt is made to design patch

Antenna on metamaterial surface in order to enhance the performance of an antenna for real time on-demand applications

II. CLASSIFICATION OF METAMATERIALS

Metamaterial shows its properties in different quadrants based on its relative values.

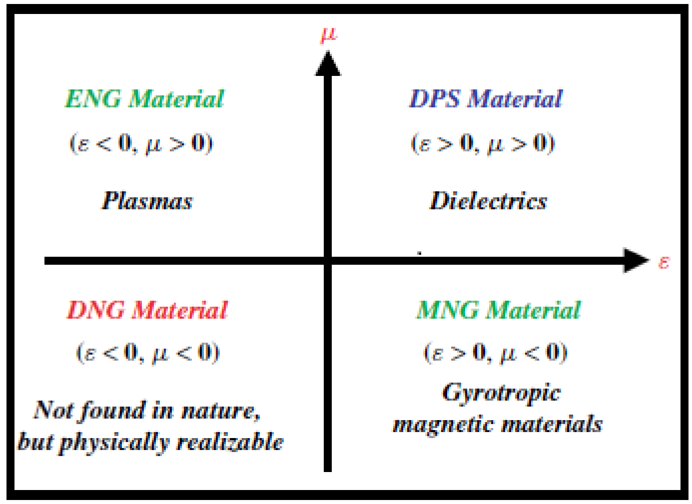

Figure 2.1: Types of Meta-material based on permittivity and permeability

In Figure 2.1, Quadrant 1 represents the materials with simultaneously positive value of permittivity and permeability both. It covers mostly dielectric materials. Quadrant 2 represents the materials with negative permittivity below plasma frequency

And positive permeability. It covers metals, ferroelectric materials, and extrinsic semi- conductors. Quadrant 3 represents the materials with simultaneously negative value of permittivity and permeability both. No such material is found in nature. Quad- rant 4 represents the materials with negative permeability below plasma frequency and positive permittivity. It includes ferrite materials.

2.1 Realisation of Metamaterials

To realize metamaterial, two properties i.e. negative permittivity and negative permeability are main constraints.

2.1.1 Negative permittivity

For obtaining negative value of permittivity a metallic mesh of thin wires is used. The effective permittivity is negative when the frequency is below the plasma frequency. When operating at the plasma frequency, the effective permittivity is zero, and hence yields a zero index of refraction. Thin metallic wires of Aluminium, Silver and Gold etc. are arranged periodically as shown in Figure 2.2

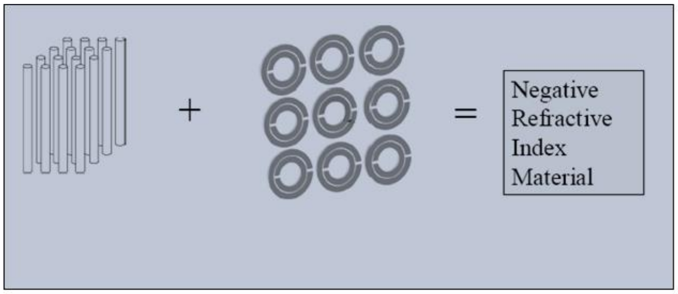

Figure 2.2: Alternate layers of SRR

2.1.2 Metamaterial as antenna

Metamaterial coatings have been used to enhance the radiation and matching properties of electrically small electric and magnetic dipole antennas. Metamaterial step up the radiated power. The newest Metamaterial antenna radiate 95% of input radio signal at 350 MHz. Experimental metamaterial antenna are as small as one fifth of a wavelength. Patch antenna with metamaterial cover have increased directivity. Flat horn antenna with at aperture constructed of zero index metamaterial has advantage of improved directivity. Zero-index metamaterials can be used to achieve high directivity antennas.

2.1.3 Metamaterial as cloaks

Cloaking can be achieved by cancellation of the electric and magnetic field generated by an object or by guiding the electromagnetic wave around the object. Guiding the wave means transforming the coordinate system in such a way that inside the hollow cloak electromagnetic field will be zero this makes the region inside the shell disappears.

III. DESIGN, SIMULATION & EXTRACTION OF PARAMETERS

Metamaterial unit cell is designed in HFSS having SRR (split ring resonator) structure at 10 GHz. S11 & S21 parameters are extracted from the design in HFSS & by its magnitude & angle (rad) to .csv file. In MATLAB, Refractive index (n) and Impedance (z) are determined using following Equations:

$$Z = \pm\sqrt{\frac{(1+S_{11})^2 - S_{21}^2}{(1-|S_{11})^2 - S_{21}^2}}$$

$$n = -j.\ln\left(\frac{S_{21}}{1-S_{11}\left(\frac{Z-1}{Z+1}\right)}\right)\frac{1}{k_0 d}$$

From above equations, Effective permittivity and effective permeability is determined using equations below

$$\varepsilon_{eff} = n/Z$$

$$\mu_{eff} = n.Z$$

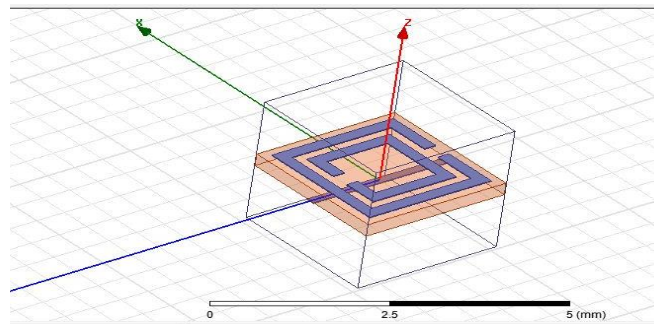

Figure 3.1: Metamaterial unit cell in HFSS at 10 GHz

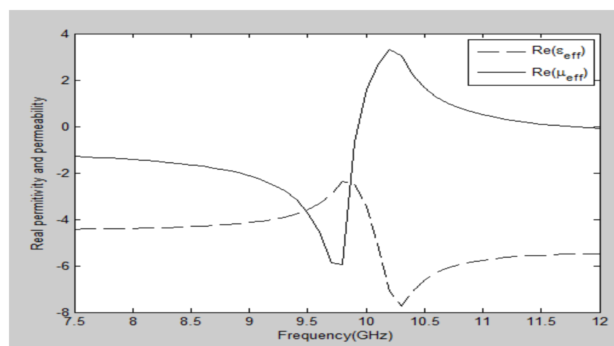

Figure 3.2: Real Permittivity & Permeability Vs. GHz

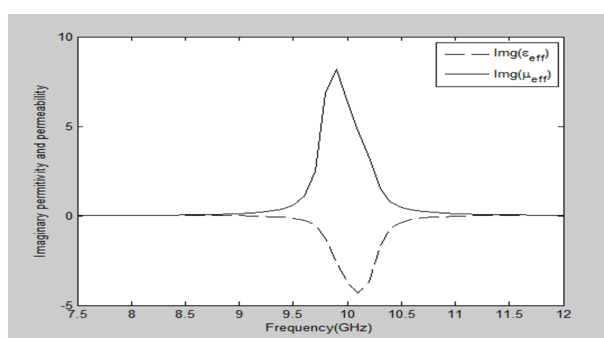

Figure 3.3: Imaginary Permittivity & Permeability Vs. GHz

3.1 Metasurface antenna

Meta surface based antenna has been designed in HFSS using unit cell array 7*7 structure as shown in fig 3.4. Coaxial feed is given to match impedance.

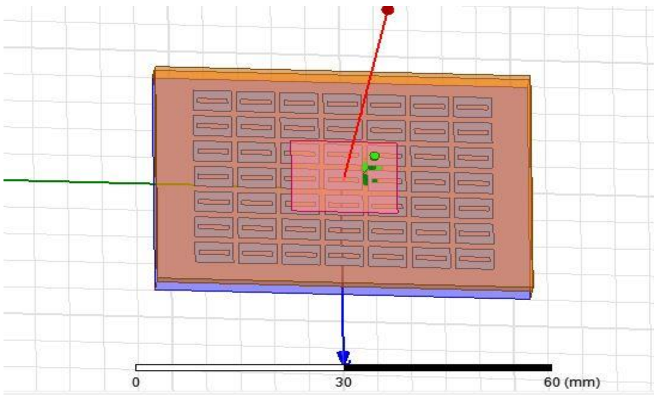

Fig 3.4 Antenna with Metasurface at h1 height

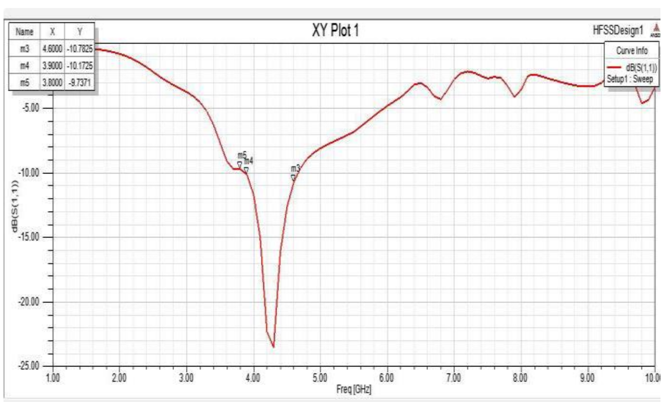

Figure 3.5: Return loss (dB) Vs. Frequency (GHz)

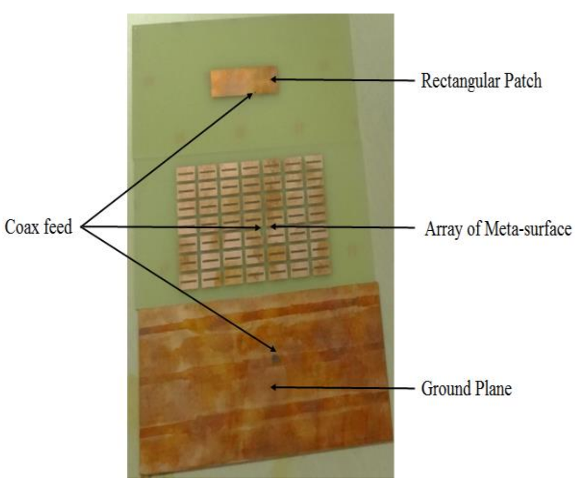

Figure 3.6: Fabricated PCB for stacking

IV. CONCLUSION

Conventional patch antenna is designed & simulated using HFSS. Metasurface antenna is simulated using unit cell array structure. Simulated return loss for conventional patch is -12.1 dB at 5 GHz. Bandwidth is obtained as 310 MHz (6.2%). Improved return loss for metasurface antenna is -23.51 dB having wide bandwidth 790 MHz (17.9%). Metasurface antenna is fabricated having stacked PCBs structure by FR4 substrate. Fabricated results show good agreement with simulated results.

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