Compact High Radiation Metamaterial Antenna for Wireless Applications

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***Abstract*— The rationale behind our work is that a small planar antenna is proposed using DNG (Double Negative) metamaterials. The double negative property is being obtained by introducing conductance, inductance and capacitance in the antenna structure by inserting a via (cylindrical hole) and gaps in the antenna patch. 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 3.768 dB, a radiation efficiency of 99.11% and a WSWR of 1.6 at 5 GHz frequency which is very good for point to point wireless communication and wireless LANs. Our antenna has better VSWR, gain and radiation efficiency compared to an ordinary patch antenna.**

Keywords- DNG Metamaterials, Left-handed material, Via, CST Microwave Studio, Wireless LAN, Duroid, PEC.

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 artificial materials which exhibit negative permittivity, negative permeability and negative refractive index, not found in readily available materials. For the proposed antenna only the negative permittivity and permeability are important. Veselago first analyzed theoretically the wave propagation in a material with a negative magnetic Permeability and a negative electric permittivity [1]. In such a left-handed (LH) material [1], the electric field, the magnetic field, and the wave vector of an electromagnetic wave propagating obey the left-hand rule (instead of the right-hand rule for usual 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 can be obtained as well as size of the antenna can be reduced for convenience. For the proposed antenna a cylindrical via is used throughout the whole antenna width, which is the main radiating element of the antenna [2].

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 0.4mm 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 fig 1 at the centre point of the patch, a via of radius 0.2mm is inserted. 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

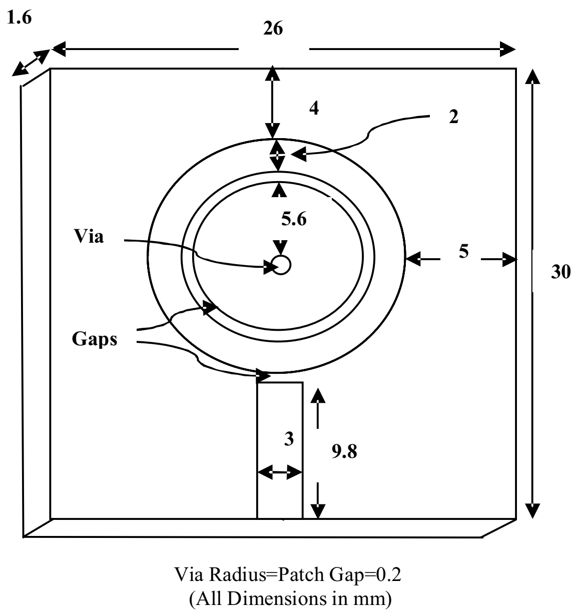

Fig 1: Structure of the Proposed Antenna

used a via (inductive), a circlular gap in the patch (conductive) and a gap of 0.2mm between the patch and the microstripline (capacitive) to directly convert the PEC (Perfect Electric Conductor) patch to DNG metamaterial [4]. Directly, negative permittivity and permeability values can be entered using HFSS, based on finite element method.

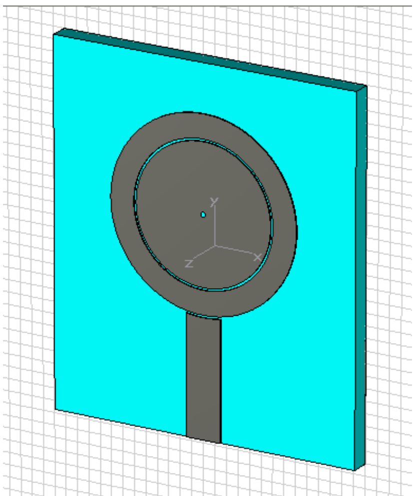

Fig 2: Prospective View of the Proposed Antenna

III. Results and Discussion

For simulation of our antenna we have taken the frequency range 2.4-5.5 GHz to satisfy the wireless requirements [9]. From the 3D radiation pattern shown in fig 3, at 5 GHz frequency the gain of the antenna is 3.768 dB, which is enough for point to point wireless communication [10]. The radiation efficiency for our antenna is excellent i.e. 99.11%. As shown in fig 4 the VSWR at 5 GHz is 1.6. Fig 5 shows a well balanced surface current at 5 GHz.

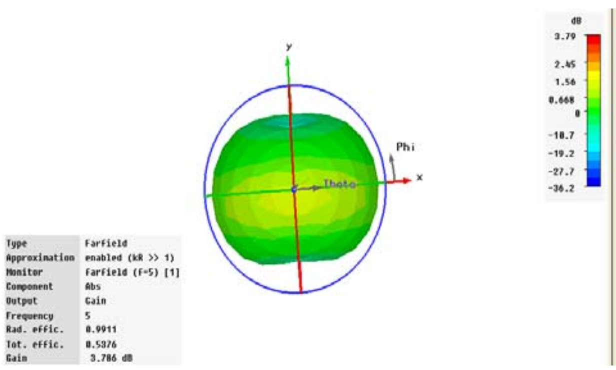

Fig 3: 3D Radiation Pattern at 5 GHz

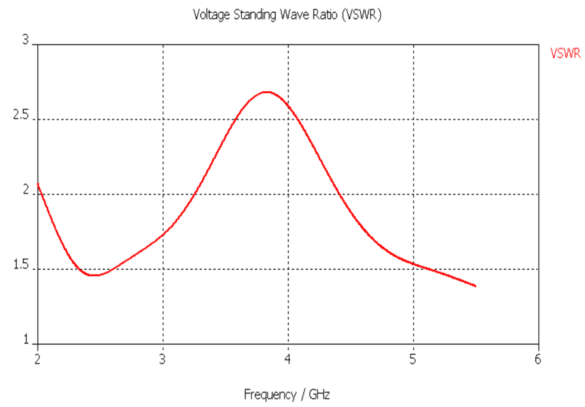

Fig 4: VSWR curve

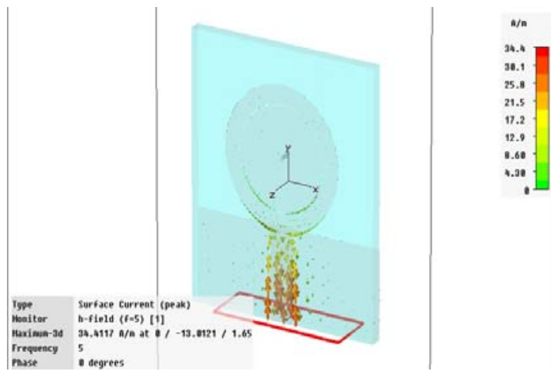

Fig 5: Surface current 5 GHz

IV. Conclusion

By observing the simulated results it is very clear that the compact DNG metamaterial antenna gives better gain and radiation efficiency compared to an ordinary patch antenna which is very useful for point to point wireless propagation. This is possible only because of the unusual properties of metamaterials. We got a very good result at 5 GHz and for current wireless standards 5 GHz is the best frequency.

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