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Design of a Metamaterial Absorber

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ABSTRACT

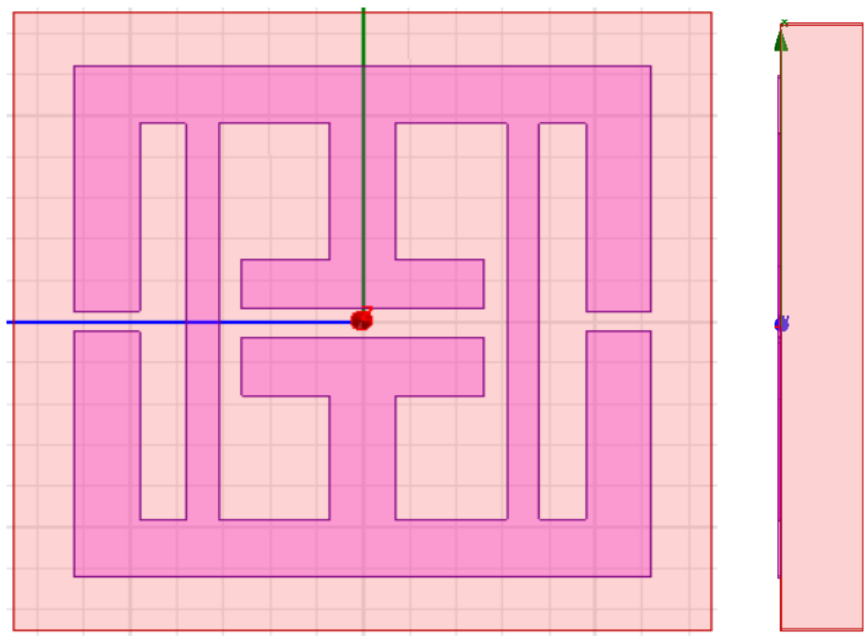
This paper describes the electric field-driven LC (ELC) resonator structure behaving as microwave absorbers at two different frequencies for the application of battlefield and airborne radar. The proposed ELC driven metamaterial structure is simulated and subsequently optimized using Ansoft HFSS which shows an absorption peak at 6.5 GHz and 10 GHz with peak absorbance of 99.1% and 99.9% respectively with S_{11} minima of -24.9 dB and -19 dB. The proposed structure also behaves as microwave absorber up to the angular incidence of 60^0.

1. Introduction

Now a days, metamaterials are becoming very popular for different applications like imaging, antenna system, cloaking etc. They also find applications in the domain of microwave absorber as the size can be reduced significantly with much lesser thickness and economic point of view. Electric Field Driven LC (ELC) resonator-based metamaterial structure has been first proposed by Landy et al. as microwave absorber which is advantageous over conventional Split Ring Resonator (SRR) based metamaterial absorber, where incident electromagnetic wave must travel much lesser distance. Earlier, dual-band metamaterial structures behaving as absorbers have been realized in the terahertz domain using a single basic unit cell. In the present paper, an ELC driven resonator structure has been proposed to obtain dual-band absorbance. The absorption occurs at 6.5 GHz and 10 GHz respectively, where the absorbance peaks are 99.1% and 99.9% respectively with S_{11} of -24.9 dB and -19 dB respectively. The structure is designed near to the centre frequency of the band where it can be used in the battlefield or airborne radar applications.

2. Design Of The Structure

The basic unit cell of the proposed structure is a combination of the structure proposed. The structure shows an absorption peak at a single frequency of 10 GHz and 6.5 GHz, respectively. The basic unit cell is designed in such a way that it shows an absorption peak at two distinct frequencies instead of a single frequency in the desired band. The extra metallic patches are introduced at a distance symmetrically away from each end of the metallic patches as shown in Fig. In the earlier proposed structures, the total structure gives rise to a single frequency only for a single unit cell.



(a) (b)

Fig. 1. Front view and side view Structure of proposed antenna

The structure is made up with two layers of copper separated by a dielectric substrate of FR-4 (ε_r = 4.25 and *tanδ* = 0.02) of 1 mm thickness, where the upper layer consists of the ELC resonator structure and the lower layer is completely laminated (conductivity of 5.8 x 107 S/m). The structure is simulated in Ansoft HFSS using periodic boundary conditions. The absorbance can be found out as in equation (1), where $A(\omega)$, $|S11|^2$ and $|S21|^2$ is the absorbance, reflected power and transmitted power respectively at an angular frequency ω. Due to the copper backing (|S21 |=0), the reduction in reflection from the surface enables the maximum absorption of the structure.

$$A(\omega)=1-|S11|^2-|S21|^2 \qquad (1)$$

3. Simulation And Results

The simulation of the structure shown in Fig. 1 is carried out for normal incidence which shows two distinct minima of S_{11} of -24.9 dB and -19 dB at

6.5 GHz and 10 GHz with the absorbance of 99.1% and 99.9% respectively as shown in Fig. 2. The surface current densities in the ELC resonator structure and the current volume densities within the dielectric are shown in Fig. 3 and Fig. 4 at the frequencies where absorption takes place. The plot shows that at 6.5 GHz and at 10 GHz, the surface current densities are concentrated within the metallic patches at the top surface and volume current densities are very high within the gaps of the ELC resonator structure as consistent for a periodic structure.

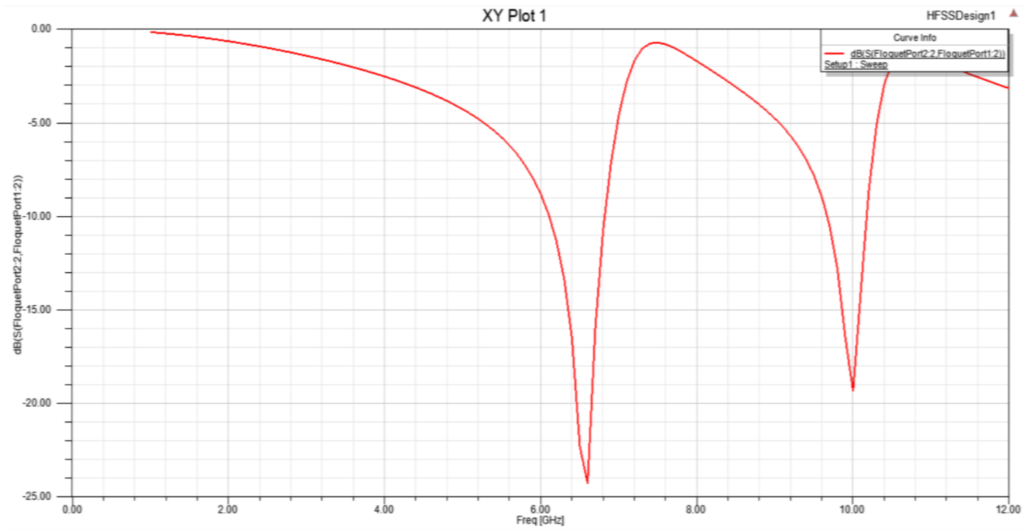


Fig. 2. S 11 plot of the proposed antenna.

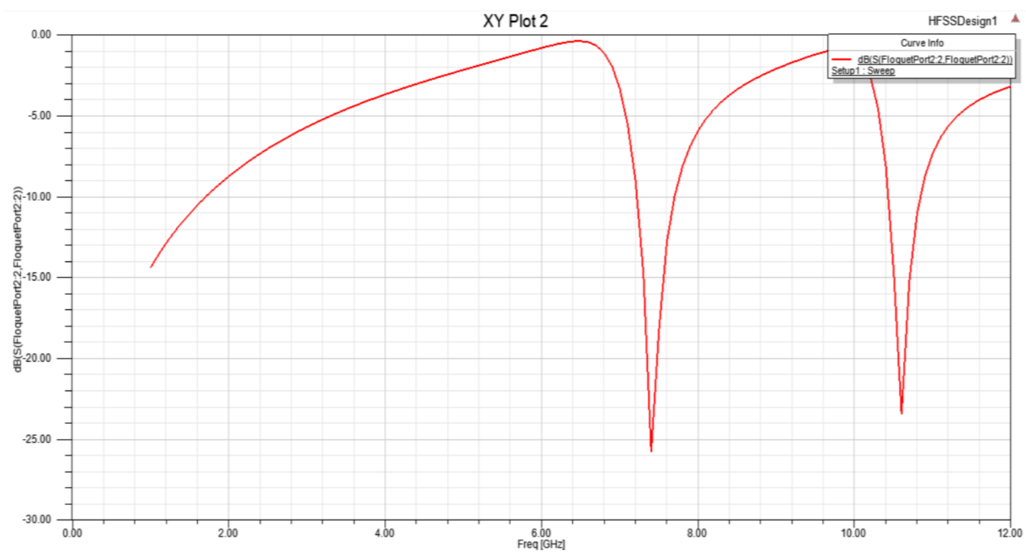


Fig. 3. S 12 plot of the proposed antenna.

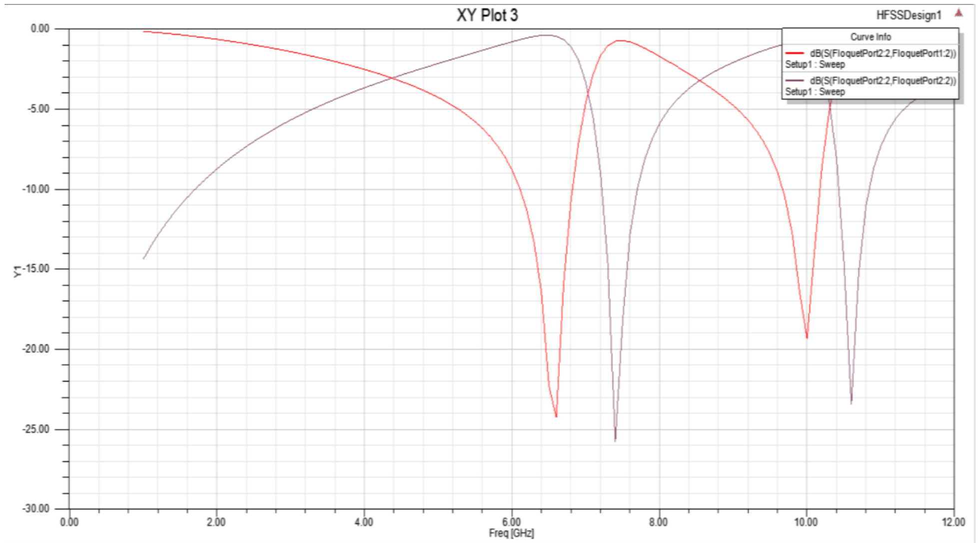


Fig. 4. S 11 vs. S 12 plot of the proposed antenna.

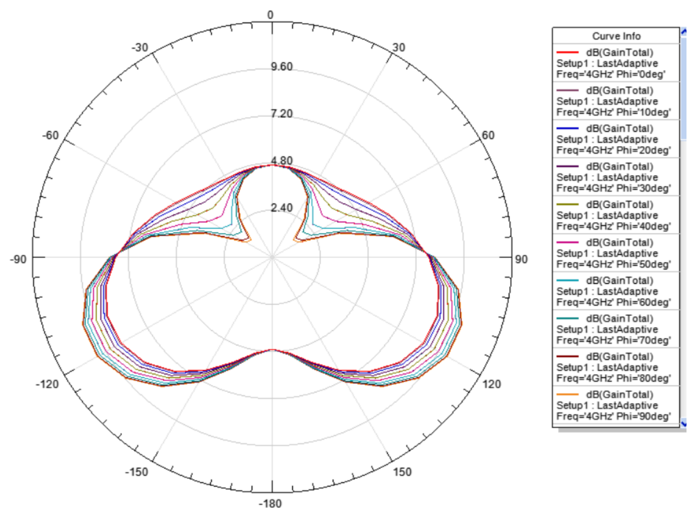
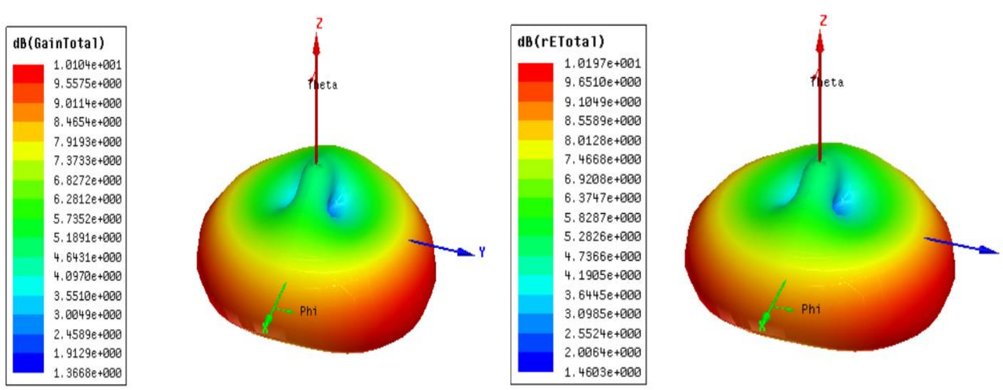


Fig. 5. 2D radiation patterns of the proposed antenna.



(a) (b)

Fig. 6. Total-gain and rETotal of the proposed antenna.

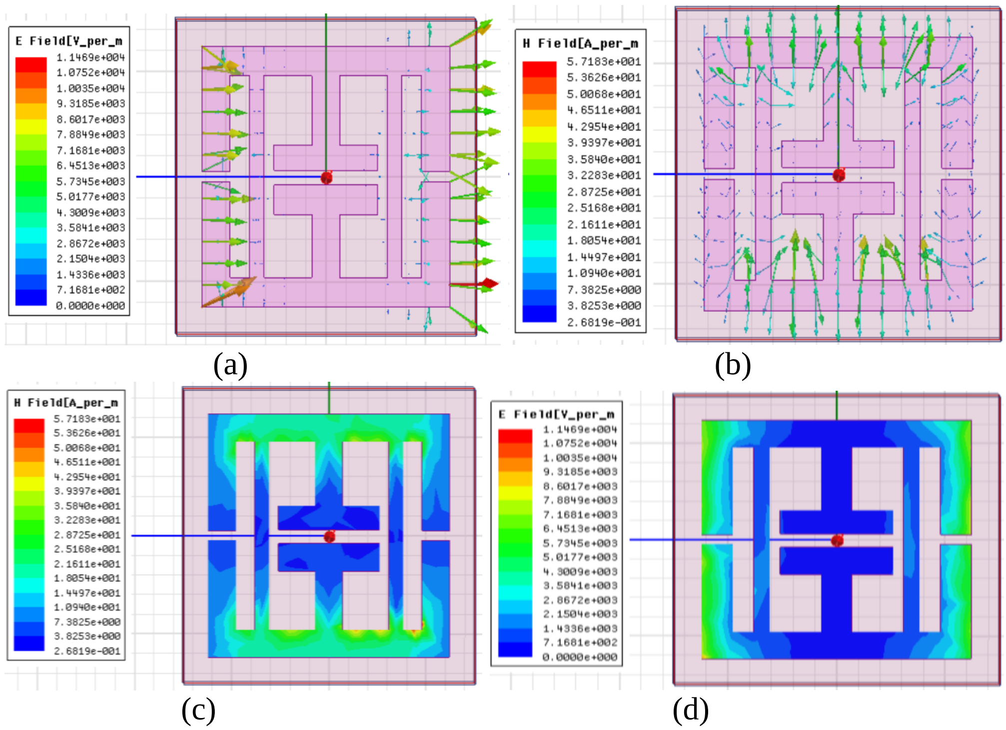


Fig. 7. E Field and H Field patterns of the proposed antenna

4. Application

The applications of this antenna are: -

- Imaging system application.
- Cloaking application.
- Microwave absorber application.
- Battlefield application.
- Air borne radar application.

5. Conclusion

An ELC driven resonator structure behaving as microwave absorber has been proposed in this paper having high absorbance peaks at dual bands and its parameters are optimized suitably to obtain the frequency of absorption near to 6.5 GHz and 10 GHz, which can be used for the battlefield and airborne radar applications. The structure is also behaving as an absorber for variations over wide angular incidence. The structure can be further modified in such a way that it can be used as a broadband absorber covering the full band of operations of the battlefield or airborne radar applications.

References

M.H. Li, L. Hua Yang, B. Zhou, X. Peng Shen, Q. Cheng, and T. J. Cui, "Ultrathin multiband gigahertz metamaterial absorbers," Journal of Applied Physics, 110, pp. 014909, 2011.

D. Schurig, J.J. Mock, and D.R. Smith, "Electric-field-coupled resonators for negative permittivity metamaterials," Applied Physics Letters 88, pp. 041109, 2006.

F. Bilotti, L. Nucci and L.Vegni, "An SRR-based microwave absorber," Microwave and Optical Technology Letters, vol. 48, no. 11, pp. 2171-2175, Nov. 2006.

H. Tao, C. M. Bingham, D. Pilon, K. Fan, A. C. Strikwerda, D. Shrekenhamer, W. J. Padilla, X. Zhang, and R. D. Averitt, "A dual band terahertz metamaterials absorber," Journal of Applied Physics D, 43, pp. 225102, 2010.

Q. Y. Wen, H. W. Zhang, Y. S. Xie, Q. H. Yang, and Y. L. Liu, "Dual band terahertz metamaterials absorber: design, fabrication and characterization," Applied Physics Letters, 95, 241111, 2009.