Metamaterial Unit Cell Antenna For WLAN Application

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ABSTRACT- The rationale behind our work is that a small planar resonating antenna is proposed using DNG (Double Negative) metamaterials. The double negative property is being obtained by inserting series capacitors and shunt inductors using plates and via respectively. Metamarerials are artificial materials having negative permeability, permittivity and refractive index and due to this it exhibits unusual properties compared to readily available materials. Due to the unusual properties of the metamaterials here we got a better gain of 5.197 dB, total efficiency of 92.5% and a return loss of -13.5 dB at 5 GHz frequency and the gain, efficiency and return loss are 4.183 dB, 60.78%, -14.5 respectively for 2.4 GHz, which are very good for wirelessly access network resources at home and elsewhere with up to 5 GHz performance, like IEEE 802.11a, widely available IEEE 802.11b, downwardly compatible IEEE 802.11g, and advanced IEEE 802.11n. Using this metamaterial antenna the demerits of ordinary patch antenna like low gain and efficiency can be overcome.

Keywords- DNG Metamaterials,Unit Celll, Via, CST Microwave Studio, Wireless LAN, Duroid, SRR

I. INTRODUCTION

The utilization of the unusual properties of the metamaterials [3] in small antennas is tried here to get an efficient antenna. Metamaterials were introduced by Veselago [1] in 1967. Metamaterials are human made materials. In Greek Meta means above/after/beyond/superior, so metamaterial is named so as it exhibits properties beyond the properties of naturally available materials. For metamaterials the structural average cell size is smaller than the guided wavelength. It gains its properties from structure rather than composition and is a combination of metal and dielectric composite. The advantage of using metamaterial structures in patch antennas is that enhanced antenna properties like gain and efficiency can be obtained as well as size of the antenna can be reduced for convenience. Metamaterials are artificial material which exhibit negative permittivity, negative permeability and refractive index, which is not found in readily available materials. Metamaterials have –ve refractive index that is a reversal of Snell's law, hence called as –ve index materials. Due to –ve refractive index, the group and phase velocities of electromagnetic wave appear in opposite direction such that the direction of propagation is reversed with respect to the energy flow direction. Negative μ_r and ε_r occur in nature, but not simultaneously. Negative refraction can be achieved when both μ_r and ε_r are negative, as described in the following equation.

$$n = \sqrt{(-\mu_r)\,(-\varepsilon_r)}$$

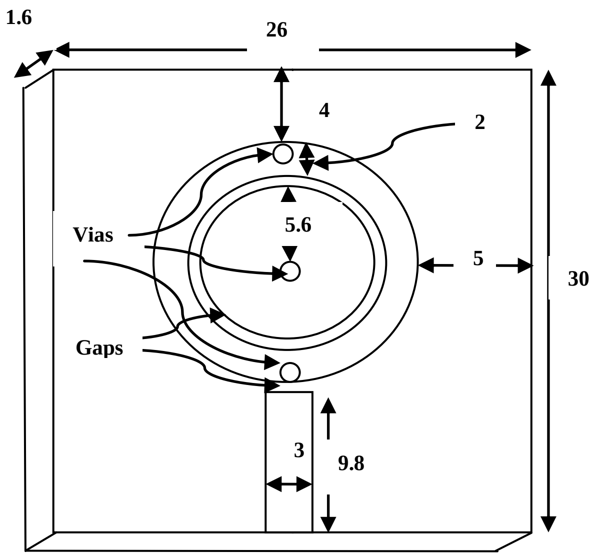
$$=(\mu_r(e^{-j\pi})\,\varepsilon_r(e^{-j\pi}))^{1/2}\ \mu_r(e^{-j\pi/2})\,\varepsilon_r(e^{-j\pi/2})$$

$$=\sqrt{(\mu_r\,\varepsilon_r)}\,e^{-j\pi} < 0 \ \ldots\ldots\ldots(i)$$

Early metamaterials relied on a combination of Split-ring resonators (SSRs) and conducting wires/posts.SSRs used to generate desired μ_r for a resonant band of frequencies. Conducting posts are polarized by the electric field, generating the desired ε_r for all frequencies below a certain cutoff frequency.

II. DESIGN OF THE DNG ANTENNA

Here we have designed a single layer planar DNG antenna photo etched on thin substrate [2]. First we have taken a ground plane of 0.5mm next a rectangular substrate (26mm×30mm×1.6mm) of duroid having permittivity 2.2 is developed. A circular patch having radius 8mm, thickness 0.1mm and a gap circle having outer radius 6mm and inner radius 5.8mm is printed on the substrate. As shown in the figure at the centre point of the patch and at the top and bottom of the gap circle there are three vias of radius 0.2mm each. For feeding we have used a microstripline of length 9.8mm, width 3mm and thickness 0.1mm, by using the above dimensions a gap of 0.2 mm is found between the microstrip line and the patch. Our antenna is simulated using CST Microwave Studio [6] based on finite integration method. But as CST transient solver doesn't support negative permittivity and permeability we can't enter negative permittivity and permeability values for the metamaterial directly, so we have used shunt inductor i.e. via, shunt capacitor i.e. free plate and series capacitor i.e. gap between free plates [4]. Directly, negative permittivity and permeability values can be entered using HFSS, based on finite element method.



Via Radius=Patch Gap=0.2

All Dimensions in mm

Fig 1: Structure of The Antenna

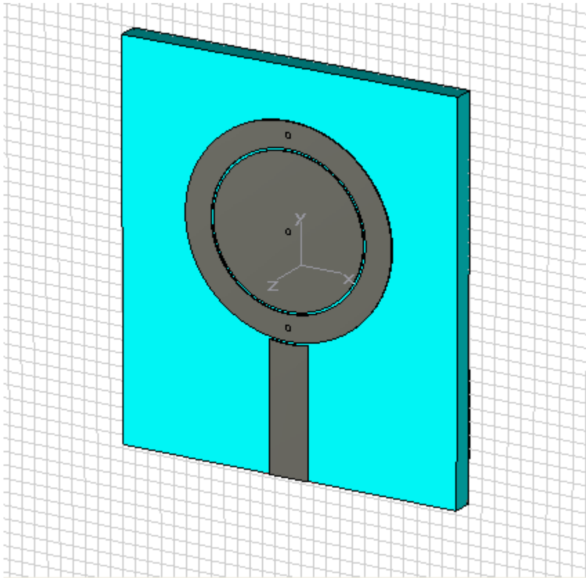
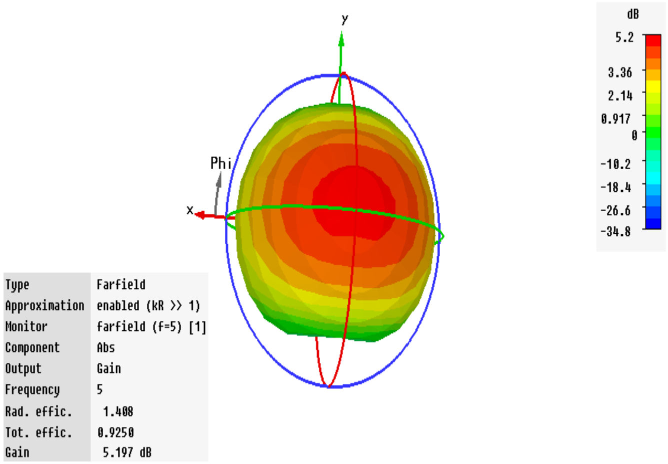


Fig 2: Prospective View of The Antenna

III. RESULTS AND DISCUSSION

For simulation of our antenna we have taken the frequency range 2-5.5 GHz to satisfy the wireless requirements [9]. From the 3D radiation pattern shown in fig 3, at 5 GHz frequency the gain is 5.197 dB, total efficiency is 92.5% and as shown in fig 4 the gain and efficiency are 4.183 dB and 60.78% respectively. Figure 6 shows the return loss at 5 GHz is -13.5 dB and at 2.4 GHz is -14.5 dB. These parameters are enough for point to point wireless communication [10]. The efficiency for our antenna is excellent i.e. 92.5% at 5 GHz. Fig 7 shows the VSWR curve and it says the VSWR for our antenna is 1.5 and 1.6 at 2.4 and 5 GHz respectively. As our VSWRs are close to 1 there will be a very good impedance matching for our antenna. Figures 8 and 9 show a well balanced surface current for our antenna having a maximum of 43.8 A/m at 5 GHz and 48.6 at 2.4 GHz frequency. Figures 4 and 5 show the 2D radiation patterns for our antenna with E and H field.



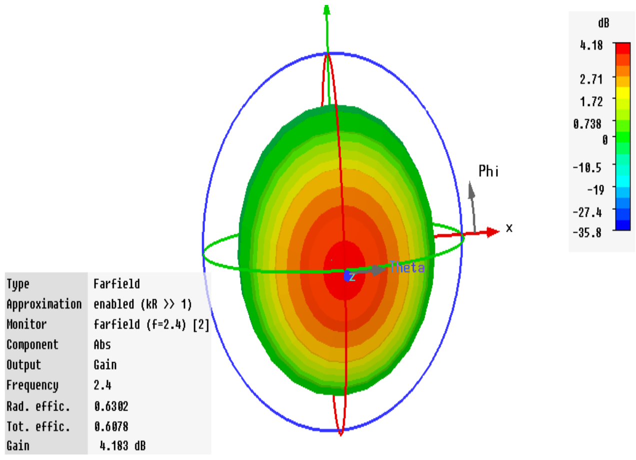
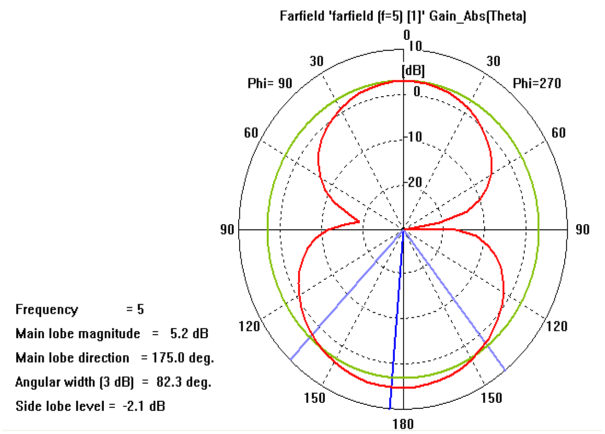


Fig 2: 3D Radiation Pattern at 5 GHz

Fig 3: 3D Radiation Pattern at 2.4 GHz



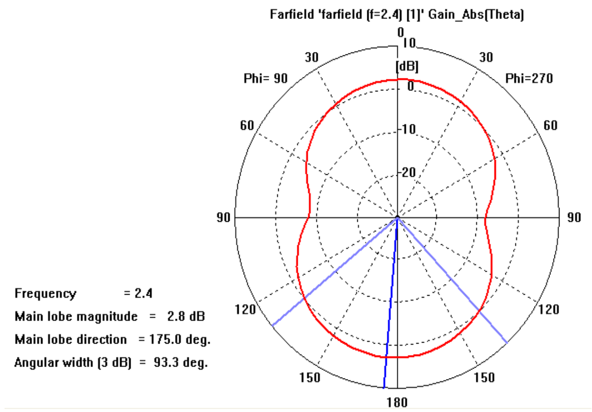


Fig 4: 2D Radiation Pattern at 5 GHz

Fig 5: 2D Radiation Pattern at 2.4 GHz

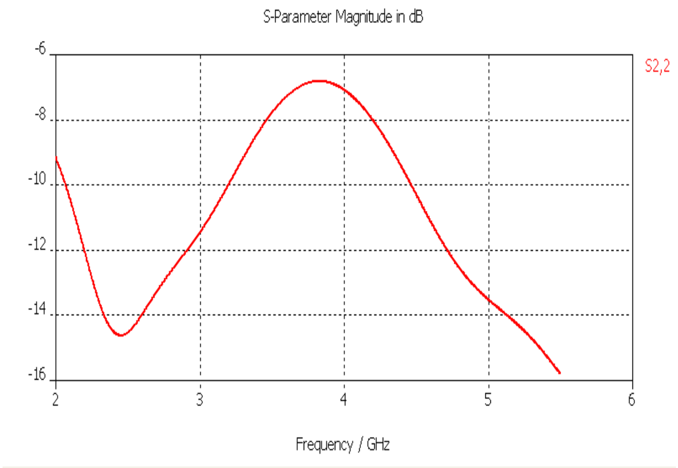


Fig 6: Return Loss

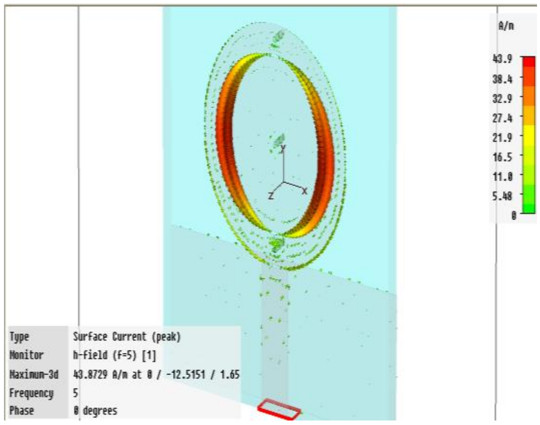


Fig 7: Surface currents at 5 GHz

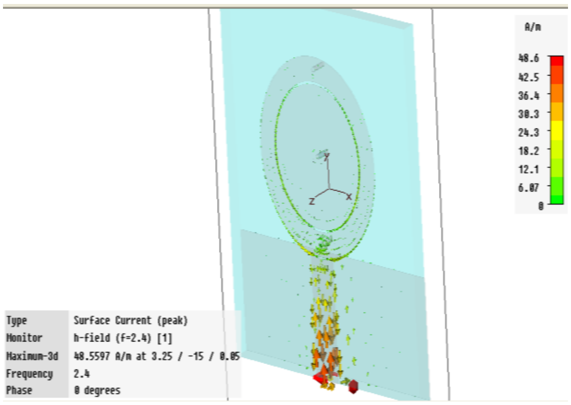


Fig 8: Surface currents at 2.4 GHz

IV. CONCLUSION

By observing the simulated results it is very clear that the proposed metamaterial antenna gives better gain and efficiency compared to an ordinary patch antennas and which is very useful for point to point wireless propagation. Also due to the miniaturization it is very convenient to use in wireless networks. This is possible only because of the unusual properties of metamaterials. We got very good results at 2.4 and 5 GHz frequencies and for current wireless standards 2.4 and 5 GHz are the best.

V. REFERENCES

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