METAMATERIAL BASED MICROSTRIP PATCH ANTENNA USING UNIT CELL ARRAY FOR GAIN ENHANCEMENT

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Abstract : In this paper, an array of 7*7 novel compact metamaterial unit cells is characterized and employed for the gain enhancement of a microstrip antenna operating at 7.1 GHz. This 7.1 GHz operating frequency is the C-band frequency which is use in the long distance for the satellite communication. The unique property of the metamaterial gathers the wave radiated from the antenna and collimates it towards the normal direction when used as a superstrate array. The proposed unit cell is obtained by suitably adding extra metal strips to the conventional mirrored S like structures. The unit cell analysis and parameter extraction using periodic boundary condition confirms the near zero index behaviour as well as significant reduction (almost 52%) in the unit cell footprint. The proposed design provides a gain enhancement of 9.4dB using a single layer superstrate, when suspended above a microstrip patch at 7.1 GHz. Simulation and measurement results confirm that Near-Zero Index Metamaterial (NZIM) lens significantly improves the gain (by more than 1.8 dBi) . A parameter-retrieval method using the *S* parameters is used to calculate the curves for the complex permittivity and permeability of the metamaterial based on its unit element. The S parameters are extracted using HFSS^{TM}, which is a Finite-Element-Method (FEM)-based full-wave simulator. , Near Zero Index Metamaterials (NZIM) have the ability to control the direction of radiation.

***IndexTerms* - HFSS, , Near Zero Index Metamaterials (NZIM),S Parameters**

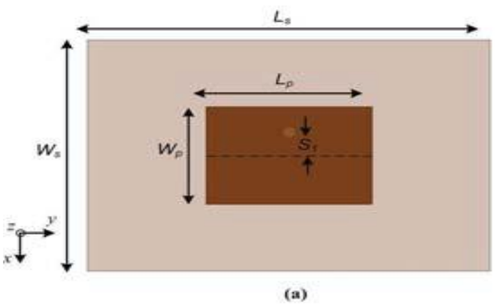
I. INTRODUCTION

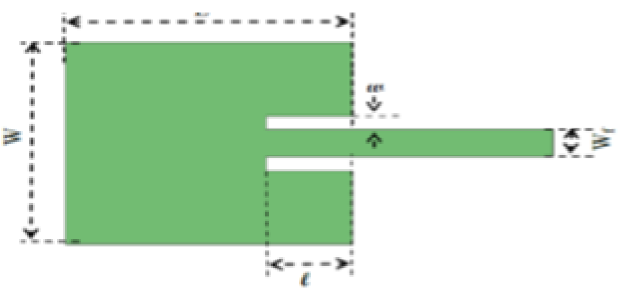
In wireless Communication the antenna plays an important role. For point to point wireless communication and Wi-Fi the antenna should be compact and efficient for convenience. Metamaterial radio wires are a class of receiving wires which utilize Metamaterials to expand execution like pick up and proficiency of scaled down (electrically little) reception apparatus systems. Metamaterial is the main material (fake) on the planet which displays all the while negative permittivity and porousness which prompts negative refractive list. Due to having the negative refractive list it bolsters in reverse waves (antiparallel stage and gathering speeds) and does not comply with some optical properties of nature. These uncommon properties assist Metamaterial with changing the electric and attractive property of electromagnetic waves going through it and this aide in getting improved properties when connected to radio wire outline. Again as the auxiliary normal cell size of Metamaterial is short of what one-fourth of the guided wavelength so it underpins high level of scaling down. These Metamaterial receiving wires will be exceptionally reasonable to use in WLAN due to its superior and little size. Here Metamaterial radio wire utilizing unit cell exhibit is proposed, planned and recreated utilizing HFSS (High recurrence structure test system).

II. DESIGN METHODOLOGY OF PROPOSED ANTENNA

A. Reference Patch Antenna

An insect-fed rectangular microstrip patch antenna operating at 7.1 GHz is taken as the reference design. The schematic diagram of rectangular patch antenna is shown in Fig. 1. Low cost FR4 substrate(ε_r = 2.2, loss tangent δ = 0.02) of height 1.6 mm with copper trace thickness of 35 μm is used for antenna design. The width Wp and length Lp of patch are optimized to give resonant frequency of 7.1 GHz. The physical dimensions of FR4 substrate are Ws and Ls. Simulations in Ansys HFSS shows that the reference patch antenna has impedance bandwidth of 4.25% (7.1GHz) and peak realized gain of 7.6 dBi.





(b)

Fig. 1. schematic diagram of insect fed microstrip patch antenna: (a) Top view [5]. (b) Side view; Lp= 12.8635 mm, Wp= 17.3181 mm, Ls= 31.5 mm, Ws= 31.5 mm, S1= 3 mm ,W1 =1.4798 mm

B. NZIM Unit Cell

Fig.2 shows the metamaterial unit cell, which is used as basic building block of NZIM superstrate for gain enhancement of the MPA. The unit cell is printed on both side of 0.8 mm thick FR4 substrate (εr = 4.4, tan δ = 0.02). The periodicity is denoted by ax and ay in x and y directions respectively. The design parameters of NZIM unit cell are shown in Fig. 2, by changing these parameters the frequency range corresponding to near zero refractive index can easily be tuned.

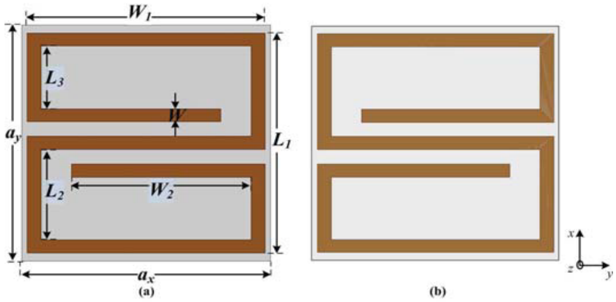


Fig. 2. The schematic diagram of NZIM unit cell: (a) Top surface[5], (b) Bottom surface[5]; ax = ay =4.5 mm, L1 = 4.2 mm, L2 = 1.725 mm, L3 = 1.2 mm, W1 = 4.3 mm, W2 = 3.5 mm, W = 0.25 mm.

C. High Gain Patch Antenna with the NZIM superstrate

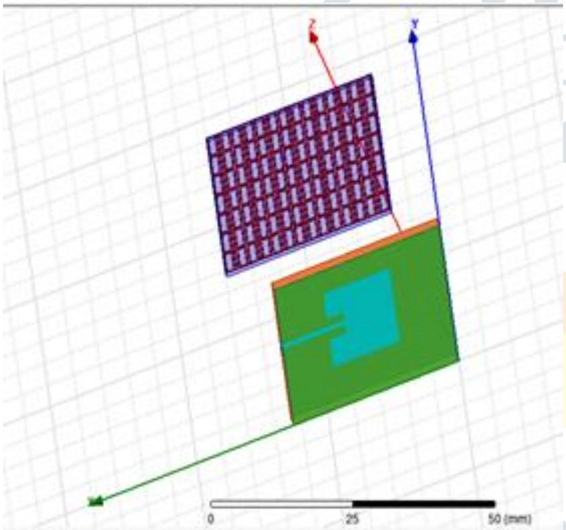


Fig.3 3D view of patch antenna with NZIM superstrate NZIM superstrate:

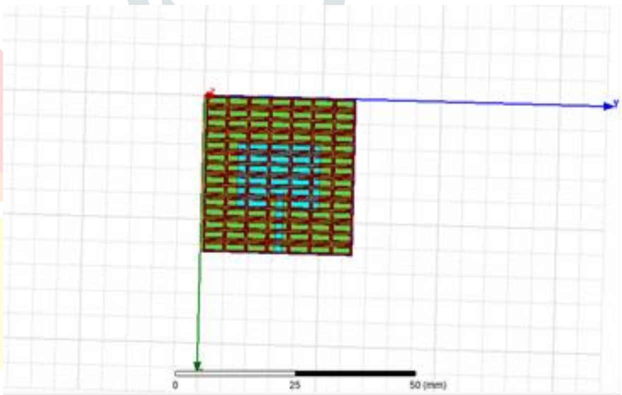


Fig. 4. The schematic diagram of proposed antenna with Top view

III RESULTS

Fig.5 exhibits the significant reduction in the unit-cell footprint that is achieved by using this novel NZIM unit cell. The proposed unit-cell is derived from the mirrored S like structure by adding extra metal-strips (Fig. 5). The encircled regions in the return loss plot (S11) Fig. 5 shows the NZIM operating region of the unit-cells. It is observed that 51.72% reduction in the electrical size of the NZIM unit-cell is achieved by the use of proposed unit cell in Fig. 5(c) as compared to that in Fig. 5(a).

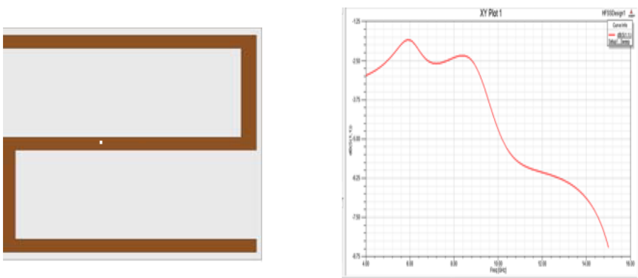


Fig. 5 (a)

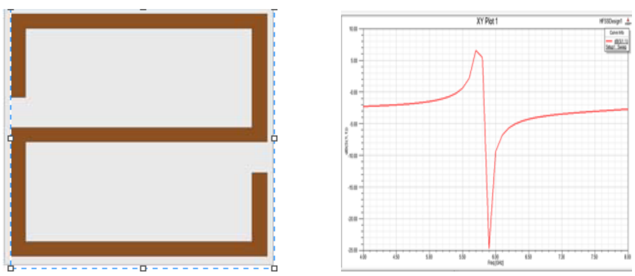


Fig. 5 (b)

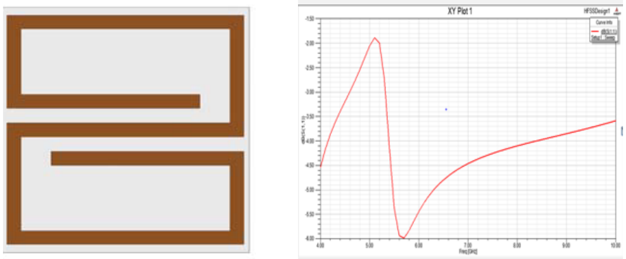


Fig.5(c)

Fig. 5. design procedure of the proposed miniaturized NIM unit cell: (a) stage-1, (b) stage-2, (c) final proposed structure.

Fig. 6 shows the variation of S11, gain of the patch antenna with frequency for a single layer of NZIM superstrate and Efficiency of the patch antenna with NIZM unit cell. It can be observed that the impedance bandwidth is 4.28% and peak gain is 9.4 dBi. Hence the concept of enhancement of gain by convergence of beam is verified.

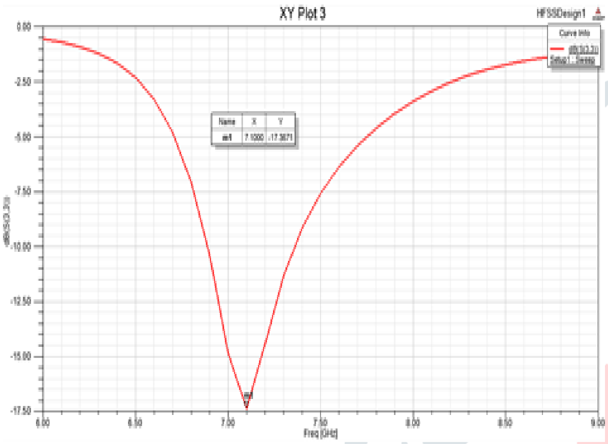


Fig 6(a)

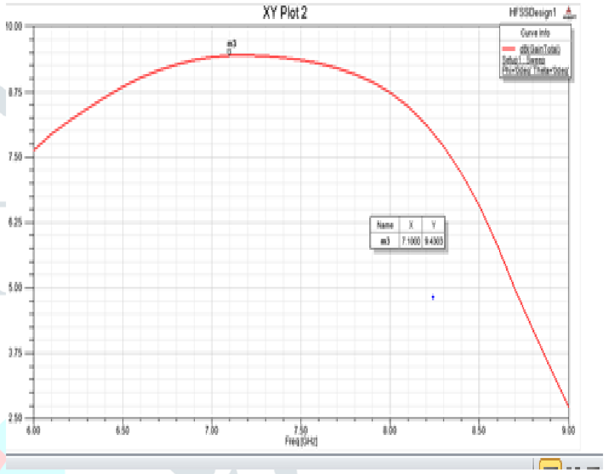


Fig.6(b)

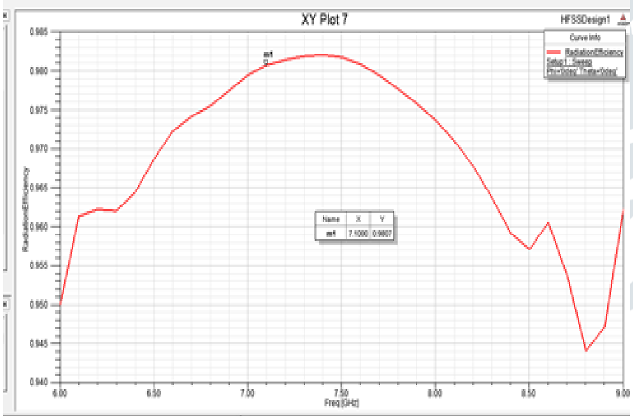


Fig 6(c)

Fig.6 (a) Variation of simulated |S11| with frequency for proposed antenna with single layer NZIML. (b) Variation of simulated gain with frequency.(c) Efficiency of the patch antenna with NIZM unit cell.

IV CONCLUSION

Because of the unordinary properties of the Metamaterials by utilizing a solitary unit cell the receiving wire gives of 1.8 dB, general effectiveness of 98.76 and a VSWR of 1.6 at 7.1 GHz recurrence which is useful for point to point remote correspondence and remote LANs. This radio wire has better VSWR, pick up and radiation proficiency contrasted with a conventional fix reception apparatus. The outcomes acquired through "HFSS" plan programming and are useful for remote access arrange assets at home and somewhere else with up to 7.1GHz execution, as IEEE 802.11a, generally accessible IEEE 802.11b, descending perfect IEEE 802.11g, and progressed IEEE 802.11n

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