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Metamaterial Inverted-F Antenna(IFA) for Ultra-Wideband Application

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***Abstract*— A printed multiband inverted-F antenna (IFA) is presented in this letter. The concept of loading a printed-IFA with composite right/left-handed (CRLH) unit cells is theoretically and analyze investigated by using electromagnetic simulators, High Frequency Structure Simulator (HFSS), for wireless communication. The proposed printed-IFA with two arms interconnect by CRLH unit cell to achieve extra operating bands in addition to the two fundamental resonant frequencies of two IFA arms. The structure is designed to operate at GSM 1.8 GHz and WLAN 5.2 GHz. simulated results are in good agreement with the theoretical predictions.**

Keywords- Antennas IFA,Transmission ligne metamaterial, CRLH, wireless communication.

I. INTRODUCTION

Recently, emerging electromagnetic metamaterials have drawn considerable interest in the engineering and physics communities. [1-2], novel CRLH unit cell metamaterial structures have been developed and studied extensively, and they have already lead to many ground breaking guided-wave, radiated- wave, and refracted-wave microwave applications.[2-3-4]. Recently, the authors have demonstrated the concept of loading monopole antenna metamaterial CRLH unit cell, while maintaining the antenna's small form factor. Later, we provide that the idea of metamaterial inspired to enhance the antenna performance is not pertinent to monopole antennas only, but can be applied to a coplanar waveguide (CPW)- fed printed-IFA, to be used for wireless applications.[5]

This work deals with the analysis and simulation of

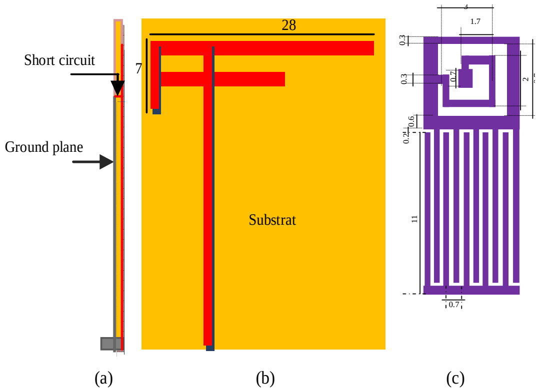

Figure.1.Structure of patch antenna with dimension (in mm)
(a) Side view. (b) Top view. (c) CRLH unit cell

Inverted-F Antenna loaded with interconnected CRLH Structure at a height of 2mm from the ground Plane.

The work also investigates the potential properties of the proposed Metamaterial Structure. The proposed Antenna is designed at an operating frequency of 1.8GHz and 5GHz to meet S-Band (2-4GHz) and WLAN to be used for Wireless data USB applications, By loading Interconnected CRLH Metamaterial Structure with the IF Antenna at a height of 2mm, the Antenna's bandwidth is found to be increased and return loss is reduced to -50.52dB i.e. the potential properties like return loss, bandwidth, directivity, gain and total efficiency increases of the proposed Antenna to a great extent in comparison to the IF Antenna alone.

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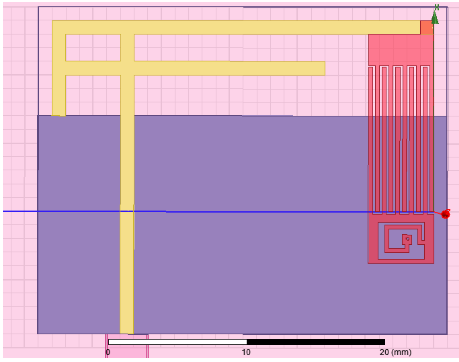


Figure.2. printed two IFA arms are inspired by one metamaterial-inspired cell

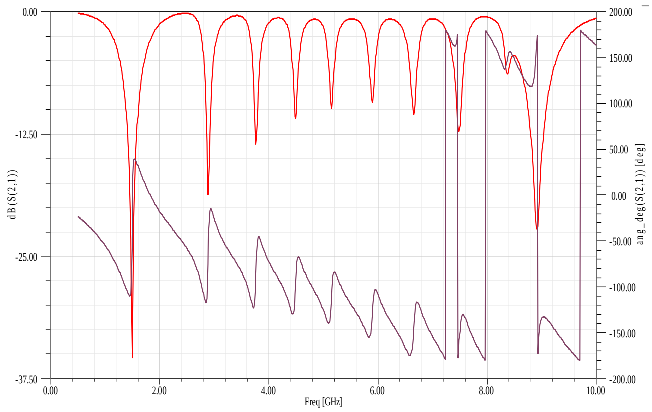


Figure.3. $S_{21}$and ang_deg(S_{21}) results of the proposed CRLH transmission lines unit cell using single spiral inductor

The proposed metamaterials CRLH cell based on the interdigital capacitor and single inductor are shown in the Figure.1. (c). [6] The spiral inductor is more easily to design and fabrication.

The antenna comprises two stacked inverted-F metal lines, which are short circuited to the ground plane printed on the other side of the substrate. The two shorted metal lines are both designed to operate as quarter wavelength structures [7].The antenna is designed on a low-cost FR4 substrate with height h_{sub}= 2 mm, dielectric constant ε_r=4.4, and loss tangent tangδ=0.02. The antenna is fed by a CPW transmission line (TL), which can be easily integrated with other CPW-based microwave circuits printed on the same substrate.

The printed two IFA arms are inspired by one metamaterial-inspired cell, as shown in Figure. 2.

$$F = \frac{C}{4\sqrt{\varepsilon_{reff}}L_i}$$

Where C, L_i and ε_{reff} are the speed of light, the IFA first and second arm lengths, and the effective dielectric constant, respectively.

III. RESULTS AND DISCUSION

This section presents the simulated parameters antenna. Figure 4 it is noted that the realized transition frequency is located at 1.8 GHz and 5GHz. It is clear from figure that the bandwidth of the proposed Antenna is remarkably improved in return loss is significantly reduced in comparison to the conventional antenna. Figure 5 shows the simulated result of the IFA along with proposed Metamaterial Structure, it is clear from the figure that the bandwidth of the proposed Antenna is remarkably improved in operating frequency range (60GHz) and return loss is significantly reduced -60dB in comparison to the IFA alone.

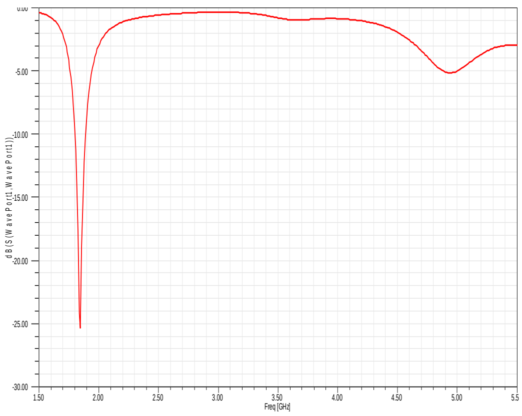


Figure.4.Return loss in frequency function of the proposed conventional antenna

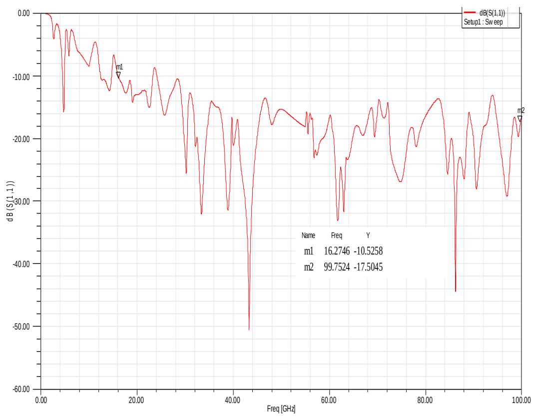
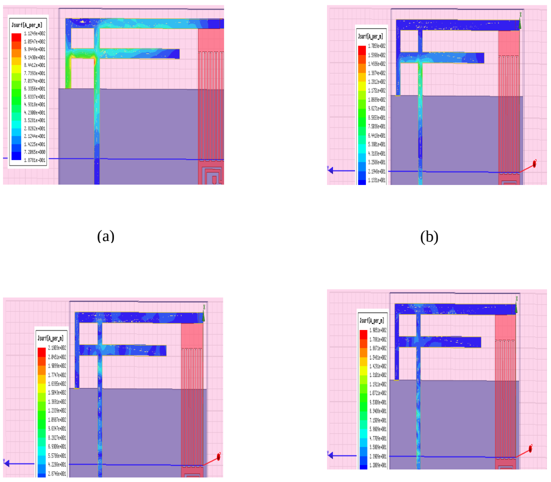


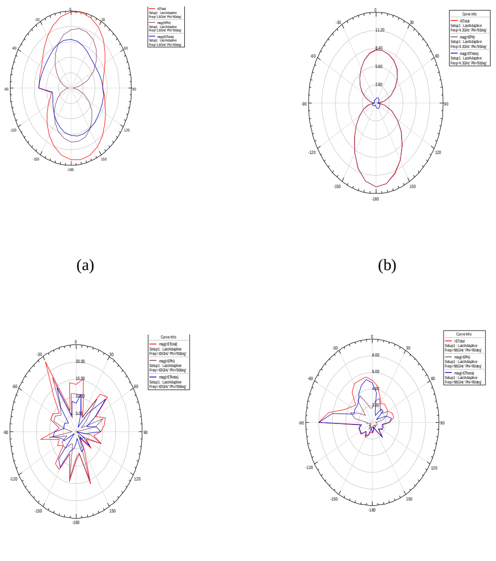
Figure.5.Return loss in frequency function of the proposed printed-IFA with Interconnected CRLH unit cell



(a) (b)

(c) (d)

Figure.6.Surface current distribution at (a) 1.8, (b) 5, (c) 43and (d) 60 GHz.



(a) (b)

(c) (d)

Figure.7. Radiation patterns E_{total} E_{φ} E_{θ} at Frequency (a) 1.8, (b) 5, (c) 43 and (d) 60 GHz.

The surface current distributions at each resonant frequency are plotted in Fig. 6. The two fundamental resonant frequencies of the two IFA arms are at 1.8 and 5 GHz as shown in Fig.5 (a) and (b).the surface current density mainly flows on its corresponding IFA arm and the meander slot of corresponding unit cell, which causes a slight change on the resonant frequency of each IFA arm by interconnect with CRLH unit cell.

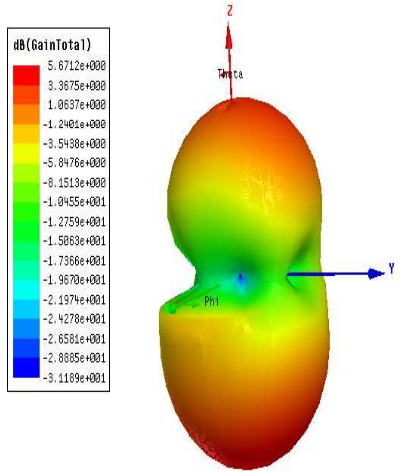
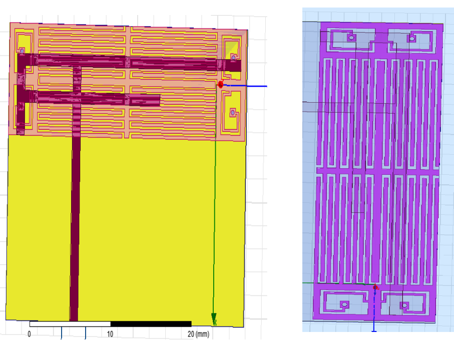


Figure.8.Gain total en dB at frequency 4.3 GHz

IV. COMPARISON



(a) (b)

Figure.9. printed two IFA arms are loaded with “INTERCONNECTED CRLH” Metamaterial Structure.

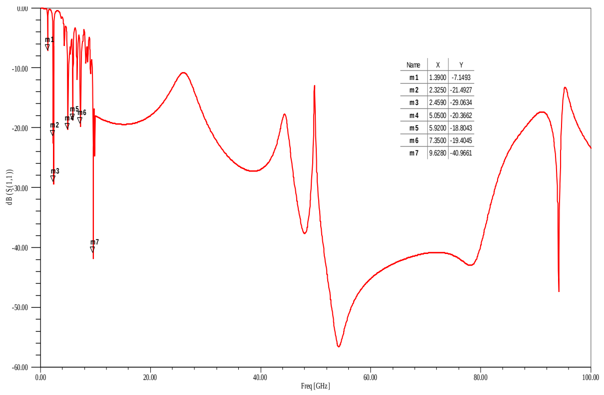


Figure.10.Return loss in frequency function of the proposed printed-IFA with Interconnected CRLH unit cell

Two types of the proposed antenna to fit different wireless applications are simulated by using HFSS. Second structure is shown in Fig. 9.

Fig. 10.shows the simulated S_{11} of the implemented antenna proposed in the design steps that operates at 1.8, 2.4, 5 and 60GHz(ultra wideband) for application in high data rate point-to-point communication systems.

V. Conclusion

A compact new distributed metamaterials quasi-standard transmission lines unit cell based on the microstrip technology is proposed. Spiral inductor is introduced in the unit cell for replacing the classic short stub inductor in order to greatly reduce the total unit cell area.

Ultra wide band printed-IFA loaded interconnecting with transmission lines unit cells (CRLH). The antenna proposed for wireless communication applications. The theory of the proposed antenna was verified by using electromagnetic simulator HFSSv15 .The radiation patterns approximate an omni-directional pattern. The overall size of the antenna including the ground plane is 30*24*2 mm^3. The proposed antenna was easily fabricated on FR4 substrate. The proposed antenna design methodology has been successfully applied in antenna and array designs for GSM1.8GHz WLAN 2.4&5GHz and 60-GHz WPAN applications. The proposed antenna could be used in several microwave applications that requires improved bandwidth & reduced return loss at multiband applications.

The second proposed structure could be considered as a novel approach for improving antenna's potential characteristics.

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