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Design of a Dual Band Metamaterial Absorber

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ABSTRACT

The design and description of a dual band electromagnetic (EM) absorber for the C-band and Ku-band are presented in this study paper. In the proposed structure the absorber is composed of two ring and four-square resonators. The Two ring resonators, four square resonators and ground of the proposed microwave metamaterial absorber are made of copper(annealed) with FR-4(lossy) serving as the substrate. The suggested structure has an absorption bandwidth of 400 MHz and 600 MHz with absorption peaks of 99.60% and 99.54% at resonant center frequencies of 7.42 GHz and 13.32 GHz respectively. The results demonstrated that such an absorber does have good absorption and is polarization-independent about large incident angles for both TE mode and TM mode in the two absorption bands.

Key words : Metamaterial, absorber, Dual-band, Absorption, Electromagnetic.

1. INTRODUCTION

1.1 Metamaterial Absorber

Researchers have focused on unusual, well-engineered Metamaterials for the last ten years. The fundamental idea behind absorbers is to use a metamaterial with a high absorption coefficient to transform sound waves or electromagnetic radiation into another kind of energy, such as heat and electricity.

An electro-magnetic system with the ability to absorb electromagnetic energy with minimal reflection and transmission is regarded as an excellent microwave absorber. The practical applications of traditional microwave absorbers are greatly limited [1]. A single-band absorber with perfect unity absorption was developed by Landy et al. in 2008 [2]. These absorbers were developed with the aid of cut wires and electric resonators, which provided a narrow bandwidth response. Subsequently, extensive research on single band microwave absorbers [3], functioning in the C-band has been proposed. The application of metamaterial absorbers has been limited by the difficulty of overcoming the narrow bandwidth. Many researchers have worked on improving the operational frequency band. Furthermore, the realizations of wideband [4-5], polarization in sensitive [6], miniaturized ultra-thin [7], low profile [8] frequency-tunable microwave absorbers, and coherent ideal absorbers (whose absorption output could be controlled by the interference of two EM waves that propagate counter clockwise) have been implemented [9].

On a grounded substrate, two metallic rings and four-square resonators are designed. Except substrate remaining all the components are made of copper(annealed). The substrate is made of FR-4(lossy) material. The main agenda is that the proposed microwave absorber should increase absorption rate and reflection coefficient while lowering electromagnetic interference and electromagnetic compatibility. For simulation, it is necessary to fix the frequency such that the planned absorber operates adequately within the specified frequency range. After that, in order to obtain the simulation results for the microwave absorber model, device must modify the Background and Boundary settings. The monitors part of the CST software tool bar contains the results of the testing and validation of the suggested absorber. The only component that needs to be studied for this absorber model is the Field Monitor and there are three possible mode types are possible such as Surface current, Magnetic field, and Electric field. It can test and evaluate a variety of various mode types for our absorber model's specifications. At frequencies 7.42GHz and 13.2 GHz, require testing and validation. Have to apply for each frequency before pressing the start button. The test and validation findings for the microwave absorber design will be provided here.

Contrary to natural materials, amazing properties of metamaterials, which do not exist in nature, have led to a wide range of applications for metamaterials, including electromagnetic wave absorbers, highly sensitive sensors, optical imaging, antennas, filters, SAR reduction, electromagnetic wave modulators, etc., Due to their ultra-thin, uniform absorption qualities that are independent of polarization and angle of incidence, metamaterials have been demonstrated to be an exceptional and ideal choice to suit the needs of state-of-the-art absorber applications. The fundamentals of absorbers, their design, and their applications in many industries will be reviewed in this work. We will also go over current developments in absorber technologies and materials, as well as how they might affect applications in the future.

2. DESIGN OF A METAMATERIAL ABSORBER

The proposed microwave absorber's designing process and measurements are covered in this section. The suggested absorber is designed in three stages, beginning with the design of the Circular Ring Resonator(CRR)unit cell, and continuing with the capacitive loading of the CRR unit cell with copper(annealed) and FR-4 lossy substrate.

As in detail we can start with CST Studio Suite. Firstly, we can select a new MW and RF template. Then go on with the steps included. At last select the frequency and also tick the box for calculating Absorption Transmission and Reflection plot. It creates an page where we have to create a design. Start designing the absorber based on our requirements with suitable dimensions. Save the model and Start Simulation. After the simulation we can observe the Reflection Coefficient Graph and the Absorption Efficiency graph. The bands in this S-parameters should cross -10db line if it has to be a good metamaterial absorber.

For this design the bands will cross -24db line which makes this an almost a perfect metamaterial absorber. The absorber is good if these crosses even more negative db lines. There is no change in the S-parameters for angle phi but when it comes to oblique angle there will be a change in the results.

2.1 Figures and Tables

The Figure 1 depicts the design the proposed metamaterial absorber which is done in CST Studio Suite.

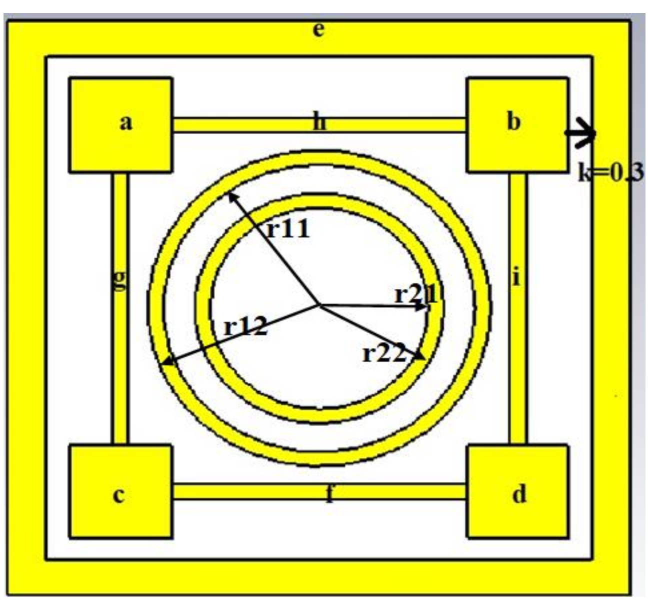


Figure 1: Design of the proposed system.

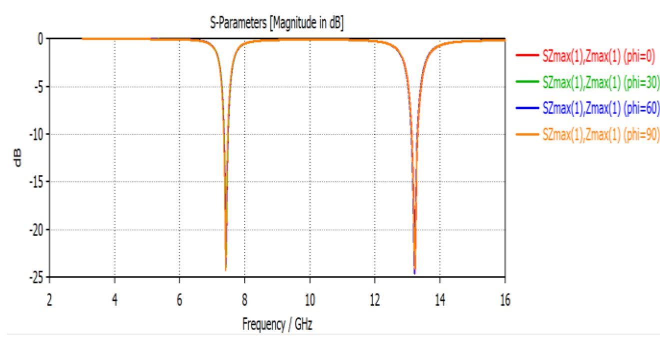
For designing this we required many parameters, so to avoid confusion we can list out these parameters in a table 1.

Table 1: Parameters and their values

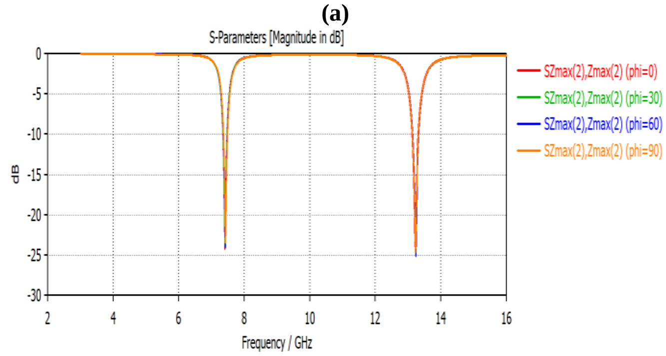
S.No	Parameter	Value(mm)
1	Length and width of substrate	8*8
2	Height of substrate(h)	1
3	r11	2
4	r12	2.2
5	r21	1.4
6	r22	1.6
7	Side of squares(a,b,c,d)	1.3
8	Length &width of boundary(e)	8 &0.5
9	Thickness(t)	0.035
10	Length &width of wires(f,g,h,i)	3.8 & 0.2
11	Gap between squares from boundary(k)	0.3
12	Ground	8*8

3. RESULTS AND DISCUSSIONS

3.1 Reflection Coefficient



(a)



(b)

Figure 2: Simulated result of reflection coefficient for variations in the angle of polarization under (a)TE mode and (b) TM mode.

3.2 Reflectance-Transmittance-Absorbance

These parameters are also evaluated for predicting the nature of a metamaterial absorber. The main parameter we should take into consideration is Absorption Efficiency. Greater the efficiency the greater will be the chances of absorption of EM signals.Figure3.21 shows Reflectance Transmittance plot.

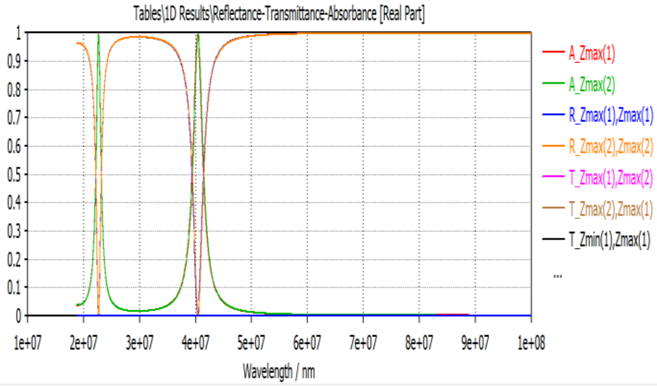
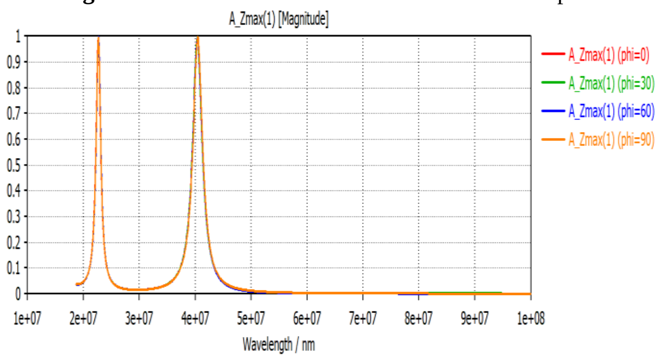
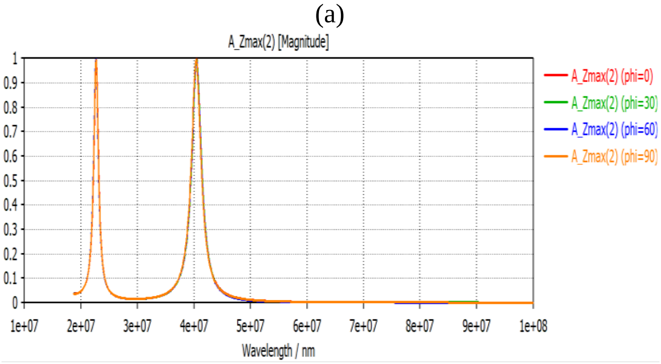


Figure 3.1 Reflectance-Transmittance-Absorbance plot



(a)



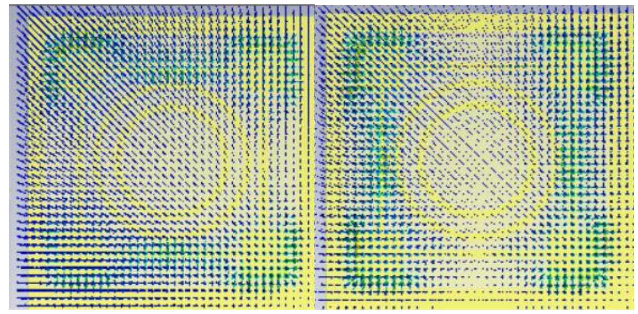
(b)

Figure 3.2: Simulated result of absorption plot for variations in the angle of polarization under (a)TE mode and (b) TM mode.

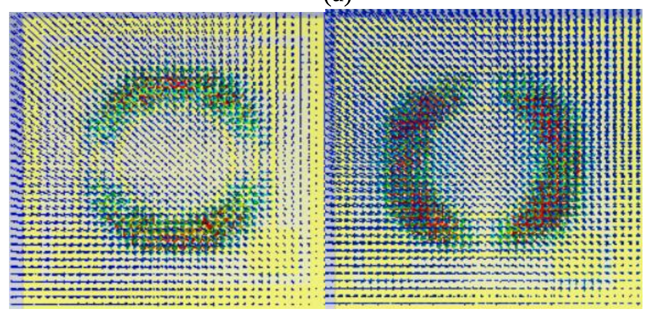
The above figures depicts the absorption efficiency at two frequencies. The absorption peaks at 7.42GHz with 99.6% and also at 13.32GHz with 99.54%. These frequencies come under C-band and Ku- band. Satellite downlink communication is an application for 7.42GHz and uplink communication for 13.32GHz.

3.3 E-Field, H-Field and Surface Current

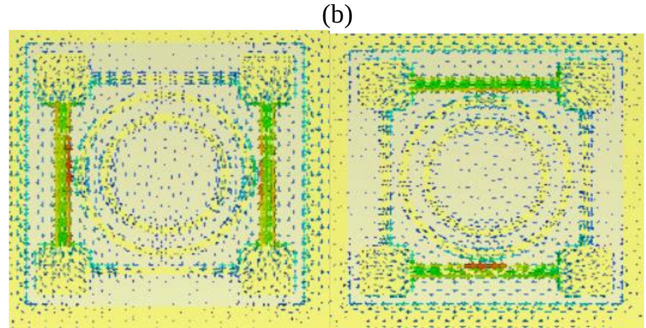
For example, click on the Electric field for the frequency of 7.42 GHz to confirm it first. Then, validate the remaining Electric field results at the other acquired frequency, such as 13.23 GHz. The H-Field and Surface Current are then treated in the same manner for all obtained frequencies (Figure 4 and Figure 5).



(a)

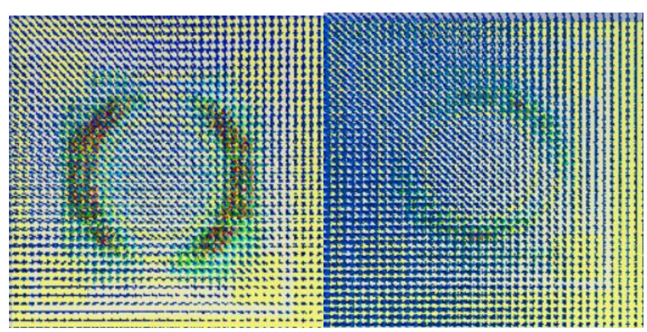


(b)

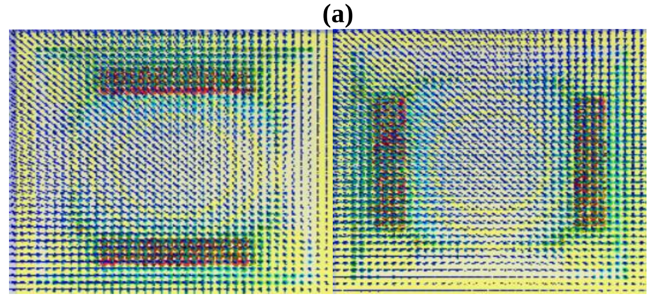


(c)

Figure 4: Simulated results at Port 1 and Port 2 For 7.42GHz in (a) E-Fields (b)H-Fields (c)Surface Current



(a)



(b)

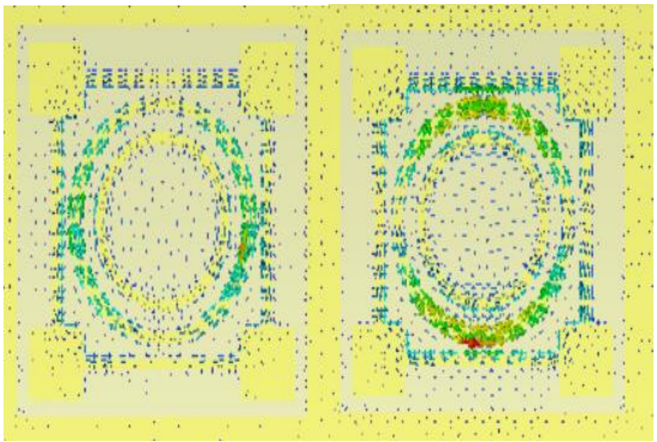


Figure 5: Simulated results at Port 1 and Port 2 For 13.2GHz in (a) E-Fields (b)H-Fields (c)Surface Current

4.CONCLUSION

In this study, a C-band and Ku-band dual-band electromagnetic (EM) absorber has been constructed and described. In the suggested configuration, the absorber is composed of two ring resonators. The two rings and ground of the proposed Microwave absorber metamaterial are made of copper(annealed) with FR-4(lossy) serving as the substrate. It is demonstrated that the suggested precaution is conformal and insensitive in regard to electromagnetic wave polarization and the point of slanted rate of approach. The suggested structure has an absorption bandwidth of 400, 410, and 600 MHz, with absorption maxima of 99.6%, and 99.5% at resonant center frequencies of 7.42 and 13.24 GHz. The experimental outcomes are consistent with the calculations, and the proposed structure is insensitive to the polarization of the transverse magnetic and electric fields as well as the angle of incidence of the incoming wave.

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