Dual Band Polarization Insensitive Metamaterial Absorber in X-band

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Abstract - **This paper presents the design of dual band polarization insensitive metamaterial absorber at 9 GHz and 10 GHz. The unit cell of the metamaterial consists of four circular rings copper with copper lines printed on 0.8 mm thick FR4 substrate with dielectric constant of 4.6 and loss tangent of 0.019. The simulated result shows that the dual band metamaterial absorber achieves 97.00% and 97.77% for normal incident electromagnetic waves at 9 GHz and 10 GHz respectively. The corresponding full width half maximum (FWHM) are 3.59% and 3.31%. The simulation result verified that the absorber well performance at any polarization of incident electromagnetic waves.**

Index Terms — **metamaterial absorber, polarization insensitive, dual band electromagnetic absorber.**

I. Introduction

The metamaterial absorbers have gain great deal of interest in science and engineering community due to their capability of absorbing electromagnetic waves at specific range of frequency. The unique electromagnetic properties of these kind of structures make them as good candidates for several potential applications such as electromagnetic cloaking, super lens, sensing, absorber, EM filters, high frequency polarization rotators and bolometer [1]. In general, these structures are artificial structures that can be fabricated at desired electromagnetic spectrum from radio to optical frequencies [2]. In 2008, Landy et. al [3] presented metamaterial absorber that achieved nearly unity absorbance using both electric and magnetic resonators. Since then, many works has been done relating to the microwave absorber using metamaterials. For example, J. Lee and S. Lim [4] introduce bandwidth enhance metamaterial absorber using a double resonant metamaterial. Next, Li et al [5] presented ultra-thin electromagnetic absorber with different modes. Then, Zhu et. al [6] proposed a metamaterial absorber with polarization insensitive. Many other works have been presented relating to the metamaterial absorbers at many operating frequencies depending to the applications.

II. Metamaterial Design and Simulation

The design of dual band circular ring metamaterial structure using FR4 material is shown in Fig. 1. The schematic of the proposed unit cell metamaterial structure consists of dielectric substrate sandwiched by two metallic layers. The top metallic layer is dual resonant copper layer constructed by four circular rings structure with copper lines in different arrangement for each circular ring. The copper lines are connected to each circular ring to obtain resonant frequency of 9 GHz. The circular ring itself resonate at 10 GHz. The dimension of the structure is optimized using full wave simulation. The bottom metallic layer is full copper ground plane. The size of substrate for the unit cell is 18 mm x 18 mm x 0.8 mm (W x L x h). The average radius of the circular ring structures, R is 2.70 mm. The width of the rings, W_r is 0.24 mm. The length, l_c and width, W_c of the copper lines are 1.23 mm and 0.24 mm respectively. At the bottom of the substrate, full copper ground plane is used to simplify the analysis where the transmittance can be reduced to zero for all frequency. Added advantage of using full copper ground layer is the analyses can be simplify by minimizing value of reflectance only to obtain absorbance magnitude.

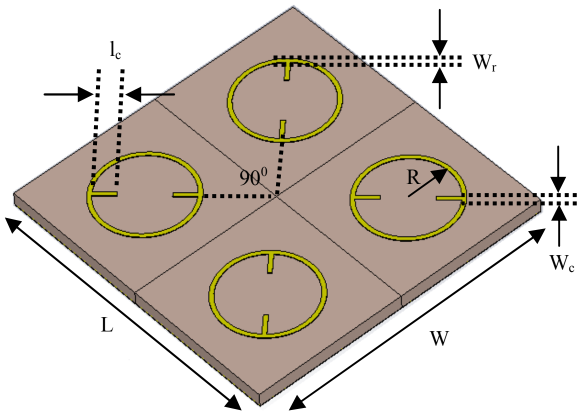


Fig. 1. The geometry of the unit cell of dual band polarization insensitive metamaterial absorber.

III. Simulation Result and Discussion

A. Absorbance Magnitude for Different Polarization State

In this absorber design, the additional of copper lines within the copper ring shape will introduce a second resonant frequency at 9 GHz, while the original circular ring resonate at 10 GHz. Using the resonant element arranged as shown in Fig. 1, the dual band metamaterial absorber can be achieved with independent to the polarization state. Figure 2 shows the simulated absorbance magnitude for the proposed metamaterial absorber. The structure is simulated for different polarization angles which are 0^0, 22.5^0, 45^0, 60^0 and 90^0. The simulated result shows that the absorbance magnitudes and the resonance frequencies are almost unchanged for all angle of incident of electromagnetic waves. This indicates that this structure do not sensitive to any polarization angles. For 0^0, the absorbance magnitudes are very high which are 97.00% and 97.77% for 9 GHz and 10 GHz respectively. The corresponding full width half maximum (FWHM) are 3.59% and 3.31%. For other cases, the variation of absorbance magnitude is less than 5%.

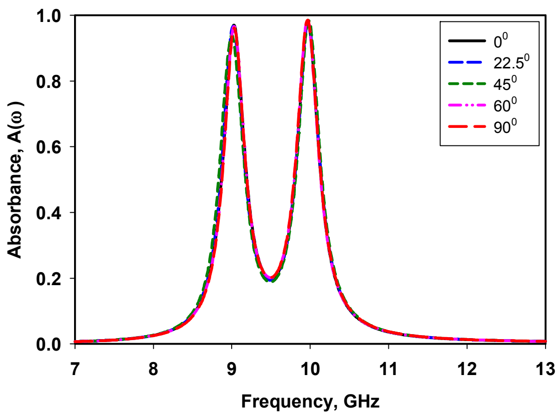
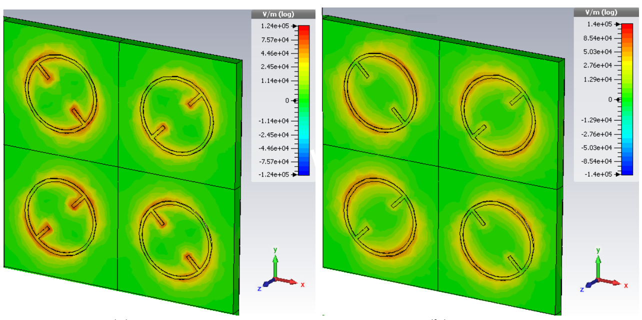


Fig. 2. Absorbance Magnitude for Different Polarization State.

B. Electric Field Current Distribution

To better understanding of the physical behavior of the metamaterial absorbers, the electric field distribution and surface currents are simulated at both resonance frequencies. Fig. 3 shows the electric field distribution for the proposed metamaterial absorber. It can be observed that the concentration of power loss distribution for 9 GHz is highest at the circular ring part near the copper lines and at the copper lines itself as shown in Fig. 3(a). This is because the copper lines give an additional electrical length that enable the absorber to resonate at lower frequency. At 10 GHz, the electric field distribution is strong at circular ring part, 90^0 from the location of copper lines as shown in Fig. 3(b).

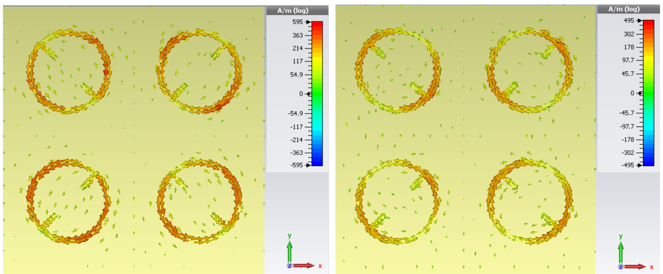


(a) (b)

Fig. 3. The electric field distribution for the proposed metamaterial absorber at (a) 9 GHz and (b) 10 GHz

C. Surface Current Distribution

Subsequently, the surface current distribution is investigated for the proposed metamaterial absorber. Upon interaction with incident electromagnetic waves, the dipolar response is observed in which the currents are flowing upward and downward alternately as shown in Fig. 4. In Fig. 4(a), the currents are flowing inside and outside the copper lines alternately for 9 GHz resonant frequency. For 10 GHz as shown in Fig. 4 (b), the currents do not enter the copper lines but they are flowing upward and downward only at the circular ring structure.



(a) (b)

Fig. 4. The surface current electric distribution for the proposed metamaterial absorber at (a) 9 GHz and (b) 10 GHz

IV. Conclusion

In summary, a dual band polarization insensitive metamaterial absorber has been designed and simulated. The performance of this metamaterial absorber is observed in term of absorbance magnitude for different polarization angle. The simulated result shows that this kind of absorber do not sensitive to any polarization state of incident electromagnetic waves. To understand the physical behavior of the dual band metamaterial absorber, the surface current and electric field distribution are plotted and studied.

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